



Service Manual

(Models 41229 and 41235)

Workman[®] 200 Spray System

Preface

The purpose of this publication is to provide the service technician with information for troubleshooting, testing, and repair of major systems and components on the Workman 200 Spray System (Models 41229 and 41235).

REFER TO THE OPERATOR'S MANUAL FOR OPERATING, MAINTENANCE, AND ADJUSTMENT INSTRUCTIONS. Keep the Operator's Manual, Installation Instructions and Parts Catalog for your machine with this Service Manual. Replacement Operator's Manuals and Parts Catalogs are available on the internet at www.Toro.com.

The Toro Company reserves the right to change product specifications or this publication without notice.



This safety symbol means **DANGER, WARNING, or CAUTION, PERSONAL SAFETY INSTRUCTION**. When you see this symbol, carefully read the instructions that follow. Failure to obey the instructions may result in personal injury.

NOTE: A **NOTE** will give general information about the correct operation, maintenance, service, testing, or repair of the machine.

IMPORTANT: The **IMPORTANT** notice will give important instructions which must be followed to prevent damage to systems or components on the machine.



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Safety and Product Records

Electrical System

Spray System

Sonic Boom System

Ultra Sonic Boom System

Electrical Diagrams

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Safety and Product Records

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Safety Instructions

The Workman 200 Spray System is designed and tested to offer safe service when operated and maintained properly. Although hazard control and accident prevention are partially dependent upon the design and configuration of the machine, these factors are also dependent upon the awareness, concern, and proper training of the personnel involved in the operation, transport, maintenance, and storage of the machine. Improper use or maintenance of the machine can result in injury or death. To reduce the potential for injury or death, comply with the following safety instructions.



Before Operating

1. Read and understand the contents of the Operator's Manual before starting and operating the machine. Become familiar with the controls and know how to stop the machine and engine quickly. A replacement Operator's Manual is available on the Internet at www.Toro.com.
2. Keep all shields, safety devices, and decals in place. If a shield, safety device, or decal is defective, illegible or damaged, repair or replace it before operating the machine. Also tighten any loose nuts, bolts or screws to ensure machine is in safe operating condition.

While Operating

1. Sit on the seat when starting and operating the machine.
2. Before starting the engine:
 - A. Engage the parking brake.
 - B. Make sure drive system is in the NEUTRAL position and the pump switch is OFF.
3. Do not run engine in a confined area without adequate ventilation. Exhaust fumes are hazardous and could possibly be deadly.
4. Do not touch engine, radiator, muffler or exhaust pipe while engine is running or soon after it is stopped. These areas could be hot enough to cause burns.
5. Before getting off the seat:
 - A. Ensure that drive system is in the NEUTRAL position.
 - B. Set parking brake.
 - C. Turn pump switch OFF.
 - D. Stop engine and remove key from ignition switch.
 - E. Do not park on slopes unless wheels are chocked or blocked.
6. Follow spray chemical manufacturer's recommendations for handling precautions, protective equipment, and mixing proportions.

Maintenance and Service

1. Before servicing or making adjustments, turn PTO off, put shift lever in neutral, stop engine, set parking brake, and remove key from the switch.
2. Prior to servicing sprayer components, determine what chemical(s) have been used in the sprayer. Follow precautions and recommendations printed on chemical container labels or Material Safety Data Sheets when servicing sprayer components. Use appropriate protective equipment: protective clothing, chemical resistant gloves, and eye protection.
3. Make sure machine is in safe operating condition by keeping all nuts, bolts and screws tight.
4. Never store the machine or fuel container inside where there is an open flame, such as near a water heater or furnace.
5. If major repairs are ever needed or assistance is desired, contact an Authorized Toro Distributor.
6. If engine must be running to perform maintenance or an adjustment, keep clothing, hands, feet, and other parts of the body away from moving parts. Keep bystanders away.
7. Disconnect battery before servicing the machine. Disconnect negative (–) battery cable first and positive (+) cable last. If battery voltage is required for troubleshooting or test procedures, temporarily connect the battery. Reconnect positive (+) cable first and negative (–) cable last.
8. Battery acid is poisonous and can cause burns. Avoid contact with skin, eyes, and clothing. Protect your face, eyes, and clothing when working with a battery.
9. Battery gases can explode. Keep cigarettes, sparks, and flames away from the battery.
10. To assure optimum performance and continued safety of the machine, use genuine Toro replacement parts and accessories. Replacement parts and accessories made by other manufacturers may result in non-conformance with safety standards, and the warranty may be voided.

Safety and Instruction Decals

Numerous safety and instruction decals are affixed to the Workman 200 Spray System. If any decal becomes illegible or damaged, install a new decal. Part numbers are listed in your Parts Catalog. Order replacement decals from your Authorized Toro Distributor.

Product Records

Insert Operator's Manual, Installation Instructions and Parts Catalog for your Workman 200 Spray System at the end of this Chapter. Refer to Operator's Manual for recommended maintenance intervals. Additionally, insert Installation Instructions, Operator's Manuals, and Parts Catalogs for other accessories (e.g. Foam Marking Kit, Hose Reel Kit) that have been installed on your Workman vehicle at the end of this Chapter.

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Electrical Schematic and Electrical Harness and Connector Drawings

The electrical schematic and other electrical drawings for the Workman 200 Spray System are located in Chapter 4 – Electrical Diagrams.

Special Tools

Multimeter

The multimeter can test electrical components and circuits for current, resistance, or voltage.

NOTE: Toro recommends the use of a DIGITAL Volt–Ohm–Amp multimeter when testing electrical circuits. The high impedance (internal resistance) of a digital meter in the voltage mode will make sure that excess current is not allowed through the meter. This excess current can cause damage to circuits not designed to carry it.

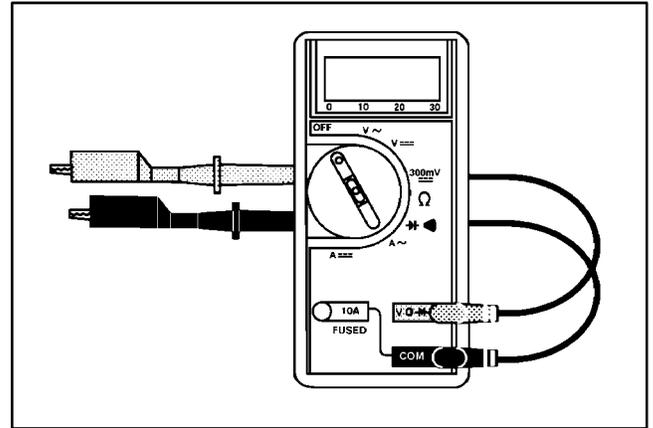


Figure 1

Component Testing

Master Boom Switch

The master boom switch is located on the spray control enclosure faceplate (Fig. 2).

Testing

1. Remove spray control enclosure faceplate, locate master boom switch and unplug wire harness connector from switch.
2. The switch terminals are marked as shown in Figure 3. In the ON position, continuity should exist between terminals 2 and 3 and also between terminals 5 and 6. In the OFF position, continuity should exist between terminals 1 and 2 and also between terminals 4 and 5.
3. Reconnect the harness connectors to the switch after testing. Install console panel to machine.



Figure 2

1. Master boom switch

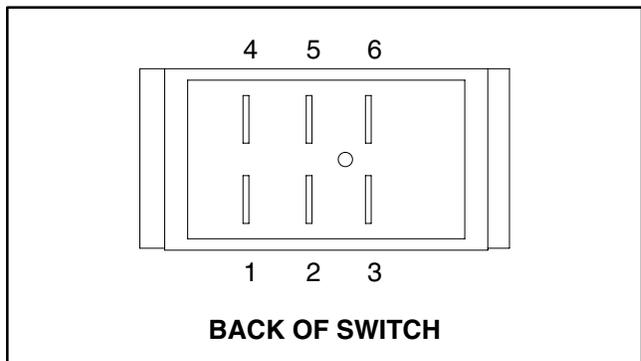


Figure 3

Rate Control and Boom Actuator Switches

The rate control (increase/decrease) switch is located on the spray control enclosure faceplate (Fig. 4).

On machines equipped with the electric boom lift, this is the same switch that is used to operate the boom actuators.

Testing

1. Remove spray control enclosure faceplate, locate switch to be tested and unplug wire harness connector from switch.
2. The switch terminals are marked as shown in Figure 5. In the INCREASE or boom raise position, continuity should exist between terminals 2 and 3 and also between terminals 5 and 6. In the neutral, center position, there should be no continuity between any switch terminals. In the DECREASE or boom lower position, continuity should exist between terminals 2 and 1 and also between terminals 5 and 4.
3. Reconnect the harness connector to the switch after testing. Install console panel to machine.

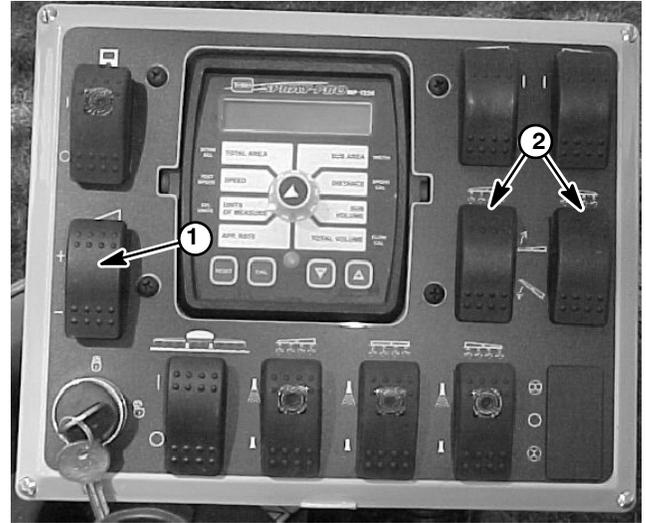


Figure 4

1. Rate control switch
2. Boom actuator switch

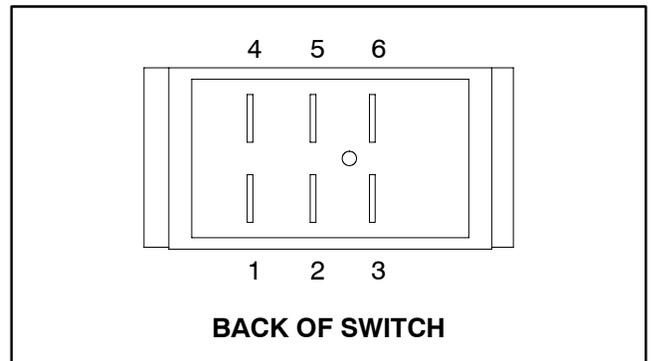


Figure 5

Supervisor Key Switch

The supervisor key switch (rate lockout) is located on the spray control enclosure faceplate (Fig. 6). When the supervisor key switch is in the OFF (locked) position, the application rate switch is disabled.

The supervisor key switch used on sprayers with serial numbers below 270000000 is shown in Figure 7. The key switch used on sprayers with serial numbers above 270000000 is shown in Figure 8.

Testing

1. Remove spray control enclosure faceplate, locate supervisor key switch and remove wire harness connectors from switch.

2. Test switch for continuity as follows:

A. For sprayers with serial numbers below 270000000 (Fig. 7), when the key is in the ON position, continuity should exist between the two switch terminals. In the OFF position, there should be no continuity between the switch terminals.

B. For sprayers with serial numbers above 270000000 (Fig. 8), when the key is in the ON position, continuity should exist between switch terminals A and D. In the OFF position, there should be no continuity between switch terminals A and D. Switch terminals B and C are not used on the Workman 200 sprayer.

3. Reconnect the harness connectors to the switch after testing. Install console panel to machine.



Figure 6

1. Supervisor key switch

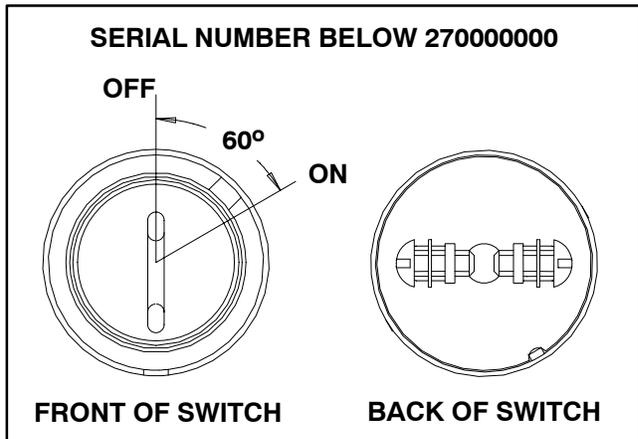


Figure 7

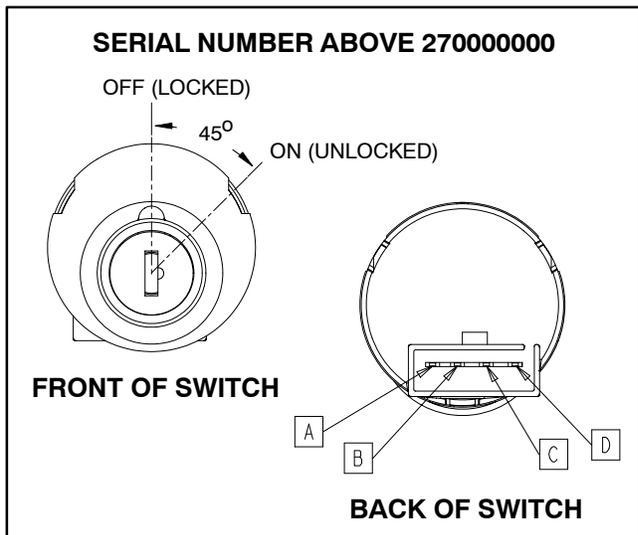


Figure 8

Boom Control and Monitor Power Switches

The three boom control (on/off) and monitor power switches are located on the spray control enclosure faceplate (Fig. 8).

Testing

1. Remove spray control enclosure faceplate, locate boom control switch and unplug wire harness connector from switch.

2. The switch terminals are marked as shown in Figure 9. In the ON position, continuity should exist between terminals 2 and 3 and also between terminals 5 and 6. In the OFF position, continuity should exist between terminals 1 and 2 and also between terminals 4 and 5.

3. Terminals 7 (-) and 8 (+) are used for the indicator light in the switch. The light should be illuminated when the switch is in the ON position.

4. Reconnect the harness connector to the switch after testing. Install console panel to machine.

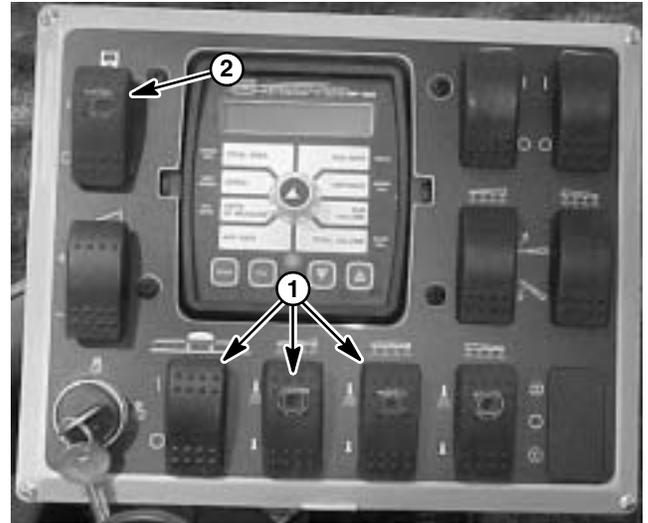


Figure 8

1. Boom control switch 2. Monitor power switch

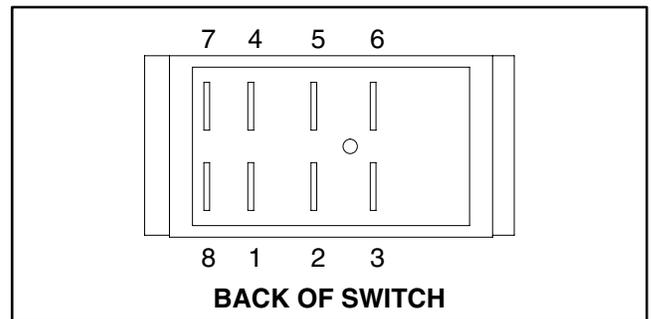


Figure 9

Hold and Boom Actuator (Serial Numbers Above 26000000) Relays

Workman sprayers with serial numbers below 260000000 use a single relay for the sprayer hold function. Sprayers with serial numbers above 260000000 use the hold relay and four (4) additional relays for the boom actuators. The hold and boom actuator relays are located in the spray control enclosure. The relays can be identified by a tag at the relay wire harness connector.

The relay used on sprayers with serial numbers below 260000000 (Fig. 11) has a different terminal layout than relays used on sprayers with serial numbers above 260000000 (Fig. 12). Relay operation and circuit logic is the same regardless of serial number.

Testing

1. Remove spray control enclosure faceplate, locate relay that is to be tested and unplug wire harness connector from relay.
2. Connect multimeter (ohms setting) leads to relay terminals 30 and 87. Ground terminal 86 and apply +12 VDC to terminal 85. The relay should make and break continuity between terminals 30 and 87 as +12 VDC is applied and removed from terminal 85.
3. Disconnect voltage from terminal 85 and multimeter lead from terminal 87.
4. Connect multimeter (ohms setting) leads to relay terminals 30 and 87A. Apply +12 VDC to terminal 85. The relay should make and break continuity between terminals 30 and 87A as +12 VDC is applied and removed from terminal 85.
5. Disconnect voltage and multimeter leads from the relay terminals. Reconnect relay to machine wire harness and install spray control enclosure faceplate.

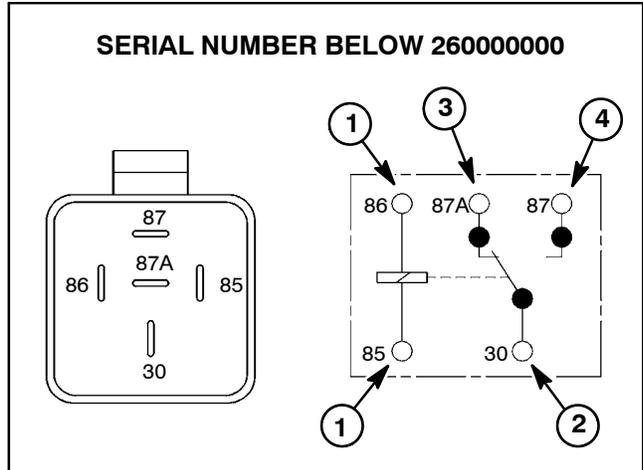


Figure 11

1. Coil terminal
2. Common terminal
3. Normally closed term.
4. Normally open term.

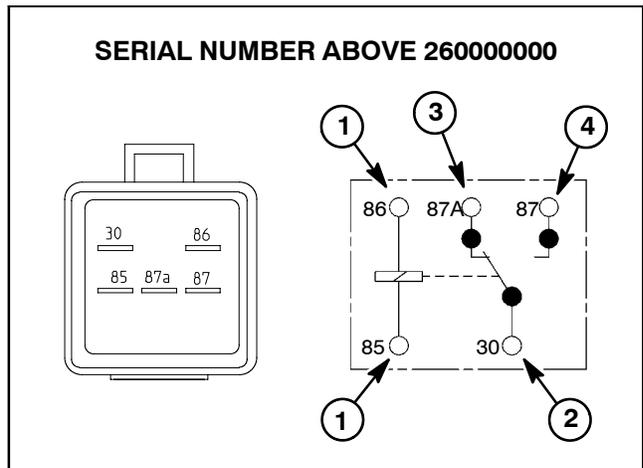


Figure 12

1. Coil terminal
2. Common terminal
3. Normally closed term.
4. Normally open term.

Traction Speed Sensor

The traction speed sensor is attached to the upper transaxle cover (Fig. 13). It uses a magnetically based, Hall Effect integrated circuit. As the differential in the transaxle turns, the sensor accurately senses the movement of the differential ring gear teeth passing by the sensor. The red striped connector wire is the positive lead, the black wire is the ground lead, and the gray striped wire is the signal output.

