888 Service Technician's Manual

02−02−2015

Operator’s Manual 1-8 Numeric Tabs

888 MANITOWOC

IDENTIFICATION AND LOCATION OF COMPONENTS

SERVICE TRAINING

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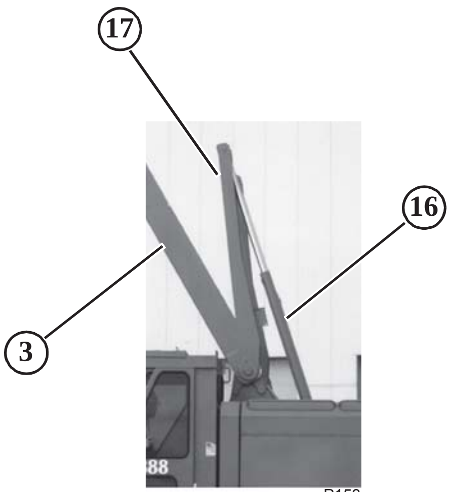
NOTICE

Because of a program of continuing improvements, Manitowoc Engineering Co. reserves the right to change this publication at any time, without notice to reflect those improvements. This publication identifies optional systems which may or may not be a part of your crane.

CRANE ORIENTATION

Terms RIGHT, LEFT, FRONT, REAR used in this publication refer to operator’s right, left, front, and rear sides when seated in operator’s cab looking forward.



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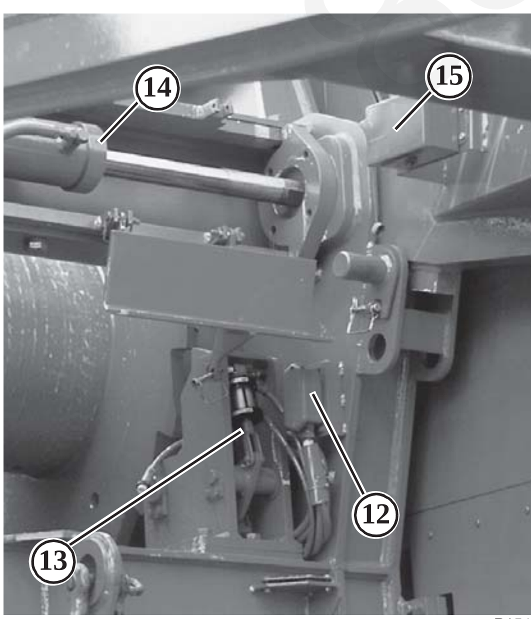

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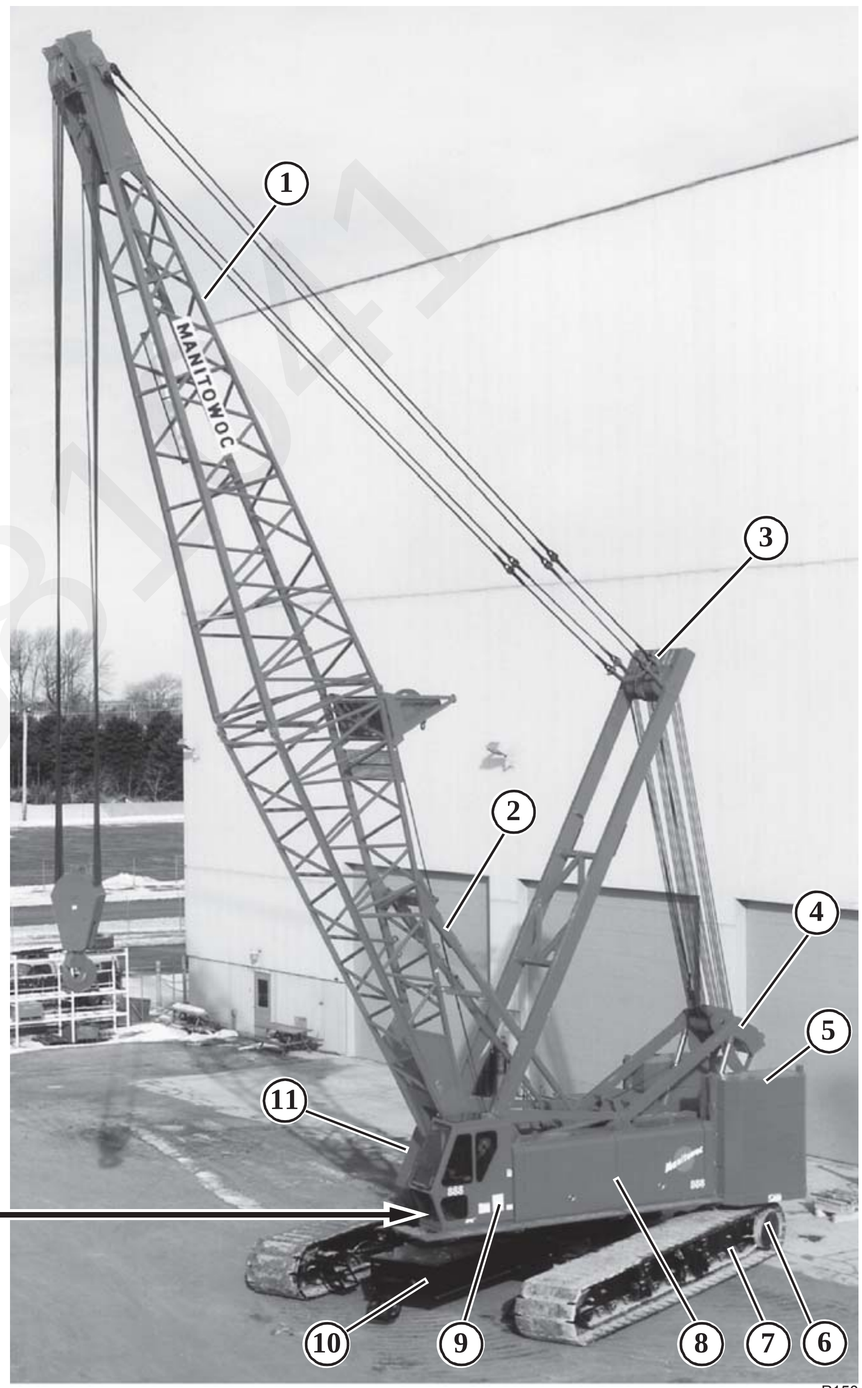

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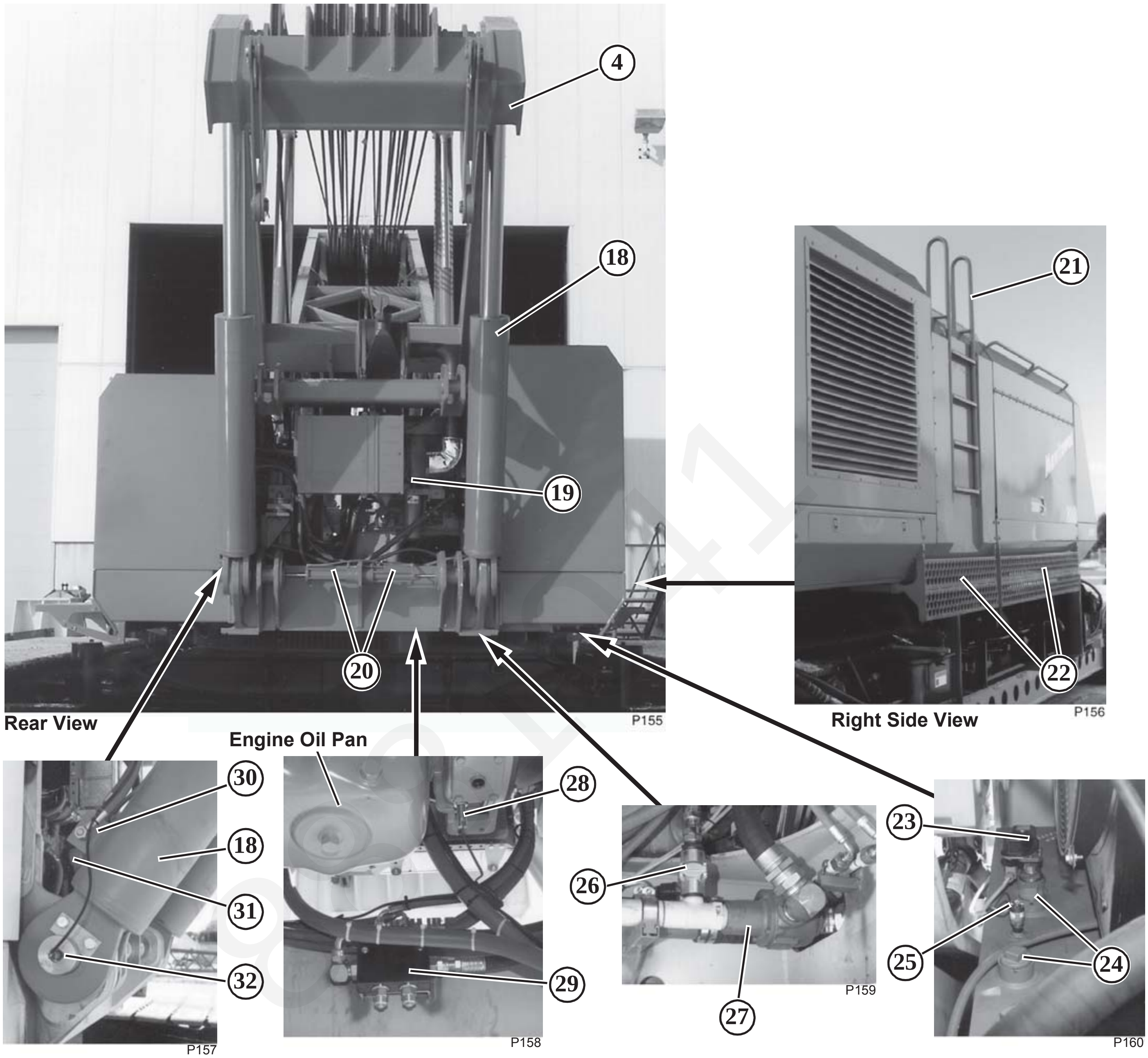
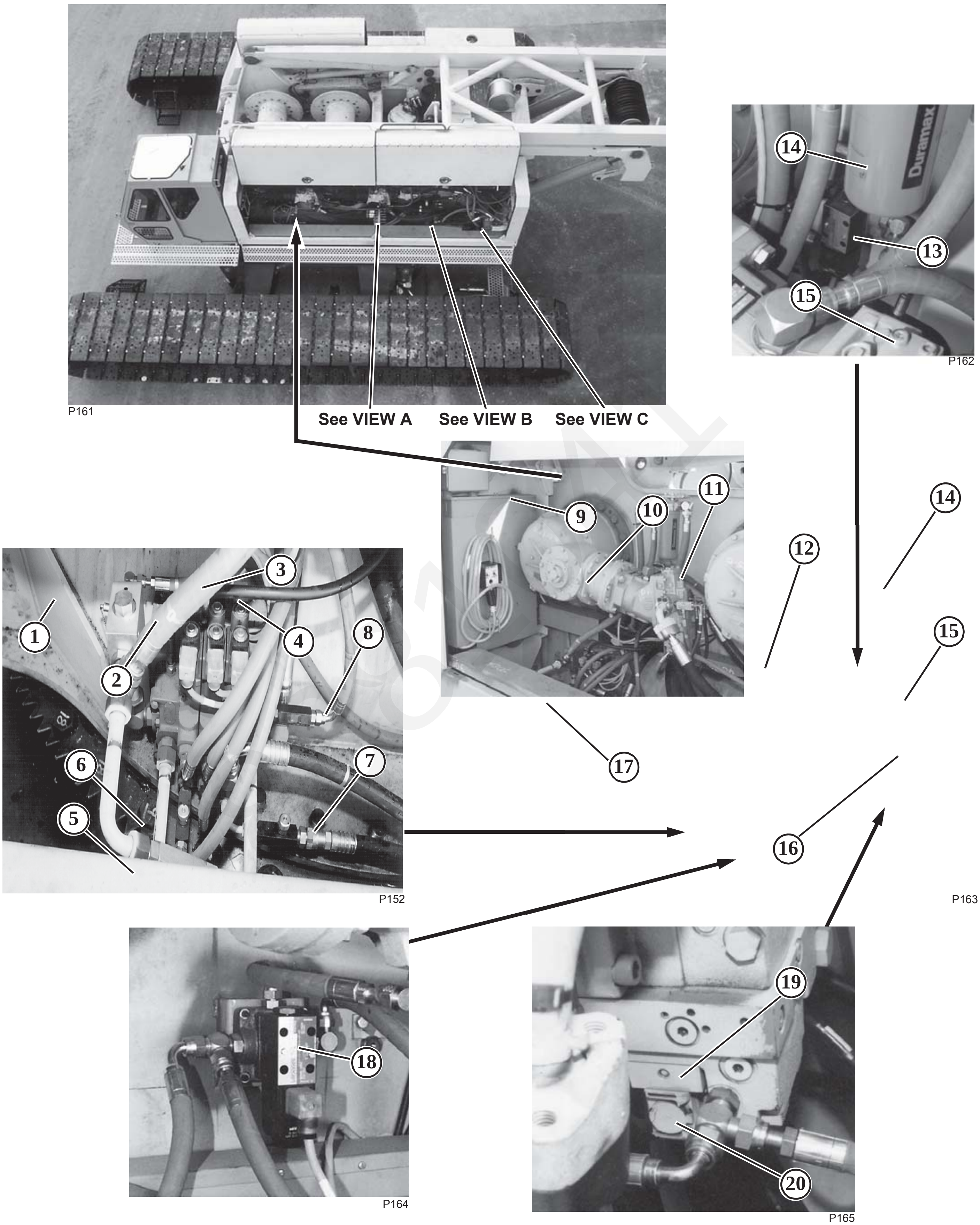


1 - 22E Boom
2 - Physical Boom Stop
3 - Mast
4 - Gantry
5 - Crane Counterweight
6 - Crawler Drive
7 - Crawler Assembly
8 - Left Enclosure
9 - Operator’s Cab
10 - Carbody Counterweight
11 - Right Enclosure
12 - Block-Up Limit Shorting Plug
13 - Drum Pawl (typical front and rear drums and boom hoist)
14 - Boom Hinge Pins Cylinder
15 - Boom Angle Indicator Junction Box
16 - Mast Assist Cylinder
17 - Mast Assist Arm
18 - Gantry Cylinder
19 - Engine
20 - Counterweight Pin Cylinders
21 - Ladder (stored)
22 - Catwalks (stored-typical both sides of crane)
23 - Hydraulic Tank Level Alarm Switch
24 - Hydraulic Tank Heater (if equipped)
25 - Hydraulic Tank Temperature Alarm Switch
26 - Oil Cooler Pressure Bypass Valve
27 - Oil Cooler Thermal Bypass Valve
28 - Engine Speed Sensor
29 - Gantry Load Equalizing Valve
30 - Gantry Extend Counterbalance Valve
31 - Gantry Retract Counterbalance Valve
32 - Load Sensor Pin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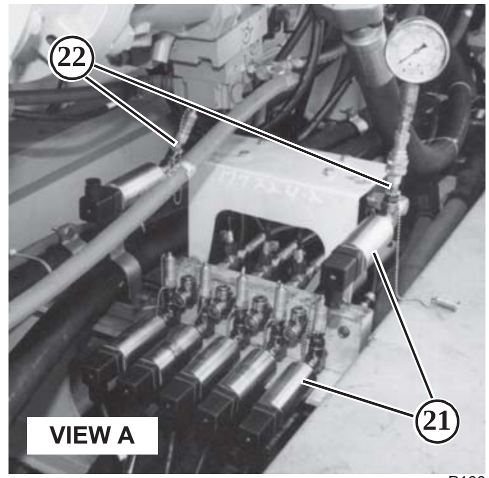
1 - Accessory System Dump Valve
2 - Mast Assist Control Valve
3 - Boom Hinge Pins Control Valve
4 - Gantry Control Valve
5 - 65 psi (4.5 bar) Back Pressure Check Valve
6 - Mast Assist Flow Regulator (extend side)
7 - Gantry Flow Regulator (extend side)
8 - Mast Raising Replenishment Valve
9 - Fuse Junction Box
10 - Main Junction Box
11 - Front Drum Planetary (rear drum identical)
12 - Front Drum Disc Brake (rear drum identical)
13 - Travel 2-Speed Control Valve
14 - Accessory System Hydraulic Filter
15 - Front Drum Motor (rear drum identical)
16 - Orifice
17 - Remote Controller
18 - Front Drum Disc Brake Control Valve (rear drum identical)
19 - Electrohydraulic Proportional Control (EPC)
20 - Manual Motor Override (speed control)
21 - Hydraulic Pressure Sensors
22 - Diagnostic Gauge Couplers
23 - Boom Hoist Motor
24 - Electrohydraulic Proportional Control (EPC)
25 - Boom Hoist Disc Brake
26 - Boom Hoist Planetary (inside boom hoist drum)
27 - Boom Hoist Brake Control Valve
28 - Front Drum Pump
29 - Swing, Travel, and Boom Hoist Hydraulic Supercharge Filter
30 - Front Drum Hydraulic Charge Filter
31 - Engine Junction Box
32 - Rear Drum Hydraulic Charge Filter
33 - Super Charge/Accessory System Pump
34 - Right Travel Pump
35 - Left Travel Pump
36 - Boom Hoist Pump
37 - Rear Drum Pump
38 - Swing Pump
39 - Multi-Function Valve (2 each pump)
40 - Electric Displacement Control (1 each pump)
41 - Manual Pump Override (1 each pump)
42 - Neutral Adjustment Screw (1 each pump)
43 - Charge Pressure Relief (1 each pump)
44 - Engine Ether Start Valve



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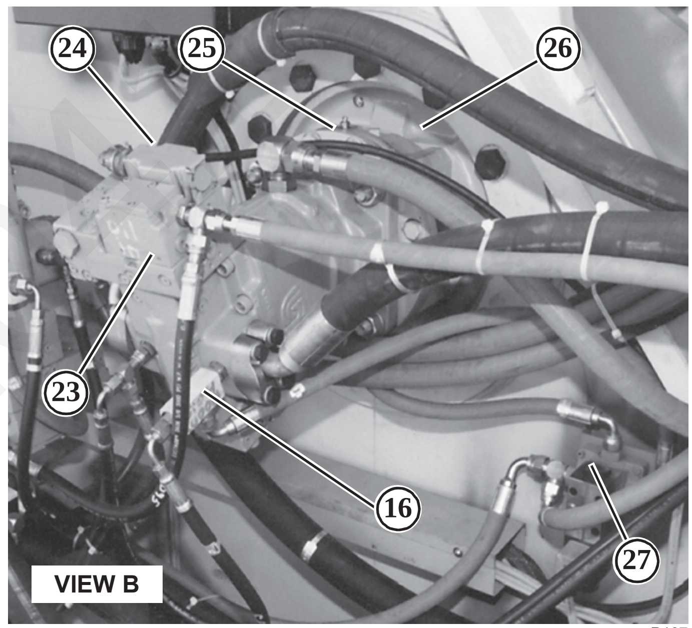

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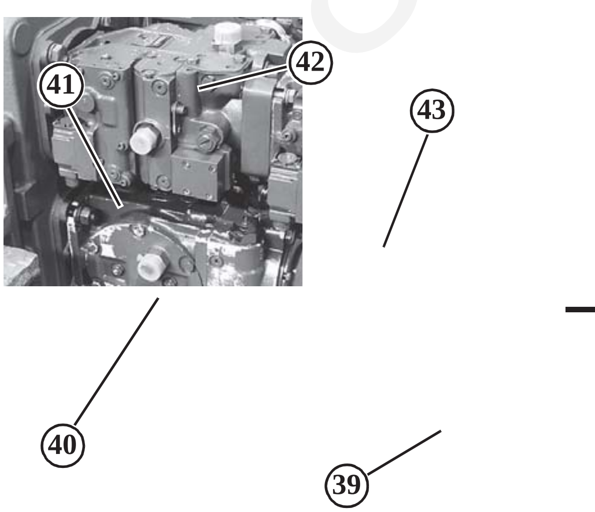

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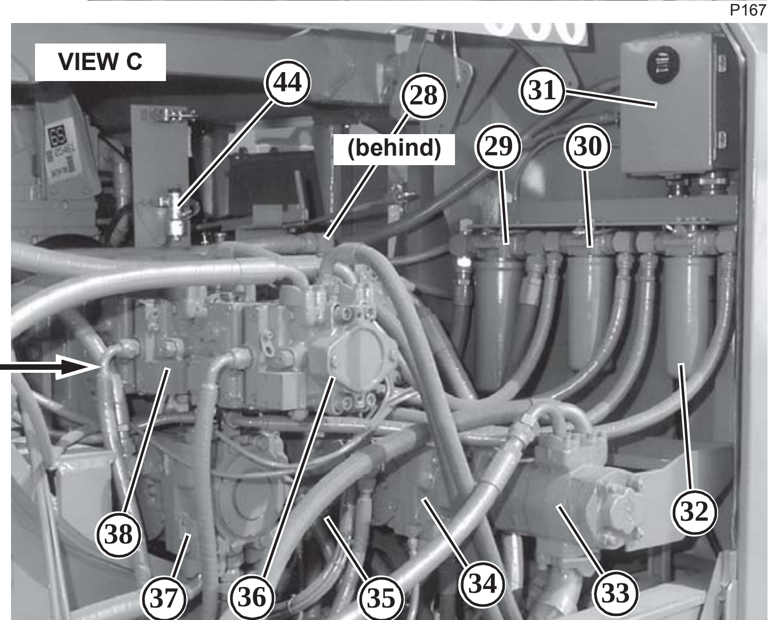

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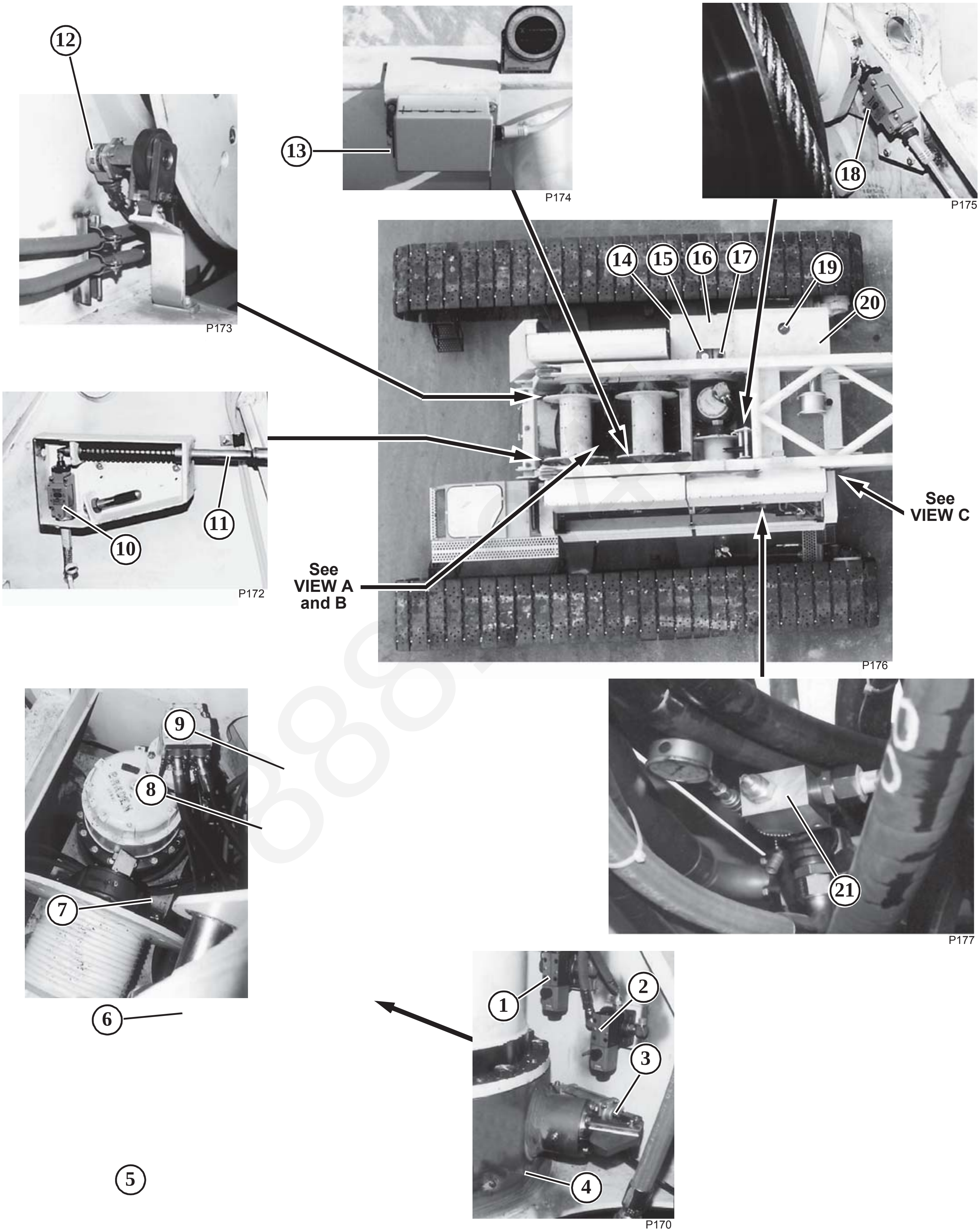
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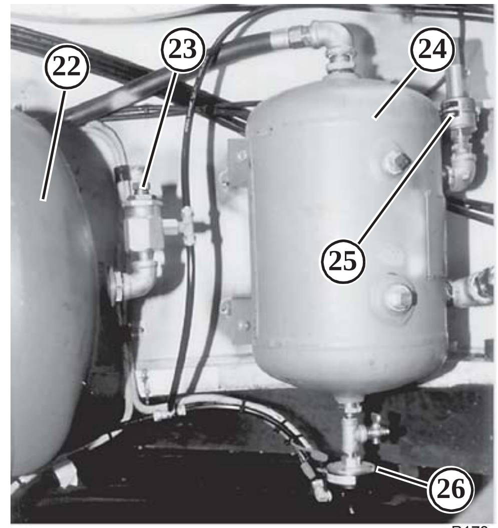
1 - Travel Brakes Control Valve
2 - Swing Brake Control Valve
3 - Swing Lock Air Cylinder
4 - Swing Shaft/Lock Housing
5 - Boom Hoist Drum (planetary inside)
6 - Boom Hoist Drum Speed Sensor
7 - Swing Planetary
8 - Swing Disc Brake
9 - Swing Motor
10 - Automatic Boom Stop Limit Switch
11 - Automatic Boom Stop Actuator Rod
12 - Drum Speed Sensor
13 - Mast Assist Angle Indicator
14 - Fuel Tank
15 - Fuel Tank Fill Cap
16 - Hydraulic Tank
17 - Hydraulic Tank Fill Cap
18 - Gantry Up Limit Switch
19 - Radiator Fill Cap
20 - Radiator/Oil Cooler
21 - Supercharge Valve
22 - Dry Air Tank
23 - Air System Unloader Valve (120-132 psi [8.3-9.1 bar])
24 - Wet Air Tank
25 - Air System Safety Valve (165 psi [11.4 bar]) (past location)
26 - Air System Moisture Ejector
27 - Left Rear Carbody Jack Flow Regulator (retract side)
28 - Mast Assist Load Equalizing Valve
29 - Right Rear Carbody Jack Flow Regulator (retract side)
30 - Hydraulic Swivel
31 - Engine
32 - Engine Clutch
33 - Pump Drive

VIEW A
Inside
Carbody



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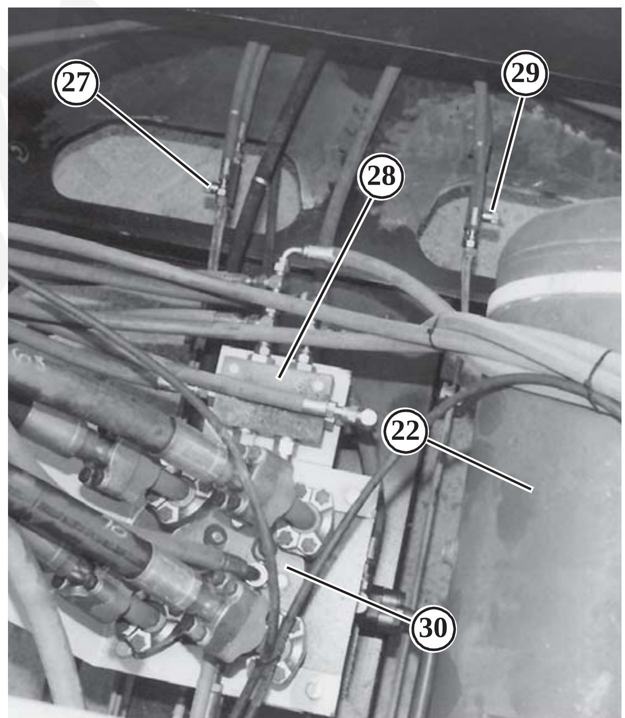
VIEW B
Inside
Carbody



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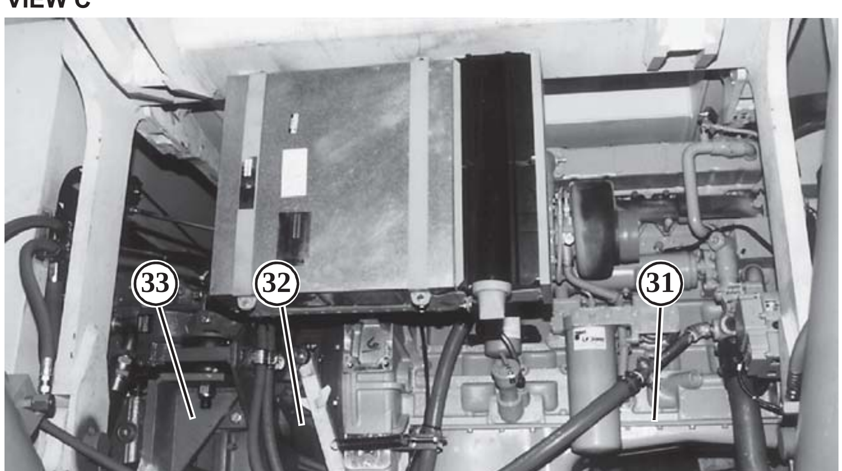
VIEW C



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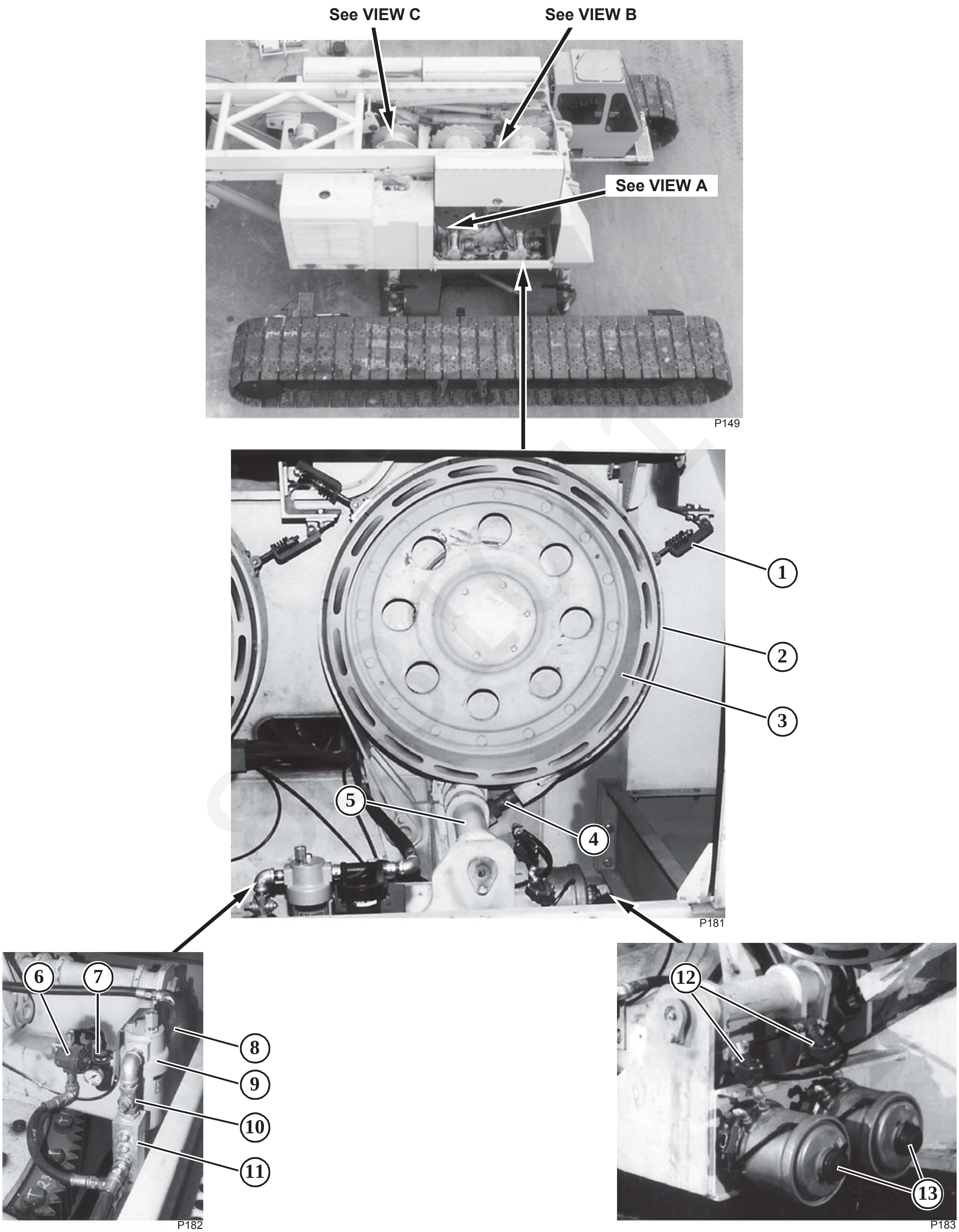
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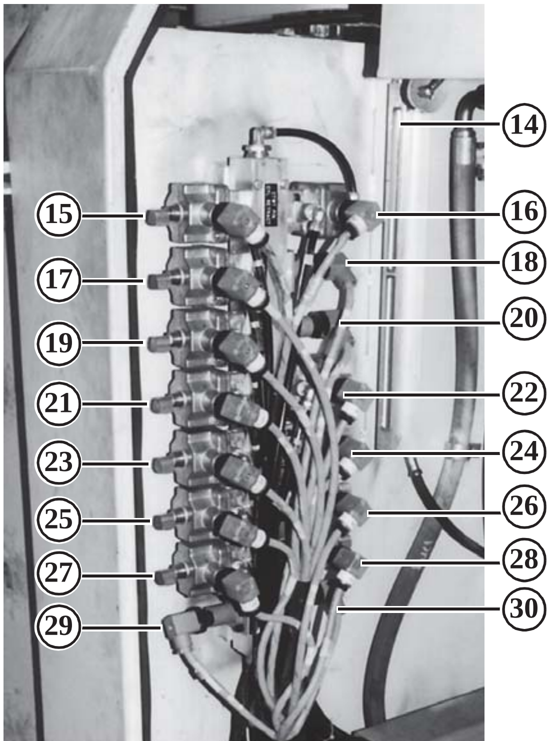

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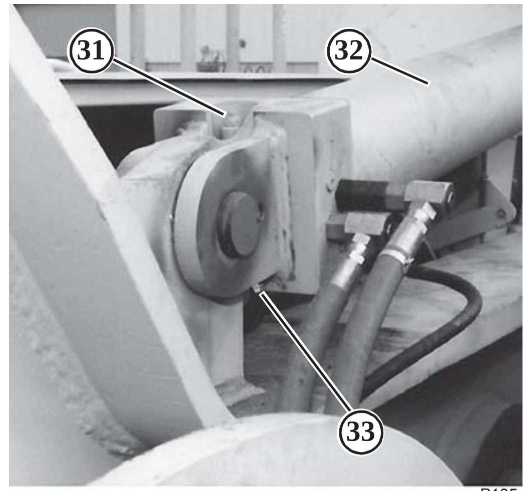
VIEW A
Air Solenoid Valves



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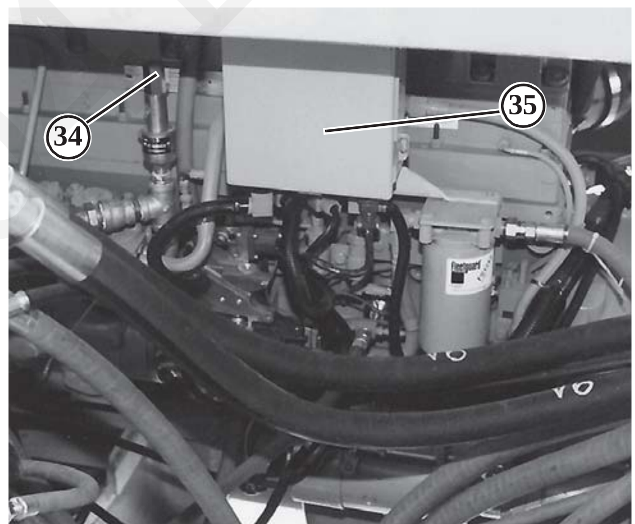
VIEW B



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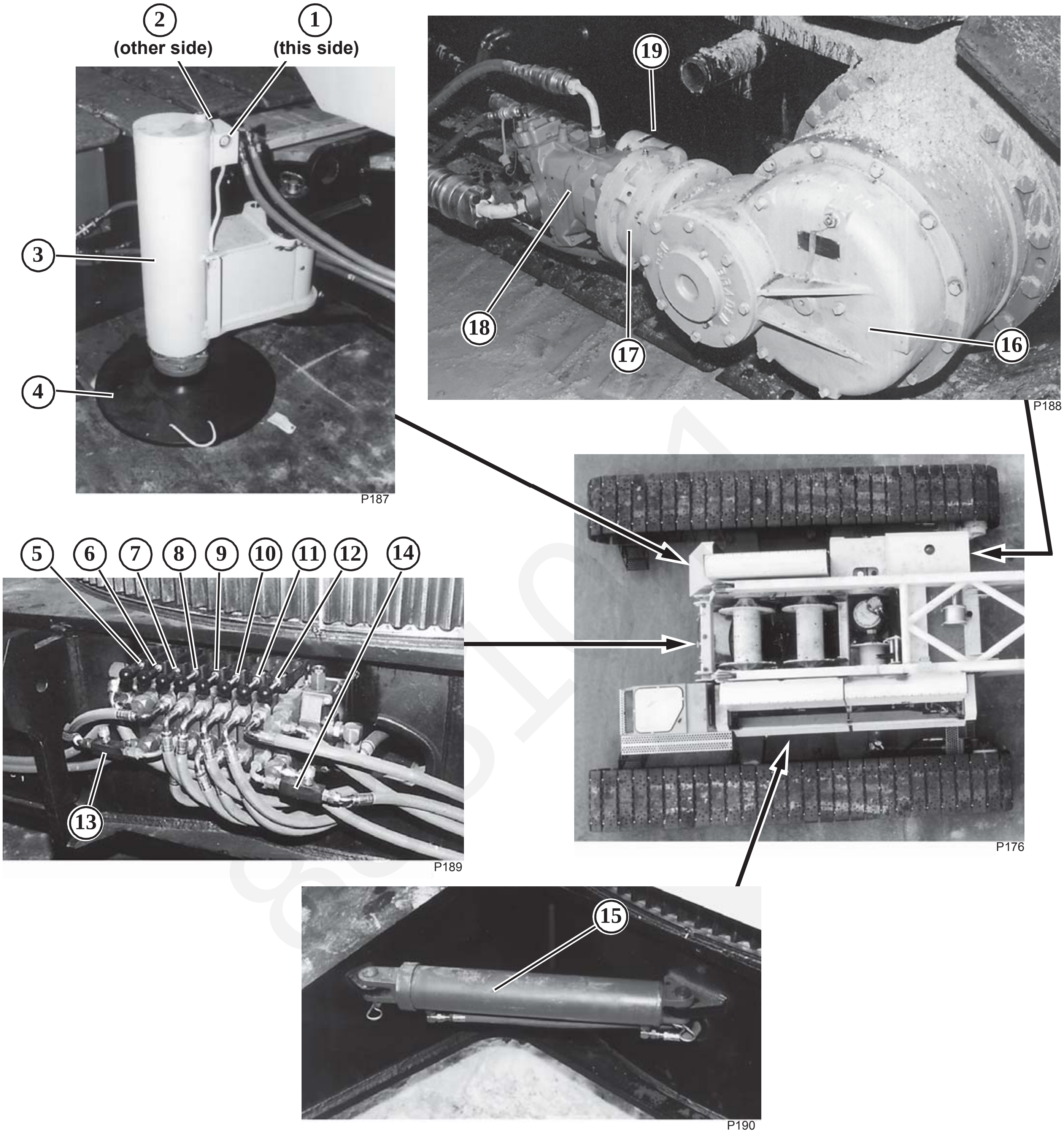
VIEW C

1 - Band Support (2 each band)
2 - Front Drum Band Brake (rear drum identical)
3 - Drum Flange
4 - Band Adjusting Screw
5 - Brake Shaft/Lever
6 - Air Relay Valve (drum working brake)
7 - Brake Release Air Regulator (drum parking brake)
8 - Air System Deicer
9 - Air System Filter
10 - Air System Shut-Off Valve
11 - Air System Manifold
12 - Quick-Release Valves
13 - Band Brake Air Actuators (parking and working)
14 - Hydraulic Tank Sight Gauge
15 - Counterweight Pins (retract)
16 - Counterweight Pins (extend)
17 - Front Drum Pawl (in)
18 - Auxiliary Drum Pawl (in)
19 - Front Drum Pawl (out)
20 - Auxiliary Drum Pawl (out)
21 - Rear Drum Pawl (in)
22 - Boom Hoist Pawl (in)
23 - Rear Drum Pawl (out)
24 - Boom Hoist Pawl (out)
25 - Swing Lock (in)
26 - Front Drum Brake
27 - Swing Lock (out)
28 - Rear Drum Brake
29 - Front Drum Clutch
30 - Rear Drum Clutch
31 - Mast Assist Retract Counterbalance Valve (see NOTE)
32 - Mast Assist Cylinder (left side)
33 - Mast Assist Extend Counterbalance Valve (see NOTE)
34 - Air System Safety Valve (165 psi [11.4 bar]) (current location)
35 - Engine Electrical Junction Box

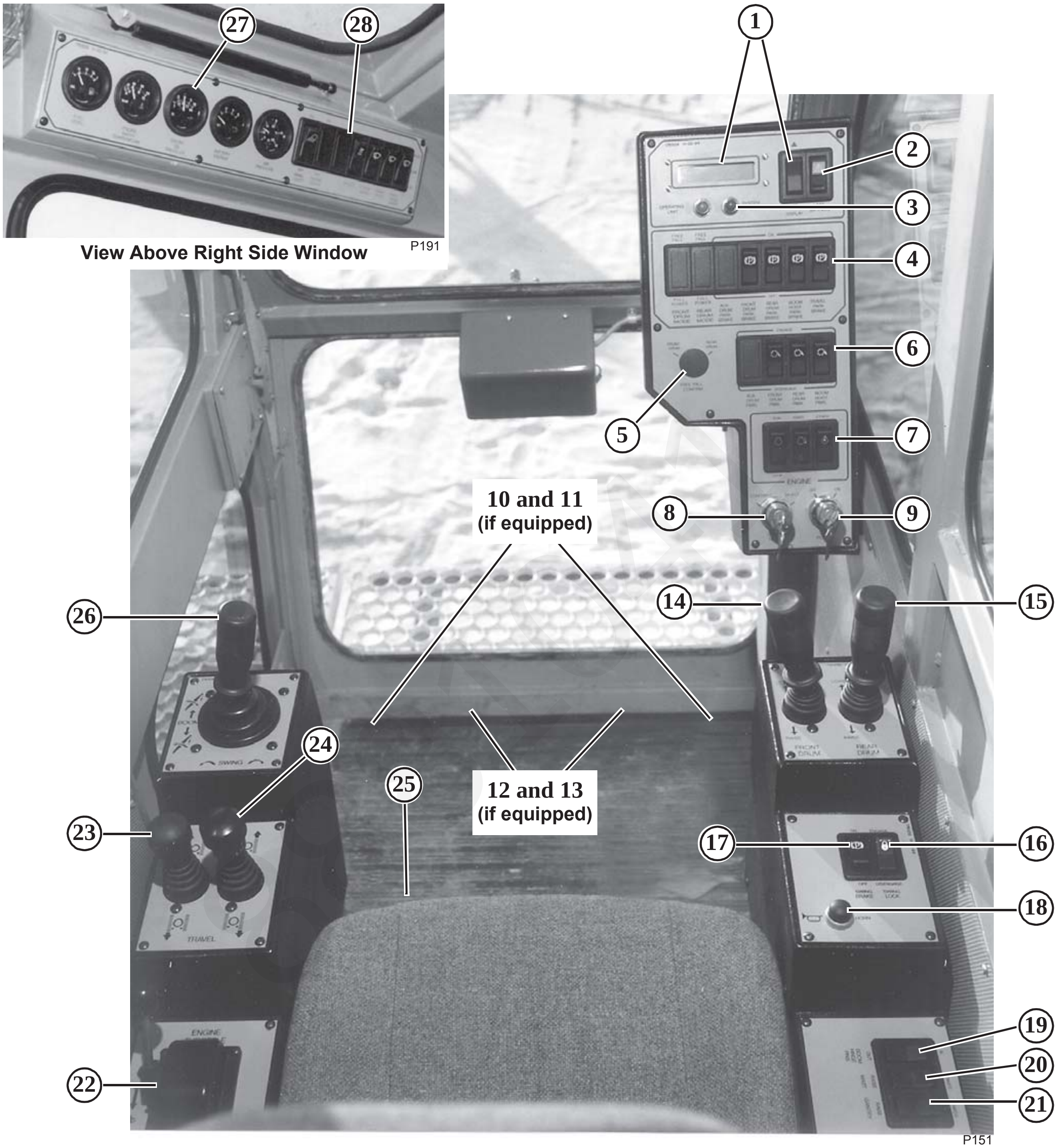
NOTE Right side cylinder shown. For left side cylinder, retract valve is on bottom and extend valve is on top.



1 - Carbody Jack Extend Counterbalance Valve
2 - Carbody Jack Retract Counterbalance Valve
3 - Carbody Jack
4 - Jack Pad (stored on carbody)

Carbody/Crawler Controls -

5 - Crawler Pins (right crawler)
6 - Carbody Jack (right front)
7 - Carbody Jack (right rear)
8 - Crawler Positioning (right crawler)
9 - Crawler Positioning (left crawler)
10 - Carbody Jack (left rear)
11 - Carbody Jack (left front)
12 - Crawler Pins (left crawler)
13 - Right Front Carbody Jack Flow Regulator (retract side)
14 - Left Front Carbody Jack Flow Regulator (retract side) (rear carbody jack flow regulators are inside carbody)
15 - Crawler Positioning Cylinder (both sides carbody)
16 - Crawler Input Planetary (both crawlers; output planetary on opposite side)
17 - Crawler Disc Brake (both crawlers)
18 - Crawler Motor (both crawlers)
19 - Accumulator



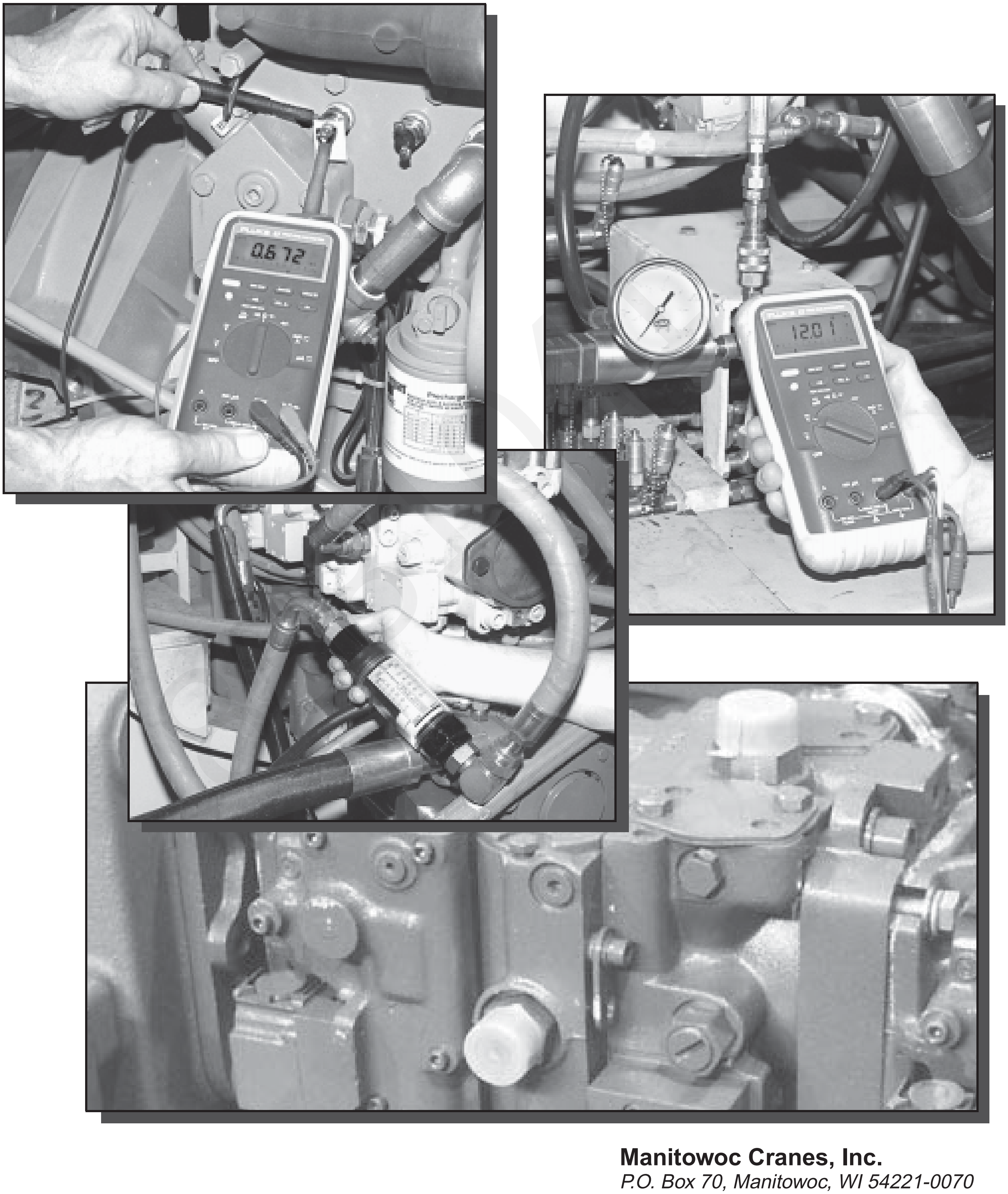
1 - Digital Display Controls
2 - Limit By-Pass Switch
3 - System Fault/Operating Limit Alerts
4 - Drum Mode/Park Switches
5 - Free-Fall Confirm Selector
6 - Pawl Switches
7 - Engine Switches
8 - Crane Mode Selector
9 - Cab Power Switch
10 - Front Drum Working Brake Pedal (with free-fall only)
11 - Rear Drum Working Brake Pedal (with free-fall only)
12 - Left Crawler Pedal (optional)
13 - Right Crawler Pedal (optional)
14 - Front Drum Handle
15 - Rear Drum Handle
16 - Swing Lock Switch
17 - Swing Park Switch
18 - Horn Switch
19 - Boom Hinge Pins Switch
20 - Mast Assist Switch
21 - Gantry Switch
22 - Engine Hand Throttle
23 - Left Crawler Handle
24 - Right Crawler Handle
25 - Engine Foot Throttle (on floor)
26 - Boom/Swing Handle
27 - Gauges
28 - Accessory Controls

Operator’s Manual 1-8 Numeric Tabs

MANITOWOC
888

TROUBLESHOOTING GUIDE

SERVICE TRAINING



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CONTENTS

ABOUT THIS MANUAL

SECTION 1 - TROUBLESHOOTING CHARTS

SECTION 2 - TESTING

APPENDIX

ABOUT THIS MANUAL

INTRODUCTION

This two part manual is designed as a troubleshooting resource for qualified service technicians familiar with the operation and repair of electrical, hydraulic, and pneumatic equipment. It is not possible to predict all problems which might occur or the proper procedure for troubleshooting each situation. **If you encounter a problem not covered in this manual, first consult your dealer. The factory Service Department can provide further assistance if necessary.**

Section 1 provides a series of flow charts that identify problems which could be encountered during normal operation of the Manitowoc 888. These charts contain step by step instructions to assist you in identifying and correcting such problems efficiently and effectively. Follow the procedural steps in the order indicated. Some steps will direct you to other charts in this manual or reference specific tests which must be performed in order for you to successfully move through and complete the prescribed troubleshooting procedure. These tests are described in Section 2. If directed to do so, consult the factory Service Department before proceeding.

Section 2 contains specific instructions for testing and servicing the various systems and components described in the troubleshooting charts. Use this section to perform the tests correctly in accordance with the factory recommendations.

SAFETY SUMMARY

Hazards are always involved when performing troubleshooting operations on heavy equipment. To minimize the risk of potential hazards and prevent serious injury or death, you must comply with the following:

- Carefully read the Manitowoc 888 *Troubleshooting Guide* and *Description of Operation*. Make sure you understand all instructions and warnings contained in these manuals before beginning troubleshooting operations.
- You must be a qualified service technician competent in the repair and testing of electrical, hydraulic, and pneumatic equipment. Manitowoc Cranes, Inc. shall not be responsible for the training of personnel who might use this manual to perform the operations herein.
- Whenever possible, turn off the engine for your protection and keep unauthorized personnel away from the crane while troubleshooting.
- Never troubleshoot alone. Always perform troubleshooting procedures with a qualified operator stationed in the crane cab. Maintain constant communication with this operator when performing operations that require the crane to be running.
- Do not return crane to service after completion of maintenance or repair procedures until all guards and covers have been reinstalled, trapped air has been bled from hydraulic systems, safety devices have been reactivated, and maintenance equipment has been removed.
- Perform a function check to ensure proper operation at completion of maintenance or repair operations.

The following warnings apply to all troubleshooting operations, but are not all inclusive. Manitowoc Cranes, Inc. cannot foresee all hazards which might be encountered.

You must be familiar with the equipment, trained in testing methods, and use common sense while troubleshooting to avoid other hazards.

WARNING

EYE, SKIN, AND RESPIRATORY HAZARDS!

Wear proper eye and skin protection and avoid direct contact with battery acid, exhausting air, oil, or ether spray when searching for leaks, opening connections, or installing pressure gauges.

Pressurized air and hydraulic oil can cause serious injury. Turn OFF engine, render starting means inoperative, and relieve pressure on system before disconnecting, adjusting, or repairing any component.

Ensure that reconnections are properly made, O-rings or gaskets are in place, and connectors are tight before pressurizing system.

Use necessary precautions against electrical burns when checking battery charging and starter circuits.

Death or serious injury can occur if these warnings are ignored.

WARNING

UNEXPECTED MOVING PART HAZARD!

Keep personnel away from crane while manually actuating a valve or pump to avoid unexpected equipment movement which can result in death or serious injury.

GENERAL GUIDELINES

The following guidelines apply to all troubleshooting operations:

- Terms RIGHT, LEFT, FRONT, and REAR used in this manual to describe specific crane component locations correspond to the operator's right, left, front, and rear sides when seated in the operator's cab looking forward.
- Do not remove cylinders or remove counterbalance valve(s) from a cylinder until its working unit has been securely restrained against movement.
- Do not use your hands to check for air and hydraulic oil leaks.

  NOTE Use soap and water solution to check for air leaks (apply to fittings and lines and watch for bubbles). Use a piece of cardboard to check for hydraulic oil leaks.
- Use gauges of the appropriate pressure range when checking air and hydraulic circuits.

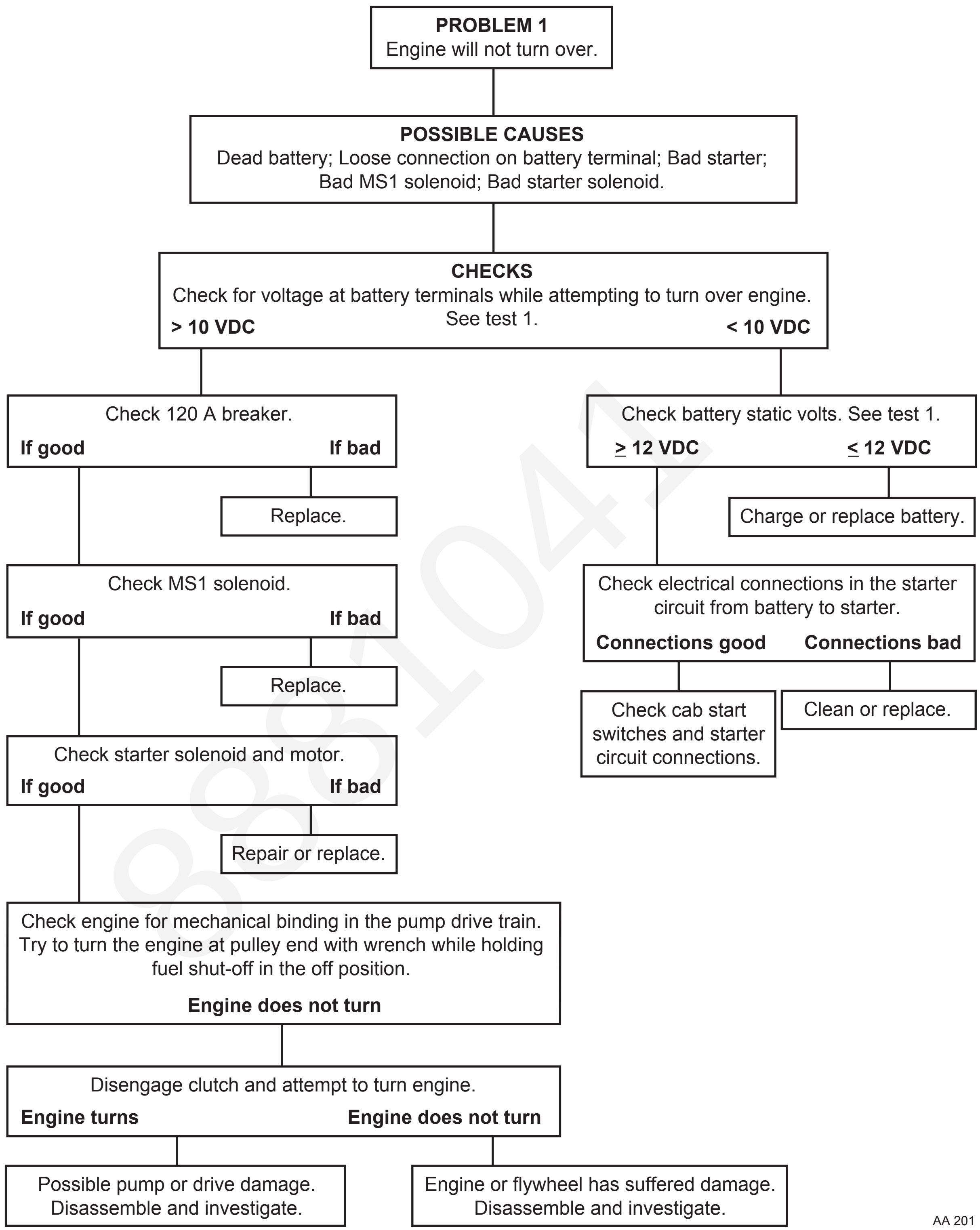
- When applicable, use the standard test plug adapter (available from Manitowoc Cranes, Inc.) for electrical testing.
- Check ground potentials when testing electric circuits for continuity, voltage, or resistance (ohms).

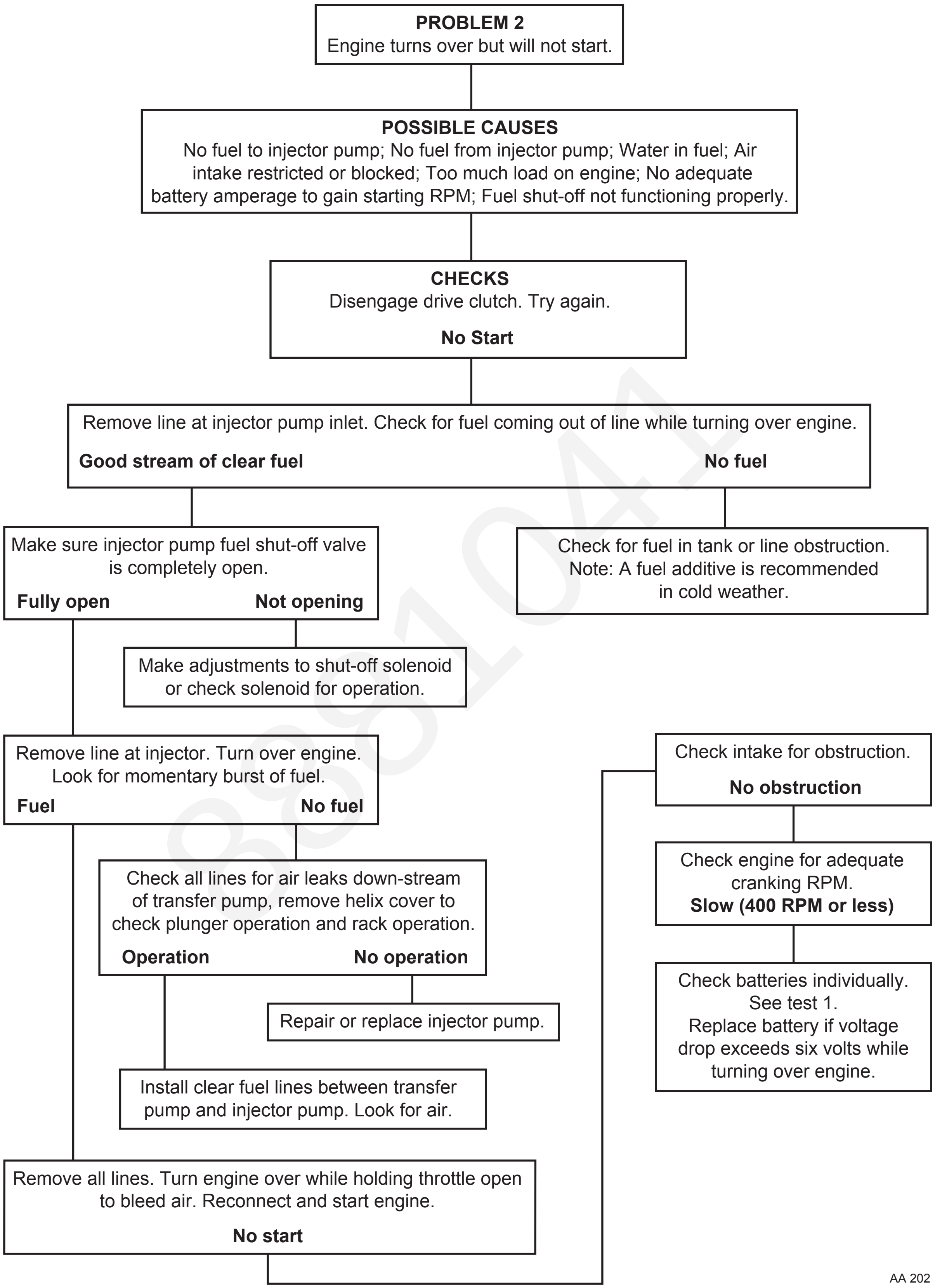
  NOTE When checking voltages, use ground point for circuit being checked. If voltage does not register on multimeter, use a known ground; if reading is then obtained, the ground of the circuit in question is probably faulty.
- Check all terminal points for cleanliness and tight connection.
- Check pressures at the specified air and hydraulic component ports.
- Check the motor pressure control pilots at the PCP valve assembly located on the motor under test. Likewise, test the pump electric displacement controls at the EDC assembly located on the pump under test.
- Check the individual pressure transducer electric supplies at the transducer manifold assembly located in the center of the left side enclosure.
- Check the air solenoid electric supplies at the air solenoid valve manifold located in the right side enclosure.
- Check the encoder electric supplies at the individual encoder under test using the test plug adapter.
- Verify correct operating limit electric supplies by viewing the diagnostic operator display in the cab.
- Check control handle electrical input and output voltages at the individual control handle under test.
- Check basic system electric supplies and cab power relay MS2 supply at the fuse box mounted above the main electrical junction box in the left enclosure.
- Check programmable controller (PC) input and output cables at the connector pins.

TEST EQUIPMENT

The test equipment shown or described herein, is available for testing the 888 hydraulic, electric, and air systems. This equipment can be purchased in kit form (with or without equipment carrying case) or separately, as needed, by contacting the factory Parts Department.

SECTION 1 - TROUBLESHOOTING CHARTS




PROBLEM 2
Engine turns over but will not start.
POSSIBLE CAUSES
No fuel to injector pump; No fuel from injector pump; Water in fuel; Air intake restricted or blocked; Too much load on engine; No adequate battery amperage to gain starting RPM; Fuel shut-off not functioning properly.
CHECKS
Disengage drive clutch. Try again.
No Start
Remove line at injector pump inlet. Check for fuel coming out of line while turning over engine.
Good stream of clear fuel
No fuel
Make sure injector pump fuel shut-off valve is completely open.
Fully open
Not opening
Check for fuel in tank or line obstruction. Note: A fuel additive is recommended in cold weather.
Make adjustments to shut-off solenoid or check solenoid for operation.
Remove line at injector. Turn over engine. Look for momentary burst of fuel.
Fuel
No fuel
Check all lines for air leaks down-stream of transfer pump, remove helix cover to check plunger operation and rack operation.
Operation
No operation
Repair or replace injector pump.
Install clear fuel lines between transfer pump and injector pump. Look for air.
Remove all lines. Turn engine over while holding throttle open to bleed air. Reconnect and start engine.
No start
Check intake for obstruction.
No obstruction
Check engine for adequate cranking RPM.
Slow (400 RPM or less)
Check batteries individually. See test 1. Replace battery if voltage drop exceeds six volts while turning over engine.

AA 202

PROBLEM 3
Engine runs but no hydraulic operation.

POSSIBLE CAUSES
Clutch not engaged; No hydraulic fluid in tank; Blocked charge inlet to pumps; Clogged tank vent; Drive train damaged from flywheel to pump mount.

CHECKS
Check filter service shut-off valve.

OK

Check clutch engagement.

Clutch engaged

Remove tank cap and check vent, fluid level, and viscosity. Note: In extreme cold conditions, oil may not flow freely to pump inlets causing cavitation to occur.

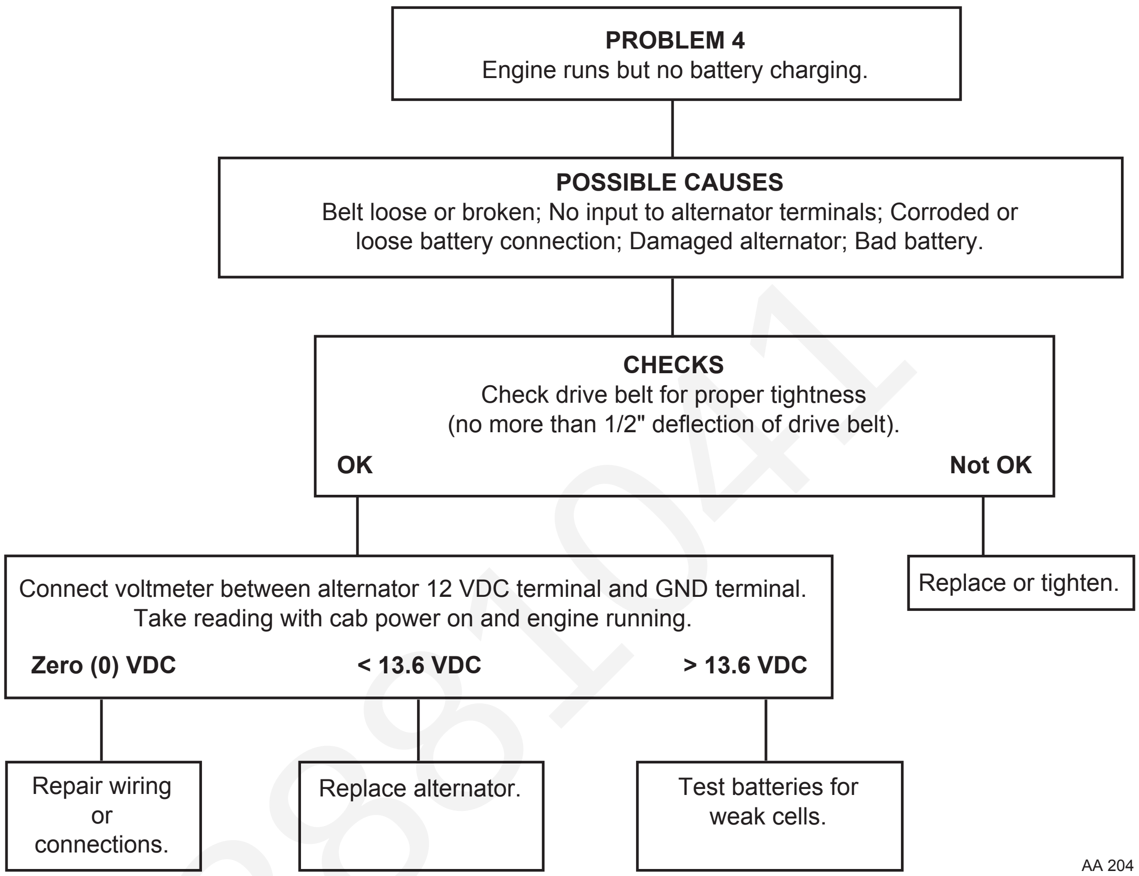
Tank vent, oil level, viscosity OK

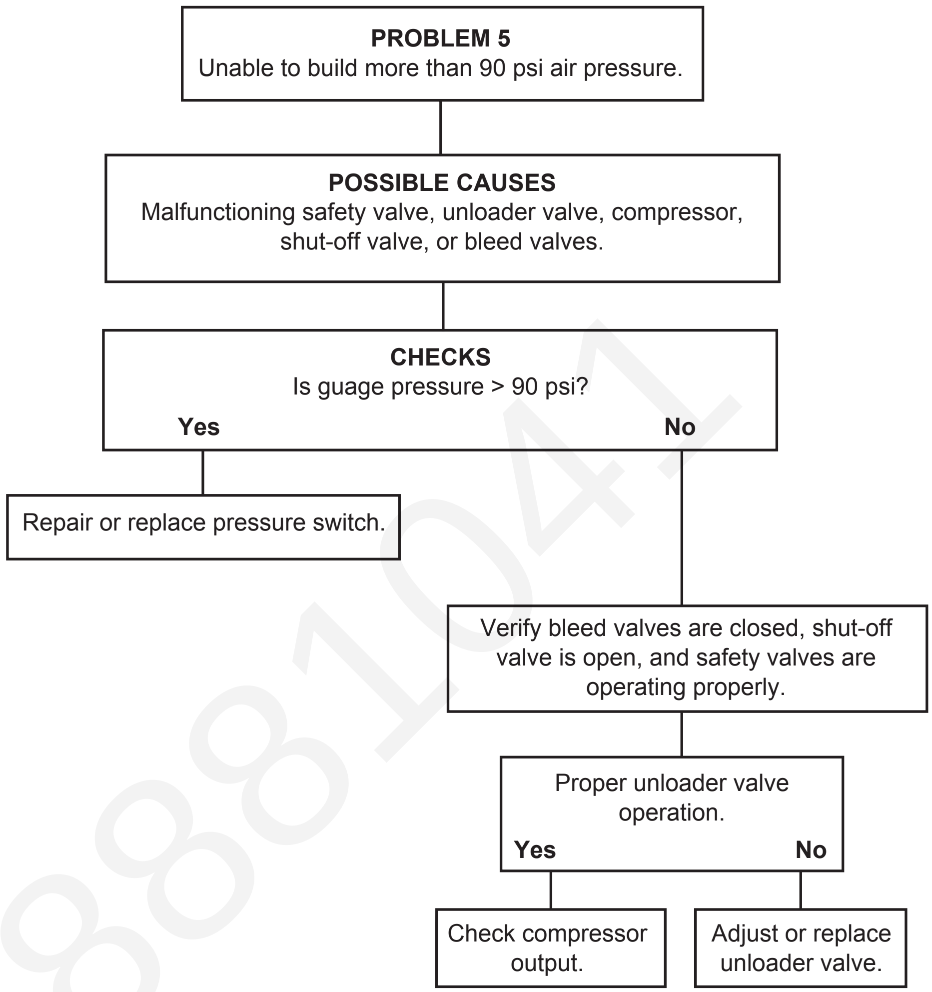
Check manual overrides on two or more pumps. Does the engine load when manual override is applied? See test 11. Note: Be sure all brakes are applied and swing lock is in place before this test.

Pump loads — Check electrical input from controller to pump. See test 5.

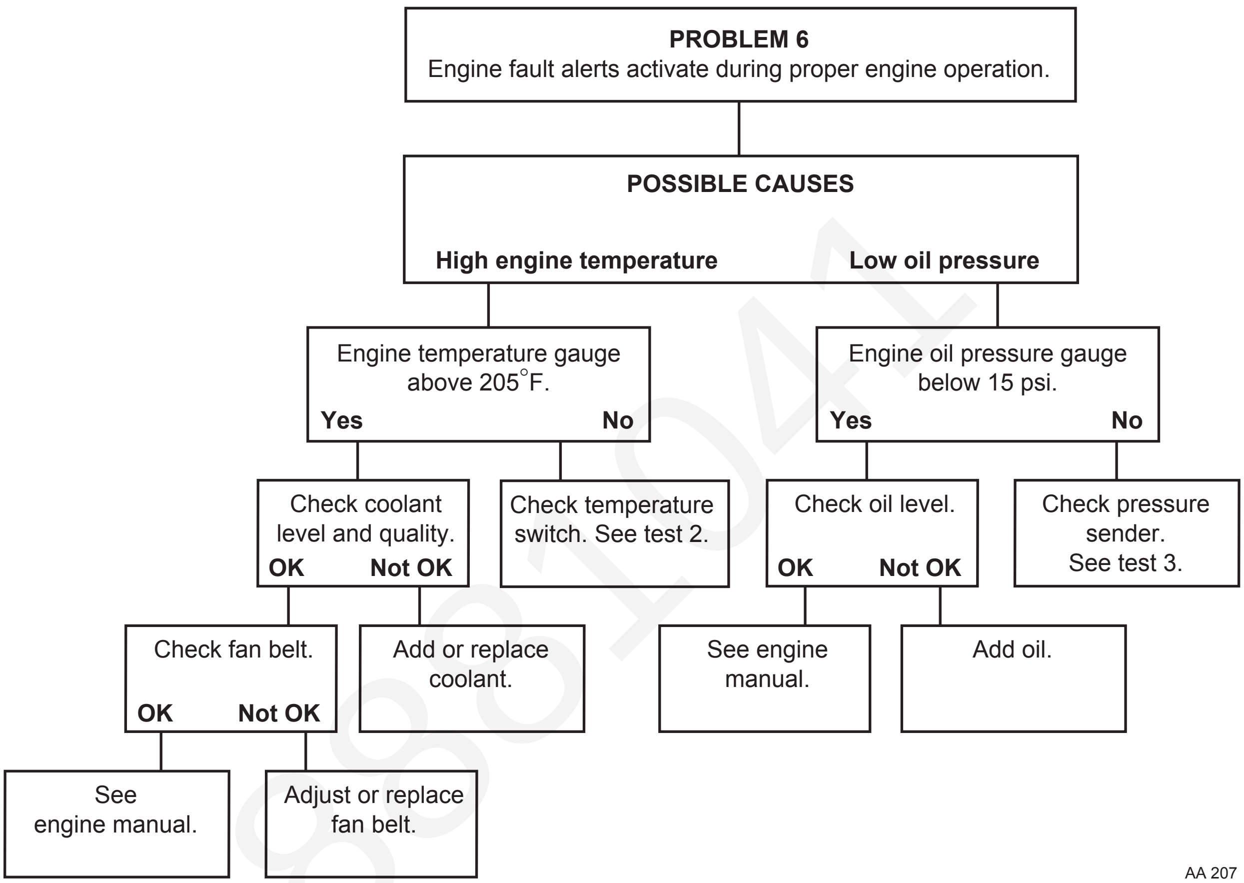
Pump does not load — Consult factory.

AA 203


PROBLEM 4
Engine runs but no battery charging.
POSSIBLE CAUSES
Belt loose or broken; No input to alternator terminals; Corroded or loose battery connection; Damaged alternator; Bad battery.
CHECKS
Check drive belt for proper tightness (no more than 1/2" deflection of drive belt).
OK
Not OK
Connect voltmeter between alternator 12 VDC terminal and GND terminal. Take reading with cab power on and engine running.
Zero (0) VDC
< 13.6 VDC
> 13.6 VDC
Replace or tighten.
Repair wiring or connections.
Replace alternator.
Test batteries for weak cells.
AA 204

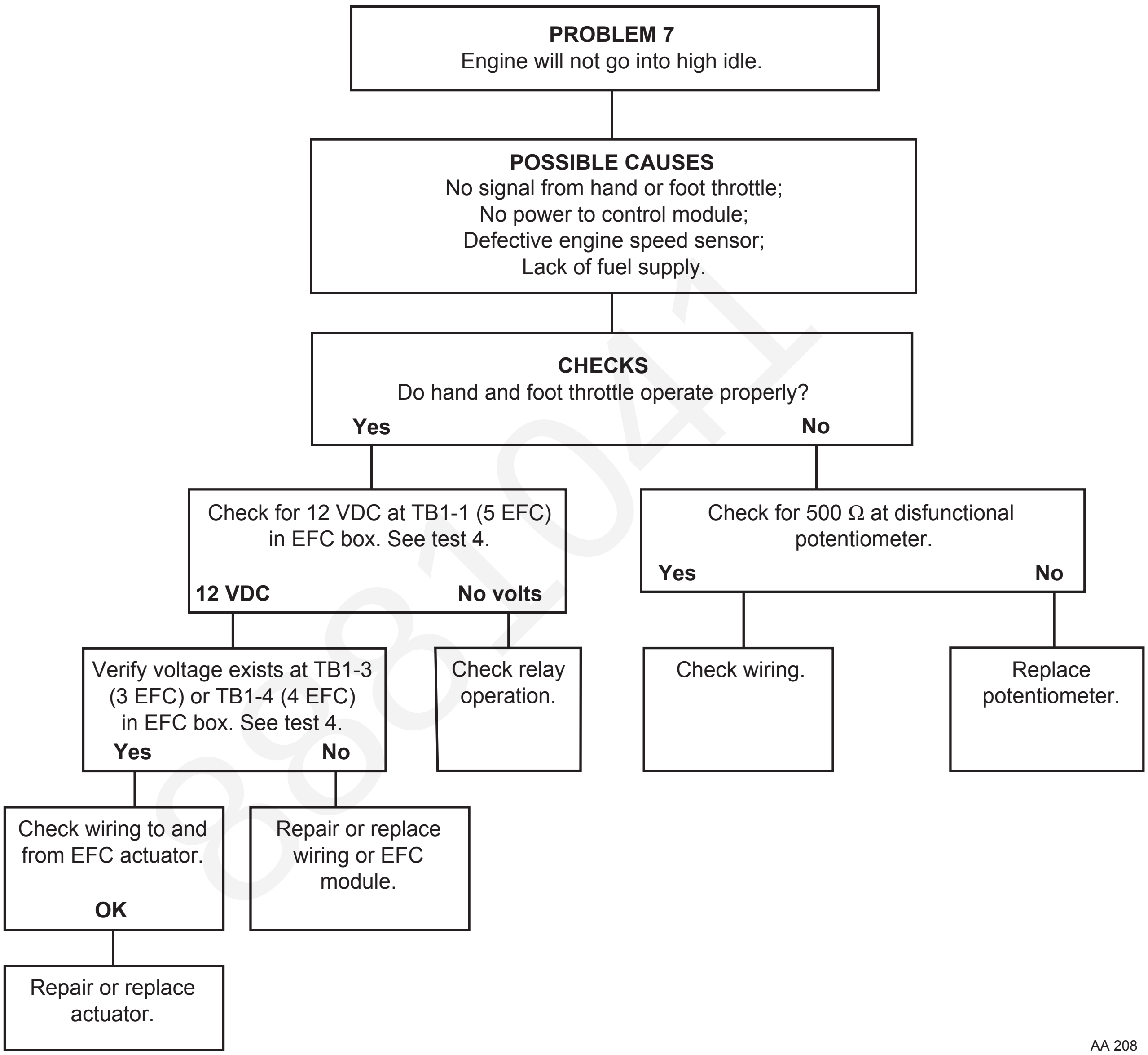

PROBLEM 5
Unable to build more than 90 psi air pressure.
POSSIBLE CAUSES
Malfunctioning safety valve, unloader valve, compressor, shut-off valve, or bleed valves.
CHECKS
Is guage pressure > 90 psi?
Yes
No
Repair or replace pressure switch.
Verify bleed valves are closed, shut-off valve is open, and safety valves are operating properly.
Proper unloader valve operation.
Yes
No
Check compressor output.
Adjust or replace unloader valve.

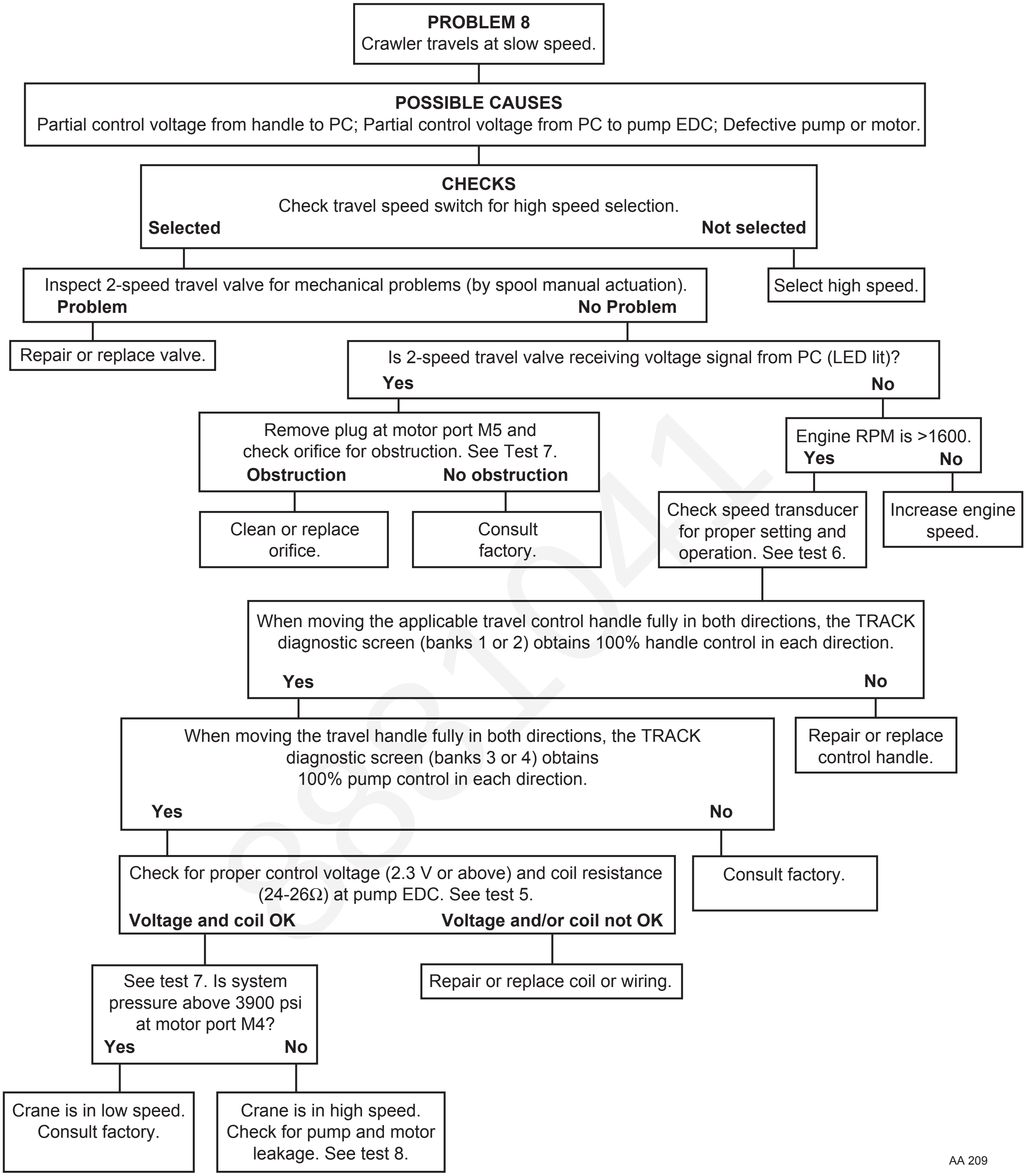
AA 206



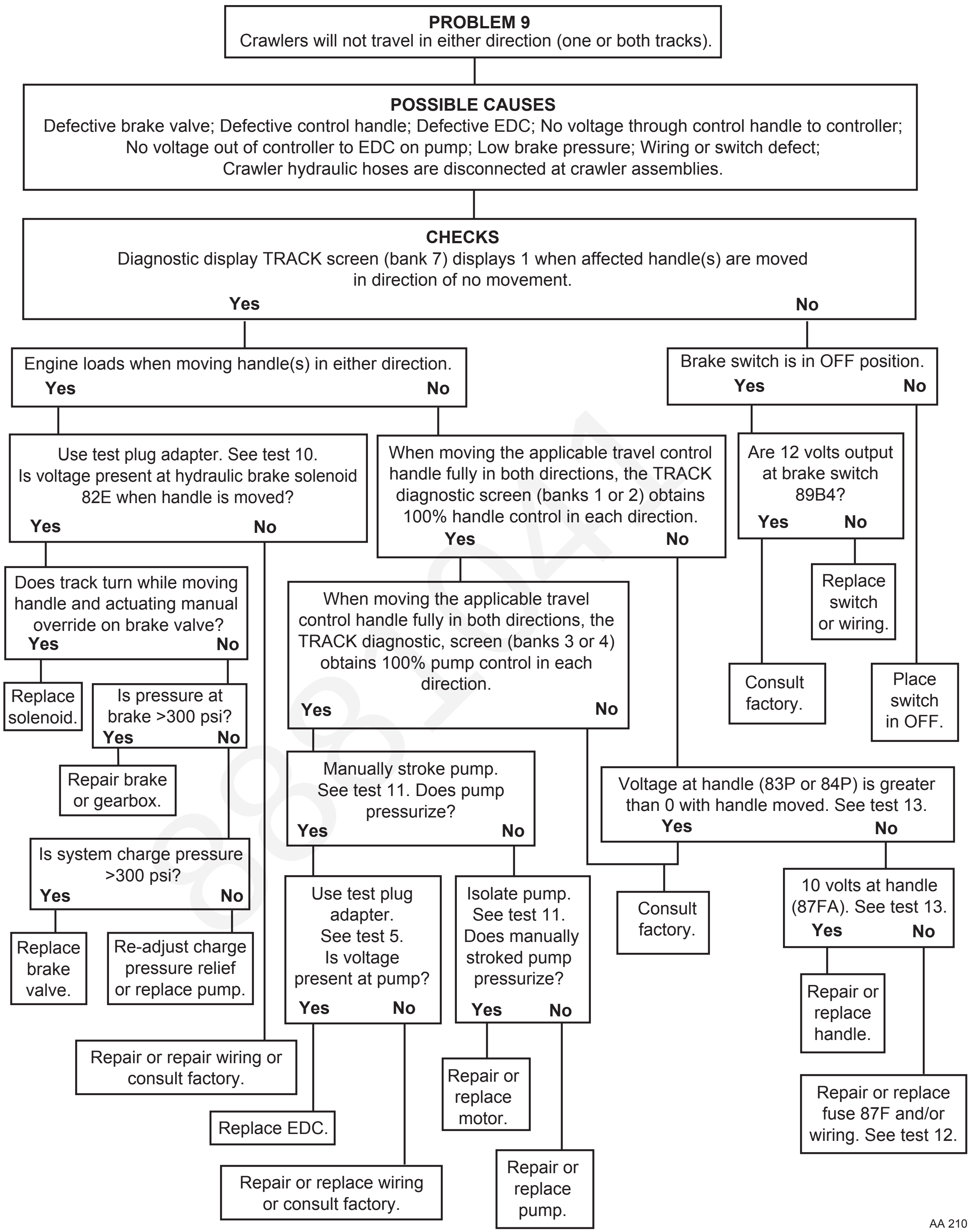
PROBLEM 6
Engine fault alerts activate during proper engine operation.
POSSIBLE CAUSES
High engine temperature
Low oil pressure
Engine temperature gauge above 205°F.
Yes
No
Engine oil pressure gauge below 15 psi.
Yes
No
Check coolant level and quality.
OK
Not OK
Check temperature switch. See test 2.
Check oil level.
OK
Not OK
Check pressure sender. See test 3.
Check fan belt.
OK
Not OK
Add or replace coolant.
See engine manual.
Add oil.
See engine manual.
Adjust or replace fan belt.

AA 207

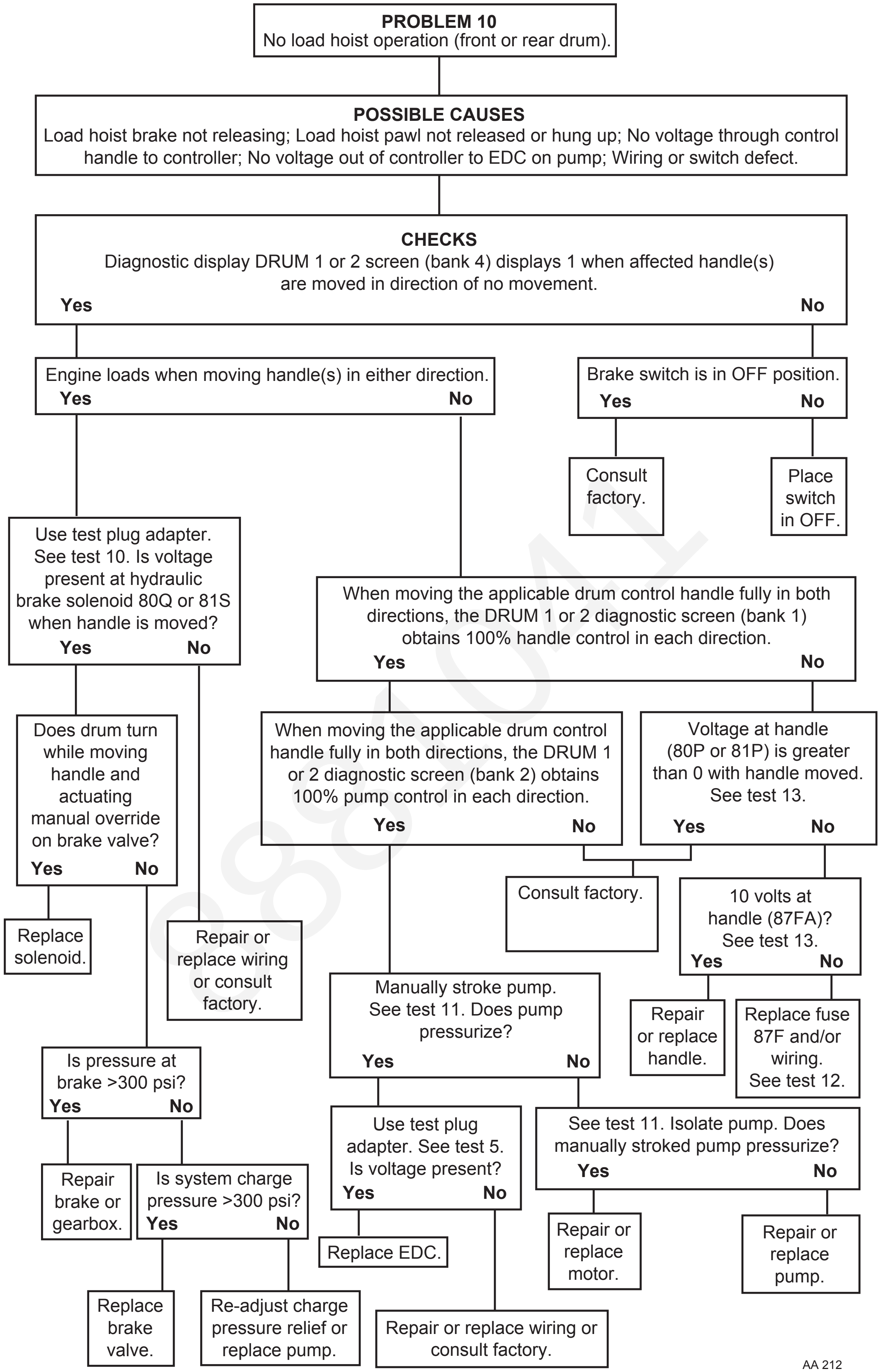

PROBLEM 7
Engine will not go into high idle.
POSSIBLE CAUSES
No signal from hand or foot throttle;
No power to control module;
Defective engine speed sensor;
Lack of fuel supply.
CHECKS
Do hand and foot throttle operate properly?
Yes
No
Check for 12 VDC at TB1-1 (5 EFC) in EFC box. See test 4.
12 VDC
No volts
Check for 500 Ω at disfunctional potentiometer.
Yes
No
Verify voltage exists at TB1-3 (3 EFC) or TB1-4 (4 EFC) in EFC box. See test 4.
Yes
No
Check relay operation.
Check wiring.
Replace potentiometer.
Check wiring to and from EFC actuator.
OK
Repair or replace wiring or EFC module.
Repair or replace actuator.
AA 208

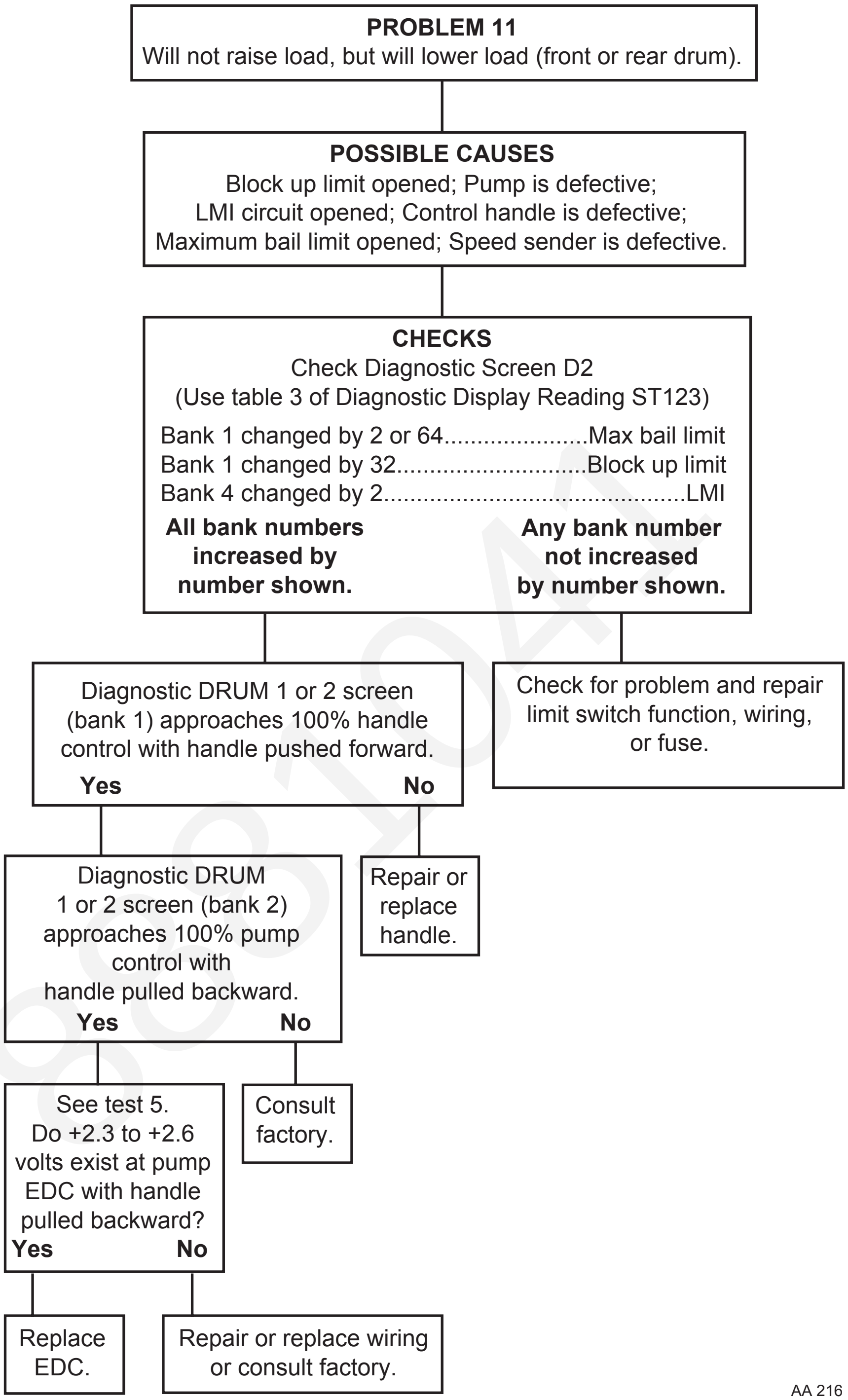

PROBLEM 8
Crawler travels at slow speed.
POSSIBLE CAUSES
Partial control voltage from handle to PC; Partial control voltage from PC to pump EDC; Defective pump or motor.
CHECKS
Check travel speed switch for high speed selection.
Selected
Not selected
Inspect 2-speed travel valve for mechanical problems (by spool manual actuation).
Problem
No Problem
Select high speed.
Repair or replace valve.
Is 2-speed travel valve receiving voltage signal from PC (LED lit)?
Yes
No
Remove plug at motor port M5 and check orifice for obstruction. See Test 7.
Obstruction
No obstruction
Engine RPM is >1600.
Yes
No
Clean or replace orifice.
Consult factory.
Check speed transducer for proper setting and operation. See test 6.
Increase engine speed.
When moving the applicable travel control handle fully in both directions, the TRACK diagnostic screen (banks 1 or 2) obtains 100% handle control in each direction.
Yes
No
When moving the travel handle fully in both directions, the TRACK diagnostic screen (banks 3 or 4) obtains 100% pump control in each direction.
Yes
No
Repair or replace control handle.
Check for proper control voltage (2.3 V or above) and coil resistance (24-26Ω) at pump EDC. See test 5.
Voltage and coil OK
Voltage and/or coil not OK
Consult factory.
See test 7. Is system pressure above 3900 psi at motor port M4?
Yes
No
Repair or replace coil or wiring.
Crane is in low speed. Consult factory.
Crane is in high speed. Check for pump and motor leakage. See test 8.

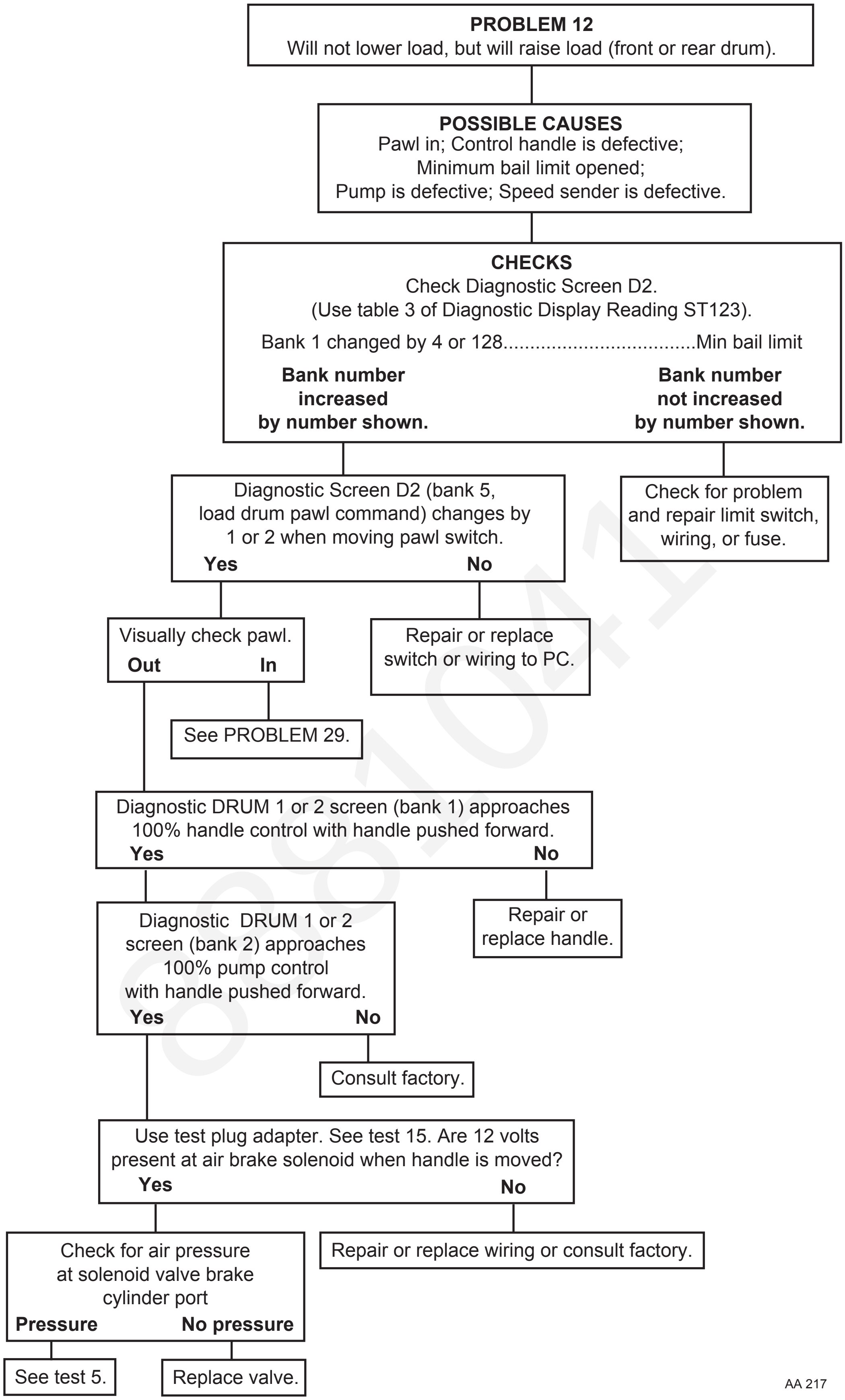
AA 209

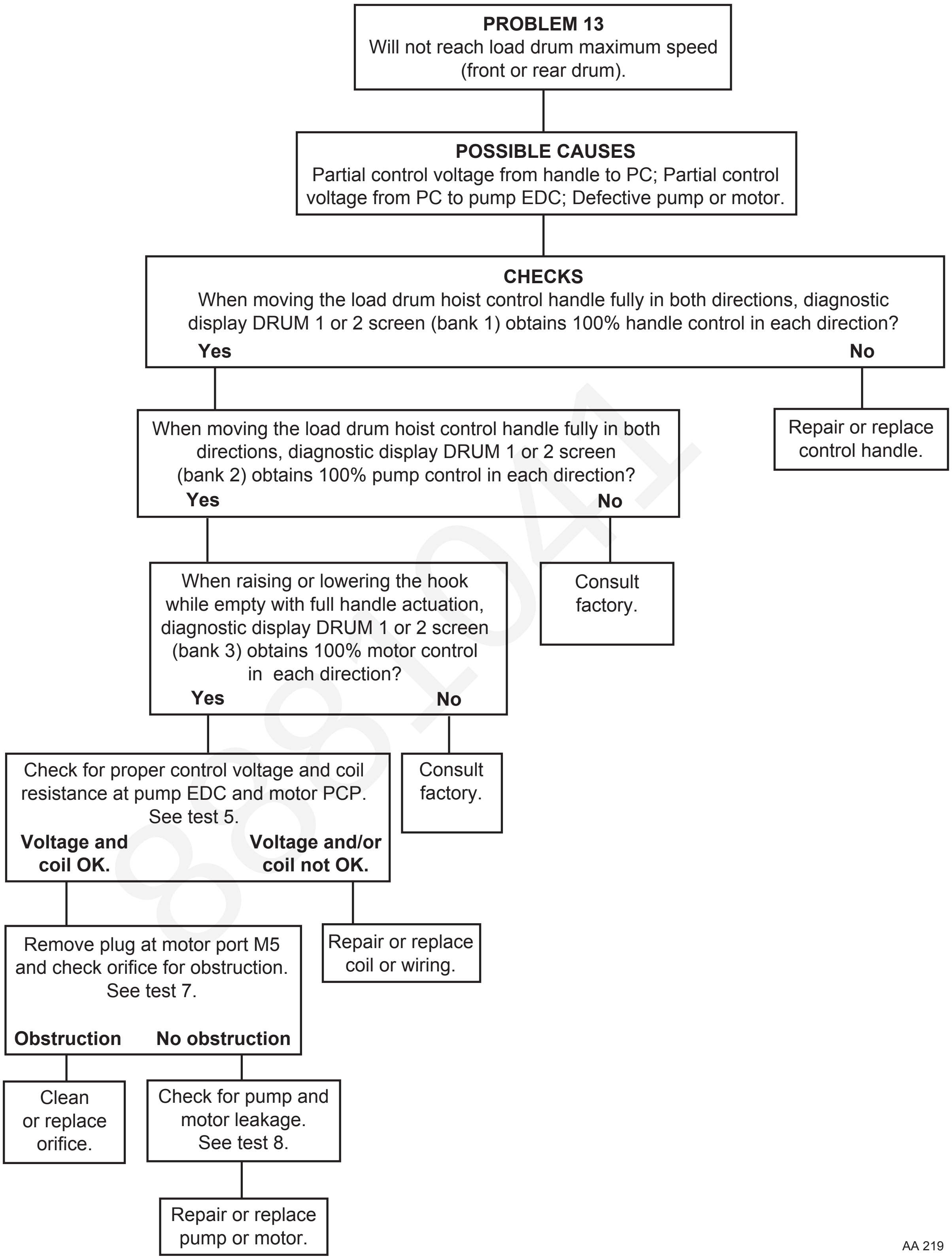

PROBLEM 9
Crawlers will not travel in either direction (one or both tracks).
POSSIBLE CAUSES
Defective brake valve; Defective control handle; Defective EDC; No voltage through control handle to controller; No voltage out of controller to EDC on pump; Low brake pressure; Wiring or switch defect; Crawler hydraulic hoses are disconnected at crawler assemblies.
CHECKS
Diagnostic display TRACK screen (bank 7) displays 1 when affected handle(s) are moved in direction of no movement.
Yes
No
Engine loads when moving handle(s) in either direction.
Yes
No
Brake switch is in OFF position.
Yes
No
Use test plug adapter. See test 10. Is voltage present at hydraulic brake solenoid 82E when handle is moved?
Yes
No
When moving the applicable travel control handle fully in both directions, the TRACK diagnostic screen (banks 1 or 2) obtains 100% handle control in each direction.
Yes
No
Are 12 volts output at brake switch 89B4?
Yes
No
Replace switch or wiring.
Does track turn while moving handle and actuating manual override on brake valve?
Yes
No
When moving the applicable travel control handle fully in both directions, the TRACK diagnostic, screen (banks 3 or 4) obtains 100% pump control in each direction.
Yes
No
Consult factory.
Place switch in OFF.
Replace solenoid.
Is pressure at brake >300 psi?
Yes
No
Repair brake or gearbox.
Manually stroke pump. See test 11. Does pump pressurize?
Yes
No
Voltage at handle (83P or 84P) is greater than 0 with handle moved. See test 13.
Yes
No
Is system charge pressure >300 psi?
Yes
No
Use test plug adapter. See test 5. Is voltage present at pump?
Yes
No
Isolate pump. See test 11. Does manually stroked pump pressurize?
Yes
No
Consult factory.
10 volts at handle (87FA). See test 13.
Yes
No
Replace brake valve.
Re-adjust charge pressure relief or replace pump.
Repair or replace handle.
Repair or repair wiring or consult factory.
Repair or replace motor.
Replace EDC.
Repair or replace fuse 87F and/or wiring. See test 12.
Repair or replace wiring or consult factory.
Repair or replace pump.

AA 210

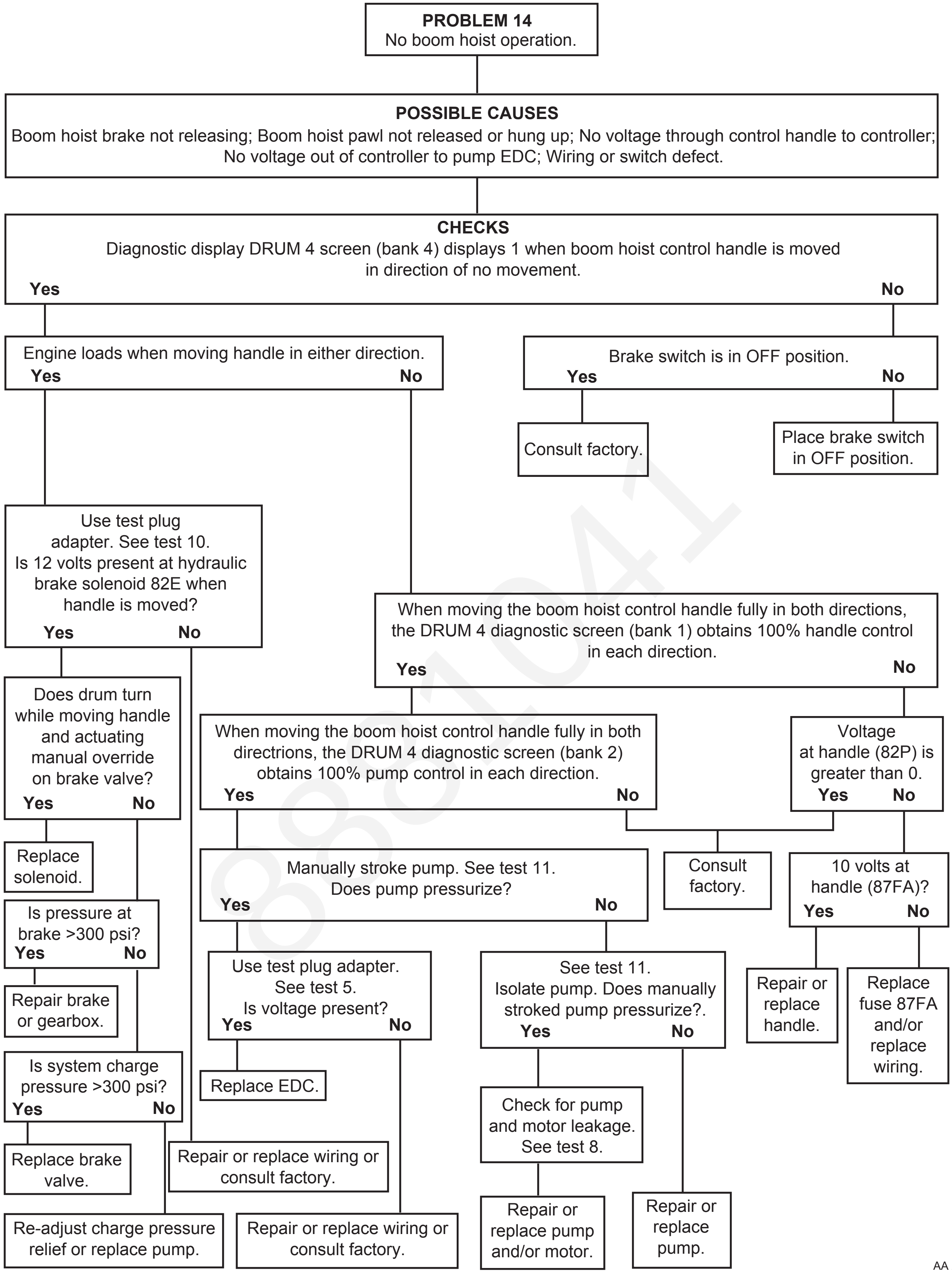

PROBLEM 10
No load hoist operation (front or rear drum).
POSSIBLE CAUSES
Load hoist brake not releasing; Load hoist pawl not released or hung up; No voltage through control handle to controller; No voltage out of controller to EDC on pump; Wiring or switch defect.
CHECKS
Diagnostic display DRUM 1 or 2 screen (bank 4) displays 1 when affected handle(s) are moved in direction of no movement.
Yes
No
Engine loads when moving handle(s) in either direction.
Yes
No
Brake switch is in OFF position.
Yes
No
Consult factory.
Place switch in OFF.
Use test plug adapter. See test 10. Is voltage present at hydraulic brake solenoid 80Q or 81S when handle is moved?
Yes
No
When moving the applicable drum control handle fully in both directions, the DRUM 1 or 2 diagnostic screen (bank 1) obtains 100% handle control in each direction.
Yes
No
Does drum turn while moving handle and actuating manual override on brake valve?
Yes
No
When moving the applicable drum control handle fully in both directions, the DRUM 1 or 2 diagnostic screen (bank 2) obtains 100% pump control in each direction.
Yes
No
Voltage at handle (80P or 81P) is greater than 0 with handle moved. See test 13.
Yes
No
Consult factory.
10 volts at handle (87FA)? See test 13.
Yes
No
Replace solenoid.
Repair or replace wiring or consult factory.
Manually stroke pump. See test 11. Does pump pressurize?
Yes
No
Repair or replace handle.
Replace fuse 87F and/or wiring. See test 12.
Is pressure at brake >300 psi?
Yes
No
Use test plug adapter. See test 5. Is voltage present?
Yes
No
See test 11. Isolate pump. Does manually stroked pump pressurize?
Yes
No
Repair brake or gearbox.
Is system charge pressure >300 psi?
Yes
No
Replace EDC.
Repair or replace motor.
Repair or replace pump.
Replace brake valve.
Re-adjust charge pressure relief or replace pump.
Repair or replace wiring or consult factory.
AA 212

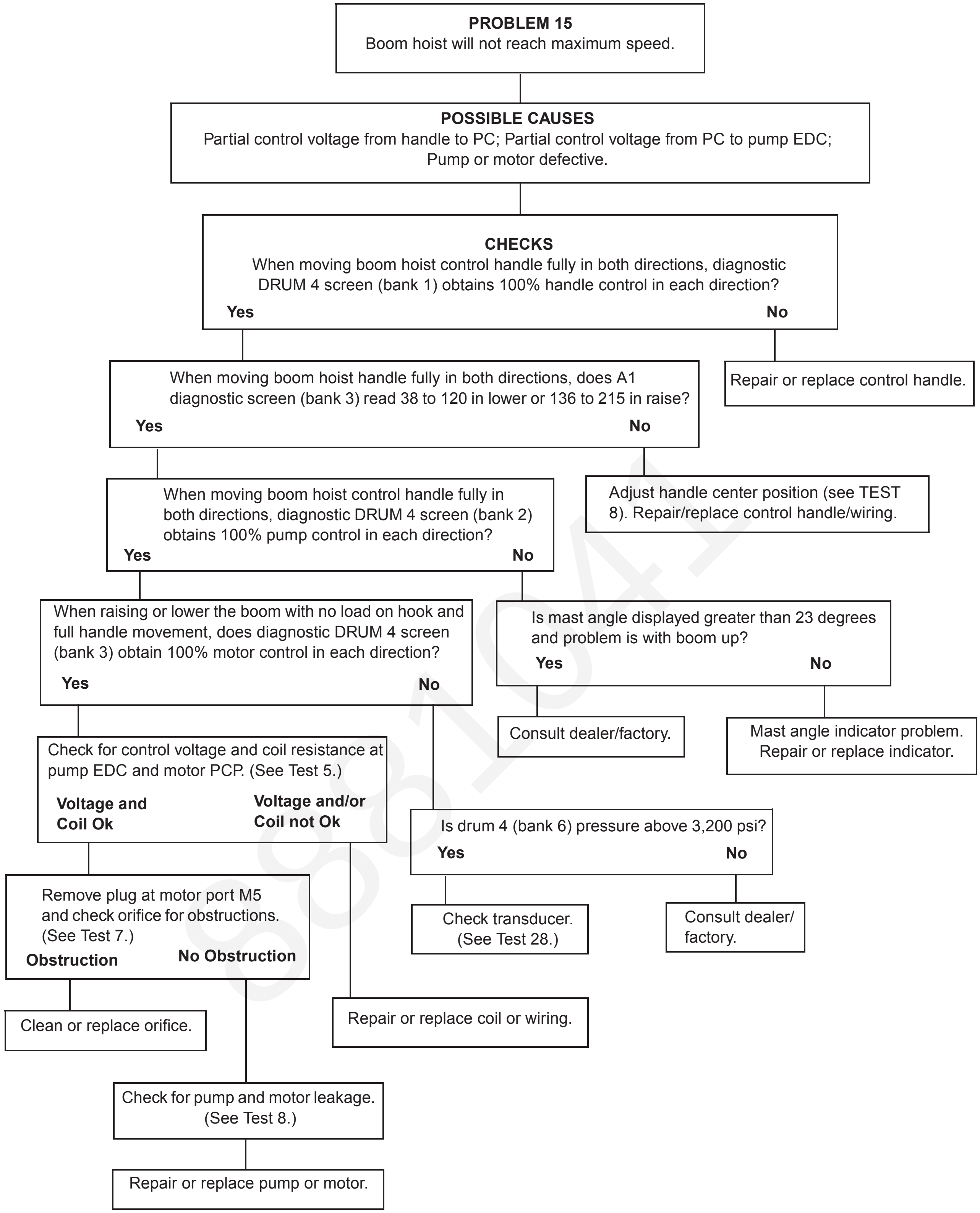

PROBLEM 11
Will not raise load, but will lower load (front or rear drum).
POSSIBLE CAUSES
Block up limit opened; Pump is defective;
LMI circuit opened; Control handle is defective;
Maximum bail limit opened; Speed sender is defective.
CHECKS
Check Diagnostic Screen D2
(Use table 3 of Diagnostic Display Reading ST123)
Bank 1 changed by 2 or 64......................Max bail limit
Bank 1 changed by 32.............................Block up limit
Bank 4 changed by 2...LMI
All bank numbers increased by number shown.
Any bank number not increased by number shown.
Diagnostic DRUM 1 or 2 screen (bank 1) approaches 100% handle control with handle pushed forward.
Yes
No
Check for problem and repair limit switch function, wiring, or fuse.
Diagnostic DRUM 1 or 2 screen (bank 2) approaches 100% pump control with handle pulled backward.
Yes
No
Repair or replace handle.
See test 5. Do +2.3 to +2.6 volts exist at pump EDC with handle pulled backward?
Yes
No
Consult factory.
Replace EDC.
Repair or replace wiring or consult factory.
AA 216

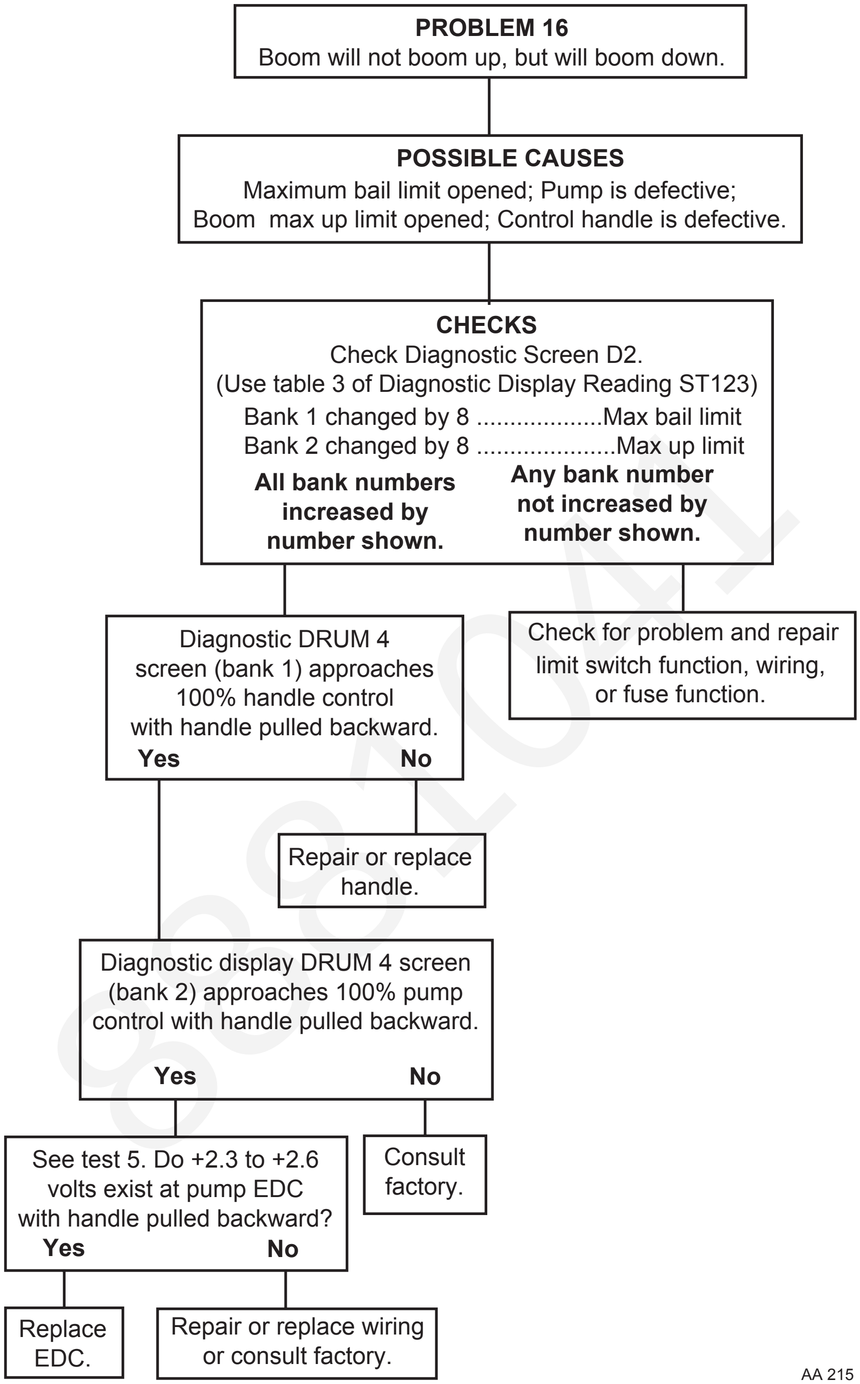

PROBLEM 12
Will not lower load, but will raise load (front or rear drum).
POSSIBLE CAUSES
Pawl in; Control handle is defective;
Minimum bail limit opened;
Pump is defective; Speed sender is defective.
CHECKS
Check Diagnostic Screen D2.
(Use table 3 of Diagnostic Display Reading ST123).
Bank 1 changed by 4 or 128....................................Min bail limit
Bank number increased by number shown.
Bank number not increased by number shown.
Diagnostic Screen D2 (bank 5, load drum pawl command) changes by 1 or 2 when moving pawl switch.
Yes
No
Check for problem and repair limit switch, wiring, or fuse.
Visually check pawl.
Out
In
Repair or replace switch or wiring to PC.
See PROBLEM 29.
Diagnostic DRUM 1 or 2 screen (bank 1) approaches 100% handle control with handle pushed forward.
Yes
No
Diagnostic DRUM 1 or 2 screen (bank 2) approaches 100% pump control with handle pushed forward.
Yes
No
Repair or replace handle.
Consult factory.
Use test plug adapter. See test 15. Are 12 volts present at air brake solenoid when handle is moved?
Yes
No
Check for air pressure at solenoid valve brake cylinder port
Pressure
No pressure
Repair or replace wiring or consult factory.
See test 5.
Replace valve.
AA 217


PROBLEM 13
Will not reach load drum maximum speed (front or rear drum).
POSSIBLE CAUSES
Partial control voltage from handle to PC; Partial control voltage from PC to pump EDC; Defective pump or motor.
CHECKS
When moving the load drum hoist control handle fully in both directions, diagnostic display DRUM 1 or 2 screen (bank 1) obtains 100% handle control in each direction?
Yes
No
Repair or replace control handle.
When moving the load drum hoist control handle fully in both directions, diagnostic display DRUM 1 or 2 screen (bank 2) obtains 100% pump control in each direction?
Yes
No
Consult factory.
When raising or lowering the hook while empty with full handle actuation, diagnostic display DRUM 1 or 2 screen (bank 3) obtains 100% motor control in each direction?
Yes
No
Consult factory.
Check for proper control voltage and coil resistance at pump EDC and motor PCP. See test 5.
Voltage and coil OK.
Voltage and/or coil not OK.
Repair or replace coil or wiring.
Remove plug at motor port M5 and check orifice for obstruction. See test 7.
Obstruction
No obstruction
Clean or replace orifice.
Check for pump and motor leakage. See test 8.
Repair or replace pump or motor.

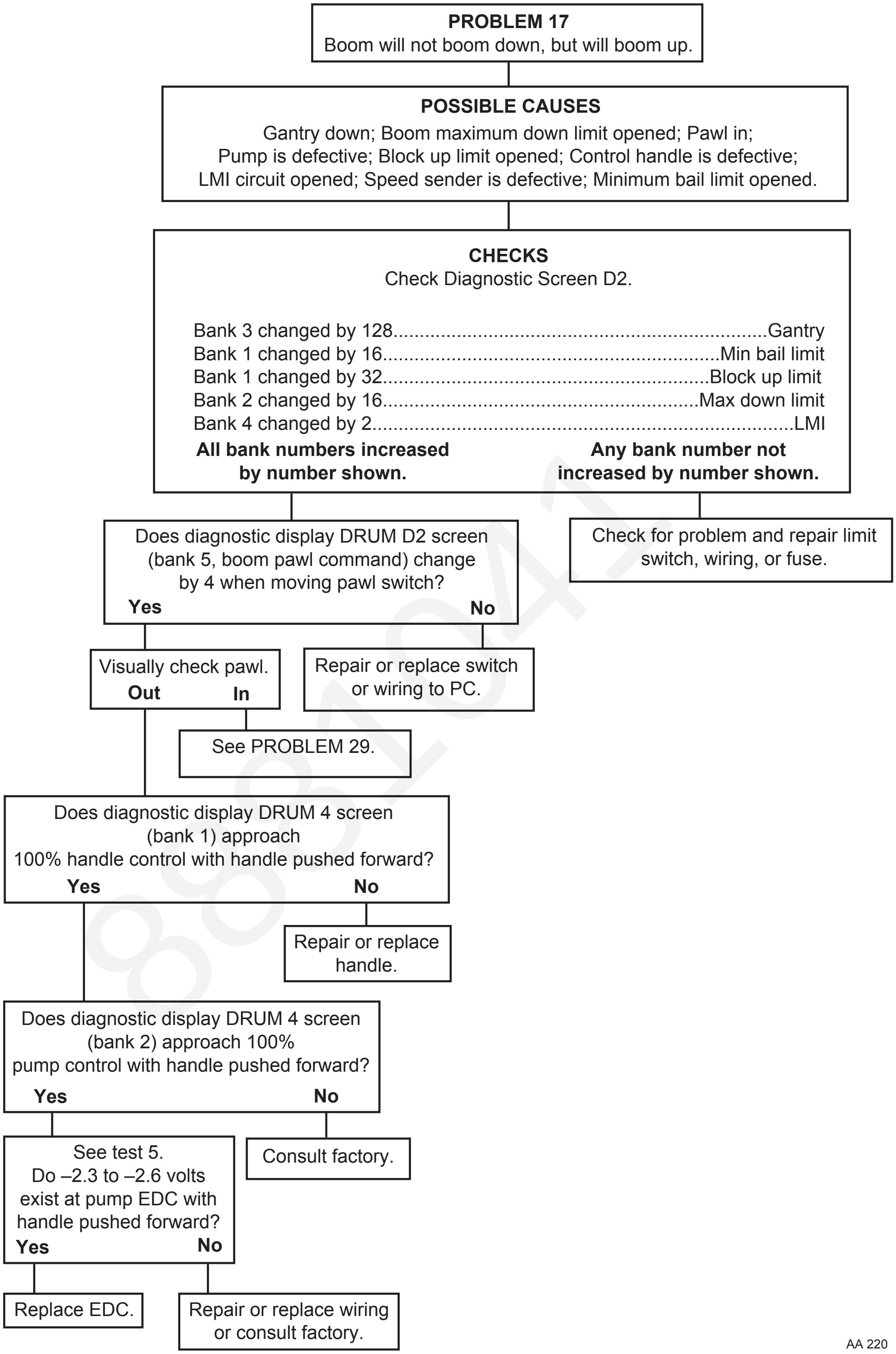
AA 219


PROBLEM 14
No boom hoist operation.
POSSIBLE CAUSES
Boom hoist brake not releasing; Boom hoist pawl not released or hung up; No voltage through control handle to controller; No voltage out of controller to pump EDC; Wiring or switch defect.
CHECKS
Diagnostic display DRUM 4 screen (bank 4) displays 1 when boom hoist control handle is moved in direction of no movement.
Yes
No
Engine loads when moving handle in either direction.
Yes
No
Brake switch is in OFF position.
Yes
No
Consult factory.
Place brake switch in OFF position.
Use test plug adapter. See test 10. Is 12 volts present at hydraulic brake solenoid 82E when handle is moved?
Yes
No
When moving the boom hoist control handle fully in both directions, the DRUM 4 diagnostic screen (bank 1) obtains 100% handle control in each direction.
Yes
No
Does drum turn while moving handle and actuating manual override on brake valve?
Yes
No
When moving the boom hoist control handle fully in both directrions, the DRUM 4 diagnostic screen (bank 2) obtains 100% pump control in each direction.
Yes
No
Voltage at handle (82P) is greater than 0.
Yes
No
Replace solenoid.
Manually stroke pump. See test 11. Does pump pressurize?
Yes
No
Consult factory.
10 volts at handle (87FA)?
Yes
No
Is pressure at brake >300 psi?
Yes
No
Repair brake or gearbox.
Use test plug adapter. See test 5. Is voltage present?
Yes
No
See test 11. Isolate pump. Does manually stroked pump pressurize?.
Yes
No
Repair or replace handle.
Replace fuse 87FA and/or replace wiring.
Is system charge pressure >300 psi?
Yes
No
Replace EDC.
Check for pump and motor leakage. See test 8.
Replace brake valve.
Repair or replace wiring or consult factory.
Re-adjust charge pressure relief or replace pump.
Repair or replace wiring or consult factory.
Repair or replace pump and/or motor.
Repair or replace pump.
AA 213

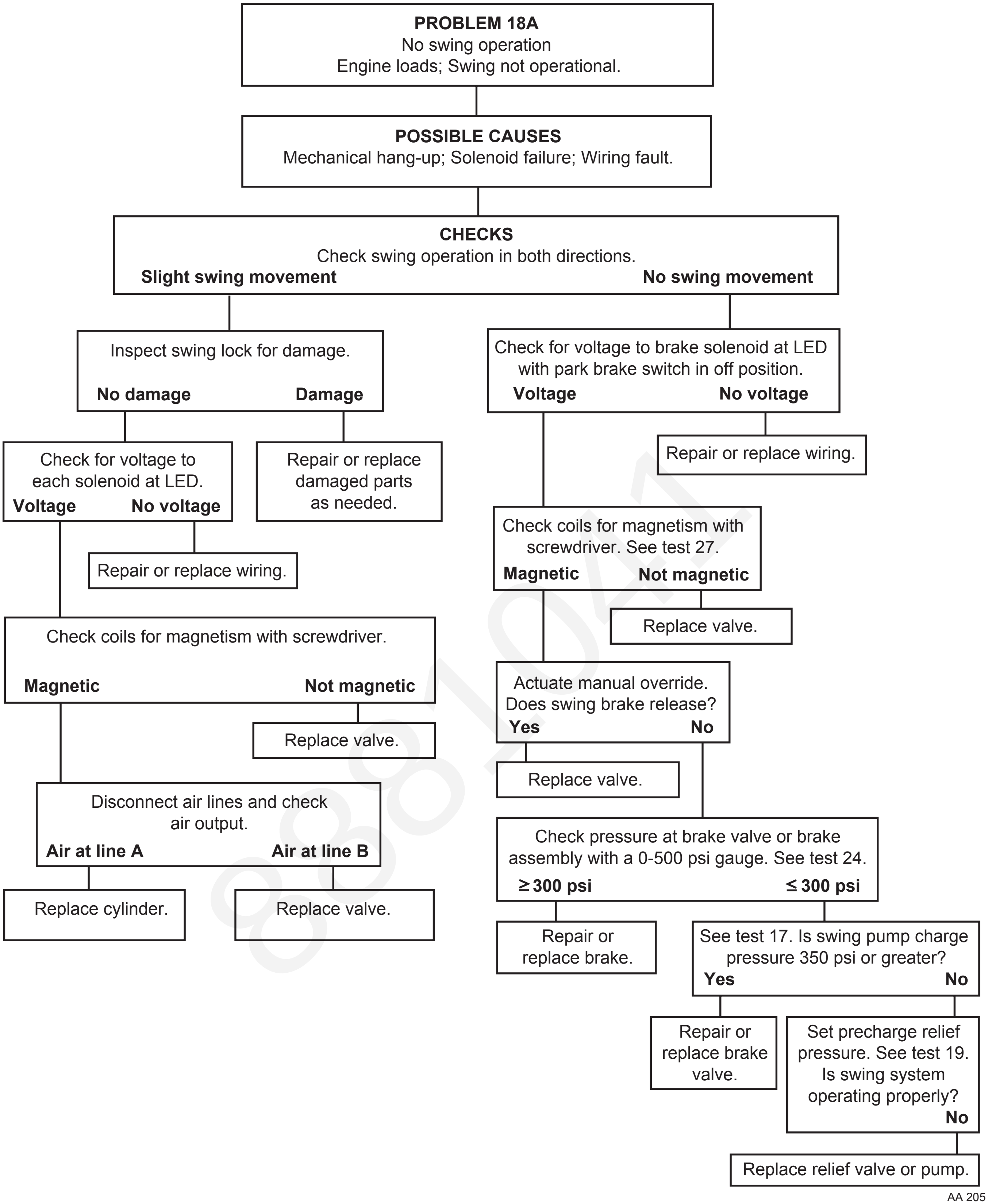

PROBLEM 15
Boom hoist will not reach maximum speed.
POSSIBLE CAUSES
Partial control voltage from handle to PC; Partial control voltage from PC to pump EDC; Pump or motor defective.
CHECKS
When moving boom hoist control handle fully in both directions, diagnostic DRUM 4 screen (bank 1) obtains 100% handle control in each direction?
Yes
No
Repair or replace control handle.
When moving boom hoist handle fully in both directions, does A1 diagnostic screen (bank 3) read 38 to 120 in lower or 136 to 215 in raise?
Yes
No
Adjust handle center position (see TEST 8). Repair/replace control handle/wiring.
When moving boom hoist control handle fully in both directions, diagnostic DRUM 4 screen (bank 2) obtains 100% pump control in each direction?
Yes
No
Is mast angle displayed greater than 23 degrees and problem is with boom up?
Yes
No
Consult dealer/factory.
Mast angle indicator problem. Repair or replace indicator.
When raising or lower the boom with no load on hook and full handle movement, does diagnostic DRUM 4 screen (bank 3) obtain 100% motor control in each direction?
Yes
No
Check for control voltage and coil resistance at pump EDC and motor PCP. (See Test 5.)
Voltage and Coil Ok
Voltage and/or Coil not Ok
Is drum 4 (bank 6) pressure above 3,200 psi?
Yes
No
Check transducer. (See Test 28.)
Consult dealer/ factory.
Remove plug at motor port M5 and check orifice for obstructions. (See Test 7.)
Obstruction
No Obstruction
Clean or replace orifice.
Repair or replace coil or wiring.
Check for pump and motor leakage. (See Test 8.)
Repair or replace pump or motor.

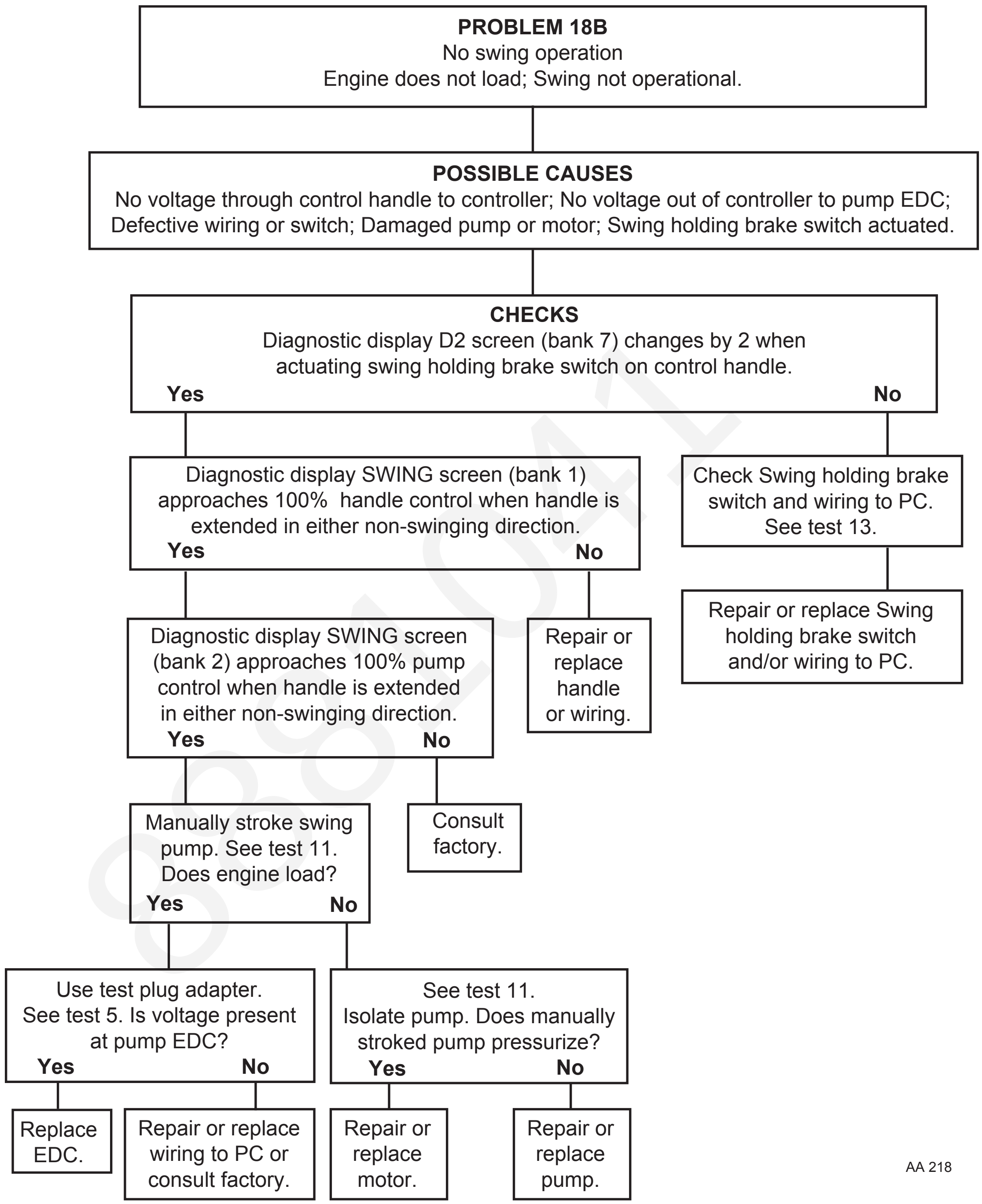

PROBLEM 16
Boom will not boom up, but will boom down.
POSSIBLE CAUSES
Maximum bail limit opened; Pump is defective;
Boom max up limit opened; Control handle is defective.
CHECKS
Check Diagnostic Screen D2.
(Use table 3 of Diagnostic Display Reading ST123)
Bank 1 changed by 8 ....Max bail limit
Bank 2 changed by 8 ....Max up limit
All bank numbers increased by number shown.
Any bank number not increased by number shown.
Diagnostic DRUM 4 screen (bank 1) approaches 100% handle control with handle pulled backward.
Yes
No
Check for problem and repair limit switch function, wiring, or fuse function.
Repair or replace handle.
Diagnostic display DRUM 4 screen (bank 2) approaches 100% pump control with handle pulled backward.
Yes
No
See test 5. Do +2.3 to +2.6 volts exist at pump EDC with handle pulled backward?
Yes
No
Consult factory.
Replace EDC.
Repair or replace wiring or consult factory.

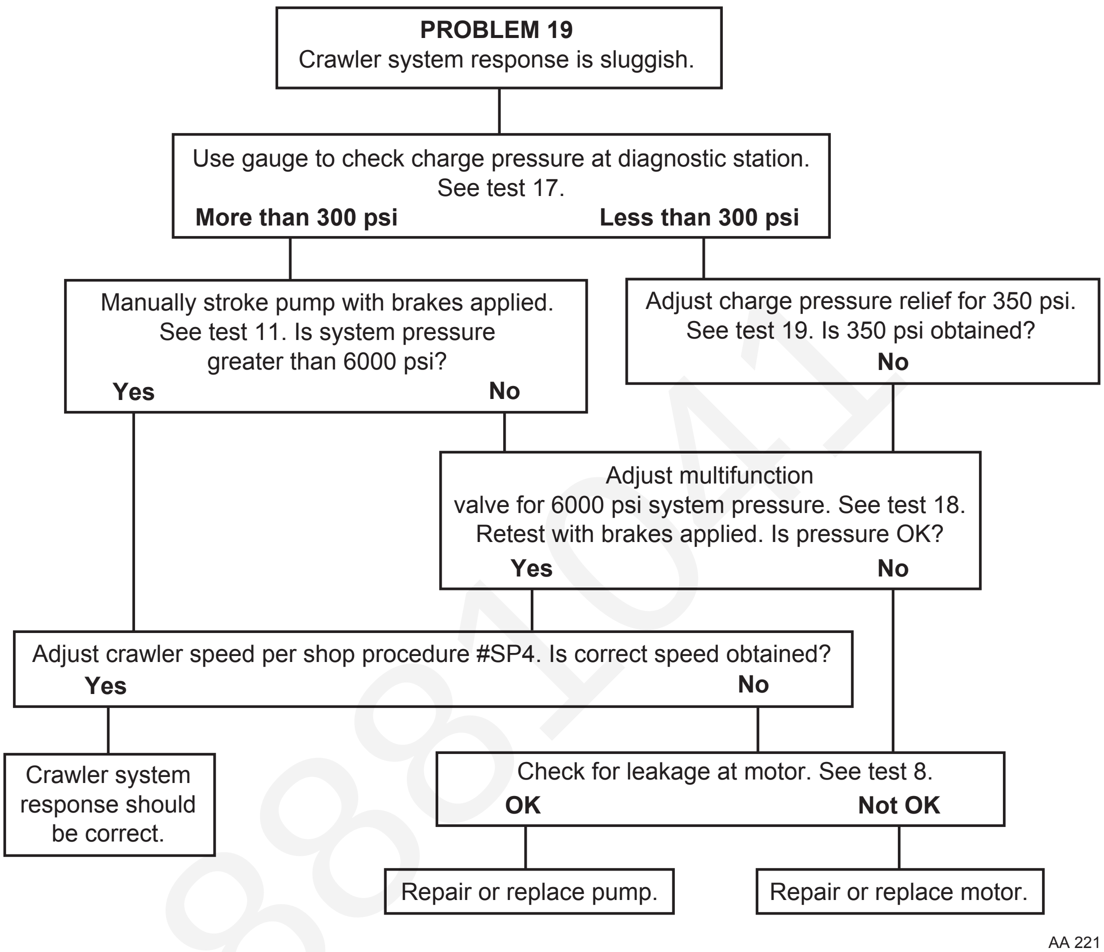
AA 215

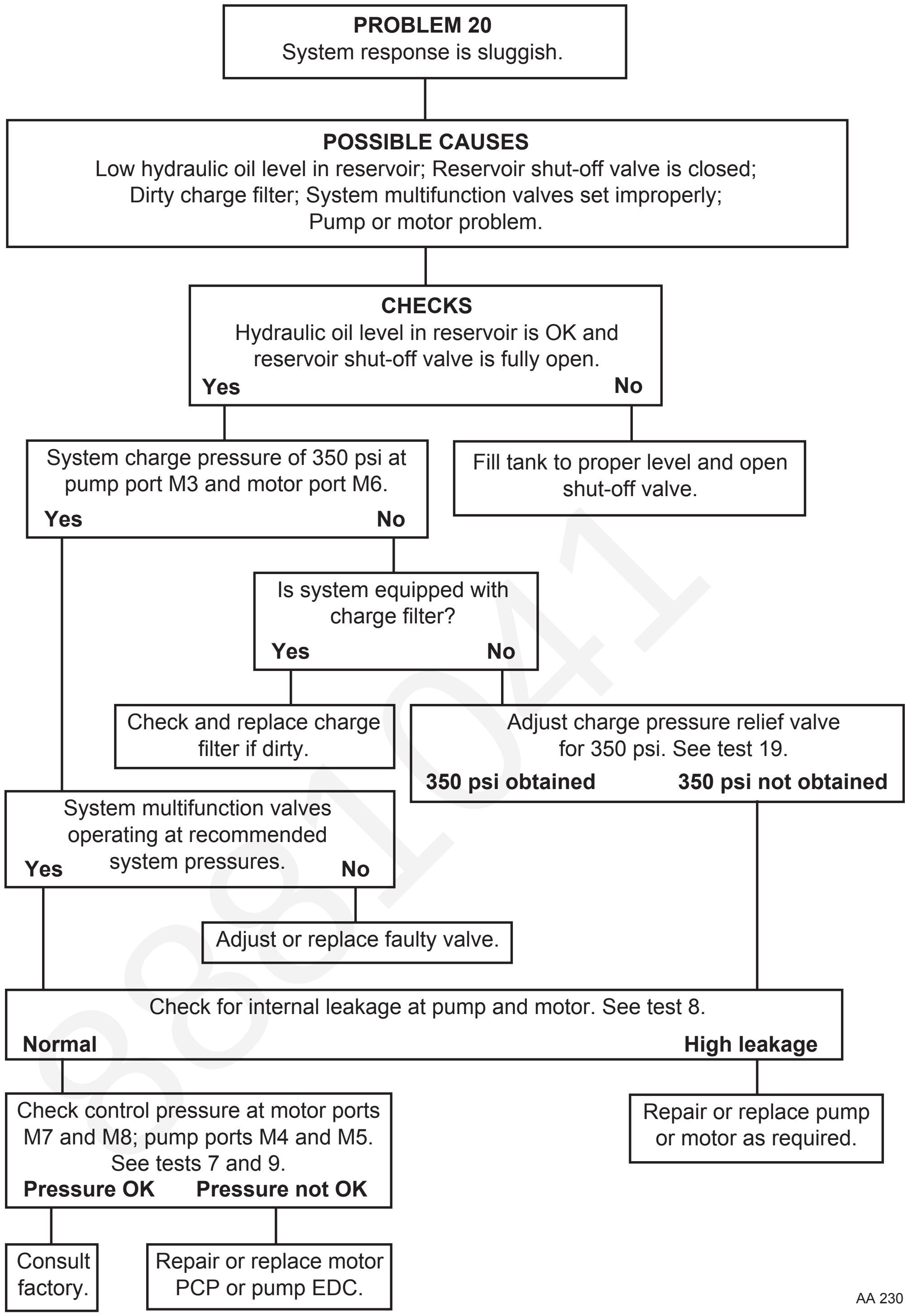

PROBLEM 17
Boom will not boom down, but will boom up.
POSSIBLE CAUSES
Gantry down; Boom maximum down limit opened; Pawl in;
Pump is defective; Block up limit opened; Control handle is defective;
LMI circuit opened; Speed sender is defective; Minimum bail limit opened.
CHECKS
Check Diagnostic Screen D2.
Bank 3 changed by 128.......Gantry
Bank 1 changed by 16.......Min bail limit
Bank 1 changed by 32.......Block up limit
Bank 2 changed by 16.......Max down limit
Bank 4 changed by 2.......LMI
All bank numbers increased by number shown.
Any bank number not increased by number shown.
Does diagnostic display DRUM D2 screen (bank 5, boom pawl command) change by 4 when moving pawl switch?
Yes
No
Check for problem and repair limit switch, wiring, or fuse.
Visually check pawl.
Out
In
Repair or replace switch or wiring to PC.
See PROBLEM 29.
Does diagnostic display DRUM 4 screen (bank 1) approach 100% handle control with handle pushed forward?
Yes
No
Repair or replace handle.
Does diagnostic display DRUM 4 screen (bank 2) approach 100% pump control with handle pushed forward?
Yes
No
See test 5.
Do –2.3 to –2.6 volts exist at pump EDC with handle pushed forward?
Yes
No
Consult factory.
Replace EDC.
Repair or replace wiring or consult factory.

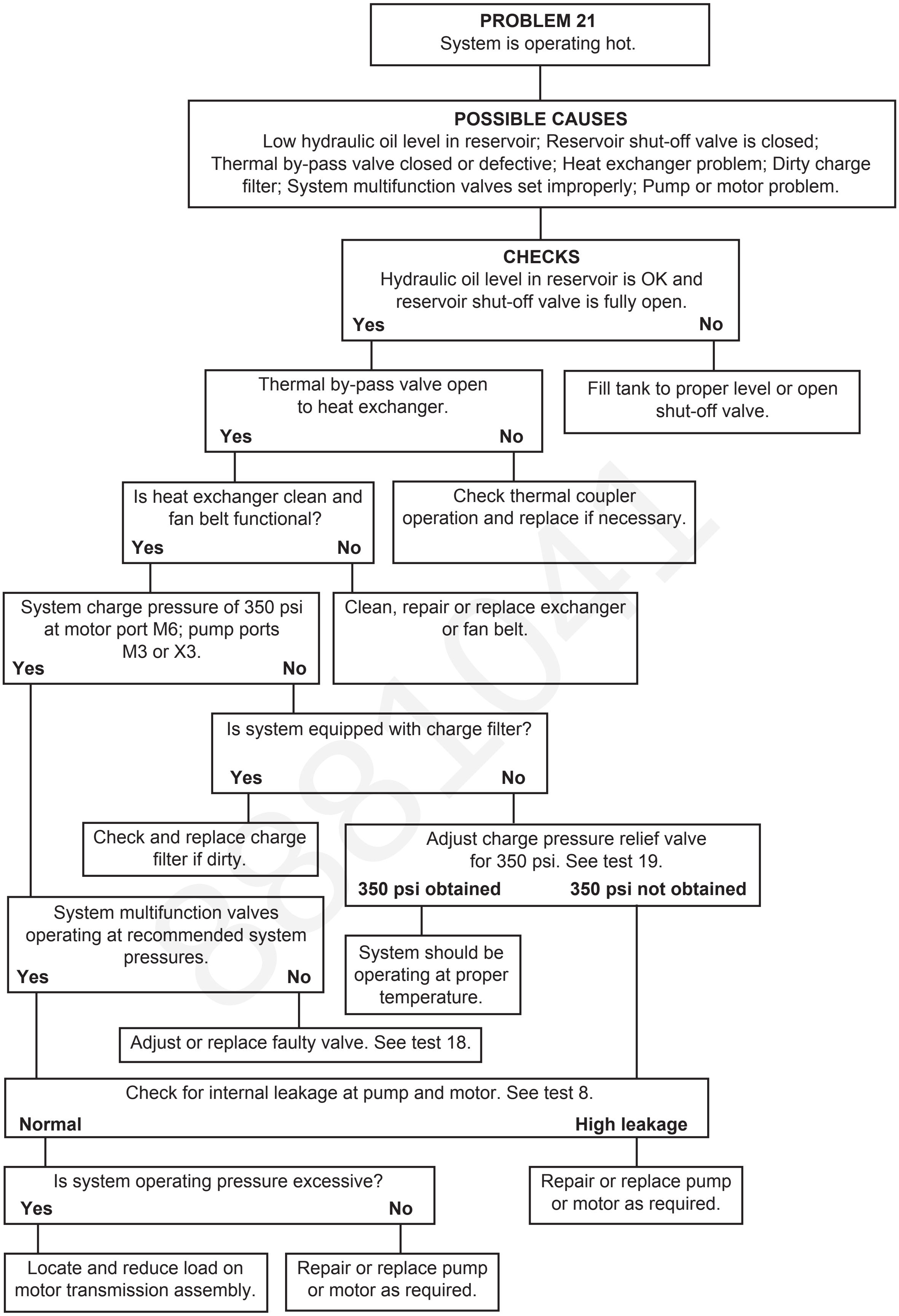
AA 220


PROBLEM 18A
No swing operation
Engine loads; Swing not operational.
POSSIBLE CAUSES
Mechanical hang-up; Solenoid failure; Wiring fault.
CHECKS
Check swing operation in both directions.
Slight swing movement
No swing movement
Inspect swing lock for damage.
No damage
Damage
Check for voltage to each solenoid at LED.
Voltage
No voltage
Repair or replace damaged parts as needed.
Repair or replace wiring.
Check coils for magnetism with screwdriver.
Magnetic
Not magnetic
Replace valve.
Disconnect air lines and check air output.
Air at line A
Air at line B
Replace cylinder.
Replace valve.
Check for voltage to brake solenoid at LED with park brake switch in off position.
Voltage
No voltage
Repair or replace wiring.
Check coils for magnetism with screwdriver. See test 27.
Magnetic
Not magnetic
Replace valve.
Actuate manual override. Does swing brake release?
Yes
No
Replace valve.
Check pressure at brake valve or brake assembly with a 0-500 psi gauge. See test 24.
≥ 300 psi
≤ 300 psi
Repair or replace brake.
See test 17. Is swing pump charge pressure 350 psi or greater?
Yes
No
Repair or replace brake valve.
Set precharge relief pressure. See test 19. Is swing system operating properly?
No
Replace relief valve or pump.
AA 205

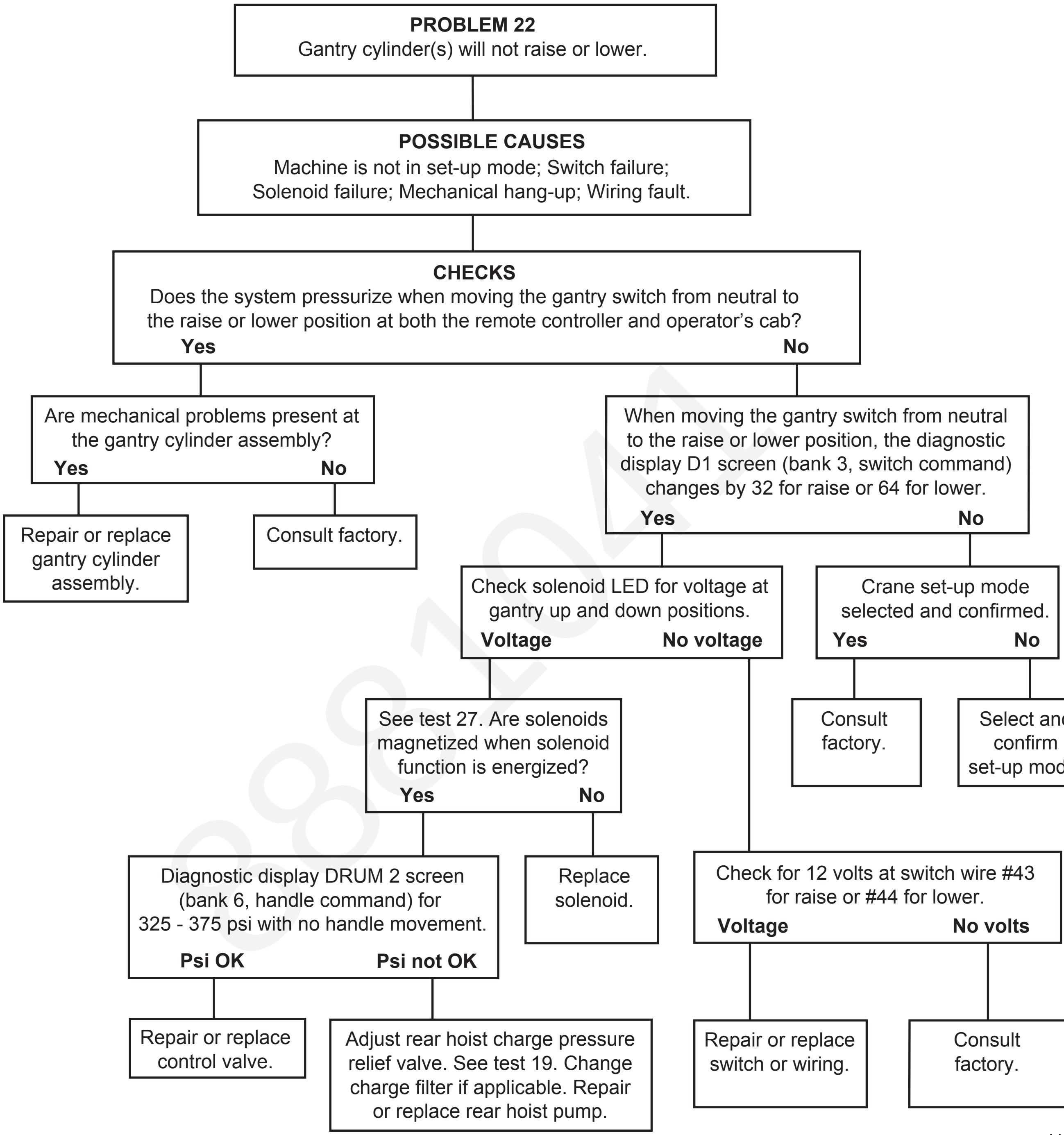

PROBLEM 18B
No swing operation
Engine does not load; Swing not operational.
POSSIBLE CAUSES
No voltage through control handle to controller; No voltage out of controller to pump EDC; Defective wiring or switch; Damaged pump or motor; Swing holding brake switch actuated.
CHECKS
Diagnostic display D2 screen (bank 7) changes by 2 when actuating swing holding brake switch on control handle.
Yes
No
Diagnostic display SWING screen (bank 1) approaches 100% handle control when handle is extended in either non-swinging direction.
Yes
No
Check Swing holding brake switch and wiring to PC. See test 13.
Repair or replace Swing holding brake switch and/or wiring to PC.
Diagnostic display SWING screen (bank 2) approaches 100% pump control when handle is extended in either non-swinging direction.
Yes
No
Repair or replace handle or wiring.
Manually stroke swing pump. See test 11. Does engine load?
Yes
No
Consult factory.
Use test plug adapter. See test 5. Is voltage present at pump EDC?
Yes
No
See test 11. Isolate pump. Does manually stroked pump pressurize?
Yes
No
Replace EDC.
Repair or replace wiring to PC or consult factory.
Repair or replace motor.
Repair or replace pump.
AA 218


PROBLEM 19
Crawler system response is sluggish.
Use gauge to check charge pressure at diagnostic station. See test 17.
More than 300 psi
Less than 300 psi
Manually stroke pump with brakes applied. See test 11. Is system pressure greater than 6000 psi?
Yes
No
Adjust charge pressure relief for 350 psi. See test 19. Is 350 psi obtained?
No
Adjust multifunction valve for 6000 psi system pressure. See test 18. Retest with brakes applied. Is pressure OK?
Yes
No
Adjust crawler speed per shop procedure #SP4. Is correct speed obtained?
Yes
No
Crawler system response should be correct.
Check for leakage at motor. See test 8.
OK
Not OK
Repair or replace pump.
Repair or replace motor.
AA 221

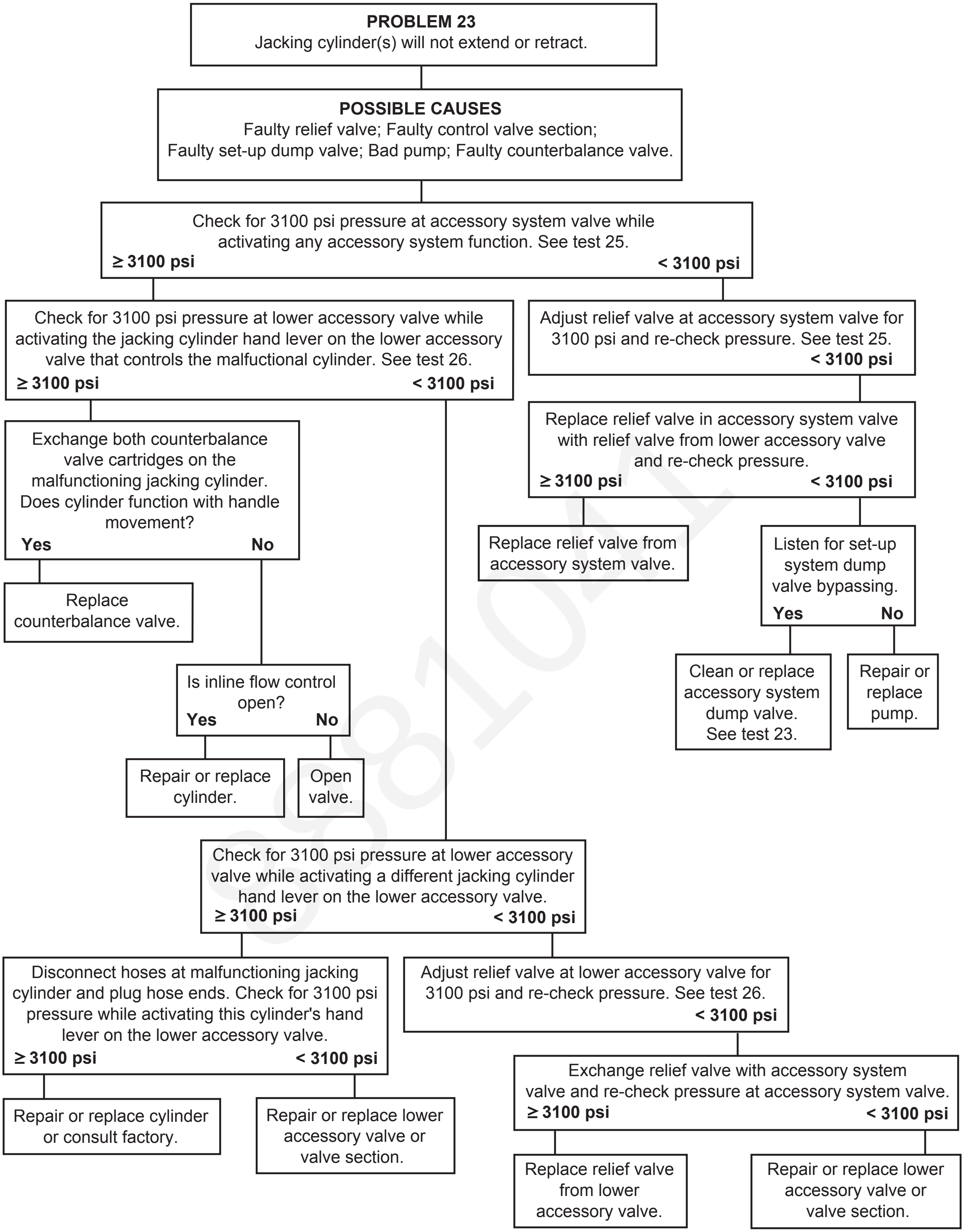

PROBLEM 20
System response is sluggish.
POSSIBLE CAUSES
Low hydraulic oil level in reservoir; Reservoir shut-off valve is closed; Dirty charge filter; System multifunction valves set improperly; Pump or motor problem.
CHECKS
Hydraulic oil level in reservoir is OK and reservoir shut-off valve is fully open.
Yes
No
System charge pressure of 350 psi at pump port M3 and motor port M6.
Yes
No
Fill tank to proper level and open shut-off valve.
Is system equipped with charge filter?
Yes
No
Check and replace charge filter if dirty.
Adjust charge pressure relief valve for 350 psi. See test 19.
350 psi obtained
350 psi not obtained
System multifunction valves operating at recommended system pressures.
Yes
No
Adjust or replace faulty valve.
Check for internal leakage at pump and motor. See test 8.
Normal
High leakage
Check control pressure at motor ports M7 and M8; pump ports M4 and M5. See tests 7 and 9.
Pressure OK
Pressure not OK
Repair or replace pump or motor as required.
Consult factory.
Repair or replace motor PCP or pump EDC.
AA 230


PROBLEM 21
System is operating hot.
POSSIBLE CAUSES
Low hydraulic oil level in reservoir; Reservoir shut-off valve is closed; Thermal by-pass valve closed or defective; Heat exchanger problem; Dirty charge filter; System multifunction valves set improperly; Pump or motor problem.
CHECKS
Hydraulic oil level in reservoir is OK and reservoir shut-off valve is fully open.
Yes
No
Thermal by-pass valve open to heat exchanger.
Yes
No
Fill tank to proper level or open shut-off valve.
Is heat exchanger clean and fan belt functional?
Yes
No
Check thermal coupler operation and replace if necessary.
System charge pressure of 350 psi at motor port M6; pump ports M3 or X3.
Yes
No
Clean, repair or replace exchanger or fan belt.
Is system equipped with charge filter?
Yes
No
Check and replace charge filter if dirty.
Adjust charge pressure relief valve for 350 psi. See test 19.
350 psi obtained
350 psi not obtained
System multifunction valves operating at recommended system pressures.
Yes
No
System should be operating at proper temperature.
Adjust or replace faulty valve. See test 18.
Check for internal leakage at pump and motor. See test 8.
Normal
High leakage
Is system operating pressure excessive?
Yes
No
Repair or replace pump or motor as required.
Locate and reduce load on motor transmission assembly.
Repair or replace pump or motor as required.

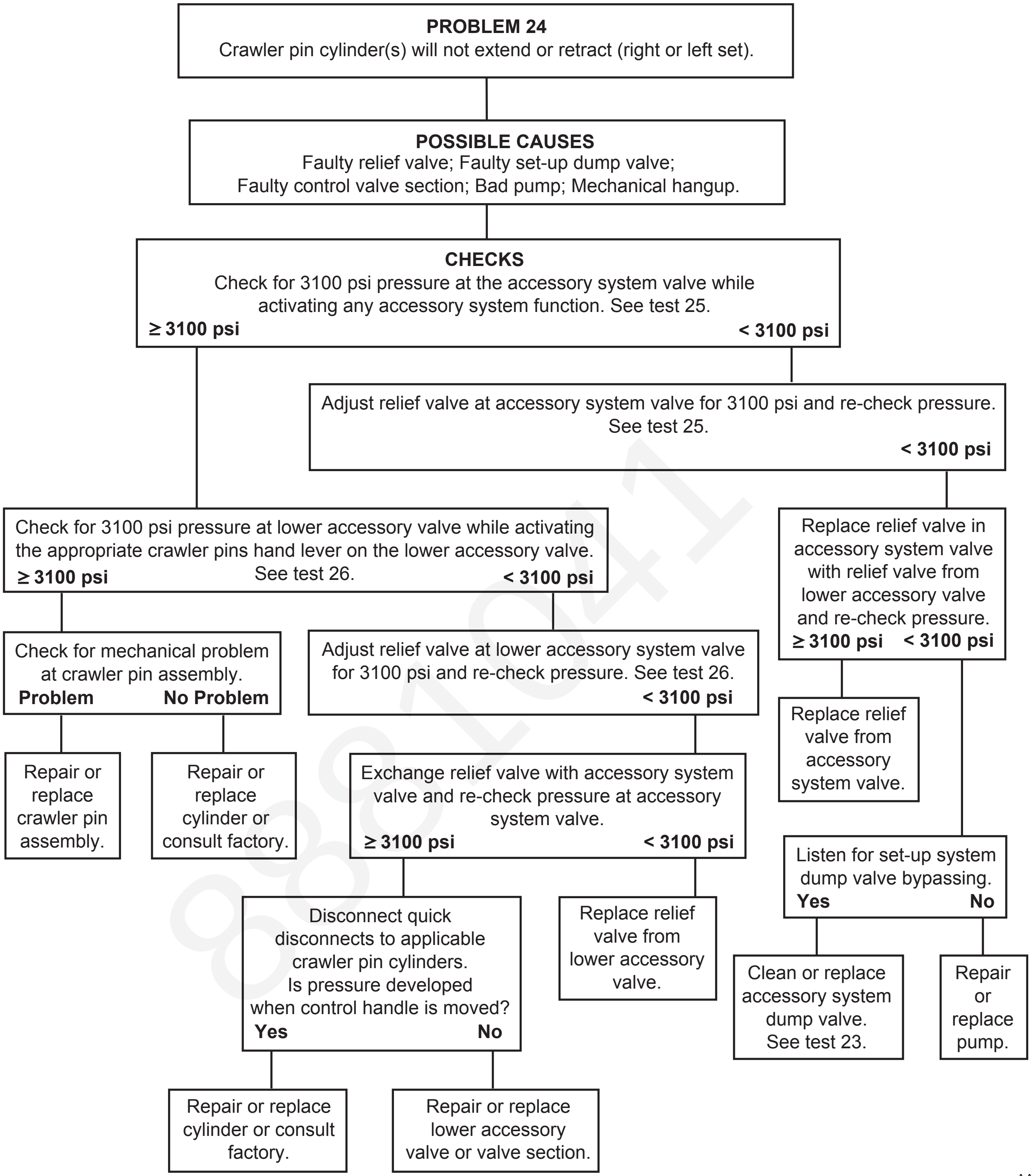
AA 231


PROBLEM 22
Gantry cylinder(s) will not raise or lower.
POSSIBLE CAUSES
Machine is not in set-up mode; Switch failure; Solenoid failure; Mechanical hang-up; Wiring fault.
CHECKS
Does the system pressurize when moving the gantry switch from neutral to the raise or lower position at both the remote controller and operator's cab?
Yes
No
Are mechanical problems present at the gantry cylinder assembly?
Yes
No
Repair or replace gantry cylinder assembly.
Consult factory.
When moving the gantry switch from neutral to the raise or lower position, the diagnostic display D1 screen (bank 3, switch command) changes by 32 for raise or 64 for lower.
Yes
No
Check solenoid LED for voltage at gantry up and down positions.
Voltage
No voltage
Crane set-up mode selected and confirmed.
Yes
No
See test 27. Are solenoids magnetized when solenoid function is energized?
Yes
No
Consult factory.
Select and confirm set-up mode.
Diagnostic display DRUM 2 screen (bank 6, handle command) for 325 - 375 psi with no handle movement.
Psi OK
Psi not OK
Replace solenoid.
Check for 12 volts at switch wire #43 for raise or #44 for lower.
Voltage
No volts
Repair or replace control valve.
Adjust rear hoist charge pressure relief valve. See test 19. Change charge filter if applicable. Repair or replace rear hoist pump.
Repair or replace switch or wiring.
Consult factory.

AA 222


PROBLEM 23
Jacking cylinder(s) will not extend or retract.
POSSIBLE CAUSES
Faulty relief valve; Faulty control valve section;
Faulty set-up dump valve; Bad pump; Faulty counterbalance valve.
Check for 3100 psi pressure at accessory system valve while activating any accessory system function. See test 25.
≥ 3100 psi
< 3100 psi
Check for 3100 psi pressure at lower accessory valve while activating the jacking cylinder hand lever on the lower accessory valve that controls the malfuctional cylinder. See test 26.
≥ 3100 psi
< 3100 psi
Adjust relief valve at accessory system valve for 3100 psi and re-check pressure. See test 25.
< 3100 psi
Replace relief valve in accessory system valve with relief valve from lower accessory valve and re-check pressure.
≥ 3100 psi
< 3100 psi
Exchange both counterbalance valve cartridges on the malfunctioning jacking cylinder. Does cylinder function with handle movement?
Yes
No
Replace relief valve from accessory system valve.
Listen for set-up system dump valve bypassing.
Yes
No
Replace counterbalance valve.
Clean or replace accessory system dump valve. See test 23.
Repair or replace pump.
Is inline flow control open?
Yes
No
Repair or replace cylinder.
Open valve.
Check for 3100 psi pressure at lower accessory valve while activating a different jacking cylinder hand lever on the lower accessory valve.
≥ 3100 psi
< 3100 psi
Disconnect hoses at malfunctioning jacking cylinder and plug hose ends. Check for 3100 psi pressure while activating this cylinder's hand lever on the lower accessory valve.
≥ 3100 psi
< 3100 psi
Adjust relief valve at lower accessory valve for 3100 psi and re-check pressure. See test 26.
< 3100 psi
Exchange relief valve with accessory system valve and re-check pressure at accessory system valve.
≥ 3100 psi
< 3100 psi
Repair or replace cylinder or consult factory.
Repair or replace lower accessory valve or valve section.
Replace relief valve from lower accessory valve.
Repair or replace lower accessory valve or valve section.

AA 232


PROBLEM 24
Crawler pin cylinder(s) will not extend or retract (right or left set).
POSSIBLE CAUSES
Faulty relief valve; Faulty set-up dump valve;
Faulty control valve section; Bad pump; Mechanical hangup.
CHECKS
Check for 3100 psi pressure at the accessory system valve while activating any accessory system function. See test 25.
≥ 3100 psi
< 3100 psi
Adjust relief valve at accessory system valve for 3100 psi and re-check pressure. See test 25.
< 3100 psi
Check for 3100 psi pressure at lower accessory valve while activating the appropriate crawler pins hand lever on the lower accessory valve. See test 26.
≥ 3100 psi
< 3100 psi
Replace relief valve in accessory system valve with relief valve from lower accessory valve and re-check pressure.
≥ 3100 psi
< 3100 psi
Check for mechanical problem at crawler pin assembly.
Problem
No Problem
Adjust relief valve at lower accessory system valve for 3100 psi and re-check pressure. See test 26.
< 3100 psi
Replace relief valve from accessory system valve.
Repair or replace crawler pin assembly.
Repair or replace cylinder or consult factory.
Exchange relief valve with accessory system valve and re-check pressure at accessory system valve.
≥ 3100 psi
< 3100 psi
Listen for set-up system dump valve bypassing.
Yes
No
Disconnect quick disconnects to applicable crawler pin cylinders. Is pressure developed when control handle is moved?
Yes
No
Replace relief valve from lower accessory valve.
Clean or replace accessory system dump valve. See test 23.
Repair or replace pump.
Repair or replace cylinder or consult factory.
Repair or replace lower accessory valve or valve section.

AA 233

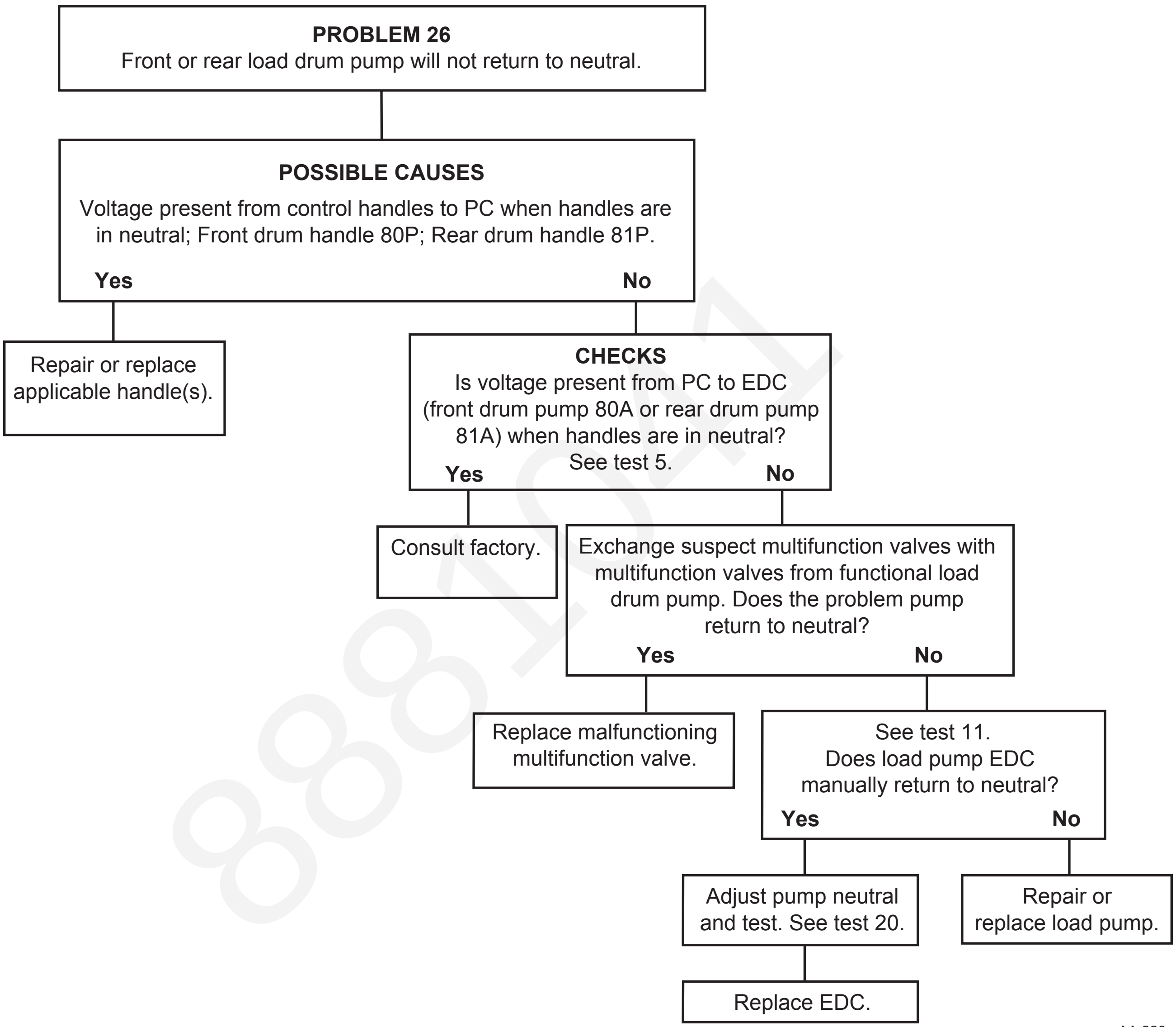
PROBLEM 25
Boom hinge pin cylinder will not extend or retract.

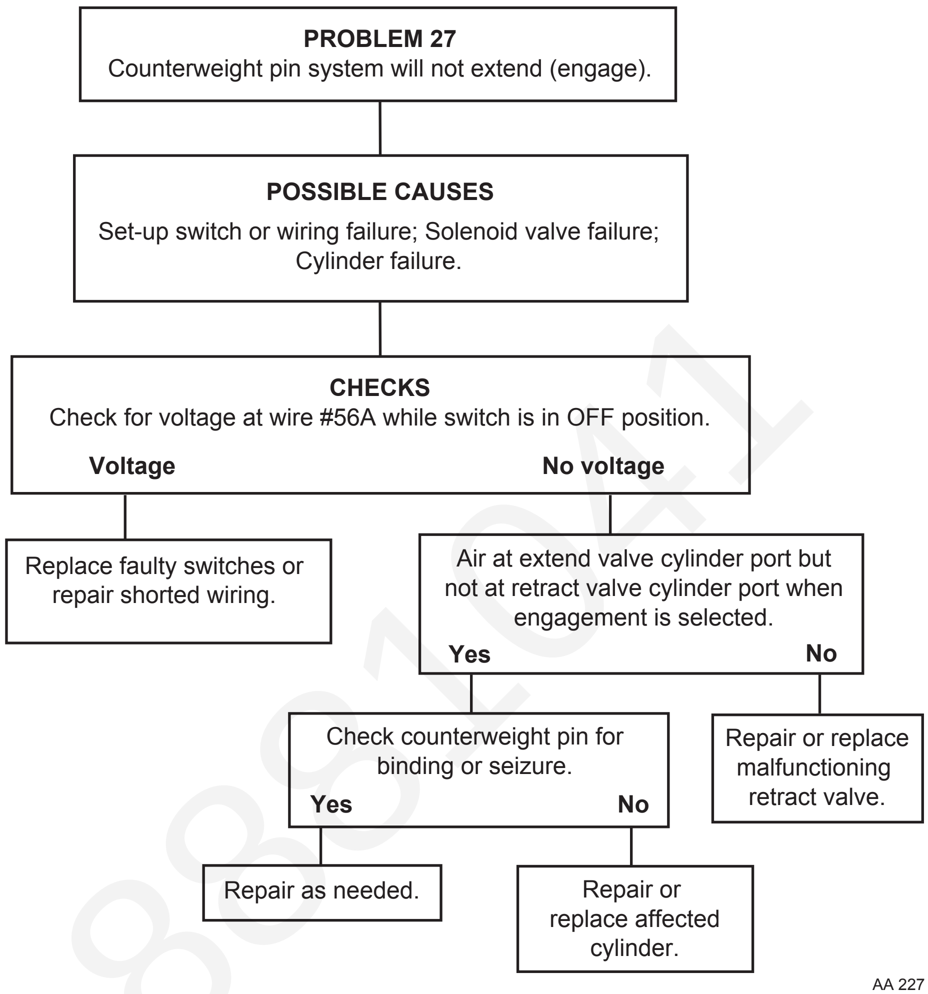
POSSIBLE CAUSES
Machine not in set-up mode; Switch failure;
Solenoid failure; Mechanical hang-up; Wiring fault.

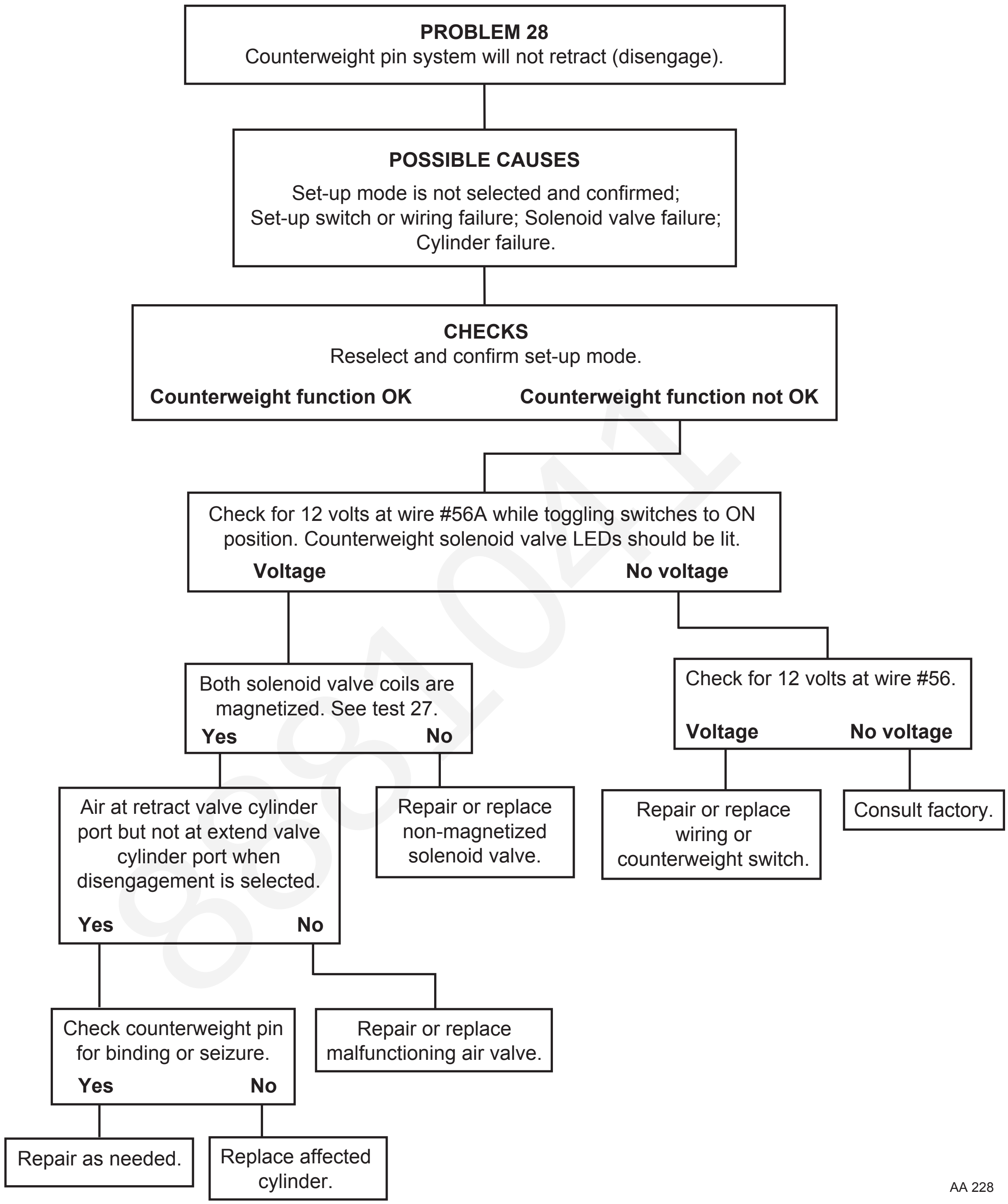
CHECKS
Does the system pressurize when moving the boom hinge pins switch from neutral to the “in” or “out” position?

- **Yes** → Check for mechnical problems at boom hinge pin assembly.
  - **Problem** → Repair or replace boom hinge pin cylinder.
  - **No problem** → Check for 3100 psi system pressure. See test 25.
    - **Yes** → Repair or replace cylinder or consult factory.
    - **No** → Adjust relief valve for 3100 psi. See test 26.
- **No** → Does the diagnostic display D1 screen (bank 4 command changes by 2) when moving the switch from neutral to the lower or raise position?
  - **Yes** → Check for voltage at boom hinge pin extend/retract solenoid LED.
    - **Voltage** → Energize solenoid function and check for magnetism.
      - **Magnetic** → Check diagnostic display DRUM 2 screen (bank 6, system pressure) for 325 - 375 psi with no handle movement.
        - **Psi OK** → Exchange relief valve in accessory system valve with relief valve in lower accessory valve. Re-energize solenoid function.
          - **Pressure** → Replace relief valve from accessory system valve.
          - **No pressure** → Repair or replace control valve or valve section.
        - **Psi not OK** → Adjust rear hoist charge pressure relief valve. See test 19. Change charge filter if applicable. Repair or replace rear hoist pump.
      - **Not magnetic** → Replace solenoid.
    - **No voltage** → Repair or replace wiring from PC to valve.
  - **No** → Is crane set-up mode selected and confirmed?
    - **Yes** → Check for voltage at switch line wire #52.
      - **Yes** → Replace switch.
      - **No** → Repair or replace wiring.
    - **No** → Select and confirm set-up mode.

AA 225


PROBLEM 26
Front or rear load drum pump will not return to neutral.
POSSIBLE CAUSES
Voltage present from control handles to PC when handles are in neutral; Front drum handle 80P; Rear drum handle 81P.
Yes
No
Repair or replace applicable handle(s).
CHECKS
Is voltage present from PC to EDC (front drum pump 80A or rear drum pump 81A) when handles are in neutral? See test 5.
Yes
No
Consult factory.
Exchange suspect multifunction valves with multifunction valves from functional load drum pump. Does the problem pump return to neutral?
Yes
No
Replace malfunctioning multifunction valve.
See test 11. Does load pump EDC manually return to neutral?
Yes
No
Adjust pump neutral and test. See test 20.
Repair or replace load pump.
Replace EDC.
AA 226


PROBLEM 27
Counterweight pin system will not extend (engage).
POSSIBLE CAUSES
Set-up switch or wiring failure; Solenoid valve failure; Cylinder failure.
CHECKS
Check for voltage at wire #56A while switch is in OFF position.
Voltage
No voltage
Replace faulty switches or repair shorted wiring.
Air at extend valve cylinder port but not at retract valve cylinder port when engagement is selected.
Yes
No
Check counterweight pin for binding or seizure.
Yes
No
Repair or replace malfunctioning retract valve.
Repair as needed.
Repair or replace affected cylinder.
AA 227


PROBLEM 28
Counterweight pin system will not retract (disengage).
POSSIBLE CAUSES
Set-up mode is not selected and confirmed; Set-up switch or wiring failure; Solenoid valve failure; Cylinder failure.
CHECKS
Reselect and confirm set-up mode.
Counterweight function OK
Counterweight function not OK
Check for 12 volts at wire #56A while toggling switches to ON position. Counterweight solenoid valve LEDs should be lit.
Voltage
No voltage
Both solenoid valve coils are magnetized. See test 27.
Yes
No
Check for 12 volts at wire #56.
Voltage
No voltage
Air at retract valve cylinder port but not at extend valve cylinder port when disengagement is selected.
Yes
No
Repair or replace non-magnetized solenoid valve.
Repair or replace wiring or counterweight switch.
Consult factory.
Check counterweight pin for binding or seizure.
Yes
No
Repair or replace malfunctioning air valve.
Repair as needed.
Replace affected cylinder.
AA 228

PROBLEM 29
Pawl not operating (boom hoist, front drum, rear drum, or auxiliary drum).

POSSIBLE CAUSES
Mechanical hang-up; No air pressure;
No voltage to pawl solenoids; Cylinder failure.

CHECKS
Check for damage to pawl or pawl linkage. Check for pawl or pawl cylinder freedom of movement.

No damage | **Damage**

Damage: Repair damage. Test and adjust.

No damage: Move pawl selector switch and verify pawl solenoid is energized. See test 27.
Note: one valve will always be energized.

Voltage | **No voltage**

No voltage: Check and replace defective 8S fuse, pawl selector switch or wiring.

Voltage: While shifting the pawl selector switch, check pawl cylinder for system air pressure at both cylinder ports.

Air pressure | **Low or no air pressure**

Low or no air pressure: Repair air system.

Air pressure: Air pressure is present at both valve cylinder ports at the same time.

Yes | **No**

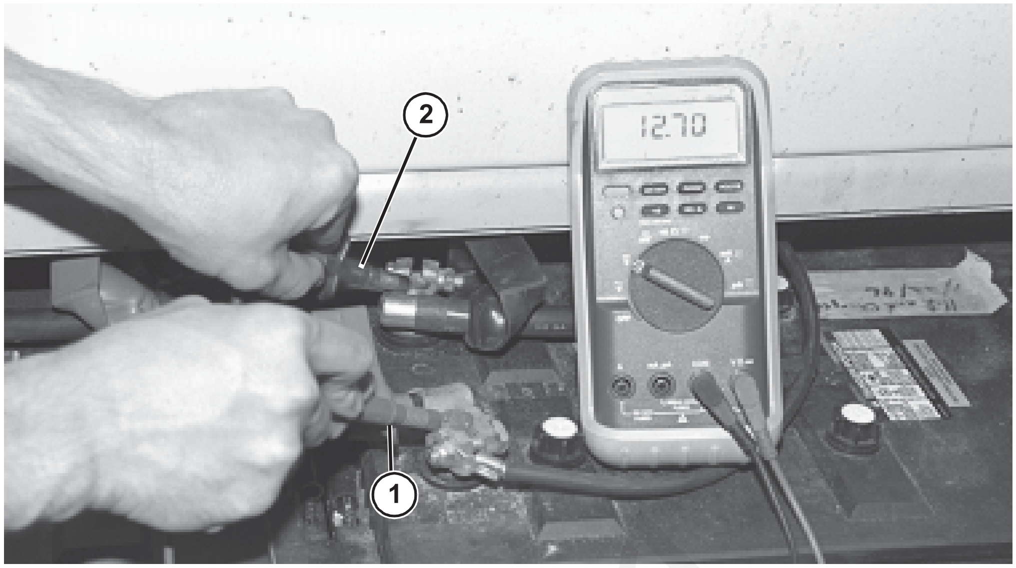
Yes: Replace bad air valve.

No: Repair or replace cylinder.

AA 229

SECTION 2 - TESTING

TEST 1 Battery Test (12 and 24 VDC)

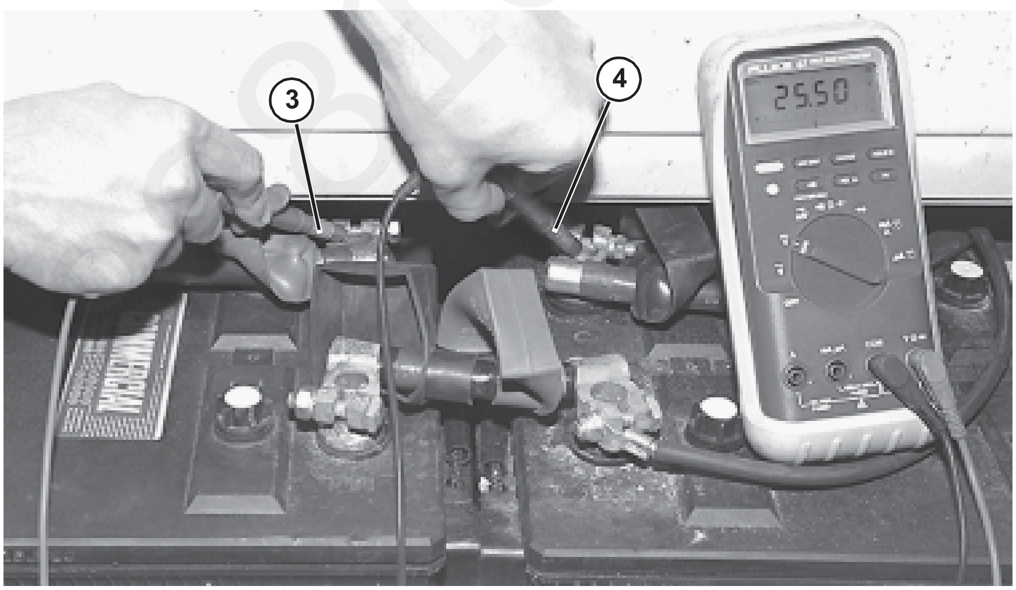


12 VDC

AA301

(1) Positive probe **(2)** Negative probe

To test the 12 VDC accessory system voltage using a digital multimeter, record the voltage before and during cranking. A voltage reading of 12 volts or less before cranking may indicate a charging system fault. A drop of 4 volts or more indicates the battery is failing.



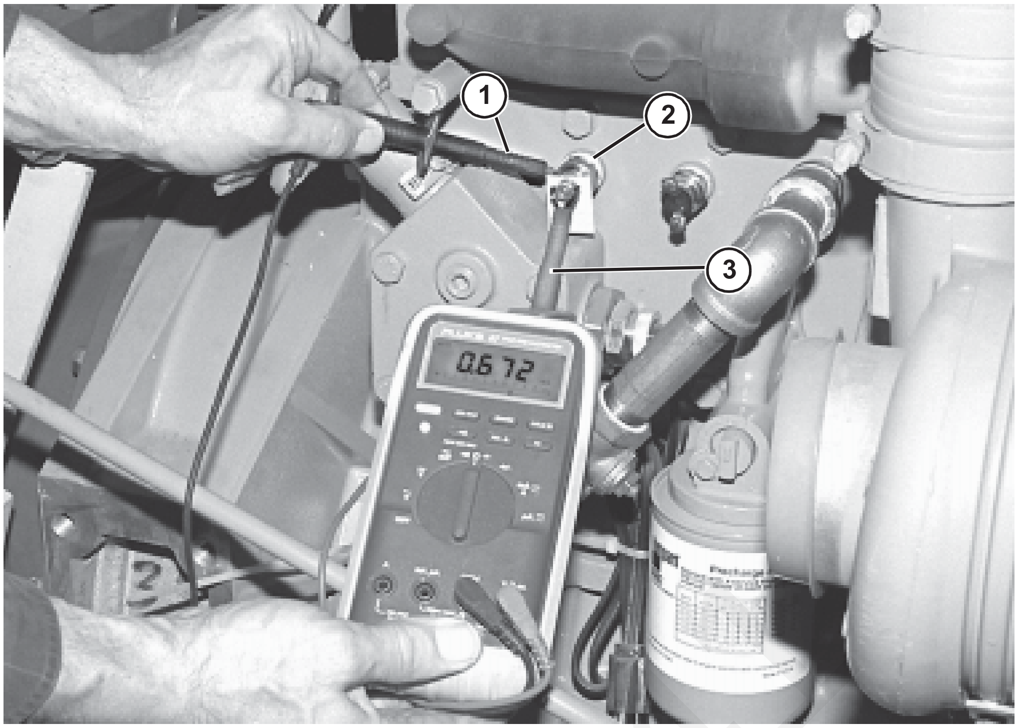
24 VDC

AA302

(3) Positive probe **(4)** Negative probe

To test the 12 VDC starting batteries connected in series for 24 volts using a digital multimeter, record the voltage before and during cranking. A voltage reading of 24 volts or less before cranking may indicate a charging system fault. A drop of 8 volts or more during cranking indicates a failing battery.

TEST 2 Checking Resistance at Engine Temperature Switch

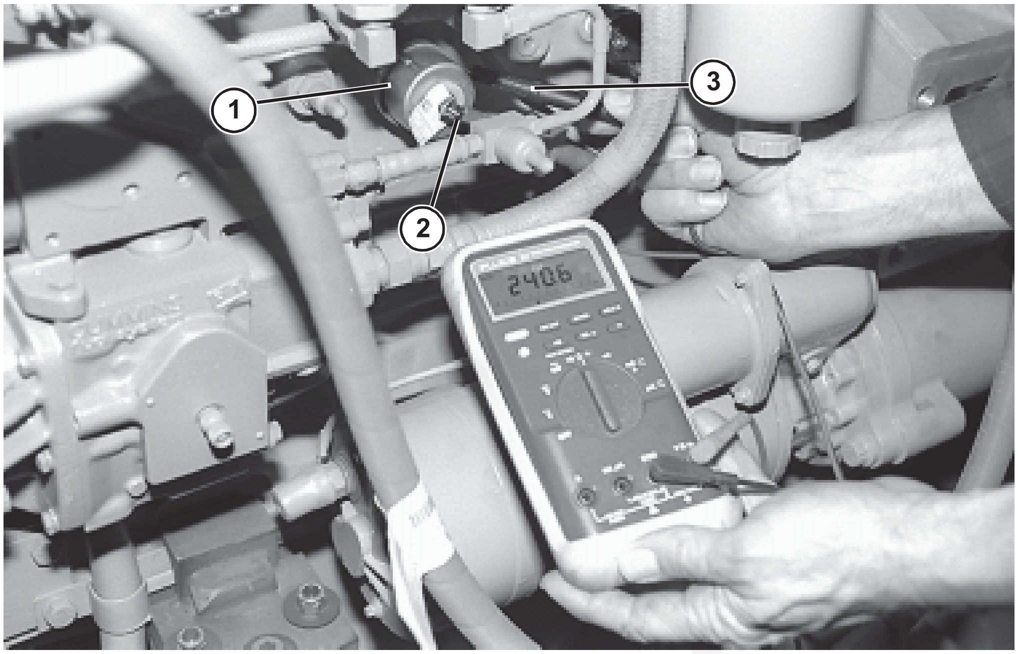


AA303

(1) Negative probe
(2) Temperature switch
(3) Positive probe

Using a digital multimeter, measure the resistance at the engine temperature switch wire terminal with the engine cold. The correct resistance is approximately 0.67 ohms.