Testing

6. Locate traction speed sensor on the transaxle assembly. Disconnect the wire harness connector from the traction speed sensor.

7. Remove cap screw and lock washer that secure speed sensor to transaxle. Remove speed sensor from transaxle.

8. Connect positive multimeter test lead to the sensor connector gray striped wire terminal and the negative multimeter lead to the connector black wire terminal (Fig. 14). Set multimeter to ohms setting.

IMPORTANT: Incorrect jumper wire connections during testing can damage the sensor.

9. Using a +12 VDC battery, a multimeter, a 1K ohm resistor and appropriate jumper wires, connect the battery and multimeter to the speed sensor using Figure 14 as a guide.

10. Set multimeter to DC volts setting.

11. The multimeter should display very low voltage when a metal object is held near the sensor tip. The multimeter should display battery voltage when the metal object is moved away from the sensor tip.

12. After testing is complete, remove jumper wires, resistor and multimeter leads from sensor connector.

13. Replace speed sensor if necessary.

14. After testing is complete, remove jumper wires and multimeter leads from sensor connector. Reinstall speed sensor into transaxle and secure with cap screw and lock washer. Reconnect speed sensor to wire harness.

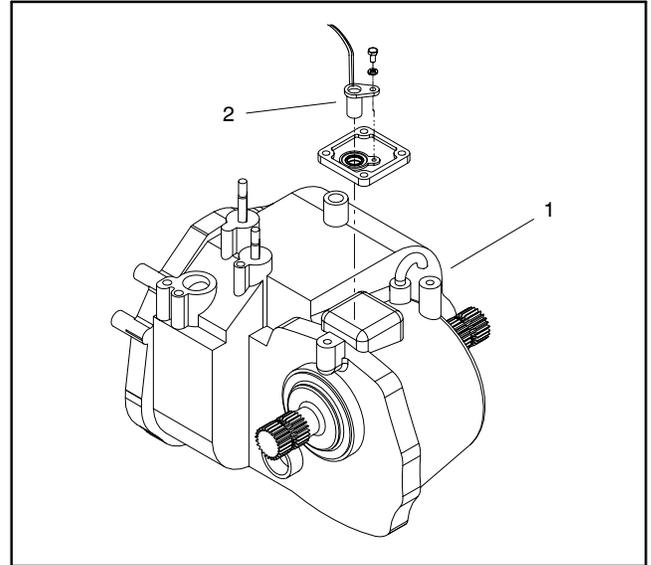


Figure 13

1. Transaxle assembly 2. Traction speed sensor

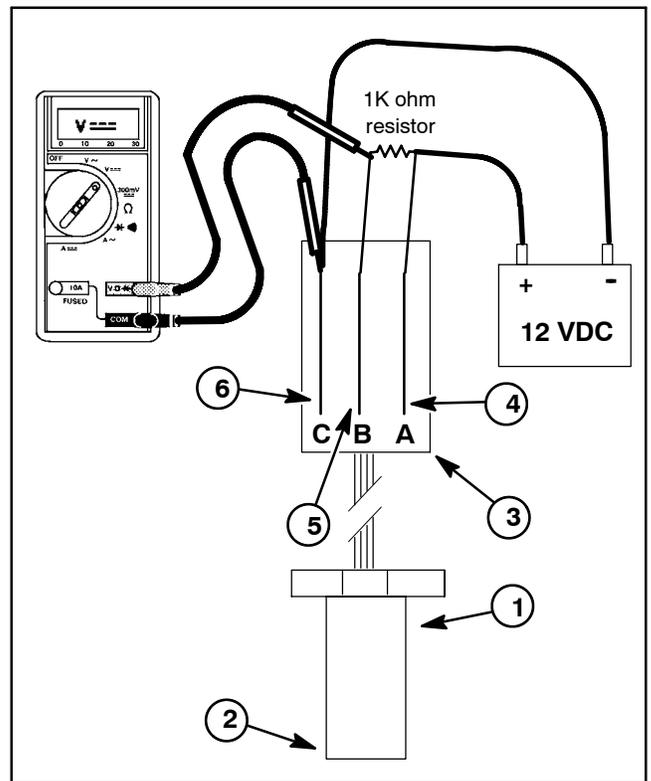


Figure 14

1. Speed sensor 4. Red striped wire
 2. Sensor tip 5. Gray striped wire
 3. Sensor connector 6. Black wire

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Spray System

Spray System

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Specifications

Item	Description
Spray Pump	Diaphragm Pump, 29 GPM
Spray Pressure Relief Valve	Poppet Style, 220 PSI Maximum
Sprayer Tank	200 Gallon (757 Liter), Polyethylene
Suction Strainer	50 Mesh, Stainless Steel, Tank Mounted (30 Mesh and 90 Mesh Optional)

General Information

Precautions Concerning Chemicals Used in Spray System

Chemicals can injure persons, animals, plants, soil, or other property. To eliminate environmental damage and personal injury:

1. Select the proper chemical for the job.
2. Carefully read the directions printed on the chemical manufacturer's labels before handling chemicals. Instructions on chemical manufacturer's container labels regarding mixing proportions should be read and strictly followed.
3. Keep spray material away from skin. If spray material comes in contact with a person, wash it off immediately in accordance with manufacturer's recommendations (container labels and Material Safety Data Sheets).

4. Always wear protective clothing, chemical resistant gloves, eye protection, and other personal protective equipment as recommended by the chemical manufacturer.

5. Properly dispose of chemical containers, unused chemicals, and chemical solution.

Precautions for Removing or Adjusting Spray System Components

1. Stop the vehicle and set the parking brake.
2. Shut off the vehicle's engine and remove the key from the ignition switch.
3. Disengage all power and wait until all moving parts have stopped.

4. Remove chemicals from pump, hoses, and other spray components. Thoroughly neutralize and rinse spray system before loosening or removing any spray system component(s).

5. Make sure line pressure is relieved before loosening any system component.

O-Ring Seal Kit (Serial Numbers Below 310000000)

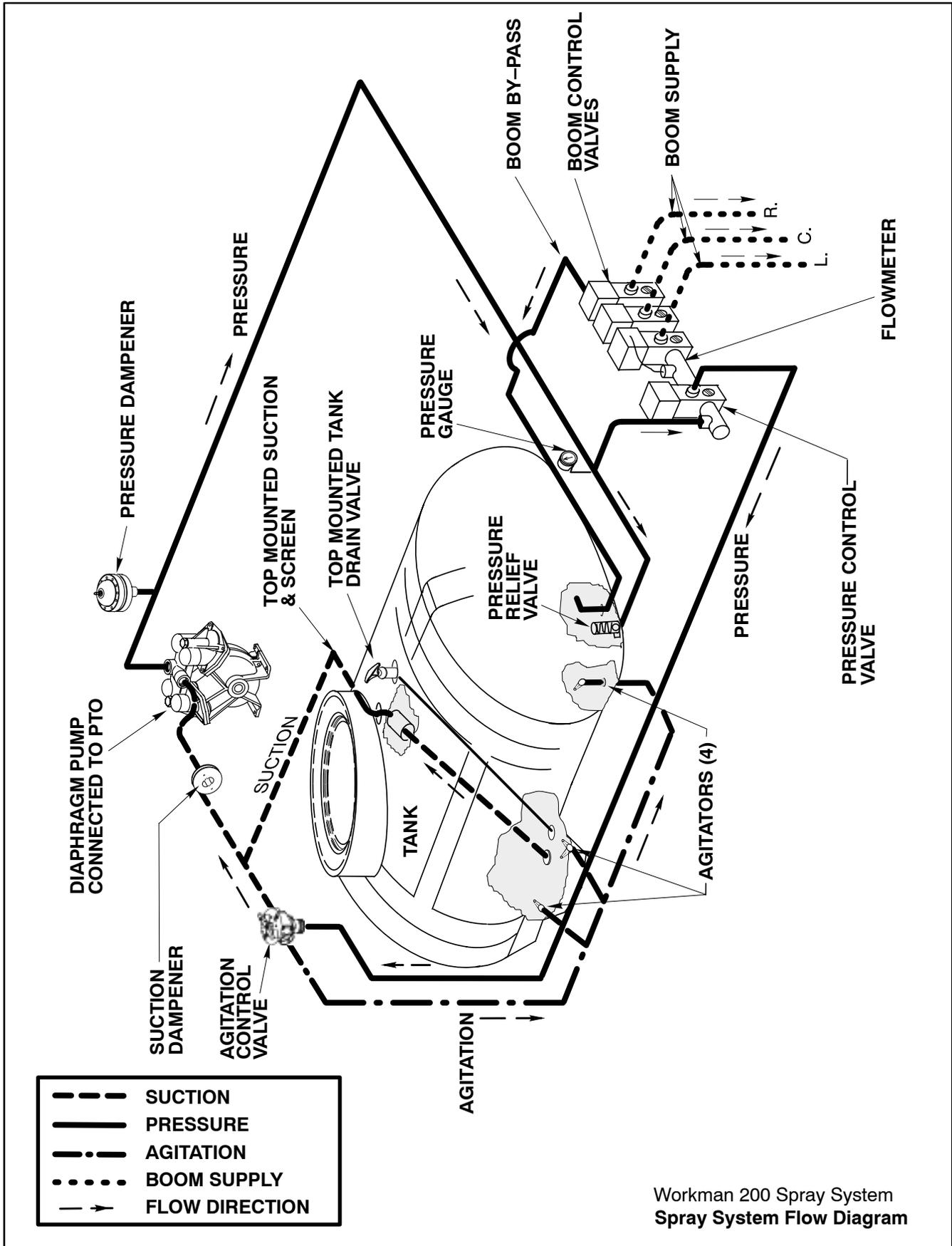
Part Number: 106-4846

The O-Ring Seal Kit includes an assortment of O-rings used for sealing the spray control valves on Workman sprayers with serial numbers below 310000000. It is recommended that O-rings be replaced every two (2) years or whenever a valve is loosened.



Figure 1

Spray System Flow Diagram



Spray System Operation

The Workman 200 Spray System uses a positive displacement diaphragm pump to move spray solution from the spray tank to the boom nozzles. The spray pump is self-priming and has a dry crankcase. The pump is driven by the transaxle PTO kit output shaft at a speed that is proportional to the ground speed of the vehicle. It should be noted that pump rotation will stop whenever the vehicle clutch pedal is depressed.

The downward stroke of the pumps' connecting rods and diaphragms create suction to allow fluid to be drawn from the spray tank to the pump through the suction tube, suction strainer, hoses, and connectors. A suction dampener placed in the suction line dampens suction pulses to smooth suction flow. Suction valves positioned in the pump valve chamber prevent fluid from being pumped back into the suction line when the connecting rods change direction. Leaks in the suction line will cause system problems and often will be indicated by erratic suction line jumping and pump noise.

Once to the pump, the fluid is pushed by the upward stroke of the pumps' connecting rods and diaphragms to the pressure side of the spray system through hoses, connectors, control valves, and spray nozzles. A pressure dampener at the pump outlet smooths system pressure pulsation. Pressure valves positioned in the pump head prevent fluid from being drawn back into the pump. Maximum pressure in the system is limited by a pressure relief valve located in the tank. A pressure gauge indicates system pressure.

The spray system is controlled electrically and consists of a rate control valve and three boom control valves. A manually adjustable boom bypass valve exists in each of the boom control valves to prevent system pressure changes when a boom section is shut off. Flow in excess of control valve settings is directed back to the spray tank.

An inline flowmeter in the pressure side of the system directly before the boom control valves measures flow to the spray booms. The Spray Pro Monitor displays information regarding application rate based on input from the flowmeter and the ground speed sensor in the trans-axle.

Flow for tank agitation comes from flow that is bypassed by the rate control valve. A manual agitation control valve directs flow to four agitation nozzles in the spray tank.

Troubleshooting

Problem	Possible Cause
Spray system leaks fluid.	Fitting(s), hose(s), or tube(s) are loose or damaged. O-ring(s) or seal(s) are missing or damaged. Spray tank drain valve is leaking.
Fluid leaking from bottom of spray pump.	Faulty diaphragm(s) in spray pump.
Excessive suction hose vibration.	Suction screen in tank is plugged. Spray pump suction line has an air leak. Suction tube in spray tank has air leak. Suction line is restricted. Suction dampener diaphragm is damaged.
Spray pressure is low.	Suction line is restricted. Suction screen in tank is plugged. Spray nozzles worn or damaged. Pressure line or component is loose or leaking. Engine speed is low. Pressure relief valve in tank is stuck. Spray pump is damaged.
Single spray boom nozzle leaks when boom is turned off.	Diaphragm in turret body is leaking or damaged.
Nozzles on one spray boom leak when boom is switched off.	Diaphragm in turret body is leaking or damaged. Boom valve motor for affected boom not seating.
Spray pump doesn't rotate.	Vehicle clutch pedal is depressed. Key on spray pump shaft is sheared. Auxiliary PTO not engaged or faulty. Auxiliary PTO output shaft damaged. PTO drive shaft damaged or missing.

<p>Erratic spray operation from booms.</p>	<p>Clogged strainer.</p> <p>Damaged suction dampener.</p> <p>Damaged pressure dampener.</p> <p>Console boom switch(es) dirty, corroded, or damaged.</p> <p>Rate control motor worn or sticking.</p> <p>Boom valve motor seat loose or damaged.</p> <p>Boom valve motor actuating cam worn or sticking.</p>
<p>No spray output from one spray boom.</p>	<p>Hoses on boom are pinched or kinked.</p> <p>Boom valve motor for affected boom not opening.</p> <p>Console boom switch dirty, corroded, or damaged.</p> <p>Check for 12 volts at affected boom valve motor in both directions (on and off).</p>
<p>Low spray rate from one nozzle.</p>	<p>Clogged or damaged spray nozzle(s).</p> <p>Spray nozzles are different sizes.</p> <p>Boom valve motor for affected boom not seating.</p>

Service and Repairs

Suction Dampener

The suction dampener is mounted to the suction line at the spray pump (Fig. 2) and is used to dampen suction pulses and smooth suction flow. During pump operation, the suction dampener diaphragm will move.

IMPORTANT: Make sure to neutralize and remove chemicals from pump and hoses before loosening and removing spray system components.

A damaged suction dampener diaphragm will allow a suction leak and will cause improper pump operation. If the diaphragm is damaged, remove diaphragm from dampener housing and replace it (Fig. 3).

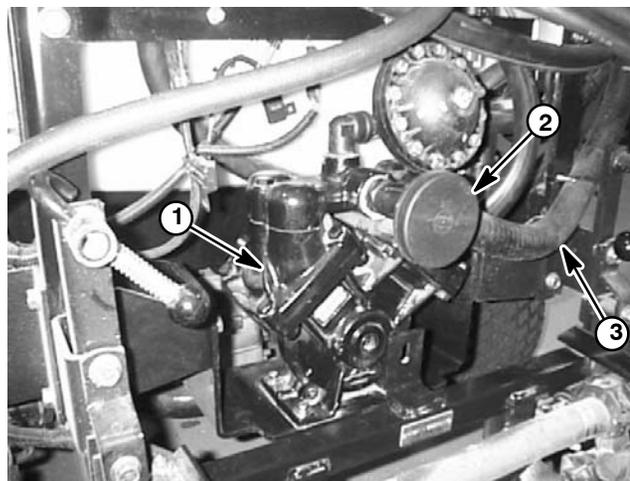


Figure 2

- 1. Spray pump
- 2. Suction dampener
- 3. Suction hose

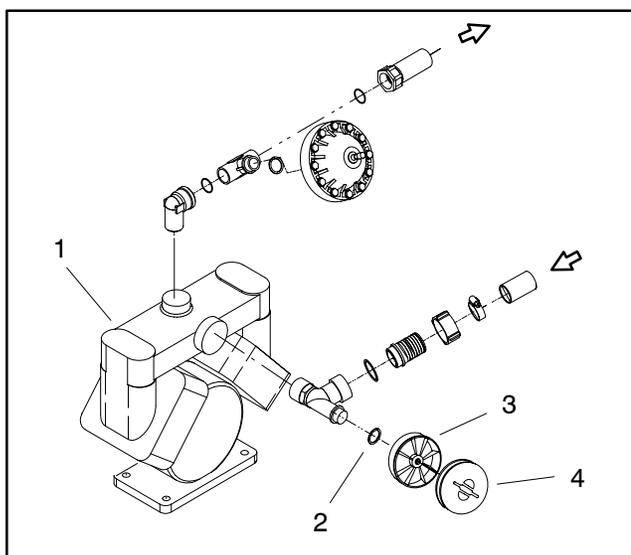


Figure 3

- 1. Spray pump
- 2. O-ring
- 3. Dampener housing
- 4. Diaphragm

Pressure Dampener

The pressure dampener is mounted to the pressure line at the spray pump (Fig. 4) and is used to smooth system pressure pulsation. Adjust air pressure on the pressure dampener from 12 to 15 PSI (.82 to 1.03 bar).

IMPORTANT: Any fluid in the pressure dampener will include spray system chemicals so take necessary precautions when working with the dampener. Use appropriate protective equipment: protective clothing, chemical resistant gloves, and eye protection.

If fluid is present when pressure in the dampener is checked, the diaphragm in the pressure dampener is damaged and should be replaced.

Dampener Service (Fig. 5)

IMPORTANT: Make sure to neutralize and remove chemicals from pump and hoses before loosening and removing spray system components.

1. Loosen and remove cap screws and nuts that secure diaphragm between housings.
2. Remove diaphragm from dampener.
3. Replace diaphragm and reassemble dampener.

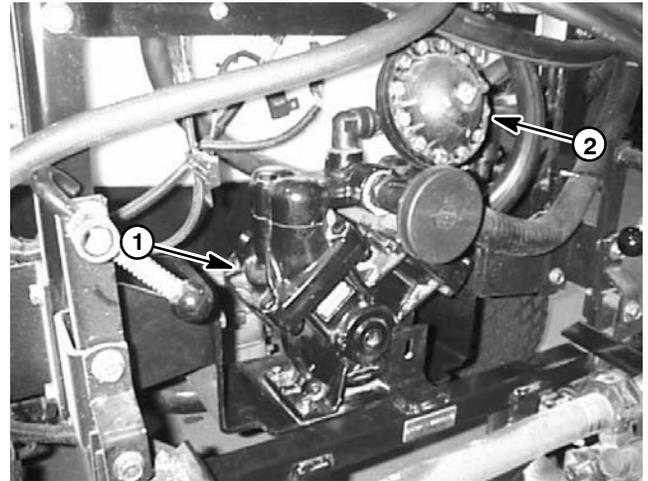


Figure 4

1. Spray pump
2. Pressure dampener

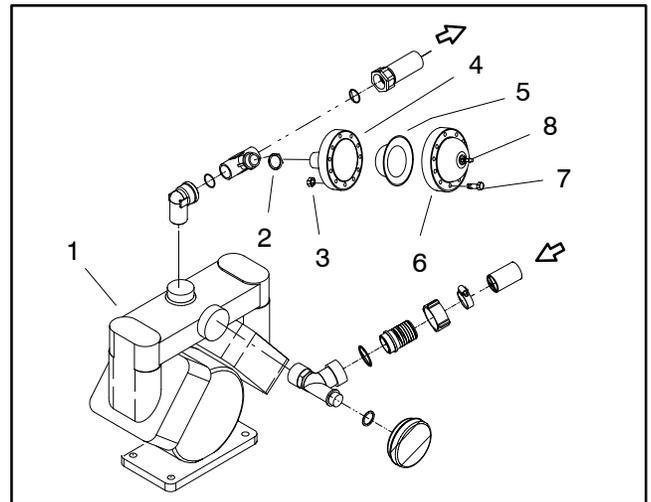


Figure 5

1. Spray pump
2. O-ring
3. Hex nut (12 used)
4. Rear housing
5. Diaphragm
6. Front housing
7. Cap screw (12 used)
8. Air valve

Spray Pump

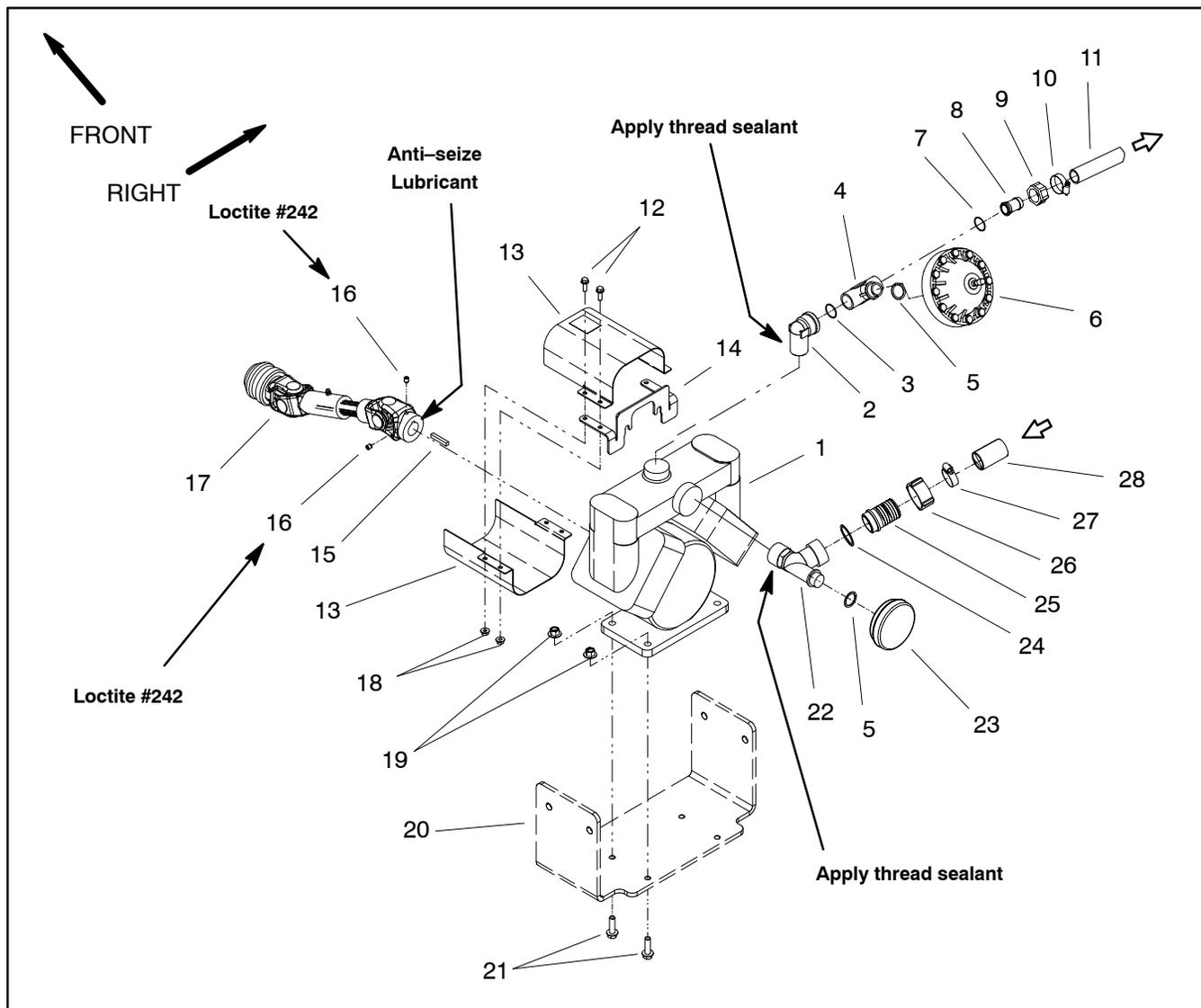


Figure 6

- | | | |
|-------------------------|--------------------------------|--------------------------------|
| 1. Spray pump assembly | 11. Pressure hose | 20. Pump mount bracket |
| 2. Elbow (pressure) | 12. Flange head screw (4 used) | 21. Flange head screw (4 used) |
| 3. Gasket | 13. Pump drive shroud | 22. Suction tee fitting |
| 4. Pressure tee fitting | 14. Shroud bracket | 23. Suction dampener |
| 5. O-ring | 15. Square key | 24. Gasket |
| 6. Pressure dampener | 16. Set screw | 25. Hose barb |
| 7. O-ring | 17. PTO driveshaft | 26. Nut |
| 8. Hose barb | 18. Flange nut (4 used) | 27. Hose clamp |
| 9. Nut | 19. Flange nut (4 used) | 28. Suction hose |
| 10. Hose clamp | | |

Removal (Fig. 6)

IMPORTANT: Make sure to neutralize and remove chemicals from pump and hoses before loosening and removing spray system components.

1. Park machine on a level surface, stop engine, engage parking brake, and remove key from the ignition switch.
2. Loosen hose clamp that secures suction hose (item 28) to hosebarb (item 25). Pull suction hose from hosebarb.
3. Loosen hose clamp that secures pressure hose (item 11) to hosebarb (item 8). Pull pressure hose from hosebarb.
4. Remove PTO driveshaft (item 17) from output shaft of transaxle PTO assembly.
5. Remove four (4) flange head screws and flange nuts that secure pump assembly to pump mount bracket.
6. Remove pump assembly (with PTO driveshaft and drive shrouds attached) from machine.
7. Remove four (4) flange head screws and flange nuts that secure pump drive shrouds (item 13) to shroud bracket (item 14). Remove pump drive shrouds.
8. Loosen two (2) set screws (item 16) that secure PTO drive shaft to pump shaft. Separate PTO drive shaft from pump. Locate and remove key from pump shaft.
9. As needed, remove pressure and suction components from pump using Figure 6 as a guide. Discard any removed o-rings and gaskets.

Installation (Fig. 6)

NOTE: Coat all o-rings with vegetable oil before installation to reduce the chance of damage during assembly.

1. Apply thread sealant to threads of pressure tee fitting, elbow (pressure), and suction tee fitting. Position new o-rings and gaskets on suction and pressure fittings that were removed during disassembly.
2. Install suction tee fitting and suction dampener to pump inlet. Orientate tee toward right side of machine (Fig. 7).

3. Install elbow (pressure), pressure tee fitting, and pressure dampener to pump outlet. Orientate elbow toward right side of machine (Fig. 7).

4. Remove set screws (item 16) from PTO driveshaft. Clean threads of set screws and set screw threads in driveshaft.

5. Apply anti-seize lubricant to pump shaft. Position square key in pump shaft and slide PTO driveshaft fully onto pump shaft.

6. Apply Loctite #242 (or equivalent) to threads of set screws. Install set screws into PTO drive shaft to secure PTO shaft to pump shaft.

7. Position pump drive shrouds (item 13) to shroud bracket (item 14). Install four (4) flange head screws and flange nuts to secure shrouds to bracket.

8. Position pump on pump mount bracket. Install flange head screws and flange nuts to pump and mount bracket. Secure pump to mount bracket.

9. Attach PTO driveshaft to output shaft of transaxle PTO assembly.

10. Install pressure and suction hoses to correct barb fittings. Secure hoses with hose clamps.

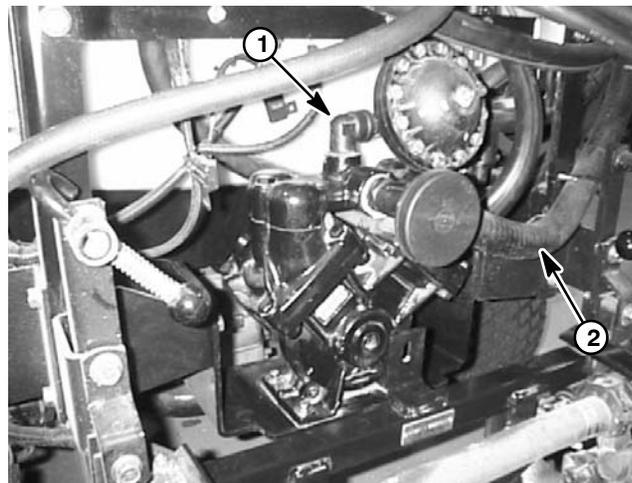


Figure 7

1. Elbow (pressure)
2. Suction hose

Spray Pump Service

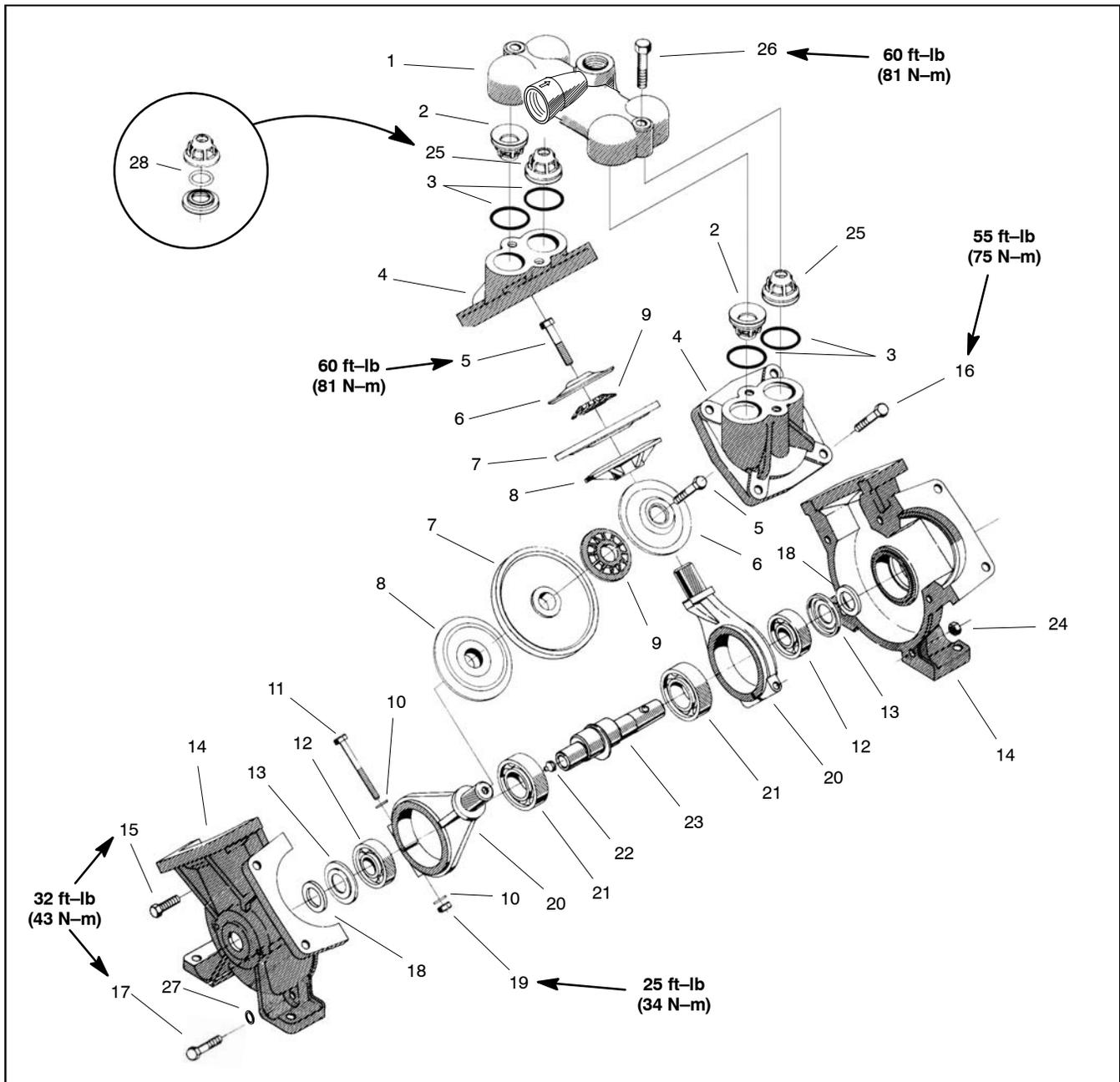


Figure 8

- | | | |
|--|---|---|
| <ul style="list-style-type: none"> 1. Valve chamber 2. Valve (inlet position) 3. O-ring 4. Diaphragm cover 5. Hex bolt 6. Washer 7. Diaphragm 8. Diaphragm back disc 9. Nylon washer 10. Lock washer | <ul style="list-style-type: none"> 11. Hex bolt 12. Ball bearing (crankshaft) 13. Dust plate 14. Pump casing 15. Hex bolt (30 mm long) (3 used) 16. Hex bolt (4 used per cover) 17. Hex bolt (55 mm long) (2 used) 18. Felt seal 19. Hex nut | <ul style="list-style-type: none"> 20. Connecting rod 21. Ball bearing (connecting rod) 22. Grease fitting 23. Crankshaft 24. Hex nut (5 used) 25. Valve (outlet position) 26. Hex bolt (2 used) 27. Washer (2 used) 28. Poly o-ring |
|--|---|---|

Disassembly (Fig. 8)

IMPORTANT: Make sure to remove and neutralize chemicals from pump before disassembly. Wear protective clothing, chemical resistant gloves, and eye protection during pump repair.

NOTE: Many pump components can be easily reversed. During disassembly, make note of component position (e.g. crankshaft, valve chamber) to assure correct assembly.

1. Remove two (2) hex bolts that retain valve chamber to pump. Separate valve chamber from pump.
2. Remove inlet and outlet valves and o-rings from each diaphragm cover. Note orientation of valves. Discard valves and o-rings. Clean valve and o-ring seats in the valve chambers and diaphragm covers.
3. Remove hex bolts that secure diaphragm covers to pump. Remove diaphragm covers.
4. Remove hex bolt, washer, nylon washer, diaphragm, and diaphragm back disc from each connecting rod. Discard diaphragms.
5. Remove five (5) hex bolts and nuts that secure pump casing halves together. Note location of two (2) longer hex bolts with washers. Carefully separate pump casing halves.
6. Clean grease from bottom of housing and check condition of bearings on crankshaft. If bearings require replacement, remove and disassemble crankshaft:

A. Remove crankshaft assembly from pump casing.

B. Slide felt seal and dust plate from both ends of crankshaft.

C. Loosen hex bolt and hex nut that secure connecting rods to crankshaft. Slide connecting rods from crankshaft. Press ball bearings from crankshaft.

Assembly (Fig. 8)

1. If disassembled, reassemble crankshaft.
 - A. Hand pack new bearings with #2 general purpose lithium base grease.
 - B. Pressing on bearing inner race, install two connecting rod and two crankshaft ball bearings onto crankshaft.
 - C. Slide connecting rods onto connecting rod bearings. Offsets of the connecting rods should face each other. Install hex bolt, flat washers, and hex nut to each connecting rod. Torque hex nuts to 25 ft-lb (34 N-m) to secure connecting rods to crankshaft.

D. Position dust plate and felt seal on both ends of crankshaft.

IMPORTANT: If connecting rod position is incorrect, pump will not operate properly.

E. Slide crankshaft assembly into pump casing. The rear connecting rod should be positioned to the left side and the connecting rod closest to you to the right side (Fig. 9).

2. Place second pump casing onto assembly. Pump casing surfaces should mate together.

3. Install three (3) shorter (30 mm) bolts and two (2) longer (55 mm) bolts with washers into pump casing assembly (Fig. 10). Thread hex nuts onto bolts but do not fully tighten. Check that crankshaft turns freely.

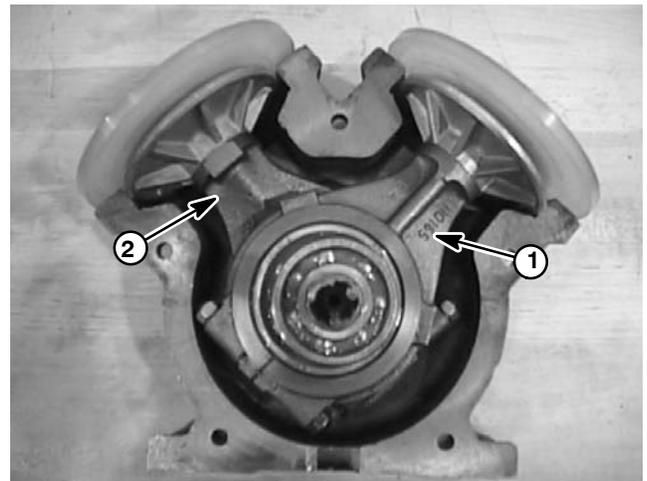


Figure 9

1. Closest connecting rod (to right side)
2. Rear connecting rod (to left side)

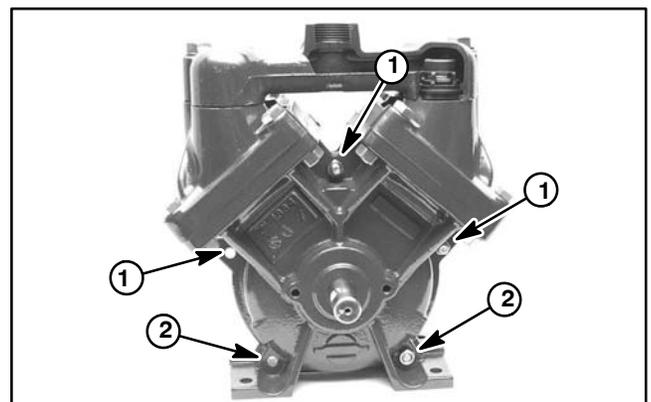


Figure 10

1. Hex bolt (30 mm long)
2. Hex bolt (55 mm long)

4. Place diaphragm back disc and new diaphragm onto each connecting rod. The connecting rods should extend above the diaphragms when correctly installed (Fig. 11). Position nylon washer and washer on each connecting rod and then thread hex bolt into connecting rod. Torque bolt to 60 ft-lb (81 N-m).

5. Make sure that pump casings align and then secure pump casing assembly by torquing five (5) bolts to 32 ft-lb (43 N-m).

6. Secure diaphragm covers to pump using hex bolts (4 per cover). Torque bolts to 55 ft-lb (75 N-m).

7. Place new o-rings and valves into diaphragm cover openings (Fig. 12). Inlet valves should be installed with the spring down into the cover and should be on the same side of the pump as the crankshaft grease fitting. Outlet valves should be installed with the spring up and away from cover and should be on the same side of the pump as the crankshaft extension.