TEST 3 Checking Resistance at Engine Oil Pressure Sender

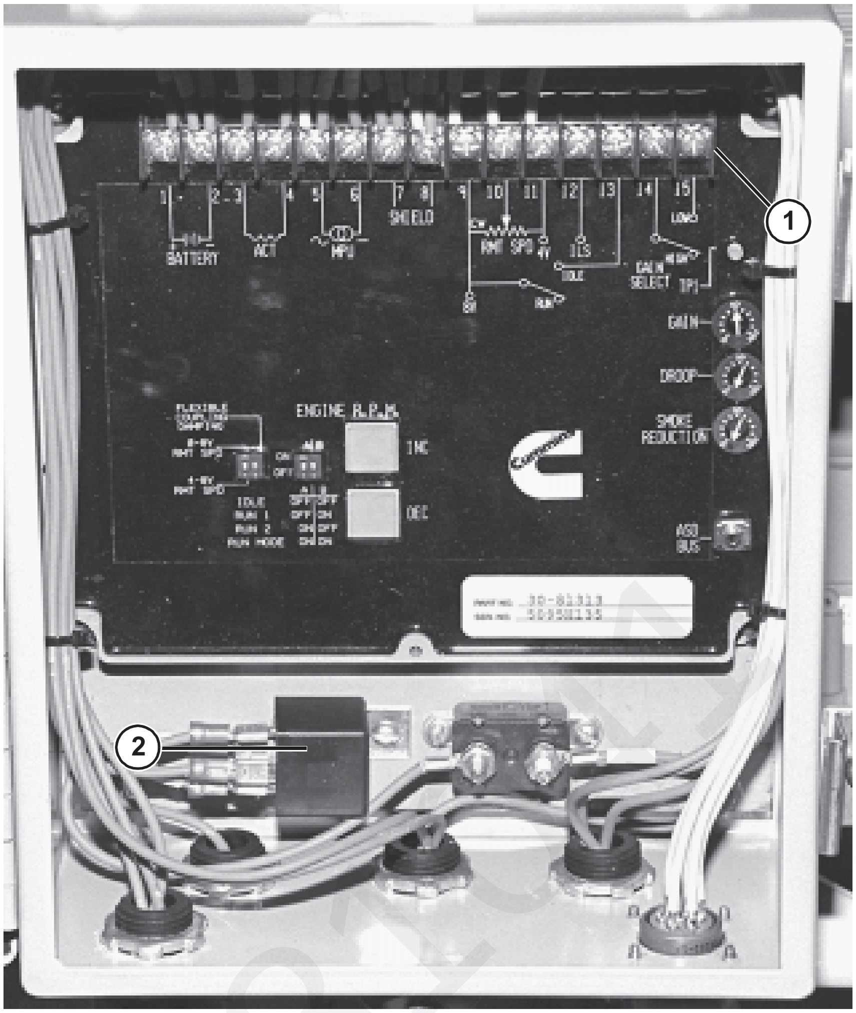


AA304

(1) Oil pressure sender
(2) Positive probe
(3) Negative probe

Using a digital multimeter, measure the resistance at the engine oil pressure switch wire terminal. The correct approximate resistance is 240 ohms.

TEST 4 Electric Fuel Control (EFC) Box Test Points



AA305

(1) Terminal block TB1 **(2)** EFC relay

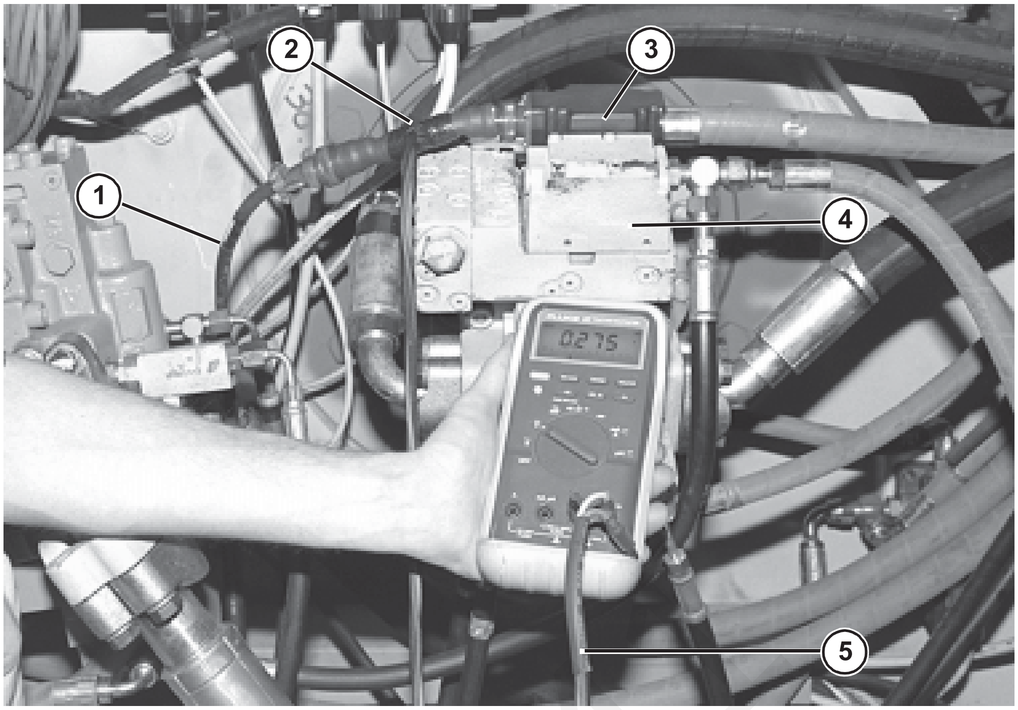
TB1 Test Points

TB1-1 Battery (+)	TB1-6 Magnetic pick up (0)	TB1-11 Remote speed pot (68L)
TB1-2 Battery (-)	TB1-7 Shield	TB1-12 No contact
TB1-3 Actuator (3EFC)	TB1-8 Shield	TB1-13 No contact
TB1-4 Actuator (4EFC)	TB1-9 Remote speed pot (68J)	TB1-14 Gain select
TB1-5 Magnetic pick up (24)	TB1-10 Remote speed pot (68K)	TB1-15 Gain select

To determine if the correct voltage is available from the hand and foot throttle, use a digital multimeter to test at the EFC box. With engine off and power on, verify 7.75 volts DC at TB1-9, 4.40 volts DC at TB1-10, and 4.50 volts DC at TB1-11. While in low idle, verify 7.80 volts DC at TB1-9, 4.70 volts DC at TB1-10, and 4.55 volts DC at TB1-11. Use the engine as the ground contact when testing at these terminals.

To determine if the correct voltage is available from the engine RPM transducer, use a digital multimeter to test at the EFC box. While in low idle, verify 9.25 volts AC is present between TB1-5 and TB1-6. If this reading is not obtained, the engine RPM transducer may require servicing. Refer to TEST 6.

TEST 5 Testing the Motor PCP and Pump EDC



AA307

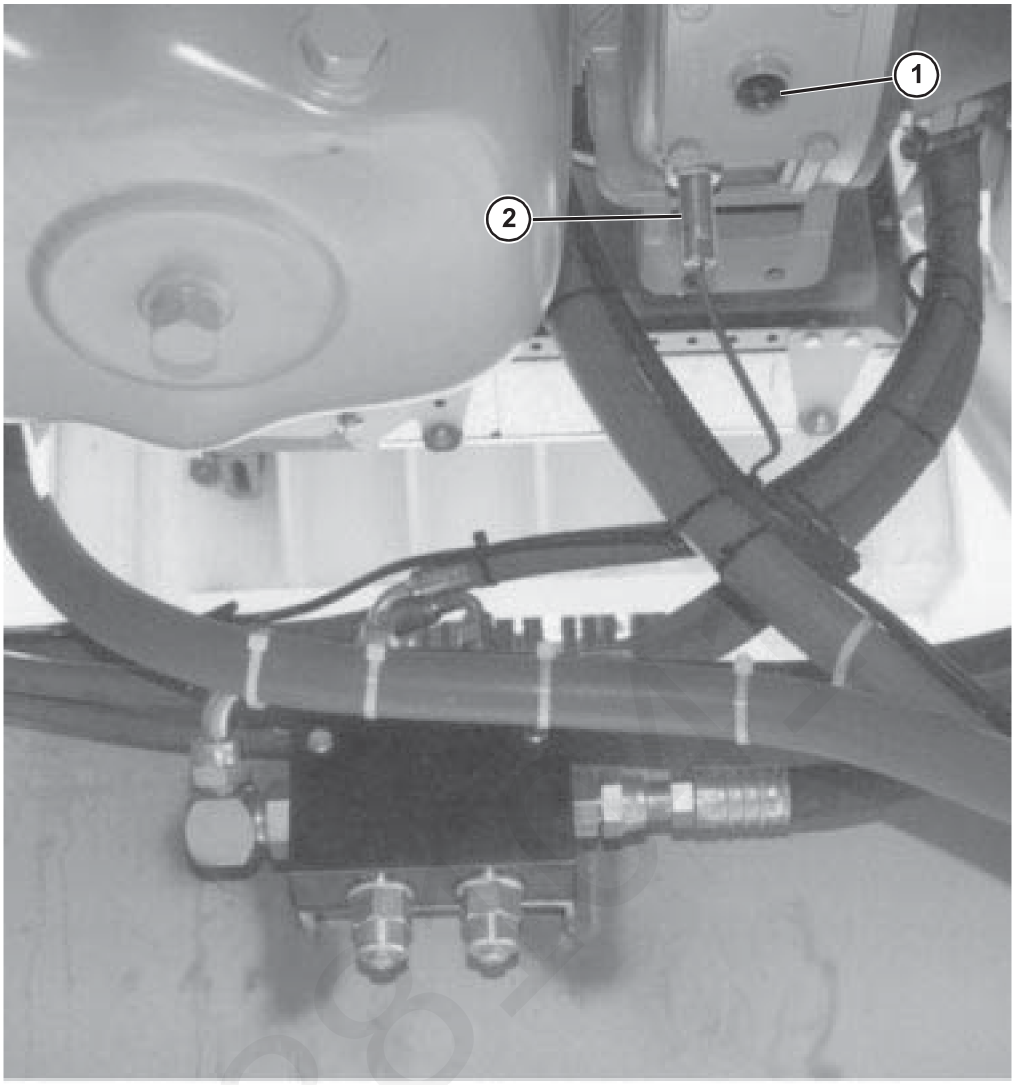
(1) PC input cable
(2) Test plug adapter
(3) Motor PCP
(4) Motor
(5) Adapter cable

Testing any of the motor PCPs or pump EDCs requires a standard test plug adapter (which can be ordered from Manitowoc Cranes, Inc.) and a digital multimeter.

To test motor functionality, connect the adapter to the motor PCP to be tested. Leave the PC end of the adapter disconnected. Make the appropriate connections (white and black) from the adapter cable to the digital multimeter and verify a resistance of 24 to 26 ohms. Reconnect the adapter cable connections (white and black) between the PC input cable and the digital multimeter for measuring volts DC. Slowly actuate the appropriate control handle in the operator's cab and verify the range of voltage change is between 0 and 1.96 volts DC. The load current (or amperage draw) at any given point in the high speed to low speed range and vice versa is equivalent to the voltage at the given point in the speed range. Load current (amps) can be measured directly by making the appropriate adapter connections (red and white) to the digital multimeter.

To test pump functionality, remove the PC input line from the pump EDC and connect the adapter in its place. Perform the same tests as described above (for motor functionality) and verify 24 to 26 ohms and 0 to ±2.45 volts DC with amperage equivalent to the voltage at any given point in the speed range.

TEST 6 Cleaning and Adjusting the Engine RPM Transducer

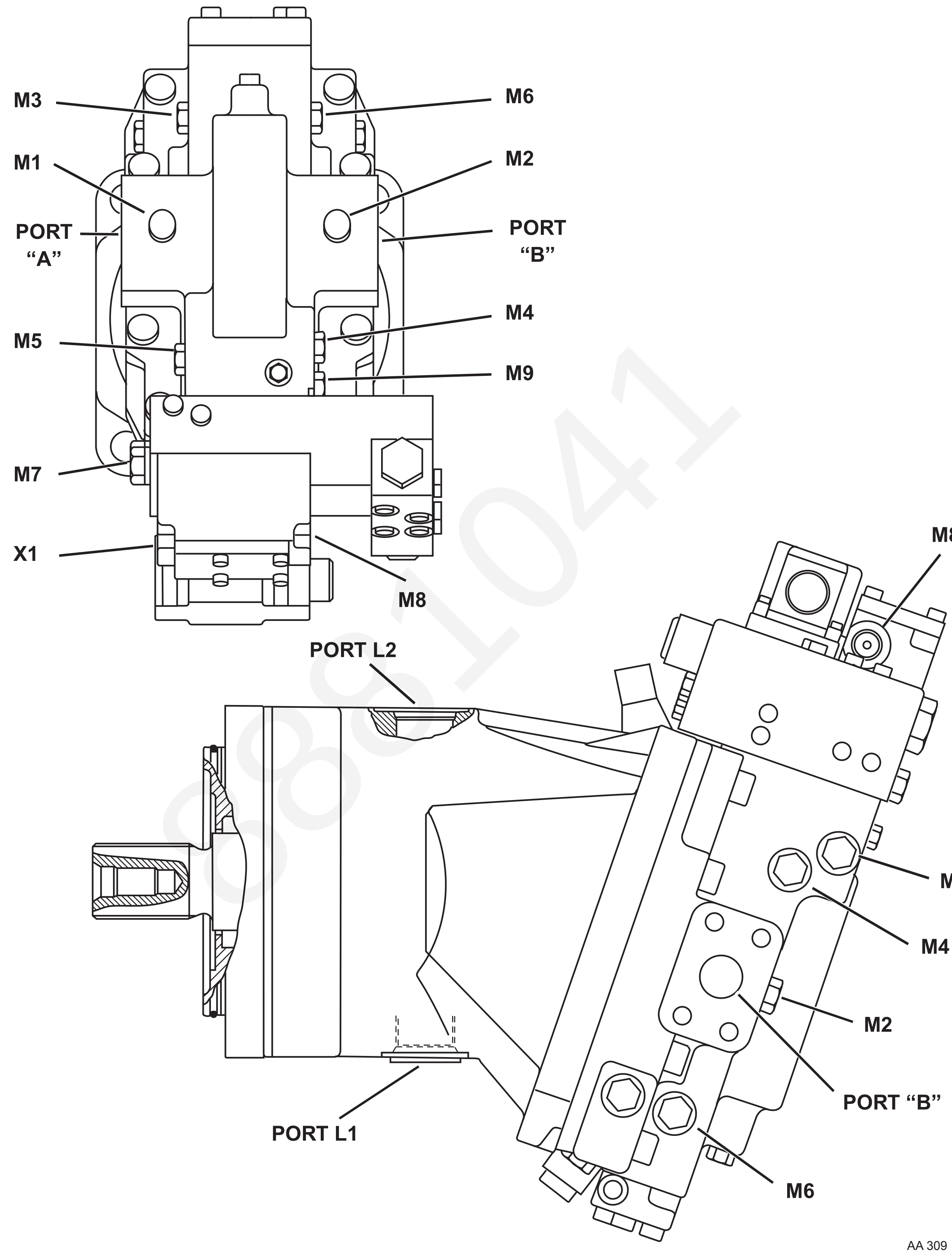


(1) Flywheel housing **(2)** RPM transducer

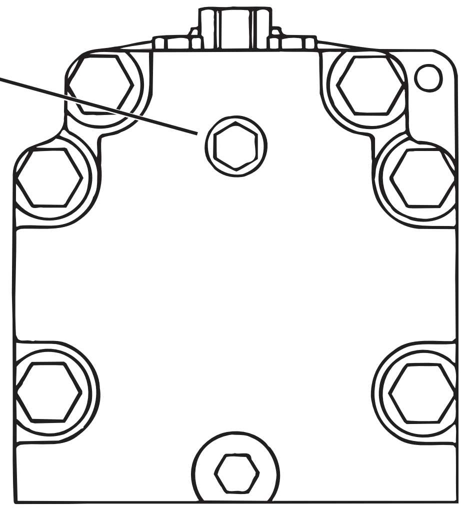
Loosen the locking nut and remove the threaded transducer from the flywheel housing. Clean any metallic debris from the magnetic pickup on the transducer with a cleaning solvent. Re-install the transducer so the magnetic pickup makes contact with the flywheel. Loosen transducer 1/4 turn and secure the lock nut.

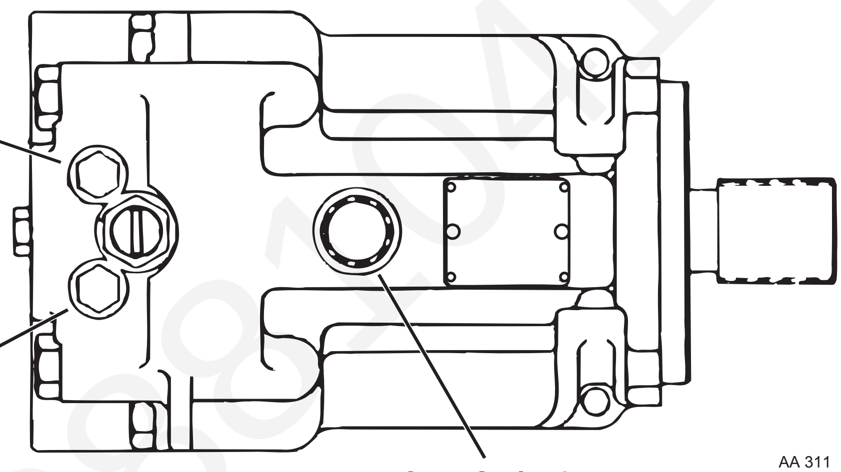
TEST 7 Location of Motor Test Ports

SYSTEM MOTORS (Excluding Swing)



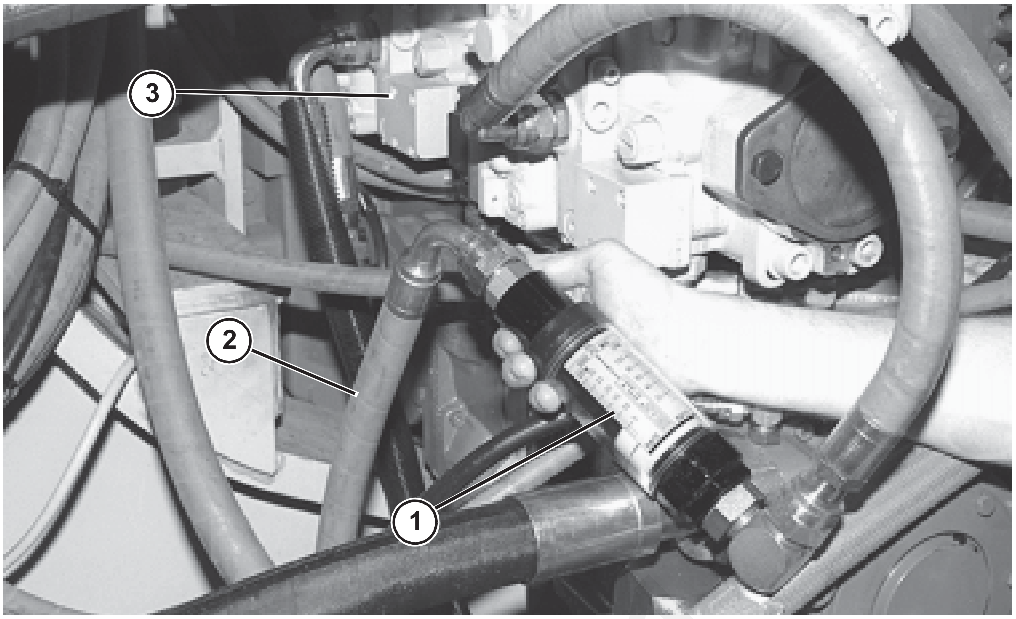
SWING MOTOR



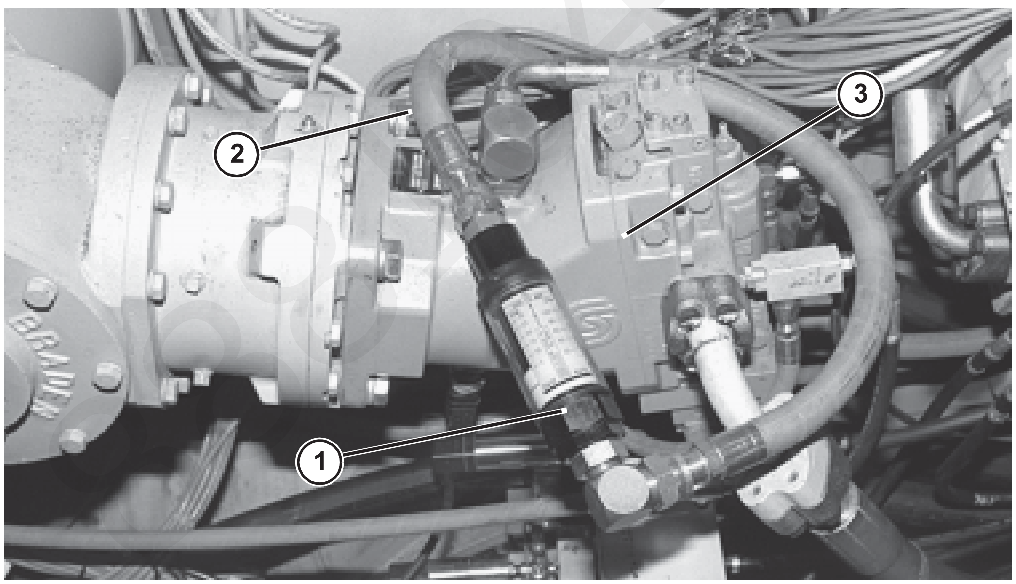


Port Designation	Port Description	Gauge (psi)	O-Ring Fitting
“A” and “B”	Main system pressure	N/A	1" code 62 port flange
M1	Gauge port for Port “A”	10,000	SAE 6
M2	Gauge port for Port “B”	10,000	SAE 6
M3	Servo pressure (minimum angle)	10,000	SAE 6
M4	Servo pressure (maximum angle)	10,000	SAE 6
M5 and M9	Servo supply pressure	10,000; Tee into control pressure line	SAE 6
M6	Motor charge pressure	600	SAE 6
M7 and M8	Control pressure	600	SAE 6
L1 and L2	Case pressure	600	SAE 12
X1	External PCP supply pressure	1,000	SAE 6

TEST 8 Testing for Pump and Motor Leakage



(**1**) Inline flow meter **(2)** Pump case drain hose **(3)** Pump



(1) Inline flow meter **(2)** Motor case drain hose **(3)** Motor

Testing for pump and motor leakage requires a 3,000 psi inline flow meter with minimum flow rate capacity of 10 gpm. Suitable flow meters can be ordered from Manitowoc Cranes, Inc.

Since the amount of flow from the individual pump and motor drains is dependent on several operational factors and settings, it is difficult to define in exact numbers. Therefore, acceptable leakage is generally based on the combined case flow of the pump and motor.

The combined case flow out of the main hoist pump and motor should be approximately equal to a charge pump flow of 8.9 gpm per 1,000 rpm of the engine. The combined case flow out of the boom hoist, swing, or travel pump and motor should be approximately equal to a charge pump flow of 4.8 gpm per 1,000 rpm of the engine.

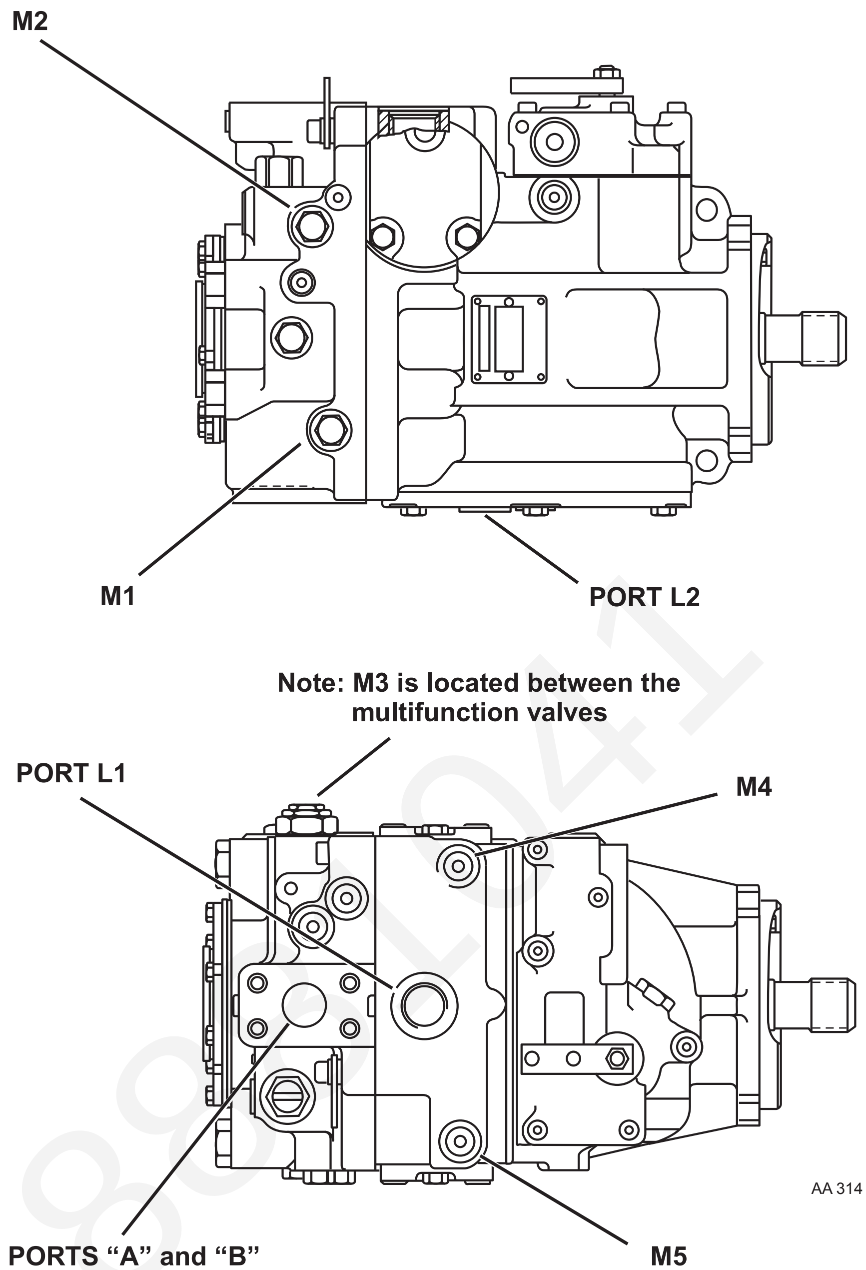
For the boom hoist, main hoist, or travel motor, begin by connecting the flow meter between the motor case drain hose and motor port L1 or L2 (use the highest port for testing). To test the swing motor, first connect the flow meter between the motor case drain hose and Case Outlet 1. Refer to TEST 7 for location of motor test ports. With the engine running at 1,000 rpm, measure the flow rate of the motor. Due to the continuous loop flushing modification of the main hoist motor, case flow at neutral or very light loads should be approximately 3 to 4 gpm. At heavier loads, normal case flow for the main hoist motor may go up to approximately 6 gpm. Since the boom hoist, swing, and travel motors are not modified for continuous loop flushing, case flow at neutral should not exceed approximately 1 gpm. At heavier loads and higher rpm, case flow for these systems may increase to 4 or 5 gpm. Record the measurement at neutral and reconnect the motor case drain hose to its motor port.

The difference between the circuit's charge pump flow and motor case flow at neutral is the acceptable pump case flow at neutral for the circuit under test.

Next, connect the flow meter between the pump case drain hose and pump port L1 or L2 (use the highest port for testing). Refer to TEST 9 for location of pump test ports. With the engine running at 1,000 rpm, measure the flow rate of the pump at neutral and compare to the calculated acceptable pump case flow.

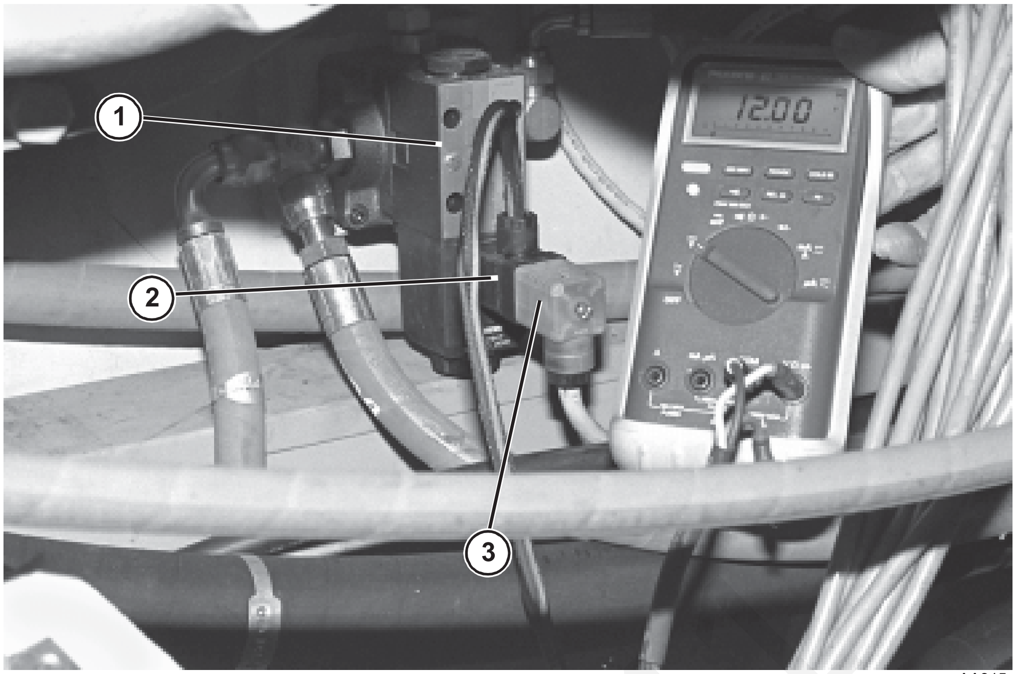
Major deviations from the normal or major changes with increasing system pressure more than ±1 gpm are indicators of pump or motor problems.

TEST 9 Location of Pump Test Ports



Port Designation	Port Description	Gauge (psi)	O-Ring Fitting (boom hoist, swing, travel)	O-Ring Fitting (main hoist)
“A” and “B”	Main system pressure	6,000	1" code 62 port flange	1-1/4" code 62 port flange
M1	Gauge port for Port “A”	10,000	SAE 6	SAE 6
M2	Gauge port for Port “B”	10,000	SAE 6	SAE 6
M3	Charge pressure	500	SAE 6	SAE 6
M4	Servo pressure	500	SAE 6	SAE 6
M5	Servo pressure	500	SAE 6	SAE 6
L1 and L2	Case pressure	500	SAE 12	SAE 16

TEST 10 Checking Voltage at the Hydraulic Brake Valve



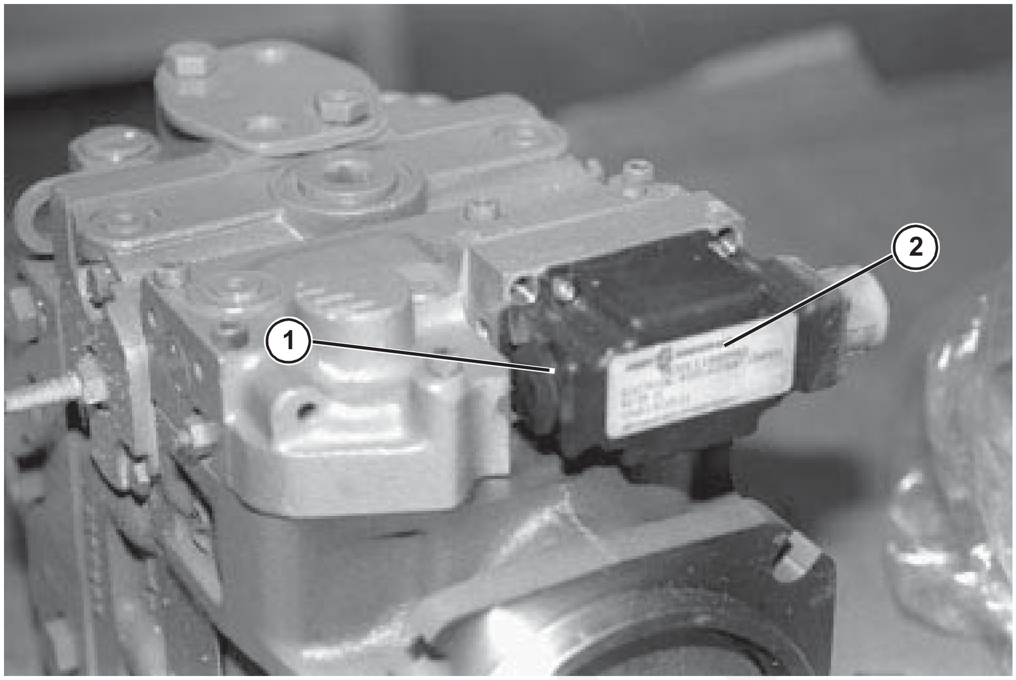
AA315

(1) Hydraulic brake valve
(2) Test plug adapter
(3) Electrical connector

Testing for voltage at any hydraulic brake valve requires the use of a standard test plug adapter (which can be ordered from Manitowoc Cranes, Inc.) and a digital multimeter.

Connect the test plug adapter between the brake valve and the electrical connector. Make the appropriate connections (white and black) from the adapter cable to the digital multimeter and verify 12 volts DC while actuating the appropriate system function that releases the brake under test. Load current (amps) can be measured directly by making the appropriate adapter connections (red and white) to the digital multimeter.

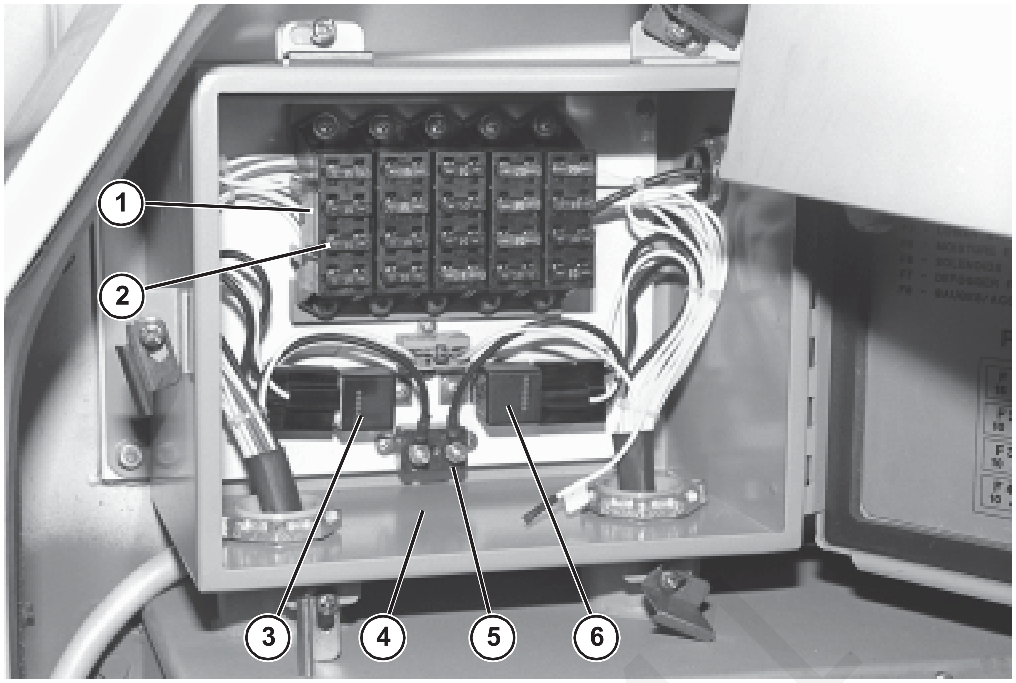
TEST 11 Manually Stroking the Pump



(1) Manual stroke override
(2) Pump EDC

With the engine running and all brakes and locks engaged, rotation of the manual override in the clockwise direction will cause engine load down and pressure rise in port “A” of the pump under test. Counterclockwise rotation of the manual override will cause engine load down and pressure rise in port “B” of the pump under test. Refer to TEST 9 for location of pump ports “A” and “B”.

TEST 12 Testing for Voltage at the Fuse Box



(1) Fuse block
(2) Metal fuse contact
(3) MS2 cab power relay
(4) Fuse box chassis
(5) 50A overload relay
(6) Flood light relay

Fuse Identification

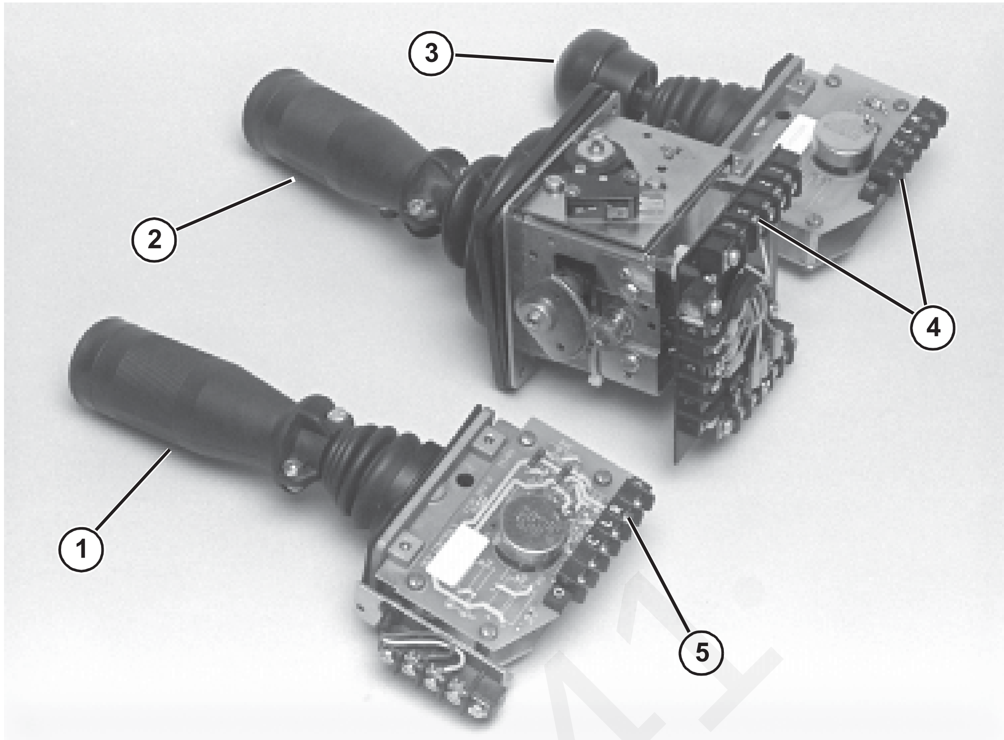
Fuse No.	Function	Wire No.	Amps
F1	Cab Heater	8H	15
F2	Upper Wiper	8W1	10
F3	Overhead Wiper	8W2	10
F4	Lower Wiper	8W3	10
F5	Moisture Ejectors	8M	15
F6	Solenoids	8S	15
F7	Defogger Fan	8F	10
F8	Gauges/Accessories	8A	10
F9	Sensor Inputs	8D	10
F10	Transducers/Encoders	8T	10
F11	Spare	------	10
F12	10VDC Reg. Supply	87FA	3
F13	Lights/Accessories	8	20
F14	Lights/Accessories	8	20
F15	Horn	5H	20
F16	Engine/Dome Light	5D	10
Spare	---------------	------	20
Spare	---------------	------	15
Spare	---------------	------	10
Spare	---------------	------	10

Use a digital multimeter for testing voltage at the fuse box.

To test for volts DC at any given fuse socket, place the positive probe on either of the metal fuse contacts and the negative probe on the grounded fuse box chassis. Repeat this procedure using the other fuse contact as a test point. Note all fuse sockets excluding F12 (3A, 10V) should yield 12 volts DC.

To determine if relay MS2 is fully functional, ground off the fuse box chassis and verify 12 volts DC exist at relay wire 8 when the relay is energized. Also verify 12 volts constant at relay wire 5.

TEST 13 Checking Voltage at the Control Handle



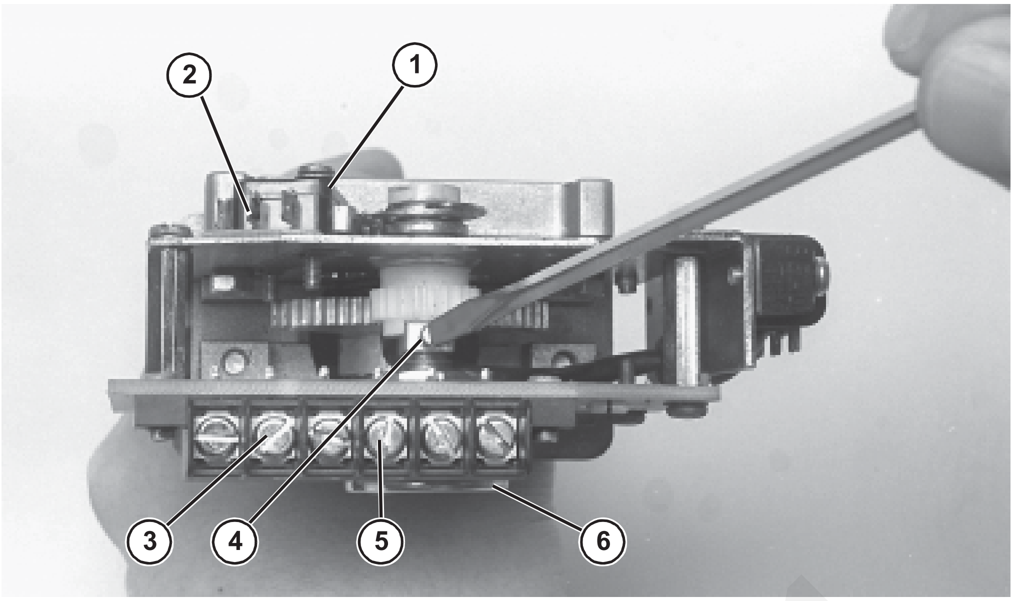
AA318

(1) Load drum handle
(2) Boom/swing handle
(3) Crawler handle
(4) Test terminals
(5) Ground terminal “R”

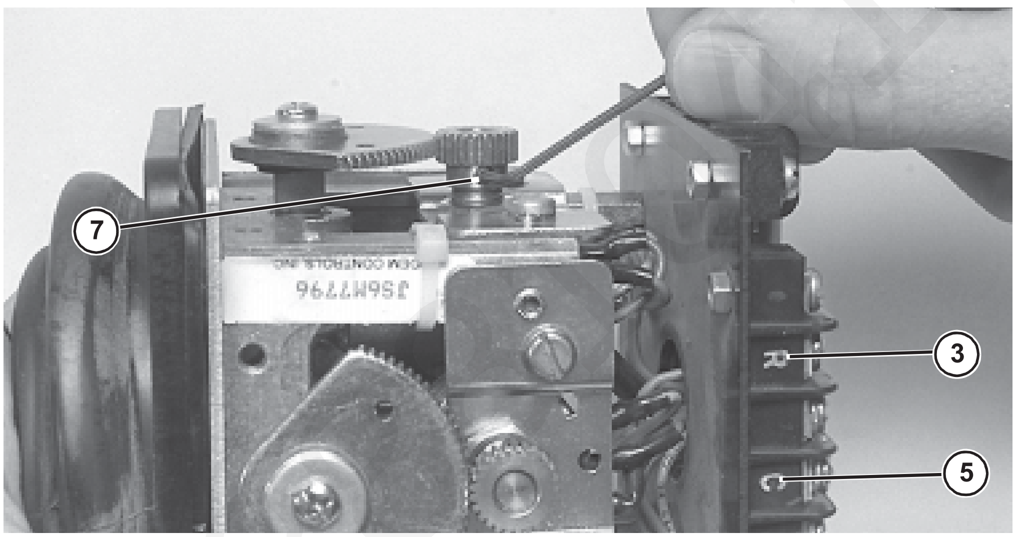
Use the following test points to determine the correct voltages are present at the desired control handle. With engine off/power on, and all brakes and locks engaged, actuate the desired control handle and measure the voltage with a digital multimeter. The positive probe must be placed on the test terminal and the negative probe on a grounded component of the machine or terminal “R” on the control handle. Voltages outside the normal range may indicate a problem with the control handle, its circuits, or inline components such as relays and fuses.

Hand Controller	Test Terminal	Wire No.	Acceptable Voltage (VDC)
Swing	L	87FA	10
	R	0	Ground
	C	85P	1.4 to 8.6
	3	8D	12
	4	89B2	12
Boom Hoist	L	87FA	10
	R	0	Ground
	C	82P	1.4 to 8.6
	1	0	Ground
	2	82N	12
Travel	L	87FA	10
	R	0	Ground
	C	83P (Right)	1.4 to 8.6
		84P (Left)	
	3	8D	12
	4	89X	12
Load Drum	L	87FA	10
	R	0	Ground
	C	80P (Front)	1.4 to 8.6
		81P (Rear)	Ground
	1	0	12
	2	80N (Front)	12
		81N (Rear)	

TEST 14 Adjusting the Control Handle Potentiometer



Single Axis Controller



Double Axis Controller

(1) Neutral (snap) switch
(2) Jumper connection (N/O)
(3) Groung terminal “R”
(4) Slotted set screw
(5) Terminal “C” (center)
(6) Potentiometer
(7) Socket set screw (1 of 2)

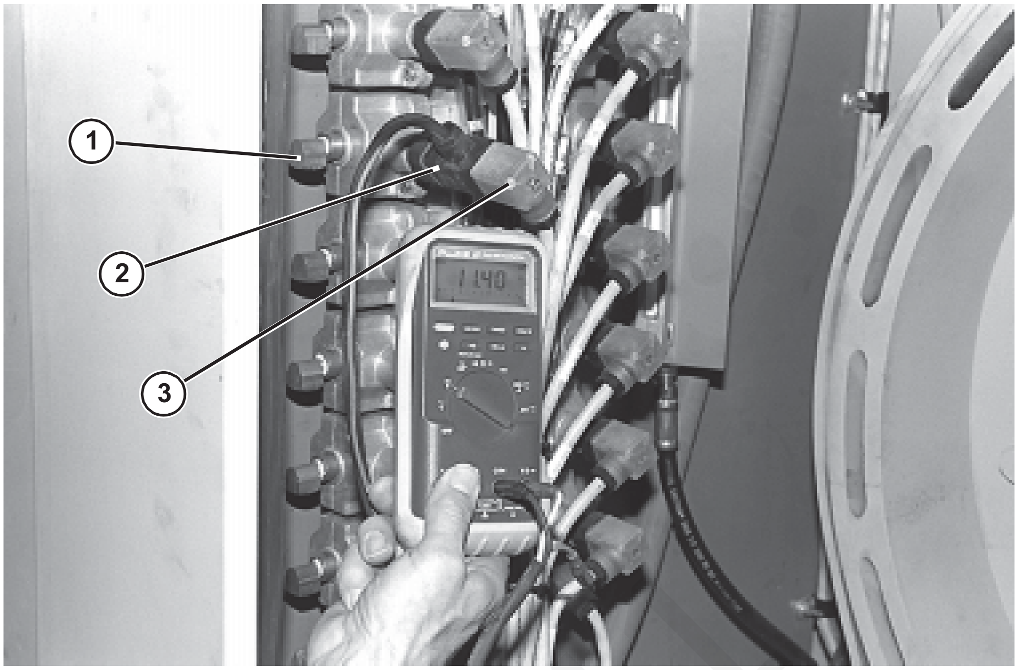
An abnormal reaction of a crane system function in relation to the degree of hand control movement may indicate a misalignment of the handle potentiometer. Adjusting a single axis controller (crawler and load drum handles) or double axis joystick (boom/swing handle) requires aligning the hand lever assembly and the potentiometer in the correct neutral position. Neutral is the position at which 5 volts DC is present from the potentiometer.

With engine off, begin by connecting a jumper wire between the normally open (N/O) terminal on the neutral switch and terminal “C” on the handle terminal block. Connect the positive lead of a digital multimeter to terminal “C” and the negative lead to a grounded contact on the machine or control handle.

For single axis controller adjustment, fully loosen the slotted set screw with a screwdriver and allow the hand lever to return to its inactivated position. Retighten the set screw and move the hand lever until a reading of 5 volts DC is obtained on the digital multimeter. Keeping the hand lever in the 5 volt DC position, fully loosen the set screw, allow the hand lever to return to its inactivated position, and retighten the set screw.

The double axis joystick is adjusted in the same manner but involves loosening and tightening two socket set screws on the gear collar instead of the slotted set screw on the single axis controller.

TEST 15   Testing at the Air Solenoid Manifold



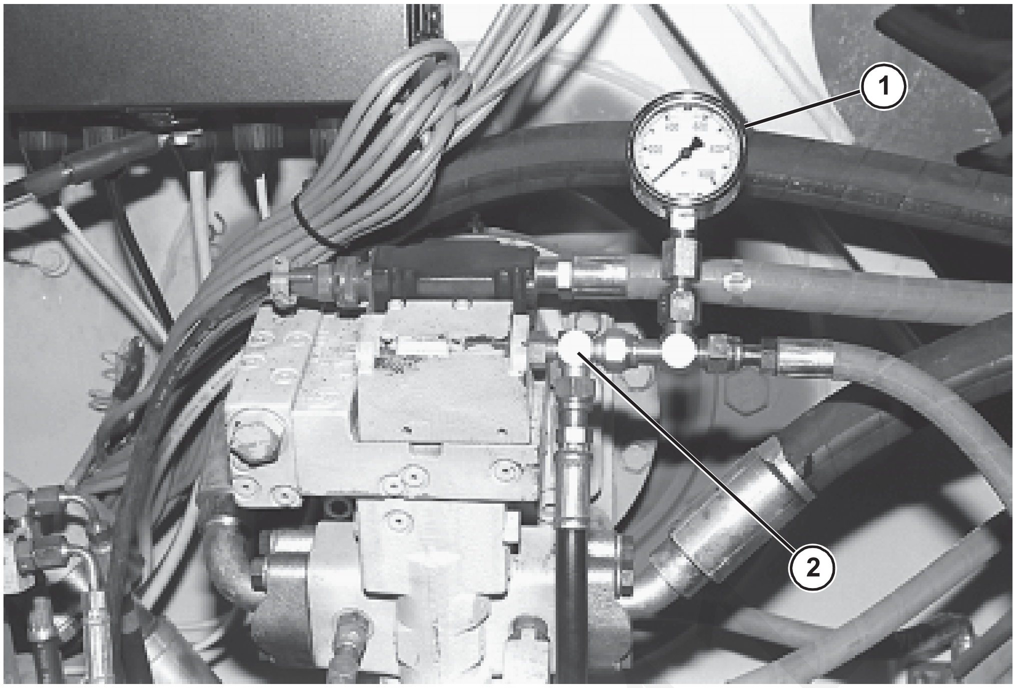
AA321

(1) Air solenoid
(2) Test plug adapter
(3) Electrical connector

Testing the air solenoids for correct voltage and amperage requires the use of a standard test plug adapter (which can be ordered from Manitowoc Cranes, Inc.) and a digital multimeter.

Connect the test plug adapter between the solenoid valve and its electrical connector. Make the appropriate connections from the adapter cable (black and white) to the digital multimeter and verify approximately 12 volts DC while actuating the appropriate air system function under test. Load current (amps) can be measured directly by making the appropriate adapter connections (red and white) to the digital multimeter.

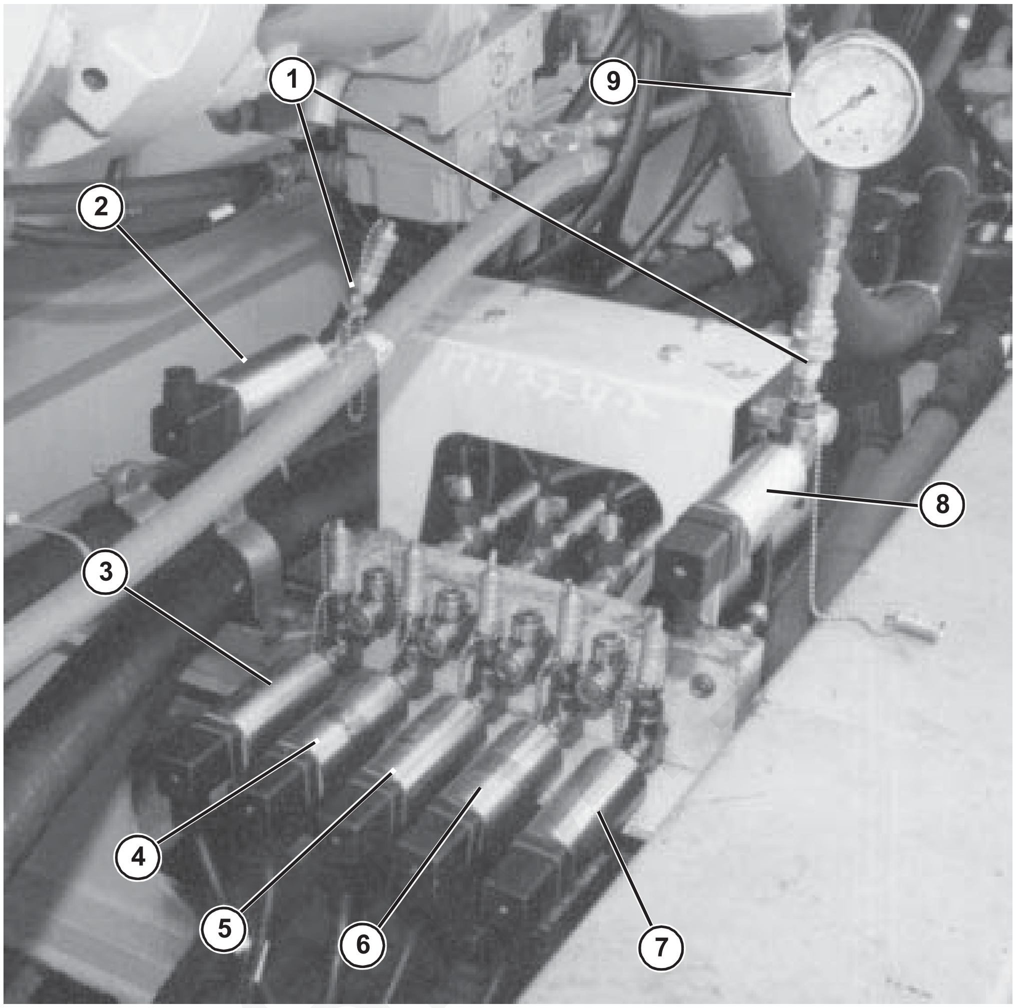
TEST 16 Checking Charge Pressure at Motor Port X1



(1) 0-500 psi gauge
(2) X1 connection

Install a 0-500 psi gauge between the hydraulic hose and the tee connector at port X1. Verify approximately 350 psi pressure with system on at idle speed. A lower pressure reading indicates the need for an adjustment or replacement of the rear hoist charge pump. Refer to TEST 19.

TEST 17 Checking Pump Charge Pressure

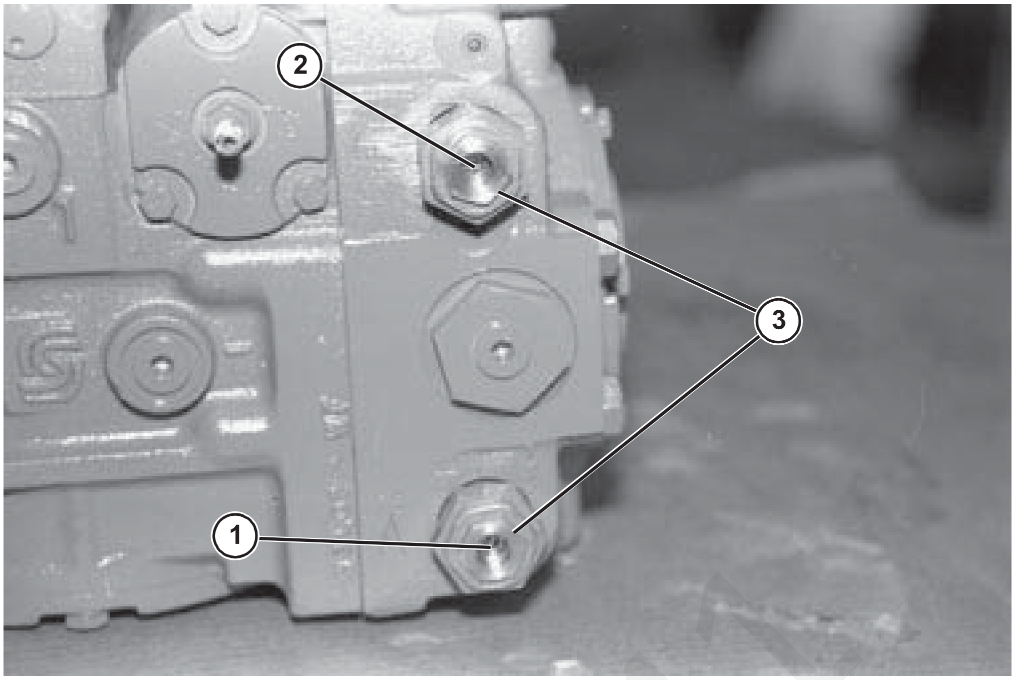


AA 323

(1) Diagnostic gauge couplers
(2) Left travel
(3) Rear hoist
(4) Front hoist
(5) Boom hoist
(6) Right swing
(7) Left swing
(8) Right travel
(9) 0-500 psi gauge

The most convenient method of measuring the pump charge pressure is to install a 0-500 psi gauge at the desired system diagnostic gauge coupler at the transducer manifold assembly. Start the system and record the charge pressure at engine idle speed. No hydraulic systems should be energized. A measurement of 350 psi is normal charge pressure. A measurement under 350 psi indicates a charge pressure relief adjustment is necessary. Refer to TEST 19.

TEST 18 Setting the Pump Pressure

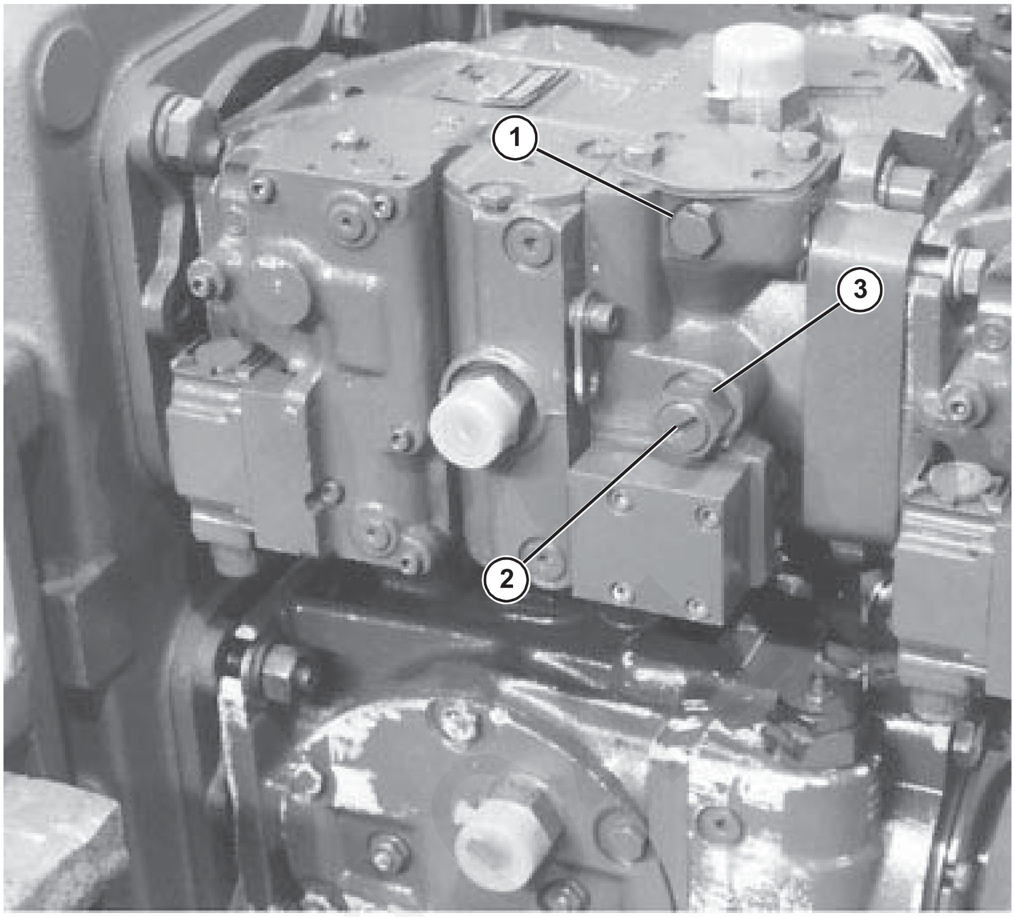


AA 324

(1) “A” multifunction valve
(2) “B” multifunction valve
(3) Jam nut

Loosen the jam nut and insert a hex wrench into the multifunction valve adjuster. Turning the valve clockwise will increase relief pressure. Turning the valve counterclockwise will decrease the valve pressure.

TEST 19 Adjusting Charge Pressure Relief



AA 325

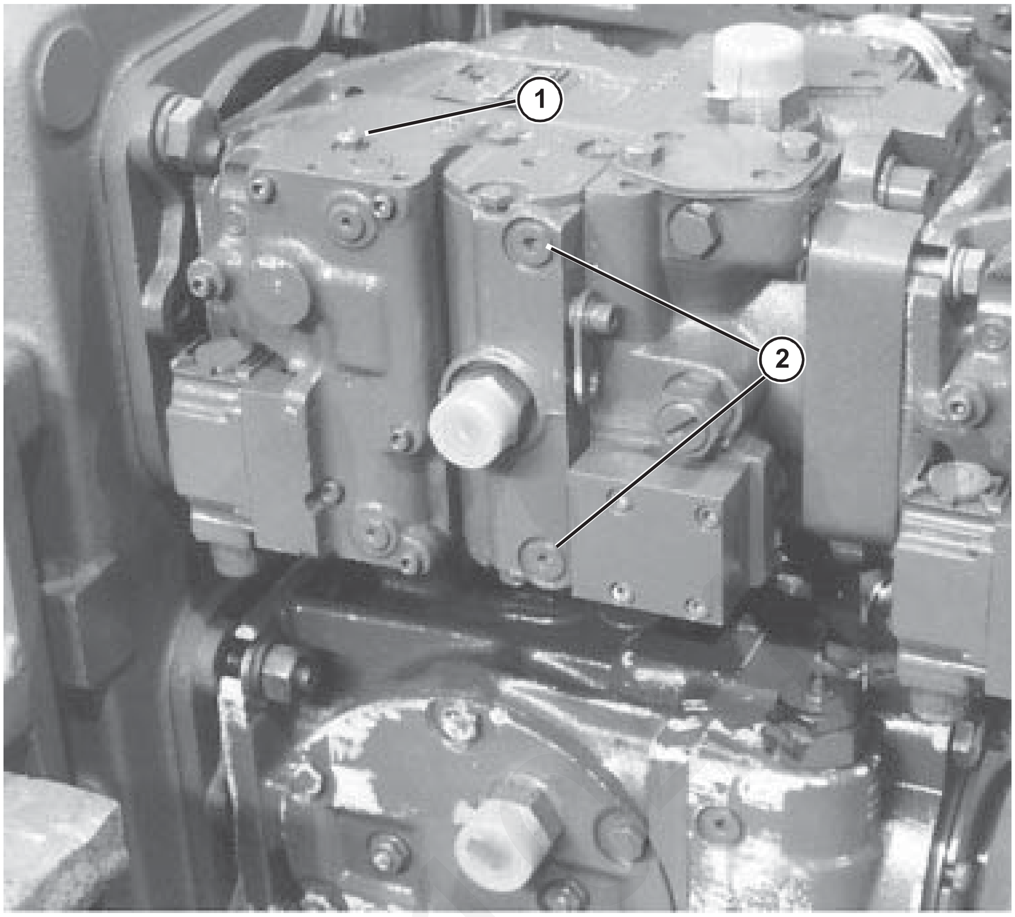
(1) System pressure port
(2) Adjustment screw
(3) Adjustment lock nut

The pump charge pressure must be measured in order to accurately adjust the charge pressure relief. For convenience of adjustment, charge pressure should be measured using a 0-500 psi gauge installed at system pressure gauge ports M1 or M2, or at charge pressure gauge port M3 if it unused in the hydraulic circuit application (the external filtration system prevents the use of M3 for testing the auxiliary hoist and load drum pumps). Charge pressure can also be measured at the transducer manifold as indicated in TEST 17. Refer to TEST 9 for location of pump test ports M1, M2, and M3.

Install the gauge at the selected test port. Start the machine and make sure all brakes are in the lock position, and all hydraulic systems remain off. A measurement of approximately 350 psi indicates correct charge pressure relief.

To adjust charge pressure relief, loosen the adjustment lock nut and turn the adjustment screw with a screwdriver until 350 psi is obtained. Torque the lock nut to 34-41 ft. lbs. Remove the gauge and replace the port plug.

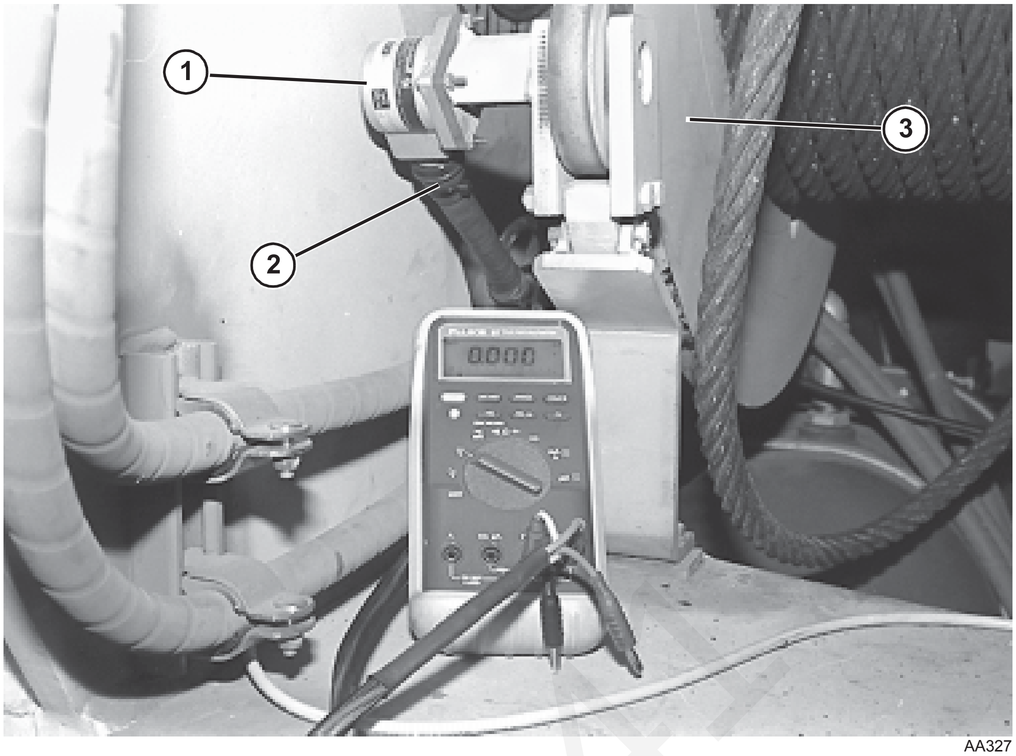
TEST 20 Setting Pump Neutral



(1) Neutral adjustment screw
(2) Servo gauge ports

To set pump neutral, set the pawls and brakes, and disable the pump from the PC by disconnecting the PC cable at the EDC. Install a 500 psi gauge in each of the servo gauge ports. Start and operate the engine at normal speed. Loosen the lock nut and rotate the neutral adjustment screw with a hex wrench until pressure increases in one of the gauges. Note the handle position of the hex wrench at this time, and without removing the wrench, rotate the neutral adjustment screw counter-clockwise until pressure increases in the other gauge. Note the position of the hex wrench now, and rotate the neutral adjustment screw clockwise halfway between the wrench positions. The control should now be in neutral with both gauges reading the same case pressure. While holding the neutral adjustment screw with the hex wrench, tighten the lock nut. Remove the gauges and reinstall the servo gauge port plugs.

TEST 21 Checking Voltage at the Load Drum Encoder



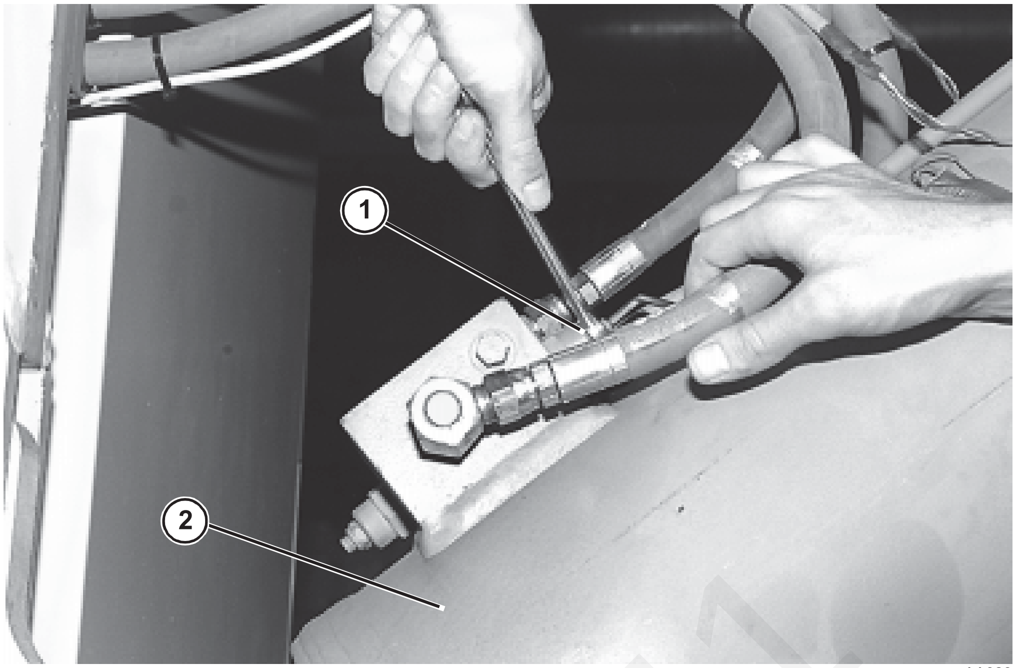
(1) Encoder
(2) Test plug adapter
(3) Load drum

Testing a load drum encoder for correct voltages requires the use of a standard test plug adapter (which can be ordered from Manitowoc Cranes, Inc.) and a digital multimeter. Connect the test plug adapter at the encoder electrical connector and start the machine.

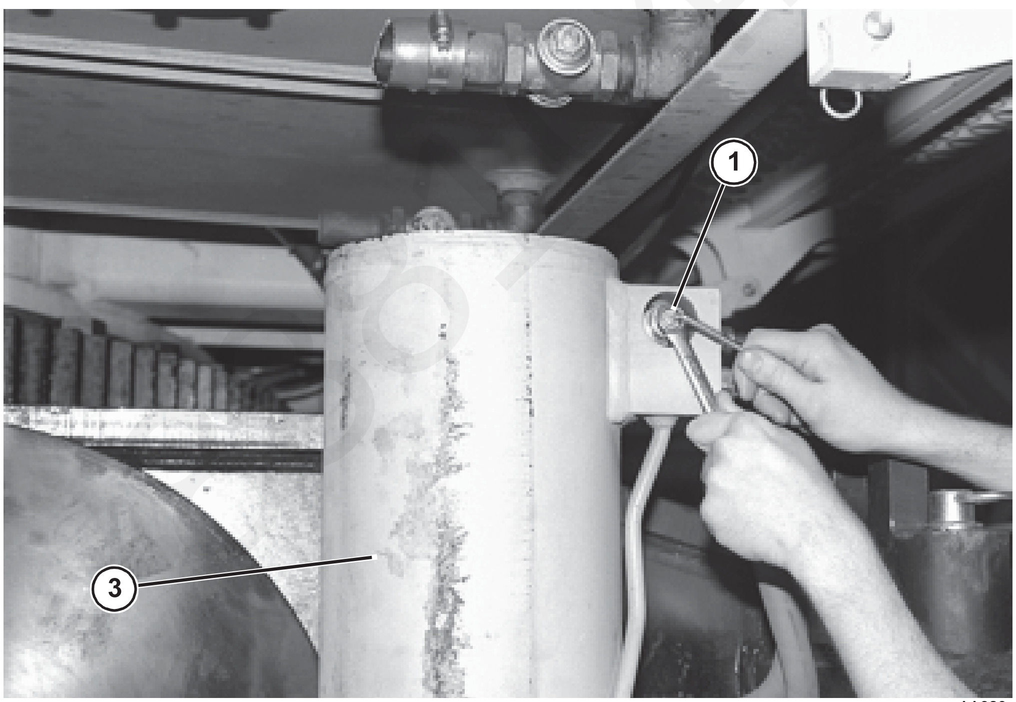
The load drum should remain at rest. Make the appropriate connections from the adapter cable to the digital multimeter for testing incoming power (red + and black -) and verify approximately 12 volts DC. If 12 volts DC is not present, check the 10 amp fuse at the fuse box (refer to TEST 12).

To verify the correct output voltage from the encoder to the PC, make the appropriate connections at the digital multimeter (white + and black -, channel 1) or (green + and black -, channel 2). With the load drum at rest, verify 0.00 or approximately 7.40 volts DC exists. With the load drum actuated, verify 3.5 to 3.9 volts DC. If these readings are not obtained, check the encoder drive assembly and output wiring to the PC.

TEST 22 Adjusting Counterbalance Valves



AA328

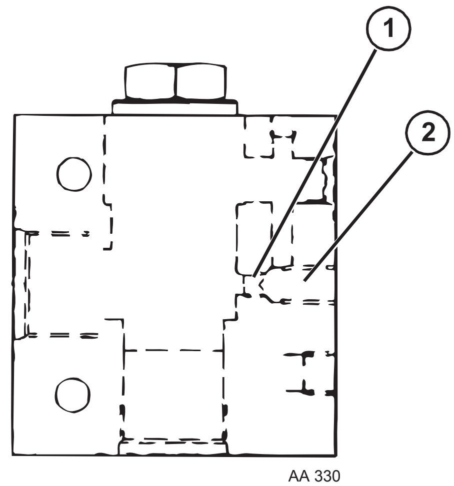


AA329

(1) Counterbalance valve
(2) Gantry cylinder
(3) Jacking cylinder

To adjust a gantry, mast, or jacking cylinder counterbalance valve, loosen the adjustment lock nut and rotate the counterbalance adjustment screw 1/2 turn clockwise to release the pressure or 1/2 turn counterclockwise to increase the pressure setting. While holding the counterbalance adjustment screw with the hex wrench, tighten the lock nut. Recheck the cylinder set for equal load support.

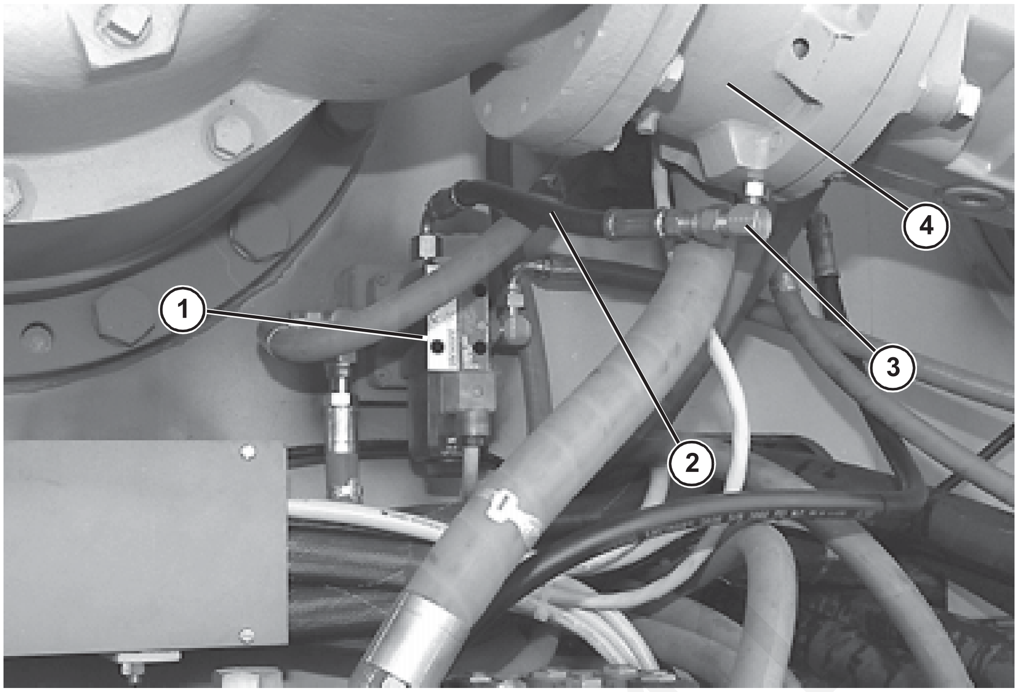
TEST 23 Servicing the Accessory System Dump Valve



(1) Orifice
(2) Plug

Remove the plug from the accessory system dump valve. Insert a thin wire or 1/8 inch drill bit into the orifice to remove any debris that may have accumulated. If the valve is severely plugged, it may be necessary to drill out the orifice with a drill bit not exceeding 1/8 inch in diameter.

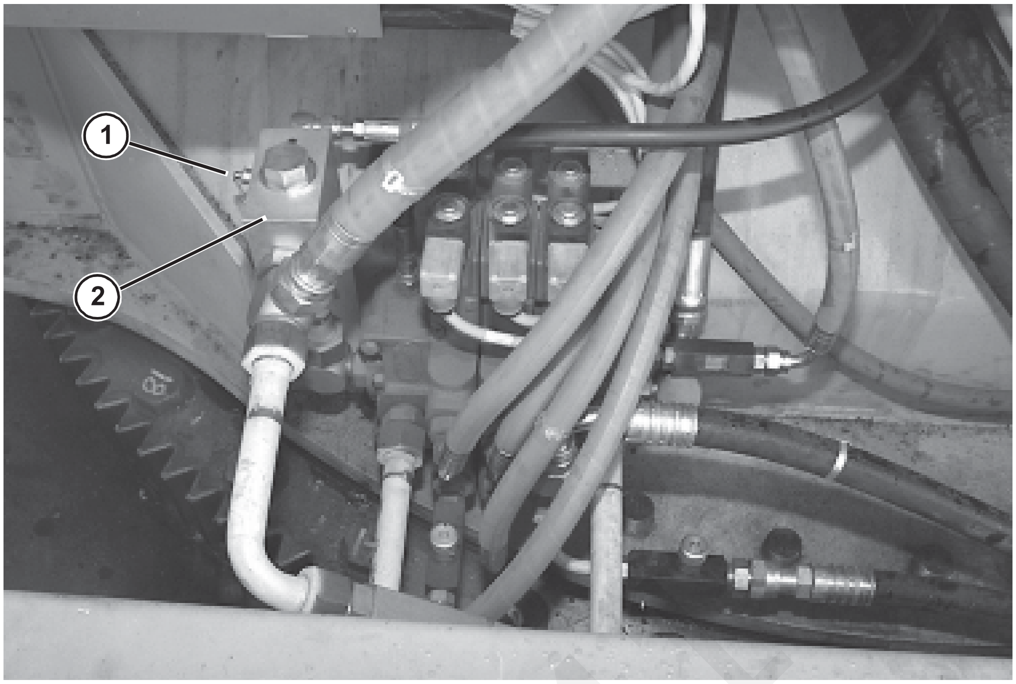
TEST 24 Checking Hydraulic Brake Pressure



(1) Brake control valve
(2) Flexible hose
(3) 90° elbow
(4) Disc brake housing

The hydraulic brake pressure is obtained by activating the desired system brake while measuring the hydraulic pressure at the brake control valve or disc brake housing with a 0-500 psi gauge. Both test ports will yield the same measurement. To test at the control valve, connect the gauge between the flexible hose and the adapter fitting at the top of the valve. To test at the disc brake housing, connect the gauge between the flexible hose and the 90° elbow at the disc brake housing. Acceptable hydraulic brake pressure is 300 psi or greater. If the pressure is less than 300 psi, the system pump charge pressure should be checked. See TEST 17. If the charge pressure is adequate, repair or replace the brake control valve.

TEST 25   Checking Accessory System Working Pressure

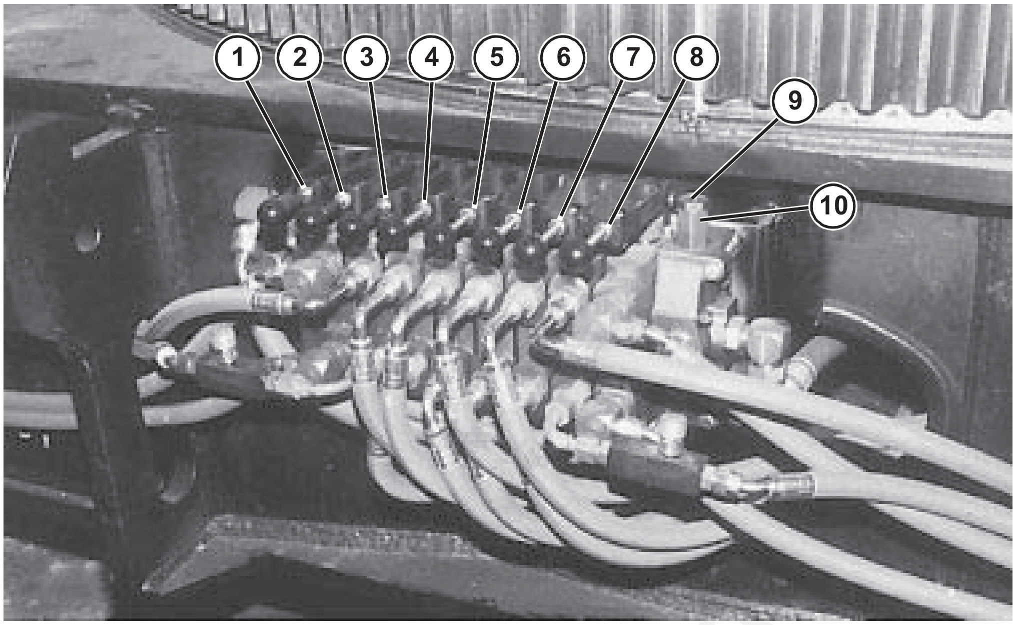


AA332

(1) Test port
(2) Accessory system dump valve

Remove the cap from the test port on the accessory system dump valve. Connect a 0-5,000 psi gauge to the test port and verify 3,100 psi pressure while activating the desired accessory system (gantry, mast, or boom pin) function.

TEST 26 Adjusting the Lower Accessory Relief Valve



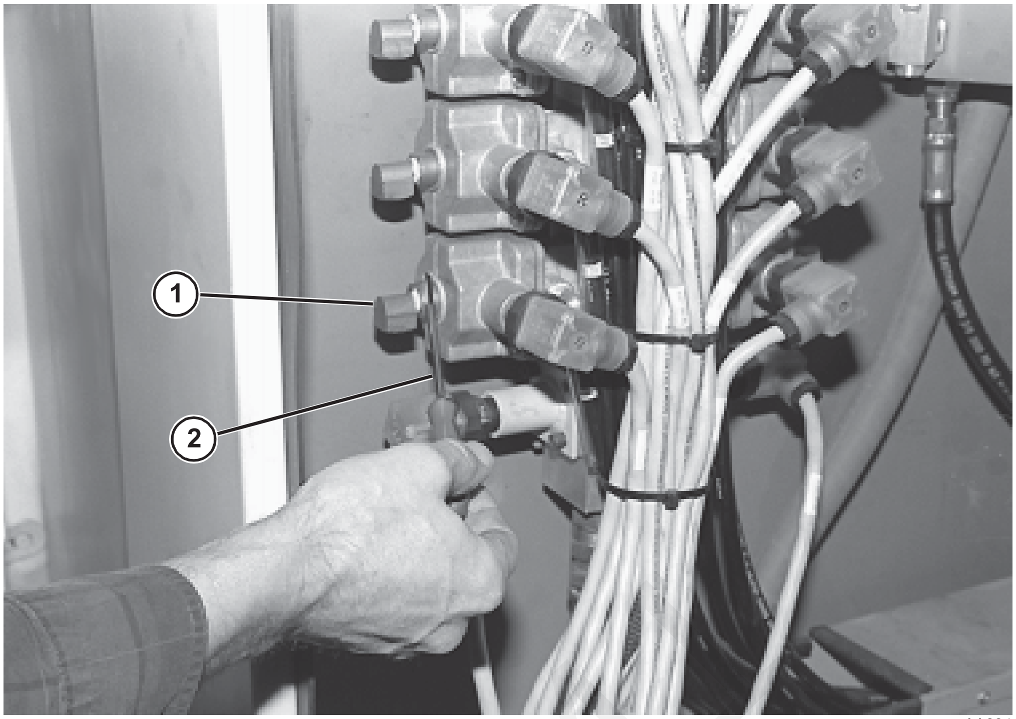
AA 333

(1) Right crawler pins
(2) Right front carbody jack
(3) Right rear carbody jack
(4) Right crawler positioning
(5) Left crawler positioning
(6) Left rear carbody jack
(7) Left front carbody jack
(8) Left crawler pins
(9) Adjustment screw
(10) Adjustment lock nut

Remove the cap from the test port on the accessory system dump valve and install a 0-5,000 psi pressure gauge (refer to TEST 25). Make sure all brakes are in the lock position. Start the machine and activate the desired lower accessory valve function by actuating the appropriate carbody or crawler control handle at the lower accessory valve. A measurement of approximately 3,100 psi indicates correct lower accessory valve relief pressure.

To adjust the lower accessory valve relief pressure, loosen the adjustment lock nut with a wrench, remove the system pressure, turn the adjustment screw with a screwdriver, and repressurize. Continue this procedure until 3,100 psi is obtained during actuation of a lower accessory valve function. When the correct relief pressure is obtained, tighten the relief valve lock nut, remove the gauge from the lower accessory valve and replace the port plug.

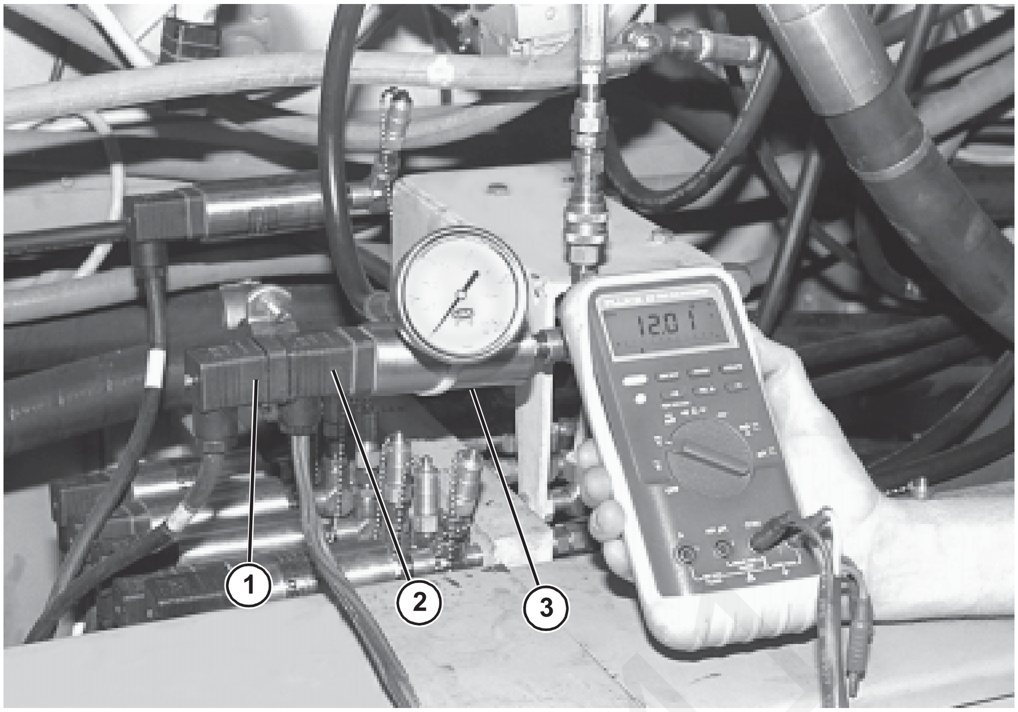
TEST 27 Checking Solenoid Magnetism



(1) Solenoid
(2) Screwdriver

To determine if an air or hydraulic solenoid is energized, simply place any metallic tool such a screwdriver on the solenoid. The solenoid is energized if the tool is magnetically pulled toward the solenoid.

TEST 28 Transducer Test



AA335

(1) Electrical connector
(2) Test plug adapter
(3) Transducer

Testing the voltage and resistance at a transducer requires the use of a standard test plug adapter (which can be ordered from Manitowoc Cranes, Inc.) and a digital multimeter. Connect the test plug adapter between the desired transducer and its electrical connector. Turn the cab power switch on with engine off.

To test incoming power, make the appropriate connections from the adapter cable to the digital multimeter for testing incoming power (white + and black -) and verify approximately 12 volts DC. If this reading is not obtained, check the F10 (10 amp) fuse at the fuse box (refer to TEST 12).

When checking for the correct voltage output from the transducer to the programmable controller, test with engine off/power on. Make the appropriate connections at the digital multimeter (green + and black -) and verify 1.00 to 1.04 volts DC. Note: the PC nulling routine permits the equipment to operate outside of the 1.00 to 1.04 voltage range. However, if readings less than or equal to 0.50 volts, or greater than or equal to 2.0 volts are obtained, the transducer must be changed.

APPENDIX — ABBREVIATIONS AND SYMBOLS USED IN THIS MANUAL

Abbreviations

A (amp)	Amp
AC	Alternating Current
DC	Direct Current
EDC	Electric Displacement Control (Pump)
EFC	Electric Fuel Control
ft. lbs.	Foot Pounds
GND	Ground
gpm	Gallons Per Minute
LED	Light Emitting Diode
LMI	Load Moment Indicator
max	Maximum
min	Minimum
N/O	Normally Open (Switch)
No.	Number
PC	Programmable Controller
PCP	Pressure Controller Pilot (Motor)
pot	Potentiometer
psi	Pounds Per Square Inch
Reg.	Regulated
RPM (rpm)	Revolutions Per Minute
SAE	Society of Automotive Engineers
TB	Terminal Block
V	Volts
VAC	Volts Alternating Current
VDC	Volts Direct Current

Symbols

±	Positive *or* negative numerical value
+	Positive voltage
-	Negative voltage
>	Greater than
≥	Greater than *or* equal to
<	Less than
%	Percent
¾	Ohms
°	Angular degrees
°F	Degrees Fahrenheit
"	Inches

NOTES

TEST VOLTAGES

MODEL 888

General

This publication contains test voltages sorted into four categories:

TABLE 1	Pin Identification
TABLE 2	Wire Identification
TABLE 3	Description Identification

Controller Board Layout

The board locations in the programmable controller are shown below.

Abbreviations

The following abbreviations are used in this folio:

AI	=	Analog Input
AO	=	Analog Output
Aux.	=	Auxiliary
CPU	=	Central Processing Unit
DI	=	Digital Input
DO	=	Digital Output
I/O	=	Input/Output
Ma	=	Milliamp
Max	=	Maximum
M/C	=	Motor Control
Min	=	Minimum
P/C	=	Pump Control
psi	=	Pounds per Square Inch
N/C	=	No Connection
VDC	=	Volts Direct Current

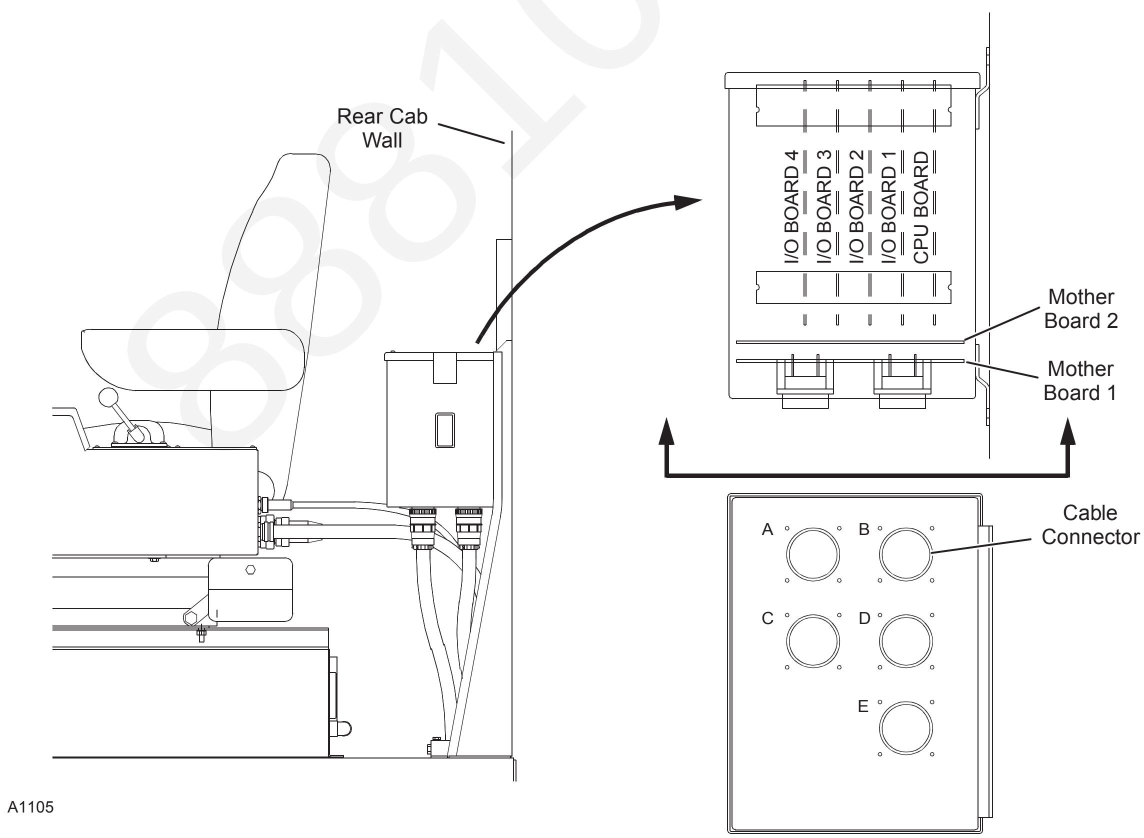


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Table 1 Pin Identification

PIN #	WIRE #	I/O #	Description	Test Voltage (DC unless otherwise specified)	Connection
A-01	87F	-	10 VDC Regulated	10 Volts	
A-02		Ai35	Spare		CPU J3-64
A-03	80P	Ai1	Front Drum Handle (Handle 1)	0 Volts Neutral, 5 to 1.4 Volts Lower, 5 to 8.6 Volts Raise	I/O 1 J5-50
A-04	81P	Ai2	Rear Drum Handle (Handle 2)	0 Volts Neutral, 5 to 1.4 Volts Lower, 5 to 8.6 Volts Raise	I/O 1 J5-52
A-05	82P	Ai3	Boom Hoist Handle (Handle 3)	0 Volts Neutral, 5 to 1.4 Volts Lower, 5 to 8.6 Volts Raise	I/O 1 J5-54
A-06	83P	Ai4	Right Track Handle (Handle 5)	0 Volts Neutral, 5 to 1.4 Volts Reverse, 5 to 8.6 Volts Forward	I/O 1 J5-56
A-07	84P	Ai5	Left Track Handle (Handle 6)	0 Volts Neutral, 5 to 1.4 Volts Reverse, 5 to 8.6 Volts Forward	I/O 1 J5-58
A-08	85P	Ai6	Swing Handle (Handle 4)	0 Volts Neutral, 5 to 1.4 Volts Right, 5 to 8.6 Volts Left	I/O 1 J5-60
A-09	86P	Ai7	Aux. Drum Handle (Handle 7)	0 Volts Neutral, 5 to 1.4 Volts Lower, 5 to 8.6 Volts Raise	I/O 1 J5-62
A-10		Ai8	Spare		I/O 1 J5-64
A-11	Shield	-	Shield		
A-12	83PF	Ai9	Right Track Pedal 1	0 Volts Neutral, 5 to 1.4 Volts Reverse, 5 to 8.6 Volts Forward	I/O 2 J7-50
A-13	84PF	Ai10	Left Track Pedal 2	0 Volts Neutral, 5 to 1.4 Volts Reverse, 5 to 8.6 Volts Forward	I/O 2 J7-52
A-14	8TA	Ai11	Battery Voltage	6.5 Volts at 13 Volts	I/O 2 J7-54
A-15		Ai12	Spare		I/O 2 J7-56
A-16	87M	Ai13	10 VDC Regulated Monitor	5 Volts	I/O 2 J7-58
A-17		Ai14	Spare		I/O 2 J7-60
A-18		Ai15	Spare		I/O 2 J7-62
A-19		Ai16	Spare		I/O 2 J7-64
A-20	82BA	Ai17	Boom Angle Indicator	1.88 Volts at 0°, 8.7 Volts 82°, 6.88 Volts at 60°	CPU J3-49
A-21	87BA	Ai18	Luffing Jib Angle Indicator	3.33 Volts at 0°, 6.66 Volts 60°, 7.88 Volts at 82°	CPU J3-51
A-22	80QS	Ai19	Front Drum System Pressure (Pump 0A)	1.2 Volts at 300 PSI, 1 Volt at No Pressure	CPU J3-53
A-23	81QS	Ai20	Rear Drum System Pressure (Pump 1A)	1.2 Volts at 300 PSI, 1 Volt at No Pressure	CPU J3-55
A-24	82QS	Ai21	Boom Hoist System Pressure (Pump 2A)	1.2 Volts at 300 PSI, 1 Volt at No Pressure	CPU J3-57
A-25	85QR	Ai22	Swing Right Pressure (Pump 3A)	1.2 Volts at 300 PSI, 1 Volt at No Pressure	CPU J3-59
A-26	85QL	Ai23	Swing Left Pressure (Pump 3B)	1.2 Volts at 300 PSI, 1 Volt at No Pressure	CPU J3-61
A-27	86QS	Ai24	Aux. Drum System Pressure (Pump 10A)	1.2 Volts 300 PSI, 1 Volt at No Pressure	CPU J3-63
A-28		Ai25	Spare		CPU J3-50
A-29		Ai26	Spare		CPU J3-52
A-30	90E	Ai27	Load Pin	4.5 Volts No Load, 9.5 Volts Max. Load	CPU J3-54
A-31		Ai28	Spare		I/O 3 J9-50
A-32		Ai29	Spare		I/O 3 J9-52
A-33		Ai30	Spare		I/O 3 J9-54
A-34		Ai31	Spare		CPU J3-56

PIN #	WIRE #	I/O #	Description	Test Voltage (DC unless otherwise specified)	Connection
A-35	88MA	Ai32	Mast Angle Indicator	5 Volts Mast at Vertical	CPU J3-58
A-36		Ai33	Spare		CPU J3-60
A-37		Ai34	Spare		CPU J3-62
B-01	89X	Di1	Travel Detent	12 Volts Nominal	I/O 1 J6-07
B-02	89V	Di2	Front Drum Maximum Bail Limit	12 Volts Nominal	I/O 1 J6-08
B-03	89T	Di3	Front Drum Minimum Bail Limit	12 Volts Nominal	I/O 1 J6-09
B-04	89J4	Di4	Boom Hoist Maximum Bail Limit	12 Volts Nominal	I/O 1 J6-10
B-05	89K4	Di5	Boom Hoist Minimum Bail Limit	12 Volts Nominal	I/O 1 J6-11
B-06	89W	Di6	Block Up Limit	10 Volts Nominal	I/O 1 J6-12
B-07	89U	Di7	Rear Drum Maximum Bail Limit	12 Volts Nominal	I/O 1 J6-13
B-08	89S	Di8	Rear Drum Minimum Bail Limit	12 Volts Nominal	I/O 1 J6-14
B-09	89S2	Di9	Crane Mode Select	12 Volts Nominal	I/O 1 J6-15
B-10	89T2	Di10	Crane Mode Confirm	12 Volts Nominal	I/O 1 J6-16
B-11	88S	Di11	Auxiliary System Disable	12 Volts Nominal	I/O 1 J6-17
B-12	89R	Di12	Boom Maximum Up Limit	12 Volts Nominal	I/O 1 J6-18
B-13	89Q	Di13	Boom Maximum Down Limit	12 Volts Nominal	I/O 1 J6-19
B-14	89W1	Di14	Luffing Jib Maximum Up Limit	10 Volts Nominal	I/O 1 J6-20
B-15	89S1	Di15	Luffing Jib Maximum Down Limit	10 Volts Nominal	I/O 2 J8-07
B-16	89R3	Di16	Hydraulic Fluid Level	0 Volts Low Level, 12 Volts High Level	I/O 2 J8-08
B-17	89S3	Di17	Hydraulic Fluid Temperature	0 Volts at 180°F, 12 Volts at Normal Temp.	I/O 2 J8-09
B-18	89T3	Di18	Engine Oil Pressure	8 PSI (switch on)	I/O 2 J8-10
B-19	89U3	Di19	Engine Coolant Temperature	0 Volts at Normal Temp., 12 Volts at 210°F	I/O 2 J8-11
B-20	89V3	Di20	Low Air Pressure	0 Volts at 0 PSI, 12 Volts at 95 PSI	I/O 2 J8-12
B-21	89X2	Di21	Rear Drum Free-Fall Enable	12 Volts Nominal	I/O 2 J8-13
B-22	89W3	Di22	Gantry Up Limit	12 Volts Nominal	I/O 2 J8-14
B-23	89M	Di23	Front Drum Free-Fall Enable	12 Volts Nominal	I/O 2 J8-15
B-24	89P	Di24	Load Moment Indicator	12 Volts Nominal	I/O 2 J8-16
B-25	89L	Di25	Limit Bypass	12 Volts Nominal	I/O 2 J8-17
B-26	89J	Di26	Display Scroll Up	12 Volts Nominal	I/O 2 J8-18
B-27	89B	Di27	Rear Drum Free-Fall Mode	12 Volts Nominal	I/O 2 J8-19
B-28	89D	Di28	Front Drum Free-Fall Mode	12 Volts Nominal	I/O 2 J8-20
B-29	89L3	Di29	Front Drum Pawl In	12 Volts Nominal	I/O 3 J10-07
B-30	89M3	Di30	Rear Drum Pawl In	12 Volts Nominal	I/O 3 J10-08
B-31	89N	Di31	Boom Hoist Pawl In	12 Volts Nominal	I/O 3 J10-09
B-32	89T1	Di32	Aux. Drum Pawl In	12 Volts Nominal	I/O 3 J10-10
B-33	89K	Di33	Display Scroll Down	12 Volts Nominal	I/O 3 J10-11
B-34	89Q3	Di34	Seat Switch	12 Volts Nominal	I/O 3 J10-12
B-35	89L1	Di35	High Speed Travel Switch	12 Volts Nominal	I/O 3 J10-13
B-36	89M1	Di36	Gantry Raise/Lower Switch	12 Volts Nominal	I/O 3 J10-14
B-37	N/C	Key	Receptacle Insert	12 Volts Nominal	
C-01	8P1	-	12 VDC System	12 Volts Nominal	
C-02	0	-	System Ground	0 Volts	
C-03	8P1	-	12 VDC System	12 Volts Nominal	

PIN #	WIRE #	I/O #	Description	Test Voltage (DC unless otherwise specified)	Connection
C-04	0	-	System Ground	0 Volts	
C-05	80A	Ao1	Front Drum P/C (Servo Driver 1)	0 to 2.8 ± 10% (110 Ma ± 10%) Volts Down 0 to -2.8 ± 10% (-110 Ma ± 10%) Volts Up	I/O 1 J6-41
C-06	81A	Ao2	Rear Drum P/C (Servo Driver 2)	0 to 2.8 ± 10% (110 Ma ± 10%) Volts Down 0 to -2.8 ± 10% (-110 Ma ± 10%) Volts Up	I/O 1 J6-42
C-07	80E	Do1	Front Drum Parking Brake - Air	12 Volts Nominal	I/O 1 J6-21 -22
C-08	81E	Do2	Rear Drum Parking Brake - Air	12 Volts Nominal	I/O 1 J6-23 -24
C-09	82E	Do3	Boom Hoist Parking Brake - Hydraulic	12 Volts Nominal	I/O 1 J6-25 -26
C-10	84E	Do4	Travel Parking Brake	12 Volts Nominal	I/O 1 J6-27 -28
C-11		Do5	Spare		I/O 1 J6-29 -30
C-12	8P1	-	12 VDC System	12 Volts Nominal	
C-13	0	-	System Ground	0 Volts	
C-14	82A	Ao3	Boom Hoist P/C (Servo Driver 3)	0 to 2.8 ± 10% (110 Ma ± 10%) Volts Down 0 to -2.8 ± 10% (-110 Ma ± 10%) Volts Up	I/O 2 J8-41
C-15	83A	Ao4	Right Track P/C (Servo Driver 4)	0 to 2.8 ± 10% (110 Ma ± 10%) Volts Forward 0 to -2.8 ± 10% (-110 Ma ± 10%) Volts Reverse	I/O 2 J8-42
C-16	80F	Do6	Front Drum Clutch	12 Volts Nominal	I/O 1 J6-31 -32
C-17	81F	Do7	Rear Drum Clutch	12 Volts Nominal	I/O 1 J6-34 -33
C-18	80Q	Do8	Front Drum Parking Brake - Hydraulic	12 Volts Nominal	I/O 1 J6-35 -36
C-19	81S	Do9	Rear Drum Parking Brake - Hydraulic	12 Volts Nominal	I/O 1 J6-37 -38
C-20		Do10	Spare		I/O 1 J6-39 -40
C-21	8P1	-	12 VDC System	12 Volts Nominal	
C-22	0	-	System Ground	0 Volts	
C-23	84A	Ao5	Left Track P/C (Servo Driver 5)	0 to 2.8 ± 10% (110 Ma ± 10%) Volts Reverse 0 to -2.8 ± 10% (-110 Ma ± 10%) Volts Forward	I/O 3 J10-41
C-24	85A	Ao6	Swing P/C (Servo Driver 6)	0 to 2.8 ± 10% (110 Ma ± 10%) Volts Right 0 to -2.8 ± 10% (-110 Ma ± 10%) Volts Left	I/O 3 J10-42
C-25	87E	Do11	Aux. Drum Parking Brake	12 Volts Nominal	I/O 2 J8-21 -22
C-26		Do12	Spare		I/O 2 J8-23 -24
C-27	25X	Do13	Swing Alarms	12 Volts Nominal	I/O 2 J8-25 -26
C-28	25A	Do14	Operating Limit Alarms	12 Volts Nominal	I/O 2 J8-27 -28
C-29	25	Do15	System Fault Alarms	12 Volts Nominal	I/O 2 J8-29 -30
C-30	8P1	-	12 VDC System	12 Volts Nominal	
C-31	0	-	System Ground	0 Volts	
C-32	43	Do16	Gantry Raise Enable	12 Volts Nominal	I/O 2 J8-31 -32

PIN #	WIRE #	I/O #	Description	Test Voltage (DC unless otherwise specified)	Connection
C-33	44	Do17	Gantry Lower Enable	12 Volts Nominal	I/O 2 J8-33 -34
C-34	55D	Do18	Mast Assist Raise	12 Volts Nominal	I/O 2 J8-35 -36
C-35	55C	Do19	Mast Assist Enable	12 Volts Nominal	I/O 2 J8-37 -38
C-36	52	Do20	Boom Hinge Pins Enable	12 Volts Nominal	I/O 2 J8-39 -40
C-37	N/C	Key	Cable Plug Insert		
D-01	80MA	-	Front Drum Flange Speed Encoder	7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 1 J6-01
D-02	80MB	-	Front Drum Flange Direction Encoder	7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 1 J6-02
D-03	81MA	-	Rear Drum Flange Speed Encoder	7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 1 J6-03
D-04	81MB	-	Rear Drum Flange Direction Encoder	7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 1 J6-04
D-05	82MA	-	Boom Hoist Drum Speed Encoder	7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 2 J8-01
D-06	82MB	-	Boom Hoist Drum Direction Encoder	7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 2 J8-02
D-07	24	-	Engine rpm Transducer	Above 9.0 Volts AC	I/O 1 J6-05
D-08	89Y3	Di37	Front Drum Park Switch	12 Volts Nominal (when brake is applied)	I/O 3 J10-15
D-09	89Z3	Di38	Rear Drum Park Switch	12 Volts Nominal (when brake is applied)	I/O 3 J10-16
D-10	89A4	Di39	Boom Hoist Park Switch	12 Volts Nominal (when brake is applied)	I/O 3 J10-17
D-11	89B4	Di40	Travel Park Switch	12 Volts Nominal (when brake is applied)	I/O 3 J10-18
D-12	89C4	Di41	Aux. Drum Park Switch	12 Volts Nominal (when brake is applied)	I/O 3 J10-19
D-13	89Q1	Di42	Aux. Drum MIN Bail Limit	12 Volts Nominal (when brake is applied)	I/O 3 J10-20
D-14	89R1	Di43	Aux. Drum MAX Bail Limit	12 Volts Nominal (when brake is applied)	I/O 4 J12-07
D-15	89B2	Di44	Swing Park Switch/Holding Brake	12 Volts Nominal (when brake is applied)	I/O 4 J12-08
D-16	RX1	-	RS-232 Receptacle		CPU J4-02
D-17	TX1	-	RS-232 Receptacle		CPU J4-01
D-18	TX1-0	-	RS-232 Receptacle		CPU J4-03 -04
D-19	TX2	-	Display - White	Approximately 2.5 Volts	CPU J4-05
D-20	TX2-0	-	Display - Black		CPU J4-07 -08
D-21	RX3	-	2nd Computer Receive		CPU J4-10
D-22	TX3	-	2nd Computer Transmit		CPU J4-09
D-23	N/C	Key	Cable Plug Insert		Keyhole
D-24	80R	Ao7	Front Drum M/C	0 Volts Up to 1/3 Handle Movement 0.96 to 2.19 Volts 1/3 to Full Handle Movement	I/O 1 J6-06
D-25	81S	Ao8	Rear Drum M/C	0 Volts Up to 1/3 Handle Movement 0.96 to 2.19 Volts 1/3 to Full Handle Movement	I/O 2 J8-06
D-26	56	Do21	Enable Remote Controller	12 Volts Nominal	I/O 3 J10-23
D-27	80N	Do22	Front Drum Rotation Indicator	12 Volts Nominal	I/O 3 J10-23 -24
D-28	81N	Do23	Rear Drum Rotation Indicator	12 Volts Nominal	I/O 3 J10-25 -26

PIN #	WIRE #	I/O #	Description	Test Voltage (DC unless otherwise specified)	Connection
D-29	82N	Do24	Boom Hoist Rotation Indicator	12 Volts Nominal	I/O 3 J10-27 -28
D-30	87N	Do25	Aux. Drum Rotation Indicator	12 Volts Nominal	I/O 3 J10-29 -30
D-31	88R	Do26	Track Motor	12 Volts Nominal	I/O 3 J10-31 -32
D-32		Do27	Spare		I/O 3 J10-33 -34
D-33		Do28	Spare		I/O 3 J10-35 -36
D-34		Do29	Spare		I/O 3 J10-37 -38
D-35		Do30	Spare		I/O 3 J10-39 -40
D-36		Do31	Spare		I/O 4 J12-21 -22
D-37	N/C	-	Pin Not Terminated		
E-01	87MA	-	Aux. Drum Speed Encoder	Above 7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 2 J8-03
E-02	87MB	-	Aux. Drum Direction Encoder	Above 7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 2 J8-04
E-03	80MAS	-	Front Drum Shaft Speed Encoder	Above 7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 3 J10-01
E-04	80MBS	-	Front Drum Shaft Direction Encoder	Above 7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 3 J10-02
E-05	81MAS	-	Rear Drum Shaft Speed Encoder	Above 7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 3 J10-03
E-06	81MBS	-	Rear Drum Shaft Direction Encoder	Above 7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 3 J10-04
E-07	MAG PU2	-	Spare		I/O 2 J8-05
E-08	83Q	Ai36	Travel Pressure Right Track	1.2 Volts at 300 PSI, 1 Volt at No Pressure	I/O 2 J9-56
E-09	84Q	Ai37	Travel Pressure Left Track	1.2 Volts at 300 PSI, 1 Volt at No Pressure	I/O 2 J9-58
E-10		Ai38	Spare		I/O 2 J9-60
E-11		Ai39	Spare		I/O 2 J9-62
E-12		Ai40	Spare		I/O 2 J9-64
E-13	89D4	Di45	Hydraulic Filter Alarm 1	12 Volts Nominal	I/O 4 J12-09
E-14	89E4	Di46	Hydraulic Filter Alarm 2	12 Volts Nominal	I/O 4 J12-10
E-15	89F4	Di47	Hydraulic Filter Alarm 3	12 Volts Nominal	I/O 4 J12-11
E-16	89G4	Di48	Hydraulic Filter Alarm 4	12 Volts Nominal	I/O 4 J12-12
E-17	89H4	Di49	Hydraulic Tank Strainer Alarm	12 Volts Nominal	I/O 4 J12-13
E-18		Di50	Spare		I/O 4 J12-14
E-19	89L4	Di51	Motor Temperature Alarm	12 Volts Nominal	I/O 4 J12-15
E-20		Di52	Spare		I/O 4 J12-16
E-21		Di53	Spare		I/O 4 J12-17
E-22		Di54	Spare		I/O 4 J12-18
E-23		Di55	Spare		I/O 4 J12-19
E-24		Di56	Spare		I/O 4 J12-20

PIN #	WIRE #	I/O #	Description	Test Voltage (DC unless otherwise specified)	Connection
E-25	ENC7 CHA	-	Spare		I/O 4 J12-01
E-26	ENC7 CHB	-	Spare		I/O 4 J12-02
E-27	Spare	-	Spare		I/O 4 J12-03
E-28	Spare	-	Spare		I/O 4 J12-04
E-29	82R	Ao9	Boom Hoist M/C	0 Volts Up to 1/3 Handle Movement 0.96 to 2.19 Volts 1/3 to Full Handle Movement	I/O 3 J10-06
E-30	86C	Ao10	Aux. Drum M/C	0 Volts Up to 1/3 Handle Movement 0.96 to 2.19 Volts 1/3 to Full Handle Movement	I/O 4 J12-06
E-31	N/C	-	Pin Not Terminated		
E-32	N/C	-	Pin Not Terminated		
E-33		Do33	Spare		I/O 4 J12-25 -26
E-34		Do34	Spare		I/O 4 J12-27 -28
E-35		Do35	Spare		I/O 4 J12-29 -30
E-36	87A	Do36	Aux. Drum P/C Up	0 to 2.8 Volts Engine Running 0 to 2.4 Volts Engine Off	I/O 4 J12-31 -32
E-37	87B	Do37	Aux. Drum P/C Down	0 to 2.8 Volts Engine Running 0 to 2.4 Volts Engine Off	I/O 4 J12-33 -34

Table 2 Wire Identification

Wire #	Pin #	I/O #	Description	Test Voltage (DC unless otherwise specified)	Connection
	A-02	Ai35	Spare		CPU J3-64
	A-10	Ai8	Spare		I/O 1 J5-64
	A-15	Ai12	Spare		I/O 2 J7-56
	A-17	Ai14	Spare		I/O 2 J7-60
	A-18	Ai15	Spare		I/O 2 J7-62
	A-19	Ai16	Spare		I/O 2 J7-64
	A-28	Ai25	Spare		CPU J3-50
	A-29	Ai26	Spare		CPU J3-52
	A-31	Ai28	Spare		I/O 3 J9-50
	A-32	Ai29	Spare		I/O 3 J9-52
	A-33	Ai30	Spare		I/O 3 J9-54
	A-34	Ai31	Spare		CPU J3-56
	A-36	Ai33	Spare		CPU J3-60
	A-37	Ai34	Spare		CPU J3-62
	C-11	Do5	Spare		I/O 1 J6-29 -30
	C-20	Do10	Spare		I/O 1 J6-39 -40
	C-26	Do12	Spare		I/O 2 J8-23 -24
	D-32	Do27	Spare		I/O 3 J10-33 -34
	D-33	Do28	Spare		I/O 3 J10-35 -36
	D-34	Do29	Spare		I/O 3 J10-37 -38
	D-35	Do30	Spare		I/O 3 J10-39 -40
	D-36	Do31	Spare		I/O 4 J12-21 -22
	E-10	Ai38	Spare		I/O 2 J9-60
	E-11	Ai39	Spare		I/O 2 J9-62
	E-12	Ai40	Spare		I/O 2 J9-64
	E-18	Di50	Spare		I/O 4 J12-14
	E-20	Di52	Spare		I/O 4 J12-16
	E-21	Di53	Spare		I/O 4 J12-17
	E-22	Di54	Spare		I/O 4 J12-18
	E-23	Di55	Spare		I/O 4 J12-19
	E-24	Di56	Spare		I/O 4 J12-20
	E-33	Do33	Spare		I/O 4 J12-25 -26
	E-34	Do34	Spare		I/O 4 J12-27 -28
	E-35	Do35	Spare		I/O 4 J12-29 -30
ENC7 CHA	E-25	-	Spare		I/O 4 J12-01

Wire #	Pin #	I/O #	Description	Test Voltage (DC unless otherwise specified)	Connection
ENC7 CHB	E-26	-	Spare		I/O 4 J12-02
MAG PU2	E-07	-	Spare		I/O 2 J8-05
N/C	B-37	Key	Receptacle Insert	12 Volts Nominal	
N/C	C-37	Key	Cable Plug Insert		
N/C	D-23	Key	Cable Plug Insert		Keyhole
N/C	D-37	-	Pin Not Terminated		
N/C	E-31	-	Pin Not Terminated		
N/C	E-32	-	Pin Not Terminated		
RX1	D-16	-	RS-232 Receptacle		CPU J4-02
RX3	D-21	-	2nd Computer Receive		CPU J4-10
Shield	A-11	-	Shield		
Spare	E-27	-	Spare		I/O 4 J12-03
Spare	E-28	-	Spare		I/O 4 J12-04
TX1	D-17	-	RS-232 Receptacle		CPU J4-01
TX2	D-19	-	Display - White	Approximately 2.5 Volts	CPU J4-05
TX3	D-22	-	2nd Computer Transmit		CPU J4-09
0	C-02	-	System Ground	0 Volts	
0	C-04	-	System Ground	0 Volts	
0	C-13	-	System Ground	0 Volts	
0	C-22	-	System Ground	0 Volts	
0	C-31	-	System Ground	0 Volts	
TX1-0	D-18	-	RS-232 Receptacle		CPU J4-03 -04
TX2-0	D-20	-	Display - Black		CPU J4-07 -08
8P1	C-01	-	12 VDC System	12 Volts Nominal	
8P1	C-03	-	12 VDC System	12 Volts Nominal	
8P1	C-12	-	12 VDC System	12 Volts Nominal	
8P1	C-21	-	12 VDC System	12 Volts Nominal	
8P1	C-30	-	12 VDC System	12 Volts Nominal	
8TA	A-14	Ai11	Battery Voltage	6.5 Volts at 13 Volts	I/O 2 J7-54
24	D-07	-	Engine rpm Transducer	Above 9.0 Volts AC	I/O 1 J6-05
25	C-29	Do15	System Fault Alarms	12 Volts Nominal	I/O 2 J8-29 -30
25A	C-28	Do14	Operating Limit Alarms	12 Volts Nominal	I/O 2 J8-27 -28
25X	C-27	Do13	Swing Alarms	12 Volts Nominal	I/O 2 J8-25 -26
43	C-32	Do16	Gantry Raise Enable	12 Volts Nominal	I/O 2 J8-31 -32
44	C-33	Do17	Gantry Lower Enable	12 Volts Nominal	I/O 2 J8-33 -34
52	C-36	Do20	Boom Hinge Pins Enable	12 Volts Nominal	I/O 2 J8-39 -40

Wire #	Pin #	I/O #	Description	Test Voltage (DC unless otherwise specified)	Connection
55C	C-35	Do19	Mast Assist Enable	12 Volts Nominal	I/O 2 J8-37 -38
55D	C-34	Do18	Mast Assist Raise	12 Volts Nominal	I/O 2 J8-35 -36
56	D-26	Do21	Enable Remote Controller	12 Volts Nominal	I/O 3 J10-23
80A	C-05	Ao1	Front Drum P/C (Servo Driver 1)	0 to 2.8 ± 10% (110 Ma ±10%) Volts Down 0 to -2.8 ± 10% (-110 Ma ± 10%) Volts Up	I/O 1 J6-41
80E	C-07	Do1	Front Drum Parking Brake - Air	12 Volts Nominal	I/O 1 J6-21 -22
80F	C-16	Do6	Front Drum Clutch	12 Volts Nominal	I/O 1 J6-31 -32
80MA	D-01	-	Front Drum Flange Speed Encoder	7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 1 J6-01
80MAS	E-03	-	Front Drum Shaft Speed Encoder	Above 7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 3 J10-01
80MB	D-02	-	Front Drum Flange Direction Encoder	7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 1 J6-02
80MBS	E-04	-	Front Drum Shaft Direction Encoder	Above 7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 3 J10-02
80N	D-27	Do22	Front Drum Rotation Indicator	12 Volts Nominal	I/O 3 J10-23 -24
80P	A-03	Ai1	Front Drum Handle (Handle 1)	0 Volts Neutral, 5 to 1.4 Volts Lower, 5 to 8.6 Volts Raise	I/O 1 J5-50
80Q	C-18	Do8	Front Drum Parking Brake - Hydraulic	12 Volts Nominal	I/O 1 J6-35 -36
80QS	A-22	Ai19	Front Drum System Pressure (Pump 0A)	1.2 Volts at 300 PSI, 1 Volt at No Pressure	CPU J3-53
80R	D-24	Ao7	Front Drum M/C	0 Volts Up to 1/3 Handle Movement 0.96 to 2.19 Volts 1/3 to Full Handle Movement	I/O 1 J6-06
81A	C-06	Ao2	Rear Drum P/C (Servo Driver 2)	0 to 2.8 ± 10% (110 Ma ± 10%) Volts Down 0 to -2.8 ±10% (-110 Ma ± 10%) Volts Up	I/O 1 J6-42
81E	C-08	Do2	Rear Drum Parking Brake - Air	12 Volts Nominal	I/O 1 J6-23 -24
81F	C-17	Do7	Rear Drum Clutch	12 Volts Nominal	I/O 1 J6-34 -33
81MA	D-03	-	Rear Drum Flange Speed Encoder	7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 1 J6-03
81MAS	E-05	-	Rear Drum Shaft Speed Encoder	Above 7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 3 J10-03
81MB	D-04	-	Rear Drum Flange Direction Encoder	7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 1 J6-04
81MBS	E-06	-	Rear Drum Shaft Direction Encoder	Above 7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 3 J10-04
81N	D-28	Do23	Rear Drum Rotation Indicator	12 Volts Nominal	I/O 3 J10-25 -26
81P	A-04	Ai2	Rear Drum Handle (Handle 2)	0 Volts Neutral, 5 to 1.4 Volts Lower, 5 to 8.6 Volts Raise	I/O 1 J5-52
81QS	A-23	Ai20	Rear Drum System Pressure (Pump 1A)	1.2 Volts at 300 PSI, 1 Volt at No Pressure	CPU J3-55
81S	C-19	Do9	Rear Drum Parking Brake - Hydraulic	12 Volts Nominal	I/O 1 J6-37 -38
81S	D-25	Ao8	Rear Drum M/C	0 Volts Up to 1/3 Handle Movement 0.96 to 2.19 Volts 1/3 to Full Handle Movement	I/O 2 J8-06

Wire #	Pin #	I/O #	Description	Test Voltage (DC unless otherwise specified)	Connection
82A	C-14	Ao3	Boom Hoist P/C (Servo Driver 3)	0 to 2.8 ± 10% (110 Ma ± 10%) Volts Down 0 to -2.8 ± 10% (-110 Ma ± 10%) Volts Up	I/O 2 J8-41
82BA	A-20	Ai17	Boom Angle Indicator	1.88 Volts at 0°, 8.7 Volts 82°, 6.88 Volts at 60°	CPU J3-49
82E	C-09	Do3	Boom Hoist Parking Brake - Hydraulic	12 Volts Nominal	I/O 1 J6-25 -26
82MA	D-05	-	Boom Hoist Drum Speed Encoder	7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 2 J8-01
82MB	D-06	-	Boom Hoist Drum Direction Encoder	7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 2 J8-02
82N	D-29	Do24	Boom Hoist Rotation Indicator	12 Volts Nominal	I/O 3 J10-27 -28
82P	A-05	Ai3	Boom Hoist Handle (Handle 3)	0 Volts Neutral, 5 to 1.4 Volts Lower, 5 to 8.6 Volts Raise	I/O 1 J5-54
82QS	A-24	Ai21	Boom Hoist System Pressure (Pump 2A)	1.2 Volts at 300 PSI, 1 Volt at No Pressure	CPU J3-57
82R	E-29	Ao9	Boom Hoist M/C	0 Volts Up to 1/3 Handle Movement 0.96 to 2.19 Volts 1/3 to Full Handle Movement	I/O 3 J10-06
83A	C-15	Ao4	Right Track P/C (Servo Driver 4)	0 to 2.8 ± 10% (110 Ma ± 10%) Volts Forward 0 to -2.8 ± 10% (-110 Ma ± 10%) Volts Reverse	I/O 2 J8-42
83P	A-06	Ai4	Right Track Handle (Handle 5)	0 Volts Neutral, 5 to 1.4 Volts Reverse, 5 to 8.6 Volts Forward	I/O 1 J5-56
83PF	A-12	Ai9	Right Track Pedal 1	0 Volts Neutral, 5 to 1.4 Volts Reverse, 5 to 8.6 Volts Forward	I/O 2 J7-50
83Q	E-08	Ai36	Travel Pressure Right Track	1.2 Volts at 300 PSI, 1 Volts at No Pressure	I/O 2 J9-56
84A	C-23	Ao5	Left Track P/C (Servo Driver 5)	0 to 2.8 ± 10% (110 Ma ± 10%) Volts Reverse 0 to -2.8 ± 10% (-110 Ma ± 10%) Volts Forward	I/O 3 J10-41
84E	C-10	Do4	Travel Parking Brake	12 Volts Nominal	I/O 1 J6-27 -28
84P	A-07	Ai5	Left Track Handle (Handle 6)	0 Volts Neutral, 5 to 1.4 Volts Reverse, 5 to 8.6 Volts Forward	I/O 1 J5-58
84PF	A-13	Ai10	Left Track Pedal 2	0 Volts Neutral, 5 to 1.4 Volts Reverse, 5 to 8.6 Volts Forward	I/O 2 J7-52
84Q	E-09	Ai37	Travel Pressure Left Track	1.2 Volts at 300 PSI, 1 Volts at No Pressure	I/O 2 J9-58
85A	C-24	Ao6	Swing P/C (Servo Driver 6)	0 to 2.8 ± 10% (110 Ma ± 10%) Volts Right 0 to -2.8 ± 10% (-110 Ma ± 10%) Volts Left	I/O 3 J10-42
85P	A-08	Ai6	Swing Handle (Handle 4)	0 Volts Neutral, 5 to 1.4 Volts Right, 5 to 8.6 Volts Left	I/O 1 J5-60
85QL	A-26	Ai23	Swing Left Pressure (Pump 3B)	1.2 Volts at 300 PSI, 1 Volt at No Pressure	CPU J3-61
85QR	A-25	Ai22	Swing Right Pressure (Pump 3A)	1.2 Volts at 300 PSI, 1 Volt at No Pressure	CPU J3-59
86C	E-30	Ao10	Aux. Drum M/C	0 Volts Up to 1/3 Handle Movement 0.96 to 2.19 Volts 1/3 to Full Handle Movement	I/O 4 J12-06
86P	A-09	Ai7	Aux. Drum Handle (Handle 7)	0 Volts Neutral, 5 to 1.4 Volts Lower, 5 to 8.6 Volts Raise	I/O 1 J5-62
86QS	A-27	Ai24	Aux. Drum System Pressure (Pump 10A)	1.2 Volts 300 PSI, 1 Volt at No Pressure	CPU J3-63
87A	E-36	Do36	Aux. Drum P/C Up	0 to 2.8 Volts Engine Running, 0 to 2.4 Volts Engine Off	I/O 4 J12-31 -32
87B	E-37	Do37	Aux. Drum P/C Down	0 to 2.8 Volts Engine Running, 0 to 2.4 Volts Engine Off	I/O 4 J12-33 -34
87BA	A-21	Ai18	Luffing Jib Angle Indicator	3.33 Volts at 0°, 6.66 Volts 60°, 7.88 Volts at 82°	CPU J3-51
87E	C-25	Do11	Aux. Drum Parking Brake	12 Volts Nominal	I/O 2 J8-21 -22

Wire #	Pin #	I/O #	Description	Test Voltage (DC unless otherwise specified)	Connection
87F	A-01	-	10 VDC Regulated	10 Volts	
87M	A-16	Ai13	10 VDC Regulated Monitor	5 Volts	I/O 2 J7-58
87MA	E-01	-	Aux. Drum Speed Encoder	Above 7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 2 J8-03
87MB	E-02	-	Aux. Drum Direction Encoder	Above 7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 2 J8-04
87N	D-30	Do25	Aux. Drum Rotation Indicator	12 Volts Nominal	I/O 3 J10-29 -30
88MA	A-35	Ai32	Mast Angle Indicator	5 Volts Mast at Vertical	CPU J3-58
88R	D-31	Do26	Track Motor	12 Volts Nominal	I/O 3 J10-31 -32
88S	B-11	Di11	Auxiliary System Disable	12 Volts Nominal	I/O 1 J6-17
89A4	D-10	Di39	Boom Hoist Park Switch	12 Volts Nominal (when brake is applied)	I/O 3 J10-17
89B	B-27	Di27	Rear Drum Free-Fall Mode	12 Volts Nominal	I/O 2 J8-19
89B2	D-15	Di44	Swing Park Switch/Holding Brake	12 Volts Nominal (when brake is applied)	I/O 4 J12-08
89B4	D-11	Di40	Travel Park Switch	12 Volts Nominal (when brake is applied)	I/O 3 J10-18
89C4	D-12	Di41	Aux. Drum Park Switch	12 Volts Nominal (when brake is applied)	I/O 3 J10-19
89D	B-28	Di28	Front Drum Free-Fall Mode	12 Volts Nominal	I/O 2 J8-20
89D4	E-13	Di45	Hydraulic Filter Alarm 1	12 Volts Nominal	I/O 4 J12-09
89E4	E-14	Di46	Hydraulic Filter Alarm 2	12 Volts Nominal	I/O 4 J12-10
89F4	E-15	Di47	Hydraulic Filter Alarm 3	12 Volts Nominal	I/O 4 J12-11
89G4	E-16	Di48	Hydraulic Filter Alarm 4	12 Volts Nominal	I/O 4 J12-12
89H4	E-17	Di49	Hydraulic Tank Strainer Alarm	12 Volts Nominal	I/O 4 J12-13
89J	B-26	Di26	Display Scroll Up	12 Volts Nominal	I/O 2 J8-18
89J4	B-04	Di4	Boom Hoist Maximum Bail Limit	12 Volts Nominal	I/O 1 J6-10
89K	B-33	Di33	Display Scroll Down	12 Volts Nominal	I/O 3 J10-11
89K4	B-05	Di5	Boom Hoist Minimum Bail Limit	12 Volts Nominal	I/O 1 J6-11
89L	B-25	Di25	Limit Bypass	12 Volts Nominal	I/O 2 J8-17
89L1	B-35	Di35	High Speed Travel Switch	12 Volts Nominal	I/O 3 J10-13
89L3	B-29	Di29	Front Drum Pawl In	12 Volts Nominal	I/O 3 J10-07
89L4	E-19	Di51	Motor Temperature Alarm	12 Volts Nominal	I/O 4 J12-15
89M	B-23	Di23	Front Drum Free-Fall Enable	12 Volts Nominal	I/O 2 J8-15
89M1	B-36	Di36	Gantry Raise/Lower Switch	12 Volts Nominal	I/O 3 J10-14
89M3	B-30	Di30	Rear Drum Pawl In	12 Volts Nominal	I/O 3 J10-08
89N	B-31	Di31	Boom Hoist Pawl In	12 Volts Nominal	I/O 3 J10-09
89P	B-24	Di24	Load Moment Indicator	12 Volts Nominal	I/O 2 J8-16
89Q	B-13	Di13	Boom Maximum Down Limit	12 Volts Nominal	I/O 1 J6-19
89Q1	D-14	Di43	Aux. Drum MIN Bail Limit	12 Volts Nominal (when brake is applied)	I/O 4 J12-07
89Q3	B-34	Di34	Seat Switch	12 Volts Nominal	I/O 3 J10-12
89R	B-12	Di12	Boom Maximum Up Limit	12 Volts Nominal	I/O 1 J6-18
89R1	D-13	Di42	Aux. Drum MAX Bail Limit	12 Volts Nominal (when brake is applied)	I/O 3 J10-20
89R3	B-16	Di16	Hydraulic Fluid Level	0 Volts Low Level, 12 Volts High Level	I/O 2 J8-08
89S	B-08	Di8	Rear Drum Minimum Bail Limit	12 Volts Nominal	I/O 1 J6-14
89S1	B-15	Di15	Luffing Jib Maximum Down Limit	10 Volts Nominal	I/O 2 J8-07
89S2	B-09	Di9	Crane Mode Select	12 Volts Nominal	I/O 1 J6-15

Wire #	Pin #	I/O #	Description	Test Voltage (DC unless otherwise specified)	Connection
89S3	B-17	Di17	Hydraulic Fluid Temperature	0 Volts at 180°, 12 Volts at Normal Temp.	I/O 2 J8-09
89T	B-03	Di3	Front Drum Minimum Bail Limit	12 Volts Nominal	I/O 1 J6-09
89T1	B-32	Di32	Aux. Drum Pawl In	12 Volts Nominal	I/O 3 J10-10
89T2	B-10	Di10	Crane Mode Confirm	12 Volts Nominal	I/O 1 J6-16
89T3	B-18	Di18	Engine Oil Pressure	8 PSI (switch on)	I/O 2 J8-10
89U	B-07	Di7	Rear Drum Maximum Bail Limit	12 Volts Nominal	I/O 1 J6-13
89U3	B-19	Di19	Engine Coolant Temperature	0 Volts at Normal Temp., 12 Volts at 210°F	I/O 2 J8-11
89V	B-02	Di2	Front Drum Maximum Bail Limit	12 Volts Nominal	I/O 1 J6-08
89V3	B-20	Di20	Low Air Pressure	0 Volts at 0 PSI, 12 Volts at 95 PSI	I/O 2 J8-12
89W	B-06	Di6	Block Up Limit	10 Volts Nominal	I/O 1 J6-12
89W1	B-14	Di14	Luffing Jib Maximum Up Limit	10 Volts Nominal	I/O 1 J6-20
89W3	B-22	Di22	Gantry Up Limit	12 Volts Nominal	I/O 2 J8-14
89X	B-01	Di1	Travel Detent	12 Volts Nominal	I/O 1 J6-07
89X2	B-21	Di21	Rear Drum Free-Fall Enable	12 Volts Nominal	I/O 2 J8-13
89Y3	D-08	Di37	Front Drum Park Switch	12 Volts Nominal (when brake is applied)	I/O 3 J10-15
89Z3	D-09	Di38	Rear Drum Park Switch	12 Volts Nominal (when brake is applied)	I/O 3 J10-16
90E	A-30	Ai27	Load Pin	4.5 Volts No Load, 9.5 Volts Max. Load	CPU J3-54

Table 3 Description Identification

Description	Wire #	Pin #	I/O #	Test Voltage (DC unless otherwise specified)	Connection
10 VDC Regulated	87F	A-01	-	10 Volts	
10 VDC Regulated Monitor	87M	A-16	Ai13	5 Volts	I/O 2 J7-58
12 VDC System	8P1	C-01	-	12 Volts Nominal	
12 VDC System	8P1	C-03	-	12 Volts Nominal	
12 VDC System	8P1	C-12	-	12 Volts Nominal	
12 VDC System	8P1	C-21	-	12 Volts Nominal	
12 VDC System	8P1	C-30	-	12 Volts Nominal	
2nd Computer Receive	RX3	D-21	-		CPU J4-10
2nd Computer Transmit	TX3	D-22	-		CPU J4-09
Aux. Drum System Pressure (Pump 10A)	86QS	A-27	Ai24	1.2 Volts 300 PSI, 1 Volt at No Pressure	CPU J3-63
Aux. Drum Direction Encoder	87MB	E-02	-	Above 7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 2 J8-04
Aux. Drum Handle (Handle 7)	86P	A-09	Ai7	0 Volts Neutral, 5 to 1.4 Volts Lower, 5 to 8.6 Volts Raise	I/O 1 J5-62
Aux. Drum M/C	86C	E-30	Ao10	0 Volts Up to 1/3 Handle Movement 0.96 to 2.19 Volts 1/3 to Full Handle Movement	I/O 4 J12-06
Aux. Drum MAX Bail Limit	89R1	D-14	Di43	12 Volts Nominal (when brake is applied)	I/O 4 J12-07
Aux. Drum MIN Bail Limit	89Q1	D-13	Di42	12 Volts Nominal (when brake is applied)	I/O 3 J10-20
Aux. Drum P/C Down	87B	E-37	Do37	0 to 2.8 Volts Engine Running 0 to 2.4 Volts Engine Off	I/O 4 J12-33 -34
Aux. Drum P/C Up	87A	E-36	Do36	0 to 2.8 Volts Engine Running 0 to 2.4 Volts Engine Off	I/O 4 J12-31 -32
Aux. Drum Park Switch	89C4	D-12	Di41	12 Volts Nominal (when brake is applied)	I/O 3 J10-19
Aux. Drum Parking Brake	87E	C-25	Do11	12 Volts Nominal	I/O 2 J8-21 -22
Aux. Drum Pawl In	89T1	B-32	Di32	12 Volts Nominal	I/O 3 J10-10
Aux. Drum Rotation Indicator	87N	D-30	Do25	12 Volts Nominal	I/O 3 J10-29 -30
Aux. Drum Speed Encoder	87MA	E-01	-	Above 7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 2 J8-03
Auxiliary System Disable	88S	B-11	Di11	12 Volts Nominal	I/O 1 J6-17
Battery Voltage	8TA	A-14	Ai11	6.5 Volts at 13 Volts	I/O 2 J7-54
Block Up Limit	89W	B-06	Di6	10 Volts Nominal	I/O 1 J6-12
Boom Angle Indicator	82BA	A-20	Ai17	1.88 Volts at 0°, 8.7 Volts 82°, 6.88 Volts at 60°	CPU J3-49
Boom Hinge Pins Enable	52	C-36	Do20	12 Volts Nominal	I/O 2 J8-39 -40
Boom Hoist Drum Direction Encoder	82MB	D-06	-	7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 2 J8-02
Boom Hoist Drum Speed Encoder	82MA	D-05	-	7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 2 J8-01
Boom Hoist Handle (Handle 3)	82P	A-05	Ai3	0 Volts Neutral, 5 to 1.4 Volts Lower, 5 to 8.6 Volts Raise	I/O 1 J5-54
Boom Hoist M/C	82R	E-29	Ao9	0 Volts Up to 1/3 Handle Movement 0.96 to 2.19 Volts 1/3 to Full Handle Movement	I/O 3 J10-06
Boom Hoist Maximum Bail Limit	89J4	B-04	Di4	12 Volts Nominal	I/O 1 J6-10
Boom Hoist Minimum Bail Limit	89K4	B-05	Di5	12 Volts Nominal	I/O 1 J6-11

Description	Wire #	Pin #	I/O #	Test Voltage (DC unless otherwise specified)	Connection
Boom Hoist P/C (Servo Driver 3)	82A	C-14	Ao3	0 to 2.8 ± 10% (110 Ma ± 10%) Volts Down 0 to -2.8 ± 10% (-110 Ma ± 10%) Volts Up	I/O 2 J8-41
Boom Hoist Park Switch	89A4	D-10	Di39	12 Volts Nominal (when brake is applied)	I/O 3 J10-17
Boom Hoist Parking Brake - Hydraulic	82E	C-09	Do3	12 Volts Nominal	I/O 1 J6-25 -26
Boom Hoist Pawl In	89N	B-31	Di31	12 Volts Nominal	I/O 3 J10-09
Boom Hoist Rotation Indicator	82N	D-29	Do24	12 Volts Nominal	I/O 3 J10-27 -28
Boom Hoist System Pressure (Pump 2A)	82QS	A-24	Ai21	1.2 Volts at 300 PSI, 1 Volt at No Pressure	CPU J3-57
Boom Maximum Down Limit	89Q	B-13	Di13	12 Volts Nominal	I/O 1 J6-19
Boom Maximum Up Limit	89R	B-12	Di12	12 Volts Nominal	I/O 1 J6-18
Cable Plug Insert	N/C	C-37	Key		
Cable Plug Insert	N/C	D-23	Key		Keyhole
Crane Mode Confirm	89T2	B-10	Di10	12 Volts Nominal	I/O 1 J6-16
Crane Mode Select	89S2	B-09	Di9	12 Volts Nominal	I/O 1 J6-15
Display - Black	TX2-0	D-20	-		CPU J4-07 -08
Display - White	TX2	D-19	-	Approximately 2.5 Volts	CPU J4-05
Display Scroll Down	89K	B-33	Di33	12 Volts Nominal	I/O 3 J10-11
Display Scroll Up	89J	B-26	Di26	12 Volts Nominal	I/O 2 J8-18
Enable Remote Controller	56	D-26	Do21	12 Volts Nominal	I/O 3 J10-23
Engine Coolant Temperature	89U3	B-19	Di19	0 Volts at Normal Temp., 12 Volts at 210°F	I/O 2 J8-11
Engine Oil Pressure	89T3	B-18	Di18	8 PSI (switch on)	I/O 2 J8-10
Engine rpm Transducer	24	D-07	-	Above 9.0 Volts AC	I/O 1 J6-05
Front Drum Clutch	80F	C-16	Do6	12 Volts Nominal	I/O 1 J6-31 -32
Front Drum Flange Direction Encoder	80MB	D-02	-	7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 1 J6-02
Front Drum Flange Speed Encoder	80MA	D-01	-	7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 1 J6-01
Front Drum Free-Fall Enable	89M	B-23	Di23	12 Volts Nominal	I/O 2 J8-15
Front Drum Free-Fall Mode	89D	B-28	Di28	12 Volts Nominal	I/O 2 J8-20
Front Drum Handle (Handle 1)	80P	A-03	Ai1	0 Volts Neutral, 5 to 1.4 Volts Lower, 5 to 8.6 Volts Raise	I/O 1 J5-50
Front Drum M/C	80R	D-24	Ao7	0 Volts Up to 1/3 Handle Movement 0.96 to 2.19 Volts 1/3 to Full Handle Movement	I/O 1 J6-06
Front Drum Maximum Bail Limit	89V	B-02	Di2	12 Volts Nominal	I/O 1 J6-08
Front Drum Minimum Bail Limit	89T	B-03	Di3	12 Volts Nominal	I/O 1 J6-09
Front Drum P/C (Servo Driver 1)	80A	C-05	Ao1	0 to 2.8 ± 10% (110 Ma ± 10%) Volts Down 0 to -2.8 ± 10% (-110 Ma ± 10%) Volts Up	I/O 1 J6-41
Front Drum Park Switch	89Y3	D-08	Di37	12 Volts Nominal (when brake is applied)	I/O 3 J10-15
Front Drum Parking Brake - Air	80E	C-07	Do1	12 Volts Nominal	I/O 1 J6-21 -22
Front Drum Parking Brake - Hydraulic	80Q	C-18	Do8	12 Volts Nominal	I/O 1 J6-35 -36
Front Drum Pawl In	89L3	B-29	Di29	12 Volts Nominal	I/O 3 J10-07
Front Drum Rotation Indicator	80N	D-27	Do22	12 Volts Nominal	I/O 3 J10-23 -24

Description	Wire #	Pin #	I/O #	Test Voltage (DC unless otherwise specified)	Connection
Front Drum Shaft Direction Encoder	80MBS	E-04	-	Above 7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 3 J10-02
Front Drum Shaft Speed Encoder	80MAS	E-03	-	Above 7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 3 J10-01
Front Drum System Pressure (Pump 0A)	80QS	A-22	Ai19	1.2 Volts at 300 PSI, 1 Volt at No Pressure	CPU J3-53
Gantry Lower Enable	44	C-33	Do17	12 Volts Nominal	I/O 2 J8-33 -34
Gantry Raise Enable	43	C-32	Do16	12 Volts Nominal	I/O 2 J8-31 -32
Gantry Raise/Lower Switch	89M1	B-36	Di36	12 Volts Nominal	I/O 3 J10-14
Gantry Up Limit	89W3	B-22	Di22	12 Volts Nominal	I/O 2 J8-14
High Speed Travel Switch	89L1	B-35	Di35	12 Volts Nominal	I/O 3 J10-13
Hydraulic Filter Alarm 1	89D4	E-13	Di45	12 Volts Nominal	I/O 4 J12-09
Hydraulic Filter Alarm 2	89E4	E-14	Di46	12 Volts Nominal	I/O 4 J12-10
Hydraulic Filter Alarm 3	89F4	E-15	Di47	12 Volts Nominal	I/O 4 J12-11
Hydraulic Filter Alarm 4	89G4	E-16	Di48	12 Volts Nominal	I/O 4 J12-12
Hydraulic Fluid Level	89R3	B-16	Di16	0 Volts Low Level, 12 Volts High Level	I/O 2 J8-08
Hydraulic Fluid Temperature	89S3	B-17	Di17	0 Volts 180°F, 12 Volts at Normal Temp.	I/O 2 J8-09
Hydraulic Tank Strainer Alarm	89H4	E-17	Di49	12 Volts Nominal	I/O 4 J12-13
Left Track Handle (Handle 6)	84P	A-07	Ai5	0 Volts Neutral, 5 to 1.4 Volts Reverse, 5 to 8.6 Volts Forward	I/O 1 J5-58
Left Track P/C (Servo Driver 5)	84A	C-23	Ao5	0 to 2.8 ± 10% (110 Ma ± 10%) Volts Reverse 0 to -2.8 ± 10% (-110 Ma ± 10%) Volts Forward	I/O 3 J10-41
Left Track Pedal 2	84PF	A-13	Ai10	0 Volts Neutral, 5 to 1.4 Volts Reverse, 5 to 8.6 Volts Forward	I/O 2 J7-52
Limit Bypass	89L	B-25	Di25	12 Volts Nominal	I/O 2 J8-17
Load Moment Indicator	89P	B-24	Di24	12 Volts Nominal	I/O 2 J8-16
Load Pin	90E	A-30	Ai27	4.5 Volts No Load, 9.5 Volts Max. Load	CPU J3-54
Low Air Pressure	89V3	B-20	Di20	0 Volts 0 PSI, 12 Volts at 95 PSI	I/O 2 J8-12
Luffing Jib Angle Indicator	87BA	A-21	Ai18	3.33 Volts at 0°, 6.66 Volts 60°, 7.88 Volts at 82°	CPU J3-51
Luffing Jib Maximum Down Limit	89S1	B-15	Di15	10 Volts Nominal	I/O 2 J8-07
Luffing Jib Maximum Up Limit	89W1	B-14	Di14	10 Volts Nominal	I/O 1 J6-20
Mast Angle Indicator	88MA	A-35	Ai32	5 Volts Mast at Vertical	CPU J3-58
Mast Assist Enable	55C	C-35	Do19	12 Volts Nominal	I/O 2 J8-37 -38
Mast Assist Raise	55D	C-34	Do18	12 Volts Nominal	I/O 2 J8-35 -36
Motor Temperature Alarm	89L4	E-19	Di51	12 Volts Nominal	I/O 4 J12-15
Operating Limit Alarms	25A	C-28	Do14	12 Volts Nominal	I/O 2 J8-27 -28
Pin Not Terminated	N/C	D-37	-		
Pin Not Terminated	N/C	E-31	-		
Pin Not Terminated	N/C	E-32	-		
Rear Drum Clutch	81F	C-17	Do7	12 Volts Nominal	I/O 1 J6-34 -33
Rear Drum Flange Direction Encoder	81MB	D-04	-	7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 1 J6-04

Description	Wire #	Pin #	I/O #	Test Voltage (DC unless otherwise specified)	Connection
Rear Drum Flange Speed Encoder	81MA	D-03	-	7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 1 J6-03
Rear Drum Free-Fall Enable	89X2	B-21	Di21	12 Volts Nominal	I/O 2 J8-13
Rear Drum Free-Fall Mode	89B	B-27	Di27	12 Volts Nominal	I/O 2 J8-19
Rear Drum Handle (Handle 2)	81P	A-04	Ai2	0 Volts Neutral, 5 to 1.4 Volts Lower, 5 to 8.6 Volts Raise	I/O 1 J5-52
Rear Drum M/C	81S	D-25	Ao8	0 Volts Up to 1/3 Handle Movement 0.96 to 2.19 Volts 1/3 to Full Handle Movement	I/O 2 J8-06
Rear Drum Maximum Bail Limit	89U	B-07	Di7	12 Volts Nominal	I/O 1 J6-13
Rear Drum Minimum Bail Limit	89S	B-08	Di8	12 Volts Nominal	I/O 1 J6-14
Rear Drum P/C (Servo Driver 2)	81A	C-06	Ao2	0 to 2.8 ± 10% (110 Ma ± 10%) Volts Down 0 to -2.8 ± 10% (-110 Ma ± 10%) Volts Up	I/O 1 J6-42
Rear Drum Park Switch	89Z3	D-09	Di38	12 Volts Nominal (when brake is applied)	I/O 3 J10-16
Rear Drum Parking Brake - Air	81E	C-08	Do2	12 Volts Nominal	I/O 1 J6-23 -24
Rear Drum Parking Brake - Hydraulic	81S	C-19	Do9	12 Volts Nominal	I/O 1 J6-37 -38
Rear Drum Pawl In	89M3	B-30	Di30	12 Volts Nominal	I/O 3 J10-08
Rear Drum Rotation Indicator	81N	D-28	Do23	12 Volts Nominal	I/O 3 J10-25 -26
Rear Drum Shaft Direction Encoder	81MBS	E-06	-	Above 7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 3 J10-04
Rear Drum Shaft Speed Encoder	81MAS	E-05	-	Above 7.5 Volts or 0 Volts Not Moving, 3.5 Volts Moving	I/O 3 J10-03
Rear Drum System Pressure (Pump 1A)	81QS	A-23	Ai20	1.2 Volts at 300 PSI, 1 Volt at No Pressure	CPU J3-55
Receptacle Insert	N/C	B-37	Key	12 Volts Nominal	
Right Track Handle (Handle 5)	83P	A-06	Ai4	0 Volts Neutral, 5 to 1.4 Volts Reverse, 5 to 8.6 Volts Forward	I/O 1 J5-56
Right Track P/C (Servo Driver 4)	83A	C-15	Ao4	0 to 2.8 ± 10% (110 Ma ± 10%) Volts Forward 0 to -2.8 ± 10% (-110 Ma ± 10%) Volts Reverse	I/O 2 J8-42
Right Track Pedal 1	83PF	A-12	Ai9	0 Volts Neutral, 5 to 1.4 Volts Reverse, 5 to 8.6 Volts Forward	I/O 2 J7-50
RS-232 Receptacle	RX1	D-16	-		CPU J4-02
RS-232 Receptacle	TX1	D-17	-		CPU J4-01
RS-232 Receptacle	TX1-0	D-18	-		CPU J4-03 -04
Seat Switch	89Q3	B-34	Di34	12 Volts Nominal	I/O 3 J10-12
Shield	Shield	A-11	-		
Spare		A-02	Ai35		CPU J3-64
Spare		A-10	Ai8		I/O 1 J5-64
Spare		A-15	Ai12		I/O 2 J7-56
Spare		A-17	Ai14		I/O 2 J7-60
Spare		A-18	Ai15		I/O 2 J7-62
Spare		A-19	Ai16		I/O 2 J7-64
Spare		A-28	Ai25		CPU J3-50
Spare		A-29	Ai26		CPU J3-52
Spare		A-31	Ai28		I/O 3 J9-50
Spare		A-32	Ai29		I/O 3 J9-52

Description	Wire #	Pin #	I/O #	Test Voltage (DC unless otherwise specified)	Connection
Spare		A-33	Ai30		I/O 3 J9-54
Spare		A-34	Ai31		CPU J3-56
Spare		A-36	Ai33		CPU J3-60
Spare		A-37	Ai34		CPU J3-62
Spare		C-11	Do5		I/O 1 J6-29 -30
Spare		C-20	Do10		I/O 1 J6-39 -40
Spare		C-26	Do12		I/O 2 J8-23 -24
Spare		D-32	Do27		I/O 3 J10-33 -34
Spare		D-33	Do28		I/O 3 J10-35 -36
Spare		D-34	Do29		I/O 3 J10-37 -38
Spare		D-36	Do31		I/O 4 J12-21 -22
Spare		E-10	Ai38		I/O 2 J9-60
Spare		E-11	Ai39		I/O 2 J9-62
Spare		E-12	Ai40		I/O 2 J9-64
Spare		E-18	Di50		I/O 4 J12-14
Spare		E-20	Di52		I/O 4 J12-16
Spare		E-21	Di53		I/O 4 J12-17
Spare		E-22	Di54		I/O 4 J12-18
Spare		E-23	Di55		I/O 4 J12-19
Spare		E-24	Di56		I/O 4 J12-20
Spare		E-33	Do33		I/O 4 J12-25 -26
Spare		E-34	Do34		I/O 4 J12-27 -28
Spare		E-35	Do35		I/O 4 J12-29 -30
Spare	ENC7 CHA	E-25	-		I/O 4 J12-01
Spare	ENC7 CHB	E-26	-		I/O 4 J12-02
Spare	MAG PU2	E-07	-		I/O 2 J8-05
Spare	Spare	E-27	-		I/O 4 J12-03
Spare	Spare	E-28	-		I/O 4 J12-04
Spare		D-35	Do30		I/O 3 J10-39 -40
Swing Alarms	25X	C-27	Do13	12 Volts Nominal	I/O 2 J8-25 -26
Swing Handle (Handle 4)	85P	A-08	Ai6	0 Volts Neutral, 5 to 1.4 Volts Right, 5 to 8.6 Volts Left	I/O 1 J5-60
Swing Left Pressure (Pump 3B)	85QL	A-26	Ai23	1.2 Volts at 300 PSI, 1 Volt at No Pressure	CPU J3-61
Swing P/C (Servo Driver 6)	85A	C-24	Ao6	0 to 2.8 ± 10% (110 Ma ± 10%) Volts Right 0 to -2.8 ± 10% (-110 Ma ± 10%) Volts Left	I/O 3 J10-42

Description	Wire #	Pin #	I/O #	Test Voltage (DC unless otherwise specified)	Connection
Swing Park Switch/Holding Brake	89B2	D-15	Di44	12 Volts Nominal (when brake is applied)	I/O 4 J12-08
Swing Right Pressure (Pump 3A)	85QR	A-25	Ai22	1.2 Volts at 300 PSI, 1 Volt at No Pressure	CPU J3-59
System Fault Alarms	25	C-29	Do15	12 Volts Nominal	I/O 2 J8-29 -30
System Ground	0	C-02	-	0 Volts	
System Ground	0	C-04	-	0 Volts	
System Ground	0	C-13	-	0 Volts	
System Ground	0	C-22	-	0 Volts	
System Ground	0	C-31	-	0 Volts	
Track Motor	88R	D-31	Do26	12 Volts Nominal	I/O 3 J10-31 -32
Travel Detent	89X	B-01	Di1	12 Volts Nominal	I/O 1 J6-07
Travel Park Switch	89B4	D-11	Di40	12 Volts Nominal (when brake is applied)	I/O 3 J10-18
Travel Parking Brake	84E	C-10	Do4	12 Volts Nominal	I/O 1 J6-27 -28
Travel Pressure Left Track	84Q	E-09	Ai37	1.2 Volts at 300 PSI, 1 Volt at No Pressure	I/O 2 J9-58
Travel Pressure Right Track	83Q	E-08	Ai36	1.2 Volts at 300 PSI, 1 Volt at No Pressure	I/O 2 J9-56

CONNECTOR PIN IDENTIFICATION

All Models

TABLE OF CONTENTS

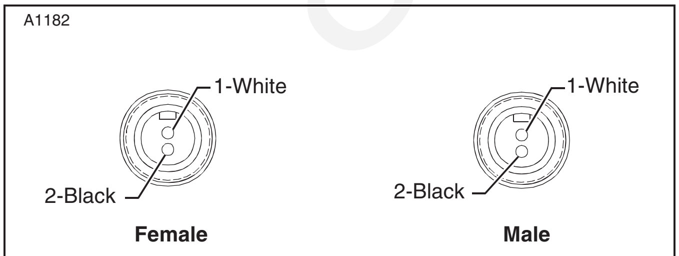
GENERAL

This publication is provided to assist service and maintenance personnel in identifying connector pins for all Brad Harrison type connectors used on Manitowoc cranes:

- Extension cords with plug on both ends — M (male) one end and F (female) other end.
- Cords with plug on only one end — either M (male) or F (female).
- Receptacles — either M (male) or F (female).

MINI-CHANGE TYPE CONNECTORS

2-Pole Plugs



EXTENSION:

Length	Plug	Part #
3 ft (0,9 m)	M/F	477485
3 ft (0,9 m)	M/F	A02087
6 ft (1,8 m)	M/F	477486
6 ft (1,8 m)	M/F	477491
8 ft (2,4 m)	M/F	477390
10.4 ft (3,1 m)	M/F	477391
12 ft (3,7 m)	M/F	477487
12 ft (3,7 m)	M/F	477492
12 ft (3,7 m)	M/F	911046
15 ft (4,6 m)	M/F	477493
15.4 ft (4,7 m)	M/F	477392
19.4 ft (5,9 m)	M/F	477393
20.4 ft (6,2 m)	M/F	477394
21.4 ft (6,5 m)	M/F	477395
24 ft (7,3 m)	M/F	477338
25.4 ft (7,7 m)	M/F	477396
30.4 ft (9,6 m)	M/F	477397
35 ft (10,7 m)	M/F	477479
40.4 ft (12,3 m)	M/F	477398
60 ft (18,3 m)	M/F	477438
65 ft (19,8 m)	M/F	911031
70 ft (21,3 m)	M/F	477494
130 ft (40,0 m)	M/F	477354
130 ft (40,0 m)	M/F	477562
150 ft (45,7 m)	M/F	477561
205 ft (62,5 m)	M/F	911028
210 ft (64,0 m)	M/F	477371
325 ft (99,1 m)	M/F	477420

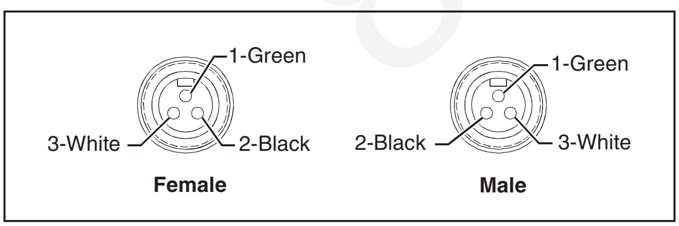
Plug With Cord:

Length	Plug	Part #
3 ft (0,9 m)	M	572334
3 ft (0,9 m)	F	572444
3 ft (0,9 m)	M	572514
3 ft (0,9 m)	F	572518
3 ft (0,9 m)	M	911879
6 ft (1,8 m)	M	572335
6 ft (1,8 m)	F	572485
6 ft (1,8 m)	F	572515
6 ft (1,8 m)	M	572592
12 ft (3,7 m)	M	572336
12 ft (3,7 m)	F	572345
12 ft (3,7 m)	F	572573
15 ft (4,6 m)	M	572416
15 ft (4,6 m)	F	572497
15 ft (4,6 m)	F	572509
20 ft (6,1 m)	F	572406
20 ft (6,1 m)	M	572572
20 ft (6,1 m)	M	572574
30 ft (9,1 m)	F	477389
50 ft (15,2 m)	F	572407
100 ft (30,5 m)	F	A05250

Receptacle:

Plug	Part #
F	589650
F 90°	589651
M	589654
M 90°	589944

3-Pole Plugs



Extension:

Length	Plug	Part #
3 ft (0,9 m)	M/F	477445
12 ft (3,7 m)	M/F	477333
25 ft (7,6 m)	M/F	572434
30 ft (9,1 m)	M/F	572502
35 ft (10,7 m)	M/F	572480
40 ft (12,2 m)	M/F	572410

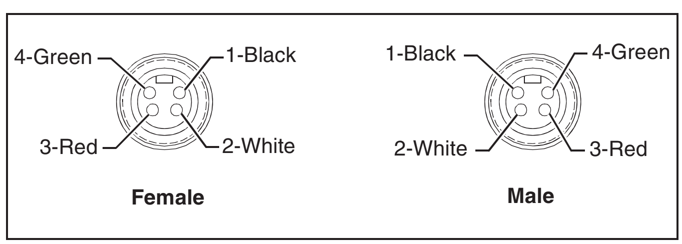
Plug With Cord:

Length	Plug	Part #
3 ft (0,9 m)	M	572324
3 ft (0,9 m)	F	572495
3 ft (0,9 m)	F	572519
3 ft (0,9 m)	F	572531
6 ft (1,8 m)	M	572325
6 ft (1,8 m)	F	572499
12 ft (3,7 m)	M	572326
12 ft (3,7 m)	F	572498
12 ft (3,7 m)	M	572516
12 ft (3,7 m)	F	572587
15 ft (4,6 m)	M	297998
15 ft (4,6 m)	M	572511
15 ft (4,6 m)	F	572550
20 ft (6,1 m)	M	572488
20 ft (6,1 m)	F	572489
25 ft (7,6 m)	M	572372
25 ft (7,6 m)	F	572510
25 ft (7,6 m)	M	572594
30 ft (9,1 m)	F	572477
30 ft (9,1 m)	M	572491
30 ft (9,1 m)	F	572576
35 ft (10,7 m)	M	572386
50 ft (15,2 m)	M	572402
50 ft (15,2 m)	M	572591
50 ft (15,2 m)	F	A00954

Receptacle:

Plug	Part #
F	589635
F 90°	589636
M	589871
M 90°	589938

4-Pole Plugs



Extension:

Length	Plug	Part #
12 ft (3,7 m)	M/F	477449

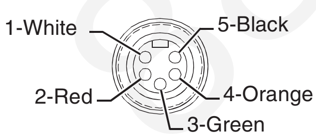
Plug With Cord:

Length	Plug	Part #
3 ft (0,9 m)	M	572330
3 ft (0,9 m)	M	572508
3 ft (0,9 m)	F	572532
6 ft (1,8 m)	M	572331
6 ft (1,8 m)	M	572419
6 ft (1,8 m)	F	572513
6 ft (1,8 m)	F	572521
12 ft (3,7 m)	M	572332
12 ft (3,7 m)	F	572527
15 ft (4,6 m)	M	572599
20 ft (6,1 m)	F	572417
25 ft (7,6 m)	M	572374
30 ft (9,1 m)	F	572577
50 ft (15,2 m)	M	572441

Receptacle:

Plug	Part #
F	589630
F 90°	589638
M	589872
F	589908

5-Pole Plugs



Male

Plug With Cord:

Length	Plug	Part #
15 ft (4,6 m)	M	572398

Receptacle:

Plug	Part #
F 90°	589839

6-Pole Plugs

Female **Male**

Extension:

Cord	Plug	Part #
20 ft (6,1 m)	M/F	572400
80 ft (24,4 m)	M/F	477426
130 ft (40,0 m)	M/F	477444
200 ft (61,0 m)	M/F	477419
210 ft (64,0 m)	M/F	477443
350 ft (106,7 m)	M/F	477399

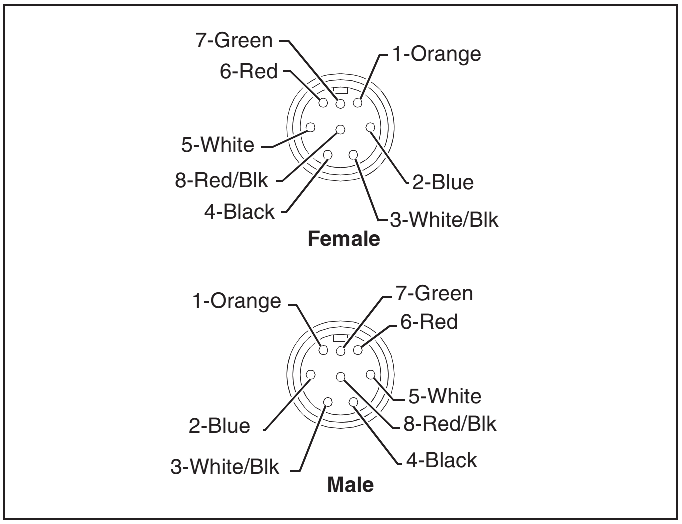
Plug With Cord:

Length	Plug	Part #
3 ft (0,9 m)	F	572520
3 ft (0,9 m)	F	572528
3 ft (0,9 m)	M	572569
6 ft (1,8 m)	M	572442
6 ft (1,8 m)	F	572517
12 ft (3,7 m)	M	572415
12 ft (3,7 m)	F	572568
20 ft (6,1 m)	M	572391
30 ft (9,1 m)	F	A02463
50 ft (15,2 m)	M	572500

Receptacle:

Plug	Part #
F	589805
M	589836
F 90°	589974

8-Pole Plugs



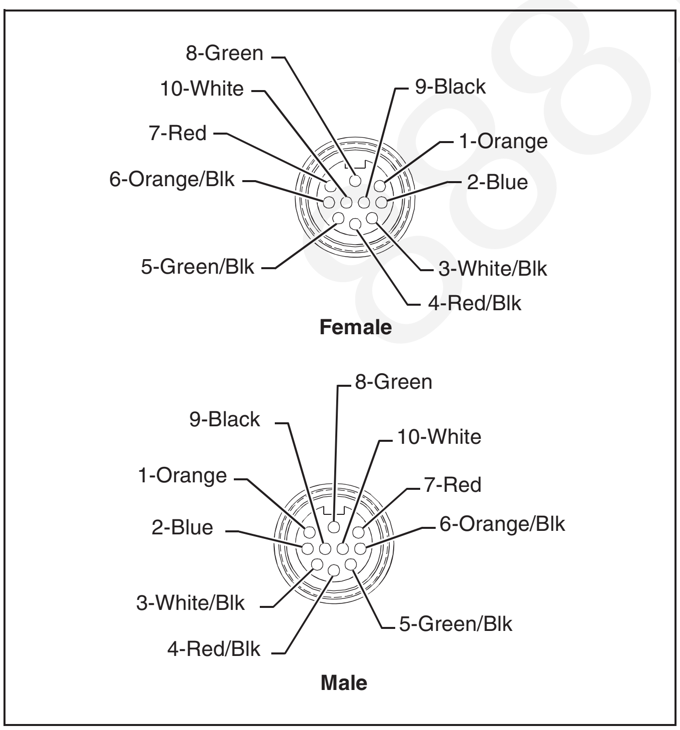
Plug With Cord:

Length	Plug	Part #
12 ft (3,7 m)	M	572512
12 ft (3,7 m)	M	572529

Receptacle:

Plug	Part #
F	589933

10-Pole Plugs



Extension:

Length	Plug	Part #
12 ft (3,7 m)	M/F	477484
25 ft (7,6 m)	M/F	477466
35 ft (10,7 m)	M/F	477467
45 ft (13,7 m)	M/F	477476
300 ft (91,4 m)	M/F	477413
300 ft (91,4 m)	M/F	477414

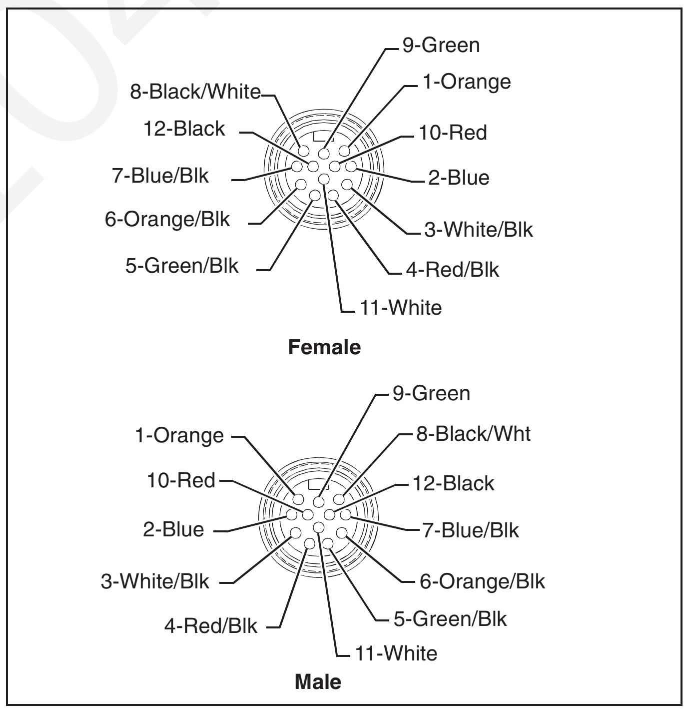
Plug With Cord:

Length	Plug	Part #
12 ft (3,7 m)	M	572443
50 ft (15,2 m)	M	572399

Receptacle:

Plug	Part #
F	589869
M	589969

12-Pole Plugs



Extension:

Length	Plug	Part #
21 ft (6,4 m)	M/F	A03688
27 ft (8,2 m)	M/F	477468
38 ft (12,0 m)	M/F	477469
41.5 ft (12,6 m)	M/F	477441

Length	Plug	Part #
350 ft (107,0 m)	M/F	477442
400 ft (122,0 m)	M/F	477481

Plug With Cord:

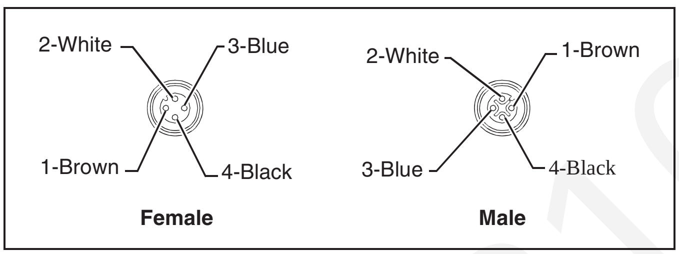
Length	Plug	Part #
6 ft (1,8 m)	F	572327
12 ft (3,7 m)	F	572389
20 ft (6,1 m)	M	572507
25 ft (7,6 m)	F	572382

Receptacle

Plug	Part #
M	589646
F	589915

MICRO-CHANGE TYPE CONNECTORS

4-Pole Plugs



Extension:

Length	Plug	Part #
3 ft (0,9 m)	M/F	477463
6.6 ft (2,0 m)	F/F	477447
6.6 ft (2,0 m)	M/F	477475
6.6 ft (2,0 m)	F/F 90°	477488
6.6 ft (2,0 m)	M/F 90°	477489
13.1 ft (4,0 m)	F/F	477473
13.1 ft (4,0 m)	M/F	477474
16.4 ft (5,0 m)	M/F	477436
16.4 ft (5,0 m)	F/F	477478
19.7 ft (6,0 m)	M/F	477339
32.8 ft (10,0 m)	M/F	477433
32.8 ft (10,0 m)	F/F	477554
90 ft (27,4 m)	F/F	477453
131.2 ft (40,0 m)	M/F	477334
150.9 ft (46,0 m)	M/F	477560
400 ft (122,0 m)	M/F	477439

Plug With Cord

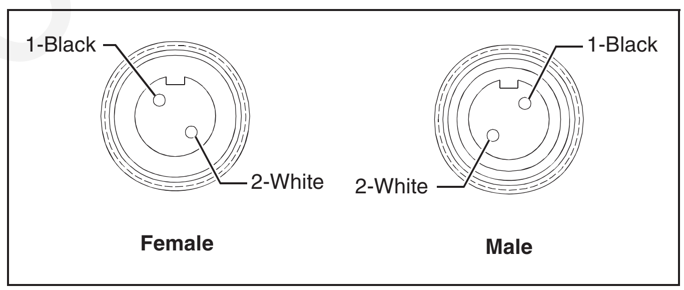
Length	Plug	Part #
3.28 ft (1,0 m)	F	572575
6 ft (1,8 m)	F 90°	572504
6.6 ft (2,0 m)	F	572418
9.8 ft (3,0 m)	F	572586
13.1 ft (4,0 m)	M	572474
13.1 ft (4,0 m)	F	572476
16 ft (4,9 m)	F	572472
16 ft (4,9 m)	F 90°	572501
16.4 ft (5,0 m)	M	572475
23 ft (7,0 m)	F	572503
32.8 ft (10,0 m)	M	A01666
32.8 ft (10,0 m)	F	A02673

Receptacle:

Plug	Part #
M	589870
F	589908

QUICK-CHANGE TYPE CONNECTORS

2-Pole Plugs



Extension

Length	Plug	Part #
25 ft (7,6 m)	M/F	477479

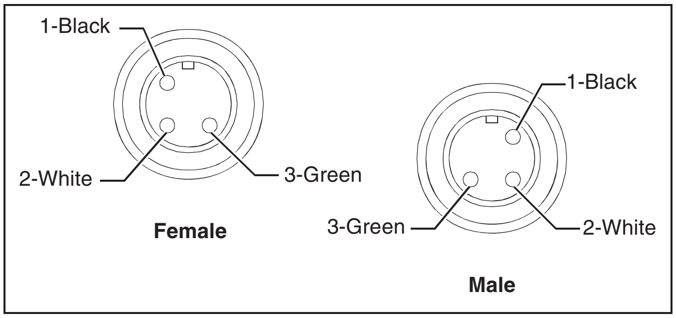
Plug With Cord:

Length	Plug	Part #
6 ft (1,8 m)	F	572432
30 ft (9,1 m)	F	572565

Receptacle:

Plug	Part #
M	589862
M	589963

3-Pole Plugs



Extension:

Length	Plug	Part #
8 ft (2,4 m)	M/F	477416
12 ft (3,7m)	M/F	477432
20 ft (6,1 m)	M/F	477430
45 ft (13,7 m)	M/F	477448

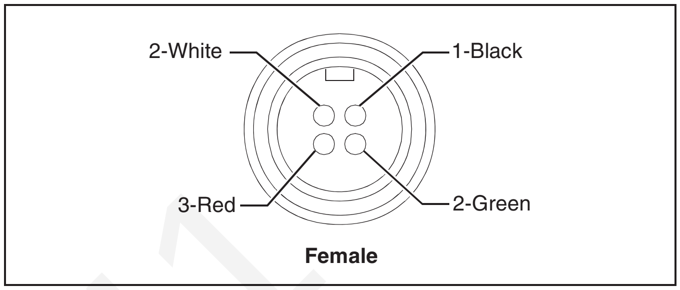
Plug With Cord:

Length	Plug	Part #
12 ft (3,7 m)	F	572403
12 ft (3,7 m)	M	572437
12 ft (3,7 m)	M	572552
25 ft (7,6 m)	F	572478
35 ft (7,6 m)	F	572597
50 ft (15,2 m)	M	572438

Receptacle:

Plug	Part #
M	589853
F	589861
M	589862
F	589866
M	589942
F	589952

4-Pole Plugs



Plug With Cord:

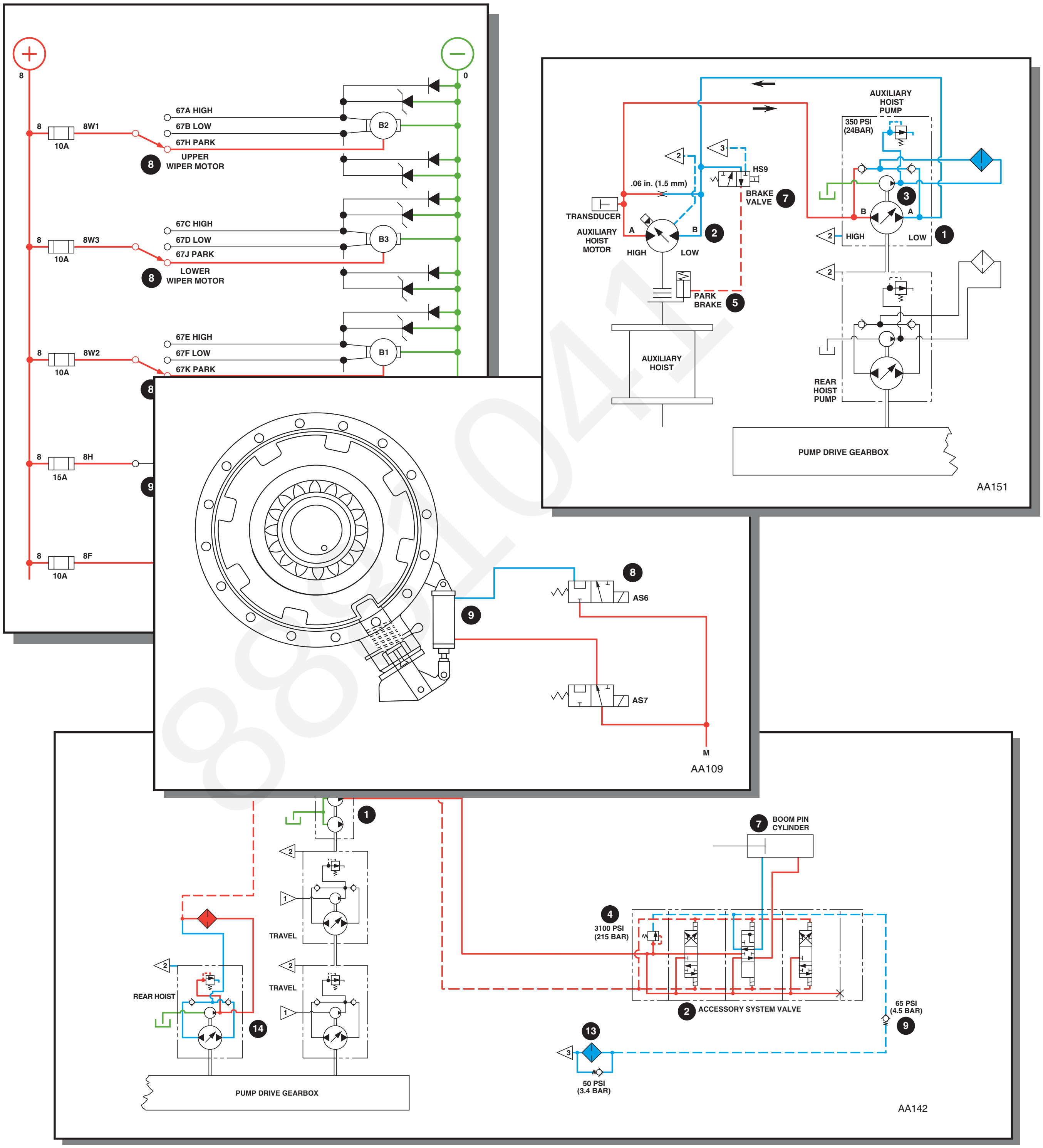
Length	Plug	Part #
20 ft (6,1 m)	F	572566

Operator’s Manual 1-8 Numeric Tabs

MANITOWOC 888

DESCRIPTION OF OPERATION
HYDRAULIC • ELECTRIC • AIR SYSTEMS

SERVICE TRAINING



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ST126
Rev. 02-28-97

NOTICE

Because of a program of continuing improvements, Manitowoc Cranes, Inc. reserves the right to change this publication at any time, without notice, to reflect those improvements. This publication describes optional systems which may or may not be a part of your crane.

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GENERAL OPERATION

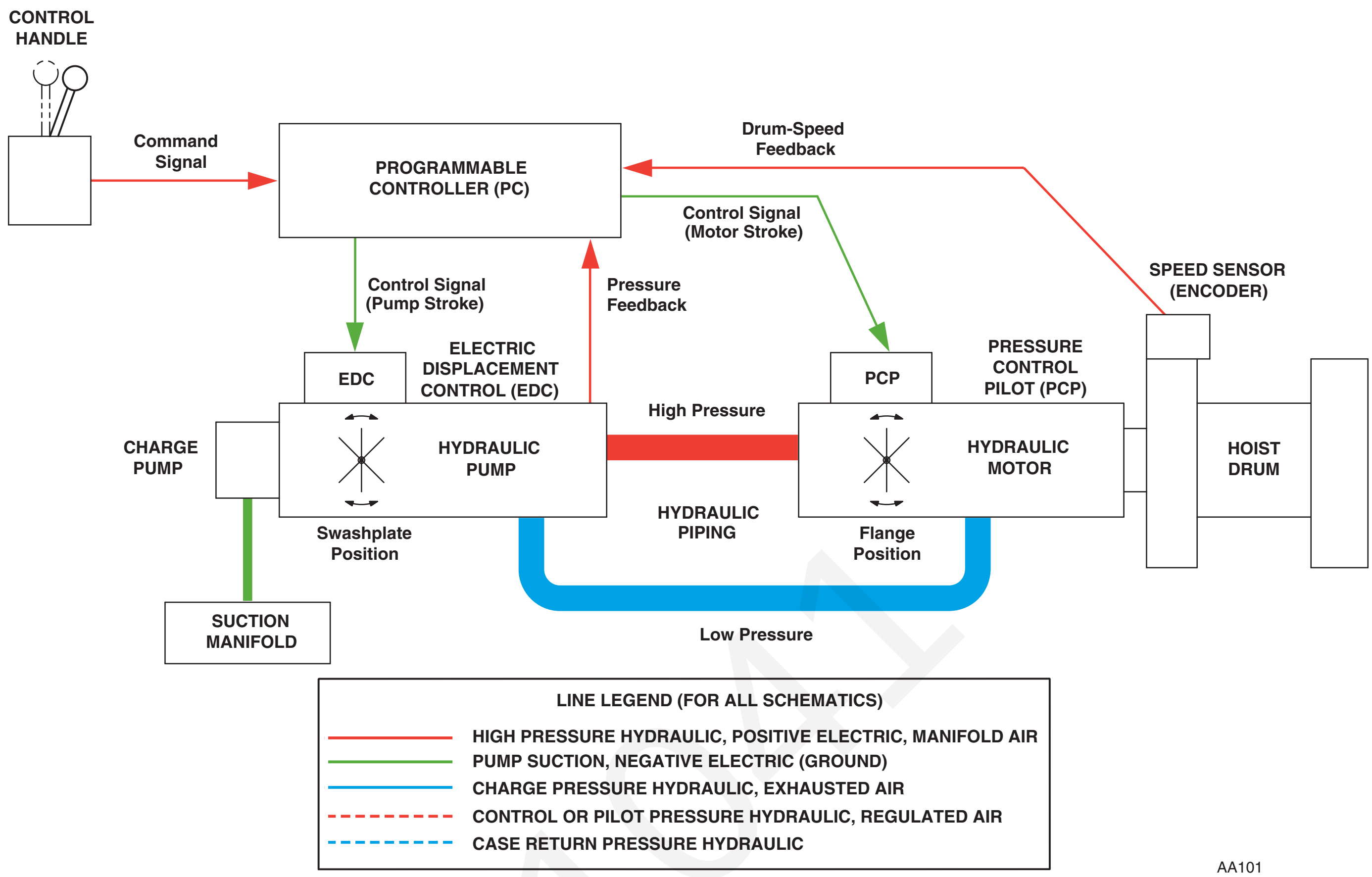


FIGURE 1 CLOSED-LOOP HYDRAULIC SYSTEM DIAGRAM

Systems Operation

Operation of the EPIC® Hydraulic-Series crane is governed by a safety mechanism that prevents systems operation of the machine until the cab seat is occupied by the operator. When the engine is running and the operator is not seated, the seat switch circuit is open, all control handles are inoperable, all park brakes are applied, and the free-fall (if equipped) and travel detent systems are turned off. At this time, the display will indicate an operating limit message (FUNCTION IS PARKED).

Hydraulic Systems (Figure 1)

Each operation system is controlled through a programmable controller (PC) and independently powered by a hydraulic pump and motor in a “closed-loop” hydraulic system. Refer to Table A for the types of pumps and motors used in each system, and to Sundstrand Series 90 Service Manual for an operational description of a hydrostatic transmission.

In a closed-loop hydraulic system, the oil output from the system pump drives a hydraulic motor and then returns directly to the pump’s input instead of returning to the crane’s hydraulic tank.

TABLE A PUMP AND MOTOR DESCRIPTIONS

Pump	Type
Boom Hoist, Front and Rear Hoists (Load Drums), Auxiliary Hoist, Swing, and Crawler.	Variable Displacement, Axial Piston
Accessory	Fixed Displacement, Gear
Motor	**Type**
Crawler, Front and Rear Hoists (Load Drums), Boom Hoist, and Auxiliary Hoist	Variable Displacement, Bent-Axis Piston
Swing	Fixed Displacement, Bent-Axis Piston
Travel motors are normally in minimum displacement position (low torque, high speed). Travel motors start to shift to maximum displacement position at approximately 3,500 psi (240 bar) (high torque, low speed).	

A gear pump on each system pump supplies oil at charge pressure to maintain the closed-loop system's minimum pressure requirements. This oil is also used to regulate the oil flow from the pump by moving a swashplate servo mechanism within the pump in response to an external electric displacement control (EDC).

An accessory pump supplies supercharged filtered oil to the suction ports of some of these pumps and provides oil to establish cylinder valve actuation.

The PC controls each pump EDC in reaction to operator commands through the system's control handles. The PC compares the handle commands with feedback information it derives from continuous monitoring of the system's sensors. Data derived from this monitoring can be viewed on a digital display in the operator's cab by selecting the desired information.

HYDRAULIC PUMPS (Figures 2 and 3)

Variable displacement, axial piston pumps are used in the boom hoist, load drum, swing, travel, and auxiliary hoist (if equipped) systems. Each pump contains a cylinder block in which the pistons are positioned axially around the drive shaft, a tiltable swashplate against which the pistons ride, a servo mechanism which tilts the swashplate, and two multifunction valve cartridges.

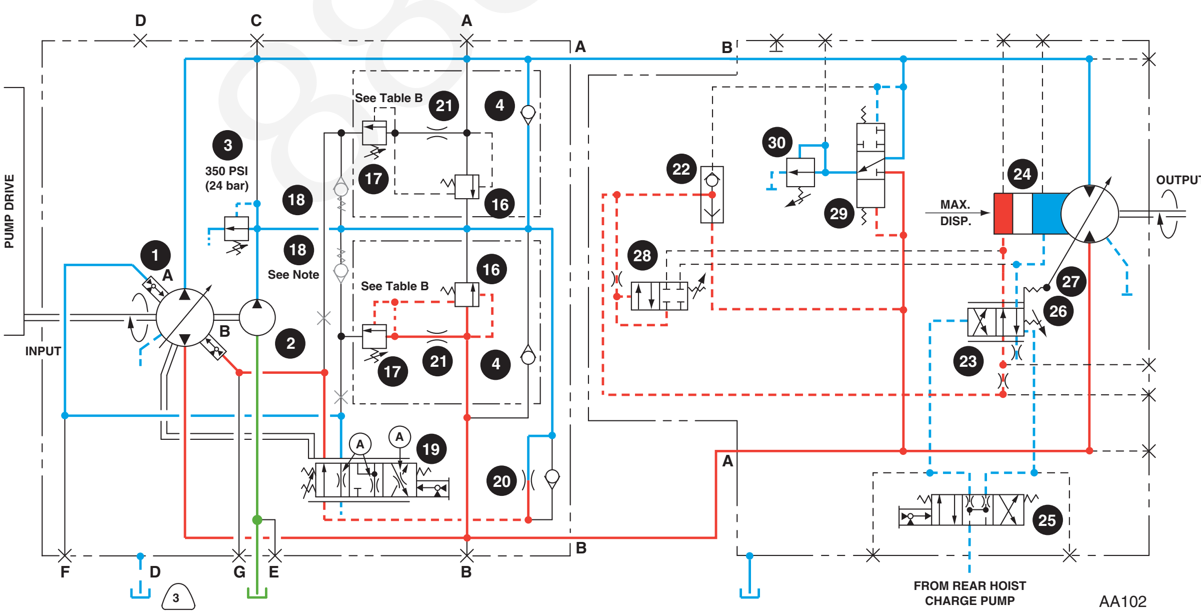
Pump displacement is dependent upon the speed at which the pump is driven by the engine through the pump drive gearbox and the angle at which the swashplate is tilted. The engine provides the horsepower available for work, while the swashplate tilt provides speed control. Engine speed is set by an electrical hand throttle and temporary increases are accomplished with an electrical foot throttle.

The pump's external EDC sets the amount and direction that the swashplate is tilted by internal servo control cylinder (1). Tipping direction establishes the direction that the oil flows from the pump to the motor pistons. This determines the direction of motor rotation.

The gerotor type gear pump is internally mounted on the end of each system pump's drive shaft. Charge pump (2) draws oil directly from the hydraulic tank's suction manifold or filtered make-up oil and delivers it to the closed-loop at approximately 350 psi (25 bar) depending upon load and engine speed and the setting of charge pump relief valve (3). The charge oil provides oil cooling, positive pressure maintenance in the low pressure side of the loop, control pressure for the pump swashplate servo mechanism, and make-up oil for replacement due to internal leakage. From the charge pump, the oil flows to charge flow make-up check valves (4), and passes over the check on the low side of the loop. It combines with oil returning from the system motor and enters the system pump.

In the system pump, the oil holds each piston in turn against the face of the swashplate as the cylinder block is rotated by the engine.

The PC transmits a command signal to one of the two coils in the EDC via two of the four EDC connector pins. The first pin energizes the coil. The current travels through the coil and returns to the connector as negative charge through the second pin. The polarity changes for opposite stroke direction and positive current returns to the coil through the second pin and back to negative through the first pin. This charge cycle causes armature (5) to become more magnetized, initiating its movement to begin blocking orifice (6). The increasing blockage of orifice (6) causes a larger pressure increase in port (6) than in port (7), resulting in a pressure difference across spool (8). This pressure difference overcomes the resistance of spring (9) and initiates the movement of spool (8) causing internal servo control cylinder (10) to pressurize and servo (11) to be routed to tank. This movement causes swashplate (12) to shift, stroke the main pump,



Note: Servo check valves (18) are only used in the travel pump closed-loop circuit. In all other system pumps, these valves are removed and the paths to the servo control cylinders are plugged as shown with (X).

FIGURE 2 CLOSED-LOOP CIRCUIT

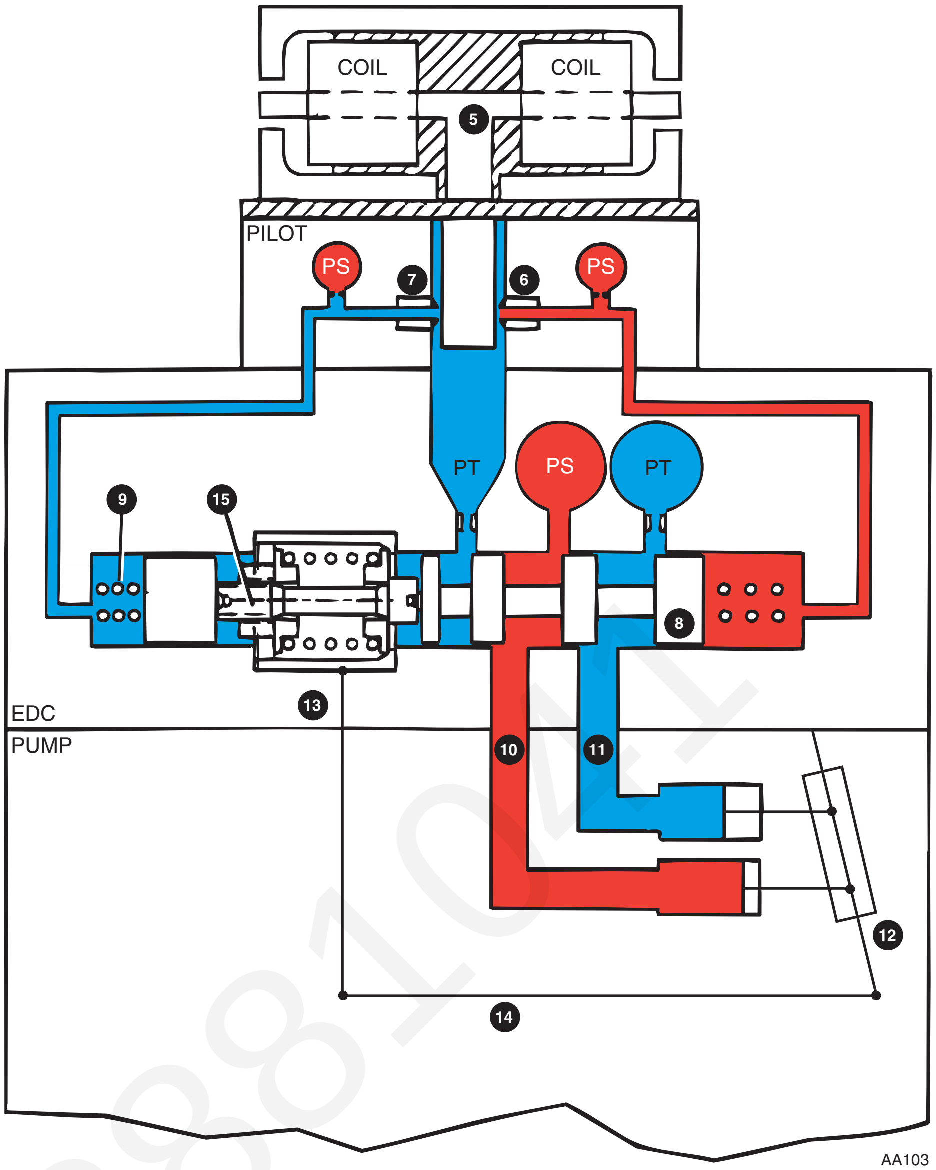


FIGURE 3 EDC COMPONENT CONFIGURATION

and initiate the flow of oil out of the pump. As swashplate (12) shifts, spring chamber (13) is pulled opposite the direction of spool (8) via linkage (14). This actuation centers and maintains spool (15) in a neutral position until the 16 psi (1 bar) preset pressure of spring (13) is reached.

Because the swashplate is now tilted, the pistons are reciprocated within the cylinder block as the block is rotated. The lengthening stroke of each piston draws returning oil into the cylinder; as the stroke shortens, the oil is pumped out of the pump cylinder to the motor cylinders at system pressure. Note that when the swashplate is not tilted, there is no output from the pump.

The amount that the swashplate is tilted determines the amount of oil that is pumped to the motor. Increasing the swashplate tilt increases the stroke length, causing more oil to be pumped to fill the motor cylinders.

At this point, pressure develops within the closed-loop system while the resistance of the load on the motor is overcome. When movement begins, the volume displacement of the pump maintains the motor speed. More flow from the pump will operate the motor faster to perform the desired activity.

Since each system pump operates in a bi-directional closed-loop circuit, the pumps contain two different multifunction valve cartridges, each of which consists of system relief valve (16) and pressure limiting valve (17) which protect the crane's hydraulic system from excessive pressure and heat build-up. When the preset system pressure is reached in the loop, the multifunction valves will limit system pressure by causing the pump to destroke and/or allowing oil to transfer from the high pressure side of the loop to the low pressure side.

In the travel pump's main hydraulic loop, the system relief and pressure limiting sections of the multifunction valve will respond when the preset relief pressure at port “B” is reached. At this time, the oil pressure will actuate the spring in pressure limiting valve (17), shifting its spool to open an exhaust path for the oil. Since servo check valves (18) are spring loaded with an opening pressure of 750 psi (52 bar), the oil flows through the exhaust port of displacement control valve (19). The exhaust port of valve (19) is restricted by orifices (A), causing flow to pressurize servo control cylinder (1) and destrokes the pump's swashplate to limit the system pressure. When rapid loading produces pressure spikes, system relief valve (16) shifts, allowing the high pressure oil to be returned to tank through charge pump relief valve (3) or transferring the oil into the low pressure side of the loop through charge flow make-up check valve (4).

In all other system pumps [both load drums, boom hoist, auxiliary hoist (if equipped), and swing], the pressure limiting feature of the multifunction valve is not present. Orifices (A) in the multifunction valve and flow control orifice (20) are removed from the EDC. In addition, servo check valves (18) are removed from the pump and the paths to the servo control cylinders are plugged. These internal changes to the pump configuration permit the pump to react more quickly to commands from the PC.

Also in these systems, pressure limiting valves (17) function as pilot valves to open system relief valves (16) when the relief pressure setting is reached. For example, when a pressure imbalance occurs on both sides of flow restrictor (21), pressure limiting valve (17) opens and system relief valve (16) relieves the system pressure from the circuit by directing the oil to tank through charge pump relief valve (3) or transferring the flow to the low pressure side of the loop through charge flow make-up check valve (4).

HYDRAULIC MOTORS

Variable displacement low torque/high speed, bent-axis piston motors are used in the hydrostatic transmissions of the load drum, boom hoist, travel, and auxiliary hoist (if equipped) systems. A fixed displacement low torque/high speed bent-axis piston motor is used in the hydrostatic transmission of the swing system. Each bent-axis motor contains a cylinder block, nine pistons, output shaft flange, and loop flushing (purge) valve assembly. The boom hoist, load drum, and auxiliary hoist (if equipped) bent-axis motors are also equipped with a pressure control pilot (PCP) valve that serves the same basic function and demonstrates similar operating characteristics as the pump EDC. Each travel motor contains a pressure compensator regulator (PCR) valve to accomplish the pressure control function.

The cylinder block of all system motors is tilted at an angle to the output shaft with the pistons fitted axially around its axis. The internal end of the output shaft has a large flange face which provides similar function to that of the pump swashplate. However, since the motor piston ends are retained to the output flange face, the pistons cannot rotate around the axis of the rotatable flange as the pump pistons do on the stationary swashplate.