8. Place valve chamber over valves noting orientation of chamber inlet and outlet. Secure valve chamber with two (2) hex bolts. Torque bolts 60 ft-lb (81 N-m).

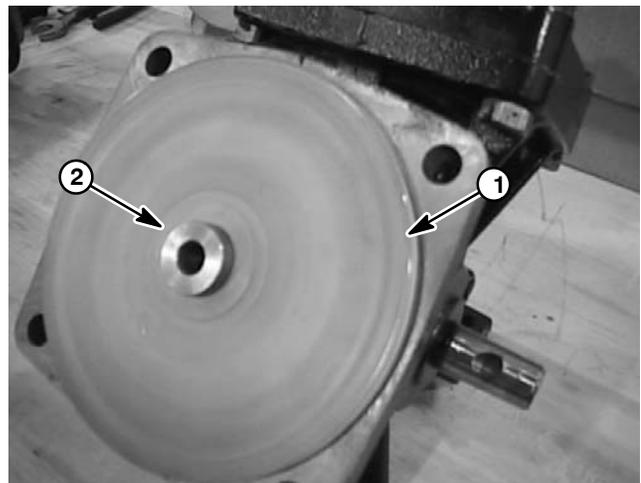


Figure 11

- 1. Diaphragm
- 2. Connecting rod

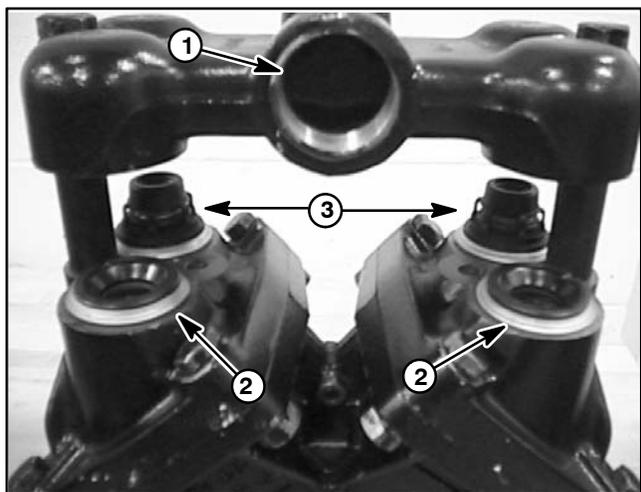


Figure 12

- 1. Inlet (suction)
- 2. Inlet valve
- 3. Outlet valve

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Agitation Control Valve

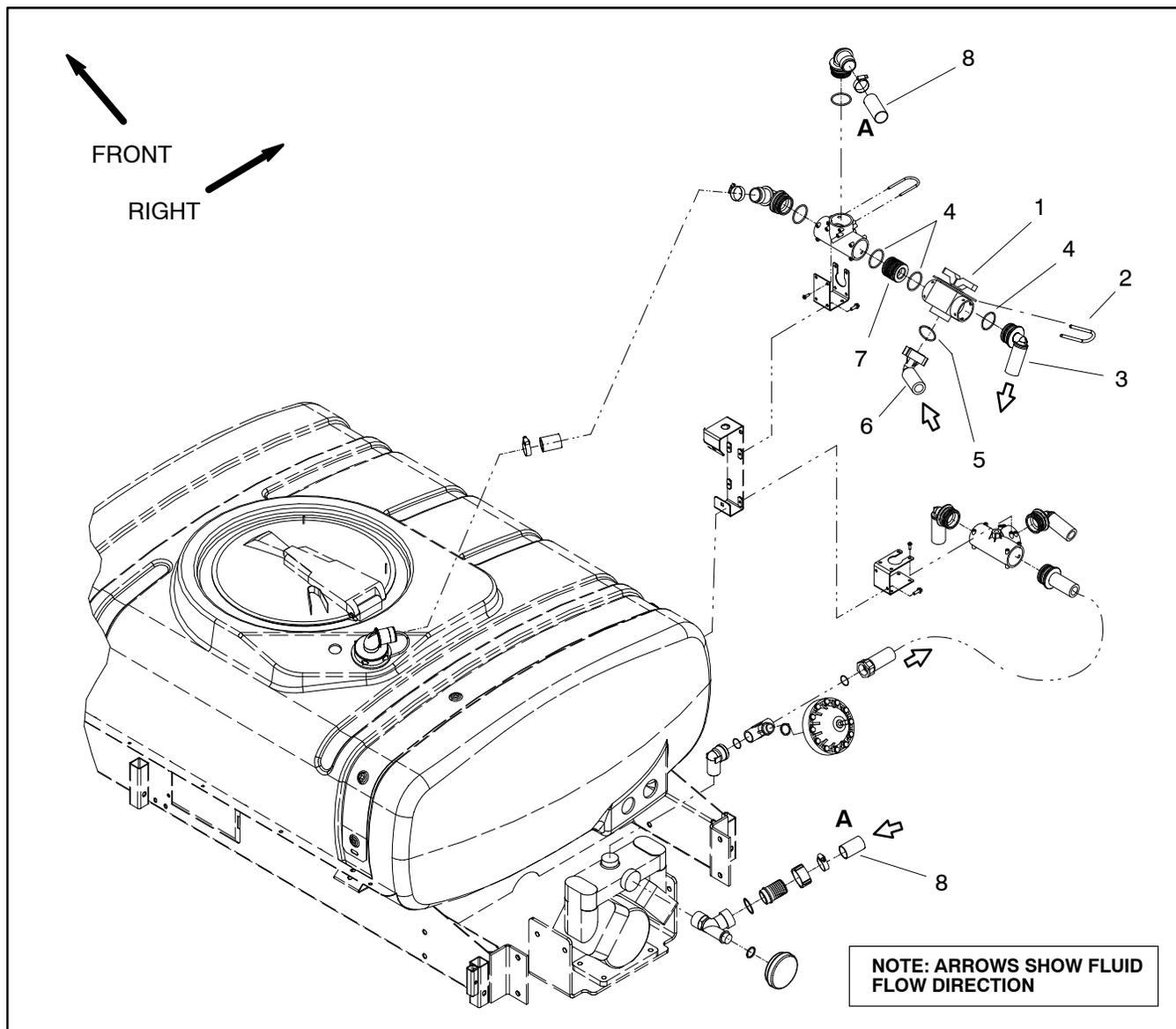


Figure 13

- | | | |
|---|---------------------------------------|----------------------|
| 1. Agitation control valve | 4. O-ring | 7. Connector |
| 2. Fork | 5. O-ring | 8. Pump suction hose |
| 3. Hosebarb/hose (to agitation nozzles) | 6. Hosebarb/hose (from spray control) | |

Removal (Fig. 13)

IMPORTANT: Make sure to remove and neutralize chemicals from spray components before disassembly. Wear protective clothing, chemical resistant gloves, and eye protection during repair.

1. Park machine on a level surface, stop engine, engage parking brake, and remove key from the ignition switch.
2. Label disconnected hoses for proper installation after repairs are completed.
3. Remove agitation control valve using Figures 13 and 14 as guides.
4. Disassemble agitation valve as required (Fig 15).

Installation (Fig. 13)

NOTE: Coat all o-rings with vegetable oil before installation to reduce the chance of damage during assembly.

1. Assemble agitation control valve (Fig 15). Align arrow on valve handle with large hole in valve ball during assembly (Fig. 16).
2. Install agitation valve using Figures 13 and 14 as guides.
3. Check spray system for leaks.

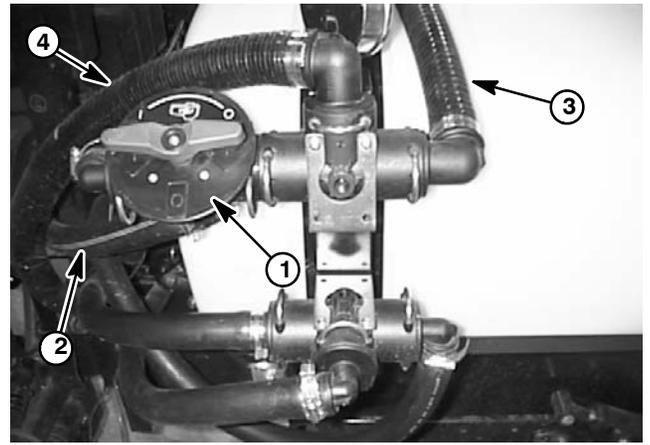


Figure 14

- | | |
|----------------------------|-----------------------------|
| 1. Agitation control valve | 3. Suction hose (from tank) |
| 2. Control bypass hose | 4. Suction hose (to pump) |

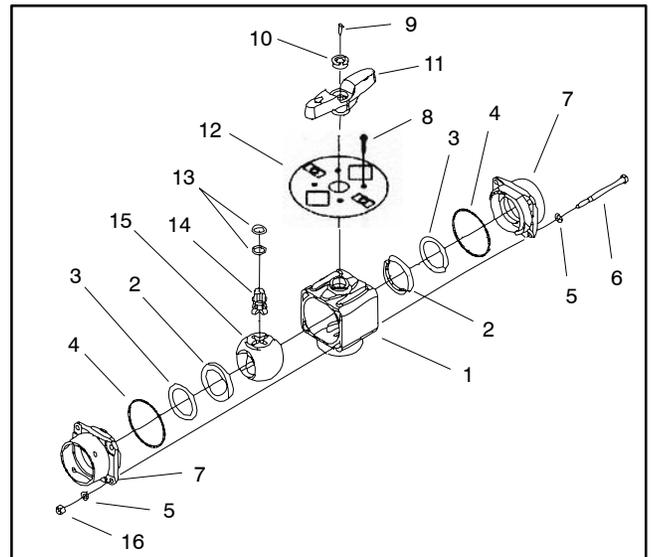


Figure 15

- | | |
|-----------------------|-----------------------|
| 1. Valve housing | 9. Screw |
| 2. Ball seat | 10. Button |
| 3. O-ring | 11. Valve handle |
| 4. O-ring | 12. Disc |
| 5. Washer (8 used) | 13. O-ring |
| 6. Cap screw (4 used) | 14. Spindle |
| 7. End cover | 15. Valve ball |
| 8. Screw (4 used) | 16. Lock nut (4 used) |

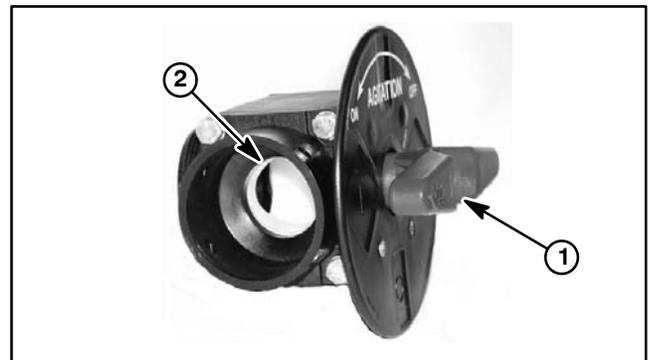


Figure 16

- | | |
|-----------------------|--------------------------|
| 1. Valve handle arrow | 2. Valve ball large hole |
|-----------------------|--------------------------|

Spray System

Agitation Nozzles (Tank mounted)

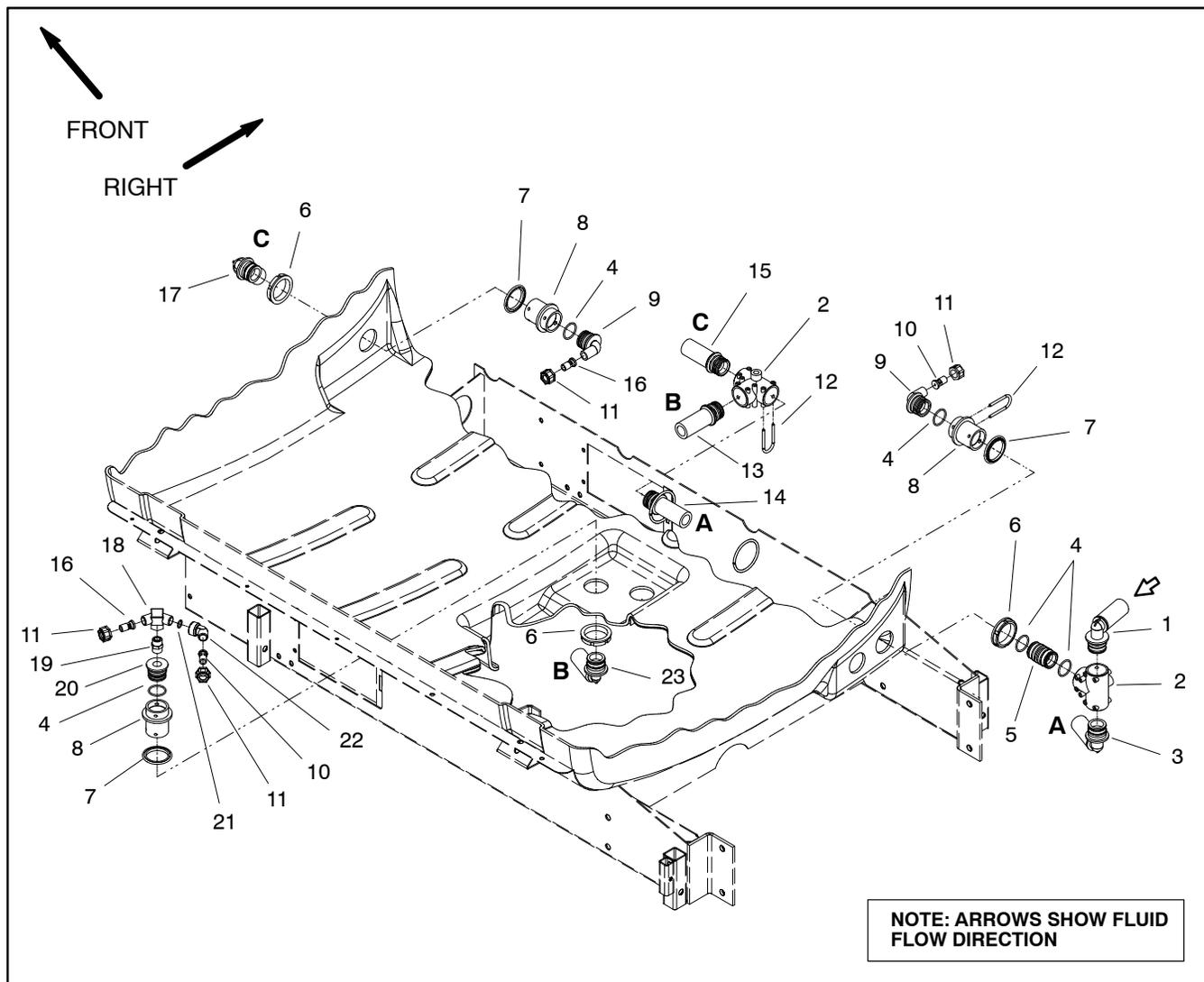


Figure 17

- 1. Agitation supply
- 2. Tee fitting
- 3. Hosebarb/hose
- 4. O-ring
- 5. Connector
- 6. Bulkhead nut
- 7. Gasket
- 8. Bulkhead fitting

- 9. Hosebarb
- 10. Agitation nozzle
- 11. Nut
- 12. Fork (12 used)
- 13. Hosebarb/hose
- 14. Hosebarb/hose
- 15. Hosebarb/hose
- 16. Agitation nozzle

- 17. Hosebarb/hose
- 18. Tee fitting
- 19. Nipple
- 20. Adapter
- 21. O-ring
- 22. Elbow
- 23. Hosebarb/hose

Disassembly (Fig. 17)

IMPORTANT: Make sure to remove and neutralize chemicals from tank and other components before disassembly. Wear protective clothing, chemical resistant gloves, and eye protection during repair.

1. Park machine on a level surface, stop engine, engage parking brake, and remove key from the ignition switch.
2. Drain spray tank (see Operator's Manual).
3. Label hoses for proper installation after repairs are completed.
4. Remove agitation nozzles as required using Figure 17 as a guide. Discard all removed o-rings and gaskets.

Assembly (Fig. 17)

NOTE: Coat all o-rings with vegetable oil before installation to reduce the chance of damage during assembly.

1. Install agitation nozzles using Figure 17 as a guide. Replace all removed o-rings and gaskets.
2. Check spray system for leaks.

Pressure Relief Valve (Tank Mounted)

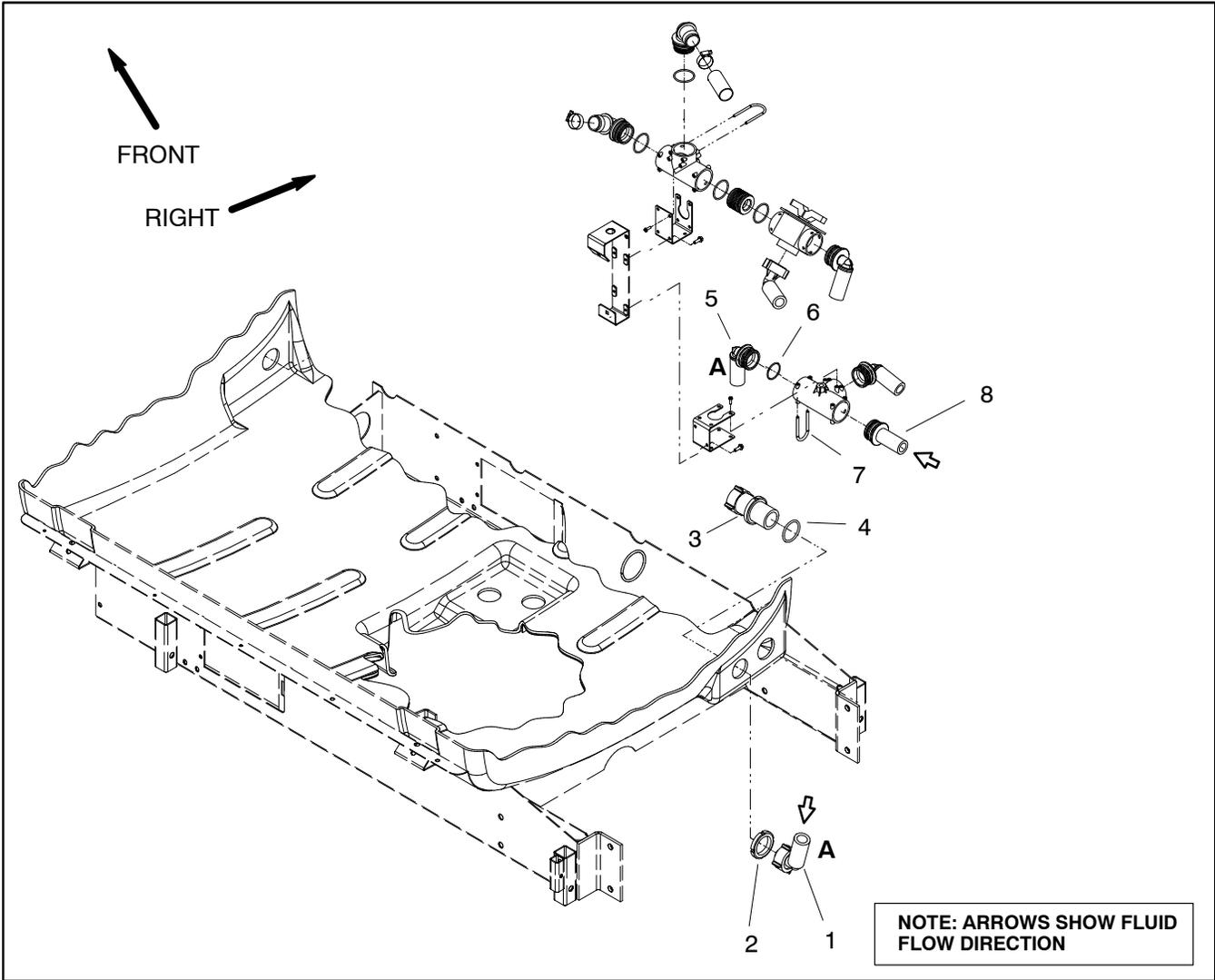


Figure 18

- | | | |
|--------------------------|------------------|------------------------------------|
| 1. Hosebarb/hose | 4. Gasket | 7. Fork |
| 2. Ringnut | 5. Hosebarb/hose | 8. Hosebarb/hose (from spray pump) |
| 3. Pressure relief valve | 6. O-ring | |

Removal (Fig. 18)

IMPORTANT: Make sure to remove and neutralize chemicals from tank and other components before disassembly. Wear protective clothing, chemical resistant gloves, and eye protection during repair.