Oil entering the motor from a system pump provides force against the motor pistons, causing the retained piston ends to thrust against the output flange with a rotational torque that turns the output shaft on its axis. This thrust also rotates the cylinder block on the bent axis while its tilt to the flange face reciprocates the pistons as they rotate. The oil displaced by the pistons returns to the system pump.

All motors, excluding the swing system motor, have a servo mechanism which tilts the cylinder block to vary the oil displacement. Contingent upon the particular system motor, the servo mechanism includes shuttle valve (22), servo control valve (23), and servo cylinder (24). These servo mechanism components initiate the motor operation for the load drums, boom hoist, and auxiliary hoist (if equipped) at maximum displacement. This provides maximum starting torque at a lower speed. When the servo mechanism tilts the cylinder block to the position of minimum oil displacement, the shaft output speed will be approximately five times faster and the available output torque decreases by approximately one-fifth of the maximum torque value.

The actuation of the travel motor servo mechanism is opposite of the other system motors. If working conditions permit, the travel motors begin operation at minimum displacement and tilt the cylinder block to maximum displacement after operation commences. Depending on the particular system motor in operation, the servo mechanism may utilize internally or externally supplied servo pressure to perform the shifting operation. Servo control oil is supplied from the high pressure line of motor port A or B and travels through shuttle valve (22) and servo control valve (23) before entering servo cylinder (24).

The hoist motors remain in maximum displacement until servo control valve (23) receives a command from PCP valve (25) to direct the constant pressure and flow from shuttle valve (22) to the minimum (or maximum) displacement side of servo cylinder (24) which shifts the motor. As the PCP valve opens in proportion to the current received from the PC, pilot oil from the rear drum charge pump is directed to shift servo control valve (23). After overcoming adjustable valve spring (26) and valve spring (27), which is preset by the cylinder block tilt angle, servo control valve (23) shifts and directs pressurized oil to stroke the motor into minimum displacement output. If the load on the motor increases, the cylinder block force on adjustable valve spring (26) increases. This forces servo control valve (23) to destroke the motor to maximum displacement for safe load handling.

The load drum and boom hoist circuits are also equipped with pressure compensated over-ride (PCOR) system valve (28) which activates at a preset pressure of 4,930 psi (340 bar). When increasing system pressure exceeds the PCOR setting, PCOR valve (28) shifts to direct oil flow from shuttle valve (22) into the maximum displacement side of servo cylinder (24). PCOR valve (28) overrides the command from servo control valve (23), causing an increase in motor displacement and output torque and a reduction in output speed. When PCOR valve (28) closes, the control of the motor returns to servo control valve (23).

Like all hydraulic motors, those used on the 888 have case oil drainage that lubricates the motors and provides a source for continuous recirculation of the oil supply to control heat generation in the closed-loop circuit. In addition to oil slippage for the prevention of excessive heat build-up, the motors incorporate an integral loop flushing (purge valve) system consisting of control valve (29) and relief valve (30). This loop flushing system allows 5 gpm (19 l/m) of oil at 350 psi (23 bar) to be removed from the main hydraulic circuit for additional cooling and purification. When pressurized by oil from the high pressure lines of motor ports A or B, control valve (29) shifts, initiating the flow of oil from the low pressure side of the circuit through the control valve and over relief valve (30) into the motor case. These valves assist the system in absorbing load shock or over-pressurization.

Charge Pressure

The diagnostic display can be used to obtain information about the system charge pressure. When a system handle is in the neutral position, the system diagnostic screens (DRUM 1, 2, 4, and 8; SWING; and TRAVEL) can provide this information (see 888 Diagnostic Display Folio).

Charge pressure in each of the closed-loop systems is established by setting the poppet-type relief valve in the system's charge pump. The charge pressure relief is preset by the manufacturer at 350 psi (25 bar) and will maintain the system pressure at a value greater or equal to this value depending on engine rpm. The charge pressure must be at a minimum of 120 to 150 psi (8 to 10 bar) for closed-loop system pump operation to occur; lower pressures cause a slowing or ceasing of system operation. When charge pressure is low, the PC does not destroke the closed-loop system pumps.

If charge pressure drops in the load drum, boom hoist, swing, travel, or auxiliary hoist (if equipped) systems, the low pressure system hydraulic brakes will automatically apply since the actuating brake pressure is indirectly sourced from its system charge pump. The brakes will begin to apply at a system pressure of 295 psi (20 bar) for the load drum systems, 308 psi (26 bar) for the swing system, 260 psi (18 bar) for the boom hoist system, and 250 psi (17 bar) for the travel and auxiliary hoist (if equipped) systems. The brakes will be fully applied at 219 psi (15 bar) for the load drums, 168 psi (12 bar) for the swing system, 140 psi (10 bar) for the boom hoist, and 165 psi (11 bar) for the travel and auxiliary hoist (if equipped) systems.

The charge pressure system of the rear hoist provides the pilot pressure to shift the servo cylinders of the load drum, boom hoist, and auxiliary hoist (if equipped) motors from maximum to minimum displacement, and the travel motor from minimum to maximum displacement. The rear hoist charge pump pressure is also used as pilot pressure to shift the accessory system valve.

Main System Pressure

The diagnostic display can also be used to acquire information about the main system pressure. When in use, the system diagnostic screens (DRUM 1, 2, 4, and 8; SWING; and TRAVEL) can provide this information (see 888 Diagnostic Display Folio). A more accurate indication of system pressure, however, can be obtained by monitoring the diagnostic manifold with a high pressure gauge [7,500 psi (517 bar) minimum] when the pump is stroked. As previously described, the system pressure for the load drum, boom hoist, swing, travel, and auxiliary (if equipped) pumps is controlled by one of two different configurations of multifunction valve cartridges consisting of system relief and pressure limiting valves. The pressure setting of the multifunction valves for each pump is listed in Table B. The limits should not be reached unless there is a failure in these systems.

This pressure limiting action prevents overheating of travel system oil by reducing discharging flow rate through relief valve feature of system multifunction valve.

The relief valve feature of the multifunction valves in all system pumps protects the pump systems from damage by limiting pressure above the system limits in each direction of operation.

Accessory System Pressure (Figures 4 and 5)

The crane setup hydraulic circuit is controlled through the use of the 30 gpm rear section of a tandem gear pump called accessory pump (1) and two “mobile-type” control valves called accessory system valve (2) and lower accessory valve (3). Each control valve has parallel operating circuits and contains relief valves (4) which are preset for 3,100 psi (215 bar).

When pressurizing a valve section in the setup system, by moving a system handle or energizing a valve solenoid, the flow passages to the high pressure carryover of either control valve is blocked, stopping oil flow to pilot-operated check valve (5). The pressurized oil within the pilot cavity of valve (5) exhausts to tank through bleed-off orifice (6) and permits the valve to close. The 30 gpm output from accessory pump (1) is no longer discharged to tank through check valve (5) but supplied to a function of the setup system.

TABLE B SYSTEM PRESSURE SETTINGS

SYSTEM	LOAD DRUMS		BOOM HOIST		SWING	TRAVEL
FUNCTION	Hoist	Lower	Up	Down	Left/Right	Fwd/Rev
PRESSURE psi (bar)	6,000 (414)	2,000 (138)	6,000 (414)	2,000 (138)	5,500 (379)	6,090 (420)

The pressure limiting feature of the multifunction valves in the travel pumps is not disabled. Should the pressure reach 6,090 psi (420 bar), the multifunction valves will destroke the pumps as needed.

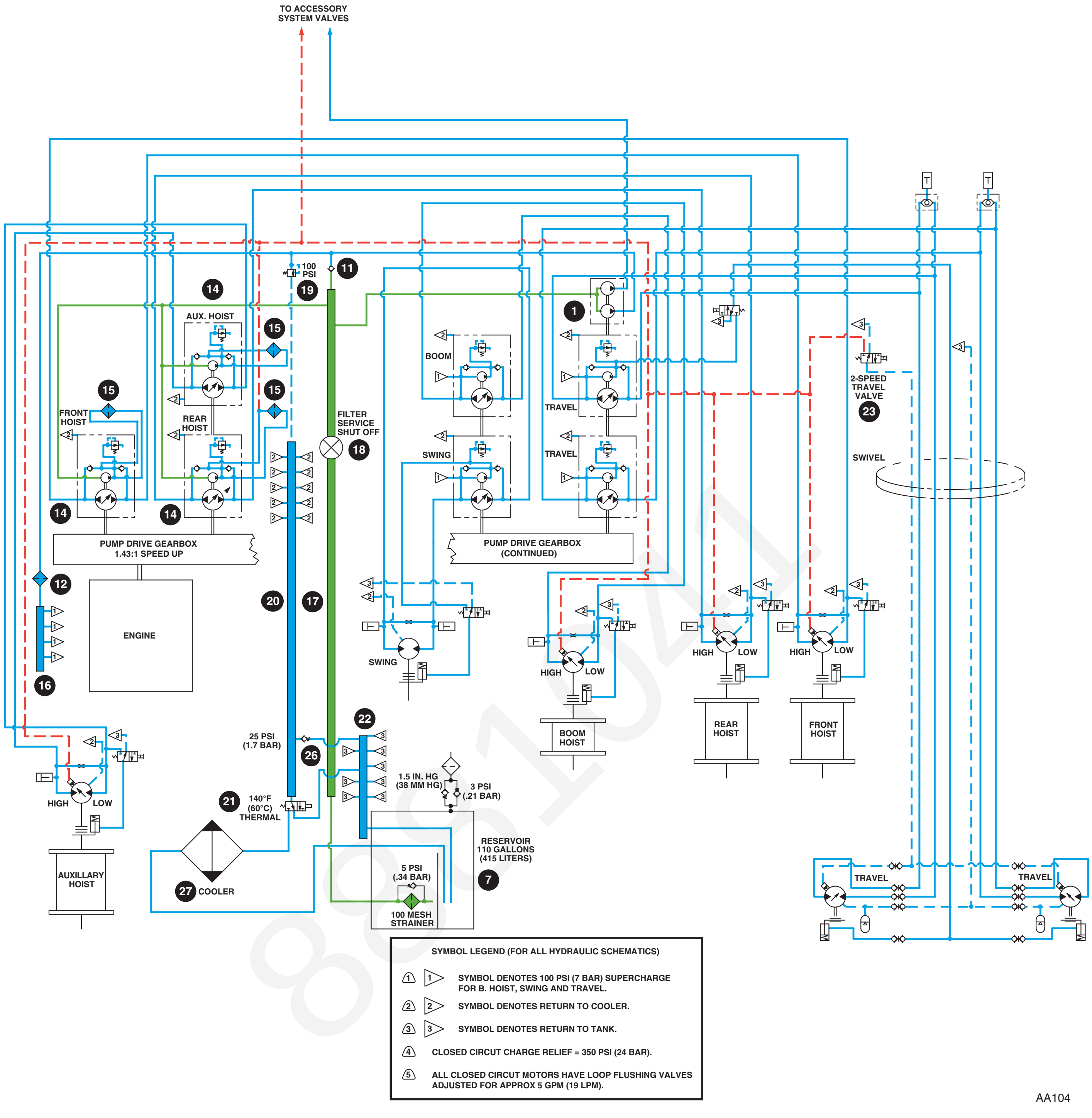


FIGURE 4 CRANE OPERATION HYDRAULIC SCHEMATIC

Hydraulic Supply (Figure 4)

The hydraulic supply is maintained by accessory pump (1) which provides 30 gpm of oil at 3,100 psi (215 bar) to all setup system hydraulic cylinders and 60 gpm of oil at up to 100 psi (7 bar) maximum pressure to the filtration super charge circuit. The super-charged oil is supplied to the boom hoist, swing, and travel pumps.

HYDRAULIC TANK

Hydraulic tank (7) is mounted on the right side of the upperworks. It has a vented fill cap, high and low level sight gauge, and temperature and level sensors. The digital display indicates the hydraulic oil temperature exceeding 180°F (82°C), and, if applicable, a low level hydraulic oil sensor in the reservoir.

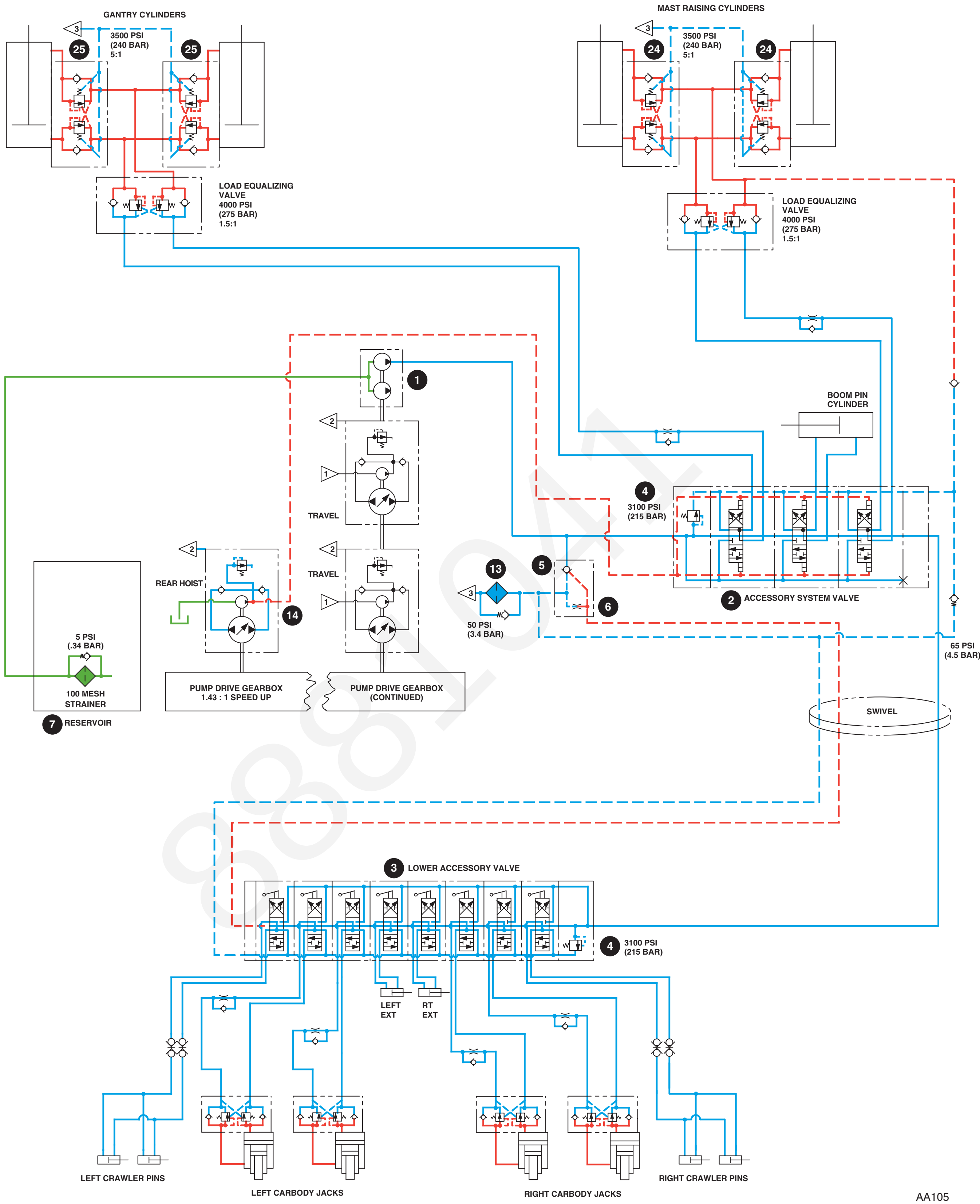


FIGURE 5 CRANE ACCESSORY SYSTEM HYDRAULIC SCHEMATIC

FILTRATION (Figures 4, 5 and 6)

NOTE Hydraulic circuit filters remove contaminants introduced by replacement oil or parts, dust particles acquired from the surrounding work area, and impurities generated from normal wear during system operations. To protect the crane's hydraulic circuit from harmful concentrations of these contaminants, filter elements should be periodically changed in accordance with an established maintenance schedule.

The hydraulic system provides various filtration circuits for maintaining the manufacturer's standards for hydraulic oil purity. The methods of filtration include return line, charge pressure, supercharge pressure, and suction filtration.

All oil exiting hydraulic tank (7) is suctioned through a 100 mesh strainer equipped with a 5 psi (0.34 bar) bypass valve. The bypass valve opens to permit oil flow to the various crane systems when the strainer is dirty or the oil temperature is too cold for direct operating conditions. At this time, hydraulic vacuum switch (8) on the filter head closes to complete the circuit to the PC. The PC responds by sending a diagnostic message (HYDRAULIC FILTER 5) to the operator display, indicating the strainer requires servicing. In addition, the PC activates fault system light (9) and fault system alarm (10). If activation of the fault system continues after the oil has warmed to normal operating temperatures, the tank strainer must be cleaned and/or the hydraulic oil changed as soon as possible to meet the operational viscosity requirements.

The crane setup hydraulic system employs a return-to-tank mode of filtration which ensures all oil is filtered before returning to tank. The chief advantage of this mode of filtration is apparent when the setup system is not being utilized. At this time, the system functions as a continuous tank filtration circuit. Accessory pump (1) withdraws oil from the tank and pumps it through pilot-operated check valve (5) and filter 4 (13) before returning to tank. Return line filtration also provides added protection by filtering contaminants which may have been injected into the setup system during repair or maintenance operations.

The return-to-tank filter or filter 4 (13) is equipped with a 50 psi (3.4 bar) bypass valve and a filter element with a rating of 13 micron absolute (μ abs). As the element becomes soiled, the pressure differential between the inlet and discharge flow ports of the filter increases, causing the element to lift and permitting the oil to return directly to tank unfiltered. Prior to the oil bypassing the filter, the filter 4 hydraulic sensing switch on the filter head closes to complete the circuit to the PC. The PC responds by sending a diagnostic message (HYDRAULIC FILTER 4) to the operator display, indicating filter 4 requires servicing, and activating fault system light (9) and fault system alarm (10). The filter must be replaced at this time.

The front and rear hoist pumps employ charge pressure filtration to meet the needs of each hoist's closed-loop circuit. In this method of filtration, charge pump section of pump (14) withdraws oil from the tank and pumps it through a remote filter adapter into filter (15) to be processed. The oil is then routed back into the front or rear hoist pump through the remote filter adapter. Note that the filter element contained in filter (15) has a rating of 13 μ abs. As the element becomes soiled, the pressure differential between the inlet and discharge flow ports of the

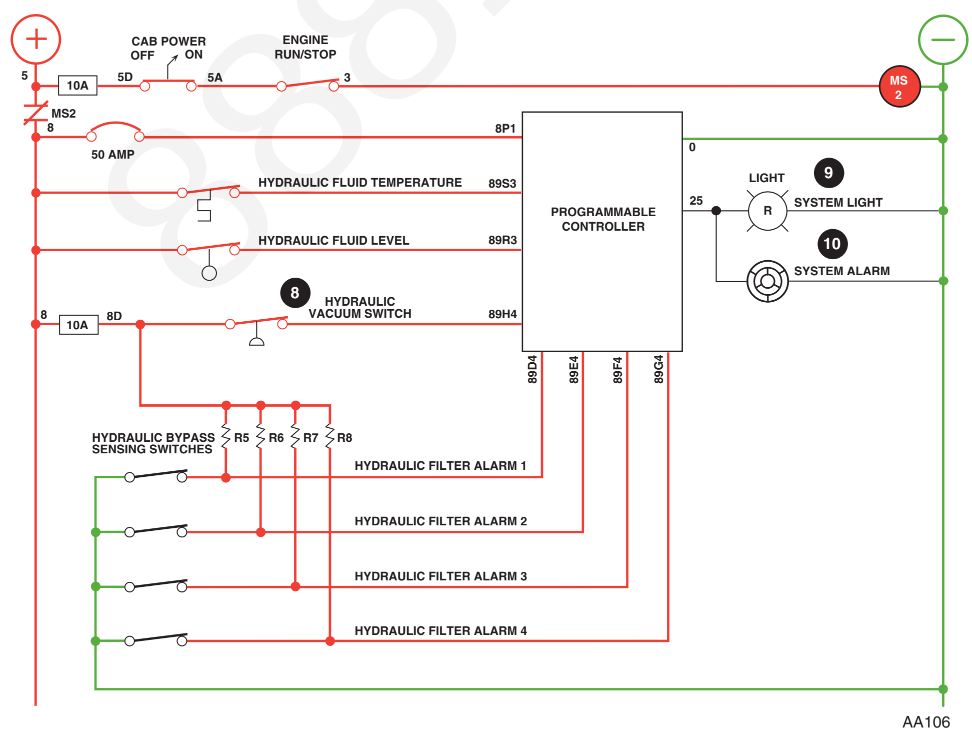


FIGURE 6 FILTRATION ELECTRIC CIRCUIT

filter increases. When the filter 2 or filter 3 hydraulic sensing switch on the filter head detects the pressure differential to be 40 psi (3.4 bar), the switch closes to complete the circuit to the PC. The PC responds by sending a diagnostic message (HYDRAULIC FILTER 2 for front hoist or HYDRAULIC FILTER 3 for rear hoist) to the operator display, indicating filter 2 or 3 requires servicing, and activating fault system light (9) and fault system alarm (10). The affected filter must be replaced at this time.

A supercharge filtration circuit supplies filtered oil to the charge pumps of the boom hoist, swing, and travel systems. This circuit uses accessory pump (1) to withdraw oil from the tank and deliver it at a pressure up to 100 psi (7 bar) through filter 1 (12) and into supercharge manifold (16). The pressure differential between the inlet and discharge flow ports of the filter increases as the element becomes soiled, causing the filter 1 hydraulic sensing switch on the filter head to close and complete the circuit to the PC. The PC responds by sending a diagnostic message (HYDRAULIC FILTER 1) to the operator display, indicating filter 1 requires servicing, and activating fault system light (9) and fault system alarm (10). The filter must be replaced at this time.

NOTE System filtration does not transform oil that has deteriorated from prolonged use into a purified fluid. Factors affecting the service life of hydraulic fluid include high operating temperatures, excessive exposure to moisture or dust in the work area, high concentrations of contaminant particles in the oil, or admixtures to the oil of unlike viscosity or chemical composition. A program to test or replace the hydraulic oil at timely intervals should be established in order to ensure efficient operation of the crane's hydraulic system.

NOTE Reference the 888 Lubrication Guide for recommended replacement oil for the 888 hydraulic system.

SUCTION MANIFOLD

Supply oil to load drum and auxiliary hoist (if equipped) pumps (14) and accessory pump (1) is obtained from suction manifold (17). When necessary, manifold (17) supplies oil to supercharge manifold (16) through check valve (11).

Suction manifold (17) is equipped with 4 inch ball valve (18). During hydraulic system maintenance operations, ball valve (18) can be closed to function as a service shut-off mechanism for the hydraulic system.

SUPERCHARGE MANIFOLD

The front section of tandem accessory pump (1) delivers 65 gpm of supercharge oil to supercharge manifold (16). The oil is filtered as it enters manifold (16) through filter 1 (12). Pressure in manifold (16) is controlled by relief valve (19) which is preset for 100 psi (7 bar). Manifold (16) distributes oil to the charge pumps of the boom hoist, swing, and travel systems.

OIL RETURN MANIFOLDS AND COOLING SYSTEM

The hydraulic system oil temperature is controlled by routing the return oil from all pump and motor case drain lines and the supercharge relief valve discharge line to return-to-cooler manifold (20). If thermal control valve (21) detects that the temperature of the return oil in manifold (20) is below 140°F (60°C), it directs the flow into return-to-tank manifold (22). Here, it combines with return oil from all hydraulic system brake valves, 2-speed travel valve (23), mast raising cylinders counterbalance valves (24), gantry cylinders counterbalance valves (25), accessory system valve (2), lower accessory valve (3), and cooler bypass safety valve (26) which is preset at 25 psi (2 bar). The combined flow from return-to-tank manifold (22) is then routed to tank.

If thermal control valve (21) detects that the temperature of the return oil in manifold (20) is above 140°F (60°C), it directs the flow into cooler (27) before returning to tank.

Pneumatic Supply (Figure 7)

The pneumatic supply provides air to the crane's pneumatic cylinders, both load drum brakes, and, if equipped, clutches for these systems. Air from compressor (1) fills wet tank (2) and dry tank (3) mounted internally above the rotating bearing between the right and left enclosures. The wet tank dries the air received from the compressor by removing and storing water and oil molecules. Water and oil which accumulates in wet tank (2) is automatically extracted and displaced at regular intervals by electric moisture ejector (4) mounted on the bottom of the tank. A manual bleed-off valve is also provided and should be opened at the end of usage each day to remove any moisture in the wet tank. There are no crane functions directly supplied by the wet tank, as the excess moisture would cause freezing or corrosion of downline components.

Dry tank (3) is the main storage tank that provides adequate air capacity to meet all air-actuated system requirements of the crane. While the air stored in the dry tank is relatively moisture-free, it is equipped with automatic electric moisture ejector (5) and manual drain line (6) for added protection against moisture accumulation. In general, moisture carryover from the wet tank would indicate excessive air system leakage or heavier than normal air usage. Optional air dryer (7) is specifically designed to remove excessive moisture from the air system when the crane is operated in extreme conditions such as highly humid environments.

In freezing temperatures, even small amounts of moisture accumulated in the air system can solidify and disable pneumatic operation. To prevent freezing and maintain uninterrupted operation of the air system, alcohol injector (8) forces small volumes of alcohol into the air circuit. The alcohol mixes with any moisture in the air system, substantially raising the freezing point at which operational problems can occur.

Air filter (9) is mounted with the alcohol injector in the right enclosure of the crane and helps separate particu-

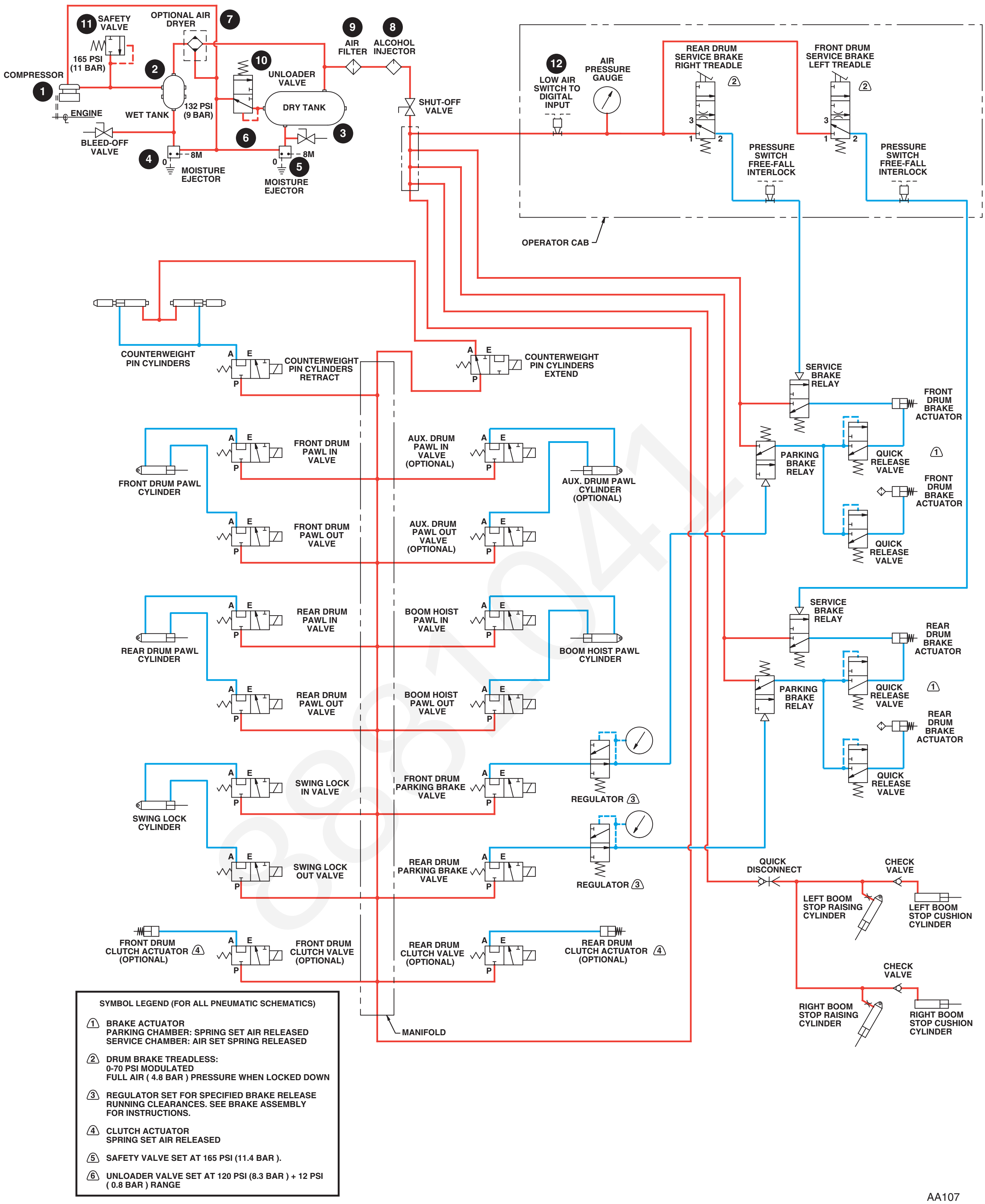


FIGURE 7 CRANE SYSTEMS PNEUMATIC SUPPLY SCHEMATIC

late matter from the system air prior to entering the downline alcohol injector.

Unloader valve (10) monitors the air pressure in the dry tank and adjusts the compressor's delivery rate when 132 psi (9 bar) is detected. Valve (10) controls this rate by briefly shutting down air flow from the compressor. During shutdown, the compressor cools while operating in a non-pumping (or non-loaded) condition. At approximately 120 psi (8 bar), valve (10) returns the compressor to its regular delivery rate. In the event that the unloader valve were to fail, safety relief valve (11) protects the air system by limiting the system pressure to 165 psi (11 bar).

To guard against unsafe system malfunctions related to low system pressure, low air switch (12), mounted below the cab, provides pressure data to the PC. Should the system air pressure drop below 90 psi (6 bar), the PC will activate the fault alert.

EPIC Programmable Controller (PC) (Figure 8)

Most of the crane's solenoid valves, pumps, and motors are directly controlled by electronic components on the PC's printed circuit boards. This simplifies the crane's electrical control system by avoiding mechanical control switches and relays; reliability and service convenience is increased, while service down-time is decreased.

The PC's standard or custom programming enhances operation convenience and precision control of the crane. The programming allows the PC to automatically adjust each operational mode's acceleration rate and speed, as well as apply brakes and release clutches when appropriate.

Voltage outputs from the controls, selectors, and switches command to the PC the function, direction, and rate of action the operator desires. The PC compares these input voltages to feedback voltages continuously received from the systems' monitoring sensors, and to memory data and directives entered into the PC's programming.

The PC then provides the solenoid valves, pump EDCs, and motor PCPs with the appropriate voltages needed to obtain the selected functions and control the systems' operation rates and direction. The PC varies the voltage levels and voltage flow directions to correspond with the voltages entering the PC from the control handles.

The monitoring sensors include limit switches; engine operation, hydraulic oil, and boom angle senders; an air system low pressure sender; pressure senders in each closed-loop hydraulic circuit; and boom hoist, load drum, and auxiliary hoist (if equipped) motor speed senders.

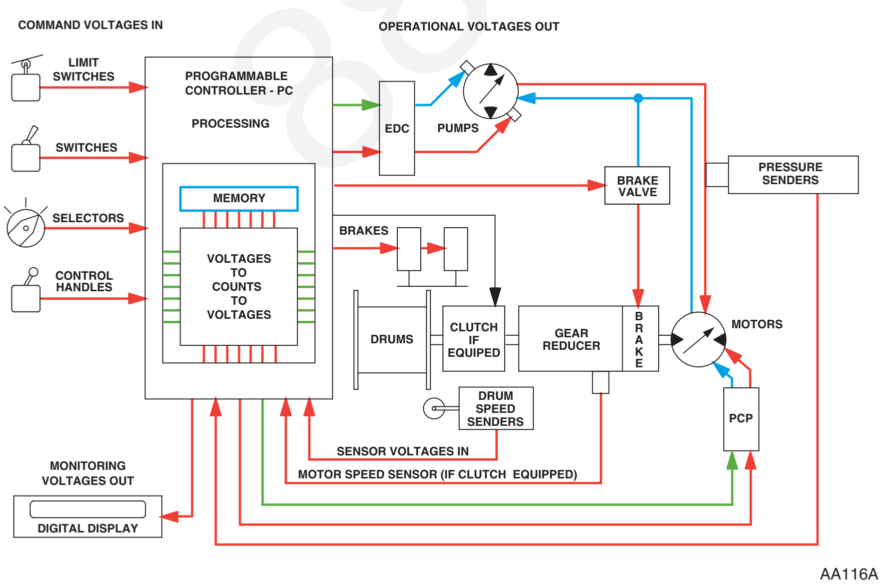
- Pressure senders measure system pressures and supply the PC with equivalent voltages. The pressures are memorized in the form of binary "counts" at crucial points during operation. See Figure 8 for a detailed system diagram.

The pressure senders are used by the PC in any liftcrane full power operation to determine the pressure needed to hold the load, boom, or luffing jib (if equipped) and prevent it from lowering momentarily when starting after releasing the brake.

- Drum speed senders detect the amount and direction of drum movement. The PC receives this information in the form of two out-of-phase square wave voltages which are also converted into "counts."

The speed senders are used by the PC to determine when to apply the brakes and to trim or adjust pump flow.

The monitored data and programmed memory are also used by the PC in providing voltage to air and hydraulic solenoids for automatic control of the brakes and clutches (if equipped) in their operational systems.



The programmable controller uses the binary mathematical system for its basic alphabet.

The binary system is based on 2 rather than 10 as is our mathematical system. This is because the controller recognizes only 0 and 1 as OFF and ON voltages. As 0 and 1 are two numbers, the system is called "binary," meaning composed of "two" alternate units or "bits" (the digits 0 and 1).

The basic "letters" of this system or "counts" are exponents of the number 2. These are formed into "words" or "bytes" of eight (or sixteen) numbers each. These numbers must therefore be 1, 2, 4, 8, 16, 32, 64, and 128 (for an 8-bit controller), or a combination thereof up to 255.

They are used to represent the electrical inputs to the controller. The controller processes this information by comparing it to its programming requirements, and its stored data or memory, and then provides appropriate voltages to the electric control devices of the crane's components.

FIGURE 8 SYSTEMS CONTROL DIAGRAM

Therefore, the operational systems function in direct relation to the control handles' commands while the PC automatically accounts for system conditions, equipment positions, and desired actions or limitations entered into the PC's program directives.

STANDARD CRANE MODE

Hoisting or lowering a load are operations performed using the load drums. Raising or lowering are operations performed with the boom hoist. For simplification, the handle commands for these operations will be referred to as "up" or "down."

When an up or down command is received from a control handle in full power mode, the PC compares the command with current sensor data and to previously memorized sensor data in order to control brake application and pump output. Enough pressure must be available to hold the load before the PC releases the park brakes. This also prevents momentary lowering of the load. Should there be a pressure loss, the brakes are automatically applied.

The control handle position provides a linear electric output to the PC, increasing or decreasing in proportion to the handle movement. The PC responds to the handle movement with a voltage output to the pump EDC which is appropriate for the task being performed. For example, in drum operation, the program provides more precise control needed during initial handle movement.

The PC receives the linear handle voltage and adjusts the voltage output to the appropriate load drum hoist pump EDC and motor PCP. During hoisting, the voltage is increased at a slower rate during the first half of handle travel than the last half. During lowering, the voltage is decreased at a slower rate as the handle gets closer to the off position until a switch in the handle opens the circuit at the off position.

The voltage sent to the pump EDC is either negative or positive as is appropriate to obtain commanded operation direction. The EDC tilts the pump swashplate to a position which strokes the pump to obtain the flow amount needed to perform the operation speed commanded; the more voltage received, the more the EDC tilts the swashplate. Therefore, operation is regulated in response to movement of the handle. Oil then flows from pump to motor; and at the appropriate moment, the PC releases the drum brakes.

When the load drums are equipped with clutches and operating in full power mode, the PC compares the drum speed sender output to the motor speed sender output to determine a speed difference. If there is a speed difference of the drum while lowering or if the drum lowers while raising (indicating a faulty clutch), the PC will activate the system fault warning light and alarm alerts, show a drum speed fault on the digital display, and apply the drum brakes.

As the control handle is moved back toward the off position, the PC proportionally decreases voltage to the EDC to decrease pump output flow. When the control handle is moved near the off position, the PC applies the park brakes.

Brake Application

As the control handle nears the off position, the PC compensates for hydraulic system leakage. System leakage is caused by changing load weight or changing engine speed. The PC adjusts the swashplate in the up direction until the load is supported, the handle command is off, and the drum speed sensor output is zero (indicating the drum has stopped moving). The PC then memorizes the holding pressure and applies the park brakes.

Brake Release

In all operation commands, even after an engine shutdown, the PC will not release the brakes until there is sufficient pump displacement to hold the load.

In an "up" operation, when the previously memorized holding pressure is reached as determined from the pressure senders, the PC releases the park brakes.

In a "down" operation, the PC first tilts the swashplate momentarily in the up direction by applying voltage to the EDC opposite to the control handle command. The PC then releases the park brakes when the previously memorized holding pressure is reached.

After releasing the brakes, the PC reverses the voltage to the EDC and responds directly to the control handle down command.

Brake and/or Clutch Application Verification

To verify the park brakes or clutches (if equipped) have physically applied when the control handle is brought to the off position during a load drum mode change from free-fall to full power, the PC checks for drum movement as indicated by zero output from the applicable drum speed sender.

- Should the boom hoist or load drum speed sender sense speed, the PC will activate the system fault warning light and alarm alerts and display a speed fault after the brakes set.
- Should the PC detect an output from the load drum motor speed sender (if equipped with clutches) during a load drum proving cycle, or detect an output only from the drum speed sender (indicating the clutch is not applied), it activates the system fault warning light and alarm alerts, initiates a drum speed fault at the display, and prevents the load drum from being used until the problem is corrected.
- If there is any sizable difference in output from the drum speed sender and motor speed sender during hoisting, there is movement in the drum caused by a faulty clutch. When this situation is detected, the PC activates the system fault warning light and alarm alert.

OTHER CRANE OPERATION MODES

The PC activates brake and clutch (if equipped) application, controls pump speeds, and arranges control handle use contingent upon other crane operation modes.

- In clamshell operation, the PC allows two drums to be operated at the same time with one control handle and turns on the power-down and closing features of this mode. The PC operates the EDC and engages and disengages the clutches (if equipped) when the drums are operated in free-fall mode. The park brakes are controlled by the PC.
- In luffing jib mode, the PC assigns appropriate limits to the luffing drum, and, if equipped for free-fall operation, disables this function for the luffing drum.
- In crane setup mode, the PC functions as it does in full power mode, as well as enables the setup cylinder functions.

DIGITAL DISPLAY

A digital display in the operator's cab shows the operating conditions, operating limits, and system faults being monitored by the PC. The information is accessible by scrolling to the desired display with the display selector scroll switch.

A listing of the specific data which is viewable on the digital display is shown in the three tables of the Digital Display Readings Folio. Table 1 identifies the operating conditions, unit of measurement, and the operating range. Table 2 identifies the operating limits, function response, and the required corrective actions. Table 3 identifies the system faults, alert activated, cause or result of the fault, and the response of the PC or the condition of the function.

SYSTEM FAULT ALERT

A system fault alert (red light and buzzer) will activate in the cab should any system fault occur which is listed in Table 3 of the Digital Display Readings Folio. The fault will be shown in the system fault section of the digital display when scrolled to that section. After the cause for the fault is corrected, the alert will turn off.

OPERATING LIMIT ALERT

An operating limit alert (yellow light and beeper) will activate in the cab should any operating limit listed in Table 2

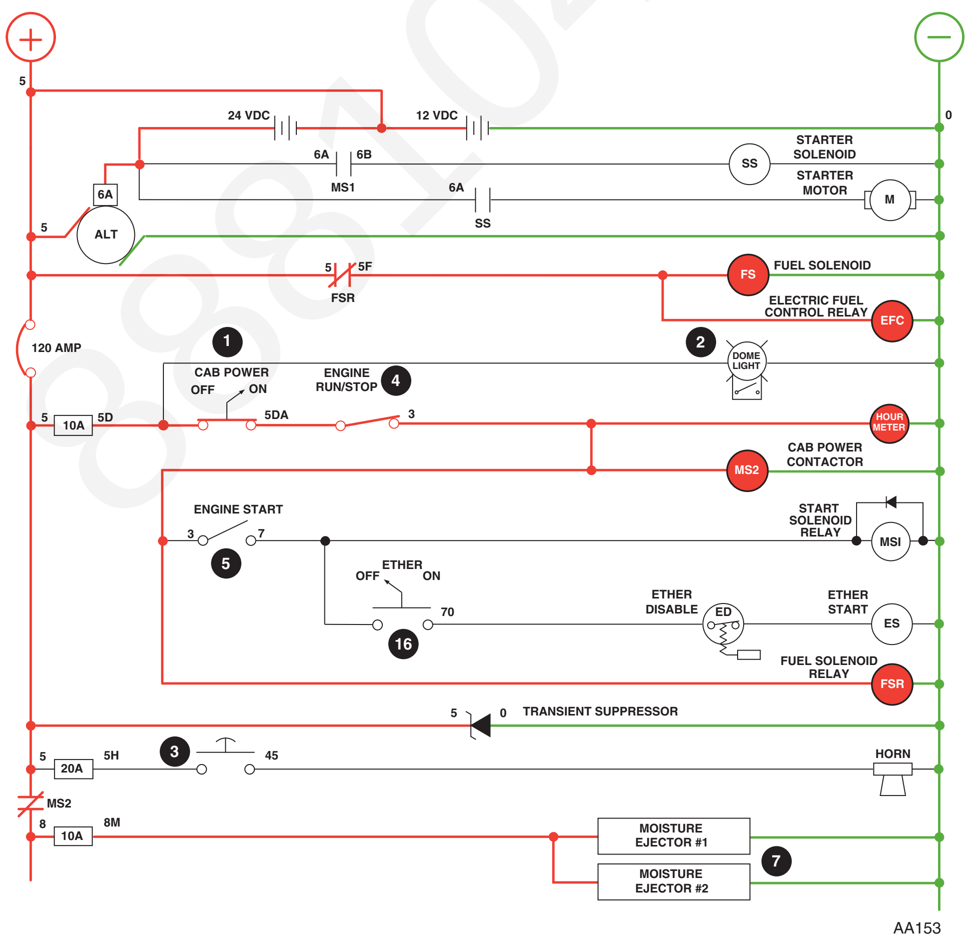


FIGURE 9 ENGINE START-UP ELECTRIC CIRCUIT (Engine Running)

of the Digital Display Readings Folio be reached. The limit will be shown in the operating limit section of the digital display when scrolled to that section. After the cause for the limit is corrected, the alert will turn off.

Voltage Availability (Figures 9, 10, 11, 12, and 13)

Voltage is available at key-operated cab power on/off switch (1), dome light switch (2), horn switch (3), and alternator ALT. After cab power switch (1) is activated, voltage is available to engine run/stop switch (4), which, when activated, provides power to the engine hour meter, cab power contactor MS2, and engine start switch (5).

When the contacts of MS2 close, voltage is available to the PC, low air pressure switch (6), and the hydraulic system and charge pressure senders (Figure 12). In addition, voltage is available to moisture ejectors #1 and #2 (7); the cab accessory controls including wipers (8),

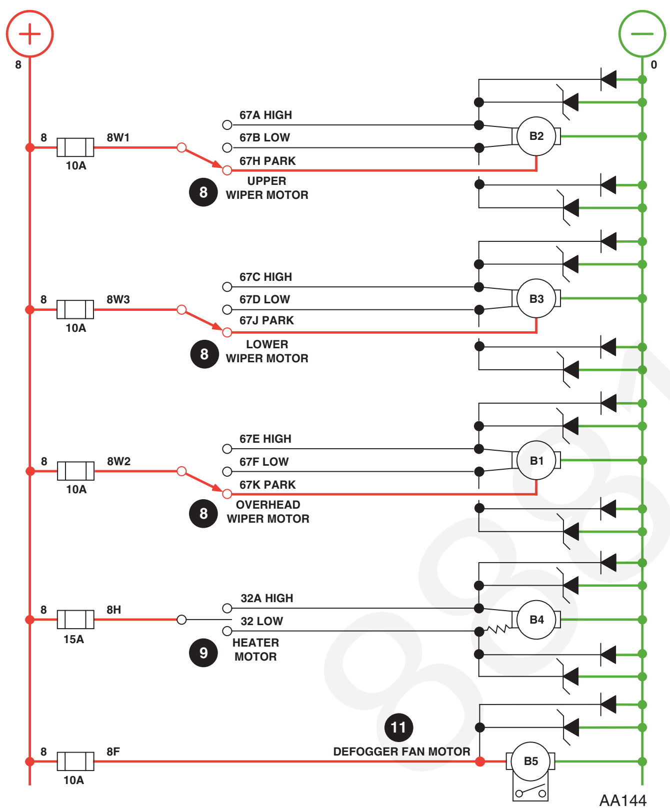


FIGURE 10 CAB ACCESSORIES ELECTRIC CIRCUIT

heater motor (9), and defogger fan (11); display scroll switch (12); battery voltage level sensor (13); operating limit switches and load moment indicator (14 and 15 if equipped); the crane mode and function switches; and the crane remote function switches.

Since voltage to engine start switch (5) is provided through cab power switch (1) and engine run/stop switch (4), these switches must be closed before attempting to start the engine. When engine start switch (5) is activated, power is supplied to start solenoid relay MS1. When the contacts of MS1 close, voltage is available to starter solenoid SS which closes contacts to starter motor M.

Activating engine start switch (5) also provides power to ether starting aid switch (16). In order to prime the ether injection mechanism for assisting with crane start-up, engine start switch (5) and ether switch (16) must be depressed and held at the same time to complete the circuit to ether start switch ES and ether disable switch ED. Release of ether switch (16) after approximately three seconds of priming discharges the ether into the engine air inlet manifold and disables the injection mechanism.

The PC also makes regulated voltage available to boom (17), luffing jib (18), and mast (19) angle indicators. Engine rpm is sensed by DC magnetic sensor (20). The PC processes the signal and displays the information on the digital display.

Limit Switches (Figures 12 and 13)

When MS2 is energized and contact MS2 is closed, voltage is available to operating limit switches (14) and limit by-pass switch (21).

The seat switch (Figure 12) and boom and gantry up limit switches (Figure 13) are standard equipment on the crane. The boom down and all other limit switches are optional.

During normal operation, all limit switches are closed, completing circuits to the PC. The PC will complete circuits to the pump EDCs and drum park brake solenoid valves to allow the pumps to be operated and the park brakes to be released.

If a limit switch is opened, the PC will open the appropriate circuit to the pump EDC and the brake solenoid. The pump then strokes to off and the solenoid valve closes, causing the brake to apply. However, any function can be operated in the opposite direction to correct the problem.

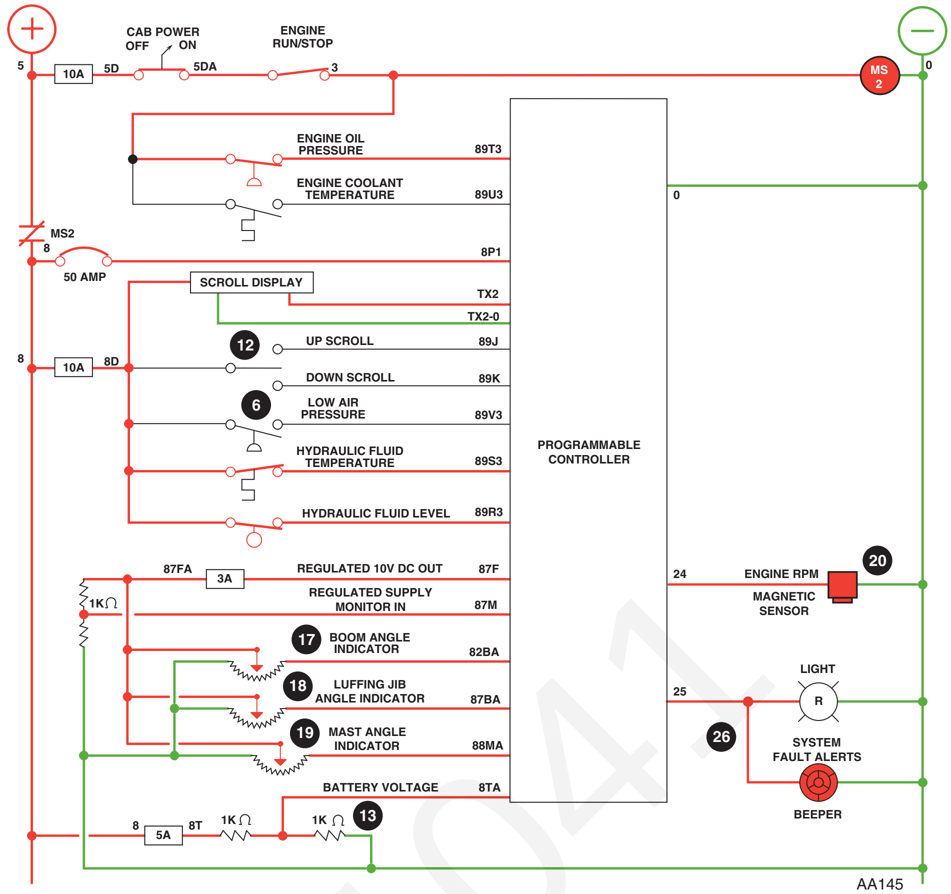


FIGURE 11 ENGINE AND FLUIDS MONITORING ELECTRIC CIRCUIT (Engine Running - System Fault)

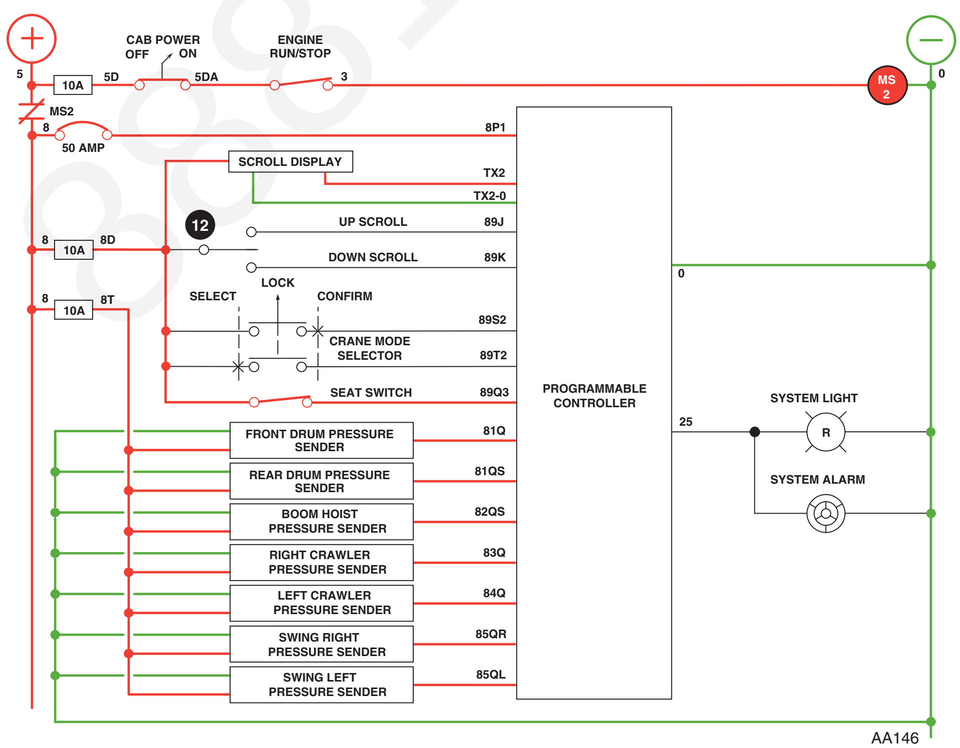


FIGURE 12 SYSTEMS MONITORING SENDERS ELECTRIC CIRCUIT (Engine Running - Normal Operation)

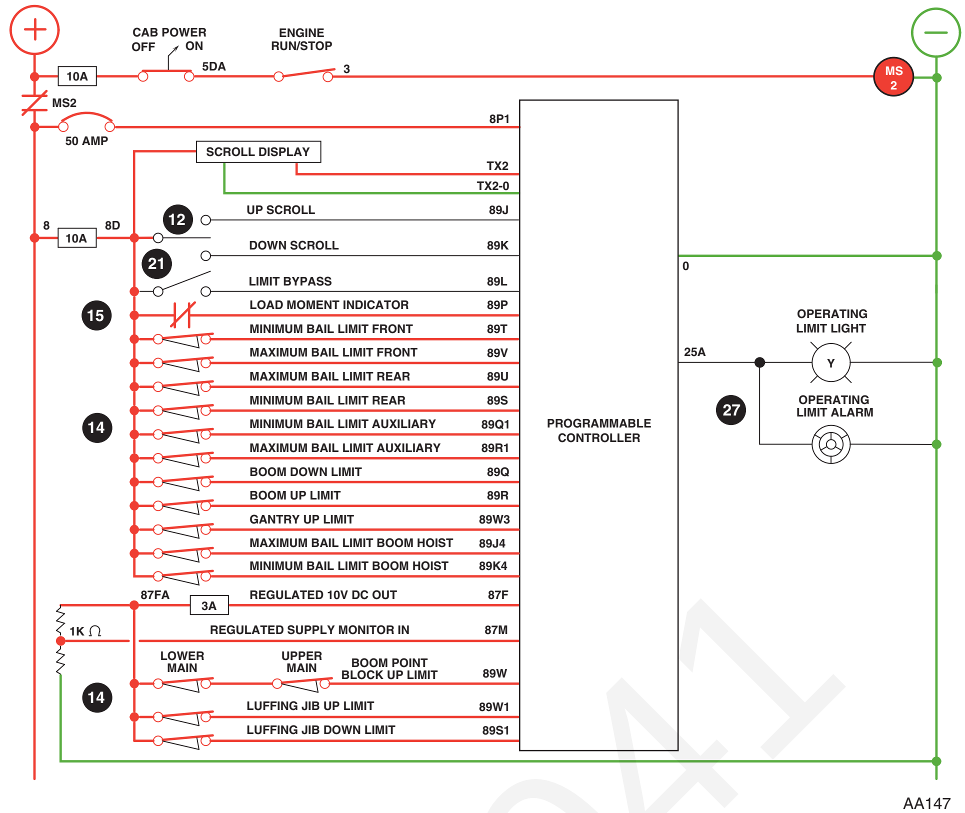


FIGURE 13 OPERATING LIMITS ELECTRIC CIRCUIT (Engine Running - Operating Fault)

The limits are actuated and the PC responds as follows:

- BOOM UP LIMIT automatically stops the boom when it is raised to a preset maximum angle (82° Inline Top, 83° Offset Top, 88° Luffing Jib).
- BOOM DOWN LIMIT automatically stops the boom when it is lowered to a preset minimum angle (usually 0°).
- BLOCK-UP LIMIT automatically stops the boom or luffing hoist from lowering and the load drums from hoisting if the load contacts a block-up limit switch.
- LUFFING JIB UP LIMIT automatically stops the luffing jib when the boom to luffing jib angle is 168°.
- LUFFING JIB DOWN LIMIT automatically stops the luffing jib when the boom to luffing jib angle is 60°.
- MAXIMUM BAIL LIMIT automatically stops the corresponding load drum from hoisting when there is a preset maximum number of wire rope layers on the drum.
- MINIMUM BAIL LIMIT automatically stops the corresponding load drum when there are three wraps of wire rope remaining on the drum.
- LOAD MOMENT INDICATOR (if equipped) refer to the manufacturer's manual for description of function.
- GANTRY DOWN LIMIT automatically stops the boom hoist when the mast is lowered to 135° with the gantry down.
- MAST TOO FAR FORWARD automatically stops the boom hoist when the mast is lowered to 175°.
- PARK MODE prevents the crane from being operated by rendering all control handles inoperable, maintaining application of all park brakes, and turning off the free-fall (if equipped) and travel detent systems.

The operating limit alerts will activate when one of the limit switches is opened. The digital display will identify the limit involved if display scroll switch (12) is used to scroll the display up or down to the operating limits display function.

Limit by-pass switch (21) allows the crane functions to be operated beyond the limits for maintenance purposes only. For example, to spool excess wire rope onto the load drums or to remove the wire rope from the load drums after an operating limit has been activated.

Brake Release System

The load drum, travel, swing, boom hoist, and auxiliary hoist (if equipped) brakes are hydraulically released. The load drums also have a pneumatically released band-type brake, and, when equipped with free-fall, have a spring-released working brake.

<u>HYDRAULICALLY RELEASED</u> (Figure 4)

Release of the load drum, travel, boom hoist, and auxiliary hoist (if equipped) brakes is controlled automatically by the PC once the selected system's park switch is placed in the OFF position and its control handle is move from off. The release of the swing brake is controlled independently when the operator places the swing brake switch in the OFF position.

When the load drum, travel, swing, boom hoist, or auxiliary hoist (if equipped) brake hydraulic solenoid is energized, the applicable valve shifts to block the tank port and to supply charge pressure from the low pressure side of the system's closed-loop circuit to the appropriate brake. The brake then releases.

When a brake solenoid is de-energized, the valve closes to block the pump port and to vent pressure in the brake to tank. The brake then spring-applies.

If brake pressure or electric current is lost for any reason during operation, the brakes will spring-apply to stop the function.

<u>AIR OR SPRING RELEASED</u> (Figures 14 and 15)

The front and rear load drums are equipped with air-controlled brakes. Each drum brake is actuated by two air cylinders having two chambers each: a parking brake chamber which is spring-applied/air-released and a working brake chamber which is air-applied/spring-released. The working brake chamber of one cylinder is not used, and the other is only used when the crane is equipped for free-fall operation.

<u>Parking Brakes</u>

When rear/luffing drum park brake or front drum park brake air solenoid AS10 or AS12 is energized by the PC, via activation of the selected park switch, air from regulator (1) flows into and shifts park brake relay (2). This allows a proportional amount of manifold air to flow through to close the diaphragms of quick release valves (3). The air flows into the parking chambers of brake cylinders (4), compressing the springs to release the brakes. With the brakes released, the appropriate load drum motor can handle the load when operating in full power mode or the operator can control the load with the working brakes when operating in free-fall mode.

When in standard crane mode and the selected load drum handle is in the neutral position, or its park switch is

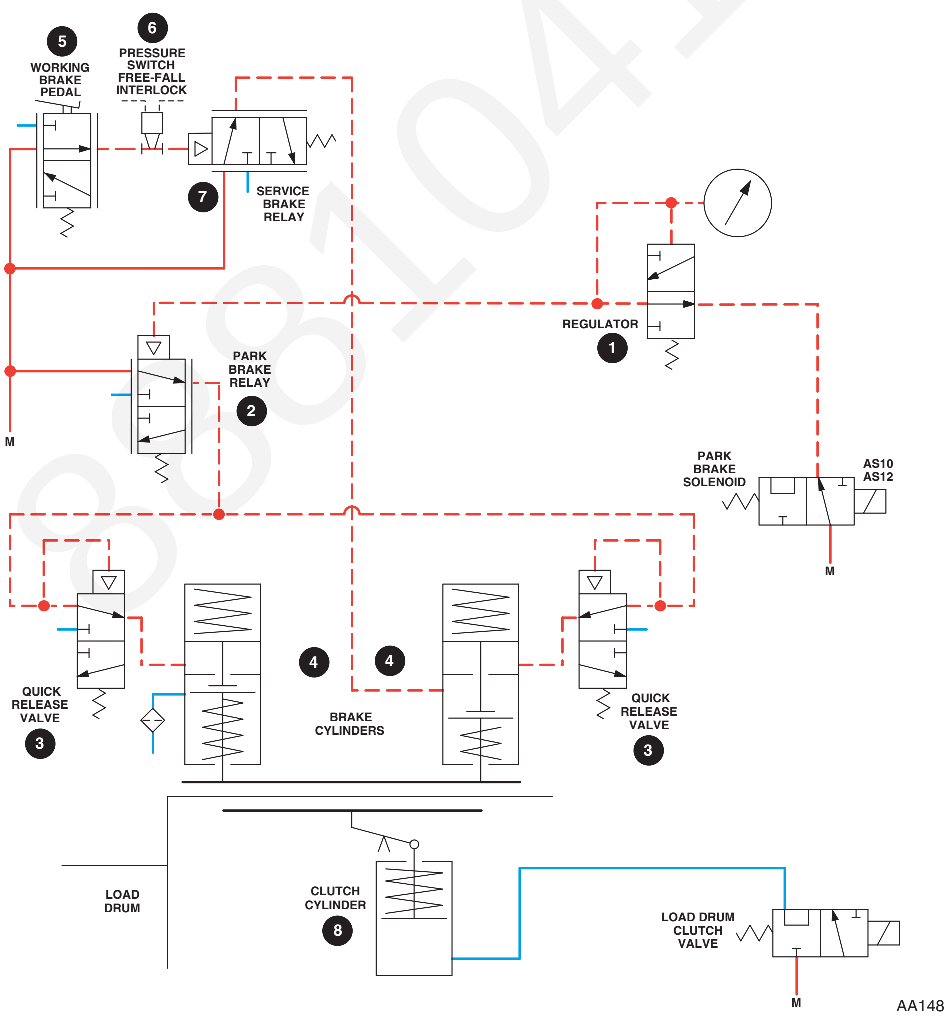


FIGURE 14 LOAD DRUM AIR SCHEMATIC (Working Brake Applied - Parking Brake Released - Clutch Applied)

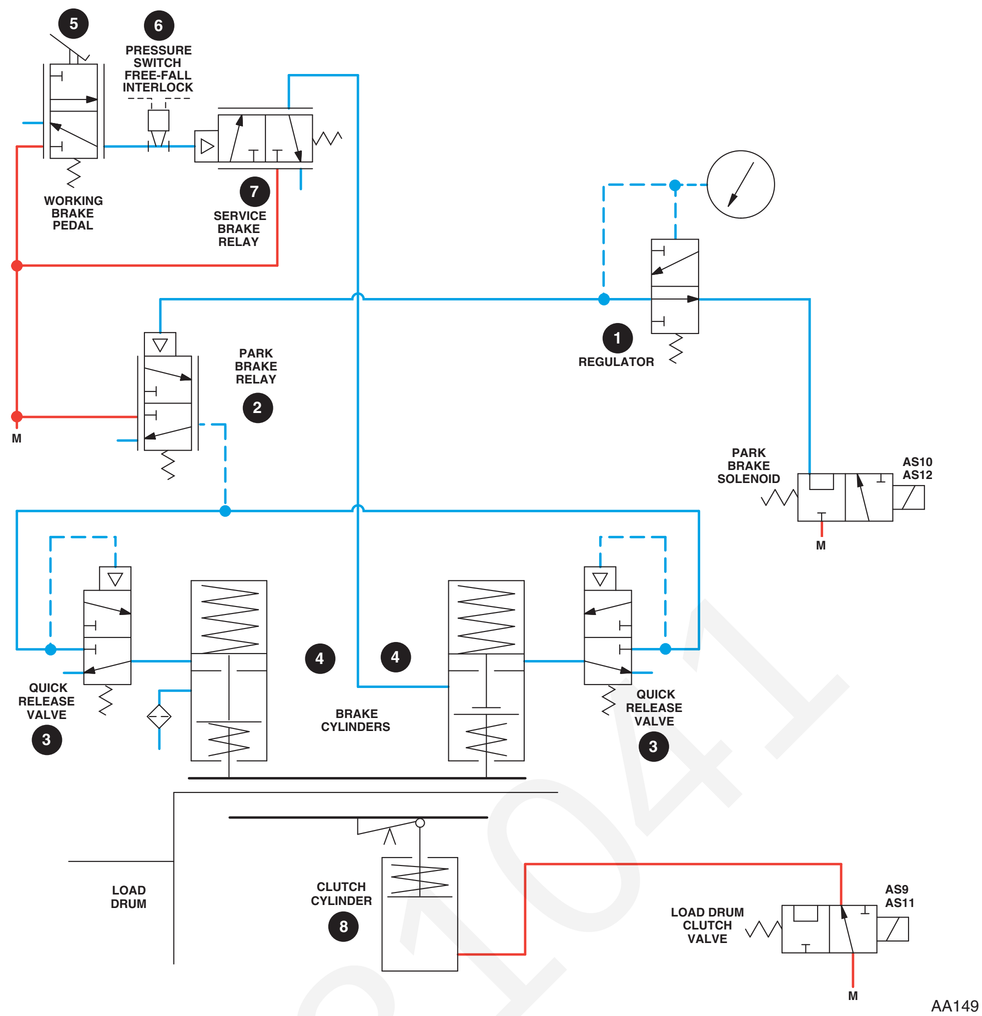


FIGURE 15 LOAD DRUM AIR SCHEMATIC
(Working Brake Released - Parking Brake Applied - Clutch Released)

in the OFF position as when the operator leaves the crane, the park brakes are immediately spring-applied. Air in cylinders (4) is dumped to ensure that the drum brakes spring-apply. The air is exhausted from the cylinders directly through quick release valves (3) when sealing pressure is exhausted off the diaphragms of these valves, opening the exhaust ports. This occurs when pilot pressure is removed from park brake relay valve (2).

When AS10 or AS12 is de-energized and pilot pressure is exhausted from park brake relay (2), the park brake relay valve closes, exhausting the sealing air from the diaphragms of quick release valves (3) to directly exhaust the air from cylinders (4), causing the cylinder springs to apply the park brakes.

<u>Working Brakes</u> (if equipped for free-fall)

The working brake chamber is controlled manually by the operator with the working brake pedal for the selected drum. When working brake pedal (5, Figure 14) is applied, the amount of air that flows through its pressure switch free-fall interlock (6) acts as pilot pressure upon service (working) brake relay (7).

Service brake relay (7) shifts to allow a proportional air flow from the manifold to pass through to the working brake chamber of one cylinder (4), compressing the release spring and applying the brake against the drum.

The pressure applied by the brake is in direct proportion to the brake pedal movement. When the pedal is fully applied and latched, full brake application is obtained. When pedal (5, Figure 15) is released, the working brake is released at the same rate as the pedal movement until completely released.

Load Drum Clutch Release System (if equipped for free-fall)

The clutches of the front and rear load drums are air controlled. Each is spring-applied/air-released. The clutches are controlled automatically by the PC in conjunction with movement of the selected load drum control handle when operating in free-fall mode.

When in free-fall mode with the control handle in the neutral position, the circuit to AS9 or AS11 is shifted closed by the PC and air flows to drum clutch cylinder (8, Figure

15). Therefore, the clutch application spring is compressed so the clutch disconnects the drum from the motor.

When the control handle is actuated in free-fall mode, the PC ensures the circuit to rear/luffing drum or front drum clutch air solenoid AS9 or AS11 is open. Manifold pressure is then blocked and air is exhausted from the cylinder of drum clutch (8, Figure 14). Therefore, the clutch spring-applies.

Throttle System (Figures 9 and 16)

The primary components of the crane throttle system include electronic fuel control (EFC) module (1), EFC actuator (2), magnetic engine rpm transducer (3), foot throttle (4), and hand throttle (5).

When throttles (4 or 5) are moved from the off position, a regulated voltage circuit from the throttle linear potentiometer is completed to EFC module (1). Module (1) compares this input signal to an electronic signal received from engine rpm transducer (3) which monitors the speed of the engine flywheel via a magnetic pickup. When detecting a difference in the two signals, module (1) changes the current input to EFC actuator (2), causing the actuator shaft to rotate in the appropriate direction to either increase or decrease the fuel flow and engine speed and power.

In addition to communicating with module (1), transducer (3) also provides an electronic signal to the PC. The PC interrupts the incoming signal and provides engine speed data for scroll display (6).The PC also limits the travel motor speed to maximum displacement and controls the travel system hydraulic pressure when engine speed is below 1500 rpm.

Transducer (3) is also used in the PC nulling routine of the hydraulic pressure senders at engine start-up. After placing engine run/stop switch (4, Figure 9) in the RUN position and prior to placing engine start switch (5, Figure 9) in the START position, the PC monitors engine speed data received from transducer (3). If the PC detects no engine speed after four seconds, the PC sets the incoming voltages from the pressure senders to 0 psi.

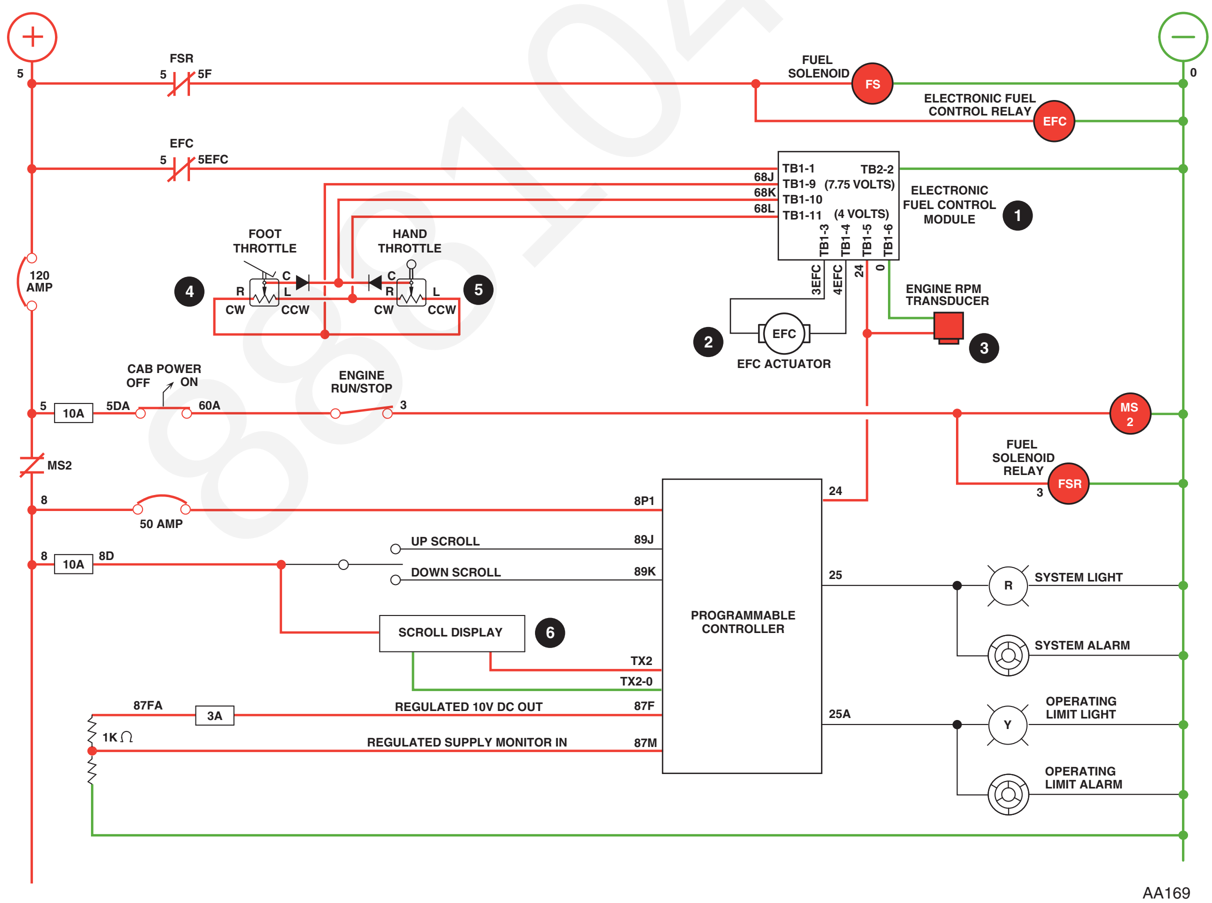


FIGURE 16 THROTTLE SYSTEM ELECTRIC CIRCUIT (Throttles OFF)

BOOM HOIST SYSTEM OPERATION

NOTE If boom hoist charge pressure is lost for any reason, boom hoist park brake (1) will apply to stop the hoist since the brake is indirectly sourced from this pressure.

General (Figures 17 and 18)

If the boom hoist park switch, located on the front console in the operator's cab, is placed in the ON position, the boom control handle circuit to the PC opens and does not complete the circuit from the PC to boom hoist park brake hydraulic solenoid HS6. Because these circuits are open, boom hoist park brake (1) remains applied and boom hoist pump (2) does not stroke in response to movement of boom hoist control handle (3). The boom hoist park brake is sourced from the boom hoist charge pump, and charge pressure must be at least 260 psi (18 bar) for full release of the boom hoist park brake.

BOOM HOIST ROTATION INDICATOR

Whenever the boom hoist drum rotates, boom hoist drum speed sender (4) completes a circuit to the PC which activates rotation thumper (5) in control handle (3). This causes rotation thumper (5) to move up and down with a varying frequency that conveys the rotational speed of the drum to the operator.

Boom Off (Figures 17 and 18)

When control handle (3) is in the off position, the PC receives no voltage from the handle, and the PC opens the circuits to the boom hoist pump EDC, boom hoist motor PCP valve, and boom hoist park brake hydraulic solenoid HS6. Because these circuits are open, boom hoist pump (2) does not stroke, boom hoist motor (6) remains at low speed, and boom hoist park brake (1) remains spring-applied to prevent the boom hoist from turning.

Boom Raise (Figures 18 and 19)

When control handle (3) is pulled back for up operation, the PC closes regulated voltage circuits to the boom hoist pump EDC and boom hoist motor PCP valve. In addition, the circuit to the boom hoist park brake hydraulic solenoid HS6 closes. These circuits will close only if the boom hoist park switch is in the OFF position, the boom up limit switch (see Figure 13) is closed, and no system or operating faults are present.

PC programming requires boom hoist pump (2) to stroke before the boom hoist park brake is released. This ensures adequate pressure is present to hold the boom

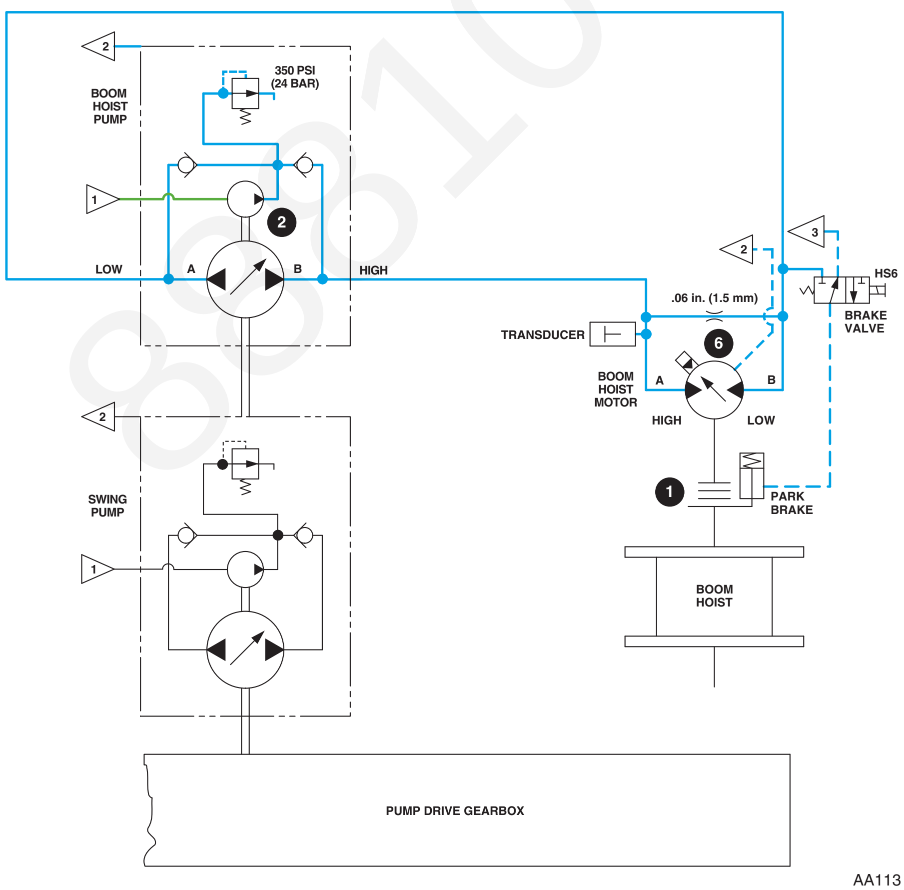


FIGURE 17 BOOM HOIST HYDRAULIC SYSTEM (Standard Mode: OFF)

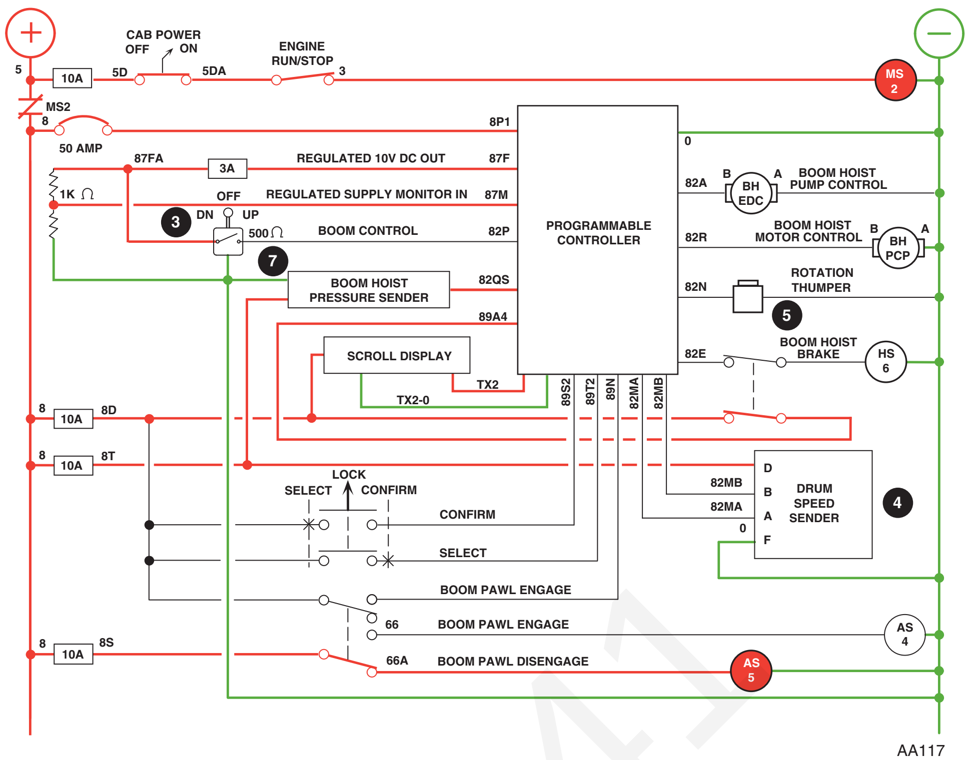


FIGURE 18 BOOM HOIST ELECTRIC CIRCUIT (Standard Mode: OFF)

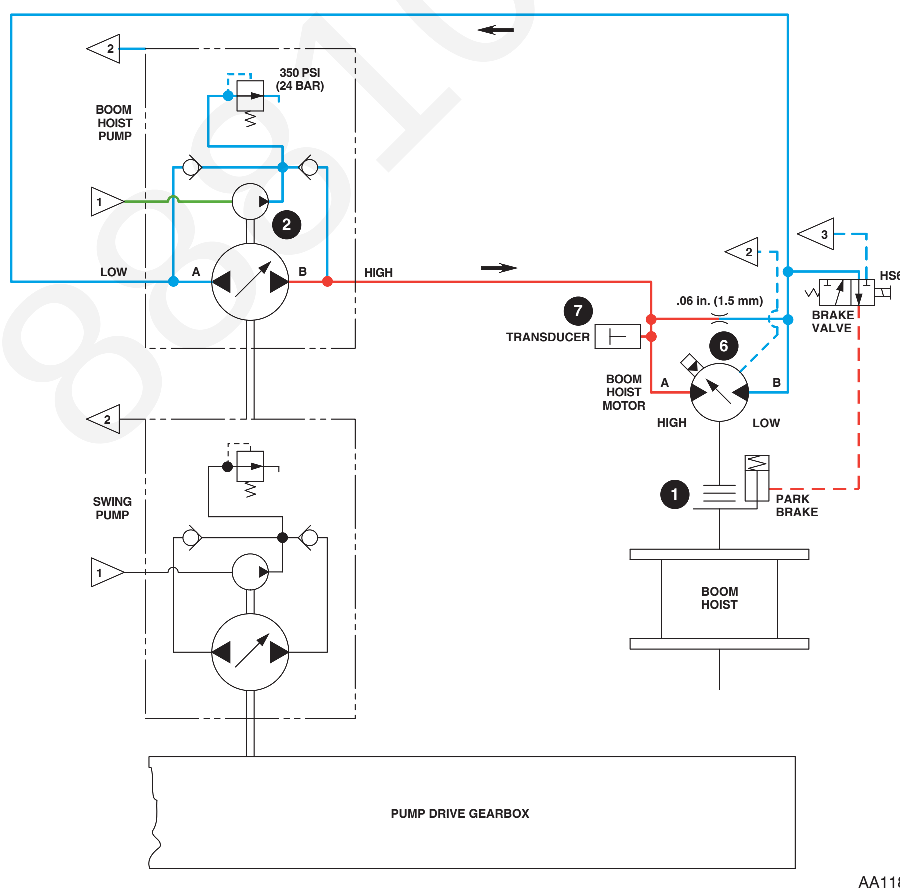


FIGURE 19 BOOM HOIST HYDRAULIC SYSTEM (Standard Mode: RAISE)

after full release of the park brake. The PC sends a regulated voltage to the boom hoist pump EDC which tilts the pump swashplate to stroke the pump in the up direction. Oil then flows from pump port B to port A of boom hoist motor (6) as oil returns to pump port A from motor port B.

Boom hoist pressure sender (7) supplies the PC with pressure development data which the PC compares to the memorized holding pressure of the boom hoist. When adequate pressure is available, the PC energizes HS6 to shift the brake valve. This initiates full release of park brake (1) and boom hoist motor (6) raises the boom assembly.

The PC governs the raising speed of the boom by varying the voltage to the pump EDC in proportion to movement of control handle (3). Therefore, the angle of the pump swashplate is increased as the control handle is moved farther backward, pumping more oil to the motor and raising the boom faster.

As control handle (3) approaches the full handle command position, and if lifting conditions permit, the boom hoist motor PCP valve is instructed by the PC to shift and redirect oil flow to motor servo cylinder (24, Figure 2). This allows the servo mechanism to shift the motor to minimum displacement for maximum motor speed.

As control handle (3) is returned to the off position, the PC decreases the boom hoist pump swashplate angle. This change in swashplate tilt reduces oil flow output and commands the boom hoist motor PCP valve to shift the motor to maximum piston stroke for slower output speed. This slowing of the output speed slows the drum rotation.

When the control handle is in the fully off position, the PC memorizes the pressure required to support the load and stores it into its “pressure memory.” The PC also de-energizes HS6 to apply the brake after the control handle neutral switch opens or after receiving a zero command from drum speed sender (4).

<u>BOOM STOP, CUSHION, AND LIMIT</u> (Figure 20)

Should the load suddenly be reduced while the boom is raised to an angle between 75° and 77°, cushion cylinders (8) slow the boom's opposite movement. Check valves (9) prevent compressing air from escaping the cylinders, in turn, maintaining the continuous increase of pressure in the cylinders and slowing the boom before it stops. The orifices of boom stop cylinders (10) act as shock absorbers for the lowered boom struts during transport of the crane.

If the boom is raised to the maximum boom stop position (83° above horizontal during boom hoist operation), the boom up limit switch (see Figure 13) opens the circuit. Boom hoist pump (2) then strokes to off and park brake (1) applies to stop the boom hoist. The boom should be lowered to correct the problem.

Boom Lower (Figures 18 and 21)

When boom hoist control lever (3) is pushed forward for down operation, the PC closes a reverse polarity regulated voltage circuit to the boom hoist pump EDC, a regulated voltage circuit to the boom hoist motor PCP valve,

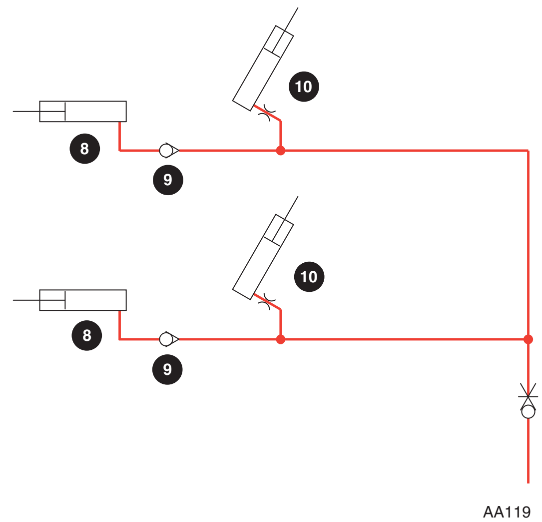


FIGURE 20 BOOM STOP AIR SYSTEM

and boom hoist park brake hydraulic solenoid HS6, provided the boom hoist park switch is in the OFF position, the boom down limit switch is closed, and no system or operating faults are present.

Before releasing the park brake, the PC programming requires boom hoist pump (2) strokes momentarily in the hoisting direction to reach the memorized boom hoist holding pressure.

Boom hoist pressure sender (7) supplies the PC with pressure development data which the PC compares to its pressure memory. When adequate pressure is available, the PC energizes HS6, shifting the brake valve to block the tank port and open the port from the low pressure side of the closed loop to the spring chamber cylinder of park brake (1). This process releases the brake. At the same time, the PC reverses voltage to the boom hoist pump EDC to tilt the swashplate in the lowering direction. Oil then flows from pump port A to port B of boom hoist motor (6) to begin lowering the boom as oil returns to pump port B from motor port A.

The weight of the boom attempts to drive the motor faster than return oil is available to the pump. Boom hoist charge pump (2), however, maintains the oil supply at a positive pressure to boom hoist motor (6).

The position of the pump's swashplate restricts the returning oil flow. Pressure builds on the return oil side of the closed-loop circuit, acting as a brake against the boom hoist motor to control the lowering speed.

The PC governs the lowering speed of the boom by varying the voltage to the boom hoist pump EDC in proportion to movement of control handle (3). Therefore, the angle of the pump swashplate is increased as the control handle is moved farther forward; more oil is allowed to return to the pump, more oil is pumped to the motor, and the boom lowers the load faster.

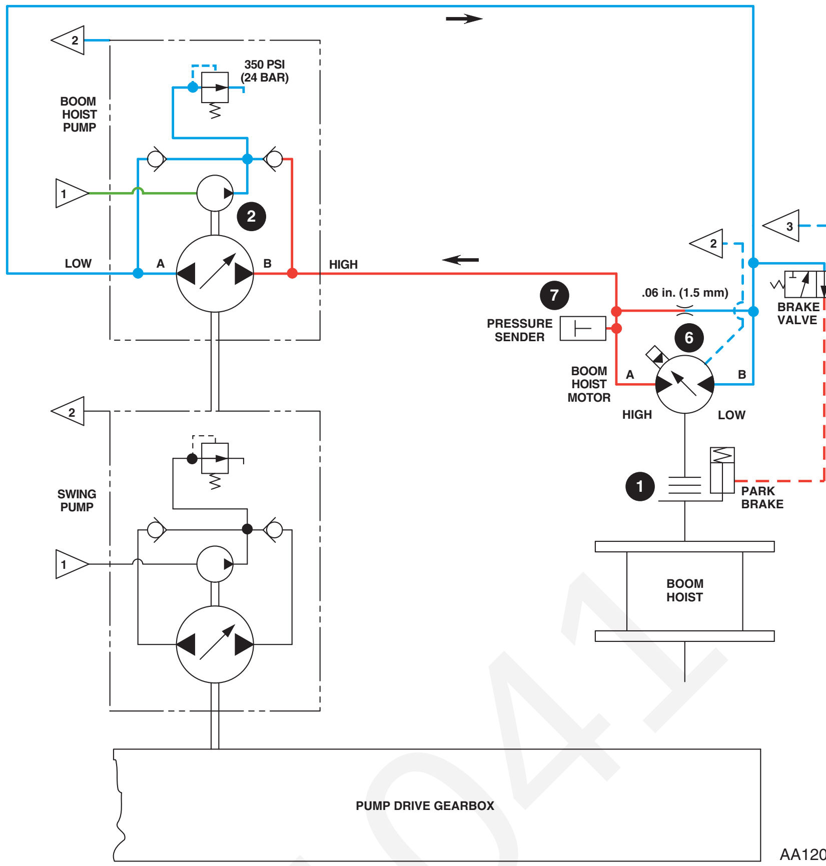


FIGURE 21 BOOM HOIST HYDRAULIC SYSTEM
(Standard Mode: LOWER)

As control handle (3) approaches the full handle command position, and if lifting conditions permit, the boom hoist motor PCP valve is instructed by the PC to shift and redirect oil flow to motor servo cylinder (24, Figure 2). This allows the servo mechanism to shift the motor to minimum displacement for maximum motor speed and less operating torque.

As control handle (3) is returned to the off position, the PC decreases the boom hoist pump swashplate angle. This change in swashplate tilt reduces oil flow output and commands the boom hoist motor PCP valve to shift the motor to maximum piston stroke for slower output speed. This slowing of the output speed slows the drum rotation.

When the control handle is in the fully off position, the PC memorizes the pressure required to support the load and stores it into its “pressure memory.” The PC also de-energizes HS6 to apply the brake after the control handle neutral switch opens or after receiving a zero command from drum speed sender (4).

SWING SYSTEM OPERATION

General (Figures 22 and 23)

In order for normal swing operation to occur, the swing closed-loop charge pressure must be about 180 psi (12 bar). If the charge pressure drops below this amount, the hydraulic brake will begin to partially or fully apply.

After start-up, swing park switch (2), located on the right console in the operator’s cab, is placed in the OFF position, closing the circuit to swing park brake hydraulic solenoid HS7. Swing brake control valve (3) is shifted against its spring, allowing oil to flow through to swing park brake (4). The pressure compresses the brake spring to release the brake.

When swing park switch (2) is placed in the ON position, the circuit to swing brake hydraulic solenoid HS7 is opened. Spring force shifts swing brake valve (3) and the pressure in swing park brake (4) is vented to tank so the brake spring-applies.

Swing holding brake switch (5), located on the side of swing control handle (1), provides the operator with an alternative means of preventing swing movement. Depressing switch (5) opens a circuit to the PC. The PC then opens this circuit to the swing pump EDC which places swing pump (6) in neutral and applies the brake by closing the circuit to swing park brake hydraulic solenoid HS7.

NOTE To prevent damage to the swing system components, swing holding brake switch (5) should only be applied when the machine is in a stand-still position. When in a swinging motion, the preferred method of stopping or slowing the crane is to move swing control handle (1) beyond center in the opposite direction of movement. This causes a hydrodynamic slowing of the upperworks.

SWING LOCK (Figures 22 and 24)

When swing lock switch (7), located on the right console in the operator's cab, is placed in the DISENGAGE position, the circuit to swing lock disengage air solenoid AS7 is closed, and the circuit to swing lock engage air solenoid AS6 is opened. Swing lock-in valve (8) shifts to supply manifold air pressure to the head end of swing lock cylinder (9) while exhausting air pressure in the rod end of the cylinder. The cylinder rod extends, lifting the cylinder lock out of its detent and disengaging the swing pawl in the swing gearbox. The opposite occurs when the swing lock switch is placed in the ENGAGE position.

Off (Figures 22 and 23)

When swing control handle (1) is in the off position, the PC opens a circuit to the swing pump EDC and swing pump (6) does not stroke. The upperworks is free to coast if the swing brake is released and the swing lock is disengaged.

During free coast, the PC maintains balanced pressure between swing motor ports A and B to eliminate swing movement even though the handle is not commanding displacement.

Swing (Figures 22 and 23)

NOTE The schematics show electric current flow to the swing EDC and hydraulic oil flow to the motor for swing right operation. The flows are opposite for swing left operation.

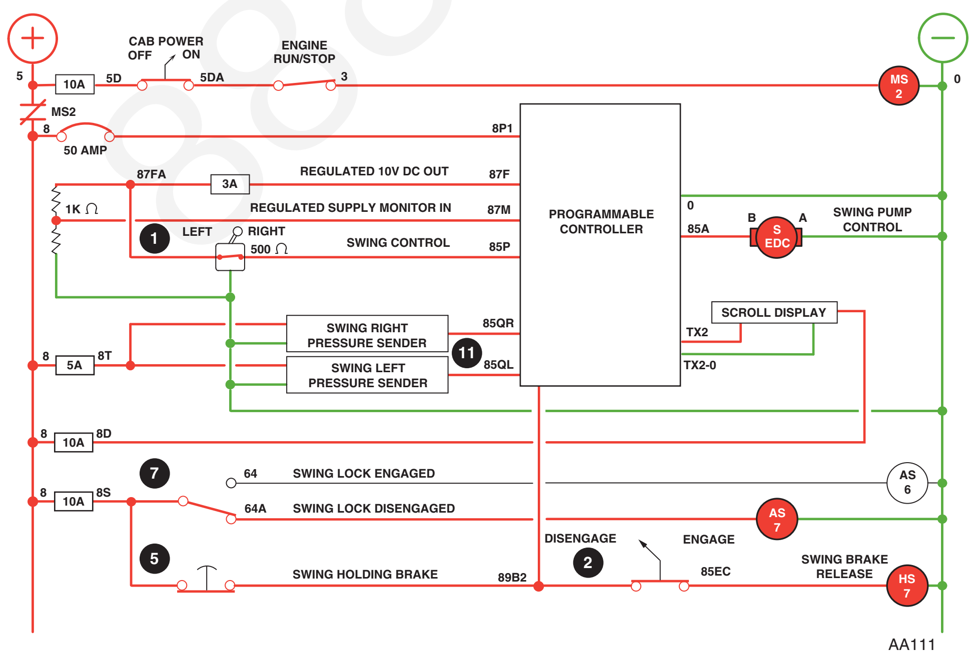


FIGURE 22 SWING ELECTRIC CIRCUIT
(Swing Right)

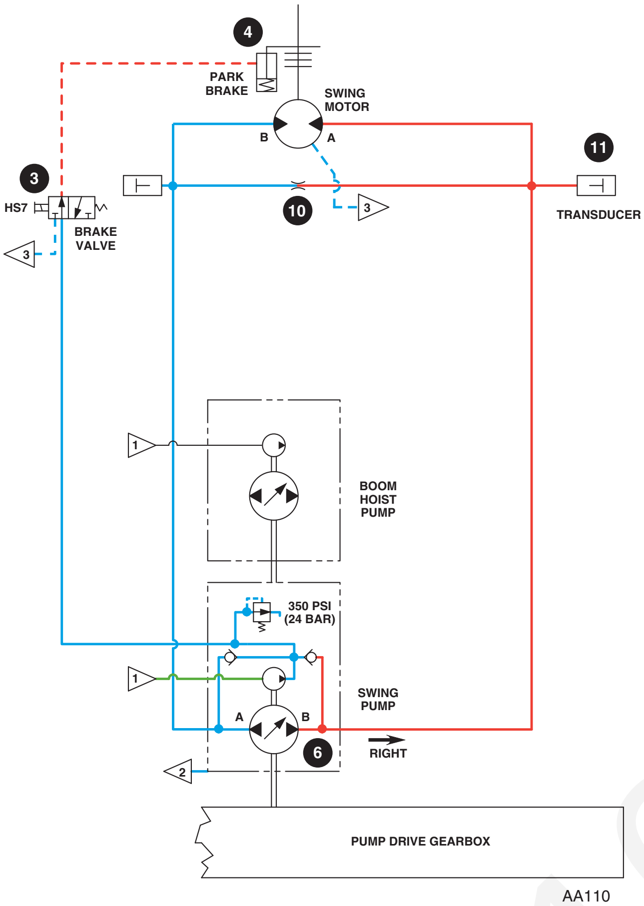


FIGURE 23 SWING HYDRAULIC SYSTEM
(Swing Right)

When swing control handle (1) is moved in either direction from off, the control varies the voltage for an appropriate command to the PC. The PC provides corresponding voltage direction and gain to the swing pump EDC. The PC tilts the pump swashplate an amount which generates a displacement pump output quantity relative to the handle movement.

When swing right is commanded, swing pump (6) is stroked in the appropriate direction so oil flows from pump port B to port A of the swing motor, rotating the upperworks in the corresponding direction.

NOTE If there is low swing charge pressure or if either pressure sender fails, swing movement may be somewhat erratic.

Orifice (10), across swing motor ports A and B, the low and high sides of the hydraulic circuit, enables smoother oil flow shifting when swinging from one direction to the other.

Pressure senders (11) inform the PC of the pressure on the low and high sides of the hydraulic circuit. The PC uses this information to provide a “free coasting” effect when swing control handle (1) is returned to neutral and an automatic boom “centering” command is given during side loading of the boom.

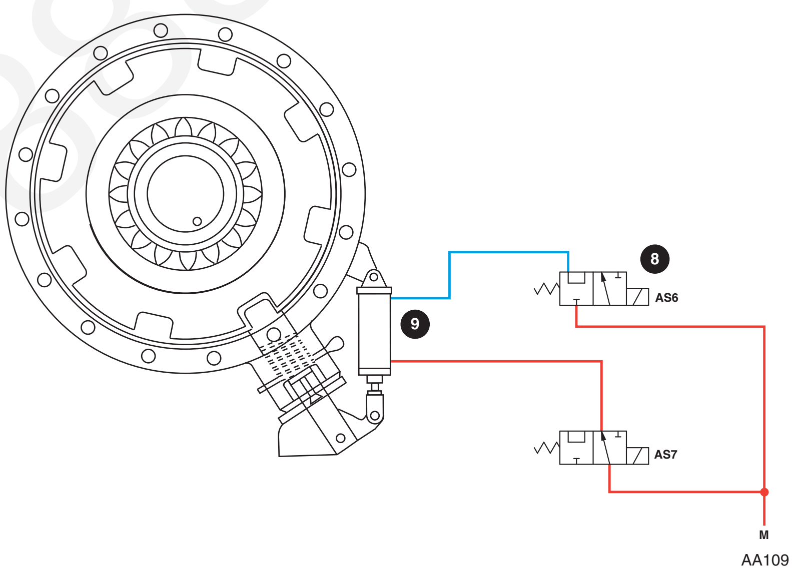


FIGURE 24 SWING LOCK AIR SYSTEM
(Swing Lock Engaged)

TRAVEL SYSTEM OPERATION

(Figures 25 and 26)

General

When travel park brake switch (1), located on the front console in the operator's cab, is placed in the ON position, the control opens the travel command input circuit to the PC and does not energize travel brake hydraulic solenoid HS1. Therefore, travel park brakes (2) remain applied and travel pumps (3 and 4) do not stroke in response to commands from right and left crawler control handles (5 and 6).

When travel park brake switch (1) is placed in the OFF position, the travel command input voltage circuit to the PC is completed. After receiving the voltage signal, the PC prepares the crane's travel system for activation.

Off

When crawler control handles (5 and 6) are in the OFF position, the PC opens the circuits to the right and left travel pump EDCs and travel brake hydraulic solenoid HS1. Therefore, travel pumps (3 and 4) do not stroke and travel park brakes (2) remain spring-applied to hold the crane in position.

Right Crawler Forward

NOTE Electric current to the EDCs and the hydraulic oil flow to the motor are opposite for reverse travel.

When right crawler control handle (5) is moved in the forward direction, the PC closes a regulated voltage circuit to the right travel pump EDC and completes a circuit to HS1 through travel park brake switch (1). Travel park brake valve (9) shifts to release travel park brakes (2) with charge pressure from right travel pump (4) before right travel pump (3) strokes.

The EDC tilts the swashplate of right travel pump (3) in the forward direction, and the pump strokes on. Oil flows from port A of pump (3), through the swivel and quick disconnect to port A of right travel motor (7). The PC controls voltage to the right travel pump EDC, governing travel speed in response to movement of right crawler control handle (5). If left crawler control handle (6) is pushed forward, oil flows from port B of left travel pump (4) to port B of left travel motor (8).

The travel motors are variable displacement in configuration and shift internally via an adjustable spring in each of the motor's pressure compensator regulator (PCR) valves preset at 3,915 psi (270 bar). With the system pressure below the compensator setting and high speed travel switch (10) open (high speed position), the travel motor is maintained in the minimum displacement position. When the system pressure exceeds the PCR setting, the pressure causes the servo mechanism to tilt the cylinder block, increasing motor displacement and output torque and decreasing the motor speed. Therefore, when the crawler begins to move, the motor PCR valve shifts the motor into the maximum displacement position required for breakaway torque, then gradually returns to minimum displacement output when the crawler is moving with less effort.

The travel motor may be externally shifted into the maximum displacement position during periods when precise controllability over the load is required. The motor shifts

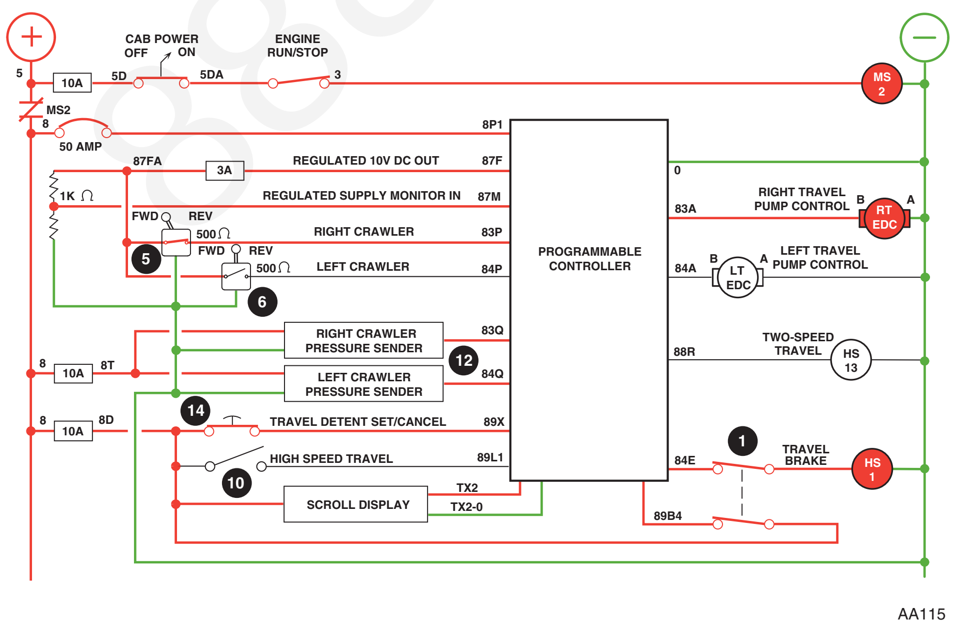


FIGURE 25 TRAVEL ELECTRIC CIRCUIT
(Left Crawler OFF - Right Crawler FORWARD)

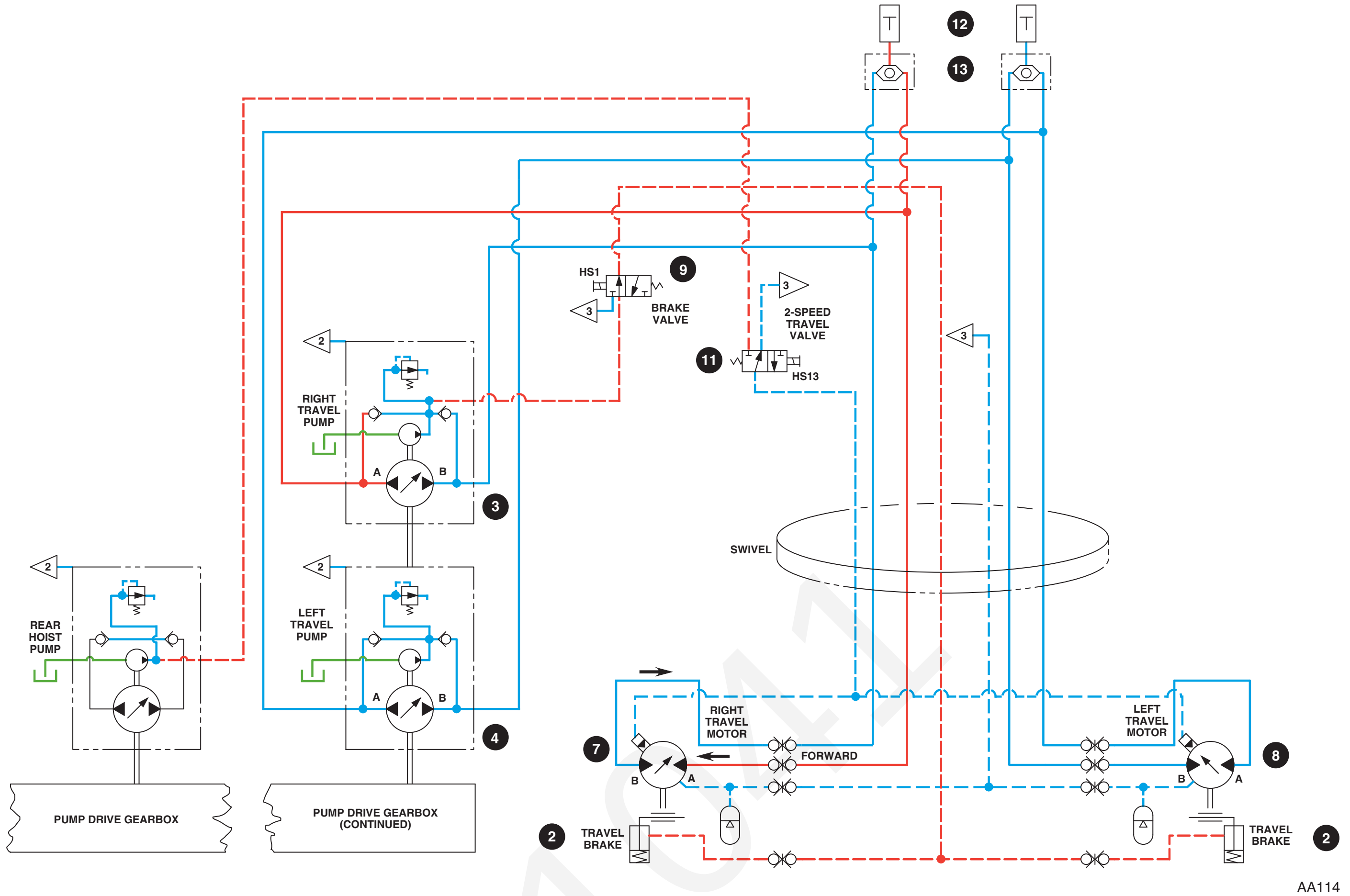


FIGURE 26 TRAVEL HYDRAULIC SYSTEM
(Left Crawler OFF - Right Crawler FORWARD)

when high speed travel switch (10) is closed (low speed position), completing an input circuit to the PC. The PC energizes travel speed hydraulic solenoid HS13 and 2-speed travel valve (11) shifts, directing pressure from the rear hoist charge pump to externally shift the travel motor to maximum displacement and remain in this position until high speed travel switch (10) is opened.

To ensure crane travel in a straight forward or reverse direction, both crawler hydraulic drive circuits in the travel system are equipped with pressure sender (12) and shuttle valve (13). When traveling, the PC monitors signals from pressure senders (12) and adjusts the displacement of the travel pumps to achieve and maintain equal pressure in each crawler drive circuit. This causes the crane to track in a straight and controlled condition.

TRAVEL DETENT BUTTON

Travel detent button (14), located on right crawler control handle (5), allows any travel command to be locked-in. This allows the crawlers to be operated in either direction at a selected speed without the operator's hand being on the crawler control handles. When travel detent button (14) is lifted into the dome of the handle, the travel command received from one or both crawler control handles is memorized and locked-in by the PC. When the handle(s) is released back to the off position, the speed and direction of travel is maintained by the PC.

Lifting travel detent button (14) again or moving either control handle in the opposite direction opens the travel detent circuit and returns direct control of the travel system to the operator via actuation of the control handle(s).

This control also serves as a parking function. Lifting the travel detent button when the crawler control handles are in the off position, locks-in the off condition (brakes applied) and ensures the crawler control handles are inoperable until the detent button is released.

PAWL SYSTEM OPERATION

(Figures 27 and 28)

General

NOTE The following descriptions of operation are the same for all drum pawl systems. However, the components used during the engage/disengage operation for a selected drum pawl (park brakes, cylinders, air solenoids and valves, etc.) are specific to the drum pawl system being operated.

The ratchet and pawl mechanisms provide a positive means of locking the boom hoist drum, front drum, rear drum, and auxiliary drum (if equipped). Each pawl system operates independently and is controlled by a 2-position switch at the front console in the operator's cab.

The boom hoist pawl should be used to maintain the boom and loadline positions, especially when the crane is in park or left unattended. It is controlled by the boom hoist pawl switch. Likewise, the front, rear, and auxiliary drum pawls should be used for locking the corresponding drum in position when not in use. A selected pawl must be disengaged before its drum can rotate.

Should a pawl switch be accidentally activated, the PC will open the circuit to the appropriate park brake. For the boom hoist pawl and auxiliary drum pawl, the spring-applied park brake on the motor end of the drum shaft activates, and the corresponding pump strokes to off to stop the function. The load drum pawls respond in a similar manner, however, the front and rear load drum park brakes consist of two braking systems controlled simultaneously.

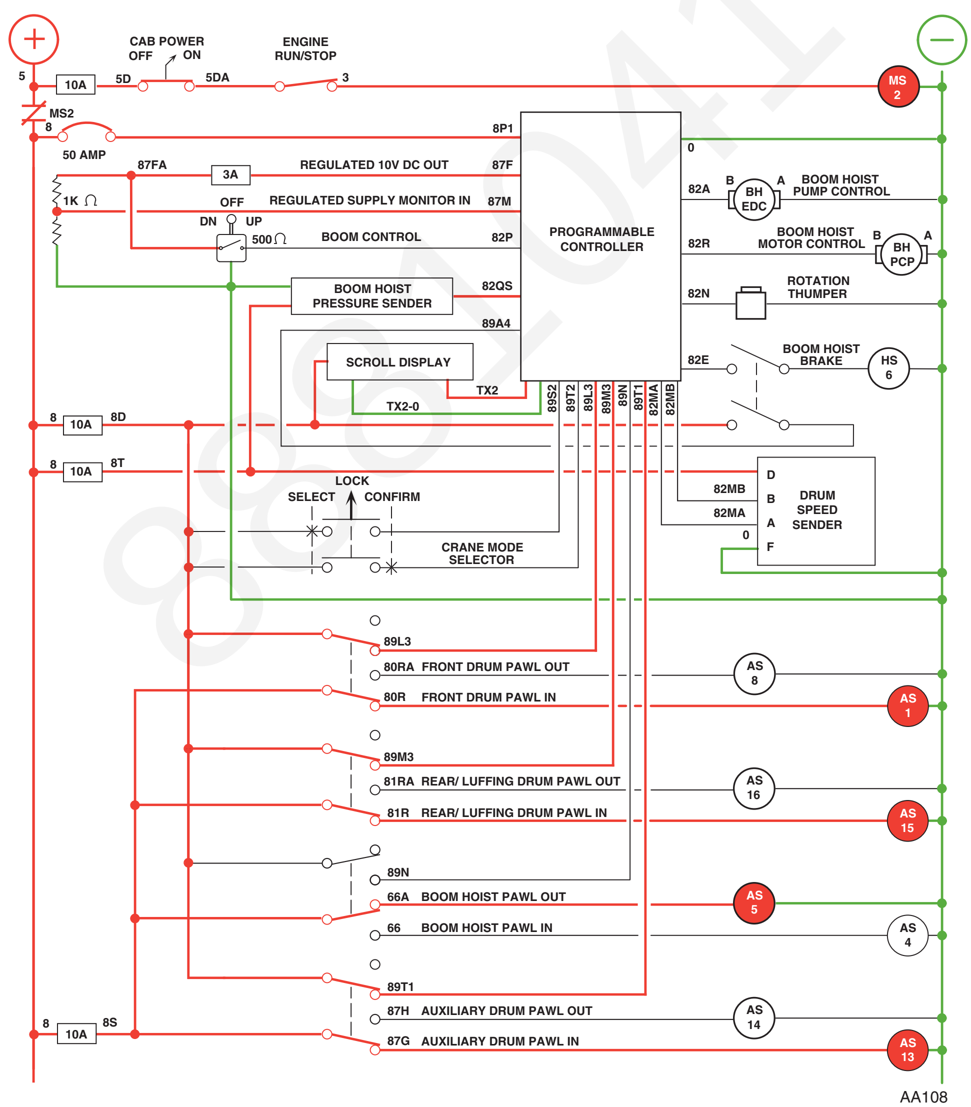


FIGURE 27 PAWL ELECTRIC CIRCUIT

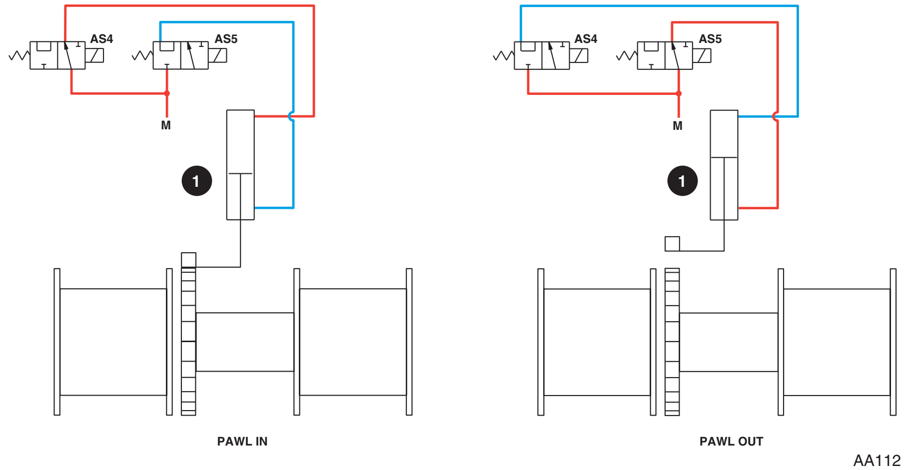


FIGURE 28 PAWL AIR SYSTEM

Drum Pawl Engage

NOTE If a pawl is engaged during hoisting, a hoist operating drive fault will occur when function is stopped because the PC will not command down against the pawl in order to prove the brake is applied.

When a selected pawl switch is placed in the ENGAGE position, a circuit is completed from the switch to the PC. This keeps the appropriate park brake solenoid de-energized (so the brake remains applied) and prevents the corresponding system's hydraulic pump from stroking. In addition, the pawl IN air solenoid energizes and the pawl OUT air solenoid de-energizes. This causes the pawl IN valve to shift, supplying manifold air pressure to the head end of pawl cylinder (1) and extending the cylinder rod to move the pawl in. The drum is secure and will not move in the lowering direction until its pawl switch is disengaged and its park brake is released.

Drum Pawl Disengage

When a selected pawl switch is placed in the DISENGAGE position, the park brake remains applied and the pawl OUT air solenoid energizes and the pawl IN air solenoid de-energizes. This causes the pawl OUT valve to shift, supplying manifold air pressure to the rod end of pawl cylinder (1) and exhausting air pressure from the head end of the cylinder. The cylinder rod then retracts to move the pawl out.

LOAD DRUM SYSTEM OPERATION

(Full Power Mode)

<u>NOTE</u> The following descriptions of operation are for the front drum without optional clutch assembly while operating in full power mode. Function of the rear drum in full power mode is identical. The clutch assembly is described in the free-fall mode section of this manual.

<u>NOTE</u> The front and rear hoist control handles are located adjacent to one another on the right console in the operator's cab. However, the position of these handles may be interchanged depending on the functional orientation of the front and rear drums.

General (Figures 29, 30, 31 and 32)

The hydraulic connection between front hoist pump (1) and front hoist motor (2) forms a simple closed-loop circuit. Make-up oil from front hoist charge pump (3) replaces oil in the system that is primarily displaced due to internal leakage of the pump and motor assemblies.

If front drum park switch (4), located on the front console in the operator's cab, is placed in the ON position, the front hoist control handle circuit to the PC opens and does not complete the circuit from the PC to front drum park brake hydraulic solenoid HS12 and air solenoid AS12. Because these circuits are open, front drum hydraulic park brake (5) and air park brakes (6) remain applied and front hoist pump (1) does not stroke in response to movement of front hoist control handle (7).

When performing liftcrane, clamshell, or luffing operations in full power mode without optional clutch assembly, the park brake function employs two independent brake systems, one being air actuated and the other being hydraulically actuated.

The air brake system is actuated by two air brake cylinders (6) which are spring applied/air released. When front hoist control handle (7) is moved from the off position, the PC automatically energizes front drum park brake air solenoid AS12 and parking brake relay (8) shifts to allow air pressure into cylinders (6) to release the brake.

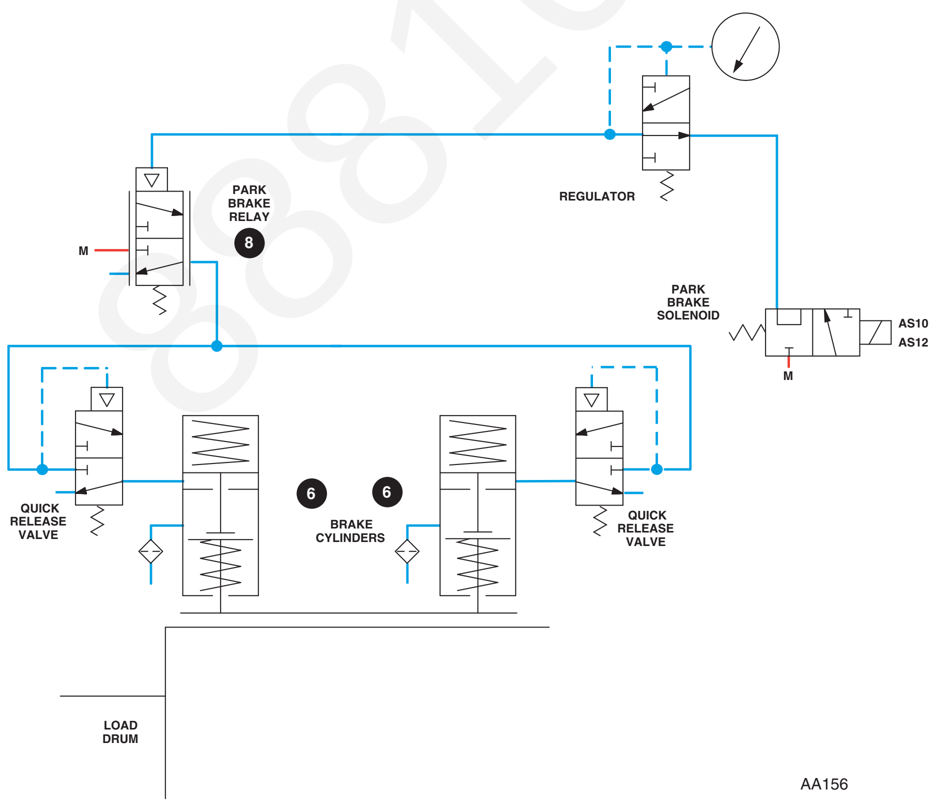


FIGURE 29 LOAD DRUM AIR BRAKE CIRCUIT - NO CLUTCH
(Load Drum OFF)

The hydraulic brake system is spring applied/pressure released, and, like the air system, is controlled automatically by the PC in conjunction with movement of front drum control handle (7). Release of park brake (5) during operation of the front drum is sourced from 350 psi (25 bar) charge pressure on the low pressure side of the closed-loop circuit.

When releasing brake (5), charge pressure is directed into brake valve (9) through HS12. If the charge pressure drops to below 295 psi (20 bar), hydraulic brake application will begin, and if the pressure continues to drop to approximately 220 psi (15 bar) or lower, the brake will be fully applied.

Liftcrane Operation

GENERAL (Figure 31)

When FULL-POWER mode is selected and confirmed at crane mode selector (10), the crane is ready for general liftcrane usage, and the PC ensures the clamshell, luffing, and setup operations are inoperable.

When the front drum park switch is placed in the OFF position while in full power mode, the front drum hydraulic and air brakes are controlled automatically by the PC in conjunction with movement of front hoist control handle (7).

Front Hoist Rotation Indicator

Whenever the front drum rotates, front drum flange speed sender (11) completes a circuit to the PC which activates rotation thumper (12) in control handle (7). This causes the rotation thumper to move up and down with a varying frequency that conveys the rotational speed of the front drum to the operator.

OFF (Figures 29, 31, and 32)

When front hoist control handle (7) is in the off position, the handle neutral switch is open and the control circuit from the handle potentiometer to the PC is not completed. Therefore, the PC receives no voltage from the handle, and it opens the circuits to the front hoist pump EDCs, front hoist motor PCP valve, and front drum park brake hydraulic solenoid HS12 and air solenoid AS12. Because these circuits are open, front hoist pump (1) does not stroke, front hoist motor (2) remains at low speed, and front drum park brakes (5 and 6) remain applied to prevent the front drum from turning.

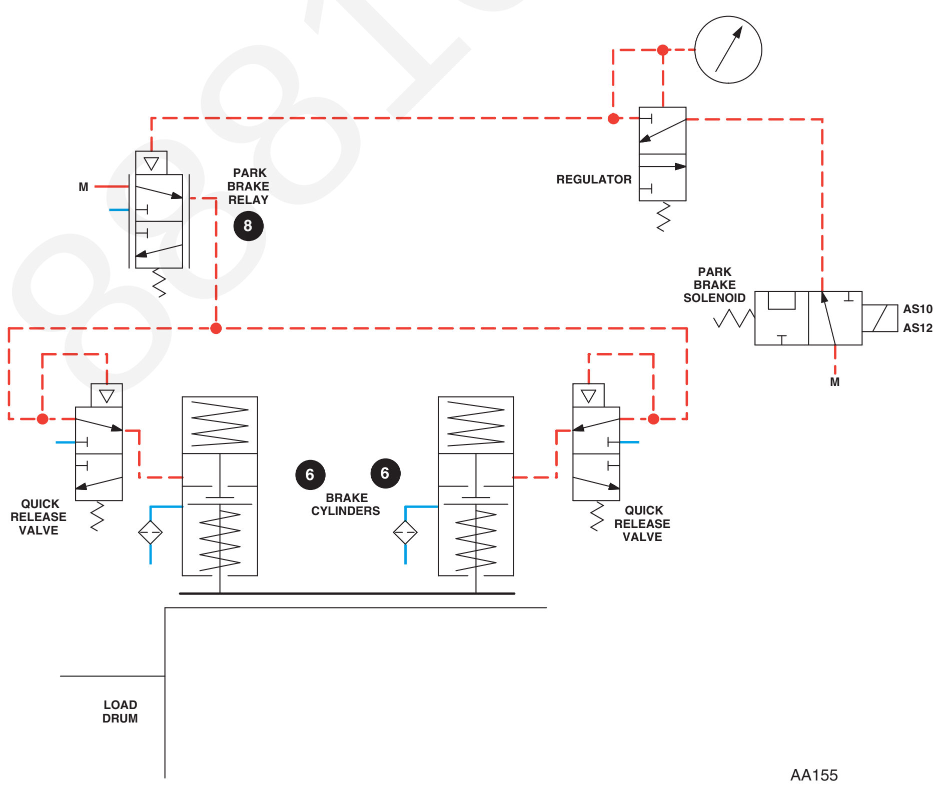


FIGURE 30 LOAD DRUM AIR BRAKE CIRCUIT - NO CLUTCH
(Load Drum HOIST or LOWER)

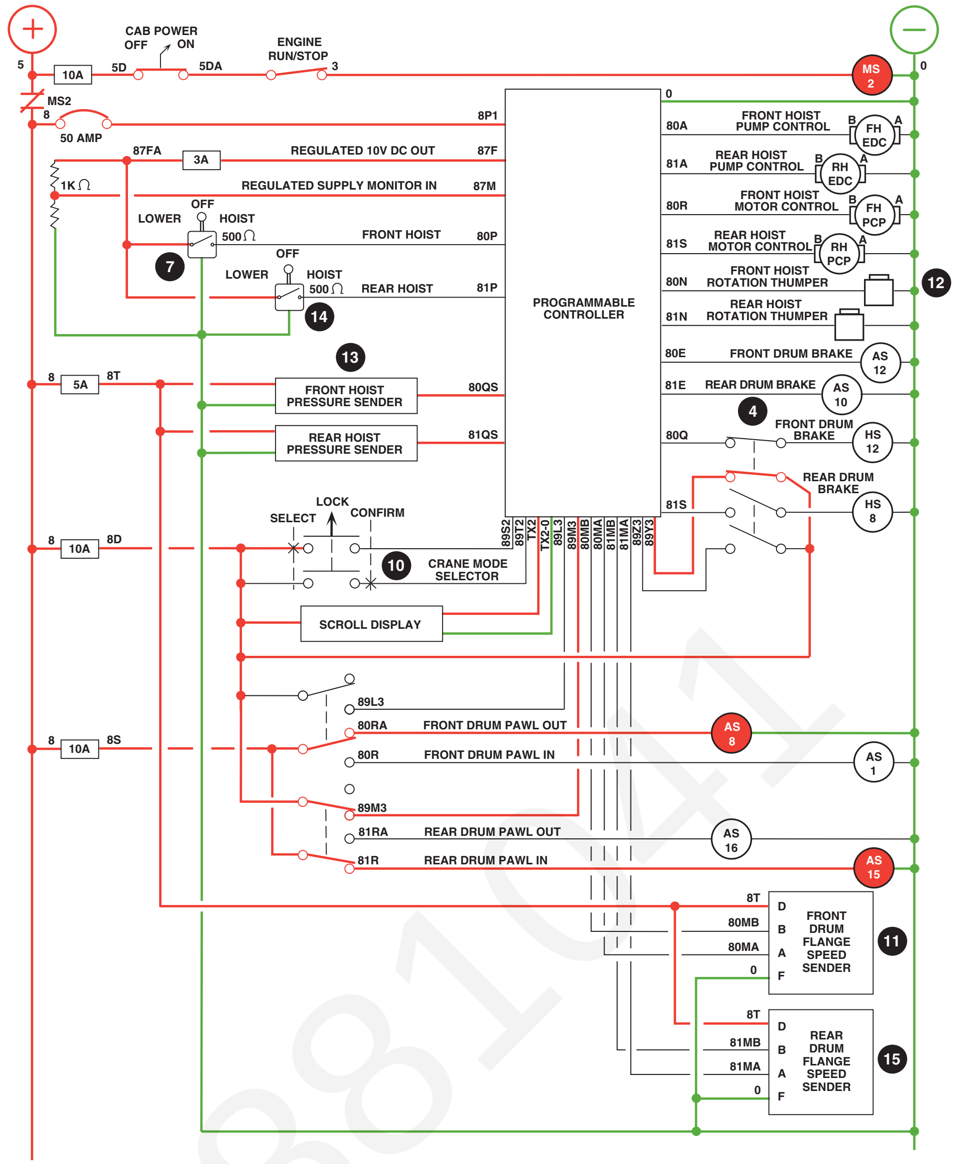


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FIGURE 31 FRONT/REAR HOIST ELECTRIC CIRCUIT (Full Power Mode: Liftcrane or Clamshell OFF)

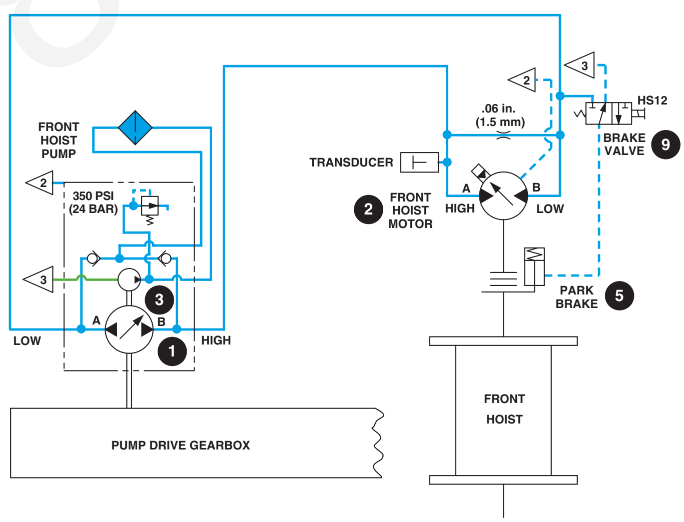

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FIGURE 32 FRONT HOIST HYDRAULIC SYSTEM (Full Power Mode: Liftcrane OFF)

<u>HOIST</u> (Figures 30, 33, and 34)

When front hoist control handle (7) is pulled back for up operation, the handle neutral switch closes, completing a regulated voltage circuit from the handle potentiometer to the PC. The PC interprets the signal for speed and direction and closes voltage regulated circuits to the front hoist pump EDC, front hoist motor PCP, and front drum park brake solenoids HS12 and AS12. These circuits will close only if the front drum park switch is off, applicable operating limit switches are closed (see Figure 13), and no system or operating faults are present.

PC programming requires front hoist pump (1) to stroke before the front drum park brake is released. This ensures adequate pressure is present to hold the load after full release of the park brake. The regulated voltage to the front hoist pump EDC tilts the pump swashplate to stroke the pump in the up direction. Oil then flows from pump port A to port B of front hoist motor (1).

Front hoist pressure sender (13) supplies the PC with pressure development data which the PC compares to the memorized holding pressure of the front hoist. When adequate pressure is available, the PC energizes HS12 and AS12 to shift the brake valves. This initiates full release of park brakes (5 and 6) and front hoist motor (2) raises the load.

The PC governs the raising speed of the load by varying the voltage to the pump EDC in proportion to movement of the control handle. Therefore, the angle of the pump swashplate is increased as the control handle is moved farther backward, pumping more oil to the motor and raising the load faster.

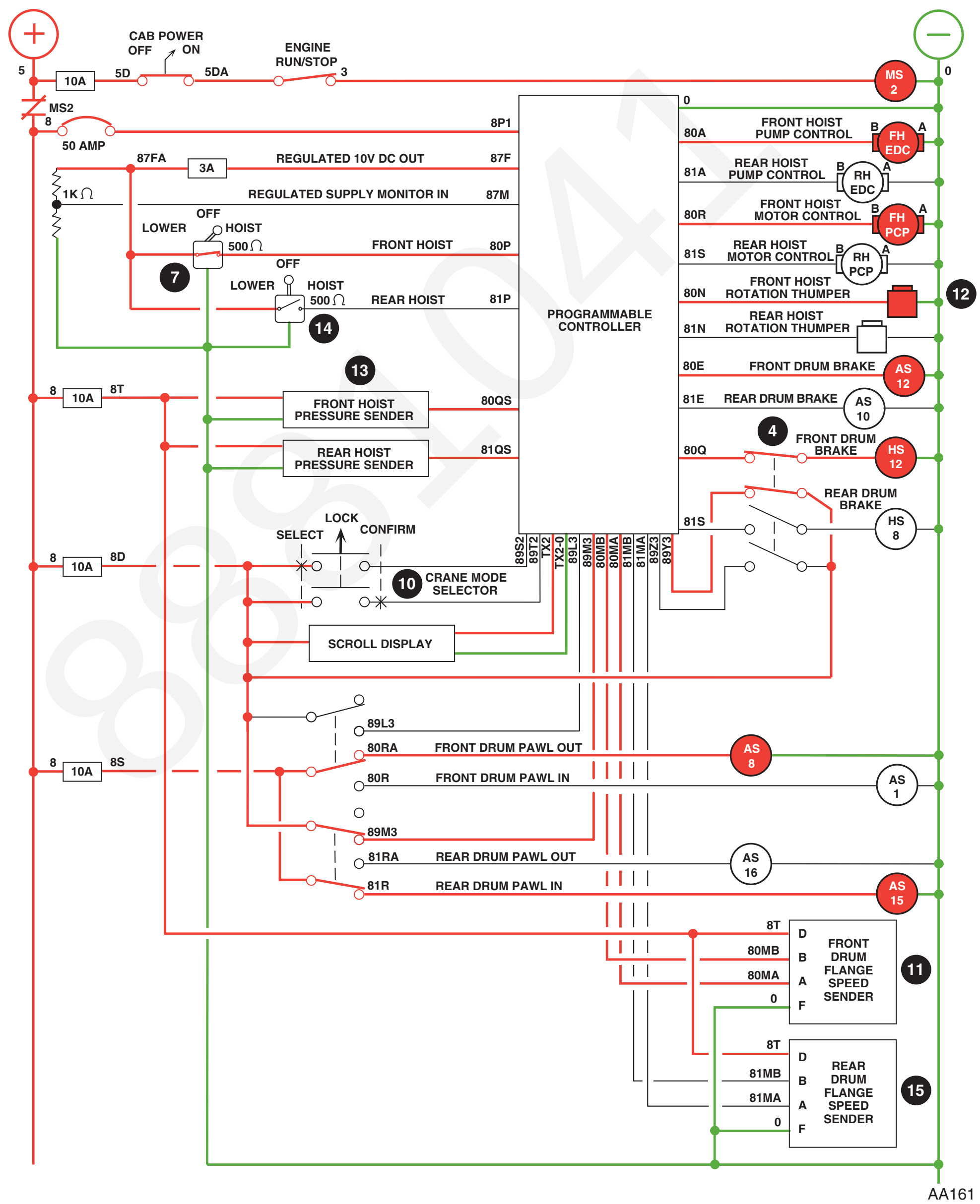


FIGURE 33 FRONT/REAR HOIST ELECTRIC CIRCUIT
(Full Power Mode: Liftcrane HOIST or Clamshell CLOSE BUCKET)

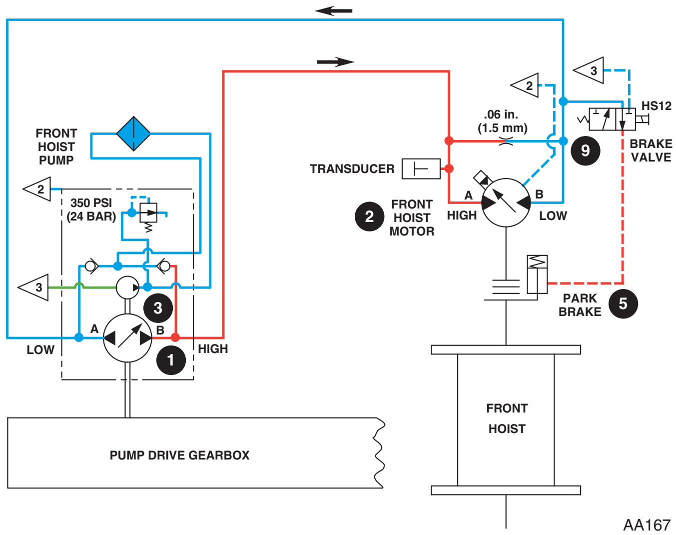


FIGURE 34 FRONT HOIST HYDRAULIC SYSTEM
(Full Power Mode: Liftcrane HOIST)

As control handle (7) approaches the full handle command position, and if lifting conditions permit, the front hoist motor PCP valve (25, Figure 2) is instructed by the PC to shift and redirect oil flow to motor servo cylinder (24, Figure 2). This allows the servo mechanism to shift the motor to minimum displacement for maximum motor speed and less operating torque.

As control handle (7) is returned to the off position, the PC commands the front hoist pump EDC to decrease the angle of the pump swashplate, causing a reduction in oil flow output. The PC also instructs the front hoist motor PCP valve (25, Figure 2) to shift front hoist motor (2) to maximum displacement for slower output speed to slow the drum rotation. When the control handle is fully off, the PC memorizes the pressure required to support the load and de-energizes HS12 and AS12 to apply the brakes after the control handle neutral switch opens or after receiving a zero command from front drum flange speed sender (11).

<u>LOWER</u> (Figures 30, 35, and 36)

When front hoist control handle (7) is pushed forward for down operation, the handle neutral switch closes, completing a regulated voltage circuit from the handle potentiometer to the PC. The PC interprets the signal for speed and direction and closes a reverse regulated polarity voltage circuit to the front hoist pump EDC, a regulated voltage front hoist motor PCP, and front drum park brake solenoids HS12 and AS12. These circuits will close only if the front drum park switch is off, the front drum pawl switch is disengaged, applicable operating limit switches are closed (see Figure 13), and no system or operating faults are present.

PC programming requires front hoist pump (1) to stroke momentarily in the hoisting direction to reach memorized load holding pressure before the front drum park brake is released. This ensures adequate pressure is present to hold the load after full release of the park brake. Front hoist pressure sender (13) supplies the PC with pressure development data which the PC compares to the memorized holding pressure of the front hoist. When adequate pressure is available, the PC energizes HS12 and AS12 to shift the brake valves. This initiates full release of park brakes (5 and 6) and front hoist motor (2) lowers the load. The regulated voltage to the front hoist pump EDC then tilts the pump swashplate to stroke the pump in the down direction. Oil then flows from pump port B to port A of front hoist motor (2).

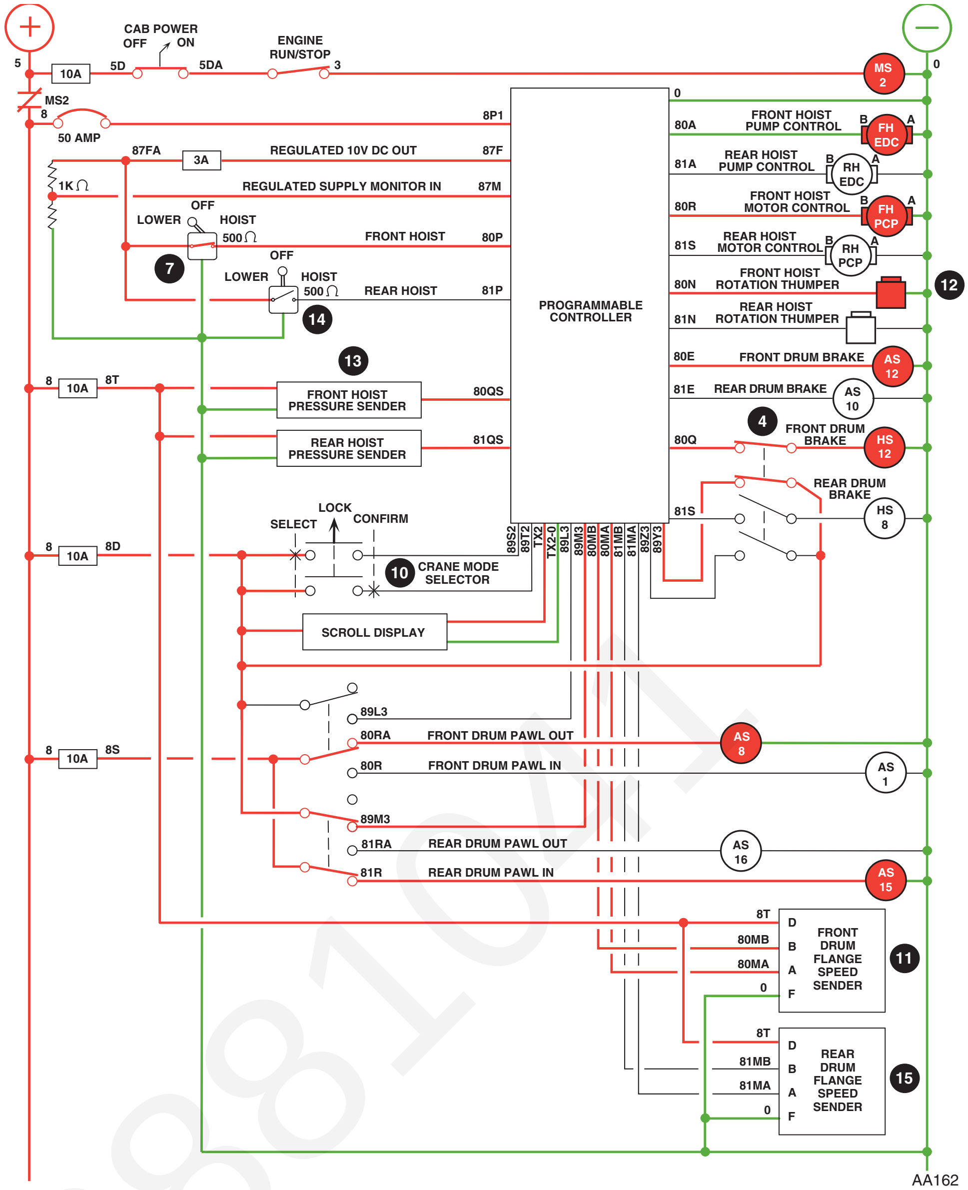
The weight of the load on the front drum will attempt to drive the motor faster than return oil is available to the pump. However, front hoist charge pump (3) maintains the oil supply at a positive pressure to front hoist motor (2).

The position of the pump swashplate restricts the returning oil flow and pressure builds on the return side of the closed-loop circuit, acting as a brake against the front hoist motor to control the lowering speed.

The PC governs the lowering speed of the load by varying the voltage to the pump EDC in proportion to movement of the control handle. Therefore, the angle of the pump swashplate is increased as the control handle is moved farther forward; more oil is allowed to return to the pump, more oil is pumped to the motor, and the front drum lowers the load faster.

As control handle (7) approaches the full handle command position, and if lifting conditions permit, the front hoist motor PCP valve (25, Figure 2) is instructed by the PC to shift and redirect oil flow to motor servo cylinder (24, Figure 2). This allows the servo mechanism to shift the motor to minimum displacement for maximum motor speed and less operating torque.

As control handle (7) is returned to the off position, the PC commands the front hoist pump EDC to decrease the angle of the pump swashplate, causing a reduction in oil



*During clamshell OPEN BUCKET condition, rear drum pawl is “out” and rear drum brake switch is “closed.”

FIGURE 35 FRONT/REAR HOIST ELECTRIC CIRCUIT (Full Power Mode: Liftcrane LOWER or *Clamshell OPEN BUCKET)

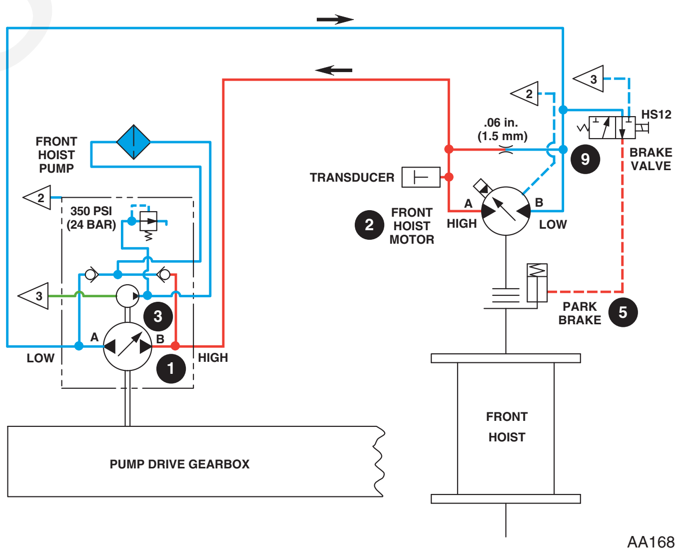


FIGURE 36 FRONT HOIST HYDRAULIC SYSTEM (Full Power Mode: Liftcrane LOWER)

flow output. The PC also instructs the front hoist motor PCP valve (25, Figure 2) to shift front hoist motor (2) to maximum displacement for slower output speed to slow the drum rotation. When the control handle is fully off, the PC memorizes the pressure required to support the load and de-energizes HS12 and AS12 to apply the brake after the control handle neutral switch opens or after receiving a zero command from front drum flange speed sender (11).

Clamshell Operation

NOTE The following descriptions of clamshell operation apply when operating in full power mode. If equipped, the drums may be operated in free-fall mode for faster dumping and lowering functions. If either drum is operated in free-fall mode, the corresponding drum working brake must be used to control the position of the bucket when the hoist control handle is released to off.

NOTE The load drum hydraulic systems and air brake circuits for clamshell operation in full power mode are identical to those illustrated for liftcrane operation in full power mode.

GENERAL (Figure 31)

When CLAMSHELL excavator mode is selected and confirmed at crane mode selector (10), front hoist control handle (7) operates the front drum for opening and closing the bucket and rear hoist control handle (14) operates the front and rear drums for raising and lowering the bucket.

PROGRAMMING (Figure 31)

The PC controls the speed of the drums in proportion to movement of the control handles and the weight of the bucket. Therefore, the more the bucket weighs and/or the farther the handle is moved in the forward direction, the faster the bucket will lower.

When an open or closed bucket is lowered, the PC monitors both front and rear drum flange speed senders (11 and 15) for variance in rotational speed of the drums. If a speed difference is determined, the PC calculates a speed correction factor which is then used to increase or decrease the displacement of each load drum pump as needed to maintain equal rotational speed of the drums.

To ensure the bucket remains closed when raising, the PC monitors the high pressure side of both load drum systems for variance in working pressures. If pressure differences are detected, the PC calculates a pressure correction factor which is then used to increase or decrease the displacement of each load drum pump as needed to maintain equal working pressures.

When the bucket comes in contact with an object that offers resistance, such as striking a pile of excavatable material, the hoist lines relax and system pressure decreases. Front and rear hoist pressure senders (13) supply the PC with data obtained from the high pressure side of both load drum hydraulic systems. The PC monitors this data and uses it to destroke the load drum pumps when pressure decreases and automatically stops the load drums from turning.

OFF (Figure 31)

When front and rear hoist control handles (7 and 14) are in the off position, the following conditions exist:

- Front and rear hoist pump EDC circuits are opened, and the pumps do not stroke.
- Front and rear drum park brake solenoids (HS12, AS12, HS8, and AS10) are de-energized, causing the front and rear drum park brakes to spring-apply and prevent the drums from turning.

CLOSE BUCKET (Figure 33)

When front hoist control handle (7) is pulled back, the PC closes a regulated voltage circuit to the front hoist pump EDC. The EDC tilts the pump swashplate in the hoisting direction, causing the bucket to close with the closing line. The PC governs the closing speed by varying the current to the EDC in conjunction with movement of the front hoist control handle.

The PC also energizes front drum park brake solenoids HS12 and AS12. As the solenoids shift, hydraulic system pressure is supplied to release the front drum hydraulic park brake and regulated air pressure is supplied to release the front drum air park brake. The brakes then release, permitting the front hoist motor to rotate the front drum in the hoisting direction and close the bucket.

HOIST BUCKET (Figure 37)

When rear hoist control handle (14) is pulled back, the PC energizes front and rear drum park brake solenoids HS12, AS12, HS8, and AS10. As the solenoids shift, hydraulic system pressure is supplied to release the front and rear drum hydraulic park brakes and regulated air pressure is supplied to release the front and rear drum air park brakes.

At the same time, the PC closes regulated voltage circuits to the front and rear hoist pump EDCs. The EDCs tilt the pump swashplates in the hoisting direction, causing the front and rear hoist motors to rotate the drums and raise the bucket. To ensure the bucket remains closed when raising, the PC monitors the high pressure side of both load drum systems for differences in working pressures. The PC compares this data and then calculates a correction factor to maintain equal lifting pressure in both systems. This correction factor is then used to increase or decrease the displacement of each pump to control both system working pressures.

OPEN BUCKET (Figure 35)

When front hoist control handle (7) is pushed forward, the PC closes a regulated voltage circuit to the front hoist pump EDC. The EDC tilts the pump swashplate in the lowering direction, causing the bucket to open with the closing line. The PC governs the opening speed by varying the current to the EDC in conjunction with movement of the front hoist control handle.

The PC also energizes front drum park brake solenoids HS12 and AS12. As the solenoids shift, hydraulic system pressure is supplied to release the front drum hydraulic park brake and regulated air pressure is supplied to release the front drum air park brake. The brakes then release, permitting the front hoist motor to rotate the front drum in the lowering direction and opening the bucket.

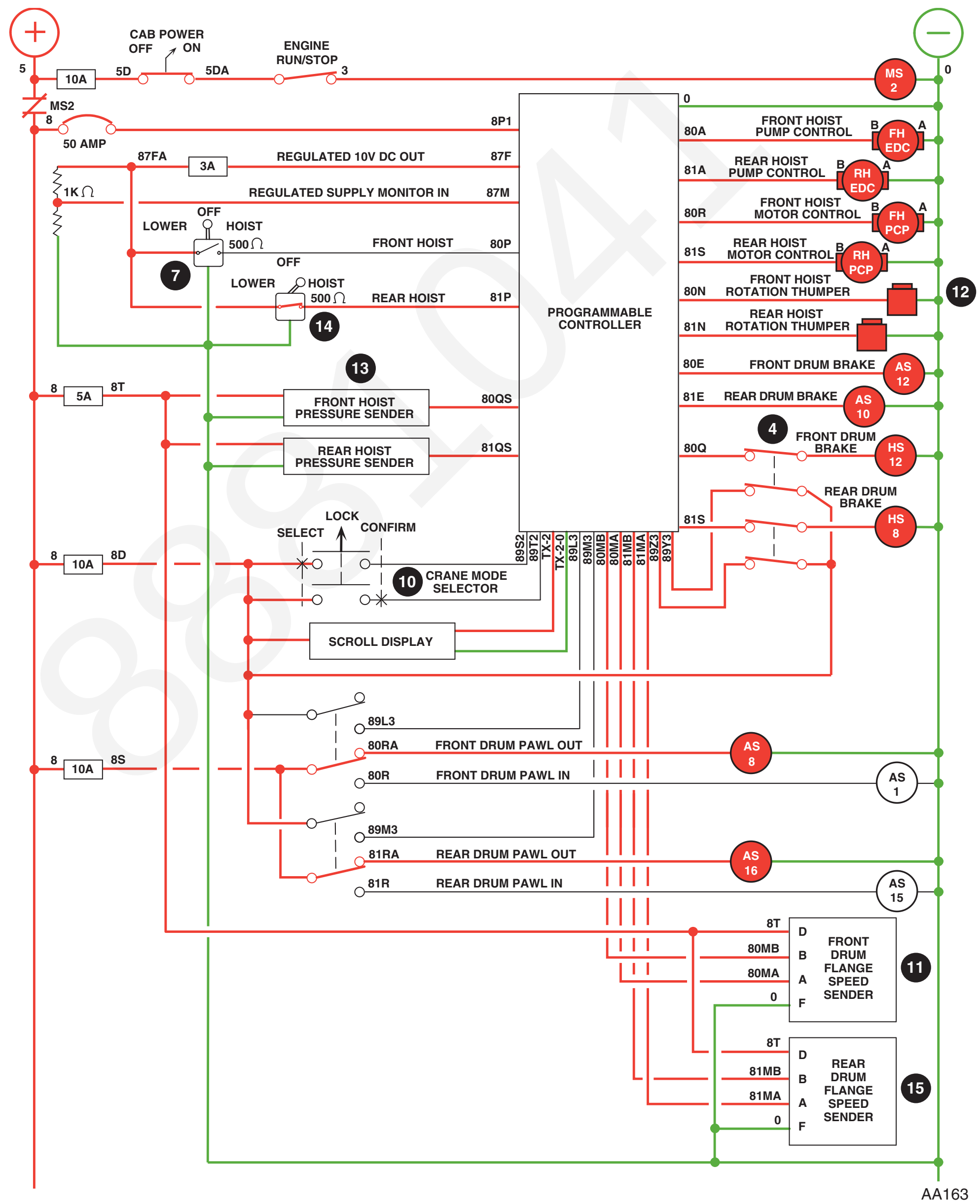


FIGURE 37 FRONT/REAR HOIST ELECTRIC CIRCUIT
(Full Power Mode: Clamshell HOIST BUCKET)

LOWER BUCKET (Figure 38)

When rear hoist control handle (14) is pushed forward, the PC energizes front and rear drum park brake solenoids HS12, AS12, HS8, and AS10. As the solenoids shift, hydraulic system pressure is supplied to release the front and rear drum hydraulic park brakes and regulated air pressure is supplied to release the front and rear drum air park brakes.

At the same time, the PC closes reverse regulated polarity voltage circuits to the front and rear hoist pump EDCs. The EDCs tilt the pump swashplates in the lowering direction, causing the front and rear hoist motors to rotate the drums and lower the bucket. The PC maintains equal linepull on the drums by monitoring the speed data received from front and rear drum flange speed senders (11 and 15) and making the necessary adjustments. The PC also governs the lowering speed by varying the current to the front and rear hoist pump EDCs in conjunction with movement of rear hoist control handle (14).

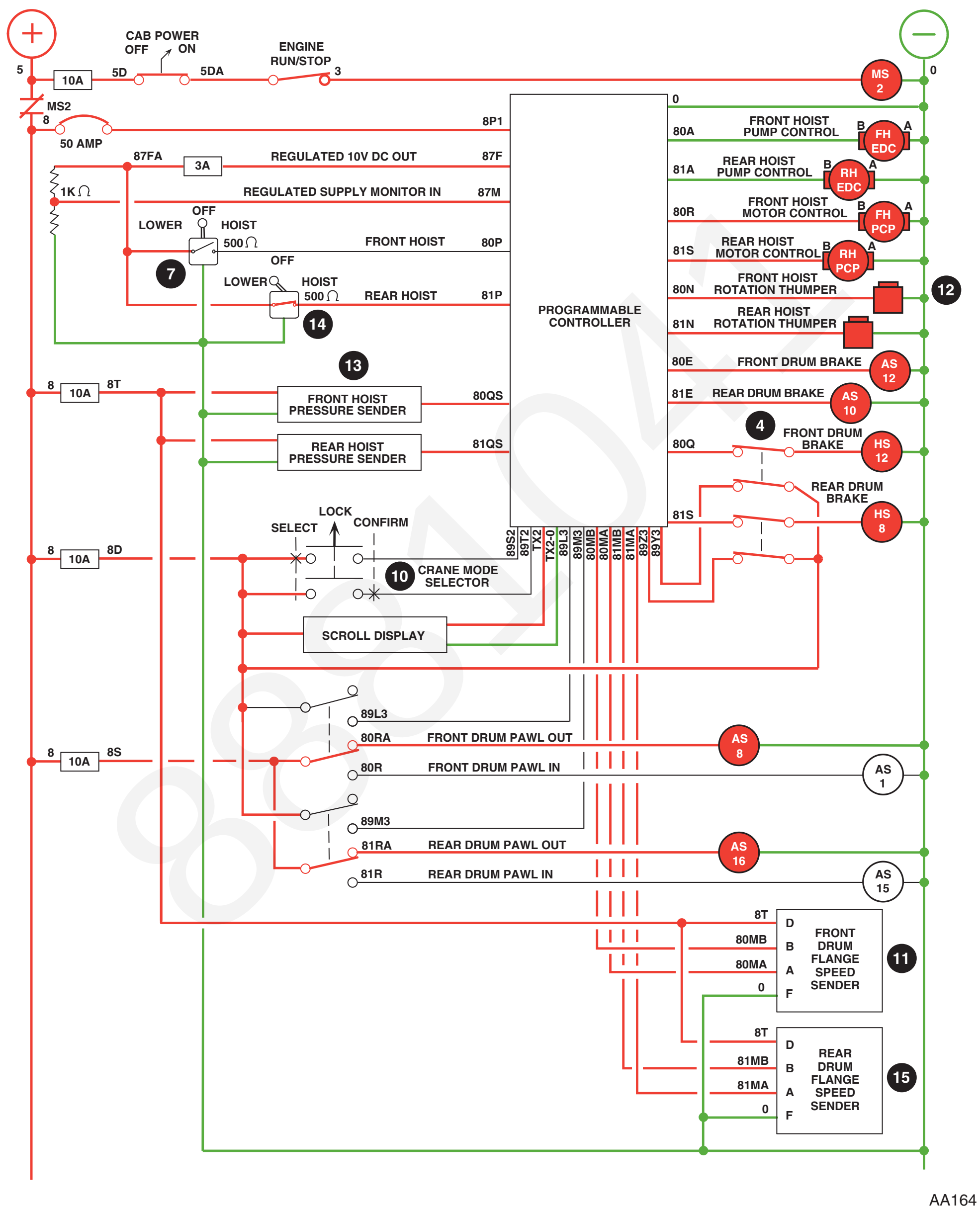


FIGURE 38 FRONT/REAR HOIST ELECTRIC CIRCUIT
(Full Power Mode: Clamshell LOWER BUCKET)

LOAD DRUM SYSTEM OPERATION

(Free-fall Mode)

NOTE The following descriptions of operation are for the front drum if the crane is equipped for, and operating in, free-fall mode. Operation of the rear drum is identical.

NOTE The PC will not allow a drum to be switched to free-fall mode until its working brake pedal is latched down, the free-fall mode selector is switched on, and the free-fall confirm switch is activated.

NOTE The park brakes are automatically applied by the PC only when the load drum park brake switch is in the PARK position. Therefore, always park load drums not in use and fully apply and latch the working brake for the load drum being used.

NOTE Brake and clutch actuation during free-fall operation are described in further detail in the General Operations section.

General (Figure 39)

When the working brake pedal is fully depressed, system air pressure closes free-fall safety switch (1), allowing the operator to select the front drum for free-fall operation via front drum mode selector switch (2), and confirm free-fall selection by placing free-fall confirm selector switch (2) in the FRONT DRUM position.

When front hoist control handle (7) in the off position, the PC opens the circuit to the front hoist pump EDC and the front hoist pump does not stroke.

With the front drum selected and confirmed via switches (2), the PC closes the circuits to front drum clutch solenoid AS11 and front drum park brake solenoids HS12 and AS12. The clutch releases to disconnect the front drum from the front hoist motor and the front drum park brakes are released.

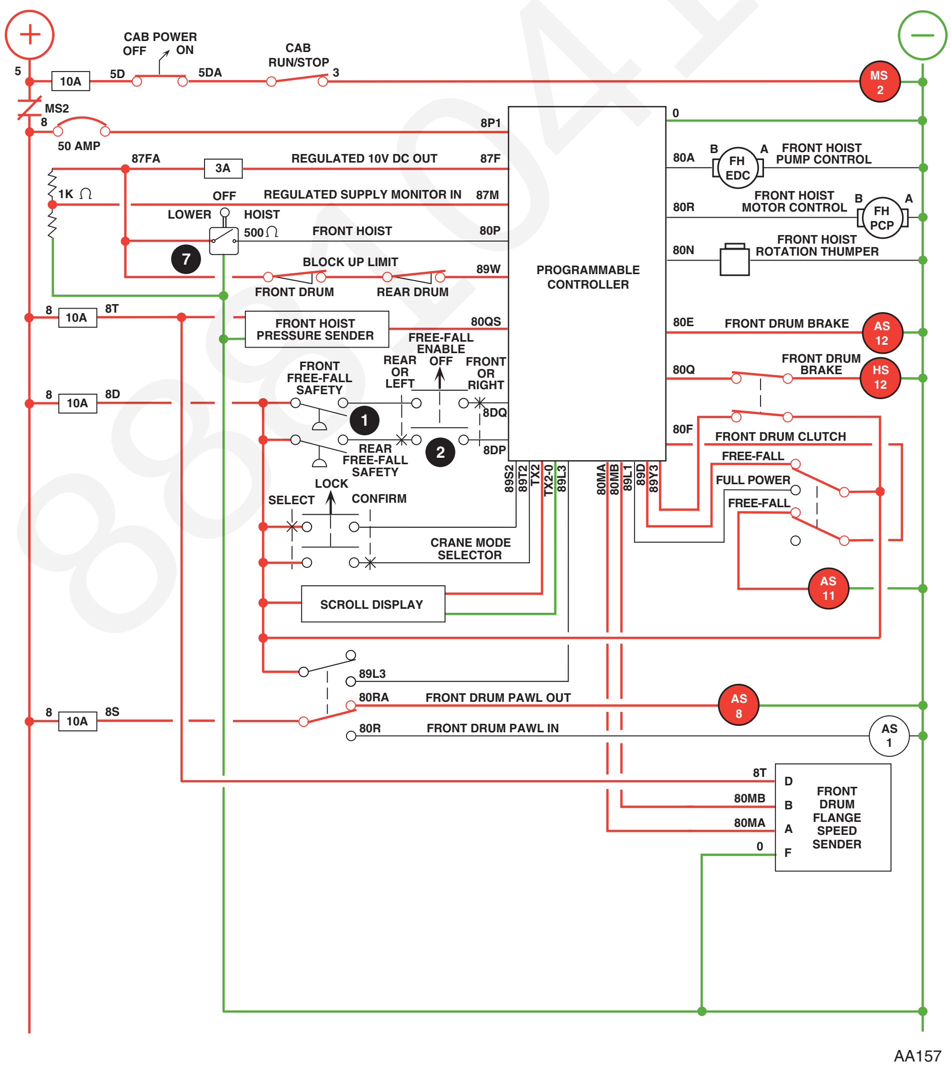


FIGURE 39 FRONT HOIST ELECTRIC CIRCUIT
(Free-fall Mode: FREE-FALL)

Should a limit or operating fault develop while hoisting or power lowering, APPLY AND LATCH WORKING BRAKE before returning control handle (7) to off.

WARNING **DROPPING LOAD!**

Apply working brake if a limit or operating fault occurs while hoisting or power lowering.

Hoisted load will drop if working brake is not applied!

Should charge pressure drop below 295 psi (20 bar) on the low pressure side of the closed-loop while hoisting, power lowering, or in free-fall, the hydraulic park brakes will begin to apply. If pressure drops below 220 psi (15 bar), the park brakes will be fully applied.

Front Drum in Free-fall (Figure 40)

For free-fall lowering, front hoist control handle (7) must be in the off position. The PC then closes the circuit to front drum clutch solenoid AS11, supplying air pressure to the front drum clutch cylinder which disconnects the front drum from the front hoist motor drive assembly

NOTE When the drum working brakes are released, the load on the drum will free-fall. Lowering speed must be controlled with the drum working brake.

If control handle (7) is moved in either direction from off, the PC will immediately open the circuit to AS11, spring-applying the clutch to connect the front drum to the motor drive assembly. The load is then powered in the specified direction. However, when handle (7) is returned to off, the clutch will again be released, returning the drum to the free-fall condition. At this time, a hoisted load will drop unless controlled by application of the working brake.

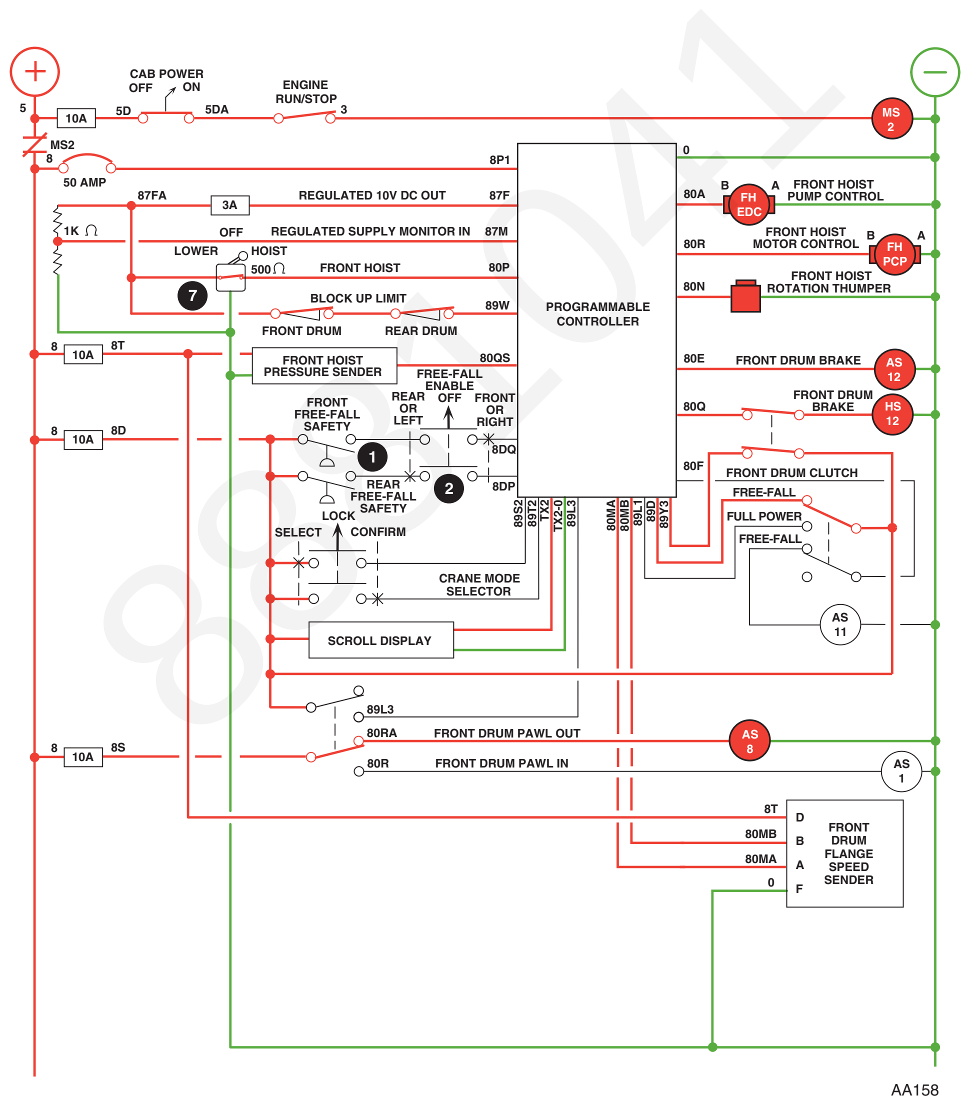


FIGURE 40 FRONT HOIST ELECTRIC CIRCUIT
(Free-fall Mode: HOIST)

Front Drum Hoist (Figure 40)

CAUTION **MOMENTARY LOAD DROP!**

Begin moving control handle before releasing working brake to hold load while clutch engages and power becomes available to drum.

Load will drop immediately unless held by working brake!

When front drum control handle (7) is pulled back in the hoist position, the PC opens and closes the following circuits:

- OPENS circuit to front drum clutch solenoid AS11. This exhausts air pressure from the cylinder of the front drum clutch. The clutch spring-applies, connecting the drum to the motor drive assembly.
- CLOSES a regulated voltage circuit to the front hoist pump EDC.

The circuit to front drum brake solenoids HS12 and AS12 remains closed, keeping the park brakes released.

The front drum clutch applies first, then the front hoist pump EDC strokes the front hoist pump to hoist the load. The PC governs the hoisting speed by varying the voltage to the EDC in conjunction with movement of the front hoist control handle and its program requirements.

Front Drum Power Lower (Figure 41)

CAUTION **DROPPING LOAD!**

Begin applying drum working brake as control handle is moved to off to hold drum when clutch disengages drum from motor drive assembly.

Load will lower uncontrolled if working brake is not applied prior to handle being moved to off!

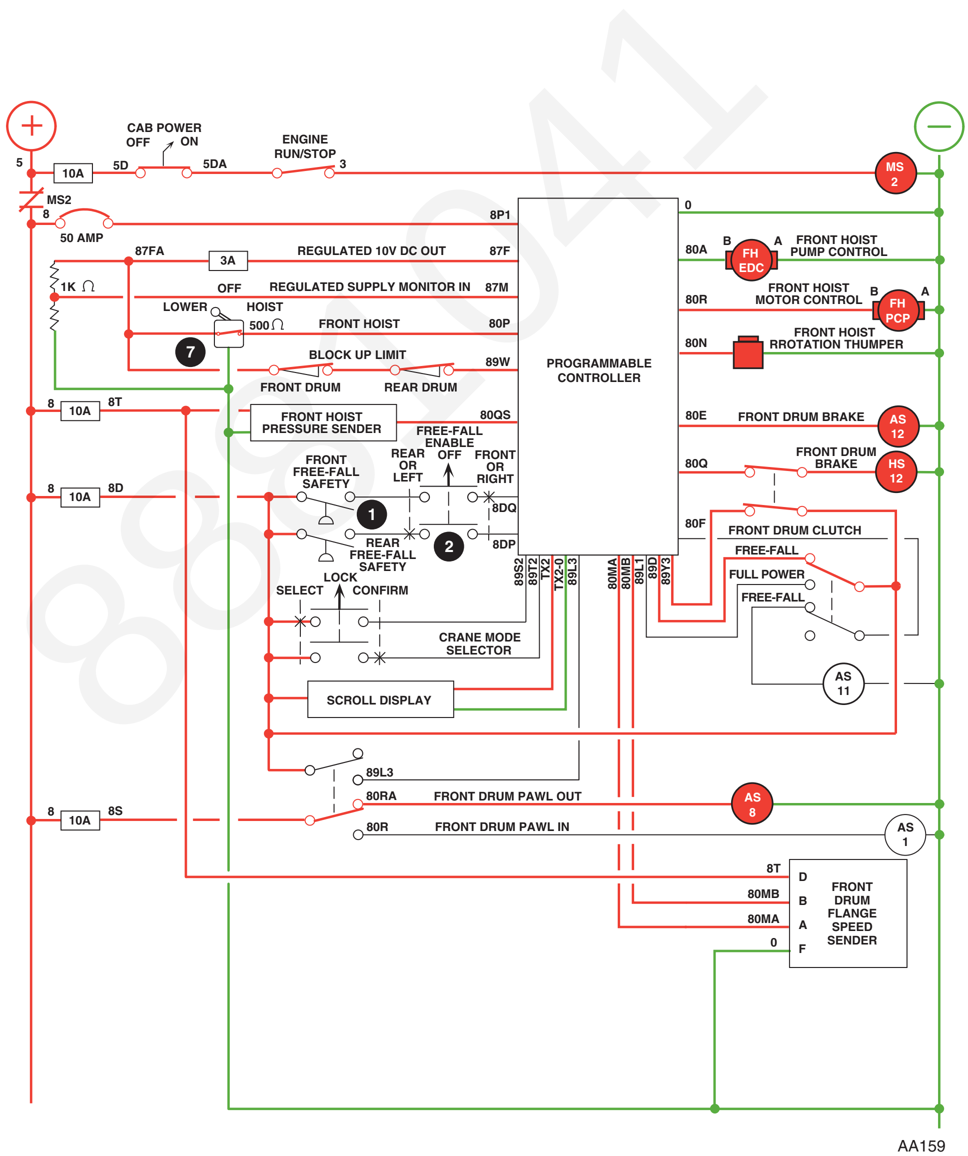


FIGURE 41 FRONT HOIST ELECTRIC CIRCUIT
(Free-fall Mode: POWER LOWER)

When front drum control handle (7) is pushed forward in the lowering position, the PC opens and closes the following circuits:

- OPENS circuit to front drum clutch solenoid AS11. This exhausts air pressure from the cylinder of the front drum clutch. The clutch spring-applies, connecting the drum to the motor drive assembly.
- CLOSES a reverse polarity regulated voltage circuit to the front hoist pump EDC.

The circuit to front drum brake solenoids HS12 and AS12 remains closed, keeping the park brakes released.

The front drum clutch applies first, then the front hoist pump EDC strokes the front hoist pump to lower the load. The PC governs the lowering speed by varying the voltage to the EDC in conjunction with movement of the front hoist control handle and its program requirements.

CRANE SETUP SYSTEMS OPERATION

General (Figure 42)

With the crane setup operating mode selected and confirmed at the crane mode selector, the PC activates the raise and lower functions of the gantry and mast cylinders; the insertion and retraction of the boom hinge pins, counterweight pins, and crawler lock pins; and the cylinder actuation for carbody jacking and crawler positioning. The PC also activates the gantry up operating limit.

The crane setup hydraulic circuit is controlled through the use of two “mobile-type” control valves called accessory system valve (2) and lower accessory valve (3). Each control valve has parallel operating circuits and contains relief valves (4) which are preset for 3,100 psi (215 bar). The accessory system valve is activated by switched solenoids and controls actuation of gantry cylinders (6), boom pin cylinder (7), and mast raising cylinders (8). When energized, the solenoid for a valve section shifts its main spool with charge pressure from rear hoist pump (14) at approximately 350 psi (25 bar). The lower accessory valve controls carbody jacking cylinders (10), crawler extension cylinders (11), and crawler lock pin cylinders (12). These valve sections are activated by spring-loaded hand levers which return to a neutral position when not activated.

The output flow from the crane setup pump section of tandem gear accessory pump (1) is discharged to tank through pilot-operated check valve (5) when all sections of either control valve are not being used. Check valve (5) opens when discharge oil from the high pressure carry-over section of lower accessory valve (3) enters its pilot cavity and pressurizes. The oil then flows through check valve (5) and back to tank through system return filter (13).

When pressurizing a valve section in the setup system, the supply flow passages of either control valve are blocked, stopping oil flow to check valve (5). The pressurized oil within the pilot cavity of valve (5) exhausts to tank through bleed-off orifice (6) and permits the valve to close. The output from the setup pump section of accessory pump (1) is no longer discharged to tank but supplied to a function of the setup system.

Carbody Jacking System

NOTE The following descriptions of operation are for single carbody jacking cylinder. Operation of one or all four cylinders is identical, and all cylinders can be operated at the same time if the crane is in a level position.

NOTE Each carbody jacking cylinder is equipped with a counterbalance valve at the cylinder port. These valves ensure smooth control when raising or lowering the crane and will lock the carbody jacking cylinders in place when not in use, in the event of a hydraulic line breakage, or during the occurrence of accidental or unauthorized operation of the control valve when the crane's power system is shut down. In addition, the counterbalance valves provide relief protection for the cylinders and shield them from unforeseen mechanical overloading.

NOTE The accessory valve used in this circuit contains a “motor spool” (both cylinder ports and tank port of the valve spool section are connected in the center position). This spool selection prevents premature opening of the counterbalance valves.

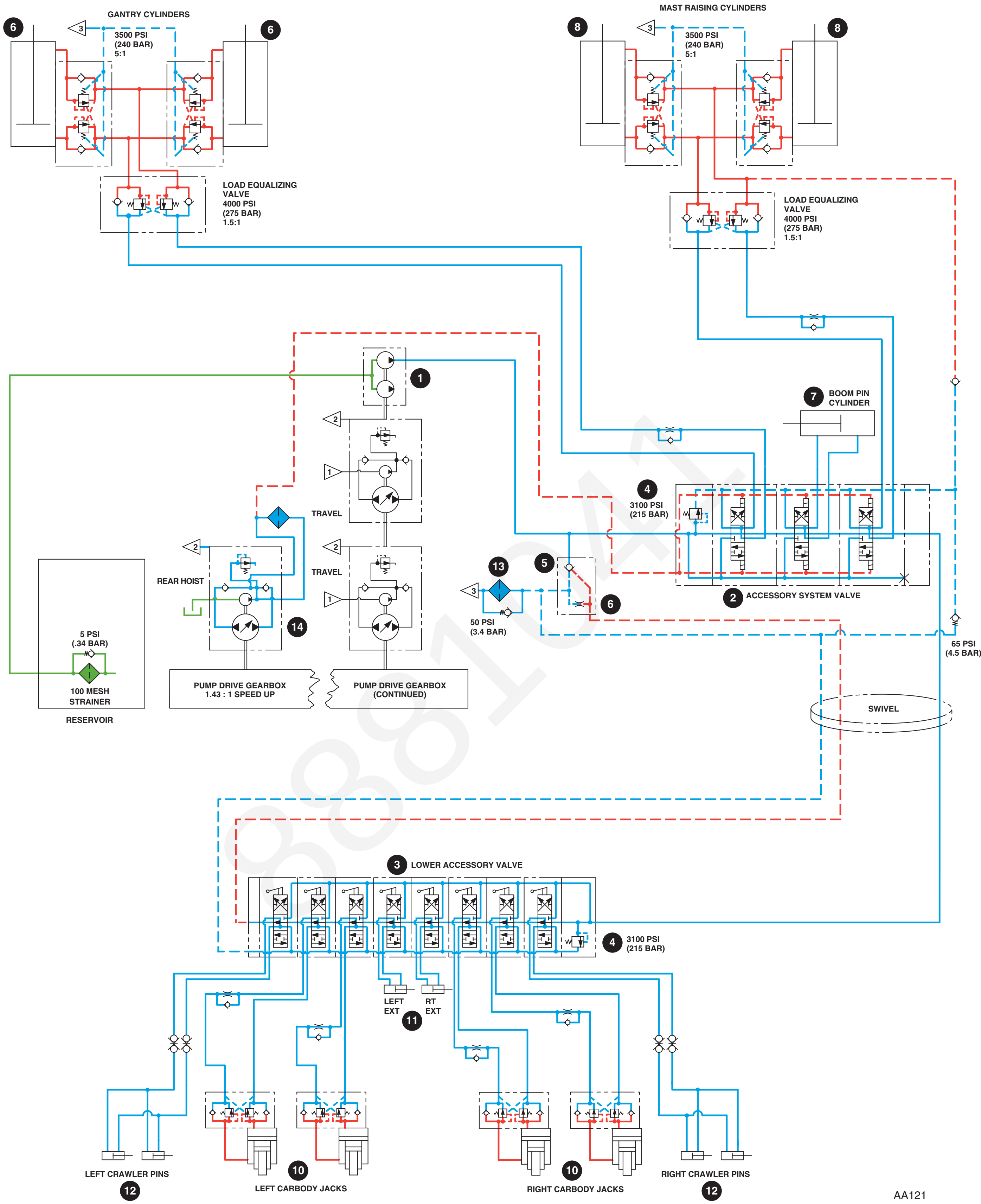


FIGURE 42 CRANE SETUP SYSTEMS HYDRAULIC SCHEMATIC

JACKING CYLINDER EXTEND (Figure 43)

When a carbody jacking cylinder control valve handle is held in the EXTEND position, moving the lever downward on lower accessory valve (3), the valve section shifts to direct oil flow from the setup pump section of accessory pump (1) through the high pressure carry-over of the accessory system valve (2) and into relief valve section (4) of lower accessory valve (3) where system pressure is limited to 3,100 psi (215 bar). Note the system oil flow is also exposed to relief valve (4) in accessory system valve (2) which is set at approximately 3,100 psi (215 bar).

The oil exits the valve section of lower accessory valve (3) into counterbalance valve (15). The oil then enters the head end of carbody jacking cylinder (10), extending the cylinder to lift the carbody. The carbody jacking cylinders are two-stage telescopic in configuration.

Oil returning to tank from the rod end of the carbody jacking cylinder is blocked by the free-flow poppet (check valve) section of counterbalance valve (15) and flows through the flow restraining section which is preset with a relief setting of 3,500 psi (240 bar). The counterbalance valve serves as a deceleration control and functions with a 3:1 pilot ratio of the relief pressure, permitting the valve to open when the pressure in the rod end of the cylinder is approximately 1,170 psi (81 bar). The restraining section of counterbalance valve (15) opens, controlling the oil flow out of the carbody jacking cylinder. The oil then flows through the free-flow poppet (check valve) section of flow control valve (16) before proceeding to lower accessory valve (3). The oil leaving the lower accessory valve is filtered by system filter (13) before returning to tank.

JACKING CYLINDER NEUTRAL

(Not shown on schematics)

When a carbody jacking cylinder control valve handle is not activated, it assumes a neutral position and oil flow passage to carbody jacking cylinder (10) is blocked. In this position, both valve section cylinder ports are connected to tank which prevents inline pressure from opening counterbalance valve (15). Therefore, the carbody load is essentially held in position by the counterbalance valve.

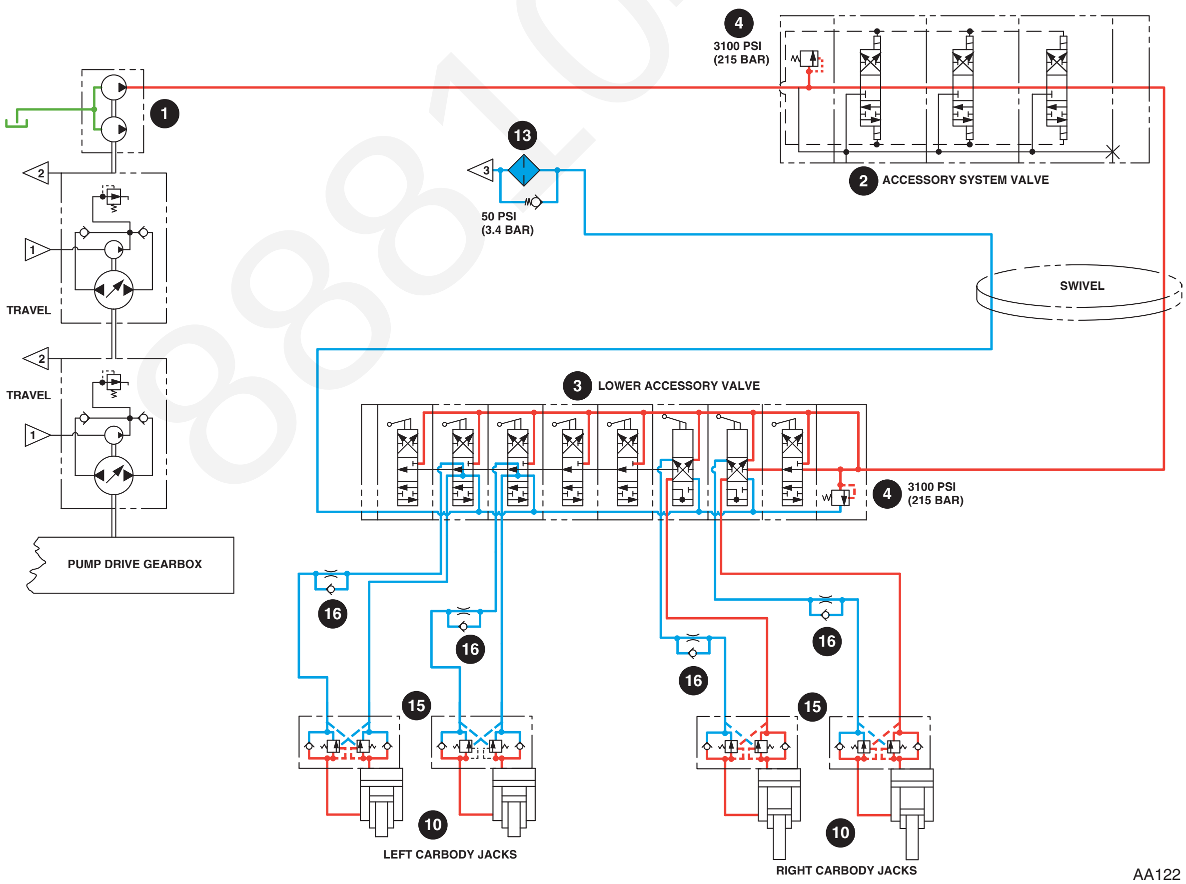


FIGURE 43 CARBODY JACKING CYLINDER HYDRAULIC SYSTEM
(Cylinder EXTEND)

JACKING CYLINDER RETRACT (Figure 44)

When a jacking cylinder control valve handle is held in the RETRACT position, moving the lever upward on lower accessory valve (3), the valve section shifts to direct oil flow from the setup pump section of accessory pump (1) through the high pressure carry-over of accessory system valve (2) and into relief valve section (4) of lower accessory valve (3) where the system pressure is limited to 3,100 psi (215 bar). Note the system oil flow is also exposed to relief valve (4) in accessory system valve (2) which is set at approximately 3,100 psi (215 bar).

The oil exits the valve section of lower accessory valve (3) and flows through the restraining section of flow control valve (16) which controls the rate of speed for the cylinder to retract by limiting the velocity of oil flow before passing through the free-flow poppet (check valve) section of counterbalance valve (15). The oil then proceeds into the rod end of carbody jacking cylinder (10).

NOTE Hydraulic pressure entrapped by the cylinder counterbalance valve at the head end of the carbody jacking cylinder supports the weight and gravitational force of the carbody.

Oil exhausting from the head end of the carbody jacking cylinder is blocked by the free-flow poppet (check valve) section of counterbalance valve (15) and flows through the flow restraining section which is preset for a relief setting of 3,500 psi (240 bar). The counterbalance valve serves as a deceleration control and functions with a 3:1 pilot ratio of the relief pressure, permitting the valve to open when the pressure in the rod end of the cylinder is approximately 1,170 psi (81 bar). The restraining section of counterbalance valve (15) opens which controls oil flow out of the carbody jacking cylinder to lower accessory valve (3). The oil leaving the lower accessory valve is filtered by system filter (13) before returning to tank.

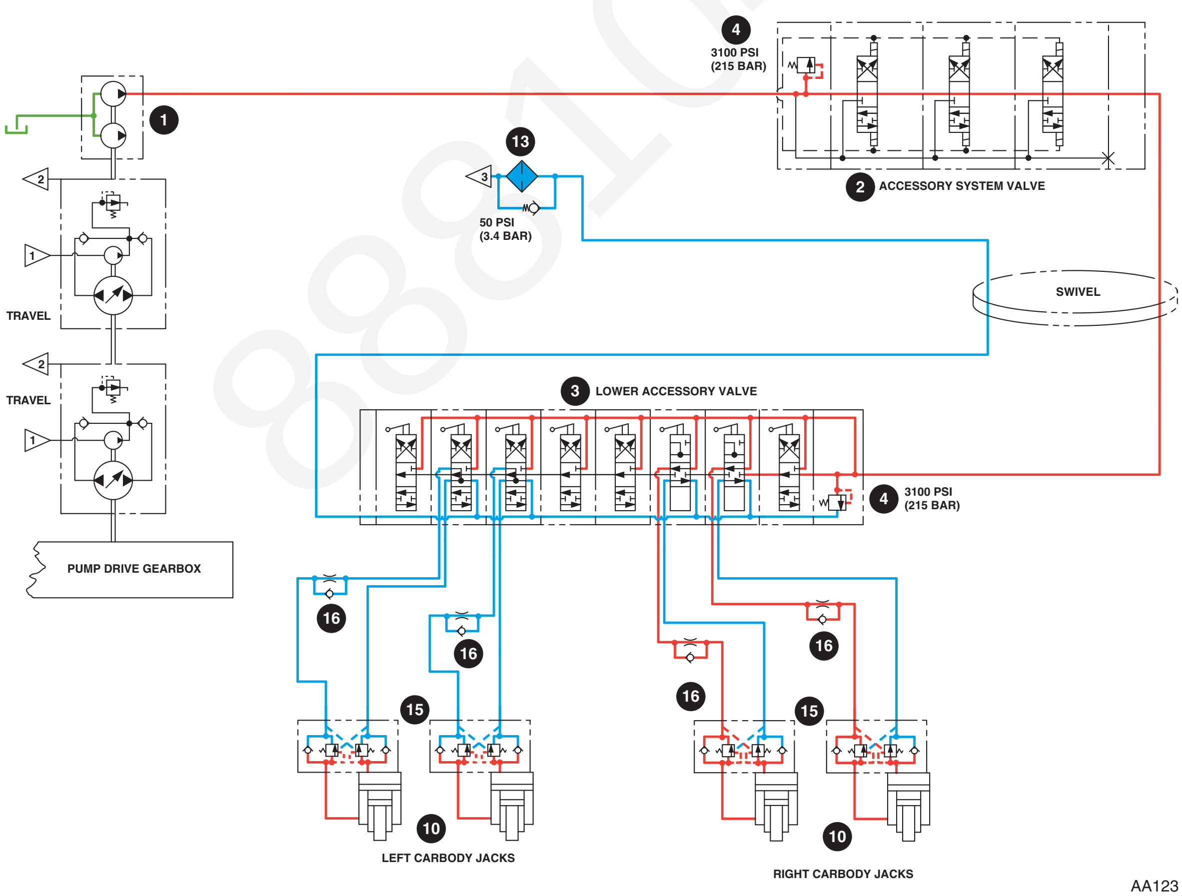


FIGURE 44 CARBODY JACKING CYLINDER HYDRAULIC SYSTEM
(Cylinder RETRACT)

Crawler Attachment System

NOTE The following descriptions of operation are for one set of crawler lock pin cylinders. Operation of both sets of cylinders is identical.

CRAWLER LOCK PIN EXTEND (Figure 45)

When a crawler lock pin control valve handle is held in the EXTEND position, moving the lever downward on lower accessory valve (3), the valve section shifts to direct oil flow from the setup pump section of accessory pump (1) through the high pressure carry-over of accessory system valve (2) and into relief valve section (4) of lower accessory valve (3) where the system pressure is limited to 3,100 psi (215 bar). Note the system oil flow is also exposed to relief valve (4) in accessory system valve (2) which is preset at approximately 3,100 psi (215 bar).

The oil leaves the valve section of lower accessory valve (2) and enters the head end of both crawler lock pin cylinders (12), causing each of the cylinder rods to extend, rotating each assembly lever, and securing the attachment of the crawler to the carbody.

Oil exhausting from the rod end of both crawler lock pin cylinders returns to lower accessory valve (3) and is filtered by system filter (13) before returning to tank.

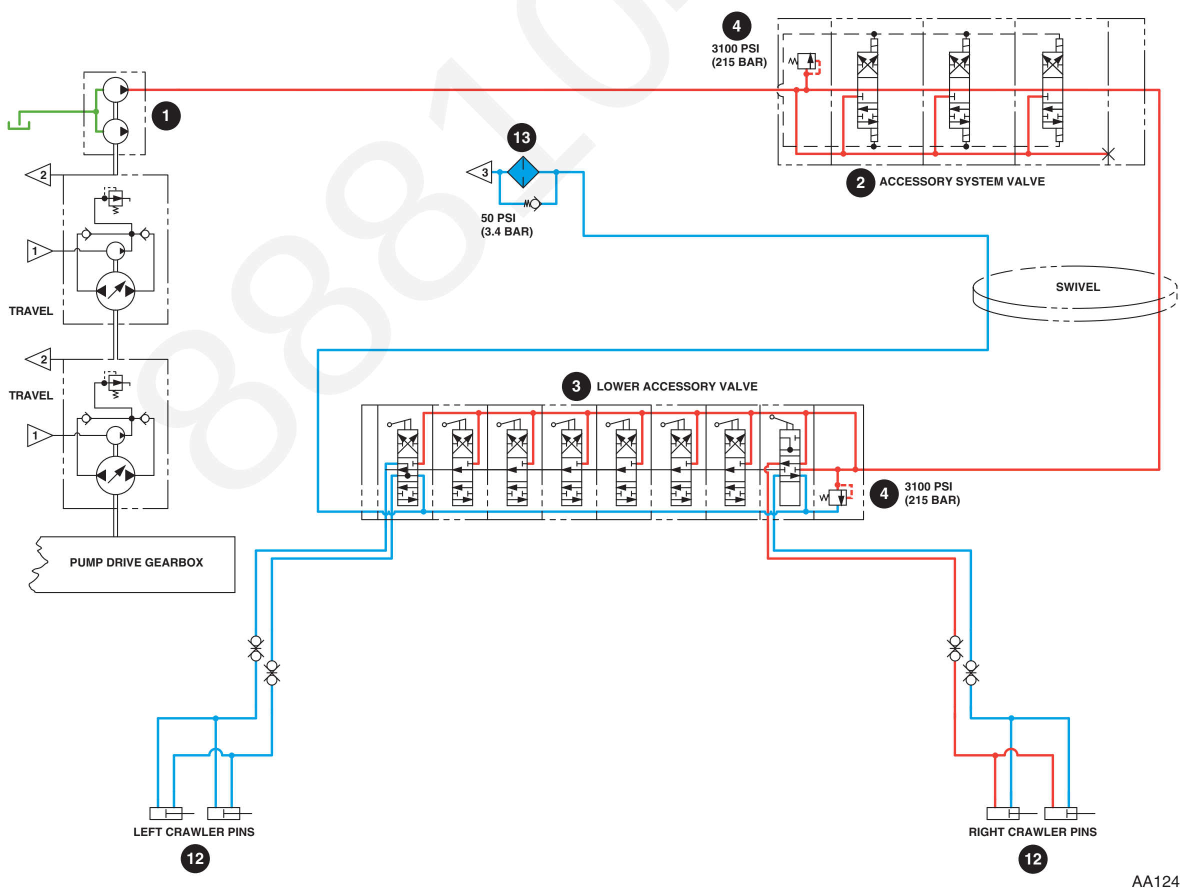


FIGURE 45 CRAWLER LOCK PIN HYDRAULIC SYSTEM
(Pins EXTEND)

CRAWLER LOCK PIN RETRACT (Figure 46)

When a crawler lock pin cylinder control valve handle is held in the RETRACT position, moving the lever upward on lower accessory valve (3), the valve section shifts to direct oil flow from the setup pump section of accessory pump (1) through the high pressure carry-over of accessory system valve (2) and into relief valve section (4) of lower accessory valve (3) where the system pressure is limited to 3,100 psi (215 bar). Note the system oil flow is also exposed to relief valve (4) in accessory system valve (2) which is set at approximately 3,100 psi (215 bar).

The oil leaves the pin cylinder valve section of lower accessory valve (3) and enters the rod end of both crawler lock pin cylinders (12), causing the cylinder rods to retract, rotating the pin assembly levers, and permitting the crawler to be released and separated from the carbody.

Oil exhausting from the head end of both crawler lock pin cylinders returns to lower accessory valve (3) and is filtered by system filter (13) before returning to tank.

Crawler Positioning System

CRAWLER POSITIONING CYLINDER EXTEND
(Figure 47)

When a crawler positioning control valve handle is held in the EXTEND position, moving the lever downward on lower accessory valve (3), the valve section shifts to direct oil flow from the setup pump section of accessory pump (1) through the high pressure carry-over of accessory system valve (2) and into relief valve section (4) of lower accessory valve (3) where the system pressure is limited to 3,100 psi (215 bar). Note the system oil flow is also exposed to relief valve (4) in accessory system valve (2) which is set at approximately 3,100 psi (215 bar). The oil leaves the crawler positioning valve section and enters the head end of crawler positioning cylinder (11), causing the cylinder rod to extend and move the crawler outward, away from the carbody.

Oil exhausting from the rod end of the crawler positioning cylinder returns to lower accessory valve (3) and is filtered by system filter (13) before returning to tank.

CRAWLER POSITIONING CYLINDER RETRACT
(Figure 48)

When a crawler positioning control valve handle is held in the RETRACT position, moving the lever upward on lower accessory valve (3), the valve section shifts to direct oil flow from the setup pump section of accessory pump (1) through the high pressure carry-over of accessory system valve (2) and into relief valve section (4) of lower accessory valve (3) where system pressure is limited to 3,100 psi (240 bar). Note the system oil flow is also exposed to relief valve (4) in accessory system valve

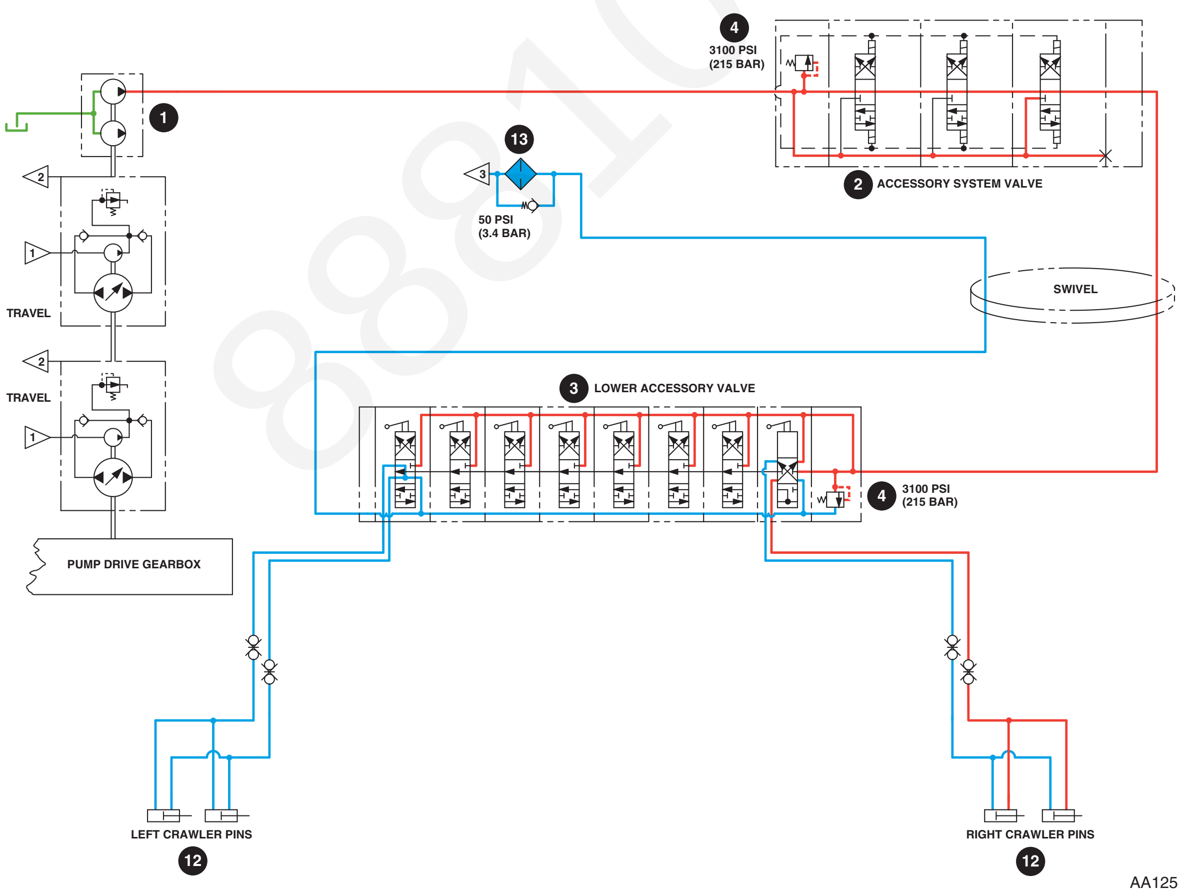


FIGURE 46 CRAWLER LOCK PIN HYDRAULIC SYSTEM
(Pins RETRACT)

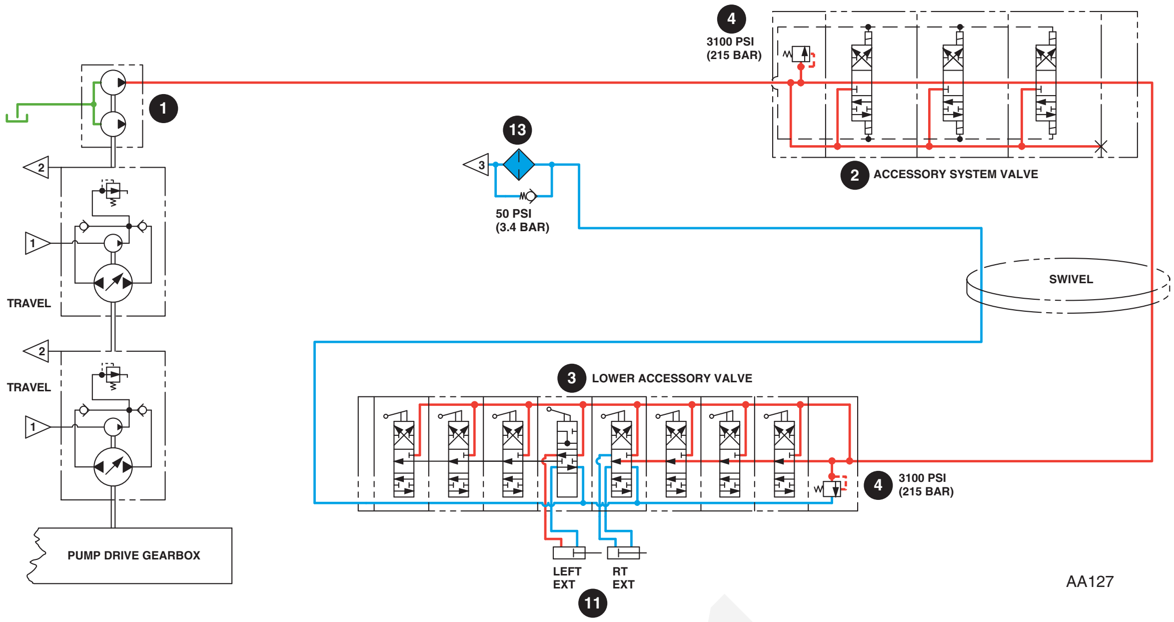


FIGURE 47 CRAWLER POSITIONING CYLINDER HYDRAULIC SYSTEM
(Cylinder EXTEND)

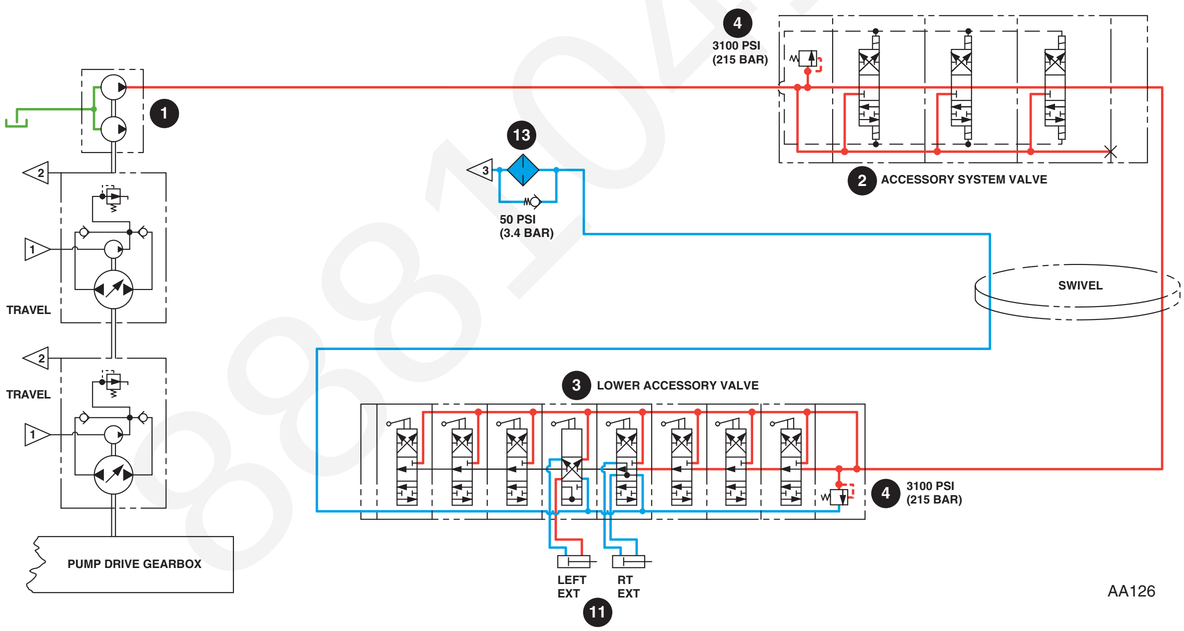


FIGURE 48 CRAWLER POSITIONING CYLINDER HYDRAULIC SYSTEM
(Cylinder RETRACT)

(2) which is set at approximately 3,100 psi (215 bar). The oil leaves the crawler cylinder positioning valve section and enters the rod end of crawler positioning cylinder (11), causing the cylinder rod to retract and pull the crawler inward, toward the carbody.