1. Park machine on a level surface, stop engine, engage parking brake, and remove key from the ignition switch.
2. Drain spray tank (see Operator's Manual).
3. Label disconnected hoses for proper installation after repairs are completed.
4. Remove pressure relief valve from spray tank using Figure 18 and 19 as guides. Discard all removed o-rings and gaskets.
5. Disassemble pressure relief valve using Figure 20 as a guide.

Assembly (Fig. 18)

NOTE: Coat all o-rings with vegetable oil before installation to reduce the chance of damage during assembly.

1. Assemble and install pressure relief valve using Figure 18, 19 and 20 as guides. Replace all removed o-rings and gaskets.
2. Check spray system for leaks.

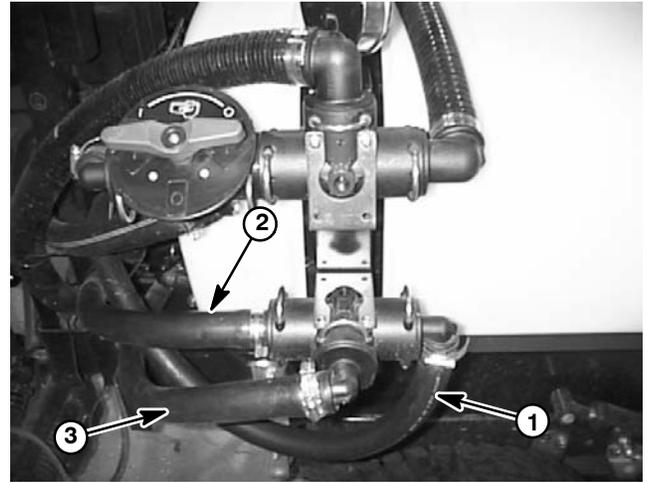


Figure 19

1. Hose to pressure relief
2. Hose from spray pump
3. Control supply hose

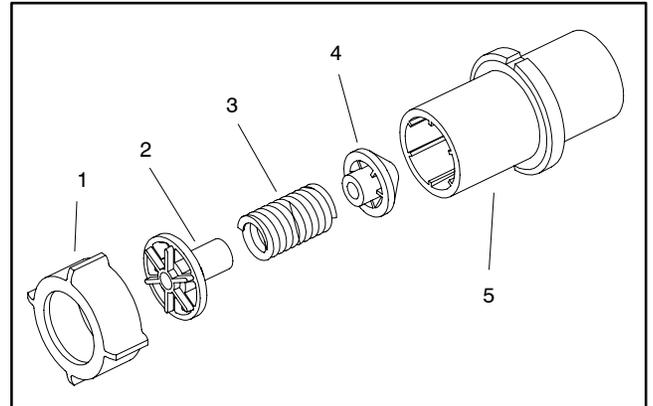


Figure 20

1. Nut
2. Seat
3. Spring
4. Cone
5. Relief valve housing

Spray Control (Serial Numbers Below 290999999)

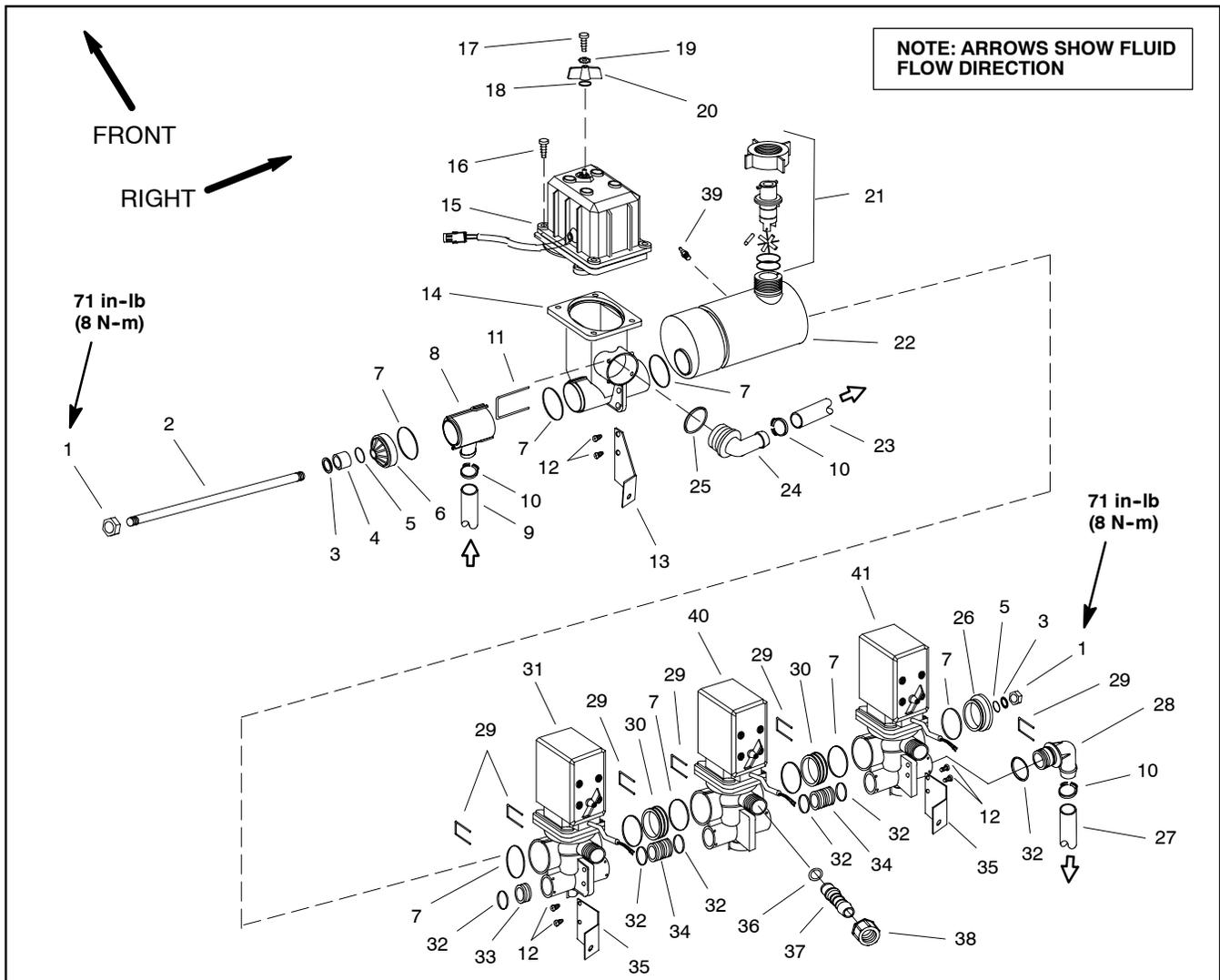


Figure 21

- | | | |
|--------------------------------|-------------------------------|--------------------------------------|
| 1. Nut | 15. Rate control motor | 29. Fork |
| 2. Threaded rod | 16. Screw (4 used) | 30. Joiner |
| 3. Washer | 17. Screw | 31. LH boom valve motor/manifold |
| 4. Bushing | 18. O-ring | 32. O-ring |
| 5. O-ring | 19. Lock washer | 33. End cap |
| 6. Cap | 20. Handgrip | 34. Joiner |
| 7. O-ring | 21. Flowmeter assembly | 35. Boom valve bracket |
| 8. Tee piece | 22. Flowmeter housing | 36. O-ring (3 used) |
| 9. Hose: control supply (1") | 23. Hose: control bypass (1") | 37. Hosebarb: boom supply (3 used) |
| 10. Hose clamp | 24. Hosebarb | 38. Nut (3 used) |
| 11. Fork | 25. O-ring | 39. Coupler (pressure gauge) |
| 12. Screw | 26. End cap | 40. Center boom valve motor/manifold |
| 13. Control valve bracket | 27. Hose: boom bypass (1") | 41. RH boom valve motor/manifold |
| 14. Rate control valve housing | 28. Hosebarb | |

IMPORTANT: Rate control and boom valve motors may have a fuse for circuit protection. Make sure that correct fuse is installed in the in-line fuse holder located in the motor harness.

IMPORTANT: Make sure to remove and neutralize chemicals from spray components before disassembly. Wear protective clothing, chemical resistant gloves, and eye protection during repair.

Removal (Fig. 21)

1. Park machine on a level surface, stop engine, engage parking brake, and remove key from the ignition switch.
2. Label hoses for proper installation after repairs are completed. Loosen hose clamps and disconnect hoses from spray control.
3. Unplug electrical connectors from rate control motor, flowmeter, and three (3) boom valve motors from machine electrical harness.
4. Remove pressure gauge tube from coupler on back of flowmeter housing (Fig. 23).
5. Remove three (3) flange head screws that secure spray control assembly to valve mounting bar. Remove spray control assembly from machine.
6. Remove spray control components as required using Figure 21 as a guide. Discard all removed o-rings and gaskets.

Assembly (Fig. 21)

NOTE: Coat all o-rings with vegetable oil before installation to reduce the chance of damage during assembly.

1. Install spray control components using Figure 21 as a guide. Replace all removed o-rings and gaskets.
2. Before installing rod (Item 2) into assembly, thread nut (item 1) fully onto rod end that has fewer threads. Make sure that o-ring (Item 3) is not damaged during installation over rod. To secure assembly, torque nut 71 in-lb (8 N-m).
3. Position spray control assembly to valve mounting bar and secure with three (3) flange head screws.
4. Install hoses to correct locations on spray control assembly. Secure hoses with hose clamps.
5. Install pressure gauge tube to coupler on back of flowmeter housing (Fig. 23).
6. Plug electrical connectors from rate control motor, flowmeter, and three (3) boom valve motors to machine electrical harness.
7. Operate spray system and check for leaks.

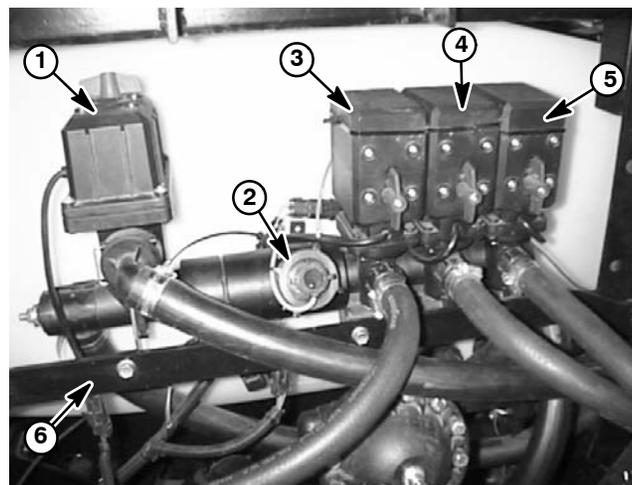


Figure 22

- | | |
|------------------------|----------------------------|
| 1. Rate control motor | 4. Center boom valve motor |
| 2. Flowmeter | 5. RH boom valve motor |
| 3. LH boom valve motor | 6. Valve mounting bar |

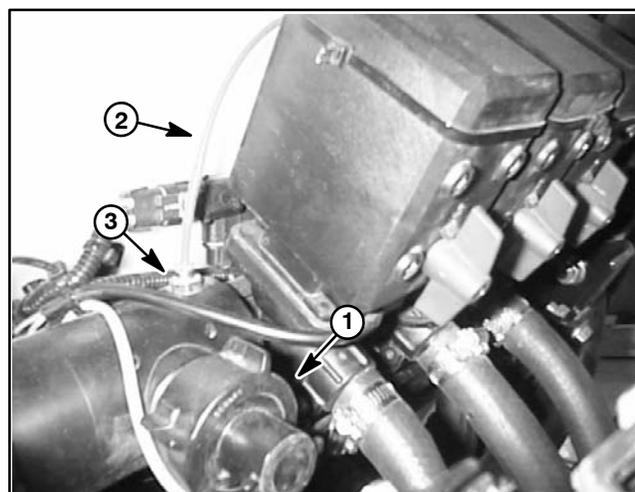


Figure 23

- | | |
|------------------------|------------|
| 1. Flowmeter | 3. Coupler |
| 2. Pressure gauge tube | |

Spray Control (Serial Numbers Above 31000000)

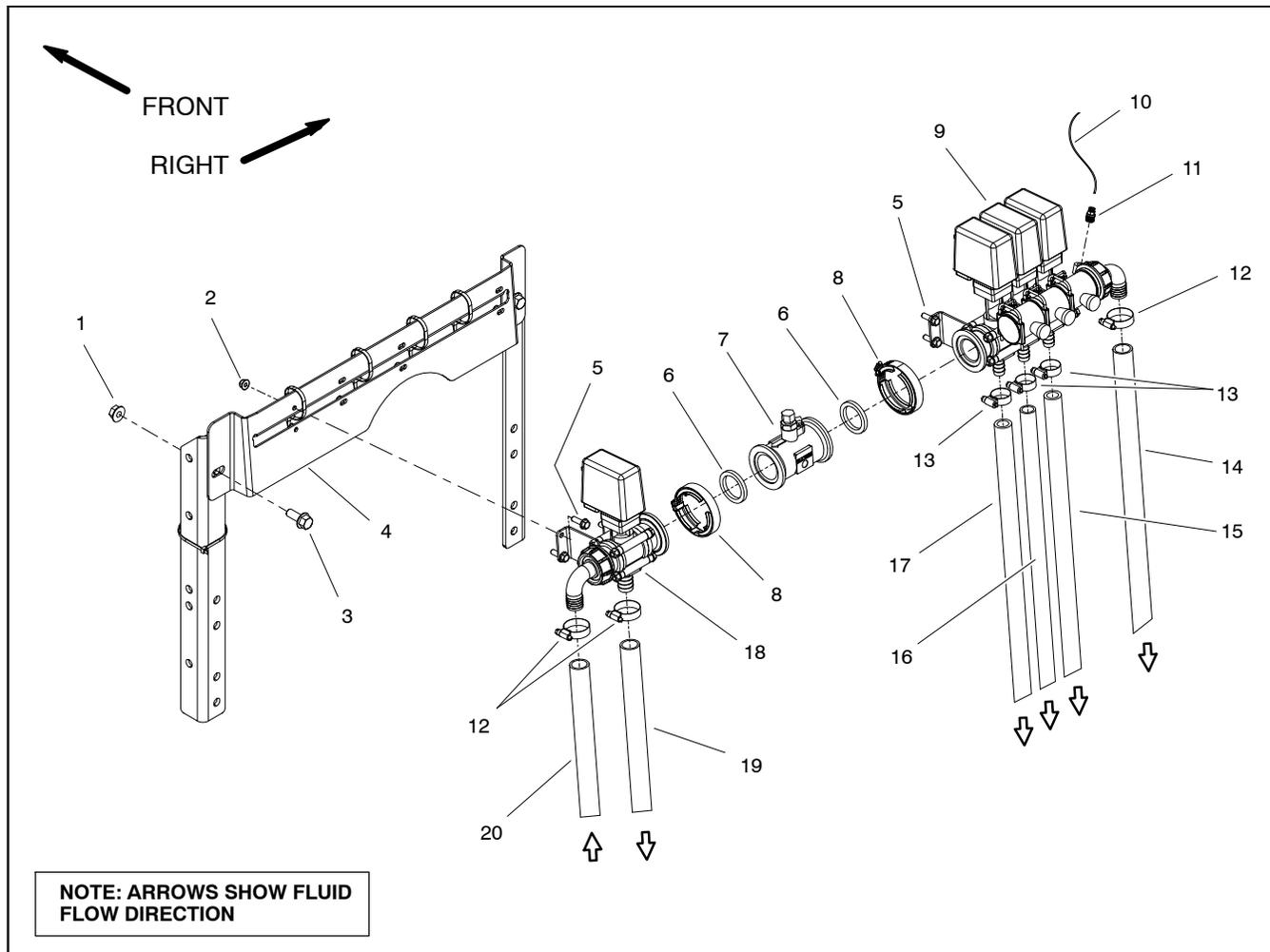


Figure 23.1

- | | | |
|-------------------------------|------------------------------|-------------------------------|
| 1. Flange nut (2 used) | 8. Clamp (2 used) | 15. Hose: RH boom supply |
| 2. Flange nut (8 used) | 9. Boom valve manifold | 16. Hose: center boom supply |
| 3. Flange head screw (2 used) | 10. Pressure gauge tube | 17. Hose: LH boom supply |
| 4. Valve mount | 11. Coupler (pressure gauge) | 18. Regulating valve assembly |
| 5. Flange head screw (8 used) | 12. Hose clamp (3 used) | 19. Hose: control bypass |
| 6. Gasket (2 used) | 13. Hose clamp (3 used) | 20. Hose: control supply |
| 7. Flowmeter | 14. Hose: boom bypass | |

Disassembly (Fig. 23.1)

IMPORTANT: Make sure to remove and neutralize chemicals from tank and spray components before disassembly. Wear protective clothing, chemical resistant gloves, and eye protection during repair.

1. Park machine on a level surface, stop engine, engage parking brake, and remove key from the ignition switch.
2. Label all spray control assembly hoses for proper installation after repairs are completed. Loosen hose clamps and disconnect hoses from spray control.
3. Label all wire harness leads for assembly purposes. Disconnect wire harness connectors from regulating valve, flowmeter and three (3) boom valve motors.
4. Remove pressure gauge tube (item 10) from coupler on pressure gauge port on right side of boom valve manifold assembly.
5. Support spray control assembly to prevent it from falling.
6. Remove eight (8) flange head screws, flat washers and flange nuts that secure spray control assembly to valve mount. Remove spray control assembly from machine.

IMPORTANT: Before removing flowmeter from spray control assembly, note direction of arrow on top of flowmeter (Fig. 23.3). The arrow should point toward boom valve manifold assembly.

7. Separate spray control assembly as required using Figure 23.1 as a guide. Discard all removed gaskets.

Assembly (Fig. 23.1)

NOTE: Coat all gaskets and o-rings with vegetable oil before installation to reduce the chance of damage during assembly.

1. Assemble spray control using Figure 23.1 as a guide. Replace all removed gaskets. Make sure that arrow on flowmeter body points toward boom valve manifold assembly (Fig. 23.3).
2. Position spray control assembly to valve mounting bar and secure with eight (8) flange head screws, flat washers and flange nuts.

3. Using labels placed during disassembly, install hoses to correct locations on spray control assembly. Secure hoses with hose clamps.
4. Install pressure gauge tube (item 10) to coupler on pressure gauge port on right side of boom valve manifold assembly.
5. Using labels placed during disassembly, secure wire harness connectors to regulating valve, flowmeter and three (3) boom valve motors.
6. Operate spray system and check for leaks. Repair all leaks before returning the sprayer to service.

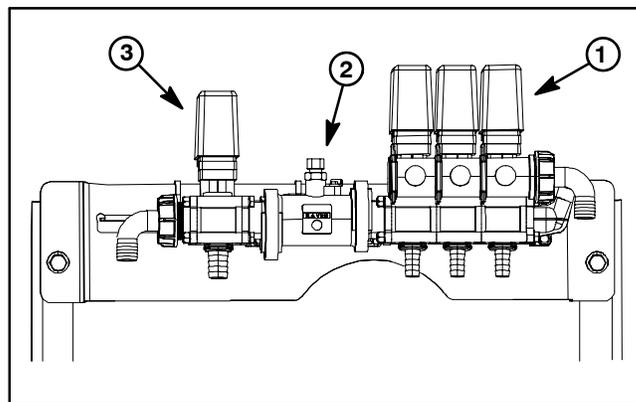


Figure 23.2

- | | |
|------------------------|---------------------|
| 1. Boom valve manifold | 3. Regulating valve |
| 2. Flowmeter | |

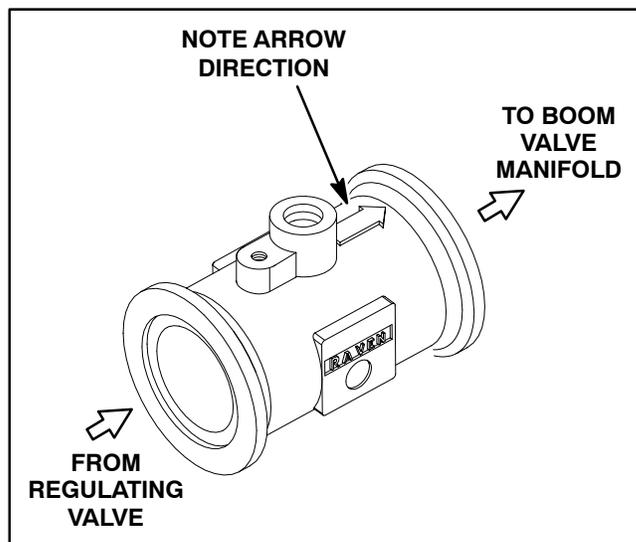


Figure 23.3

Flowmeter (Serial Numbers Below 290999999)

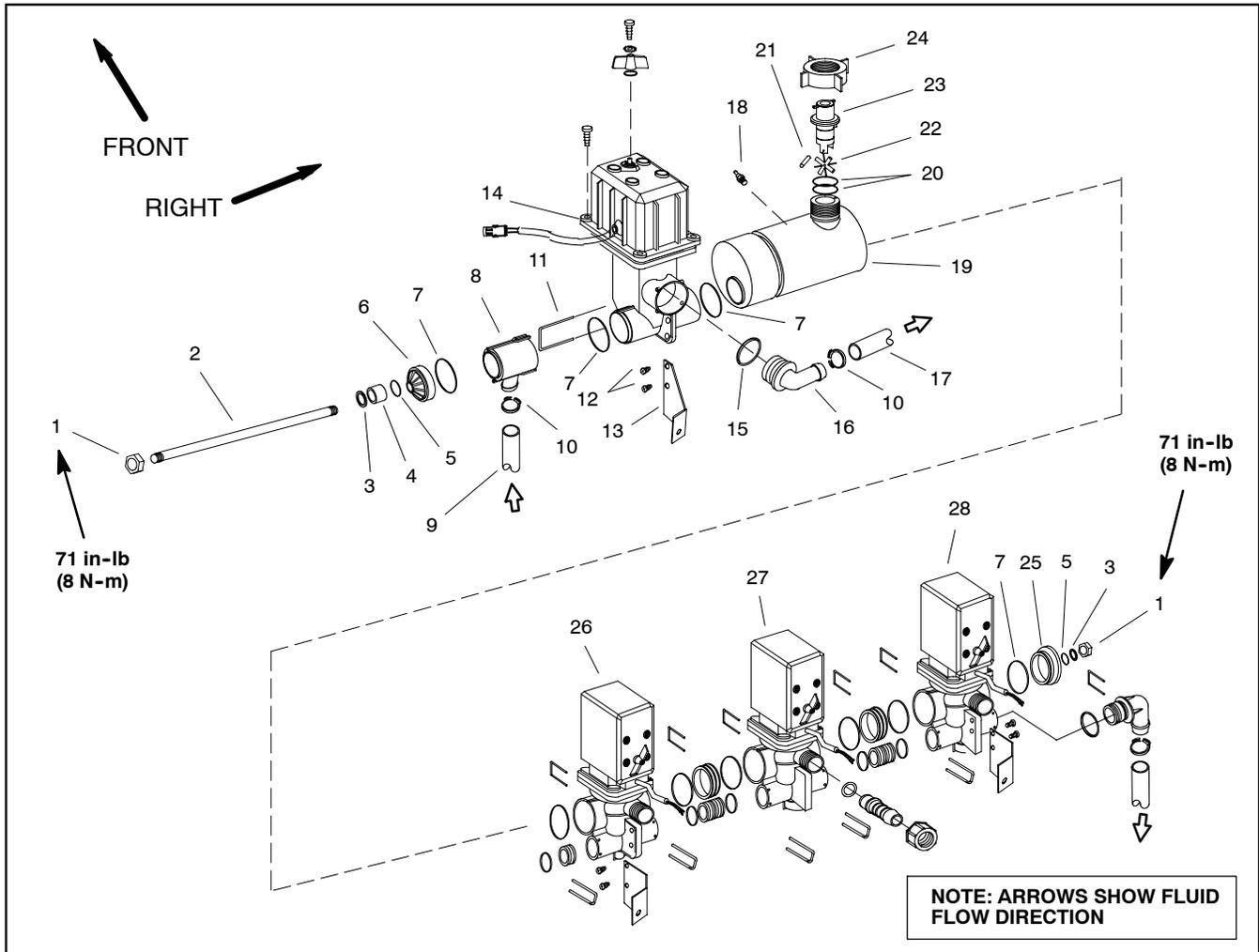


Figure 24

- | | | |
|------------------------------|--------------------------------|-------------------------------|
| 1. Nut | 11. Fork | 20. O-ring |
| 2. Threaded rod | 12. Screw | 21. Flowmeter rotor shaft |
| 3. Washer | 13. Control valve bracket | 22. Flowmeter rotor |
| 4. Bushing | 14. Rate control motor/housing | 23. Flow sensor |
| 5. O-ring | 15. O-ring | 24. Nut |
| 6. Cover | 16. Hosebarb | 25. End cap |
| 7. O-ring | 17. Hose: control bypass (1") | 26. LH boom control motor |
| 8. Tee piece | 18. Coupler (pressure gauge) | 27. Center boom control motor |
| 9. Hose: control supply (1") | 19. Flowmeter housing | 28. RH boom control motor |
| 10. Hose clamp | | |

Removal and Inspection (Fig. 24)

IMPORTANT: Make sure to remove and neutralize chemicals from spray components before disassembly. Wear protective clothing, chemical resistant gloves, and eye protection during repair.

1. Park machine on a level surface, stop engine, engage parking brake, and remove key from the ignition switch.
2. Loosen and remove nut that secures flow sensor to flowmeter housing. Carefully remove flow sensor from housing.
3. Inspect for worn rotor shaft and/or bushings. Make sure that rotor magnets are not missing or damaged.
4. Clean rotor, rotor shaft, and flowmeter sensor if required (see Operator's Manual).
5. With the flow sensor harness connected to the machine and the ignition key in the ON position, slowly spin the flowmeter rotor. The flowmeter LED should illuminate as a rotor magnet passes the flow sensor and should go out as the next magnet passes the sensor.

NOTE: When using a magnet to check the flowmeter, make sure to alternately use both north and south poles of the magnet.

6. If the flowmeter LED does not flash, remove rotor and rotor shaft from sensor. With the flowmeter harness connected to the machine and the ignition key in the ON position, slowly pass alternate poles of a magnet past the flow sensor. If the flowmeter LED flashes as the magnet poles pass the sensor, replace the rotor and rotor shaft. If the flowmeter LED does not flash as the magnet poles pass the sensor, replace the flow sensor.

7. If necessary, remove flowmeter housing using Figures 24 and 26 as guides (also see Spray Control) in this section). Discard all removed o-rings and gaskets.

Assembly (Fig. 24)

NOTE: Coat all o-rings with vegetable oil before installation to reduce the chance of damage during assembly.

NOTE: When installing flow sensor into housing, make sure to align locating pin on sensor flange with hole in housing.

1. Reassemble flowmeter using Figures 24 and 26 as guides. Replace all removed o-rings and gaskets.
2. Operate spray system and check for leaks.

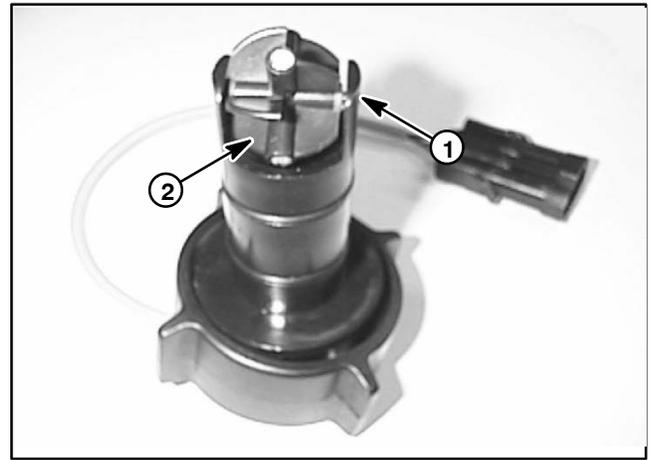


Figure 25

1. Rotor shaft
2. Rotor

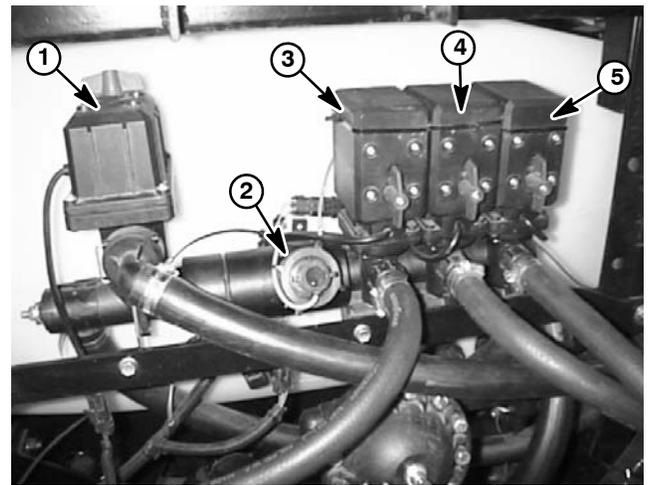


Figure 26

1. Rate control motor
2. Flowmeter
3. LH boom valve motor
4. Center boom valve motor
5. RH boom valve motor

Flowmeter (Serial Numbers Above 31000000)

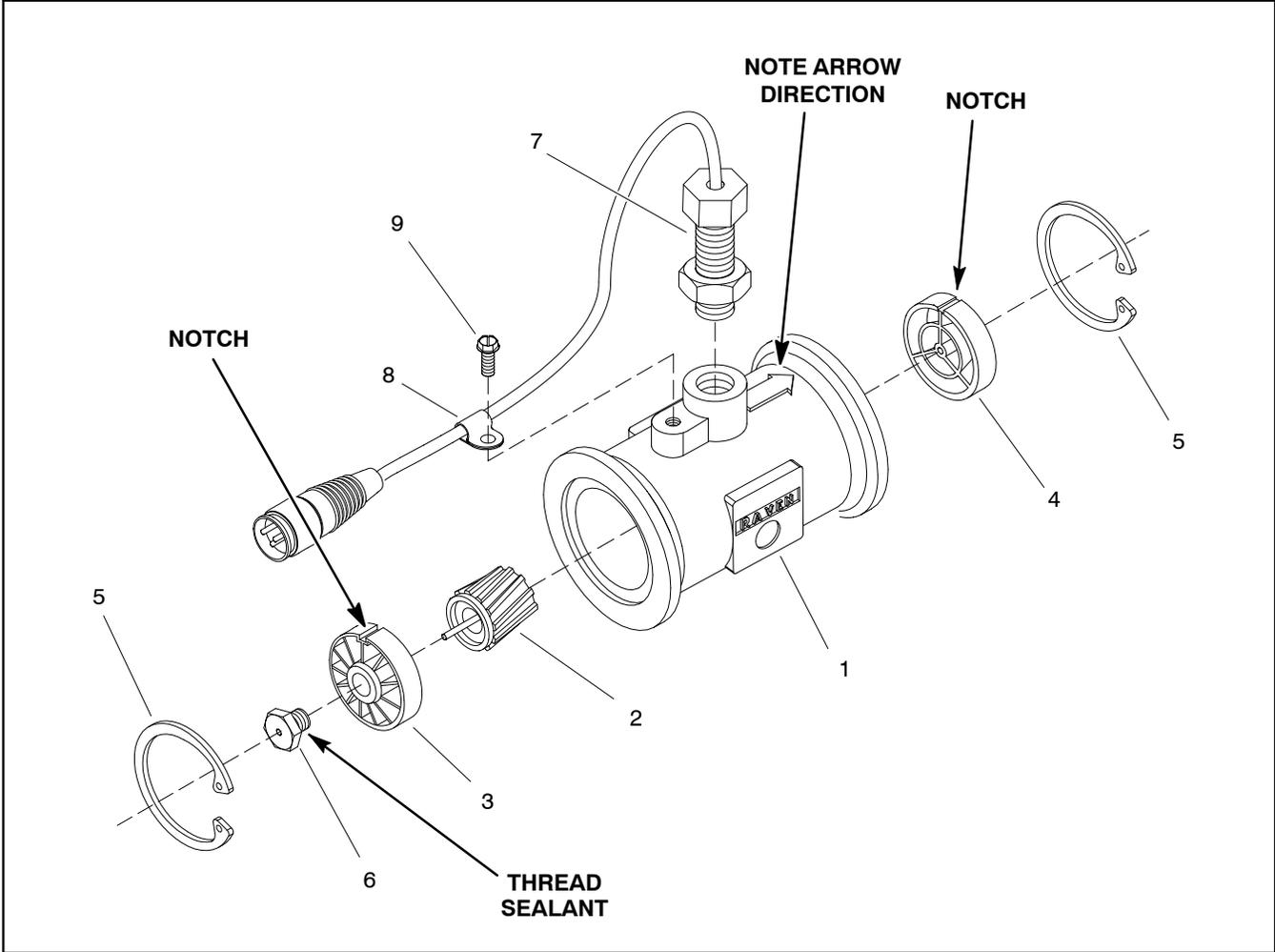


Figure 26.1

- | | | |
|------------------------------|------------------------------|--------------------|
| 1. Flowmeter body | 4. Downstream hub | 7. Sensor assembly |
| 2. Rotor/magnet assembly | 5. Retaining ring (2 used) | 8. Cable clamp |
| 3. Upstream hub with bearing | 6. Turbine stud with bearing | 9. Screw |

Removal and Inspection (Fig. 26.1)

IMPORTANT: Make sure to remove and neutralize chemicals from spray components before disassembly. Wear protective clothing, chemical resistant gloves, and eye protection during repair.

1. Remove spray control assembly from machine and separate flowmeter from spray control (see Spray Control Assembly (Serial Numbers Above 310000000) Removal in this section).
2. Disassemble flowmeter as required using Figures 26.1 and 26.3 as guides.
3. Clean rotor (item 2), both hubs (items 3 and 4) and flowmeter body to remove any metal filings, spray chemicals or other materials.

Assembly (Fig. 26.1)

1. Assemble flowmeter using Figures 26.1 and 26.3 as guides. Check the following items during flowmeter assembly.
 - A. If turbine stud (item 6) was removed from upstream hub, apply thread sealant to threads of stud before installation.
 - B. Check that rotor spins freely with very little drag. If necessary, loosen the turbine stud 1/16 of a turn and check rotor drag. Continue the process of loosening stud until rotor spins freely.
 - C. When installing hubs (items 3 and 4) into housing, make sure to align locating notch on each hub with boss in housing bore.
 - D. If sensor (item 7) was removed from flowmeter body, thread sensor into housing so that it lightly bottoms in the housing. Secure sensor in position by tightening jam nut.
 - E. Make sure that retaining rings are fully seated in grooves of flowmeter housing.
2. Attach flowmeter assembly to spray control and then install spray control assembly to machine (see Spray Control Assembly (Serial Numbers Above 310000000) Installation in this section).