Oil exhausting from the head end of the crawler positioning cylinder returns to lower accessory valve (3) and is filtered by system filter (13) before returning to tank.

Boom Attachment System

BOOM HINGE PINS INSERT (Figures 49 and 50)

When the right end of the boom hinge pins switch, located on the right console in the operator's cab, is depressed and held in the IN position, an electrical power supply circuit is completed from the PC to the boom hinge pins cylinder insert hydraulic solenoid HS10. When

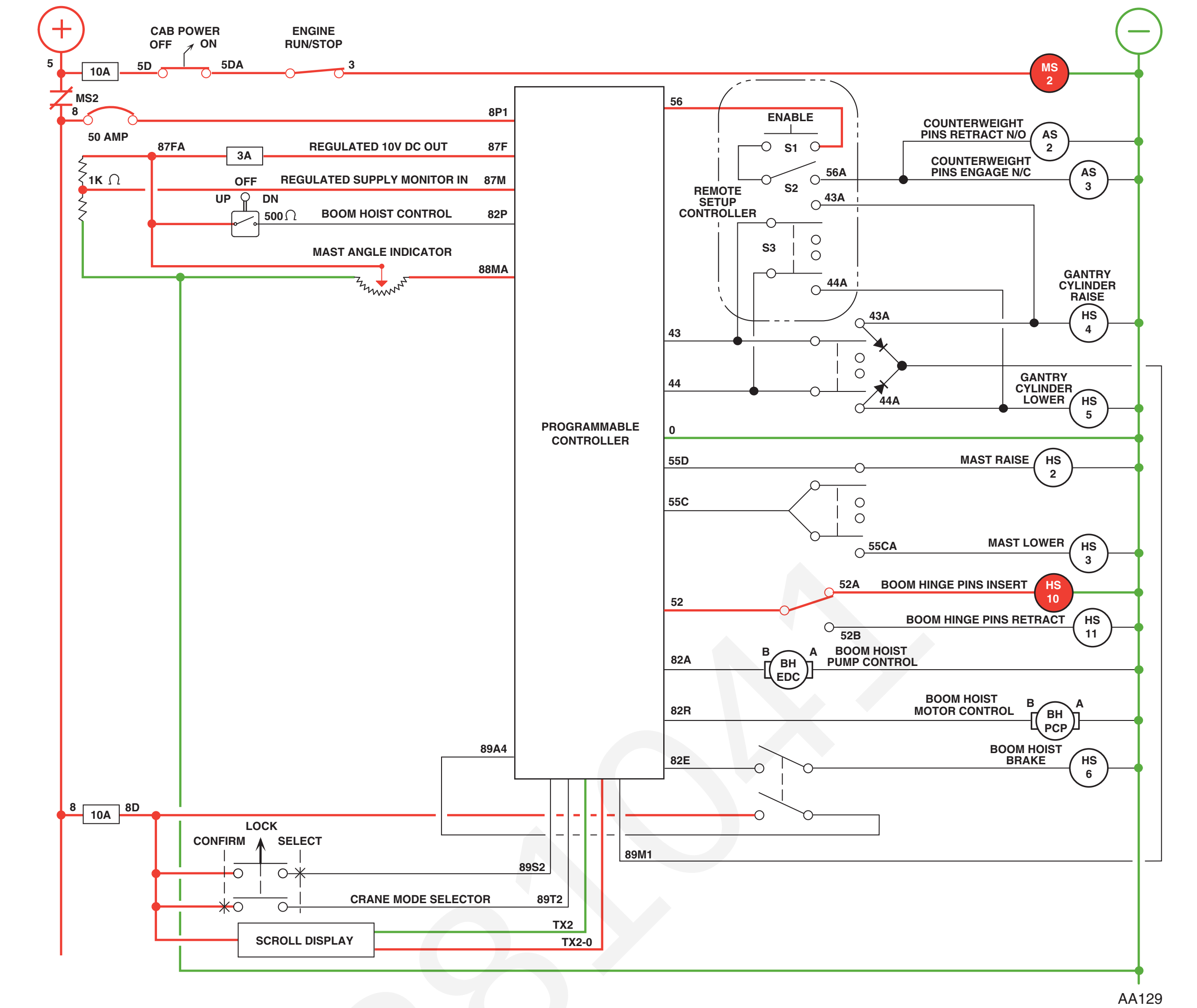


FIGURE 49 BOOM HINGE PIN ELECTRIC CIRCUIT
(Pins INSERT)

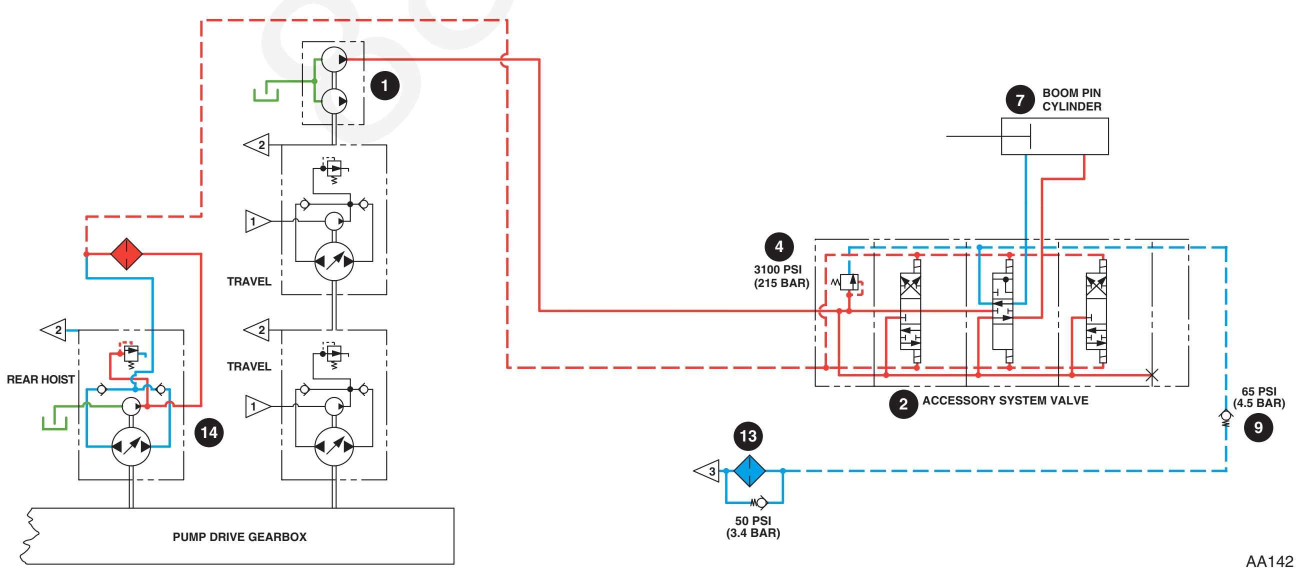


FIGURE 50 BOOM HINGE PIN HYDRAULIC SYSTEM
(Pins INSERT)

HS10 is energized, its valve is shifted by 350 psi (25 bar) pilot pressure from rear load drum hoist charge pump (14). Oil then flows from the system setup pump section of accessory pump (1) into relief valve section (4) of accessory system valve (2) where the system oil pressure is limited to 3,100 psi (240 bar). The oil leaves the cylinder valve section and enters the head end of boom pin cylinder (7), causing the cylinder rod to extend from the cylinder and engage the hinge pins.

Exhaust oil from the rod end of boom pin cylinder (7) leaves accessory system valve (2) and passes through check valve (9) before being returned to tank through system filter (13).

BOOM HINGE PINS RETRACT (Figures 51 and 52)

When the left end of the boom hinge pins switch, located on the right console in the operator's cab, is depressed and held in the OUT position, an electrical power supply circuit is completed from the PC to the boom hinge pins cylinder retract hydraulic solenoid HS11. When HS11 is energized, its valve is shifted by 350 psi (25 bar) pilot pressure from rear hoist charge pump (14). Oil then flows from the system setup pump section of accessory pump (1) into relief valve section (4) of accessory system valve (2) where the system oil pressure is limited to 3,100 psi (240 bar). The oil leaves the cylinder valve section and enters the rod end of boom pin cylinder (7), causing the cylinder rod to retract into the cylinder housing and disengage the hinge pins.

Exhaust oil from the head end of boom pin cylinder (7) leaves accessory system valve (2) and passes through check valve (9) before being returned to tank through system filter (13).

Gantry System

NOTE When the crane system is confirmed for setup mode and the mast angle indicator monitors the mast position at less than 25°, a circuit is closed from the PC to boom hoist hydraulic park brake

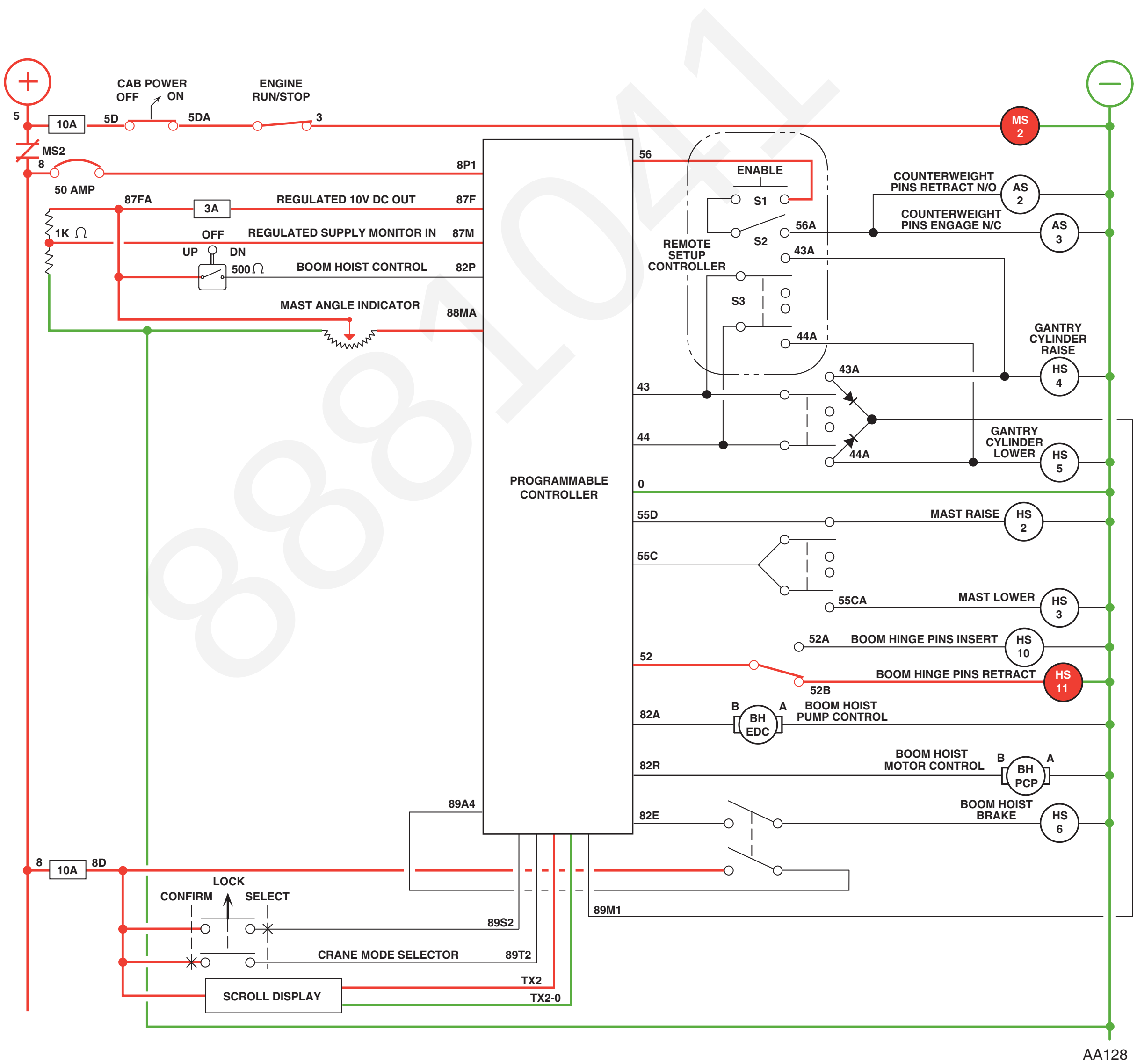


FIGURE 51 BOOM HINGE PIN ELECTRIC CIRCUIT
(Pins RETRACT)

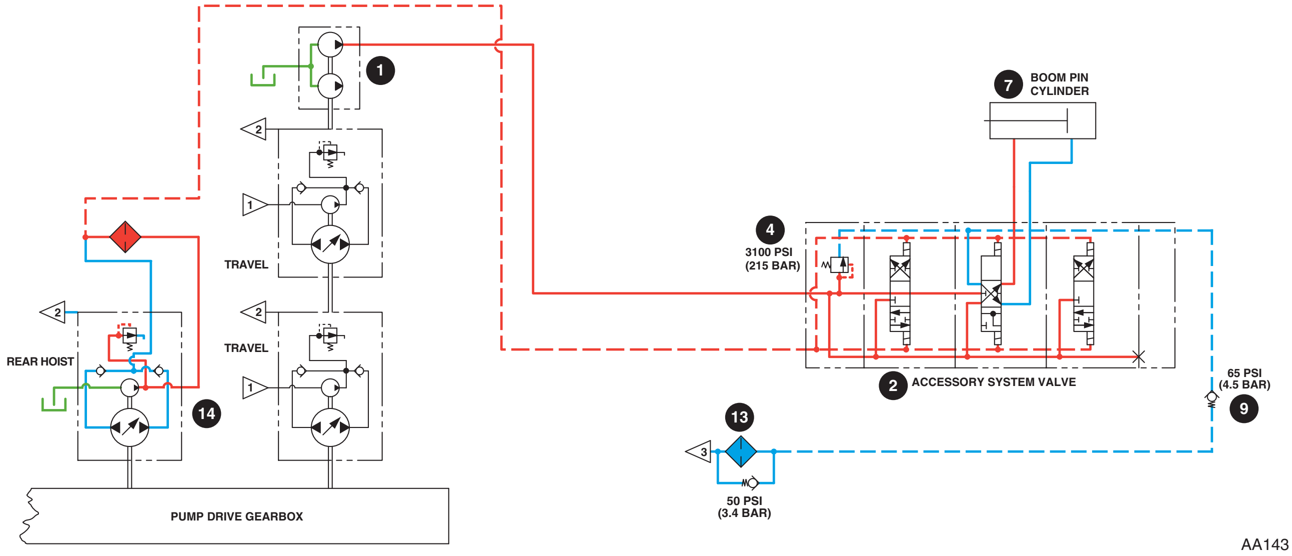


FIGURE 52 BOOM HINGE PIN HYDRAULIC SYSTEM (Pins RETRACT)

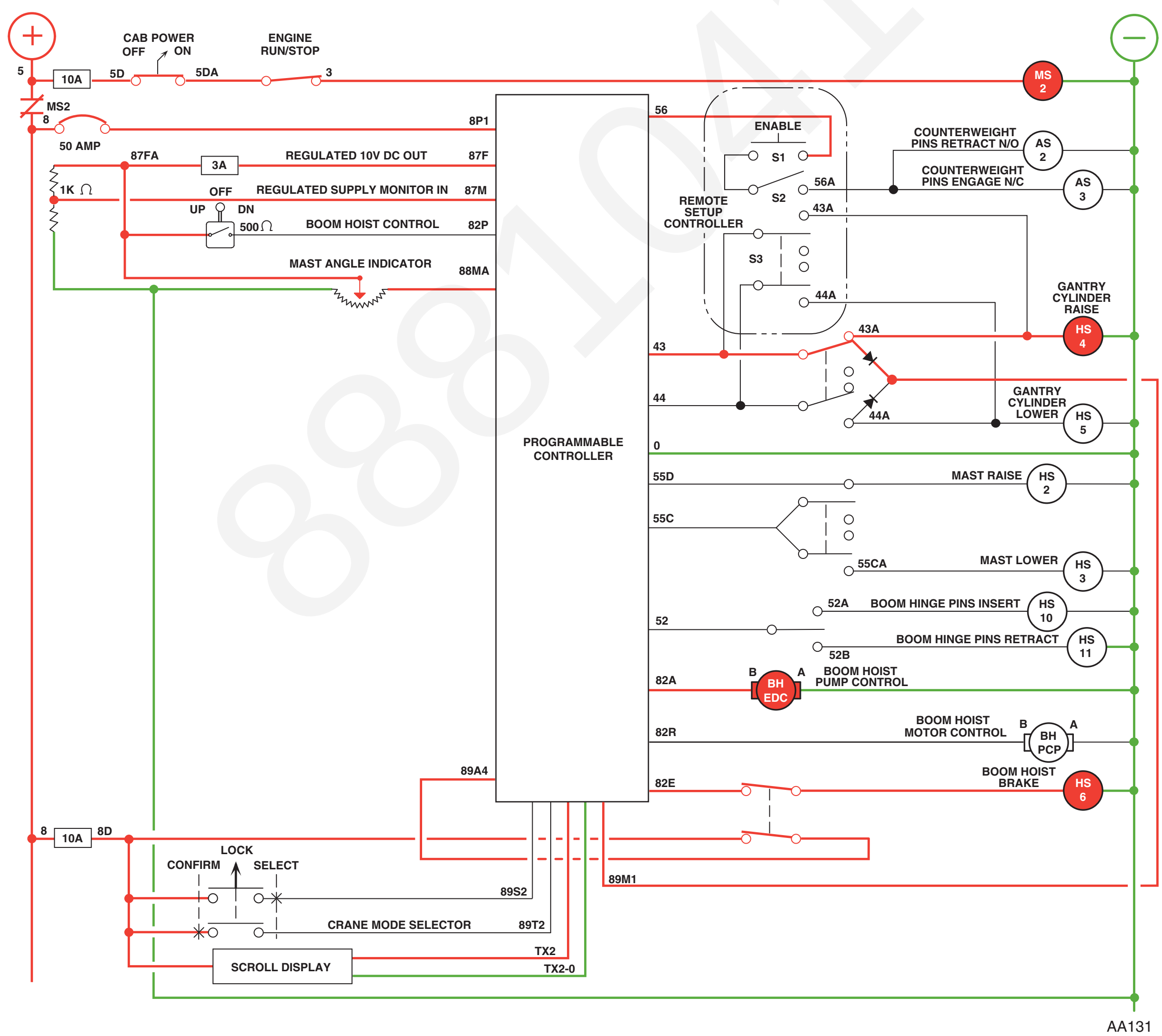


FIGURE 53 GANTRY CYLINDER ELECTRIC CIRCUIT (Cylinders RAISE)

solenoid HS6. This permits the boom hoist drum to wind or release wire rope onto or from the reeving between the gantry and mast sheaves as the gantry is raised or lowered.

NOTE A gantry operating limit fault message (GANTRY DOWN) will appear on the digital display when the gantry is down and the mast is lowered to 135°. The PC will detect this fault when the mast angle indicator monitors the mast position at 135° and the gantry up limit switch circuit to the PC is closed. The operator should fully raise the gantry at this time.

NOTE Each gantry cylinder (6) is equipped with a counterbalance valve (25) at each cylinder port. These valves ensure smooth control when raising or lowering the gantry and will lock the cylinder in place when the gantry is at a desired position or in the event of a hydraulic line breakage.

NOTE The accessory valve used in this circuit contains a "motor spool" (both cylinder ports and tank port of the valve spool section are connected in the center position). This spool selection prevents premature opening of load equalizing valve (17).

GANTRY SUPPORT CYLINDERS RAISE

(Figures 53 and 54)

When the left end of the gantry support switch, located on the right console in the operator's cab, is depressed and held in the RAISE position, or gantry operation is activated via remote hand controller, an electric power supply circuit is completed from the PC to the gantry cylinders raise hydraulic solenoid HS4. Oil then flows from the setup pump section of accessory pump (1) into relief valve section (4) of accessory system valve (2) where the system oil pressure is limited to 3,100 psi (240 bar). When HS4 is energized, its valve spool is shifted by 350 psi (25 bar) pilot pressure from rear hoist charge pump (14). The oil leaves the gantry cylinder valve section of accessory system valve (2) and flows through the free-flow poppet (check valve) sections on side "A" of load equalizing valve (17) and counterbalance valves (25) and into the head end of gantry cylinders (6), causing the cylinder rams to extend and raise the gantry.

Oil exhausting from the rod end of gantry cylinders (6) is blocked by the free-flow poppet (check valve) sections on side "B" of counterbalance valves (25) and passes through the valves' flow restrain sections preset at a relief setting of 3,500 psi (240 bar). Counterbalance valves (25) serve as a deceleration control and function with a

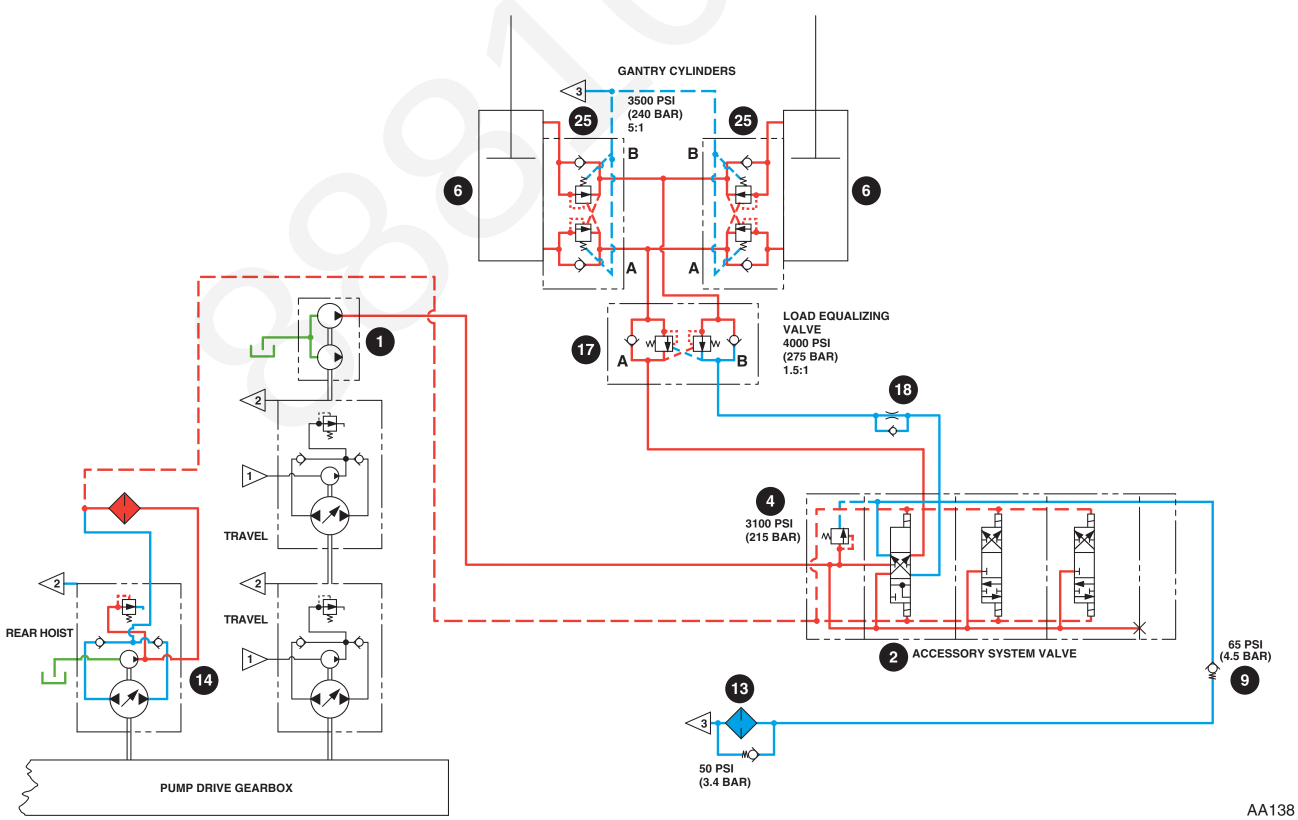


FIGURE 54 GANTRY CYLINDER HYDRAULIC SYSTEM
(Cylinders RAISE)

5:1 pilot ratio of the relief valve pressure, permitting the valves to open when the pressure in the head end of the cylinders is approximately 700 psi (48 bar). The exhaust oil from side “B” of both counterbalance valves combines, and the flow is blocked by the free-flow poppet (check valve) sections on side “B” of load equalizing valve (17). The oil then passes through the flow restrain section of valve (17) which is preset at 4,000 psi (275 bar). Load equalizing valve (17) operates with a 1.5:1 pilot ratio of the relief valve pressure, permitting the valve to open when oil pressure (from the setup pump) on side “A” of the valve is approximately 2,670 psi (185 bar). The restraining section on side “B” of load equalizing valve (17) opens, controlling the oil flow out of both cylinders and ensuring cylinder actuation is in unison.

The oil passes through the non-restrictive portion of flow control valve (18) before entering accessory system valve (2). The oil exits the accessory system valve through the gantry valve section and passes through check valve (9) before returning to tank through system filter (13).

GANTRY SUPPORT CYLINDERS LOWER

(Figures 55 and 56)

When the right end of the gantry support switch, located on the right console in the operator's cab, is depressed and held in the LOWER position, or gantry operation is activated via remote hand controller, an electric power supply circuit is completed from the PC to the gantry cylinders lower hydraulic solenoid HS5. Oil then flows from the system setup pump section of accessory pump (1) into relief valve section (4) of accessory system valve (2) where the system oil pressure is limited to 3,100 psi (240 bar). When HS5 is energized, its valve spool is shifted by 350 psi (25 bar) pilot pressure from rear hoist charge pump (14). The oil leaves the gantry cylinder valve section of accessory system valve (2) and passes through the restrictive section of flow control valve (18). The oil then passes through the free-flow poppet (check valve) sections on side “B” of load equalizing valve (17) and counterbalance valves (25) and into the rod end of gantry cylinders (6), causing the cylinder rams to retract and lower the gantry.

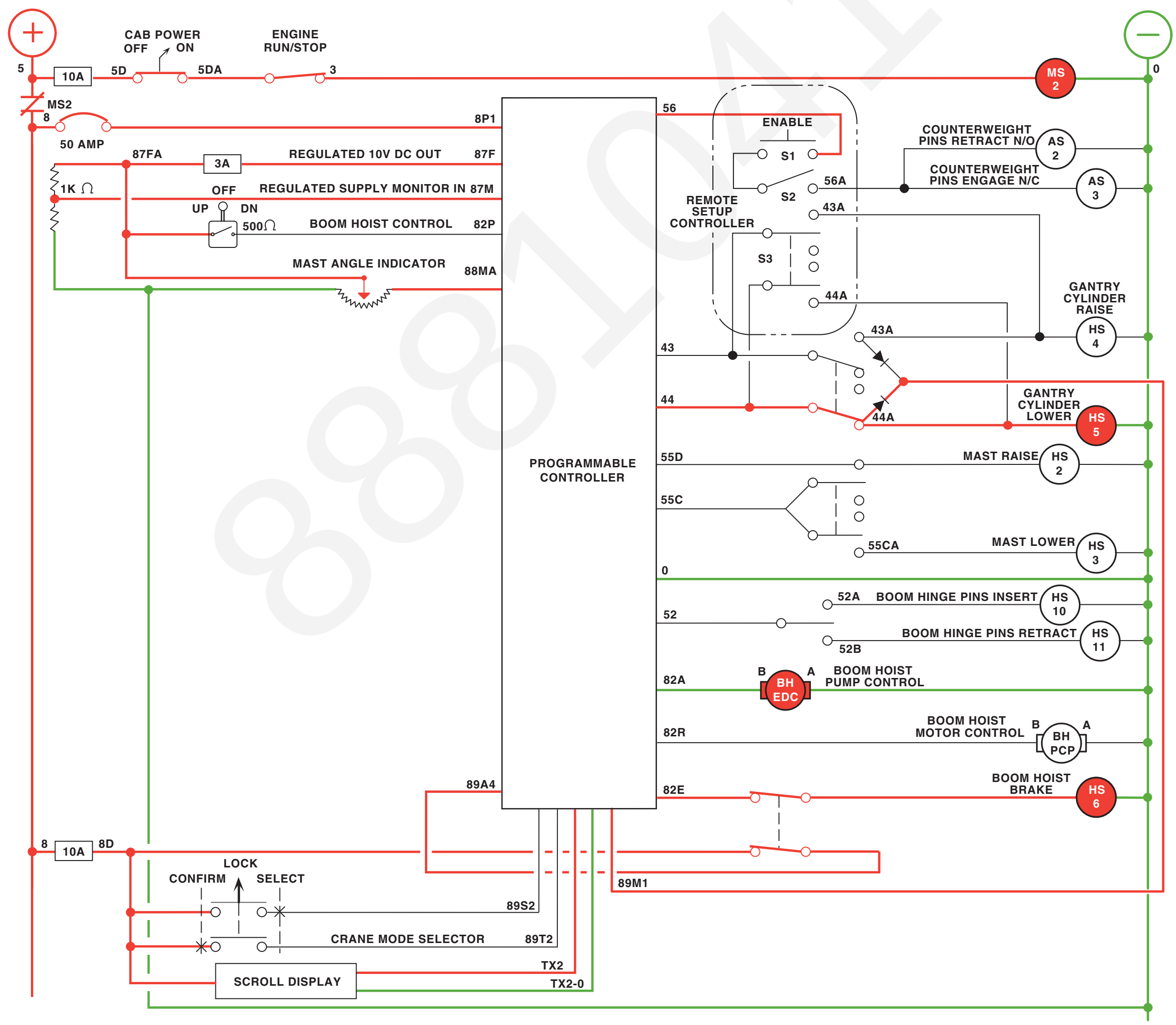


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FIGURE 55 GANTRY CYLINDER ELECTRIC CIRCUIT
(Cylinders LOWER)

Oil exhausting from the head end of gantry cylinders (6) is blocked by the free-flow poppet (check valve) sections on side “A” of counterbalance valves (25) and passes through the valves’ flow restrain sections preset at a relief setting of 3,500 psi (240 bar). Counterbalance valves (25) operate with a 5:1 pilot ratio of the relief valve pressure, permitting the valve to open when oil pressure in the rod end of the cylinders is approximately 700 psi (48 bar). The exhaust oil from side “A” of counterbalance valves (25) combines and the flow is blocked by the free-flow poppet (check valve) section on side “A” of load equalizing valve (17). The oil then passes through the flow restrain section of valve (17) which is preset at 4,000 psi (275 bar). Load equalizing valve (17) operates with a 1.5:1 pilot ratio of the relief valve pressure, permitting the valve to open when the oil pressure (from the setup pump) on side “B” of load equalizing valve (17) is approximately 2,670 psi (185 bar). The restraining section on side “A” of load equalizing valve (17) opens, controlling the oil flow out of both cylinders and ensuring cylinder actuation is in unison.

The oil exits the accessory system valve through the gantry valve section and passes through check valve (9) before returning to tank through system filter (13).

Mast Assist System

NOTE When the crane system is confirmed for setup mode and the mast angle indicator monitors the mast position at less than 25°, a circuit is closed from the PC to boom hoist hydraulic park brake solenoid HS6. This permits the boom hoist drum to wind or release wire rope onto or from the reeving between the gantry and mast sheaves as the gantry is raised or lowered.

NOTE A mast operating limit fault message (MAST TOO FAR FORWARD) will appear on the digital display when the mast is lowered to 175°. The PC will detect this fault when the mast angle indicator registers the mast position at 175°, and will override the boom down command to automatically stop the boom from lowering. It is not possible for the operator to boom down at this time, and the boom should be raised to correct this fault.

NOTE Each mast raising cylinder (8) is equipped with a counterbalance valve (24) at each cylinder port. These valves ensure smooth control when raising or lowering the mast and will lock the gantry in a desired position or secure it in the event of a hydraulic line breakage.

NOTE The accessory valve used in this circuit contains a “motor spool” (both cylinder ports and tank port of the valve spool section are connected in the center position). This spool selection prevents premature opening of load equalizing valve (20).

NOTE The rate at which the mast can be raised and lowered is controlled by the boom hoist handle,

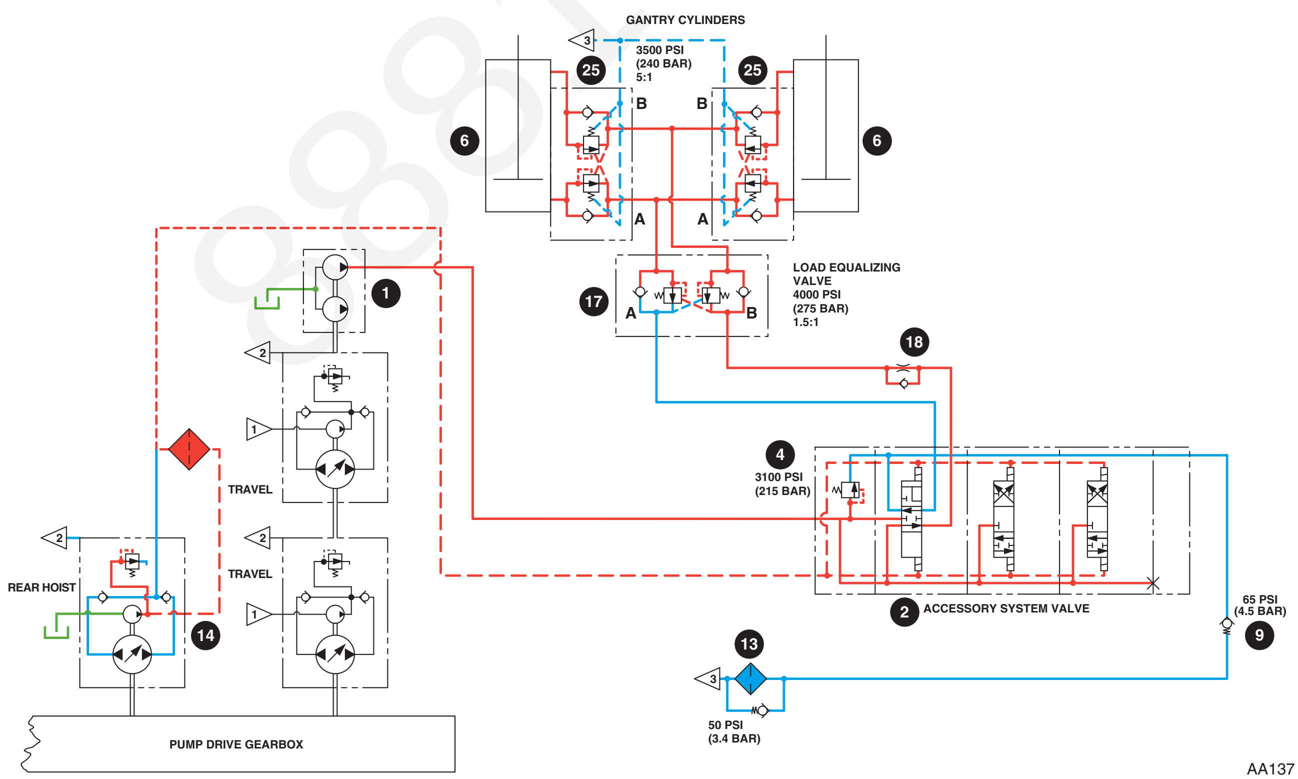


FIGURE 56 GANTRY CYLINDER HYDRAULIC SYSTEM
(Cylinders LOWER)

as it directly regulates the rotational "spool-out" speed of the boom hoist drum and the reeving of cable between the gantry and mast sheaves. Mast raising cylinders (8) provide assistance to lift and lower the mast during reeving of the mast and gantry sheaves.

MAST RAISE AT ASSEMBLY (Figures 57 and 58)

NOTE The hydraulic pressure required for boom hoist brake release and mast cylinder control valve actuation is directly sourced from the low pressure side of the boom hoist closed-loop circuit. If this pressure is lost for any reason, the boom hoist park brake will apply and the mast raising operation will cease.

When preparing to raise the mast at the time of assembly, the following steps must be completed:

- The crane operating system must be confirmed for setup mode.
- The boom hoist park brake switch must be placed in the OFF position.
- The gantry must be fully raised (see Gantry Support Cylinders Raise).

When raising the mast with the gantry support cylinders, the boom hoist system hydraulic pressure is monitored by the PC through boom hoist pressure sender (26) and controlled by the PC to maintain a minimum rope tension on the boom hoist drum. The PC maintains this tension by stroking or destroking the boom hoist pump to create an average system back pressure of approximately 1200 psi, while the gantry support cylinders are fully extended with the mast resting on top of the gantry.

After the gantry support cylinders are fully extended, the boom hoist control handle can be moved forward in the "boom down" direction to extend the mast cylinders and push the mast upward. Electric power supply circuits are then completed from the PC to the boom hoist pump EDC, boom hoist motor PCP, boom hoist hydraulic park

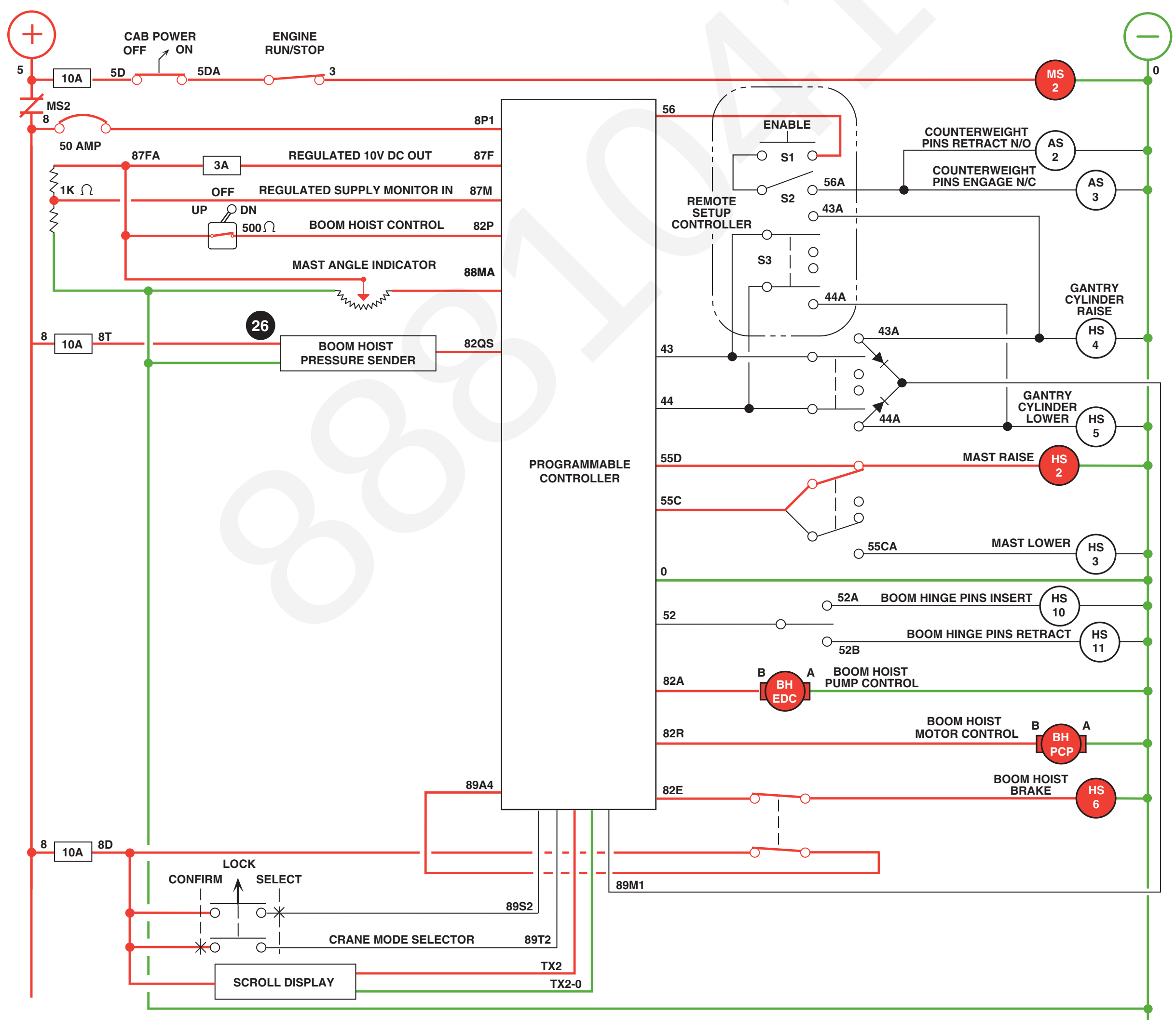


FIGURE 57 MAST CYLINDER ELECTRIC CIRCUIT
(Cylinders RAISE at Assembly Only)

brake solenoid HS6, and mast cylinders raise hydraulic solenoid HS2.

As part of the normal operating routine, the PC program requires the boom hoist pump swashplate strokes in the up direction to satisfy system pressure memory requirements and initiate the release of the boom hoist park brake. When adequate pressure is detected, the PC energizes the boom hoist park brake valve to release the brake. This allows the boom hoist motor to rotate in the down direction, causing cable to unwind from the boom hoist drum and reeve between gantry and mast sheaves.

Actuation of the boom hoist control handle energizes the mast cylinders control valve section of accessory system valve (2). When this occurs, oil flows from the setup pump section of accessory pump (1) into relief valve section (4) of accessory system valve (2), where the system oil pressure is limited to 3,100 psi (240 bar). When HS2 is energized, its spool is shifted by 350 psi pilot pressure from rear hoist charge pump (14). The oil exits the mast cylinders valve section of accessory system valve (2) and flows through the free-flow poppet (check valve) sections on side “A” of load equalizing valve (20) and counterbalance valves (24). The oil then enters into the head end of mast raising cylinders (8), extending the cylinder rams to lift the mast assembly.

Oil exhausting from the rod end of mast raising cylinders (8) is blocked by the free-flow poppet (check valve) sections on side “B” of counterbalance valves (24) and flows through the valves’ flow restrain sections preset for a relief pressure of 3,500 psi (240 bar). Counterbalance valves (24) operate with a 5:1 pilot ratio of the relief valve pressure, permitting the valve to open when pressure in the head end of the cylinders is approximately 700 psi (48 bar).

NOTE Load equalizing valve (20) ensures mast raising cylinders (8) operate in unison, protecting the mast from structural damage caused by twisting. The load equalizing valve also provides support resistance against the mast to ensure control of the unit while rotating it 120° at the time of assembly.

The exhaust oil from the side “B” sections of both counterbalance valves (24) combines, and the flow is blocked by the free-flow poppet (check valve) section on side “B” of load equalizing valve (20). The oil then passes through the valve’s flow restrain section preset at 4,000 psi (275 bar). Load equalizing valve (20) operates with a 1.5:1 pilot ratio of the relief valve pressure, permitting the valve to open when the oil pressure (from the setup pump) on side “A” of the load equalizing valve is approximately 2,670 psi (185 bar). The restraining section on side “B” of load equalizing valve (20) opens, controlling the flow of oil out of the cylinders and ensuring cylinder operation is in unison.

The oil then passes through the non-restrictive portion of flow control valve (21) and enters accessory system valve (2). The oil exits the accessory system valve through the gantry cylinders control valve section and passes through check valve (9) before returning to tank through system filter (13).

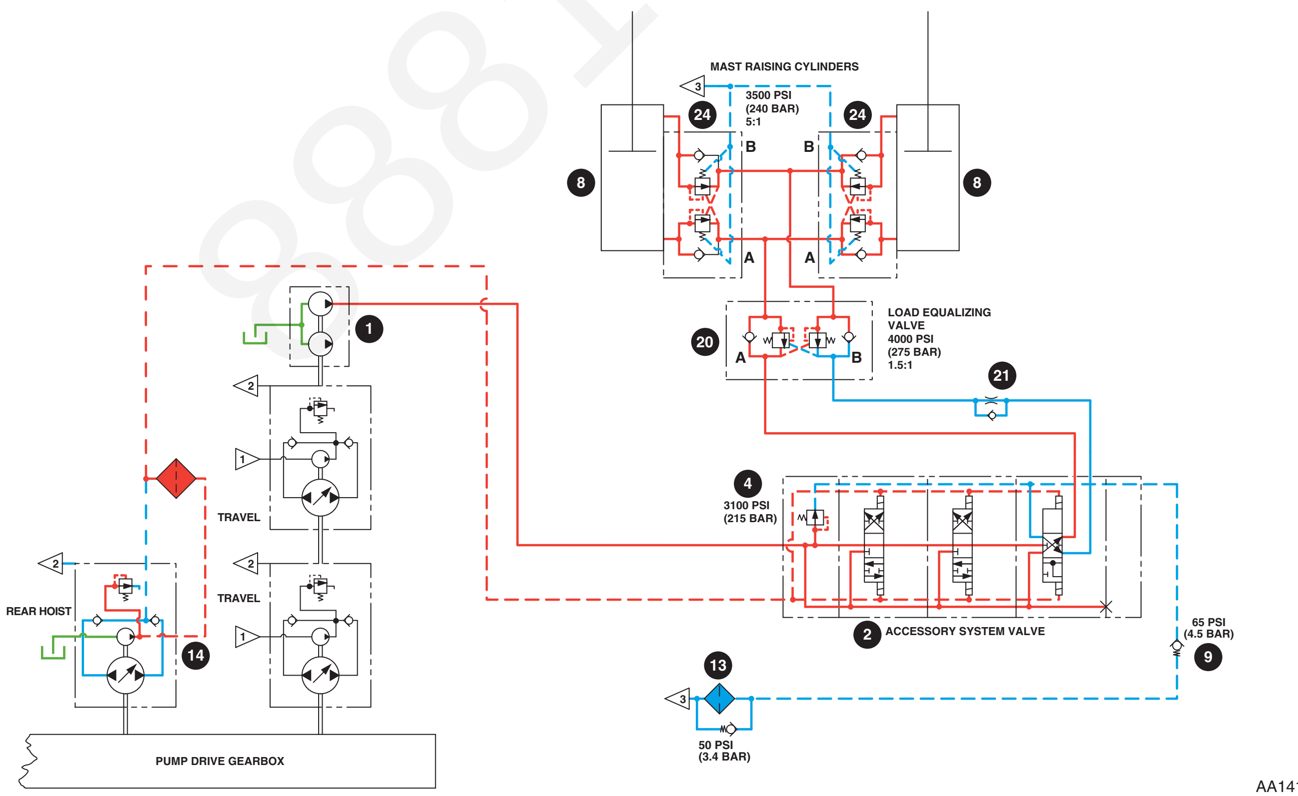


FIGURE 58 MAST CYLINDER HYDRAULIC SYSTEM
(Cylinders RAISE)

MAST LOWER AT DISASSEMBLY (Figures 59 and 60)

NOTE The hydraulic pressure required for boom hoist brake release actuation is directly sourced from the low pressure side of the boom hoist closed-loop circuit. If this pressure is lost for any reason, the boom hoist park brake will apply and the mast lowering operation will stop.

When the boom hoist control handle, located on the left console in the operator's cab, is moved backward in the “boom up” direction, the boom hoist park brake switch is off and the crane operating system is confirmed for setup mode. The electric power supply circuits are then completed from the PC to the boom hoist pump EDC, boom hoist motor PCP valve, and boom hoist brake hydraulic solenoid HS6.

As part of the normal operating routine, the PC program requires the boom hoist pump swashplate to stroke in the up direction to satisfy system pressure memory requirements and initiate the release of the boom hoist park brake. When adequate pressure is detected, the PC energizes the boom hoist brake valve and releases the brake. This allows the boom hoist motor to rotate in the up direction, causing cable to wind onto the boom hoist drum from the reeving between the gantry and mast sheaves.

NOTE The mast cylinders provide supportive resistance against the mast while lowering (rotating) it into the disassembled position.

When lowering the mast at the time of disassembly, the mast cylinders lower hydraulic solenoid HS3 is not energized. The mast cylinder rods are retracted by the exertion of gravitational force from the weight of the mast and the boom hoist line pull.

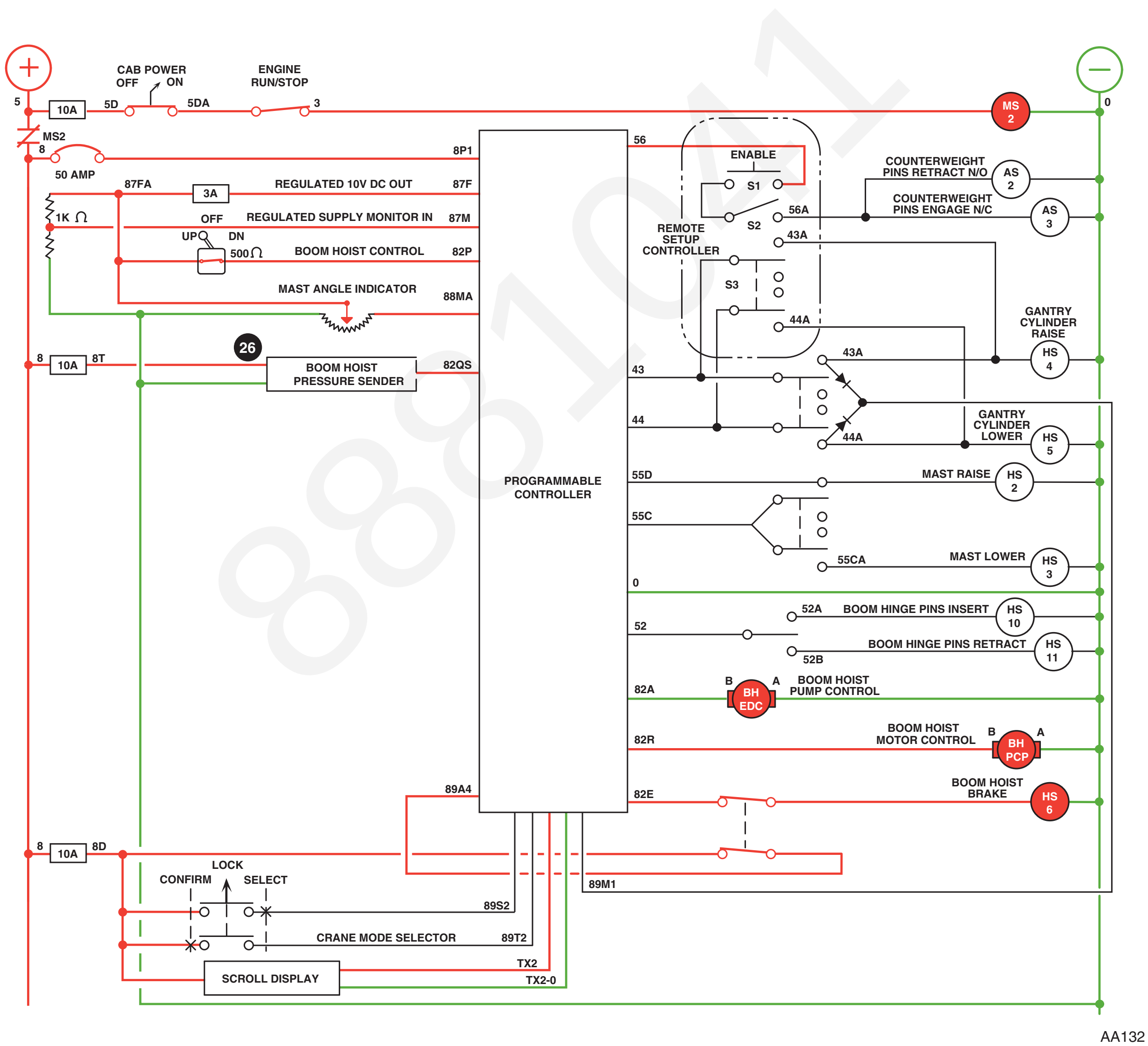


FIGURE 59 MAST CYLINDER ELECTRIC CIRCUIT
(Cylinders LOWER at Disassembly Only)

When the cylinder rods retract, the oil exhausting from the head end of the cylinders is blocked by the free-flow poppet (check valve) section on side “A” of counterbalance valves (24) and passes through the valves’ flow restrain sections preset for a relief pressure of 3,500 psi (240 bar). The exhaust oil from the side “A” sections of both counterbalance valves (24) combines, and the flow is blocked by the free-flow poppet (check valve) section on side “A” of load equalizing valve (20) where it passes through the valve’s flow restrain section preset at 4,000 psi (275 bar). The restraining section on side “A” of load equalizing valve (20) opens, controlling the flow of oil out of both cylinders and ensuring cylinder actuation is in unison.

The oil exiting side “A” of load equalizing valve (20) enters and passes through the mast cylinders control valve section of accessory system valve (2) and into check valve (9) which has a cracking pressure of 65 psi (4.5 bar). Because the mast cylinders lower hydraulic solenoid HS3 does not energize when lowering the mast, because the valve spool is of “motor spool” design (both cylinder ports are interconnected with the tank port while the valve spool is in the inactivated position), and because both cylinder ports and tank port of valve (2) encounter a common 65 psi (4.5 bar) resistance, the mast cylinder exhaust oil can flow through the restriction of check valve (9) and be filtered by system filter (13) before returning to tank, or it can flow through check valve (22) at 65 psi (4.5 bar) to replenish the oil on side “B” of the mast raising cylinders during retraction of the rods. The pressurized oil flows through the free-flow poppet (check valve) sections on side “B” of counterbalance valves (24) and enters into the rod end of the mast raising cylinders.

When the mast comes to rest against the gantry, the boom hoist drum will stop turning. At this time, the mast cylinders must be fully lowered by use of the mast switch located on the right console in the operator’s cab (see Mast Cylinders Lower). To continue lowering the mast, the gantry must be lowered (see Gantry Support Cylinders Lower). Again, while lowering the gantry support cylinders to the fully retracted position, the boom hoist hydraulic system is monitored by the PC through boom hoist system pressure sender (26) and controlled by the PC to maintain a minimum rope tension on the boom hoist drum. The PC maintains this tension by stroking or destroking the boom hoist pump to create an average system back pressure of approximately 1200 psi, while the mast and gantry lower in conjunction with the gantry support cylinders.

The mast switch, located on the right console in the operator's cab, can be used to raise or lower the mast raising cylinders when the mast is in the working position.

<u>MAST CYLINDERS RAISE</u> (Figure 58)

When the left end of the mast switch, located on the right console in the operator’s cab, is depressed and held in

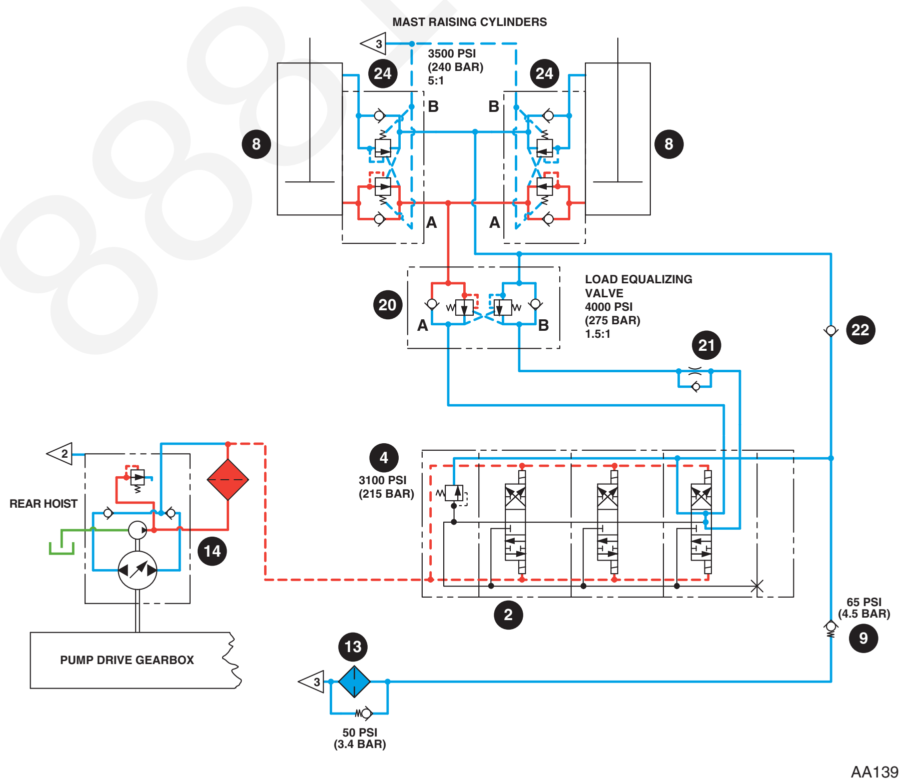


FIGURE 60 MAST CYLINDER HYDRAULIC SYSTEM
(Cylinders LOWER at Disassembly Only)

the RAISE position under working conditions, an electric power supply circuit is completed from the PC to the mast cylinders raise hydraulic solenoid HS2. Oil then flows from the setup pump section of accessory pump (1) into relief valve section (4) of accessory system valve (2). When HS2 is energized, its valve spool is shifted by 350 psi (25 bar) pilot pressure from rear hoist charge pump (14). The oil leaves the mast cylinders control valve section of accessory system valve (2) and flows through the free-flow poppet (check valve) sections on side “A” of load equalizing valve (20) and counterbalance valves (24) and into the head end of mast raising cylinders (8), extending the cylinder rams and raising the mast.

Oil exhausting from the rod end of mast raising cylinders (8) is blocked by the free-flow poppet (check valve) sections on side “B” of counterbalance valves (24) and passes through the valves’ flow restrain sections preset at a relief setting of 3,500 psi (240 bar). Counterbalance valves (24) operate with a 5:1 pilot ratio of the relief valve pressure, permitting the valve to open when pressure in the head end of the cylinders is approximately 700 psi (48 bar). The exhaust oil from the side “B” sections of both counterbalance valves combines, and the flow is blocked by the free-flow poppet (check valve) section on side “B” of load equalizing valve (20) where it passes through the valve’s flow restrain section preset at 4,000 psi (275 bar). Load equalizing valve (20) operates with 1.5:1 pilot ratio of the relief valve pressure, permitting the valve to open when the oil pressure (from the setup pump) on side “A” of the valve is approximately 2,670 psi (185 bar). The restraining section on side “B” of load equalizing valve (20) opens, controlling the oil flow out of both cylinders and ensuring cylinder actuation is in unison.

The oil passes through the non-restrictive portion of flow control valve (21) before entering accessory system valve (2). The oil exits the accessory system valve through the mast cylinders control valve section and passes through check valve (9) before returning to tank through system filter (13).

MAST CYLINDERS LOWER (Figure 61)

When the right end of the mast switch, located on the right console in the operator’s cab is depressed and held in the LOWER position under working conditions, an electric power supply circuit is completed from the PC to the mast cylinders lower hydraulic solenoid HS3. Oil then flows from the setup pump section of accessory pump (1) into relief valve (4) of accessory system valve (2). When HS3 is energized, its valve spool is shifted by 350 psi (25 bar) pilot pressure from rear hoist charge pump (14). The oil leaves the mast cylinders control valve section of accessory system valve (2) and flows through the free-flow poppet (check valve) sections on side “B” of load equalizing valve (20) and counterbalance valves (24) and into the rod end of mast raising cylinders (8), retracting the cylinder rams and lowering the mast.

Oil exhausting from the head end of mast raising cylinders (8) is blocked by the free-flow poppet (check valve) sections on side “A” of counterbalance valves (24) and passes through the valves’ flow restrain sections preset

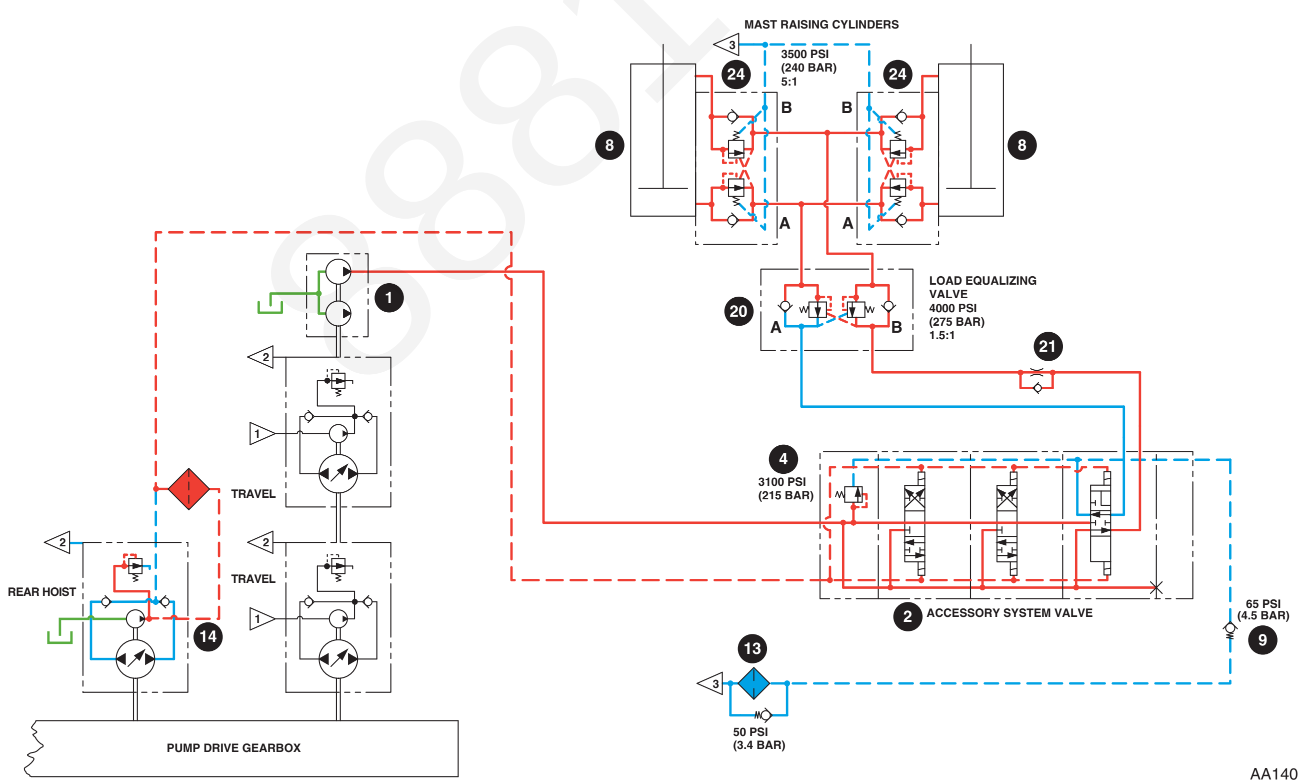


FIGURE 61 MAST CYLINDER HYDRAULIC SYSTEM
(Cylinders LOWER)

at a relief setting of 3,500 psi (240 bar). Counterbalance valves (24) operate with a 5:1 pilot ratio of the relief valve pressure, permitting the valve to open when pressure in the head end of the cylinders is approximately 700 psi (48 bar). The exhaust oil from the side “A” sections of the counterbalance valves combines, and the flow is blocked by the free-flow poppet (check valve) section on side “A” of load equalizing valve (20) where it passes through the valve’s flow restrain section preset at 4,000 psi (275 bar). Load equalizing valve (20) operates with 1.5:1 pilot ratio of the relief valve pressure, permitting the valve to open when the oil pressure (from the setup pump) on side “B” of the valve is approximately 2,670 psi (185 bar). The restraining section on side “A” of load equalizing valve (20) opens, controlling the oil flow out of both cylinders and ensuring cylinder actuation is in unison.

The oil enters and exits the mast cylinder control valve section of accessory system valve (2) and passes through check valve (9) before returning to tank through system filter (13).

Counterweight Pins System

NOTE When the crane setup operating mode is selected and confirmed at the crane mode selector, the PC energizes an electrical power supply circuit to the power switch on the remote setup controller. This circuit is not complete to the counterweight pins solenoids until the power switch is depressed and the counterweight pins switch is activated. The counterweight pins switch is a momentary switch wired in series with the power switch.

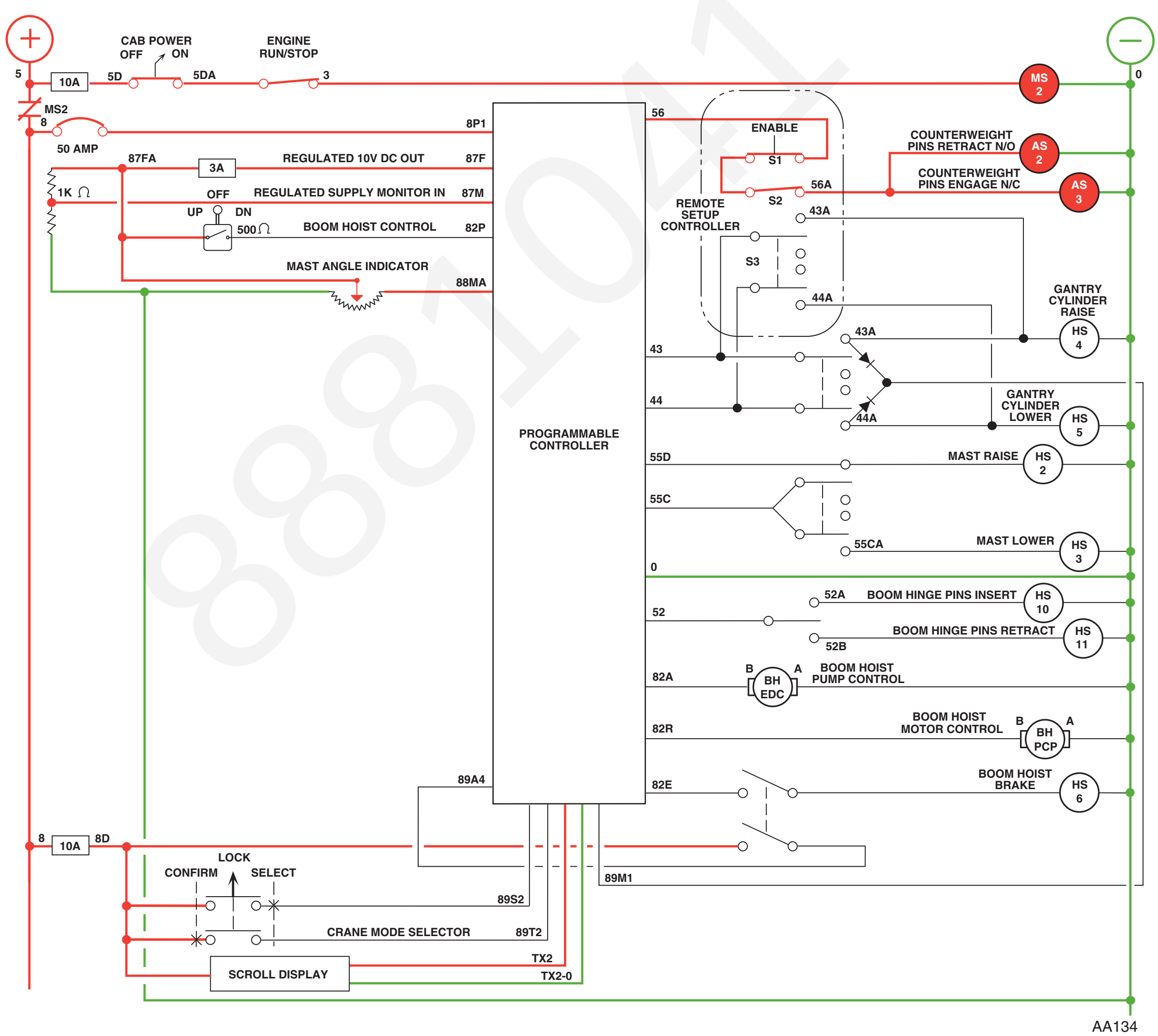


FIGURE 62 COUNTERWEIGHT PIN ELECTRIC CIRCUIT
(Pins ENGAGE)

COUNTERWEIGHT PINS ENGAGE (Figures 62 and 63)

When the counterweight pins switch, located on the remote hand controller, is held in the ENGAGE position, an electric circuit is completed from the PC to both counterweight air solenoid valves. Counterweight pins extend air solenoid AS3 opens to supply manifold air pressure to the head end of the counterweight pin cylinders. At the same time, the counterweight pins retract air solenoid AS2 closes, exhausting pressure from the rod end of the cylinders to atmosphere. The cylinder rods then extend to engage counterweight pins (26) and maintain this pin position when the machine is in operation.

COUNTERWEIGHT PINS DISENGAGE (Figures 62 and 64)

When the counterweight pins switch is held in the DISENGAGE position, an electric circuit from the PC is completed to both counterweight air solenoid valves. Counterweight pins retract air solenoid AS2 opens to supply manifold air pressure to the rod end of the counterweight pin cylinders. At the same time, the counterweight pins extend air solenoid AS3 closes, exhausting pressure from the head end of the cylinders to atmosphere. The cylinder rods then retract to disengage counterweight pins (26).

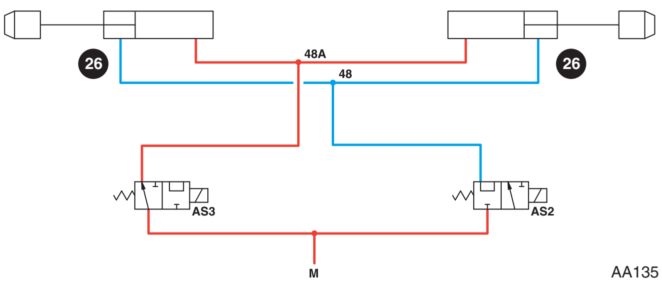


FIGURE 63 COUNTERWEIGHT PIN AIR SYSTEM (Pins ENGAGE)

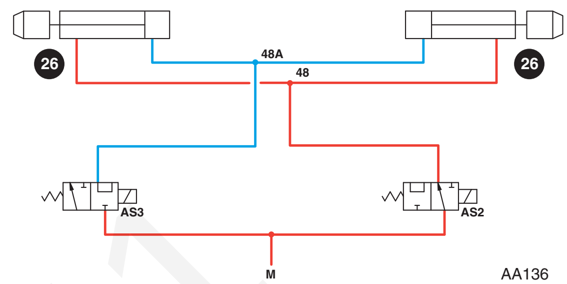


FIGURE 64 COUNTERWEIGHT PIN AIR SYSTEM (Pins DISENGAGE)

Luffing Jib Hoist System Operation

NOTE If crane is equipped with optional clutch assembly, the PC opens the circuit to rear drum clutch air solenoid AS9 when entering luffing jib mode. This ensures manifold air is blocked from entering the solenoid valve, and the valve's exhaust port is open to the drum clutch. Therefore, the rear drum clutch remains applied during the luffing function.

NOTE In the luffing mode, the rear drum operates the luffing jib while the front drum is the whip line. The front and rear (luffing jib) hoist control handles are located adjacent to one another on the right console in the operator's cab.

NOTE If a BLOCK UP LIMIT or LMI operating fault occurs while luffing, the PC will command the rear drum to stop lowering. The corrective action for these operating faults is to raise the jib. In full power mode, however, corrective action requires lowering the load with the rear drum.

GENERAL (Figure 65)

When LUFFING JIB has been selected and confirmed at crane mode selector (10), and rear drum park brake switch (1), located on the front console in the operator's cab, is placed in the OFF position, the PC is prepared for any luffing commands received from rear hoist control handle (14). With handle (14) in the off position, the regu-

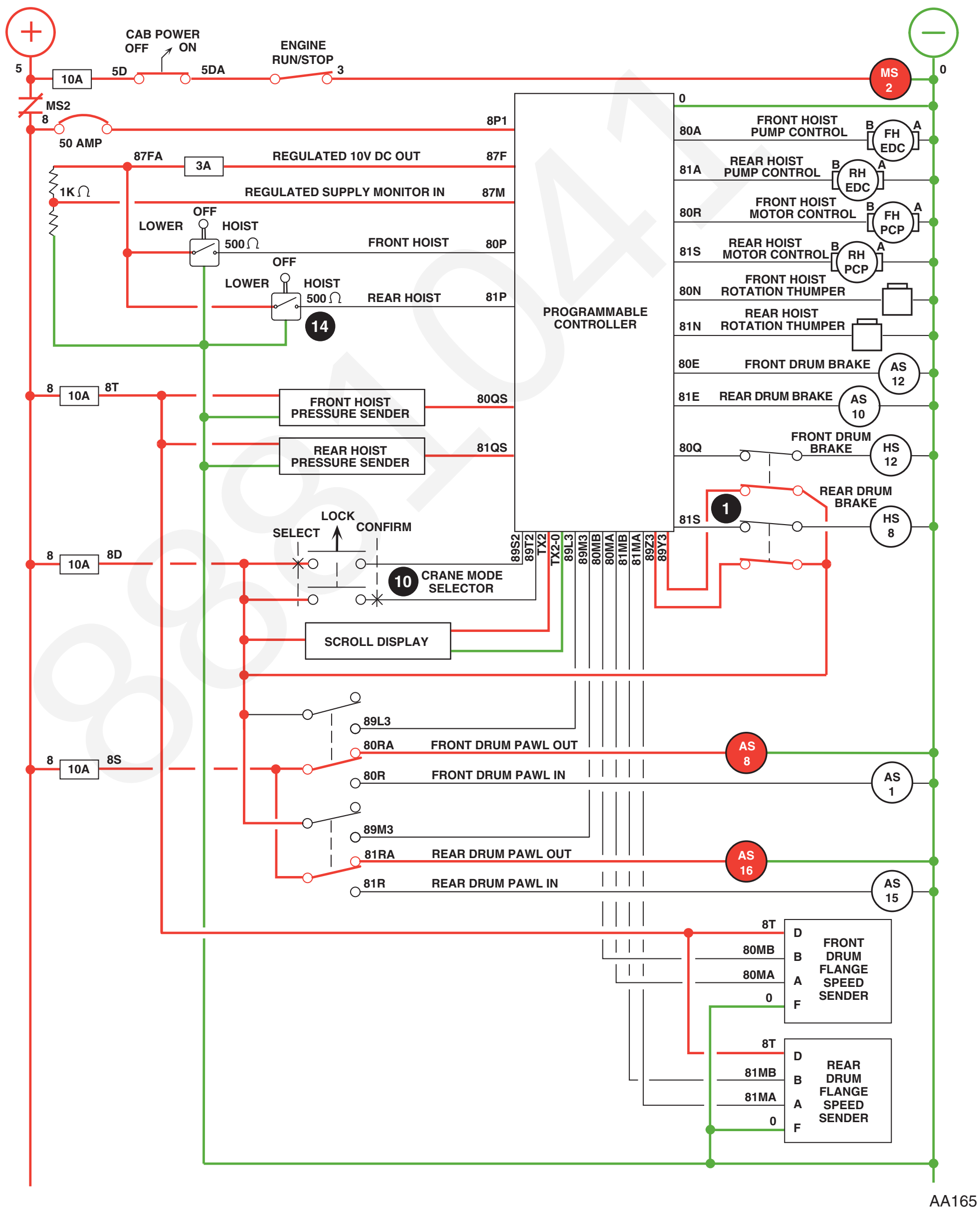


FIGURE 65 REAR LOAD DRUM ELECTRIC CIRCUIT
(Luffing Jib Mode: OFF)

lated voltage circuit for all luffing commands to the PC remains open. Therefore, rear drum park brake solenoids HS8 and AS10 are not energized and the rear hoist pump does not stroke until the handle is moved in either direction from off.

The descriptions of all normal load handling operations with the rear drum in luffing mode are identical to those described for the front drum while performing liftcrane operations in full power mode.

Auxiliary Hoist System Operation

NOTE If crane is equipped with an auxiliary hoist, its drum is located in the boom butt.

NOTE Unlike all other system pumps, displacement in the auxiliary hoist pump is controlled by both coils in the EDC valve and function only with straight current rather than straight and reverse polarity.

NOTE If auxiliary hoist charge pressure is lost for any reason, auxiliary hoist park brake (5) will apply to stop the hoist since the brake is directly sourced from this pressure.

GENERAL (Figures 66 and 67)

Like all other crane operation systems, the hydraulic connection between auxiliary hoist pump (1) and auxiliary hoist motor (2) forms a simple closed-loop circuit. Make-

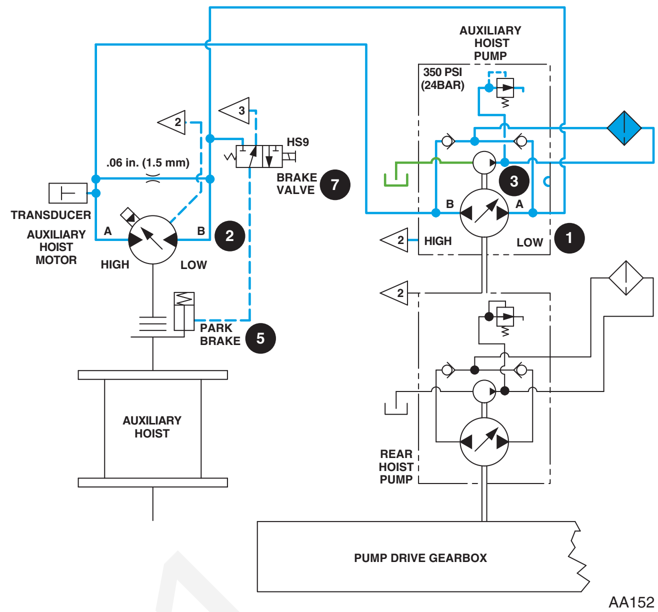


FIGURE 66 AUXILIARY HOIST HYDRAULIC SYSTEM (Standard Mode: OFF)

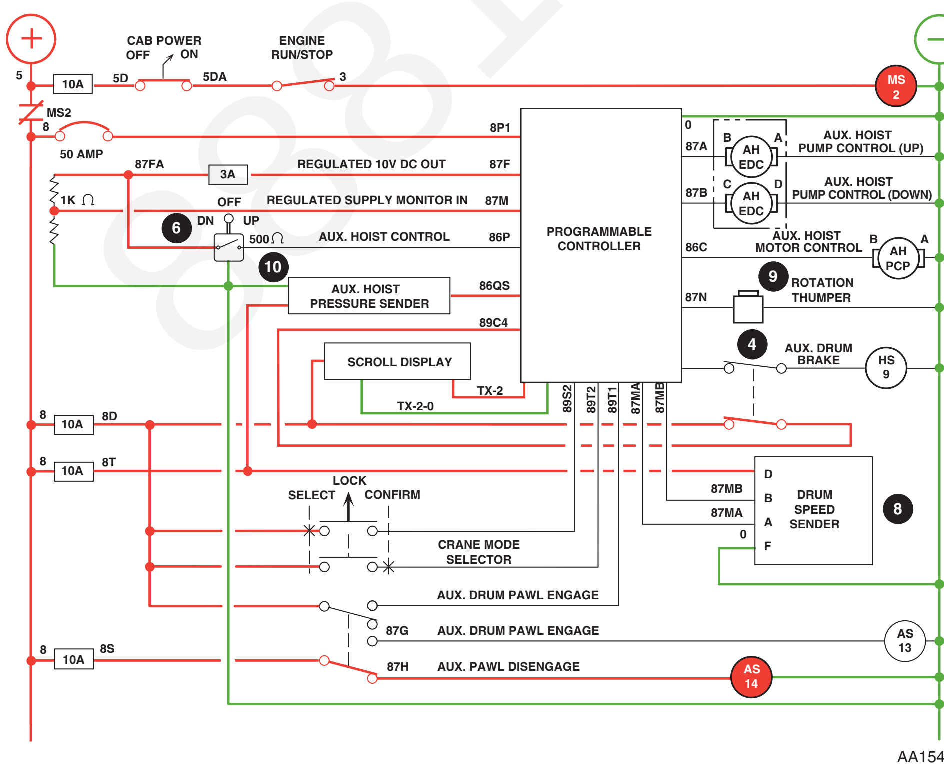


FIGURE 67 AUXILIARY HOIST ELECTRIC CIRCUIT (Standard Mode: OFF)

up oil from auxiliary hoist charge pump (3) replaces oil in the system that is primarily displaced due to internal leakage of the pump and motor assemblies.

If auxiliary drum park switch (4), located on the front console in the operator's cab, is placed in the ON position, the auxiliary hoist control handle circuit to the PC opens and does not complete the circuit from the PC to auxiliary drum brake hydraulic solenoid HS9. Because these circuits are open, auxiliary drum park brake (5) remains applied and auxiliary hoist pump (1) does not stroke in response to movement of auxiliary hoist control handle (6).

The hydraulic actuation of auxiliary drum park brake (5) is spring-applied/pressure released and controlled automatically by the PC in conjunction with movement of auxiliary hoist control handle (6). Release of brake (5) during operation of the auxiliary drum, is sourced from 350 psi (25 bar) charge pressure on the low pressure side of its closed-loop circuit.

When releasing brake (5), charge pressure is directed into brake valve chamber (7) through HS9. If the charge pressure drops to below 250 psi (17 bar), brake application will begin, and if the pressure continues to drop to approximately 165 psi (11 bar) or lower, the brake will be fully applied.

Auxiliary Hoist Rotation Indicator

Whenever the auxiliary drum rotates, auxiliary drum speed sender (8) completes a circuit to the PC which activates rotation thumper (9) in control handle (6). This causes rotation thumper (9) to move up and down with a varying frequency that conveys the rotational speed of the drum to the operator.

AUXILIARY HOIST OFF (Figures 66 and 67)

When auxiliary hoist control handle (6), located on the right console in the operator's cab, is in the off position, the PC receives no voltage from the handle, and the PC opens the circuits to the auxiliary hoist pump EDCs, auxiliary hoist motor PCP valve, and auxiliary drum brake hydraulic solenoid HS9. Because these circuits are open, auxiliary hoist pump (1) does not stroke, auxiliary hoist motor (2) remains at low speed, and auxiliary drum park brake (5) remains spring-applied to prevent the auxiliary drum from turning.

AUXILIARY HOIST RAISE (Figures 67 and 68)

When control handle (6) is pulled back for up operation, the handle neutral switch closes, completing a regulated voltage circuit from the handle potentiometer to the PC. The PC interprets the signal for speed and direction and closes regulated voltage circuits to the auxiliary hoist pump (up) EDC, auxiliary hoist motor PCP, and auxiliary drum park brake hydraulic solenoid HS9. These circuits will close only if the auxiliary drum park switch is off, applicable operating limit switches are closed (see Figure 13), and no system or operating faults are present.

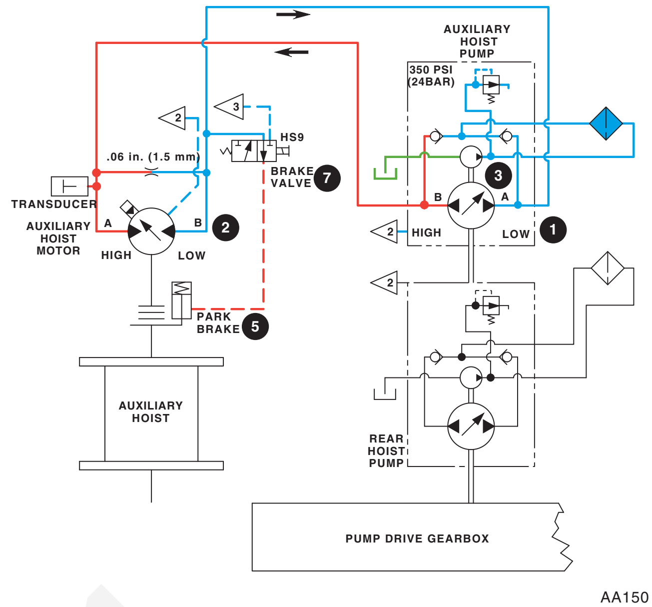


FIGURE 68 AUXILIARY HOIST HYDRAULIC SYSTEM
(Standard Mode: RAISE)

PC programming requires auxiliary hoist pump (1) to stroke before the auxiliary drum park brake is released. This ensures adequate pressure is present to hold the load after full release of the park brake. The regulated voltage to the auxiliary hoist pump (up) EDC tilts the pump swashplate to stroke the pump in the up direction. Oil then flows from pump port A to port B of auxiliary hoist motor (2).

Auxiliary hoist pressure sender (10) supplies the PC with pressure development data which the PC compares to the memorized holding pressure of the auxiliary hoist. When adequate pressure is available, the PC energizes HS9 to shift the brake valve. This initiates full release of park brake (5) and auxiliary hoist motor (2) raises the load.

The PC governs the raising speed of the load by varying the voltage to the pump (up) EDC in proportion to movement of the control handle. Therefore, the angle of the pump swashplate is increased as the control handle is moved farther backward, pumping more oil to the motor and raising the load faster.

As control handle (6) approaches the full handle command position, and if lifting conditions permit, the auxiliary hoist motor PCP valve is instructed by the PC to shift and redirect oil flow to motor servo cylinder (24, Figure 2). This allows the servo mechanism to shift the motor to minimum displacement for maximum motor speed and less operating torque.

As control handle (6) is returned to the off position, the PC commands the auxiliary hoist pump (up) EDC to decrease the angle of the pump swashplate, causing a reduction in oil flow output. The PC also instructs the auxiliary hoist motor PCP valve to shift auxiliary hoist motor (2) to maximum displacement for slower output speed to slow the drum rotation. When the control handle is fully off, the PC memorizes the pressure required to support the load and de-energizes HS9 to apply the brake after the control handle neutral switch opens or after receiving a zero command from drum speed sender (8).

AUXILIARY HOIST LOWER (Figures 67 and 69)

When control handle (6) is pushed forward for down operation, the handle neutral switch closes, completing a regulated voltage circuit from the handle potentiometer to the PC. The PC interprets the signal for speed and direction and closes regulated voltage circuits to the auxiliary hoist pump (down) EDC, auxiliary hoist motor PCP, and auxiliary drum park brake hydraulic solenoid HS9. These circuits will close only if the auxiliary drum park switch is off, the auxiliary drum pawl switch is disengaged, applicable operating limit switches are closed (see Figure 13), and no system or operating faults are present.

Before the auxiliary drum brake is released, the PC supplies regulated voltage to the auxiliary pump (up) EDC. The PC programming requires auxiliary hoist pump (1) to stroke momentarily in the hoisting direction to ensure adequate pressure is present to hold the load after full release of the brake.

Auxiliary hoist pressure sender (10) supplies the PC with pressure development data which the PC compares to the memorized holding pressure of the auxiliary hoist. When adequate pressure is available, the PC energizes HS9 to shift brake valve (7), releasing the drum brake while de-energizing the (up) EDC and energizing the (down) EDC. The regulated voltage to the auxiliary hoist pump (down) EDC then causes the swashplate to tilt, stroking the pump in the down direction and directing oil flow from pump port B to port A of auxiliary hoist motor (2).

The weight of the load on the auxiliary drum will attempt to drive the motor faster than return oil is available to the pump. However, auxiliary hoist charge pump (3) maintains the oil supply at a positive pressure to auxiliary hoist motor (2).

The position of the pump swashplate restricts the returning oil flow and pressure builds on the return side of the closed-loop circuit, acting as a brake against the auxiliary hoist motor to control the lowering speed.

The PC governs the lowering speed of the load by varying the voltage to the pump (down) EDC in proportion to movement of the control handle. Therefore, the angle of

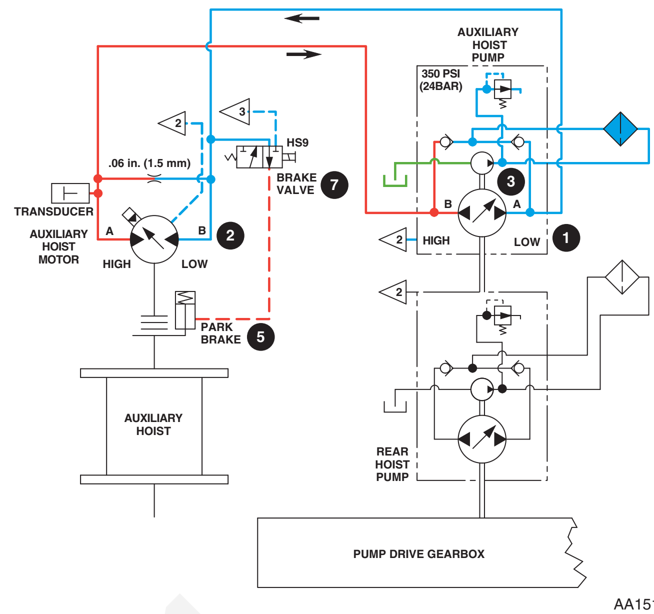


FIGURE 69 AUXILIARY HOIST HYDRAULIC SYSTEM (Standard Mode: LOWER)

the pump swashplate is increased as the control handle is moved farther forward; more oil is allowed to return to the pump, more oil is pumped to the motor, and the auxiliary drum lowers the load faster.

As control handle (6) approaches the full handle command position, and if lifting conditions permit, the auxiliary hoist motor PCP valve is instructed by the PC to shift and redirect oil flow to motor servo cylinder (24, Figure 2). This allows the servo mechanism to shift the motor to minimum displacement for maximum motor speed and less operating torque.

As control handle (6) is returned to the off position, the PC commands the auxiliary hoist pump (down) EDC to decrease the angle of the pump swashplate, causing a reduction in oil flow output. The PC also instructs the auxiliary hoist motor PCP valve to shift auxiliary hoist motor (2) to maximum displacement for slower output speed to slow the drum rotation. When the control handle is returned to the neutral handle position, the PC monitors the system pressure sender while de-energizing the (down) EDC and momentarily energizing the (up) EDC to develop the required pressure to support the load. The monitored load supporting pressure is retained in the "pressure memory" bank of the PC. The (up) EDC then de-energizes while HS9 de-energizes to set the brake after the control handle neutral switch opens or after receiving a zero command from drum speed sender (8).

APPENDIX A — Abbreviations Used in Schematics

Hydraulic Solenoid Valves

HS1	Travel Park Brake
HS2	Mast Cylinders RAISE
HS3	Mast Cylinders LOWER
HS4	Gantry Cylinders RAISE
HS5	Gantry Cylinders LOWER
HS6	Boom Hoist Drum Brake
HS7	Swing Park Brake
HS8	Rear/Luffing Drum Park Brake
HS9	Auxiliary Drum Park Brake
HS10	Boom Hinge Pins INSERT
HS11	Boom Hinge Pins RETRACT
HS12	Front Drum Park Brake
HS13	Two-speed Travel

Air Solenoid Valves

AS1	Front Drum Pawl IN
AS2	Counterweight Pins RETRACT
AS3	Counterweight Pins EXTEND
AS4	Boom Hoist Pawl IN
AS5	Boom Hoist Pawl OUT
AS6	Swing Lock ENGAGE
AS7	Swing Lock DISENGAGE
AS8	Front Drum Pawl OUT
AS9	Rear/Luffing Drum Clutch
AS10	Rear/Luffing Drum Park Brake
AS11	Front Drum Clutch
AS12	Front Drum Park Brake
AS13	Auxiliary Drum Pawl IN
AS14	Auxiliary Drum Pawl OUT
AS15	Rear/Luffing Drum Pawl IN
AS16	Rear/Luffing Drum Pawl OUT

Pump Controls

AH	EDC	Auxiliary Hoist
BH	EDC	Boom Hoist
FH	EDC	Front Hoist
LT	EDC	Left Travel
RH	EDC	Rear Hoist
RT	EDC	Right Travel
S	EDC	Swing

Motor Controls

AH	PCP	Auxiliary Hoist
BH	PCP	Boom Hoist
FH	PCP	Front Hoist
RH	PCP	Rear Hoist

ALT	Alternator
ED	Ether Disable
EDC	(Pump) Electric Displacement Control
EFC	Electronic Fuel Control
ES	Ether Start
FS	Fuel Solenoid
FSR	Fuel Solenoid Relay
M	Motor
PC	Programmable Controller
PCOR	(Motor) Pressure Compensated Over-ride
PCP	(Motor) Pressure Control Pilot
PCR	(Motor) Pressure Compensator Regulator

NOTES:

1. "Closed" in reference to an electric system means current can flow.
2. "Closed" in reference to an air or hydraulic system means air or oil cannot flow.
3. All solenoid valves are 2-position valves.

APPENDIX B — Figure Listing

APPENDIX B — Figure Listing (continued)

APPENDIX B — Figure Listing (continued)

Operator’s Manual 1-8 Numeric Tabs

RATED CAPACITY INDICATOR/LIMITER OPERATION

Models 111, 222, 777, 777T, 888, 999, 2250, and 2250T with Front Console 179941

(Software Program Version lmi03_ or lmi13_ and Newer)

Table of Contents

GENERAL

The purpose of this publication is to provide qualified operators with operation and calibration instructions for Manitowoc Rated Capacity Indicator/Limiter (RCL).

These instructions only apply to Software Program Version lmi03_or lmi13_ and newer with front console 179941.

⚠ WARNING

Overload Hazard!

RCL has been installed on crane to aid operator.

Presence of RCL on crane in no way substitutes for, or lessens, requirement that operator knowledge, experience, and judgment are required to ensure safe operation of crane.

Some programming steps may have to be performed before each lift. If RCL is not programmed correctly, it will not properly sense load and alert operator to overload conditions. Before using RCL, operator shall read and understand instructions in this publication.

The system is designed to aid the operator in identifying overload conditions, which can cause structural failure of boom and jib or loss of stability (tipping).

The Rated Capacity Indicator/Limiter is an electronic and mechanical load sensing system consisting of the following components (see Figure 1):

CONTROL CONSOLE (with its own memory and processor) mounted on front console in the operator's cab.

PROGRAMMABLE CONTROLLER (controls crane functions) located behind operator's seat.

LOAD SENSING SHEAVES located at boom and jib points. See Figure 2 for identification of load sensing sheaves.

ANGLE SENSING POTENTIOMETERS located in junction boxes on boom butt and, if equipped, on luffing jib butt.

RIN CONTROLLER (Models 111, 222, 888 and 999 only) remote controller that sends input signals from load sensing sheaves and angle sensing potentiometers to programmable controller.

The RCL monitors programmed inputs and signals from load sensing sheaves and angle sensing potentiometers. It compares input data with capacity charts stored in the program and displays load information on the control console screen.

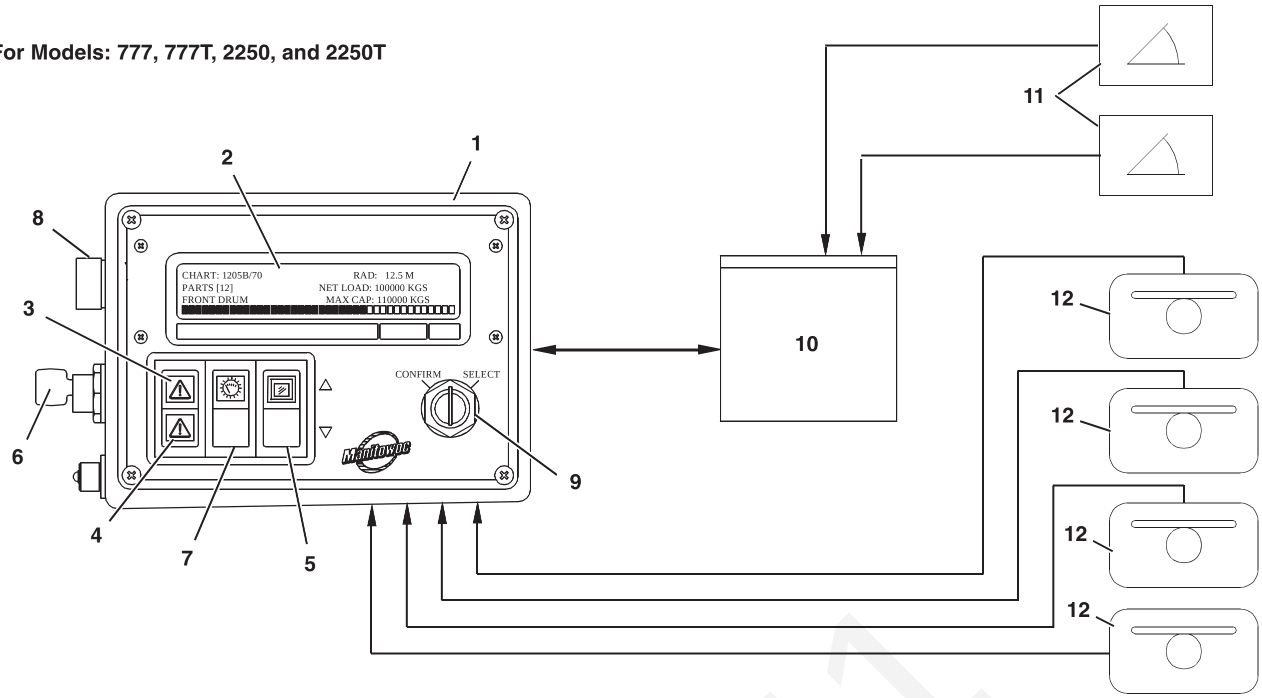
When the system detects an overload condition, the operator is alerted both visually and audibly. Additionally, if shutdown feature is on, the programmable controller disables the following crane functions until overload condition is corrected:

- Hoist UP.
- Boom DOWN.
- Luffing jib DOWN.

NOTE: When equipped with a luffing jib, you can operate at any boom angle between minimum and maximum boom chart angles. The boom hoist is automatically disabled if you operate more than 5° above the maximum boom chart angle or more than 5° below the minimum boom chart angle. If you operate between two boom chart angles, the luffing jib capacity is de-rated.

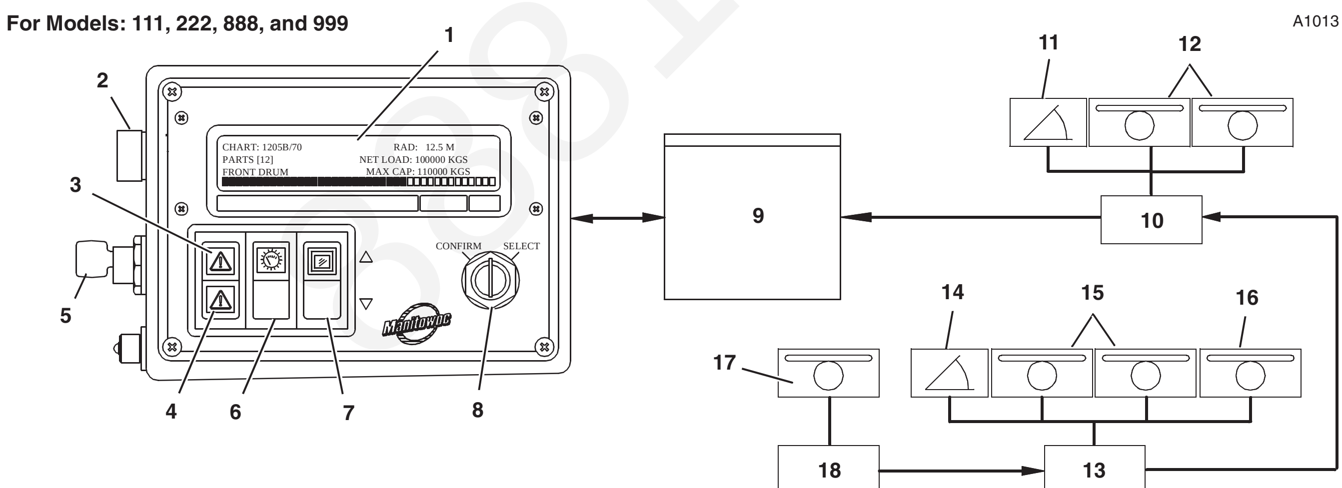
To alert job site personnel to an overload or tipping condition, an optional rotating amber light and continuous tone horn can be mounted on the outside of operator's cab.

For Models: 777, 777T, 2250, and 2250T



Item	Identification	Item	Identification
1	Control Console	7	Screen Light Switch
2	Display	8	Display Contrast Switch
3	Caution Light	9	Select/Confirm Rocker
4	Warning Light	10	Programmable Controller
5	Scroll Up/Down Switch	11	Angle Sensing Potentiometers
6	Limiter Key Switch	12	Load Sensing Sheaves

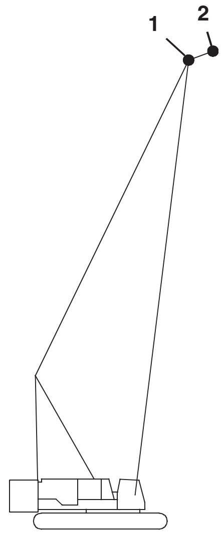
For Models: 111, 222, 888, and 999



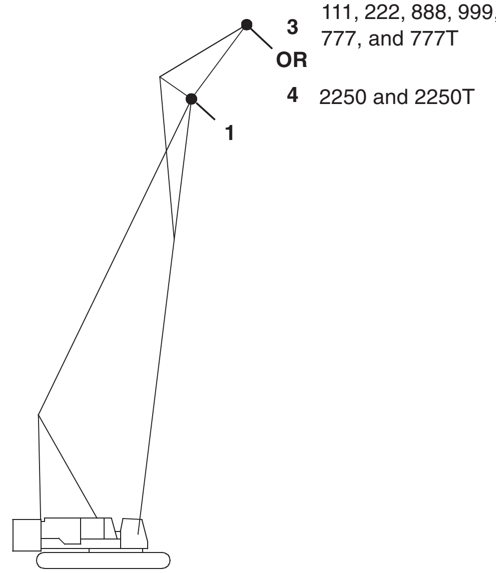
NOTE: Retrofit models 111 and 222 are different.

Item	Identification	Item	Identification	Item	Identification
1	Display	7	Scroll Up/Down Switch	13	Luffing Jib Top RIN Controller
2	Screen Contrast Switch	8	Select/Confirm Key Switch	14	Luffing Jib Angle Potentiometer
3	Caution Light	9	Programmable Controller	15	Jib Point Load Sensing Sheaves
4	Warning Light	10	Boom Top RIN Controller	16	Intermediate Fall Load Sensing Sheave
5	Shutdown Switch	11	Boom Angle Potentiometer	17	Fixed Jib Point Load Sensing Sheaves
6	Screen Light Switch	12	Boom Point Load Sensing Sheaves	18	Fixed Jib Top RIN Controller

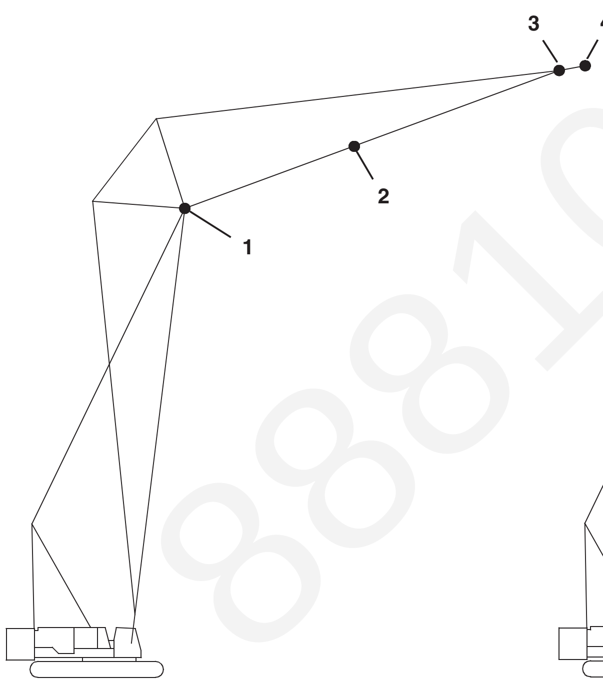
FIGURE 1



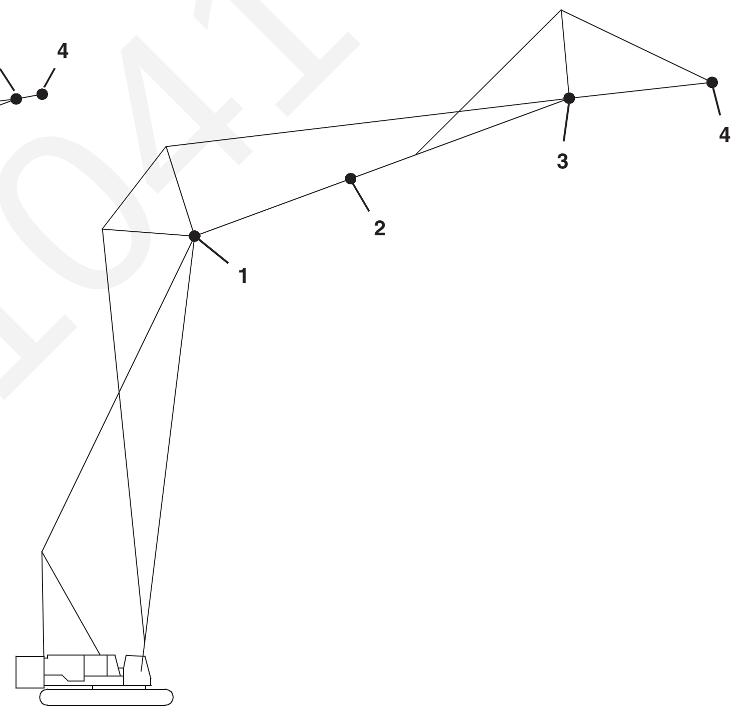
Boom with Upper and Lower Boom Points



Boom with Fixed Jib



Luffing Jib with Upper and Lower Jib Points



Luffing Jib with Fixed Jib

Item	Sheave Identification
1	Lower Boom Point
2	Upper Boom Point
2	Intermediate Fall (for Luffing Jib)
3	Lower Luffing Jib Point
4	Upper Luffing Jib Point or Fixed Jib Point

FIGURE 2

CONTROL CONSOLE IDENTIFICATION

Front console consists of following controls (see Figure 1):

Display

The display contains 18 screens:

- One working screen
- One option screen
- Ten configuration screens
- One multiple sheave screen
- Four calibration screens
- One diagnostic screen

Select / Confirm Key Switch

The key must be inserted before this switch can be operated.

This switch serves two purposes:

- Switch the mode of the scroll up/down rocker from SELECT to PROGRAM and vice versa.
- CONFIRM programmed data.

NOTE: Select is not active when programming in configuration screens.

Scroll Up / Down Rocker

Depress TOP end of rocker to:

- In SELECT mode (*), SCROLL UP from item to item in a screen or from screen to screen. The cursor stops only at programmable items.
- In PROGRAM mode (>), INCREASE data for a selected item.

Depress BOTTOM end of rocker to:

- In SELECT mode (*), SCROLL DOWN from line to line in a screen or from screen to screen. The cursor stops only at programmable items.
- In PROGRAM mode (>), DECREASE data for a selected item.

Shutdown Key Switch

The key must be inserted before this switch can be operated. The key can be removed from either position to lock the switch. Turn switch key CLOCKWISE to TURN ON shutdown feature described earlier.

Turn key COUNTERCLOCKWISE to TURN OFF shutdown feature. When shutdown is turned off, OFF flashes next to LOAD LIMITER on crane configuration screen (Figure 14).

Display Light

Depress TOP end of rocker to TURN ON display light. Depress BOTTOM end of rocker to TURN OFF display light.

NOTE: Display light is not available on some crane models.

Warning Light

Glows RED and a buzzer (in control console) comes on to alert the operator to an overload condition.

Caution Light

Glows YELLOW and a beeper (in control console) comes on to alert the operator to an approaching overload condition.

Display Contrast Switch

Turn in either direction to adjust display screen to desired contrast.

WORKING SCREEN

The working screen (Figure 3) identifies the current configuration and displays load data for load drum being operated. When operation is switched from one drum to another, the working screen automatically switches to display load information for new drum, without having to reprogram. Automatic switching can be turned off by selecting DRUM Not Used when programming crane configuration screen (Figure 8). See Operating Controls publication for drum identification.

The working screen appears when power is applied and RCL is turned ON. The program goes through a system test when first turned ON. The message CONFIRM flashes until CONFIRM/SELECT key switch is turned counter-clockwise to CONFIRM present configuration. If there are no changes, the operator can start operating the crane without going to any other screen.

A four-digit number and either one or two alpha characters identify each capacity chart. A single alpha character (A, B, etc.) identifies an ANSI (United States) approved capacity chart. A single alpha character followed by an M (AM, BM, etc.) identifies a metric or European approved capacity chart.

The units of measure displayed in the working screen corresponds to type of chart selected:

- Feet and pounds for an ANSI capacity chart.
- Meters and Metric Tons for a metric or European capacity chart.

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Working screen displays the following information (Figure 3):

CONFIGURATION	This is a coded representation of the crane / chart configuration: **7941A** MCC Chart number. **120** Boom Length. **70** Luffing Jib Length. _ Fixed Jib Length. **80** Chart Angle 1 -. • Jib Offset (for Fixed Jib Chart or Boom Chart with Fixed Jib Attached). • Boom to Luffing Jib (for Boom Chart with Luffing Jib Attached). • Boom (for Luffing Jib Chart). _ Special Chart Configurations. • Barge List in Degrees (0, 1, 2, 3). • Number of Truck Crane Counterweights (see View B or C, Figure 3). **R** after number = Over REAR rating. No Letter after Number = 360° Rating. • Number of MAX-ER™ Counterweights (see View A, Figure 3). **4** Parts of Line. **295** Line Pull in units (U.S. SYSTEM) lb/100 or (METRIC) metric ton *times* 10. **82** Deducts to Chart Capacity. The program does not automatically compensate for any deducts required by various capacity charts (for example: jib and wire rope, load blocks, slings, etc. below boom and jib points). *Operator is responsible for determining and calculating deducts specified on applicable capacity charts and for entering data into program. Always round calculations UP (Example: if calculated deduct is 1,675 lbs, enter 1,700 lb).* Crane can be overloaded — tipping or structural failure can occur — if required deducts are not entered into program. For assistance in determining and calculating deducts, see Guide for Determining Total Load in Capacities Section of Operator's Manual provided with crane.
TARE	TARE load is subtracted from displayed LOAD. The actual load being lifted *equals* line pull *times* parts of line *minus* tare. This feature allows the operator to view load differences. For example, wire rope, load block or weight ball, and lifting slings can be tared (deducted) so that displayed load equals only the load that is being lifted. *Tare is subtracted only from displayed load.* Tare does not effect percent of capacity display.
LOAD	Actual load being lifted *equals* line pull *times* parts of line *minus* tare.
RADIUS	Horizontal distance from the crane's centerline of rotation to center of the freely suspended load block or single-part load line. Radius is calculated from boom and jib length, boom and jib angle, and selected load sensing sheave.
MAX CAP	Capacity chart rating for the crane's programmed configuration. Maximum capacity is always the least of following values: • Manitowoc Capacity Chart. • Rope Line Pull. • Drum Torque Capacity.
PERCENT OF CAPACITY BAR	Graphical indication of how close crane is to its maximum capacity. The bar moves to the right above the color coded scale as load increases. The color coded scale is divided into three sections: • GREEN = Safe Working Area. • YELLOW = Use Caution (approaching an overload condition). • RED = Maximum Load Condition.

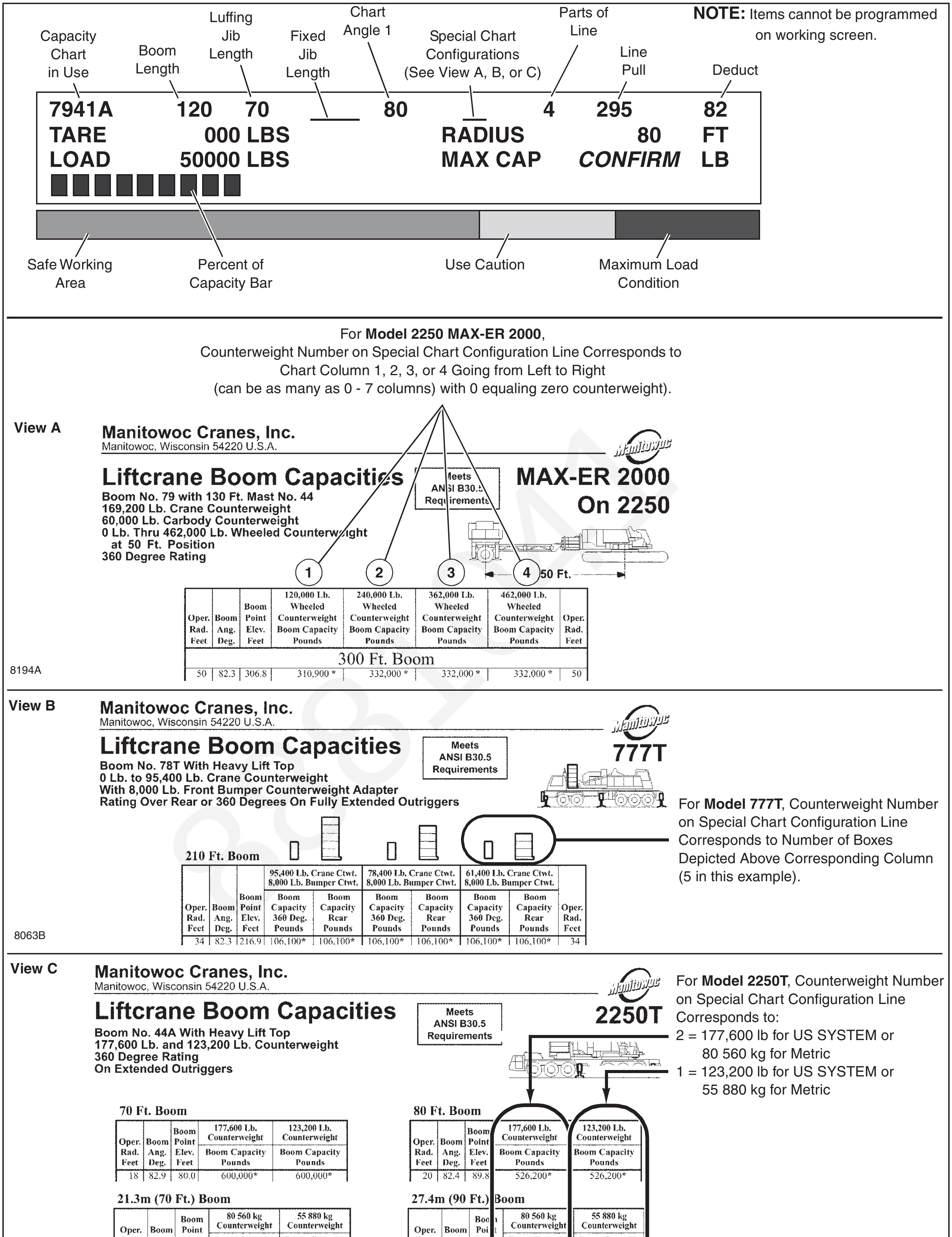
NOTE: Items cannot be programmed on working screen.
Capacity Chart in Use
Boom Length
Luffing Jib Length
Fixed Jib Length
Chart Angle 1
Special Chart Configurations (See View A, B, or C)
Parts of Line
Line Pull
Deduct
7941A 120 70 ___ 80 _ 4 295 82
TARE 000 LBS RADIUS 80 FT
LOAD 50000 LBS MAX CAP CONFIRM LB
Safe Working Area
Percent of Capacity Bar
Use Caution
Maximum Load Condition
For Model 2250 MAX-ER 2000,
Counterweight Number on Special Chart Configuration Line Corresponds to
Chart Column 1, 2, 3, or 4 Going from Left to Right
(can be as many as 0 - 7 columns) with 0 equaling zero counterweight).
View A
Manitowoc Cranes, Inc.
Manitowoc, Wisconsin 54220 U.S.A.
Liftcrane Boom Capacities
Meets ANSI B30.5 Requirements
MAX-ER 2000 On 2250
Boom No. 79 with 130 Ft. Mast No. 44
169,200 Lb. Crane Counterweight
60,000 Lb. Carbody Counterweight
0 Lb. Thru 462,000 Lb. Wheeled Counterweight at 50 Ft. Position
360 Degree Rating
1 2 3 4
50 Ft.
Oper. Rad. Feet | Boom Ang. Deg. | Boom Point Elev. Feet | 120,000 Lb. Wheeled Counterweight Boom Capacity Pounds | 240,000 Lb. Wheeled Counterweight Boom Capacity Pounds | 362,000 Lb. Wheeled Counterweight Boom Capacity Pounds | 462,000 Lb. Wheeled Counterweight Boom Capacity Pounds | Oper. Rad. Feet
300 Ft. Boom
50 | 82.3 | 306.8 | 310,900 * | 332,000 * | 332,000 * | 332,000 * | 50
8194A
View B
Manitowoc Cranes, Inc.
Manitowoc, Wisconsin 54220 U.S.A.
Liftcrane Boom Capacities
Meets ANSI B30.5 Requirements
777T
Boom No. 78T With Heavy Lift Top
0 Lb. to 95,400 Lb. Crane Counterweight
With 8,000 Lb. Front Bumper Counterweight Adapter
Rating Over Rear or 360 Degrees On Fully Extended Outriggers
210 Ft. Boom
Oper. Rad. Feet | Boom Ang. Deg. | Boom Point Elev. Feet | 95,400 Lb. Crane Ctwt. 8,000 Lb. Bumper Ctwt. Boom Capacity 360 Deg. Pounds | Boom Capacity Rear Pounds | 78,400 Lb. Crane Ctwt. 8,000 Lb. Bumper Ctwt. Boom Capacity 360 Deg. Pounds | Boom Capacity Rear Pounds | 61,400 Lb. Crane Ctwt. 8,000 Lb. Bumper Ctwt. Boom Capacity 360 Deg. Pounds | Boom Capacity Rear Pounds | Oper. Rad. Feet
34 | 82.3 | 216.9 | 106,100* | 106,100* | 106,100* | 106,100* | 106,100* | 106,100* | 34
8063B
For Model 777T, Counterweight Number on Special Chart Configuration Line Corresponds to Number of Boxes Depicted Above Corresponding Column (5 in this example).
View C
Manitowoc Cranes, Inc.
Manitowoc, Wisconsin 54220 U.S.A.
Liftcrane Boom Capacities
Meets ANSI B30.5 Requirements
2250T
Boom No. 44A With Heavy Lift Top
177,600 Lb. and 123,200 Lb. Counterweight
360 Degree Rating
On Extended Outriggers
For Model 2250T, Counterweight Number on Special Chart Configuration Line Corresponds to:
2 = 177,600 lb for US SYSTEM or 80 560 kg for Metric
1 = 123,200 lb for US SYSTEM or 55 880 kg for Metric
70 Ft. Boom
Oper. Rad. Feet | Boom Ang. Deg. | Boom Point Elev. Feet | 177,600 Lb. Counterweight Boom Capacity Pounds | 123,200 Lb. Counterweight Boom Capacity Pounds
18 | 82.9 | 80.0 | 600,000* | 600,000*
80 Ft. Boom
Oper. Rad. Feet | Boom Ang. Deg. | Boom Point Elev. Feet | 177,600 Lb. Counterweight Boom Capacity Pounds | 123,200 Lb. Counterweight Boom Capacity Pounds
20 | 82.4 | 89.8 | 526,200* | 526,200*
21.3m (70 Ft.) Boom
Oper. Rad. Meters | Boom Ang. Deg. | Boom Point Elev. Meters | 80 560 kg Counterweight Boom Capacity Kilograms | 55 880 kg Counterweight Boom Capacity Kilograms
5.5 | 82.9 | 24.4 | 272 100* | 272 100*
27.4m (90 Ft.) Boom
Oper. Rad. Meters | Boom Ang. Deg. | Boom Point Elev. Meters | 80 560 kg Counterweight Boom Capacity Kilograms | 55 880 kg Counterweight Boom Capacity Kilograms
6.4 | 82.6 | 30.4 | 226 000* | 226 000*
8462A_AM

FIGURE 3

OPTION SCREEN

The configuration, calibration, diagnostic, and multiple sheave screens are accessed from OPT (option) screen (Figure 4).

To access OPT screen, scroll up or down as required until screen appears. Continue to scroll up or down until the select cursor (*) appears next to desired option. Then turn CONFIRM/SELECT key switch clockwise to SELECT.

The operator can toggle back to the working screen by scrolling up or down until working screen appears.

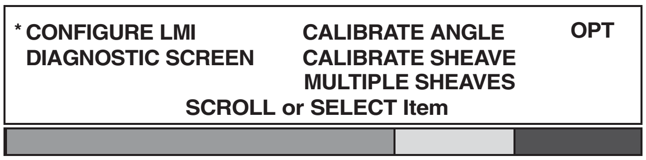

FIGURE 4

SETUP

Configure LMI

The SHEAVE configuration screen (Figure 5) appears when Configure LMI is selected on OPT screen. The program requires the operator to confirm all ten configuration screens before returning to working screen. The program cursor (>) appears next to first item on each screen. Select is not active when programming in configuration screens. The program automatically moves to next configuration screen when CONFIRM/SELECT key switch is turned counterclockwise to CONFIRM.

NOTE: For identification of load sensing sheaves, see Figure 2.

The last programmed chart and crane configuration for each load sensing sheave is retained in memory. This allows the operator to switch between sheaves without having to reprogram the configurations, *assuming no changes have been made to parts of lines, boom length, etc.*

NOTE: If multiple load sensing sheaves from one point are used, both sheaves must be configured before being selected.

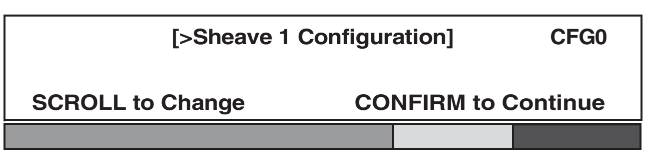

FIGURE 5

On POINT configuration screen (Figure 6), program cursor (>) appears next to POINT selection. Scroll up or down as required to select and program desired point – upper, lower, or intermediate-fall (INFALL).

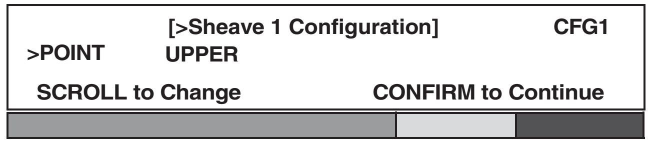

FIGURE 6

On CAPACITY CHART configuration screen (Figure 7), program cursor (>) appears next to capacity chart number (7941A in this example). Once this screen is selected, data in bottom three lines changes automatically while scrolling through possible chart configurations.

If you program data for any item without confirming it, data will be lost when computer is turned off and previously stored data will take effect when computer is turned back on.

The program will not allow any data to be changed if corresponding load sensing sheave detects a line pull greater than 3,300 lbs (1-1/2 Metric Tons).

A four-digit number and either one or two alpha characters identify each capacity chart. A single alpha character (A, B, etc.) identifies an ANSI (United States) approved capacity chart. A single alpha character followed by an M (AM, BM, etc.) identifies a metric or European approved capacity chart.

The chart configuration screen does not display units of measure. Units of measure corresponds to type of chart selected:

- Feet and pounds for an ANSI capacity chart.
- Meters and Kilograms for a metric or European capacity chart.

The following items are programmed for the selected chart configuration in Figure 8:

CHART	Chart Number
BOOM	Boom Length
JIB1	Luffing Jib Length
JIB2	Fixed Jib Length
BOOM ANG	Boom Angle if Luffing Jib Chart
JIB1 ANG	Boom to Luffing Jib Angle if Boom Chart with Luffing Jib Attached
JIB2 ANG	Fixed Jib Offset
LIST	List Angle if Barge Chart
RATING	Truck Crane Rating Over Rear or 360° Swing
CRAWLER	Crawler Extended (out) or Retracted (in) on Models 111, 222, or 888 only
STINGER	MAX-ER 2000 Trailer Arm Length — 30, 40, or 50 ft (9,1, 12,2, or 15,2 m)
CTWT	Total Counterweight in Pounds or Kilograms (Truck Crane and MAX-ER only)

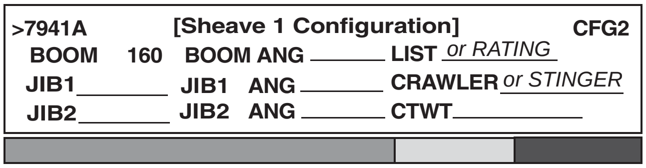

FIGURE 7

On DRUM configuration screen (Figure 8), program cursor (>) appears next to DRUM selection. Drum (1, 2, 3, 4, etc. or Not Used) corresponds to selected load sensing sheave. If a sheave is not used or provided, or if automatic switching between load drums is not desired, select DRUM Not Used in crane configuration screen.

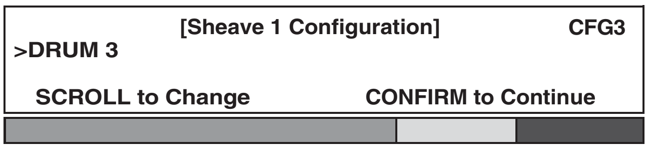

FIGURE 8

On PARTS configuration screen (Figure 9), program cursor (>) appears next to PARTS selection. Scroll up or down as required to select and program desired parts of line.

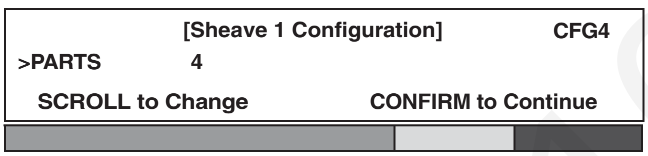

FIGURE 9

On LINEPULL configuration screen (Figure 10), program cursor (>) appears next to LINEPULL selection. Scroll up or down as required to select and program the required single line pull for selected drum and sheave configuration.

Several line pull options are available. ***To determine required SINGLE line pull for drum in use, see Capacities Chart and Wire Rope Specifications Chart for boom or boom and jib in use.***

NOTE: Single line pull equals maximum load divided by parts of line.

Copies of load charts are in the operator's cab.

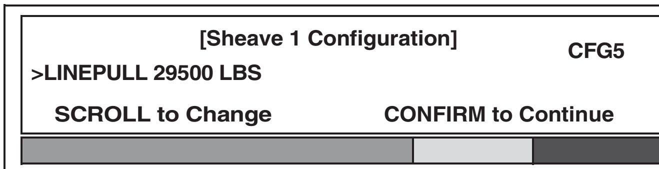

FIGURE 10

On DEDUCT configuration screen (Figure 11), program cursor (>) appears next to DEDUCT selection. Scroll up or down as required to select and program the desired deduct value. As DEDUCT value is increased, capacity value is subtracted the same amount.

For assistance in determining and calculating deducts, see Guide for Determining Total Load in Capacities Section of Operator's Manual provided with crane.

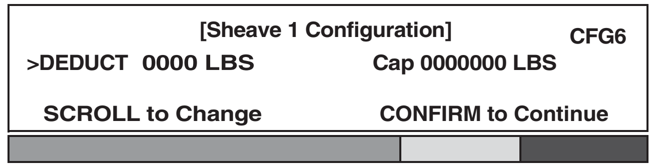

FIGURE 11

On TARE configuration screen (Figure 12), program cursor (>) appears next to TARE selection.

For an unknown tare value:

1. Lift all items that are to be tared out clear of ground (example: load block and lifting slings).
2. Note displayed LOAD value.
3. Scroll up or down until tare value equals displayed load value noted earlier. The load value goes to zero as this step is performed.
4. CONFIRM tare value. The displayed LOAD equals net load (tare value is subtracted automatically).

To turn tare off:

1. Scroll up or down until tare value equals zero.
2. CONFIRM zero tare value.
3. The displayed LOAD value will equal total load (weight of all load lines, load block or weight ball, all rigging and lifted load).

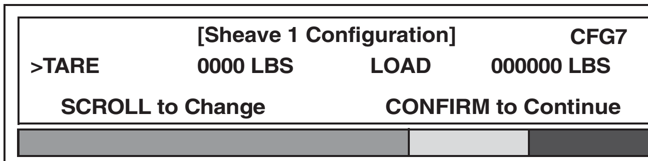

FIGURE 12

On LANGUAGE configuration screen (Figure 13), program cursor (>) appears next to LANGUAGE selection. Scroll up or down as required to select and program desired language. This selection affects language on all screens.

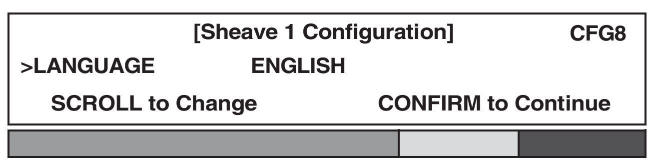

FIGURE 13

On ALARM configuration screen (Figure 14), program cursor (>) appears next to ALARM selection. Scroll up or down as required to select and program desired alarm/load limiter condition.

The alarm item indicates whether alarms (warning/caution lights in cab, beeper/buzzer in cab, amber light/horn outside cab) are ON or OFF. The alarms can be turned off only when LIMITER is OFF.

Load Limiter indicates whether shutdown feature is turned ON or OFF. When shutdown switch is off, the word OFF flashes on the screen.

Turn CONFIRM/SELECT key switch counter-clockwise to CONFIRM selected screen and return to working screen.

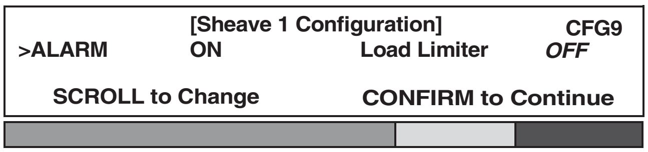

FIGURE 14

Select Multiple Sheaves

The multiple sheave screen (Figure 15) appears when selected on OPT screen. The select cursor (*) appears next to currently active sheave arrangement. Scroll to desired sheave arrangement. Turn CONFIRM/SELECT key switch counterclockwise to CONFIRM desired sheave arrangement.

NOTE: If multiple load sensing sheaves from one point are used, both sheaves must be configured before being selected.

If boom point load sensing sheaves 1 and 2 or luffing point load sensing sheaves 3 and 4 are selected, rated line pull for each sheave is compared to the maximum rated line pull. The sum of both sheaves' load is calculated for total percent of chart capacity. The line pull or chart capacity that is closest to 100 percent rated capacity is displayed in MAX CAP line on working screen. The MAX CAP line changes if another sheave load or total rated capacity is closest to maximum capacity. The displayed LOAD corresponds to displayed MAX CAP. If program is limited by maximum line pull, LOAD and MAX CAP reflects that line pull.

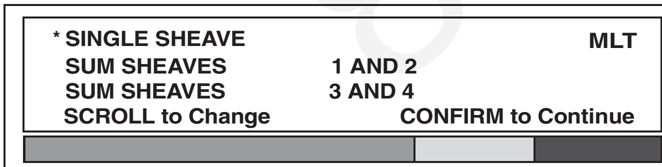

FIGURE 15

Calibrate

The calibration screens are used to calibrate load sensing sheaves and boom/luffing jib angle sensing potentiometers. The proper chart and crane configuration must be programmed and confirmed before performing the calibration procedure.

The last programmed crane and chart configuration for each load sensing sheave and associated drum is retained in memory (even if engine is stopped). This allows the operator to switch between load drums without having to reprogram configurations, *assuming no changes have been made to parts of lines, boom length, etc.*

The units of measure displayed on calibration screen corresponds to type of chart selected:

- Feet and pounds for an ANSI capacity chart.
- Metric Tons for a metric or European capacity chart.

The first calibration screen (Figure 16) appears when Calibrate Angle or Calibrate Sheave is selected and confirmed on option screen. The program cursor (>) appears next to CODE #. The operator or technician must scroll up or down as required to enter code number before calibration screens can be accessed. Turn CONFIRM/SELECT key switch counter-clockwise to CONFIRM to enter boom/luffing jib angle or sheave calibration screens.

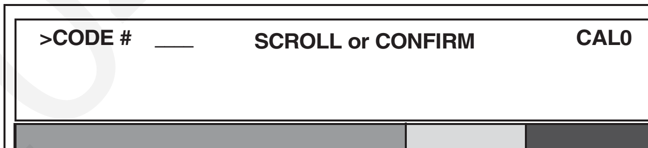

FIGURE 16

Check RCL calibration and calibrate if required, at following intervals (see Calibration Procedure in this publication for detailed instructions):

- Before the first time use of any load sensing sheave.
- It is not necessary to recalibrate a sheave for each type of attachment, once it is calibrated.

  EXAMPLE: *load-sensing sheave 1 is for lower boom point of heavy lift top and long reach top on 2250. Once sheave 1 is calibrated for each attachment, the data is retained in memory. This allows the operator to switch between attachments without having to re-calibrate.*
- When a known lifted load and displayed load are in error more than plus or minus 400 lbs (181kg) or 4%, whichever is greater. Perform this check daily when first known load is lifted on each hook.
- When any part of the system is replaced.
- Yearly.

Following items must be programmed in calibration screens:

CODE #	Calibration Access Code. The number 128 must be programmed to allow calibration.
LOAD	Two known loads are required to properly calibrate load sensing sheaves: • Light Load – produces single line pull of less then 3,300 lbs (1-1/2 Metric Tons). • Heavy Load – which is greater than 2/3 drum's rated single line pull. When calibrating a load the operator can use two different angles. A prompt appears to indicate if lifted load is suitable for calibration: • LESS REQD- Indicates that weight must be removed to complete calibration. • MORE REQD-Indicates that more weight must be added to complete calibration. *Tare must be off (zero) during calibration* so that LOAD includes weight of the load lines, lifting slings, load block or weight ball, and lifted load.
BOOM	The boom angle sensing potentiometer must be calibrated at two angles, LOW ANGLE and HIGH ANGLE. Measure angles with an accurate angle indicator on the centerline of boom butt as described in calibration procedure or by measured radius.
JIB ANGLE	The luffing jib angle sensing potentiometer must be calibrated at two angles, LOW ANGLE and HIGH ANGLE. Measure jib angle by measuring radius from centerline of rotation to centerline of the freely suspended load block or weight ball.

Calibrate Load Sensing Sheaves

To calibrate load sensing sheaves, proceed as follows:

1. Turn off tare so that load lines, load block or weight ball, and all rigging are included in calibration.
2. On option screen, turn CONFIRM/SELECT key switch clockwise to select CALIBRATE SHEAVE.
3. Cursor appears next to CODE #.
4. Scroll up or down until CODE # 128 is selected. RCL cannot be calibrated until this step is performed.
5. Turn CONFIRM/SELECT key switch counter-clockwise to CONFIRM to enter sheave calibration screen (Figure 17). The select cursor (*) appears before selected sheave.

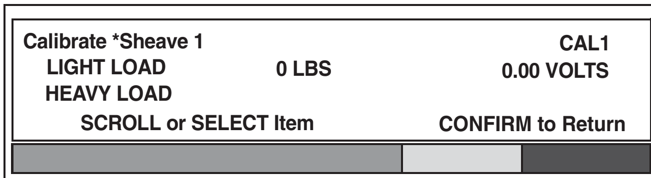

FIGURE 17

6. Turn CONFIRM/SELECT key switch clockwise to SELECT. Program cursor (>) appears. Scroll to desired sheave.
7. Turn CONFIRM/SELECT key switch counter-clockwise to CONFIRM desired sheave.
8. Move select cursor (*) to LIGHT LOAD.
9. Turn CONFIRM/SELECT key switch clockwise to SELECT. Program cursor (>) appears.
10. Lift light load until it is freely suspended. Then scroll up or down until displayed load is equal to known value of light load.
11. Turn CONFIRM/SELECT key switch counter-clockwise to CONFIRM.
12. Move select cursor (*) to HEAVY LOAD.
13. Turn CONFIRM/SELECT key switch clockwise to SELECT. Program cursor (>) appears.
14. Lift heavy load until it is freely suspended. Then scroll up or down until displayed load is equal to known value of heavy load.
15. Turn CONFIRM/SELECT key switch counter-clockwise to CONFIRM to save all calibration changes to this screen and return to working screen.

Calibrate Boom Angle Potentiometers

To calibrate boom potentiometers, proceed as follows:

1. On option screen, turn CONFIRM/SELECT key switch clockwise to select CALIBRATE ANGLE.
2. Cursor appears next to CODE #.
3. Scroll up or down until CODE # 128 is selected. RCL cannot be calibrated until this step is performed.
4. Turn CONFIRM/SELECT key switch counter-clockwise to CONFIRM to enter boom angle calibration screen (Figure 19). The select cursor (*) appears before BOOM or LUFF JIB.
5. If LUFF JIB appears, turn CONFIRM/SELECT key switch clockwise to SELECT and scroll until BOOM appears. Turn CONFIRM/SELECT key switch counter-clockwise to CONFIRM.
6. Turn CONFIRM/SELECT key switch clockwise to SELECT. Program cursor (>) appears before LOW ANGLE.

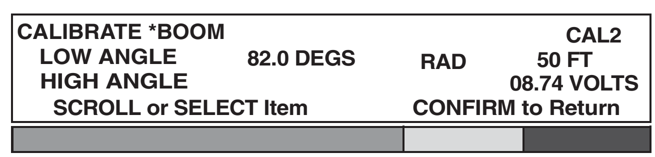

FIGURE 18

7. Position boom between 10° and 30°. *Measure boom angle with an electronic angle indicator placed on centerline of boom butt or by measuring radius of load line.*
   a. Measure and mark (on ground) largest valid radius given in boom capacity chart.
   b. Position boom so centerline of load block or weight ball is at radius marked on ground.

8. Scroll up or down until BOOM ANGLE on calibration screen equals angle measured in step above or radius on calibration screen equals measured radius.
9. Turn CONFIRM/SELECT key switch counter-clockwise to CONFIRM.
10. The select cursor (*) appears before HIGH ANGLE.
11. Turn CONFIRM/SELECT key switch clockwise to SELECT. Program cursor (>) appears.
12. Position boom between 65° and 80°. *Measure boom angle with an electronic angle indicator placed on centerline of boom butt or by measuring radius of load line.*
13. Scroll up or down until BOOM ANGLE on calibration screen equals angle measured in step above or radius on calibration screen equals measured radius.
14. Turn CONFIRM/SELECT key switch counter-clockwise to CONFIRM.

Calibrate Luffing Jib Angle Potentiometers

If equipped with a luffing jib, calibrate boom angle potentiometers first, and then proceed as follows:

1. On option screen, turn CONFIRM/SELECT key switch clockwise to select CALIBRATE ANGLE.
2. Cursor appears next to CODE #. Scroll up or down until CODE # 128 is selected. The RCL cannot be calibrated until this step is performed.
3. Turn CONFIRM/SELECT key switch counter-clockwise to CONFIRM to enter luffing jib angle calibration screen (Figure 19). The select cursor (*) appears before LUFF JIB or BOOM.
4. If BOOM appears, turn CONFIRM/SELECT key switch clockwise to SELECT and scroll until LUFF JIB appears. Turn CONFIRM/SELECT key switch counter-clockwise to CONFIRM.
5. Scroll through luffing jib angle calibration screen until select cursor (*) appears before luffing jib LOW ANGLE.

```
CALIBRATE *LUFF JIB                          CAL3
 LOW ANGLE       82.0 DEGS        RAD        FT
 HIGH ANGLE                           08.74 VOLTS
  SCROLL to Change           CONFIRM to Continue
```

FIGURE 19

6. Turn CONFIRM/SELECT key switch clockwise to SELECT. Program cursor (>) appears.
7. Accurately position boom at lowest specified boom angle given in appropriate luffing jib capacity chart.
8. Measure and mark (on ground) largest valid radius given in luffing jib capacity chart.
9. Position luffing jib so centerline of load block or weight ball is at radius marked on ground in step above.
10. Scroll up or down until RADIUS on calibration screen equals measured radius in step above.
11. Turn CONFIRM/SELECT key switch counter-clockwise to CONFIRM.
12. The select cursor (*) appears before HIGH ANGLE.
13. Turn CONFIRM/SELECT key switch clockwise to SELECT. Program cursor (>) appears.
14. Measure and mark (on ground) a valid radius from luffing jib capacity chart that corresponds to a jib angle between 65° and 80°.
15. Position luffing jib so centerline of load block or weight ball is at radius marked on ground in step above.
16. Scroll up or down until RADIUS on calibration screen equals measured radius in step above.
17. Turn CONFIRM/SELECT key switch counter-clockwise to CONFIRM.

DIAGNOSTIC SCREEN

The diagnostic screen (Figure 20) contains the following information for use by factory service personnel when troubleshooting problems:

- Program Software Data.
- Boom angle and luffing jib angle sender voltages.
- Load sensing sheave voltages.

The following program items are shown on the diagnostic screen:

Program Software	This is a coded representation of the software program version .	
	Imi030	Version for Models 777, 777T, 2250, and 2250T.
	Imi130	Version for Models 111, 222, 888, and 999.
	S999	This is the crane model.
	000000	Program configuration.

```
Imi130   S999    000000            ShV1  0.00 V
>BOOM    VOLT    DEG               ShV2  0.00 V
         8.74    +82.0             ShV3  0.00 V
 JIB     0.00    -86.0     Mem 0   ShV4  0.00 V
```

FIGURE 20

VOLTAGES

Tables 1 and 2 contain voltages for various loads and angles. Use these voltages as a starting point only. Actual voltages may vary 10% to 15%, depending on type of load pin, boom top, and wrap angle.

Table 1 Load Sensing Sheaves Loads and Voltages

Models: 111 and 222[1]			Models: 777, 777T, 2250, and 2250T		
lbs[2]	Metric Ton	Voltage	lbs[2]	Metric Ton	Voltage
0	0	0.50	0	0	0.80
10,000	4.5	2.25	15,000	6.8	3.63
16,000	7.2	3.30	21,000	9.5	4.77
20,000	9.0	4.00	24,000	10.8	5.33
24,000	10.8	4.70	30,000	13.6	6.46

Models: 888 and 999		
lbs[2]	Metric Ton	Voltage
0	0	0.50
15,000	2.0	2.25
21,000	9.5	2.95
24,000	10.8	3.30
30,000	13.5	4.00

1 Model 222HD with 1-1/4 in (3,18 cm) rope use 777 columns.

2 Single part line pull at any sheave (S1, S2, S3, or S4).

Table 2 Boom and Luffing Jib Angle Voltages

Models 777, 777T, 2250, and 2250T				Models 111, 222, 888 & 999			
Boom Angle		**Luffing Jib Angle**		**Boom Angle** 222 #260 Boom with Luffing Jib, 888, 999		**Boom Angle** 111 Boom 222 w/out Luffing Jib **Luffing Jib Angle** 222 #222 Luffing Jib	
Degrees	Voltage	Degrees	Voltage	Degrees	Voltage	Degrees	Voltage
0	1.86	-60	1.48	0	0.93	-60	0.74
30	4.38	-45	2.31	30	2.19	-45	1.16
45	5.60	0	4.80	45	2.80	0	2.40
60	6.86	45	7.32	60	3.43	45	3.66
80	8.54	70	8.72	80	4.27	60	4.08
						70	4.36
						80	4.67

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General

The digital display and selector (see Operating Controls Folio) allow the operator to monitor three groups of crane information: operating conditions, operating limits, and system faults.

Depress top or bottom of selector to scroll up and down through the display readings. Release selector when the desired information is displayed.

To display diagnostic operating conditions listed in Table 1, depress limit by-pass switch while scrolling up with selector.

Refer to page 7 for a list of abbreviations used in the tables and for identification of the drums.

Operating Conditions

Table 1 lists operating conditions which can be displayed and the normal operating range of each.

When an operating condition is selected (such as ENGINE SPEED), the current status of the condition displays (see Figure 1).

ENGINE SPEED
900 RPM

FIGURE 1

Operating Limits

Table 2 lists operating limits which can be displayed.

When one or more operating limits is reached, the operating limit alert (yellow light and buzzer in cab) turns on to warn the operator. At the same time, the operating limit display immediately appears (see Figure 2) and automatically scrolls through the names of the limits, stopping at each for approximately three seconds.

OPERATING LIMIT
BLOCK UP

FIGURE 2

The operating limit alert turns off when the cause of each limit is corrected. The name of each limit reached during operation is retained in memory, however, *until two things happen*:

1. Name of limit appears on display at least once.
2. Cause of limit is corrected.

For this reason, it is normal for the names of limits to appear when you scroll to the operating limit group, even when the operating limit alert is off.

To erase the names of inactive limits, scroll to the operating limit group. Wait until the display scrolls through the name of each limit. The names of inactive limits will be erased automatically. If the alert is on, only the names of active limits will remain.

NO FAULT appears on the display (see Figure 3) when no limits have been reached.

OPERATING LIMIT
NO FAULT

FIGURE 3

System Faults

Table 3 lists system faults which can be displayed.

When one or more system faults occur, the system fault alert (red light and beeper in cab) turns on to warn the operator. At the same time, the system fault display immediately appears (see Figure 4) and automatically scrolls through the names of the faults, stopping at each for approximately three seconds.

SYSTEM FAULT
DRUM 1 SPEED

FIGURE 4

The system fault alert turns off when the cause of each fault is corrected. The name of each fault that has occurred during operation is retained in memory, however, *until two things happen*:

1. Name of fault appears on display at least once.
2. Cause of fault is corrected.

For this reason, it is normal for the names of faults to appear when you scroll to the system fault group, even when the system fault alert is off.

To erase the names of inactive faults, scroll to the system fault group. Wait until the display scrolls through the name of each fault. The names of inactive faults will be erased automatically. If the alert is on, only the names of active faults will remain.

NO FAULT appears on the display (see Figure 5) when there are no faults.

SYSTEM FAULT
NO FAULT

FIGURE 5

Selecting Display Language

Current software for the Model 888 contains English and several foreign-language display readings. When installing a new chip, any one of the installed languages could appear on the screen when the system is powered up the first time. Once the desired language is selected, it will remain in memory until another language is selected.

To select a different display language, perform both of the following steps at the same time:

1. Depress limit by-pass switch.
2. Turn crane mode selector key to "confirm" position.

Repeat the steps until the screen displays the desired language.

Table 1
Operating Conditions
Listed below are the operating conditions which can be viewed on the digital display.

Display Reading	Unit of Measure	Operating Range
Normal Operating Conditions The operating conditions listed below are displayed by scrolling up or down with the digital display selector.		
ENGINE SPEED	RPM	950 rpm low idle; 2,160 rpm high idle, 2,100 rpm full load governed.
AUX ENGINE SPEED [4]	RPM	
AUX ENGINE OIL PRESS [4]	PSI	Refer to engine manufacturer’s manual for operating conditions.
AUX ENGINE TEMP [4]	DEG	
BOOM ANGLE	DEG	Degrees boom is positioned above horizontal [1].
LUFFING JIB ANGLE [2]	DEG	Degrees luffing jib is positioned above horizontal [1].
BOOM TO LUFF JIB ANG [2]	DEG	Degrees between centerline of boom and centerline of luffing jib.
MAST ANGLE	DEG	Degrees mast is positioned above transport position [3].
CLAM CLOSING PRESS	PSI	Refer to Clamshell Operation instructions in Operating Controls folio for procedure to adjust pressure.
CRANE MODE (name of mode)	—	Refer to Crane Mode Selector instructions in Operating Controls folio for procedure to select and confirm desired crane mode.
Diagnostic Screens Operating conditions listed below are displayed only by depressing limit by-pass switch and scrolling up with digital display selector. To turn off diagnostic screens, depress limit by-pass switch and scroll down or stop and restart engine.		
A1	2 Rows of numbers	These numbers are used to monitor and troubleshoot controls and hydraulic systems. Refer to Diagnostics Display, ST123, for explanation of these screens.
A2		
A3 [4]		
D1		
D2		
D3 [4]		
DRUM 1		
DRUM 2		
DRUM 4		
DRUM 6 [4]		
DRUM 7 [4]		
DRUM 8 [2]		
DRUM 9 [2, 4]		
SWING		
TRACK		
PROGRAM M000000.0FP	—	Computer Program Version. *Factory service personnel will request these numbers when troubleshooting crane problems.*
CON 00000000000	—	Computer and Crane Configuration Code. *Factory service personnel will request these numbers when troubleshooting crane problems.*

[1] Past Production: boom angle and luffing jib angle are displayed separately.
Current Production: boom angle and luffing jib angle are displayed at same time.

[2] Optional Item

[3] Mast angles are measured from transport position which is 0°.

[4] Ringer

Table 2
Operating Limits

Listed below are the limits which turn on the operating limit alert (yellow light and continuous buzzer). When the alert comes on, the OPERATING LIMIT group of the digital display will indicate which limit has been reached; take corrective action.

Display Reading	Function Response	Corrective Action
BLOCK UP	Load drums stop hoisting and boom or jib hoist stops lowering.	Lower corresponding load or raise boom or jib.
BOOM MAXIMUM DOWN	Boom stops lowering [5].	Raise boom.
BOOM MAXIMUM UP	Boom stops rising [5].	Lower boom.
CONFIRM MODE	All drums inoperable until an operating mode is selected and confirmed.	Select and confirm the desired operating mode (refer to Operating Controls folio for procedure).
DRUM 1 MAXIMUM BAIL [2]	Drum stops hoisting.	Operate drum in lowering direction.
DRUM 2 MAXIMUM BAIL [2]		
DRUM 4 MAXIMUM BAIL [2]		
DRUM 8 MAXIMUM BAIL [2]		
DRUM 1 MINIMUM BAIL [2]	Drum stops lowering.	Operate drum in hoisting direction.
DRUM 2 MINIMUM BAIL [2]		
DRUM 4 MINIMUM BAIL [2]		
DRUM 8 MINIMUM BAIL [2]		
DRUM 1 PAWL IN	Drum doesn't lower or stops lowering.	Disengage pawl. It may be necessary to hoist slightly before pawl will disengage.
DRUM 2 PAWL IN		
DRUM 6 PAWL IN [4]		
DRUM 7 PAWL IN [4]		
DRUM 8 PAWL IN [2]		
DRUM 9 PAWL IN [2, 4]		
DRUM 4 PAWL IN		
GANTRY DOWN	Boom hoist inoperable in both directions.	Raise gantry.
ILLEGAL ENTRY F'FALL [2]	Free-fall doesn't engage. Drum remains in full power mode.	Latch down load drum brake pedals and confirm free-fall for corresponding drum with selector OR switch corresponding drum mode selector to full power.
JIB BELOW HORIZONTAL [2]	Luffing jib operable. Refer to capacity chart for luffing jib minimum operating angles.	Raise luffing jib above horizontal.
LOAD MOMENT [2]	All load drums stop hoisting and boom and luffing jib hoist stop lowering.	Land load on load drum or raise boom or jib.
LUFFING JIB MAX DOWN [2]	Luffing jib stops lowering when boom to jib angle is 10° for crane with luffing jib or 75° for Ringer with luffing jib.	Raise luffing jib.
LUFFING JIB MAX UP [2]	Luffing jib stops rising when boom to jib angle is 168° for crane with luffing jib or 170°.for Ringer with luffing jib.	Lower luffing jib.
MAST TOO FAR FWD	Boom hoist inoperable in lowering direction.	Raise mast.
FUNCTION IS PARKED	Function inoperable because it is parked.	Turn corresponding park switch off or sit down in operator's seat.

[2] Optional item.

[4] Ringer

[5] Angles at which boom stops vary with attachment.
See Operating Controls folio for specifications.

Table 3
System Faults
Listed below are the faults which turn on the system fault alert (red light and beeper). When the alert comes on, the SYSTEM FAULT group of the digital display will indicate which fault has occurred; take corrective action.

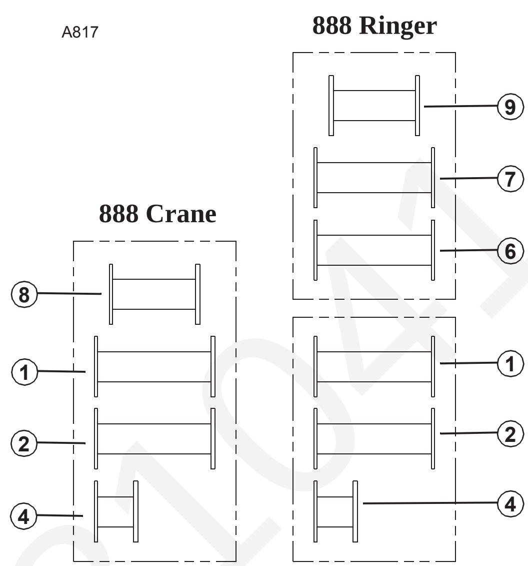
The beeper sounds intermittently (I) or continuously (C) as indicated in alert column.

Display Reading	Alert	Function Response	Cause of Fault
AIR PRESSURE	I	If air pressure continues to drop, load drum parking brakes will apply.	Manifold air pressure below 90 psi (6.2 bar).
BOOM ANGLE SENDER	I	All functions operable, but BOOM ANGLE and BOOM TO LUFFING JIB ANGLE display will be faulty; correct cause of transducer fault as soon as possible.	Sender output voltage 0 volts or above 9.7 volts. Fault not active when crane is in SETUP mode.
DRUM 1 SPEED	C	With cause **A**, drum stops turning and brake applies. With cause **B**, drum motion continues. Drum can be stopped by moving control handle from neutral position. Slowly lower load to ground or engage pawl (if so equipped) and correct cause of fault.	**A:** Downward speed is greater than allowable maximum**.** **B:** Drum motion after parking brake is applied**.**
DRUM 2 SPEED	C		
DRUM 4 SPEED	C		
DRUM 6 SPEED [4]	C		
DRUM 7 SPEED [4]	C		
DRUM 8 SPEED [2]	C		
DRUM 9 SPEED [2, 4]	C		
DRUM 1 SPEED SENDER	I	Function operable, but operation may be erratic; correct cause of sender fault as soon as possible.	Sender indicates motion in wrong direction.
DRUM 2 SPEED SENDER	I		
DRUM 4 SPEED SENDER	I		
DRUM 6 SPEED SENDER [4]	I		
DRUM 7 SPEED SENDER [4]	I		
DRUM 8 SPEED SENDER [2]	I		
DRUM 9 SPEED SENDER [2, 4]	I		
ENGINE OIL PRESSURE	I	Does not affect operation. Correct cause of low oil pressure as soon as possible to prevent engine damage.	Oil pressure below 15 psi (1.0 bar).
AUX ENGINE OIL PRESS [4]	I		
ENGINE TEMPERATURE	I	Does not affect operation. Correct cause of overheating as soon as possible to prevent engine damage.	Engine coolant temperature above 205°F (96°C).
AUX ENGINE TEMP [4]	I		
HYD TANK FLUID TEMP	I	Does not affect operation. Reduce loads and/or speeds to allow oil to cool.	Oil temperature in hydraulic tank above 180°F (82°C).
AUX HYD TANK TEMP [4]	I		
HYD TANK FLUID LEVEL	I	Does not affect operation. Fill tank as soon as possible.	Hydraulic oil at CAUTION LOW LEVEL indicated on tank gauge.
HYDRAULIC FILTER 1	I	All functions operable. Replace filter as soon as possible.	Corresponding filter is dirty.
HYDRAULIC FILTER 2	I		
HYDRAULIC FILTER 3	I		
HYDRAULIC FILTER 4	I		
AUX HYD FILTER 1 [4]	I		
AUX HYD FILTER 2 [4]	I		
HYDRAULIC FILTER 5	I	All functions operable. Clean strainer in tank on crane as soon as possible.	Strainer is dirty.
LUFF JIB ANGLE SEND [2]	I	All functions operable, but LUFFING JIB ANGLE and BOOM TO LUFFING JIB ANGLE display will be faulty; correct cause of transducer fault as soon as possible.	Sender output voltage 0 volts or above 9.7 volts. Fault not active when crane is in SETUP mode.
MAST SYSTEM	I	Boom hoist inoperable in either direction.	Stop operating. Find cause of fault (faulty boom hoist brake or transducer) and correct.
MAST ANGLE SENDER	I	Boom hoist operation stops due to associated limit faults; correct cause of transducer fault as soon as possible.	Sender output voltage 0 volts or above 9.7 volts.
AUX CONTROLLER	C	No communication or improper communication between crane PC and Ringer PC.	Load drums and Ringer swing will be inoperable. Aux engine speed will drop to low idle.
MOTOR TEMPERATURE [6]	I	All functions operable. Red lights in left machinery cab indicate which motor is overheating (see Figure 7). Stop operating or reduce speed and load of corresponding motor until temperature lowers to normal.	Temperature of hydraulic motor 240°F (116°C) or higher.
AUX MOTOR TEMP [4]	I	All functions operable. Stop operating or reduce speed and load of corresponding motor until temperature lowers to normal. To determine which Ringer motor is overheating, disconnect and connect DIN connector at switch on each motor. Fault on screen will turn off when proper DIN connector is disconnected.	

[2] Optional Item. [4] Ringer Motors. [6] Crane Motors.

Abbreviations

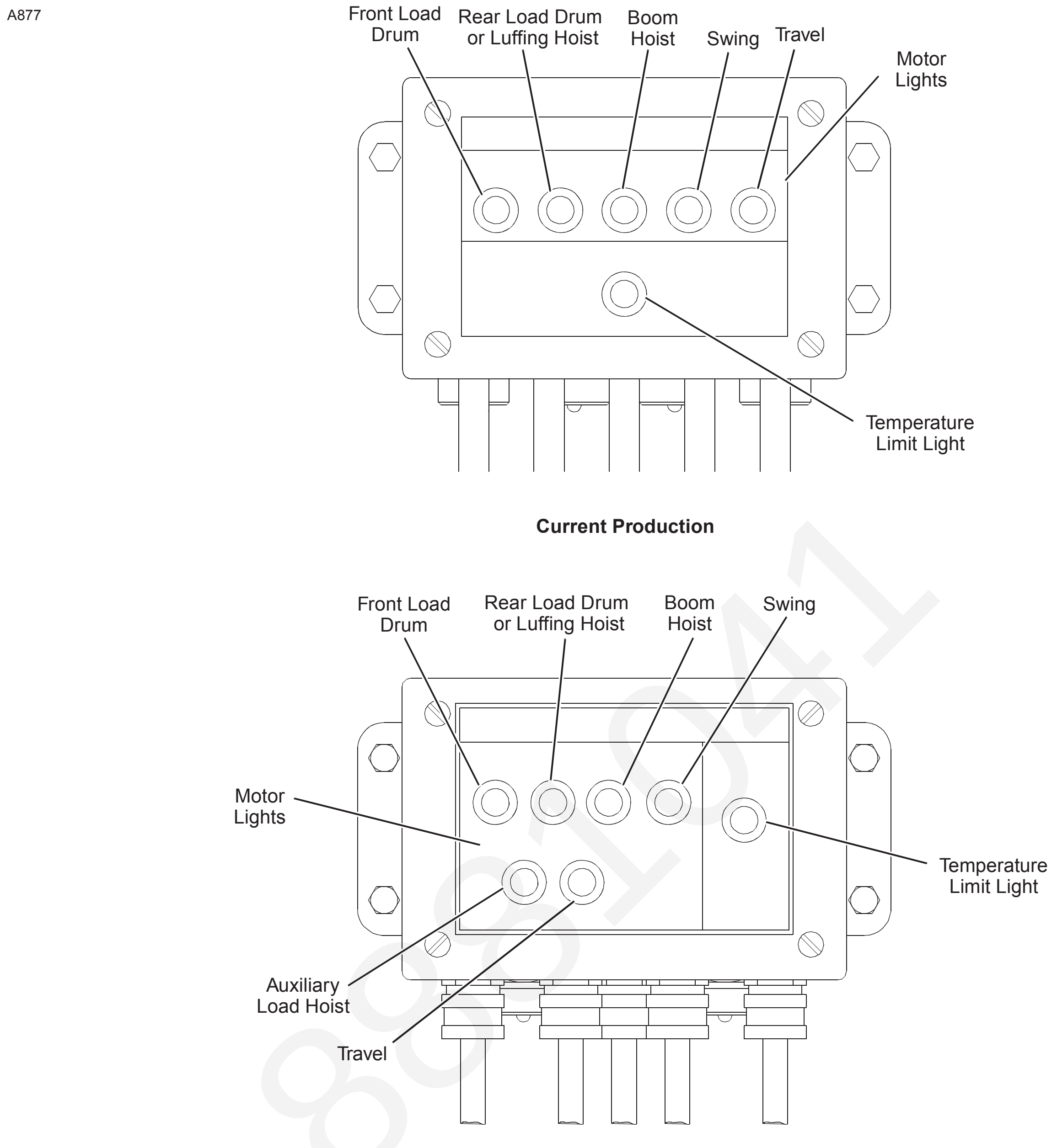
Abbreviation	Definition	Abbreviation	Definition
ANG	Angle	HYD	Hydraulic
AUX	Auxiliary	LUFF	Luffing
CLAM	Clam Shell	PRESS	Pressure
DEG	Degrees (angle)	SEND	Sender
FWD	Forward	TEMP	Temperature
F'FALL	Free-Fall		



Drum Identification

Drum Number	888 Crane	888 Ringer
1	Front Load Drum	Front Boom Hoist
2	Rear Load Drum	Rear Boom Hoist
4	Boom Hoist	Mast Hoist
6	—	Rear Load Drum
7	—	Front Load Drum
8	Auxiliary Load Drum (in boom butt)	—
9	—	Auxiliary Load Drum (in boom butt)

FIGURE 6



Current Production

Past Production

FIGURE 7

Normal Operation

Motor Temperature Below 240°F (116°C):

1. Temperature limit light off.
2. Motor lights on.

High Temperature

Motor Temperature At or Above 240°F (116°C):

1. MOTOR TEMPERATURE fault on.
2. Temperature limit light on.
3. Motor light for faulty motor off.

DIAGNOSTIC DISPLAY

MODEL 888 AND 888 RINGER® ATTACHMENT

Table of Contents

General

To activate the diagnostic display screens, depress the limit by-pass switch and scroll up. Once this step is performed, you can scroll up and down through the diagnostic screens in addition to the normal operating screens. To deactivate the diagnostic screens, depress the limit by-pass switch and scroll down. The normal operating screens will remain active.

The diagnostic display provides information about the status of all main crane components as well as the controller inputs and outputs during operation. There are a total of sixteen diagnostic screens:

- Ten which display information about particular crane functions — DRUMS 1, 2, 4, 6, 7, 8, and 9, SWING (crane), SWING (Ringer), and TRAVEL.
- Four which display information about digital inputs and outputs — D1 (outputs from crane controller), D2 (inputs to crane controller), D3 (inputs to Ringer controller), and A1 (handle/pedal inputs to crane controller).
- Two which display controller programming information — A2 and A3. These screens are for factory use only, and are not shown in this folio.

Refer to Figures 1 – 3 for drum, handle/pedal, and pump identification.

Drum 1, 2, 4 and 8

```
_ _1_ _      _ _2_ _      _ 3 _      4      5
_ _6_ _      _7_                     DRUM X
```

1: Handle command in percent from neutral (+ raise, – lower)*

2: Pump command in percent from neutral (+ raise, – lower)

3: Motor command in percent (0% max. displacement, 100% min. displacement)

4: Parking brake command (1 release, 0 engage)

5: Clutch command (1 release, 0 engage) (applies only to drums with free-fall, otherwise has no meaning)

6: Measured pump pressure (port A) in psi

7: Measured drum speed in rpm (+ raise, – lower)

X: Corresponding drum number appears

* For certain operating conditions the handle command can be set to neutral by the controller even if the handle is not in neutral.

Drum 6 and 7

1	2	3	4	
5	6	7	8	**DRUM** X

1: Handle command in percent from neutral (+ raise, – lower)*
2: Auxiliary pump command in percent from neutral (+ raise, – lower)
3: Pump command in percent from neutral (+ raise, – lower)
4: Measured drum speed in rpm (+ raise, – lower)
5: Measured auxiliary pump pressure (port A) in psi
6: Measured pump pressure (port A) in psi
7: Motor command in percent (0% max. displacement, 100% min. displacement)
8: Parking brake command (1 release, 0 engage)
X: Corresponding drum number appears

Drum 9

1	2	3	4	
5	6			**DRUM** X

1: Handle command in percent from neutral (+ raise, – lower)*
2: Pump command in percent from neutral (+ raise, – lower)
3: Motor command in percent (0% max. displacement, 100% min. displacement)
4: Parking brake command (1 release, 0 engage)
5: Measured pump pressure (port A) in psi
6: Measured drum speed in rpm (+ raise, – lower)
X: Corresponding drum number appears

Swing
(Crane)

1	2	
3	4	**SWING**

1: Handle command in percent from neutral (+ right, – left)*
2: Pump command in percent from neutral (+ right, – left)
3: Measured pump pressure swing right (port A) in psi
4: Measured pump pressure swing left (port B) in psi

Swing
(Ringer)

1	2	3	4	
5	6			**SWING**

1: Measured front pump pressure swing right (port A) in psi
2: Measured front pump pressure swing left (port B) in psi
3: Measured rear pump pressure swing right (port A) in psi
4: Measured rear pump pressure swing left (port B) in psi
5: Front pump command in percent from neutral (+ right, – left)
6: Rear pump command in percent from neutral (+ right, – left)

* For certain operating conditions the handle command can be set to neutral by the controller even if the handle is not in neutral.

Track

_ _1_ _	_ _2_ _	_ _3_ _	_ _4_ _	
_ _5_ _	_ _6_ _	7		**TRACK**

1: Right handle/pedal command in percent from neutral (+ forward, – backward)*
2: Left handle/pedal command in percent from neutral (+ forward, – backward)*
3: Right pump command in percent from neutral (+ forward, – backward)
4: Left pump command in percent from neutral (+ forward, – backward)
5: Measured system pressure right track in psi
6: Measured system pressure left track in psi
7: Parking brake command (1 release, 0 engage)

A1 (Handles)

The variable control handle output voltage is represented in the controller by a number between 0 (0 Volts) and 255 (10 Volts). Diagnostic screen A1 displays this number for each of the control handles/pedals. The normal operating outputs of the handles range from:

- approximately 38 (1.5 Volts) to 120 (4.7 Volts) for lower/reverse/right**
- approximately 136 (5.3 Volts) to 215 (8.5 Volts) for raise/forward/left**

A switch opens when the handle is in the neutral range (4.7 – 5.3 volts). In the neutral range, the screen reads 0 (0 volts).

_ 1 _	_ 2 _	_ 3 _	_ 4 _	_ 5 _
_ 6 _	_ 7 _	_ 8 _	_ 9 _	**A1**

1: Handle 1 – Front Drum
2: Handle 2 – Rear Drum
3: Handle 3 – Boom Hoist
4: Handle 5 – Right Track
5: Handle 6 – Left Track
6: Handle 4 – Swing
7: Handle 7 – Auxiliary Drum
8: Pedal 1 – Right Track
9: Pedal 2 – Left Track

* For certain operating conditions the handle command can be set to neutral by the controller even if the handle is not in neutral.

** Some dual-axis handles (joysticks) are internally limited and will not put out the full range stated here.

D1, D2, and D3
(Digital Outputs and Inputs)

The status of the digital outputs from the controller and the inputs to the controller is displayed in several banks in screens D1, D2, and D3. Each bank can indicate the state of up to eight individual digital inputs or outputs.

_ 1 _	_ 2 _	_ 3 _	_ 4 _	_ 5 _
_ 6 _	_ 7 _	_ 8 _		**D** X

1 – 8: Bank number

X: Corresponding digital screen number (1, 2, or 3) appears.

Each individual input/output is assigned a number (identifier) in the binary system (powers of two). The identifiers of all inputs/outputs that are ON (active), are added to a total in each bank. Thus, the number displayed for each bank is the sum of all identifiers of the inputs/outputs that are ON (0 – 255). With this system, each possible ON/OFF combination per bank has a unique total.

For identification of the digital outputs and inputs (and the crane components connected to them) refer to Tables 1, 2, and 3 in this folio.

To determine the state of the individual inputs/outputs in a bank, find the number displayed for the bank in the first column in Table 4. In the corresponding row the identifier numbers that are ON (active) in the bank are shaded. Use Tables 1, 2, and 3 to identify the crane components associated with the identifiers for the corresponding bank.

Example 1: The number displayed in Bank 3 of screen D2 of the digital display is 41. Go to row number 41 in Table 4. The boxes for identifiers 1, 8 and 32 are shaded in this row, indicating that the corresponding inputs are active. Find the component description for the identifiers in Table 2, Bank 3. In this example, the inputs for Luffing Jib Maximum Down Limit Switch (1), Engine Oil Pressure Switch (8) and Low Air Pressure Switch (32) are active.

Example 2: You want to know if the controller output for the rear drum clutch is ON. In Table 1 you will find Rear Drum Clutch in Bank 1 (identifier 64). Look up the current number for Bank 1 in screen D1 on the digital display (e.g. 152). Then go to the corresponding row number (152) in Table 4. Identifier 64 box is not shaded in this row, indicating that the controller output to the rear drum clutch is OFF.

NOTE: All numbers in screen D1, and the pump/motor command values in screens DRUM, SWING and TRACK represent controller commands to the corresponding output devices only. The state of a certain output port on the controller may not necessarily correspond to the actual state of the associated crane component (brake valve, clutch valve, etc.), since the connection between the controller and the component may be faulty due to loose connections, corroded terminals, broken wiring or improperly operating components.

Table 1 D1 (Crane Digital Outputs

Identifier*	Component
Bank 1	
1	Front Drum Air Parking Brake
2	Rear Drum Air Parking Brake
4	Boom Hoist Parking Brake
8	Travel Parking Brake
16	Spare
32	Front Drum Clutch
64	Rear Drum Clutch
128	Front Drum Hydraulic Parking Brake
Bank 2	
1	Rear Drum Hydraulic Parking Brake
2	Spare
Bank 3	
1	Auxiliary Drum Parking Brake
2	Spare
4	Swing Alarm
8	Operating Limit Alarm/Lamp
16	System Fault Alarm/Lamp
32	Gantry Raise Cylinder
64	Gantry Lower Cylinder
128	Mast Assist Raise Cylinder
Bank 4	
1	Mast Assist Lower Cylinder
2	Boom Hinge Pins Cylinder
Bank 5	
1	Counterweight Pins Retract
2	Front Drum Rotation Indicator
4	Rear Drum Rotation Indicator
8	Boom Hoist Rotation Indicator
16	Auxiliary Drum Rotation Indicator
32	Track Motor Speed
64	Spare
128	Spare
Bank 6	
1	Spare
2	Swing Brake
Bank 7	
1	Spare
2	Spare
4	Spare
8	Spare
16	Spare
32	Auxiliary Drum Pump Control Up **
64	Auxiliary Drum Pump Control Down **
128	Not Used
Bank 8	
Not used	

Table 2 D2 (Crane Digital Inputs)

Identifier*	Component
Bank 1	
1	Travel Detent
2	Front Drum Maximum Bail Limit Switch
4	Front Drum Minimum Bail Limit Switch
8	Boom Hoist Maximum Bail Limit Switch
16	Boom Hoist Minimum Bail Limit Switch
32	Block Up Limit Switch
64	Rear Drum Maximum Bail Limit Switch
128	Rear Drum Minimum Bail Limit Switch
Bank 2	
1	Crane Mode Select
2	Crane Mode Confirm
4	Spare
8	Boom Maximum Up Limit Switch
16	Boom Maximum Down Limit Switch
32	Luffing Jib Maximum Up Limit Switch
Bank 3	
1	Luffing Jib Maximum Down Limit Switch
2	Hydraulic Fluid Level Switch
4	Hydraulic Fluid Temperature Switch
8	Engine Oil Pressure Switch
16	Engine Coolant Temperature Switch
32	Low Air Pressure Switch
64	Rear Drum Free-Fall Confirm
128	Gantry Up Switch
Bank 4	
1	Front Drum Free-Fall Confirm
2	Load Moment Indicator Input
4	Limit By-Pass Switch
8	Display Scroll Up
16	Rear Drum Free-Fall Mode Switch
32	Front Drum Free-Fall Mode Switch
Bank 5	
1	Front Drum Pawl In
2	Rear Drum Pawl In
4	Boom Hoist Pawl In
8	Auxiliary Drum Pawl In
16	Display Scroll Down
32	Seat Switch
64	Travel High Speed Switch
128	Gantry Raise/Lower Switch
Bank 6	
1	Front Drum Park Switch
2	Rear Drum Park Switch
4	Boom Hoist Park Switch
8	Travel Park Switch
16	Auxiliary Drum Park Switch
32	Auxiliary Drum Maximum Bail Limit Switch
Bank 7	
1	Auxiliary Drum Minimum Bail Limit Switch
2	Swing Holding Brake Switch
4	Hydraulic Filter Alarm Switch 1
8	Hydraulic Filter Alarm Switch 2
16	Hydraulic Filter Alarm Switch 3
32	Hydraulic Filter Alarm Switch 4
64	Hydraulic Filter Alarm Switch 5
128	Spare
Bank 8	
1	Spare
2	Spare
4	Spare
8	Spare
16	Spare
32	Spare

* Binary

** These digital ports are pulsed for auxiliary pump control. For both ports a digital ON is displayed when pulsing, to prevent a flickering number for the corresponding bank.

Table 3 D3 (Ringer Digital Inputs)

Identifier*	Component
Bank 1	
1	Block Up Limit
2	Maximum Luffing Jib Angle
4	Minimum Luffing Jib Angle
8	Maximum Boom Angle
16	Drum 6 Pawl In
32	Not Used
64	Drum 7 Pawl In
128	Drum 9 Pawl In
Bank 2	
1	Engine Oil Pressure
2	Engine Coolant Temperature
4	Hydraulic Filter 1
8	Hydraulic Filter 2
16	Front Right Motor Temperature
32	Not Used
64	From Left Motor Temperature
128	Rear Motor Temperature
Bank 3	
1	Auxiliary Motor Temperature
2	Spare
4	Spare
8	Spare
16	Spare
32	Not Used
64	Spare
128	Spare

* Binary

Drum Identification

Drum Number	Crane	Ringer
1	Front Load Drum	Front Boom Hoist
2	Rear Load Drum	Rear Boom Hoist
4	Boom Hoist	Mast Hoist
6	—	Rear Load Drum
7	—	Front Load Drum
8	Auxiliary Load Drum (in boom butt)	—
9	—	Auxiliary Load Drum (in boom butt)

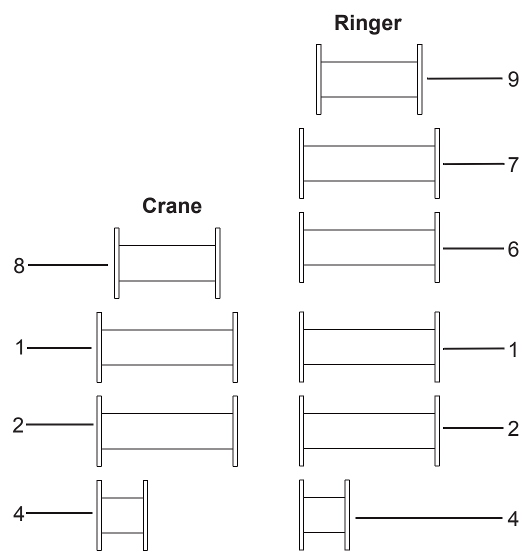


FIGURE 1

Handle/Pedal Identification

Handle Number	Crane (All Modes)	Ringer (Standard Mode)	Ringer (Set-Up Mode)
1	Front Load Drum	Front Load Drum	Front Boom Hoist
2	Rear Load Drum or Luffing Hoist*	Rear Load Drum or Luffing Hoist*	Rear Boom Hoist
3	Boom Hoist or Luffing Hoist**	Boom Hoist	Mast Hoist
4	Swing	Swing	Swing
5	Right Crawler	Inoperable	Right Crawler
6	Left Crawler	Inoperable	Left Crawler
7	Auxiliary Load Drum (in butt) or Luffing Hoist**	Auxiliary Load Drum (in butt)	Auxiliary Load Drum (in butt)
Pedal Number			
1	Right Crawler	Inoperable	Right Crawler
2	Left Crawler	Inoperable	Left Crawler

* Activated only in LUFFING JIB Mode.

** Special handle arrangement activated only in LUFFING JIB Mode.

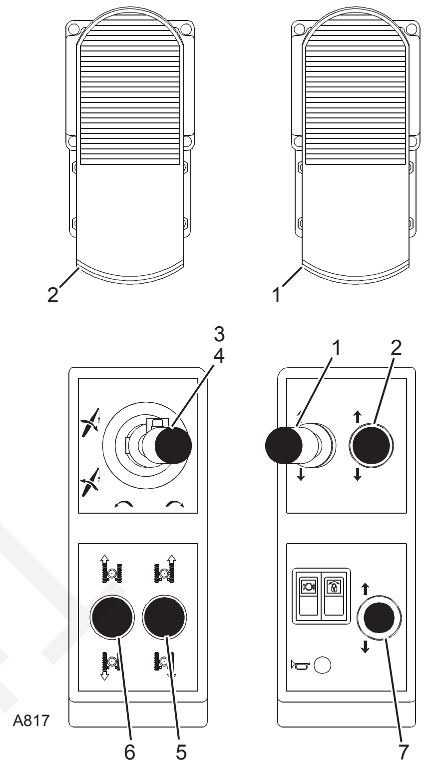


FIGURE 2

Pump Identification

Pump Number	Crane	Ringer
0	Front Load Drum	Front Boom Hoist
1	Rear Load Drum or Luffing Hoist	Rear Boom Hoist
2	Boom Hoist	Mast Hoist
3	Swing	—
4	Right Crawler	Right Crawler
5	Left Crawler	Left Crawler
6	—	Rear Load Drum (right motor)
7	—	Front Load Drum (right motor)
8	—	Front Swing
9	—	Rear Swing
10	Auxiliary Load Drum (in butt)	Front Load Drum (left motor)
12	—	Rear Load Drum (left motor)
13	—	Auxiliary Load Drum (in butt)

Pump Port Identification

Pump Number	Port A	Port B
0, 1, 2, 6, 7, 10, 12, 13	Raise	Lower
3, 8, 9	Right	Left
4	Forward	Reverse
5	Reverse	Forward

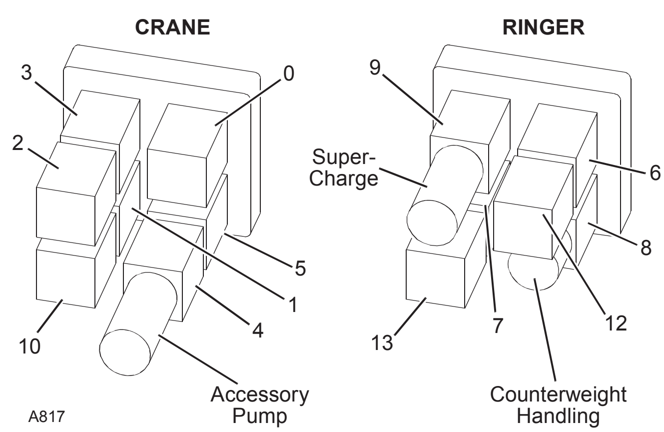


FIGURE 3

Table 4 8-Bit Binary System

	1	2	4	8	16	32	64	128
1	■							
2		■						
3	■	■						
4			■					
5	■		■					
6		■	■					
7	■	■	■					
8				■				
9	■			■				
10		■		■				
11	■	■		■				
12			■	■				
13	■		■	■				
14		■	■	■				
15	■	■	■	■				
16					■			
17	■				■			
18		■			■			
19	■	■			■			
20			■		■			
21	■		■		■			
22		■	■		■			
23	■	■	■		■			
24				■	■			
25	■			■	■			
26		■		■	■			
27	■	■		■	■			
28			■	■	■			
29	■		■	■	■			
30		■	■	■	■			
31	■	■	■	■	■			
32						■		
33	■					■		
34		■				■		
35	■	■				■		
36			■			■		
37	■		■			■		
38		■	■			■		
39	■	■	■			■		
40				■		■		
41	■			■		■		
42		■		■		■		
43	■	■		■		■		
44			■	■		■		
45	■		■	■		■		
46		■	■	■		■		
47	■	■	■	■		■		
48					■	■		
49	■				■	■		
50		■			■	■		
51	■	■			■	■		
52			■		■	■		
53	■		■		■	■		
54		■	■		■	■		
55	■	■	■		■	■		
56				■	■	■		
57	■			■	■	■		
58		■		■	■	■		
59	■	■		■	■	■		
60			■	■	■	■		
61	■		■	■	■	■		
62		■	■	■	■	■		
63	■	■	■	■	■	■		
64							■	
65	■						■	
66		■					■	
67	■	■					■	
68			■				■	
69	■		■				■	
70		■	■				■	
71	■	■	■				■	
72				■			■	
73	■			■			■	
74		■		■			■	
75	■	■		■			■	
76			■	■			■	
77	■		■	■			■	
78		■	■	■			■	
79	■	■	■	■			■	
80					■		■	
81	■				■		■	
82		■			■		■	
83	■	■			■		■	
84			■		■		■	
85	■		■		■		■	
86		■	■		■		■	
87	■	■	■		■		■	
88				■	■		■	
89	■			■	■		■	
90		■		■	■		■	
91	■	■		■	■		■	
92			■	■	■		■	
93	■		■	■	■		■	
94		■	■	■	■		■	
95	■	■	■	■	■		■	
96						■	■	
97	■					■	■	
98		■				■	■	
99	■	■				■	■	
100			■			■	■	
101	■		■			■	■	
102		■	■			■	■	
103	■	■	■			■	■	
104				■		■	■	
105	■			■		■	■	
106		■		■		■	■	
107	■	■		■		■	■	
108			■	■		■	■	
109	■		■	■		■	■	
110		■	■	■		■	■	
111	■	■	■	■		■	■	
112					■	■	■	
113	■				■	■	■	
114		■			■	■	■	
115	■	■			■	■	■	
116			■		■	■	■	
117	■		■		■	■	■	
118		■	■		■	■	■	
119	■	■	■		■	■	■	
120				■	■	■	■	
121	■			■	■	■	■	
122		■		■	■	■	■	
123	■	■		■	■	■	■	
124			■	■	■	■	■	
125	■		■	■	■	■	■	
126		■	■	■	■	■	■	
127	■	■	■	■	■	■	■	
128								■
129	■							■

Dark shaded boxes indicate ON; white boxes OFF.

Table 4 8-Bit Binary System (continued)

	1	2	4	8	16	32	64	128
130		■						■
131	■	■						■
132			■					■
133	■		■					■
134		■	■					■
135	■	■	■					■
136				■				■
137	■			■				■
138		■		■				■
139	■	■		■				■
140			■	■				■
141	■		■	■				■
142		■	■	■				■
143	■	■	■	■				■
144					■			■
145	■				■			■
146		■			■			■
147	■	■			■			■
148			■		■			■
149	■		■		■			■
150		■	■		■			■
151	■	■	■		■			■
152				■	■			■
153	■			■	■			■
154		■		■	■			■
155	■	■		■	■			■
156			■	■	■			■
157	■		■	■	■			■
158		■	■	■	■			■
159	■	■	■	■	■			■
160						■		■
161	■					■		■
162		■				■		■
163	■	■				■		■
164			■			■		■
165	■		■			■		■
166		■	■			■		■
167	■	■	■			■		■
168				■		■		■
169	■			■		■		■
170		■		■		■		■
171	■	■		■		■		■
172			■	■		■		■
173	■		■	■		■		■
174		■	■	■		■		■
175	■	■	■	■		■		■
176					■	■		■
177	■				■	■		■
178		■			■	■		■
179	■	■			■	■		■
180			■		■	■		■
181	■		■		■	■		■
182		■	■		■	■		■
183	■	■	■		■	■		■
184				■	■	■		■
185	■			■	■	■		■
186		■		■	■	■		■
187	■	■		■	■	■		■
188			■	■	■	■		■
189	■		■	■	■	■		■
190		■	■	■	■	■		■
191	■	■	■	■	■	■		■
192							■	■
193	■						■	■
194		■					■	■
195	■	■					■	■
196			■				■	■
197	■		■				■	■
198		■	■				■	■
199	■	■	■				■	■
200				■			■	■
201	■			■			■	■
202		■		■			■	■
203	■	■		■			■	■
204			■	■			■	■
205	■		■	■			■	■
206		■	■	■			■	■
207	■	■	■	■			■	■
208					■		■	■
209	■				■		■	■
210		■			■		■	■
211	■	■			■		■	■
212			■		■		■	■
213	■		■		■		■	■
214		■	■		■		■	■
215	■	■	■		■		■	■
216				■	■		■	■
217	■			■	■		■	■
218		■		■	■		■	■
219	■	■		■	■		■	■
220			■	■	■		■	■
221	■		■	■	■		■	■
222		■	■	■	■		■	■
223	■	■	■	■	■		■	■
224						■	■	■
225	■					■	■	■
226		■				■	■	■
227	■	■				■	■	■
228			■			■	■	■
229	■		■			■	■	■
230		■	■			■	■	■
231	■	■	■			■	■	■
232				■		■	■	■
233	■			■		■	■	■
234		■		■		■	■	■
235	■	■		■		■	■	■
236			■	■		■	■	■
237	■		■	■		■	■	■
238		■	■	■		■	■	■
239	■	■	■	■		■	■	■
240					■	■	■	■
241	■				■	■	■	■
242		■			■	■	■	■
243	■	■			■	■	■	■
244			■		■	■	■	■
245	■		■		■	■	■	■
246		■	■		■	■	■	■
247	■	■	■		■	■	■	■
248				■	■	■	■	■
249	■			■	■	■	■	■
250		■		■	■	■	■	■
251	■	■		■	■	■	■	■
252			■	■	■	■	■	■
253	■		■	■	■	■	■	■
254		■	■	■	■	■	■	■
255	■	■	■	■	■	■	■	■

Dark shaded boxes indicate ON; white boxes OFF.

Manitowoc

CRANE SOFTWARE INSTALLATION

All Models (Software rev00c or rev00f and newer)

TABLE OF CONTENTS

GENERAL

This publication provides qualified service technicians with instructions for installing crane software and capacity chart files on Manitowoc cranes equipped with an EPIC control system — either non-CAN bus or CAN bus.

Crane software terms:

- MCC Controls Application — Personal computer application used to download crane software and capacity chart information.
- Crane Software — EPIC controller program designated by the **.HEX** suffix in 4X40 programs and the **.H86** suffix in CAN-bus programs.
- Chart Software — Crane capacity chart information designated by the **.IHX** suffix.

NOTE: Chart software is serial number specific and should not be used on any other crane.

PERSONNEL

Crane software and capacity chart files must be installed only by a qualified, trained technician as instructed in this document.

To become qualified to install software, the technician must be trained by a qualified instructor. Properly completed Software Installation Training Form OOSVFM044 (at end of this document) must be submitted to Manitowoc Crane Care Customer Service verifying technician training.

SOFTWARE INSTALLATION REQUIREMENTS

To successfully install crane software and capacity chart files, the following items are required:

- Laptop PC with Windows XP or Windows 7.
- The laptop should have a RS 232 serial port. If it doesn't, you can use a RS 232-to-USB adapter — Manitowoc # 90019155.
- Data downloading cable — Manitowoc # A06301-0.
- Current version of crane software installed on laptop PC.

INSTALLING PROGRAM ON LAPTOP

The MCC Controls Application is updated when necessary. You should verify your program version with Manitowoc Crane Care Customer Service before installing software or capacity charts.

The MCC Controls Application can be ordered on compact disc (CD) from Manitowoc Crane Care Customer Service at the time you order crane software and chart software for a particular crane.

Before the crane software program can be installed, a folder must be created on the laptop's hard drive (C drive), as follows:

1. Click on **My Computer** Icon.
2. Click on **C** drive icon.
3. Click on **File** menu.
4. Click on **New**.
5. Select **Folder**.
6. A folder is created in **C** drive called **New Folder**.
7. Click on **New Folder** icon to rename folder.
8. Enter new name **MCC Controls**, for example.

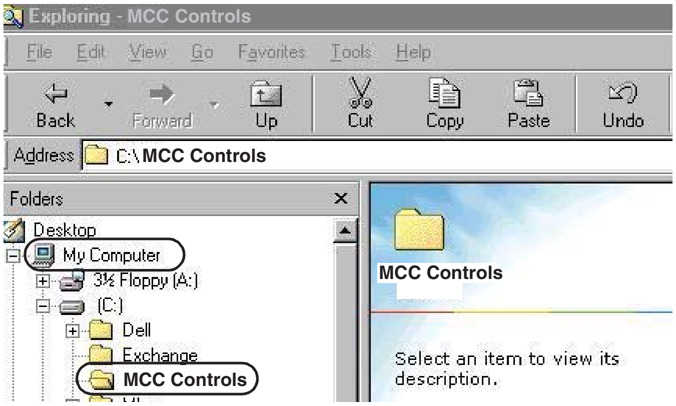


FIGURE 1

To install crane software and capacity chart files from CD:

1. Insert CD disc into laptop's CD drive.
2. Click on **My Computer** Icon (see Figure 1).
3. Click on CD disc drive icon to reveal folder similar to **rev00c** or **rev00f or newer** (see Figure 2).

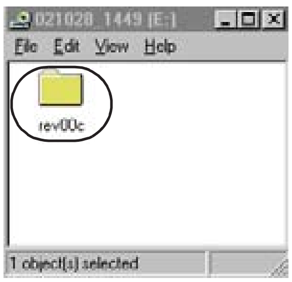


FIGURE 2

4. Click on folder icon to install loading program.
5. Click on **package** folder icon (see Figure 3).

FIGURE 3

6. Click on **setup.exe** icon (see Figure 4).

FIGURE 4

7. The program will begin to copy some files and proceed to the setup screen.
8. When the **MCC Controls Setup** program screen is displayed, click **OK** (see Figure 5).

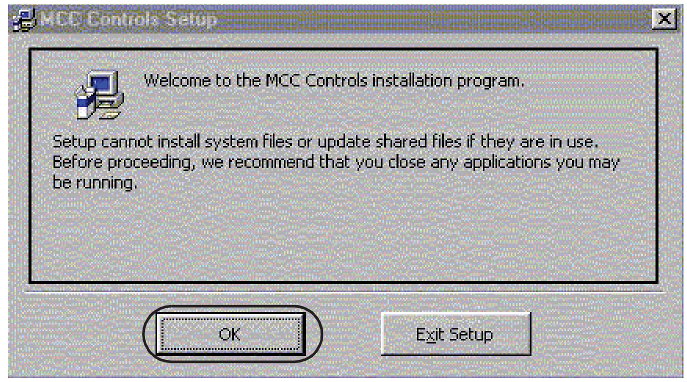


FIGURE 5

9. On the **MCC Controls Setup** screen (see Figure 6), click **Change Directory** to set location to the pre-created **MCC Controls** folder.

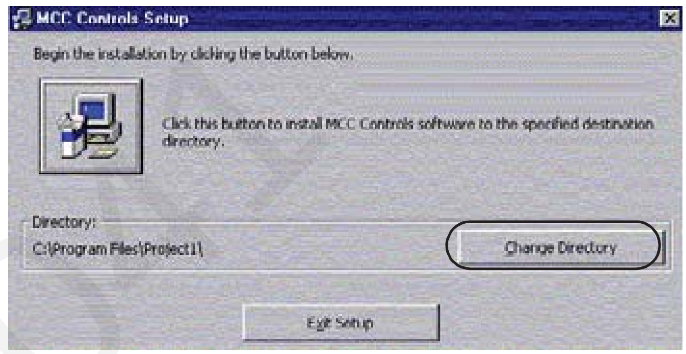


FIGURE 6

10. Locate the **MCC Controls** folder on the **C** drive and click **OK** (see Figure 7).

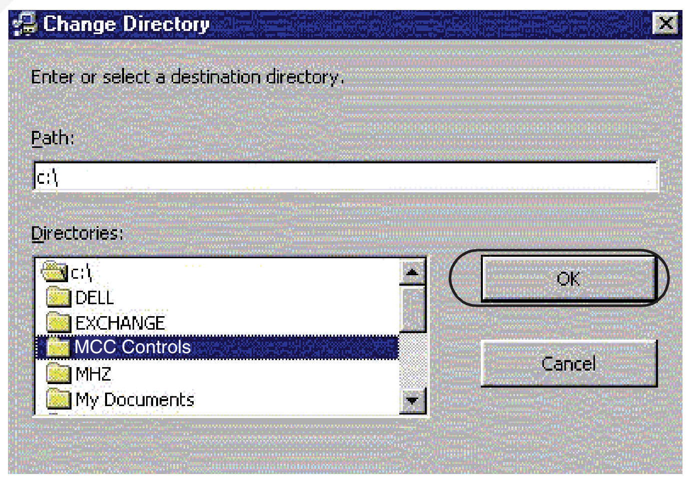


FIGURE 7

11. Click on the **Computer** icon to proceed with the installation of the download program into the **MCC Controls** folder (see Figure 8).

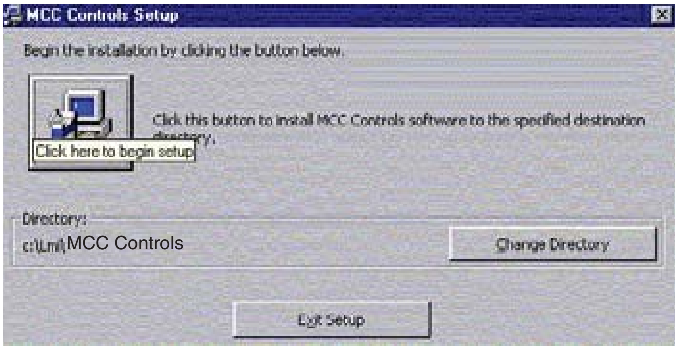


FIGURE 8

12. When asked to verify **Program group**, click **Continue.**

13. While in setup, a pop up screen may be displayed indicating a newer file exists on your laptop. Click **Yes** to keep your newer existing file.

14. The screen will indicate when setup is complete. Click on **OK.**

15. A desktop shortcut to the download program may be desired. To create a shortcut:

- **a.** Select **My Computer** icon on the desktop screen and click.
- **b.** Select **C** drive and click.
- **c.** Select **MCC Controls** folder and ***Left*** click.
- **d.** In the folder Right click on **MCC Control App.exe** and select **Create Shortcut** and click. A shortcut icon will then be displayed.
- **e.** Move shortcut icon to desktop or other desired area.

16. When a new MCC Controls Application version becomes available, the older version must first be removed from the laptop before the new program can be loaded. To remove an old program:

- **a.** Click on **Start** for menu column in bottom left corner of screen.
- **b.** Click on **Settings.**
- **c.** Click on **Control Panel.**
- **d.** Click on **Add/Remove Programs** icon.
- **e.** Select **MCC Controls App.exe** from menu (see Figure 9).

FIGURE 9

17. Click **Add/Remove** button and existing program will be removed from **C** drive of the laptop.

INSTALLING SOFTWARE AND CHARTS ON LAPTOP

The software provided will be for a specific crane unless advised differently.

1. Before installing new crane software, a folder must be created on laptop's desktop, as follows:

- **a.** **Right** click on desktop (main screen) for menu bar and select **New**. A secondary menu screen is displayed.
- **b.** Click on **Folder** on secondary menu. A folder called **New Folder** becomes visible on desktop screen.
- **c.** Rename folder. For example, you could use the crane serial number (2251025).

2. Open crane software files. **Right** click **MEC2.HEX** (non-CAN bus) or **Master.H86** (CAN bus) file icon.

3. When menu bar becomes visible, click **Save As…**

4. When **Save Attachment** screen appears, select desktop location to locate renamed folder created in step 1c.

5. When **Save Attachment** screen for intended folder becomes visible, click on **Save** button.

MEC2.HEX or **Master.H86** file is now saved to selected folder. Do not change names of files.

6. Return to crane software files and **right** click on **Imidata.ihx** (non-CAN bus) or **candata.ihx** (CAN bus) file icon.

7. When menu bar becomes visible, click **Save As…**

8. **Save Attachment** screen for intended folder should become visible, (if not, select from desktop location).

9. Click on **Save** button. **Imidata.ihx** or **candata.ihx** file is now saved to selected folder.

DOWNLOADING SOFTWARE AND CHARTS TO CRANE PC

The procedure for downloading non-CAN bus crane software with or without RCI/RCL Master Node is different from the procedure for downloading CAN bus crane software. ***Refer to proper procedure***.

Non-CAN bus Software without Master Node

Before installing non-CAN bus software and capacity charts on crane without RCI/RCL Master Node, perform following steps:

- PARK all crane functions.
- STOP engine. It must be off for entire procedure.
- TURN ON cab power.
- RECORD current configuration settings (handle, chart numbers, etc.) before downloading new software. When download is complete, use this information to confirm crane is configured as it was before download.

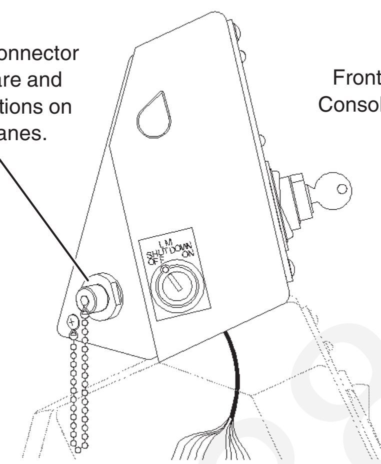


FIGURE 10

Installing Software Program rev00c

1. Click on shortcut icon **MCC Controls App**. The selected folder appears (see Figure 11).
2. Click on **MCC Controls App.exe** icon to launch program (see Figure 11).

FIGURE 11

3. **Manitowoc Controls Interface - rev00c** screen is displayed (see Figure 12).
4. Select desired laptop serial port to be used as well as “LMI” (see Figure 12).
5. Turn on cab power. ***Do not start engine.***
6. Wait until program switches from Bootstrap screen to working screen.
7. Connect download harness to install port and to RS 232 serial port on laptop (see Figure 10).
8. Press **Reset and Load Hex** button in lower center (see Figure 12). A screen will drop down called **Open**.
9. Locate and open crane **MCC Controls** folder (example: 2251123 folder).
10. Locate and click on **Mec2.hex** icon to select file and then click on **Open** button (see Figure 12). The hex file will now download the program. A screen displays bootstrap information during download process and controls application shows data address.

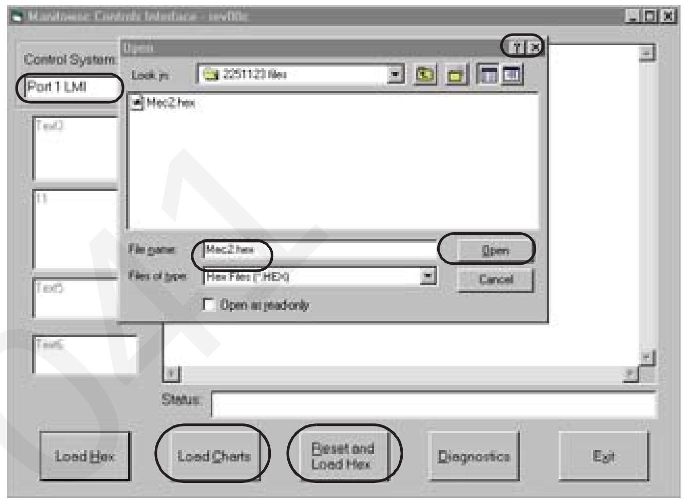


FIGURE 12

11. When laptop interface screen displays **Process Complete/Timed Out** the screen closes automatically.
12. Select and press **Load Charts** button at bottom of screen. A screen will drop down called **Open**.
13. To reduce chart loading time, scroll up or down one screen from display working screen to menu screen. Locate on **Open** screen and click on **lmidata.ihx** icon to select file (see Figure 13).

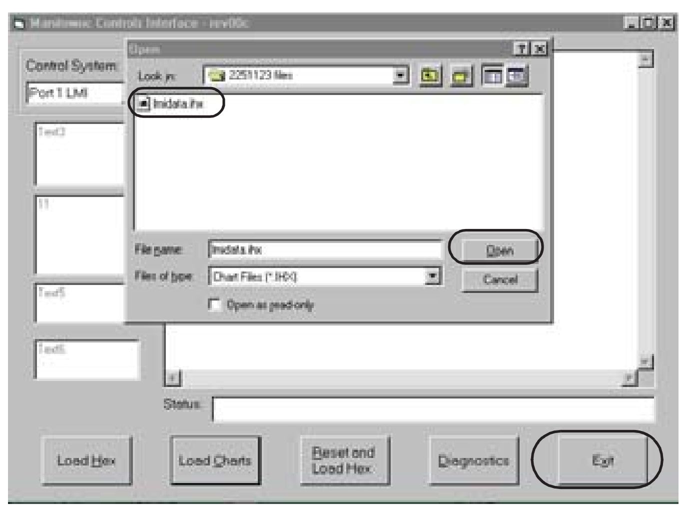


FIGURE 13

14. Click on **Open** button to open file. Capacity charts will now begin to load. While charts are loading the screen will display status (**Erasing page** or **Load data good**) in the lower left corner of display menu screen.

15. When screen changes to indicate in **Status** bar that programming is finished (example: Load Data in Address 49480 Close File), the capacity charts are fully loaded into crane's rated capacity indicator/limiter (load moment indicator) system. Click **Exit** button on control interface screen (see Figure 13) and disconnect cable. Scroll up or down on display and working screen will return.

16. Check configuration screen to ensure the system is configured as it was before chart loading. Lift a few different loads to determine if system is weighing loads correctly.

17. **Right** click on serial number folder (example: 2251123). Select delete on bar and click to remove folder from laptop.

18. Fill in Field Software Installation form **OOSVFM045** and return form to Manitowoc Crane Care Customer Service as instructed on form.

Installing Software Program rev00f or Newer

1. Click on shortcut icon **MCC Controls App**. The selected folder appears (see Figure 14).

2. Open folder and click on **MCC Controls App.exe** icon to start program installation (see Figure 14).

FIGURE 14

3. **Manitowoc Controls Interface - rev00f or newer** screen is displayed (see Figure 15).

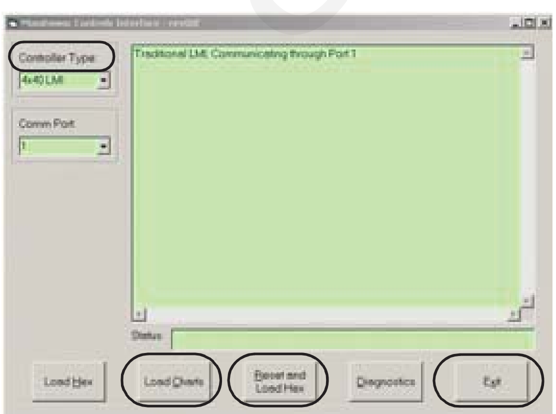


FIGURE 15

4. The 4 X 40 program is for all Non CAN-Bus Systems.

5. TURN ON cab power (RUN) position. ***Do not start engine.***

6. Wait until program switches from Bootstrap screen to working screen.

7. Connect download harness to install port and to RS 232 serial port on laptop (see Figure 10).

8. Select and press **Reset and Load Hex** button in lower center (see Figure 15).

9. A screen will drop down called **Open** as shown in Figure 16.

10. Locate and open crane **MCC Controls** folder (example: 2251123 folder).

FIGURE 16

11. Locate and click **mec2.HEX** icon to select file (see Figure 16). The hex file will now download the program. The screen will display **Process Complete/Timed Out** when files are fully loaded and file closes automatically.

12. Go back to the **Manitowoc Controls Interface - rev00f or newer** screen (see Figure 15).

13. Select and press **Load Charts** button at bottom of screen.

14. A screen will drop down called **Open** (see Figure 17).

FIGURE 17

15. Locate and click **lmidata.ihx** icon to select file (see Figure 17). The hex file will now download the capacity charts. The screen will display **Process Complete/Timed Out** when files are fully loaded and file closes automatically.

16. To reduce chart loading time, scroll up or down one screen from display working screen to menu screen.

17. Click **Exit** button on control interface screen (see Figure 15) and disconnect cable. Scroll up or down on display and working screen will return.

18. Check configuration screen to ensure system is configured as it was before chart loading. Lift a few different loads to determine if system is weighing loads correctly.

19. **Right** click on serial number folder. Select delete on bar and click to remove folder from laptop.

20. Fill in Field Software Installation form **OOSVFM045** and return form to Manitowoc Crane Care Customer Service as instructed on form.

Non-CAN bus Software with Master Node

The RCI/RCL software and charts are stored in the Master Node located in the front console. The following is required to perform download procedure:

- Manitowoc Controls Interface software must be installed on the laptop PC.
- Always use the most current version of Manitowoc Controls Interface software. Rev00i or newer is required if using a USB to RS232 adapter.
- Data Download Connection on RCI/RCL console.
- Laptop PC with Windows (32 or 64-bit) operating system software with DB9 (9 pin) RS232 serial (COM) port, or USB to RS232 adapter (MCC part # 90019155).
- Data downloading cable (MCC part # A06301-0).

Installing Software with Master Node

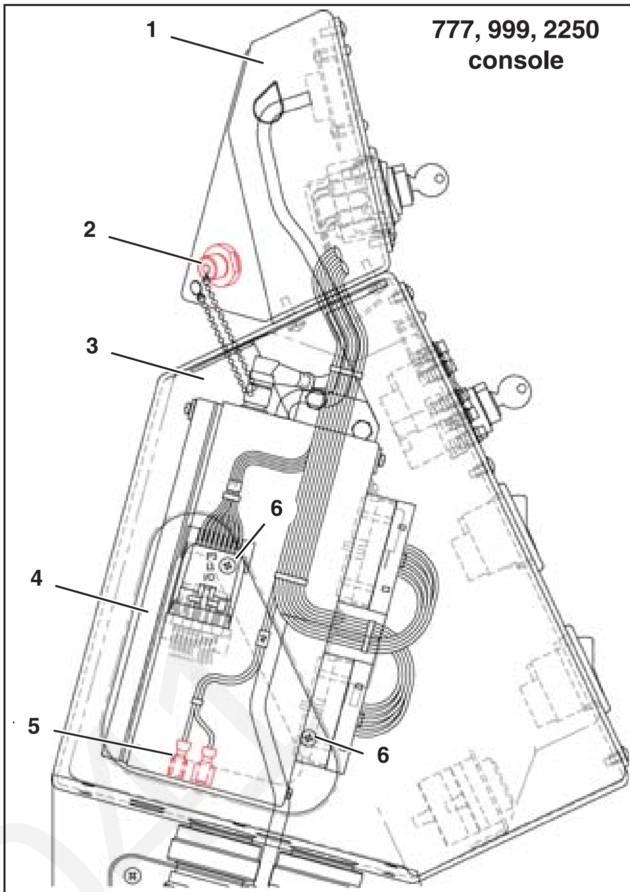
1. PARK all crane functions.

2. With cab power on, RECORD current capacity chart configuration settings (handle, chart numbers, etc.) before downloading new RCI/RCL software to Master Node. When download is complete, use this information to confirm crane is configured as it was before download.

3. Turn cab power and engine OFF. The engine must be off for the entire data download procedure.

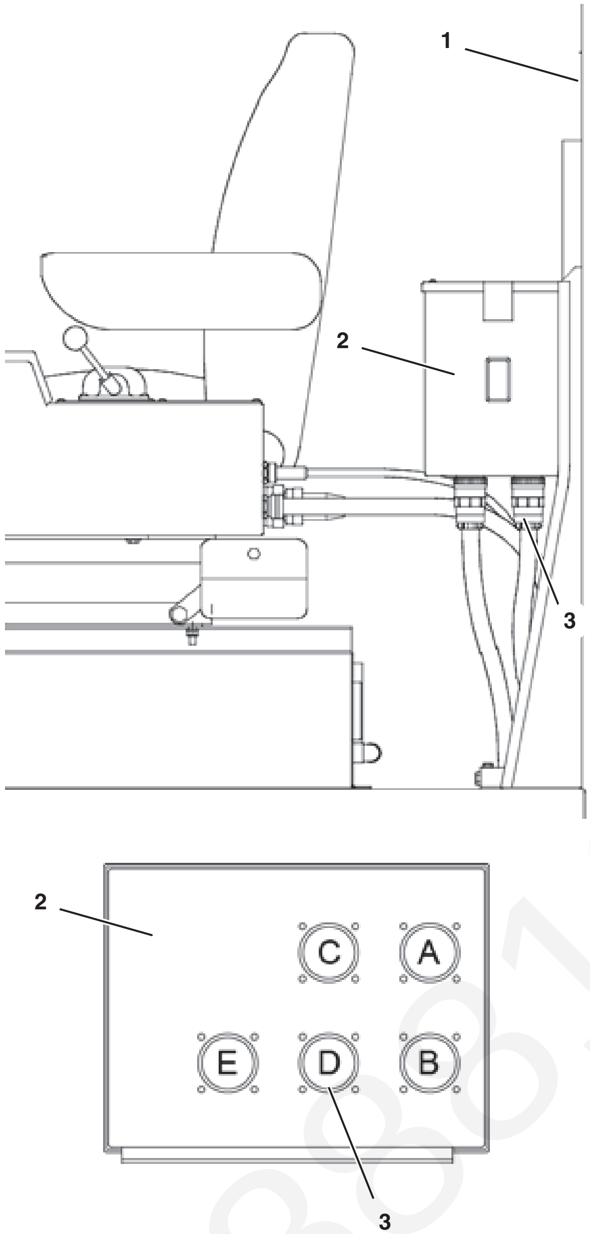
4. Remove the front console access cover as shown in Figure 18 and locate the A2 terminals. Jumper the connections by plugging the two terminals together.

5. Disconnect the “D” cable connection at the crane controller as shown in Figure 19.



Item	Component
1	RCI/RCL Console
2	Data Download Connection
3	Front Console
4	Front Console Access Cover
5	A2 Terminals
6	Access Cover Mounting Screw

FIGURE 18



Item	Component
1	Rear Cab Wall
2	Crane Controller
3	“D” Cable Connection

FIGURE 19

6. Connect the laptop PC to the data download connection located on the RCI/RCL console as shown in Figure 18 using the data downloading cable

7. Launch **MCC Controls App** software from the program menu on the laptop PC.

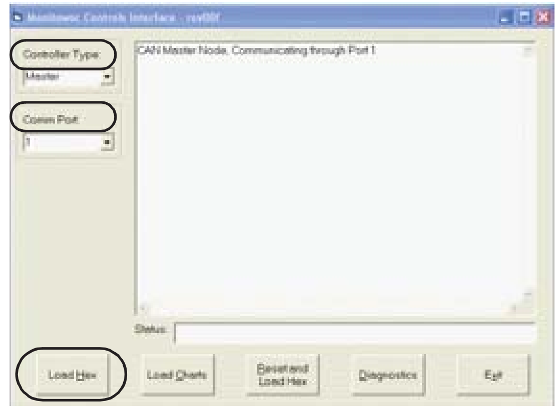


FIGURE 20

8. Press button under **Controller Type**, in upper left corner of screen and select **Master** from the drop down menu (see Figure 20).

9. In the **Comm Port** drop down menu, select the communication port that the download cable is connected to (see Figure 20).

10. TURN ON cab power (RUN) position. ***Do not start engine.***

11. Select and press **Load Hex** button in lower left corner (see Figure 20). A screen will drop down called **Open** as shown in Figure 21.

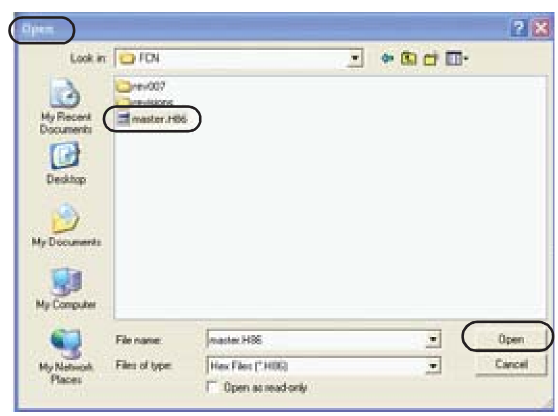


FIGURE 21

12. Locate and left click **Master.H86** icon to select file (see Figure 21). Click on **Open** button to open file. The **MCC Controls App** will now download the selected file to the Master Node. The controls interface main screen will display **Process Complete/ Timed Out** when files are fully loaded and file closes automatically.

13. Return to the **Manitowoc Controls Interface - rev00f or newer** screen (see Figure 22).

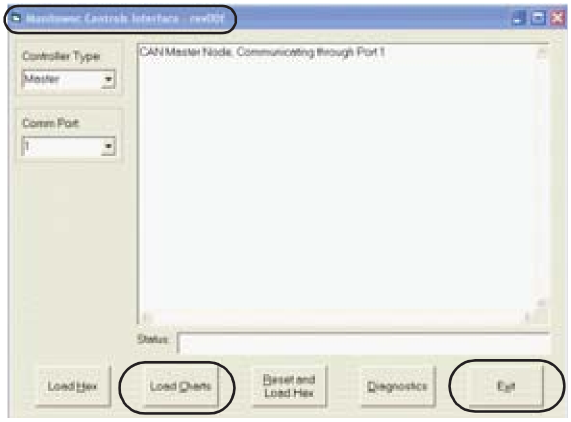


FIGURE 22

14. Select and press **Load Charts** button in lower left (see Figure 22). A screen will drop down called **Open**.
15. Locate on **Open** screen and left click on **candata.ihx** icon to select file (see Figure 23). Click on **Open** button to open file. Rated capacity charts will now begin to load.
16. To reduce chart loading time, scroll up or down one screen from display working screen to menu screen.

FIGURE 23

17. When screen changes to indicate a **Status** bar that programming is finished (Load Data in Address and Close File), the charts will be fully loaded into the Master Node.
18. Click the **Exit** button, lower right corner on control interface screen (see Figure 22).
19. Disconnect the data downloading cable. **Turn the cab power OFF.**
20. Unplug the A2 terminals inside the front console access cover as shown in Figure 18. Install front console access cover.
21. Carefully reconnect the "D" cable connection at the crane controller as shown in Figure 19.
22. **Turn the cab power on.**
23. Scroll up or down on crane display and working screen will return
24. Using notes recorded in step 2, check RCI/RCL configuration screen to ensure system is configured as it was before software download. Lift a few different loads to determine if system is weighing loads correctly.
25. **Right** click on serial number folder on laptop PC. Select delete on bar and click to remove folder.
26. Fill in Field Software Installation form **OOSVFM045** and return form to Manitowoc Crane Care Customer Service as instructed on form.

CAN Bus Software

The CAN bus software includes capacity charts. Before installing CAN bus software, perform following steps:

1. PARK all crane functions.
2. STOP engine. It must be off for entire procedure.
3. RECORD current capacity chart configuration settings (handle, chart numbers, etc.) before downloading new CAN bus software. When download is complete, use this information to confirm crane is configured as it was before download.
4. Cab power must be OFF to start download.
5. Connect download harness to console CAN bus install port and to RS 232 serial port on laptop (see Figure 24).
6. Determine if you have software program **rev00c** (go to installing rev00c topic) or **rev00f or newer** (go to installing rev00f or newer topic).

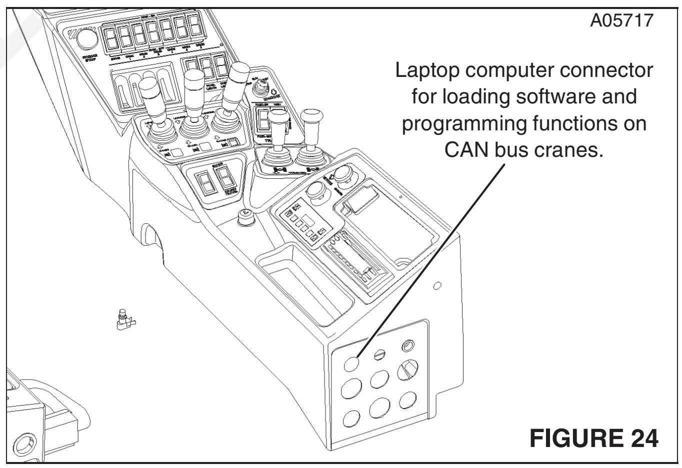


FIGURE 24

Installing Software Program rev00c

1. Click on shortcut icon **MCC Controls App**. The selected folder appears (see Figure 14).

FIGURE 25

2. Click on **MCC Controls App.exe** icon to launch program (see Figure 25).
3. Manitowoc Controls Interface screen is displayed (see Figure 26). Press button under **Control System**, located in upper left corner of screen.
4. Select desired laptop serial port to be used as well as CAN shown in Figure 26.
5. TURN ON cab power (RUN) position. ***Do not start engine.***

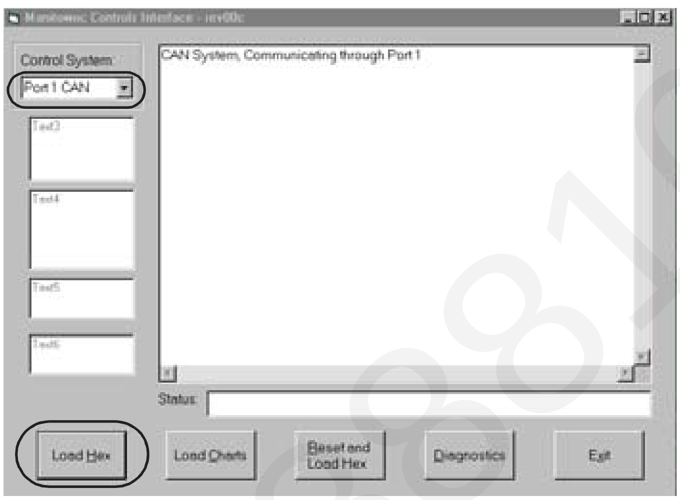


FIGURE 26

6. Select and press **Load Hex** button in lower left corner (see Figure 26). A screen will drop down called **Open**.
7. Click side of box displaying **MCC Controls** icon. Scroll up or down to desktop icon and click on desktop icon.
8. Locate and open the crane folder (***crane serial number file***).
9. Locate and click **Master.H86** icon to select file and then click on **Open** button (see Figure 27). The hex file will now download into the bus system. While loading the file, the screen will display rows of squares and the status bar will indicate address of download. When the controls interface **MCC Controls App.** displays **Process Complete/Timed Out** the files are fully loaded and the screen closes automatically.

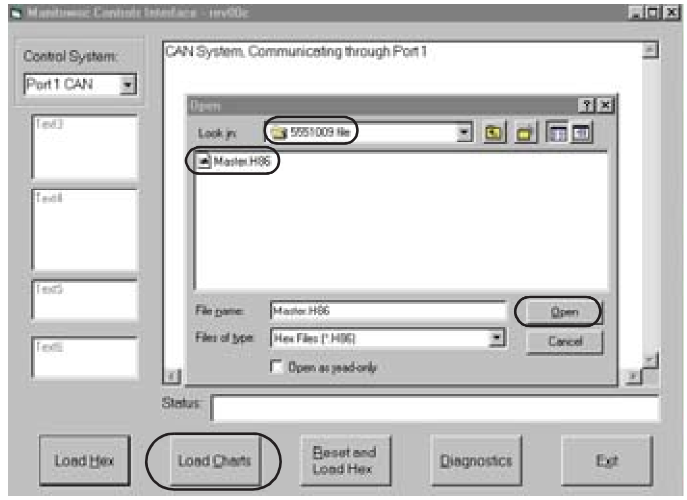


FIGURE 27

10. Select and press **Load Charts** button in lower left part of screen. A screen will drop down called **Open**.
11. Locate and open the ***crane model*** folder.
12. Select and click on **candata.ihx** icon to select file (see Figure 28). Click on **Open** button to open file. Rated capacity charts will now begin to load.
13. To reduce chart loading time, scroll up or down one screen from display working screen to menu screen.

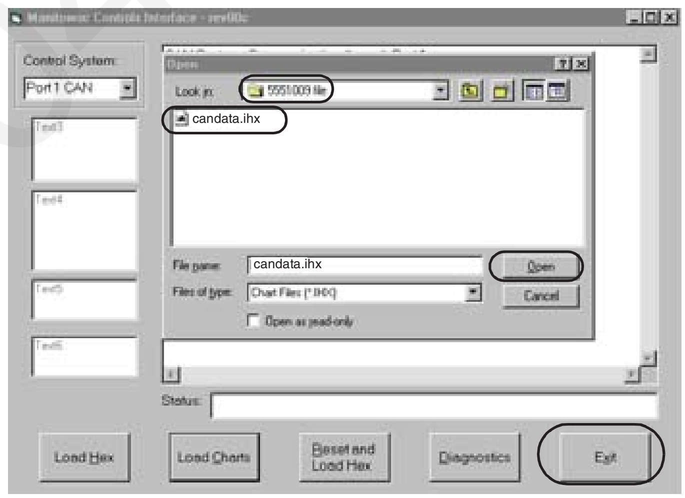


FIGURE 28

14. When screen changes to indicate a **Status** bar that programming is finished (Load Data in Address and Close File), the charts will be fully loaded into the crane's CAN bus system. Click **Exit** button on control interface screen (see Figure 28) and disconnect download cable.
15. Scroll up or down on rated capacity screen and working screen will return.
16. Check configuration screen to ensure system is configured as it was before chart loading. Lift a few different loads to determine if system is weighing load correctly.
17. Right click on serial number folder, select delete on bar, and click to remove folder from laptop.

18. Fill in Field Software Installation form **OOSVFM045** and return form to Manitowoc Crane Care Customer Service as instructed on form.

Installing Software Program rev00f or Newer

1. Click on shortcut icon **MCC Controls App**. The selected folder appears (see Figure 29).

FIGURE 29

2. Open folder and click on **MCC Controls App.exe** icon to start program installation.

3. Manitowoc Controls Interface screen is displayed — **Manitowoc Controls Interface - rev00f or newer** (see Figure 30).

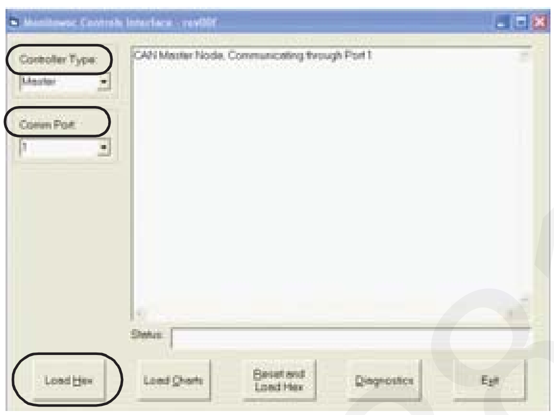


FIGURE 30

4. Press button under **Controller Type**, in upper left corner of screen to select controller type to be loaded (Figure 30). The controller options are:

   a. Master: Master Node
   b. Bin: Bin Node
   c. Boom: Boom or Jib Node
   d. Display: Graphic Interface
   e. Remote: Remote Controller
   f. Universal: Universal Node (2 through 9)
   g. Engine: Engine Node
   h. 4 X 40: Non CAN-Bus System

5. In the **Comm Port** drop down menu, select the communication port that the download cable is connected to (see Figure 30).

6. TURN ON cab power (RUN) position. ***Do not start engine.***

7. Select and press **Load Hex** button in lower left corner (see Figure 30). A screen will drop down called **Open** as shown in Figure 31.

FIGURE 31

8. Locate and click **Master.H86** icon to select file (see Figure 31). The hex file will now download the selected controller. The controls interface main screen will display **Process Complete/ Timed Out** when files are fully loaded and file closes automatically.

9. Go back to the **Manitowoc Controls Interface - rev00f or newer** screen (see Figure 32).

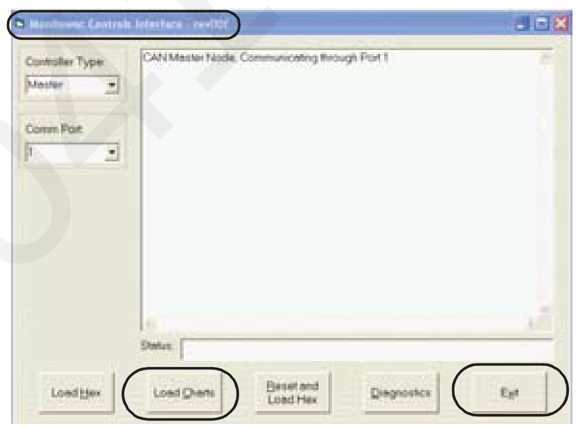


FIGURE 32

10. Select and press **Load Charts** button in lower left. A screen will drop down called **Open**.

11. Locate on **Open** screen and click on **candata.ihx** icon to select file (see Figure 33). Click on **Open** button to open file. Rated capacity charts will now begin to load.

12. To reduce chart loading time, scroll up or down one screen from display working screen to menu screen.

FIGURE 33

13. When screen changes to indicate a **Status** bar that programming is finished (Load Data in Address and Close File), the charts will be fully loaded into the crane's CAN bus system.
14. Click **Exit** button on control interface screen (see Figure 32) and disconnect cable. Scroll up or down on display and working screen will return.
15. Check configuration screen to ensure system is configured as it was before chart loading. Lift a few different loads to determine if system is weighing loads correctly.
16. **Right** click on serial number folder. Select delete on bar and click to remove folder from laptop.
17. Fill in Field Software Installation form **OOSVFM045** and return form to Manitowoc Crane Care Customer Service as instructed on form.

RULES-DISCARDING FILES

1. Only install files to crane systems that you are instructed to or that are agreed upon. Authorization by Manitowoc Crane Care Customer Service to download a particular system is the key to this program.
2. Manitowoc Crane Care Customer Service is to be informed in writing when files have been installed. Serial number of crane and version of files must be included.
3. Files must be deleted from the laptop when installation is completed.
4. Failing to abide by these rules will result in forfeiture of this privilege.

DOCUMENTATION

Field Software Installation Form **00SVFM045** (at end of this document) must be completed and returned to Manitowoc Crane Care Customer Service at the time of software installation. If the software is installed on more than one crane, a form must be completed for each crane.

FIELD SOFTWARE INSTALLATION

Date __________________

Dealer _______________________________________

Branch ______________________________________

Model Crane______________________________

Serial Number______________________________

Software Version______________________________

Reason for installation:

____

____

____

____

____

____

____

____

____

Software Installed by:

Name____

Telephone #____

E-mail address ____

Upon installation of new software, please return completed form to
Crane Care Customer Service at Manitowoc:

Email: latticeteam@manitowoc.com

Fax: 920-683-6278

Manitowoc

SOFTWARE INSTALLATION TRAINING

Date ___________________

Dealer ____

Branch ____

Model Crane________________________________

Serial Number________________________________

Software Version_______________________________

Trainees

1. Name____

Telephone # ____

E-mail address if you wish to receive updates____

2. Name____

Telephone # ____

E-mail address if you wish to receive updates____

3. Name____

Telephone # ____

E-mail address if you wish to receive updates____

Instructed by:

____

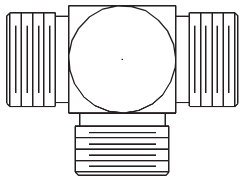
Operator's Manual 1-8 Numeric Tabs

HYDRAULIC TEST KIT

The test equipment listed in this bulletin is recommended for testing the hydraulic/electrical systems on Manitowoc hydraulic cranes.

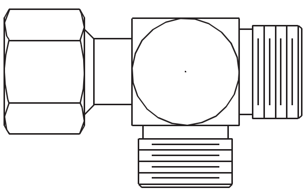
This equipment can be purchased either in kit form (with or without carrying case as listed below) or individually as desired by contacting Crane CARE Customer Service Department at Manitowoc Cranes.

Test Kit Part Numbers	
Kit With Case (EPIC)	499791-7
Kit Without Case (EPIC)	499792-9
Kit With Case (CAN-Bus)	499798-0
Kit Without Case (CAN-Bus)	499793-0



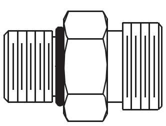
A425h

ORS Tee		
MCC Part No.	**Size**	**Qty.**
428229-0	06	2
428336-0	08	2
428230-0	12	2
428162-0	16	2
A03548-0	20	2
A04530-0	24	2



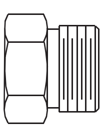
A425g

Female ORS Swivel Run Tee		
MCC Part No.	**Size**	**Qty.**
428445-0	04	2
428258-0	06	2
428259-0	08	2
428247-0	12	2
428248-0	16	2
428493-0	20	2
A03294-0	24	2



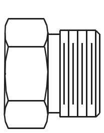
A425f

ORS to SAE Adapter		
MCC Part No.	**Size**	**Qty.**
428450-0	04 x 06	4
428389-0	08 x 12	4
428232-0	12 x 12	4



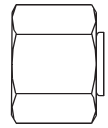
A425e

ORS Plug with 1/8 inch NPT Gauge Port		
MCC Part No.	**Size**	**Qty.**
170971-2	06	4
170970-2	08	4
170969-2	12	4
170968-2	16	4
170977-2	20	4
A14296-2	24	4



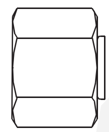
A425e

ORS Plug		
MCC Part No.	**Size**	**Qty.**
428403-0	04	4



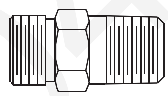
A425d

ORS Cap with 1/8 inch NPT Gauge Port		
MCC Part No.	**Size**	**Qty.**
170975-2	06	4
170974-2	08	4
170973-2	12	4
170972-2	16	4
170976-2	20	4
A14297-2	24	4



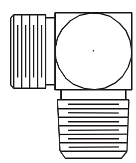
A425d

ORS Cap		
MCC Part No.	**Size**	**Qty.**
428406-0	04	4



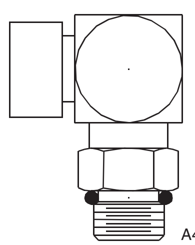
A425gg

NPT to ORS Connector		
MCC Part No.	**Size**	**Qty.**
428451-0	04 x 04	4
A14294-0	02 x 04	4



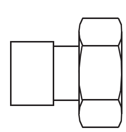
A425ff

NPT to ORS Elbow		
MCC Part No.	**Size**	**Qty.**
428449-0	04 x 04	4
A14295-0	02 x 04	4

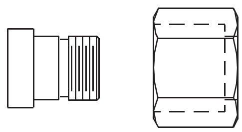


A425pa

ORS to SAE Adapter		
MCC Part No.	**Size**	**Qty.**
428446-0	04 x 06	2
428420-0	08 x 12	2
428238-0	12 x 12	2

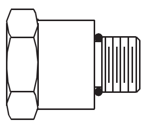


ORS x ORS Adapter (Reducer)		
MCC Part No.	**Size**	**Qty.**
A13500-0	4 ORS FE/ 6 ORS MA	2



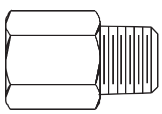
A425hh

ORS Reducer		
MCC Part No.	Size	Qty.
428368-0	04 x 12	4
429807-0	06 x 12	4
428421-0	08 x 12	4
428412-0	08 x 16	4



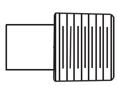
A425x

Female NPT to SAE Connector		
MCC Part No.	Size	Qty.
429730-0	04 x 04	2



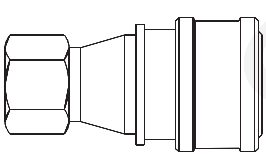
A425w

Female to Male NPT Reducer		
MCC Part No.	Size (inch)	Qty.
429886-0	1/4 x 1/8	4



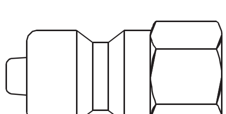
A425va

Square Head Pipe Plug		
MCC Part No.	Size (inch)	Qty.
571700-0	1/8	10
571701-0	1/4	10



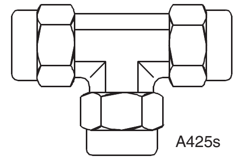
A425u

Quick-Coupler (Female Socket)		
MCC Part No.	Size (inch)	Qty.
375305-0	1/8	6
Test Port Coupling		
375956-0	1/4-18 NPT	6



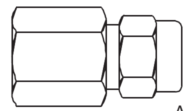
A425t

Quick-Coupler (Male Socket)		
MCC Part No.	Size (inch)	Qty.
375303-0	1/8	2
Test Port Coupling		
375954-0	1/4-18 NPT	2
375955-0	9/16-18 UNF	2



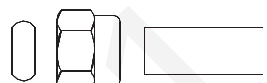
A425s

Plastic Tube Union Tee		
MCC Part No.	Size (inch)	Qty.
429629-0	3/8	4



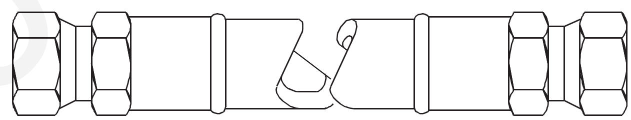
A425r

Plastic Tube Female NPT Connector		
MCC Part No.	Size (inch)	Qty.
429820-0	3/8 x 1/4	4



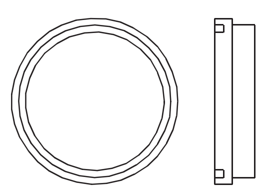
A425q

3/8 inch Plastic Tubing and Ends		
MCC Part No.	Description	Qty.
429627-0	Ferrule	6
429628-0	Nut	6
486056-0	Tubing	10 ft.



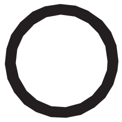
A425y

High Pressure Test Hose with ORS 04 Swivel Ends		
MCC Part No.	Size (inch)	Qty.
481986-0	1/4 x 27 lg	6
A13856-0	24 lg 6 x 6 ORS Hose Code # 755520270	2
Low Pressure Test Hose with ORS Swivel Ends		
MCC Part No.	Size (inch)	Qty.
481240-0	08 x 35 lg	2
481243-0	12 x 32 lg	2



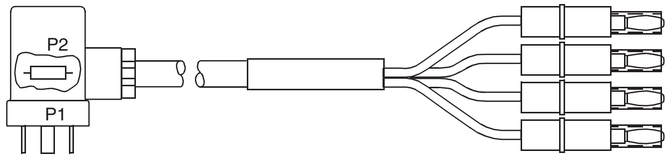
A425aa

Flange Plug		
MCC Part No.	Size (inch)	Qty.
431734-0	1	4
431735-0	1-1/4	4
431736-0	1-1/2	4



A425bb

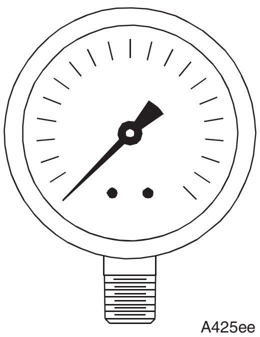
O-Rings				
Description	Qty.	MCC Part No.	I.D. (Inch)	W
Kit - Split Flange O-ring	1	495207-0		
Kit - SAE O-ring	1	495208-0		
Kit - ORS O-ring	1	495209-0		
Kit - Pump Flange O-ring	1	495210-0		
# 24 ORS O-ring	10	596289-0		
O-ring Pump Flange	10	A08135-0	4.74	.070
O-ring Pump Flange	10	A08136-0	5.91	.12



A425ii

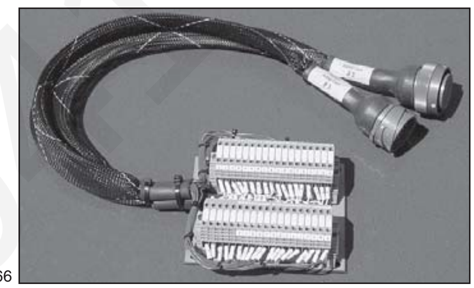
EPIC/EDER Cranes Only

Electrical Testing Adapters		
MCC Part No.	Description	Qty.
177641-2	Transducer	1
177642-2	Hydraulic/Air Valve	1
177643-2	Encoder	1
177644-2	EDC/PCP	1
417350-0	CPU Test Strip	1



A425ee

Liquid Filled Pressure Gauge		
MCC Part No.	Pressure	Qty.
460389-0	0 – 200	2
460390-0	0 – 1,000	2
460391-0	0 – 3,000	2
460392-0	0 – 10,000	2



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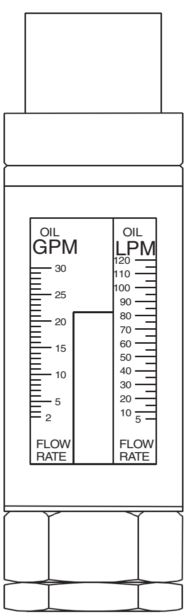
CAN-Bus Cranes Only

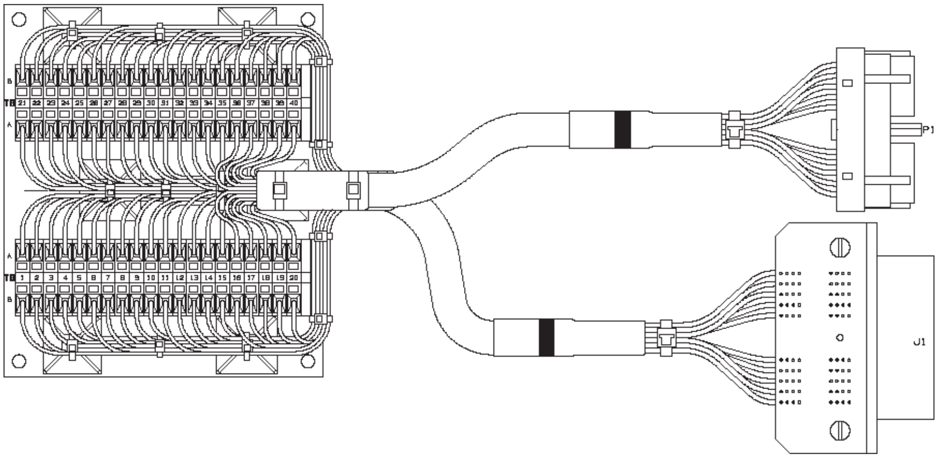
Electrical Testing Adapters		
MCC Part No.	Description	Qty.
A10832-0	Adapter - W3	1
A10831-0	Adapter - W4	1
A10833-0	Adapter - W6	1
A10912-0	Adapter - Power and Communication	1



A425dd

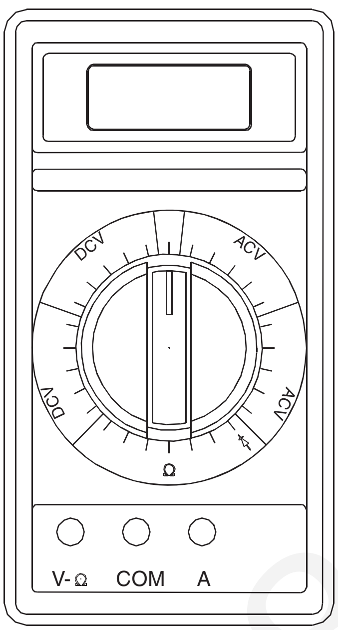
3,000 psi Inline Flow Meter		
MCC Part No.	Description	Qty.
531025-0	1 – 10 gpm	1
531026-0	2 – 30 gpm	1

A15455



CAN-Bus Cranes Only

Test Adapter		
MCC Part No.	**Description**	**Qty.**
A15454-0	40 Points Key A	1
A15455-0	40 Points Key B	1



A425cc

Digital Multi-Meter with Audible Continuity Buzzer	
MCC Part No.	531024-0

DE-ICANT SELECTION

Problem

Possible air valve malfunction during cold weather when using a de-icant in the air system. Many of the commercially available de-icants are not chemically compatible with the seals in the air valves used on Manitowoc hydraulic cranes. Selecting the wrong type de-icant can, therefore, result in seal damage.

Corrective Action

To provide best seal life, we recommend using only an isopropyl based de-icant in the air systems.

WARNING

Air Valve Malfunction! Failing to use an isopropyl based deicant may result in seal damage and improper operation of air valves. Death or injury to personnel and/or equipment damage can occur from improper operation.
Take corrective action described in this bulletin as soon as possible.

Manitowoc Engineering Co.
P.O. Box 70, Manitowoc WI 54221-0070 ● Phone: 414-684-6621 ● Fax: 414-683-6278

Hydraulic Cranes
SERVICE BULLETIN

Bulletin No. 21
Date: 10-22-2001

HYDRAULIC OIL

All Hydraulic Cranes

FACTORY FILL

Hydraulic cranes are factory filled prior to shipment with Benz Oil Flomite hydraulic oil as specified in Table 1. Flomite is an all-weather hydraulic oil suitable for use in ambient temperatures from 0 to 110°F (-18 to 43°C).

Flomite can cloud up (form wax crystals) at ambient temperatures below 0°F (-18°C). *This condition can result in damage to hydraulic components during start-up.*

When the expected ambient temperature will be below 0°F (-18°C), the hydraulic oil must be heated to at least 0°F (-18°C) prior to start-up. Tank heaters are available from Manitowoc Cranes. An alternative to heating the oil is to change to an ISO grade oil which meets the expected ambient temperature (see table in Lubrication Guide for crane).

Cloud point of oil selected must be equal to or less than expected ambient temperature.

Flomite can be purchased from Manitowoc Cranes or from the manufacturer at the following address:

Benz Oil
2724 West Hampton Avenue
Milwaukee, WI 53209

Phone:414-442-2900
Fax:414-442-8388

FIELD MAKE-UP

Table 2 lists hydraulic oils compatible with Benz Oil Flomite 46SS. Flomite can be diluted with an oil from the table to a maximum of 25% with little effect on the oil's low and high temperature characteristics.

None of the oils listed in the table have the same operating limits as Flomite. Therefore, dilution beyond the 25% maximum could effect the crane's operating performance at certain temperatures.

If a customer is in doubt about how much make-up oil has been added, we recommend that a laboratory viscosity test be performed or that the system be completely drained and refilled with the proper type Flomite or the appropriate ISO grade oil listed in the Lubrication Guide for the crane.

Table 1
Factory Fill

Crane Model	Flomite Type	MCC Part No.
All Hydraulic Crane Models	46SS	549433

Table 2
Make-Up Oils Compatible with Benz Oil Flomite 46SS

Brand	Summer Oil	Winter Oil
Amoco	1000 Fluid	None Available
Exxon	Torque Fluid 56	Univis J13
Mobil	Mobilfluid 424	Aero HFA
Shell	Donax TD	Aeroshell Fluid 4
Texaco	THD Oil	Rando HD Z-15 HV-1

Hydraulic Cranes
SERVICE BULLETIN

Bulletin No. 28
Date: 12/18/95

COUPLER ASSIST TOOL

Model No. 888 and M-250

Purpose

Notice to dealers that a Coupler Assist Tool (#177112) is available to reduce the effort involved in connecting 888 and M-250 crawler quick-disconnect couplers.

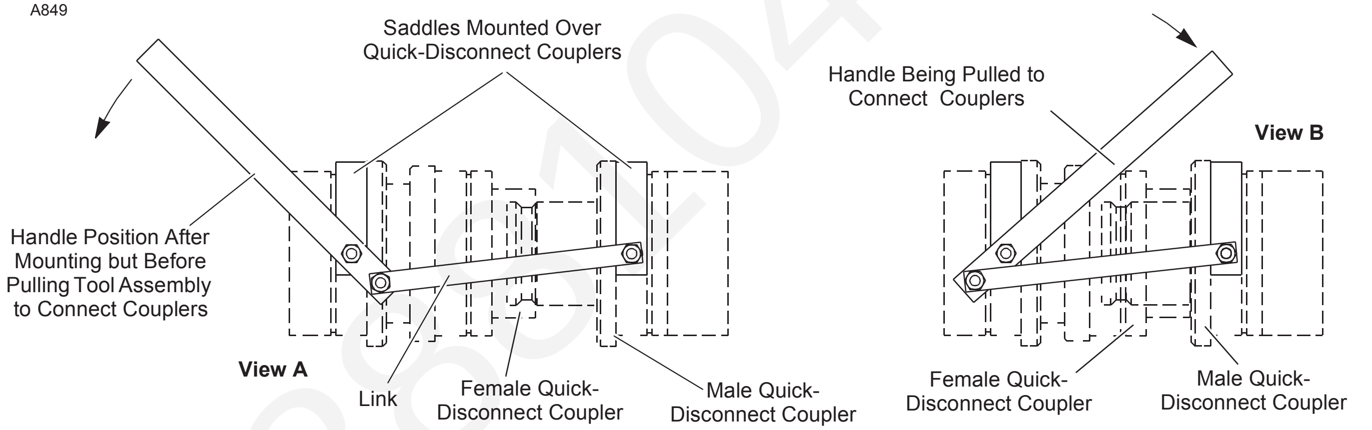
Installation and Operation

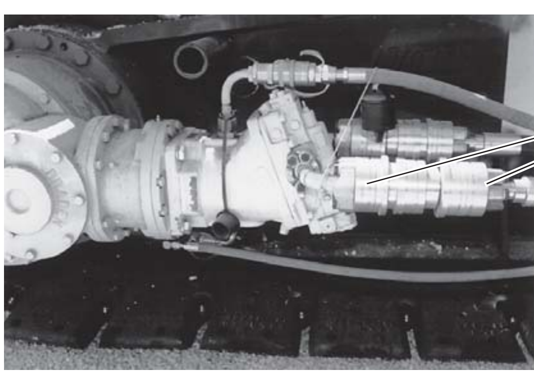
1. Insert male to female quick-disconnect couplers by hand.
2. Mount coupler assist tool saddles over both couplers as shown in View A.
3. Manually pull handle slowly to securely connect couplers (Views B and C).
4. Remove coupler assist tool and repeat procedure for other couplers.
5. Store tool for future use.

Pricing

Contact the Parts Department at the factory for pricing and parts availability.

A849





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Manitowoc

Hydraulic Cranes
SERVICE BULLETIN

Bulletin No. 31
Rev.: 10-29-2002

HYDRAULIC FILTER REPLACEMENT

Hydraulic Crane Models

FACTORY FILL

The hydraulic filter elements on the subject cranes are specially designed to withstand high pressure as the elements fill with dirt. This feature prevents the elements from collapsing.

Refer to the table on the back page of this bulletin for the Manitowoc part numbers of replacement filter elements. Refer to the Lubrication Guide in your Operator's Manual for identification and location of the filter elements.

CAUTION

Hydraulic System Damage!

Original Equipment Manufacturers' filter elements – available from Manitowoc – must be used on your crane. Substituting with any other brand or type filter element is prohibited.

Filter elements made by other manufacturers may collapse under pressure. This action will allow unfiltered oil to be drawn into hydraulic system — pumps, motors, and valves can be destroyed.

Manitowoc will reject warranty claims for damaged hydraulic components if proper hydraulic filter elements are not used.

555	777	777T	888	888R	999	1015	18000	21000	MCC Part No.	System
X						X	X		A00652	Charge Pumps (555, 1015, and 18000) In-Tank Return (1015 and 18000)
			X							Accessory System (current)**
		X								Carrier Steering and Outriggers
X	X		X							Customer Supplied Pile Driving System
X					X				427282	Free Fall
								X		Return
				X						RINGER® Hydraulic Reservoir
	X	X	X		X					Swing, Travel, Boom Hoist, Supercharge (upper)
			X							Accessory System (past)*
								X		Charge Pumps
	X	X	X						427283	Front Drum Charge
	X	X	X							Rear Drum Charge
	X	X	X	X	X					Auxiliary Drum Charge
	X	X							427292	Accessory System (upperworks)

* Crane S/N 8881001-8881020

** Crane S/N 8881021 and Newer

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HYDRAULIC CRANES SERVICE BULLETIN

Bulletin No. 32
Date: 06-21-96

OIL IN AIR SYSTEM
Hydraulic Cranes

Problem

Oil entering the air system due to a faulty or failed air compressor. This problem causes air valves to operate improperly or not at all.

Corrective Action

Perform the following steps to correct this problem:

1. Repair or replace air compressor.
2. Carefully inspect entire air system – valves, air lines, filters, tanks – for accumulation of oil and other contaminants directly related to the compressor problem.
3. Thoroughly clean or replace all valves, filters, air lines, and tanks if oil and other contaminants are found.
   - Clean air lines, tanks, and metal parts of valves, filters, and air compressor with non-flammable solvent.
   - Clean rubber and plastic parts of valves, filters, and air compressor only ***with a mild soap and water solution. Using solvent on these parts can result in damage***.

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LOOP FLUSHING VALVE INSTALLATION

MODEL 888 AND 888 RINGER® ATTACHMENT

General

Each Sauer-Sundstrand Series 51 hydraulic motor on the load drums of the subject cranes is equipped with a loop flushing valve. The valve provides loop cooling by flushing hot oil from the low pressure side of the motor during operation.

Refer to Figure 1 for identification and proper orientation of the loop flushing valve in the various load drum motors on the subject cranes.

The loop valve spool is retained in the motor by two plugs – a special plug and a standard plug. The special plug is solid and is stamped with the Manitowoc logo and the letter M. The standard plug is counter bored and has a groove in the outside diameter.

When installing a new or repaired motor, carefully inspect the motor to make sure the shuttle valve is installed in the proper position for the corresponding motor location.

DANGER

Falling Load Hazard! Load drum motors will not hoist load or load will fall when handle is pulled back to hoist position if loop flushing valve is not properly installed.

Carefully inspect position of loop flushing valve prior to installing a new or repaired motor. If required, reposition loop flushing valve according to instructions in this bulletin.

Installing Loop Flushing Valve

1. Determine if loop flushing valve plugs are properly positioned as shown in Figure 1.
2. If necessary, reposition loop flushing valve plugs, as follows:
   a. Thoroughly clean area around plugs. *Take every precaution to prevent dirt and other foreign matter from entering motor.*
   b. Remove both plugs and spring from motor. *Do not remove washers and spool.*
   c. Make sure O-rings are not damaged and properly installed on plugs.
   d. Install special plug on proper side of motor. See Table in Figure 1.
   e. Install spring and standard plug on other side of motor.
   f. Securely tighten plugs.
3. Slowly operate load drum to make sure there are no oil leaks at motor and drum operates properly.

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Crane Model	Motor Location	Special Plug Location	
		A Port	B Port
888	Front Drum		X
888	Rear Drum		X
888	Auxiliary Drum (in boom butt)		X
888 Ringer	Front Drum Right Side	X	
888 Ringer	Front Drum Left Side		X
888 Ringer	Rear Drum	X	
888 Ringer	Auxiliary Drum (in boom butt)		X

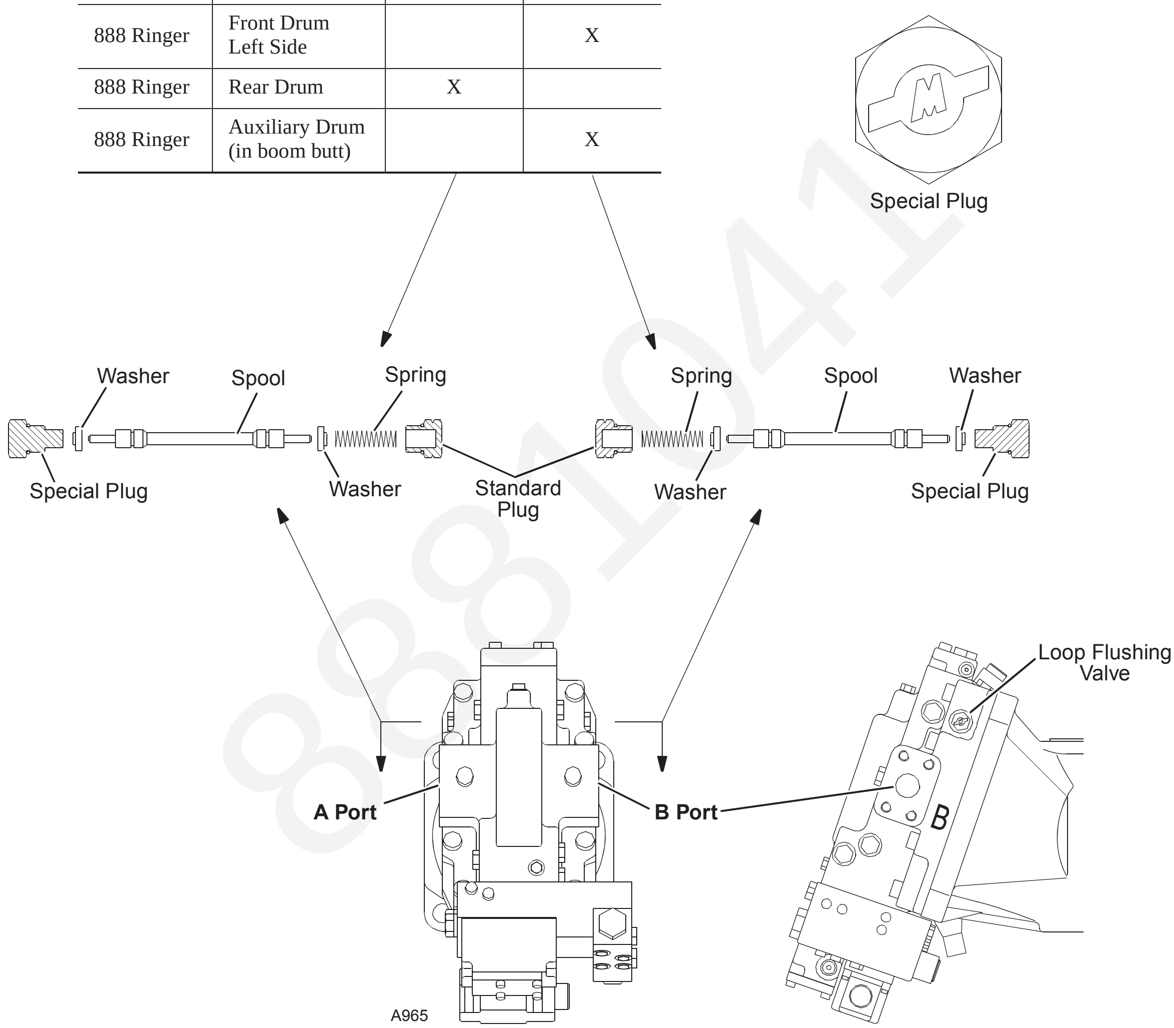

FIGURE 1

Hydraulic Cranes
SERVICE BULLETIN

Bulletin No. 43
Date: 05-04-2000

MAST ASSIST BYPASS VALVE

MODEL 888

Table of Contents

Problem

During normal operation, the mast assist cylinders are not used and must be fully retracted. Over a period of time, valve leakage can cause the mast cylinders to extend and raise the mast arms. If this happens, the mast can contact the arms and be damaged.

Corrective Action

Install a bypass line with a manual shut-off valve between mast supply and return hydraulic lines.

Operation

Set-Up Mode

Bypass shut-off valve handle must be turned to CLOSED position (View C) for proper mast operation.

Normal Operating Mode

Bypass shut-off valve handle must be turned to OPEN position (View D) to prevent mast assist arms from rising.

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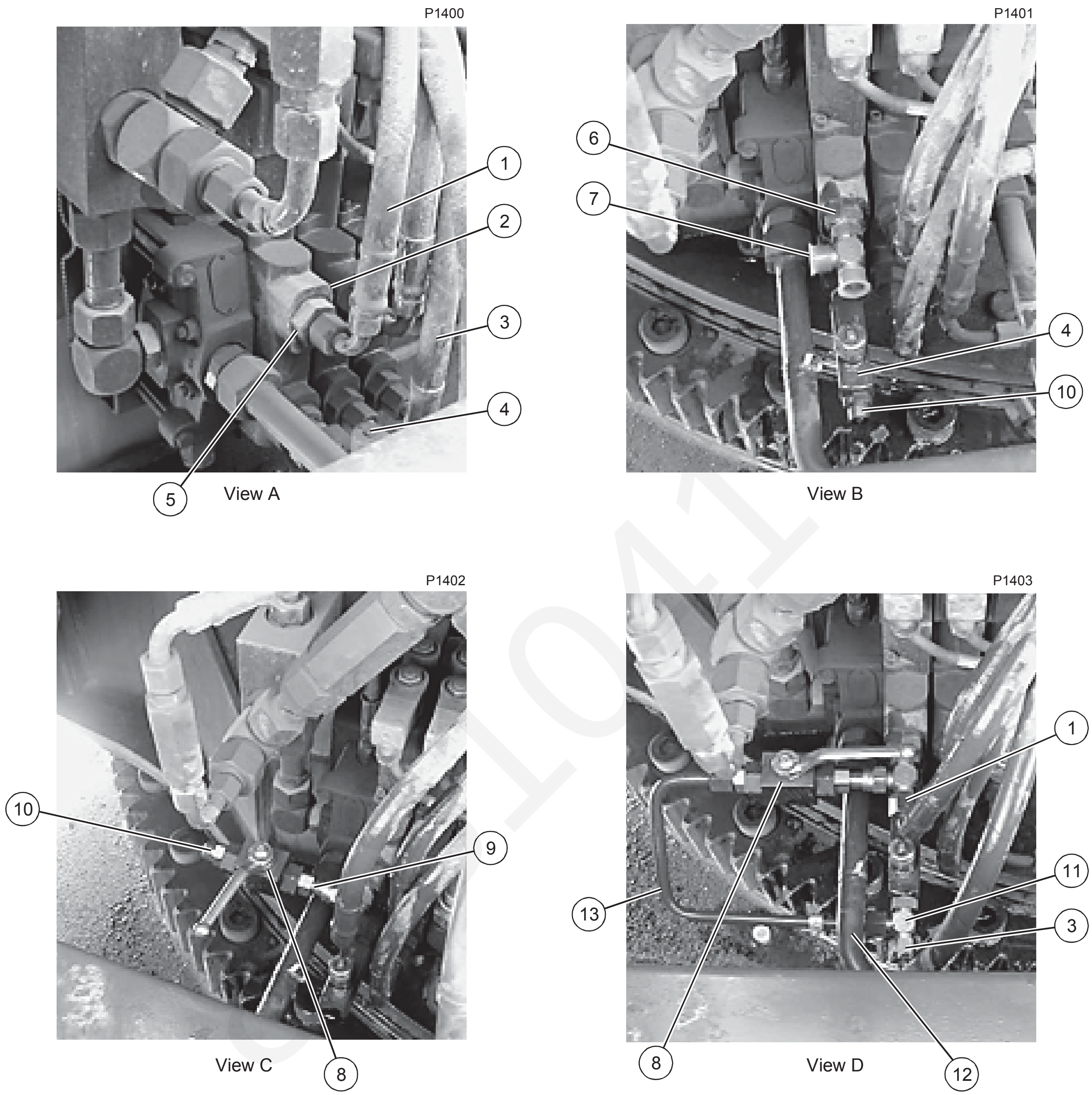
Installing Bypass Valve

Refer to Figure 1 for following procedure.

1. Stop crane engine and wait a few minutes for hydraulic pressure to drop.
2. Open left enclosure to access hydraulic piping under front drum planetary.
3. Disconnect hose (1, View A) from mast control valve (2, View A).
4. Disconnect hose (3, View A) from end of mast assist flow regulator (4, View A).
5. Remove adapter fitting (5, View A) from mast control valve. Replace adapter fitting (5) with new reducer fitting (6, View B) and tee fitting (7, View B).
6. Connect ball shut-off valve (8, View C) to tee fitting (7) with swivel adapter (9, View C).
7. Remove existing adapter fitting (10, View B) from end of mast assist flow regulator (4, View B) and connect on end of ball shut-off valve as shown in View C.
8. Connect new tee fitting (11, View D) to end of mast assist flow regulator (4, View B).
9. Connect pre-formed tube (13, View D) between ball shut-off valve and tee fitting on end of mast assist flow regulator.

NOTE: Before reconnecting hoses make sure there in no inference between pre-formed tube (12, View D) and hose (3, View D). It may be necessary to loosen pre-formed tube (12), reposition, and retighten so there is no inference.

10. Connect hose (1, View D) to tee fitting on mast control valve.
11. Connect hose (3, View D) to tee fitting on mast assist flow regulator.
12. Check that all connections are secure.
13. Turn ball shut-off valve handle to OPEN position (handle in line with flow) as shown in View D.
14. Start crane engine and check for leaks.
15. Install safety decal (MCC 195968) as shown on Nameplate and Decal Drawing (MCC 176867).



Item	Description	MCC Part No.	Item	Description	MCC Part No.
1	Hose	Existing	8	2-Way Ball Shut-Off Valve	703474*
2	Mast Control Valve	Existing	9	Swivel Adapter – 08 ORS X 08 ORS	428577*
3	Hose	Existing	10	Adapter Fitting	Existing
4	Mast Assist Flow Regulator	Existing	11	Tee Fitting – 08 ORS X 08 SAE	428390*
5	Adapter Fitting (Not Required)	Existing	12	Pre-Formed Tube	Existing
6	Reducer Fitting – 12 SAE X 08 SAE	428456*	13	Pre-Formed Tube	195635*
7	Tee Fitting – 08 ORS X 08 SAE	428390*			

*New parts required for installing bypass system.

FIGURE 1

Hydraulic Cranes
SERVICE BULLETIN

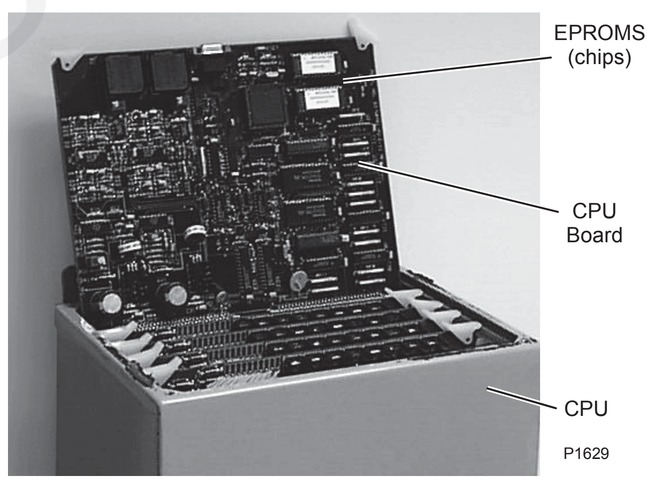
Bulletin No. 55
Date: 05-23-2001

CPU AND EPROM COMPATIBILITY
All Models

Problem

1. Faulty central processing units (CPU) in the field are replaced with new CPU 366113 which will work in any Manitowoc EPIC controlled crane equipped with a 5-plug Eder CPU. The new CPU requires 150 nano second EPROMs (chips). ***Past production 200 nano second chips cannot be used in a new CPU; crane will not operate properly***.

   The new CPU does not include chips. Therefore, when ordering a new CPU check the existing chips on your crane to determine if you already have 150 nano second chips (see chip identification below). If not, you must order new chips programmed for your crane.
2. The 150 nano second chips will work in any Manitowoc EPIC controlled crane with a 5 plug Eder CPU, as long as the chips are programmed for the specific crane.
3. The Model 999 must be equipped with CPU 366113 and 150 nano second chips.
4. When installing a Manitowoc LMI on a model 888, a new CPU 366113 or CPU card 366116 and two 150 nano second chips must be installed at the same time to ensure proper system operation.
5. New chips sent to you from Manitowoc will be 150 nano second speed and not require identification. The chips will work in any Manitowoc EPIC controlled crane with a 5 plug Eder CPU, as long as the chips are properly programmed.



EPROM (chip) Identification

There are 4 brands of 150 nano second chips that will work with CPU 366113 or CPU card 366116: AMD, Fairchild, Tompson, and Texas Instruments. All of these chips are available from Manitowoc.

continued on back page

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To identify a chip, remove the label from the top of the chip. Do this to one chip at a time so they do not get mixed up. ***Be sure to reinstall label over window in chip. They are light sensitive.***

AMD – Hold the AMD chip with the notch to the top. The word MALAYSIA will appear on the top surface near the notch. Below the window, an 8-digit code will appear in the first line and –150 must appear in the second line.

Fairchild – Hold the Fairchild chip with the notch to the top. The chip will be blank above the window. Below the window, F and a 7-digit code will appear in the first line, a 10-digit code will appear in the second line, and 150 will appear in the third line.

Texas Instruments – Hold the Texas Instruments chip with notch to the top. The chip will be blank above the window. Below the window, the Texas Instruments symbol and a 5-digit code will appear in the first line and a 6-digit code followed by –15 will appear in the second line.

Thompson – Hold the Thompson chip with the notch to the top. The chip will be blank above the window. Below the window, an 8-digit code will appear in the first line and –15 will appear in the second line.

If you have questions regarding chip identification, please contact the Service Department at Manitowoc Cranes.

Hydraulic Cranes
SERVICE BULLETIN

Bulletin No. 56
Date: 11-11-2002

DISC BRAKE KITS

Models with Braden Gearboxes

PROBLEM

The brake kits for the brake assemblies listed in the table are generic and may contain more discs, springs, and wave washers than required to overhaul a specific brake assembly.

The table indicates the exact number of brake discs, springs, and wave washer required to overhaul a specific brake assembly. ***Read and follow brake manufacturer's instructions (provided in vendor manual with your crane) when overhauling a brake. Be sure to install exact number of brake discs, springs, and wave washer specified in table.***

Part Page	MCC Assembly	MCC Kit	Qty of Friction Discs	Qty of Brake Discs	Qty of Springs	Qty of Wave Washers	Where Used	Model
O-657	465145-0	465144-6	9	12	10	0	Travel	M-50
O-658	465144-0	465144-6	9	12	10	0	Travel	M-65, M-85
O-748	465142-0	465142-6	7	8	7	7	Swinger	M-1200
O-749	465189-0	465189-6	10	11	12	0	Drum Shaft, Boom Hoist	M-250, M-1200
O-762	716978-0	716978-7	8	9	8	0	Winch	111, 222, M-80, M-85
O-770	465191-0	272140-6	12	12	12	10	Auxiliary Drum Luffing Hoist	M-250 2250
O-773	465083-0	465083-5	10	11	12	0	Drum Shaft	M-1200
O-777	465197-0	465197-6	9	12	10	0	Travel	888
O-778	465196-0	465197-6	10	11	12	0	Drum shaft	M-250, 1200 Ringer
O-783	272139-0	272139-6	6	7	8	6	Swing	888
O-788	465199-0	272140-6	9	10	10	9	Boom Hoist	888
O-789	465081-0	272140-6	10	11	12	10	Drum shaft	888
O-807	465085-0	272140-6	10	11	12	10	Drum shaft	888
O-818	465094-0	272140-6	9	10	10	9	Boom Hoist	888
O-820	465093-0	272140-6	9	12	10	9	Auxiliary Drum	888, 777, 777T, 999
O-827	465096-0	465197-6	9	12	10	0	Drum shaft	888 Ringer
O-864	465103-0	465103-7	12	12	12	12	Hi-Speed Drum Shaft	777T, 888
O-1007	911344-0	911344-6	8	9	12	0	Swing	111, 222
O-1011	911927-0	911927-6	8	10	0	0	Drum shaft	111, 222

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Hydraulic Cranes
SERVICE BULLETIN

Bulletin No. 57
Date: 07-12-2001

INTERCHANGING #135 LUFFING JIBS

Models 888 and 999

Problem

The automatic jib stop actuators are not interchangeable between the Model 888 and 999 #135 luffing jibs.

Corrective Action

Refer to Figure 1.

1. Replace Model 888 jib stop actuator (177588 or 192287) (View A) with actuator (196096) (View B) for fold-under luffing jib or actuator (196098) (View B) for layout luffing jib.
2. Replace Model 888 limit switches (672684) with limit switches (672210) and corresponding mounting hardware, if using a Model 999 actuator on a Model 888.
3. Adjust limit switches per instructions in Jib Stop Adjustment folio for Model 999 #135 Luffing Jib.

NOTE: The 170° boom to luffing jib angle limit switch (View D) will not be functional on Model 888.

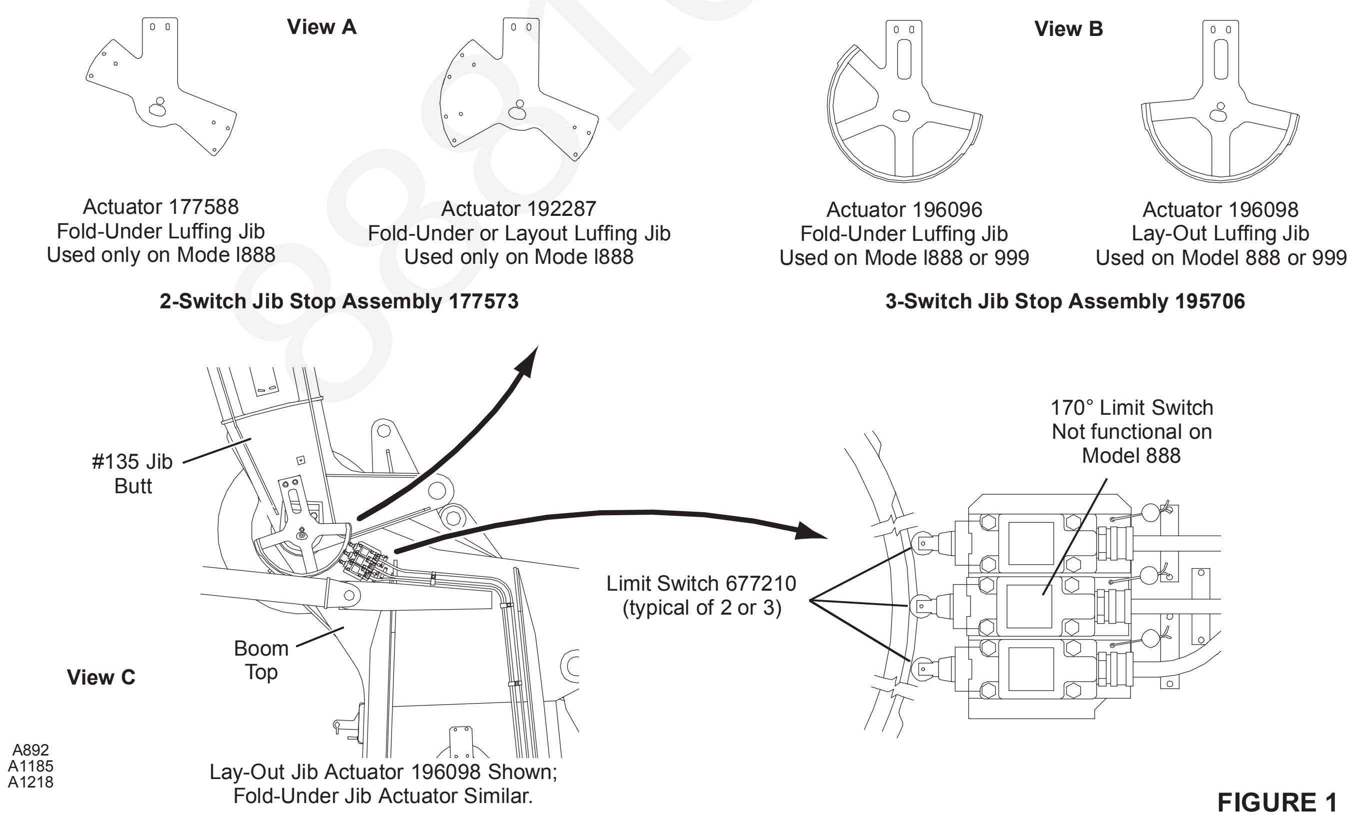

FIGURE 1

Manitowoc Cranes, Inc.
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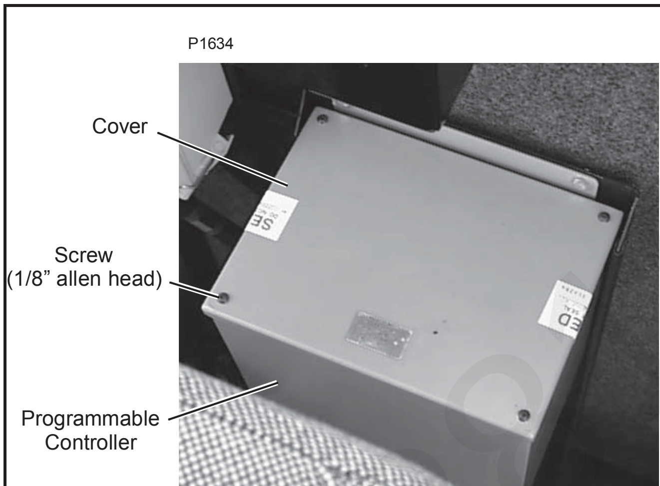
EPROM REPLACEMENT

All EPIC Cranes

To ensure proper operation of EPIC cranes, extreme care must be taken to properly install eproms (computer chips) in the filed.

Follow the procedure in this bulletin:

1. Lower any suspended loads to ground and apply all parking brakes and locks.
2. Turn engine run/stop switch to STOP position and turn cab power switch to OFF position
3. Remove cover from top of programmable controller (Figure 1).



View Behind Operator’s Cab Seat

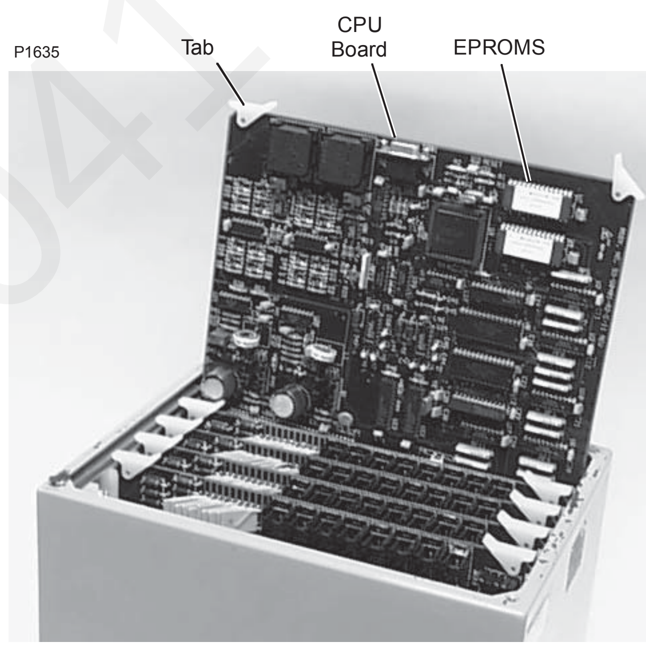
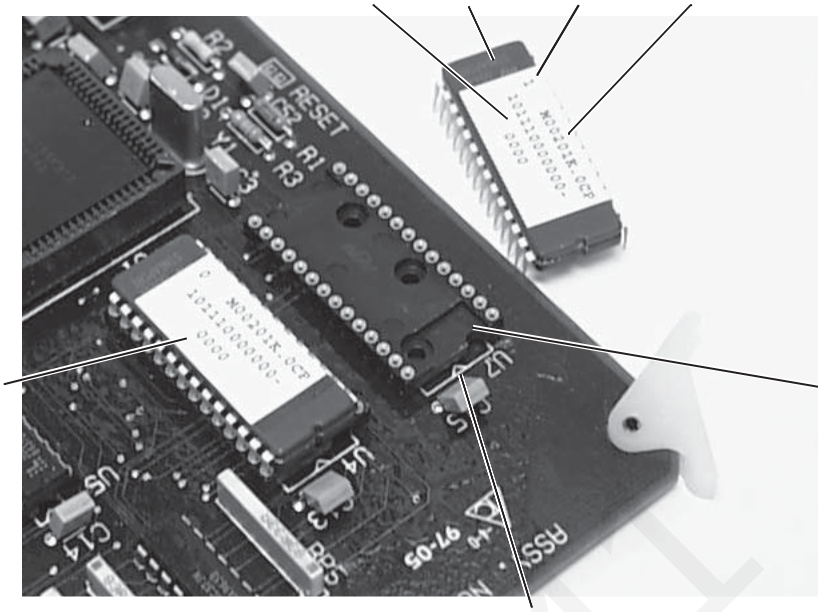


FIGURE 1

4. Remove CPU board from programmable controller (Figure 1) by pulling up on tabs on sides of board (CPU board is board closest to mounting brackets on box).
5. Carefully remove both EPROMs (Figure2) from upper right corner of CPU board (Figure 2). An EPROM remover should be used.

   Each EPROM has a label containing MCC program number, configuration number, and bit indicator.



FIGURE

6. Install new EPROMs on CPU board (Figure2).

   Notch in each EPROM must line up with silk screened notch at end of each EPROM holder.

   - Install EPROM with bit indicator number of 1 in EPROM holder U7.
   - Install EPROM with bit indicator number of 0 in EPROM holder U4.

   Use extreme care not to bend prongs on EPROMS. Make sure each prong engages corresponding terminal hole in holder
7. Reinstall CPU board in programmable controller (Figure 1).
8. Reinstall cover on programmable controller (Figure1).
9. Read all folios sent with new EPROMs.
10. Before starting engine, power up programmable controller (cab power switch ON and engine run/stop switch in RUN) and set any operator programmable control features (i.e. swing speed and torque, tagline tension, etc.) if so equipped.
11. Follow instructions in operator’s manual to calibrate pressure senders (transducers) and pump control thresholds (feed forward).
12. Test all crane functions
13. If you have any problems with new software, contact MCC Service Department at 920-684-6621.
14. Return old EPROMs to MCC Regional Service Manager for your area.

Hydraulic Cranes
SERVICE BULLETIN

Bulletin No. 75
Date: 01-03-2002

BACKWARD STABILITY – #22EL AND #82HL BOOMS

Models 888 and 999

PROBLEM

The weight of the boom hoist wire rope and mast can pull short booms backwards against the boom stops when operating at angles above the angle shown in the following table. ***Wire rope will slacken on the boom hoist drum.***

This problem can occur when calibrating the boom angle indicator or LMI.

If this occurs, it will be necessary to use an outside assist to pull the boom forward. ***Make sure boom hoist wire rope is spooled properly on drum before operating boom hoist.***

CORRECTIVE ACTION

Instruct operator's to operate with at least a 12,500 lb (5 670 kg) load suspended from the lower boom point when operating short booms above the angle given in the table.

The load includes the load block, hoist lines, and slings.

Boom Length	Angle
70 ft (21.3 m)	75°
80 ft (24.4 m)	77°
90 ft (27.4 m)	78°
100 ft (30.5 m)	79°

DISCONTINUED HOIST MOTORS

Models 888 and 888R

PROBLEM

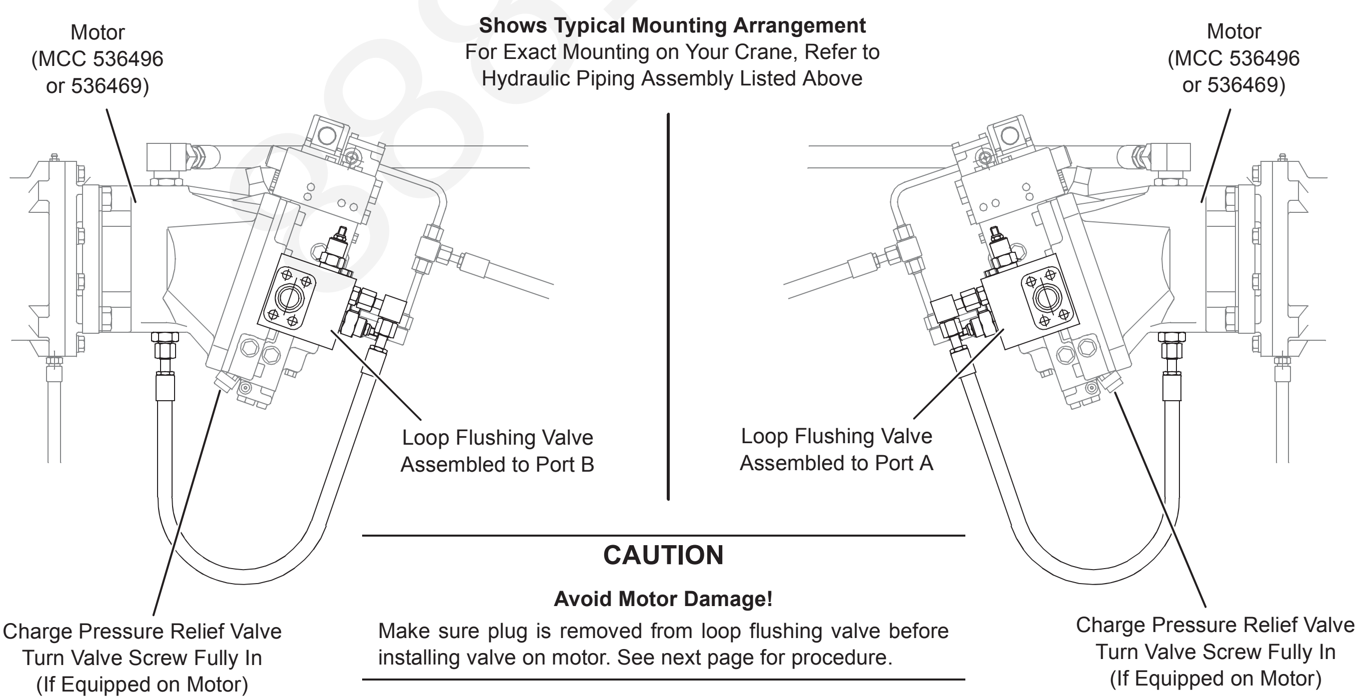
Hoist motors 536460 and 536468 have been discontinued for use on the load drums of the subject cranes.

CORRECTIVE ACTION

Replace motor 536460 with 536496 and motor 536468 with 536469. When replacing either motor, a Loop Flushing Valve Assembly must be purchased separately and installed according to the Hydraulic Piping Assembly. Refer to following table for details.

Model	Location and New Motor	Drum Assembly	Loop Flushing Assembly	Loop Flushing Location	Hydraulic Piping Assembly
888	Front Drum MCC 536496	MCC 176320[1] or MCC 176321[2]	MCC A03017	Port A	MCC 176549
888	Rear Drum MCC 536496	MCC 176320[1] or MCC 176321[2]	MCC A03017	Port A	MCC 176549
888	Auxiliary Drum MCC 536496	MCC 177255	MCC A03017	Port A	MCC 176523
888R	Front Drum MCC 536496	MCC 177864	MCC A03017[3]	Port A (left side) Port B (right side)	MCC 177937
888R	Rear Drum MCC 536469	MCC 177870	MCC A03017[3]	Port B	MCC 177937

[1] Standard Drum [2] Free Fall Drum [3] A01440 for Field Modification



CAUTION

Avoid Motor Damage!

Make sure plug is removed from loop flushing valve before installing valve on motor. See next page for procedure.

FIGURE 1

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CHARGE PRESSURE RELIEF VALVE

To allow for loop flushing, the existing or new hoist motor charge pressure relief valve (Figure 1) must be adjusted with a screwdriver by turning valve screw fully clockwise (in) until it stops.

CORRECTIVE ACTION

Remove plug from drain port in loop flushing valve (Figure 2), as follows:

WARNING

Falling Load Hazard!

To prevent loads from falling, lower all loads to ground before attempting to service loop flushing valve.

1. Remove SAE 08 plug from DR port in valve.
2. Remove sequence valve from SQ port in valve.
3. Using a 5/32 in. allen wrench, remove plug from drain port in valve.
4. Securely reinstall sequence valve and SAE 08 plug.
5. Start engine and check for leaks at valve. Tighten sequence valve and SAE 08 plug as required.

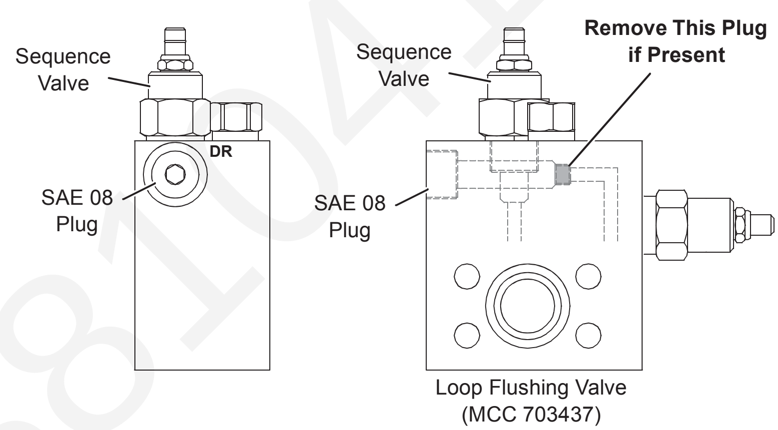


FIGURE 2

Hydraulic Cranes
SERVICE BULLETIN

Bulletin No. 90
Date: 08-01-2002

BEARING RETAINER SCREWS

Model 888 with Free-Fall Drum Shaft

PROBLEM

Loose bearing retainer screws (4, Figure 1) on inboard side of drum clutch. ***Damage to clutch assembly can occur if this problem is not corrected.***

CORRECTIVE ACTION

It will be necessary to remove the drum clutch and spider assemblies from each drum to perform steps 1-3.

1. Inspect every Model 888 equipped with free-fall drums.
2. Replace any missing screws.
3. Apply Loctite #242 to threads of screws and torque screws to 53 ft-lbs (72 Nm).
4. Complete Inspection Report on back of this bulletin and either mail or fax it to Factory Service Department (see bottom of page).

PERSONNEL

The corrective action must be performed by a qualified Manitowoc Distributor Service Technician.

EQUIPMENT/TOOLS

- Fully equipped service truck with hand tools.
- Suitable hoist for removing drum clutch and spider assemblies – approximately 1,000 lbs (454 kg).

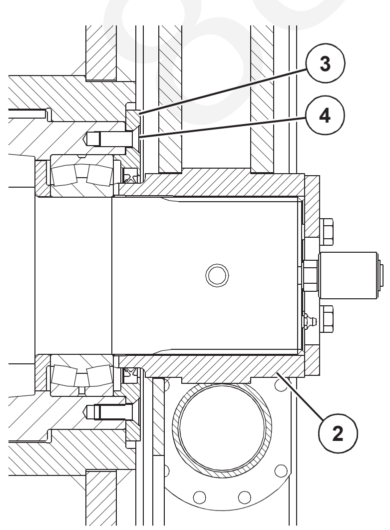
ESTIMATED TIME

Approximately 1 hour for each drum.

A903

Item	Description
1	Drum Flange
2	Clutch Assembly
3	Bearing Retainer
4	Screw, Allen Flat Head 1/2-13 UNC x 1-1/4" Long (6 each)

Typical – Right End of Each Drum Shaft
(Access Through Right Side Enclosure Door)



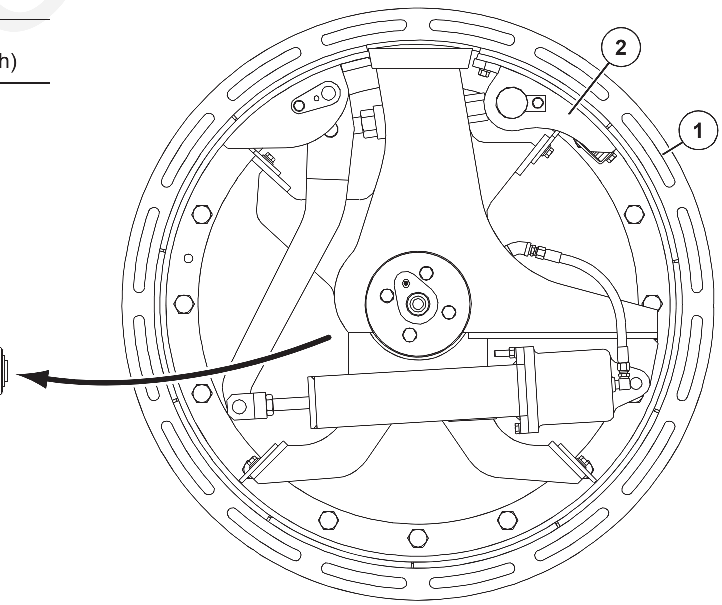


FIGURE 1

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INSPECTION REPORT
Model 888 Drum Clutch Bearing Retainer Screws

Serial Number ______________________

Owner ______________________

Location (city & state) ______________________

Technician Name (print) ______________________

Distributor ______________________

Did you find loose or missing bolts? (explain) ______________________

____

____

Did you find evidence of Loctite on the screw threads? ______________________

Did you find damage to (explain):

Clutch Band/Lining ______________________

Clutch Lever and Linkage ______________________

Spider ______________________

Drum Flange ______________________

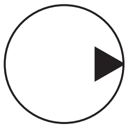
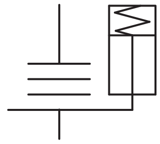
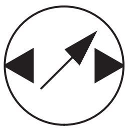
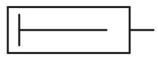
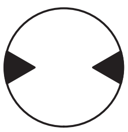
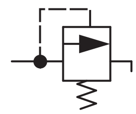
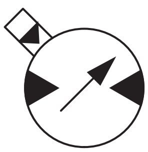
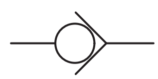
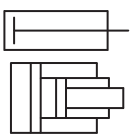
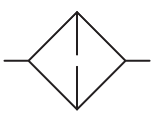
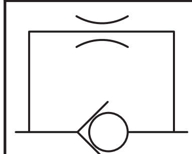
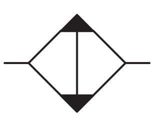
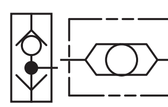
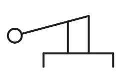
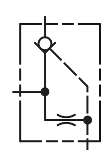
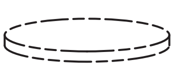
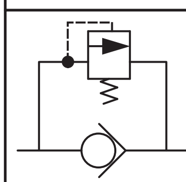
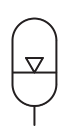
Bearing Retainer ______________________

Clutch Cylinder (pay attention to pin hole and mounting lugs) ______________________

Did you replace parts? (explain) ______________________

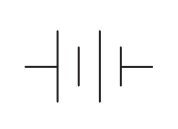
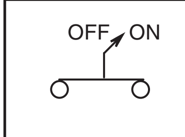
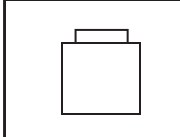
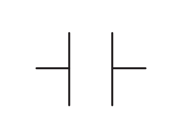
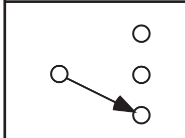
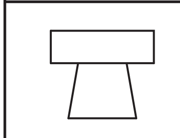
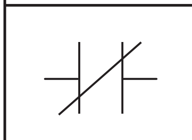
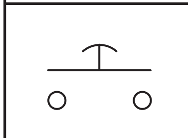
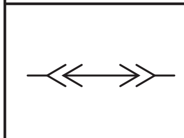
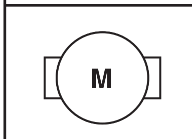
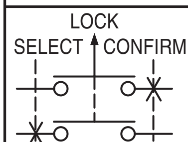
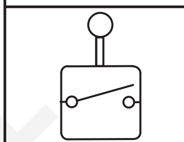
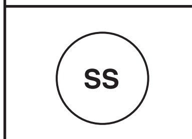
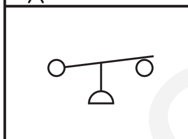
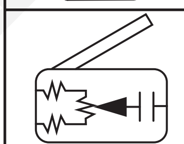
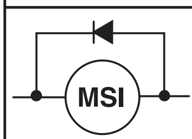
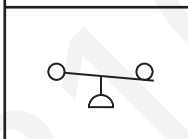
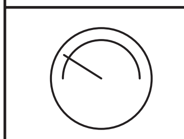
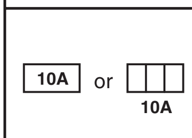
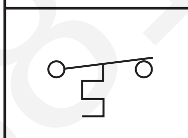
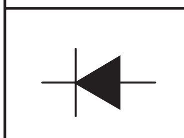
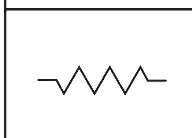
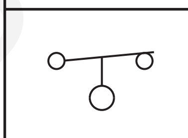
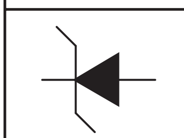
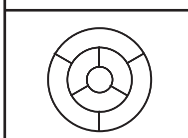
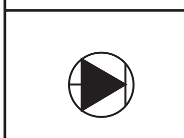
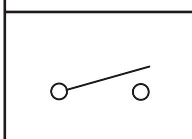
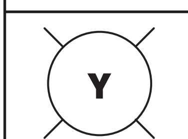
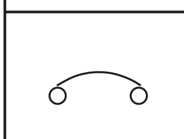
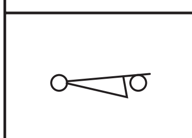
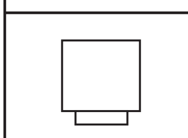
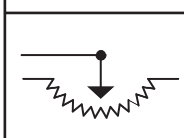
____

Operator’s Manual 1-8 Numeric Tabs

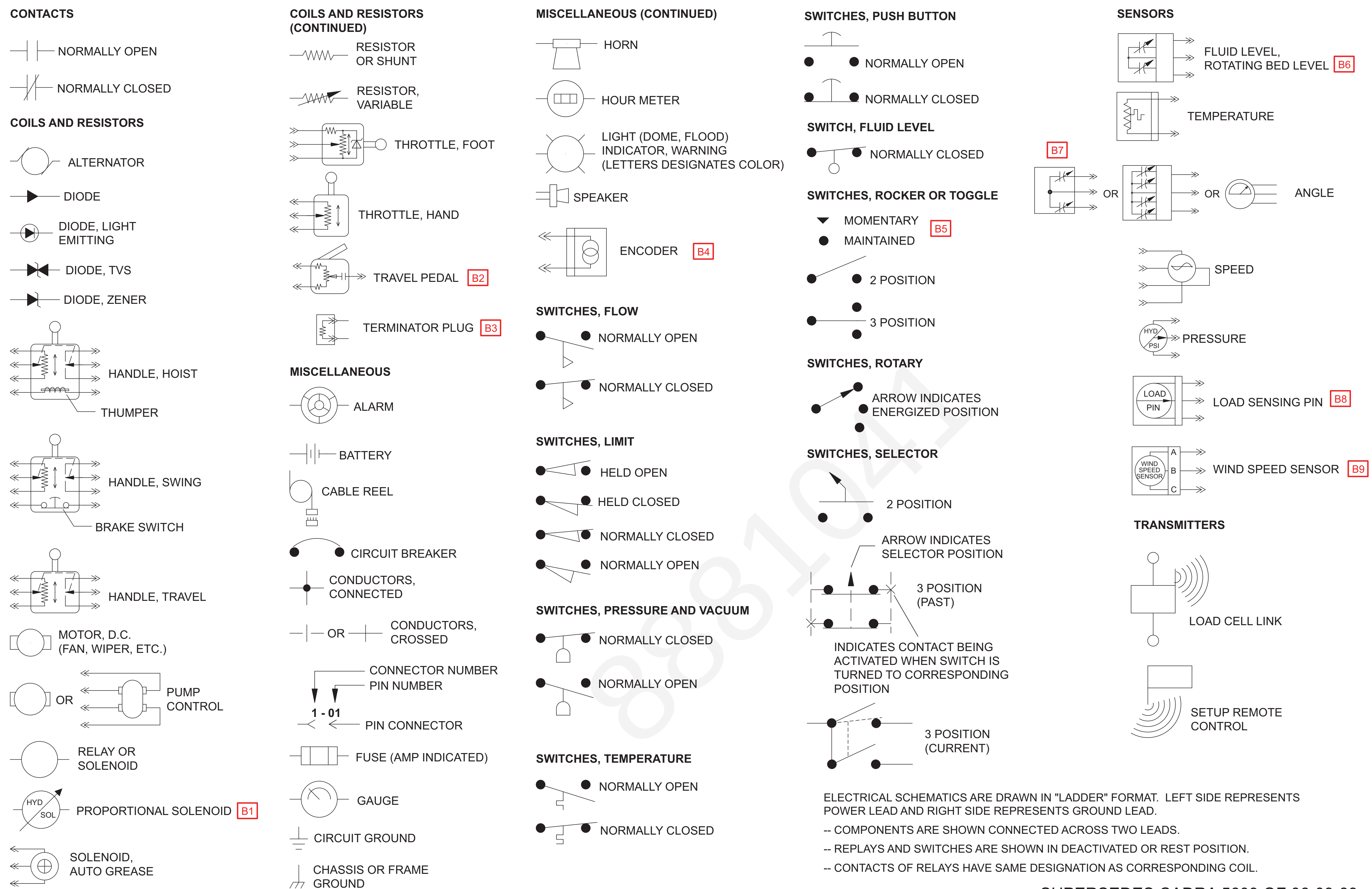
Symbol	Definition	Symbol	Definition	Symbol	Definition
	Fixed Displacement Pump		Hydraulic Brake		4-Way, 3-Position, Solenoid Actuated Directional Control Valve
	Variable Displacement Bi-directional Pilot Control Pump		Pressure Transducer		3-Way, 2-Position, Solenoid Actuated Directional Control Valve
	Fixed Displacement Bi-directional Motor		Fixed Orifice		Pressure Relief Valve
	Variable Displacement Bi-directional Pressure Compensated Motor		Blocked Line		Check Valve
	Piston Type Cylinders		Pilot Oil Flow		Spring Loaded Check Valve
	Oil Filter or Strainer		Direct Oil Flow		Flow Control Valve
	Oil Cooler		Adjustable Spring		Shuttle Valves
	Quick Disconnect		Manual Control by Lever		Pilot-operated Check Valve (Unloader Valve)
	Swivel Coupling		Counter Balance Valve		Accumulator

MEC-100-1

HYDRAULIC CRANES
ELECTRICAL SYMBOLS

Symbol	Definition	Symbol	Definition	Symbol	Definition
	Battery		Selector Switch		Rotation Thumper
	Open Contact		Multiposition Switch		Horn
	Closed Contact		Pushbutton Switch		Connector
	Motor, EDC, or PCP (As labeled)		2-Circuit Selector Switch		Hand Control
	Starter Solenoid (HS = hydraulic solenoid) (AS = air solenoid)		Vacuum-Actuated Switch		Foot Control
	Start Solenoid Relay		Pressure-Actuated Switch		Meter Instrument
	Fuse		Temperature-Actuated Switch		One-Way Diode
	General Resistor, Resistance, or Load		Fluid-Level-Actuated Switch		Zener Diode
	Variable Resistor		Audible Alarm		Light Emitting Diode (LED)
	Single Pole		Lamp (Letter designates color)		Circuit Breaker
	Limit Switch		RPM Transducer		Angle Indicator

MEC-100-2



ELECTRICAL SCHEMATICS ARE DRAWN IN "LADDER" FORMAT. LEFT SIDE REPRESENTS POWER LEAD AND RIGHT SIDE REPRESENTS GROUND LEAD.

-- COMPONENTS ARE SHOWN CONNECTED ACROSS TWO LEADS.

-- REPLAYS AND SWITCHES ARE SHOWN IN DEACTIVATED OR REST POSITION.

-- CONTACTS OF RELAYS HAVE SAME DESIGNATION AS CORRESPONDING COIL.

SUPERSEDES CADRA 5609 OF 06-09-89

REVISIONS

RELEASE NO.	CHANGED BY	DATE
	M FRIES	02-25-05

REV LTR VER	DESCRIPTION	ZONE
A1	FIRST RELEASE	

RELEASE NO.	CHANGED BY	DATE
	KKOUBADDY	08-18-14

REV LTR VER	DESCRIPTION	ZONE
B1 B2 B3 B4 B5 B6 B7 B8 B9	ADDED	

ASSEMBLIES USED ON

DATE 02-25-05

RELEASE LEVEL

TOLERANCE UNLESS OTHERWISE SPECIFIED

DECIMAL PLACES	FABRICATION <= 10 FEET	FABRICATION > 10 FEET	MACHINING 125	
(1) PLACE 0.0	±.12	±.18	±.03	INDICATES MACHINING APPLIES TO THIS DIMENSION AND / OR SURFACE
(2) PLACE 0.00	±.06	±.12	±.02	
(3) PLACE 0.000	—	—	±.005	
(4) PLACE 0.0000	AS NOTED ON THE DIMENSION			
ANGLES	±1.50°		±.50°	

MDL N/A	WEIGHT LBS N/A		
DR MFRIES	PAINT CODE N/A		
CK MKRAUSE	CRANE MODEL ALL		
APP MKRAUSE	SCALE NONE		

SHEET 1 OF 1 — DRAWING NO. 5609 — REV LTR B

Manitowoc Cranes, Inc.

Manitowoc, Wisconsin

TITLE SCHEMATIC ELECTRICAL SYMBOLS

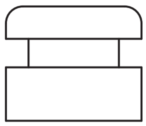
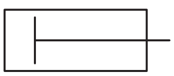
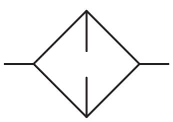
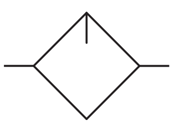
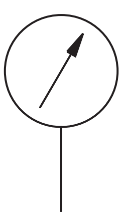
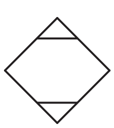
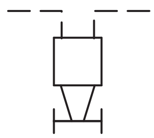
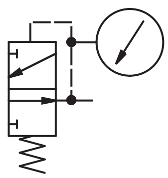
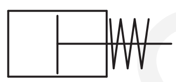
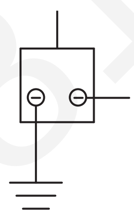
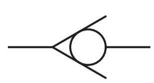
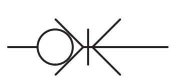
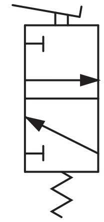
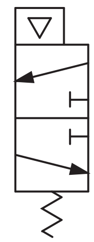
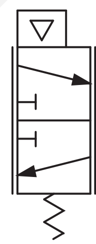
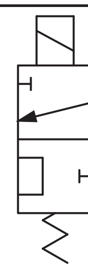
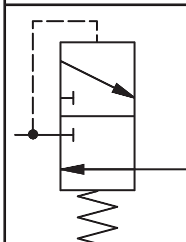
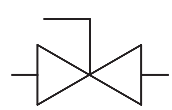
SHEET 1 OF 1

DRAWING NO. 5609 REV LTR B

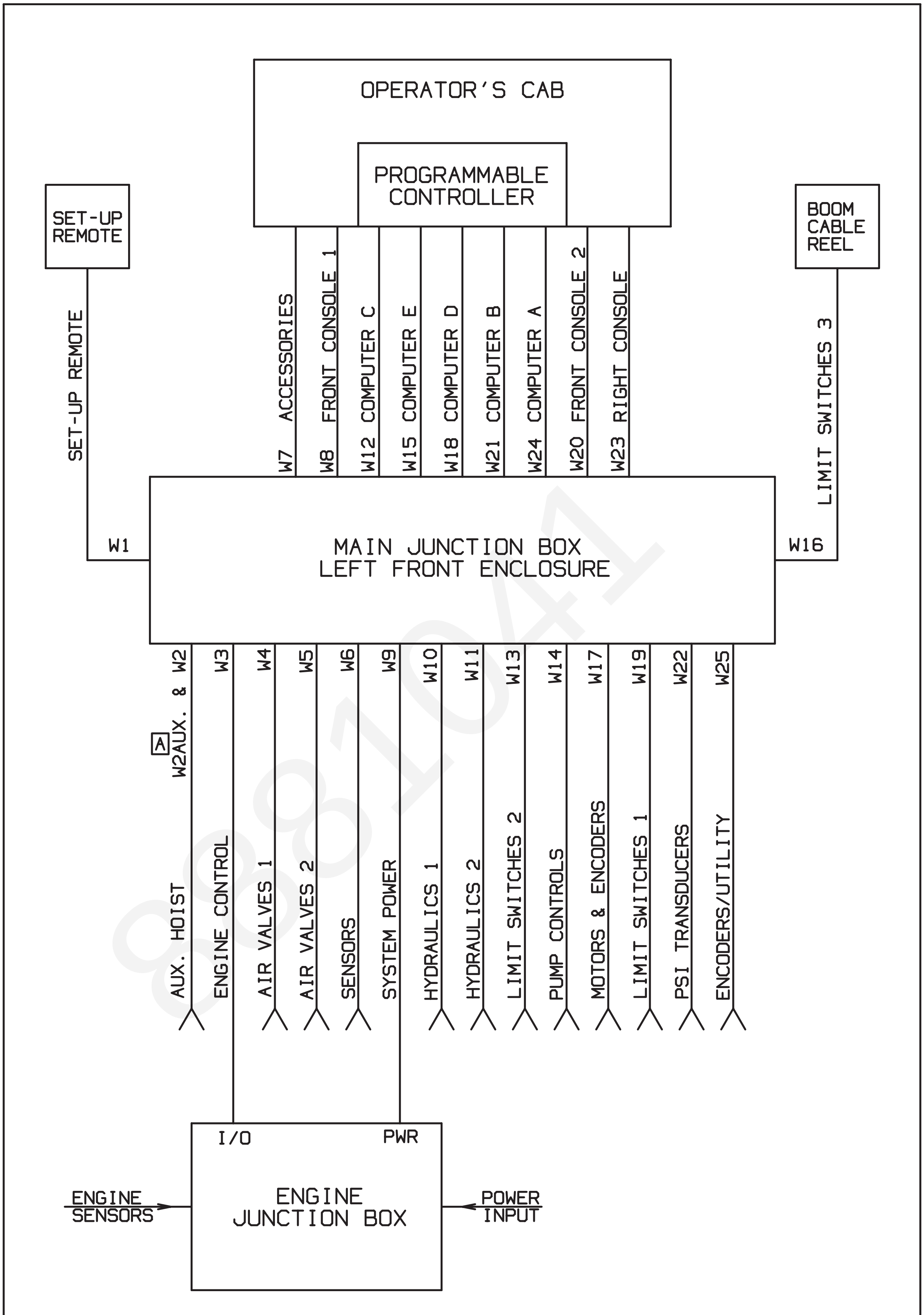
DO NOT SCALE THIS DRAWING

CREATED IN ILLUSTRATOR

HYDRAULIC CRANES
COMPRESSED AIR SYMBOLS

Symbol	Definltion
	Compressor
	Air Cylinder
	Air Filter
	Alcohol Injector
	Pressure Gauge
	Air Dryer
	Pressure Switch
	Regulator
	Spring-applied, Air-released, Clutch Cylinder
	Moisture Ejector
	Check Valve
	Quick Disconnect
	Service Brake Treadle Valve
	3-Way, 2-Position, Air Actuated, Directional Control Valve (Quick Release Valve)
	Park Brake Relay Valve
	Solenoid Actuated, Directional Control Valve
	Unloader Valve
	Shut-off or Bleed-off Valve

MEC-100-3



2-13-98 KLW B ADDED	ELECTRICAL SCHEMATIC	MANITOWOC ENGINEERING CO.	SCALE	DATE 3-21-95	
	POWER PLANT AND CONTROLS	MANITOWOC, WISCONSIN	DR. DRN	DWG. NO. 5647	
	W/EDER EPIC® CONTROL	MODEL 888	CK. MK		
REVISIONS	12V CONTROL-24V START		APP. JS	SHEET SHT.1	

W1 SET-UP REMOTE

PIN NO.	WIRE NO.	COLOR CODE
1	56	ORANGE
2	56A	BLUE
3	43	WHT/BLK
4	43A	RED/BLK
5	44	GRN/BLK
6	44A	ORG/BLK
7	SPARE	RED
8	SPARE	GREEN
9	SPARE	BLACK
10	SPARE	WHITE

A

W2 AUX. HOIST

PIN NO.	WIRE NO.
A	86C
B	0
C	0
D	0
E	8T
F	87MA
G	87MB
H	0
J	0
K	87EA
L	0
M	SPARE
N	SPARE
P	8D
Q	89Q1
R	8T
S	83Q
T	84Q
U	0
V	0
W	8D
X	89L4
Y	88R
Z	0

W3 ENGINE CONTROL

PIN NO.	WIRE NO.
A	SPARE
B	3
C	7
D	N/C
E	N/C
F	68J
G	89T3
H	89D4
J	N/C
K	0
L	68K
M	10
N	11
P	89E4
Q	24
R	N/C
S	68L
T	89U3
U	89F4
V	N/C
W	N/C
X	70
Y	SHIELD
Z	N/C

B

W4 AIR VALVES 1

PIN NO.	WIRE NO.
A	80R
B	80RA
C	SPARE
D	0
E	0
F	81R
G	SPARE
H	66
J	81RA
K	66A
L	0
M	87G
N	0
P	0
R	0
S	0

C

W5 AIR VALVES 2

PIN NO.	WIRE NO.
A	80E
B	80FA
C	SPARE
D	0
E	0
F	81E
G	SPARE
H	64
J	81FA
K	64A
L	0
M	87H
N	0
P	0
R	0
S	0

D

W6 SENSORS

PIN NO.	WIRE NO.
A	56A
B	56A
C	SPARE
D	0
E	0
F	8M
G	SPARE
H	8M
J	8D
K	8D
L	0
M	20
N	0
P	89S3
R	89R3
S	0

E

W7 ACCESSORIES

PIN NO.	WIRE NO.	COLOR CODE
A	8W1	ORANGE
B	8W2	RED/BLK
C	8H	YELLOW
D	SPARE	BLUE
E	SPARE	BROWN
F	8F	RED
G	0	BLACK
H	8W3	ORG/BLK
J	20	BLU/BLK
K	11	BRN/BLK
L	SPARE	BLU/RED
M	SPARE	BLK/RED
N	SPARE	BRN/RED
P	10	YEL/BLK
R	FLT	YEL/RED
S	8A	ORG/RED

K

W2AUX AUXILIARY DRUM

PIN NO.	WIRE NO.
A	86C
B	0
C	0
D	87G
E	8T
F	87MA
G	87MB
H	0
J	0
K	87EA
L	0
M	87H
N	N/C
P	8D
R	89Q1
S	0

L

W8 FRONT CONSOLE 2

PIN NO.	WIRE NO.
A	SPARE
B	SPARE
C	SPARE
D	0
E	84EA
F	66
G	66A
H	8S
J	82E
K	84E
L	80R
M	80RA
N	81R
P	81RA
R	82EA
S	80F
T	81F
U	80Q
V	81T
W	87E
X	87G
Z	87H
a	80FA
b	81FA
c	80QA
d	81TA
e	87EA
f	8S
g	SPARE
h	SPARE
j	TX1
k	SPARE
m	SPARE
n	TX1-0
p	RX1
r	25A
s	25

W9 SYSTEM POWER

PIN NO.	WIRE NO.
A	5
B	5
C	0
D	0

F

W10 HYDRAULICS 1

PIN NO.	WIRE NO.
A	80QA
B	81SA
C	82EA
D	0
E	0
F	84EA
G	0
H	25X
J	8D
K	SPARE
L	0
M	85EC
N	0
P	89H4
R	SPARE
S	0

G

W11 HYDRAULICS 2

PIN NO.	WIRE NO.
A	43A
B	44A
C	55DA
D	0
E	0
F	55CA
G	0
H	52B
J	89G4
K	SPARE
L	0
M	52A
N	0
P	SPARE
R	SPARE
S	0

W12 COMPUTER C

PIN NO.	WIRE NO.	PIN NO.
A	8P1	01
B	0	02
C	8P1	03
D	0	04
E	80A	05
F	81A	06
G	80E	07
H	81E	08
J	82E	09
K	84E	10
L	D05	11
M	8P1	12
N	0	13
P	82A	14
R	83A	15
S	80F	16
T	81F	17
U	80Q	18
V	81T	19
W	D010	20
X	8P1	21
Z	0	22
a	84A	23
b	85A	24
c	87E	25
d	D012	26
e	25X	27
f	25A	28
g	25	29
h	8P1	30
j	0	31
k	43	32
m	44	33
n	55D	34
p	55C	35
r	52	36
s	N/C	37

H

W13 LIMIT SWITCHES 2

PIN NO.	WIRE NO.
A	8D
B	8D
C	SPARE
D	89R
E	89Q
F	0
G	0
H	0
J	8D
K	89W3
L	87FA
M	82BA
N	0
P	87FA
R	88MA
S	0

J

W14 PUMP CONTROLS

PIN NO.	WIRE NO.
A	80A
B	0
C	0
D	81A
E	0
F	0
G	82A
H	0
J	0
K	83A
L	0
M	0
N	84A
P	0
Q	0
R	85A
S	0
T	0
U	87A
V	0
W	87B
X	0
Y	0
Z	N/C

8-23-99 DDS
W8-d WAS 81SA
L WAS FRONT CONSOLE 1

2-13-98 KLW
W8-V WAS 81S
K ADDED

4-21-97 PE
A B C D E F G H J
PIN CHARTS CORRECTED

12-17-96 DRN
W12-V CORRECTED

3-5-96 DRN
W2-M WAS 8D
W2-N WAS 89Q1
W2-Q WAS 89R1

12-21-95 TMB
W2-Y WAS DI51

8-23-95 DRN
W2-S WAS AI38
W2-T WAS AI39
W2-Y WAS D027

REVISIONS

ELECTRICAL SCHEMATIC
POWER PLANT AND CONTROLS
W/EDER EPIC® CONTROL
12V CONTROL-24V START

MANITOWOC ENGINEERING CO.
MANITOWOC, WISCONSIN

MODEL 888

SCALE
DR. DRN
CK. MK
APP. JS

DATE 3-21-95
DWG. NO. 5647
SHEET SHT.1A

W15 COMPUTER E

PIN NO.	WIRE NO.	PIN NO.
A	87MA	01
B	87MB	02
C	80MAS	03
D	80MBS	04
E	81MAS	05
F	81MBS	06
G	MAGPU2	07
H	83Q	08
J	84Q	09
K	AI38	10
L	AI39	11
M	AI40	12
N	89D4	13
P	89E4	14
R	89F4	15
S	89G4	16
T	89H4	17
U	89L4	18
V	DI51	19
W	D152	20
X	D153	21
Z	D154	22
a	DI55	23
b	DI56	24
c	ENC7CHA	25
d	ENC7CHB	26
e	SPARE	27
f	SPARE	28
g	82S	29
h	87C	30
j	N/C	31
k	N/C	32
m	DO33	33
n	DO34	34
p	DO35	35
r	87A	36
s	87B	37

W16 LIMIT SWITCHES 3

PIN NO.	WIRE NO.	PIN NO.
1	87FA	PIN#1
2	89S1	PIN#2
3	87BA	PIN#3
4	89W1	PIN#4
5	0	PIN#5
6	89W	PIN#6

A

W17 MOTORS AND ENCODERS

PIN NO.	WIRE NO.
A	80R
B	0
C	0
D	81S
E	0
F	0
G	82R
H	0
J	0
K	8T
L	80MA
M	80MB
N	0
P	0
Q	0
R	8T
S	81MA
T	81MB
U	0
V	0
W	8T
X	82MA
Y	82MB
Z	0

W18 COMPUTER D

PIN NO.	WIRE NO.	PIN NO.
A	80MA	01
B	80MB	02
C	81MA	03
D	81MB	04
E	82MA	05
F	82MB	06
G	24	07
H	89Y3	08
J	89Z3	09
K	89A4	10
L	89B4	11
M	89C4	12
N	89Q1	13
P	SPARE	14
R	89B2	15
S	RX1	16
T	TX1	17
U	TX1-0	18
V	TX2	19
W	TX2-0	20
X	RX3	21
Z	TX3	22
a	N/C	23
b	80S	24
c	81S	25
d	56	26
e	80N	27
f	81N	28
g	82N	29
h	87N	30
j	88R	31
k	DO27	32
m	DO28	33
n	DO29	34
p	DO30	35
r	DO31	36
s	N/C	37

B

W19 LIMIT SWITCHES 1

PIN NO.	WIRE NO.
A	8D
B	8D
C	8D
D	89K4
E	89J4
F	8D
G	89T
H	8D
J	0
K	0
L	89V
M	8D
N	89U
P	SPARE
R	0
S	89S

W20 FRONT CONSOLE 1 D

PIN NO.	WIRE NO.
A	8D
B	87FA
C	0
D	8A
E	89C4
F	89A4
G	89Z3
H	89Y3
J	89S2
K	89T2
L	89B4
M	83PF
N	84PF
P	3
R	3
S	7
T	70
U	TX2-0
V	TX2
W	89V3
X	89X2
Z	5D
a	89M
b	89P
c	89L
d	89J
e	89B
f	89D
g	89L3
h	89M3
j	89N
k	89T1
m	89K
n	89M1
p	89L1
r	89M1
s	90E

W21 COMPUTER B

PIN NO.	WIRE NO.	PIN NO.
A	89X	01
B	89V	02
C	89T	03
D	89J4	04
E	89K4	05
F	89W	06
G	89U	07
H	89S	08
J	89S2	09
K	89T2	10
L	88S	11
M	89R	12
N	89Q	13
P	89W1	14
R	89S1	15
S	89R3	16
T	89S3	17
U	89T3	18
V	89U3	19
W	89V3	20
X	89X2	21
Z	89W3	22
a	89M	23
b	89P	24
c	89L	25
d	89J	26
e	89B	27
f	89D	28
g	89L3	29
h	89M3	30
j	89N	31
k	89T1	32
m	89K	33
n	89Q3	34
p	89L1	35
r	89M1	36
s	N/C	37

C

W22 PRESSURE TRANSDUCERS

PIN NO.	WIRE NO.
A	8T
B	80QS
C	0
D	0
E	8T
F	81QS
G	0
H	0
J	0
K	8T
L	82QS
M	0
N	0
P	0
Q	8T
R	8T
S	85QR
T	0
U	0
V	86QS
W	8T
X	85QL
Y	0
Z	0

W23 RIGHT CONSOLE

PIN NO.	WIRE NO.
A	87FA
B	0
C	80P
D	81P
E	82P
F	83P
G	84P
H	85P
J	86P
K	43A
L	44A
M	85EC
N	55CA
P	55DA
R	89B2
S	43
T	44
U	52A
V	52
W	52B
X	55C
Z	55D
a	8S
b	64
c	64A
d	89Q3
e	80N
f	81N
g	82N
h	87N
j	68J
k	68K
m	68L
n	8D
p	89X
r	89M1
s	SPARE

8-23-99 DDS
D WAS FRONT CONSOLE 2

7-14-96 DRN
W15-U WAS DI50
W15-V WAS 89L4

4-21-97 PE
A B C
PIN CHARTS CORRECTED

12-17-96 DRN
W15-g WAS 82R
W15-h WAS 86C
W18-b WAS 80R

3-5-96 DRN
W18-N WAS 89R1
W18-P WAS 89Q1

12-21-95 TMB
E-V WAS DI51
W23-s WAS 5H
W23-r WAS 45
W20-n WAS 45

8-23-95 DRN
W18-j WAS DO26
W20-r WAS 89M1
W21-r WAS 89M1
W15-H WAS AI36
W15-J WAS AI37

REVISIONS

ELECTRICAL SCHEMATIC	MANITOWOC ENGINEERING CO.	SCALE	DATE 3-21-95
POWER PLANT AND CONTROLS	MANITOWOC, WISCONSIN	DR. DRN	DWG. NO. 5647
W/EDER EPIC® CONTROL	MODEL 888	CK. MK	
12V CONTROL-24V START		APP. JS	SHEET SHT.1B

W24 COMPUTER A		
P1 PIN	WIRE ID	P2 PIN
A	87F	01
B	AI35	02
C	80P	03
D	81P	04
E	82P	05
F	83P	06
G	84P	07
H	85P	08
J	86P	09
K	AI8	10
L	SHIELD	11
M	83PF	12
N	84PF	13
P	8TA	14
R	AI12	15
S	87FM	16
T	AI14	17
U	AI15	18
V	AI16	19
W	82BA	20
X	87BA	21
Z	80QS	22
a	81QS	23
b	82QS	24
c	85QR	25
d	85QL	26
e	86QS	27
f	AI25	28
g	AI26	29
h	90E	30
j	AI28	31
k	AI29	32
m	AI30	33
n	AI31	34
p	88MA	35
r	A133	36
s	AI34	37

J

W25 ENCODERS AND UTILITY		
PIN ID	WIRE ID	
A	8T	
B	ENC5CHA	K
C	ENC6CHA	L
D	8T	
E	ENC5CHB	M
F	0	
G	0	
H	0	
J	ENC6CHB	N
K	0	
L	8T	
M	ENC7CHA	
N	ENC7CHB	
P	0	
R	0	
S	SPARE	
T	8T	
U	AI38	
V	AI39	
W	0	
X	0	
Z	SPARE	
a	8D	
b	DI51	
c	SPARE	
d	SPARE	
e	DI52	
f	8D	
g	D027	
h	0	
j	SPARE	
k	0	
m	D028	
n	8D	
p	DI53	
r	0	
s	D029	

W26 CONSOLE INTERCONNECT		
PIN ID	WIRE ID	COLOR CODE
A	8S	ORANGE
B	89B2	RED/BLK
C	SPARE	YELLOW
D	SPARE	BLUE
E	SPARE	BROWN
F	89X	RED
G	0	BLACK
H	82N	ORG/BLK
J	82P	BLU/BLK
K	85P	BRN/BLK
L	84P	BLU/RED
M	87FA	BLK/RED
N	83P	BRN/RED
P	68J	YEL/BLK
R	68L	YEL/RED
S	68K	ORG/RED

W27 SEAT SWITCH		
PIN ID	WIRE ID	COLOR CODE
1	8D	WHITE
2	89Q3	BLACK

W28 ENGINE FOOT THROTTLE		
PIN ID	WIRE ID	COLOR CODE
1	68J	GREEN
2	68K	BLACK
3	68L	WHITE

G

W29 AIR CONDITIONER		
PIN ID	WIRE ID	COLOR CODE
1	58A	GREEN
2	0	BLACK
3	58	WHITE

W30 AIR COND. POWER		
P1 PIN	WIRE ID	P2 PIN
A	58	2
B	58A	3
C	0	1

W31 REEL CABLE 6 CONDUCTOR CABLE		
P1 PIN	WIRE ID	P2 PIN
1	87FA	1
2	89S1	2
3	87BA	3
4	89W1	4
5	0	5
6	89W	6

H

W31 REEL CABLE 10 CONDUCTOR CABLE		
P1 PIN	WIRE ID	P2 PIN
1	89W1	1
2	89W	2
3	TOC-1	3
4	TOC-2	4
5	TOC-3	5
6	TOC-4	6
7	89S1	7
8	87BA	8
9	0	9
10	87FA	10

EP1 RECEPTACLE ENGINE LOOM	
PIN ID	WIRE ID
A	0
B	5
C	SPARE

EP2 RECEPTACLE ENGINE LOOM	
PIN ID	WIRE ID
A	3
B	6B
C	70
D	10
E	11
F	89T3
G	68J
H	89U3
J	68K
K	68L
L	5F
M	6A
N	N/C
P	N/C
R	24
S	58A

P

W31 REEL CABLE UNIVERSAL BOOM TOP J/B		
P1 PIN	WIRE ID	P2 PIN
1	N/C	1
2	N/C	2
3	TOC-1	3
4	+SIG	4
5	TOC-3	5
6	8A	6
7	SIG1L	7
8	101	8
9	0	9
10	N/C	10

C

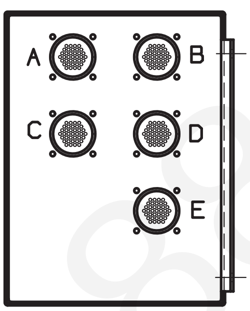
EP3 HYD. FILTER ALARMS		
PIN ID	WIRE ID	COLOR CODE
1	89D4	GREEN
2	89E4	BLACK
3	89F4	WHITE

D

W34 HORN		
PIN ID	WIRE ID	COLOR CODE
1	5H	BLACK
2	45	WHITE

E

W35 HORN AND FLOODLIGHTS		
PIN ID	WIRE ID	COLOR CODE
1	5H	BLACK
2	8	WHITE
3	8	GREEN



PROGRAMMABLE CONTROLLER RECEPTACLES

F

FUSES		
F1 -	8H -	15A
F2 -	8W1 -	10A
F3 -	8W2 -	10A
F4 -	8W3 -	10A
F5 -	8M -	15A
F6 -	8S -	15A
F7 -	8F -	10A
F8 -	8A -	10A
F9 -	8D -	10A
F10 -	8T -	10A
F12 -	87FA -	3A
F13 -	8 -	20A
F14 -	8 -	20A
F15 -	5H -	20A
F16 -	5D -	10A

A

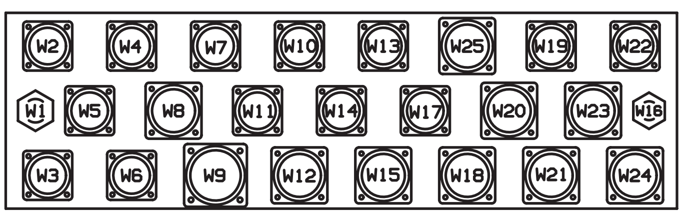
W32 FIXED JIB CABLE		
P1 PIN	WIRE ID	P2 PIN
1	87FA	1
2	89W	2

B

W33 JIB CABLE REEL		
P1 PIN	WIRE ID	P2 PIN
1	87FA	1
2	89W	2

Q

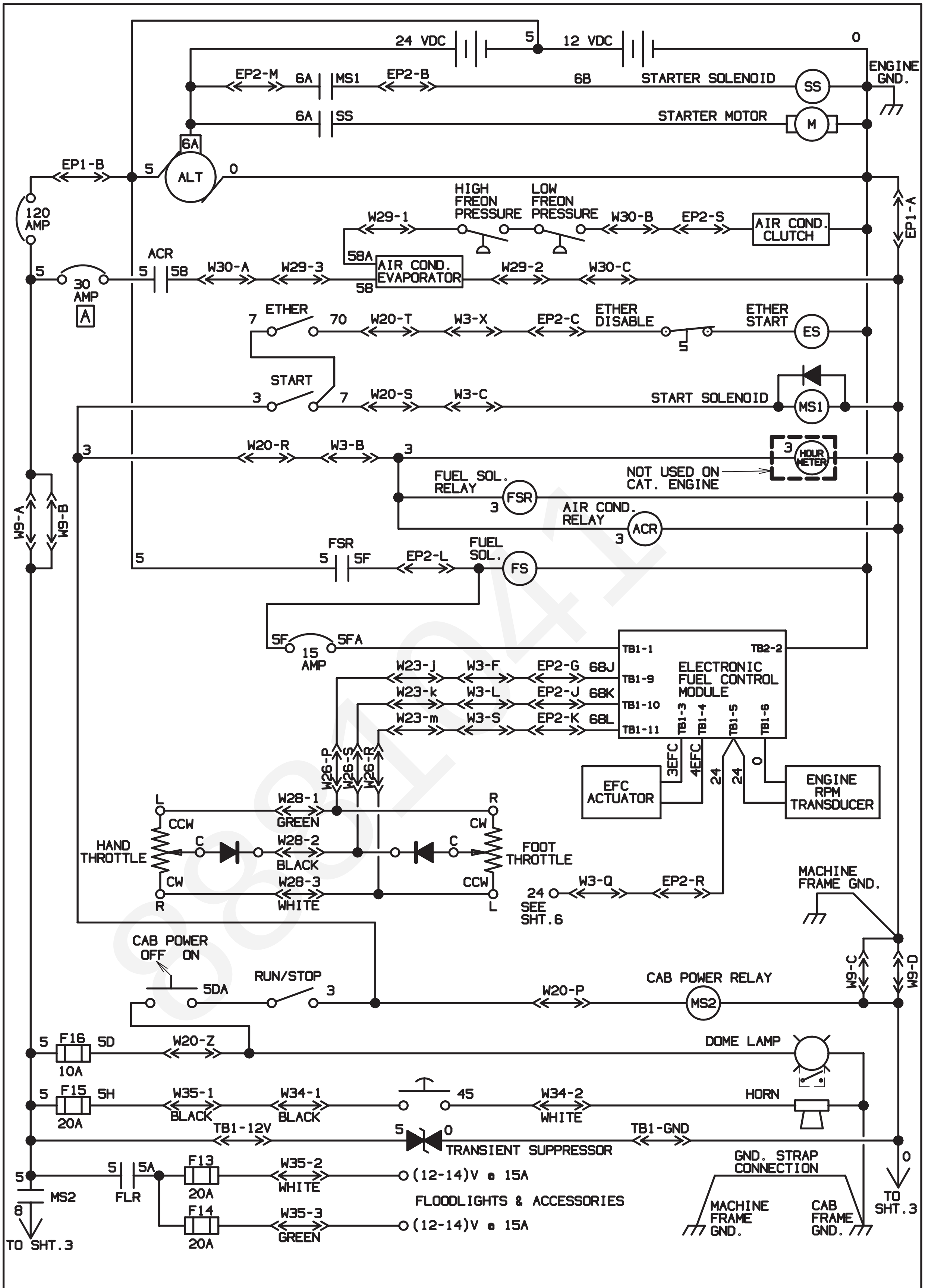
W33 JIB REEL CABLE UNIVERSAL BOOM TOP J/B		
P1 PIN	WIRE ID	P2 PIN
1	8B	1
2	89W	2
3	TOC-3	3
4	8A	4
5	0	5
6	+SIG	6



MAIN JUNCTION BOX CABLE IDENTIFICATION

REVISIONS	
2-7-01	MWK
P Q PIN CHARTS ADDED	
3-3-98	KLW
N WAS 81MBS	
M WAS 80MBS	
L WAS 81MAS	
K WAS 80MAS	
4-21-97	PE
J PIN CHART CORRECTED	
12-17-96	DRN
W24-S WAS 87M	
5-14-96	DRN
H W31 - 10 COND. CABLE CHART ADDED	
4-25-96	DRN
G CHART CORRECTED	
12-21-95	TMB
F ADDED F1-F16	
7-14-95	DRN
D E CABLES ADDED	
5-22-95	DRN
A B C CABLES ADDED	

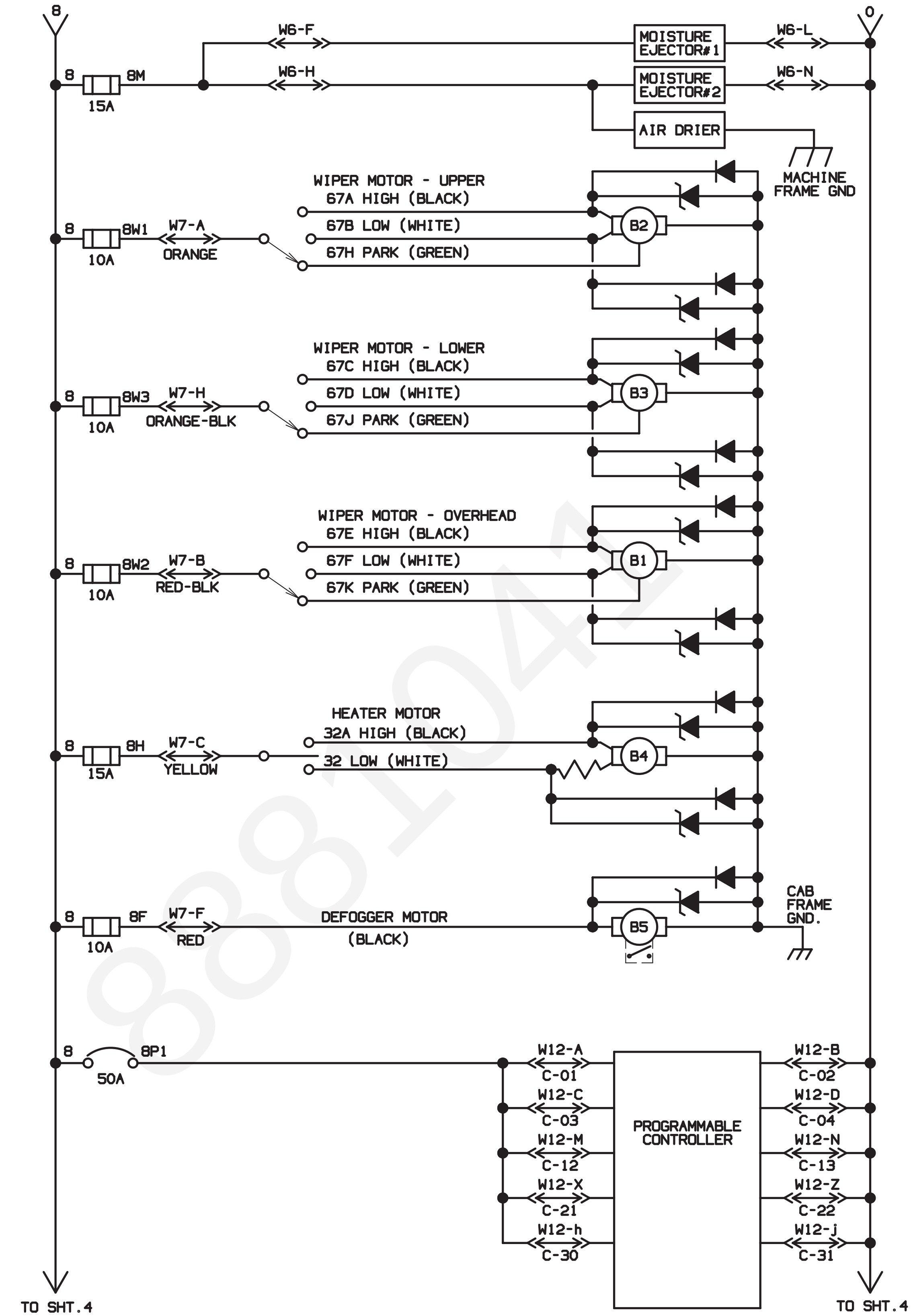
ELECTRICAL SCHEMATIC	MANITOWOC ENGINEERING CO.	SCALE	DATE 3-21-95
POWER PLANT AND CONTROLS	MANITOWOC, WISCONSIN	DR. DRN	DWG. NO. 5647
W/EDER EPIC® CONTROL	MODEL 888	CK. MK	
12V CONTROL-24V START		APP. JS	SHEET SHT.1C



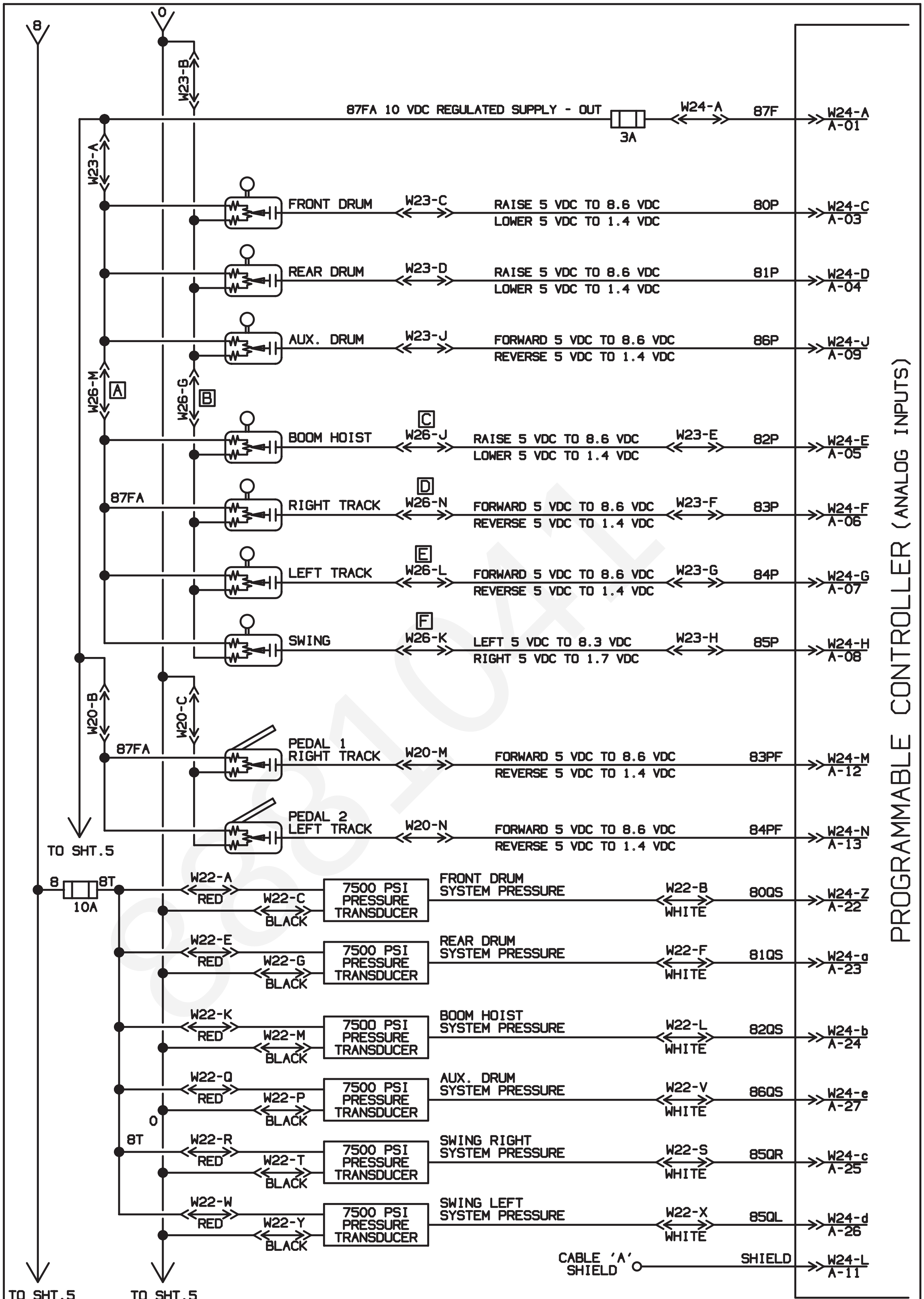
SUPERSEDES 5647 SHEET 2 OF 12-17-96

ELECTRICAL SCHEMATIC	MANITOWOC ENGINEERING CO.	SCALE	DATE 10-19-00
POWER PLANT AND CONTROLS	MANITOWOC, WISCONSIN	DR. MWK	DWG. NO. 5647
W/EDER EPIC® CONTROL	MODEL 888	CK. MWK	
12V CONTROL-24V START		APP. JS	SHEET SHT.2

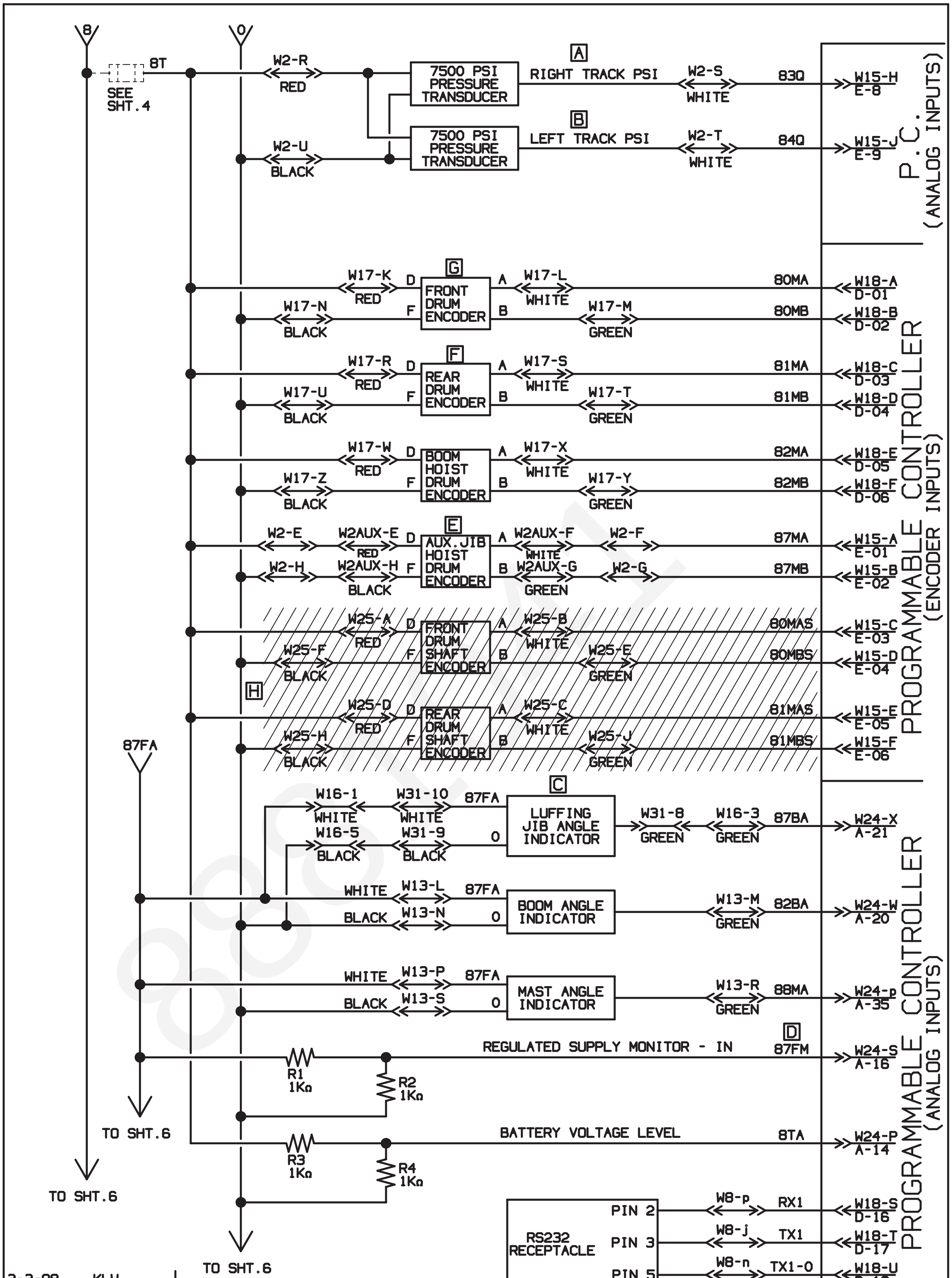
07-26-04	TMO
A WAS 25 AMP	
REVISIONS	



2-19-98 KLW AIR DRIER ADDED	ELECTRICAL SCHEMATIC	MANITOWOC ENGINEERING CO.	SCALE	DATE 3-21-95
4-25-96 DRN CAB FRAME GROUND WAS ADDED	POWER PLANT AND CONTROLS	MANITOWOC, WISCONSIN	DR. DRN	DWG. NO. 5647
	W/EDER EPIC● CONTROL	MODEL 888	CK. MK	
REVISIONS	12V CONTROL-24V START		APP. JS	SHEET SHT.3

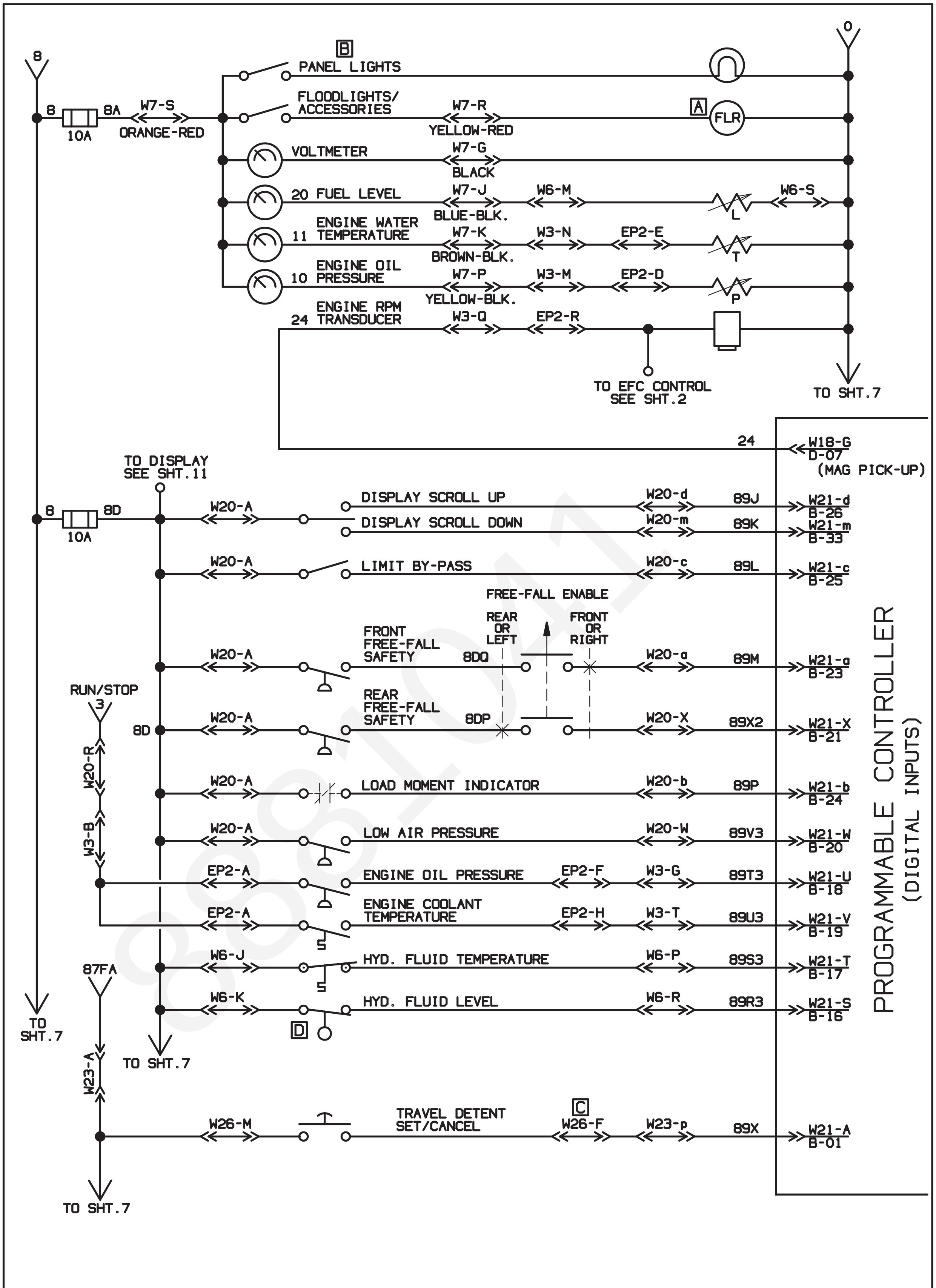


4-25-96 DRN C D E F ADDED	ELECTRICAL SCHEMATIC	MANITOWOC ENGINEERING CO.	SCALE	DATE 3-21-95
5-22-95 DRN A B ADDED	POWER PLANT AND CONTROLS	MANITOWOC, WISCONSIN	DR. DRN	DWG. NO. 5647
	W/EDER EPIC® CONTROL	MODEL 888	CK. MK	
REVISIONS	12V CONTROL-24V START		APP. JS	SHEET SHT.4



3-3-98 KLW
H DELETED
F G WAS FLANGE ENCODER
2-13-98 KLW
E ADDED CONTACTS FOR W2AUX CABLE
12-17-96 DRN
C 10 COND.CABLE I.D. WAS ADDED
D WAS 87M
8-23-95 DRN
A B ADDED
REVISIONS

ELECTRICAL SCHEMATIC	MANITOWOC ENGINEERING CO.	SCALE	DATE 3-21-95
POWER PLANT AND CONTROLS	MANITOWOC, WISCONSIN	DR. DRN	DWG. NO. 5647
W/EDER EPIC● CONTROL	MODEL 888	CK. MK	
12V CONTROL-24V START		APP. JS	SHEET SHT.5



7-14-97 DRN	
D SWITCH POSITION CORRECTED	
4-25-96 DRN	ELECTRICAL SCHEMATIC
B C ADDED	POWER PLANT AND CONTROLS
7-14-95 DRN	W/EDER EPIC® CONTROL
A WAS FLT	12V CONTROL-24V START
REVISIONS	

MANITOWOC ENGINEERING CO.
MANITOWOC, WISCONSIN

MODEL 888

SCALE

DATE 3-21-95

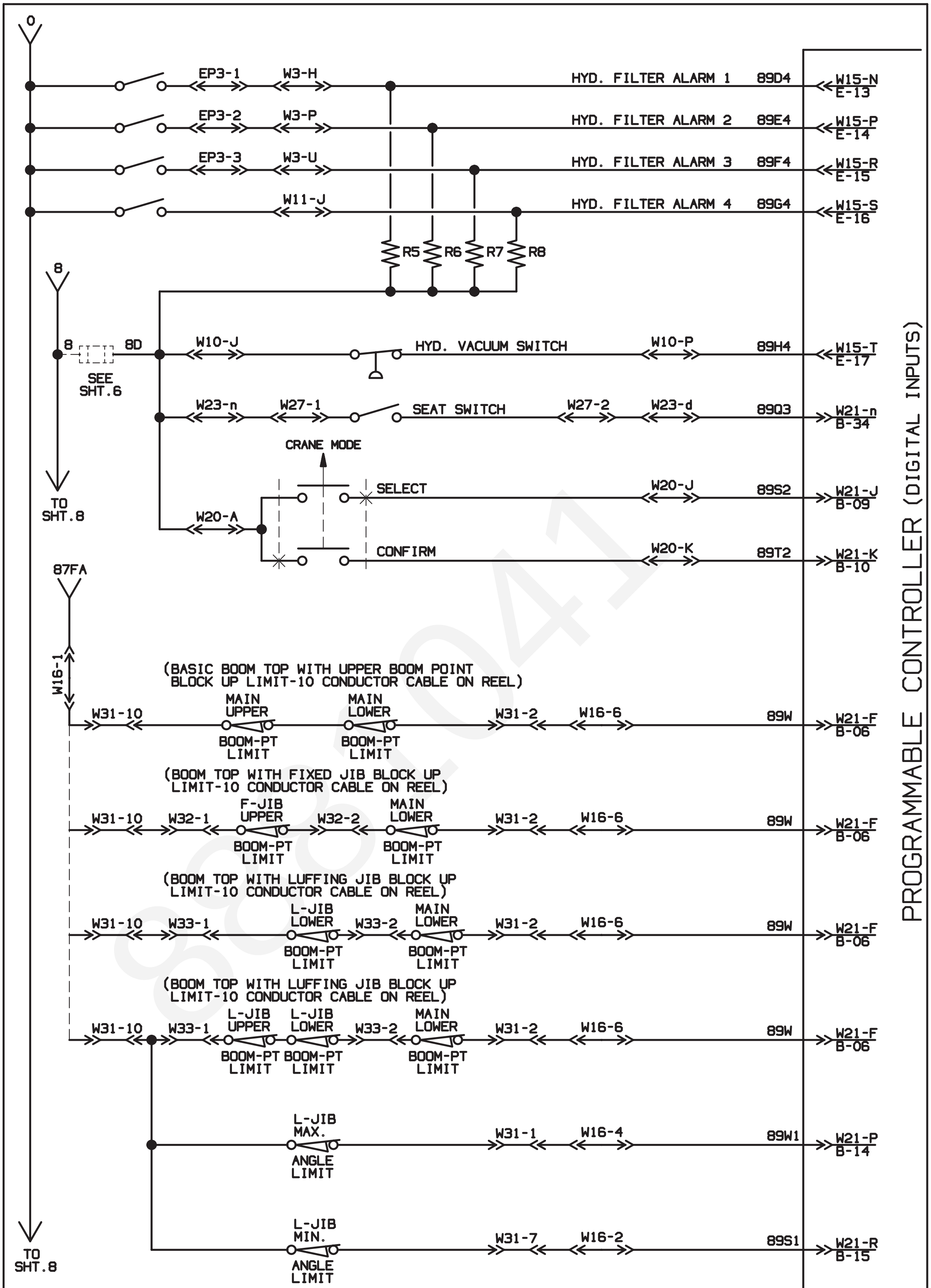
DR. DRN

CK. MK

APP. JS

DWG. NO. 5647

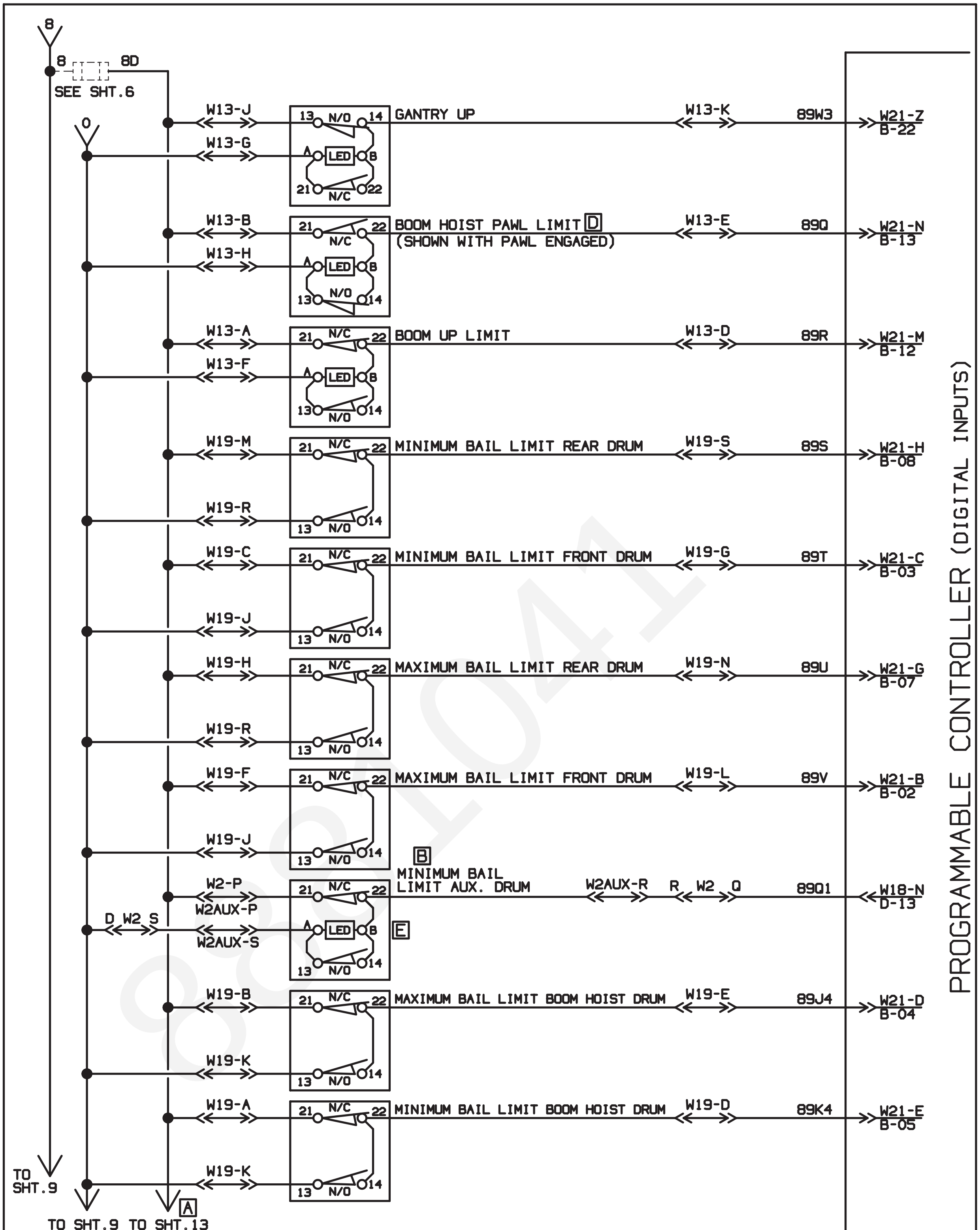
SHEET SHT.6



SUPERSEDES 5647 SHEET 7 OF 4-25-96

ELECTRICAL SCHEMATIC	MANITOWOC ENGINEERING CO.	SCALE	DATE 5-14-96
POWER PLANT AND CONTROLS	MANITOWOC, WISCONSIN	DR. DRN	DWG. NO. 5647
W/EDER EPIC® CONTROL	MODEL 888	CK. MK	
12V CONTROL-24V START		APP. JS	SHEET SHT.7

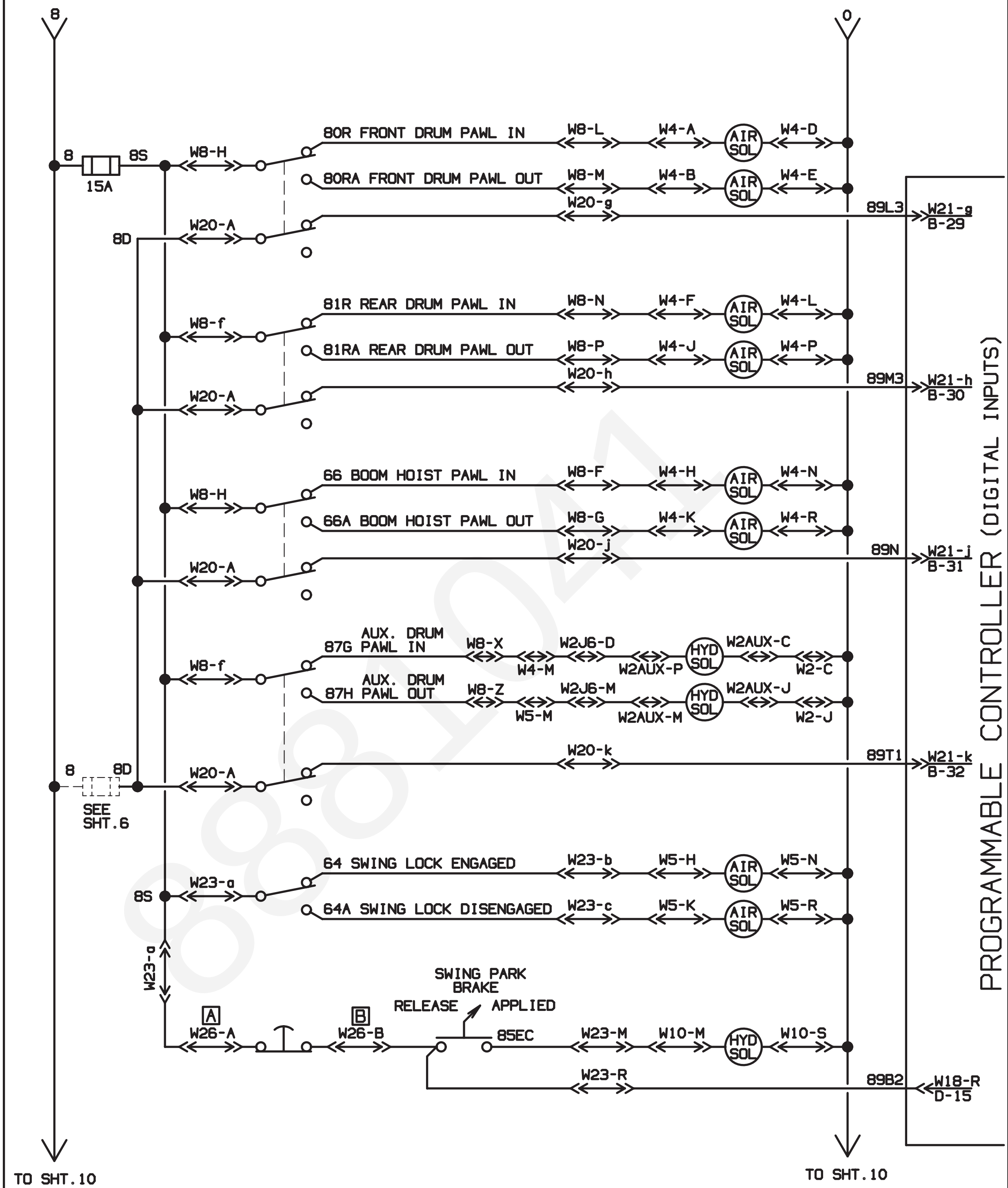
REVISIONS



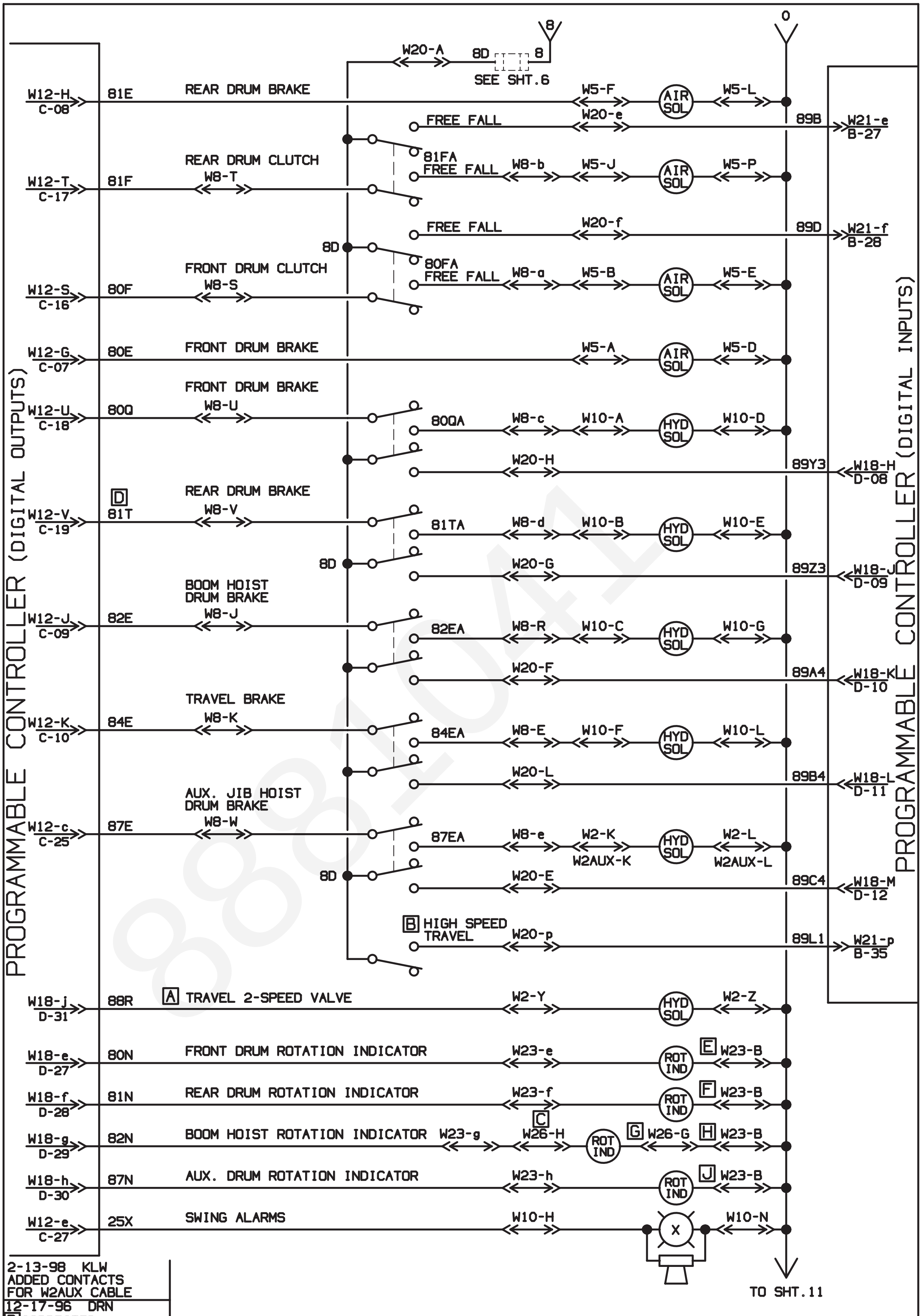
C NOTE: MACHINES WITHOUT BAIL LIMIT SWITCHES HAVE BAIL LIMIT JUMPERS IN BAIL LIMIT CABLE ASSEMBLY.

REVISIONS
5-21-98 DRN E LED WAS ADDED
2-13-98 KLW ADDED CONTACTS FOR W2AUX CABLE
01-21-98 KAC D WAS BOOM DOWN LIMIT
12-17-96 DRN LED'S REMOVED FROM BAIL LIMITS
4-25-96 DRN C NOTE ADDED
3-5-96 DRN B WAS MAX.BAIL LIMIT AUX.DRUM
12-21-95 TMB A ADDED

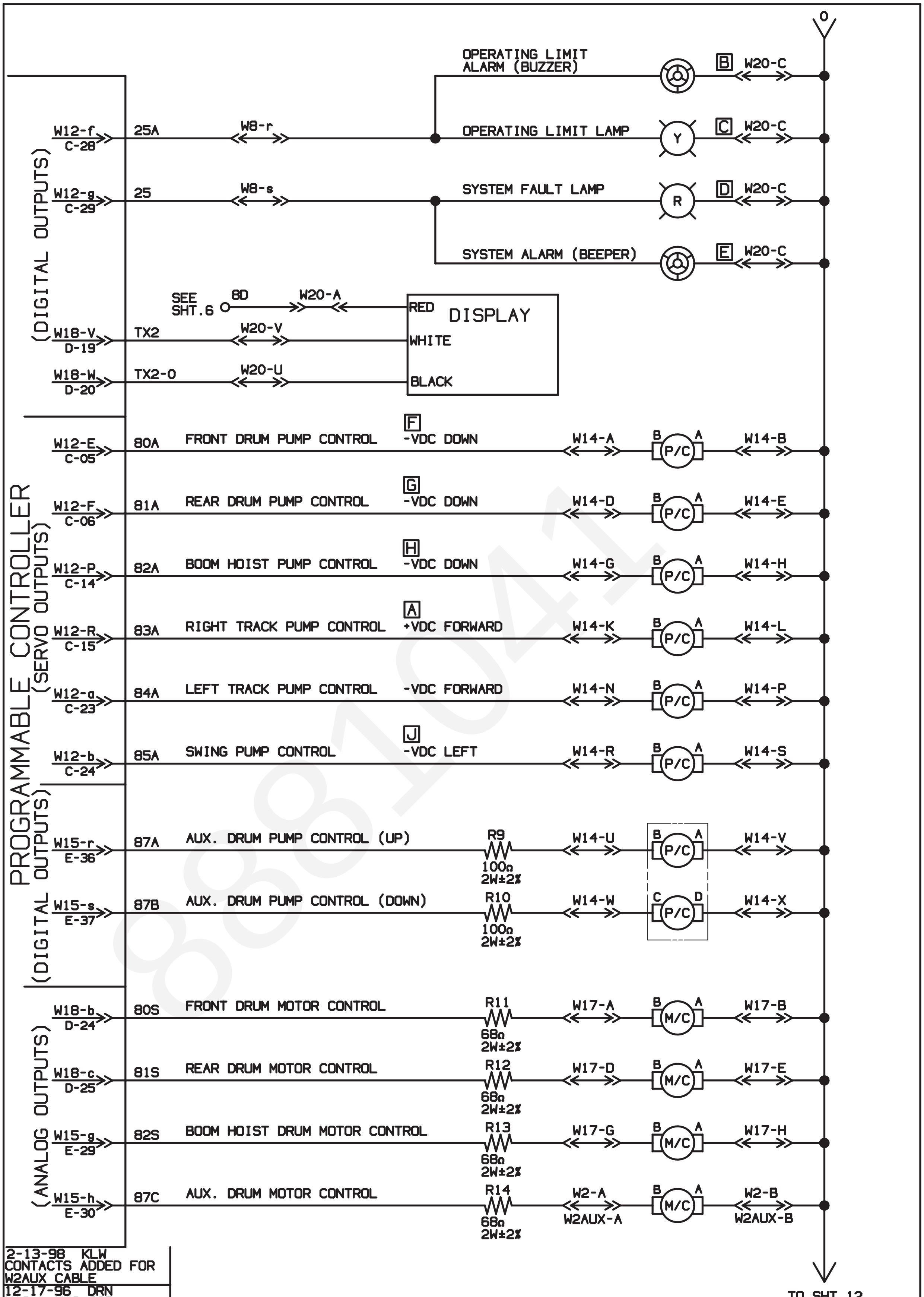
ELECTRICAL SCHEMATIC	MANITOWOC ENGINEERING CO.	SCALE	DATE 3-21-95
POWER PLANT AND CONTROLS	MANITOWOC, WISCONSIN	DR. DRN	DWG. NO. 5647
W/EDER EPIC® CONTROL	MODEL 888	CK. MK	
12V CONTROL-24V START		APP. JS	SHEET SHT.8



REVISIONS				
2-13-98 KLW ADDED CONTACTS FOR W2AUX CABLE	ELECTRICAL SCHEMATIC	MANITOWOC ENGINEERING CO.	SCALE	DATE 3-21-95
4-25-96 DRN [A][B] ADDED	POWER PLANT AND CONTROLS	MANITOWOC, WISCONSIN	DR. DRN	DWG. NO. 5647
	W/EDER EPIC● CONTROL	MODEL 888	CK. MK	
REVISIONS	12V CONTROL-24V START		APP. JS	SHEET SHT.9

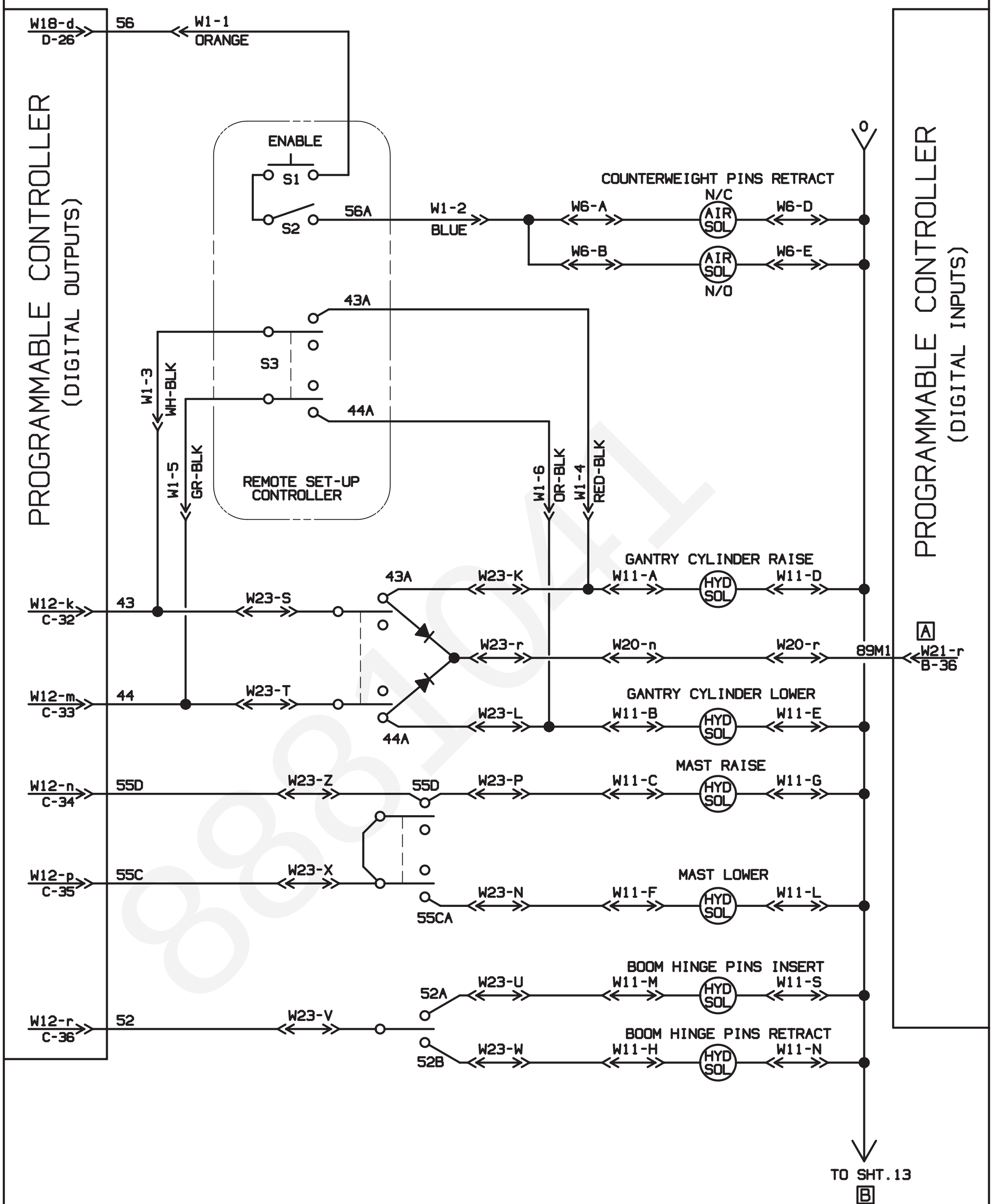


REVISIONS				
2-13-98 KLW ADDED CONTACTS FOR W2AUX CABLE	ELECTRICAL SCHEMATIC	MANITOWOC ENGINEERING CO.	SCALE	DATE 3-21-95
12-17-96 DRN D CORRECTED E F G H J ADDED	POWER PLANT AND CONTROLS	MANITOWOC, WISCONSIN	DR. DRN	DWG. NO. 5647
4-25-96 DRN C ADDED	W/EDER EPIC● CONTROL	MODEL 888	CK. MK	
8-23-95 DRN A B ADDED	12V CONTROL-24V START		APP. JS	SHEET SHT.10



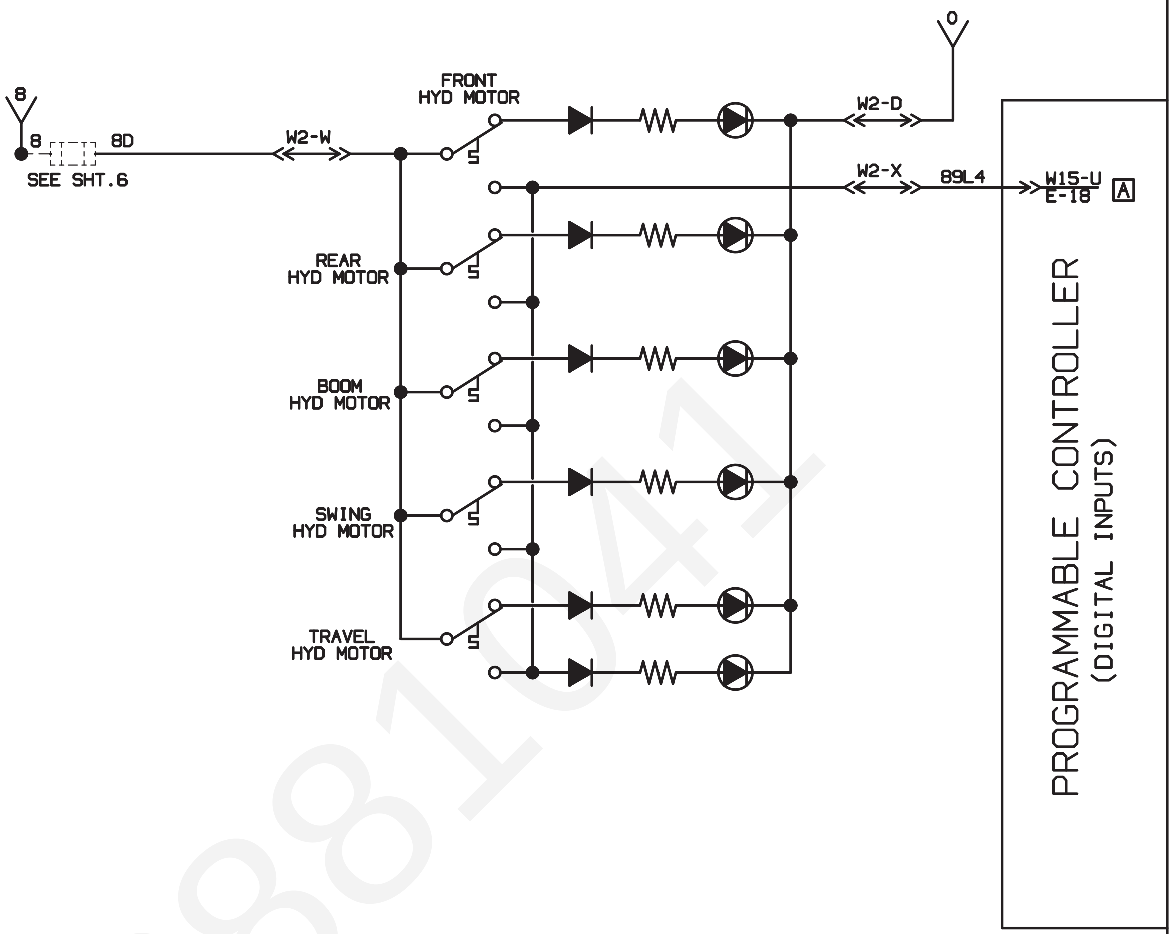
REVISIONS				
2-13-98 KLW CONTACTS ADDED FOR W2AUX CABLE 12-17-96 DRN W18-b WAS 80R W15-g WAS 82R W15-h WAS 86C B C D E ADDED F G H J VDC POLARITY CORRECTED 4-25-96 DRN A VDC POLARITY CORRECTED	ELECTRICAL SCHEMATIC POWER PLANT AND CONTROLS W/EDER EPIC® CONTROL 12V CONTROL-24V START	MANITOWOC ENGINEERING CO. MANITOWOC, WISCONSIN MODEL 888	SCALE DR. DRN CK. MK APP. JS	DATE 3-21-95 DWG. NO. 5647 SHEET SHT.11

SET -UP REMOTE

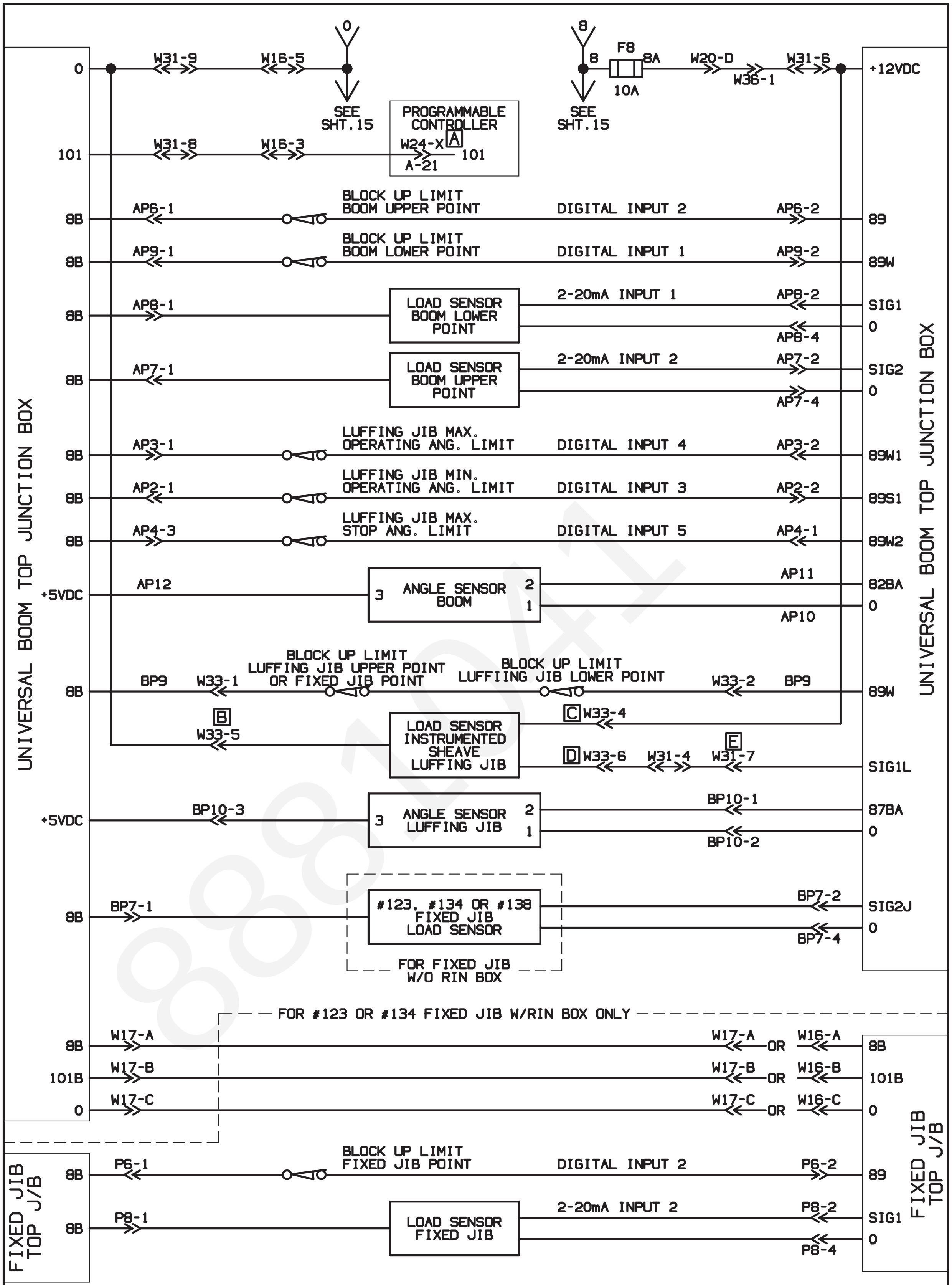


ELECTRICAL SCHEMATIC	MANITOWOC ENGINEERING CO.	SCALE	DATE 3-21-95	
POWER PLANT AND CONTROLS	MANITOWOC, WISCONSIN	DR. DRN	DWG. NO. 5647	
W/EDER EPIC● CONTROL	MODEL 888	CK. MK		
12V CONTROL-24V START		APP. JS	SHEET SHT.12	

12-21-95 TMB
A B ADDED
REVISIONS

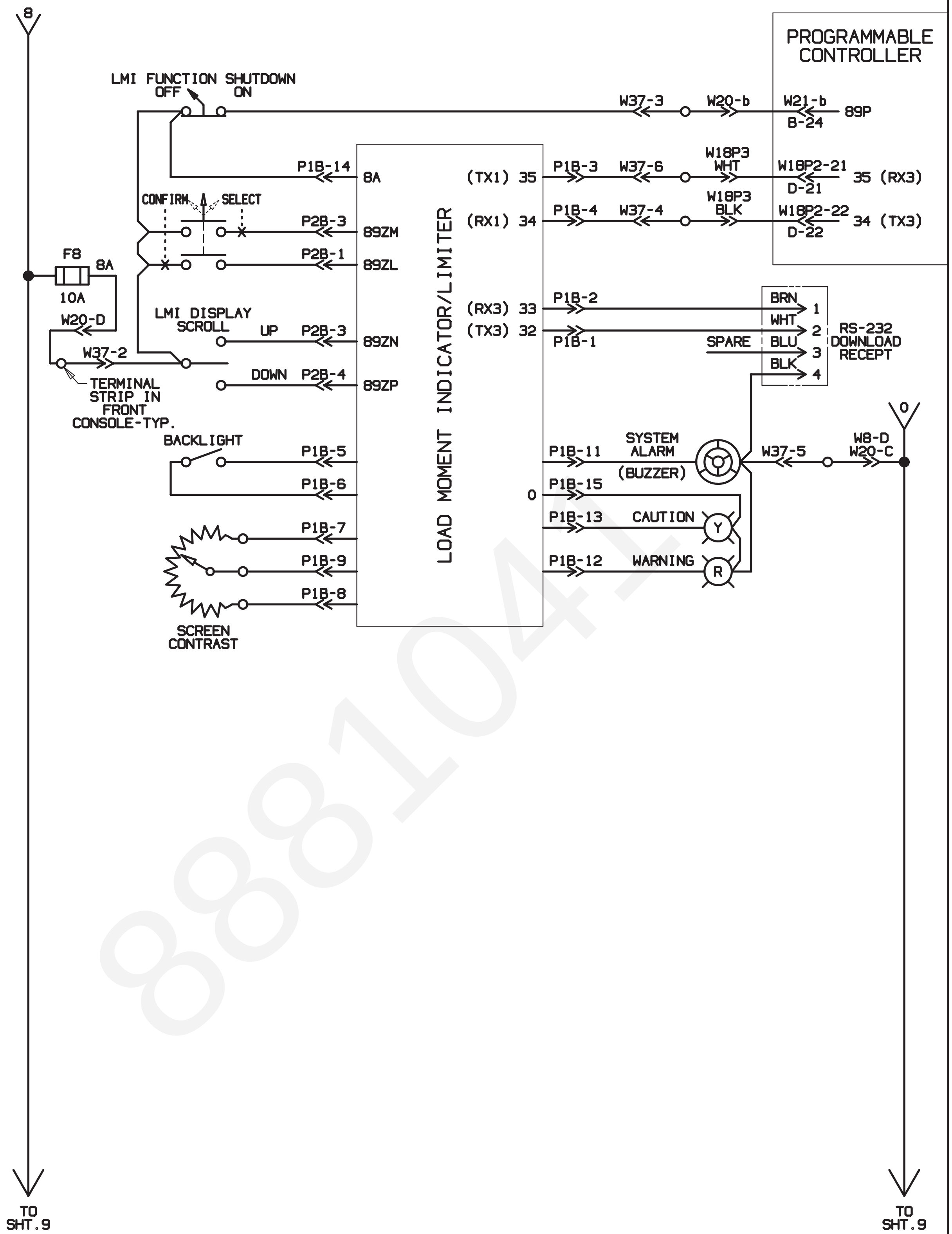


2-13-98 KLW DELETED AUX. HYD. MOTOR	ELECTRICAL SCHEMATIC	MANITOWOC ENGINEERING CO.	SCALE	DATE 12-21-95
7-14-97 DRN	POWER PLANT AND CONTROLS	MANITOWOC, WISCONSIN	DR. TMB	DWG. NO. 5647
A WAS W15-V & E-19	W/EDER EPIC® CONTROL	MODEL 888	CK. MK	
REVISIONS	12V CONTROL-24V START		APP. JS	SHEET SHT.13



THIS DRAWING FOR USE WITH MACHINES EQUIPPED WITH UNIVERSAL BOOM TOP JUNCTION BOX ONLY

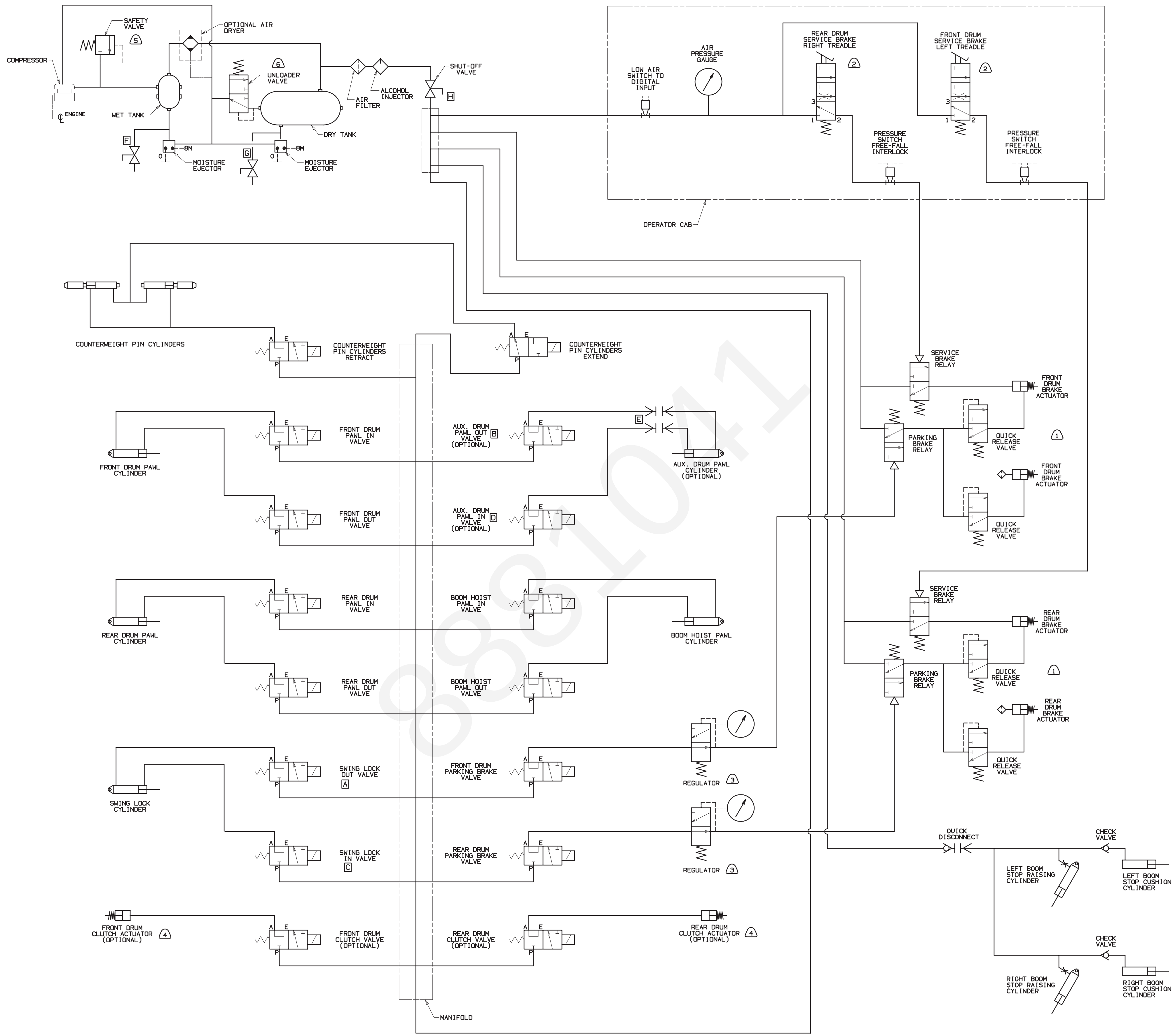
2-7-01 MWK				
E WAS W31-4	ELECTRICAL SCHEMATIC	Manitowoc Cranes, Inc.	SCALE	DATE 7-27-00
D WAS W33-4	POWER PLANT AND CONTROLS	Manitowoc, Wisconsin	DR. KLW	DWG. NO. 5647
C WAS W33-5 B WAS W33-4 A WAS W24-K, A-10	W/EDER EPIC® CONTROL	MODEL 888	CK. MWK	
REVISIONS	12V CONTROL-24V START		APP. JS	SHEET SHT.14



SUPERSEDES 5647 SHT.15 OF 7-27-00

THIS DRAWING FOR USE WITH MACHINES EQUIPPED WITH MANITOWOC LOAD MOMENT INDICATOR/LIMITER ONLY

REVISIONS	ELECTRICAL SCHEMATIC	Manitowoc Cranes, Inc.	SCALE	DATE 2-7-01
	POWER PLANT AND CONTROLS	Manitowoc, Wisconsin	DR. KLW	DWG. NO. 5647
	W/EDER EPIC● CONTROL	MODEL 888	CK. MWK	
	12V CONTROL-24V START		APP. JS	SHEET SHT.15



1. BRAKE ACTUATOR
   PARKING CHAMBER: SPRING SET AIR RELEASED
   SERVICE CHAMBER: AIR SET SPRING RELEASED
2. DRUM BRAKE TREADLES:
   0-70 PSI MODULATED
   FULL AIR (4.8 BAR) PRESSURE WHEN LOCKED DOWN
3. REGULATOR SET FOR SPECIFIED BRAKE RELEASE RUNNING CLEARANCES. SEE BRAKE ASSEMBLY FOR INSTRUCTIONS.
4. CLUTCH ACTUATOR
   SPRING SET AIR RELEASED
5. SAFETY VALVE SET AT 165 PSI (11.4 BAR).
6. UNLOADER SET AT 120 PSI (8.3 BAR) + 12 PSI (0.8 BAR) RANGE

BILL OF MATERIAL

ITEM NO.	REQD. NO.	DESCRIPTION	LENGTH	MATERIAL	CODE NO. OR DWG. NO

ASSEMBLIES USED ON

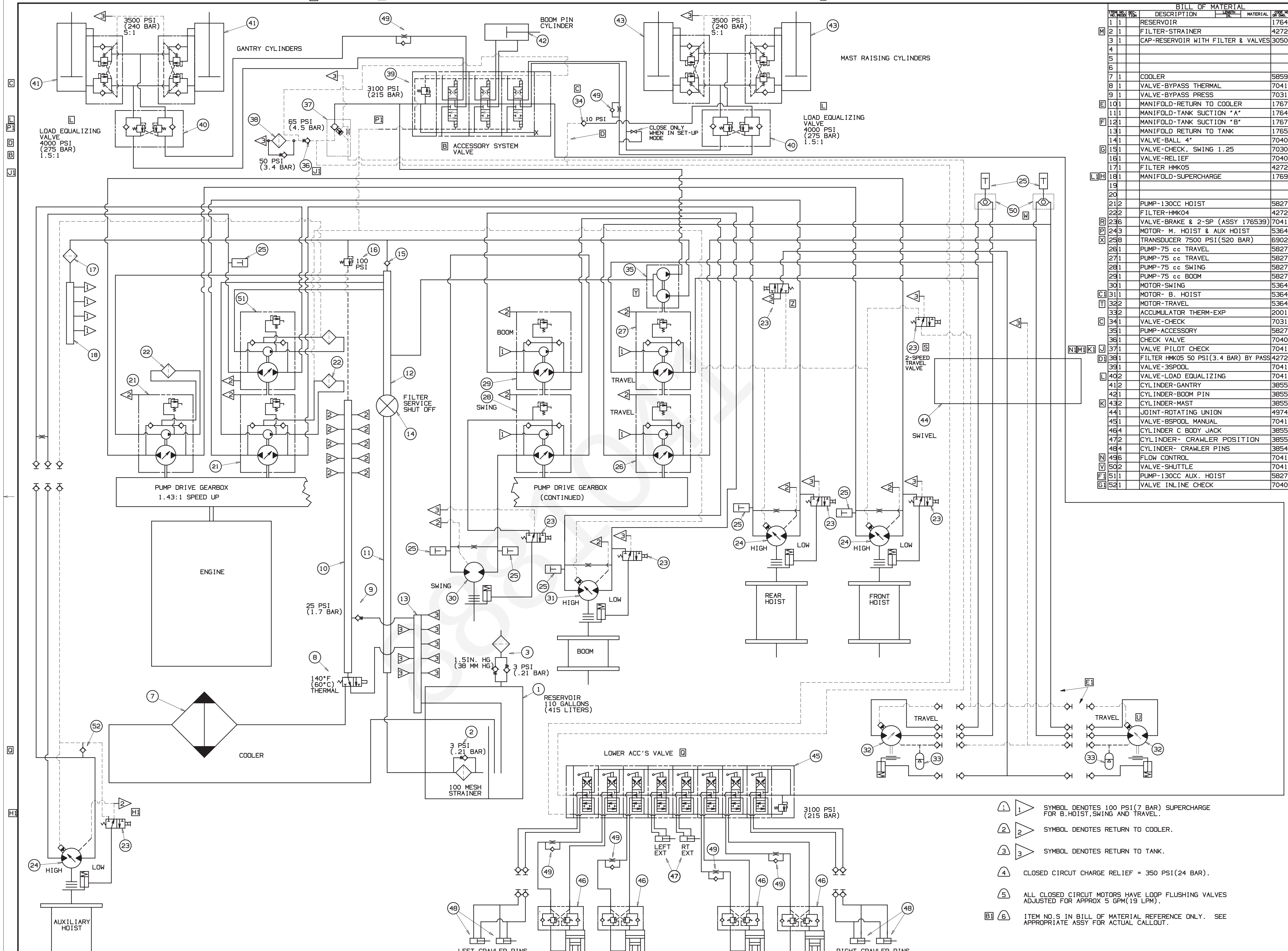
REVISIONS
2-1-96 TMB
AB WAS IN
CD WAS OUT
EFGH ADDED

DWG. NO. 6369

TOLERANCE UNLESS OTHERWISE SPECIFIED				
DECIMAL PLACES	FABRICATION		MACHINING	
	≤ 10 FEET	> 10 FEET		√ = MACHINING TOLERANCE APPLIES TO THIS DIMENSION AND/OR SURFACE
(1) PLACE 0.0	±.120	±.180	±.030	
(2) PLACE 0.00	±.060	±.120	±.015	
(3) PLACE 0.000			±.005	
ANGLES	±1°30′		±0°30′	

SCALE
DR. KLW
CK. KLW
APP JS
Manitowoc Cranes, Inc.
Manitowoc, Wisconsin
MODEL 888
AIR SCHEMATIC
DATE 2-7-95
PATTERN NO.
DWG. NO. 6369

DO NOT SCALE THIS DRAWING



BILL OF MATERIAL

ITEM NO.	NO. REQD	SECTION	DESCRIPTION	LENGTH IN.	MATERIAL	CODE NO. OR DWG. NO
1	1		RESERVOIR			176449
2	1		FILTER-STRAINER			427281
3	1		CAP-RESERVOIR WITH FILTER & VALVES			305003
4						
5						
6						
7	1		COOLER			585910
8	1		VALVE-BYPASS THERMAL			704118
9	1		VALVE-BYPASS PRESS			703119
10	1		MANIFOLD-RETURN TO COOLER			176761
11	1		MANIFOLD-TANK SUCTION "A"			176448
12	1		MANIFOLD-TANK SUCTION "B"			176762
13	1		MANIFOLD RETURN TO TANK			176515
14	1		VALVE-BALL 4"			704058
15	1		VALVE-CHECK, SWING 1.25			703012
16	1		VALVE-RELIEF			704084
17	1		FILTER HMK05			427279
18	1		MANIFOLD-SUPERCHARGE			176974
19						
20						
21	2		PUMP-130CC HOIST			582716
22	2		FILTER-HMK04			427278
23	6		VALVE-BRAKE & 2-SP (ASSY 176539)			704115
24	3		MOTOR- M. HOIST & AUX HOIST			536460
25	8		TRANSDUCER 7500 PSI(520 BAR)			690265
26	1		PUMP-75 cc TRAVEL			582712
27	1		PUMP-75 cc TRAVEL			582713
28	1		PUMP-75 cc SWING			582714
29	1		PUMP-75 cc BOOM			582715
30	1		MOTOR-SWING			536450
31	1		MOTOR- B. HOIST			536465
32	2		MOTOR-TRAVEL			536462
33	2		ACCUMULATOR THERM-EXP			200141
34	1		VALVE-CHECK			703121
35	1		PUMP-ACCESSORY			582717
36	1		CHECK VALVE			704090
37	1		VALVE PILOT CHECK			704162
38	1		FILTER HMK05 50 PSI(3.4 BAR) BY PASS			427284
39	1		VALVE-3SPOOL			704116
40	2		VALVE-LOAD EQUALIZING			704113
41	2		CYLINDER-GANTRY			385556
42	1		CYLINDER-BOOM PIN			385553
43	2		CYLINDER-MAST			385558
44	1		JOINT-ROTATING UNION			497408
45	1		VALVE-8SPOOL MANUAL			704117
46	4		CYLINDER C BODY JACK			385554
47	2		CYLINDER- CRAWLER POSITION			385552
48	4		CYLINDER- CRAWLER PINS			385449
49	6		FLOW CONTROL			704119
50	2		VALVE-SHUTTLE			704130
51	1		PUMP-130CC AUX. HOIST			582720
52	1		VALVE INLINE CHECK			704097

1 SYMBOL DENOTES 100 PSI(7 BAR) SUPERCHARGE FOR B.HOIST,SWING AND TRAVEL.

2 SYMBOL DENOTES RETURN TO COOLER.

3 SYMBOL DENOTES RETURN TO TANK.

4 CLOSED CIRCUT CHARGE RELIEF = 350 PSI(24 BAR).

5 ALL CLOSED CIRCUT MOTORS HAVE LOOP FLUSHING VALVES ADJUSTED FOR APPROX 5 GPM(19 LPM).

6 ITEM NO.S IN BILL OF MATERIAL REFERENCE ONLY. SEE APPROPRIATE ASSY FOR ACTUAL CALLOUT.

Manitowoc Cranes, Inc.
Manitowoc, Wisconsin

HYD SCHEMATIC

MODEL 888

DWG. NO. 176837

DATE 01-30-95

DO NOT SCALE THIS DRAWING

Operator’s Manual 1-8 Numeric Tabs

MANITOWOC 888

SHOP PROCEDURE

Table of Contents

General

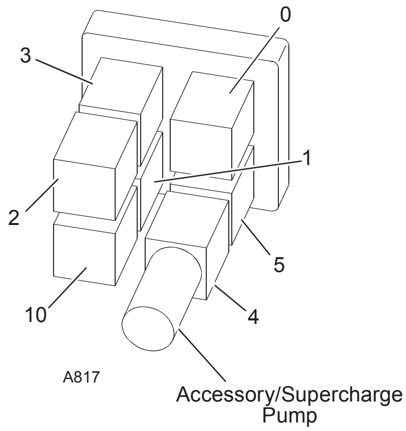
This publication covers hydraulic adjustments for the hydraulic system and related components on the 888 crane.