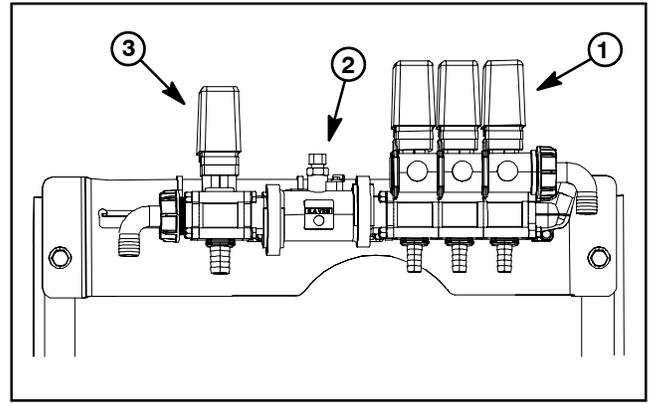


Figure 26.2

- | | |
|------------------------|---------------------|
| 1. Boom valve manifold | 3. Regulating valve |
| 2. Flowmeter | |

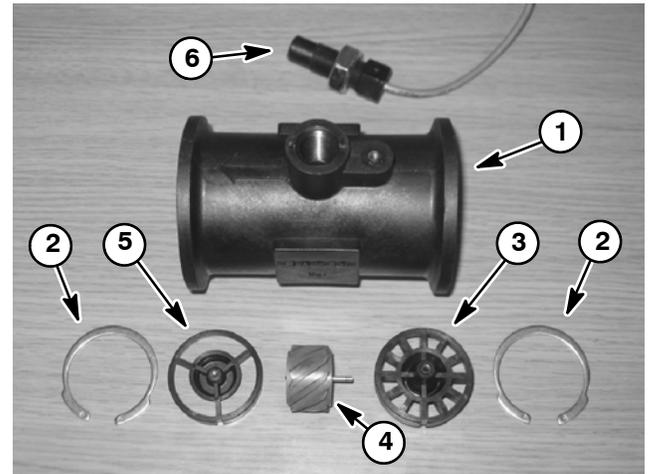


Figure 26.3

- | | |
|-------------------|-------------------|
| 1. Flowmeter body | 4. Rotor |
| 2. Retaining ring | 5. Downstream hub |
| 3. Upstream hub | 6. Sensor |

Rate Control Motor (Serial Numbers Below 290999999)

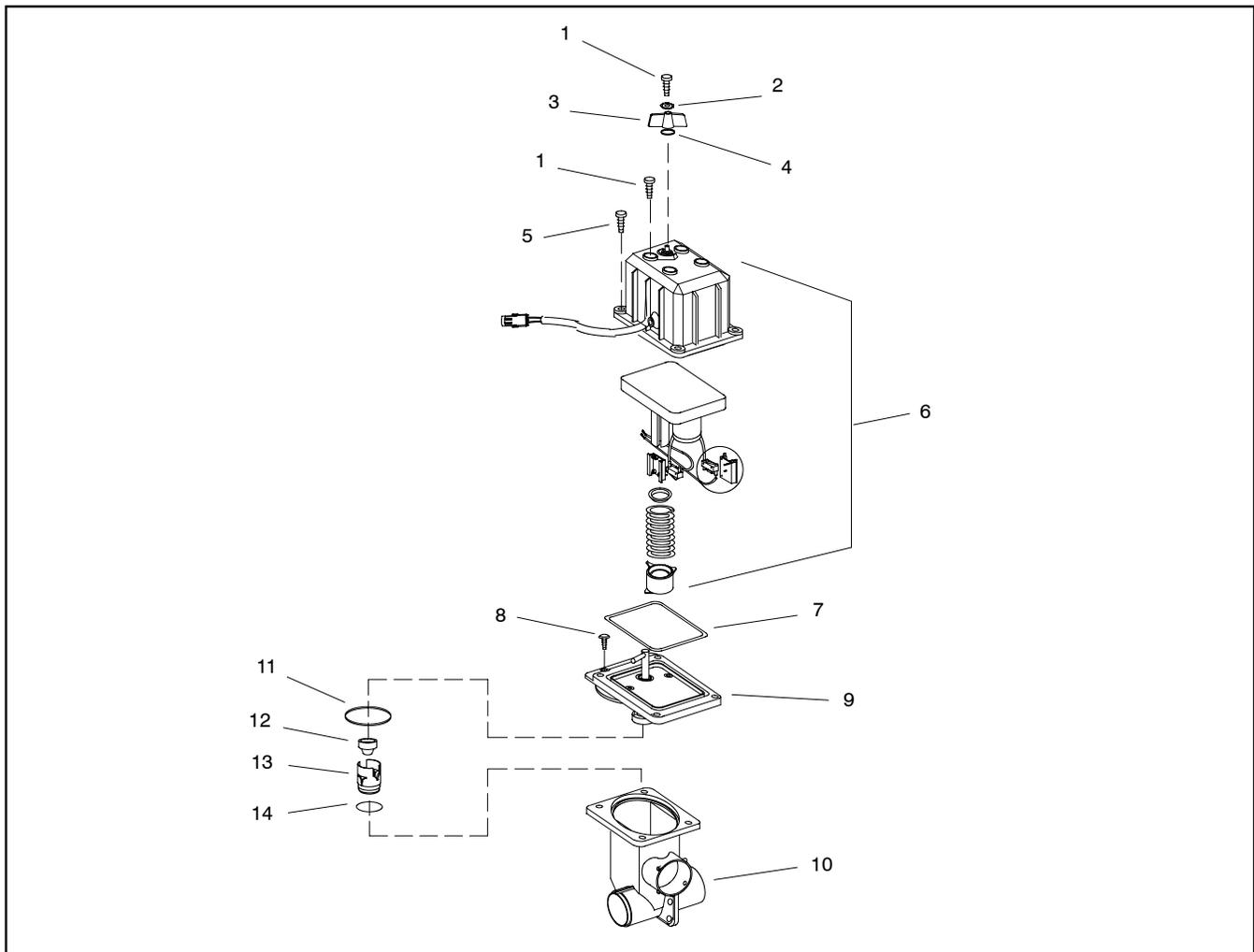


Figure 27

- | | | |
|---------------------------------|---------------------------------|-------------------|
| 1. Phillips head screw (5 used) | 6. Rate control motor assembly | 11. O-ring |
| 2. Lock washer | 7. Gasket | 12. Cone |
| 3. Hand grip | 8. Phillips head screw (4 used) | 13. Control valve |
| 4. O-ring | 9. Rate valve spindle section | 14. Seal |
| 5. Phillips head screw (4 used) | 10. Rate control valve housing | |

The rate control motor allows the operator to vary the spray application rate. The pressure increase/decrease switch on the spray console energizes the rate control motor which adjusts the valve opening and allows some flow to bypass the spray booms.

NOTE: The rate control motor affects flow to all spray booms. Therefore, a problem with the rate control motor will affect all booms and nozzles.

Disassembly and Inspection (Fig. 27)

IMPORTANT: Make sure to remove and neutralize chemicals from spray components before disassembly. Wear protective clothing, chemical resistant gloves, and eye protection during repair.

1. To remove the rate control motor:

- A. Adjust the rate control to maximum to allow the rate control motor spring to relax. This can be done with either the increase/decrease switch on the spray console or by rotating the hand grip on the motor fully in a clockwise direction.
- B. Unplug rate control motor electrical connector from machine electrical harness.
- C. Loosen four (4) phillips head screws (item 5) evenly to allow removal of the rate control motor.
- D. The inside of motor housing should be free of excessive moisture, corrosion, and dirt.

2. Remove four (4) phillips head screws (item 8) that secure spindle section to housing. Remove spindle section.

3. Locate, remove, and discard o-ring (item 11) and seal (item 14).

4. Remove valve (item 13) and inspect for wear and/or damage. Replace if needed.

5. If needed, the spindle shaft can be removed by removing lock nut that secures cone (item 12) to shaft.

NOTE: Many individual components for the rate control motor and spindle section are not available separately. If individual components are worn or damaged, assemblies must be replaced. Refer to Parts Catalog.

6. If necessary, remove rate control valve housing from machine (see Spray Control in this section).

Assembly (Fig. 27)

NOTE: Coat all o-rings with vegetable oil before installation to reduce the chance of damage during assembly.

1. If removed, install rate control valve housing to machine (see Spray Control in this section).

2. If spindle shaft was removed, assemble by reversing disassembly process. Make sure that spindle shaft support aligns with notches in housing during assembly. Secure spindle assembly with lock nut.

3. Align control valve with tabs in spindle section and install control valve. Rotate spindle to fully retract control valve.

4. Install new o-ring (item 11) and seal (item 14) to spindle section.

5. Position spindle section to rate control valve housing. Secure spindle section with four (4) phillips head screws (item 8).

6. To ease assembly of the motor, rotate spindle shaft so the post is about 1/2" (13 mm) from the spindle section housing. Align slot in motor with post in spindle and install motor.

7. Secure motor to assembly by evenly tightening four (4) phillips head screws (item 5).

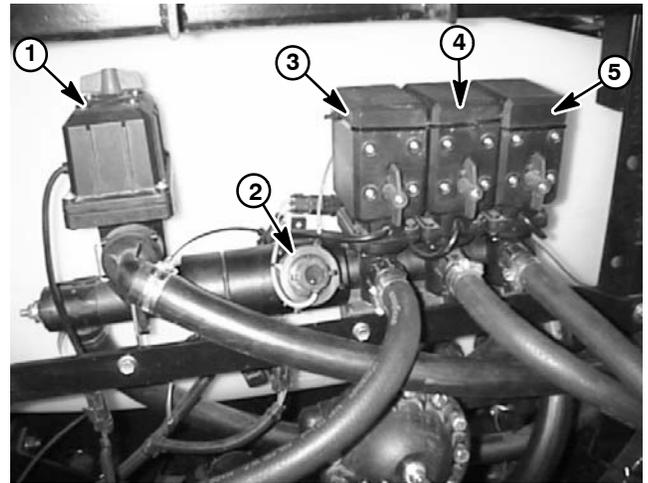


Figure 28

- | | |
|------------------------|----------------------------|
| 1. Rate control motor | 4. Center boom valve motor |
| 2. Flowmeter | 5. RH boom valve motor |
| 3. LH boom valve motor | |

Regulating Valve Assembly (Serial Numbers Above 31000000)

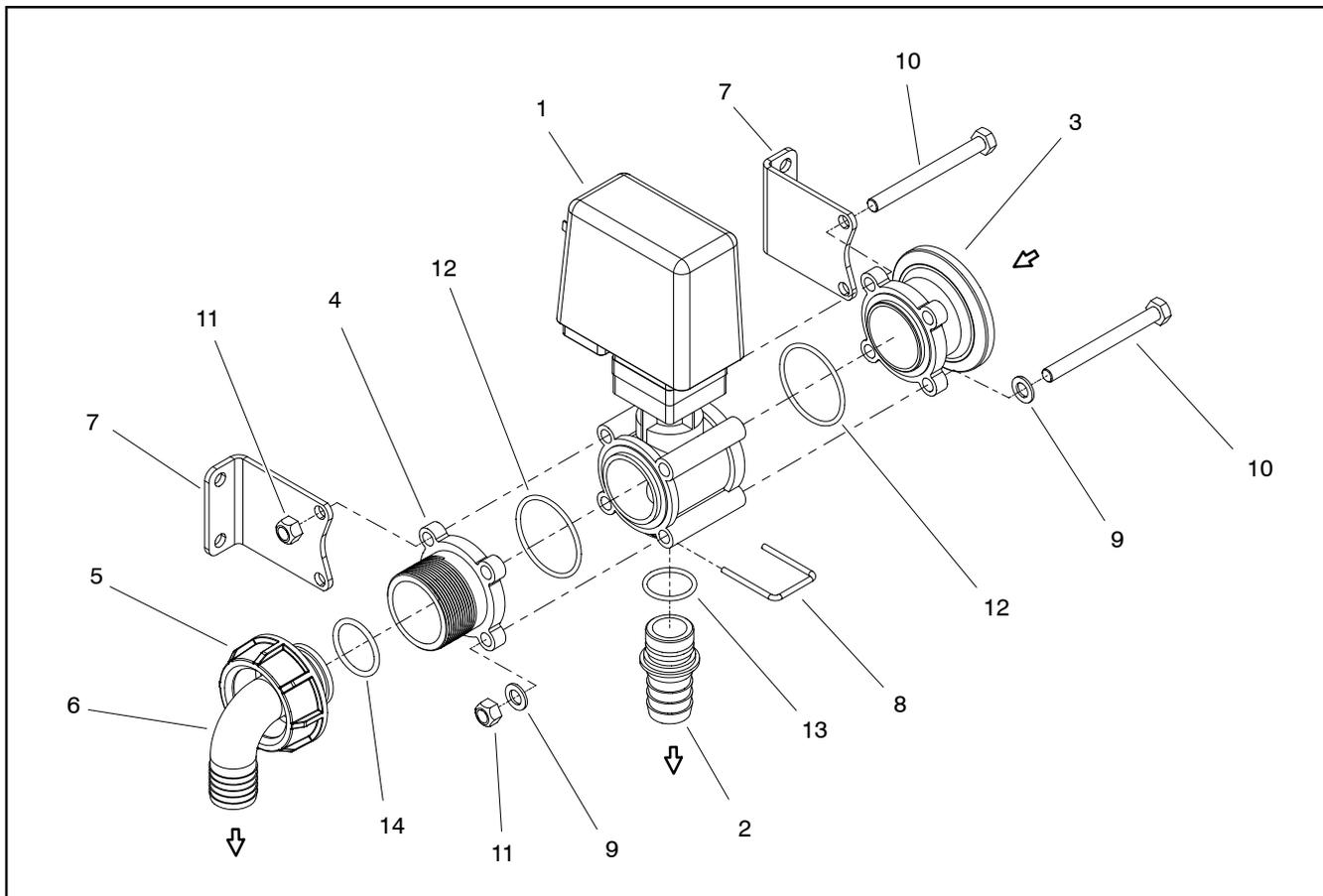


Figure 28.1

- | | | |
|---------------------------|------------------------------|-----------------------|
| 1. Regulating valve motor | 6. Elbow fitting | 11. Lock nut (4 used) |
| 2. Hose barb | 7. Mounting bracket (2 used) | 12. O-ring (2 used) |
| 3. Flange | 8. Fork | 13. O-ring |
| 4. Adaptor | 9. Washer (4 used) | 14. O-ring |
| 5. Flynut | 10. Cap screw (4 used) | |

The regulating valve allows the operator to vary the spray application rate. The pressure increase/decrease switch on the spray console energizes the regulating valve motor which adjusts the valve opening and allows some flow to bypass the spray booms.

NOTE: The regulating valve affects flow to all spray booms. Therefore, a problem with the regulating valve will affect all booms and nozzles.

Removal and Inspection (Fig. 28.1)

IMPORTANT: Make sure to remove and neutralize chemicals from spray components before disassembly. Wear protective clothing, chemical resistant gloves, and eye protection during repair.

1. Remove spray control assembly from machine and separate regulating valve assembly from spray control (see Spray Control Assembly (Serial Numbers Above 31000000) Removal in this section).

2. Disassemble regulating valve assembly as needed using Figure 28.1 as a guide. Discard all removed O-rings and gaskets.

NOTE: There are limited replacement parts available for regulating valve motor assembly. Check your parts catalog for parts that are available.

3. To remove valve motor cover from regulating valve motor (Fig. 28.3):

- A. Loosen three (3) screws that secure valve motor cover to valve motor assembly.
- B. Carefully lift and rotate cover from valve motor.
- C. Unplug wire connections and remove cover.
- D. Make sure that screws that secure valve motor are tight.

Assembly (Fig. 28.1)

1. To install valve motor cover to regulating valve motor (Fig. 28.3):

- A. Connect cover wires to motor wires. Make sure that cover wire color is the same as the motor wire color when connecting wires.
- B. Carefully rotate cover onto valve motor taking care to not damage wires.
- C. Tighten screws to secure cover to valve motor.

NOTE: Coat all O-rings with vegetable oil before installation to reduce the chance of damage during assembly.

2. Assemble regulating valve assembly using Figure 28.1 as a guide.

3. Attach regulating valve assembly to spray control and then install spray control assembly to machine (see Spray Control Assembly (Serial Numbers Above 310000000) Installation in this section).

Piston Valve Service (Fig. 28.4)

1. Remove hosebarb from bottom of valve motor to allow access to piston valve.

2. Make sure that valve is closed. If valve is not closed, spring above piston valve will be under compression and may damage valve motor or piston valve during disassembly. End of piston valve will extend into bottom of valve motor housing when valve is closed. If necessary, reconnect motor to machine wire harness and close valve before removing piston valve.

3. Use 3mm allen wrench to loosen and remove piston valve assembly from valve motor. Locate and retrieve spring from above piston valve.

4. Inspect seals on piston valve assembly. O-ring in top groove of piston valve assembly is available separately. If lower two (2) seals in piston valve are worn or damaged, replace piston valve assembly. The piston valve is not designed to be disassembled.

5. Apply silicone grease to seals on piston valve assembly.

6. Position spring into valve motor housing. Use 3mm allen wrench to secure piston valve assembly to valve motor.

7. Secure hosebarb to bottom of valve motor.

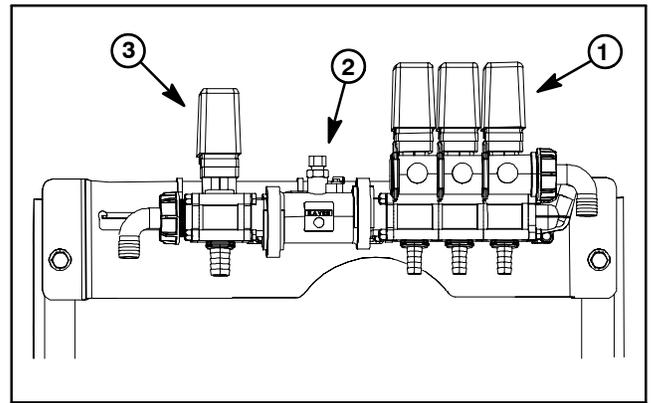


Figure 28.2

- 1. Boom valve manifold
- 2. Flowmeter
- 3. Regulating valve

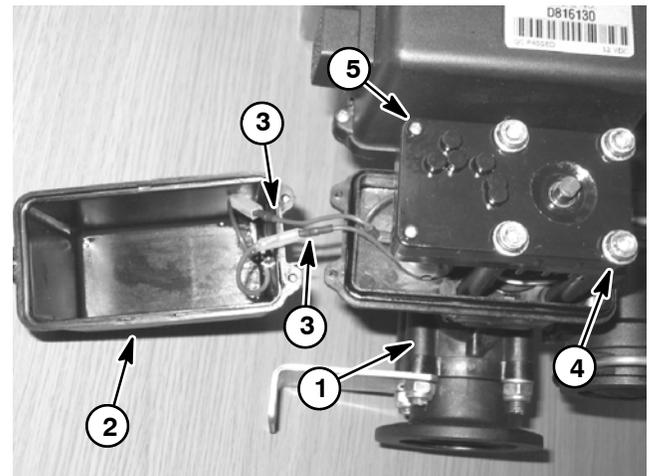


Figure 28.3

- 1. Valve motor assembly
- 2. Valve motor cover
- 3. Wire connector
- 4. Socket screw (4 used)
- 5. Phillips screw (2 used)

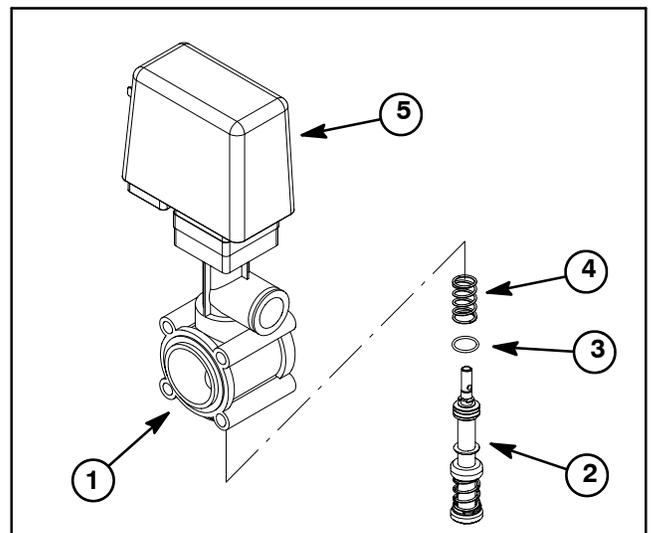


Figure 28.4

- 1. Valve motor assembly
- 2. Piston valve assembly
- 3. Valve seal
- 4. Spring
- 5. Valve motor cover

Spray System

Boom Valve Motor (Serial Numbers Below 290999999)