Experienced technicians, trained in the operation of this crane and its hydraulic system, shall perform the procedures in this publication. These technicians shall read, understand, and comply with the instructions in this publication.

Contact the factory Service Department for a detailed explanation of any procedure not fully understood.

All adjustments identified in this publication were made to the crane before it was shipped from the factory. Adjustments by field personnel are required only when parts are replaced or when instructed by the factory Service Department.

Comply with the pressure and flow settings specified in this publication. Altering settings without the approval of the factory Service Department can damage crane components or cause the crane to operate improperly. Correct procedures for connecting hydraulic fittings are in the Hydraulic System Maintenance Folio in Section 8 of the crane Operator's Manual.



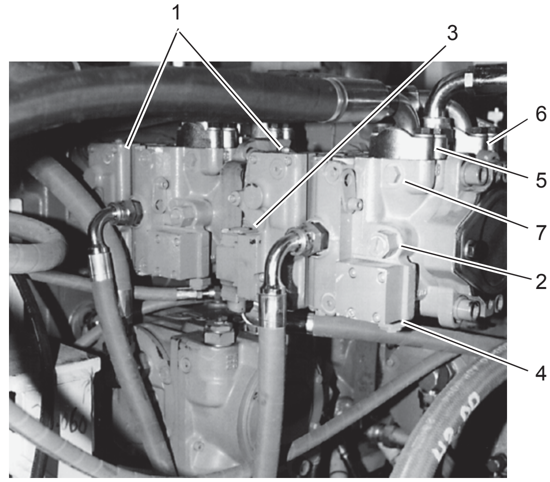
A817

Pump Identification

Pump Number	Identification
0	Front Load Drum
1	Rear Load Drum or Luffing Hoist
2	Boom Hoist
3	Swing
4	Right Crawler
5	Left Crawler
10	Auxiliary Load Drum

Pump Port Identification

Pump Number	Port A	Port B
0, 1, 2, 10	Raise	Lower
3	Right	Left
4	Forward	Reverse
5	Reverse	Forward

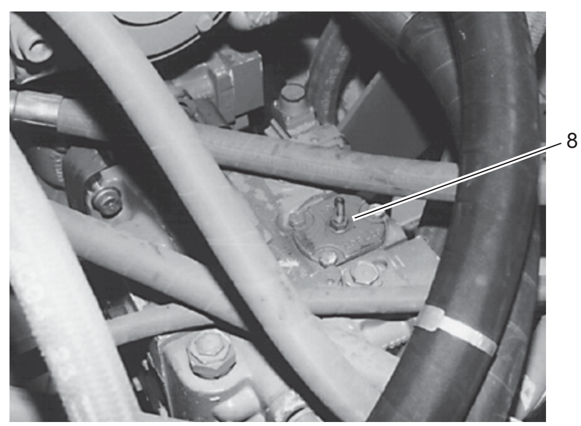


P100

Pump Components

1	Neutral Adjusting Screw
2	Charge Pressure Relief
3	Manual Override
4	Multi-Function Valve (2 each pump)[1]
5	Pump Port A
6	Pump Port B
7	High Pressure Gauge Port (1 each pump port)
8	Displacement Adjusting Screw

[1] Valve directly opposite port it protects.



P101

FIGURE 1

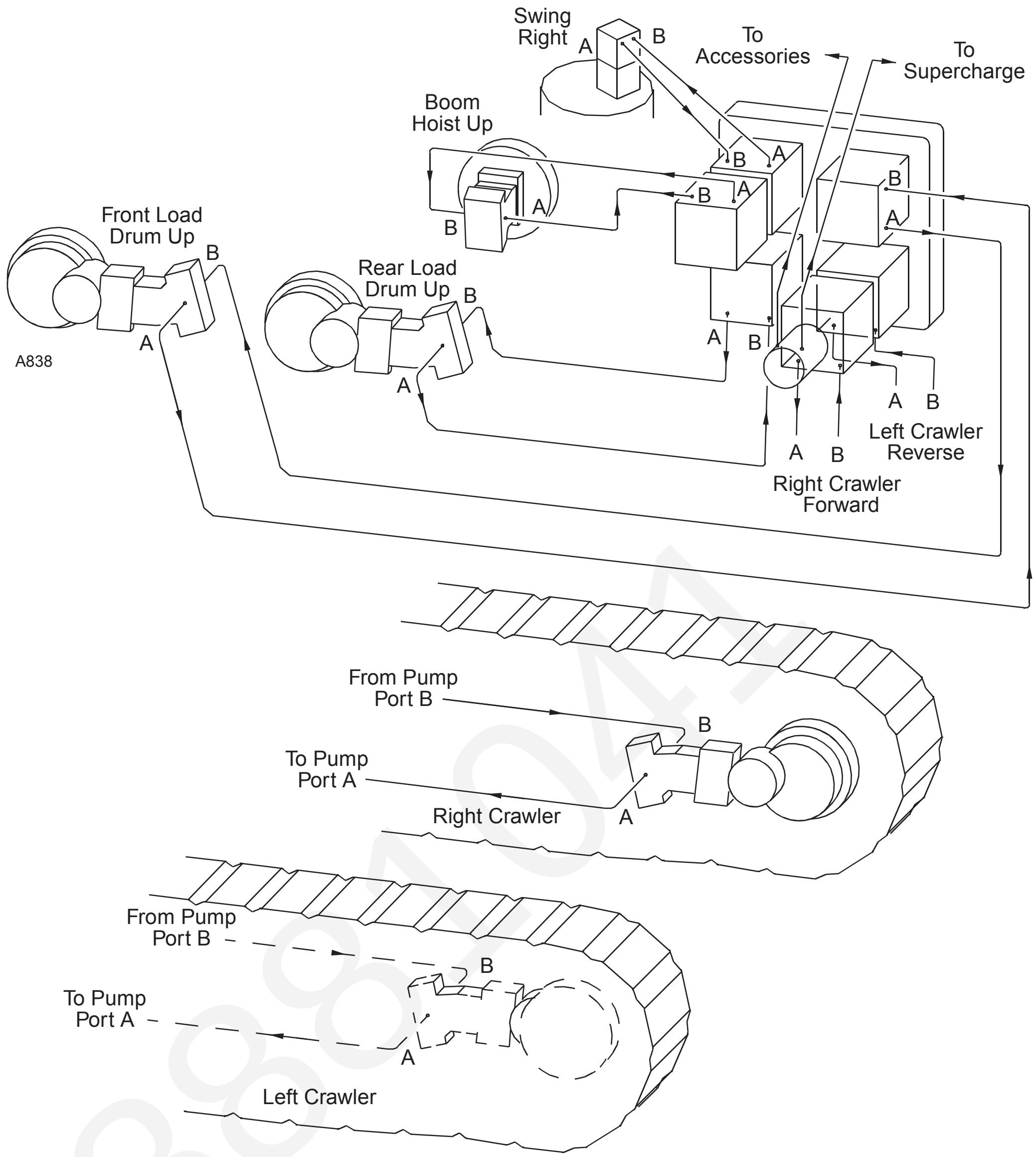

Swing
Right
A
B
To
Accessories
To
Supercharge
Boom
Hoist Up
B
A
B
A
B
A
A
B
Front Load
Drum Up
B
A
A838
Rear Load
Drum Up
B
A
A
B
A
B
Left Crawler
Reverse
A
B
Right Crawler
Forward
From Pump
Port B
B
To Pump
Port A
A
Right Crawler
From Pump
Port B
B
To Pump
Port A
A
Left Crawler

FIGURE 2

Initial Oil Fill

1. Check that arrows on filter fittings and filters for front and rear load drum pumps point in same direction as flow of hydraulic oil through system (Figure 3).

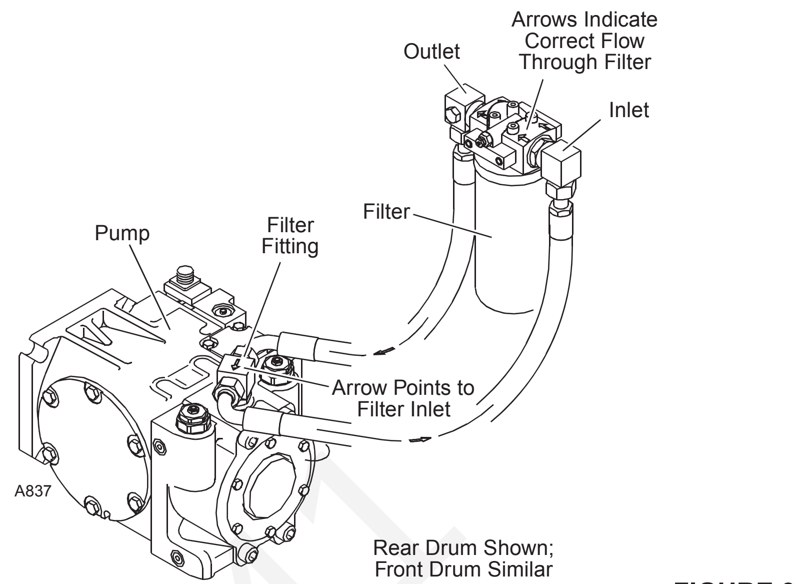


FIGURE 3

CAUTION

Equipment Damage! Filters and fittings incorrectly installed will damage pumps and motors. Arrow on filter fitting must point toward filter inlet.

2. Fill all motor cases with oil (Figure 4).
   a. Disconnect fittings at case drain ports.
   b. Fill each motor case to level of case drain port. *Use new hydraulic oil which has been filtered through a 10-micron filter.*
   c. Reconnect fittings.
3. Check that pump cases are filled with oil. *Do not fill following items at this time:*
   - Hydraulic filters.
   - Accessory/supercharge pump.
   - Auxiliary drum pump (if equipped).

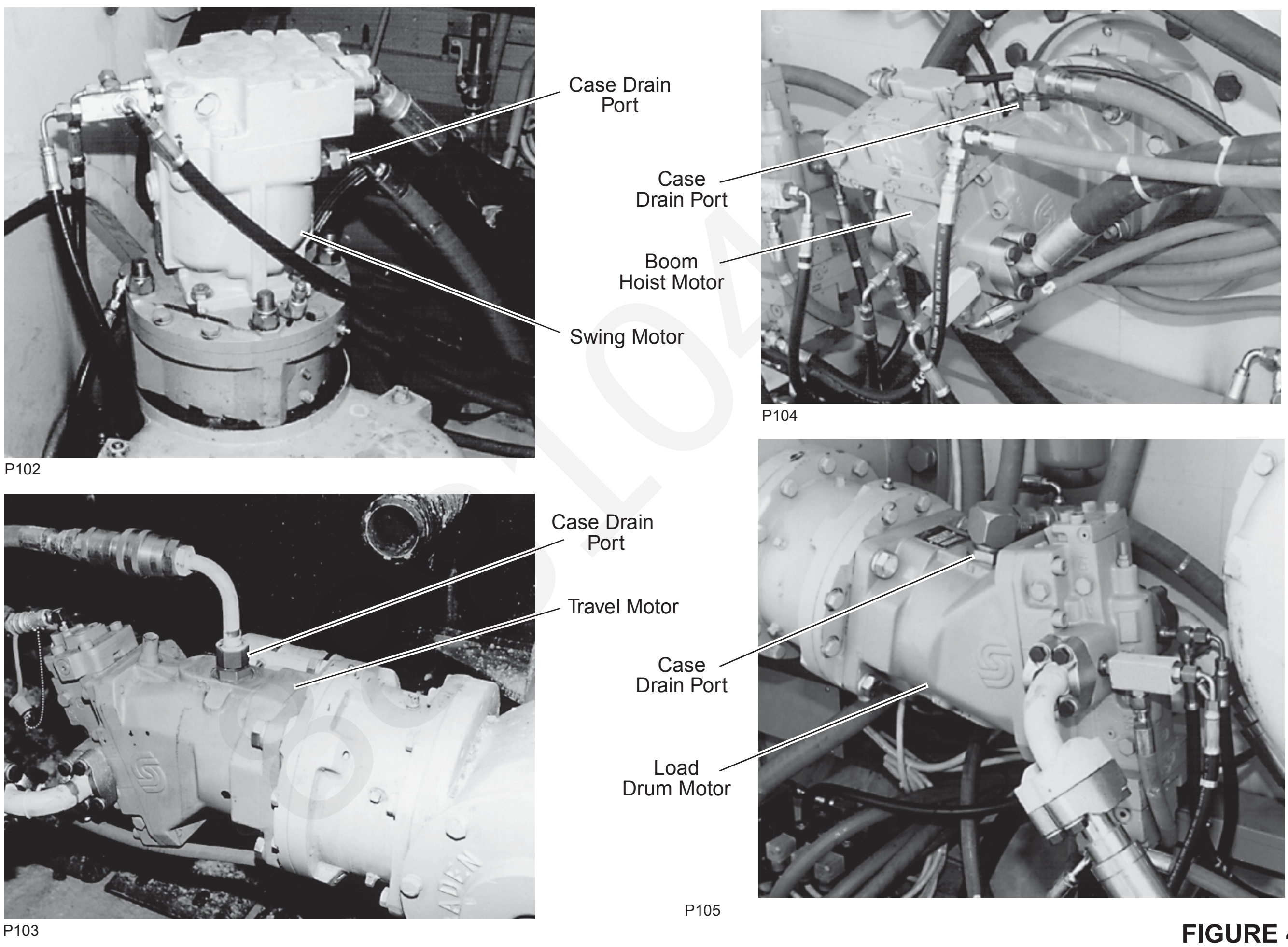


FIGURE 4

4. Make sure main shutoff valve is fully opened (Figure 5). Insert locking bolt (if provided).

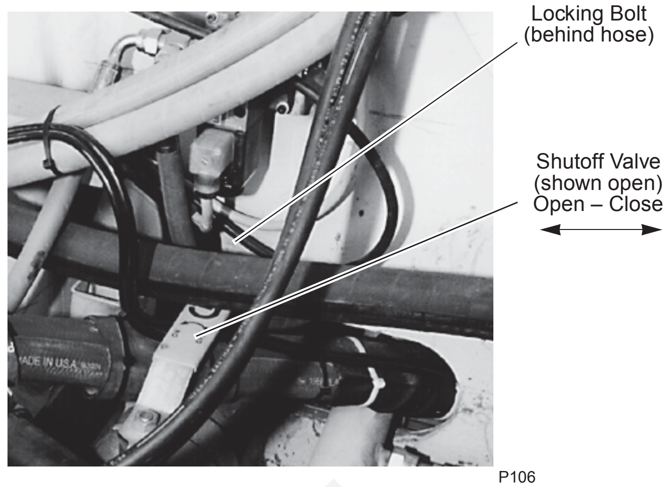


FIGURE 5

5. At engine, check that engine clutch is engaged (Figure 6).

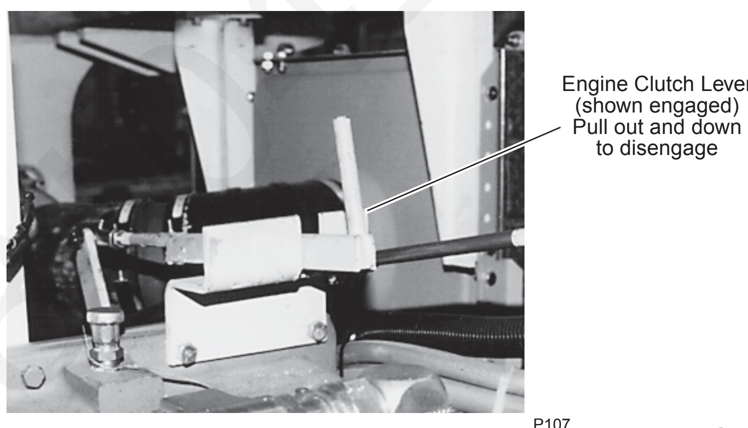


FIGURE 6

6. Remove cap from bleed port at Filters 1, 2, and 3 (Figure 7).
   Past production cranes do not have bleed ports at filters. For these units, crack open fitting at outlet hose of each filter.

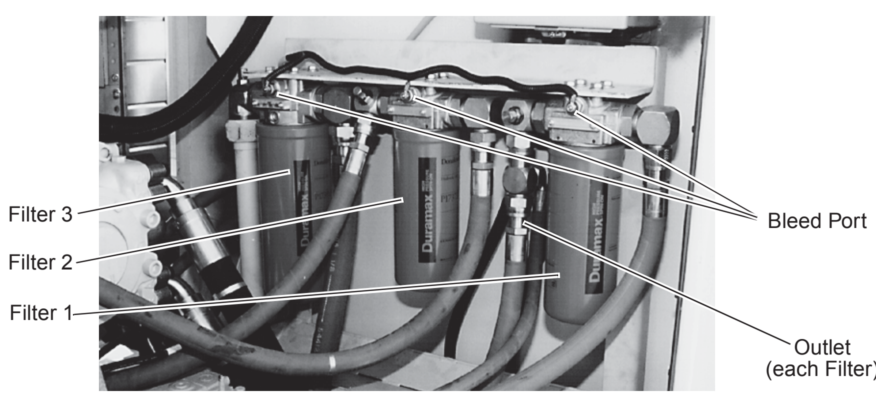


FIGURE 7

7. Loosen fittings at both outlet ports at top of accessory/supercharge pump (Figure 8).
8. Disconnect case drain hose at top of auxiliary drum pump (Figure 8).

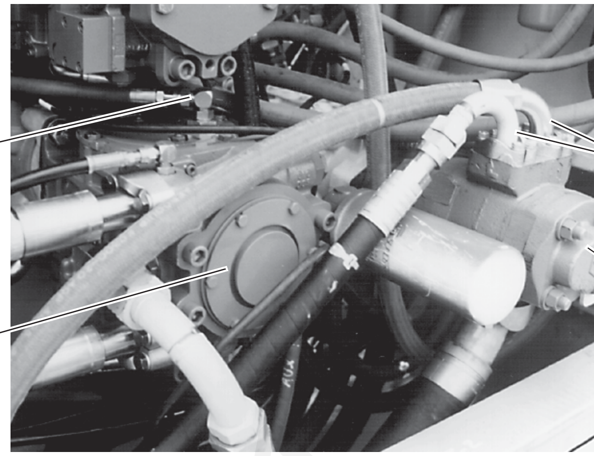


FIGURE 8

9. Fill hydraulic tank to FULL HOT level mark on sight gauge (Figure 9).

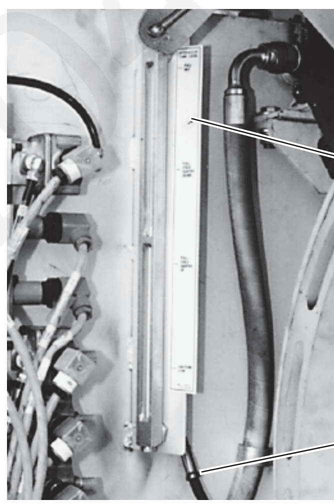


FIGURE 9

10. Bleed hydraulic tank sight gauge hose:
    a. Disconnect hose at base of gauge (Figure 9).
    b. Allow hose to hang straight down into a container.
    c. Allow oil to flow freely from hose until oil is clear (no air bubbles in oil).
    d. Reconnect hose to gauge.
11. As tank is filling, monitor accessory/supercharge pump outlet ports for oil leakage (Figure 8). Oil will flow by gravity from hydraulic tank to these ports. Securely tighten fittings when oil appears.

12. If equipped with an auxiliary drum pump, proceed as follows as tank is filling:
    a. Check to see if oil is coming out case drain port at top of pump (Figure 8).
    b. If oil is coming from pump, securely reconnect case drain hose.
    c. If no oil is coming from pump:
        - Remove fitting from case drain port.
        - Fill pump to level of case drain port. *Use new hydraulic oil filtered through a 10-micron filter.*
        - Securely reconnect fitting and hose at case drain port.
13. Monitor Filter 3 (Figure 7). Oil will flow by gravity from hydraulic tank to filter.

    Securely install cap on bleed port or securely tighten outlet fittings when oil appears.
14. Remove electrical plug from engine fuel solenoid (Figure 10) to keep engine from starting while filling filters and testing system pressures.

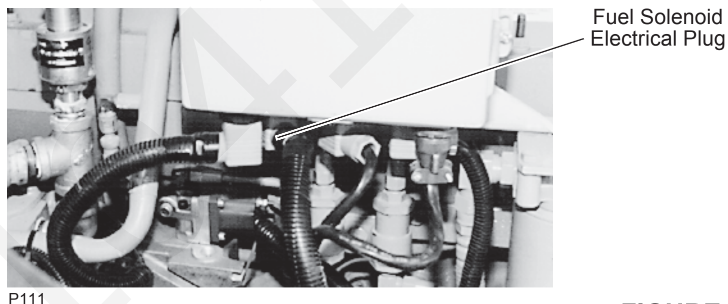


FIGURE 10

15. Crank engine for 10 seconds. Oil should appear at bleed port or outlet hose fittings at Filters 1 and 2 (Figure 7). If oil does not appear, crank engine for 10 more seconds.

    Securely install cap on bleed ports or securely tighten outlet fittings when oil appears.

Initial Start-Up

1. Connect 0 – 500 psi (0 – 34.5 bar) hydraulic gauge to quick-connect coupler at supercharge relief valve (Figure 11).

NOTE: Do not confuse supercharge relief valve with charge pressure relief valves on pumps.

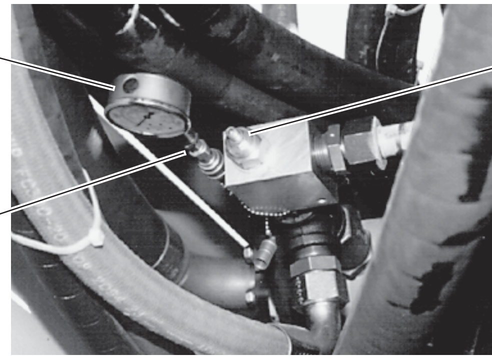


FIGURE 11

2. Loosen locknut. Turn supercharge relief valve all the way out counterclockwise (Figure 11).
3. Connect bleed lines to quick-connect couplers on transducer manifold (Figure 12). Open bleed valve on each line. Use a suitable container to catch oil flow from bleed lines.

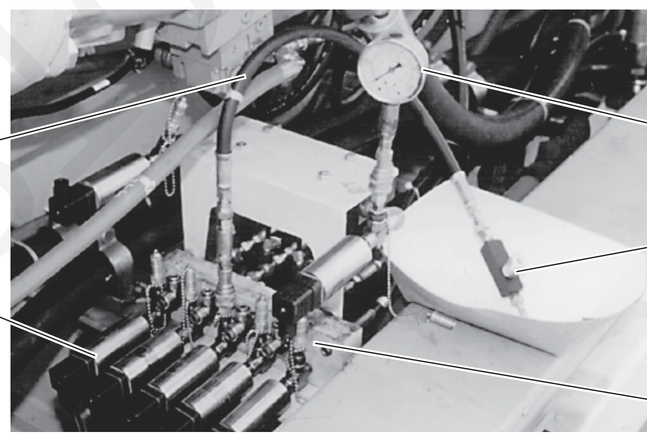


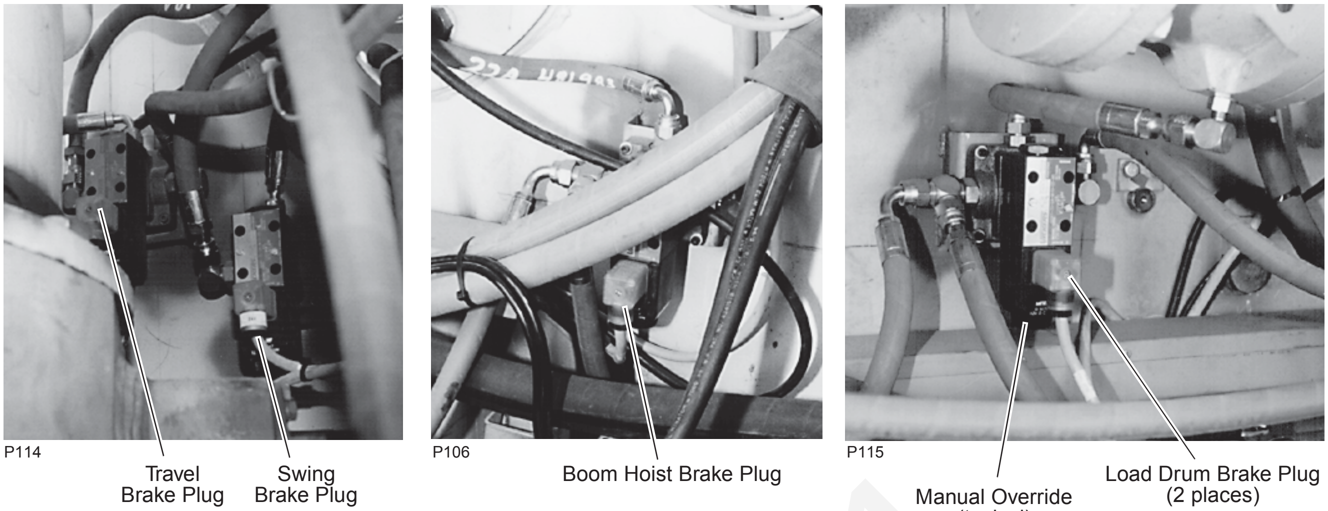
FIGURE 12

4. Reconnect electrical plug at engine fuel solenoid (Figure 10).

WARNING

Personal Injury Hazard! With engine running, crane components can operate unexpectedly while system pressures are checked and adjusted. Disconnect power to brake valves before beginning adjustments.

5. Disconnect electrical plugs at all brake valves (five places) to prevent accidental operation of crane functions (Figure 13).



Note: For all brake valves, manual override can be activated from bottom of valve.

FIGURE 13

NOTE: The following procedures require rapid response to changing operating conditions. Two people are needed for checking pressures and making adjustments. Become familiar with these procedures before starting the engine.

6. With all control handles in off, start engine and allow it to idle at 950 – 1,000 rpm.

   Have one person bleed pressure transducers (step 7) while a second person checks pressures (step 8).

7. Bleed pressure transducers:
   a. Observe oil flowing from bleed line at each transducer (Figure 12).
   b. Close each bleed valve when a clear, steady stream of oil appears (no air bubbles in oil).

CAUTION

Equipment Damage! Pump pressures displayed in operator's cab must be checked during first minute of operation. If pressure for any pump is less than 200 – 500 psi (13.8 – 34.5 bar), shut down engine immediately to prevent pump damage. Call factory Service Department for instructions.

---

8. In operator's cab, check pump pressures for following pumps: front and rear load drums, boom hoist, swing, left and right travel and auxiliary load drum (refer to Diagnostic Display folio for detailed information). These pressures must be checked during first minute of operation. To check pressures:
   a. Press limit by-pass switch and scroll up to activate diagnostic display screens.
   b. Scroll through diagnostic screens to check pump pressures.

c. Make sure all pressure readings for pumps are 200 – 500 psi (13.8 – 34.5 bar). Pump pressures will be adjusted to final setting later in this procedure.

d. If pump pressures are not within acceptable range, stop engine immediately. *Take corrective action to determine cause of faulty pressure.*

9. Turn supercharge pressure relief valve (Figure 11) in (clockwise) until pressure on gauge reads 75 – 100 psi (5.1 – 6.9 bar).
10. With engine running at low idle, bleed air from front and rear load drum brakes, boom hoist brake, swing brake, and both travel brakes:
    a. Crack open bleed screw at desired brake (Figure 14).
    b. Using a 1/8 in. (3 mm) diameter rod, push in manual override at bottom of corresponding brake valve to apply brake.

       Manual override at travel brake valve operates both travel brakes.
    c. Securely close bleed screw when a clear, steady stream of oil appears (no air bubbles in oil).
11. Remove bleed lines from quick-connect couplers at transducer manifold (Figure 12). Install dust cap over each coupler.
12. Remove gauge from quick-connect coupler at supercharge relief valve (Figure 11). Install dust cap over coupler.
13. Do not reconnect electrical plugs to brake valves at this time. Electrical plugs will be reconnected later in procedure.

NOTE: *M.E.C. Shop Personnel* - pressures and speeds noted in remaining procedures and any adjustments you make to correct them must be recorded in RECORD OF INSPECTION form for crane you are working on.

Charge Pressure Checks

Check charge pressure for each pump (both load drums, boom hoist, swing, and both travel) one at a time, as follows:

NOTE: Charge pressure can also be monitored on the diagnostic screen for each function. Charge pressure shown on the diagnostic screens can vary ±100 psi (6.9 bar) from that shown on the pressure gauges.

1. Connect 0 – 1,000 psi (0 – 68.9 bar) hydraulic pressure gauge to quick-disconnect coupler for desired pump (Figure 12).
2. Start engine and allow it to idle at 950 – 1,000 rpm.
3. Note and record gauge reading. Gauge should read 325 – 375 psi (22.4 – 25.8 bar).

   If proper pressure is not obtained, adjust charge pressure relief valve for corresponding pump. Refer to instructions in pump manufacturer’s manual.
4. Stop engine and remove gauge from quick-connect coupler (Figure 12). Install dust cap over coupler.

Operating Pressure Checks

NOTE: For all pumps except swing, system pressure is preset at 6,000 psi (413 bar). For swing pumps, system pressure is preset at 5,000 psi (345 bar).

Electrical plugs at brake valves must be disconnected to stall crane functions during pressure checks (see Initial Start-Up step 5).

1. Start engine and allow it to idle at 950 – 1,000 rpm.
2. Scroll to corresponding diagnostics screen for pump to be checked. Monitor “pump pressure” and “pump command” while moving control handles.
3. Select and confirm SETUP mode (faulty pressures will be recorded in any other mode).
4. For both load drums and boom hoist, slowly pull control handle back to check pressure in hoist direction only.

   For travel and swing move control handle in both directions, one at a time, to check pressure in both directions.
5. Specified operating pressure must be reached before 50% pump command is reached and brake must not slip.

   If specified operating pressure is not indicated or brake slips, *determine cause of problem and take corrective action*.
6. Reconnect electrical plugs at all brake valves once operating pressures have been checked.

Operating Speed Checks

Check operating speeds for below listed functions with engine running at high idle (2,100 rpm) and control handles moved fully forward and back.

Load drum and boom hoist speeds are shown in diagnostics screen for each pump.

You must count number of revolutions upperworks rotates in one minute to determine swing speed. *Make sure crane is in an area where nothing will interfere with boom or upperworks while swinging.*

If proper speeds are not indicated, *determine cause of problem and take corrective action*.

Table 1
Operating Speeds

Function	**Speed** (rpm)	
Swing	Approximately 2	
	HOIST	LOWER
Front Drum	48 – 52	42 – 52
Rear Drum	48 – 52	42 – 52
Auxiliary Drum	65 – 70	60 – 70
Boom Hoist	39 – 43	

Accessory System Checks and Adjustments

The standard accessory system includes mast assist cylinders, gantry cylinders, and crawler lock cylinders. Optional equipment includes the carbody jack cylinders, crawler extend cylinders, and boom pin cylinders, if so equipped.

1. Lower boom to ground (if necessary).
2. Connect 0 – 5000 psi (0 – 344.5 bar) hydraulic pressure gauge to quick-connect coupler at accessory system unloader valve (Figure 15).
3. Using controls in operator’s cab, extend and retract all accessory system cylinders except gantry cylinders three times to vent any air remaining in system.

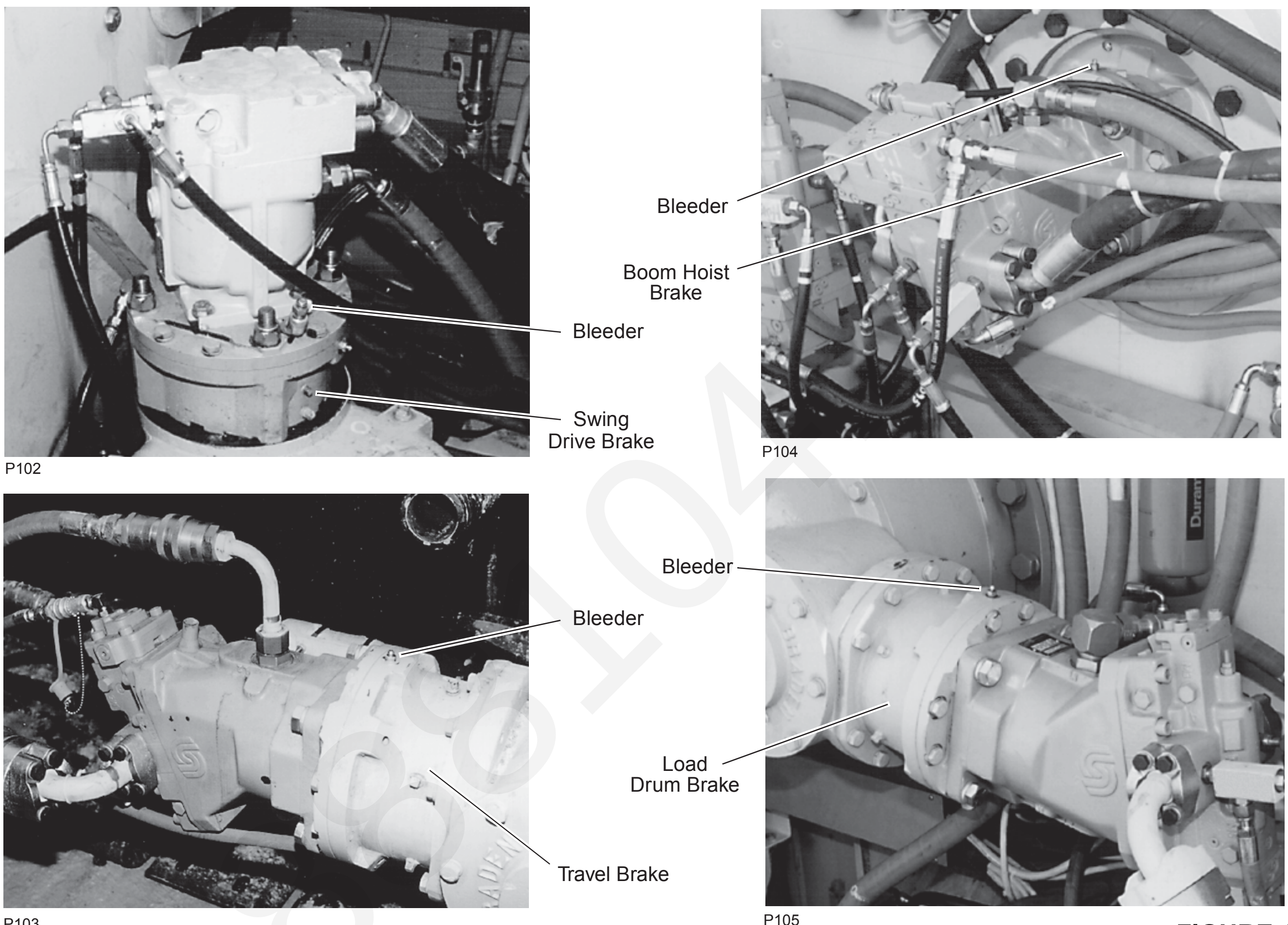


FIGURE 14

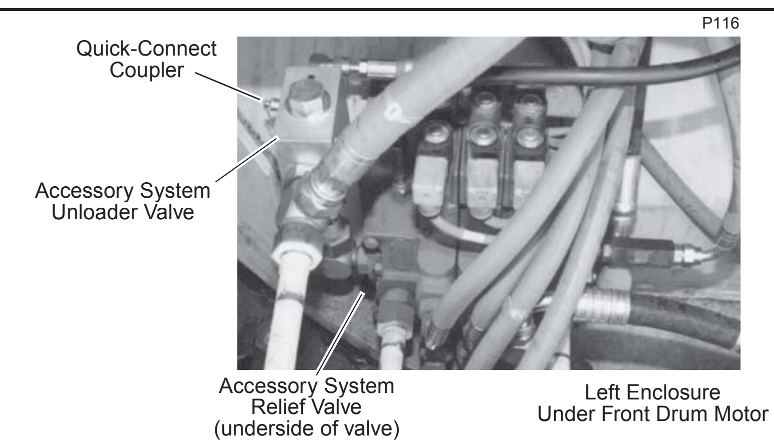


FIGURE 15

CAUTION

Structural Damage! Gantry cylinders must not twist structure of gantry. If gantry does not rise evenly, stop immediately and lower gantry to prevent structural damage. Reverse hydraulic connections on appropriate cylinder.

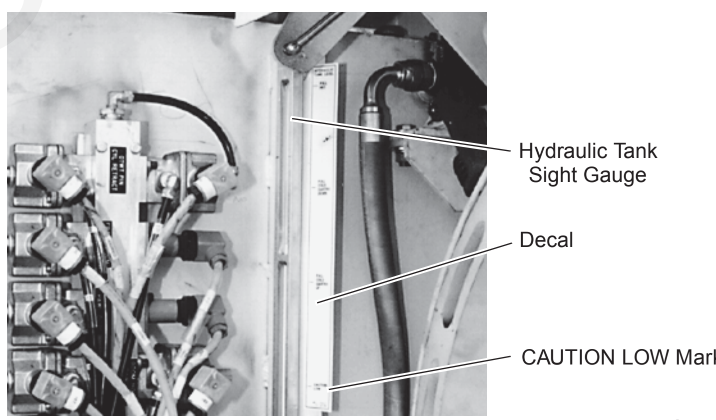
4. Check operation of gantry cylinders:
   a. Use remote setup control to operate gantry cylinders so that operation is clearly visible.
   b. Carefully extend gantry cylinders, and observe cylinder operation.
   c. If only one cylinder extends, stop and lower gantry immediately. Reverse hydraulic connections on cylinder which did not operate.
   d. With both gantry cylinders working properly, fully extend and fully retract cylinders three times to vent any air.
5. Fully extend or retract mast assist cylinders. Check pressure on gauge at accessory system unloader valve (Figure 15). Pressure should read between 3000 – 3200 psi (206.7 – 220.5 bar).

   If pressure is not within range specified, *determine cause of problem and take corrective action.*

NOTE: Steps 6 – 8 apply only to initial startup of hydraulic system on a new crane.

6. Fully extend all accessory system cylinders. Fault signal (beeper) for low oil level should sound when level at sight gauge is below CAUTION LOW mark (Figure 16).

   If alarm fails to sound, check electrical connections and interconnecting wiring. If cause for failure is not in electrical system, *determine cause of problem and take corrective action*.



P110

FIGURE 16

7. Fully retract all cylinders.
8. Refill hydraulic tank to proper FULL COLD level on decal (Figure 16).
9. Adjust cylinder flow controls for gantry, mast assist, and optional carbody jacks (if provided) (Figure 17).

NOTE: Flow control valves control speed of cylinders by restricting flow to retract side of cylinders.

Flow control valves must be installed in direction shown in Figure 17 or damage to components will result.

a. Stop engine.
b. Turn adjusting knob fully clockwise until snug.
c. For carbody jacking cylinders (4 places), turn adjusting knob out 3/4 turn and lock.
d. For mast assist (1 place), turn adjusting knob out 1-1/2 turns and lock.
e. For gantry (1 place), turn adjusting knob out 3-1/2 turns and lock.
f. To lock adjustment, insert roll pin into hole in knob. Pound roll pin down until flush with top of knob.

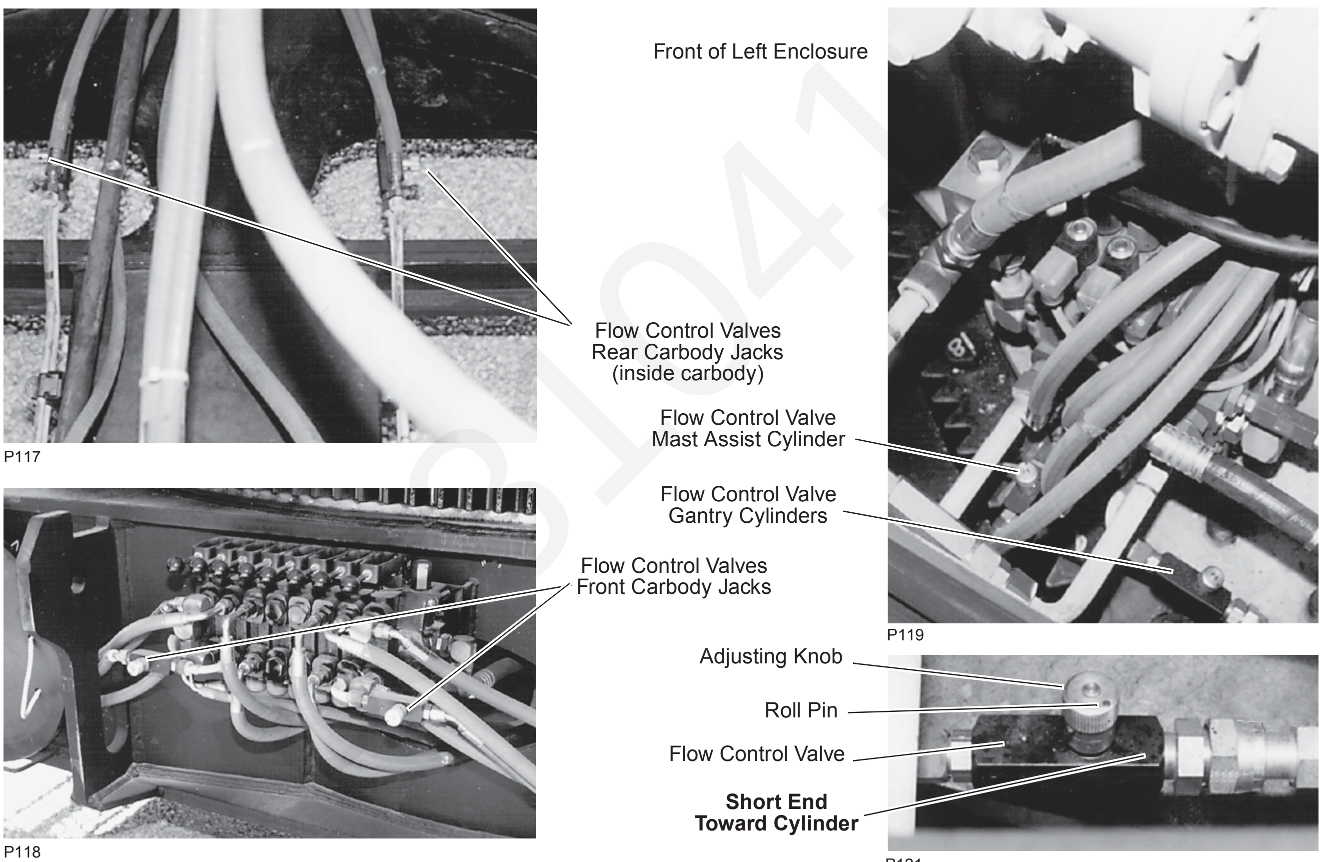


FIGURE 17

Travel Checks and Adjustments

Make all steering direction adjustments at the travel pumps (Figure 18). The pumps have a top and a bottom displacement adjusting screw. Adjusting steering requires slowing down the faster crawler.

Forward Steering

1. Start engine and set speed to high idle.
2. Push both crawler handles fully forward to travel FORWARD at full speed.

3. Travel approximately 100 feet (30 m), and stop. Check track prints on ground. Prints must be straight to within 1 foot (0.3 m) in 100 feet (30 m).
4. If track prints are not straight, adjust travel pumps as follows (Figure 18).
   a. Stop engine.
   b. If left track is fast (prints curve to right), adjust displacement screw on top of left pump. Loosen locknut and turn adjusting screw in 1/8 – 1/4 turn. Tighten locknut.
   c. If right track is fast, (prints curve to left), adjust displacement screw on bottom of right pump. Loosen locknut and turn adjusting screw in 1/8 – 1/4 turn. Tighten locknut.
5. Repeat steps 1 – 4 until track prints are straight as defined in step 3.

Reverse Steering

1. Start engine and set speed to high idle.
2. Pull both crawler handles fully back to travel REVERSE at full speed.
3. Travel approximately 100 feet (30 m), and stop. Check track prints on ground. Prints must be straight to within 1 foot (0.3 m) in 100 feet (30 m).
4. If track prints are not straight, adjust travel pumps as follows (Figure 18):
   a. Stop engine.
   b. If left track is fast (prints curve to right), adjust displacement screw on bottom of left pump. Loosen locknut and turn adjusting screw in 1/8 - 1/4 turn. Tighten locknut.
   c. If right track is fast, (prints curve to left), adjust displacement screw on top of right pump. Loosen locknut and turn adjusting screw in 1/8 – 1/4 turn. Tighten locknut.
5. Repeat steps 1 – 4 until track prints are straight as defined in step 3.

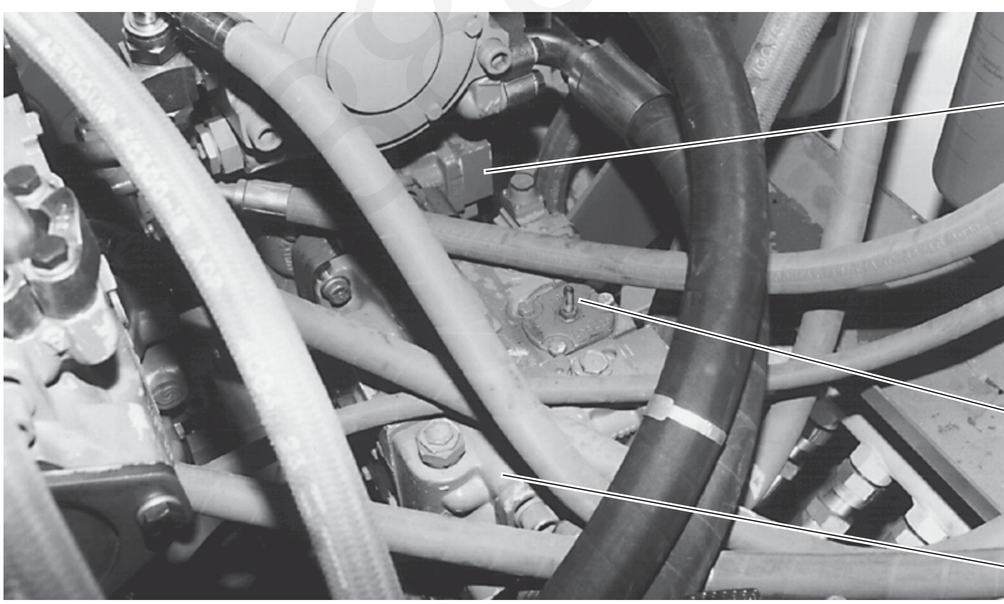


FIGURE 18

Travel Speed

After completing steering adjustments, check travel speed.

<u>Option A</u>

1. Put a timing mark on either front roller (Figure 19).

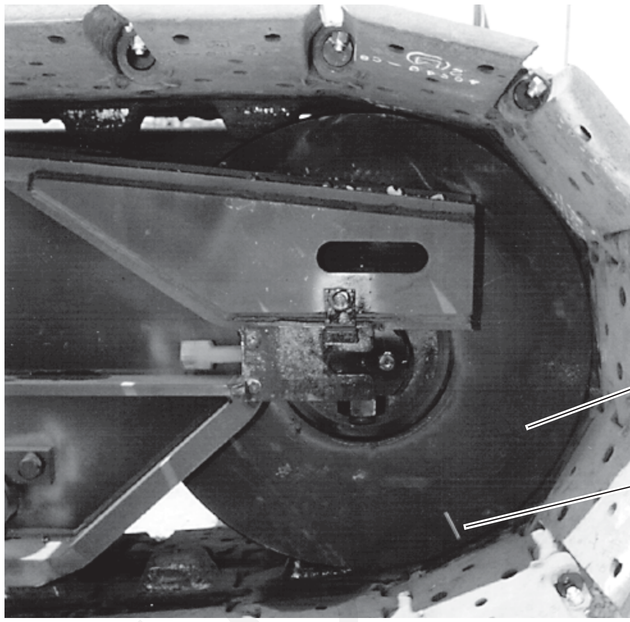


FIGURE 19

2. Start engine and set speed at high idle.
3. Push both crawler control handles fully forward to travel crane FORWARD at full speed.
4. Have an assistant count number of revolutions timing mark makes. Number should be 8-1/2 – 9 revolutions in one minute. If count does not fall within this range, *determine cause of problem and take corrective action*.

<u>Option B</u>

1. Start engine and set speed at high idle.
2. Push both crawler control handles fully forward to travel crane FORWARD at full speed.
3. Have an assistant count number of crawler pads that strike ground at front roller in one minute. At full speed 85 – 90 pads should pass over front roller during time specified.

NOTES

PROGRAMMABLE CONTROLLER CALIBRATION PROCEDURES

MODELS 777, 777T, 888, 2250

General

To ensure proper operation of the crane functions, the controls and pressure senders must be properly calibrated as described below.

Controls Calibration

The controls must be calibrated at the following intervals:

- When a pump is replaced.
- When a pump control (EDC or PCP) is replaced.
- When a boom hoist cylinder is replaced (Model 777 and 777T).
- When a new programmable controller is installed.
- When a new CPU board is installed.
- When a new controller chip is installed.
- When there is a noticeable increase in the time it takes a crane function to engage when the handle is pulled back from off.
- Every 6 months.

To calibrate the controls, proceed as follows:

1. Engage swing lock.
2. Calibrate pressure senders.
3. Start and run engine at 2,000 rpm or higher (2,100 rpm for Model 2250).
4. Depress and hold swing holding brake switch (on swing handle) for ONE MINUTE.
5. Repeat steps 3 and 4 a second time.

Pressure Sender Calibration

The pressure senders must be calibrated (zeroed) at the following intervals:

- When a new programmable controller is installed.
- When a new CPU board is installed.
- When a new controller chip is installed.
- When a pressure sender is replaced (refer to Pressure Sender Replacement folio in Operator’s Manual for procedure).
- When displayed pressure is wrong.
- Every 6 months.

To calibrate the pressure senders, proceed as follows:

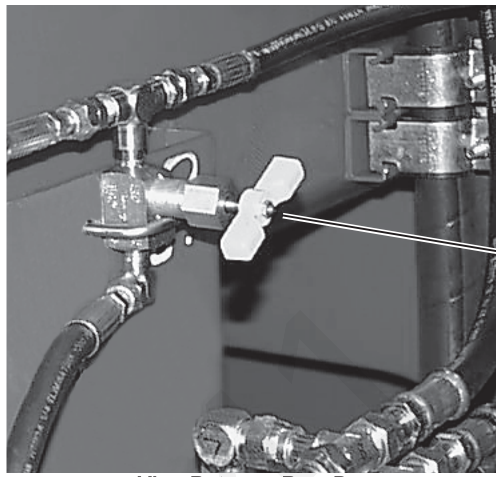
NOTE: Disregard steps 2a – 2c and 8a – 8h for Model 777 and 777T with programmable controller software version m00200i and newer. Refer to diagnostic screen on digital display to verify your software version.

1. Stop engine.
2. ***For Model 777 and 777T with programmable controller software version m00200h and older only,*** proceed as follows before going to step 3 (boom hoist pressure sender will not calibrate properly if following steps are not performed):
    a. *Securely close shut-off valve for boom hoist cylinder pressure sender* (Figure 1) — turn CLOCKWISE.
    b. Connect a bleed line equipped with a shut-off valve to coupler for boom hoist cylinder pressure sender (Figure 2).

   c. Open valve in bleed line to bleed oil. Use a suitable container to catch oil flow.

      Keep bleed line open for remainder of procedure.

3. Turn ON cab power switch.
4. Turn crane mode selector key counterclockwise to CONFIRM position and hold.



View Between Rear Drum and Hydraulic Tank

FIGURE 1

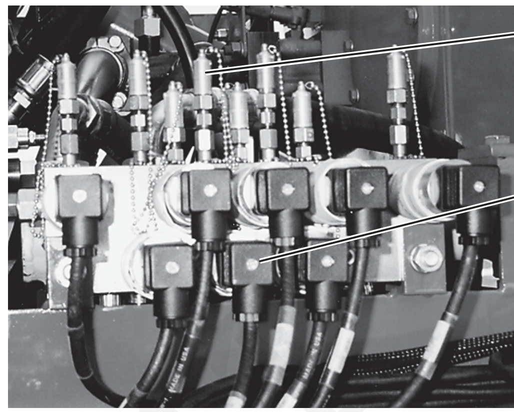
5. Press engine run/stop switch to RUN position.
6. Continue to hold crane mode selector key in CONFIRM position for ONE MINUTE after performing step 5.
7. Confirm that pressure senders are properly calibrated by checking charge pressure on diagnostic screens of digital display (refer to Diagnostic Display publication in Operator's Manual):
   a. With engine off (key in RUN), charge pressure for each crane function should be 50 psi (3.4 bar) or less.
   b. With engine running, charge pressure for each crane function should be within normal operating range – approximately 275 (19.0 bar) at low idle to 400 psi (27.6 bar) at high idle.
8. ***For Model 777 and 777T programmable controller software version m00200h and older only,*** bleed air from boom hoist cylinder pressure sender as follows:
   a. Make sure valve is open in bleed line at boom hoist cylinder pressure sender (Figure 2).
   b. With all control handles in off, start engine and allow it to idle at 950 – 1,000 rpm.
   c. Crack open shut-off valve — 1/4 turn COUNTERCLOCKWISE — for boom hoist cylinder pressure sender (Figure 1) so oil flows to bleed line. ***Boom may lower slowly during this step.***
   d. Observe oil flowing from bleed line at boom hoist cylinder pressure sender.
   e. Close shut-off valve for boom hoist cylinder pressure sender (Figure 1) when clear oil flows from bleed line (no air bubbles in oil).

f. Stop engine.

g. Remove bleed line from coupler at boom hoist cylinder pressure sender.

h. Fully open shut-off valve for boom hoist cylinder pressure sender (Figure 1) — turn COUNTERCLOCKWISE. ***Erratic boom hoist operation will result if this step is not performed.***

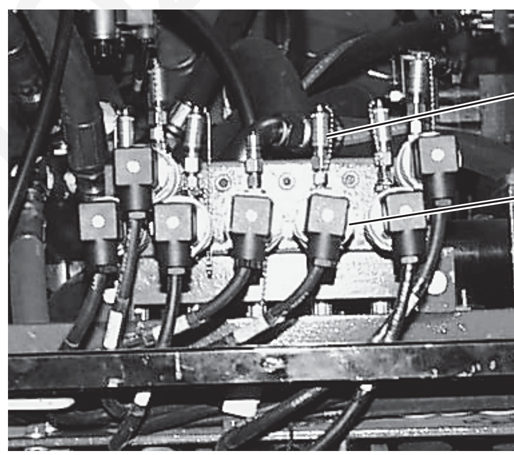
P697



Model 777

Left Side of Pumps

P1025



Model 777T

FIGURE 2

General

The instructions in this folio must be followed to ensure safe removal of faulty pressure senders and to ensure proper operation after installation of new pressure senders.

Refer to Figure 1 for identification of the pressure senders.

Pressure Sender Replacement

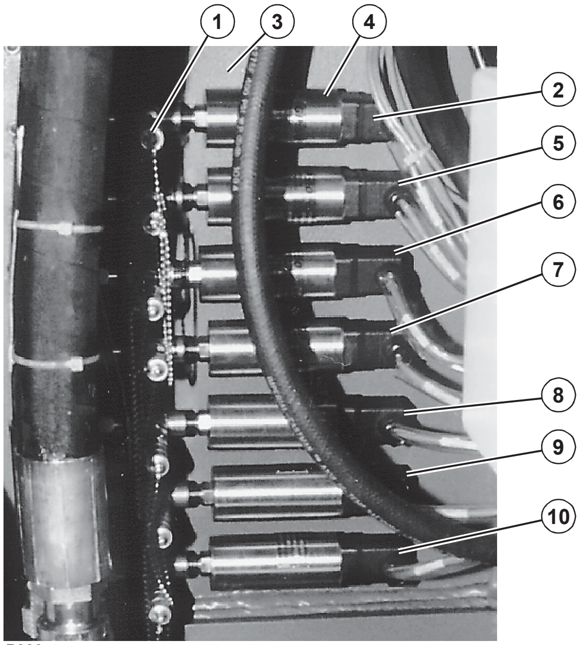
WARNING

High Pressure Oil Hazard! Do not attempt to remove a pressure sender unless following steps are performed. High pressure oil will exhaust from pressure sender ports.

1. Lower all loads to ground.
2. Move all control handles to off and park all crane functions.
3. ***Stop engine.***
4. Place a suitable container under pressure senders to catch oil leakage.

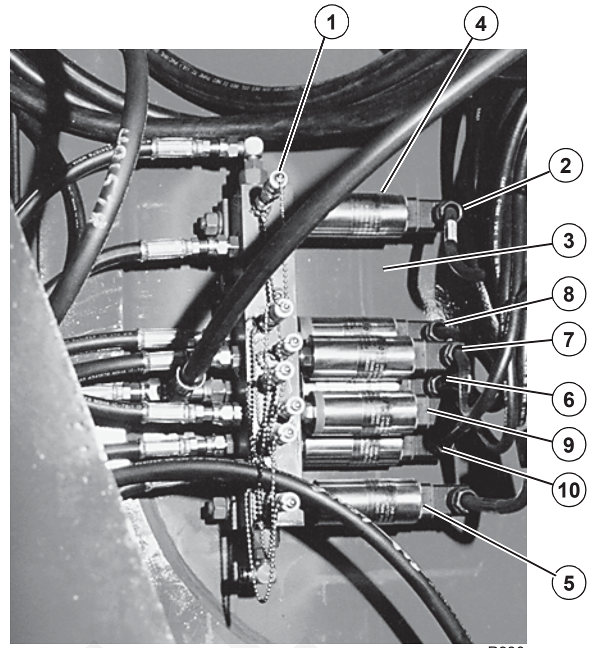
Perform steps 5-9 only at faulty pressure senders.

5. Disconnect electric plug from pressure senders.
6. *Slowly loosen* pressure senders only enough to allow any remaining pressure to exhaust.
7. Remove pressure senders.
8. Install new pressure senders and connect electric cords.
   Pressure senders have pipe threads. Be sure to install thread sealant.
9. Bleed pressure senders as follows:
   a. Connect bleed lines equipped with shut-off valves to couplers on pressure sender manifold. Open valve in bleed lines. Use a suitable container to catch oil flow.
   b. With all control handles off, start engine and allow it to idle at 950 – 1,000 rpm.
   c. Observe oil flowing from bleed lines.
   d. Close valve in bleed lines when clear oil flows (no air bubbles in oil).
   e. Stop engine.
   f. Remove bleed lines from couplers at pressure senders.
10. Calibrate pressure senders (see procedure in Operator's Manual).



P990

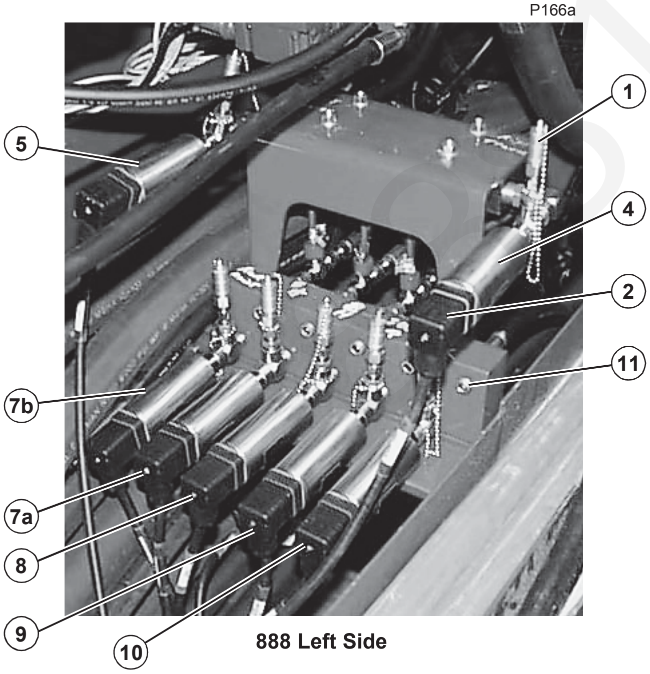
M250 Left Inboard Side of Rotating Bed (forward of pumps)



P930

2250 Left Inboard Side of Rotating Bed (forward of pumps)

P166a



888 Left Side

Item	Description
1	Gauge Coupler (typical)
2	Electric Plug (typical)
3	Independent Luffing Hoist Pressure Sender[1]
4	Right Travel System Pressure Sender
5	Left Travel System Pressure Sender
6	Load Drum Charge Pressure Sender
7	Load Drum System Pressure Sender
7a	Front Load Drum System Pressure Sender
7b	Rear Load Drum System Pressure Sender
8	Boom Hoist System Pressure Sender
9	Swing Right System Pressure Sender
10	Swing Left System Pressure Sender
11	Auxiliary Load Drum System Pressure Sender[1]
	[1] Optional

FIGURE 1

DISC BRAKE OPERATIONAL TEST
MODEL 888

Table of Contents

General

There is no physical way to check the disc brakes for travel, boom hoist, front and rear drums, and swing; therefore, an operational test of each brake must be performed weekly. Figure 1 shows brake and brake solenoid valve locations.

Operational Test

NOTE: For all pumps except swing, system pressure is preset at 6,000 psi (413 bar). For swing pump, system pressure is preset at 5,000 psi (345 bar).

Electrical plugs at brake solenoid valves must be disconnected to stall crane functions during tests.

1. Start engine and allow it to idle at 950 – 1,000 rpm.
2. Select and confirm SETUP mode (faulty pressures will be recorded in any other mode).

NOTE: For load drums, make sure crane is in full power mode (free-fall OFF). In free-fall OFF mode, band brake will release but disc brake will remain applied.

3. Disconnect electrical plug for brake being checked.
4. Scroll to corresponding diagnostics screen for brake being checked. Monitor “pump pressure” and “pump command” while moving control handles.
5. For all functions, move control handle in both directions, one at a time, to check brake operation in both directions.

CAUTION

Overheat Hazard! Do not hold any function on stall for more than 5 seconds. Damage to system components may occur.

6. Slowly move handle for function being checked. Specified system pressure must be reached before 50% pump command is reached and ***brake must not slip***.

WARNING

Falling Load/Moving Crane Hazard! If any disc brake slips when operational test is performed, repair or replace corresponding brake before placing crane back into service. Loads could fall or crane could move if brakes are not operating properly.

For load drums with a disc brake on both ends of drum, repair or replace both disc brakes.

Refer to planetary manufacturer's manual for disc brake repair instructions.

7. Reconnect electrical plugs at all brake solenoid valves at completion of operational test.
8. If disc brakes were repaired or replaced, retest brakes before operating with a load.

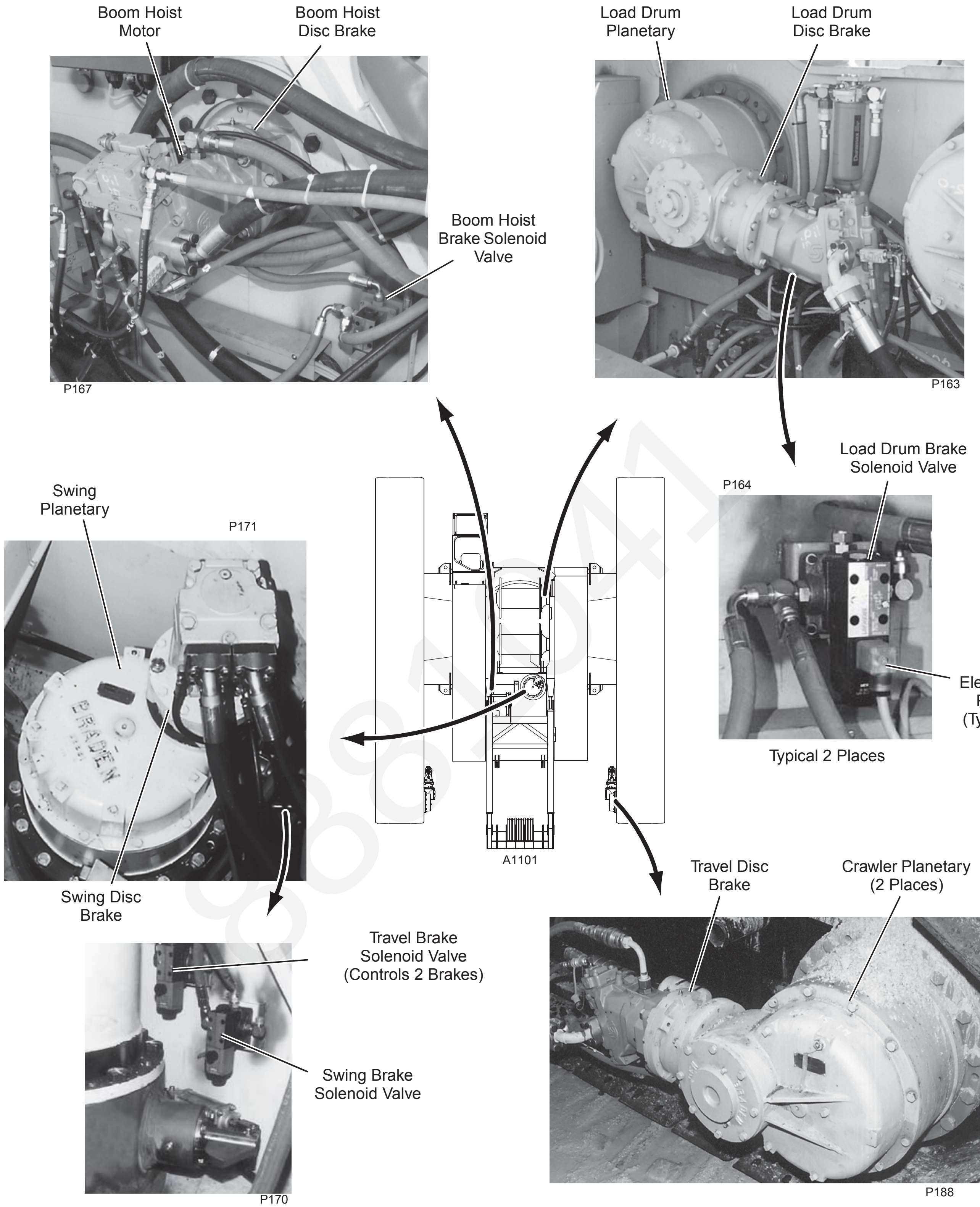

Boom Hoist Motor
Boom Hoist Disc Brake
Boom Hoist Brake Solenoid Valve
P167
Load Drum Planetary
Load Drum Disc Brake
P163
Load Drum Brake Solenoid Valve
P164
Electrical Plug (Typical)
Typical 2 Places
Swing Planetary
P171
Swing Disc Brake
A1101
Travel Brake Solenoid Valve (Controls 2 Brakes)
Swing Brake Solenoid Valve
P170
Travel Disc Brake
Crawler Planetary (2 Places)
P188

FIGURE 1

MANUAL RELEASE OF SWING BRAKE AND LOCK

All Hydraulic Cranes

GENERAL

The hydraulic swing brake and hydraulic swing lock must be released when the swing planetary is removed and reinstalled to allow alignment of the gear teeth in the swing shaft with the teeth in the ring gear.

⚠ WARNING

Unexpected Crane Movement!

Crane can swing suddenly when swing brake is released. Before releasing swing brake, secure crane using one of following methods to prevent sudden uncontrolled swinging:

- Apply swing lock - 111, 180, 222, M-250, or 888.
- Lower boom onto blocking at ground level - all other models.

Procedure given in this folio is for servicing purposes only. Swing brake and swing lock must be fully operational when operating crane.

Figure 1 shows the swing planetaries for the various crane models. Table 1 identifies the type of swing lock each model is equipped with.

MANUAL RELEASE PROCEDURE

Hydraulic hand pumps *with pressure gauges* are needed to manually release the swing brake and swing lock.

1. Disconnect hoses from fitting at brake release port and, if equipped, at swing lock OUT port.

2. Attach hand pump to each port — brake release and swing lock OUT.

3. Pressurize brake and swing lock to 350 psi (24 bar).

4. Proceed to remove or install swing planetary.

5. Relieve pressure and remove hand pumps.

CAUTION

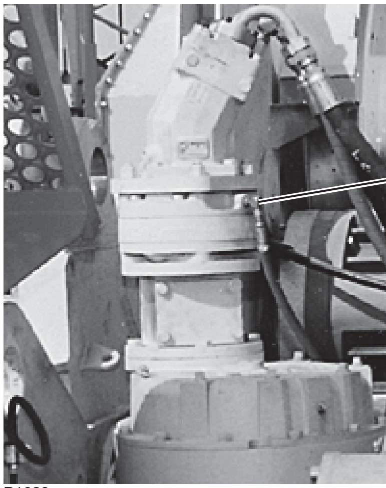
Avoid damage to parts!

Do not exceed 350 psi (24 bar) pressure when releasing swing brake or swing lock.

Table 1

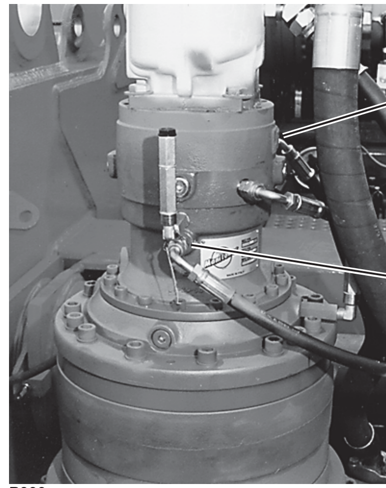
<table>
<tr><th rowspan="2">Model</th><th colspan="2">Existing Fittings</th><th rowspan="2">Illustration</th><th rowspan="2">Swing Lock</th></tr>
<tr><th>Brake</th><th>Lock</th></tr>
<tr><td>M-250</td><td>06 ORS</td><td>–</td><td>View A</td><td>Air (separate from planetary)</td></tr>
<tr><td>555</td><td>06 ORS</td><td>06 ORS</td><td rowspan="6">View B</td><td rowspan="6">Hydraulic (inside planetary)</td></tr>
<tr><td>777 & 777T</td><td>08 ORS</td><td>06 ORS</td></tr>
<tr><td>999</td><td>06 ORS</td><td>06 ORS</td></tr>
<tr><td>2250</td><td>06 ORS</td><td>06 ORS</td></tr>
<tr><td>18000</td><td>06 ORS</td><td>06 ORS</td></tr>
<tr><td>21000</td><td>06 ORS</td><td>06 ORS</td></tr>
<tr><td>111, 180 & 222</td><td>06 ORS</td><td>–</td><td>View C</td><td>Hydraulic (separate from planetary)</td></tr>
<tr><td>1015</td><td>06 ORS</td><td>06 ORS</td><td>View D</td><td>Hydraulic (inside planetary)</td></tr>
<tr><td>888</td><td>06 ORS</td><td>–</td><td>View E</td><td>Air (separate from planetary)</td></tr>
<tr><td>888R</td><td>12 ORS</td><td>–</td><td>View F</td><td>No Swing Lock</td></tr>
</table>

View A
Model 250



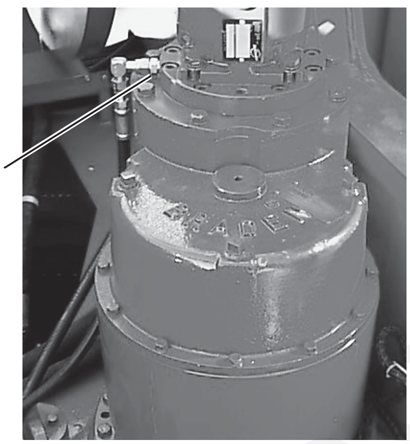
P1628

View B
Models 555, 777, 777T, 999,
2250, 18000 and 21000



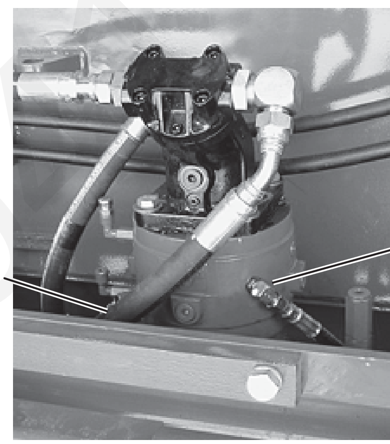
P899

View C
Models 111, 180 and 222



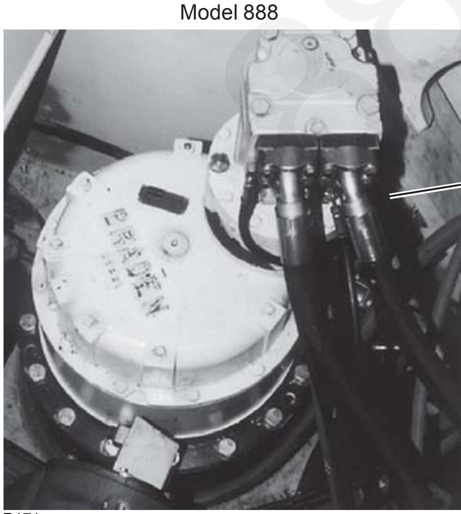
W168

View D
Model 1015



P1809

View E
Model 888



P171

View F
Model 888R

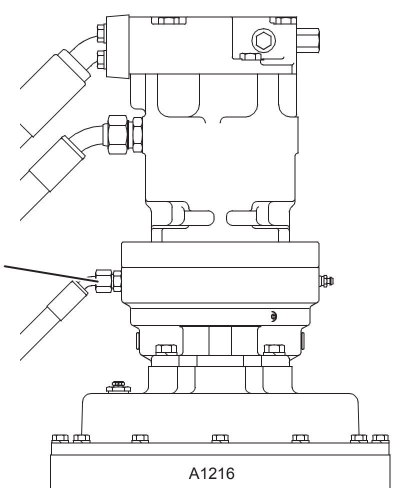
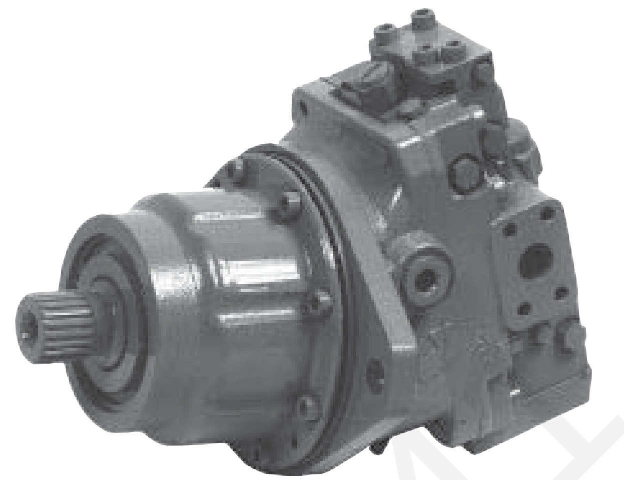
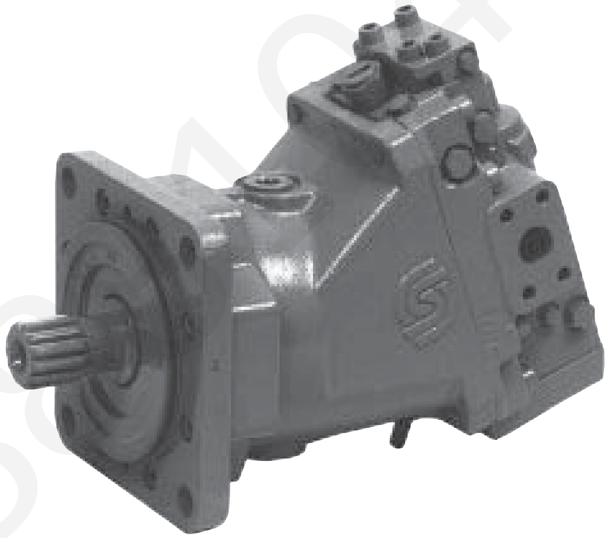


FIGURE 1

SAUER
DANFOSS

Series 51





Bent Axis

Variable Motors

Service Manual

General Description

Series 51 Variable Displacement Motors are bent axis design units, incorporating spherical pistons.

These motors are designed primarily to be combined with other products in closed circuit systems to transfer and control hydraulic power.

Series 51 Motors have a large maximum / minimum displacement ratio (5 to 1) and high output speed capabilities. SAE flange and cartridge motor configurations are available.

A complete family of controls and regulators is available to fulfill the requirements of a wide range of applications.

Motors equipped with controls normally start at maximum displacement. This provides maximum starting torque (high acceleration).

The controls may utilize externally or internally supplied servo pressure. They may be overridden by a pressure compensator which functions when the motor is operating in motor and pump modes. A defeat option is available to disable the pressure compensator override when the motor is running in pump mode.

The pressure compensator option features a low pressure rise (short ramp) to provide optimal power utilization throughout the entire displacement range of the motor. The pressure compensator is also available as a stand-alone regulator.

- **The Series 51 - Advanced Technology Today**
- **The Most Technically Advanced Hydraulic Units in the Industry**
- **SAE Flange and Cartridge Motors**
- **Cartridge Motors designed for Direct Installation in Compact Planetary Drives**
- **Large Displacement Ratio (5:1)**
- **Complete Family of Control Systems**
- **Proven Reliability and Performance**
- **Optimum Product Configurations**
- **Compact, Lightweight**

Front page: Option - hydraulic two-position control

Contents

Introduction

The purpose of this manual is to provide information necessary for the normal servicing of the Series 51 family of variable displacement hydrostatic motors.

This manual includes unit and component description, troubleshooting, adjustments, and minor repair procedures. By following the procedures in this manual, inspections and minor repairs may be performed without affecting the unit warranty.

A Series 51 motor does occasionally require servicing, and these units are designed to meet this requirement.

Many repairs or adjustments can be completed without removing the unit from the vehicle or machine, provided the unit is accessible and can be thoroughly cleaned before beginning any procedures.

Dirt or contamination is the greatest enemy of any type of hydraulic equipment. The greatest possible cleanliness is necessary when starting up the system, changing filters, or performing any other service procedure.

For Technical Information on Series 51 motors, refer to publication BLN-10042 or 368753.

For Fluid Quality Requirements, refer to publication BLN-9987 or 697581.

Sauer-Sundstrand provides a complete repair service for its products. Contact any Sauer-Sundstrand Authorized Service Center for details. Sauer-Sundstrand Authorized Service Center locations are listed in publication BLN-2-40527 or 698266.

Basic Hydraulic Circuits

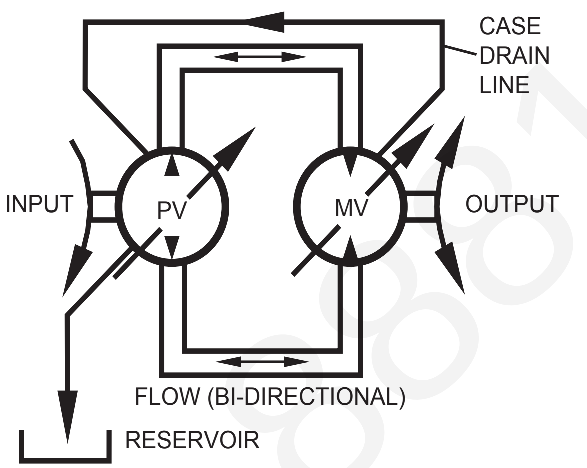


Fig. 0-1 - Basic Closed Circuit

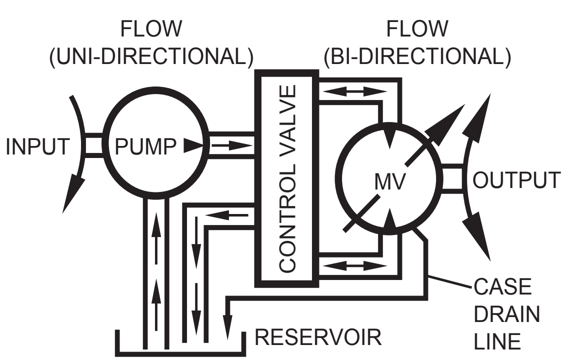


Fig. 0-2 - Basic Open Circuit

Closed Circuit

The main ports of the pump are connected by hydraulic lines to the main ports of the motor. Fluid flows in either direction from the pump to the motor then back to the pump in this closed circuit. Either of the hydraulic lines can be under high pressure. The direction and speed of fluid flow (and the motor output shaft rotation) depends on the position of the pump swashplate. The system pressure is determined by the machine load.

Open Circuit

The outlet port of the pump is connected by a hydraulic line to a directional control valve. The working ports of this valve are connected to the main ports of the motor. When the valve is actuated, fluid flows first from the pump to the valve. The valve then directs the fluid to the motor in either direction. The direction of fluid flow (and motor output shaft rotation) depends on the direction the control valve is shifted. The speed of fluid flow (and motor output shaft speed) depends on pump output volume and the distance the control valve is shifted. The system pressure is determined by the machine load.

Fluid returning from the motor is routed through the control valve to the reservoir. Additional components may be necessary to provide dynamic braking and to deal with over-running loads.

General Description of the Series 51 Variable Displacement Motors

The Series 51 variable displacement hydraulic motors use spherical pistons and piston rings. The angle between the cylinder block and the output shaft can be set between 32° and 6°, providing a 5 to 1 maximum to minimum displacement ratio.

At maximum displacement, the motor will provide a certain maximum output shaft torque and minimum speed corresponding to the pressure and flow supplied to the motor. Under the same input conditions but at minimum displacement, the shaft speed will be approximately five (5) times faster while the available output torque will decrease to approximately one-fifth (1/5) the full displacement value. The displacement is changed by a servo piston which is connected to the valve segment.

Various hydraulic and electrohydraulic controls may be mounted on the motor end cap to control the servo piston and the motor displacement. Servo pressure oil may either be supplied internally from the motor, or externally.

For all controls except the N2 and PC, servo pressure oil is supplied to a four (4) way spool valve in the motor end cap. When a combination of pilot pressure (or force) from an external control assembly and internal spring force shifts this valve, servo pressure is routed to move the servo piston and change the motor's displacement.

A synchronizing shaft, with spherical rollers, synchronizes the rotation of the output shaft and the cylinder block. The ball end of each piston runs in a socket bushing, pressed into the output shaft. There are no other parts used to connect the pistons to the shaft. Two tapered roller bearings support the output shaft.

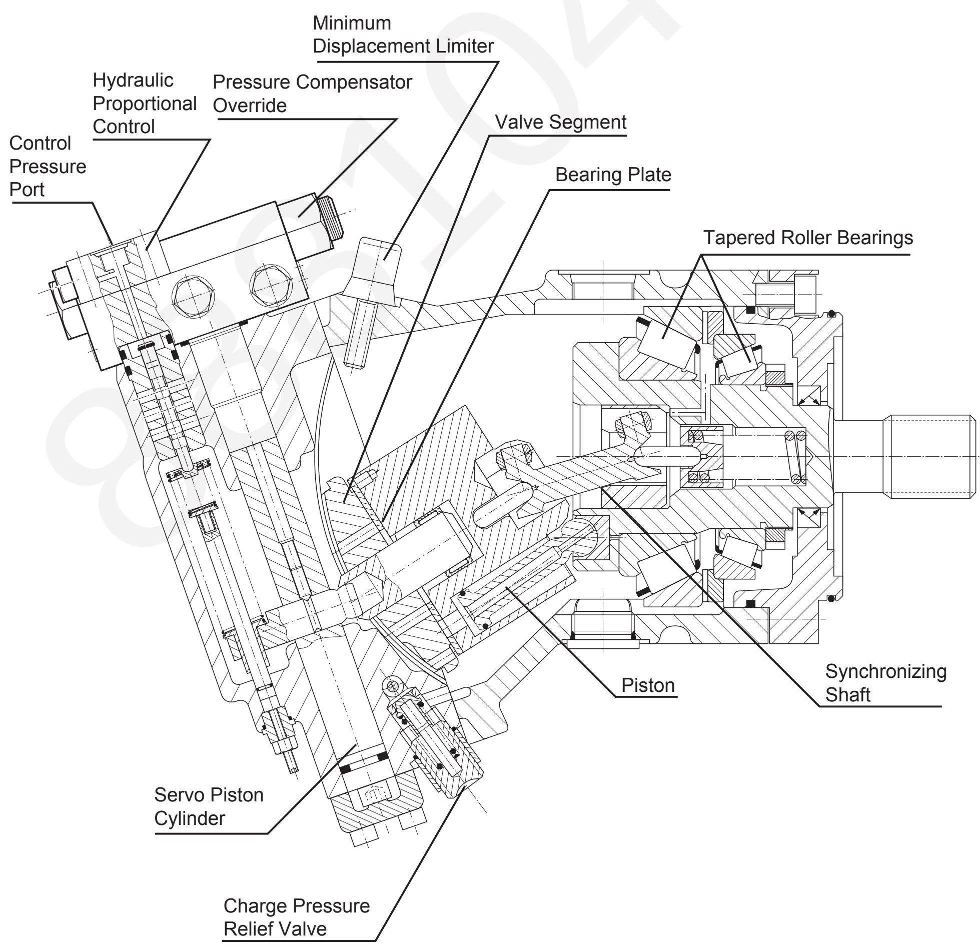
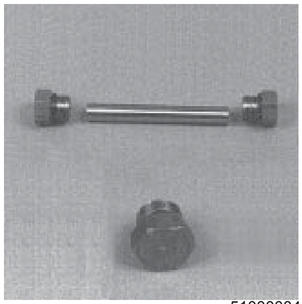


Fig. 10-1 - Sectional view of Series 51 variable displacement motor (SAE Flange Configuration) with Hydraulic Proportional Control

Functional Description

51000003

Fig. 10-2 - Loop Flushing Components



51000004

Fig. 10-3 - Loop Flushing Defeat Components

Loop Flushing

Series 51 motors used in closed circuit applications incorporate an integral loop flushing valve as standard equipment. Installations that require additional fluid to be removed from the main hydraulic circuit because of fluid cooling requirements, or circuits requiring the removal of excessive contamination from the high pressure circuit, can benefit from loop flushing. Series 51 motors used in open circuit applications may have the optional loop flushing defeat components installed.

Series 51 motors equipped with an integral loop flushing valve also include a charge pressure relief valve. The setting of the motor charge relief valve affects the function of the flushing circuit. Higher motor charge relief settings reduce the loop flushing flow and increase the flow over the pump charge pressure relief valve when the circuit is operating. Lower motor charge relief settings increase the loop flushing flow and may increase the motor case pressure when the circuit is operating.

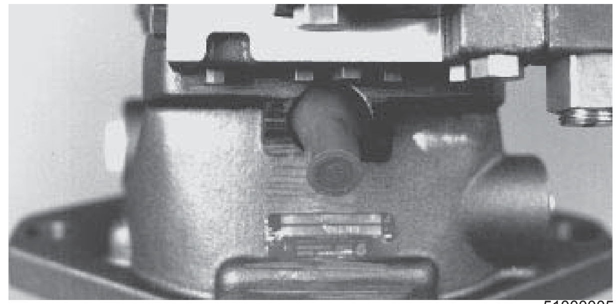
An appropriate combination of pump and motor charge pressure settings should be maintained to insure the proper function of the loop flushing circuit. Correct charge pressure must be maintained under all conditions of operation to maintain pump control performance in closed loop systems.

NOTE: An optional orifice may be installed between the motor charge relief and the motor case to limit the maximum flushing oil flow.

Functional Description (Continued)

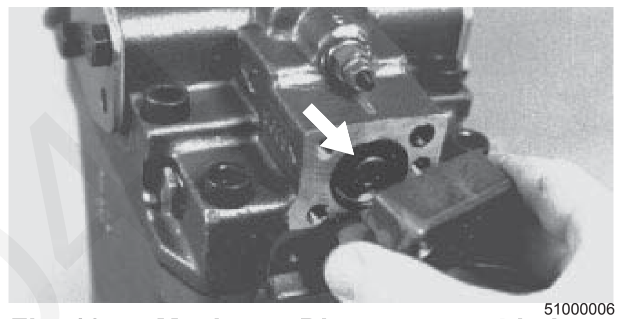
Displacement Limiters

All Series 51 motors incorporate mechanical displacement limiters. The minimum displacement of the motor can be limited within the standard range by a set screw in the motor housing. The maximum displacement can be limited with spacers installed on the servo piston.



51000005

Fig. 10-4 - Minimum Displacement Limiter with Tamper Resistant Cap (Cartridge Motor Configuration Shown)



51000006

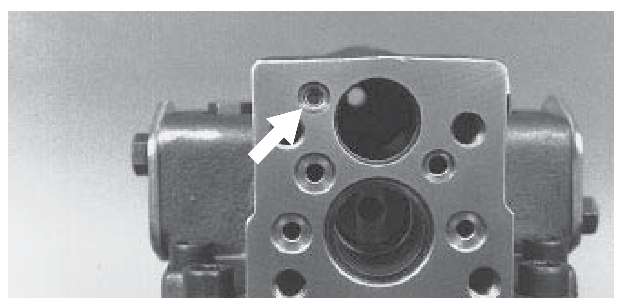
Fig. 10-5 - Maximum Displacement Limiter Screw

Controls - General

A wide range of control options is available for the Series 51 motors. These include pilot operated Electrohydraulic 2-Position Controls, Hydraulic Proportional Controls (single or two [2] connection), and Electrohydraulic Proportional Controls. A directly operated Hydraulic 2-Position Control and a Pressure Compensator regulator are also available.

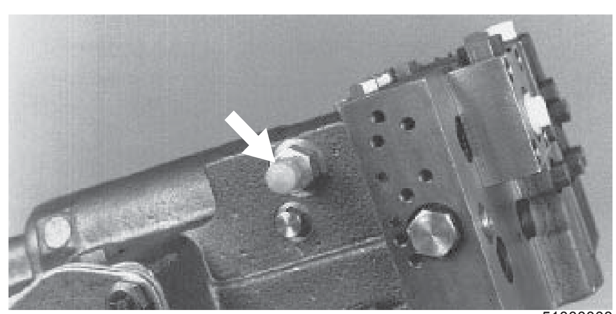
The Series 51 variable motor servo piston (except when equipped with N2 control or the PC regulator) may be operated either by servo pressure oil supplied internally from the main ports of the motor, or by servo pressure oil supplied from an external source. (The N2 control uses servo pressure supplied by an external control valve. The PC regulator obtains servo pressure from the main ports of the motor.)

Orifice plugs are installed in the control spool sleeve in the end cap to regulate the flow of oil from the servo piston to the motor housing. Orifice plugs may be installed in the end cap to regulate the flow of servo pressure supply oil to the control valve, and to regulate the flow of oil from the control valve to the servo piston.



5100007

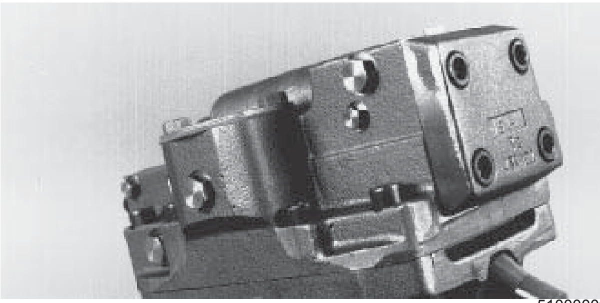
Fig. 10-6 - Internal Servo Pressure Supply Screen with Multi-function Block and/or Control Removed (Plug for External Supply)



51000008

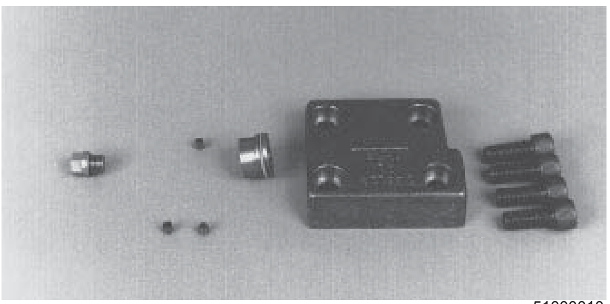
Fig. 10-7 - External Servo Pressure Supply Fitting (Plug for Internal Supply)

Functional Description (Continued)



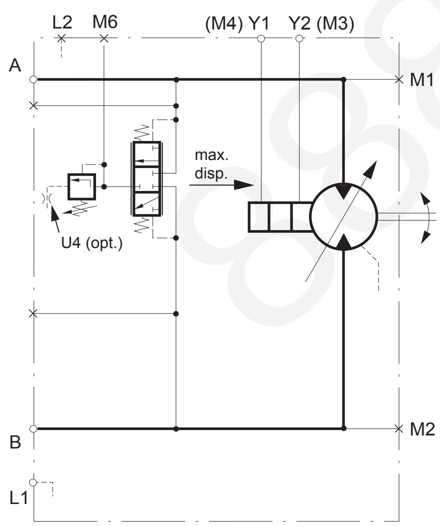
51000009

Fig. 10-8 - Series 51 Motor with N2 Control



51000010

Fig. 10-9 - N2 Control Components



51000011

Fig. 10-10 - N2 Control Schematic

Hydraulic 2-Position Control (Type N2)

This is a two (2) position (maximum - minimum displacement) control, consisting of a cover plate mounted on the end cap. An external control valve supplies servo pressure from an external source directly to the servo piston. PCOR is not available with the N2 control.

When servo pressure is supplied to port “Y1,” the setting piston moves to the maximum motor displacement position. When servo pressure is supplied to port “Y2,” the setting piston moves to the minimum motor displacement position.

Orifices may be installed in the external control valve or its connections to regulate the speed of servo piston movement.

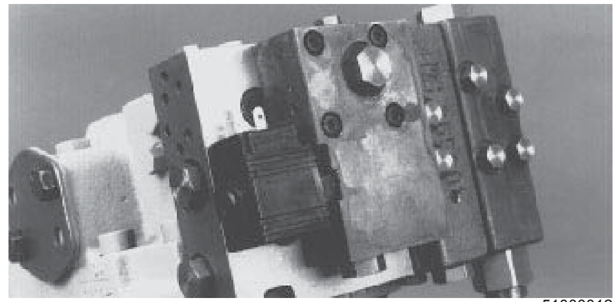
Functional Description (Continued)

Electrohydraulic 2-Position Control (Types E1•E2 and F1•F2)

A 12 or 24 VDC solenoid valve, mounted on the multi-function block, connects the end of the control valve spool in the end cap with pilot pressure (provided by the shuttle spool in the multi-function block) or with the motor case. The control valve in the end cap is biased by a threshold spring, and controls oil flow to the ends of the servo piston. Servo pressure may be supplied from an external source or internally by the shuttle spool in the multi-function block. PCOR is available with these controls.

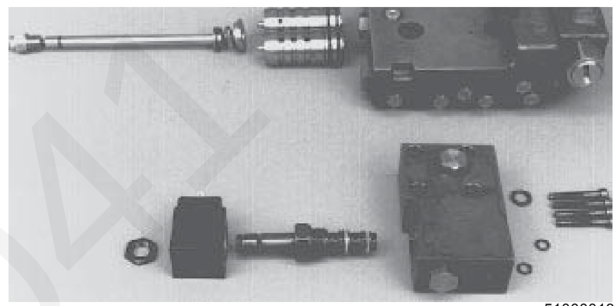
With the E1 and E2 controls, energizing the solenoid will cause the motor to shift to minimum displacement. When the solenoid is not energized, the motor is held at maximum displacement.

With the F1 and F2 controls, energizing the solenoid causes the motor to shift to maximum displacement. When the solenoid is not energized, the motor is held at minimum displacement.



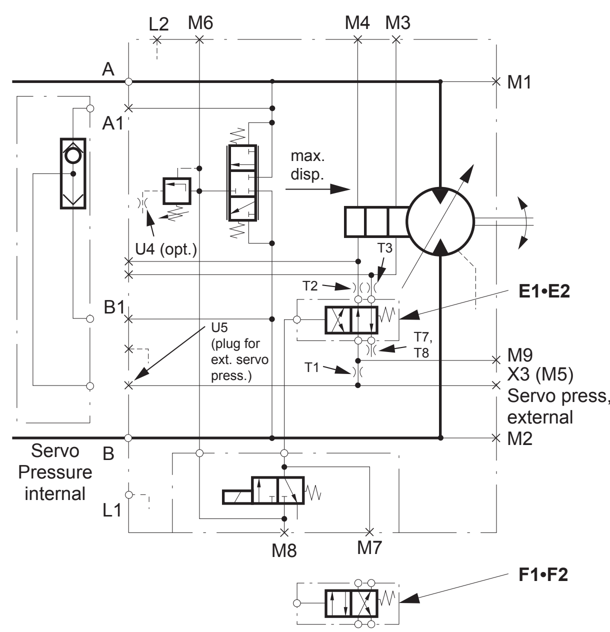
51000012

Fig. 10-11 - Series 51 Motor with E1•E2 or F1•F2 Control



51000013

Fig. 10-12 - E1•E2 and F1•F2 Control Components



51000014

Fig. 10-13 - E1•E2 and F1•F2 Control Schematic

Functional Description (Continued)

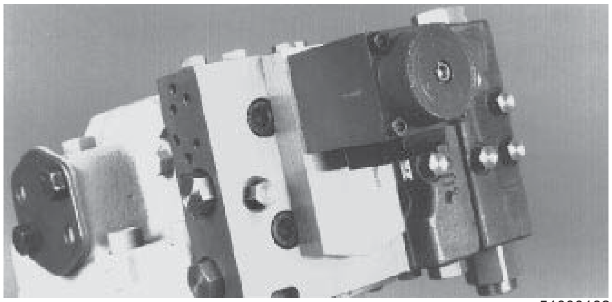


Fig. 10-14 - Series 51 Motor with S1 Control

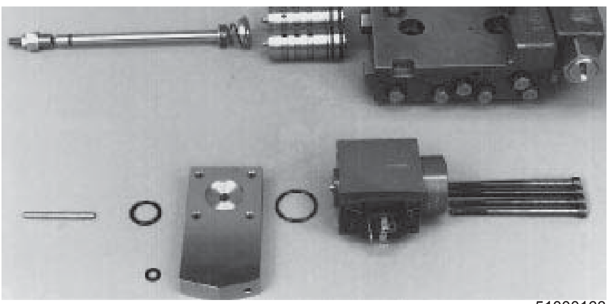


Fig. 10-15 - S1 Control Components

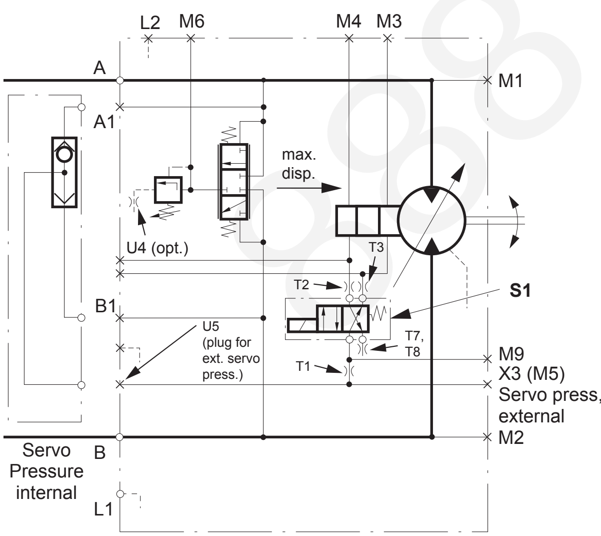


Fig. 10-16 - S1 Control Schematic

Electric 2-Position Control (Type S1)

A 12 VDC solenoid valve, mounted on the multi-function block, directly operates the control valve spool in the end cap. The control valve in the end cap is biased by a threshold spring, and controls oil flow to the ends of the servo piston. Servo pressure may be supplied from an external source or internally by the shuttle spool in the multi-function block. PCOR is available with this control.

With the S1 control, energizing the solenoid causes the motor to shift to maximum displacement. When the solenoid is not energized, the motor is held at minimum displacement.

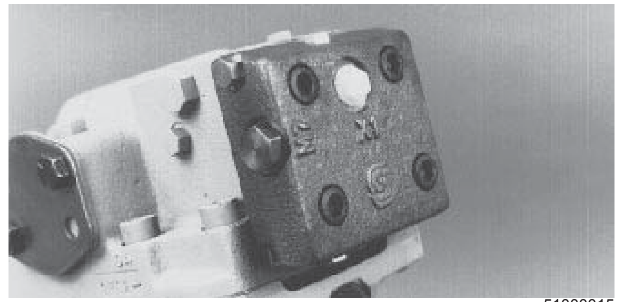
Functional Description (Continued)

Hydraulic Proportional Control (Type HZ)

The HZ control consists of a cover plate mounted directly on the end cap. A ball type shuttle valve provides internal servo pressure supply to the control valve in the end cap. PCOR is not available with the HZ control.

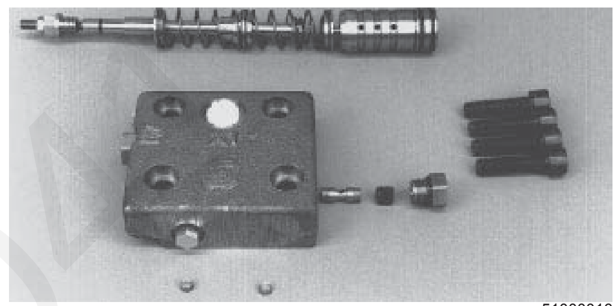
Feedback springs (single spring for 060, 080 and 110) and a threshold spring are installed in the end cap. The feedback springs and threshold spring provide a force on the end of the control spool. The force of the threshold spring is externally adjustable with an adjusting screw. The feedback spring is positioned between the control spool and a feedback lug attached to the servo piston. The force of the feedback spring increases as the motor's displacement decreases.

Pilot oil pressure from an external source is applied to the end of the control spool opposite the feedback and threshold springs. An increase in pilot pressure (above the threshold pressure and within the modulating pressure range) will result in a decrease in motor displacement, while a decrease in pilot pressure will result in an increase in motor displacement.



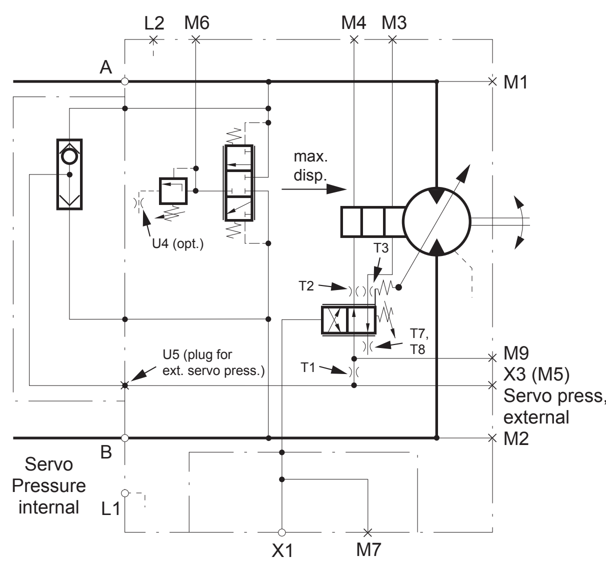
51000015

Fig. 10-17 - Series 51 Motor with HZ Control



51000016

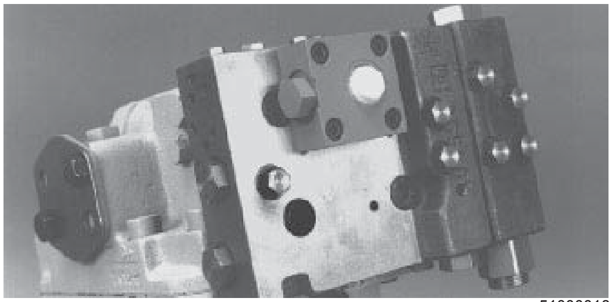
Fig. 10-18 - HZ Control Components



51000017

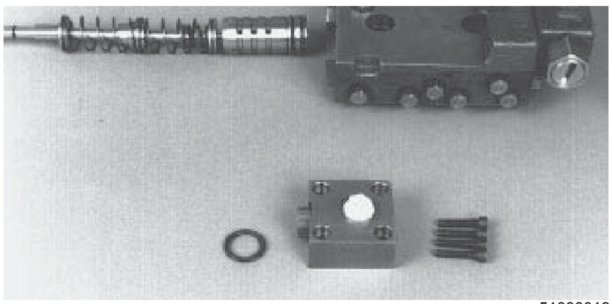
Fig. 10-19 - HZ Control Schematic

Functional Description (Continued)



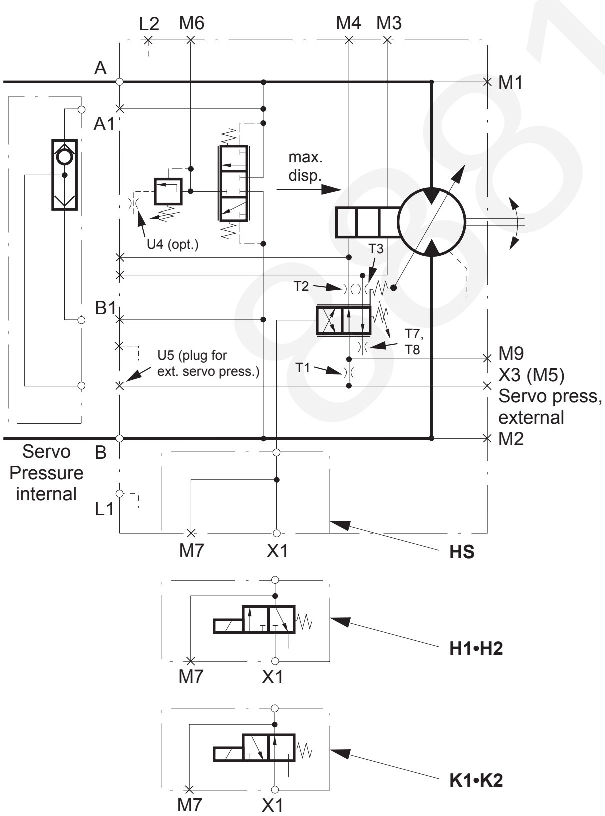
51000018

Fig. 10-20 - Series 51 Motor with HS Control



51000019

Fig. 10-21 - HS Control Components



51000022

Fig. 10-22 - HS, H1•H2, and K1•K2 Control Schematic

Hydraulic Proportional Control (Type HS)

The HS control consists of a cover plate (with a hydraulic port) mounted on the multi-function block. Servo pressure may be supplied from an external source or internally by the shuttle spool in the multi-function block. PCOR is available with this control.

The function of the HS control is identical to the function of the HZ control.

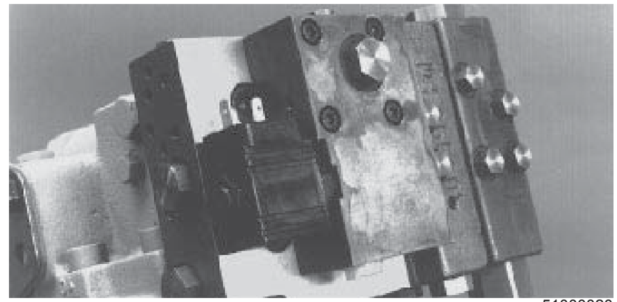
Functional Description (Continued)

Hydraulic Proportional Control with Electric Override (Types H1•H2 and K1•K2)

The function of the H1•H2 and K1•K2 controls is similar to the function of the HS control. A 12 or 24 VDC solenoid valve is installed between the external pilot pressure source and the control spool.

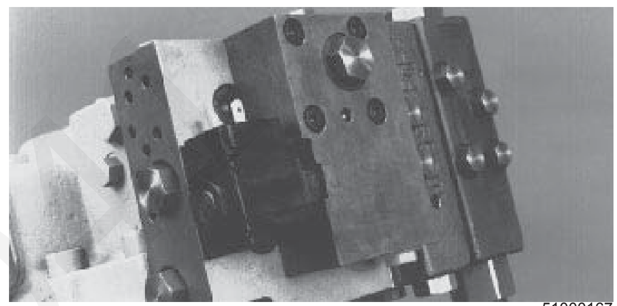
With the H1•H2 controls, energizing the solenoid allows the control to function as an HS control. When the solenoid is not energized, pilot pressure is blocked and the end of the control spool is drained to the motor case, causing the motor to shift to maximum displacement.

With the K1•K2 controls, energizing the solenoid blocks pilot pressure and drains the end of the control spool to the motor case, causing the motor to shift to maximum displacement. When the solenoid is not energized, the control functions as an HS control.



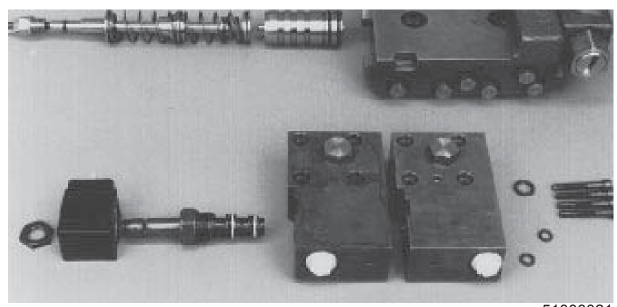
51000020

Fig. 10-23 - Series 51 Motor with H1•H2 Control



51000167

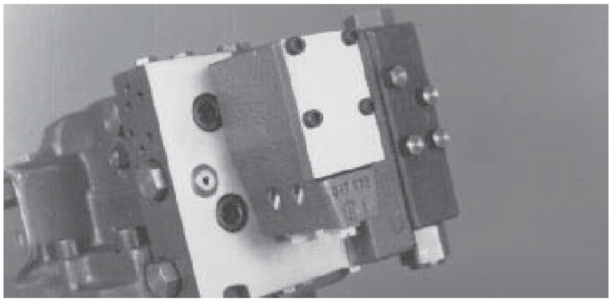
Fig. 10-24 - Series 51 Motor with K1•K2 Control



51000021

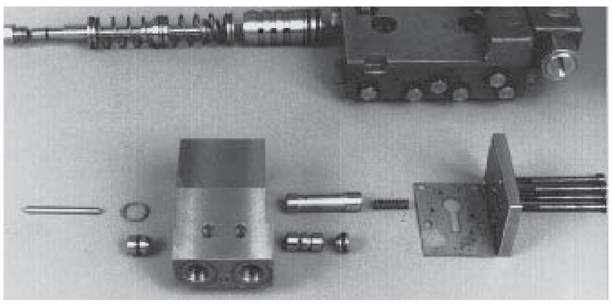
Fig. 10-25 - H1•H2 and K1•K2 Control Components

Functional Description (Continued)



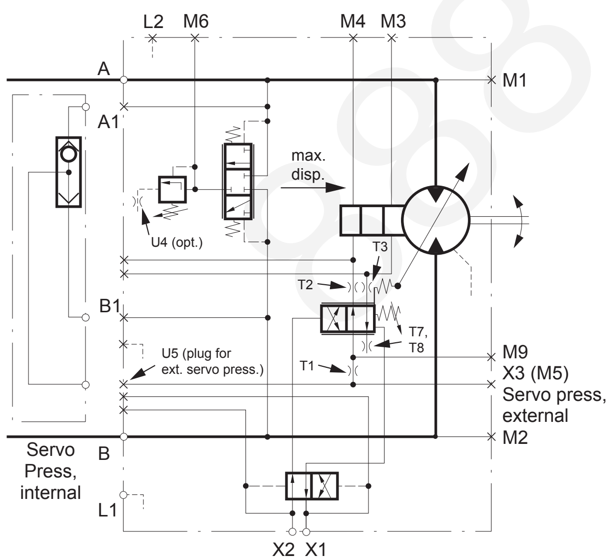
51000023

Fig. 10-26 - Series 51 Motor with HP Control



51000024

Fig. 10-27 - HP Control Components



51000025

Fig. 10-28 - HP Control Schematic

Two Line Hydraulic Proportional Control (Type HP)

This control consists of a valve block with two (2) hydraulic ports mounted on the multi-function block. The valve block incorporates a shuttle spool and a pilot piston with centering springs. A pin transmits force from the pilot piston to the control spool in the end cap. Feedback springs (single spring for 060, 080, and 110) and a threshold spring are installed in the end cap. These springs function similar to the HS control. Servo pressure may be supplied from an external source or internally by the shuttle spool in the multi-function block. PCOR is available with this control.

Two pilot pressures are provided to the control. The shuttle spool directs the higher pilot pressure to the end of the pilot piston opposite the feedback spring, and the lower pressure to the opposite side of the pilot piston. The rod transmits a force, proportional to the difference of the pilot pressures, to the control spool.

An increase in the difference between the pilot pressures will result in a decrease in motor displacement, while a decrease will result in an increase in displacement.

Functional Description (Continued)

Two Line Hydraulic Proportional Control for “Dual-Path” Vehicles (Type HC)

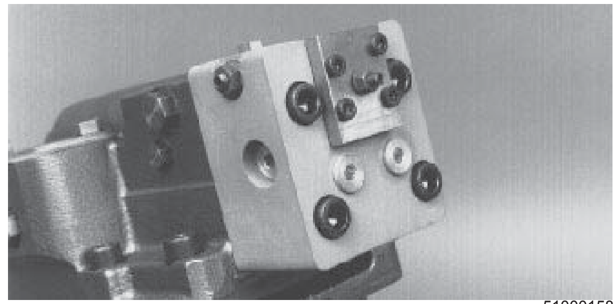
The HC control operates in a similar manner to the HP control, however the HC control is optimized for use in “dual-path” drive vehicles. This control consists of a valve block with two (2) hydraulic ports mounted on the end cap. The valve block incorporates a shuttle spool and a pilot piston with centering springs. A pin transmits force from the pilot piston to the control spool in the end cap.

A bleed valve is provided to eliminate any air which might become trapped in the pilot piston oil passages.

Feedback springs are installed in the end cap. Servo pressure is supplied internally by a ball type shuttle valve in the control housing. PCOR is not available with this control.

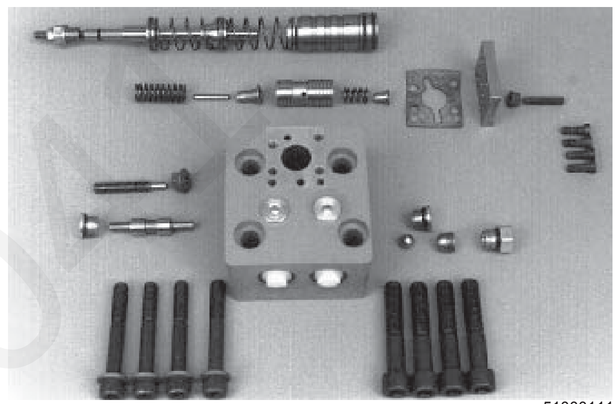
Two pilot pressures are provided to the control. The shuttle spool directs the higher pilot pressure to the end of the pilot piston opposite the feedback springs, and the lower pressure to the opposite side of the pilot piston. The pin transmits a force, proportional to the difference of the pilot pressures, to the control spool.

An increase in the difference between the pilot pressures will result in a decrease in motor displacement, while a decrease will result in an increase in displacement. The feedback springs in the end cap have differing spring rates and operate in parallel (060, 080, and 110) or series (160 or 250) to provide a linear relationship between motor displacement and pilot pressure differential.



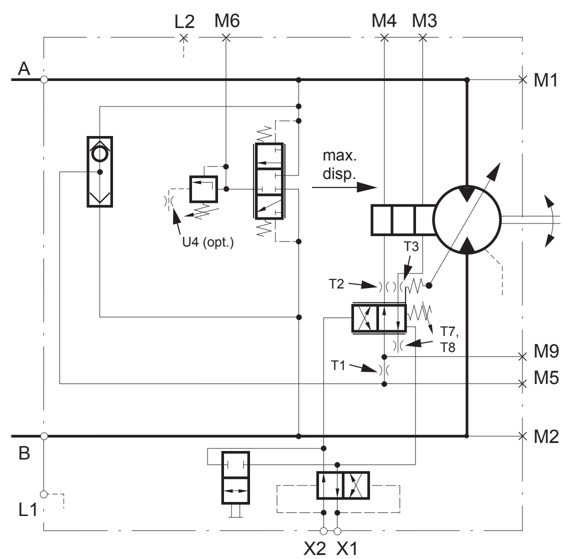
51000158

Fig. 10-29 - Series 51 Motor with HC Control



51000111

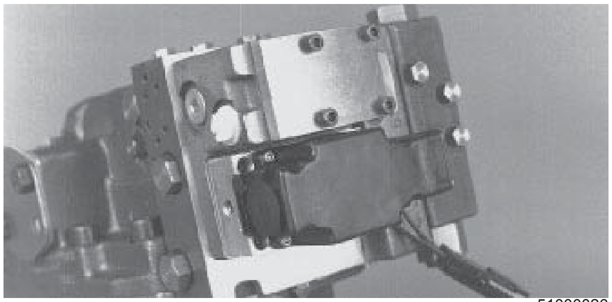
Fig. 10-30 - HC Control Components



51000160

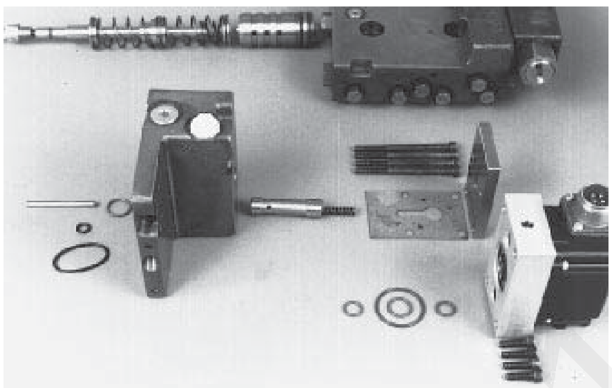
Fig. 10-31 - HC Control Schematic

Functional Description (Continued)



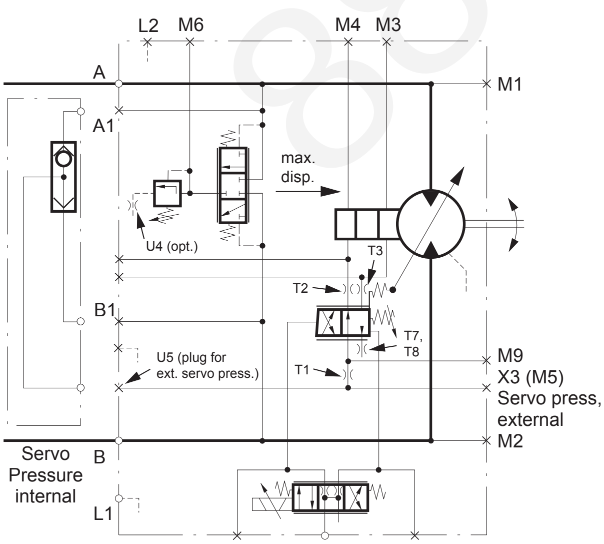
51000026

Fig. 10-32 - Series 51 Motor with EP Control (EQ Similar)



51000027

Fig. 10-33- EQ Control Components (EP Similar)



51000028

Fig. 10-34 - EP and EQ Control Schematic

Electrohydraulic Proportional Control (Types EP and EQ)

This control consists of a valve block and PCP (Pressure Control Pilot) valve mounted on the multi-function block. The valve block incorporates a pilot piston with centering springs. A pin transmits force from the pilot piston to the control spool in the end cap. Feedback springs (single spring for 060, 080, and 110) and a threshold spring are installed in the end cap. These springs function similar to the HS control. Servo pressure may be supplied from an external source or internally by the shuttle spool in the multi-function block. PCOR is available with this control.

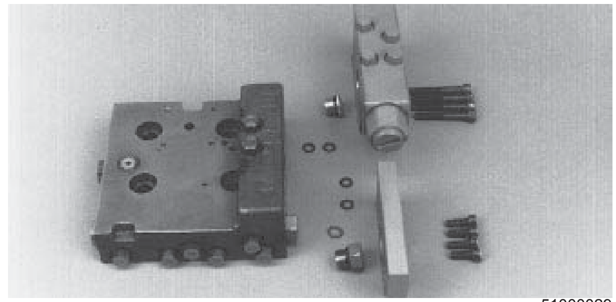
An external pilot pressure source is connected to the inlet of the PCP valve, which produces differential pilot pressures proportional to the current through it. These pressures are applied to the pilot piston. The operation of this control is similar to that of the HP Control, with the motor displacement being proportional to the current through the PCP valve.

An increase in current (above the threshold current) will result in a decrease in motor displacement, while a decrease will result in an increase in displacement.

Functional Description (Continued)

Multi-function Block Components

The Multi-function Valve Block includes a shuttle valve which provides internally supplied servo pressure, and an optional Pressure Compensator Over-Ride (PCOR) function with optional brake pressure defeat.



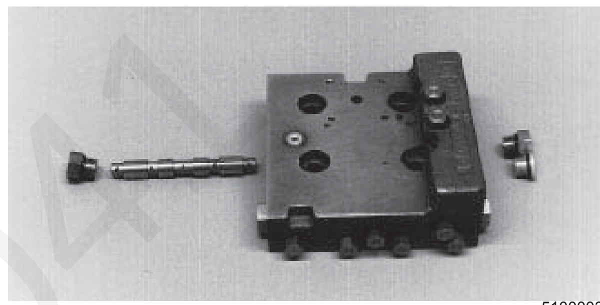
51000029

Fig. 10-35 - Multi-function Block (Without Control)

Servo Pressure Supply

For internal supply, the multi-function block incorporates a shuttle spool with internal check ball valve that routes oil from the main circuit ports of the motor to the control valve in the end cap. “High side” pressure is provided to the servo control valve in the end cap.

For external supply, the connection between the shuttle spool and the servo control valve is blocked in the end cap. The external pressure supply to the servo control valve connects to a port (“M5”) on the end cap.



51000030

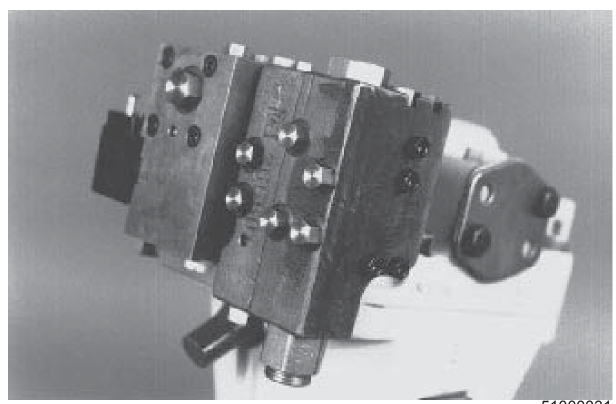
Fig. 10-36 - Multi-function Block with Servo Pressure Supply Shuttle Spool

Pressure Compensator Over-Ride (PCOR)

The Pressure Compensator Over-Ride (PCOR) system includes a spool valve located in the PCOR block which is attached to the multi-function block. This system increases the motor displacement at system pressures above the PCOR valve setting. (Pressure Compensator Over-Ride is not available with the N2 and HZ controls, or the PC regulator.)

For bi-directional PCOR operation, the shuttle valve in the multi-function block routes system high pressure to the PCOR spool valve. For single direction PCOR operation, the PCOR spool valve is connected to one (1) side of the closed loop through passages in the multi-function block

When system pressure exceeds the PCOR setting, the spool valve moves to connect the displacement reducing end of the servo piston to the motor case, and the displacement increasing end of the servo piston to system pressure. This increases the motor displacement, which reduces the motor output speed. When the PCOR valve closes, control of the servo piston returns to the control spool in the motor end cap.



51000031

Fig. 10-37 - Multi-function Block with PCOR Block and Spool Valve (K1•K2 Control Shown)

Functional Description (Continued)

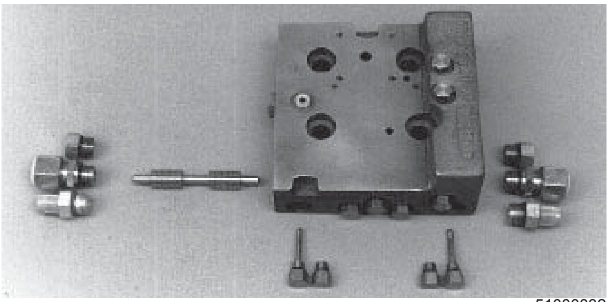


Fig. 10-38 - Multi-function Block with PCOR Defeat Spool Components

An optional “brake pressure defeat” spool may be installed in the multi-function block. When used with the PCOR, this spool assures that the PCOR does not cause the motor displacement to increase during deceleration (which could cause pump overspeed). Pressure from a source such as the pump servos or an external valve, shifts the defeat spool to block the high pressure supply to the PCOR valve from the “deceleration” side of the closed loop. Either bi-directional or single direction PCOR operation can be specified when PCOR defeat is installed.

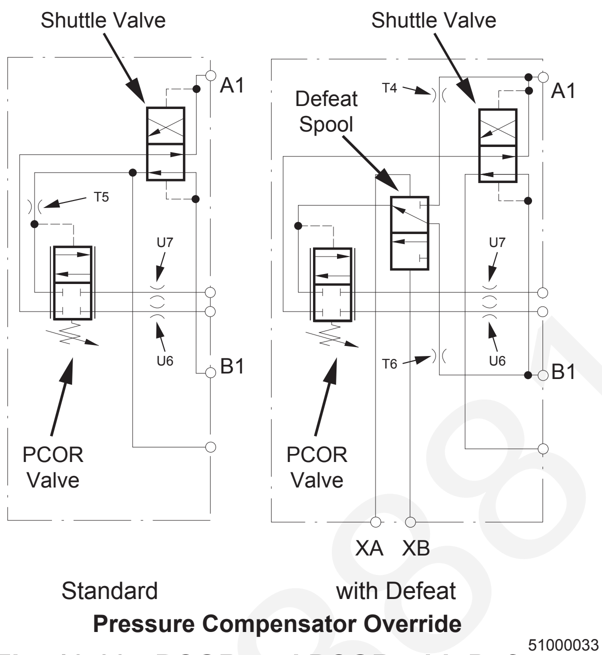


Fig. 10-39 - PCOR and PCOR with Defeat Schematic

PCOR Brake Pressure Defeat Operation

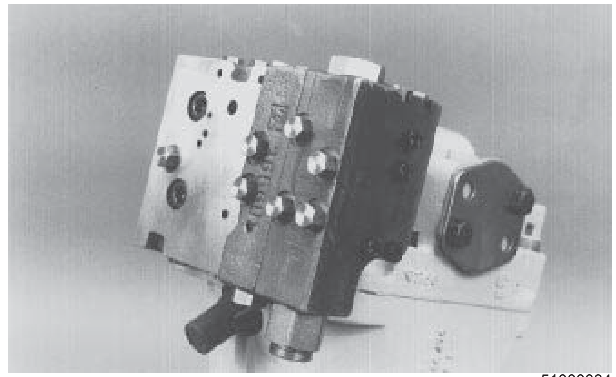
Rotation	High pressure port	Control pressure on port
CW	A	XB
CCW	B	XA

Functional Description (Continued)

Pressure Compensator Regulator (Type PC)

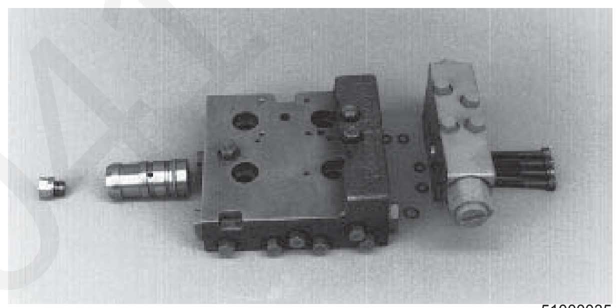
In this regulator, the Pressure Compensator system in the multi-function block assembly controls the motor displacement. At system pressures below the compensator setting, the servo piston is maintained in the minimum motor displacement position. When system pressure exceeds the POR setting, hydraulic pressure acts on the servo piston to increase the motor displacement.

With the Pressure Compensator regulator, an increase in system pressure (above the setting pressure) will result in an increase in motor displacement and output torque, and a decrease in motor shaft speed.



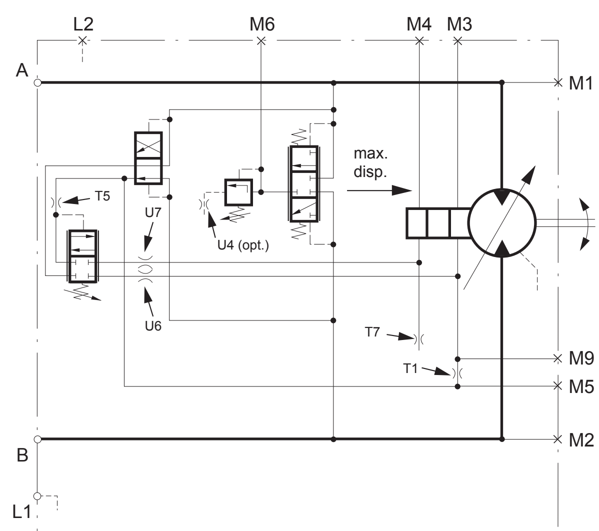
51000034

Fig. 10-40 - Series 51 Motor with PC Regulator



51000035

Fig. 10-41 - PC Regulator Components



51000036

Fig. 10-42 - PC Regulator Schematic

Technical Specifications and Data - Variable Displacement Motors

Design

Piston motor with variable displacement, bent axis construction.

Type of Mounting

SAE four (4) bolt flange – SAE Flange Configuration.
Two (2) bolt flange – Cartridge Motor Configuration.

Pipe Connections

Main pressure ports: SAE flange
Remaining ports: SAE O-ring thread

Direction of Rotation

Clockwise and counter-clockwise.

Installation Position

Installation position discretionary. The housing must always be filled with hydraulic fluid.

System Pressure Range, Input

Max: 480 bar (6960 psi)
Min: 10 bar (145 psi)

Case Pressure

Max. Continuous: 3 bar (44 psi)
Intermittent (Cold start): 5 bar (73 psi)

Hydraulic Fluid

Refer to Sauer-Sundstrand publication BLN-9887 or 697581.

Temperature [1)]

ϑ min = -40°C (-40°F), intermittent, cold start
ϑ nominal = 104°C (220°F), continuous
ϑ max = 115°C (240°F), intermittent

[1)] at the hottest point, normally the case drain line. Hydraulic fluid viscosity must be as shown below.

Fluid Viscosity Limits

ν min = 5 mm²/s (42 SUS) intermittent
ν min = 6.4 mm²/s (47 SUS) min. continuous
ν min = 13 mm²/s (70 SUS) optimum
ν max = 110 mm²/s (510 SUS) max. continuous
ν max = 1600 mm²/s (7400 SUS) intermittent, cold start

Filtration

Acceptable contamination level: ISO Code 18/13 or better. Refer to Sauer-Sundstrand publication BLN-9887 or 697581.

			Frame Size				
		Dimension	060	080	110	160	250
Displacement	maximum	cm³ in³	60.0 3.66	80.7 4.92	109.9 6.71	160.9 9.82	250.0 15.26
	minimum	cm³ in³	12.0 0.73	16.1 0.98	22.0 1.34	32.2 1.96	50.0 3.05
Continuous speed	at max disp at min disp	min⁻¹ (rpm) min⁻¹ (rpm)	3600 5600	3100 5000	2800 4500	2500 4000	2200 3400
Max. speed	at max disp at min disp	min⁻¹ (rpm) min⁻¹ (rpm)	4400 7000	4000 6250	3600 5600	3200 5000	2700 4250
Theoretical torque	at max disp	Nm / bar lbf•in / 1000 psi	0.95 583	1.28 784	1.75 1067	2.56 1563	3.98 2428
	at min disp	Nm / bar lbf•in / 1000 psi	0.19 117	0.26 156	0.35 214	0.51 313	0.80 486
Max. continuous flow	Q max	L / min gal / min	216 57	250 66	308 81	402 106	550 145
Max. corner power	Pcorner max	kW hp	336 450	403 540	492 660	644 864	850 1140
Mass moment of inertia	J	kg • m² lbf • ft²	0.0046 0.1092	0.0071 0.1685	0.0128 0.3037	0.0234 0.5553	0.0480 1.1580
Weight (with control N2)	m	kg lb	28 62	32 71	44 97	56 123	86 190

Safety Precautions

- When Series 51 units are used in vehicular hydrostatic drive systems, the loss of hydrostatic drive line power in any mode of operation may cause a loss of hydrostatic braking capacity. A braking system, redundant to the hydrostatic transmission must, therefore, be provided which is adequate to stop and hold the system should the condition develop.
- Certain service procedures may require the vehicle/machine to be disabled (wheels raised off the ground, work function disconnected, etc.) while performing them in order to prevent injury to the technician and bystanders.

- Use caution when dealing with hydraulic fluid under pressure. Escaping hydraulic fluid under pressure can have sufficient force to penetrate your skin causing serious injury. This fluid may also be hot enough to burn. Serious infection or reactions can develop if proper medical treatment is not administered immediately.
- Some cleaning solvents are flammable. To avoid possible fire, do not use cleaning solvents in an area where a source of ignition may be present.

Notes

Gauge Installation

Various pressure gauge readings can be a great asset in troubleshooting problems with the Series 51 motor or support system.

Snubbers are recommended to protect pressure gauges. Frequent gauge calibration is necessary to insure accuracy.

Fig. 30-1 - Gauge Ports, Motor with N2 Control

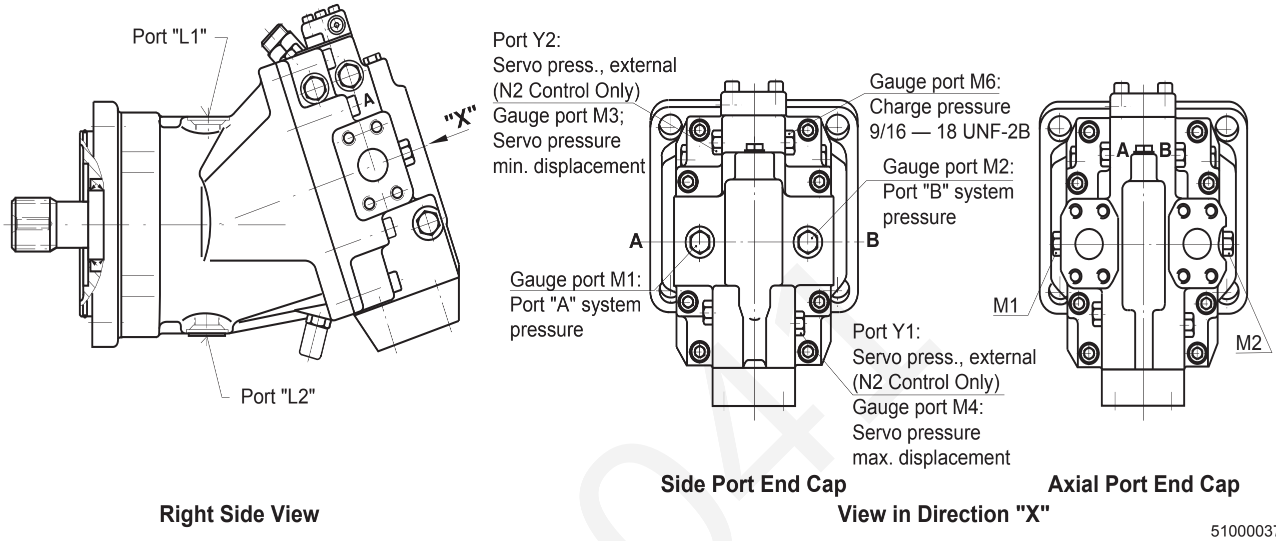


Fig. 30-2- Gauge Ports, Motor with E1•E2, F1•F2, H1•H2, and K1•K2 Controls

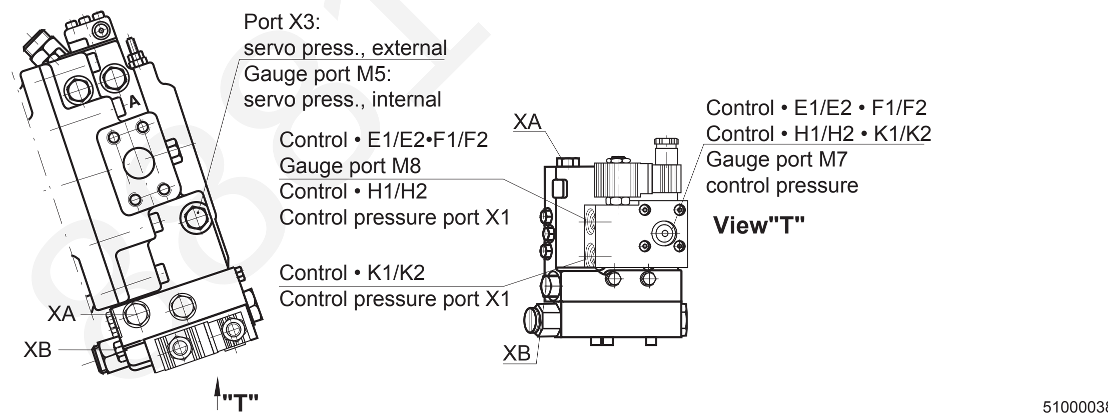
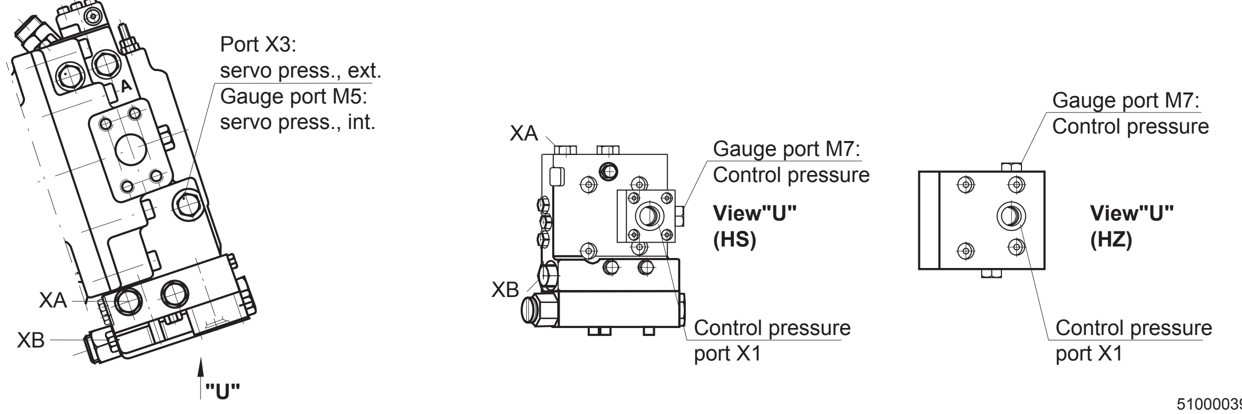


Fig. 30-3 - Gauge Ports, Motor with HS and HZ Controls



Gauge Installation (Continued)

Fig. 30-4 - Gauge Ports, Motor with HP Control

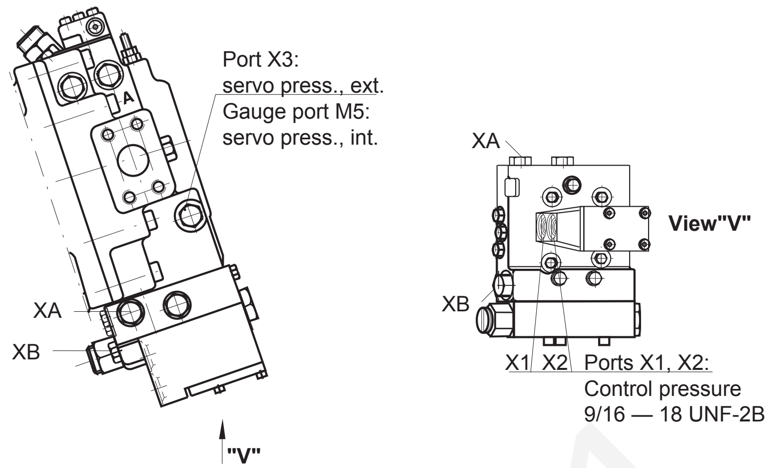


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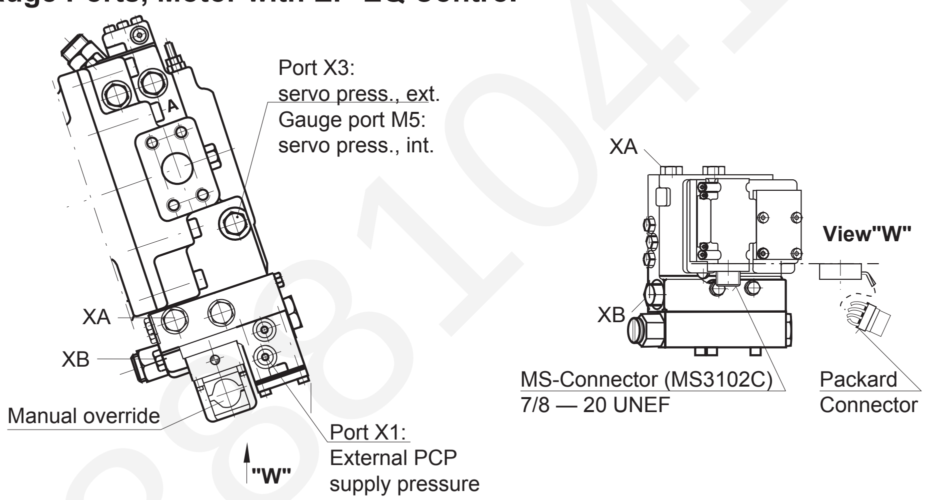
Fig. 30-5 - Gauge Ports, Motor with EP•EQ Control



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Gauge Information

M1	System Pressure Port “A”	600 bar or 10,000 psi Gauge 9/16 — 18 O-Ring Fitting
M2	System Pressure Port “B”	600 bar or 10,000 psi Gauge 9/16 — 18 O-Ring Fitting
M3	Servo Pressure (Min. Angle)	600 bar or 10,000 psi Gauge 9/16 — 18 O-Ring Fitting
M4	Servo Pressure (Max. Angle)	600 bar or 10,000 psi Gauge 9/16 — 18 O-Ring Fitting
M5 (M9)	Servo Supply Pressure	600 bar or 10,000 psi Gauge 9/16 — 18 O-Ring Fitting or Tee into Control Pressure Line

M6	Motor Charge Pressure	60 bar or 1000 psi Gauge 9/16 — 18 O-Ring Fitting
M7 M8	Control Test Port	60 bar or 1000 psi Gauge 9/16 — 18 O-Ring Fitting
L1 L2	Case Pressure	60 bar or 1000 psi Gauge **060, 080, 110**: 1-1/16 — 12 O-Ring Fitting **160, 250**: 1-5/16 — 12 O-Ring Fitting
X1 X2 X3	Control Pressure	60 bar or 1000 psi Gauge 9/16 — 18 O-Ring Fitting
XA XB	Defeat Pressure	60 bar or 1000 psi Gauge Tee into Defeat Pressure Line(s)

Start-Up Procedure and Maintenance

Start-Up Precautions

Cleanliness

Ensure that all system components, including fittings, pipes, and hoses, are completely clean. If cloths are used for cleaning components, they must be made of lint-free materials.

Follow the guidelines presented in Sauer-Sundstrand publication BLN-9887 or 697581 for required fluid cleanliness levels at machine start-up.

Reservoir and Fluid Level

The reservoir should be designed to accommodate maximum volume changes during all system operating modes, and to promote de-aeration of the fluid as it passes through the tank. The reservoir outlet (charge pump inlet) and the reservoir inlet (fluid return) must always be below the normal fluid level. A sight glass is the preferred method for checking fluid level.

The reservoir inlet (fluid return) should be positioned so that flow to the reservoir is directed into the interior of the reservoir for maximum dwell and efficient de-aeration. A baffle (or baffles) between the reservoir inlet and outlet ports will promote de-aeration and reduce surging of the fluid.

No funnel-shaped eddying at the reservoir outlet (charge pump inlet) or formation of foam at the reservoir inlet (fluid return) is permitted.

Start-Up Procedure

The following start-up procedure should always be followed when starting-up a new Series 51 installation or when restarting an installation in which either the pump or motor has been removed from the system.

> **WARNING**
>
> **The following procedure may require the vehicle/machine to be disabled (wheels raised off the ground, work function disconnected, etc.) while performing the procedure in order to prevent injury to the technician and bystanders. Take necessary safety precautions before operating the vehicle/machine.**

Prior to installing the motor, inspect the unit for damage incurred during shipping and handling. Make certain all system components (reservoir, hoses, valves, fittings, heat exchanger, etc.) are clean prior to filling with fluid.

Fill the reservoir with recommended hydraulic fluid, which should be passed through a 10 micron (nominal, no bypass) filter prior to entering the reservoir. The use of contaminated fluid will cause damage to the components, which may result in unexpected vehicle/machine movement.

The inlet line leading from the reservoir to the pump must be filled prior to start up. Check inlet line for properly tightened fittings and make sure it is free of restrictions and air leaks.

Be certain to fill the pump and motor housing with clean hydraulic fluid prior to start up. Fill the housing by pouring filtered oil into the upper case drain port.

Install a 0 to 60 bar or 0 to 1000 psi pressure gauge in the charge pressure gauge port to monitor the charge pressure during start-up.

The external control input signal should be disconnected at the pump control during initial start-up. This will allow the pump to remain in its neutral position.

“Jog” or slowly rotate prime mover until charge pressure starts to rise. Start the prime mover and run at the lowest possible RPM until charge pressure is established. Excess air may be bled from the high pressure lines through the high pressure gauge ports.

Once charge pressure is established, increase speed to normal operating RPM. Note the charge pressure. If charge pressure is incorrect, shut down and determine cause for improper pressure.

Shut down prime mover and connect external control input signal. Start prime mover, checking to be certain pump remains in neutral. With prime mover at normal operating speed, slowly check for forward and reverse machine operation.

Charge pressure should be maintained during forward or reverse operation. Continue to cycle slowly between forward and reverse for at least five (5) minutes.

Shut down prime mover, remove gauges, and plug ports. Check reservoir level and add fluid if necessary.

The transmission is now ready for operation.

Start-Up Procedure and Maintenance (Continued)

Maintenance

Cleanliness

The reservoir breather air filter (if equipped) must be kept clean. Clean the area around the filler cap before opening the reservoir. The hydraulic fluid should be filtered before it enters the reservoir.

Follow the guidelines presented in Sauer-Sundstrand publication BLN-9887 or 697581 for required fluid cleanliness levels during machine operation.

Recommended Fluids

Hydraulic fluids used with Sauer-Sundstrand products should be carefully selected with assistance from a reputable supplier, following the guidelines presented in Sauer-Sundstrand publication BLN-9887 or 697581.

Checking for Leaks

Check the system components for leakage at regular intervals. Tighten any leaking connections while the system is not under pressure. Replace any defective seals and gaskets.

Check hydraulic hoses for damage or aging. When installing replacements, be certain that the hoses are clean and connected properly.

Checking the Fluid Level

Check the reservoir daily for proper fluid level, the presence of water (noted by a cloudy or milky appearance, or free water in bottom of reservoir), and rancid fluid odor (indicating excessive heat).

Changing the Fluid and Filter

To insure optimum service life on Series 51 products, regular maintenance of the fluid and filter must be performed.

The fluid and filter must be changed per the vehicle/machine manufacturer's recommendations. In the absence of such recommendations, the following intervals may be used:

- System with a sealed type reservoir - 2000 hrs.
- System with a breathing type reservoir - 500 hrs.

It may be necessary to change the fluid more frequently if the fluid becomes contaminated with foreign matter (dirt, water, grease, etc.) or if the fluid has been operating at temperature levels greater than the maximum recommended. Never reuse fluid.

The filter should be changed when changing the fluid, or whenever the filter indicator shows that it is necessary to change the filter.

Component Inspection and Adjustment

WARNING

The following procedures may require the vehicle/machine to be disabled (wheels raised off the ground, work function disconnected, etc.) while performing the adjustments to prevent injury to the technician and bystanders.

Charge Pressure Relief Valve Adjustment

An appropriate combination of pump and motor charge pressure settings should be maintained to insure the proper function of the loop flushing circuit. **Correct charge pressure must be maintained under all conditions of operation to maintain pump control performance in closed loop systems.**

To measure motor charge pressure, install a 0 to 60 bar or 0 to 500 psi pressure gauge in the motor charge pressure gauge port. Install a gauge to measure case pressure. Operate the system with the prime mover at normal operating speed and the pump at half stroke (forward or reverse) when measuring motor charge pressure.

In most applications, the motor charge relief valve is set 2 to 4 bar (29 to 58 psi) below the setting of the pump charge relief valve (measured with the pump in its “neutral” or zero-angle position). This setting assumes a reservoir temperature of 50° C (122° F), and is referenced to case pressure.

Series 51 motors are equipped with an external screw adjustable charge pressure relief valve. To adjust the charge pressure, loosen the lock nut (with a 1-1/16" hex wrench) and turn the adjustment plug with a large screwdriver. Clockwise rotation of the plug increases the setting, and counter-clockwise rotation decreases the setting (at a rate of approximately 3.4 bar [50 psi] per turn). The lock nut should be torqued to 52 Nm (38 ft•lbsf).

Once the desired charge pressure setting is achieved, remove the gauges and reinstall the port plugs.

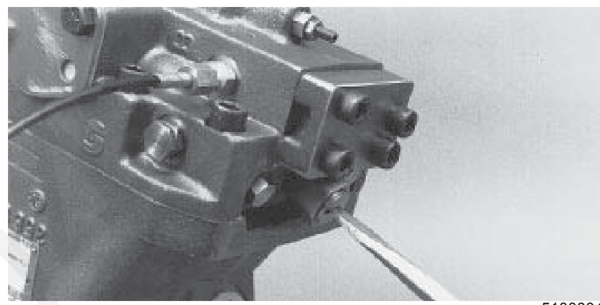

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Fig. 30-6 - Adjusting Charge Pressure Relief Valve

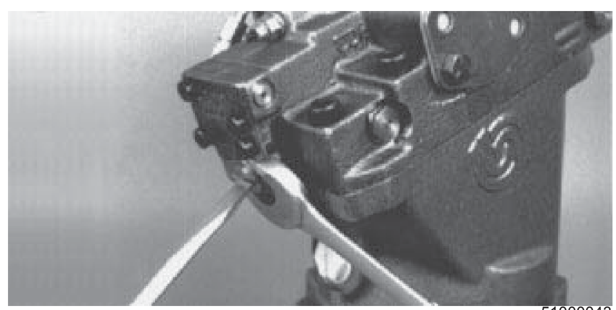

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Fig. 30-7 - Tighten Charge Pressure Relief Valve Lock Nut

Component Adjustment (Continued)

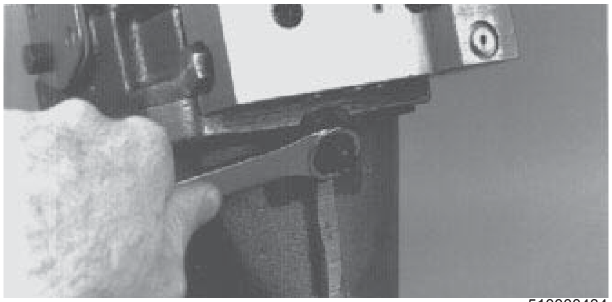

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Fig. 30-8 - Loosen Minimum Displacement Limiter Lock Nut

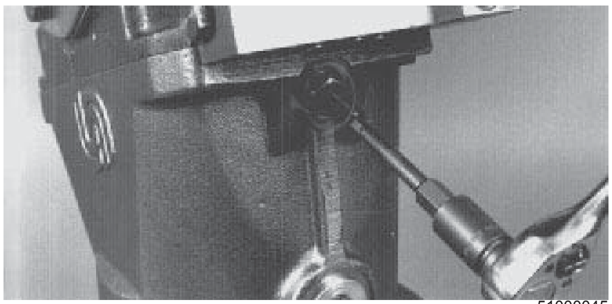

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Fig. 30-9 - Rotate Minimum Displacement Adjusting Screw

Frame Size	Approximate Change in Minimum Displacement Per Revolution of Adjusting Screw
060	1.5 cc/Rev (.09 in3/Rev)
080	2.1 cc/Rev (.13 in3/Rev)
110	3.1 cc/Rev (.19 in3/Rev)
180	4.0 cc/Rev (.24 in3/Rev)
250	6.2 cc/Rev (.38 in3/Rev)

Frame Size	Min. Displacement Range cc/Rev (in3/Rev)	Screw Size and Length mm (in)
060	12 to 29 (.73 to 1.77) 30 to 40 (1.83 to 2.44)	M10x65 (2.56) M10x80 (3.15)
080	16 to 35 (.98 to 2.14) 36 to 54 (2.20 to 3.20)	M10x65 (2.56) M10x80 (3.15)
110	22 to 46 (1.34 to 2.81) 47 to 74 (2.87 to 4.52)	M12x70 (2.76) M12x80 (3.15)
160	32 to 72 (1.95 to 4.39) 73 to 107 (4.45 to 6.53)	M12x75 (2.95) M12x90 (3.54)
250	50 to 90 (3.05 to 5.49) 91 to 130 (5.55 to 7.93) 131 to 167 (7.99 to 10.19)	M12x75 (2.95) M12x90 (3.54) M12x100 (3.94)

Minimum Displacement Limiter Adjustment

The minimum displacement is set at the factory, and the adjustment screw is covered with a tamper-resistant cap

WARNING

Care should be taken in adjusting displacement limiters to avoid undesirable speed conditions. The sealing lock nut must be retorqued after every adjustment to prevent an unexpected change in operating conditions and to prevent external leakage during unit operation.

NOTE: Changes in motor displacement can be detected by providing a constant flow of fluid to the motor, while maintaining the motor at minimum displacement and monitoring the motor output shaft speed. An increase in displacement will result in a decrease in shaft speed, while a decrease in displacement will result in an increase in shaft speed.

To adjust the minimum displacement, first remove and discard the cap covering the adjusting screw. Using a 17 mm hex wrench for 060 and 080 frame size motors or a 19 mm hex wrench for 110 through 250 frame size motors, loosen the lock nut retaining the minimum displacement limiter adjusting screw.

Using a 5 mm internal hex wrench for 060 and 080 frame size motors or a 6 mm internal hex wrench for 110 through 250 frame size motors, rotate the adjusting screw to limit the minimum displacement of the motor.

Rotating the adjusting screw clockwise will increase the minimum displacement of the motor, while rotating the adjusting screw counter-clockwise will decrease the minimum displacement.

For each full revolution, of the adjusting screw, the displacement will change according to the accompanying chart.

Different minimum displacements may require different length adjusting screws. The various lengths are shown in the accompanying chart.

After establishing the desired minimum displacement setting, tighten the lock nut on the adjusting screw to 51 Nm (38 ft•lbsf) for 060 and 080 frame size motors or 86 Nm (63 ft•lbsf) for 110 through 250 frame size motors. Install a new tamper-resistant cap on the adjusting screw.

Component Adjustment (Continued)

Maximum Displacement Limiter Adjustment

The maximum displacement of the Series 51 motors can be limited by limiting the stroke of the setting piston, and the resulting movement of the valve segment. A displacement stop screw is installed on the setting piston (under the minimum angle servo cover) to limit the stroke of the piston.

Spacers may be installed on the displacement stop screw to limit the stroke. A longer or shorter screw must be used to retain a thicker or thinner spacer.

WARNING

Care should be taken in adjusting displacement limiters to avoid undesirable speed conditions. The stop screw must be retorqued after adjustment to prevent an unexpected change in operating conditions.

NOTE: Changes in motor displacement can be detected by providing a constant flow of fluid to the motor, while maintaining the motor at maximum displacement and monitoring the motor output shaft speed. An increase in displacement will result in a decrease in shaft speed, while a decrease in displacement will result in an increase in shaft speed.

To adjust the maximum displacement, first remove the screws retaining the minimum angle servo cover to the end cap with an 8 mm internal hex wrench (060, 080, 110, and 160 units), or a 10 mm internal hex wrench (250 units). Remove the minimum angle servo cover and O-rings. Remove the displacement limiter screw with an 8 mm internal hex wrench.

Installing a thicker spacer on the end of the setting piston will reduce the maximum displacement of the motor. Installing a thinner spacer will increase the maximum displacement. The displacement will change according to the accompanying chart.

Torque the displacement limiter screw to 54 Nm (40 ft•lbsf).

Install the minimum angle servo cover and its O-rings. Install the cover screws and torque to 78 Nm (58 ft•lbsf) for 060, 080, 110, and 160 motors, or 110 Nm (81 ft•lbsf) for 250 motors.

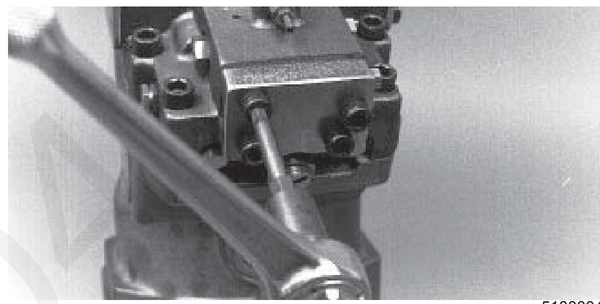

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Fig. 30-10 - Remove Minimum Angle Servo Cover Screws

Frame Size	Approximate Change in Maximum Displacement with Change in Spacer Thickness cc/mm (in^3/.1 in)
060	0.98 (.15)
080	1.14 (.18)
110	1.48 (.23)
160	1.93 (.30)
250	2.63 (.41)

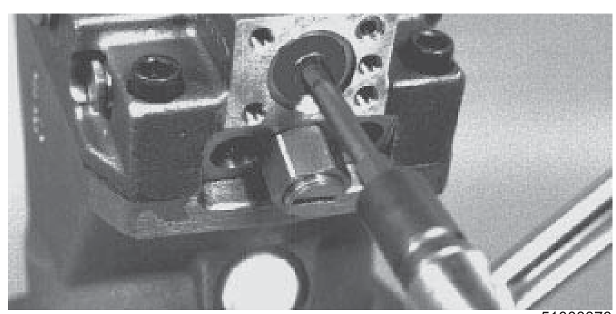

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Fig. 30-11 - Torque Maximum Displacement Limiter Screw

Component Adjustment (Continued)

Displacement Control Adjustments

NOTE: A change in motor displacement can be detected by providing a constant flow of fluid to the motor and monitoring the motor output shaft speed while adjusting the control. An increase in displacement will result in a decrease in shaft speed, while a decrease in displacement will result in an increase in shaft speed.

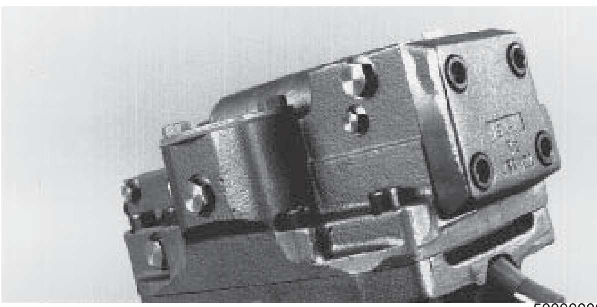

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Fig. 30-12 - Hydraulic 2-Position Control, Type N2)

Hydraulic 2-Position Control (Type N2)

No adjustments are provided for the N2 control.

A minimum of 25 bar (360 psi) servo pressure is required to change the motor displacement with the motor shaft turning. A minimum of 70 bar (1015 psi) servo pressure is required to change the motor displacement with the motor shaft locked.

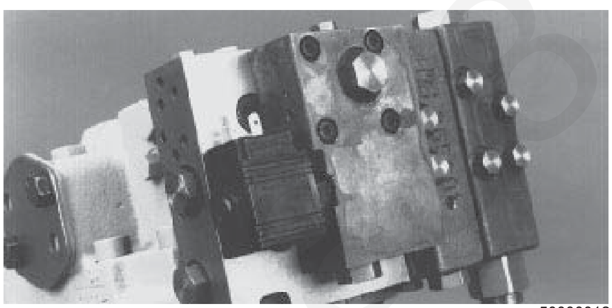

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Fig. 30-13 - Electrohydraulic 2-Position Control, Types E1•E2 and F1•F2

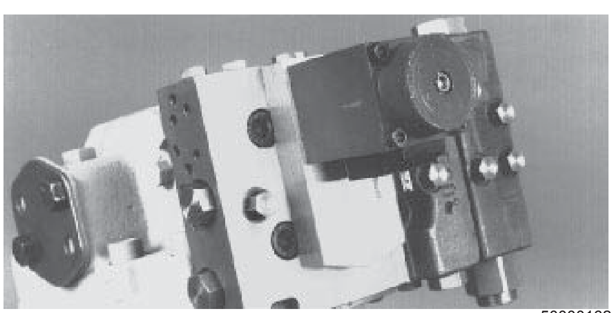

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Fig. 30-14 - Electric 2-Position Control, Type S1

Electrohydraulic 2-Position Control (Types E1•E2 and F1•F2) and Electric 2-Position Control (Type S1)

These controls do not require adjustment.

CAUTION
Do not tamper with the adjusting screw in the end cap (opposite the control).

Pilot pressure for the E1•E2 or F1•F2 electric solenoid valve is internally supplied. When the solenoid is energized, motor charge pressure should be present at test ports M7 and M8. When the solenoid is not energized, test port M8 should drop to case pressure.

The S1 control utilizes a direct acting solenoid to operate the control valve spool in the end cap.

Servo pressure supply oil is usually provided internally from the main system ports of the motor. If external servo pressure supply is utilized, a minimum of 25 bar (360 psi) is required to change the motor displacement with the motor shaft turning, and a minimum of 70 bar (1015 psi) is required with the motor shaft locked.

Component Adjustment (Continued)

Hydraulic Proportional Control (Types HZ, HS, H1•H2, and K1•K2)

The control start pressure for these controls may be adjusted with the adjusting screw on the end cap (opposite the control block). Control start is that pilot pressure at which the motor displacement starts to decrease.

To check the control start setting, install a gauge to monitor the pilot pressure (connect to port M7 or tee into the pilot line connected to port X1), and the minimum angle servo pressure (port M3). If adjusting an H1 or H2 control, the override solenoid must be energized. If adjusting a K1 or K2 control, the solenoid must not be energized.

NOTE: The pilot signal may be determined by prime mover speed, other shaft speeds, or other control pressures, depending upon the design of the vehicle / machine control circuit.

Increase the pilot signal to the required control start pressure. An increase in minimum angle servo pressure will be noted as the motor displacement starts to decrease.

To adjust the control start pressure, loosen the lock nut using a 10 mm hex wrench and turn the adjusting screw with a 4 mm internal hex wrench. Turning the screw clockwise increases the control start pressure. Torque the lock nut to 9 Nm (6.6 ft•lbsf) after adjusting.

For the H1•H2 controls, the pilot signal pressure supplied to port X1 should also be present at test port M7 when the solenoid is energized. When the solenoid is not energized, test port M7 should drop to case pressure.

For the K1•K2 controls, the pilot signal pressure supplied to port X1 should also be present at test port M7 when the solenoid is not energized. When the solenoid is energized, test port M7 should drop to case pressure.

Shut down the prime mover. Remove the gauges and install the gauge port plugs. Return the pump and motor controls to their normal operation.

Servo pressure supply oil is usually provided internally from the main system ports of the motor. If external servo pressure supply is utilized, a minimum of 25 bar (360 psi) is required to change the motor displacement with the motor shaft turning, and a minimum of 70 bar (1015 psi) is required with the motor shaft locked.

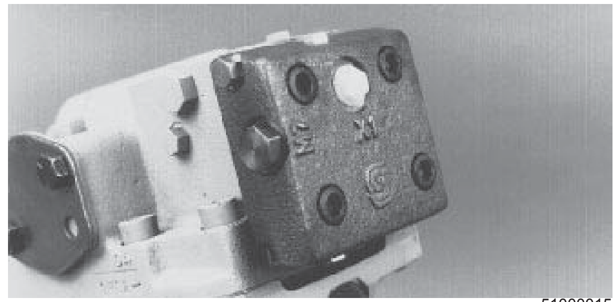
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Fig. 30-15 - Hydraulic Proportional Control, Type HZ

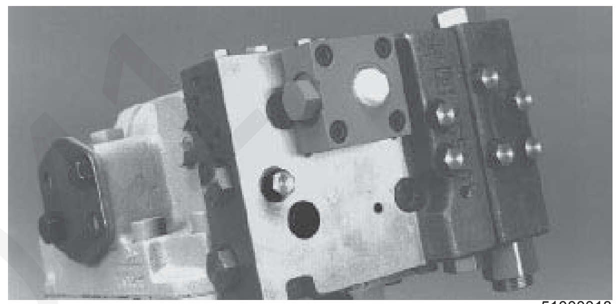
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Fig. 30-16 - Hydraulic Proportional Control, Type HS

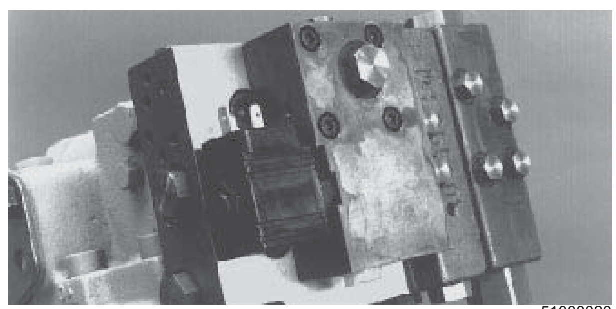
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Fig. 30-17 - Hydraulic Proportional Control with Electric Override, Type H1•H2 (K1•K2 Similar)

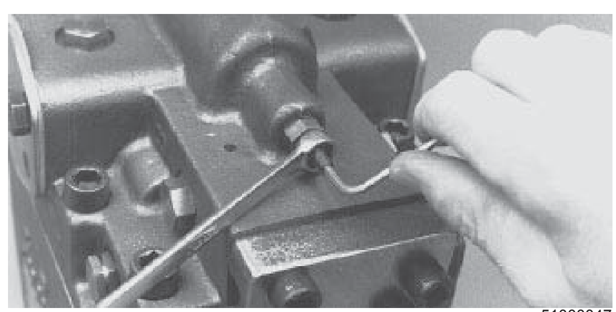
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Fig. 30-18 - Adjusting Control Threshold, Types HS, HZ, H1•H2, and K1•K2

Component Adjustment (Continued)

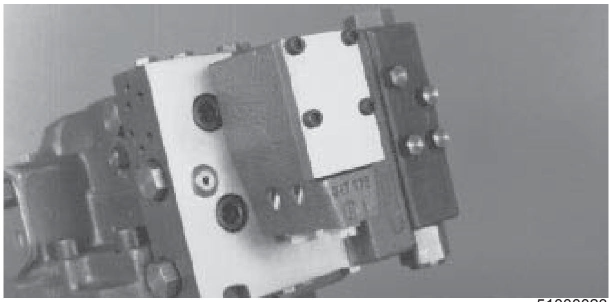

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Fig. 30-19 - Two Line Hydraulic Proportional Control, Type HP

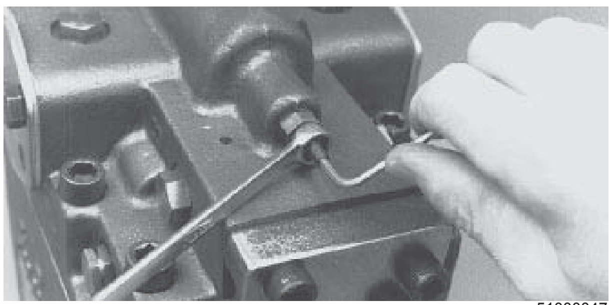

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Fig. 30-20 - Adjusting Control Threshold (Type HP)

Two Line Hydraulic Proportional Control (Type HP)

The differential control start pressure for this control may be adjusted with the adjusting screw on the end cap (opposite the control block). Control start is that differential pilot pressure at which the motor displacement starts to decrease.

To check the control start setting, install gauges to monitor the pilot pressures (tee into the pilot lines connected to ports X1 and X2), and the minimum angle servo pressure (port M3).

NOTE: The pilot signals may be determined by prime mover speed, other shaft speeds, or other control pressures, depending upon the design of the vehicle / machine control circuit.

Increase the pilot signal differential to the required control start pressure. An increase in minimum angle servo pressure will be noted as the motor displacement starts to decrease.

The differential control start pressure should be the same no matter which pilot pressure is higher. Differences in control operation when the pilot pressure differential is reversed indicate a problem with the shuttle spool in the control block.

To adjust the control start differential pressure, loosen the lock nut using a 10 mm hex wrench and turn the adjusting screw with a 4 mm internal hex wrench. Turning the screw clockwise increases the control start pressure. Torque the lock nut to 9 Nm (6.6 ft•lbsf) after adjusting.

Shut down the prime mover. Remove the gauges and install the gauge port plugs. Return the pump and motor controls to their normal operation.

Servo pressure supply oil is usually provided internally from the main system ports of the motor. If external servo pressure supply is utilized, a minimum of 25 bar (360 psi) is required to change the motor displacement with the motor shaft turning, and a minimum of 70 bar (1015 psi) is required with the motor shaft locked.

Component Adjustment (Continued)

Two Line Hydraulic Proportional Control for “Dual Path” Vehicles (Type HC)

The differential control start pressure for this control may be adjusted with the adjusting screw on the control housing. Control start is that differential pilot pressure at which the motor displacement starts to decrease.

To check the control start setting, install gauges to monitor the pilot pressures (tee into the pilot lines connected to ports X1 and X2), and the minimum angle servo pressure (port M3).

NOTE: The pilot signals may be determined by prime mover speed, other shaft speeds, or other control pressures, depending upon the design of the vehicle / machine control circuit.

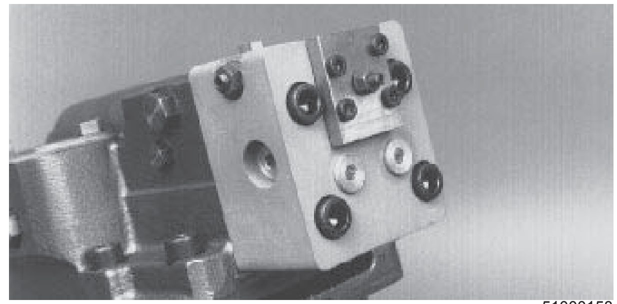
Increase the pilot signal differential to the required control start pressure. An increase in minimum angle servo pressure will be noted as the motor displacement starts to decrease.

The differential control start pressure should be the same no matter which pilot pressure is higher. Differences in control operation when the pilot pressure differential is reversed indicate a problem with the shuttle spool in the control block.

To adjust the control start differential pressure, loosen the lock nut using a 10 mm hex wrench and turn the adjusting screw with a 4 mm internal hex wrench. Turning the screw counter-clockwise (CCW) increases the control start pressure. Torque the lock nut to 9 Nm (6.6 ft•lbsf) after adjusting.

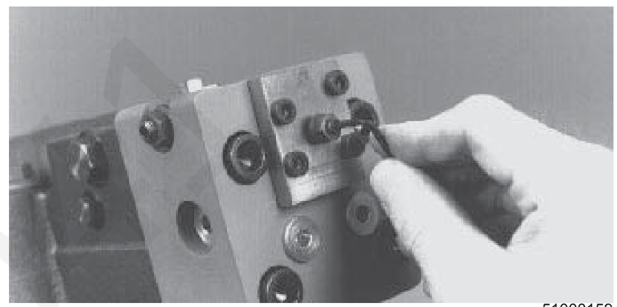
Shut down the prime mover. Remove the gauges and install the gauge port plugs. Return the pump and motor controls to their normal operation.

Servo pressure supply oil is provided internally from the main system ports of the motor.



51000158

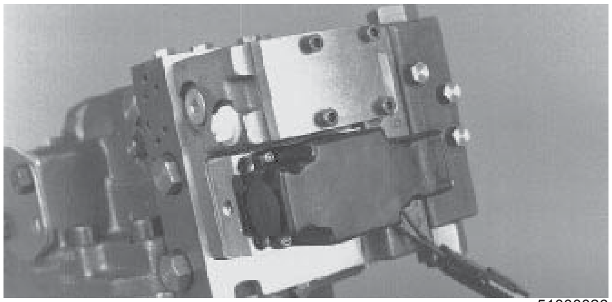
Fig. 30-21 - Two Line Hydraulic Proportional Control, Type HC



51000159

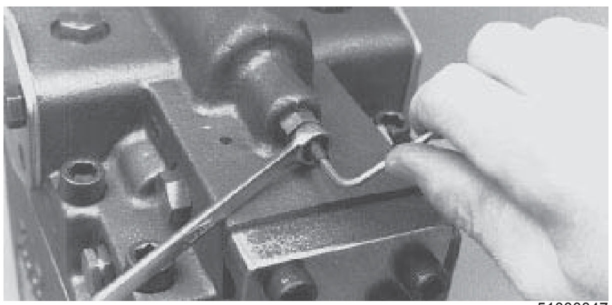
Fig. 30-22 - Adjusting Control Threshold (Type HC)

Component Adjustment (Continued)



51000026

Fig. 30-23 - Electrohydraulic Proportional Control, Type EP (EQ Similar)



51000047

Fig. 30-24 - Adjusting Control Threshold (Type EP•EP)

Electrohydraulic Proportional Control (Types EP and EQ)

The control start current for the EP and EQ controls may be adjusted with the adjusting screw on the end cap (opposite the control block). Control start is that current supplied to the PCP (Pressure Control Pilot) valve at which the motor displacement starts to decrease.

To check the threshold setting, install instruments to monitor the PCP current, and the minimum angle servo pressure (port M3).

NOTE: The current supplied to the PCP may be determined by prime mover speed, other shaft speeds, control pressures, or other electrical signals, depending upon the design of the vehicle / machine control circuit.

Increase the PCP current to the required control start current. An increase in minimum angle servo pressure will be noted as the motor displacement starts to decrease.

To adjust the control start current, loosen the lock nut using a 10 mm hex wrench and turn the adjusting screw with a 4 mm internal hex wrench. Turning the screw clockwise increases the control start current. Torque the lock nut to 9 Nm (6.6 ft•lbsf) after adjusting.

PCP supply pressure oil is provided externally. PCP supply pressure must be a minimum of 20 bar (290 psi) and no more than 70 bar (1015 psi).

Shut down the prime mover. Remove the gauges and install the gauge port plugs. Return the pump and motor controls to their normal operation.

Servo pressure supply oil is usually provided internally from the main system ports of the motor. If external servo pressure supply is utilized, a minimum of 25 bar (360 psi) is required to change the motor displacement with the motor shaft turning, and a minimum of 70 bar (1015 psi) is required with the motor shaft locked.

Component Adjustment (Continued)

Pressure Compensator Over-Ride (PCOR) and Pressure Compensator Regulator (Type PC) Adjustment

The PCOR or PC regulator valve setting may be adjusted with the adjusting screw on the PCOR/PC valve block attached to the multi-function block. The regulator start pressure is that system pressure at which the PCOR or PC regulator starts to increase the motor displacement.

In order to measure the regulator start pressure setting of the PCOR or the PC regulator, the motor output shaft must be loaded to increase the system working pressure. This can accomplished by applying the vehicle's brakes or by loading the work function.

> **WARNING**
>
> **The following procedures may require the vehicle/machine to be disabled (wheels raised off the ground, work function disconnected, etc.) while performing the adjustment to prevent injury to the technician and bystanders.**

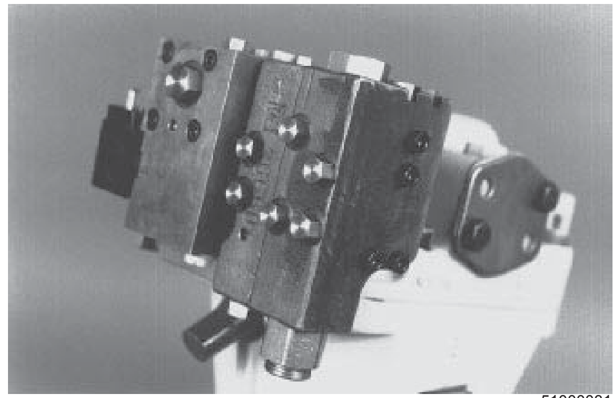
Install gauges to monitor system pressure (connect to ports M1 and M2), the minimum angle servo pressure (port M3), and the maximum angle servo pressure (port M4).

Start the prime mover and operate at normal speed. Provide a signal to the pump control to provide a constant flow of hydraulic fluid to the motor. Provide a signal to the motor control to maintain the motor at its minimum displacement.

Increase the load on the motor to increase the system pressure to the required regulator start pressure. The maximum angle servo pressure (M4) will increase and the minimum displacement servo pressure (M3) will decrease as the PCOR or PC regulator operates. The servo pressures will equalize, and the maximum angle servo pressure continue to increase, as the motor displacement starts to increase.

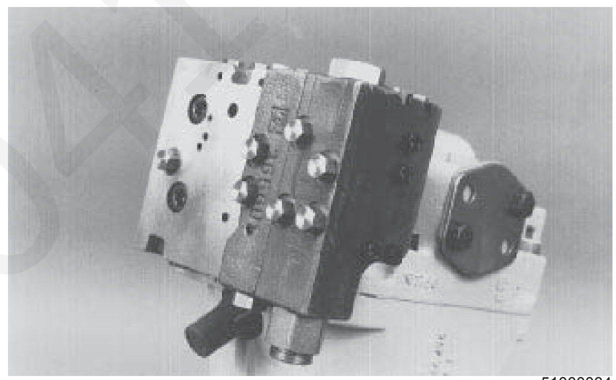
During the transition from minimum to maximum displacement, an additional 10 bar (145 psi) increase in system pressure may be noted.

Once the motor is at maximum displacement, further increases in load will result in increasing system pressure until the maximum system pressure (determined by the system relief valve or pump pressure limiter) is reached.



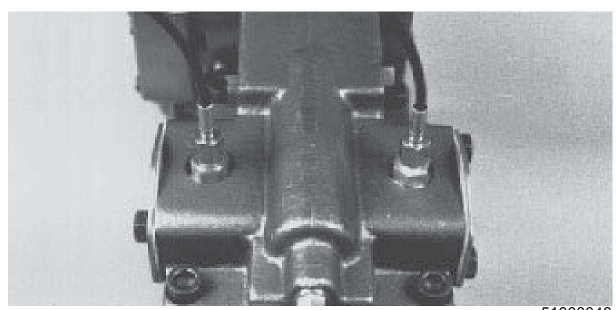
51000031

Fig. 30-25 - PCOR Block on Multi-Function Block (K1•K2 Control Shown)



51000034

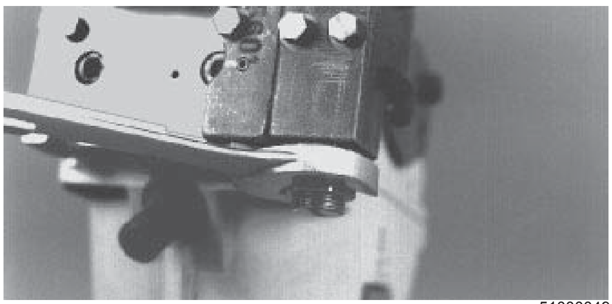
Fig. 30-26 - Pressure Compensator Regulator (Type PC)



51000048

Fig. 30-27 - System Pressure Gauge Ports (Side Port End Cap)

Component Adjustment (Continued)



51000049

Fig. 30-28 - Loosen PCOR/PC Lock Nut

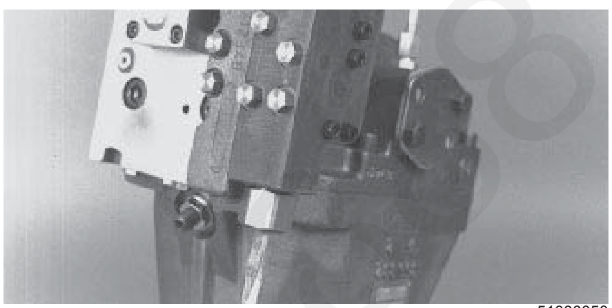


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Fig. 30-29 - Rotate PCOR/PC Adjusting Screw

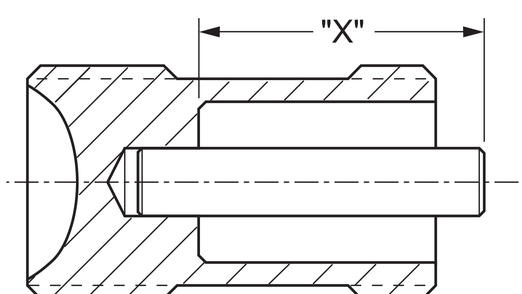

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Fig. 30-30 - PCOR/PC Adjusting Screw Stop Pin

Allow the pump to return to its neutral position. Repeat the procedure for the other side of the closed circuit if so configured. The PCOR or PC regulator must operate at the same start pressure as noted previously. Any noticeable difference in operation from side to side may indicate a problem with the pressure supply shuttle spool or brake pressure defeat spool in the multi-function block.

NOTE: Some motors may be configured for the PCOR or PC regulator to function on only one (1) side of the closed loop. Refer to the nomenclature on the motor nameplate.

In order for the PCOR or PC regulator to function properly on motors equipped with a brake pressure defeat spool, the defeat spool must be positioned correctly. The control pressure for the defeat spool should be applied to the appropriate port (XA or XB) as shown in the following table to shift the defeat spool and permit PCOR or PC regulator operation. Maximum pressure across the brake pressure defeat ports XA and XB is 50 bar (725 psi).

Pressure Compensator Override Defeat Operation

Rotation	High system pressure port	Control pressure on port
CW	A	XB
CCW	B	XA

The PCOR or PC regulator valve is screw adjustable. To adjust, loosen the locknut with a 1-1/16" hex wrench. Turn the adjusting screw with a large screwdriver until the desired pressure setting is established. Clockwise rotation of the adjustment screw will increase the pressure setting at a rate of approximately 70 bar (1000 psi) per turn.

CAUTION

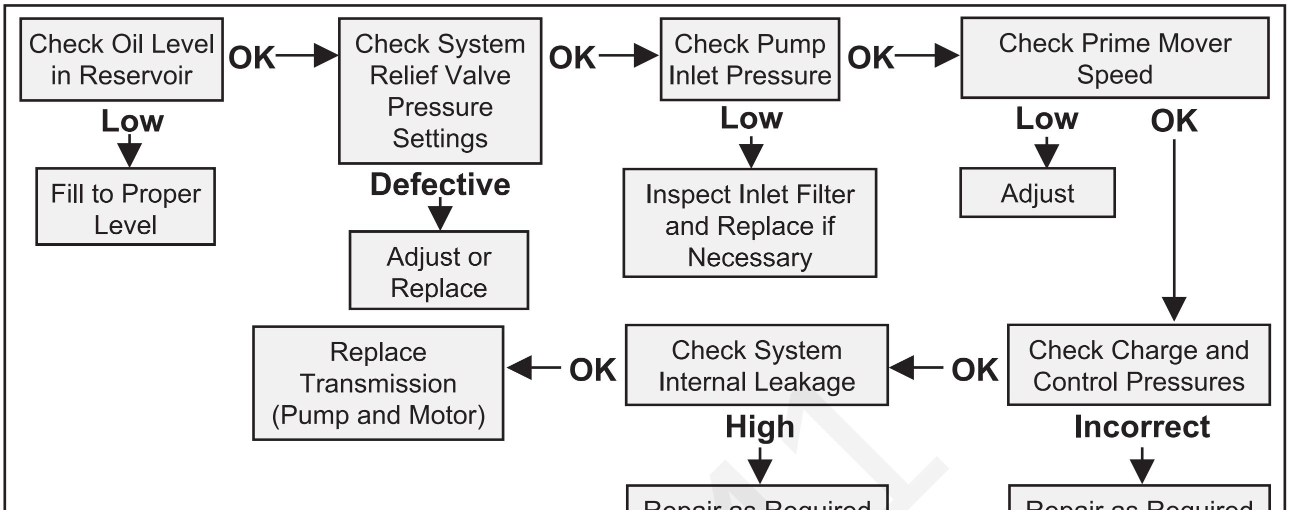
A stop pin is installed in the adjusting screw to prevent “overtravel” of the PCOR/PC valve spool. The stop pin must protrude (distance “X”) 19 mm (.75 in.) from the spring seat for settings of 270 to 370 bar (3900 to 5350 psi), or 24 mm (.94 in.) for settings of 110 to 260 bar (1600 to 3750 psi). Refer to the appropriate Service Parts Manual for further information.

While holding the adjusting screw from turning, torque the lock nut to 52 Nm (38 ft•lbsf). Recheck the PCOR or PC regulator setting.

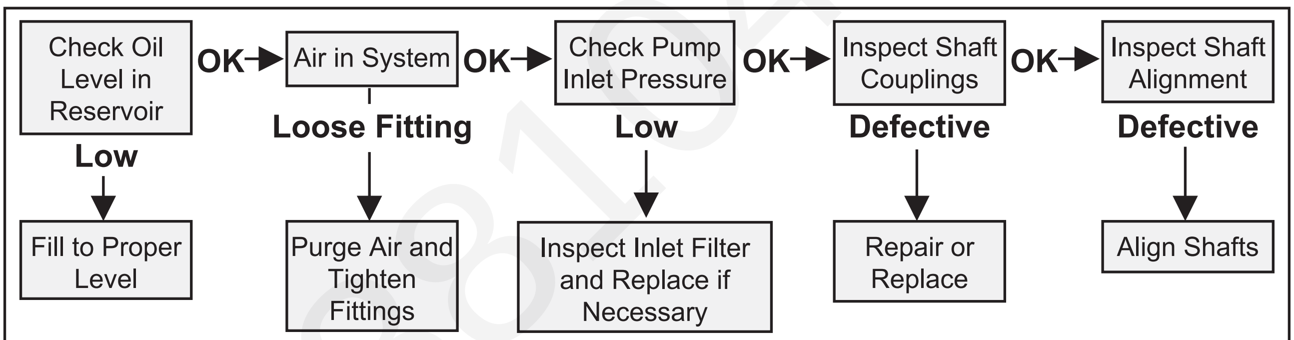
Shut down the prime mover. Remove the gauges and install the gauge port plugs. Return the pump and motor controls to their normal operation.

Troubleshooting

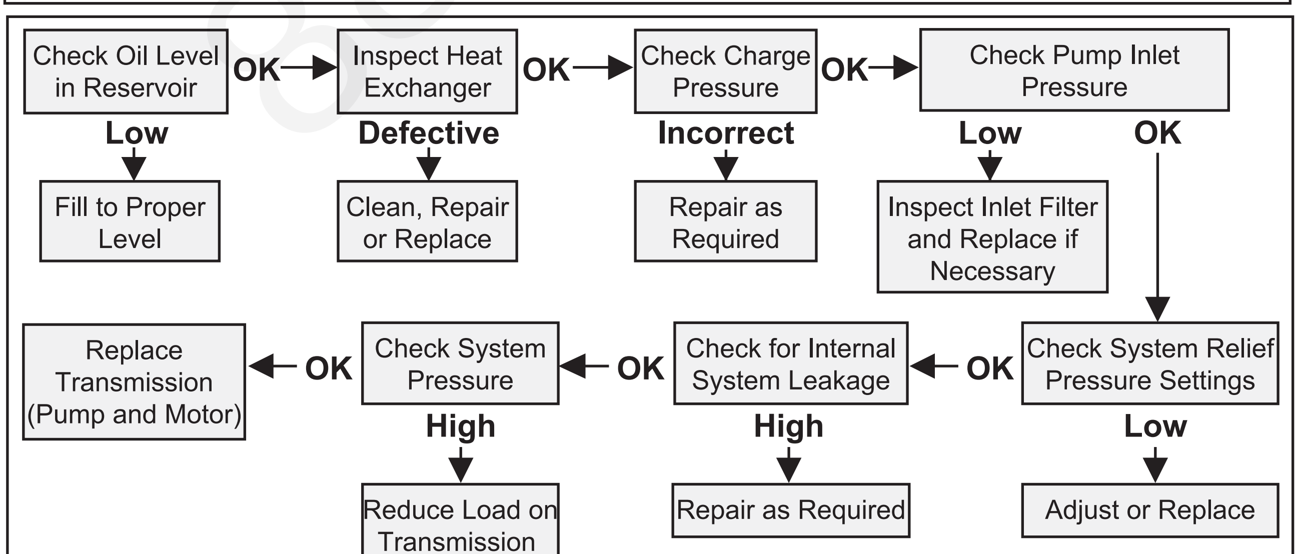
Fault-Logic Diagrams • Closed Circuit



SYSTEM RESPONSE IS SLUGGISH



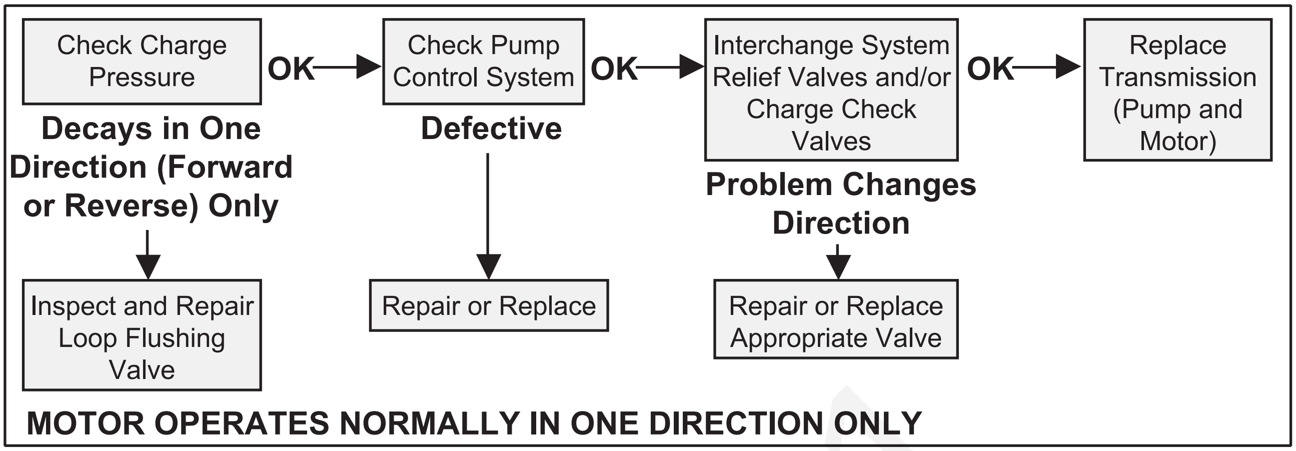
EXCESSIVE NOISE AND/OR VIBRATION

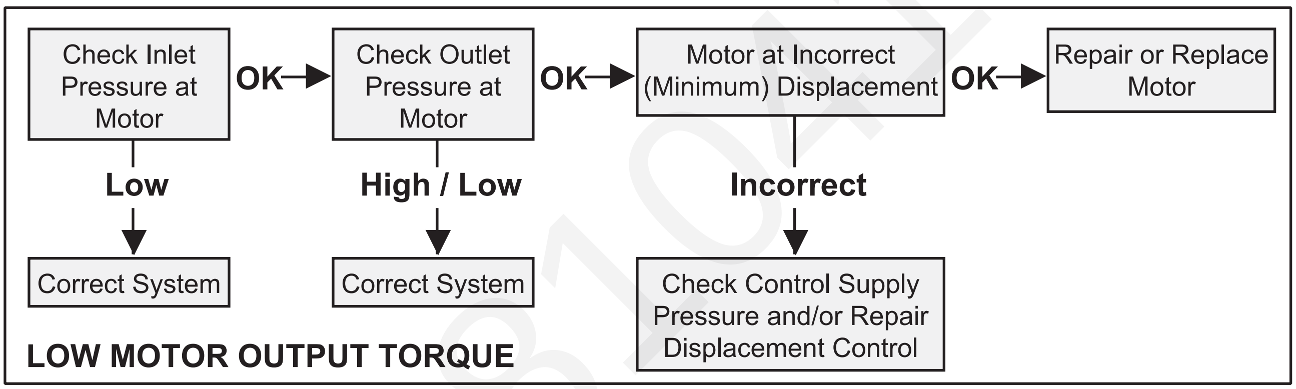


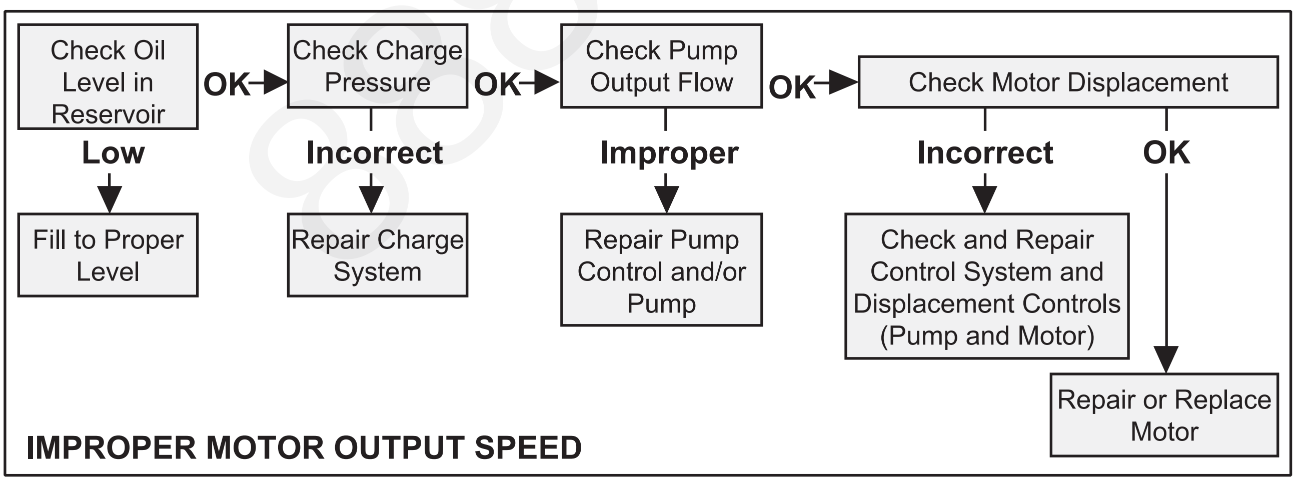
SYSTEM OPERATING HOT

Troubleshooting (Continued)

Fault-Logic Diagrams • Closed Circuit (Continued)







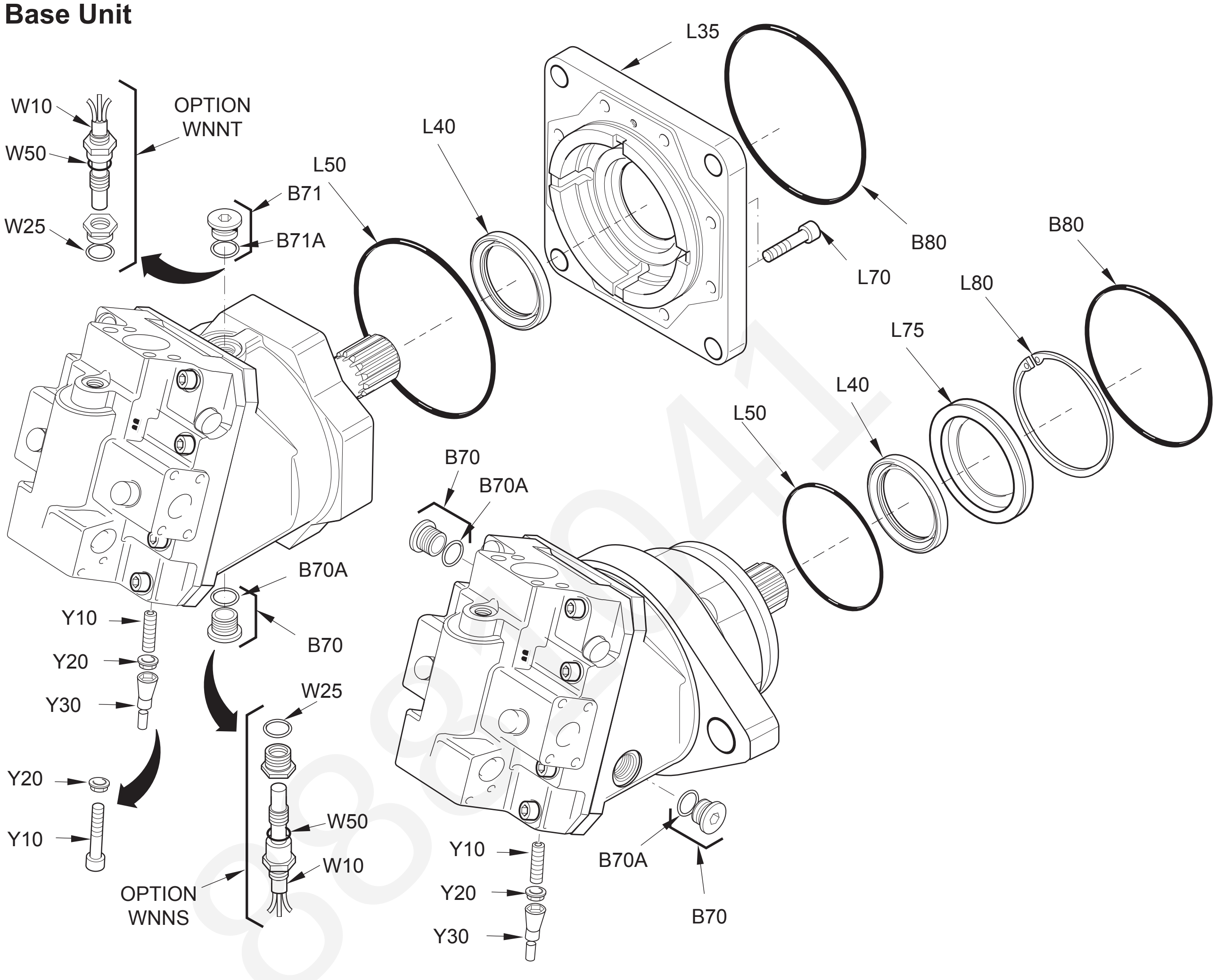
Notes

Notes

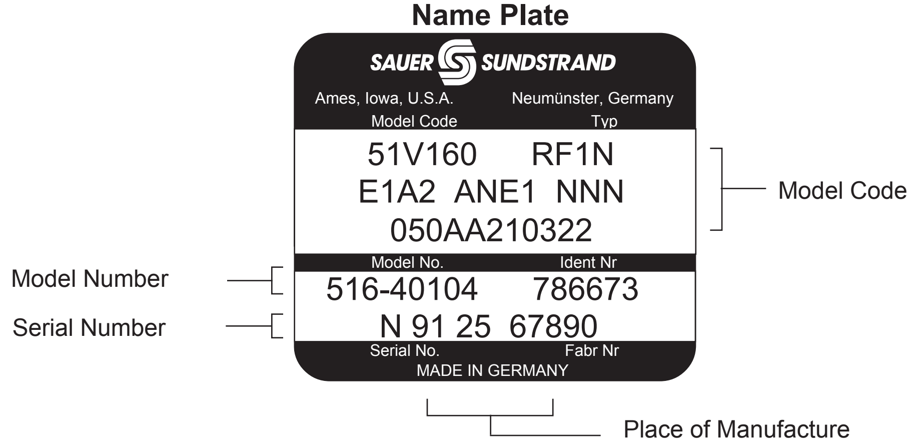
Exploded View of the Series 51 Variable Motor

The following information is for general parts identification ONLY. Refer to the applicable Service Parts List when ordering service parts.

Base Unit



Name Plate

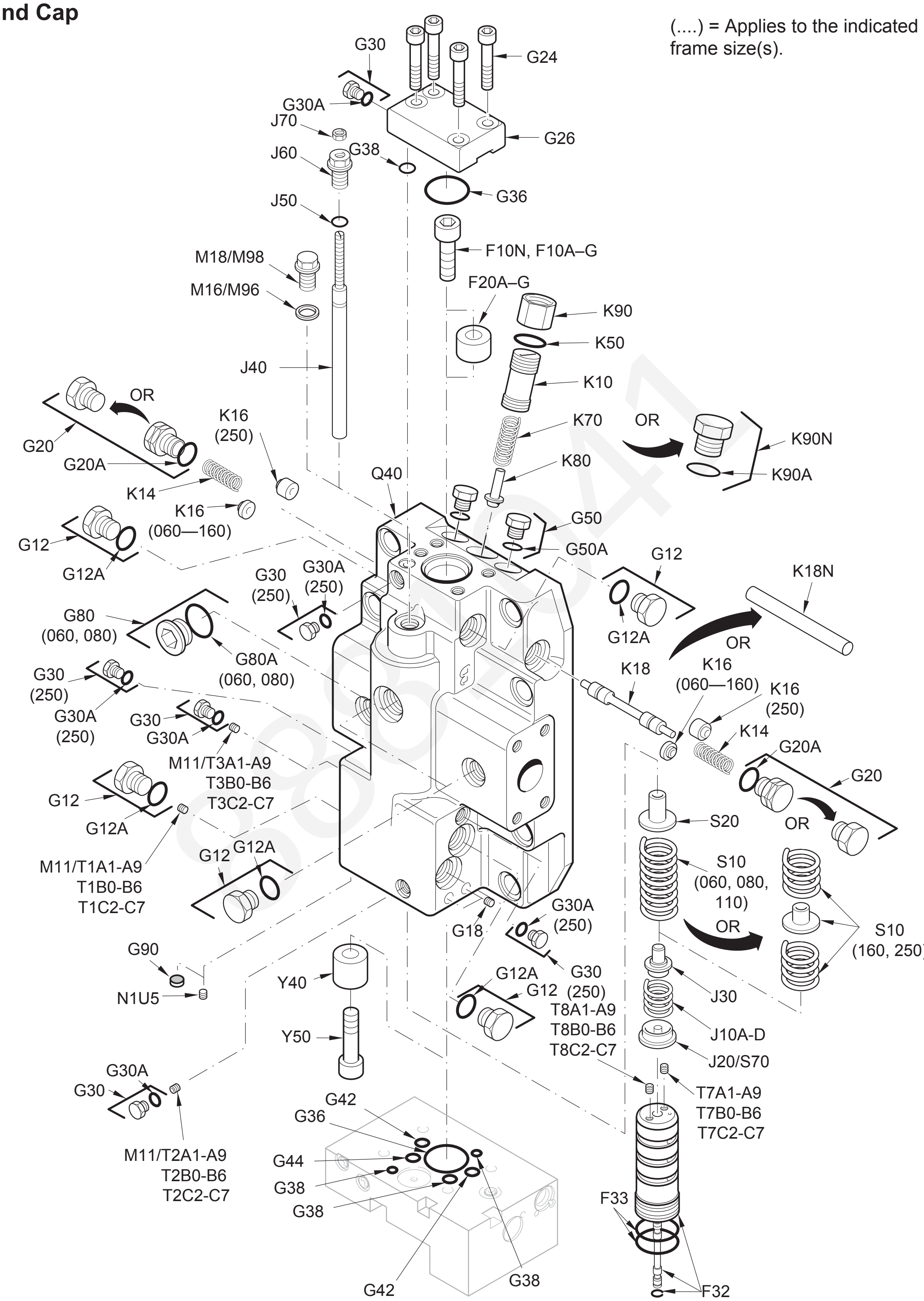


Name Plate (German Production)

Exploded View of the Series 51 Variable Motor (Continued)

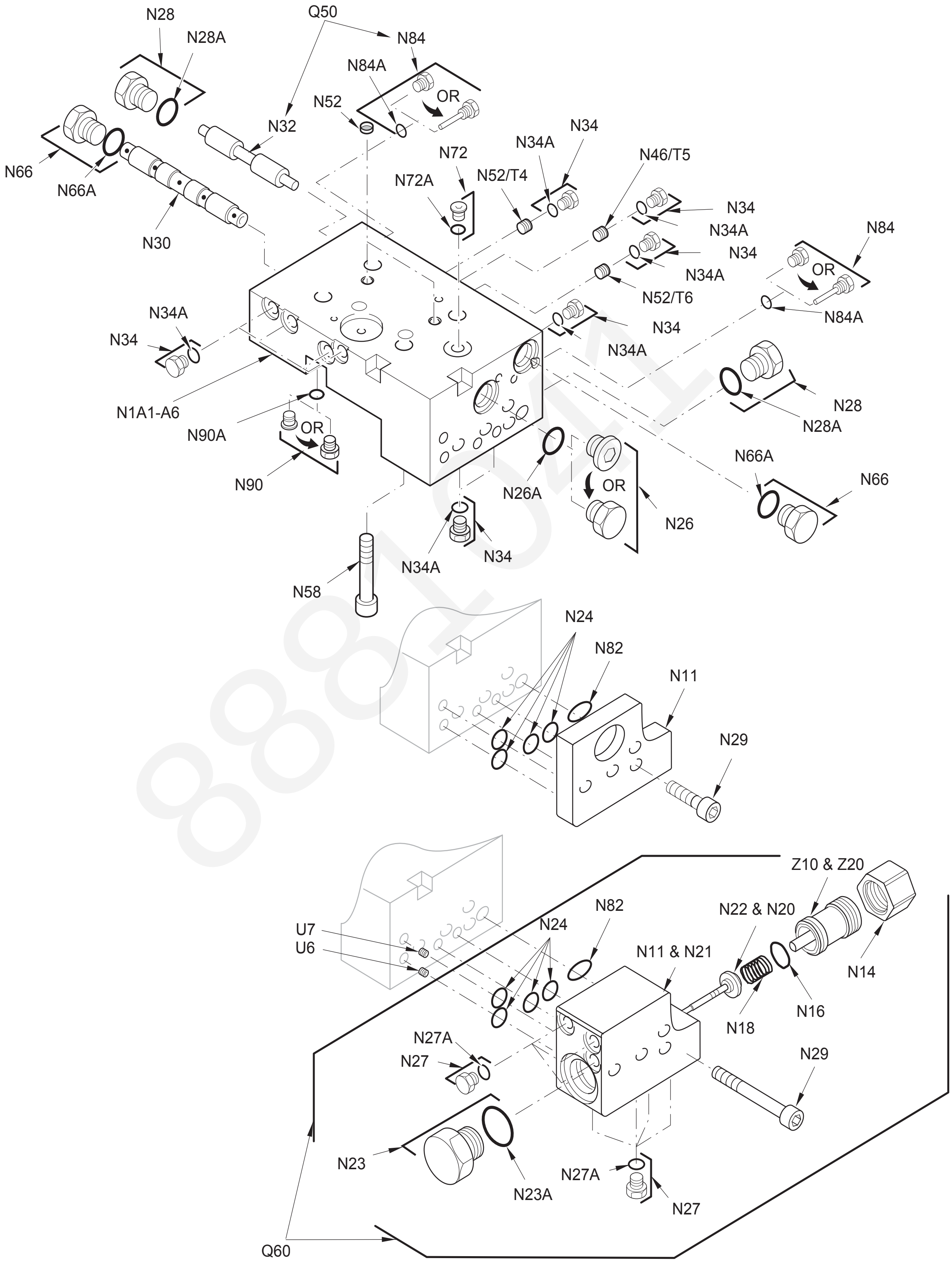
End Cap

(....) = Applies to the indicated frame size(s).



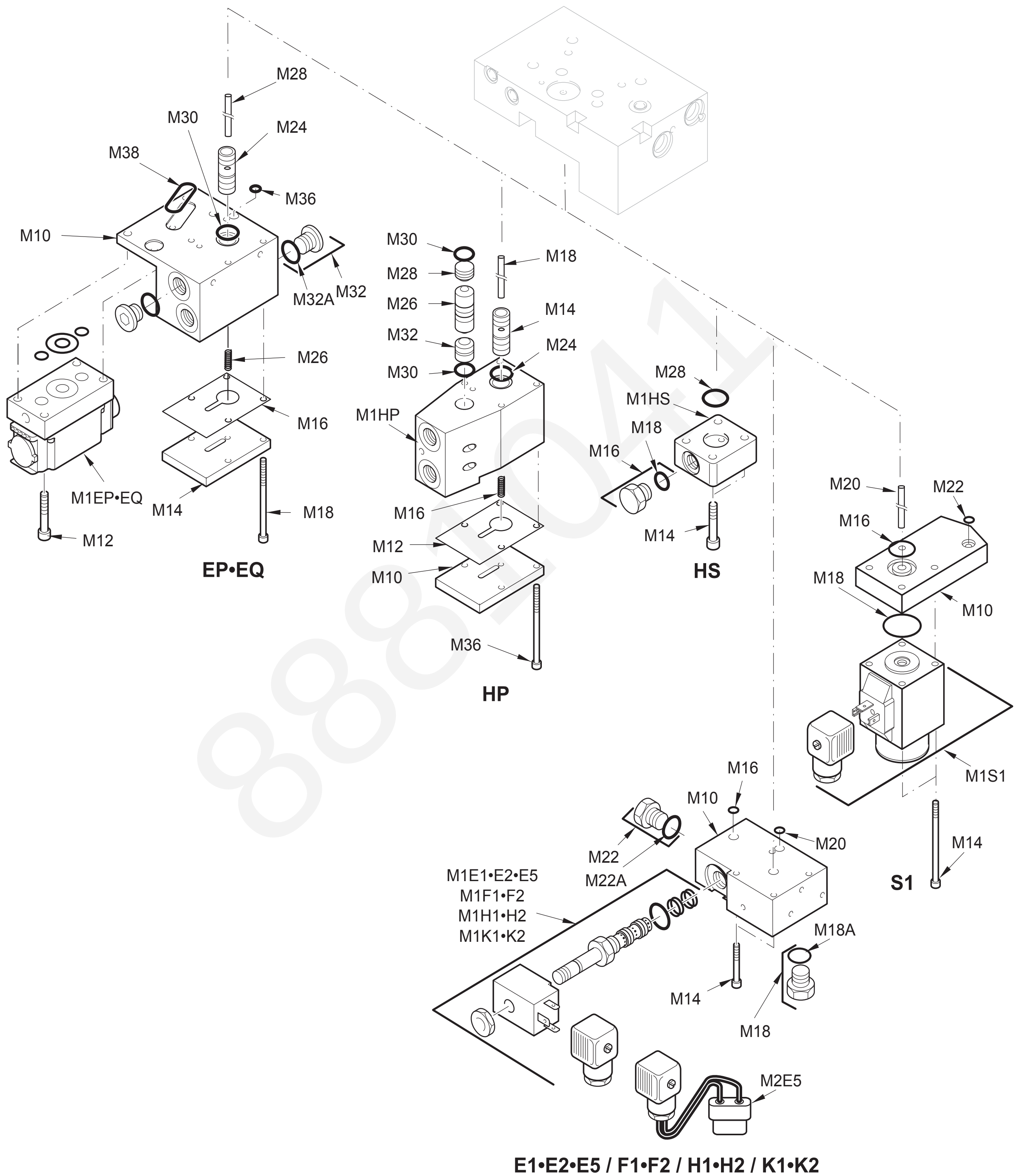
Exploded View of the Series 51 Variable Motor (Continued)

Multi-Function Valve



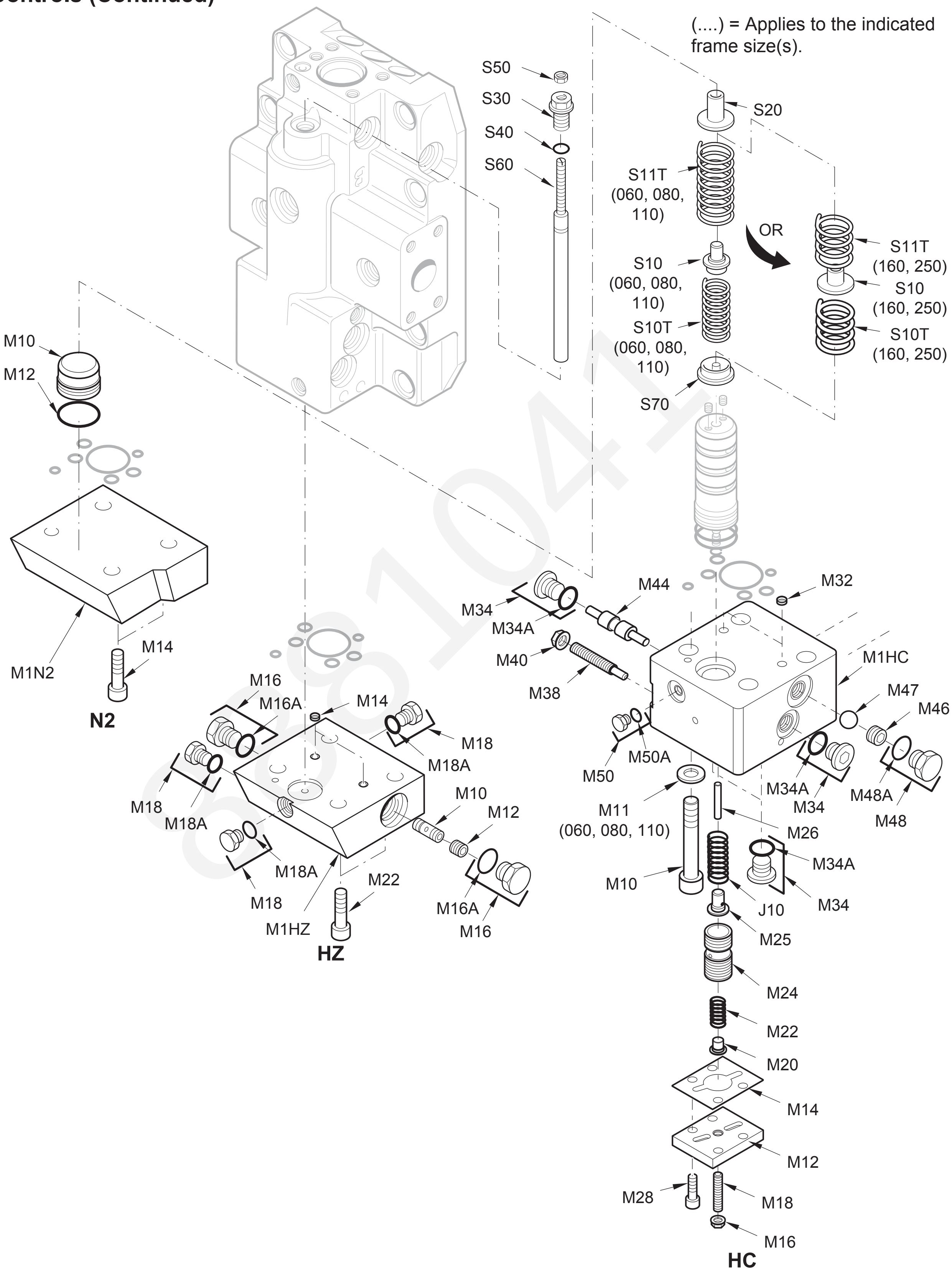
Exploded View of the Series 51 Variable Motor (Continued)

Controls



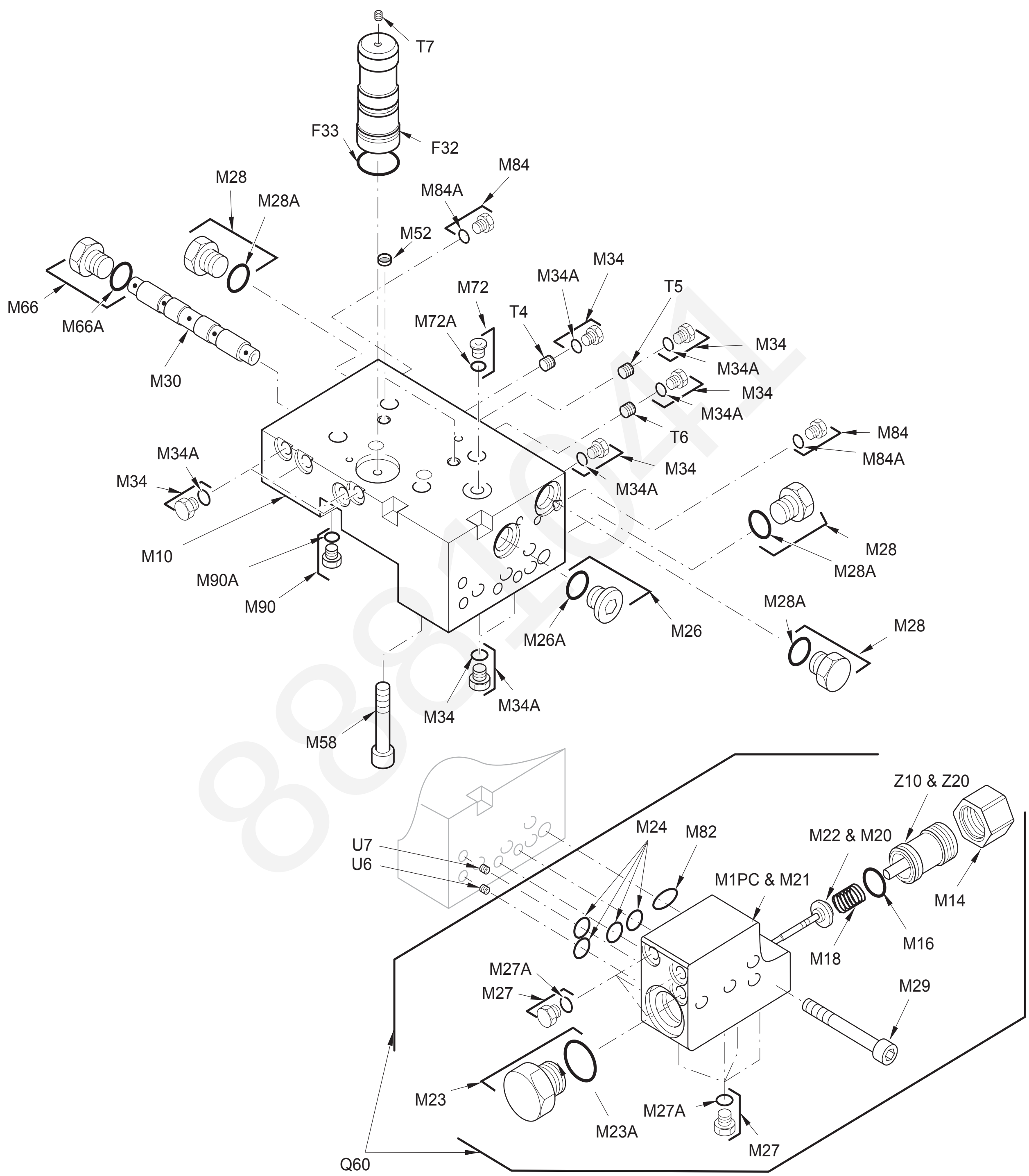
Exploded View of the Series 51 Variable Motor (Continued)

Controls (Continued)



Exploded View of the Series 51 Variable Motor (Continued)

PC Regulator



Exploded View of the Series 51 Variable Motor (Continued)

Item	Description	Quantity
B000	**COMMON PARTS GROUP (SAE FLNG)**	
B80	O-RING	1
L35	FLANGE- SAE	1
L40	SEAL- SHAFT	1
L50	O-RING	1
L70	SCREW- SOC HD	8
C000	**COMMON PARTS GROUP (CARTRIDGE)**	
L40	SEAL- SHAFT	1
L50	O-RING	1
L75	COVER- SEAL	1
L80	RING- RETAINING	1
F•••	**MAXIMUM DISPLACEMENT**	
F10	SPACER- MAX DISPL LMTR	1
F20	SCREW-SOC HD - MAX DISPL LMTR	1
G00A	**END CAP-AXIAL (160-250)**	
G00B	**END CAP-AXIAL, CODE 61 (160-250)**	
G00R	**END CAP-SIDE, LOOP FL**	
G00S	**END CAP-SIDE, LOOP FL, CODE 61**	
G12	PLUG-STR THD HEX	7
G14	PLUG-EXP	1
G16	PLUG-MANDREL	2
G18	SCREW-SET, FLAT PT	2
G20	PLUG- SPECIAL	2
G20N	PLUG- STR THD HEX	2
G24	SCREW-SOC HD	4
G26	COVER-SERVO PISTON	1
G30	PLUG-STR THD HEX	3
G36	O-RING	2
G38	O-RING	4
G42	O-RING	2
G44	O-RING	1
G50	PLUG-ST THD HEX	2
G70	COVER-PORT	2
G90	CONTROL SCREEN FILTER	1
K10	ADJ PLUG ASSY-CHG RLF	1
K14	SPRING-HELICAL COMP	2
K16	GUIDE-SPRING (060 — 160)	2
K16	GUIDE-SPRING (250)	2
K18	SHUTTLE VALVE SPOOL	1
K18N	LOOP FLUSH SPOOL- DEFEAT	1
K50	O-RING	1
K70	SPRING-HELICAL COMPRESSION	1
K80	POPPET-CHG RELIEF	1
K90	NUT-HEX LOCK	1
K90N	PLUG- ST THD HEX	1

Item	Description	Quantity
J00A-K	**CONTROL START SETTING**	
J10A-K	SPRING-HEL COMP- CONT START	1
J20	SEAT-SPRING	1
J30	SEAT-SPRING	1
J40	SCREW-ADJUSTING	1
J50	O-RING	1
J60	NUT-ADJUSTING SCREW	1
J70	NUT-LOCK	1
J00N	**CONT START N/A (FOR 2 POS CONT)**	
M0EP	**CONTROL- ELHYD PRP, PACKARD**	
M0EQ	**CONTROL- ELHYD PRP, MS**	
F32	BUSHING- VALVE ASSY	1
M1EP	PCP VALVE, PACKARD CONN	1
M1EQ	PCP VALVE, MS CONN	1
M10	HOUSING- CONTROL	1
M12	SCREW- SOC HD	4
M14	COVER	1
M16	GASKET	1
M18	SCREW- SOC HD	4
M24	PISTON- SHUTTLE, DELTA P	1
M26	SPRING- HEL COMPRESSION	1
M28	PIN	1
M30	O-RING	1
M32	PLUG-SOC HD	2
M34	PLUG-MANDREL	6
M36	O-RING	1
M38	O-RING	1
M40	CONTROL SCREEN FILTER	1
M42	PLUG-SOC HD	1
M44	PLUG-PLASTIC	1
N90	PLUG-STR THD HEX	1
M0E1/E2	**CONTROL- ELHYD 2 POS**	
M0F1/F2	**CONTROL- ELHYD 2 POS, MAX ANG**	
F32	BUSHING- VALVE ASSY	1
M1E1	VALVE ASSY- SOLENOID,12V	1
M1E2	VALVE ASSY- SOLENOID,24V	1
M10	HOUSING-CONT, ELHYD, 2 POS (E)	1
M10	HOUSING-CONT, ELHYD, 2 POS (F)	1
M12	PLUG-EXP	7
M14	SCREW-SOC HD	4
M16	O-RING	2
M18	PLUG-STR THD HEX	1
M20	O-RING	1
M22	PLUG-STR THD HEX	1
N90	PLUG-STR THD HEX	1

Exploded View of the Series 51 Variable Motor (Continued)

Item	Description	Quantity
M0HC	**CONTROL- HYD PRPNL 2LN, DUAL PATH**	
F32	BUSHING- VALVE ASSY	1
M1HC	HOUSING- HYD PRPNL (2LN),DUAL	1
M10	SCREW-SOC HD	4
M11	WASHER, FLAT (060, 080, 110)	4
M12	COVER	1
M14	GASKET	1
M16	NUT-SEAL LOCK	1
M18	SCREW-SET, FL PT	1
M20	GUIDE- SPRING	1
M22	SPRING-HELICAL COMPRESSION	1
M24	PISTON- DELTA P	1
M25	SEAT- SPRING	1
M26	PIN	1
M28	SCREW-SOC HD	4
M32	CONTROL SCREEN FILTER	2
M34	PLUG-SOC HD	4
M38	VALVE- BLEED	1
M40	NUT- SEAL LOCK	1
M44	VALVE, SHUTTLE- DELTA P	1
M46	SEAT- BALL CHECK	1
M47	BALL- SHUTTLE	1
M48	PLUG-STR THD HEX	1
M50	PLUG-STR THD HEX	1
M0HP	**CONTROL- HYD PRPNL 2LN, W/BLD**	
F32	BUSHING- VALVE ASSY	1
M1HP	HOUSING- HYD PRPNL (2LN),W/BLD	1
M10	COVER	1
M12	GASKET	1
M14	PISTON-SHUTTLE, DELTA P	1
M16	SPRING-HELICAL COMPRESSION	1
M18	PIN	1
M24	O-RING	1
M26	VALVE SHUTTLE,DELTA P	1
M28	PLUG-SEALING	1
M30	O-RING	2
M32	PLUG-SEALING	1
M34	PLUG-EXP	6
M36	SCREW-SOC HD	4
N90	PLUG-STR THD HEX	1

Item	Description	Quantity
M0HS	**CONTROL- HYD PRP, 1 LN**	
F32	BUSHING-VALVE ASSY	1
M1HS	HOUSING- VALVE, HYD PRPRNL 1 LN	1
M10	SCREW-SOC HD	4
M12	O-RING	1
M14	PLUG-STR THD HEX	1
M16	PLUG-PLASTIC	1
N90	PLUG-STR THD HEX	1
M0HZ	**CONTROL- HYD PRP, 1 LN, CMPCT**	
F32	BUSHING- VALVE ASSY	1
M1HZ	HOUSING- VALVE, HYD PRP, 1 LN, CPT	1
M10	VALVE ASSY- DBL CHECK	1
M12	SCREW- SOC- DRILLED	1
M14	CONTROL SCREEN FILTER	2
M16	PLUG-STR THD HEX	2
M18	PLUG-STR THD HEX	3
M0H1/H2	**CONTROL- HYD PRP, 1 LN, MAX ANG**	
M0K1/K2	**CONTROL- HYD PRP, 1 LN, MIN ANG**	
F32	BUSHING-VALVE ASSY	1
M1H1	VALVE ASSY-SOLENOID,12V	1
M1H2	VALVE ASSY-SOLENOID,12V	1
M10	HSG-CONT,ELHYD, 2 POS	1
M12	PLUG-EXP	8
M14	SCREW-SOC HD	4
M16	O-RING	2
M18	PLUG-STR THD HEX	1
M20	O-RING	1
M22	PLUG-PLASTIC	1
N90	PLUG-STR THD,SOC HD	1
M0N2	**CON-HYD, 2 POS, DIRECT**	
M1N2	COVER	1
M10	PLUG	1
M11	SCREW- SET,FLT PT	3
M12	O-RING	1
M14	SCREW-SOC	4
M16	GASKET	1
M18	PLUG	1

Exploded View of the Series 51 Variable Motor (Continued)

Item	Description	Quantity
M0PC	**REGULATOR- PRESS COMP**	
F32	PLUG- VALVE BUSHING BORE	1
F33	O-RING	1
M1PC	HOUSING- VALVE	1
M10	HOUSING- MULTI FUNCTION BLOCK	1
M14	NUT-HEX LOCK	1
M16	O-RING	1
M18	SPRING-HELICAL COMPRESSION	1
M20	SEAT-SPRING, PC	1
M21	BUSHING-VALVE	1
M22	SPOOL-PC VALVE	1
M23	PLUG-STR THD HEX	1
M26	PLUG-SOC HD	1
M27	PLUG-STR THD HEX	10
M28	PLUG-STR THD HEX	4
M29	SCREW-SOC	4
M30	SPOOL, BI-DIRECTIONAL CHECK	1
M34	PLUG-STR THD HEX	10
M36	SCREW-SET,FLT PT	5
M38	PLUG-EXP	11
M50	PLUG-EXP	8
M52	CONTROL SCREEN FILTER	2
M54	PLUG-EXP	1
M58	SCREW-SOC HD	4
M62	PLUG-EXP	1
M66	PLUG-STR THD HEX	2
M72	PLUG-STR THD,SOC HD	1
M82	O-RING	1
M84	PLUG-STR THD HEX	2
M86	SCREW-FL PT	1
M90	PLUG-STR THD HEX	1
M96	GASKET	1
M98	PLUG	1
N24	O-RING	5
M0S1	**CONTROL- ELECTRIC 2 POS, DIRECT**	
F32	BUSHING- VALVE ASSY	1
M1S1	SOLENOID,12V	1
M10	ADAPTER PLATE- SOLENOID	1
M14	SCREW-SOC HD	4
M16	O-RING	1
M18	O-RING	1
M20	PIN	1
M22	O-RING	1
N90	PLUG-STR THD HEX	1

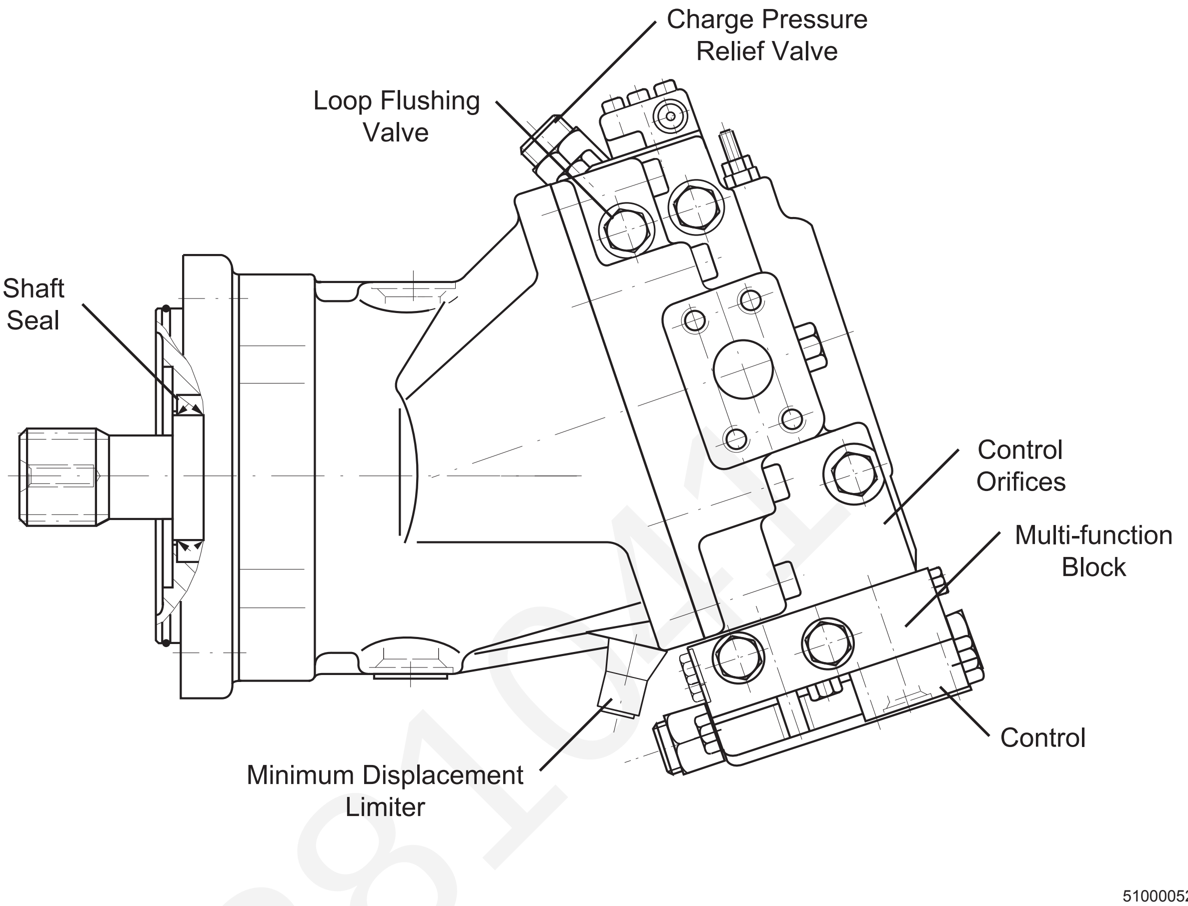
Item	Description	Quantity
N0A1-6	**SVO PRS SPLY, PCOR, DFT**	
N1A1-6	HOUSING-MULTI FUNCTION BLOCK	1
N11	HOUSING-VALVE	1
N14	NUT-HEX LOCK	1
N16	O-RING	1
N18	SPRING-HELICAL COMPRESSION	1
N20	SEAT-SPRING, PCOR	1
N21	BUSHING-VALVE	1
N22	SPOOL-PCOR VALVE	1
N23	PLUG-STR THD HEX	1
N24	O-RING	5
N26	PLUG-SOC HD (W/PCOR)	1
N26	PLUG-STR THD HEX (WO/PCOR)	1
N27	PLUG-STR THD HEX	17
N28	PLUG-PLASTIC (W/DFT)	2
N28	PLUG-STR THD HEX (WO/DFT)	2
N29	SCREW-SOC	4
N30	SPOOL, BI-DIRECTIONAL CHECK	1
N32	PISTON	1
N34	PLUG-STR THD HEX	10
N36	SCREW-SET,FLT PT	5
N38	PLUG-EXP (060 - 110 ONLY)	11
N50	PLUG-EXP (060 - 110 ONLY)	6
N52	CONTROL SCREEN FILTER	2
N54	PLUG-EXP	1
N58	SCREW-SOC HD	4
N62	PLUG-EXP	1
N66	PLUG-STR THD HEX (060-110)	2
N66	PLUG-STR THD HEX (160-250)	1
N72	PLUG-STR THD,SOC HD	1
N74	SCREW-SET, FL PT	3
N82	O-RING	1
N84	PLUG, SPECIAL	2
N84	PLUG-STR THD HEX	2
N86	SCREW-SET	1
U5	PLUG- SOC (EXT SUPPLY)	1
U6	ORIFICE, PCOR DAMPING	1
U7	ORIFICE, PCOR DAMPING	1
N0NN	**SERVO PRESS SPLY- NONE**	
P0AA	**SYS PRESS PROTECT- NONE**	

Exploded View of the Series 51 Variable Motor (Continued)

Item	Description	Quantity
S00D-G	**CONTROL RAMP- HP, HS, H1/H2, K1/K2**	
S10	GUIDE-SPRING (160-250)	1
S10D-G	CONT RAMP SPRING (060-110)	1
S10D-G	CONT RAMP SPRING ASSY (160-250)	2
S20	GUIDE-SPRING	1
S70	SEAT-SPRING	1
S00N	**CONTROL RAMP-NONE**	
S00T	**CONTROL RAMP- HC**	
S10	GUIDE-SPRING	1
S10T	CONT RAMP SPRING	1
S11T	CONT RAMP SPRING	1
S20	GUIDE-SPRING	1
S30	NUT- ADJUSTING SCREW	1
S40	O-RING	1
S50	NUT- LOCK	1
S60	SCREW- ADJUSTING	1
S70	SEAT-SPRING	1
S00U-Z	**CONTROL RAMP- EP/EQ**	
S10	GUIDE-SPRING (160-250)	1
S10U-Z	CONT RAMP SPRING (060-110)	1
S10U-Z	CONT RAMP SPRING ASSY (160-250)	1
T0A0	**CON ORIFICE (A0)- NONE**	
T0A1	**CON ORIFICE (A1)**	
T1	ORIFICE	1
T2	ORIFICE	2
T3	ORIFICE	1
T4	SCREW	2
T5	ORIFICE	1
T6	SCREW	1
T7	ORIFICE	2
T8	ORIFICE	1
U3	SCREW-FL PT	1
T0A2	**CON ORIFICE (A2)**	
T1	ORIFICE	1
T2	ORIFICE	2
T3	ORIFICE	1
T4	ORIFICE	2
T5	SCREW	1
T6	ORIFICE	1
T7	ORIFICE	2
T8	ORIFICE	1
WNNN	**SPCL HDW-NONE**	
A10	SPEED SENSOR 51V	0
B70	PLUG-SOC HD	1
B71	PLUG-PLASTIC	1

Item	Description	Quantity
Y•••	**MINIMUM DISPLACEMENT**	
Y10	SCREW- SET, FLT PT	1
Y20	NUT- HEX, SEAL LOCK	1
Y30	TAMPER RESISTANT CAP	1
Z000	**PRS COMP SET- NONE**	
Z0••	**PCOR / PRESS COMP SETTING**	
Z10	ADJUSTER- THREADED	1
Z20	PIN-STRAIGHT	1

Minor Repair and Replacement - Variable Motor



Variable Displacement Motor (SAE Flange Configuration)

Fig. 50-1 - Minor Repairs

Minor Repairs may be performed, following the procedures in this section, without voiding the unit warranty. Although specific products are illustrated, these procedures apply to all units in the Series 51 family.

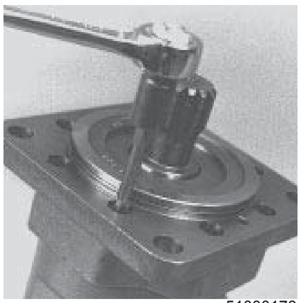
General

Cleanliness is a primary means of insuring satisfactory transmission life, on either new or repaired units. Cleaning parts by using a solvent wash and air drying is adequate, providing clean solvent is used. As with any precision equipment, the internal mechanism and related items must be kept free of foreign materials and chemicals.

Protect all exposed sealing surfaces and open cavities from damage and foreign material.

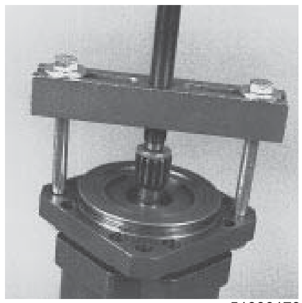
It is recommended that all gaskets and O-rings be replaced. All gasket sealing surfaces must be cleaned prior to installing new gasket. Lightly lubricate all O-rings with clean petroleum jelly prior to assembly.

Minor Repair and Replacement - Variable Motor (Continued)



51000178

Fig. 50-2 - Remove Screws Holding Flange to Housing (SAE)



51000179

Fig. 50-3 - Remove Flange (SAE)

Shaft Seal (SAE Flange Configuration)

Lip type shaft seals are used on the Series 51 motors.

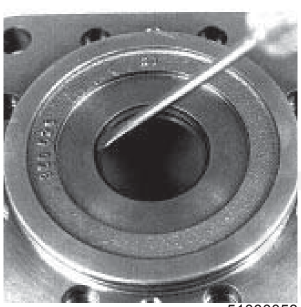
Replacement of the shaft seal usually requires removal of the motor from the machine.

Remove the screws holding the flange to the housing, using a 6 mm internal hex wrench (060 and 080 units), an 8 mm internal hex wrench (110 units), a 10 mm internal hex wrench (160 units), or a 12 mm internal hex wrench (250 units).

Remove the flange from the housing using a suitable puller. Care must be taken so as to not damage the housing bore or shaft.

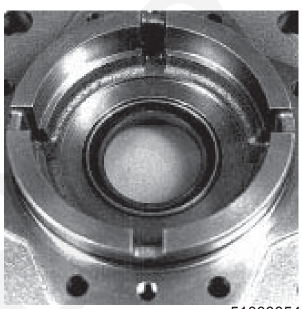
CAUTION

Do not allow the output shaft to move out of the housing while removing the flange. After the flange is removed, do not attempt to remove the shaft from the housing. If the output shaft moves out of the housing, the synchronizing shaft and rollers could fall out of position, requiring major disassembly of the unit.



51000053

Fig. 50-4 - Remove Old Seal from Flange (SAE)



51000054

Fig. 50-5 - New Seal Installed in Flange (SAE)

Remove the old seal from the flange. Once removed, the seal is not reusable.

Inspect the flange and the new seal for any damage or nicks.

Using an arbor press, press the new seal into the flange. Be careful not to damage seal.

NOTE: The outside diameter of the seal may be lightly coated with a sealant (such as Loctite High Performance Sealant #59231) prior to installation. This will aid in preventing leaks caused by damage to the seal bore in the flange.

Inspect the sealing area on the shaft for rust, wear, or contamination.

Minor Repair and Replacement - Variable Motor (Continued)

Install a new O-ring on the flange. Prior to assembly, lubricate the flange O-ring and the I.D. of the seal with petroleum jelly.

Protect the seal lip from damage during installation by wrapping the spline or key end of shaft with plastic film, or by using a seal installation tool.

Assemble the flange and seal over the shaft and into the housing bore. Install four (4) of the flange screws, and tighten them evenly to pull the flange into position. Take care to not damage the O-ring or seal lip during installation.

Install the flange screws and torque evenly to 32 Nm (24 ft•lbsf) for 060 and 080 motors, 63 Nm (46 ft•lbsf) for 110 motors, 110 Nm (81 ft•lbsf) for 160 motors, and 174 Nm (128 ft•lbsf) for 250 motors.

51000055

Fig. 50-6 - Install Flange onto Housing (SAE)

51000056

Fig. 50-7 - Torque Flange Screws (SAE)

Shaft Seal (Cartridge Configuration)

Lip type shaft seals are used on the Series 51 motors. These seals can be replaced without major disassembly of the unit. However, replacement of the shaft seal requires removal of the motor from the wheel drive or track drive gearbox.

Remove the seal carrier retaining ring from the housing.

Carefully pull the seal cover out of the housing. Care must be taken so as not to damage the housing bore or shaft.

Remove the O-ring from the housing.

Remove the old seal from the carrier. Once removed, the seal is not reusable.

Inspect the carrier and the new seal for any damage or nicks.

Using an arbor press, press the new seal into the carrier. Be careful not to damage seal.

NOTE: The outside diameter of the seal may be lightly coated with a sealant (such as Loctite High Performance Sealant #59231) prior to installation. This will aid in preventing leaks caused by damage to the seal bore in the seal carrier.

Inspect the sealing area on the shaft for rust, wear, or contamination.

51000057

Fig. 50-8 - Remove Carrier Retaining Ring (Cartridge)

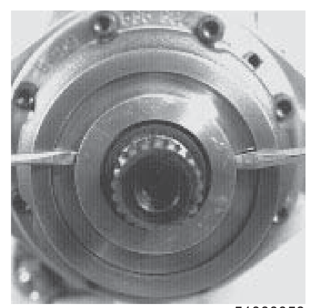


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Fig. 50-9 - Remove Seal Carrier (Cartridge)

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Fig. 50-10 - Seal Carrier Removed (Cartridge)

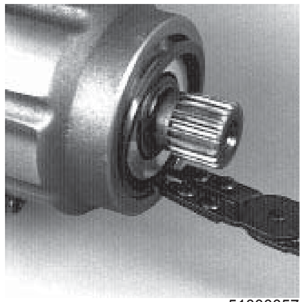
51000060

Fig. 50-11 - Seal Installed in Carrier (Cartridge)

Minor Repair and Replacement - Variable Motor (Continued)

51000061

Fig. 50-12 - Install Seal Carrier (Cartridge)



51000057

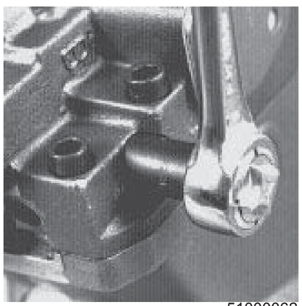
Fig. 50-13 - Install Carrier Retaining Ring (Cartridge)

Install the carrier O-ring into the groove in the housing. Prior to assembly, lubricate the carrier O-ring and the I.D. of the seal with petroleum jelly.

Protect the seal lip from damage during installation by wrapping the spline or key end of shaft with plastic film, or by using a seal installation tool.

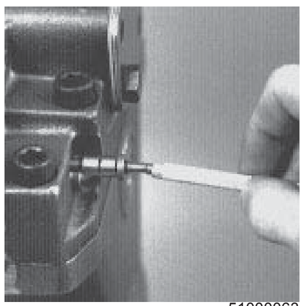
Assemble the carrier and seal over the shaft and into the housing bore. Take care to not damage the O-ring or seal lip during installation.

Install the seal carrier retaining ring.



51000062

Fig. 50-14 - Remove Shuttle Valve Plugs



51000063

Fig. 50-15 - Remove Valve Spool

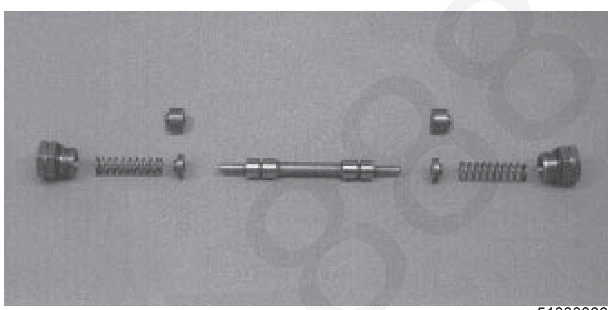
Loop Flushing Shuttle Valve (Option)

Using an 11/16" wrench, remove the hex plugs from both sides of end cap.

Remove springs and spring seat washers. Note the orientation of the washers.

NOTE The 250 frame size motors use thicker spring seat washers.

Remove flushing valve spool.



51000066

Fig. 50-16 - Loop Flushing Shuttle Valve Components

Inspect parts for damage or foreign material.

51000064

Fig. 50-17 - Install Valve Spool and Washers

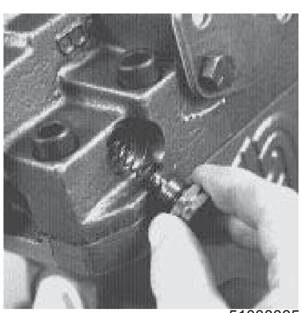


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Fig. 50-18 - Install Plugs and Springs

Install flushing valve spool in end cap, then install the spring seat washers (thick washers on 250 frame size motors) on each end of the spool. The step on the spring seat washers should face out, toward the springs.

Install the spool springs and hex plugs. Torque the plugs to 41 Nm (30 ft•lbsf).

Minor Repair and Replacement - Variable Motor (Continued)

Charge Pressure Relief Valve

Before removing the screw adjustable relief valve plug, mark the plug, lock nut, and end cap to allow maintaining the original adjustment when assembling. Remove the screw adjustable charge relief valve plug by loosening the lock nut (with a 1-1/16" hex wrench), and unscrewing the plug with a large screwdriver.

Remove the spring and relief valve poppet.

Inspect the poppet and mating seat in the end cap for damage or foreign material.

Install the poppet and spring. Install the plug with its lock nut, aligning the marks made at disassembly, and torque the lock nut to 52 Nm (38 ft•lbsf).

Check and adjust, if necessary, the charge pressure.

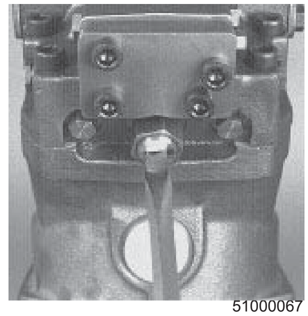

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Fig. 50-19 - Remove Charge Relief Valve Plug

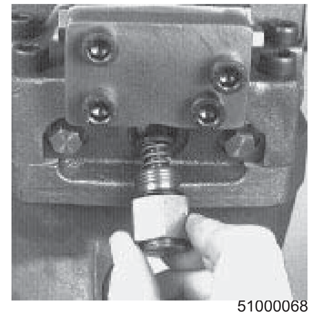

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Fig. 50-20 - Remove Charge Relief Valve

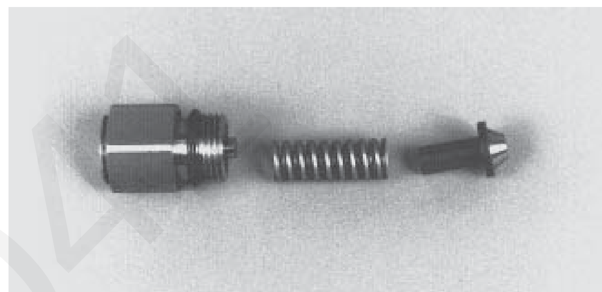

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Fig. 50-21 - Charge Relief Valve Components

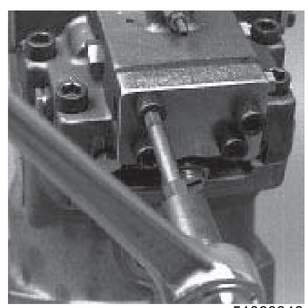
Minimum Angle Servo Cover

Thoroughly clean external surfaces prior to removal of cover.

Remove the four (4) screws retaining the cover to the end cap with an 8 mm internal hex wrench (060, 080, 110, and 160 units) or a 10 mm internal hex wrench (250 units). Remove the cover. Remove the O-rings between the cover and end cap.

Install new O-rings on the end cap and retain with petroleum jelly. Install the cover onto the end cap and install the screws. Torque the screws to 78 Nm (58 ft•lbsf) for 060, 080, or 110 units, or 110 Nm (81 ft•lbsf) for 160 or 250 units.

The plug in the cover may be removed with a 7/16" hex wrench. Torque this plug to 9 Nm (7 ft•lbsf).



51000046

Fig. 50-22 - Remove Servo Cover Screws

51000006

Fig. 50-23 - Install Servo Cover

Minor Repair and Replacement - Variable Motor (Continued)

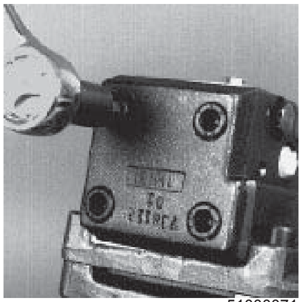


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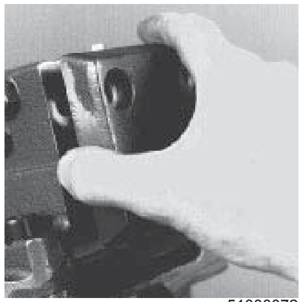
Fig. 50-24 - Remove Cover Plate Screws



51000072

Fig. 50-25 - Remove Cover Plate

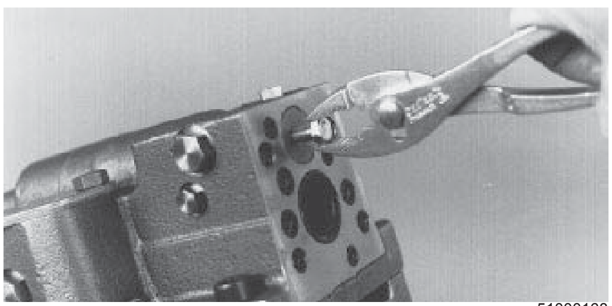


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Fig. 50-26 - Remove Valve Sleeve Bore Plug

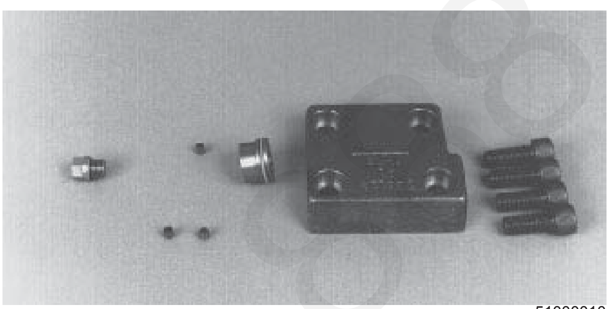

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Fig. 50-27 - N2 Control Components

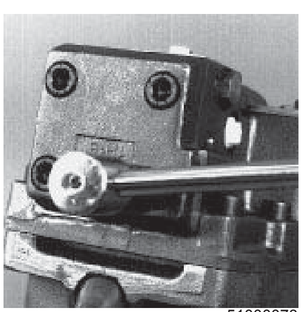

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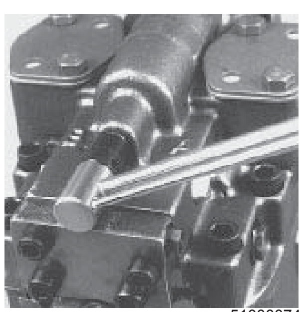
Fig. 50-28 - Torque Cover Plate Screws



51000074

Fig. 50-29 - Torque Plug in End Cap

Hydraulic 2-Position Control (Type N2)

Thoroughly clean external surfaces prior to removal of cover plate.

Remove the four (4) screws retaining the cover plate to the end cap with an 8 mm internal hex wrench (060, 080, and 110 units) or a 10 mm internal hex wrench (160 and 250 units). Remove the cover plate.

Remove the solid plug from the valve sleeve bore in the end cap. (An 8 mm threaded hole is provided in the plug for a puller screw.) Remove the O-ring from the plug.

Remove the O-rings from the end cap.

Install new O-rings on the end cap and retain with petroleum jelly.

Install a new O-ring on the solid plug and install the solid plug into the end cap.

Install the cover plate onto the end cap and install the screws. Torque the screws to 78 Nm (58 ft•lbsf) for 060, 080, or 110 units, or to 110 Nm (81 ft•lbsf) for 160 or 250 units.

Set screws are installed in control orifice holes in the end cap to plug the valve sleeve bore passages. To gain access to the screw plugs, remove the outer plugs from the end cap with a 7/16" or 11/16" hex wrench. Remove the screw plugs with a 3 mm internal hex wrench. When installing, torque the screw plugs to 4 Nm (35 in•lbsf). Torque the 5/16" outer plugs to 9 Nm (7 ft•lbsf), and the 9/16" outer plugs to 37 Nm (27 ft•lbsf). Refer to the “Control Orifices” topic for additional information.

The special plug and seal washer on the end cap opposite the control may be removed with a 13 mm hex wrench. When installing, torque this plug to 20 Nm (15 ft•lbsf).

Minor Repair and Replacement - Variable Motor (Continued)

Electrohydraulic 2-Position Controls (Types E1•E2 and F1•F2)

Thoroughly clean external surfaces prior to removing the control.

The solenoid may be removed from the valve by removing the nut with a 3/4" hex wrench. The solenoid valve may be removed from the control valve housing with a 7/8" hex wrench.

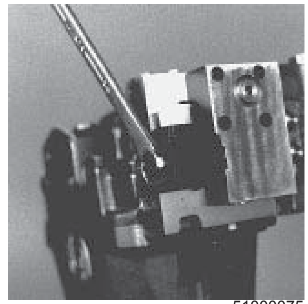

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Fig. 50-30 - Remove E1•E2 or F1•F2 Control Solenoid

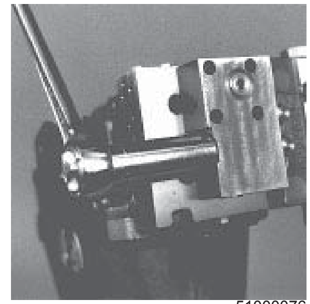
51000076

Fig. 50-31 - Remove Solenoid Valve

Remove the screws retaining the valve housing to the multi-function block with a 4 mm internal hex wrench. Remove the valve housing.

The plugs on the control housing may be removed with an 11/16" hex wrench. When reinstalling, torque the plugs to 37 Nm (27 ft•lbsf).

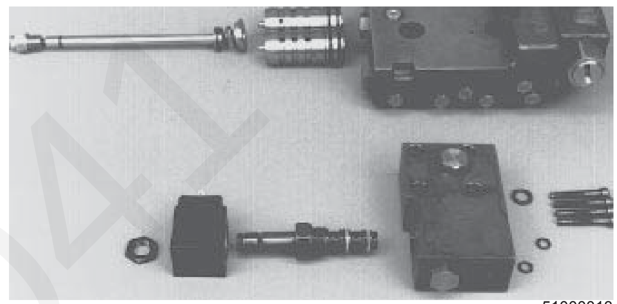
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Fig. 50-32 - E1•E2 and F1•F2 Control Components

Install new O-rings onto the valve housing. Install the valve housing onto the multi-function block, and install the screws. Torque the screws to 6.4 Nm (4.7 ft•lbsf).

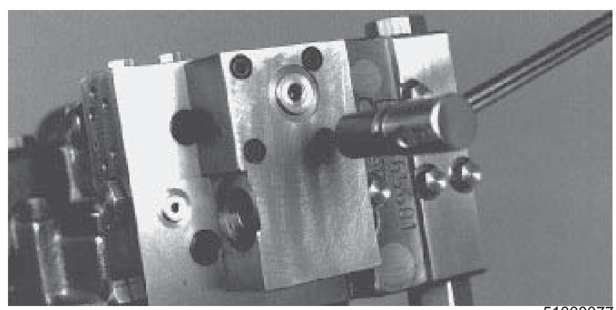
51000077

Fig. 50-33 - Install E1•E2 or F1•F2 Control Valve Housing

When installing the solenoid valve into the valve housing, the valve should be torqued to 20 Nm (15 ft•lbsf). When installing the solenoid onto the valve, torque the nut to 15 Nm (11 ft•lbsf.).

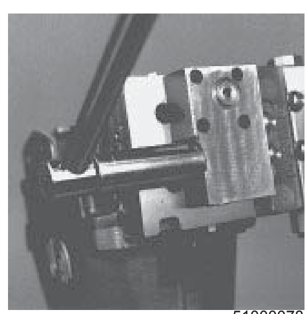
51000078

Fig. 50-34 - Install Solenoid Valve

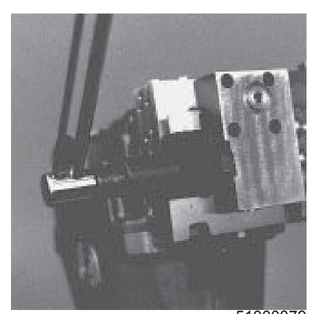
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Fig. 50-35 - Install Solenoid

Minor Repair and Replacement - Variable Motor (Continued)

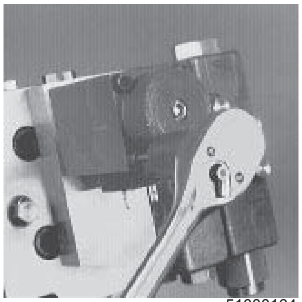
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Fig. 50-36 - Remove S1 Control Screws

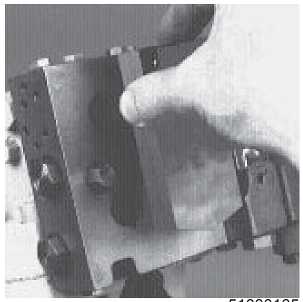
51000165

Fig. 50-37 - Remove Adapter Plate and Solenoid

Electric 2-Position Controls (Type S1)

Thoroughly clean external surfaces prior to removing the control.

Remove the screws retaining the solenoid and solenoid adapter plate to the multi-function block with a 4 mm internal hex wrench. Remove the solenoid and the solenoid adapter plate from the multi-function block.

Remove the solenoid pin from the multi-function block.

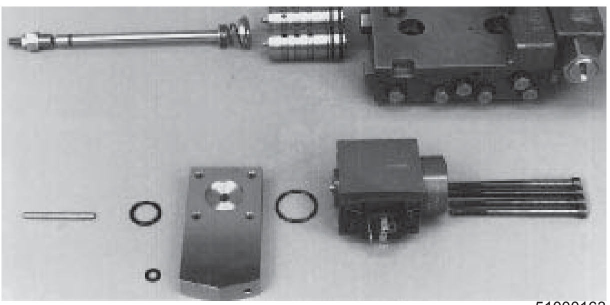
51000163

Fig. 50-38 - S1 Control Components

Install new O-rings onto the adapter plate and the solenoid.

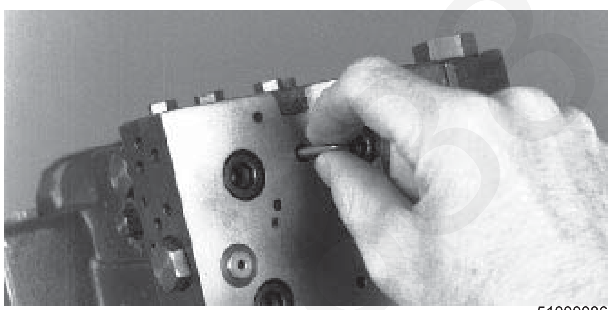
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Fig. 50-39 - Install S1 Control Solenoid Pin

Install the solenoid pin into the hole in the multi-function block.

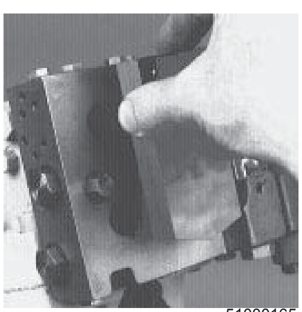

51000165

Fig. 50-40 - Install Adapter Plate and Solenoid

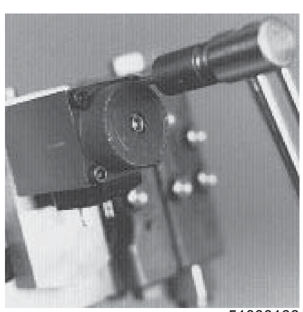

51000166

Fig. 50-41 - Torque Control Solenoid Screws

Install the adapter plate with O-rings onto the multi-function block.

Install the solenoid with O-ring onto the adapter plate.

Install the screws and torque to 6.4 Nm (4.7 ft•lbsf).

Minor Repair and Replacement - Variable Motor (Continued)

Hydraulic Proportional Control (Type HZ)

Thoroughly clean external surfaces prior to removal of control.

Remove the four (4) screws retaining the valve housing to the end cap with an 8 mm internal hex wrench (060, 080, and 110 units) or a 10 mm internal hex wrench (160 and 250 units). Remove the valve housing. Remove the O-rings between the valve housing and end cap, and the O-ring on the valve spool sleeve.

The plugs on the control housing may be removed with a 7/16" or 11/16" hex wrench. When reinstalling, torque the 5/16" plugs to 9 Nm (7 ft•lbsf), and the 9/16" plugs to 37 Nm (27 ft•lbsf)

The valve housing is equipped with filter screens in the passages between the housing and the end cap. Units with internal servo pressure supply have a filter screen installed in the end cap passage leading to the valve spool sleeve. These screens should be pressed into position (with the rounded edge of the filter screens facing “out”) until they are flush to 2.0 mm (0.08 in.) below the machined surface of the valve housing or end cap.

Units with external servo pressure supply have a plug installed in the end cap passage leading to the valve spool sleeve. This plug may be removed with a 2.5 mm internal hex wrench. When installing this plug, torque to 2 Nm (18 in•lbsf).

Install a new O-ring onto the valve spool sleeve in the end cap. Install new O-rings onto the end cap.

Install the valve housing onto the multi-function block, and install the screws.

Torque the screws to 78 Nm (58 ft•lbsf) for 060, 080, or 110 units, or to 110 Nm (81 ft•lbsf) for 160 or 250 units.

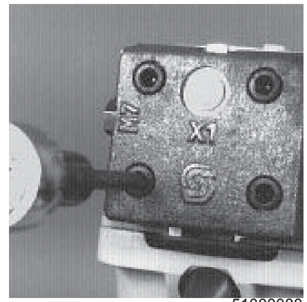

51000080

Fig. 50-42 - Remove HZ Control Housing Screws


51000081

Fig. 50-43 - Remove HZ Control Housing

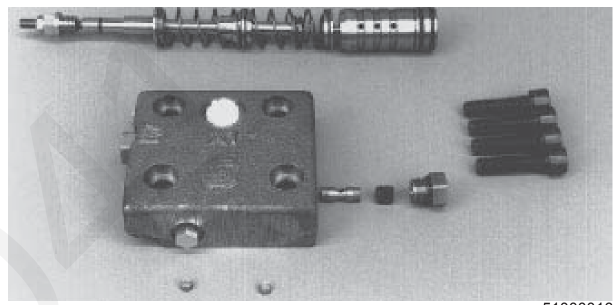

51000016

Fig. 50-44 - HZ Control Components

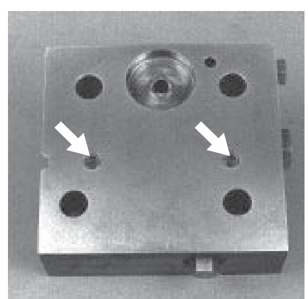

51000082

Fig. 50-45 - HZ Control Housing Screens

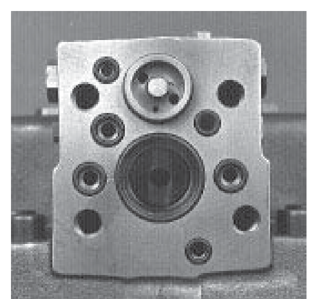

51000083

Fig. 50-46 - End Cap O-Rings Installed

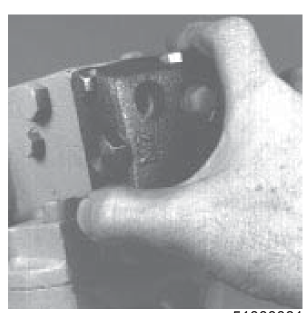

51000081

Fig. 50-47 - Install HZ Control Housing

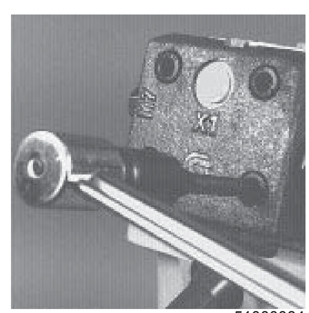

51000084

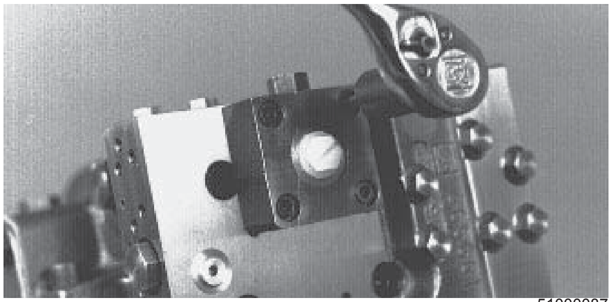
Fig. 50-48 - Torque HZ Control Valve Housing Screws

Minor Repair and Replacement - Variable Motor (Continued)

Hydraulic Proportional Control (Type HS)

Thoroughly clean external surfaces prior to removal of control.

Remove the screws retaining the valve housing to the multi-function block with a 4 mm internal hex wrench. Remove the valve housing.

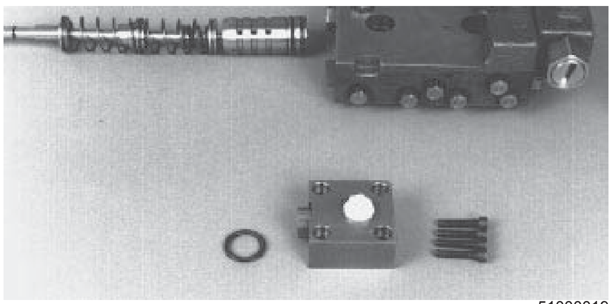


51000087

Fig. 50-49 - Remove HS Control Housing Screws

The plug on the control housing may be removed with an 11/16" hex wrench. When reinstalling, torque the plug to 37 Nm (27 ft•lbsf).

Install a new O-ring onto the valve housing.

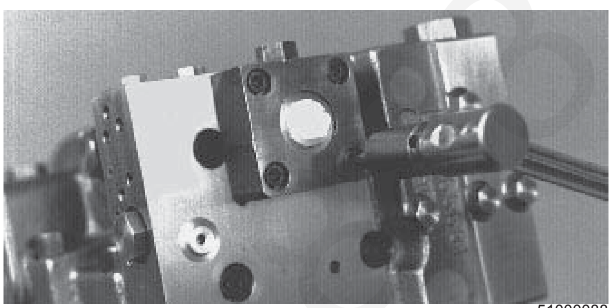


51000019

Fig. 50-50 - HS Control Components

Install the valve housing onto the multi-function block, and install the screws.

Torque the screws to 6.4 Nm (4.7 ft•lbsf).



51000088

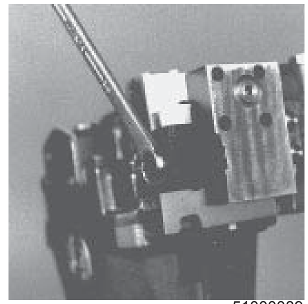
Fig. 50-51 - Torque HS Control Housing Screws

Minor Repair and Replacement - Variable Motor (Continued)

Hydraulic Proportional Control with Maximum Angle Over-ride (Types H1•H2 or K1•K2)

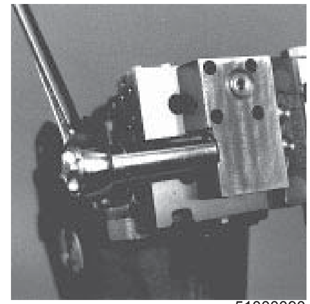
Thoroughly clean external surfaces prior to removing the control.

The solenoid may be removed from the valve by removing the nut with a 3/4" hex wrench.



51000089

Fig. 50-52 - Remove H1•H2 or K1•K2 Control Solenoid



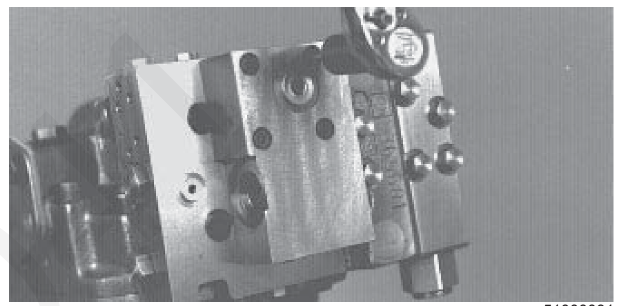
51000090

Fig. 50-53 - Remove Solenoid Valve

The solenoid valve may be removed from the control valve housing with a 7/8" hex wrench.

Remove the screws retaining the valve housing to the multi-function block with a 4 mm internal hex wrench. Remove the valve housing.

The plugs on the control housing may be removed with an 11/16" hex wrench. When reinstalling, torque the plugs to 37 Nm (27 ft•lbsf).

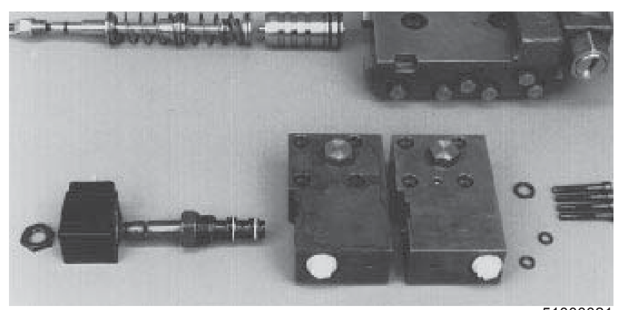


51000091

Fig. 50-54 - Remove Control Housing Screws

Install new O-rings onto the valve housing.

Install the valve housing onto the multi-function block, and install the screws. Torque the screws to 6.4 Nm (4.7 ft•lbsf).

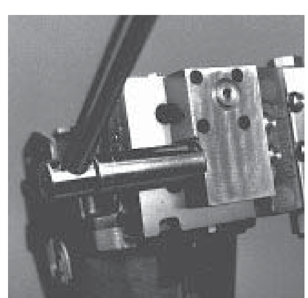


51000021

Fig. 50-55 - H1•H2 and K1•K2 Control Components

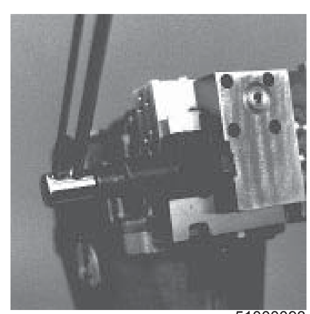
When installing the solenoid valve into the valve housing, the valve should be torqued to 20 Nm (15 ft•lbsf).

When installing the solenoid onto the valve, torque the nut to 15 Nm (11 ft•lbsf.).



51000092

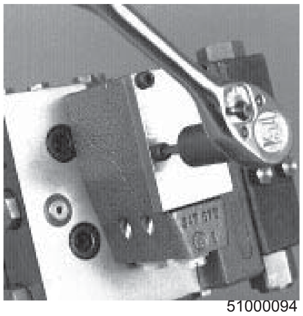
Fig. 50-56 - Install Solenoid Valve



51000093

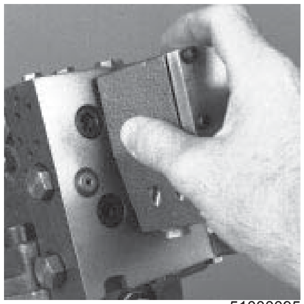
Fig. 50-57 - Install Solenoid

Minor Repair and Replacement - Variable Motor (Continued)



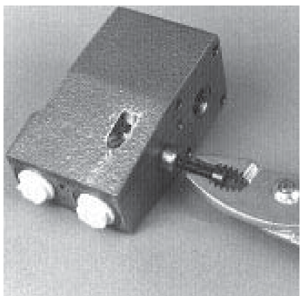
51000094

Fig. 50-58 - Remove HP Control Housing Screws



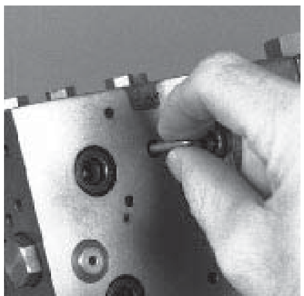
51000095

Fig. 50-59 - Remove Control Housing



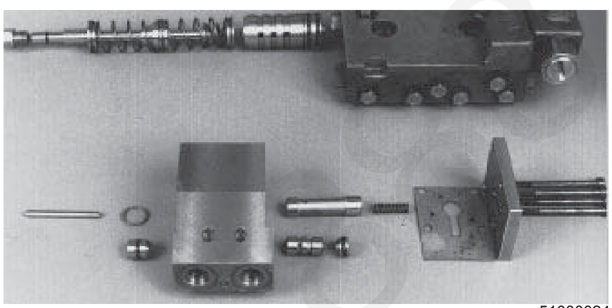
51000096

Fig. 50-60 - Remove Shuttle Spool Plug



51000086

Fig. 50-61 - Remove Pilot Piston Pin



51000024

Fig. 50-62 - HP Control Components

Two Connection Hydraulic Proportional Control (Type HP)

Thoroughly clean external surfaces prior to removal of control.

Hold the control housing in position, and remove the screws retaining the cover and control housing to the multi-function block with a 4 mm internal hex wrench. Remove the housing cover and gasket. Remove the valve housing with shuttle valve assembly and pilot piston from the multi-function block.

Remove the O-rings from the valve housing. Remove the pilot piston and spring from the valve housing.

Remove the pilot piston pin from the multi-function block.

Remove the inner shuttle spool plug from the valve housing. (A 5 mm threaded hole is provided in the inner plug for a puller screw.) Remove the shuttle spool from the valve housing. Remove the outer shuttle spool plug. Remove the O-rings from the plugs.

Install new O-rings on the shuttle spool plugs.

Install new O-rings on the valve housing and retain with petroleum jelly.

Minor Repair and Replacement - Variable Motor (Continued)

Install the pilot piston pin in the multi-function block.

Install the outer (thin) shuttle piston plug with the large chamfer toward the shuttle valve bore. Install the shuttle spool into its bore and install the inner (thick) plug with the large chamfer toward the shuttle valve bore.

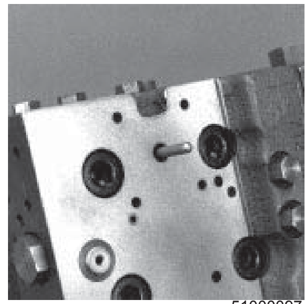

51000097

Fig. 50-63 - Pilot Piston Pin Installed

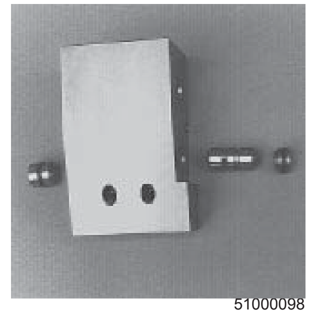

51000098

Fig. 50-64 - Install Shuttle Spool and Plugs

Position the valve housing (with O-ring) on the multi-function block.

Install the pilot piston into the housing and over the pin. The end of the piston with the cross drilled hole should engage the pin.

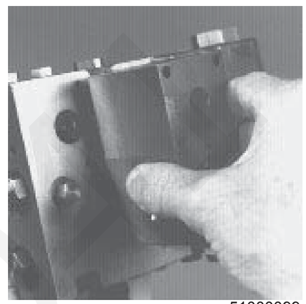

51000099

Fig. 50-65 - Install Control Housing

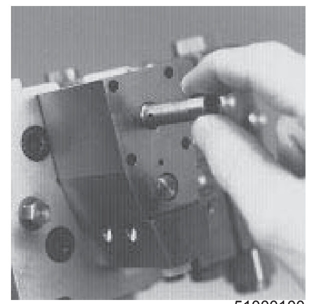

51000100

Fig. 50-66 - Install Pilot Piston

Install the small spring in the outer end of the pilot piston.

Install the control cover and gasket. Align the control assembly with the multi-function block and install the four (4) screws.

Torque the control screws to 6.4 Nm (4.7 ft•lbsf).

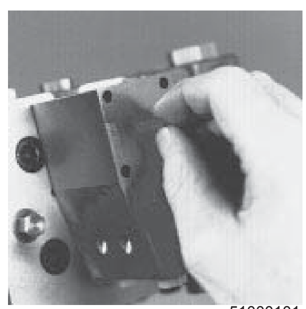

51000101

Fig. 50-67 - Install Spring

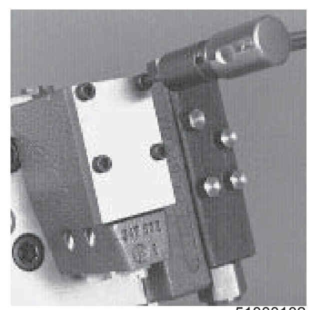
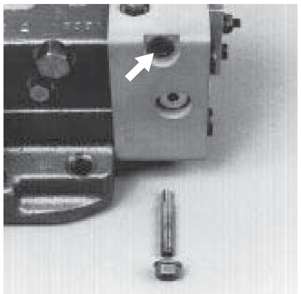

51000102

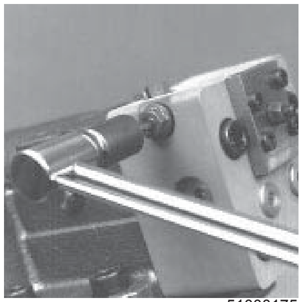
Fig. 50-68 - Install Cover, Gasket, and Screws

Minor Repair and Replacement - Variable Motor (Continued)



51000103

Fig. 50-69 - Remove HC Control Bleed Valve



51000175

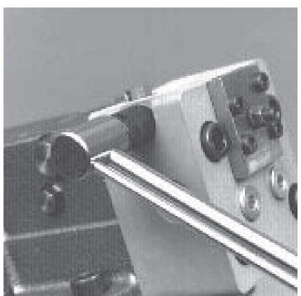
Fig. 50-70 - Install HC Control Bleed Valve

Two Connection Hydraulic Proportional Control for “Dual Path” Vehicles (Type HC)

Bleed Valve

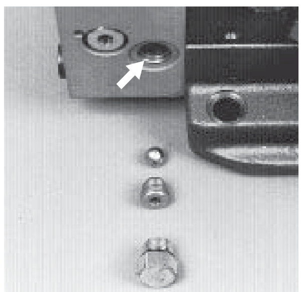
Loosen the seal lock nut on the bleed valve with a 10 mm hex wrench, and remove the valve with a 4 mm internal hex wrench.

Install the bleed valve and torque to 3 Nm (27 in•lbsf).



51000176

Fig. 50-71 - Install HC Control Bleed Valve Seal Nut



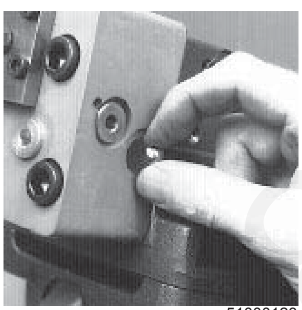
51000104

Fig. 50-72 - Remove Servo Pressure Ball Shuttle Valve

Install the seal lock nut and torque to 19 Nm (14 ft•lbsf).

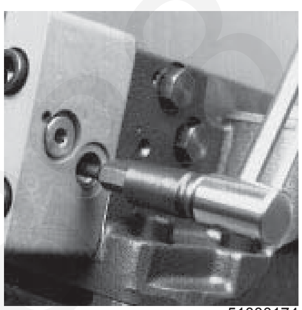
Servo Pressure Shuttle Valve

Remove the servo pressure shuttle plug with an 11⁄16" hex wrench. Remove the shuttle ball seat with a 5 mm internal hex wrench and remove the ball.



51000123

Fig. 50-73 - Install Servo Pressure Shuttle Ball Valve

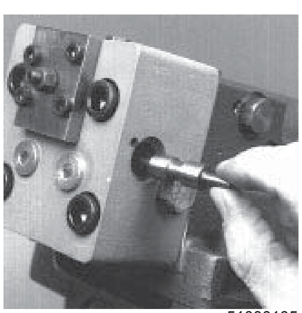


51000174

Fig. 50-74 - Torque Servo Pressure Shuttle Ball Seat

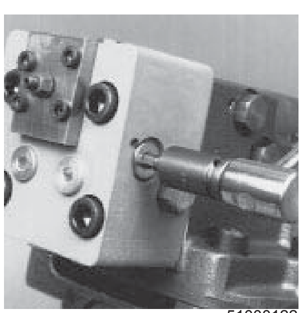
Install the servo pressure shuttle ball.

Install the shuttle ball seat and torque to 11 Nm (8 ft•lbsf). Install the shuttle passage plug and torque to 37 Nm (27 ft•lbsf).



51000105

Fig. 50-75 - Install Control Pressure Shuttle Spool



51000122

Fig. 50-76 - Torque Shuttle Spool Plugs

Control Pressure Shuttle Valve

Remove the shuttle spool plugs with a 1/4" internal hex wrench. Remove the control pressure shuttle spool.

Install the control pressure shuttle spool.

Install the shuttle spool plugs and torque to 20 Nm (15 ft•lbsf).

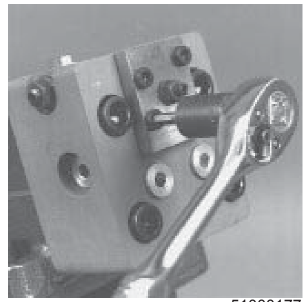
Minor Repair and Replacement - Variable Motor (Continued)

Pilot Piston and Control Housing

Thoroughly clean external surfaces prior to disassembly of control.

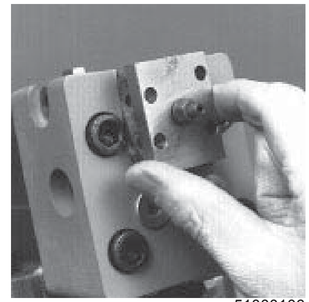
Remove the four (4) screws retaining the cover to the control housing with a 4 mm internal hex wrench.

Remove the housing cover and gasket (with the adjusting screw and seal lock nut).



51000177

Fig. 50-77 - Remove HC Control Housing Cover Screws



51000106

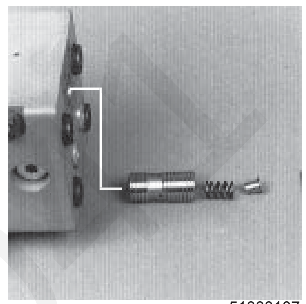
Fig. 50-78 - Remove HC Control Housing Cover

Remove the control start adjustor spring seat and spring from the pilot piston.

Remove the pilot piston from the control housing.

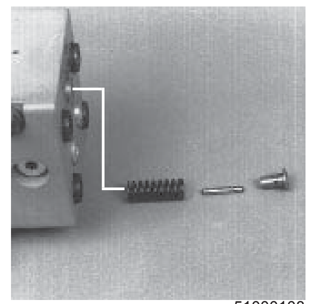
Remove the pilot piston pin seat and pin from the control housing (or pilot piston).

Remove the control start spring from the control housing.



51000107

Fig. 50-79 - Remove Adjustment Spring and Pilot Piston

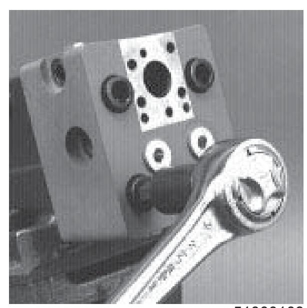


51000108

Fig. 50-80 - Remove Pilot Piston Pin and Control Start Spring

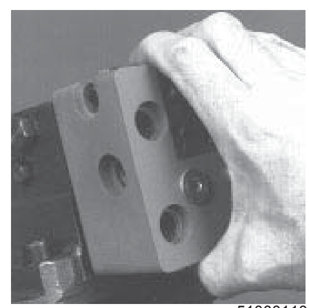
Remove the four (4) screws (and washers for 060, 080, and 110 units) retaining the control housing to the end cap with an 8 mm internal hex wrench (060, 080, and 110 units) or a 10 mm internal hex wrench (160 and 250 units).

Remove the control housing from the end cap. Remove the O-rings between the control housing and the end cap, and the O-ring on the valve spool sleeve.



51000109

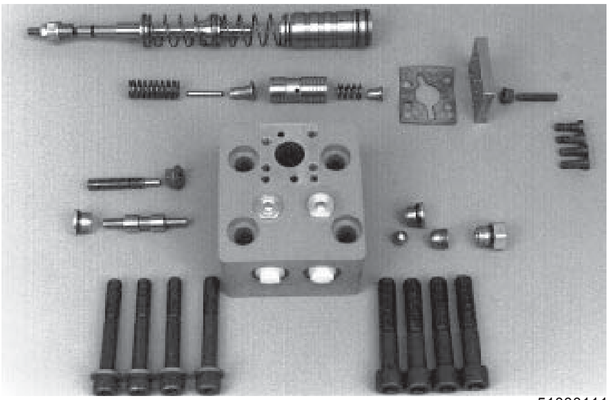
Fig. 50-81 - Remove HC Control Housing Screws



51000110

Fig. 50-82 - Remove HC Control Housing

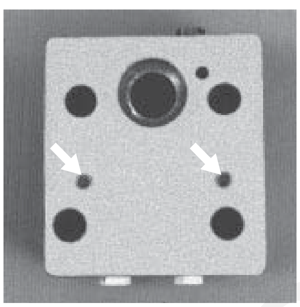
Minor Repair and Replacement - Variable Motor (Continued)



51000111

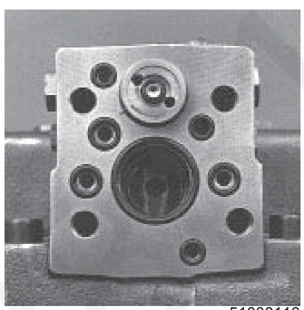
Fig. 50-83 - HC Control Components

The plugs on the control housing may be removed with a 7/16" hex wrench or a 1/4" internal hex wrench. When reinstalling, torque the 5/16" plugs to 9 Nm (7 ft•lbsf), and the 9/16" plugs to 20 Nm (15 ft•lbsf).



51000112

Fig. 50-84 - HC Control Housing Screens

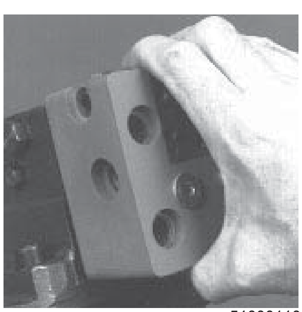


51000113

Fig. 50-85 - End Cap O-Rings Installed for HC Control

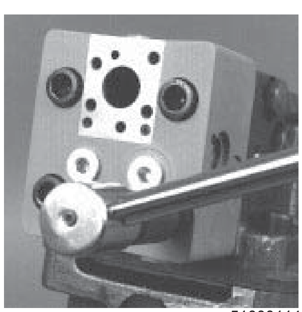
The control housing is equipped with filter screens in the passages between the housing and the end cap. Units with internal servo pressure supply have a filter screen installed in the end cap passage leading to the valve spool sleeve. These screens should be pressed into position (with the rounded edge of the filter screens facing “out”) until they are flush to 2.0 mm (0.08 in.) below the machined surface of the valve housing or end cap.

Install a new O-ring onto the valve spool sleeve in the end cap. Install new O-rings onto the end cap.



51000110

Fig. 50-86 - Install HC Control Housing



51000114

Fig. 50-87 - Torque HC Control Housing Screws

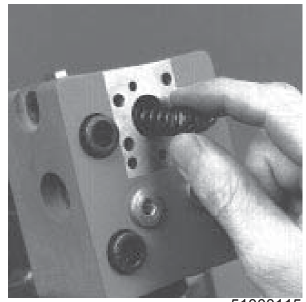
Install the valve housing onto the end cap, and install the screws (with flat washers on 060, 080, and 110 units).

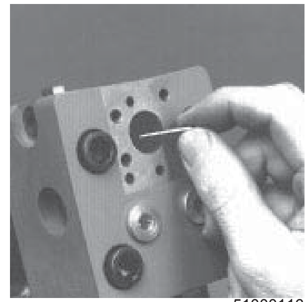
Torque the screws to 78 Nm (58 ft•lbsf) for 060, 080, and 110 units, or to 110 Nm (81 ft•lbsf) for 160 and 250 units.

Minor Repair and Replacement - Variable Motor (Continued)

Install the control start spring into the control housing.

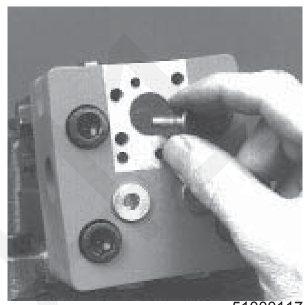
Install the pilot piston pin. The end of the pin must engage the recess in the end of the control valve spool.

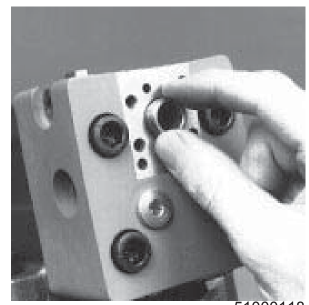

51000115
Fig. 50-88 - Install HC Control Start Spring


51000116
Fig. 50-89 - Install Pilot Piston Pin

Install the pilot piston pin seat.

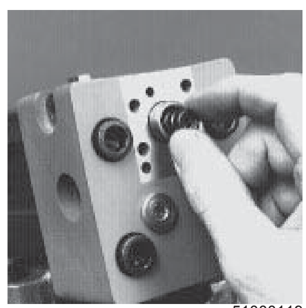
Install the pilot piston into the housing and over the spring and spring seat. The end of the piston with the deeper bore and the cross drilled hole should engage the start spring and pin seat.

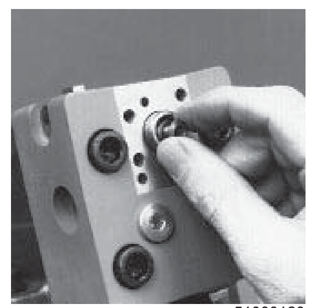

51000117
Fig. 50-90 - Install Pilot Piston Pin Seat


51000118
Fig. 50-91 - Install HC Control Pilot Piston

Install the adjustor spring in the outer end of the pilot piston.

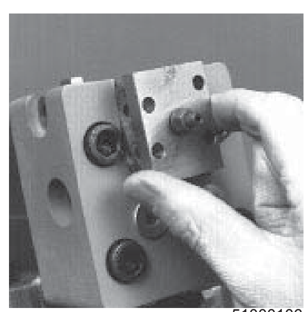
Install the adjustor spring seat.

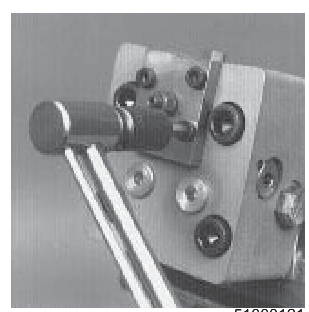

51000119
Fig. 50-92 - Install HC Control Start Adjuster Spring


51000120
Fig. 50-93 - Install HC Control Start Adjuster Spring Seat

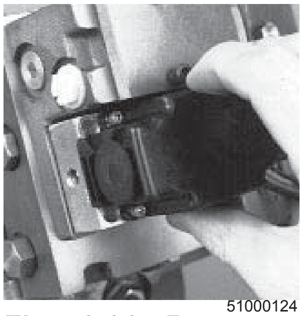
Install the control cover and gasket (with adjusting screw and seal lock nut).

Torque the control cover screws to 6.4 Nm (4.7 ft•lbsf).


51000106
Fig. 50-94 - Install HC Control Cover and Gasket

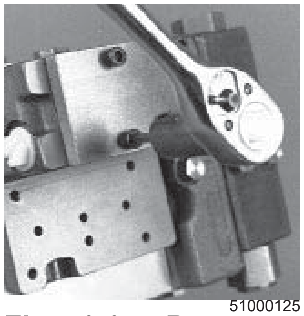

51000121
Fig. 50-95 - Torque Control Cover Screws

Minor Repair and Replacement - Variable Motor (Continued)



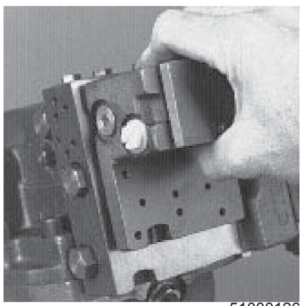
51000124

Fig. 50-96 - Remove PCP Valve



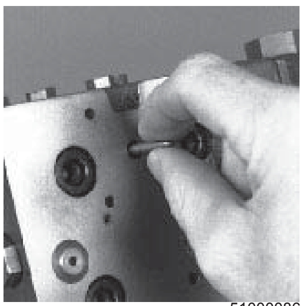
51000125

Fig. 50-97 - Remove EP•EQ Control Housing Screws



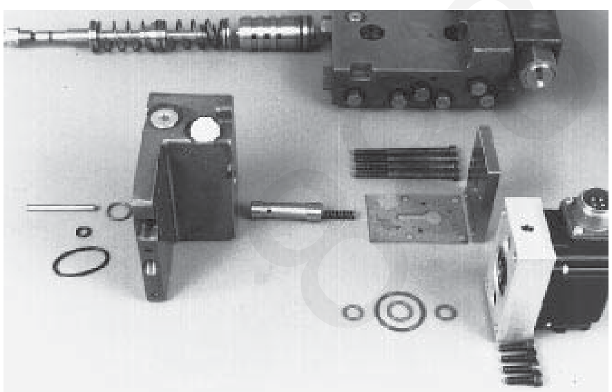
51000126

Fig. 50-98 - Remove EP•EQ Control Housing



51000086

Fig. 50-99 - Remove Pilot Piston Pin



51000027

Fig. 50-100 - EQ Control Components (EP Similar)

Electrohydraulic Proportional Control (Types EP and EQ)

Thoroughly clean external surfaces prior to removal of control.

The Pressure Control Pilot (PCP) valve may be removed from the control valve housing, as described under the following heading.

Remove the screws retaining the control housing cover and control valve housing to the multi-function block with a 4 mm internal hex wrench. Remove the housing cover and gasket.

Remove the valve housing with the pilot piston from the multi-function block.

Remove the O-rings from the valve housing. Remove the pilot piston and spring from the valve housing.

Remove the pilot piston pin from the multi-function block.

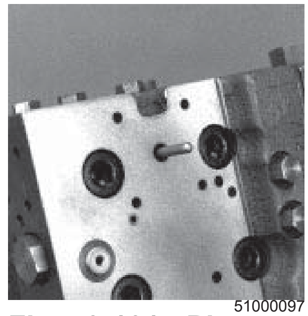
Install new O-rings on the valve housing and retain with petroleum jelly.

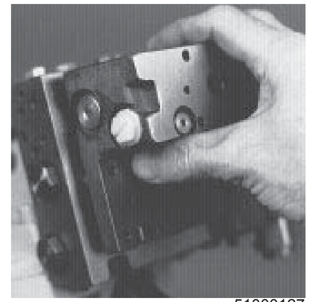
The plugs on the control housing may be removed with a 1/4" internal hex wrench. When reinstalling, torque the 9/16" plugs to 20 Nm (15 ft•lbsf).

Minor Repair and Replacement - Variable Motor (Continued)

Install the pilot piston pin in the multi-function block.

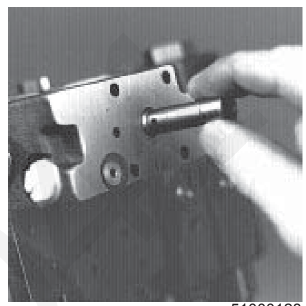
Position the valve housing (with O-rings) on the multi-function block.

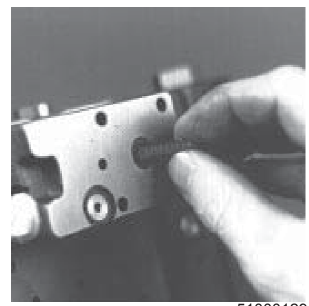

51000097
Fig. 50-101 - Pilot Piston Pin Installed


51000127
Fig. 50-102 - Install Control Housing

Install the pilot piston into the housing and over the pin. The end of the piston with the cross drilled hole should engage the pin.

Install the small spring in the outer end of the pilot piston.

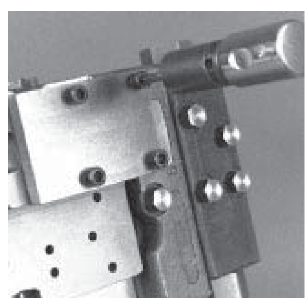

51000128
Fig. 50-103 - Install Pilot Piston

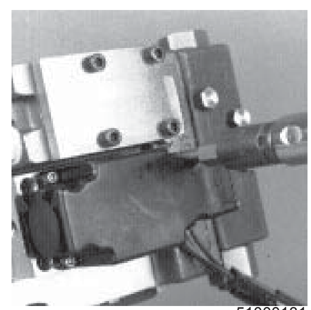

51000129
Fig. 50-104 - Install Spring

Install the control cover and gasket. Align the control assembly with the multi-function block and install the four (4) screws.

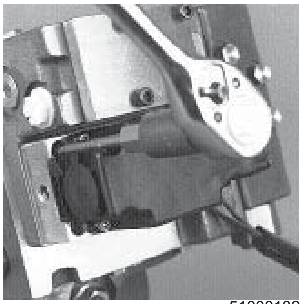
Torque the control screws to 6.4 Nm (4.7 ft•lbsf).

Reinstall the PCP valve, if removed.


51000130
Fig. 50-105 - Torque Cover, Gasket, and Screws

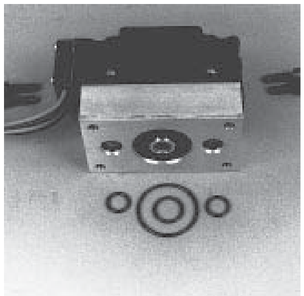

51000131
Fig. 50-106 - Install PCP Valve

Minor Repair and Replacement - Variable Motor (Continued)



51000132

Fig. 50-107 - Remove PCP Valve Screws



51000133

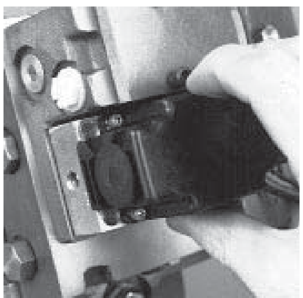
Fig. 50-108 - PCP Valve Components

Pressure Control Pilot (PCP) Valve for Electrohydraulic Proportional Control (Types EP and EQ)

Thoroughly clean external surfaces of control.

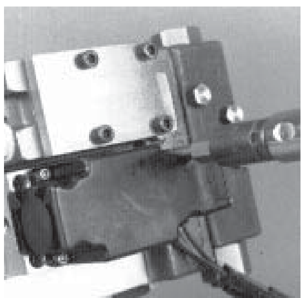
Using a 4 mm internal hex wrench, remove the four (4) screws and remove the PCP valve.

Check surfaces for nicks or damage. Clean internal screens.



51000124

Fig. 50-109 - Install PCP onto Control



51000131

Fig. 50-110 - Torque PCP Valve Screws

Install new O-rings on the PCP housing and retain with petroleum jelly. Position the PCP on the control valve housing and install the screws.

Torque the screws to 5.4 Nm (48 in•lbsf).

Minor Repair and Replacement - Variable Motor (Continued)

Multi-function Block

Removal and Installation

Remove the external control assembly as described in the instructions for the specific control.

Remove the four (4) screws (and washers for 060, 080, and 110 units) retaining the multi-function block to the end cap with an 8 mm internal hex wrench (060, 080, and 110 units) or a 10 mm internal hex wrench (160 and 250 units).

Remove the multi-function block from the end cap. Remove the O-rings between the multi-function block and the end cap, and the O-ring on the valve spool sleeve.

The multi-function block is equipped with filter screens in the passages between the block and the end cap. Units with internal servo pressure supply have a filter screen installed in the end cap passage leading to the valve spool sleeve. These screens should be pressed into position (with the rounded edge of the filter screens facing “out”) until they are flush to 2.0 mm (0.08 in.) below the machined surface of the multi-function block or end cap.

Units with external servo pressure supply have a plug installed in the end cap passage leading to the valve spool sleeve. This plug may be removed with a 2.5 mm internal hex wrench. When installing this plug, torque to 2 Nm (18 in•lbsf).

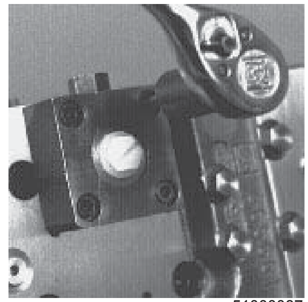
Install a new O-ring onto the valve spool sleeve in the end cap.

Install new O-rings onto the end cap.

Install the multi-function block onto the end cap, and install the screws.

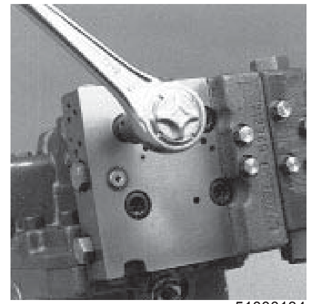
Torque the screws to 78 Nm (58 ft•lbsf) for 060, 080, or 110 units, or to 110 Nm (81 ft•lbsf) for 160 or 250 units.

Reinstall the external control assembly as described in the instructions for the specific control.



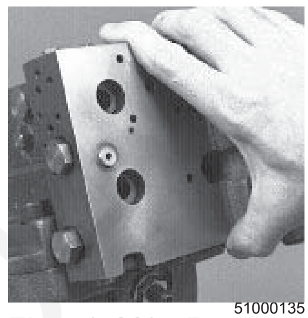
51000087

Fig. 50-111 - Remove External Control (HS Shown)



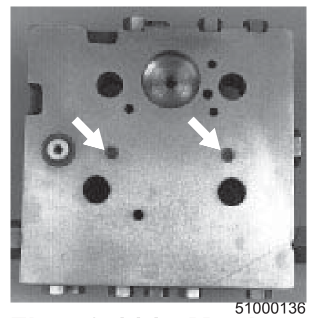
51000134

Fig. 50-112 - Remove Multi-function Block Screws



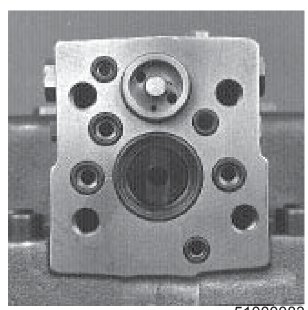
51000135

Fig. 50-113 - Remove Multi-function Block



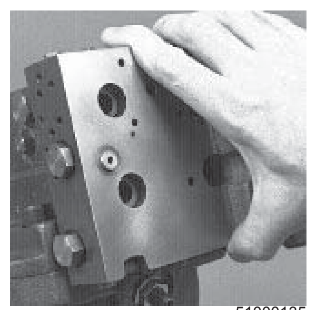
51000136

Fig. 50-114 - Multi-function Block Screens



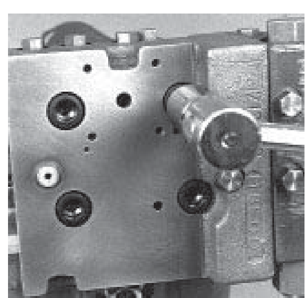
51000083

Fig. 50-115 - End Cap O-Rings Installed



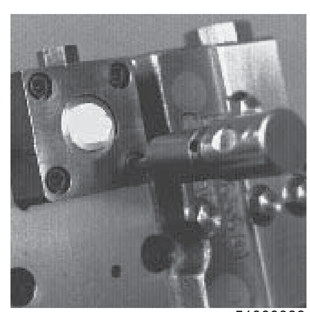
51000135

Fig. 50-116 - Install Multi-function Block



51000137

Fig. 50-117 - Torque Multi-function Block Screws



51000088

Fig. 50-118 - Install External Control (HS Shown)

Minor Repair and Replacement - Variable Motor (Continued)

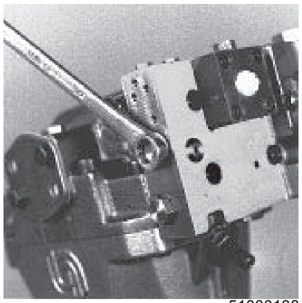

51000138

Fig. 50-119 - Remove Servo Pressure Supply Spool Plug

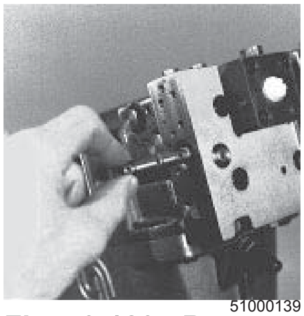

51000139

Fig. 50-120 - Remove Servo Pressure Supply Shuttle Spool

Servo Pressure Supply Shuttle Spool

Remove the servo pressure supply shuttle spool plug from the multi-function valve with a 9/16" hex wrench.

NOTE: If a pressure compensator valve block is installed, the opposite end of the shuttle spool bore in the multi-function valve is plugged with an internal hex head plug located under the valve block. If a pressure compensator valve block is not installed, the opposite end of the shuttle spool bore is plugged with a hex head plug.

Remove the servo pressure supply shuttle spool from the multi-function valve block.

Inspect the shuttle spool for burrs or scoring. The spool must slide free in its bore. The shuttle ball in the spool must be free to move.

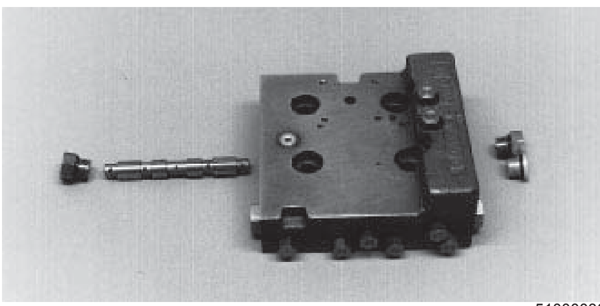

51000030

Fig. 50-121 - Multi-function Block with Servo Pressure Supply Shuttle Spool

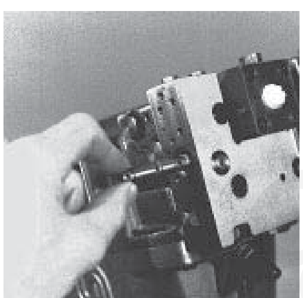

51000139

Fig. 50-122 - Install Servo Pressure Supply Shuttle Spool

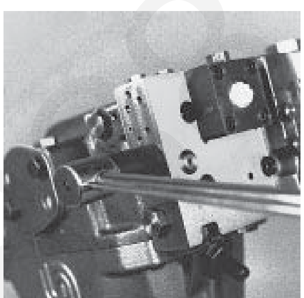

51000140

Fig. 50-123 - Torque Servo Pressure Supply Spool Plug

Install the shuttle spool into the multi-function block.

Install the hex head plug into the multi-function valve and torque to 37 Nm (27 ft•lbsf).

NOTE: If an internal hex head plug was removed from the opposite end of the shuttle spool bore, torque it to 20 Nm (15 ft•lbsf).

Minor Repair and Replacement - Variable Motor (Continued)

Blocking Plate for Multi-function Block Without PCOR

The blocking plate may be removed by removing the four (4) screws with a 5 mm internal hex wrench. Remove the O-rings from the plate.

Install new O-rings on the blocking plate and retain with petroleum jelly. Install the plate on the multi-function block and install the screws. Torque the screws to 11 Nm (8 ft•lbsf).


51000170

Fig. 50-124 - Remove Blocking Plate (Less PCOR)

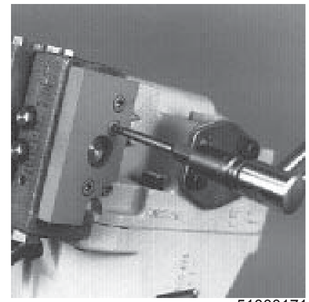

51000171

Fig. 50-125 - Torque Blocking Plate Screws (Less PCOR)

Pressure Compensator Valve for Pressure Compensator Over-Ride (PCOR) and Pressure Compensator Regulator (Type PC)

Loosen the adjusting screw lock nut with a 1-1/16" hex wrench. Remove the adjusting screw from the valve block with a large screwdriver.

Remove the pressure compensator valve spring and the spool assembly from the block.

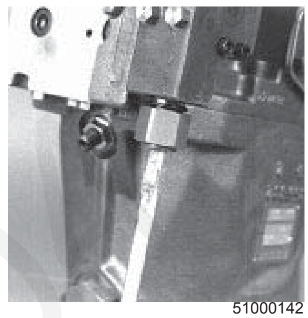

51000142

Fig. 50-126 - Remove PCOR•PC Adjustor

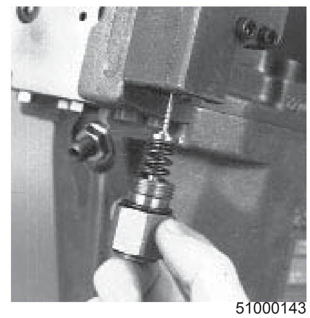

51000143

Fig. 50-127 - Remove PCOR•PC Spring and Spool Valve

Remove the valve block plug with a 1" hex wrench.

Remove the four (4) screws retaining the valve block to the multi-function block with a 5 mm internal hex wrench. Remove the valve block and O-rings.

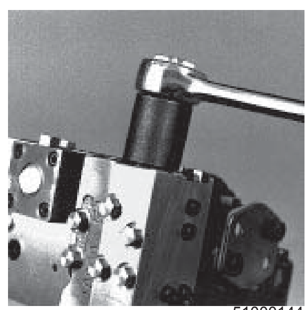

51000144

Fig. 50-128 - Remove PCOR•PC Plug

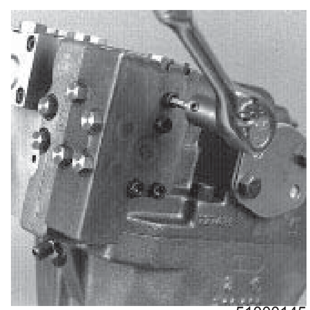

51000145

Fig. 50-129 - Remove PCOR•PC Valve Block

Install new O-rings on the pressure compensator valve block and retain with petroleum jelly. Install a new O-ring on the adjusting screw.

The plugs on the valve block may be removed with a 7⁄16" hex wrench. When reinstalling, torque the 5⁄16" plugs to 9 Nm (7 ft•lbsf).

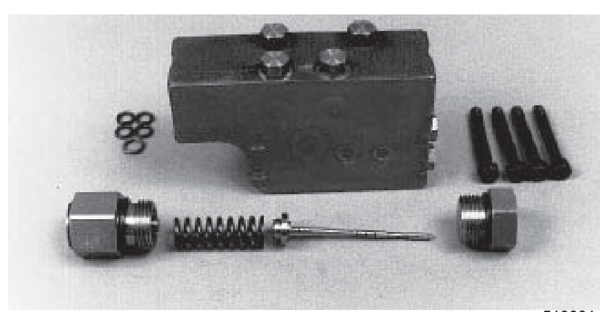
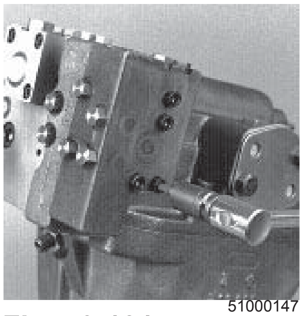

51000146

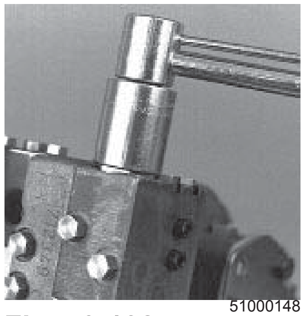
Fig. 50-130 - Pressure Compensator Valve Block Components

Minor Repair and Replacement - Variable Motor (Continued)



51000147

Fig. 50-131 - Install PCOR•PC Valve Block

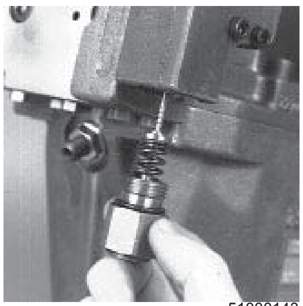


51000148

Fig. 50-132 - Install PCOR•PC Valve Plug

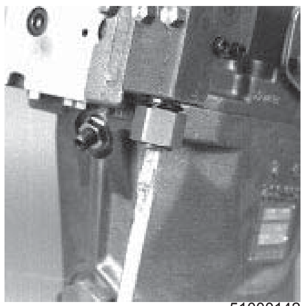
Install the valve block on the multi-function block and install the screws. Torque the screws to 11 Nm (8 ft•lbsf).

Install the valve block plug and torque to 54 Nm (40 ft•lbsf).



51000143

Fig. 50-133 - Install PCOR•PC Spring and Spool Valve

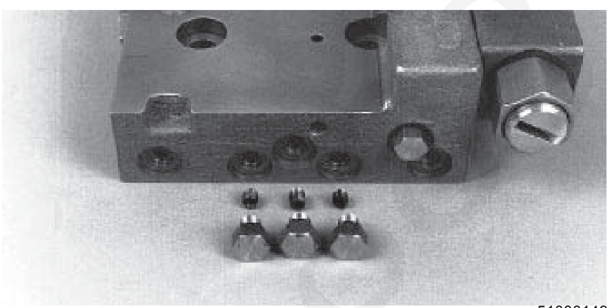


51000142

Fig. 50-134 - Install PCOR•PC Adjusting Screw

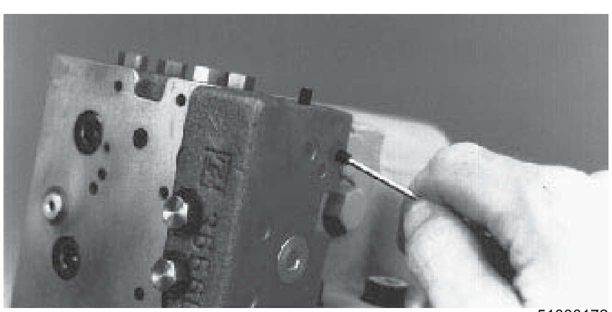
Install the pressure compensator spool assembly and the valve spring.

Install the adjusting screw and lock nut. Perform the PCOR or PC regulator pressure adjustment as described under “Component Adjustment."



51000149

Fig. 50-135 - PCOR and PC Regulator Orifices



51000172

Fig. 50-136 - PCOR and PC Regulator Orifices

PCOR and PC Regulator Orifices

To gain access to the PCOR or PC regulator orifices, remove the three (3) plugs located between the defeat spool stop plugs on the multi-function block, using a 7/16" hex wrench. Remove the PCOR brake pressure defeat spool (if installed). Remove the orifice plug(s) and plain plug(s) with a 2.5 mm internal hex wrench.

Refer to the appropriate Service Parts Manual for information on orifice locations and sizes.

Install the orifice plug(s) and plain plug(s), and torque to 4 Nm (35 in•lbsf). Install the outer plugs and torque to 6 Nm (4 ft•lbsf). Reinstall the PCOR defeat spool (if removed).

Additional orifices are installed in the passages under the pressure compensator valve block.

Minor Repair and Replacement - Variable Motor (Continued)

PCOR Brake Pressure Defeat Spool

Remove the PCOR defeat spool bore plugs or fittings with a hex wrench.

Remove the PCOR defeat spool stop plugs with a 7⁄16" hex wrench. Remove the defeat spool.

NOTE: The defeat spool may be removed from either end of its bore in the multi-function block.

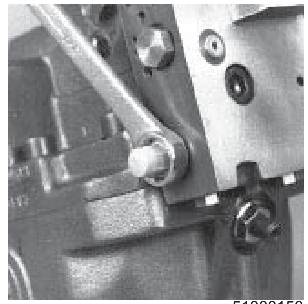

51000150

Fig. 50-137 - Remove PCOR Defeat Spool Plug or Fitting

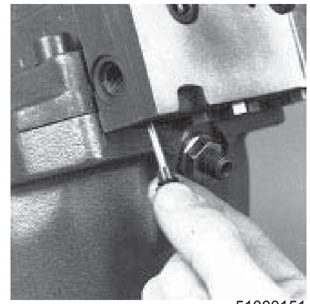

51000151

Fig. 50-138 - Remove PCOR Defeat Spool Stop Plug

Inspect the defeat spool for burrs or roughness. The spool must slide freely in its bore. Inspect the pins in the stop plugs for damage.

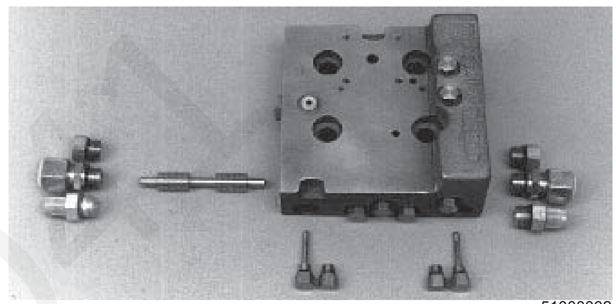

51000032

Fig. 50-139 - Multi-function Block With PCOR Defeat Spool Components

Install the PCOR defeat spool into its bore in the multi-function block.

Install the spool stop plugs into the multi-function block. Torque the stop plugs to 6 Nm (4 ft•lbsf).

Install the defeat spool bore plugs or fittings and torque to 27 Nm (20 ft•lbsf).

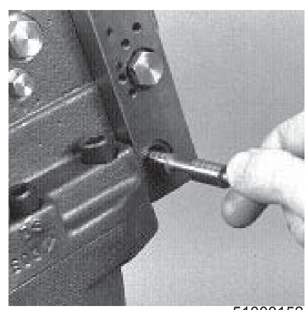

51000152

Fig. 50-140 - Install PCOR Defeat Spool

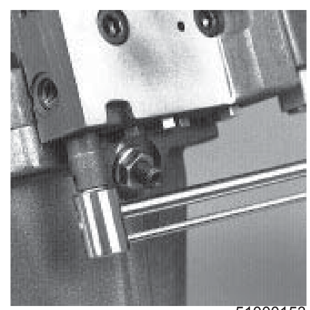
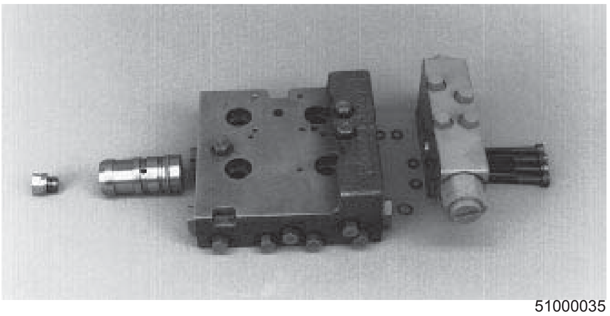

51000153

Fig. 50-141 - Install PCOR Defeat Spool Stop Plug

Minor Repair and Replacement - Variable Motor (Continued)



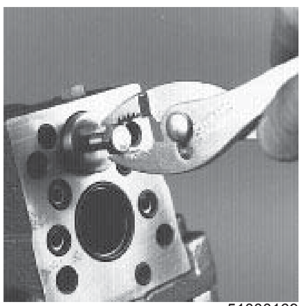
51000035

Fig. 50-142 - PC Regulator Components

Pressure Compensator Regulator (Type PC)

The PC regulator utilizes the multi-function block and pressure compensator valve to control the motor displacement.

Service procedures for these components are included in the "Multi-function Block" section of this manual.



51000169

Fig. 50-143 - Remove Valve Sleeve Bore Plug

51000173

Fig. 50-144 - Servo Drain Orifice (T7)

A valve sleeve bore plug is installed in the motor end cap in place of the valve spool sleeve. Remove the plug from the valve sleeve bore in the end cap. (An 8 mm threaded hole is provided in the plug for a puller screw.) Remove the O-ring from the plug.

A single servo drain orifice is installed in the valve sleeve bore plug. This orifice limits oil flow from the maximum displacement end of the servo piston to the motor case.

Install a new O-ring on the valve sleeve bore plug. Install the bore plug into the end cap.

The special plug and seal washer on the end cap opposite the multi-function block may be removed with a 13 mm hex wrench. When installing, torque this plug to 20 Nm (15 ft•lbsf).

Minor Repair and Replacement - Variable Motor (Continued)

Control Orifices

Orifices are installed in the motor end cap to regulate oil flow to the servo control valve and the servo piston.

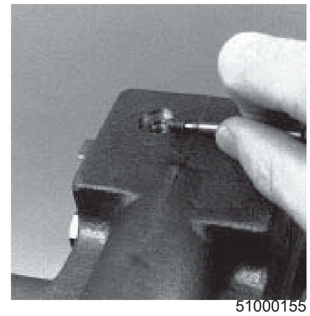
To gain access to these orifice plugs, remove the three (3) plugs located on the motor end cap nearest the multi-function block or control, using a 7/16" or 9/16" hex wrench. Remove the orifice plugs (plain plugs for N2 control) with a 3 mm internal hex wrench.

Install the orifice plugs, and torque to 4 Nm (35 in•lbsf). Torque the 5/16" outer plugs to 9 Nm (7 ft•lbsf), and the 9/16" outer plug to 37 Nm (27 ft•lbsf).

Orifices are also installed in the servo control valve sleeve to control oil flow from the servo piston to the motor case.

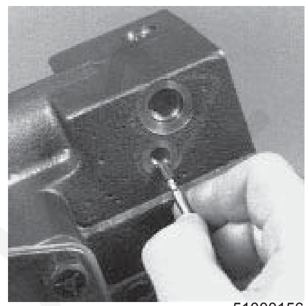
51000154

Fig. 50-145 - Servo Pressure Supply Orifice (T1)



51000155

Fig. 50-146 - Servo Orifice for Maximum Displacement (T2)



51000156

Fig. 50-147 - Servo Orifice for Minimum Displacement (T3)

51000157

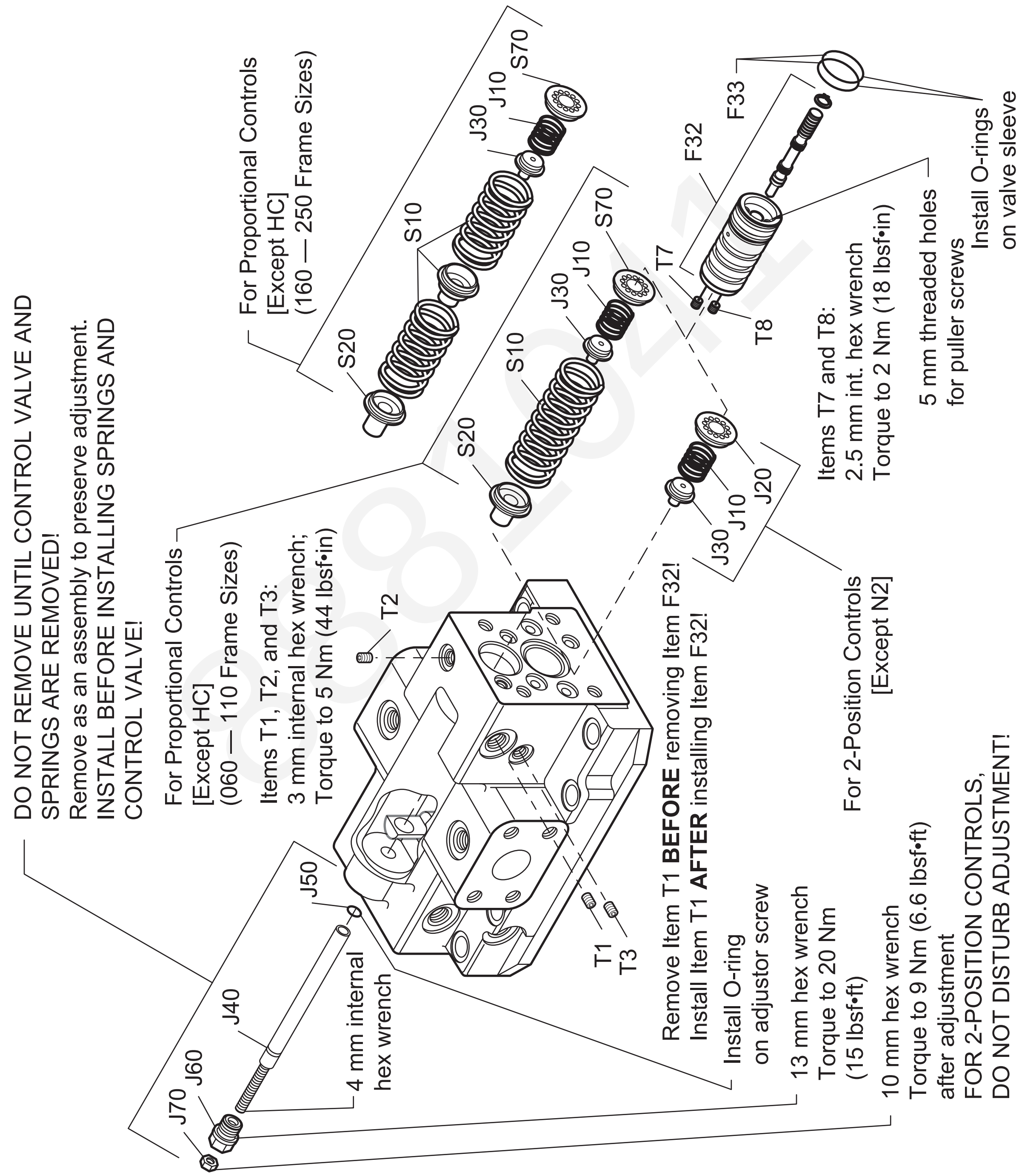
Fig. 50-148 - Servo Drain Orifices (T7 and T8)

Plug / Fitting Torques

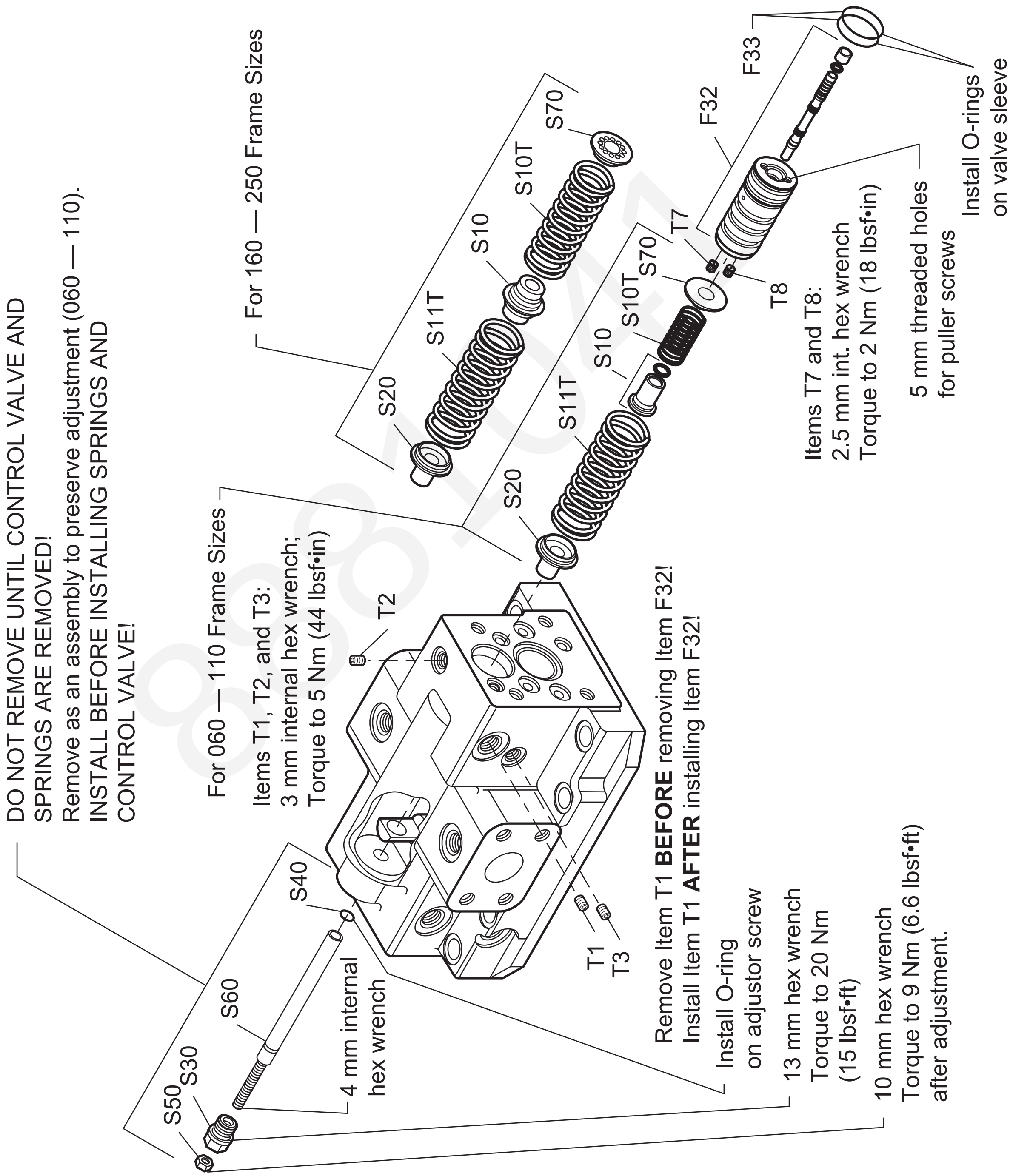
If any plugs or fittings are removed from the unit during servicing, they should be torqued as indicated in the accompanying table.

Item	Torque
Pressure Gauge Ports (9/16—18 O-Ring Hex)	37 Nm (27 ft•lbsf)
Construction Plugs (9/16—18 O-Ring Int. Hex)	20 Nm (15 ft•lbsf)
Construction Plugs (5/16—24 O-Ring)	9 Nm (7 ft•lbsf)
Screw Plugs (M6 Int. Hex)	4 Nm (35 in•lbsf)

Minor Repair Instructions
4-Way Valve and Feedback Springs



Minor Repair Instructions
4-Way Valve and Feedback Springs - HC Control



Hydraulic Power Systems

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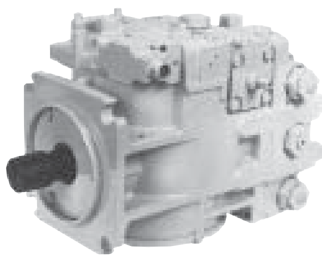
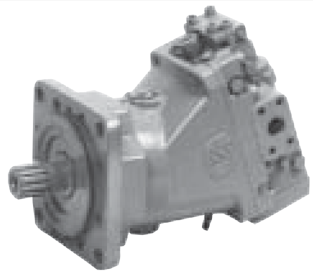
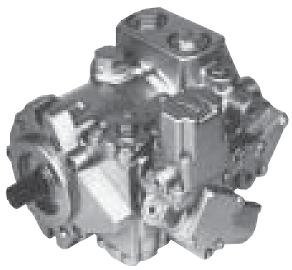


Heavy Duty Axial Piston Pumps and Motors

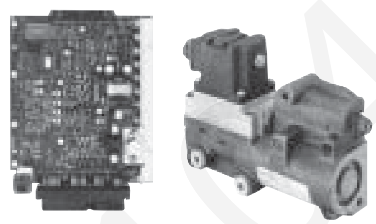


Heavy Duty Bent Axis Variable Motors

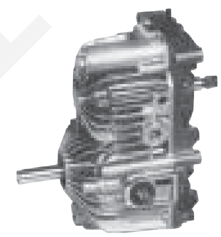
Cartridge Motors/ Compact Wheel Drives



Medium Duty Axial Piston Pumps and Motors

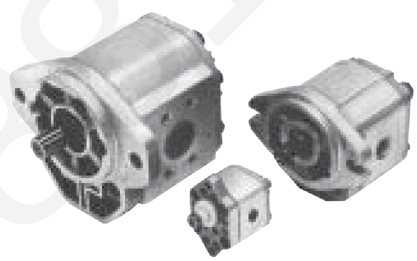


Microcontrollers and Electrohydraulic Controls



Hydrostatic Transmission Packages

Open Circuit Axial Piston Pumps



Gear Pumps and Motors

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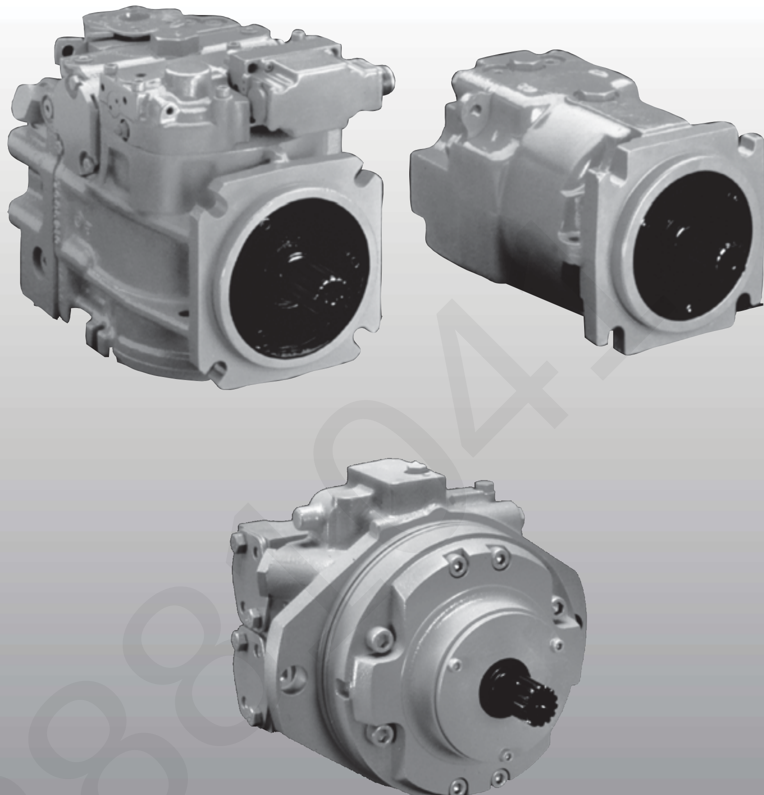
BLN-10043 • Revision A • November 1997

Series 90



Axial Piston

Pumps and Motors

Service Manual

Introduction

Use of this Manual

This manual includes information for the normal operation, maintenance, and servicing of the Series 90 family of hydrostatic pumps and motors.

The manual also includes the description of the units and their individual components, troubleshooting information, adjustment instructions, and minor repair procedures. Unit warranty obligations should not be affected if maintenance, adjustment, and minor repairs are performed according to the procedures described in this manual.

Many service and adjustment activities can be performed without removing the unit from the vehicle or machine. However, adequate access to the unit must be available, and the unit must be thoroughly cleaned before beginning maintenance, adjustment, or repair activities.

Since dirt and contamination are the greatest enemies of any type of hydraulic equipment, cleanliness requirements must be strictly adhered to. This is especially important when changing the system filter and during adjustment and repair activities.

For further information refer to Series 90 Technical Information. For information about fluid requirements refer to SAUER-SUNDSTRAND BLN 9887 or SDF (Id No. 697581).

A worldwide network of SAUER-SUNDSTRAND Authorized Service Centers is available should repairs be needed. Contact any SAUER-SUNDSTRAND Authorized Service Center for details. A list of all Service Centers can be found in bulletin BLN-2-400527, or in brochure SAW (Ident. No. 698266).

Safety Precautions

Observe the following safety precautions when using and servicing hydrostatic products.

Loss of Hydrostatic Braking Ability

WARNING
The loss of hydrostatic drive line power in any mode of operation (e.g., forward, reverse, or "neutral" mode) may cause the loss of hydrostatic braking capacity. A braking system, redundant to the hydrostatic transmission must, therefore, be provided which is adequate to stop and hold the system should the condition develop.
S000001E

Fluid under High Pressure

WARNING
Use caution when dealing with hydraulic fluid under pressure. Escaping hydraulic fluid under pressure can have sufficient force to penetrate your skin causing serious injury. This fluid may also be hot enough to burn. Serious infection or reactions can develop if proper medical treatment is not administered immediately.
S000 003E

Disable Work Function

WARNING
Certain service procedures may require the vehicle/machine to be disabled (wheels raised off the ground, work function disconnected, etc.) while performing them in order to prevent injury to the technician and bystanders.
S000 005E

Flammable Cleaning Solvents

WARNING
Some cleaning solvents are flammable. To avoid possible fire, do not use cleaning solvents in an area where a source of ignition may be present.
S000 004E

S90MVCTCD
S90PVMFCD

Contents

Contents

Functional Description

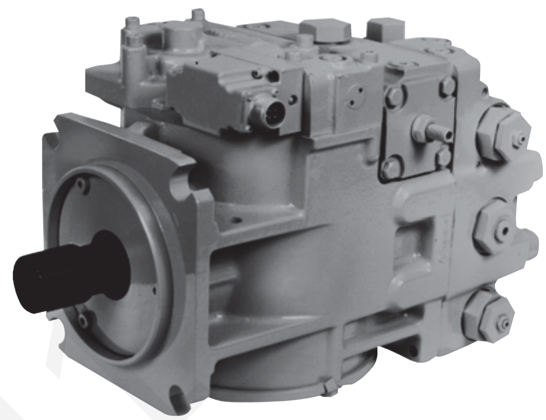
This section describes the operation of pumps, motors, and their various serviceable features. It is a useful reference for readers unfamiliar with the functioning of a specific system.

General Description and Cross Sectional Views

Variable Displacement Pumps

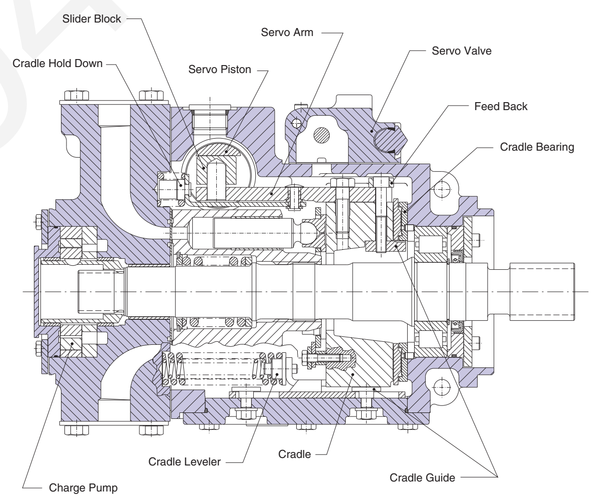
The Variable Displacement Pump (PV) is designed to convert an input torque into hydraulic power. The input shaft turns the pump cylinder which contains a ring of pistons. The pistons run against a tilted plate, called the swashplate. This causes the pistons to compress the hydraulic fluid which imparts the input energy into the hydraulic fluid. The high pressure fluid is then ported out to provide power to a remote function.

The swashplate angle can be varied by the control piston. Altering the swashplate angle varies the displacement of fluid in a given revolution of the input shaft.



F000 539

Series 90 Variable Displacement Pump (PV)

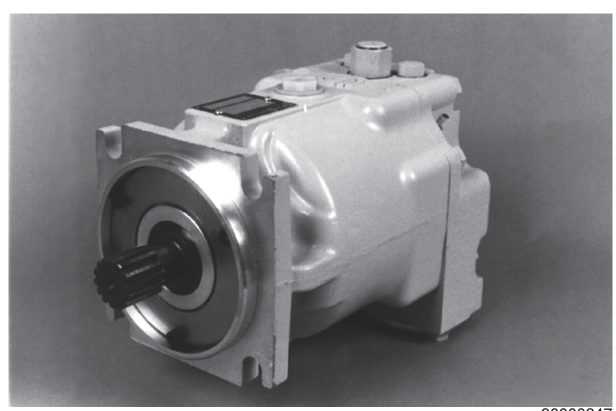


P001 413E

Series 90 PV Cross Section

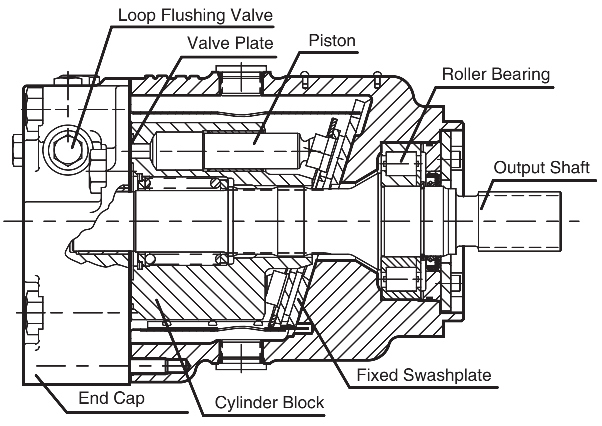
Fixed Displacement Motor

The Fixed Displacement Motor (MF) is designed to convert an input of hydraulic power into an output torque. It operates in the reverse manner of the pump. The high pressure hydraulic fluid enters through the input port. The fluid pressure builds behind the pistons causing them to move down the swashplate (the path of least resistance). As the piston returns up the swashplate again, the fluid is allowed to exit through the exit port. The spinning pistons are housed in a cylinder which is connected to the output shaft. The output torque can be applied to a mechanical function.



90000347

Series 90 Fixed Displacement Motor (MF)

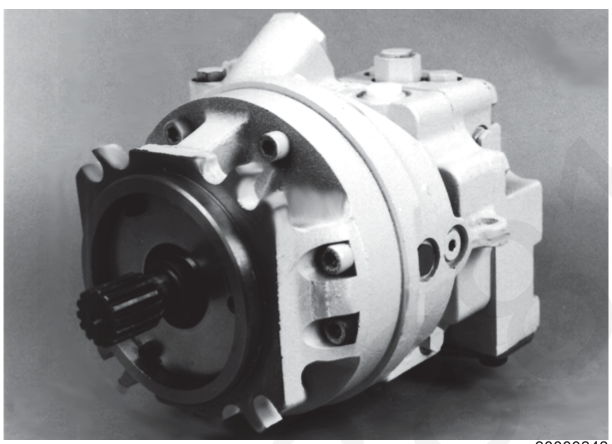


Series 90 MF Cross Section

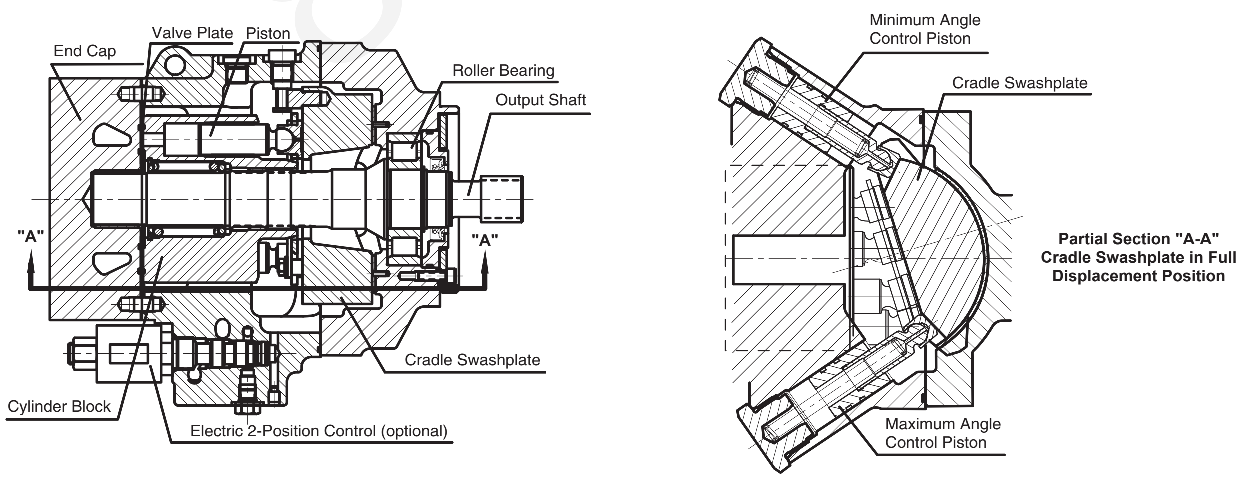
In the Fixed Displacement Motor the "swashplate" is fixed, so any variation in motor speed and torque must be made by the input mechanism, i.e. the pump.

Variable Displacement Motor

The Variable Displacement Motor (MV) operates in the same manner as the fixed motor. However, its swashplate is not fixed; it can be switched between minimum and maximum angle to amplify torque or speed like the Variable Displacement Pump.

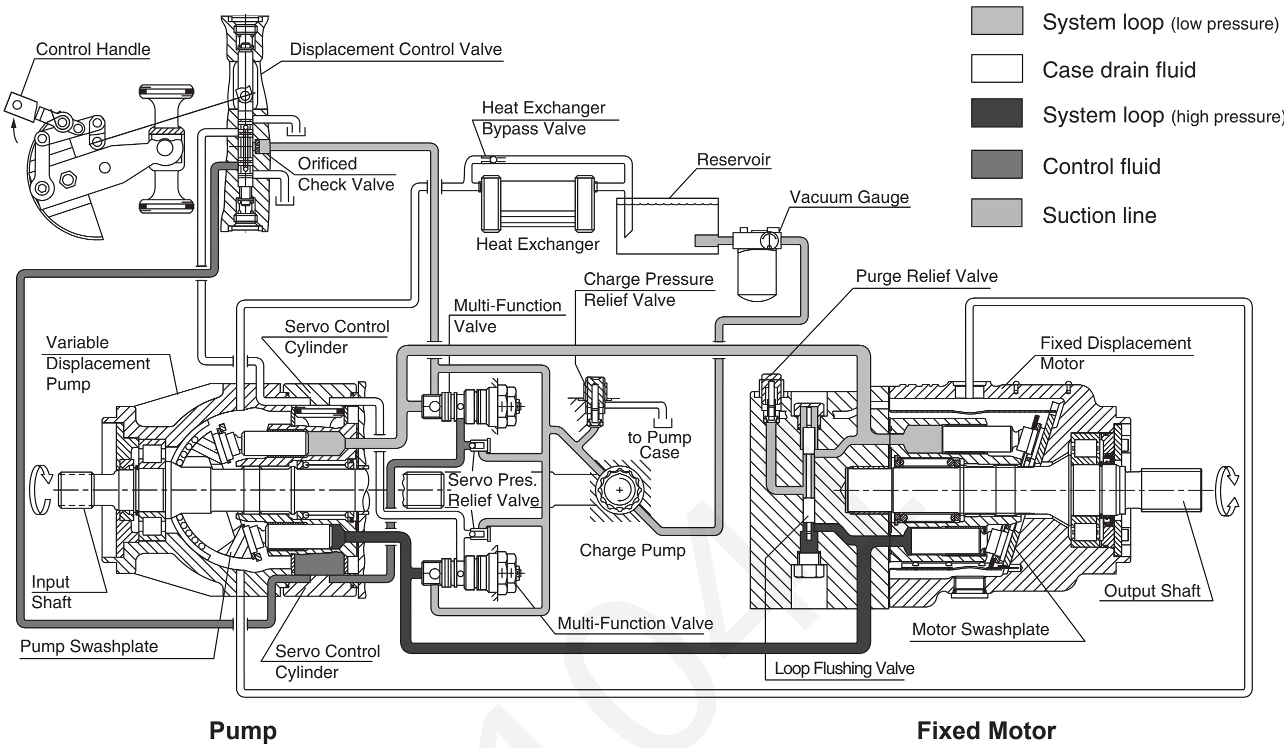


Series 90 Variable Displacement Motor (MV)



Series 90 MV Cross Section

The System Circuit



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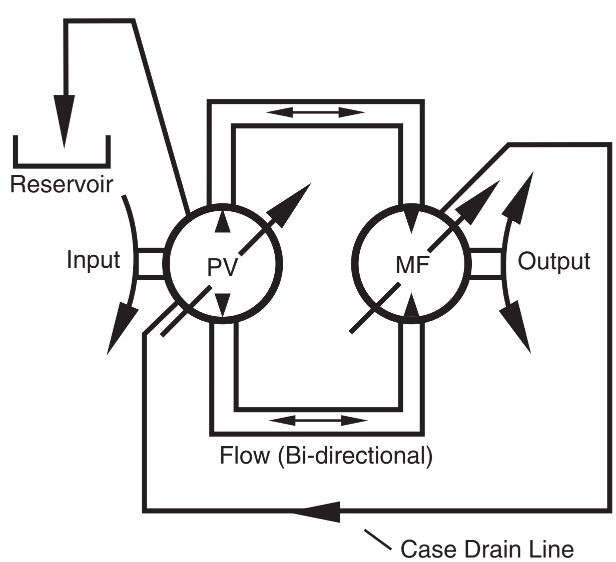
Circuit Diagram for Series 90 PV and 90 MF

The Basic Closed Circuit

The main ports of the pump are connected by hydraulic lines to the main ports of the motor. Fluid flows, in either direction, from the pump to the motor then back to the pump in this closed circuit. Either of the hydraulic lines can be under high pressure. In pumping mode the position of the pump swashplate determines which line is high pressure as well as the direction of fluid flow.

Case Drain and Heat Exchanger

The pump and motor require case drain lines to remove hot fluid from the system. The motor should be drained from its topmost drain port to ensure the case remains full of fluid. The motor case drain can then be connected to the lower drain port on the pump housing and out the top most port. A heat exchanger, with a bypass valve, is required to cool the case drain fluid before it returns to the reservoir.



90000803E

Basic Closed Circuit

Common Features of Pumps and Motors

End Caps and Shafts

Series 90 pumps and motors can be supplied with a variety of end caps and shafts to allow for almost any configuration. For pumps, end caps are available with system ports on either side ("side ports") or both ports on one side ("twin ports"). Motors have end caps with ports on the face of the end cap ("axial ports") or both ports on one side ("twin ports"). See the Series 90 Technical Information manuals (BLN-10029 and BLN-10030) or the Series 90 Price Book (BLN-2-40588) for information on available options.

Removing the end cap will void the warranty on a Series 90 pump or motor.

Speed Sensors

90000810

Speed Sensor

An optional speed sensor can be installed on Series 90 pumps and motors to provide unit speed information. The sensor reads a magnetic ring wrapped about the unit's cylinder. See the corresponding Section to locate, install and adjust the sensor.

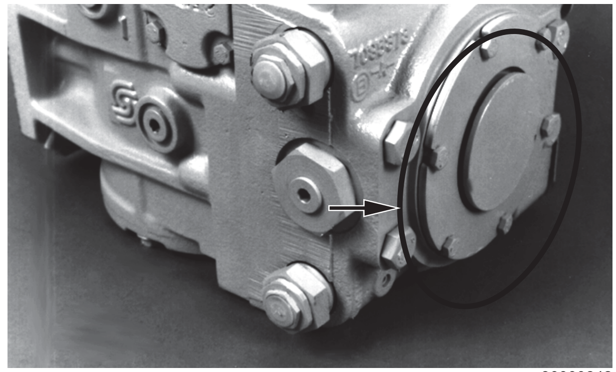
Pump Features

Charge Pump

The charge pump is necessary to supply cool fluid to the system, to maintain positive pressure in the main system loop, to provide pressure to operate the control system, and to make up for internal leakage. Charge pressure must be at its specified pressure under all conditions of driving and braking to prevent damage to the transmission.

The charge pump is a fixed-displacement, gerotor type pump installed in the variable displacement pump and driven off the main pump shaft. Charge pressure is limited by a relief valve.

The standard charge pump will be satisfactory for most applications. However, if the charge pump sizes available for the given main pump size are not adequate, a gear pump may be mounted to the auxiliary mounting pad and supply the required additional charge flow.

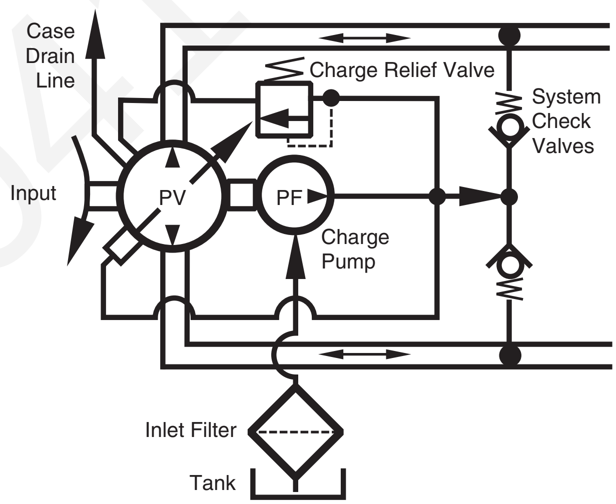


90000243

PV with Charge Pump

Charge Relief Valve

The charge relief valve on the pump serves to maintain charge pressure at a designated level. A direct-acting poppet valve relieves charge pressure whenever it surpasses a certain level. This level is nominally set referencing case pressure at 1500 rpm. This nominal setting assumes the pump is in neutral (zero flow); in forward or reverse charge pressure will be lower. The charge relief valve setting is specified on the model code of the pump.



90000804E

Pump Charge System

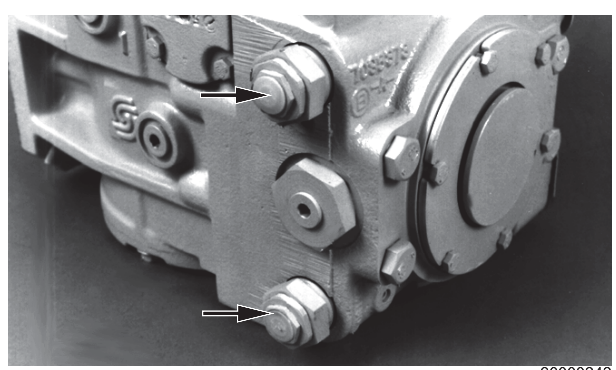
Multi-Function Valves

The multi-function valve incorporates
- the system check valve,
- the pressure limiter valve,
- the high pressure relief valve and
- the bypass valve

in a replaceable cartridge.

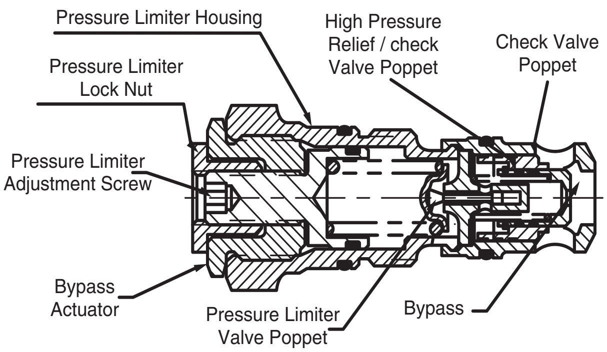
These functions are described separately. There are two multi-function valve cartridges in each Series 90 pump to handle functions in either direction. See corresponding Sections for adjustments and repairs.

NOTE: Some multi-function valves do not include a pressure limiter valve.



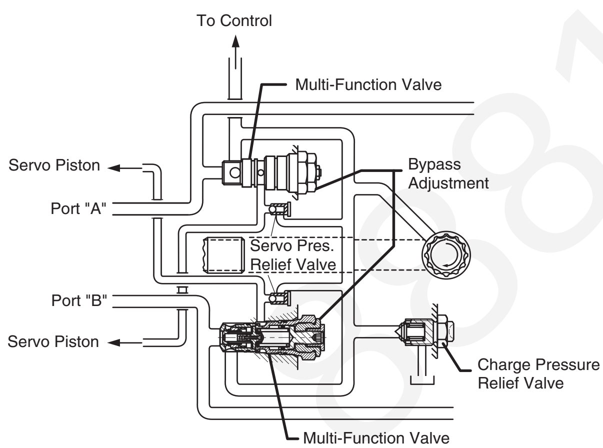
90000243

Multi-Function Valve



90000806E

Cross Section of Multi-Function Valve



90000801E

Circuit Diagram showing Pressure Control Mechanism

Pressure Limiter and High Pressure Relief Valves

Series 90 pumps are designed with a sequenced pressure limiting system and high pressure relief valves. When the preset pressure is reached, the pressure limiter system acts to rapidly destroke the pump so as to limit the system pressure. For unusually rapid load application, the high pressure relief valve acts to immediately limit system pressure by cross-porting system flow to the low pressure side of the loop. The pressure limiter valve acts as the pilot for the high pressure relief valve spool. The high pressure relief valve is sequenced to operate at approximately 35 bar (500 psi) above the level that initiates the pressure limiter valve.

Both the pressure limiter sensing valves and relief valves are built into the multi-function valves (see above).

NOTE: For some applications, such as dual path vehicles, the pressure limiter function may be defeated so that only the high pressure relief valve function remains.

System Check Valves

The system check valves allow pressurized flow from the charge pump to enter the low pressure side of the loop whenever system pressure dips below a certain level. This is needed as the pump will generally lose system pressure due to leakage and other factors. Since the pump can operate in either direction, two system check valves are used to direct the charge supply into the low pressure lines. The system check valves are poppet valves located in the multi-function valve assembly.

Bypass Valves

The bypass valves ("tow") can be operated when it is desired to move the vehicle or mechanical function when the pump is not running. The valve is opened by manually resetting the valve position.

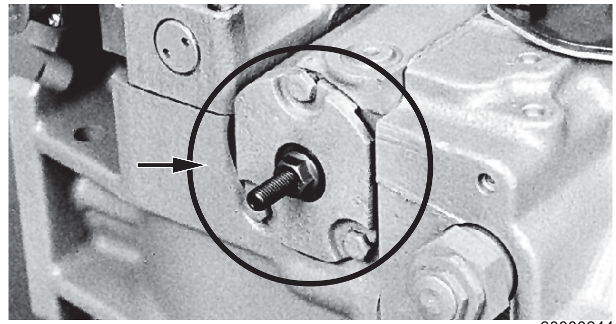
The bypass valves are built into the multi-function valves.

Displacement Limiters

All Series 90 pumps are designed for optional mechanical displacement (stroke) limiters. The maximum displacement of the pump can be limited in either direction.

The setting can be set as low as 0° in either direction.

For instructions on adjustment see corresponding Section.

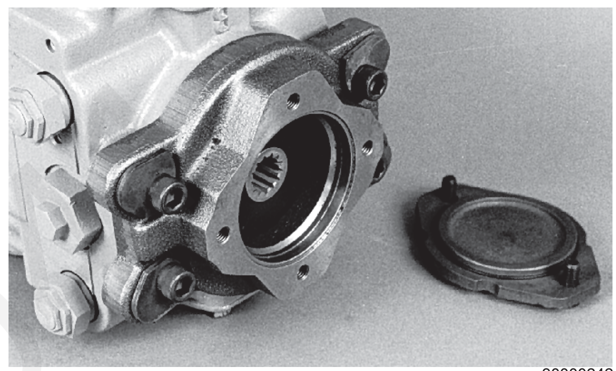


90000244

PV with Displacement Limiters

Auxiliary Mounting Pads

Auxiliary mounting pads are available on all Series 90 pumps. SAE A through E mounts are available (availability varies by pump size). This pad is used for mounting auxiliary hydraulic pumps and for mounting additional Series 90 pumps to make tandem pumps. The pads allow for full through-torque capability.



90000242

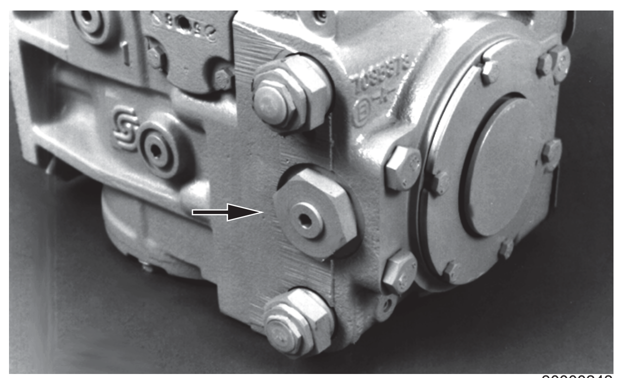
PV with Auxillary Mounting Pad

Filtration Options

All Series 90 pumps are available with provisions for either suction or charge pressure filtration (integral or remote mounted) to filter the fluid entering the charge circuit.

Suction Filtration

The suction filter is placed in the circuit between the reservoir and the inlet to the charge pump. When suction filtration is used, a reducer fitting is placed in the charge pressure gauge port (M3). Filtration devices of this type are provided by the user.



90000243

PV with Suction Filtration
(No filtration device attached)

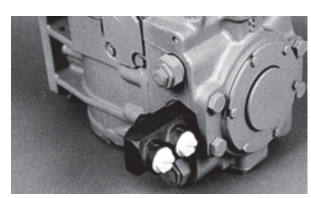
Charge Pressure Filtration

The pressure filter may be integrally mounted directly on the pump or a filter may be remotely mounted for ease of servicing.

A 125 µm screen, located in the reservoir or the charge inlet line, is recommended when using this filtration option.

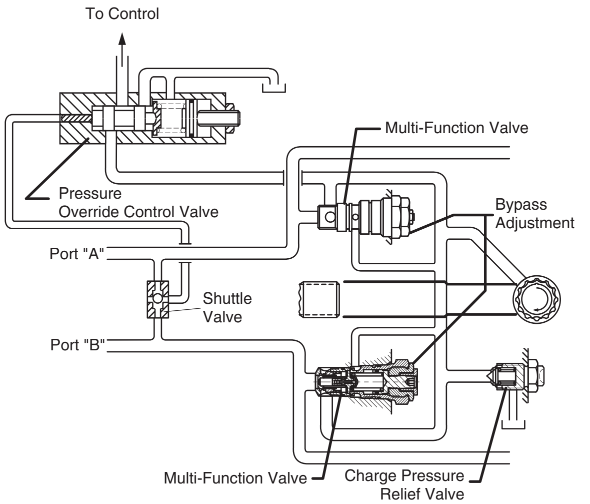
90000246

PV with Integral Charge Pump



90000247

PV with Remote Charge Pump



90000802E

POR-Valve (180 Frame Size only)

Pressure Override (POR) - 180 Frame Size Only

The pressure override valve (POR) modulates the control pressure to the displacement control to maintain a pump displacement which will produce a system pressure level less than or equal to the POR setting. For unusually rapid load application, the high pressure relief valve function of the multifunction valves is available to also limit the pressure level.

The pressure override consists of a three-way normally open valve which operates in series with the pump displacement control. Control supply pressure is normally ported through the pressure override valve to the displacement control valve for controlling the pump's displacement. If the system demands a pressure above the override setting, the POR valve will override the control by reducing the control pressure supplied to the displacement control. As the control pressure reduces, the internal forces tending to rotate the swashplate overcome the force of the servo pistons and allow the pump's displacement to decrease.

Pump Control Options

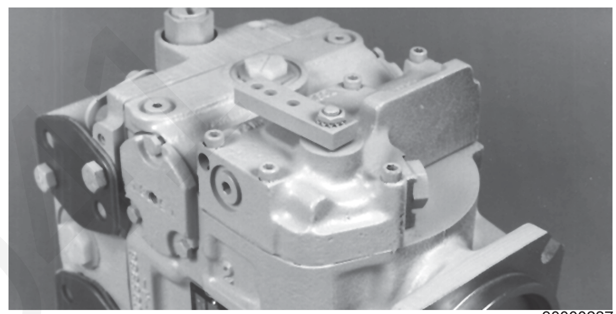
Manual Displacement Control (MDC)

The manual displacement control converts a mechanical input signal to a hydraulic signal using a spring- centered four-way servo valve. This valve ports hydraulic pressure to either side of a dual-acting servo piston. The servo piston rotates the cradle swashplate through an angular rotation of ±17°, thus varying the pump's displacement from full displacement in one direction to full displacement in the opposite direction.

The MDC is designed so the angular position of the pump swashplate is proportional to the rotation of the control input shaft.

Non-Linear MDC

The non-linear manual displacement control operates in the same manner as the regular MDC except that it is designed so the change in the angular position of the pump swashplate *progressively* increases as the control input shaft is rotated toward its maximum displacement position.



90000237

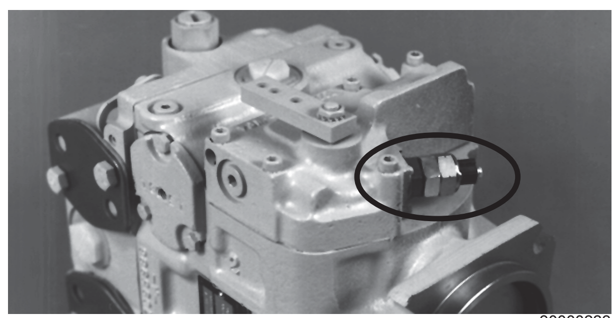
PV with Manual Displacement Control

Solenoid Override Valve for MDC

A solenoid override valve option (not shown here) is available for MDC. This safety feature will return the swashplate to zero displacement position when activated. The valve may be set in either a normally open or normally closed mode.

Neutral Start Switch (NSS)

The neutral start switch is an optional feature available with MDC. When connected properly with the vehicle's electrical system, the neutral start switch ensures that the prime mover can be started only when the control is in a neutral position.

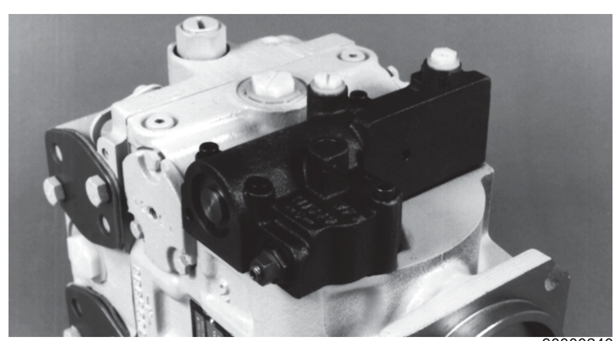


90000239

PV with Manual Displacement Control and Neutral Start Switch

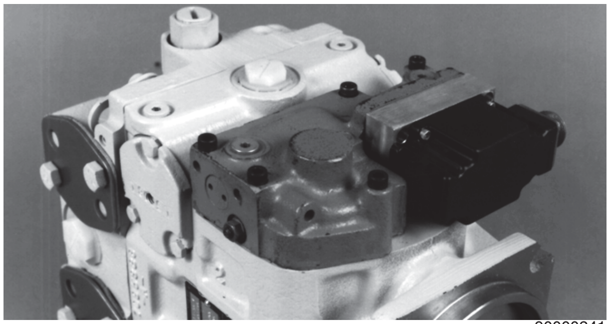
Hydraulic Displacement Control (HDC)

The hydraulic displacement control uses a hydraulic input signal to operate a spring-centered four-way servo valve. This valve ports hydraulic pressure to either side of a dual-acting servo piston. The servo piston rotates the cradle swashplate through an angular rotation of ±17°, thus varying the pump's displacement from full displacement in one direction to full displacement in the opposite direction. The HDC is designed so the angular position of the pump swashplate is proportional to input pressure.



90000240

PV with Hydraulic Displacement Control



90000241

PV with Electric Displacement Control

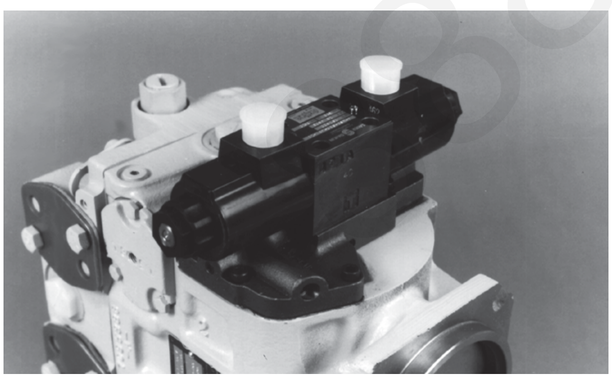
Electric Displacement Control (EDC)

The electric displacement control is similar to the hydraulic displacement control with the input signal pressure controlled by a pressure control pilot (PCP) valve. The PCP valve converts a DC electrical input signal to a hydraulic signal which operates a spring- centered four-way servo valve. This valve ports hydraulic pressure to either side of a dual-acting servo piston. The servo piston rotates the cradle swashplate through an angular rotation of ±17°, thus varying the pump's displacement from full displacement in one direction to full displacement in the opposite direction. The control is designed so the angular position of the swashplate is proportional to the EDC input.

Automotive Control (FBA II B)

Automotive Control allows a vehicle to be driven in a manner similar to an automobile with an automatic transmission.

The Automotive Control includes a three-position electric control to provide direction control.



90000354

PV with 3-Position (FNR) Electric Control

3-Position (FNR) Electric Control

This control utilizes a 12 or 24 VDC electrically operated spool valve to port pressure to either side of the pump displacement control piston. Energizing one of the solenoids will cause the pump to go to its maximum displacement in the corresponding direction.

All functions of the three-position (FNR) electric control are preset at the factory.

Motor Features

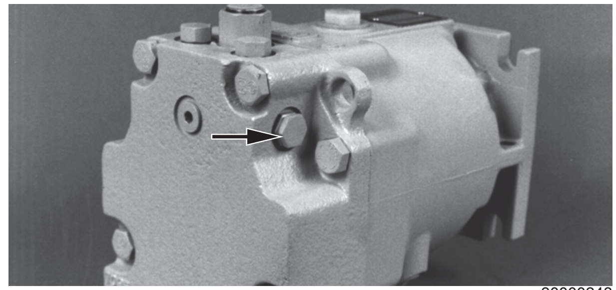
Motor Loop Flushing Valve and Charge Relief Valve

All Series 90 motors are designed to accommodate a loop flushing valve. The loop flushing valve is used in installations which require additional fluid to be removed from the main hydraulic circuit because of transmission cooling requirements, or unusual circuits requiring additional loop flushing to remove excessive contamination in the high pressure circuit.

A shuttle valve and charge relief valve are installed in the motor end cap to provide the loop flushing function. The shuttle valve provides a circuit between the low pressure side of the closed loop and the charge relief valve in the motor end cap.

The motor charge relief valve regulates the charge pressure level only when there is a pressure differential in the main loop. The shuttle valve is spring centered to the closed position so that no high pressure fluid is lost from the circuit when reversing pressures.

For charge relief valve adjustment see corresponding Section.



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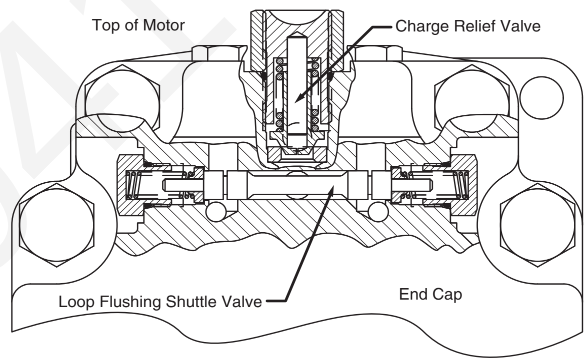
Loop Flushing Valve (MF)



90000238E

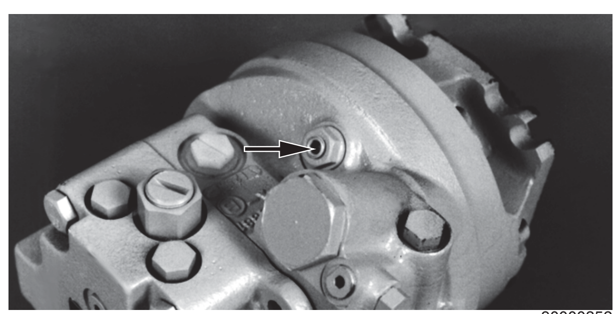
Motor Charge Relief Valve and Loop Flushing Shuttle Valve

Variable Motor Displacement Limiters

All Series 90 variable motors include mechanical displacement (stroke) limiters. Both the maximum and minimum displacement of the motor can be limited.

The range of the settings is as follows:

	055 MV	075 MV
Minimum Displacement	**19 - 40 cm³** 1.2 - 2.4 in³	**26 - 54 cm³** 1.6 - 3.3 in³
Maximum Displacement	65 - 100 %	65 - 100 %
		T002 251E



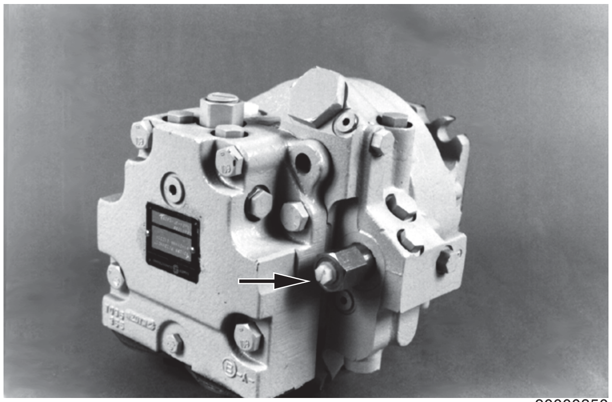
90000352

MV Maximum Displacement Limiter (Minimum Displacement Limiters on opposite side)

Variable Motor Controls

Hydraulic 2-Position Control

This control utilizes a hydraulically operated three-way hydraulic valve to port system pressure to either of the motor displacement control pistons. The motor is normally held at its maximum displacement. Supplying pilot hydraulic pressure to the valve will cause the motor to go to its minimum displacement.

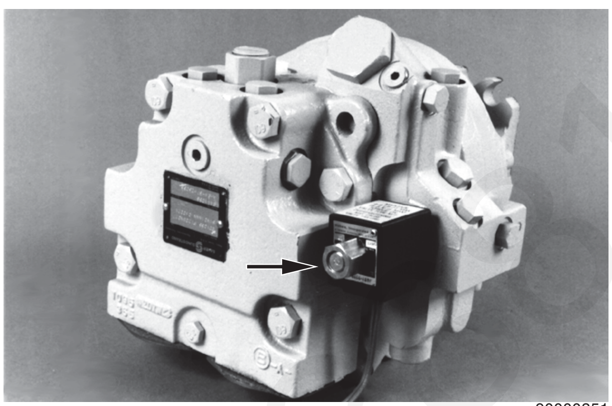


90000350

MV with Hydraulic 2-Position Control

Electric 2-Position Control

This control utilizes an electric solenoid operated three-way hydraulic valve to port system pressure to either of the motor displacement control pistons. The motor is normally held at its maximum displacement. Energizing the solenoid will cause the motor to go to its minimum displacement.



90000351

MV with Electric 2-Position Control

Technical Specifications

General Specifications

Design

Variable Pumps and Motors: Axial piston pump of variable displacement, cradle swashplate design.

Fixed Motors: Axial piston motor with fixed displacement, fixed swashplate design.

Type of Mounting (per SAE J744)

SAE flange, Size "B", 2 bolts,
SAE flange, Size "C and E", 4 bolts.

Cartridge flange, 2 bolts (for motor only).

Port Connections

(for details see chapter "Pressure Measurement")

Main pressure ports: SAE flange, Code 62,
Remaining ports: SAE straight thread O-ring boss.

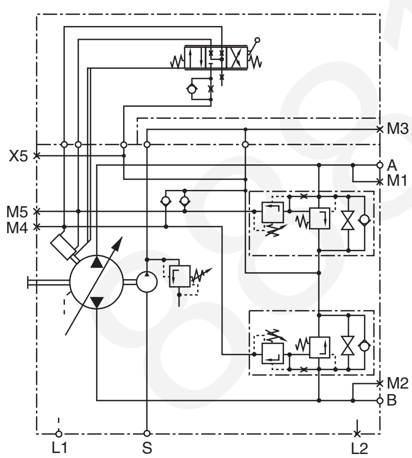
Direction of Rotation

Clockwise or counterclockwise (motors are bi-directional)

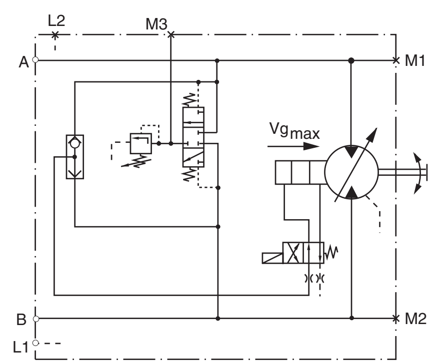
Recommended Installation Position

Pump installation recommended with control position on the top or side. Consult SAUER-SUNDSTRAND for non-conformance guidelines. The housing must always be filled with hydraulic fluid.

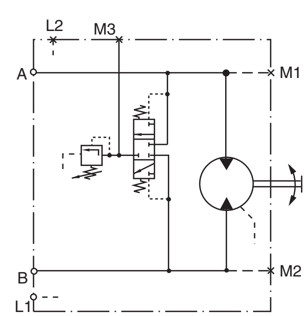
Circuit Diagrams



PV with Charge Pump and Manual Displacement Control



MV with Electrohydraulic 2-Position Control



MF

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90000813

Hydraulic Parameters

System Pressure Range	bar	psi
Rated Pressure	420	6000
Maximum Pressure	480	6960
		T002 252E

Temperature Range[1]			
	°C	[°F]	
Minimum	-40	[-40]	intermittent, cold start
Rated	104	[220]	
Maximum	115	[240]	intermittent
			T002 006E

[1] At the hottest point, normally the case drain port.

Charge Pump Inlet Vacuum (on pumps only)	bar abs	in Hg
Minimum Vacuum (continuous)	0.7	10
Minimum Vacuum during Cold Start (Intermittent)	0.2	25
		T002 253E

Viscosity			
	mm^2/s	[SUS]	
Minimum	7	[49]	intermittent
Recommended operating range	12-60	[70-278]	
Maximum	1600	[7500]	intermittent, cold start
			T002 010E

Case Pressure	bar	psi
Maximum (Continuous)	3	44
Maximum during Cold Start (Intermittent)	5	73
		T002 254E

Cleanliness Level and β_x-Ratio	
Required fluid cleanliness level	ISO 4406 Class 18/13
Recommended β_x-ratio for suction filtration	$\beta_{35\text{-}45}=75$ $(\beta_{10}\geq 2)$
Recommended β_x-ratio for charge pressure filtration	$\beta_{15\text{-}20}=75$ $(\beta_{10}\geq 10)$
Recommended inlet screen size for charge pressure filtration	100 µm-125 µm
	T002 007E

Hydraulic Fluid

Refer to SAUER-SUNDSTRAND BLN 9887 or SDF (Id No. 697581). Also refer to publication ATI-E 9101 for information relating to biogradable fluids.

Cleanliness

Refer to SAUER-SUNDSTRAND Publications BLN 9887 or SDF (NO. 697581) and ATI-E 9201.

Refer to Series 90 technical information for definitions.

Size Specific Data

Variable Displacement Pumps

	Dimension	030 PV	042 PV	055 PV	075 PV	100 PV	130 PV	180 PV	250 PV
Displacement (maximum)	cm^3 in^3	**30** 1.83	**42** 2.56	**55** 3.35	**75** 4.57	**100** 6.10	**130** 7.93	**180** 10.98	**250** 15.25
Minimum Speed	min^{-1} (rpm)	500	500	500	500	500	500	500	500
Rated Speed	min^{-1} (rpm)	4200	4200	3900	3600	3300	3100	2600	2300
Maximum Speed	min^{-1} (rpm)	4600	4600	4250	3950	3650	3400	2850	2500
Maximum attainable Speed at max. Displacement	min^{-1} (rpm)	5000	5000	4700	4300	4000	3700	3150	2750
Theoretical Torque at max. Displacement	Nm/bar lbf•in/1000 psi	**0.48** 290	**0.67** 380	**0.88** 530	**1.19** 730	**1.59** 870	**2.07** 1260	**2.87** 1750	**3.97** 2433
Weight (only base unit)	kg lb	**28** 62	**34** 75	**40** 88	**49** 108	**68** 150	**88** 195	**136** 300	**154** 340

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Fixed and Variable Displacement Motors

		Einheit	030 MF	042 MF	055 MF	075 MF	100 MF	130 MF	055 MV	075 MV
Displacement (maximum)		cm^3 in^3	**30** 1.83	**42** 2.56	**55** 3.35	**75** 4.57	**100** 6.10	**130** 7.93	**55** 3.35	**75** 4.57
Displacement (minimum)		cm^3 in^3	--	--	--	--	--	--	19	26
Rated speed	at maximum displacement	min^{-1} (rpm)	4200	4200	3900	3600	3300	3100	3900	3600
	at minimum displacement	min^{-1} (rpm)	--	--	--	--	--	--	4600	4250
Maximum speed	at maximum displacement	min^{-1} (rpm)	4600	4600	4250	3950	3650	3400	4250	3950
	at minimum displacement	min^{-1} (rpm)	--	--	--	--	--	--	5100	4700
Max. attainable speed at max. displacement		min^{-1} (rpm)	5000	5000	4700	4300	4000	3700	4700	4300
Theoretical torque at max. displacement		Nm/bar lbf•in/1000 psi	**0.48** 290	**0.67** 380	**0.88** 530	**1.19** 730	**1.59** 970	**2.07** 1260	**0.88** 530	**1.19** 730
Maximum flow ar max. displacement		l/min gal/min	**138** 36.5	**193** 51	**234** 62	**296** 78	**365** 96	**442** 117	**234** 62	**296** 78
Max. corner power		kW hp	**111** 149	**155** 208	**187** 251	**237** 318	**292** 392	**354** 475	224 300	282 378
Weight SAE-Flange		kg lb	**11** 24	**15** 34	**22** 49	**26** 57	**34** 74	**45** 99	**39** 86	**44** 98
Weight Cartridge Motor		kg lb	--	**21** 46	**26** 57	**33** 72	--	--	**40** 88	**46** 101

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Refer to Series 90 technical information for definitions.

Pressure Measurement

Required Tools

The service procedures described in this manual for Series 90 pumps and motors can be performed using common mechanic's tools. Special tools, if required are shown.

Pressure gauges should be calibrated frequently to ensure accuracy. Snubbers are recommended to protect pressure gauges.

Port Locations and Pressure Gauge Installation

The following sections list the ports for each type of hydraulic unit. The recommended pressure gauge and fitting are also specified.

Outline drawings showing port locations follow the tables below.

Variable Pump

Port	Function	Gauge Size and Fitting
M1	System Pressure Port "A"	1000 bar or 10 000 psi 9/16-18 O-ring
M2	System Pressure Port "B"	1000 bar or 10 000 psi 9/16-18 O-ring fitting
M3 (M6)	Charge Pressure	50 bar or 1000 psi 9/16-18 O-ring
M4 M5	Servo Pressure	50 bar or 1000 psi 9/16-18 O-ring

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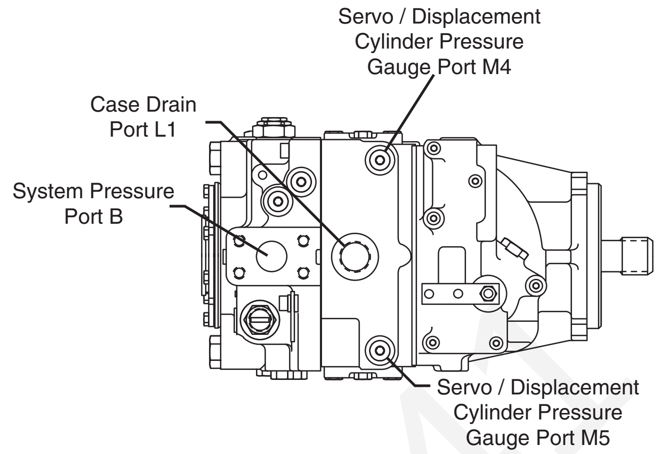
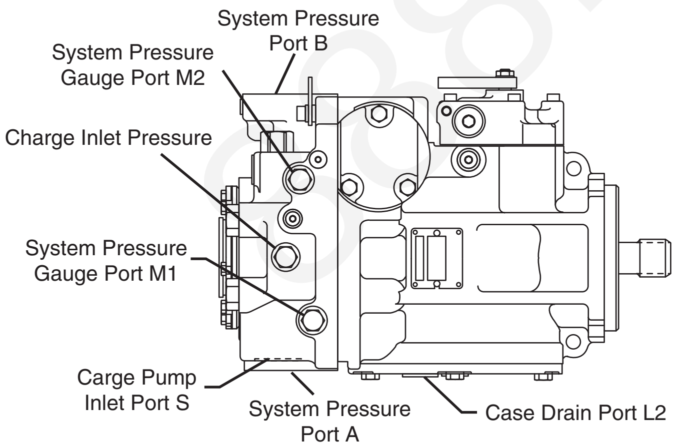
Port	Function	Gauge Size and Fitting	
L1 L2	Case Pressure	10 bar or 100 psi	
		030 042	7/8-14 O-ring
		055 075 100	1-1/16-12 O-ring
		130	1-5/16-12 O-ring
		180 250	1-5/8-12 O-ring
X1 X2	HDC / EDC Control Pressure	50 bar or 1000 psi 7/16-20 O-ring or 9/16-18 O-ring	
X3	External Control Pressure	50 bar or 1000 psi 9/16-18 O-ring	
S	Charge Pump Inlet	Vacuum Gauge, Tee into Inlet Line	
		030 042	1-1/16-12 O-ring
		055 075	1-5/16-12 O-ring
		100 130 180	1-5/8-12 O-ring
		250	1-1/2 SAE-Split Flange

T002 260E

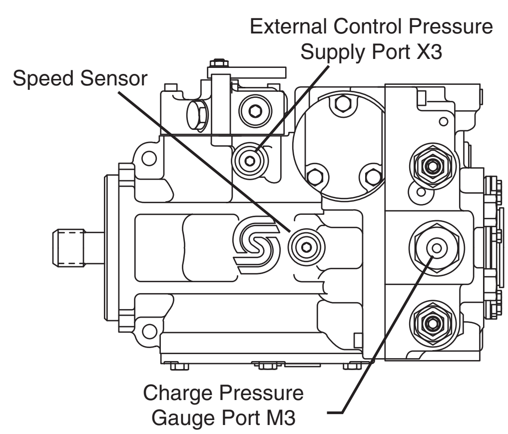


Top View

90000814E



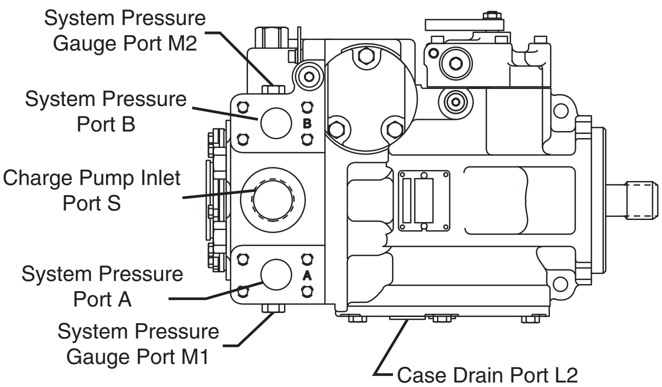
Left Side View



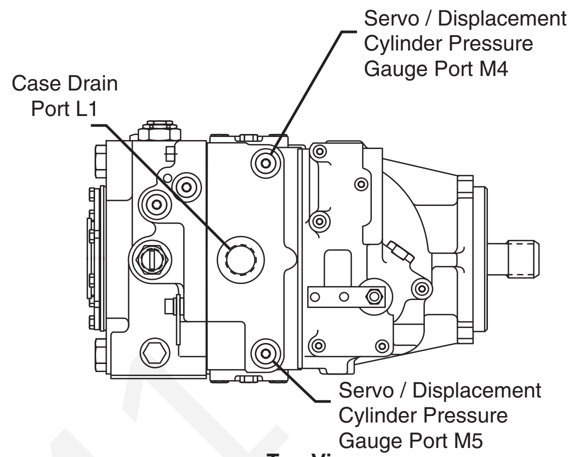
Right Side View

90000815E
90000816E

PV with Side Port End Cap and Manual Displacement Control



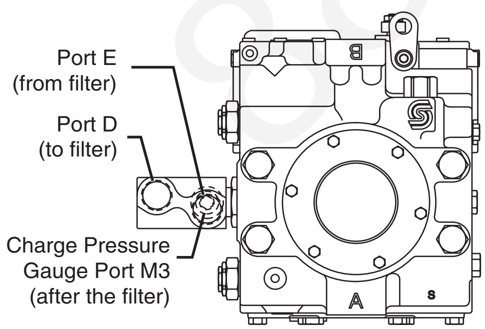
Left Side View



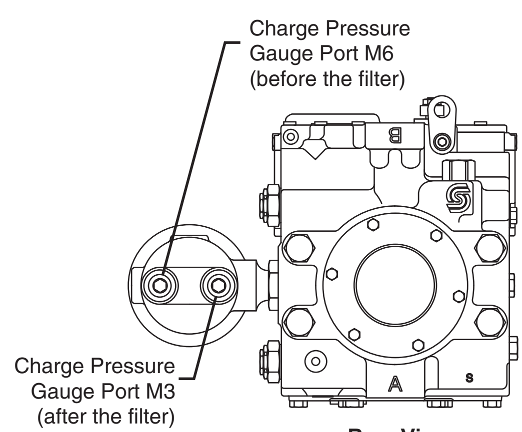
Top View

90000819E
90000820E

PV with Twin Port End Cap and Manual Displacement Control



Rear View



Rear View

90000817E
90000818E

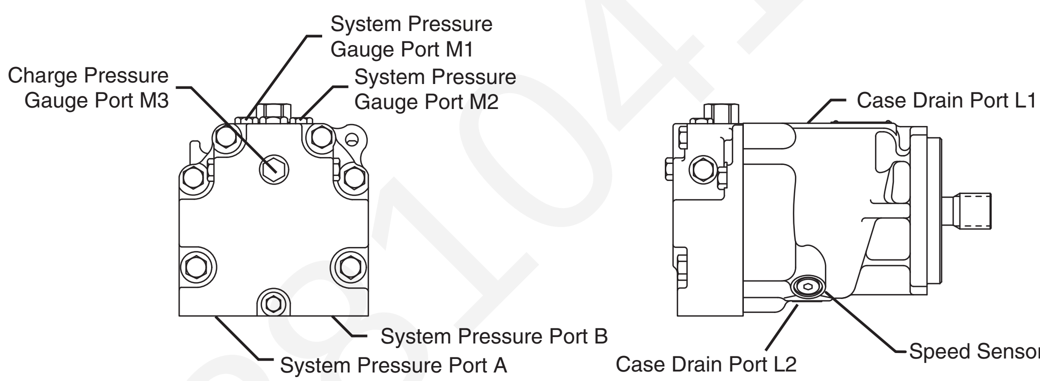
PV with Side Port End Cap and Remote Pressure Filtration

PV with Side Port End Cap and Integral Pressure Filtration

Fixed Motor

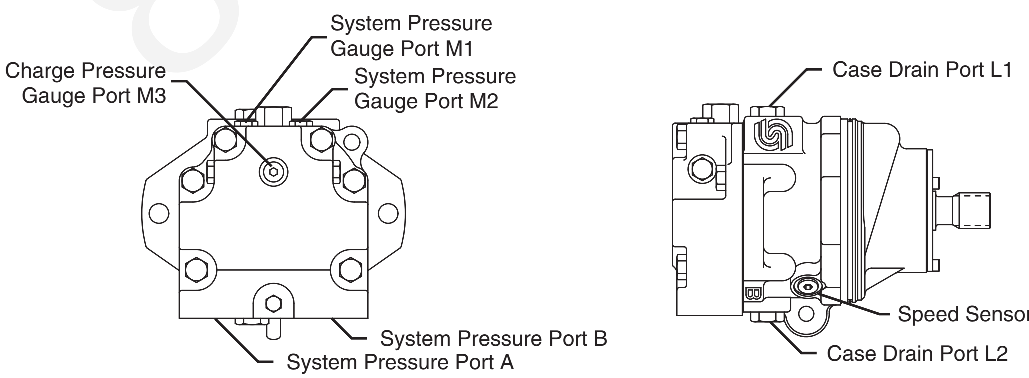
Port	Function	Gauge Size and Fitting
M1	System Pressure Port "A"	1000 bar or 10 000 psi 9/16-18 O-ring
M2	System Pressure Port "B"	1000 bar or 10 000 psi 9/16-18 O-ring
M3	Charge Pressure	50 bar or 1000 psi 9/16-18 O-ring
		T002 261E

Port	Function	Gauge Size and Fitting	
L1 **L2**	Case Pressure)	10 bar or 500 psi	
		030 042 055	7/8-14 O-ring
		075 100 130	1-1/16-12 O-ring
			T002 262E



Rear View **Left Side View**

MF with SAE Flange



Rear View **Left Side View**

90000821E

MF with Cartridge Flange

Variable Motor

Port	Function	Gauge Size and Fitting
M1	Systempressure Port "A"	1000 bar or 10 000 psi 9/16-18 O-ring
M2	Systempressure Port "B"	1000 bar or 10 000 psi 9/16-18 O-ring
M3	Charge Pressure	50 bar or 1000 psi 9/16-18 O-ring

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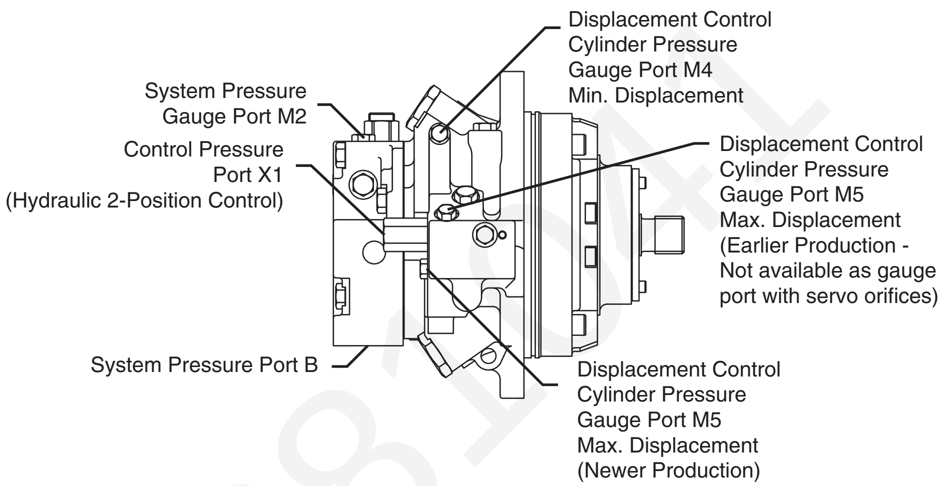
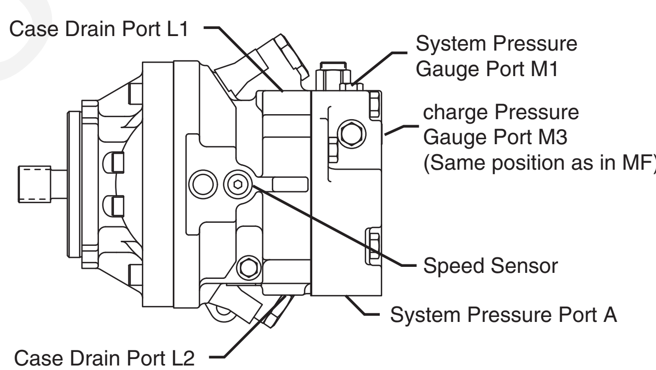
Port	Function	Gauge Size and Fitting
M4	Control Cylinbder Pressure "Minimum Displacement"	1000 bar or 10 000 psi 7/16-20 O-ring
M5	Control Cylinbder Pressure"Maximum Displacement"	1000 bar or 10 000 psi 7/16-20 O-ring
L1 **L2**	Case Pressure	10 bar or 500 psi 1-1/16-12 O-ring

T002 264E



Left Side View

MV with Cartridge Flange and Hydraulic 2-Position Control (SAE Flange Version Similar)



Right Side View

90000823E

MV with SAE Flange (Cartridge Flange Version Similar)

Initial Start-Up Procedure

The following start-up procedure should always be followed when starting-up a new Series 90 installation or when restarting an installation in which either the pump or motor had been removed.

> **WARNING**
> **The following procedure may require the vehicle/machine to be disabled (wheels raised off the ground, work function disconnected, etc.) while performing the procedure in order to prevent injury to the technician and bystanders. Take necessary safety precautions before moving the vehicle/machine.**
> S000007E

Prior to installing the pump and/or motor, inspect the units for damage incurred during shipping and handling. Make certain all system components (reservoir, hoses, valves, fittings, heat exchanger, etc.) are clean prior to filling with fluid.

Fill the reservoir with recommended hydraulic fluid. This fluid should be passed through a 10 micron (nominal, no bypass) filter prior to entering the reservoir. The use of contaminated fluid will cause damage to the components, which may result in unexpected vehicle/machine movement. See the publications BLN-9887 and SDF 697581 for further related information.

The inlet line leading from the reservoir to the pump must be filled prior to start-up. Check inlet line for properly tightened fittings and make sure it is free of restrictions and air leaks.

Be certain to fill the pump and/or motor housing with clean hydraulic fluid prior to start up.

Fill the housing by pouring filtered oil into the upper case drain port.

Install a 50 bar (or 1000 psi) pressure gauge in the charge pressure gauge port to monitor the charge pressure during start-up.

It is recommended that the external control input signal (linkage for MDC, hydraulic lines for HDC, or electrical connections for EDC) be disconnected at the pump control until after initial start-up. This will ensure that the pump remains in its neutral position.

> **WARNING**
> **Do not start prime mover unless pump is in neutral position (0° swashplate angle). Take precautions to prevent machine movement in case pump is actuated during initial start up.**
> S000008E

“Jog” or slowly rotate prime mover until charge pressure starts to rise. Start the prime mover and run at the lowest possible RPM until charge pressure has been established. Excess air may be bled from the high pressure lines through the high pressure system gauge port.

Once charge pressure has been established, increase speed to normal operating RPM. Charge pressure should be as indicated in the pump model code. If charge pressure is inadequate, shut down and determine cause for improper pressure. Refer to Troubleshooting.

> **WARNING**
> **Take necessary precautions that the motor shaft remains stationary during the adjustment procedure.**
> S000010E

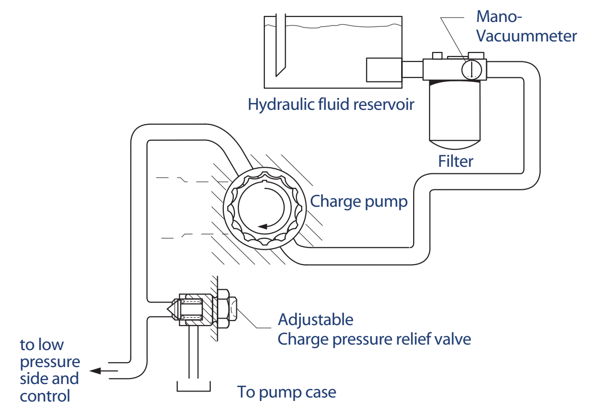
Shut down the prime mover and connect the external control input signal. Also reconnect the machine function if disconnected earlier. Start the prime mover, checking to be certain the pump remains in neutral. With the prime mover at normal operating speed, slowly check for forward and reverse machine operation.

Charge pressure may slightly decrease during forward or reverse operation. Continue to cycle slowly between forward and reverse for at least five minutes.

Shut down prime mover, remove gauges, and plug ports. Check reservoir level and add filtered fluid if needed.

The transmission is now ready for operation.

Fluid and Filter Maintenance



P000 797E

Suspension Filtration Schematic

To ensure optimum service life of Series 90 products, regular maintenance of the fluid and filter must be performed. Contaminated fluid is the main cause of unit failure. Care should be taken to maintain fluid cleanliness while performing any service procedure.

Check the reservoir daily for proper fluid level, the presence of water (noted by a cloudy to milky appearance, or free water in bottom of reservoir), and rancid fluid odor (indicating excessive heat). If either of these conditions occur, change the fluid and filter immediately.

It is recommended that the fluid and filter be changed per the vehicle/machine manufacturer's recommendations or at the following intervals:

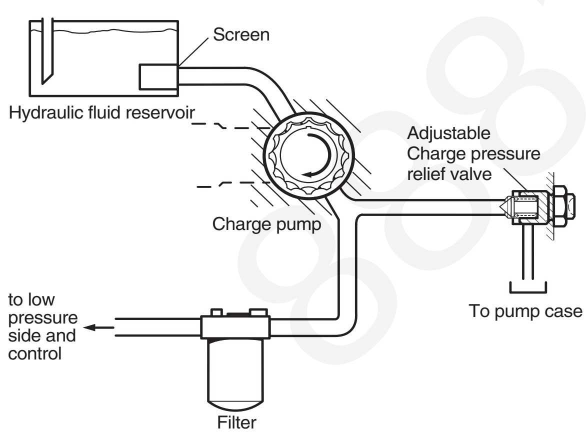
First change

500 operating hours after start up

second and subsequent changes

every **2000** operating hours or once a year.

This recommendation applies for the most applications. High temperatures and pressures will result in accelerated fluid aging and an earlier fluid change may be required. At lower fluid loads longer change intervalls are possible. Therefore we suggest to check the fluid with the manufacturer for suitability. This should be done at latest half way between fluid changes.



P000 798E

Charge Pressure Filtration Schematic
(Partial flow)

It may be necessary to change the fluid more frequently than the above intervals if the fluid becomes contaminated with foreign matter (dirt, water, grease, etc.) or if the fluid has been subjected to temperature levels greater than the recommended maximum. Never reuse fluid.

The filter should be changed whenever the fluid is changed or whenever the filter indicator shows that it is necessary to change the filter.

Cleanliness Level and β_x-Ratio	
Required fluid cleanliness level	ISO 4406 Class 18/13
Recommended β_x-ratio for suction filtration	$\beta_{35\text{-}45}=75$ $(\beta_{10}\geq 2)$
Recommended β_x-ratio for charge pressure filtration	$\beta_{15\text{-}20}=75$ $(\beta_{10}\geq 10)$
Recommended inlet screen size for charge pressure filtration	100 µm-125 µm

T002 007E

Troubleshooting

This section provides general steps to follow if certain undesirable system conditions are observed. Follow the steps in a section until the problem is solved. Some of the items will be system specific. For areas covered in this manual, a section is referenced. **Always observe the safety precautions listed in the section "Introduction" and related to your specific equipment.**

"NEUTRAL" Difficult or Impossible to Find

Check	Description	Action
1. Input to pump control.	Input to control module is operating improperly.	Check control input and repair or replace as necessary.
2. Pump displacement control.	Control linkages are not secure, control orifices are blocked, etc.	Adjust, repair, or replace control module as necessary.

If the above actions do not remedy the problem
contact a SAUER-SUNDSTRAND Authorized Service Center.

System Operating Hot

Check	Description	Action
1. Oil level in reservoir.	Insufficient hydraulic fluid will not meet cooling demands of system.	Fill reservoir to proper level.
2. Heat exchanger.	Heat exchanger not sufficiently cooling the system.	Check air flow and input air temperature for heat exchanger. Clean, repair or replace heat exchanger.
3. Charge pressure.	Low charge pressure will overwork system.	Measure charge pressure. Inspect and adjust or replace charge relief valve. Or repair leaky charge pump.
4. Charge pump inlet vacuum.	High inlet vacuum will overwork system. A dirty filter will increase the inlet vacuum. Inadequate line size will restrict flow.	Check charge inlet vacuum. If high, inspect inlet filter and replace as necessary. Check for adequate line size, length or other restrictions.
5. System relief pressure settings.	If the system relief settings are too low, the relief valves will be overworked.	Verify settings of pressure limiters and high pressure relief valves and adjust or replace multi-function valves as necessary.
6. For internal leakage in motor.	Leakage will reduce low side system pressure and overwork the system.	Monitor motor case flow without loop flushing in the circuit (use defeat spool). If flow is excessive, replace motor.
7. System pressure.	High system pressure will overheat system.	Measure system pressure. If pressure is high reduce loads.

If the above actions do not remedy the problem
contact a SAUER-SUNDSTRAND Authorized Service Center.

Transmission Operates Normally in One Direction Only

Check	Description	Action
1. Input to pump control.	Input to control module is operating improperly.	Check control input and repair or replace as necessary.
2. Pump displacement control.	Control linkages are not secure, control orifices are blocked, etc.	Repair or replace control module as necessary.
3. Interchange system pressure limiters, high pressure relief valves, and system check valves.	Interchanging the multi-function valves will show if the problem is related to the valve functions contained in the multi-function valves.	Interchange multi-function valves. If the problem changes direction, repair or replace the valve on the side that does not operate.
4. Charge pressure.	If charge pressure decays in one direction the loop flushing valve may be “sticking” in one direction.	Measure charge pressure in forward and reverse. If pressure decays in one direction, inspect and repair the motor loop flushing valve.

If the above actions do not remedy the problem
contact a SAUER-SUNDSTRAND Authorized Service Center.

System Will Not Operate in Either Direction

Check	Description	Action
1. Oil level in reservoir.	Insufficient hydraulic fluid to supply system loop.	Fill reservoir to proper level.
2. Input to pump control.	Input to control module is operating improperly.	Check control input and repair or replace as necessary.
3. Pump displacement control.	Control linkages are not secure, control orifices are blocked, etc.	Repair or replace control module as necessary.
4. Ensure bypass valve(s) are closed.	If bypass valve(s) is open, the system loop will be depressurized.	Close bypass valves. Replace multi-function valve if defective.
5. Charge pressure with pump in neutral.	Low charge pressure insufficient to recharge system loop.	Measure charge pressure with the pump in neutral. If pressure is low, go to step 6; otherwise continue with step 5.
6. Charge pressure with pump in stroke.	Low charge pressure with the pump in stroke indicates a motor charge relief valve or system pressure relief valve may be improperly set.	Measure charge pressure with pump in stroke. If pressure is low, adjust or replace motor charge relief valve, otherwise go to step 9.
7. Pump charge relief valve.	A pump charge relief valve that is leaky or set too low will depressurize the system.	Adjust or replace pump charge relief valve as necessary.
8. Charge pump inlet filter.	A clogged filter will undersupply system loop.	Inspect filter and replace if necessary.
9. Charge pump.	A malfunctioning charge pump will provide insufficient charge flow.	Repair or replace the charge pump. If OK go to last step.

10. Pump displacement control.	Control linkages are not secure, control orifices are blocked, etc.	Repair or replace control module as necessary.
11. System pressure.	Low system pressure will not provide power necessary to move load.	Measure system pressure. Continue with next step.
12. System multi-function valves.	Defective multi-function valves will cause system pressure to be low.	Repair or replace multi-function valve(s).

If the above actions do not remedy the problem
contact a SAUER-SUNDSTRAND Authorized Service Center.

Low Motor Output Torque

Check	Description	Action
1. System pressure at motor.	Low system pressure at the motor will reduce torque.	Measure system pressure at motor. If pressure limiter setting is low, increase setting.
2. Variable motor stuck at minimum displacement.	Minimum motor displacement yields low output torque.	Check control supply pressure or repair displacement control. Check motor control orifices.
3. For internal leakage.	Internal leakage will reduce system pressure.	Check for leakage in O-rings, gaskets, and other fittings. Repair unit as required, or replace leaky unit.

If the above actions do not remedy the problem
contact a SAUER-SUNDSTRAND Authorized Service Center.

Improper Motor Output Speed

Check	Description	Action
1. Oil level in reservoir.	Insufficient hydraulic fluid will reduce motor speed.	Fill oil to proper level.
2. Pump output flow.	Incorrect outflow will affect output speed. Incorrect output flow indicates the swashplate is out of position.	Measure pump output and check for proper pump speed and see that the pump is in full stroke.
3. Variable motor displacement control.	If variable motor displacement control is not functioning correctly, variable motor swashplate may be in wrong position.	See if variable motor displacement control is responding. If not, repair or replace control.
4. For internal leakage.	Internal leakage will reduce system pressure.	Check for leakage in O-rings, gaskets, and other fittings. Repair unit as required, or replace leaky unit.

If the above actions do not remedy the problem
contact a SAUER-SUNDSTRAND Authorized Service Center.

Excessive Noise and/or Vibration

Check	Description	Action
1. Oil in reservoir.	Insufficient hydraulic fluid will lead to cavitation.	Fill reservoir to proper level.
2. Air in system.	Air bubbles will lead to cavitation.	Look for foam in reservoir. Check for leaks on inlet side of system loop. Afterwards, let reservoir settle until bubbles are gone. Run system at low speed to move system fluid to reservoir. Repeat.
3. Pump inlet vacuum.	High inlet vacuum will create noise. A dirty filter will increase the inlet vacuum.	Inspect and replace filter as necessary. Check for proper suction line size.
4. Shaft couplings.	A loose shaft coupling will cause excessive noise.	Replace loose shaft coupling in charge pump or replace pump or motor.
5. Shaft alignment.	Unaligned shafts will create excessive frictional noise.	Align shafts.

If the above actions do not remedy the problem
contact a SAUER-SUNDSTRAND Authorized Service Center.

System Response is Sluggish

Check	Description	Action
1. Oil level in reservoir.	Insufficient hydraulic fluid will reduce output pressure.	Fill reservoir to proper level.
2. Multi-function valves' pressure settings.	Incorrect pressure settings will affect system reaction time.	Adjust or replace multi-function valves.
3. Pump inlet vacuum.	High pump inlet vacuum will reduce system pressure.	Measure charge inlet vacuum. If high replace inlet filter.
4. Prime mover speed.	Low engine speed will reduce system performance.	Adjust engine speed.
5. Charge and control pressures.	Incorrect charge or control pressures will affect system performance.	Measure charge and control pressures and correct if necessary.
6. System internal leakage.	Internal leakage will reduce system pressure.	Check for leakage in O-rings, gaskets, and other fittings.

If the above actions do not remedy the problem
contact a SAUER-SUNDSTRAND Authorized Service Center.

Inspections and Adjustments

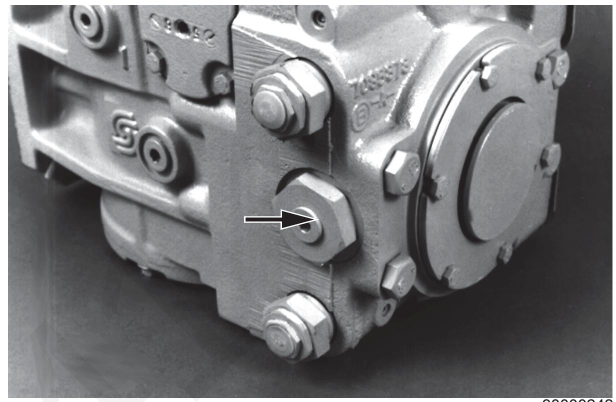
This section offers instruction on how to perform inspections and adjustments on pump and motor components. Read through the entire related section before beginning a service activity. Refer to the corresponding section for location of gauge ports and suggested gauge size.

Pump Adjustments

Charge Pressure Relief Valve Adjustment

The following procedure explains how to check and adjust the charge pressure relief valve.

> **WARNING**
> **The following procedure may require the vehicle/machine to be disabled (wheels raised off the ground, work function disconnected, etc.) while performing the procedure in order to prevent injury to the technician and bystanders. Take necessary safety precautions before moving the vehicle/machine.**
> S000007E



90000243

Charge Pressure Gauge Port (Reducer fitting shown - if filtration device attached)

1. To measure pump charge pressure, install a pressure gauge in the pump charge pressure gauge port (M3). Also install a gauge to measure case pressure (tee into L1 or L2 or use servo gauge port). Operate the system with the pump in “neutral” (zero displacement) when measuring pump charge pressure.

2. The table shows the acceptable pump charge pressure range for some nominal charge relief valve settings (see sample model code at right). These pressures assume 1500 pump rpm and a reservoir temperature of 50°C (120°F), and are referenced to case pressure (see footnote on next page). Smaller displacement charge pumps will produce charge pressure readings in the lower portion of the range, while larger displacement charge pumps will produce readings in the higher portion of the range.

90L055 EA 1 N
6 S 3 C6 C 03
HNN 35 35 **24**

Nominal Charge Pressure

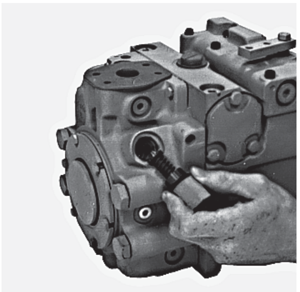
Model Code on Unit Name Plate (“24 bar”)

Model Code	Measured Charge Pressure *
20	18.1 bis 21.7 bar (262 to 315 psi)
24	22.0 bis 26.9 bar (319 to 390 psi)
28	25.8 bis 30.7 bar (374 to 445 psi)
	T002 266E

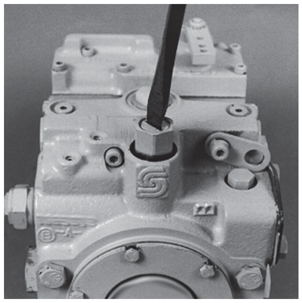
* This is the actual charge pressure port gauge reading minus the case pressure port gauge reading.

Note: These pressures assume a pump speed of 1450 - 1500 rpm. At higher pump input speeds (with higher charge flows) the charge pressure will rise over the rated setting.

* This is the actual charge pressure port gauge reading minus the case pressure port gauge reading.



90000262
Shim Adjustable Charge Pressure Relief Valve (Pump)



90000264
Screw Adjustable Charge Pressure Relief Valve (Pump)

3. Earlier production Series 90 pumps are equipped with a shim adjustable charge pressure relief valve. Shim kits are available from SAUER-SUNDSTRAND. Adjustment of charge pressure is accomplished by removing the plug [1 inch Hex] and changing the shim thickness behind the spring. The plug for this type of charge relief valve should be torqued to 68 Nm (50 lbf•ft).

   Later production Series 90 pumps are equipped with an external screw adjustable charge pressure relief valve. Adjustment of the charge pressure is accomplished by loosening the lock nut -

Frame Size	Wrench Size
030 - 100	1-1/16 inch
130 - 250	1-5/8 inch
	T002 267E

   and turning the adjustment plug with a large screwdriver or a 1/2 inch hex wrench.

   Clockwise rotation of the plug increases the setting, and counterclockwise rotation decreases the setting (at a rate of approximately 3.9 bar (50 psi) per turn). The lock nut for this type of charge relief valve should be torqued to 52 Nm (39 lbf•ft).

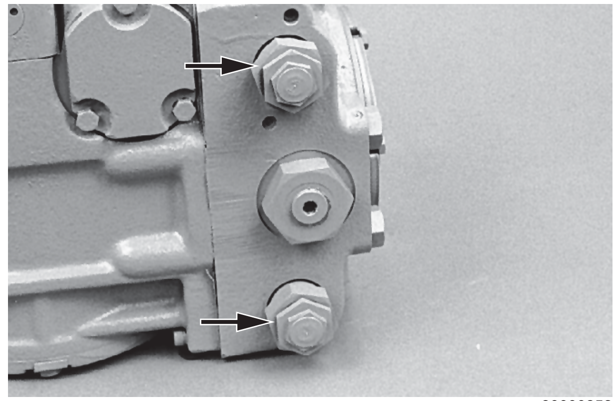
4. Once the desired charge pressure setting is achieved, remove the gauges.

Multi-Function Valve Pressure Adjustment

Adjustment of the pressure limiter setting and the high pressure relief valve setting is accomplished simultaneously. The latter is automatically set approximately 35 bar (500 psi) above the former.

In order to adjust the pressure limiter setting, the motor output shaft must be locked so it does not rotate. This may be accomplished by locking the vehicle's brakes or rigidly fixing the work function so it cannot rotate.

WARNING
Take necessary precautions that the motor shaft remains stationary during the adjustment procedure.
S000010E



90000258

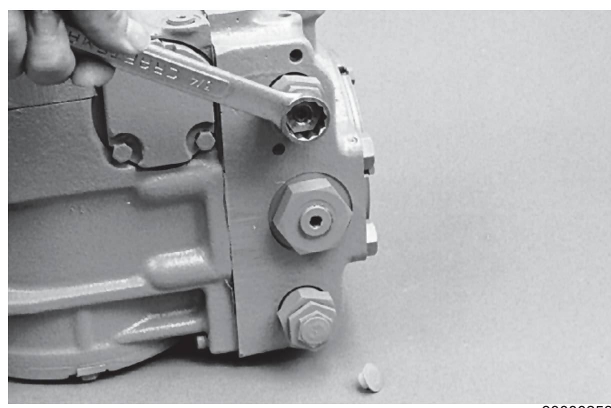
Multi-Function Valves on PV

1. Install two 1000 bar (or 10 000 psi) pressure gauges in the high pressure gauge ports (M1 and M2). Install a 50 bar (or 1000 psi) pressure gauge in the pump charge pressure gauge port (M3).

2. Start the prime mover and operate at normal speed.

3. Loosen locking nut.

Frame Size	Wrench Size
early 042 - 100	10 mm
newer 030 - 100	19 mm
early 130	13 mm
130 - 250	24 mm
	T002 268E



90000259

Loosen Pressure Adjusting Screw Lock Nut

4. Insert a internal hex wrench into the pressure adjusting screw.

Frame Size	Internal Hex Wrench Size
early 042 - 100	3 mm
newer 030 - 100	5 mm
early 130	4 mm
130 - 250	8 mm
	T002 269E

Note: A plastic dust plug is installed in the adjusting screw on 030 and late 042 through 250 units.

90L055 EA 1 N
6 S 3 C6 C 03
HNN **35** **35** 24

Pressure Limiter Setting
Ports A and B (differential
pressure in 10s of bars,
e.g. "35" = 350 bar)

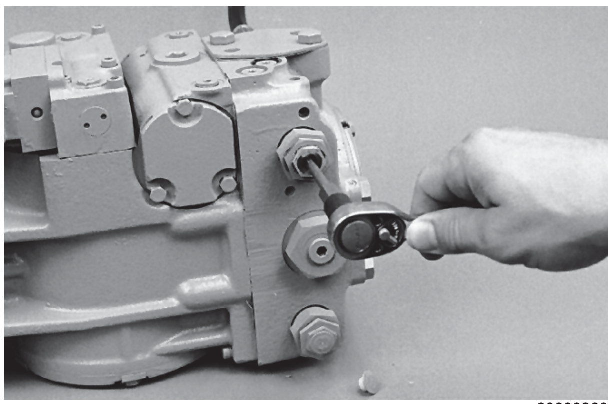
5. The factory preset pressure limiter setting is shown on the model code as at right. It is referenced to charge pressure, so the pressure limiter setting is the difference between the high and low pressure sides of the system loop. Activate or move the control input so that pressure increases in the high pressure side of the closed circuit to the pressure limiter pressure setting. The pressure limiter setting is reached when the pressure stops increasing and remains steady at a given pressure level (as shown on the gauges).

6. Return the pump to its "neutral" (zero flow) position and adjust the pressure limiter setting by rotating the pressure adjusting screw with the internal hex wrench.

   Clockwise rotation of the pressure adjustment screw will increase the pressure setting, and counterclockwise rotation will decrease the pressure setting. Each complete rotation of the pressure adjusting screw changes the pressure as shown in the following table.

Frame Size	Approx Change per Rev of the Adjusting Screw
early 042 - 100	80 bar (1157 psi) per Rev
newer 030 - 100	90 bar (1300 psi) per Rev
130 - 250	80 bar (1157 psi) per Rev

T002 270E



90000260

Rotate Pressure Adjusting Screw

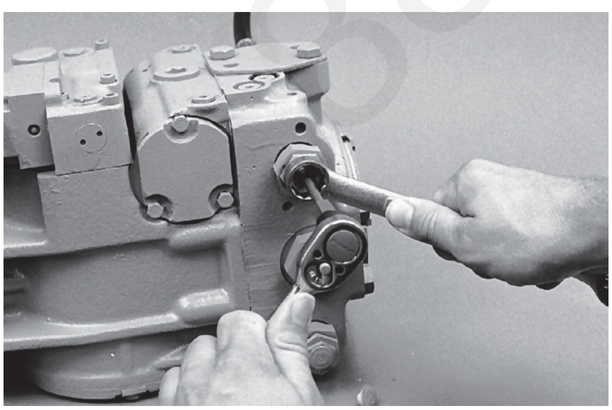
7. To verify the actual pressure setting, actuate or move the control input so that the pump again develops pressure in the high pressure circuit to the newly adjusted pressure limiter pressure setting, and read the high pressure gauge. Then allow the pump to return to its "neutral" position. The pressure in the high pressure circuit should return to the charge pressure setting.

8. While holding the pressure adjusting screw stationary, tighten the pressure adjusting screw lock.

Frame Size	Torque
early 042 - 100	3 Nm (26 lbf•in)
newer 030 - 100	20 Nm (15 lbf•ft)
130 - 250	40 Nm (30 lbf•ft)

T002 271E

Do not overtorque.



90000261

Tighten Lock Nut

9. Shut down the prime mover, remove the gauges and install the gauge port plugs. Replace the plastic dust plugs (if used).

The same procedure is used for setting the pressure limit of the other multi-function valve, but the control input signal must be activated or moved in the opposite direction so that high pressure develops in the opposite side of the closed circuit.

Engaging the Bypass Function

The bypass function is performed by the multi-function valve cartridges. The prime mover should be shut down when opening or closing the bypass valves.

The bypass valves on both of the multi-function valves must be opened to engaged the bypass function.

1. Using a

Frame Size	Wrench Size
newer 030 - 100	1-1/16 inch
130 - 250	1-3/8 inch
	T002 272E

   wrench on the middle sized hex of the multi-function valve cartridge, and a

Frame Size	Wrench Size
newer 030 - 100	1-1/4 inch
130 - 250	1-5/8 inch
	T002 273E

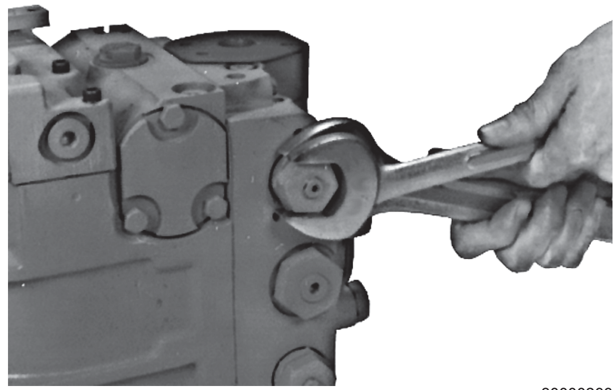
   wrench on the large hex to prevent rotation of the cartridge assembly, rotate the middle hex three revolutions counterclockwise to open the bypass valve. **Do not rotate more than 3-1/2 revolutions, as additional rotation will permit external leakage.**

2. For units with an MDC-type control, prior to moving the vehicle or otherwise causing the motor shaft to turn, move the control handle of the manual displacement control on the pump to the maximum full forward position. Hold the handle in this position during bypass valve operation.

> **Caution**
> **"Tow" at extremely low speeds and for short distances only.**
> S000011E

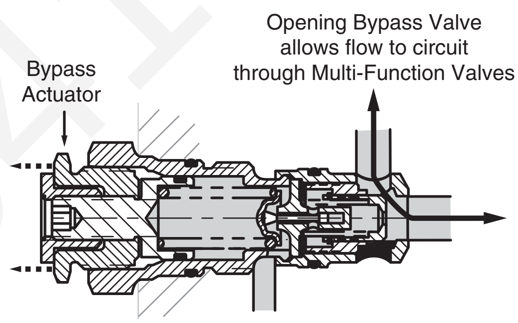
3. To close the bypass valve, rotate the middle hex clockwise until it is seated. Then torque the middle hex.

Frame Size	Torque
newer 030 - 100	41 Nm (30 lbf•ft)
130 - 250	100 Nm (75 lbf•ft)
	T002 274E



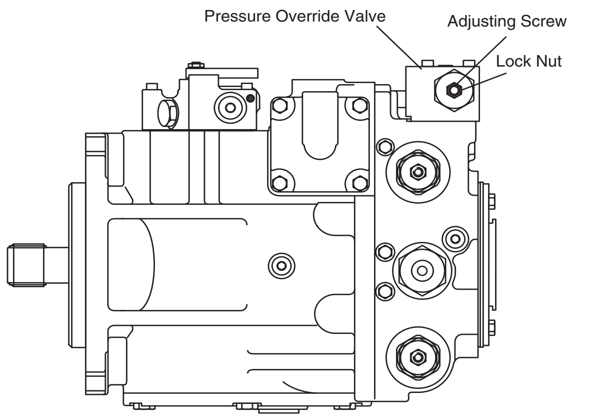
90000266

Loosening and Rotating Bypass Hex on Multi-Function Valve



90000827E

Multi-Function Valve with Bypass Function Engaged



Right Side View

90000828E

Pressure Override Valve for 180 Frame Size

Pressure Override (POR) Valve Pressure Adjustment (Option for 180 Frame Size)

The Pressure Override Valve is explained in the corresponding section.

1. Install two 1000 bar (or 10 000 psi) pressure gauges in the high pressure gauge ports (M1 and M2). Install a 50 bar (or 1000 psi) pressure gauge in the pump charge pressure gauge port (M3).

2. Start the prime mover and operate at normal speed.

3. With the pump operating at approximately 20% displacement, load the work function and note the pressure as the POR valve operates (pump displacement reduces to “zero”).

4. Adjustment of the pressure override setting is made by loosening the lock nut with a 9/16 inch hex wrench and turning the adjustment screw with a 3/16 inch internal hex wrench. The POR setting should be at least 50 bar (750 psi) below the high pressure relief valve setting of the multi-function valves for proper operation.

5. Following the adjustment, torque the lock nut to 43 Nm (32 lbf•ft).

6. Shut down the prime mover and remove the gauges and install the gauge port plugs.

Displacement Limiter Adjustment

The maximum displacement can be limited in either direction.

1. Loosen the seal lock nut retaining the displacement limiter adjusting screw.

Frame Size	Wrench Size
030 - 100	13 mm
130	17 mm
180 - 250	19 mm
	T002 275E

2. Rotate the adjusting screw.

Frame Size	Internal Hex Wrench Size
030 - 100	4 mm
130	5 mm
180 - 250	6 mm
	T002 276E

Rotating the adjusting screw clockwise will decrease the maximum displacement of the pump while rotating the adjusting screw counterclockwise will increase the maximum displacement.

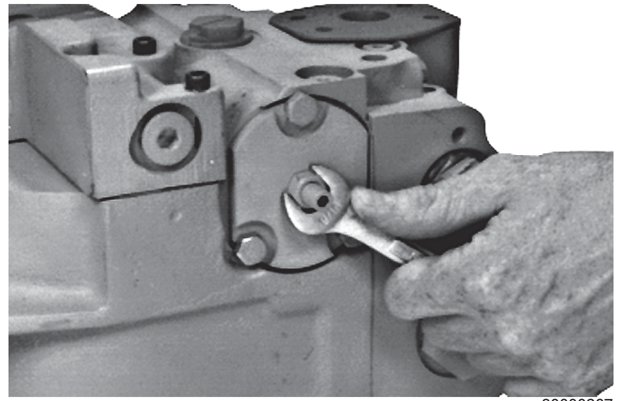
Caution
Care should be taken in adjusting displacement limiters to avoid undesirable flow or speed conditions. The seal lock nut must be retorqued after every adjustment to prevent an unexpected change in operating conditions and to prevent external leakage during unit operation.
S000012E

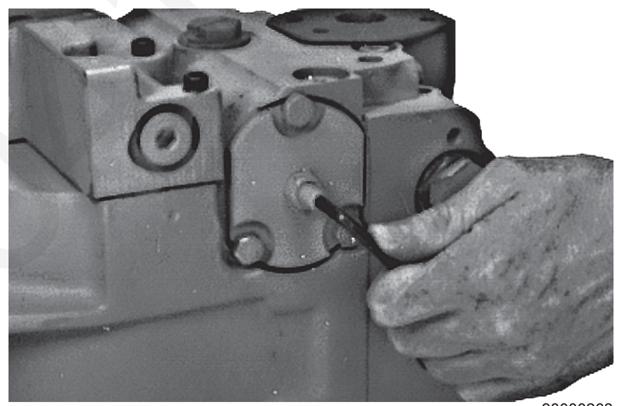
3. After establishing the desired maximum displacement setting, tighten the lock nut on the adjusting screw as follows.

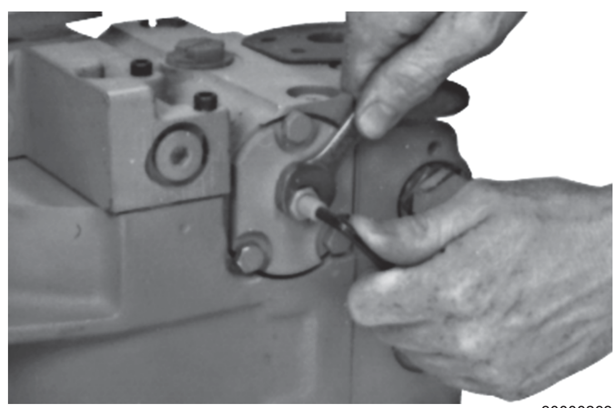
Frame Size	Torque
030 - 100	24 Nm (18 lbf•ft)
130	48 Nm (35 lbf•ft)
180 - 250	125 Nm (92 lbf•ft)
	T002 278E

4. One turn of the adjusting screw will change the maximum displacement approximately as follows.

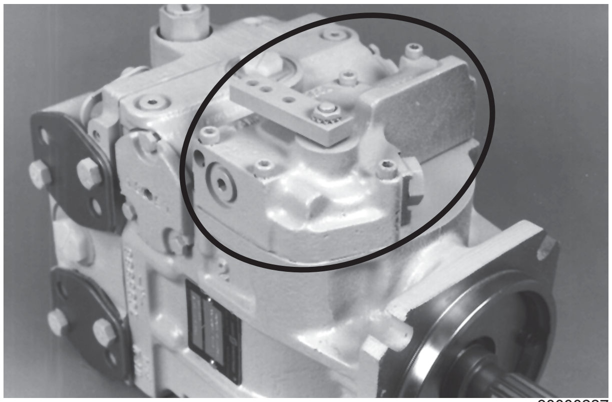
Frame Size	Approx Change in Disp per Rev of Adjusting Screw
030	2.8 cm^3 / Rev (0.17 in^3 / Rev)
042	3.5 cm^3 / Rev (0.21 in^3 / Rev)
055	4.2 cm^3 / Rev (0.26 in^3 / Rev)
075	5.1 cm^3 / Rev (0.31 in^3 / Rev)
100	6.2 cm^3 / Rev (0.38 in^3 / Rev)
130	8.8 cm^3 / Rev (0.53 in^3 / Rev)
180	12.5 cm^3 / Rev (0.76 in^3 / Rev)
250	17.3 cm^3 / Rev (1.06 in^3 / Rev)
	T002 277E


90000267
Loosen Displacement Limiter Lock Nut


90000268
Rotate Adjusting Screw


90000269
Tighten Lock Nut

Pump Control Adjustments



90000237

Variable Displacement Pump with Standard Manual Displacement Control

Standard Manual Displacement Control (MDC) Adjustment

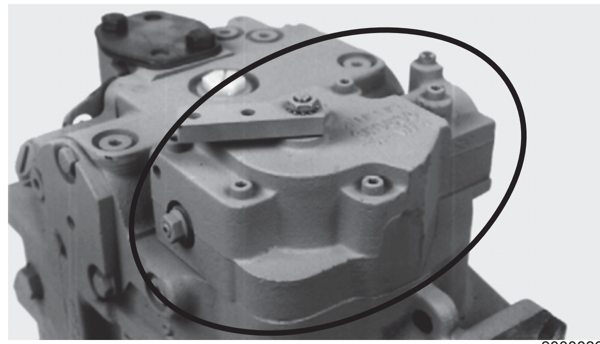
There are no adjustable elements in the manual displacement control. The control spool is held in its “neutral” position by centering springs and washers on each end of the spool. Since there is no centering spring on the control input shaft, the shaft will automatically assume the appropriate position when the control is installed on the pump.

Non-Linear Manual Displacement Control (MDC)

A centering spring, located on the control input shaft, locates the control shaft in its “neutral” position. A bias spring on the control spool maintains a force on the spool and the control linkage to eliminate looseness (“free-play”) in the linkage.

The “neutral” adjustment is the only adjustment that can be made on the nonlinear manual displacement control. All other functions are preset at the factory.

This adjustment must be made on a test stand or on the vehicle/machine with the prime mover operating.



90000829
Variable Displacement Pump with Non-Linear Manual Displacement Control

> **WARNING**
> **The following procedure may require the vehicle/machine to be disabled (wheels raised off the ground, work function disconnected, etc.) while performing the procedure in order to prevent injury to the technician and bystanders. Take necessary safety precautions before moving the vehicle/machine.**
> S000007E

1. Install two 50 bar (or 1000 psi) gauges in each of the displacement control cylinder gauge ports (M4 and M5). Disconnect the external control linkage from the control handle and make certain the control shaft is in its “neutral” position. Start the prime mover and operate at normal speed.

2. Loosen the lock nut on the neutral adjusting screw with a 13 mm hex wrench.

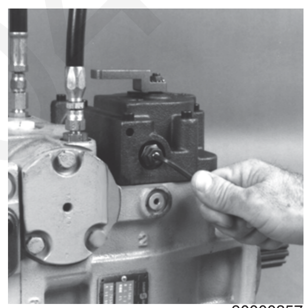
3. Using a 4 mm internal hex wrench, rotate the neutral adjusting screw clockwise until the pressure increases on one of the pressure gauges. Note the angular position of the wrench.

4. Rotate the adjusting screw counterclockwise until the pressure increases by an equal amount on the other gauge. Note the angular position of the wrench.

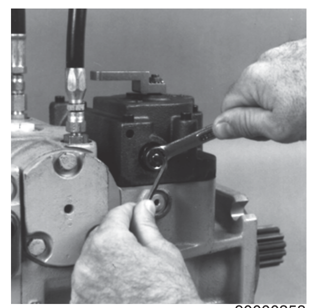
5. Rotate the adjusting screw clockwise half the distance between the locations noted above. The gauges should read the same pressure (case pressure), indicating that the control is in its “neutral” position.

6. Hold the adjusting screw stationary and tighten the lock nut to 13.5 Nm (10 lbf•ft). **Do not overtorque the nut.**

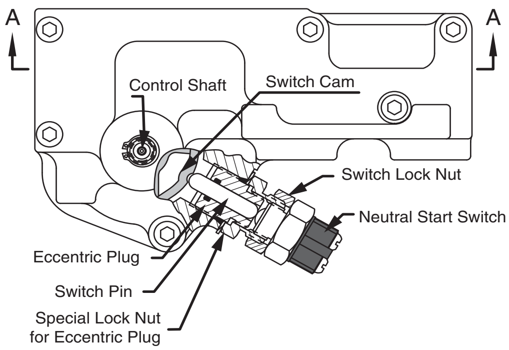
7. Once the neutral position is set, stop the prime mover, remove the gauges, and install the gauge port plugs. Reconnect the external control linkage.



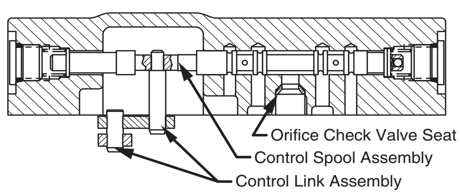
90000357
Rotate Neutral Adjusting Screw



90000358
Tighten Neutral Adjusting Screw Lock Nut



MDC with Neutral Start switch



View at Section A-A

90000830E

Components of the Standard Manual Displacement Control with Neutral Start Switch

MDC Neutral Start Switch (NSS) Adjustments

The neutral start switch (NSS) provides a means to prevent the system prime mover from starting while the pump control handle and control input shaft are in a position which would command the pump to go "in-stroke" in either the "forward" or "reverse" direction.

When the control input shaft is in its "neutral" position, the inner end of the switch pin moves into a slot on the eccentric cam attached to the control shaft. This allows the spring loaded NSS to close, completing the electrical starting circuit for the prime mover.

When the control input shaft is NOT in its "neutral" position, the eccentric cam moves the switch pin out of the slot. This forces the NSS to open, breaking the electrical starting circuit for the prime mover.

The neutral start switch is threaded into the special lock nut for the eccentric plug.

Turning the NSS clockwise (CW) into the special nut will move the NSS closer to the switch cam on the control shaft, and will narrow the NSS deadband. Turning the NSS counterclockwise (CCW) out of the special nut will move the NSS farther from the switch cam on the control shaft, and will widen the NSS deadband.

The switch pin is located in an eccentric plug which is turned to move the center of the NSS deadband.

(continued)

The NSS must be adjusted to meet the following three requirements:

i. The distance the control handle can be turned without opening the NSS is called the “NSS Deadband.” The distance the control handle can be moved without moving the control spool enough to port hydraulic fluid to the pump displacement control cylinders is called the “Control Deadband.” These deadbands **must** be centered in relation to each other.

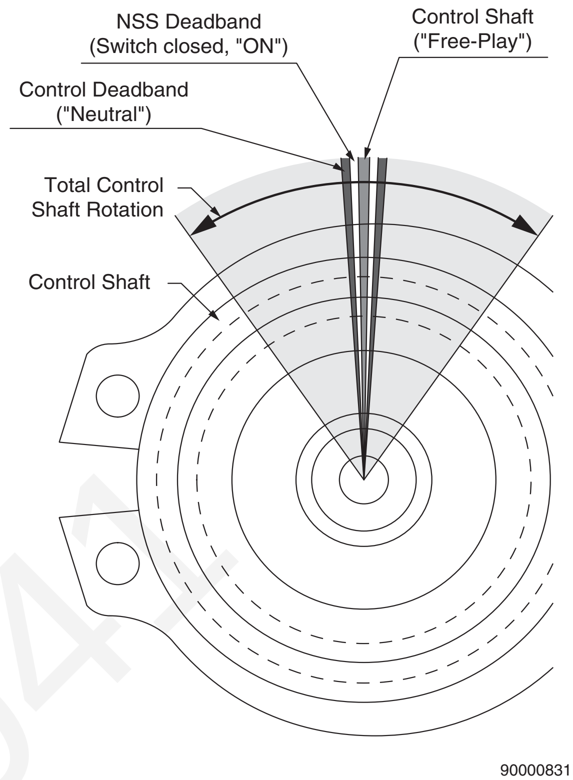
   Since the position of the control deadband cannot be adjusted, the position of the NSS deadband must be adjusted to match it.

ii. The NSS deadband must be wide enough so the NSS **will not** open within the loose area of control handle movement caused by normal operating clearances in the control linkage (control shaft “free-play”).

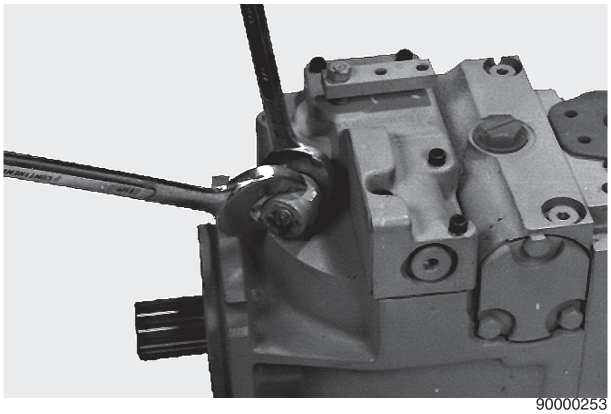
   By setting the NSS to open outside this area, the control spool springs or control shaft centering spring can always act to return the handle to “neutral” and re-close the NSS.

iii. The NSS deadband must be narrow enough so the NSS **will** open before the unit builds 7 bar (100 psi) differential system pressure in either direction.

(continued)

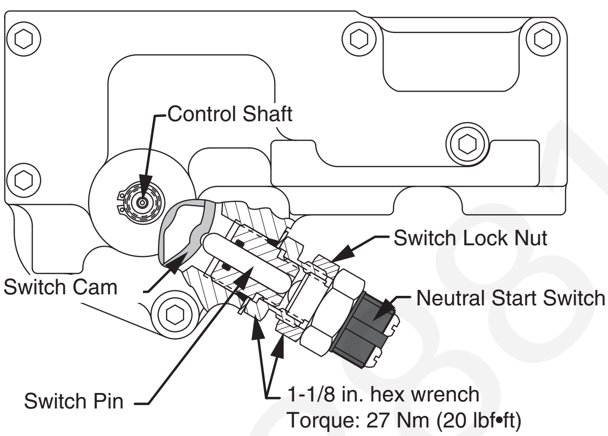


Neutral Start Switch Adjustment Requirements



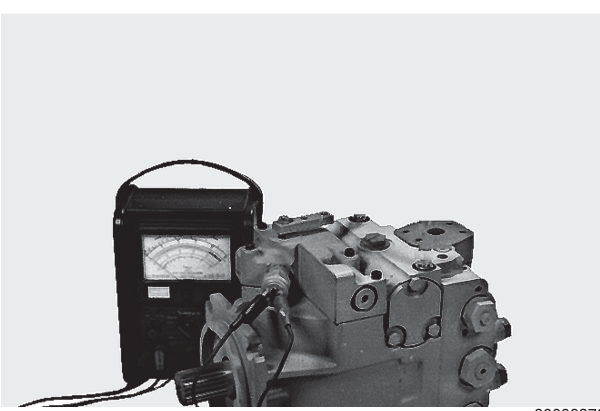
90000253

Loosening the NSS Lock Nut



90000832E

NSS



90000870

Checking Continuity of NSS (System Pressure Gauges installed on far side)

NSS Deadband Adjustment (Conditions ii & iii)

The NSS deadband must be wide enough so the NSS **will not** open within the control shaft "free-play" area, and it must be narrow enough so the NSS **will** open before the unit builds 7 bar (100 psi) differential system pressure in either direction.

1. Install two 1000 bar (10 000 psi) pressure gauges in the system pressure gauge ports M1 and M2.

2. Using two 1-1/8 inch wrenches, hold the neutral start switch from turning and loosen the locknut.

3. Disconnect the external control linkage and make certain the control shaft is in its "neutral" position.

4. Attach a continuity checker to the terminals of the switch. With the control shaft in its "neutral" position, turn the switch clockwise (CW) until electrical continuity is broken, then turn the switch counterclockwise (CCW) until electrical continuity is obtained. Turn the switch counterclockwise (CCW) an additional 1/4 turn (90°) after continuity has been obtained.

5. Hold the switch in place and tighten the locknut to 27 Nm (20 lbf•ft) torque.

6. With the continuity checker attached to the switch, rotate the control handle (or the control shaft) in each direction to assure continuity is broken when the control is not in the "neutral" position.

7. If continuity is obtained in "neutral" and satisfactorily interrupted in each direction, proceed to check the switch with the prime mover running. The switch must open **before** the unit builds 7 bar (100 psi) differential system pressure in either direction.

   If the switch opens **after** the unit builds system pressure in either direction, loosen the switch lock nut and turn the switch clockwise (CW) 1/12 turn (30°). Tighten the switch lock nut and recheck the switch operation. Repeat this procedure if necessary.

8. If continuity is not interrupted with an **equal** movement of the control handle in each direction, turn off prime mover, remove the pressure gauges, and continue with the next section.

9. If neutral start switch operation is satisfactory, turn off the prime mover, remove the pressure gauges, and reconnect the external control linkage.

Neutral Start Switch Eccentric Plug Adjustment (Condition i)

The NSS deadband and the control deadband **must** be centered in relation to each other.

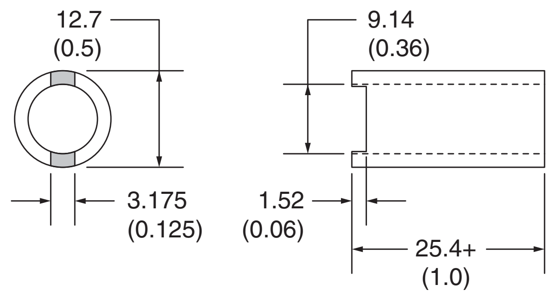
Since the position of the control deadband cannot be adjusted, the position of the NSS deadband must be adjusted to match it. The switch pin is located in an eccentric plug which is turned to move the center of the NSS deadband.

The MDC should be installed on the pump and be in its “neutral” position when adjusting the neutral start switch eccentric plug.

The accompanying drawing provides dimensions for an Eccentric Plug Adjustment Tool.

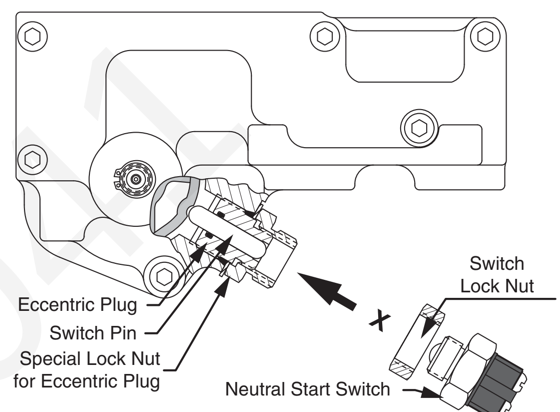
1. Hold the switch and eccentric plug from turning and use two 1-1/8 inch wrenches to loosen the locknut. Remove the neutral start switch.

> **WARNING**
> **Do not start the prime mover while the neutral start switch is removed from the control. Case pressure will force the pin out of the eccentric plug, causing oil loss.**
> S000032E

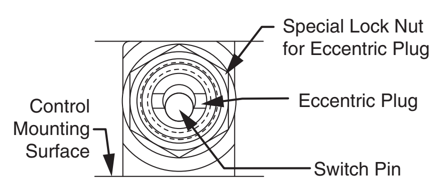


90000834E

Eccentric Plug Adjustment Tool



MDC with Neutral Start Switch



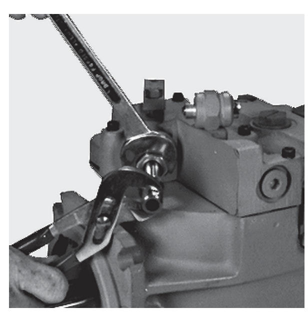
View in Direction X
(Switch and lock nut removed)

90000833E

NSS with Eccentric Plug

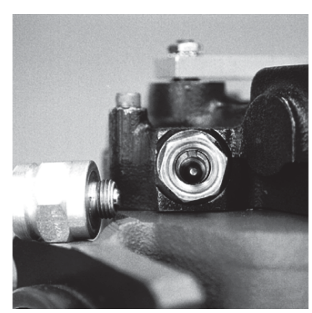
2. Note the slots on the eccentric plug for the adjustment tool. Hold the eccentric plug in place with the adjustment tool, and loosen the lock nut with a 1-1/8 inch wrench.

(continued)



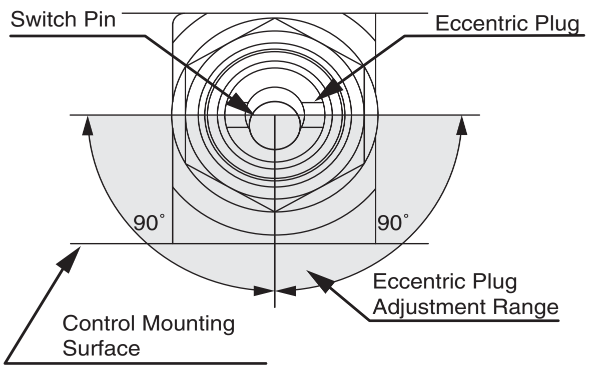
90000256

Loosen Eccentric Lock Nut

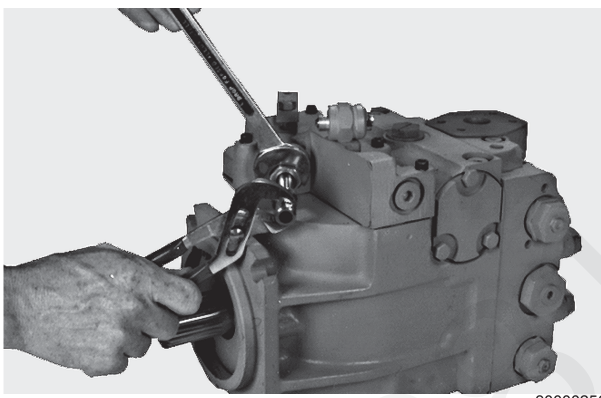


90000257

NSS Removed



Eccentric Plug Adjustment



Adjust the Eccentric Plug

3. Position the eccentric plug so the switch pin is offset toward the control mounting surface. This will provide the best contact between the pin and the cam on the control shaft.

4. Hold the control shaft in its "neutral" position (in the center of the control shaft "free-play" area). Locate the switch pin in the slot of the switch cam by turning the eccentric plug while checking the pin position (depth) in the plug. When the pin engages the cam slot, the pin will be at its maximum depth in the plug. Hand tighten the plug lock nut to hold the eccentric plug in position.

5. Turn the control shaft an equal amount in either direction from "neutral." The switch pin should move out of the eccentric plug an equal distance when the control shaft is turned. Turn the eccentric plug to center the switch pin with the cam slot. Only a small amount of adjustment in either direction should be needed to center the pin.

6. While holding the eccentric plug in place, tighten the eccentric plug lock nut to 27 Nm (20 lbf•ft). Reinstall and adjust the switch as outlined in the previous section.

Note: The eccentric plug normally requires between 5-1/2 and 6-1/2 turns to install into the control housing .

> **Caution**
> **Do not turn the eccentric plug into or out of the housing beyond specifications.**
> S000014E

7. Once the switch is correctly adjusted, hold the switch in place and tighten the locknut to 27 Nm (20 lbf•ft) torque.

(continued)

Checking Switch Continuity

Recheck switch continuity to determine whether additional adjustment of the eccentric plug is necessary.

> **WARNING**
> **The following procedure may require the vehicle/machine to be disabled (wheels raised off the ground, work function disconnected, etc.) while performing the procedure in order to prevent injury to the technician and bystanders. Take necessary safety precautions before moving the vehicle/machine.**
> S000007E

1. Install two 50 bar (or 1000 psi) gauges in each of the displacement control cylinder gauge ports (M4 and M5). Attach a continuity checker to the terminals of the neutral start switch.

2. Energize the starter circuit, and start the prime mover.

3. While operating at normal speed and with the pump in its “neutral” (zero flow) position, note the pressure reading on the gauges. This reading should be noted as the base pressure.

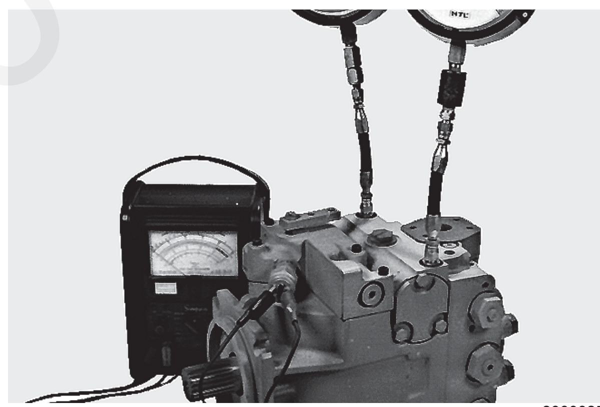
4. Slowly move the control handle in one direction while observing the pressure gauges and the continuity checker. Continuity **must** be broken before the pressure on either gauge increases more than 1 bar (12 psi) from the base pressure obtained at “neutral.”

5. Slowly move the control handle in the opposite direction. Again, continuity must be broken before the gauge pressure increases more than 1 bar (12 psi) from base pressure.

6. Continuity must again be verified when the control is returned to neutral.

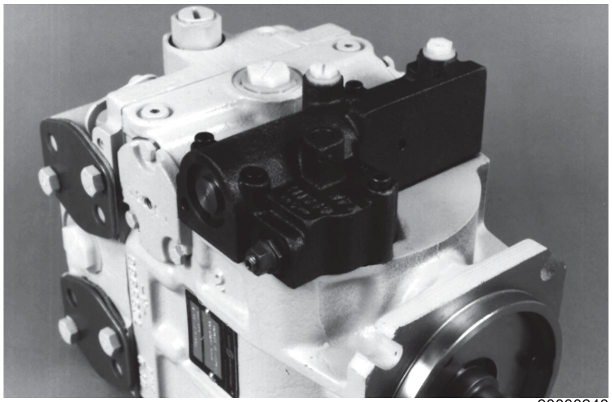
7. If continuity is not broken at base pressure plus 0 to 1 bar (0 to 12 psi) in either direction, stop the prime mover and readjust the eccentric plug as described in the previous section. If the pressure difference is equal in each direction but greater than 1 bar (12 psi), loosen the switch locknut and turn the switch clockwise 1/12 turn (30°) to increase the sensitivity. Retighten the locknut and recheck pressure differences and continuity.

8. After verifying proper control and switch operation, stop the prime mover. Remove the continuity checker and pressure gauges. Reinstall the servo pressure port plugs and reconnect the electrical leads from the machine starter circuit to the neutral start switch. Install and adjust, if necessary, the external control linkage.

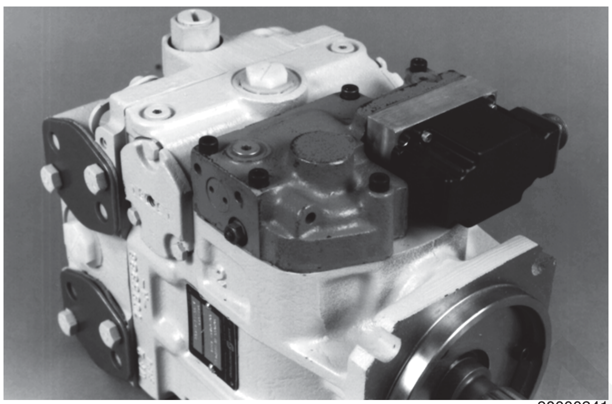


90000255

Checking Continuity of NSS
(Gauges installed in Servo Gauge Ports)


90000240

PV with Hydraulic Displacement Control


90000241

PV with Electric Displacement Control

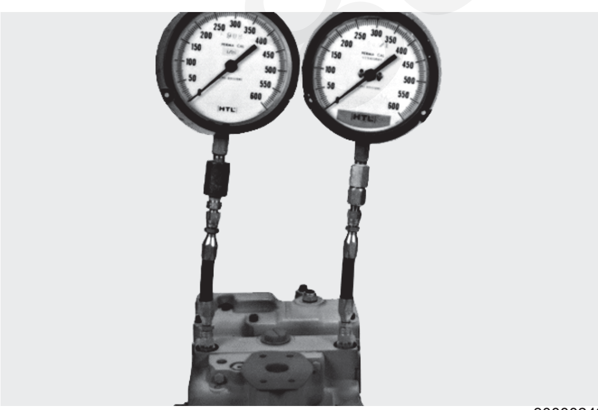
Hydraulic Displacement Control (HDC) and Electric Displacement Control (EDC) Adjustment

The “neutral” adjustment is the only adjustment that can be made on hydraulic and electric displacement controls. All other functions are preset at the factory.

This adjustment must be made on a test stand or on the vehicle/machine with the prime mover operating.

The neutral adjustment is performed by adjusting a neutral adjusting shaft (earlier production EDCs) or a neutral adjusting screw (HDCs and current production EDCs).

WARNING
The following procedure may require the vehicle/machine to be disabled (wheels raised off the ground, work function disconnected, etc.) while performing the procedure in order to prevent injury to the technician and bystanders. Take necessary safety precautions before moving the vehicle/machine.
S000007E


90000249

Install Gauges in Displacement Control Cylinder Gauge Ports

1. Install two 50 bar (or 1000 psi) gauges in each of the two displacement control cylinder gauge ports (M4 and M5). Disconnect the external control input (hydraulic or electronic) from the control. Start the prime mover and operate at normal speed.

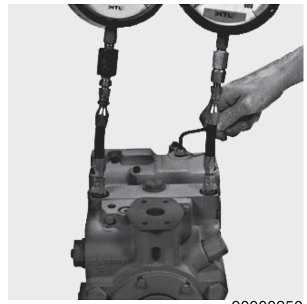
2. Loosen the lock nut with a 17 mm hex wrench for the neutral adjusting shaft or with a 10 mm or 13 mm hex wrench for the neutral adjusting screw.

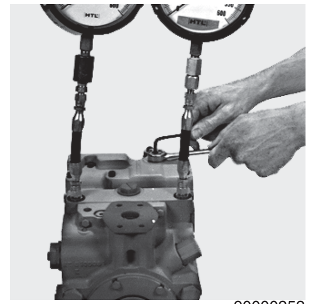
3. Using a 5 mm internal hex wrench for the neutral adjusting shaft or a 3 mm or 4 mm internal hex wrench for the neutral adjusting screw, rotate clockwise until the pressure increases in one of the pressure gauges. Note the angular position of the wrench. Then rotate the neutral adjusting shaft or screw counterclockwise until the pressure increases by an equal amount on the other gauge. Again note the angular position of the wrench.

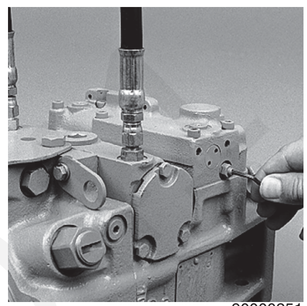
4. Rotate the neutral shaft or adjusting screw clockwise half the distance between the locations noted above. The gauges should read the same pressure (case pressure), indicating that the control is in its “neutral” position.

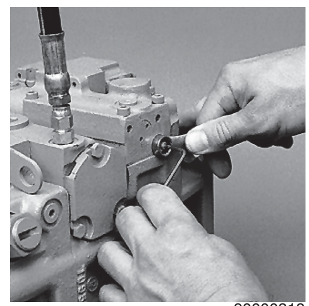
5. Hold the neutral adjusting shaft or screw stationary. Tighten the neutral shaft lock nut (early production controls) to 22 Nm (195 lbf•in.). Tighten the neutral adjusting screw lock nut (later production controls) to 7 Nm (62 lbf•in.) for the 6 mm screw or 13.5 Nm (120 lbf•in.) for the 8 mm screw. **Do not overtorque the nut.**

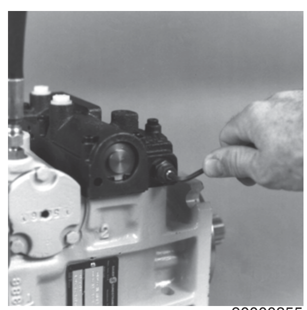
6. Once the neutral position is set, stop the prime mover, remove the gauges, and install the gauge port plugs. Reconnect the external control input.

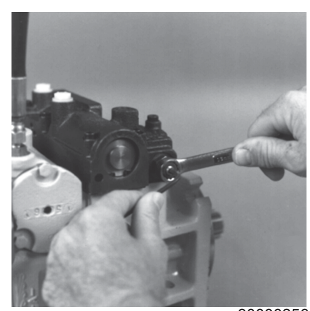

90000250
Rotate Neutral Adjusting Shaft (Early production)


90000252
Tighten Neutral Adjusting Shaft Lock Nut (Early production)

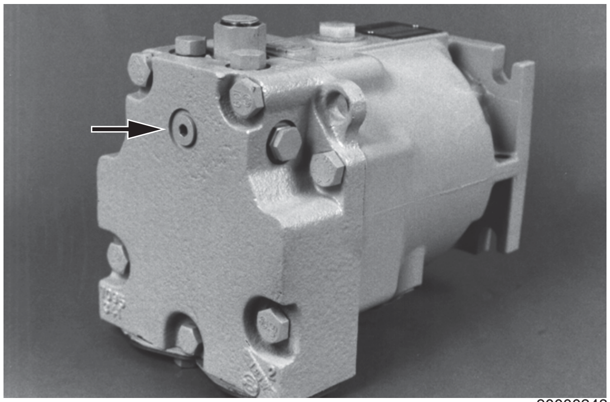

90000251
Rotate Neutral Adjusting Screw (Later production)


90000318
Tighten Neutral Adjusting Screw Lock Nut (Later production)


90000355
Rotate Neutral Adjusting Shaft (Current production HDC)


90000356
Tighten Neutral Adjusting Shaft Lock Nut (Current production HDC)

Motor Adjustments



90000248

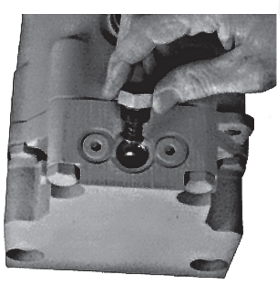
Charge Pressure Gauge Port (MF)

90M055 NC 0 N
8 N 0 C6 W 00
NNN 00 00 **24**

Nominal charge
Pressure Setting

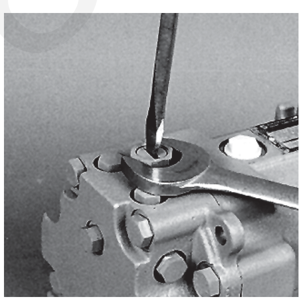
Model Code	Motor Charge Pressure (±1.4 bar [±20 psi])
10	8.1 bar (117 psi)
18	16.1 bar (233 psi)
20	18.1 bar (262 psi)
24	22.1 bar (320 psi)
28	26.1 bar (378 psi)
30	30.0 bar (435 psi)
	T002 279E

Model Code at the Name Plate (24 bar)



90000263

Shim Adjustable Charge Pressure Relief Valve (Motor)



90000343

Screw Adjustable Charge Pressure Relief Valve (Motor)

Charge Relief Valve Adjustment

1. To measure motor charge pressure, install a 50 bar (or 1000 psi) pressure gauge in the motor charge pressure gauge port (M3). Size 30 and 42 don't have the M3 gauge port. Install pressure gauge in the motor system pressure gauge port. For this kind of measurement add 1 bar (14.5 psi) to the nominal values shown in the table. Also install a gauge to measure case pressure. Operate the system with the pump in stroke (forward or reverse) when measuring motor charge pressure.

2. The following table shows acceptable motor charge pressures for some nominal charge relief valve settings (see model code at right). These pressures assume a reservoir temperature of 50°C (120°F). They are referenced to case pressure and assume a one pump/one motor system.

3. Earlier production Series 90 motors are equipped with a shim adjustable charge relief valve. Shim kits are available as service items. Adjustment of the charge pressure is accomplished by removing the plug (7/8 inch hex) and changing the shim thickness behind the spring. The plug for this type charge relief port should be torqued to 68 Nm (50 lbf•ft).

   Later production Series 90 motors are equipped with an external screw adjustable charge relief valve. Adjustment of charge pressure is accomplished by loosening the lock nut,

Frame Size	Wrench Size
030 - 130	1-1/16 inch
	T002 293E

   and turning the adjustment plug with a large screwdriver or a 1/2 inch hex wrench. Clockwise rotation of the plug increases the setting, and counterclockwise rotation decreases the setting (at a rate of approximately 5.4 bar [78 psi] per turn). The lock nut for this type charge relief valve should be torqued to 52 Nm (38 lbf•ft).

4. Once the desired charge pressure setting is achieved, remove the gauges.

Displacement Limiter Adjustment (MV)

Both the maximum and minimum displacement may be limited.

1. Remove the tamper resistant cap from the displacement limiter screw. Loosen the seal lock nut retaining the displacement limiter adjusting screw with a 19 mm wrench.

> **Caution**
> **The displacement limiters act as travel stops for the swashplate. Do not turn the limiter screws counterclockwise beyond the point of contact with the swashplate for either the maximum or minimum displacement position.**
> S000015E

2. All adjustments can only be done when the motor is running and the pump is in neutral position. Steer the respective displacement limiter by the control.

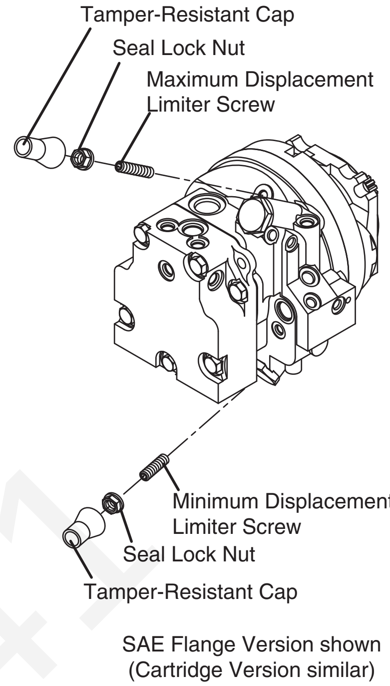
   Rotate the adjusting screw with a 6 mm internal hex wrench. Rotating the maximum displacement adjusting screw clockwise will decrease the maximum displacement of the motor. Rotating the minimum displacement adjusting screw clockwise will increase the minimum displacement of the motor.

> **Caution**
> **Care should be taken in adjusting displacement limiters to avoid undesirable flow or speed conditions. See corresponding section for speed and pressure limits.**
>
> **The seal lock nut must be retorqued after every adjustment to prevent an unexpected change in operating conditions and to prevent external leakage during unit operation.**
> S000016E

3. After establishing the desired displacement setting, tighten the lock nut on the adjusting screw to 54 Nm (40 lbf•ft). Install a new tamper resistant cap.

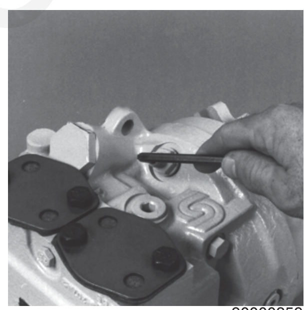
4. One turn of the adjusting screw will change the maximum or minimum displacement according to the following chart.

Frame Size	Approx Change in Disp per Rev of Adjusting Screw
055	5.6 cm³ / Rev (0.34 in³ / Rev)
075	7.1 cm³ / Rev (0.43 in³ / Rev)
	T002 280E



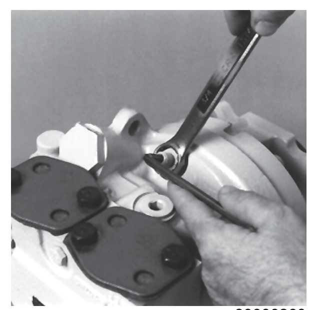
90000837E

MV Displacement Limiters



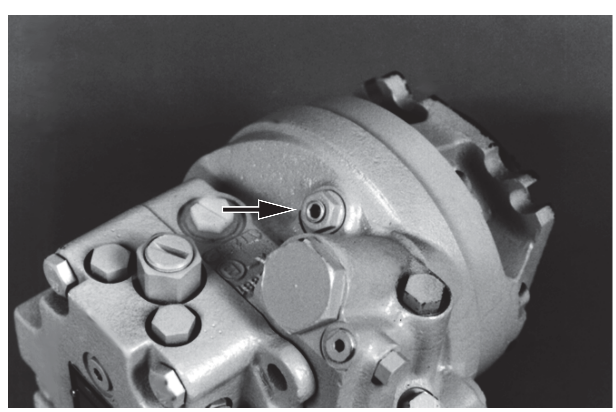
90000359

Rotate Adjusting Screw for Minimum Displacement Limiter



90000360

Tighten Lock Nut for Minimum Displacement Limiter



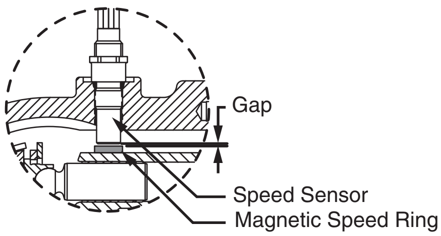
90000352

Maximum Displacement Limiter

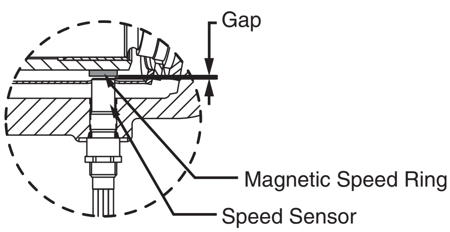
Displacement Control Adjustments

All variable motor displacement control settings do not require adjusting.

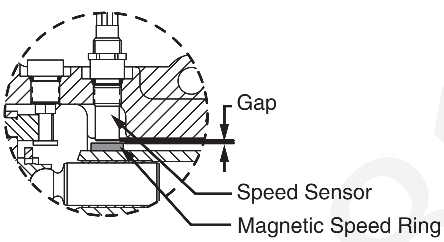
Speed Sensor Adjustment



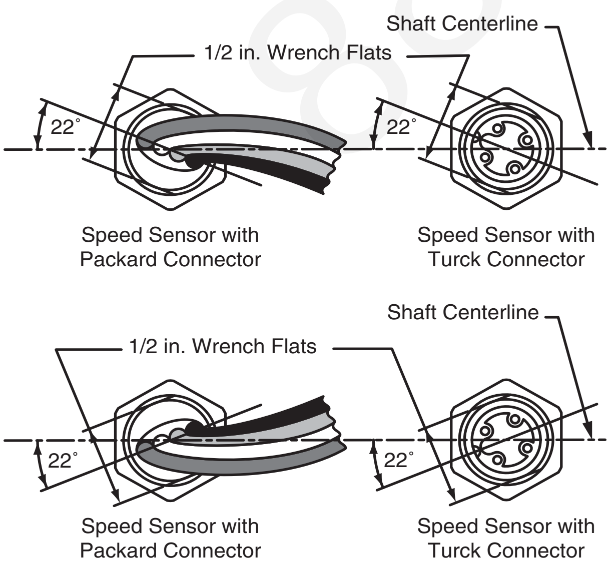
90000838E
Cross Section View of Speed Sensor in Variable Pump



90000839E
Cross Section View of Speed Sensor in fixed Motor



90000840E
Cross Section View of Speed Sensor in Variable Motor



90000841E
Positioning Speed Sensor relative to Pump or Motor Shaft

When installing or adjusting the speed sensor on a pump or motor, it must be set at a specific distance from the speed ring on the unit's cylinder. To locate the position of the speed sensor on the unit or description see the corresponding section.

1. Loosen the sensor lock nut with an 1-1/16 inch hex wrench.

2. Turn the sensor clockwise (CW) by hand until it contacts the speed ring.

3. Turn the sensor counterclockwise (CCW) 1/2 turn (180°) to establish the nominal gap of 0.71 mm (0.028 inch).

4. Then turn the sensor clockwise (CW) until the wrench flats on sensor body are positioned at a 22° angle to the pump shaft center line.

Note: Many adjustable wrenches have a 22° handle offset.

5. The final sensor position should be between 1/2 (180°) and 1/4 turn (90°) counterclockwise (CCW) from the point where the sensor contacts the speed ring.

6. Hold sensor in position with a 1/2 inch hex wrench while tightening the lock nut to 13 Nm (10 lbf•ft).

Minor Repair Instructions

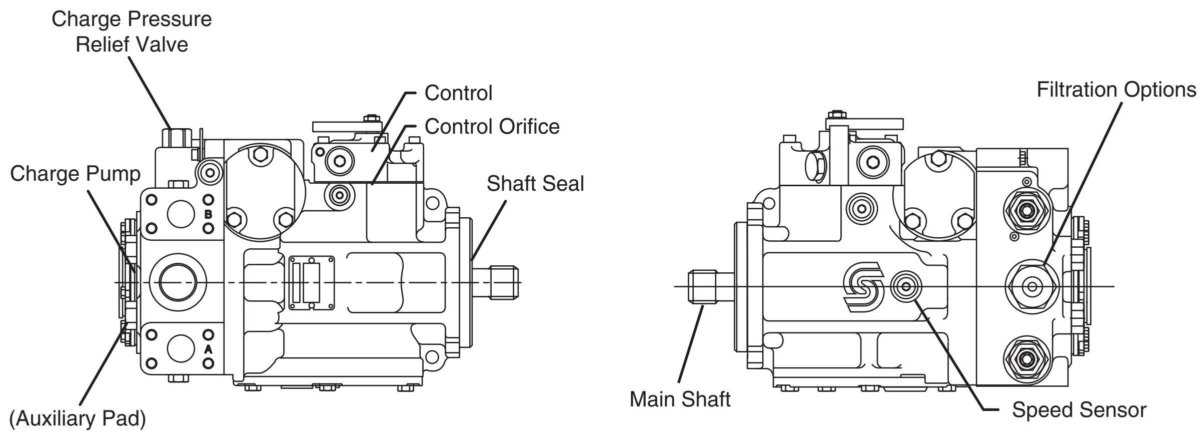
Minor repairs may be performed, following the procedures in this section, without voiding the unit warranty. Although specific models are shown, these procedures apply to all series and types of units in the Series 90 Family.

Cleanliness is a primary means of ensuring satisfactory transmission life, on either new or repaired units. Cleaning parts by using a solvent wash and air drying is adequate, providing clean solvent is used. As with any precision equipment, the internal mechanism and related items must be kept free of foreign materials and chemicals.

Protect all exposed sealing surfaces and open cavities from damage and foreign material.

It is recommended that all gaskets and O-rings be replaced when servicing. All gasket sealing surfaces must be cleaned prior to installing new gaskets. Lightly lubricate all O-rings with clean petroleum jelly prior to assembly.

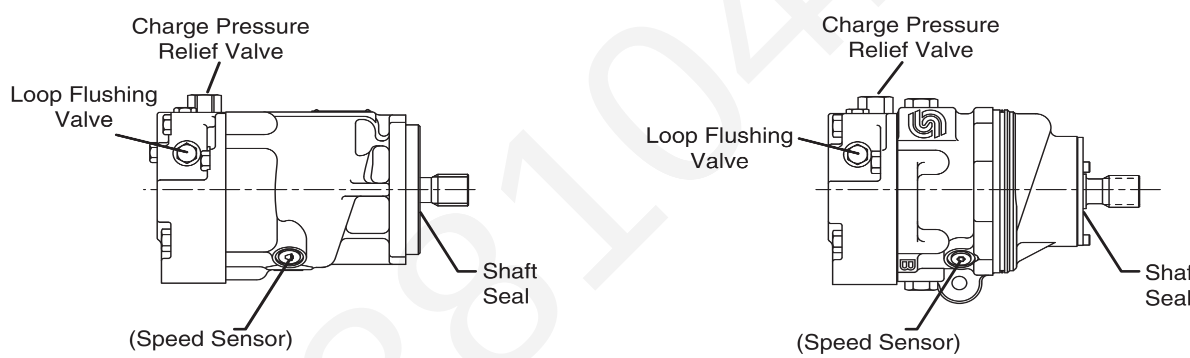
Hydrostatic Unit Outlines for Minor Repair Reference



Left Side View **Right Side View**

90000843E

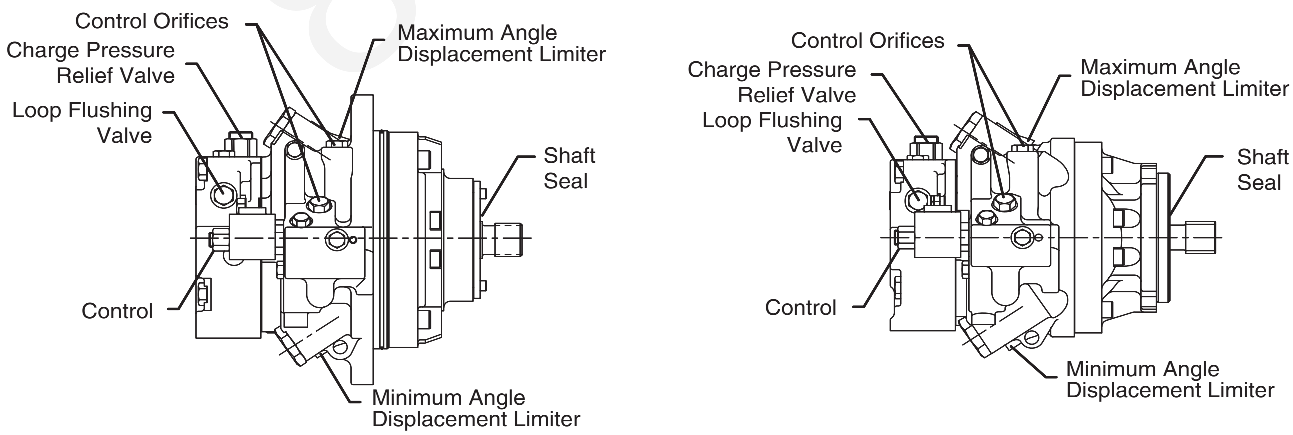
SAE-Flange PV



Left Side View **Left Side View**

SAE Flange MF **Cartridge Flange MF**

90000844E



Left Side View **Left Side View**

90000845E

Cartridge Flange MV **SAE Flange MV**

Pump and Motor Minor Repair

Pump / Fitting Torques

If any plugs or fittings are removed from the pump or motor during servicing, they should be torqued as indicated in the accompanying table.

Always install new O-rings before reinstalling the plugs or fittings.

Caution
Plugs or fittings installed into aluminum housings should always be torqued to the lower values specified for internal hex plugs of the same size.
S000017E

Description	Torque
7/16-20 O-ring 9/16 inch Hex Wrench	20 Nm (15 lbf•ft)
7/16-20 O-ring 3/16 inch Internal Hex Wrench	12 Nm (9 lbf•ft)
9/16-18 O-ring 11/16 inch Hex Wrench	37 Nm (27 lbf•ft)
9/16-18 O-ring 1/4 inch Internal Hex Wrench	23 Nm (17 lbf•ft)
3/4-16 O-ring 7/8 inch Hex Wrench	68 Nm (50 lbf•ft)
3/4-16 O-ring 5/16 inch Internal Hex Wrench	68 Nm (50 lbf•ft)
7/8-14 O-ring 1 inch Hex Wrench	95 Nm (70 lbf•ft)
7/8-14 O-ring 3/8 inch Internal Hex Wrench	68 Nm (50 lbf•ft)
1-1/16-12 O-ring 1 1/4 inch Hex Wrench	163 Nm (120 lbf•ft)
1-1/16-12 O-ring 9/16 inch Internal Hex Wrench	115 Nm (85 lbf•ft)
1-5/16-12 O-ring 1-1/2 inch Hex Wrench	190 Nm (140 lbf•ft)
1-5/16-12 O-ring 5/8 inch Internal Hex Wrench	129 Nm (95 lbf•ft)
1-5/8-12 O-ring 1-7/8 inch Hex Wrench	224 Nm (165 lbf•ft)

T002 281E

Shaft Seal and Shaft Replacement

Lip type shaft seals are used on Series 90 pumps and motors. These seals and/or the shafts can be replaced without major disassembly of the unit. However, replacement usually requires removal of the pump or motor from the machine.

1. Position the pump with the shaft facing up.

Note: If the unit is positioned horizontally when the shaft is removed, the cylinder block could move out of place, making shaft installation difficult.

2. Remove the three or four screws holding the retainer plate and seal carrier to the housing, using a 10 mm hex wrench (030 and 042 units), a 5 mm internal hex wrench (055 through 100 units), or a 6 mm internal hex wrench (130 through 250 units). Remove the retainer plate.

Note: Certain earlier production units use a one piece retainer plate and seal carrier.

3. After removing the screws, the spring force on the shaft may move the seal carrier out of its bore by approximately 5 mm (1/4 inch). If the seal carrier does not move from its bore after removing the screws, pry it from its bore as shown and/or lightly tap the end of the shaft with a soft mallet.

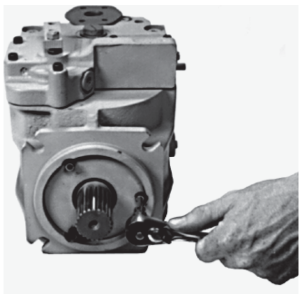
4. Remove the O-ring from the seal carrier.

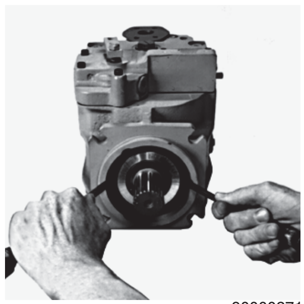
5. Place seal carrier and seal in an arbor press and press out old seal.

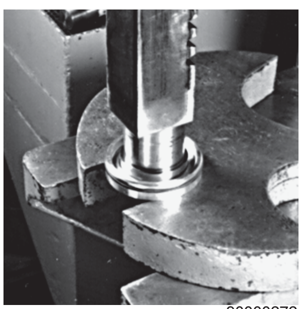
6. Inspect the seal carrier, the new seal and the O-ring for any damage or nicks.

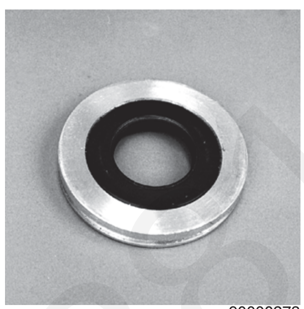
7. Using the arbor press, press the new seal into seal carrier. Be careful not to damage the seal.

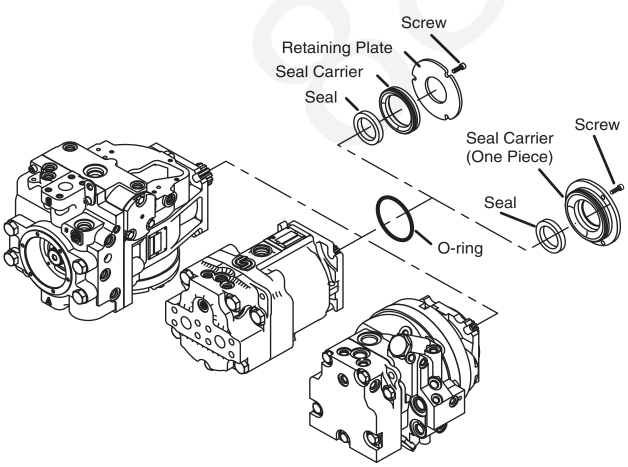
Note: The outside diameter of the seal may be lightly coated with a sealant (such as Loctite High Performance Sealant #59231) prior to installation. This aids in preventing leaks caused by damage to the seal bore in the seal carrier.


90000270
Remove Screws Holding Retainer Plate and Seal Carrier


90000271
Remove Seal Carrier


90000272
Press Out Old Seal


90000273
New Seal Installed in Carrier



90000846E
Series 90 Shaft Seal Components

8. Inspect the sealing area on the shaft for rust, wear, or contamination.

   If the shaft is not being replaced proceed to step 12.

9. Remove shaft and roller bearing assembly from pump or motor. The bearing assembly can be transferred to the new shaft.

10. Remove the retaining ring that secures roller bearing assembly with a snap ring pliers. Remove the roller bearing assembly.

11. Place roller bearing assembly on new shaft and secure with the retaining ring.

12. Wrap spline or key end of shaft with plastic film to prevent damage to the sealing lip on the seal during installation.

13. Prior to assembly, lubricate the O-ring on the O.D. of the seal carrier and the I.D. of the seal with clean petroleum jelly.

14. Assemble the seal carrier and seal over the shaft and into the housing bore. Install the retainer plate (if used).

15. Install the screws and torque like the tables.

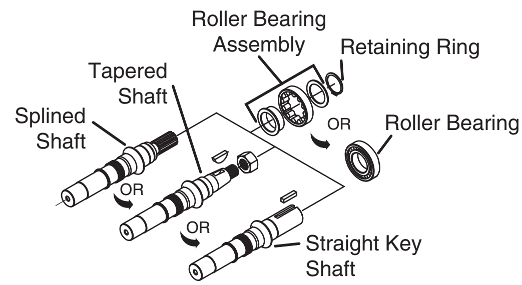
Pumps

Frame Size	Torque Pumps
030 - 042	12 Nm (9 lbf•ft)
055 - 100	16 Nm (12 lbf•ft)
130 - 250	32 Nm (24 lbf•ft)
	T002 282E

Motors

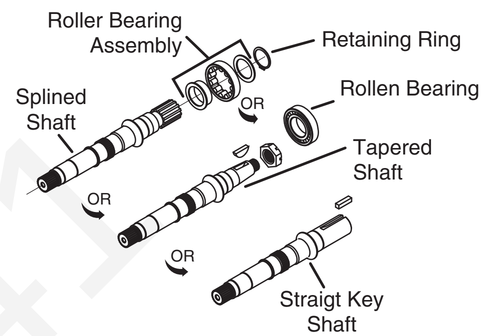
Frame Size	Torque Motors
030 - 100	9.5 Nm (7 lbf•ft)
130	22.5 Nm (16.6 lbf•ft)
	T002 283E

Note: Torque the screws in a sequenced pattern then recheck.



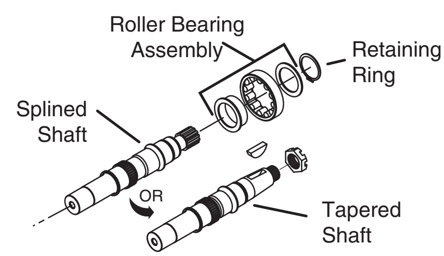
90000866E

Fixed Motor Shaft Configuration



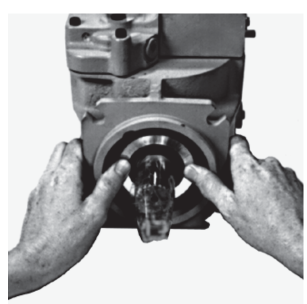
90000867E

Variable Pump Shaft Configuration



90000868E

Variable Motor Shaft Configuration



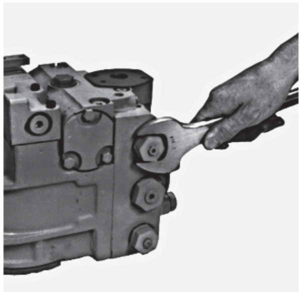
90000274

Install Seal Carrier

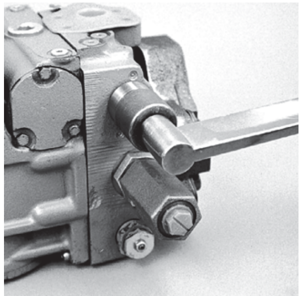
90000275

Torque Retainer Screw

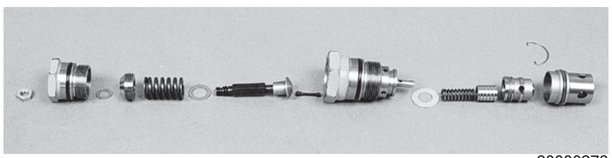
Pump Minor Repairs



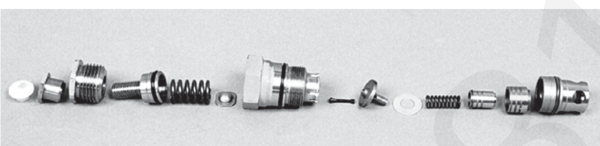
90000276
Remove Multi-Function Valve Cartridge



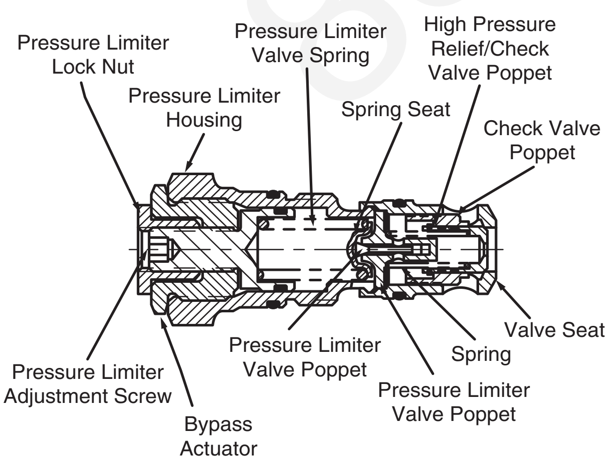
90000277
Install and Torque Cartridge



90000278
Multi-Function Valve Cartridge Components (Earlier production)



90000279
Multi-Function Valve Cartridge Components (Later production)



90000869E
Multi-Function Valve Cartridge Sectional View

Multi-Function Valve Cartridges

1. The multi-function valve cartridge is removed with a hex wrench on the largest hex on the cartridge.

Frame Size	Wrench Size
030 - 100	1-1/4 inch
130 - 250	1-5/8 inch
	T002 284E

2. Inspect cartridge for damage to parts and O-rings.

   The multi-function valve cartridge may be disassembled for cleaning. However, if the pressure limiter housing assembly is disassembled, the pressure settings must be readjusted. Usually, if there is contamination problem, it will be in the valve seat assembly. If it is not necessary to clean the interior of the cartridge, proceed to step 7.

Note: Multi-function valve components are not sold separately as service parts (except O-rings).

3. On early versions of the multi-function valves, the valve seat assembly is held by a retaining ring. Remove retaining ring with a snap ring pliers.

   On late versions, the valve seat section is pressed over a lip. Place the cartridge in a vise and pry the lower section off with an appropriate tool. Maintain sufficient control to prevent the contents from flying loose.

4. Remove pressure limiter lock nut and bypass actuator.

5. Unscrew the pressure limiter adjustment screw from the bypass actuator. Clean and inspect all disassembled parts.

6. Reassemble with new, lightly lubricated O-rings by reversing the above procedure. For early versions assemble with the retaining ring. For late versions, place the cartridge in a vise and press on lower assembly.

Caution
The pressure settings must be readjusted after disassembling the pressure limiter housing of the multi-function valve cartridge.
S000018E

7. Install cartridge in multi-function valve cavity and torque.

Frame Size	Torque
030 - 100	89 Nm (66 lbf•ft)
130 - 250	210 Nm (155 lbf•ft)
	T002 285E

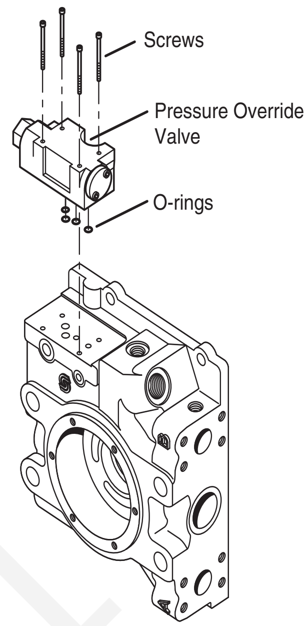
Do not overtorque the multi-function valve cartridge.

Pressure Override Valve (Option for 180 Frame Size)

1. Remove the four screws attaching the pressure override valve to the pump end cap with a 5 mm internal hex wrench. Remove the O-rings.

2. Inspect valve for damage to parts.

3. Install new O-rings. Install the valve onto the pump end cap and torque the screws to 16 Nm (12 lbf•ft).



90000870E

Pressure Override Valve Components

Charge Relief Valve

The pump charge relief valve may be shim adjustable (early models) or screw adjustable (late models).

1. Remove the shim adjustable charge relief valve plug with a 1 inch hex wrench.

   Before removing the screw adjustable relief valve plug, mark the plug, lock nut, and housing so as to approximately maintain the original adjustment when assembling. Remove the screw adjustable charge relief valve plug by loosening the lock nut with a wrench.

Frame Size	Wrench Size
030 - 100	1-1/16 inch
130 - 250	1-5/8 inch
	T002 286E

   Unscrew the plug with a large screwdriver or 1/2 inch hex wrench.

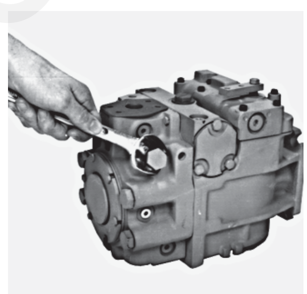
2. Remove the spring and relief valve poppet.

3. Inspect the poppet and mating seat in the end cap for damage or foreign material.

   When inspecting shim adjustable valves, do not alter the shims or interchange parts with another valve.

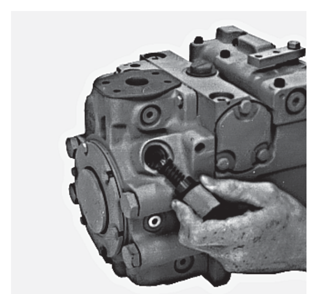
4. Install the poppet and spring. For shim adjustable valves, install the plug and torque to 68 Nm (50 lbf•ft). For screw adjustable valves, install the plug with its lock nut, aligning the marks made at disassembly, and torque the lock nut to 52 Nm (38 lbf•ft).

   Check the charge pressure and adjust, if necessary.



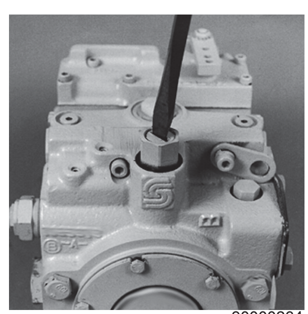
90000280

Remove Charge Relief Valve (Shim adjustable)



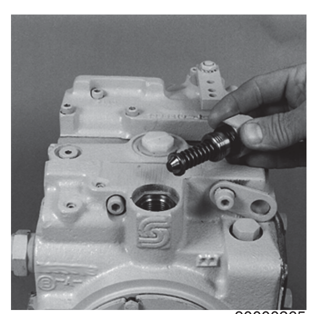
90000262

Shim Adjustable Charge Relief Valve



90000264

Remove Charge Relief Valve (Screw adjustable)



90000265

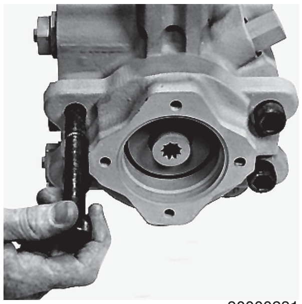
Screw Adjustable Charge Relief Valve

Charge Pump - Remove

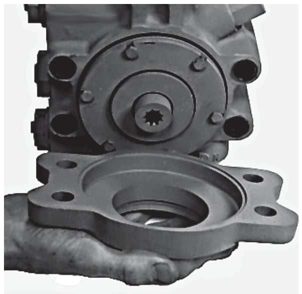
The following procedure shows how to remove and install a charge pump.

1. For pumps with an auxiliary mounting pad, remove the four screws holding the pad to the end cap and remove the pad. Refer to the Auxiliary Mounting Pad Installation instructions (next section) for details.

Note: At earlier production frame size 75 pumps with twin ports secure the end cap to the pump housing with a clamp to avoid gasket damage.

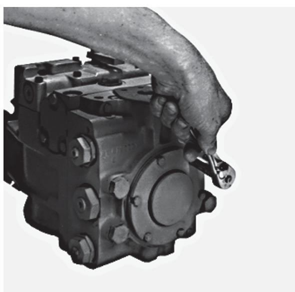


90000281
Remove Auxiliary Pad Adapter Screws

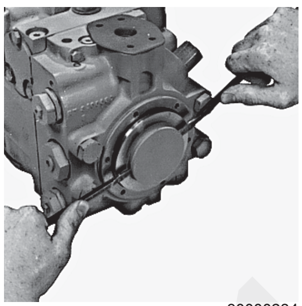


90000303
Remove Auxiliary Pad Adapter

> **Caution**
> **Do not allow the force of the cylinder block spring and swashplate leveler springs to separate the end cap from the pump housing. Gasket damage and external leakage may result.**
> S000019E



90000282
Remove Retainer Screws



90000284
Remove Charge Pump Cover

2. Remove the six screws holding the charge pump cover retainer.

Frame Size	Wrench Size
030 - 100	10 mm
130 - 250	13 mm
	T002 287E

3. Remove the retainer and the charge pump cover. For pumps with an auxiliary mounting pad, remove the auxiliary drive coupling. Note the orientation of the gerotor.

4. Remove the charge pump shaft and charge pump drive key.

5. Remove the spacer plate(s), if present (intermediate production pumps only).

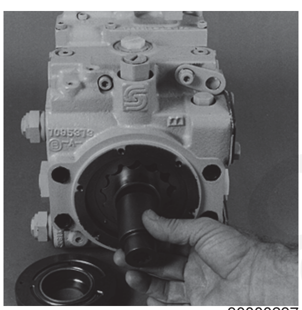
   Remove the charge pump outer port plate, if present (early and intermediate production pumps).

   Remove the charge pump gerotor assembly.

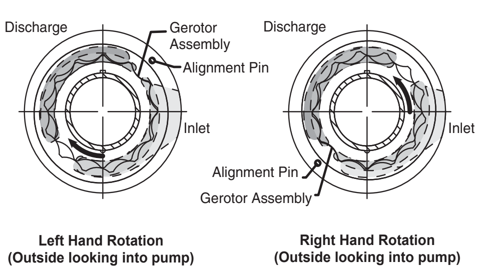
6. Remove the outer eccentric ring and alignment pin.

7. Remove the inner port plate.

8. Inspect all parts for abnormal wear or damage.



90000297
Remove Drive Coupling

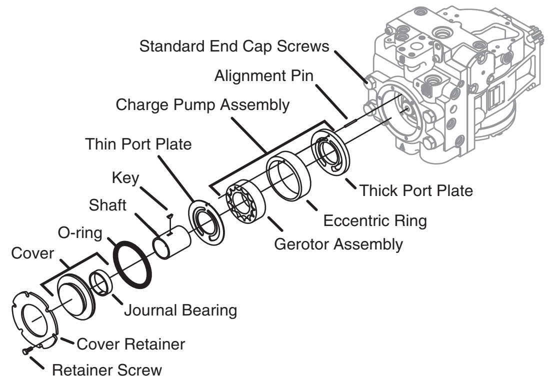


90000871E
Orienting Alignment Pin

Note: If a different displacement charge pump is being installed, the gerotor assembly, gerotor outer eccentric ring, and inner port plate (early and late production pumps) or outer spacer plate(s) (intermediate production pumps) must be replaced together. If different thickness port plates are used in an early production charge pump assembly, the thicker plate is the inner port plate (installed next to the pump end cap).

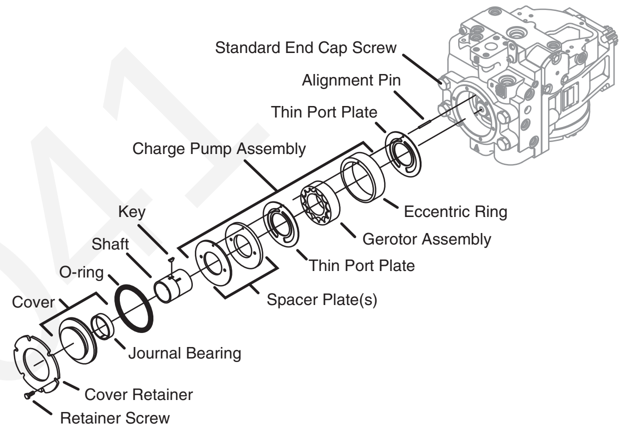
Each charge pump assembly includes a different quantity / types of port plates and spacer plates.

The charge pump kit "No Charge Pump" includes a spacer.



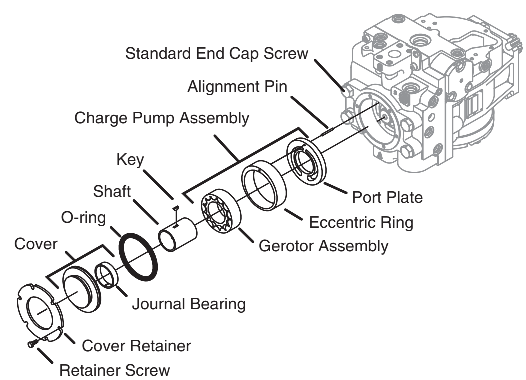
90000872E

Charge Pump Components (Early Production)



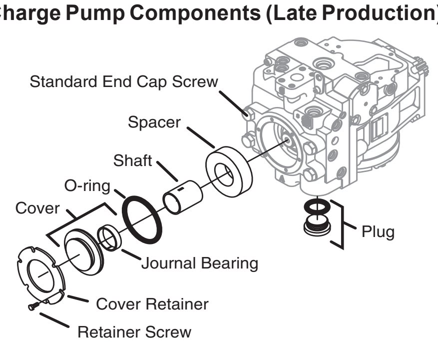
90000873E

Charge Pump Components (Intermediate Production)



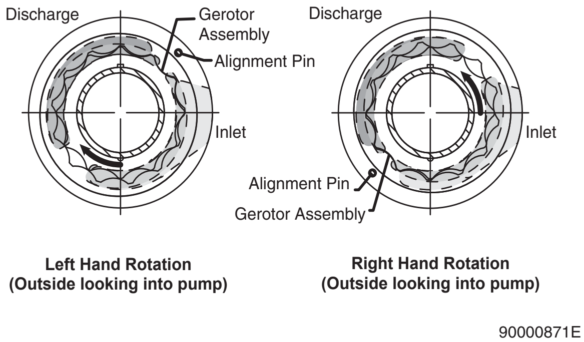
90000874E

Charge Pump Components (Late Production)



90000875E

"No Charge Pump" Components

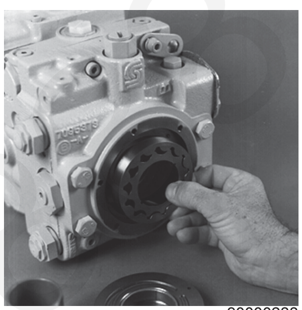


Orienting Alignment Pin

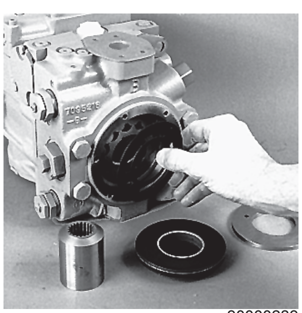
90000285
Install Inner Port Plate

90000286
Install Gerotor Assembly Outer Ring

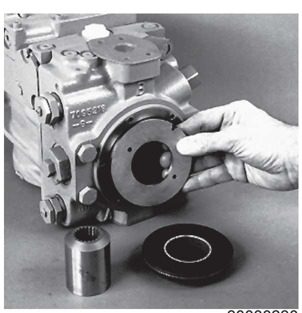
90000287
Install Alignment Pin



90000288
Install Gerotor Assembly



90000289
Install Outer Port Plate (Early and intermediate production only)



90000290
Install Spacer Plate (Intermediate production only)

Installing the Charge Pump

Be sure to install the charge pump in the proper orientation. If unsure of charge pump rotation, refer to the model code.

Note: The charge pump **rotation** is determined by the orientation of the gerotor assembly outer eccentric ring and the location of the alignment pin in the end cap.

Do not mix charge pump piece parts from different production periods. Always install as a complete assembly.

1. Install the inner port plate and the gerotor assembly outer ring.
2. Install the alignment pin to properly orient the port plates and outer eccentric ring for corresponding pump rotation.
3. Prior to installation, apply a small quantity of petroleum jelly to the I.D., O.D., and side faces of the gerotor assembly to provide initial lubrication.
4. Install the gerotor assembly.
5. Install the outer port plate (early production and intermediate production pumps only).
6. Install the spacer plate, if present (intermediate production pumps).
7. Install the charge pump drive key into the charge pump shaft and retain with petroleum jelly.

Note: Intermediate production 75 cc and 100 cc pumps use the same charge pump drive shaft. Two keyways are provided in the drive shaft for the charge pumps used in these units. The rear keyway (with identifier groove) is used in 75 cc pumps. The front keyway (closest to the internally splined end of the shaft) is used in 100 cc pumps.

8. Install the charge pump shaft. The internally splined end of the shaft must engage the main pump shaft.

Note: The outside diameter of the internally splined end of some early production charge pump shafts was chamfered. Early production end caps may not be machined to accept a non-chamfered shaft. Always use a chamfered charge pump shaft in pumps with the early end cap.

9. For pumps with an auxiliary mounting pad, install the auxiliary drive coupling.

10. Install a new O-ring onto the non-auxiliary pad charge pump cover. (If an auxiliary pad is installed, an O-ring is not used on the cover.)

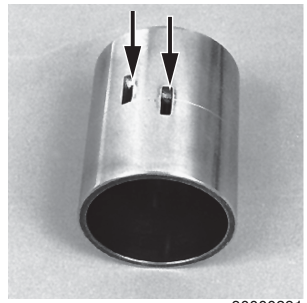
11. Carefully remove the alignment pin from the charge pump parts. Install the pin in its hole in the charge pump cover (see previous page for correct orientation) and retain with petroleum jelly. Install the cover (with alignment pin) into the end cap and aligned charge pump parts. (Take care not to damage the cover O-ring, if used.)

Caution
In order to avoid loss of charge pressure in pumps with an auxiliary mounting pad, always install the charge pump cover with the pad drain hole located on the same side of the end cap as the charge inlet port. Refer to the section „Auxiliary Pad Installation“ for details.
S000 020E

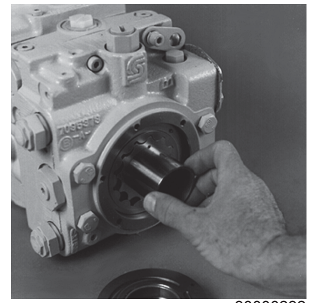
12. Install the charge pump cover retainer and the six hex screws and torque the screws.

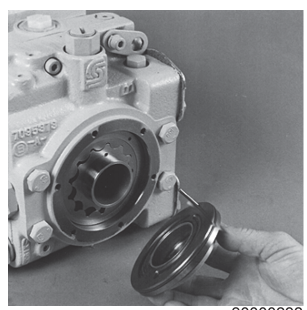
Frame Size	Torque
030 - 100	13.5 Nm (10 lbf•ft)
130 - 250	32 Nm (24 lbf•ft)
	T002 288E

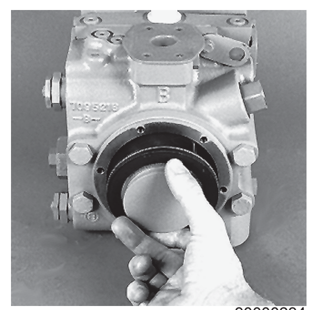
13. For pumps with auxiliary mounting pads, install the O-ring and auxiliary mounting pad adaptor onto the end cap. Refer to the corresponding section for instructions on auxiliary pad installation.

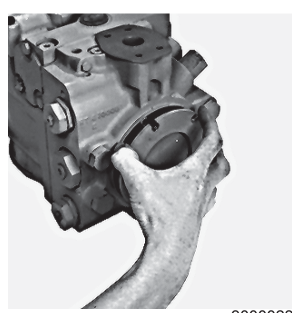


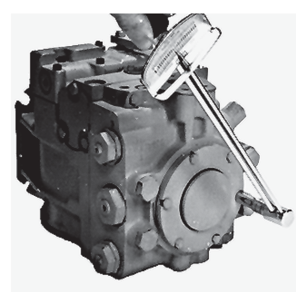
90000291
Keyways in Charge Pump Shaft (Intermediate Production 075 and 100)

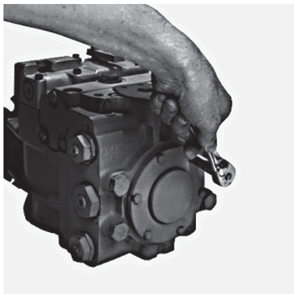

90000292
Install Charge Pump Shaft


90000293
Alignment Pin Installed in Cover

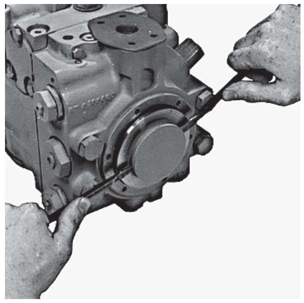

90000294
Install Charge Pump Cover


90000283
Install Cover Retainer

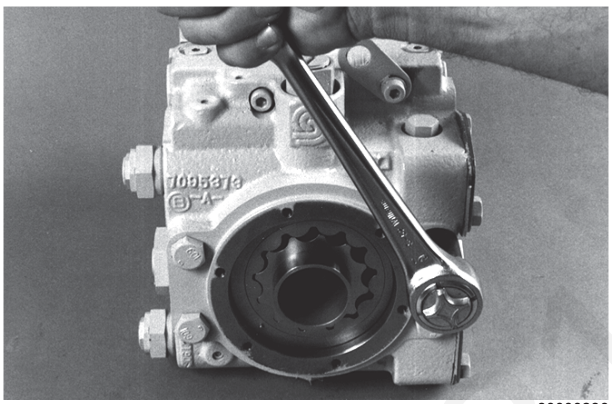

90000295
Torque Retainer Screws



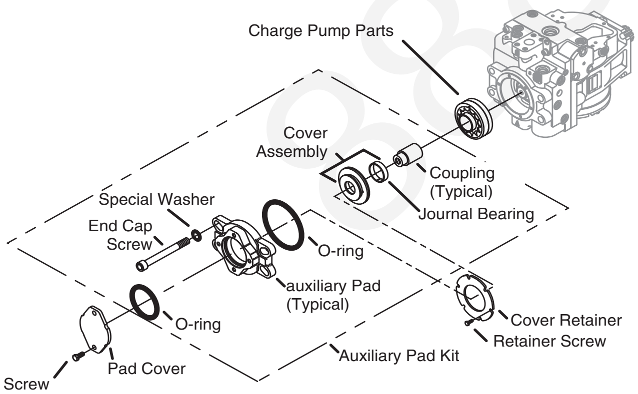
90000282
Remove Screws and Retainer



90000284
Remove Charge Pump Cover



90000296
Remove Large End Cap Screws



90000876E
Auxiliary Pad Components (Typical)

Auxiliary Pad Installation

1. Remove the six screws holding the charge pump cover retainer. Remove the retainer.

Frame Size	Wrench Size
030 - 100	10 mm
130 - 250	13 mm
	T002 287E

2. Remove the charge pump cover and its O-ring.

Note: The original charge pump cover will not be used when installing the auxiliary pad.

3. Remove the four large screws which fasten the end cap to the pump housing.

Frame Size	Wrench Sizes	
	Internal Hex	External Hex
030 - early 042	8 mm	
late 042	10 mm	
055		19 mm
075 - 100		24 mm
100 - 130	14 mm	
180 - 250	17 mm	
		T002 289E

Note: At earlier production frame size 75 pumps with twin ports secure the end cap to the pump housing with a clamp to avoid gasket damage.

Caution
Do not allow the force of the cylinder block spring and swashplate leveler springs to separate the end cap from the pump housing. Gasket damage and external leakage may result.
S000019E

4. Take care to assure the surfaces are clean and free of any foreign material or paint prior to installing the auxiliary pad.

5. Install the auxiliary drive coupling onto the pump drive shaft spline (auxiliary drive spline must be toward the rear of the pump).

6. Carefully remove the alignment pin from the charge pump parts. Install the pin in its hole in the new charge pump cover (with hole for the auxiliary coupling) and retain with petroleum jelly. Install the new charge pump cover with alignment pin into the end cap and the aligned charge pump parts.

Caution
In order to avoid loss of charge pressure in pumps with an auxiliary mounting pad, always install the charge pump cover with the pad drain hole located on the same side of the end cap as the charge inlet port. Refer to the section "Auxiliary Pad Installation" for details.
S000 020E

7. Install the charge pump cover retainer and the six hex screws and torque the screws.

Frame Size	Torque
030 - 100	13.5 Nm (10 lbf•ft)
130 - 250	32 Nm (24 lbf•ft)
	T002 288E

8. Install O-ring on end cap pilot.

9. Install the auxiliary mounting pad adapter on external pilot on rear of end cap.

10. Install four new large screws and washers through the mounting pad and end cap into the housing. Torque per the accompanying table.

Frame Size	Torque
030 - early 042	58 Nm (43 lbf•ft)
late 042	122 Nm (90 lbf•ft)
055	122 Nm (90 lbf•ft)
075 - 100	256 Nm (189 lbf•ft)
100 - 130	298 Nm (220 lbf•ft)
180 - 250	580 Nm (429 lbf•ft)
	T002 290E

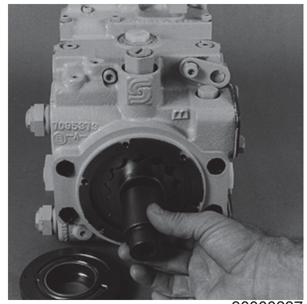
11. Install the O-ring and flange cover or auxiliary pump.

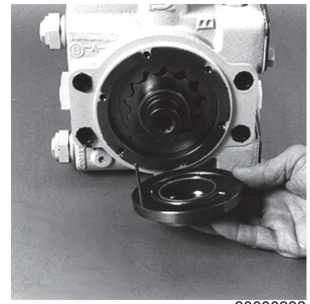
Auxiliary Pad Conversion

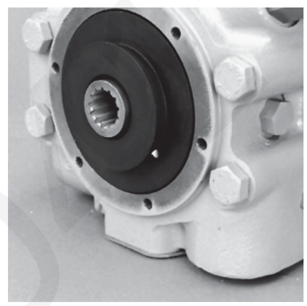
To convert an auxiliary mounting pad to a different size mounting pad, use the above procedure with the following additions:

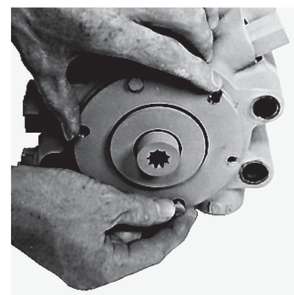
After removing the charge pump cover (step 2), remove the old auxiliary drive coupling.

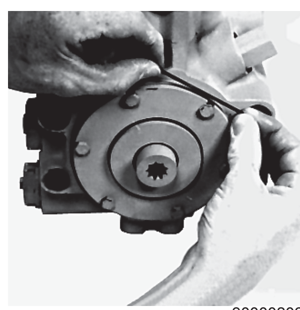
After removing the four end cap retaining screws, remove the old auxiliary mounting pad adapter.


90000297
Install Drive Coupling

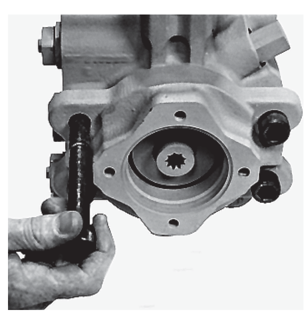

90000298
Install Alignment Pin in Cover (CCW rotation shown)

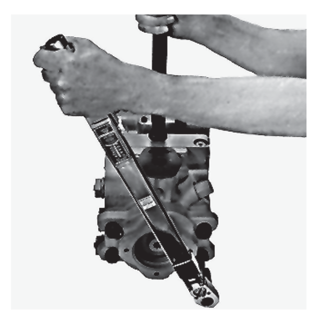

90000299
Install New Charge Pump Cover

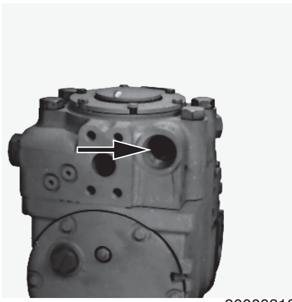

90000300
Install Screws and Cover Retainer


90000302
Install O-ring on End Cap Pilot

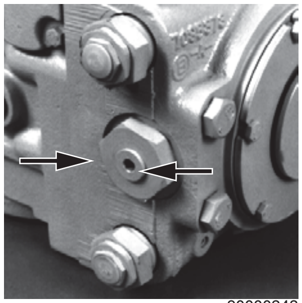

90000303
Install Auxiliary Pad Adapter


90000281
Install Auxiliary Pad Adapter Screws

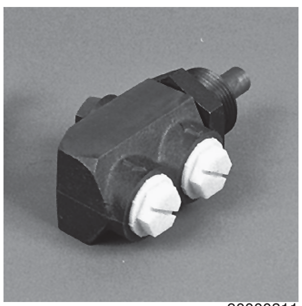

90000305
Torque Pad Adapter Screws



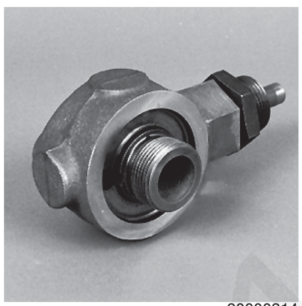
90000310
Charge Pump Inlet



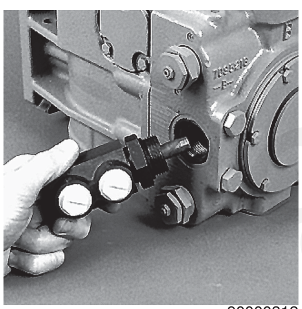
90000243
Reducer Fitting and Gauge Port Plug



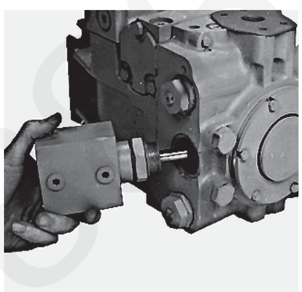
90000311
remote Pressure Filter Manifold



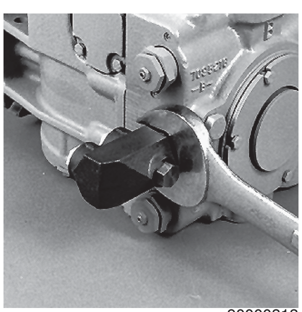
90000314
Integral Pressure Filter Head



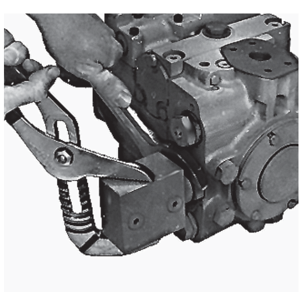
90000312
Install Remote Pressure Filter Manifold



90000315
Install Integral Pressure Filter Head



90000313
Tighten Remote Pressure Filter Manifold Lock Nut



90000316
Tighten Integral Pressure Filter Head Lock Nut

Filtration Options

Suction Filtration Installation

1. Install the hydraulic fitting to connect the external suction filter to the charge pump inlet port.

2. The reducer fitting (placed on the charge pressure gauge port) is installed as follows.

Frame Size	Wrench Size	Torque
030 - 042	1-1/4 inch	70 Nm (52 lbf•ft)
055 - 130	1-1/2 inch	122 Nm (90 lbf•ft)
180 - 250	1-1/2 inch	156 Nm (115 lbf•ft)
		T002 291E

The gauge port plug takes a 1/4 inch internal hex wrench and is torqued to 27 Nm (20 lbf•ft).

Remote Charge Pressure Filtration or Integral Charge Pressure Filtration

Install either of these two filtration devices as follows.

1. Remove the reducer fitting, located at charge pressure gauge port, from pump end cap (this part will not be used).

2. Install the filter manifold or filter head into the port. The hydraulic tube should enter its mating bore in the pump end cap with a low force.

3. After rotating the filter manifold or filter head clockwise so that the threads engage with the threads in the end cap, continue to rotate it clockwise between 6 and 7 revolutions. Face manifold or head to the desired position.

Caution
Failure to install the filter manifold or filter head to a sufficient depth in the end cap will result in insufficient engagement of the tube in the end cap bore. This may allow unfiltered oil to bypass the filter and enter the charge system.
S000021E

4. While holding the filter manifold or filter head in the desired position, tighten the swivel lock nut.

Frame Size	Wrench Size	Torque
030 - 042	1-3/8 inch	70 Nm (52 lbf•ft)
055 - 130	1-5/8 inch	122 Nm (90 lbf•ft)
180 - 250	1-5/8 inch	156 Nm (115 lbf•ft)
		T002 292E

5. After installing the integral pressure filter head assembly, install the filter canister per the instructions on the filter canister.

Pump controls

Cover Plate

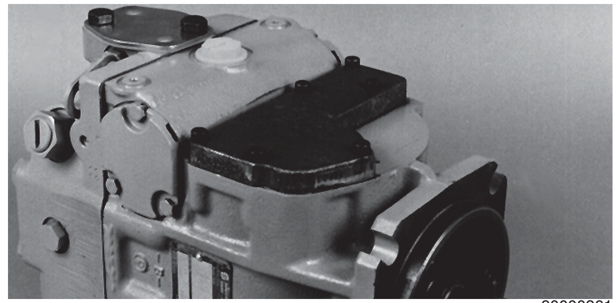
1. Thoroughly clean external surfaces prior to removal of cover plate.

2. Using a 5 mm internal hex wrench, remove the eight cover plate mounting screws. Remove the cover plate and gasket from housing.

> **Caution**
> **Protect exposed surfaces and cavities from damage and foreign material.**
> S000022E

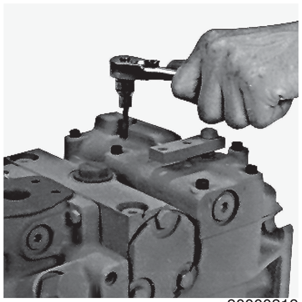
3. In preparation for installing the cover plate, place a new gasket on the housing. Place the cover plate into position and install the screws. Torque the screws to 16 Nm (12 lbf•ft).

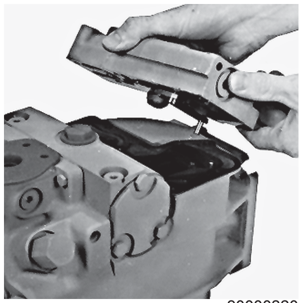
> **NOTE**
> **A sealing washer must be installed under the head of any mounting screws that are installed into "thru" holes in the housing.**
> S000023E

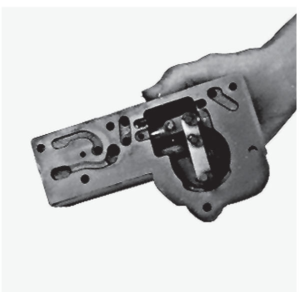


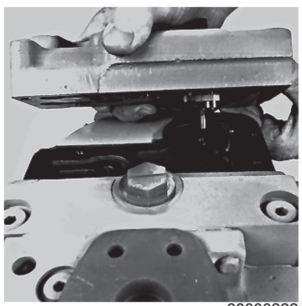
90000361

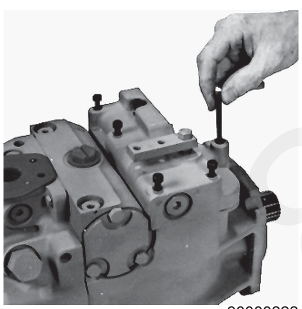
Pump with Cover Plate

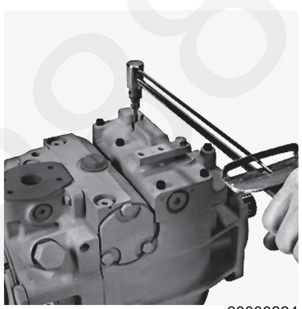

90000319
Remove Mounting Screws


90000320
Remove Control


90000321
Inner Face of Control


90000322
Assemble Control to Linkage


90000323
Assemble Control to Pump


90000324
Torque Mounting Screws

Manual Displacement Control (MDC)

1. Thoroughly clean external surfaces prior to removal of control.
2. Using a 5 mm internal hex wrench, remove the eight control mounting screws. Remove the control (with orifice check valve and spring) and control gasket from housing.

> **Caution**
> **Protect exposed surfaces and cavities from damage and foreign material.**
> S000022E

3. In preparation for installing the control, place a new gasket on the housing. Inspect to assure that the control orifice check valve and spring are in their proper position in the control.
4. While setting the control into position, engage the pin on the control linkage into the mating hole in the link attached to the swashplate.
5. With the control in position, move control lever both directions to check proper engagement of control linkage pin. Proper engagement will be indicated by centering torque as the lever is moved from center. Non-engagement of control linkage pin is indicated by lack of centering torque as the lever is moved. In case of non-engagement remove the control and repeat the above procedure.
6. Align the control gasket and install the screws. Torque the screws to 16 Nm (12 lbf•ft).

> **NOTE**
> **A sealing washer must be installed under the head of any mounting screws that are installed into "thru" holes in the housing.**
> S000023E

7. If the control is equipped with a neutral start switch, refer to the "MDC Neutral Start Switch Adjustment" instructions.

> **WARNING**
> **The neutral start switch "neutral" must be readjusted after reassembling the MDC module.**
> S000 024E

Solenoid Override Valve for MDC

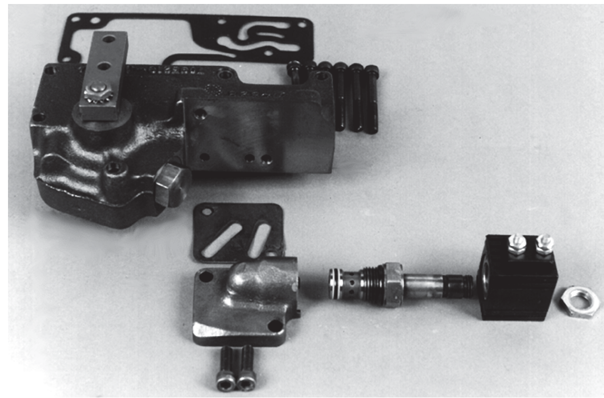
1. Thoroughly clean external surfaces prior to removal of valve.

2. Using a 5 mm internal hex wrench, remove the two screws and remove solenoid manifold from housing. Remove the old gasket.

3. The solenoid may be removed from the valve by removing the nut with a 3/4 inch hex wrench. The solenoid valve may be removed from the manifold with a 7/8 inch hex wrench.

4. When installing the solenoid valve into the manifold, the valve should be torqued to 24 ± 2.4 Nm (17.7 ± 1.8 lbf•ft). When installing the solenoid onto the valve, torque the nut to 6 Nm (53 ± 12 lbf•in).

5. In preparation for installing the solenoid manifold, place a new gasket on the control housing. Install the manifold onto the control housing, align the gasket, and install the screws. Torque the screws to 13.5 Nm (10 lbf•ft).



90000363

Components of Solenoid Override for MDC

Solenoid Override Valve for MDC with Pressure Released Brake

1. Thoroughly clean external surfaces prior to removal of valve.

2. Using a 4 mm internal hex wrench, remove the four solenoid valve mounting screws. Remove the solenoid valve (with O-rings) from the adapter plate.

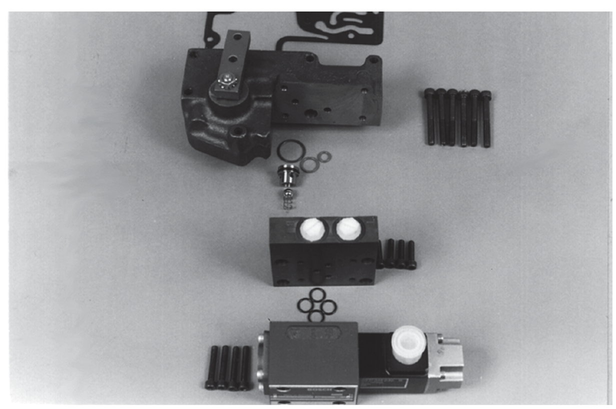
3. Using a 4 mm internal hex wrench, remove the four adapter plate mounting screws. Remove the adapter plate and O-rings from the control housing.

4. Remove the check valve seat and O-ring from the control side of the adapter plate. Remove the check ball and spring.

5. Install a new O-ring on the check valve seat and reassemble the check valve spring, ball, and seat into the adapter plate.

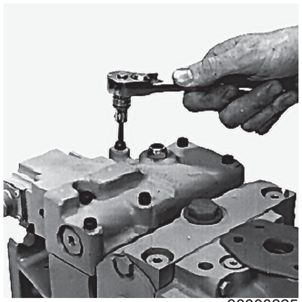
6. Install new O-rings on the adapter plate. Place the adapter plate into position and install the screws. Torque the screws to 5.4 Nm (48 lbf•in).

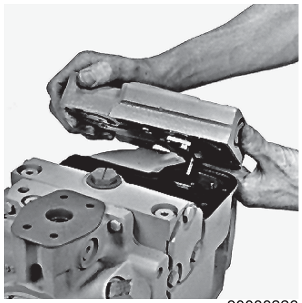
7. Install new O-rings onto the solenoid valve assembly and install the solenoid valve onto the adapter plate. Install the screws and torque to 5.4 Nm (48 lbf•in).



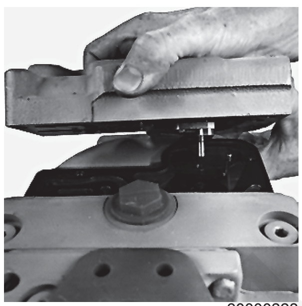
90000364

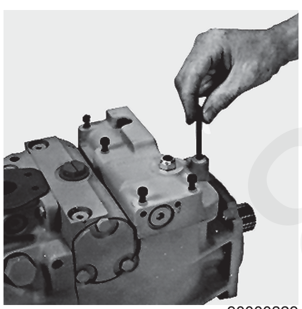
Components of Solenoid Override with Brake Pressure Defeat for MDC

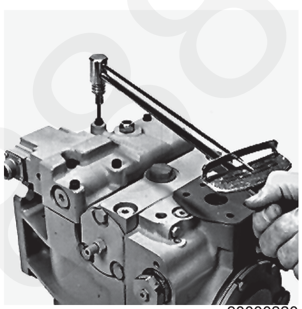

90000325
Remove Mounting Screws


90000326
Remove Control

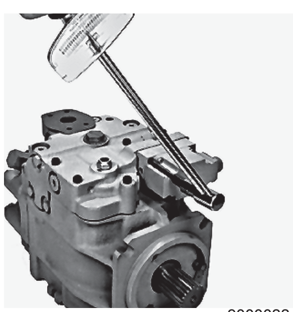

90000327
Inner Face of Control


90000328
Assemble Control to Linkage


90000329
Install Mounting Screws


90000330
Torque Mounting Screws


90000332
PCP Components


90000334
Torque PCP Valve Screws

Hydraulic and Electric Displacement Controls

1. Thoroughly clean external surfaces prior to removal of control.

2. Using a 5 mm internal hex wrench, remove the eight control mounting screws. Remove the control (with orifice check valve and spring) and control gasket from housing.

> **Caution**
> **Protect exposed surfaces and cavities from damage and foreign material.**
> S000022E

3. In preparation for installing the control, place a new gasket on the housing. Inspect to ensure that the control orifice check valve and spring are in their proper position in the control.

4. While setting the control into position, engage the pin on the control linkage into the mating hole in the link attached to the swashplate.

5. With the control in position, move control assembly left and right to check engagement of pin in the link. Proper engagement will be indicated by an increasing resistance as the control is moved away from center position. Non-engagement of pin will be indicated by lack of spring force. In case of non-engagement, remove control and repeat the above procedure.

6. Align the control gasket and install the screws. Torque the screws to 16 Nm (12 lbf•ft).

> **Caution**
> **A sealing washer must be installed under the head of any mounting screws that are installed into "thru" holes in the housing.**
> S000 023E

Pressure Control Pilot (PCP) for Electric Displacement Control

1. Thoroughly clean external surfaces of control.

2. Using a 4 mm internal hex wrench, remove the four screws and remove the PCP.

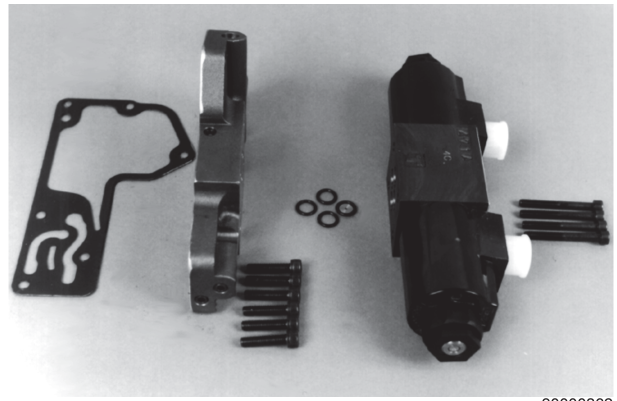
3. Check surfaces for nicks or damage. Clean internal screens.

4. Install new O-rings in PCP Housing. Place PCP against EDC housing and install the screws. Torque to 5.4 Nm (48 lbf•in).

Note: Do not remove black plastic cover from the aluminum plate. This is not a serviceable item and will void the product warranty.

3-Position (FNR) Electric Control

1. Thoroughly clean external surfaces prior to removal of control.
2. Using a 4 mm internal hex wrench, remove the four solenoid valve mounting screws. Remove the solenoid valve (with O-rings and orifice) from the adapter plate.
3. Using a 5 mm internal hex wrench, remove the eight adapter plate mounting screws. Remove the adapter plate and gasket from housing.



90000362
3-Position Electric Control Components

> **Caution**
> **Protect exposed surfaces and cavities from damage and foreign material.**
> S000022E

4. Inspect the orifice installed between the valve and adapter plate. This orifice MUST be installed in the case drain passage for proper pressure limiter operation.
5. In preparation for installing the adapter plate, place a new gasket on the housing. Place the adapter plate into position and install the screws. Torque the screws to 16 Nm (12 lbf•ft).

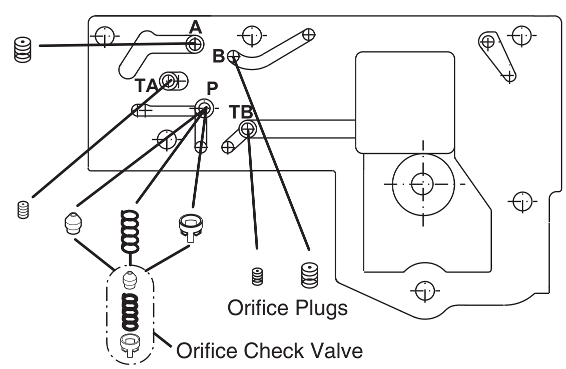
> **NOTE**
> **A sealing washer must be installed under the head of any mounting screws that are installed into „thru“ holes in the housing.**
> S000023E

6. Install new O-rings and the orifice onto the solenoid valve assembly and install the solenoid valve onto the adapter plate. Install the screws and torque to 5.4 Nm (48 lbf•in).

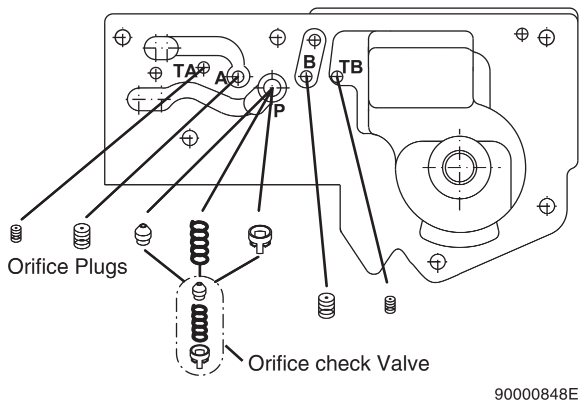
Displacement Control Components

Displacement Control Orifices

1. Remove the control assembly as described in the instructions for the specific displacement control.
2. Orifice plugs may be located in the control assembly, at the pump housing face surface. Remove the orifice plugs with a 4 mm internal hex wrench. Note the location of each plug, do not interchange plugs. Torque the orifice plugs to 3 Nm (26 lbf•in).
3. Assemble the control onto the pump. Refer to the instructions for the specific control.



90000849E
Underside of an HDC/EDC Module Showing Orifice Locations



Underside of an MDC Module Showing Orifice Locations

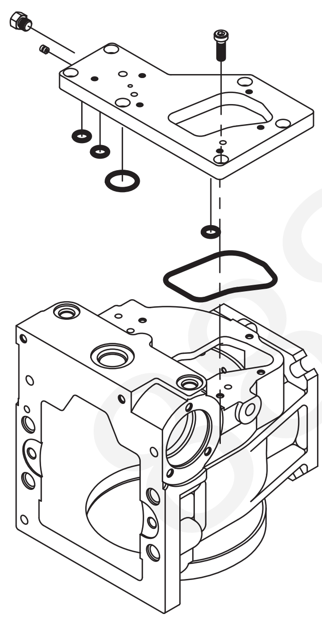
Displacement Control Orifice Check Valve

1. Remove the control assembly as described in the instructions for the specific displacement control.

2. The orifice check valve is located in the control assembly, at the surface of the pump housing face. Remove the spring retainer and spring from the orifice check valve cavity and then remove the orifice check valve.

3. Install the desired orifice check valve in the cavity and then install the spring and spring retainer to hold the orifice check valve in position.

4. Assemble the control onto the pump. Refer to the instructions for the specific control.



Displacement Control Adapter Plate (Early production 130cc Pumps only)

Displacement Control Adapter Plate (Early production 130 Pumps only)

The screws fastening the control adapter plate to the housing have retaining compound on the threads. They are removed with a 6 mm internal hex wrench.

When installing the adapter plate, ensure the O-rings are in the proper position and torque the screws to 32 Nm (24 lbf•ft).

Displacement Control Filter Screens

If the pump is equipped with control filter screens in the pump housing (late production), they should be pressed into position (with the rounded edge of the filter screens facing the control until they are flush to 2.0 mm (0.08 inch) below the surface of the housing.

Minor Repair - Motor

Loop Flushing and Charge Relief Valves

Loop Flushing Valve

1. Using an 1-1/16 inch wrench, remove the hex plugs and O-rings from both sides of the valve. Remove the springs, shoulder washers, and flushing valve shuttle spool. Note orientation of the washers. Remove the flushing valve spool.

2. Inspect parts for damage or foreign material.

Note: Early production motors used a small diameter shuttle valve spool. Late production motors use a larger diameter spool.

3. Install flushing valve spool in end cap, then install the shoulder washers (with shoulders facing “out”) and springs on each end of the spool. Install the hex plugs with O-rings, and torque to 41 Nm (30 lbf•ft) on 030 through 100 motors or 68 Nm (50 lbf•ft) on 130 motors.

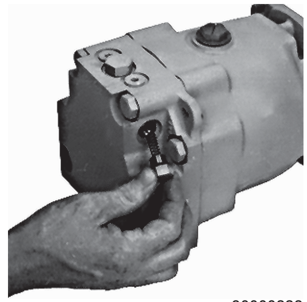
Motor Charge Relief Valve

1. Remove the shim adjustable charge relief valve plug with a 7/8 inch hex wrench.

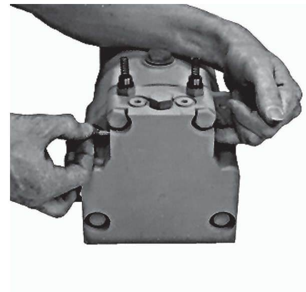
   Before removing the screw adjustable relief valve plug, mark the plug, lock nut, and housing so as to be able to maintain the original adjustment when assembling. Remove the screw adjustable charge relief valve plug by loosening the lock nut with a 1-1/16 inch hex wrench for 030 through 100 units, or a 1-5/8 inch hex wrench for 130 units, and unscrewing the plug with a large screwdriver or 1/2 inch hex wrench.

2. Remove the spring and valve poppet.

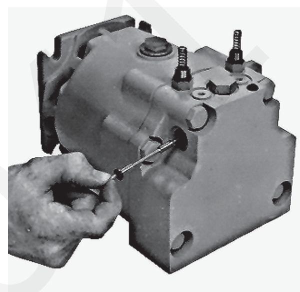
3. Inspect the poppet and mating seat in the end cap for damage or foreign material. When inspecting shim adjustable valves, do not alter the shims or interchange parts with another valve.



90000338
Remove Plugs Springs



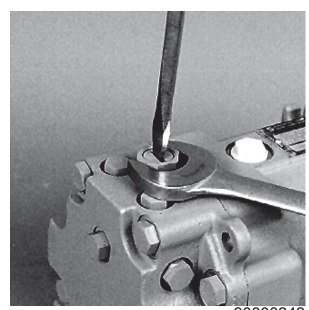
90000339
Remove Flushing Shuttle Spool



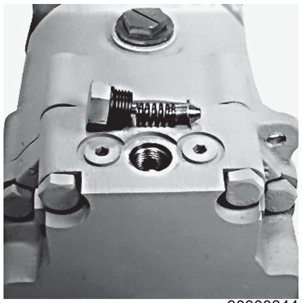
90000340
Install Flushing Shuttle Spool

90000341
Torque Plugs

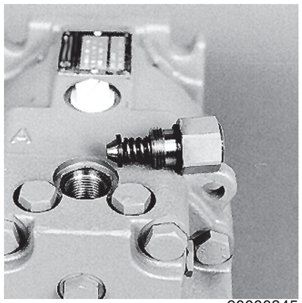
90000342
Remove Shim Charge Relief Valve



90000343
Remove Screw Charge Relief Valve



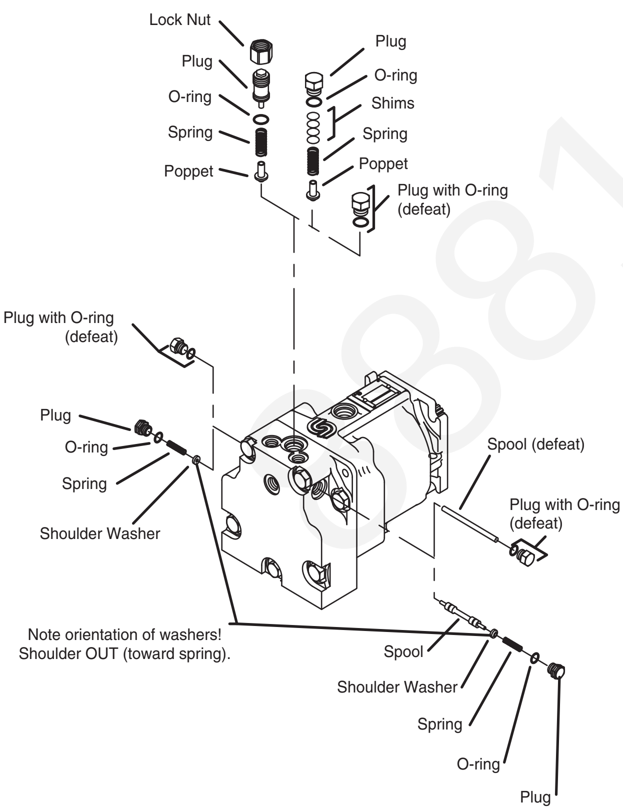
90000344
Shim Adjustable Charge Relief Valve



90000345
Screw Adjustable Charge Relief Valve

4. Install the poppet and spring. For shim adjustable valves, install the plug and torque to 68 Nm (50 lbf•ft). For screw adjustable valves, install the plug with its lock nut, aligning the marks made at disassembly, and torque the lock nut to 52 Nm (38 lbf•ft).

5. Check and adjust the charge pressure.



90000850E
Motor charge Relief Valve and Loop Flushing Valve Parts

Defeating the Loop Flushing Valve

1. Remove loop flushing valve components (these parts will not be used).

2. Install defeating spool into spool bore in end cap.

3. Install hex plugs provided and torque to 41 Nm (30 lbf•ft).

4. Remove charge relief valve components (these parts are not necessary).

5. Replace with the hex plug provided and torque to 41 Nm (30 lbf•ft).

Variable Motor Displacement Limiters

1. Remove the tamper-resistant cap from the displacement limiter. Measure and note the length of the adjustment screw up to the seal lock nut. Using a 19 mm hex wrench, loosen the seal lock nut and remove the nut. Remove the limiter screw from the motor housing with a 6 mm internal hex wrench.

2. Install the limiter screw with the noted length between adjustment screw and the seal lock nut. Do not install a new tamper-resistant cap until the limiter has been adjusted.

3. Final adjustment of the displacement limiters should be performed on a test stand.

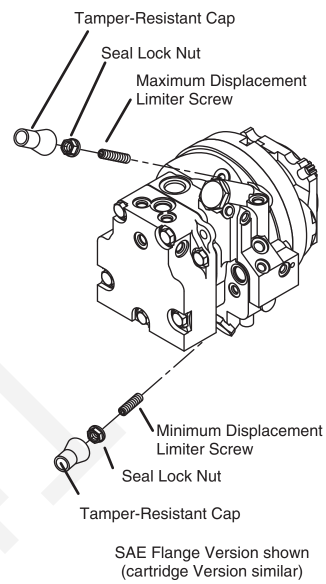
   Do not turn the limiter screws counterclockwise beyond their initial adjustment positions.

> **Caution**
> **Care should be taken in adjusting displacement limiters to avoid undesirable speed conditions. The seal lock nut must be retorqued after every adjustment to prevent an unexpected change in operating conditions and to prevent external leakage during unit operation.**
> S000026E

   One full turn of the displacement limiter adjustment screw will change the displacement as follows:

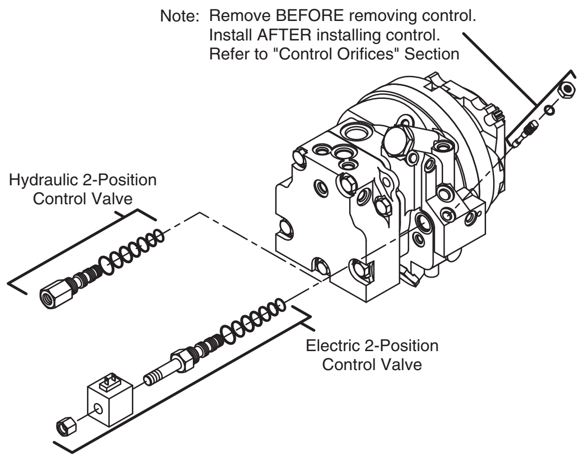
Frame Size	Approx Change in Disp per Rev of Adjusting Screw
055	5.6 cm^3 / Rev (0.34 in^3 / Rev)
075	7.1 cm^3 / Rev (0.43 in^3 / Rev)
	T002 295E

4. Following the final adjustment, install new tamper resistant caps.



MV Displacement Limiters

Variable Motor Controls



MV Control components

Electrohydraulic 2-Position Control (Types NA, NB, NC, and ND)

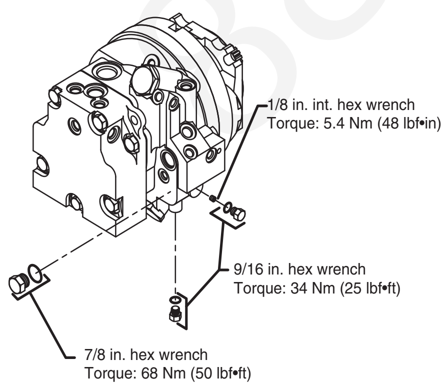
1. Thoroughly clean external surfaces prior to removal of the control.
2. Disconnect the external electrical signal connection.
3. Remove the hex nut and solenoid from the control valve.
4. Remove the orifice check valve for the maximum angle control cylinder, if equipped.
5. Remove the control valve from the motor housing.
6. Remove O-rings from the valve.
7. Install new O-rings on the control valve.
8. Install the valve into the motor housing and torque to 47 Nm (35 lbf•ft). **Do not overtorque the control valve.** Over-torquing may result in the valve spool sticking.
9. Install the solenoid onto the valve and torque the hex nut to 5 Nm (44 lbf•in). **Do not overtorque the nut.**
10. If previously removed, reinstall the orifice check valve. Reconnect the external signal connection.

Hydraulic 2-Position Control (Type PT)

Follow the steps above, except that in step 2 a hydraulic signal line will be disconnected, and steps 3 and 9 are not applicable.

Control Plugs

Remove the control plugs from the housings of earlier production motors, if necessary. Install new O-rings, reinstall, and torque.



MV Control Plugs

Variable Motor Control Orifices

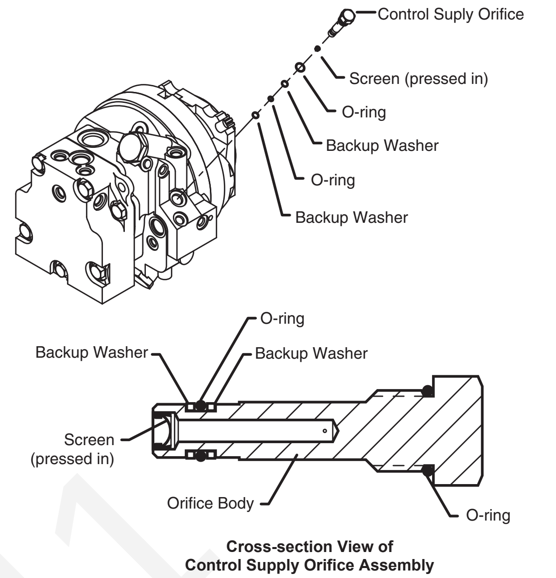
Control Supply Orifice

1. Remove the control supply orifice from the motor housing with an 1-1/16 inch hex wrench.

2. Remove the O-rings and the backup washers. Check that the filter screen is secure in the orifice body and that the screen and the orifice are not plugged.

3. Install new backup washers and O-rings onto the orifice body. Install the orifice into the motor housing and torque to 37 Nm (27 lbf•ft).

> **Caution**
> **Do not interchange the control supply orifice with the minimum displacement orifice (next section).**
> S000027E



90000854E

MV Control Supply Orifice

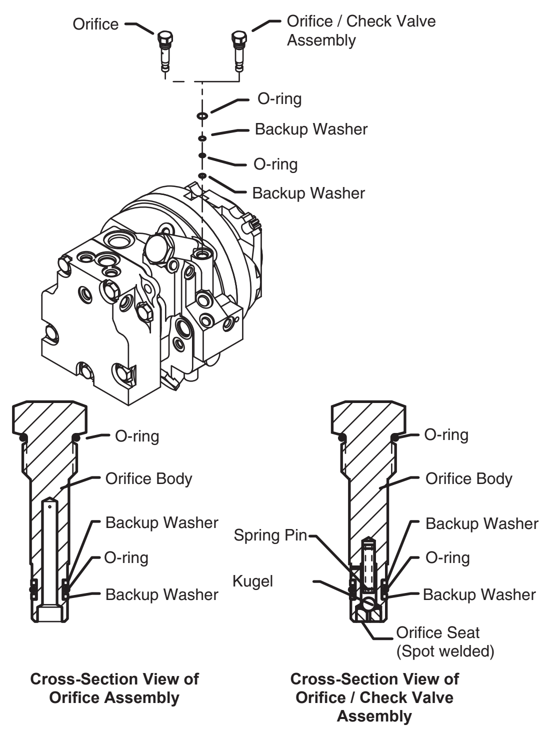
Minimum Displacement Cylinder Orifice or Orifice Check Valve

1. Remove the minimum displacement cylinder drain orifice or the orifice check valve from the motor housing with an 1-1/16 inch hex wrench.

2. Remove the O-rings and the backup washers. Check that the orifice is not plugged. Check that the check valve seat is secure in the body and that the check ball is free.

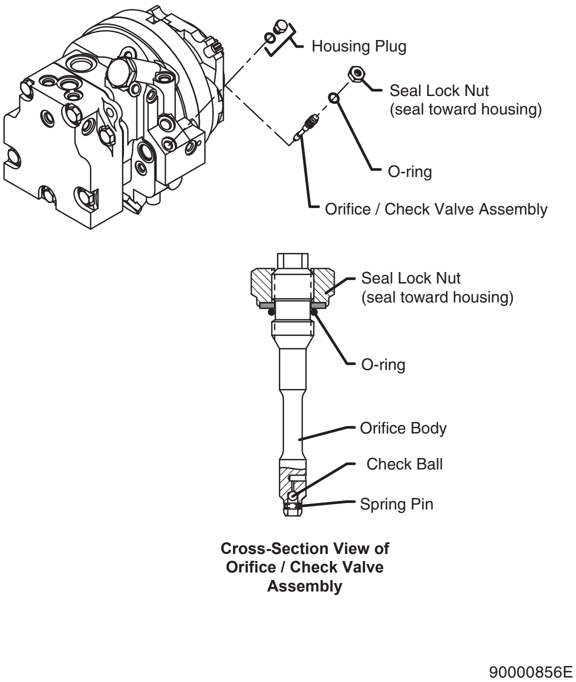
3. Install new backup washers and O-rings onto the orifice body. Install the orifice into the motor housing and torque to 37 Nm (27 lbf•ft).

> **Caution**
> **Do not interchange the control supply orifice (previous section) with the minimum displacement orifice.**
> S000 028E



90000855E

MV Minimum Displacement Orifice



MV Maximum Displacement Orifice

Maximum Displacement Cylinder Orifice Check Valve

1. Remove the seal lock nut with a 3/4 inch hex wrench. Remove the maximum displacement cylinder orifice check valve from the motor housing with a 1/4 inch end wrench. Remove the O-ring. The check ball in the valve must be free.

2. Reinstall the check valve and torque to 15 Nm (11 lbf•ft). Install a new O-ring. Install the seal lock nut with the seal toward the motor housing.

   Hold the check valve from turning while torquing the seal lock nut to 34 Nm (25 lbf•ft).

3. If no orifice check valve is installed, the housing plug may be removed with a 9/16 inch hex wrench. Always install a new O-ring. Reinstall the plug and torque to 20 Nm (15 lbf•ft).

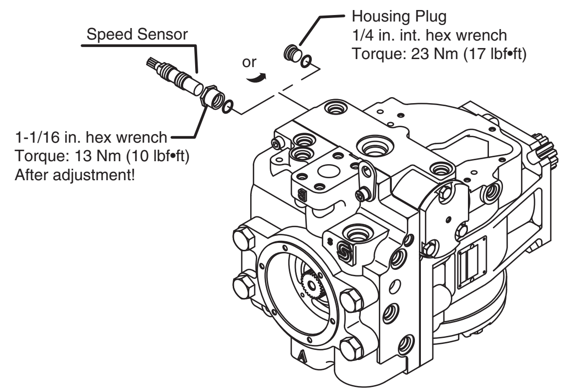
Speed Sensor

1. Remove the speed sensor by disconnecting the electrical connector, loosening the lock nut, and unscrewing the speed sensor from the pump or motor housing.

2. Always install a new O-ring before installing the sensor.

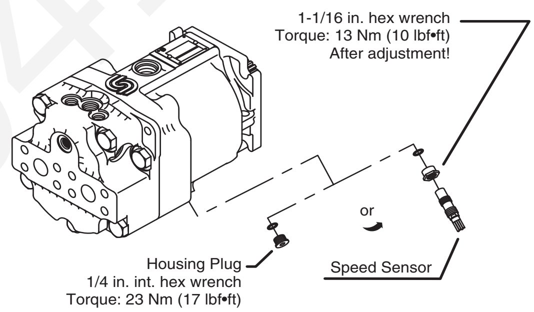
3. Reinstall the speed sensor (with lock nut and O-ring) into the housing. Adjust the gap between the sensor and the magnetic speed ring as instructed in Section "Speed Sensor Adjustment" and torque the sensor lock nut.

4. If a speed sensor is not installed, the housing plug should be torqued as indicated in the accompanying figure.



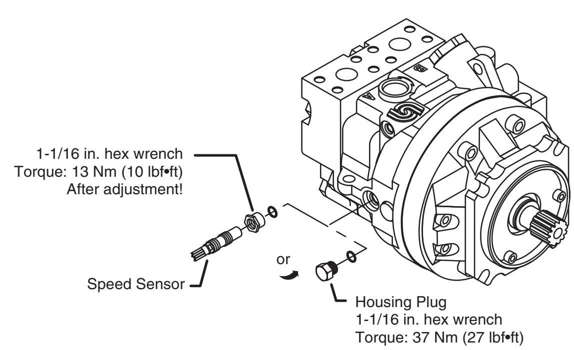
90000857E

Typical Location of Speed Sensor - PV



90000858E

Typical Location of Speed Sensor - MF



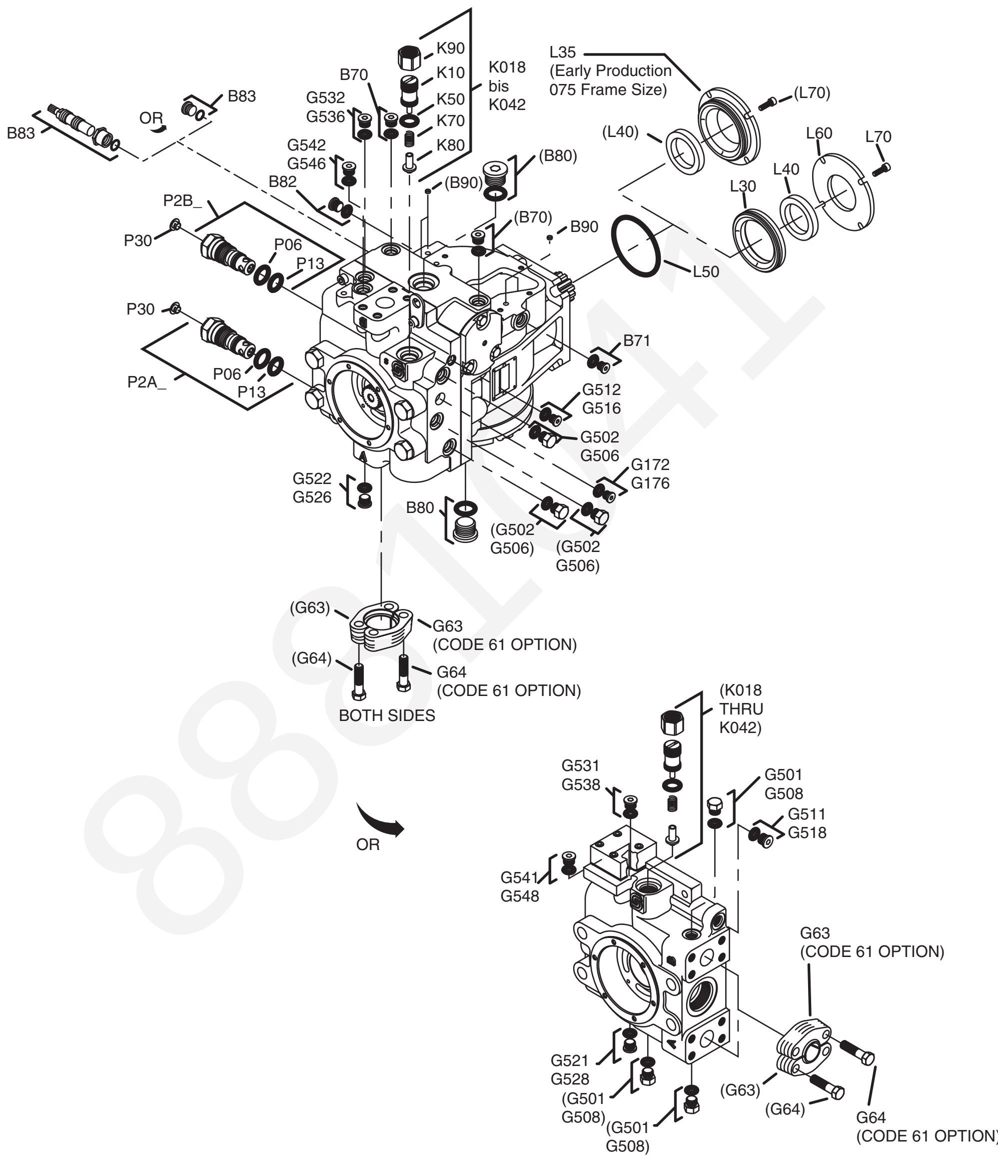
90000859E

Typical Location of Speed Sensor - MV

Exploded View Parts Drawings / Parts Lists

Variable Pumps

Minor Repair Parts



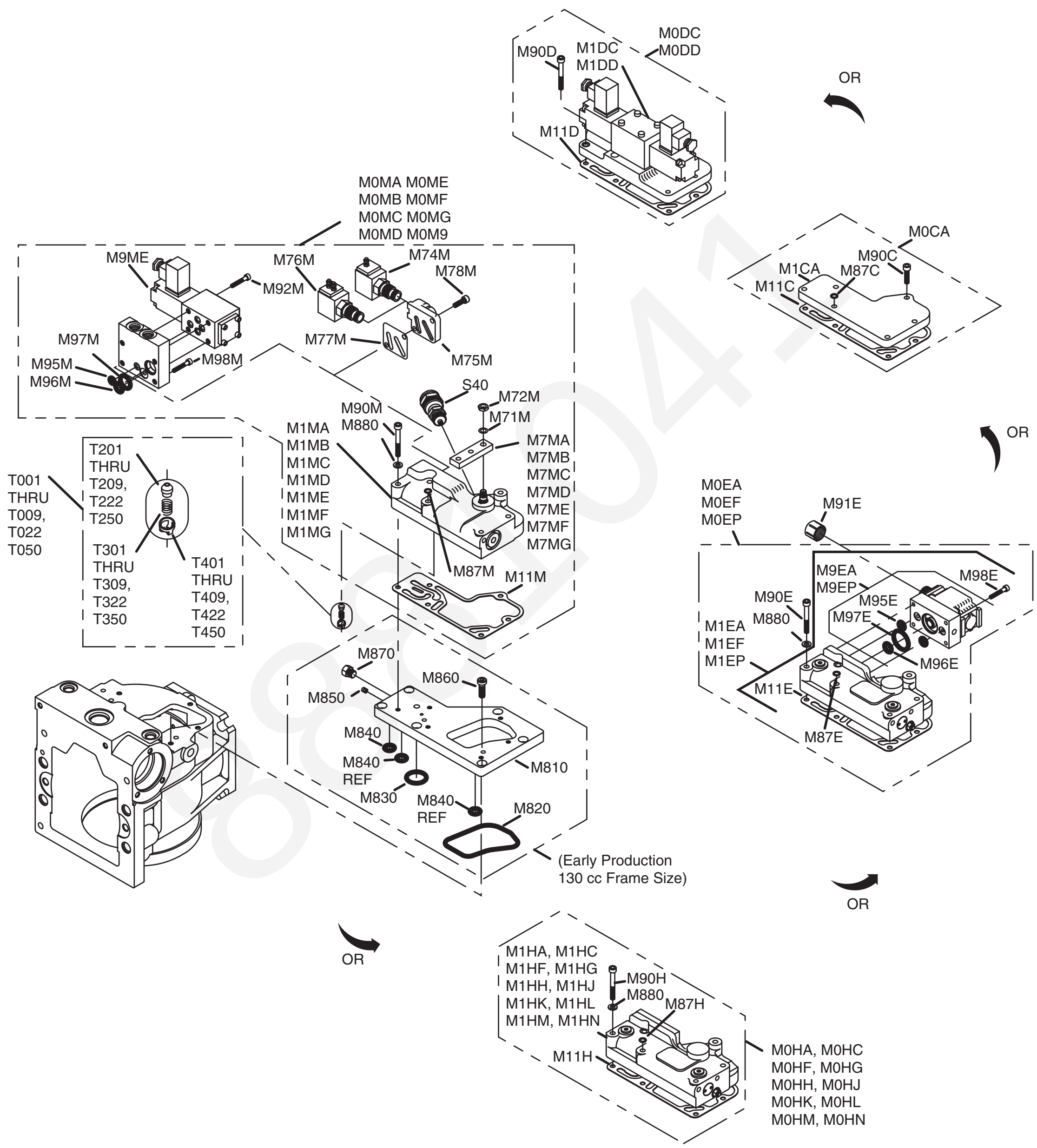
90000860E

Parts List

Item	Description	Qty
B70	Plug	2
B71	Plug	1
B80	Plug	1
B82	Plug	1
B90	Filter screen	3
G63	Split flange clamp	4
G64	Plug	4
G172	Plug	1
G176	O-ring	1
G501	Plug	3
G502	Plug	3
G506	O-ring	3
G508	O-ring	3
G511	Plug	1
G512	Plug	1
G516	O-ring	1
G518	O-ring	1
G521	Plug	1
G522	Plug	1
G526	O-ring	1
G528	O-ring	1
G531	Plug	1

Item	Description	Qty
G532	Plug	1
G536	O-ring	1
G538	O-ring	1
G541	Plug	1
G542	Plug	1
G546	O-ring	1
G548	O-ring	1
K10	Plug assembly	1
K50	O-ring	1
K70	Spring	1
K80	Poppet	1
K90	Nut	1
L30	Seal carrier	1
L35	Seal carrier	1
L40	Lip seal	1
L50	O-ring	1
L60	Retainer	1
L70	Screw	3
L8	Key	1
L9	Slotted nut	1

Variable Pump Controls

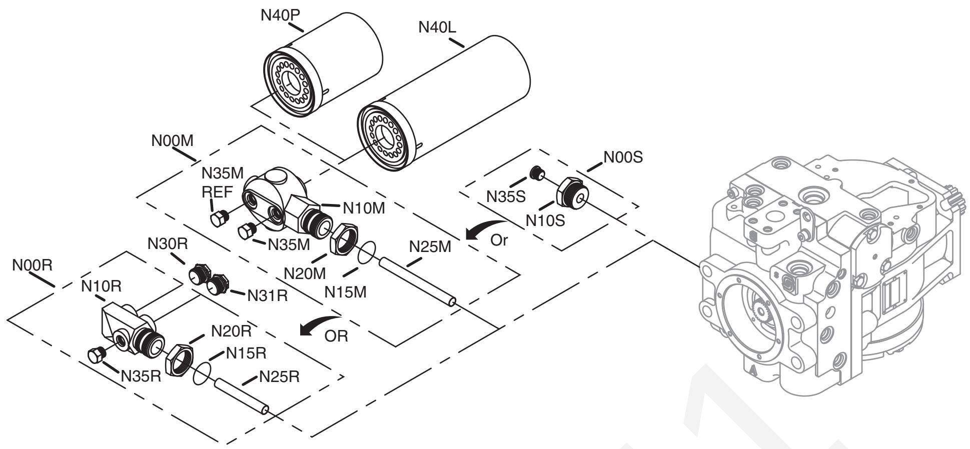


90000861E

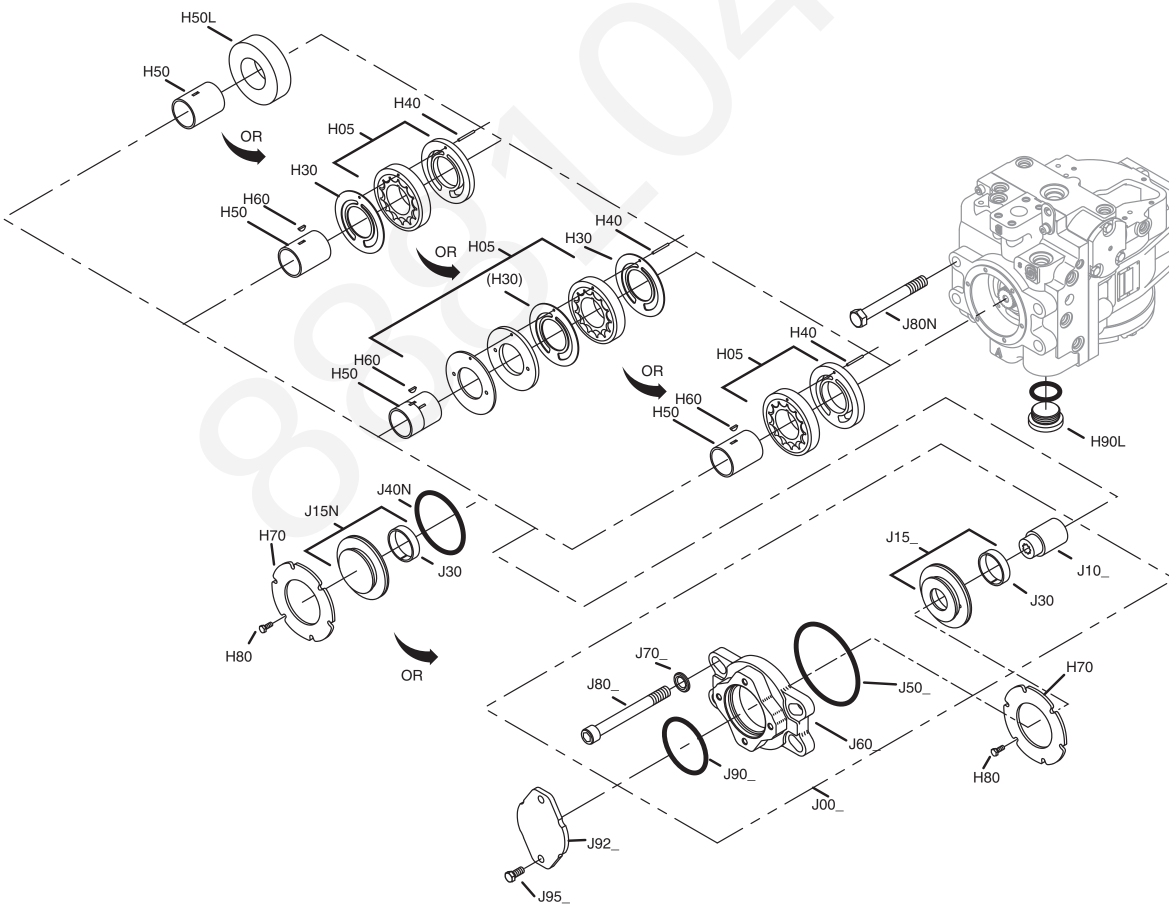
Control Parts List

Item	Description	Qty
M0CA	Cover plate kit	1
M1CA	Cover plate	1
M11C	Control gasket	1
M11D	Control gasket	1
M87C	Washer, seal (042)	1
M90C	Screw	6
M0DC	Control kit, 3-position FNR 12V	1
M0DD	Control kit, 3-position FNR 24V	1
M1DC	Control, 3-position FNR 12V	1
M1DD	Control, 3-position FNR 24V	1
M80	Control gasket	1
M87D	Washer, seal (042)	1
M90D	Screw	6
M0EA	Control kit, EDC with MS connector	1
M0EP	Control kit, EDC with Packard connector	1
M1EA	Control, EDC with MS-connector	1
M1EP	Control, EDC with Packard-connector	1
M9EA	PCP type 3 oil filled (MS)	1
M9EA	PCP type 3 oil filled (Packard)	1
M80	Control gasket	1
M87E	Washer, seal (042)	1
M90E	Screw	6
M91E	Plastic cap (MS)	1
M95E	O-ring	2
M96E	O-ring	1
M97E	O-ring	1
M98E	Screw	4
M1MA	Servovalve kit	1
M0HA	Control kit, hydraulic, HDC	1
M0HC	Control kit, hydraulic, HDC	1
M1HA	Control, hydraulic, HDC	1
M1HC	Control, hydraulic, HDC	1
M11H	Control gasket	1
M80	Control gasket	1
M87H	Washer, seal (042)	1
M90H	Screw	6
M0MA	Control MDC w/o neutral start switch	1
M7M	Control handle	1
M71M	Washer	1
M72M	Nut	1
M80	Control gasket	1
M87M	Washer, seal (042)	1
M90M	Screw	6
M0MB	Control MDC w/ neutral start switch	1
M7M	Control handle	1
M71M	Washer	1
M72M	Nut	1
M80	Control gasket	1
M87M	Washer, seal (042)	1
M90M	Screw	6
S40	Neutral start switch kit	1
M0MC	Control MDC w/ sol. valve	1
M7M	Control handle	1
M71M	Washer	1
M72M	Nut	1
M74M	Solenoid valve	1
M75M	Control manifold	1
M77M	Manifold gasket	1
M78M	Screw	2
M80	Control gasket	1
M87M	Washer, seal (042)	1
M90M	Screw	6
M0MD	Control MDC w/ sol. valve and neutral start switch	1
M7M	Control handle	1
M71M	Washer	1
M72M	Nut	1
M75M	Control manifold	1
M76M	Solenoid valve	1
M77M	Manifold gasket	1
M78M	Screw	2
M80	Control gasket	1
M87M	Washer, seal (042)	1
M90M	Screw	6
S40	Neutral start switch	1
M810	Adapter plate - Control (130 cc)	1
M820	O-ring (130 cc)	1
M830	O-ring (130 cc)	1
M840	O-ring (130 cc)	2
M850	Plug (130 cc)	1
M860	Screw (130 cc)	6
M870	Plug (130 cc)	1
M9ME	4/2 Way valve	1
M92M	Screw	4
M95M	O-ring	1
M96M	O-ring	1
M97M	O-ring	1
M98M	Screw	4
T001-9	Control orifice kit	1
T201-9	Orificed check valve	1
T301-9	Spring	1
T401-9	Spring retainer	1

Filter and Options



90000862E

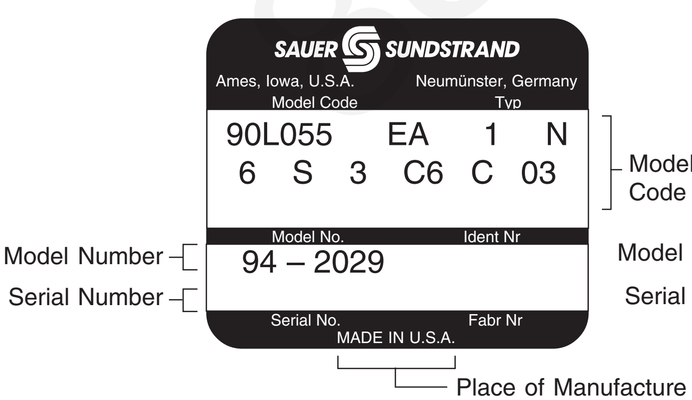


90000863E

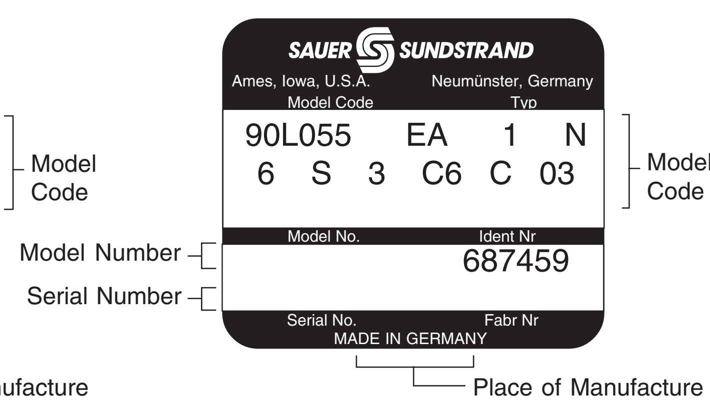
Parts List Filter and Options

Item	Description	Qty
H05B-H	Kit - Charge pump	1
H50L	Spacer (No charge pump)	1
H30	Port plate	2
H40	Pin	1
H50	Charge pump shaft	1
H60	Key	1
H70	Retaining plate	1
H80	Screw	6
H90L	Plug	1
J00A	Aux. mtg. SAE A flange	1
J00B	Aux. mtg. SAE B flange	1
J00C	Aux. mtg. SAE C flange	1
J00D	Aux. mtg. SAE D flange	1
J00T	Aux. mtg. SAE A flange (11 T)	1
J00V	Aux. mtg. SAE B-B flange	1
J00N	Aux. mtg. flange - none	1
J10A-V	Coupling	1
J15	Charge pump cover assembly	1
J15N	Charge pump cover assembly	1
J30	Bushing	1
J50A-V	O-ring	1
J60A/T	Flange adaptor SAE A	1
J60B/V	Flange adaptor SAE B	1
J60C	Flange adaptor SAE C	1
J60D	Flange adaptor SAE D	1
J70A-V	Washer	4
J80A-V	Screw	4
J80N	Screw	4
J90A-V	O-ring	1
J92A-V	Cover plate	1
J95A-V	Screw	2/4
N00M	Filtration manifold kit (Int)	1
N10M	Manifold	1
N15M	O-ring	2
N20M	Nut	1
N25M	Tube	1
N35M	Plug	2
N40L	Filter	1
N40P	Filter	1
N00R	Filtration manifold kit (Rmt)	1
N10R	Manifold	1
N15R	O-ring	1
N20R	Nut	1
N25R	Tube	1
N30R	Plastic plug	2
N35R	Plug	1
N00S	Filtration kit (Suction Flt)	1
N10S	Reducer fitting (Suction Flt)	1
N35S	Plug	1

Name Plates



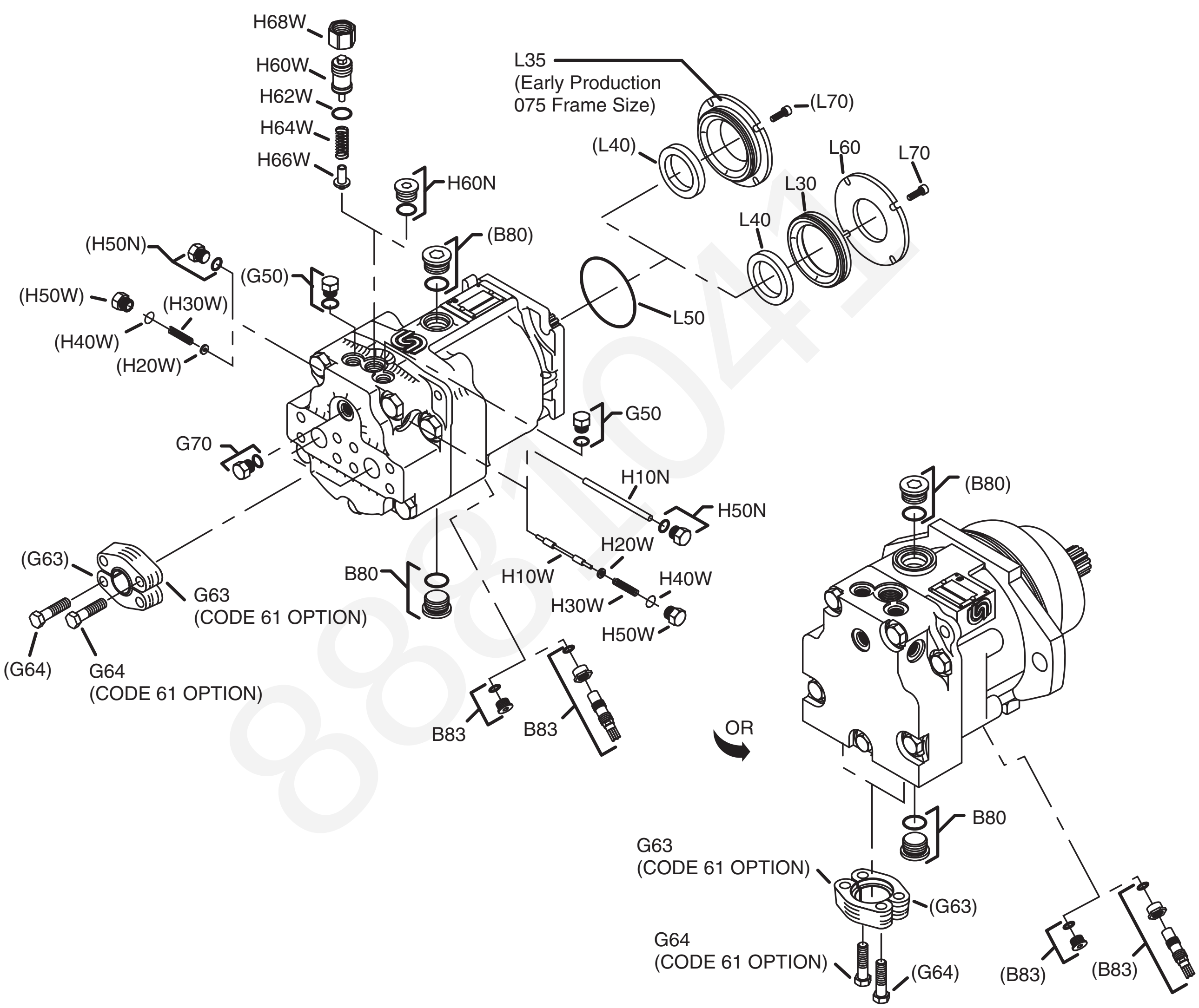
Name Plate (U.S.A. Production)



Name Plate (German Production)

Fixed Motor

Minor Repair Parts



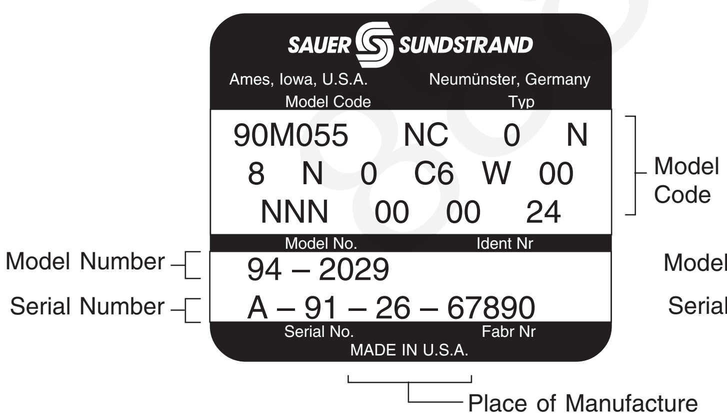
90000864E

Parts List

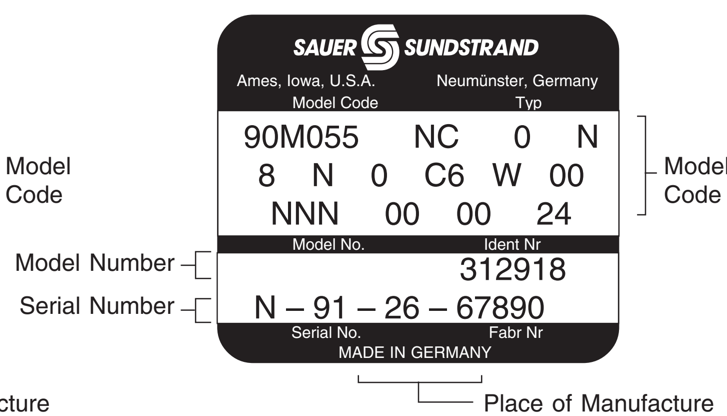
Item	Description	Qty
B80	Plug	2
B83	Plug	1
B83	Speed sensor	1
G50	Plug	2
G70	Plug	1
G63	Split flange screw	4
G64	Screw - Shipping Cover	4
H10N	Loop flushing spool - defeat	1
H50N	Plug	2
H10W	Shuttle valve spool	1
H20W	Spring guide	2
H30W	Spring	2
H40W	O-ring	2

Item	Description	Qty
H50W	Plug	2
H60W	Charge relief valve plug	1
H62W	O-ring	1
H64W	Spring	1
H66W	Charge relief poppet	1
H68W	Lock nut	1
L30	Seal carrier	1
L35	Seal carrier	1
L40	Lip seal	1
L50	O-ring	1
L60	Retainer	1
L70	Screw	3
L8	Key	1
L9	Slotted nut	1

Name Plates



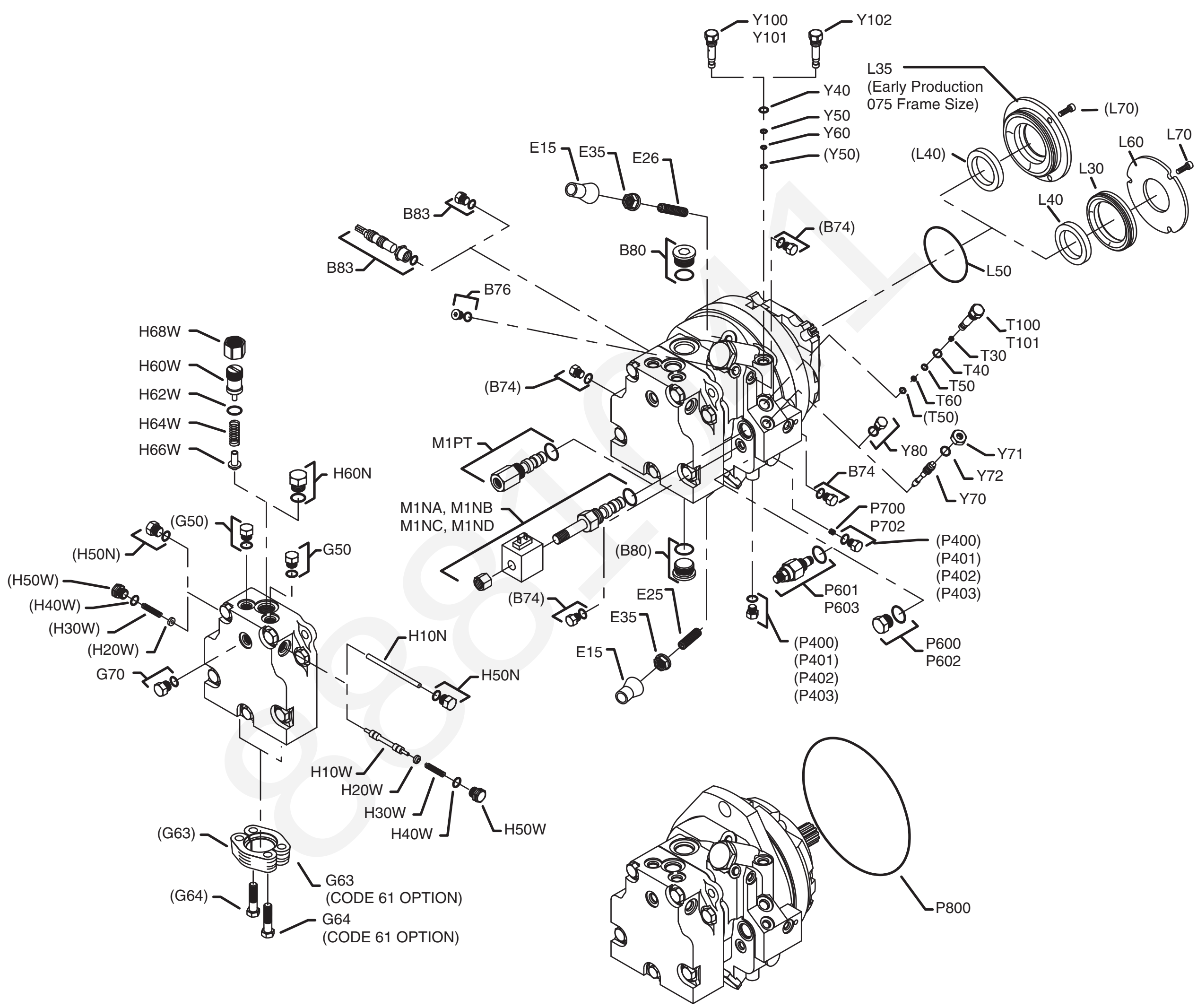
Name Plate (U.S.A. Production)



Name Plate (German Production)

Variable Motor

Minor Repair Parts



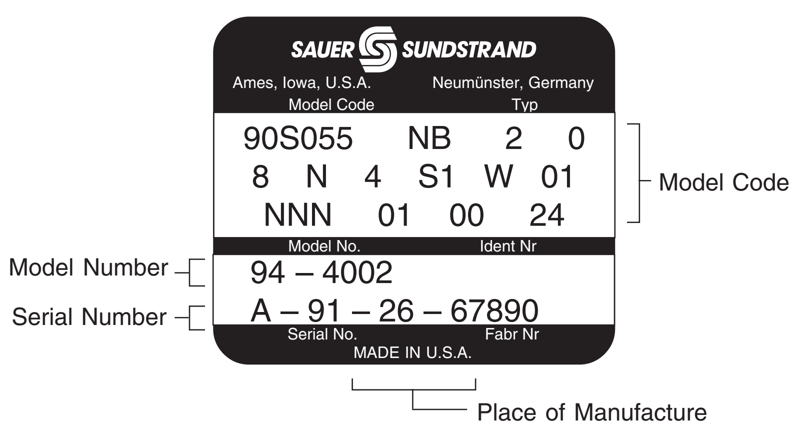
90000865E

Parts List

Item	Description	Qty
B74	Plug	4
B76	Plug	1
B80	Plug	2
B83	Plug	1
B83	Speed sensor	1
E15	Cap	1
E25	Set screw	1
E35	Nut - Seal Lock	1
G50	Plug	2
G63	Split flange clamp	4
G64	Shipping cover screw	4
G70	Plug	1
H10N	Loop flushing spool - defeat	1
H50N	Plug	2
H60N	Plug	1
H10W	Shuttle valve spool	1
H20W	Spring guide	2
H30W	Spring	2
H40W	O-ring	2
H50W	Plug	2
H60W	Charge relief valve plug	1
H62W	O-ring	1
H64W	Spring	1
H66W	Charge relief poppet	1
H68W	Lock nut	1
L8	Key	1
L9	Slotted nut	1

Item	Description	Qty
L30	Seal carrier	1
L35	Seal carrier	1
L40	Lip seal	1
L50	O-ring	1
L60	Retainer	1
L70	Screw	3
M1N	Control valve - electric	1
M1P	Control valve - hydraulic	1
P400	Plug	2
P600	Plug	1
P601	PCOR-Valve	1
P700	Special plug	1
P800	O-ring	1
T30	Filter screen	1
T40	O-ring	1
T50	Backup ring	2
T60	O-ring	1
T100	Orifice plug	1
Y40	O-ring	1
Y50	Backup ring	2
Y60	O-ring	1
Y70	Orifice check valve	1
Y71	Nut - Seal Lock	1
Y72	O-ring	1
Y80	Plug	1
Y100	Orifice plug	1
Y102	Orifice check valve	1

Name Plate



Name Plate (U.S.A. Production)

SAUER DANFOSS

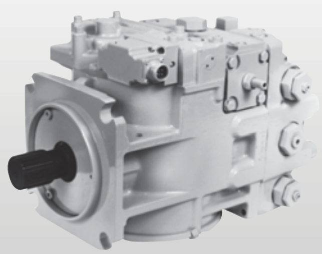
Hydraulic Power Systems

SAUER-DANFOSS Hydraulic Power Systems - Market Leaders Worldwide

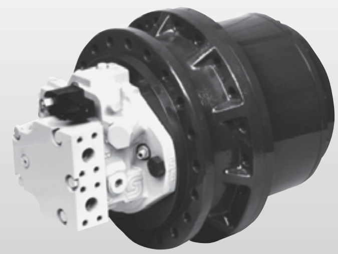
SAUER-DANFOSS is a world leader in the design and manufacture of Hydraulic Power Systems. Research and development resources in both North America and Europe enable SAUER-SUNDSTRAND to offer a wide range of design solutions utilizing hydraulic power system technology.

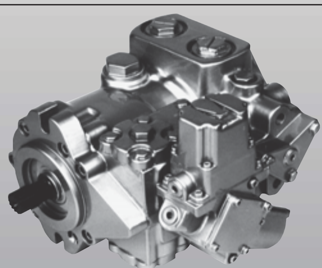
SAUER-DANFOSS specializes in integrating a full range of system components to provide vehicle designers with the most advanced total-design system.

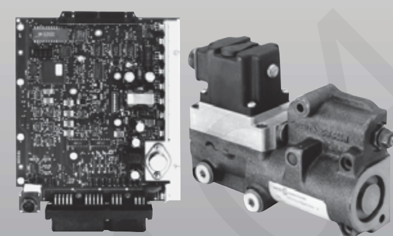
SAUER-DANFOSS is Your World Source for Controlled Hydraulic Power Systems

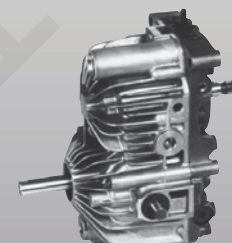

Heavy Duty Axial Piston Pumps and Motors

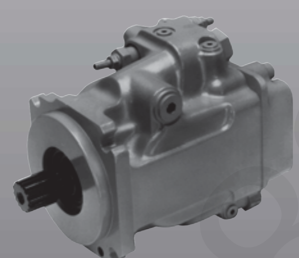

Heavy Duty Bent Axis Variable Motors

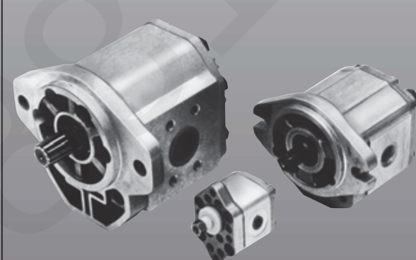

Cartridge Motors/ Compact Wheel Drives

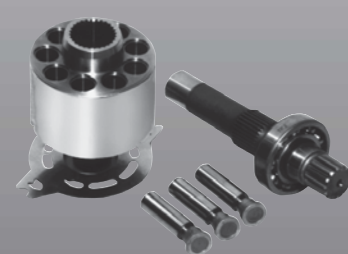

Medium Duty Axial Piston Pumps and Motors


Microcontrollers and Electrohydraulic Controls


Hydrostatc Transmission Packages


Open Circuit Axial Piston Pumps


Gear Pumps and Motors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Operator’s Manual 1-8 Numeric Tabs

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