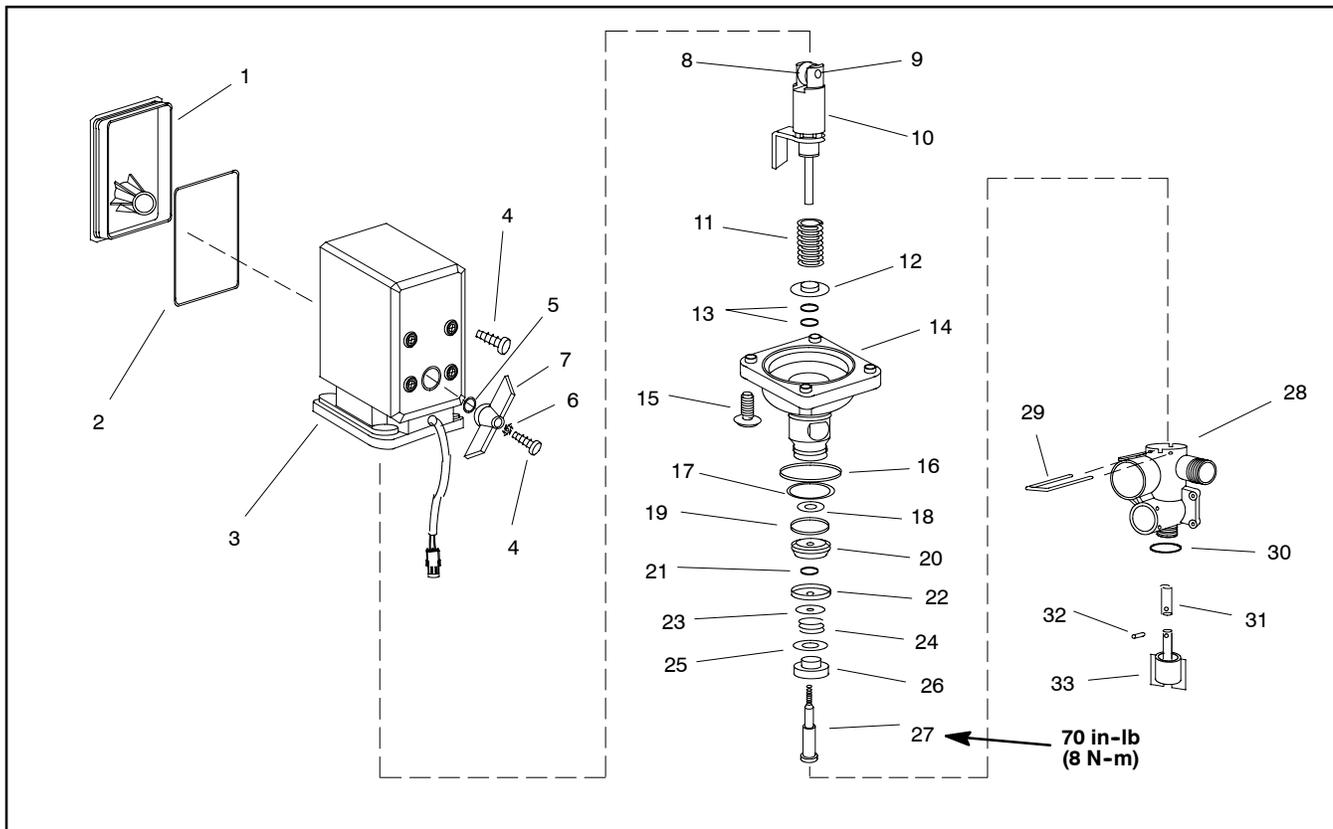


Figure 29

- | | | |
|---------------------------------|----------------------------------|---------------------------------|
| 1. Housing cover | 12. Spring seat | 23. Flat washer |
| 2. Cover seal | 13. O-ring | 24. Spring |
| 3. Boom valve motor | 14. Spindle housing | 25. Flat washer |
| 4. Phillips head screw (5 used) | 15. Phillips head screw (4 used) | 26. Cone |
| 5. O-ring | 16. O-ring | 27. Screw |
| 6. Lock washer | 17. O-ring | 28. Boom valve manifold housing |
| 7. Hand grip | 18. Flat washer | 29. Fork |
| 8. Roller | 19. Seat outer o-ring | 30. O-ring |
| 9. Roller pin | 20. Seat | 31. Balancing valve |
| 10. Spindle | 21. Seat inner o-ring | 32. Roll pin |
| 11. Spring | 22. Seat base | 33. Balancing valve knob |

The Workman 200 Sprayer (serial numbers below 290999999) uses three boom valve motor assemblies to control the spray booms. Each boom valve motor assembly includes a motor section (Fig. 29, Items 1 through 7), a spindle section (Fig. 29, Items 8 through 27), and a manifold assembly (Fig. 29, Items 28 through 33).

Disassembly and Inspection (Fig. 29)

IMPORTANT: Make sure to remove and neutralize chemicals from spray components before disassembly. Wear protective clothing, chemical resistant gloves, and eye protection during repair.

1. Remove spray control from machine. Separate spray control components to allow boom valve motor disassembly (see Spray Control in this section).

2. To remove the motor and spindle section assembly from the manifold assembly:

- A. Remove the fork (item 29) that secures the motor and spindle sections to the manifold assembly.
- B. Lift the motor and spindle section assembly from the manifold.

3. To allow easier separation of the motor and spindle sections, make sure that boom valve motor is in the closed position (green indicator is recessed into the spindle housing). Remove four phillips head screws (item 15) and separate spindle section from motor section.

4. Remove rear housing cover from boom valve motor to inspect motor components.

A. Cam should be tight on shaft. Cam surface should be free of wear and/or scoring.

B. The inside of motor housing should be free of excessive moisture, corrosion, and dirt.

C. The cam bearing surface in the housing cover should be inspected for excessive wear.

5. Inspect and disassemble spindle section (Fig. 31).

A. Inspect spindle roller surface for wear or scoring. Check that spindle roller rotates freely on roller pin. Replace roller and/or pin as required.

B. The spindle can be disassembled by removing the screw at the bottom of the spindle shaft. Take note of washer, spring, seat, and o-ring locations as spindle is removed.

C. Inspect the cone located at the bottom of the spindle. The cone should be free of nicks or worn spots. A damaged cone will allow flow to the boom bypass rather than to the spray boom.

D. The seat o-rings allow the spindle to shut off flow to the spray boom. If boom nozzles leak when the boom is shut off, the seat and seat o-rings should be inspected carefully.

6. If leakage occurs from balancing valve knob at bottom of boom valve manifold (Fig. 32):

A. Carefully remove roll pin that secures balancing valve to knob.

B. Remove knob from manifold. Remove and discard o-ring.

C. Inspect seating surfaces of manifold and balancing valve. Clean or replace components as needed.

Assembly (Fig. 29)

NOTE: Coat all o-rings with vegetable oil before installation to reduce the chance of damage during assembly.

1. Replace all removed o-rings.

2. If boom valve manifold was disassembled (Fig. 32):

A. Install o-ring, balancing valve, and knob to manifold.

B. Secure balancing valve to knob by carefully installing roll pin.

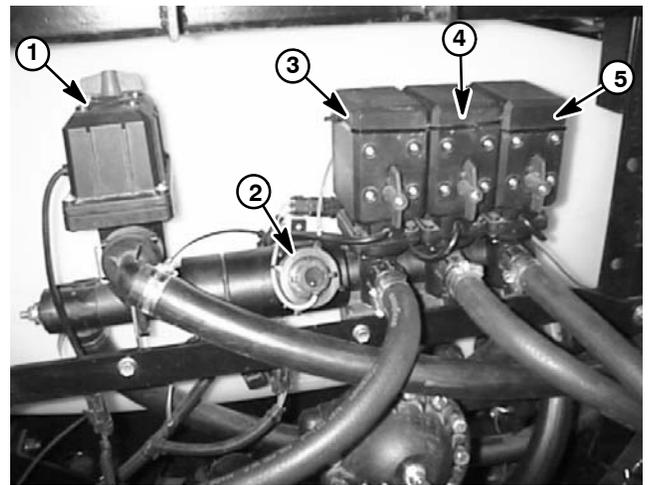


Figure 30

- | | |
|------------------------|----------------------------|
| 1. Rate control motor | 4. Center boom valve motor |
| 2. Flowmeter | 5. RH boom valve motor |
| 3. LH boom valve motor | |

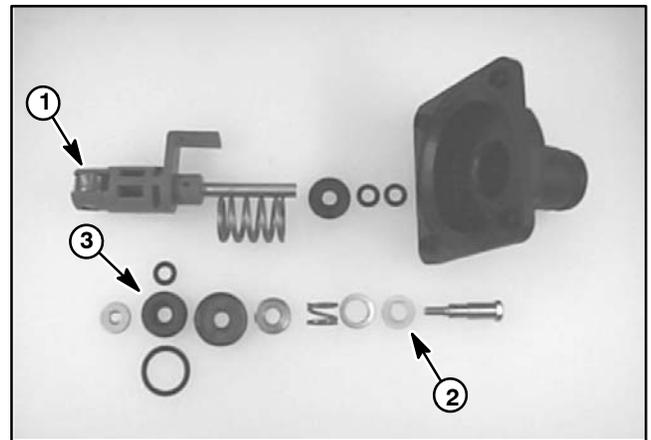


Figure 31

- | | |
|-------------------|---------|
| 1. Spindle roller | 3. Seat |
| 2. Cone | |

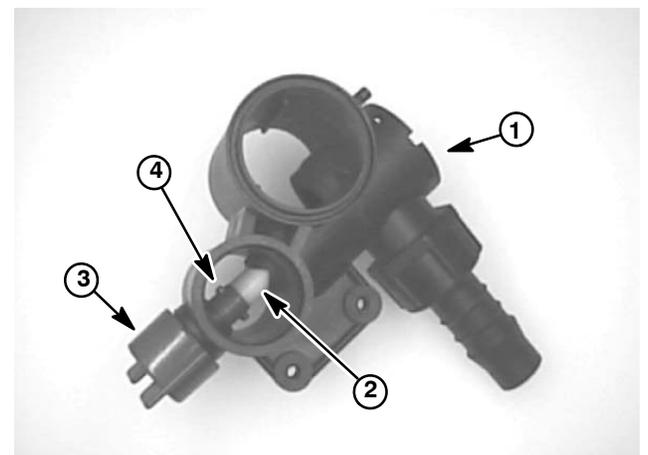


Figure 32

- | | |
|------------------------|-------------------------|
| 1. Boom valve manifold | 3. Balancing valve knob |
| 2. Balancing valve | 4. Roll pin |

3. Assemble spindle section by reversing disassembly process. Align green indicator tab on spindle to slot in spindle housing. Install screw into bottom of spindle to secure assembly. Torque screw 70 in-lb (8 N-m).
4. Position spindle section on motor section so that green indicator on spindle section is opposite the motor hand grip. Secure spindle section to motor section with four phillips head screws (item 15).
5. Replace rear housing to boom valve motor.
6. Position the motor and spindle section assembly to the manifold assembly. The motor hand grip and boom supply hosebarb on manifold should be on the same side of the assembly. Install the fork (item 29) to secure the motor and spindle sections to the manifold.
7. Assemble spray control assembly. Install spray control to machine (see Spray Control in this section).
8. Operate spray system and check for leaks.

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Boom Valve Manifold Assembly (Serial Numbers Above 31000000)

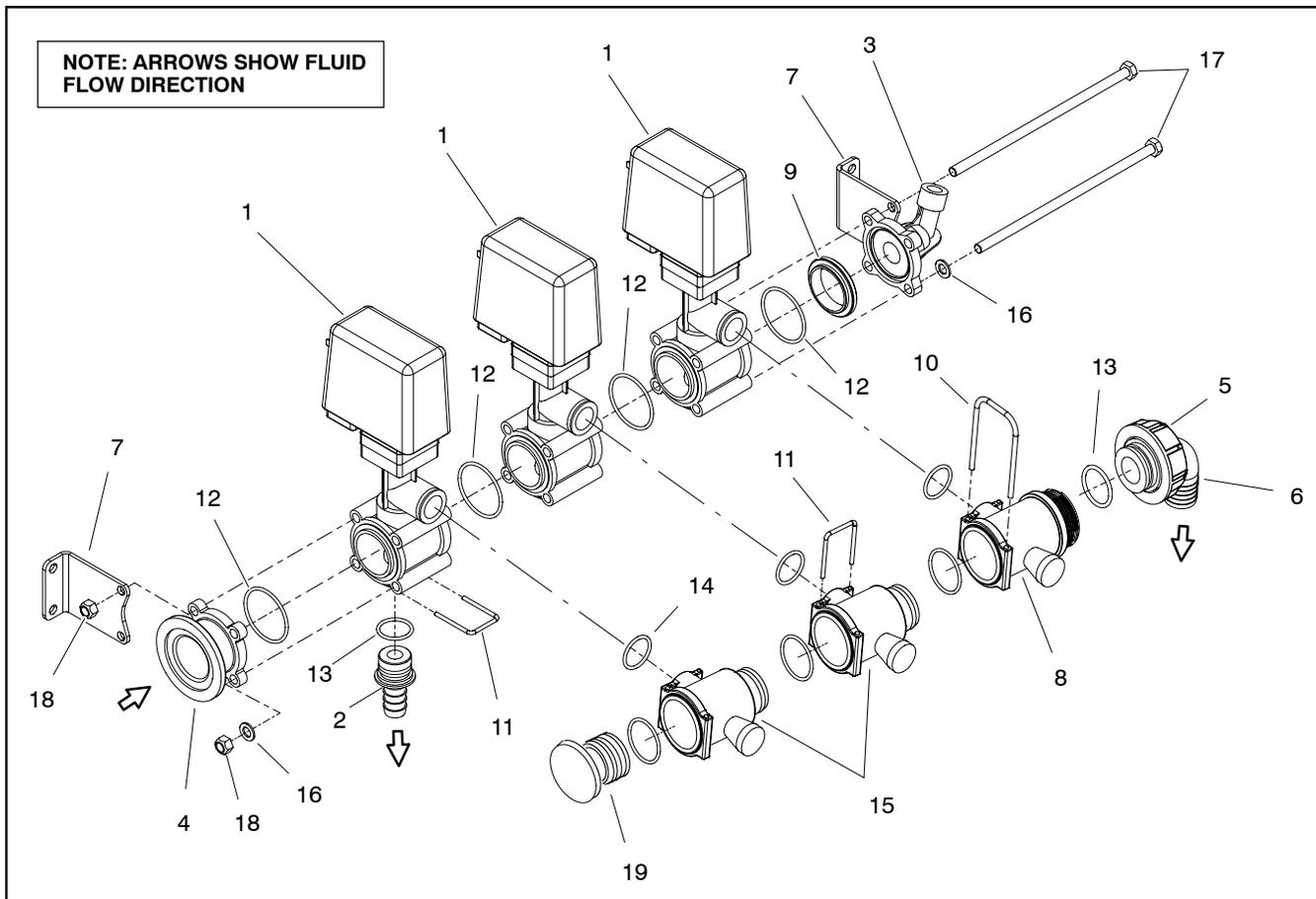


Figure 32.1

- | | | |
|------------------------------|-----------------------------|---------------------------------------|
| 1. Boom valve motor (3 used) | 8. Balancing valve assembly | 14. O-ring (3 used) |
| 2. Hose barb (3 used) | 9. Flange | 15. Balancing valve assembly (2 used) |
| 3. Pressure gauge port | 10. Fork (3 used) | 16. Washer (4 used) |
| 4. Flange | 11. Fork (6 used) | 17. Cap screw (4 used) |
| 5. Flynut | 12. O-ring (4 used) | 18. Lock nut (4 used) |
| 6. Elbow fitting | 13. O-ring (4 used) | 19. Cap |
| 7. Mounting bracket (2 used) | | |

The sprayer system for serial numbers above 310000000 uses three (3) boom valve motor assemblies to control the spray booms. Each boom valve motor assembly includes a motor section and a balancing valve assembly.

The boom control switches on the operator spray console are used to energize the boom valve motors and open the boom valves. The open boom valves allow system flow to reach the appropriate boom section (right, center or left).

Disassembly (Fig. 32.1)

IMPORTANT: Make sure to remove and neutralize chemicals from spray components before disassembly. Wear protective clothing, chemical resistant gloves, and eye protection during repair.

1. Remove spray control assembly from machine and separate boom valve manifold assembly from spray control (see Spray Control Assembly (Serial Numbers Above 310000000) Removal in this section).

2. Disassemble boom valve manifold assembly as needed using Figure 32.1 as a guide. Discard all removed O-rings and gaskets.

NOTE: There are limited replacement parts available for boom valve motor assembly. Check your parts catalog for parts that are available.

3. To remove cover from boom valve (Fig. 32.3):

- Loosen three (3) screws that secure valve motor cover to valve motor assembly.
- Carefully lift and rotate cover from valve motor.

- C. Unplug wire connections and remove cover.
- D. Make sure that screws that secure valve motor are tight.

Assembly (Fig. 32.1)

1. To install cover to boom valve motor (Fig. 32.3):
 - A. Connect cover wires to motor wires. Make sure that cover wire color is the same as the motor wire color when connecting wires.
 - B. Carefully rotate cover onto valve motor taking care to not damage wires.
 - C. Tighten screws to secure cover to valve motor.

NOTE: Coat all O-rings with vegetable oil before installation to reduce the chance of damage during assembly.

2. Assemble boom valve manifold assembly using Figure 32.1 as a guide.
3. Attach boom valve manifold assembly to spray control and then install spray control assembly to machine (see Spray Control Assembly (Serial Numbers Above 310000000) Installation in this section).

Piston Valve Service (Fig. 32.4)

1. Remove hosebarb from bottom of valve motor to allow access to piston valve.
2. Make sure that valve is closed. If valve is not closed, spring above piston valve will be under compression and may damage valve motor or piston valve during disassembly. End of piston valve will extend into bottom of valve motor housing when valve is closed. If necessary, reconnect motor to machine wire harness and close valve before removing piston valve.
3. Use 3mm allen wrench to loosen and remove piston valve assembly from valve motor. Locate and retrieve spring from above piston valve.
4. Inspect seals on piston valve assembly. O-ring in top groove of piston valve assembly is available separately. If lower two (2) seals in piston valve are worn or damaged, replace piston valve assembly. The piston valve is not designed to be disassembled.
5. Apply silicone grease to seals on piston valve assembly.
6. Position spring into valve motor housing. Use 3mm allen wrench to secure piston valve assembly to valve motor.
7. Secure hosebarb to bottom of valve motor.

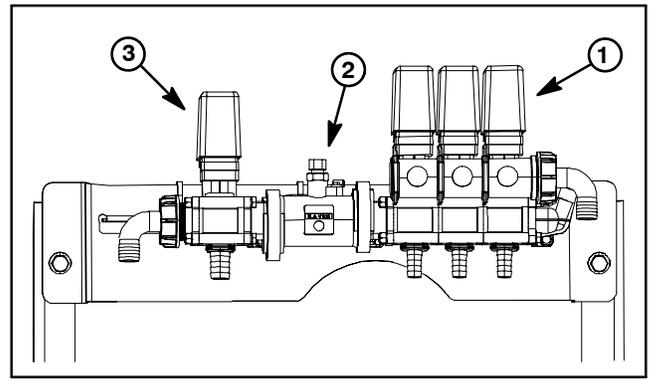


Figure 32.2

- | | |
|------------------------|---------------------|
| 1. Boom valve manifold | 3. Regulating valve |
| 2. Flowmeter | |

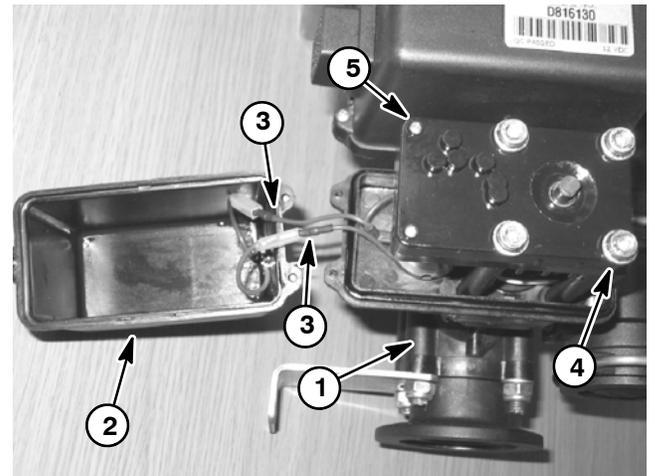


Figure 32.3

- | | |
|-------------------------|----------------------------|
| 1. Valve motor assembly | 4. Socket screw (4 used) |
| 2. Valve motor cover | 5. Phillips screw (2 used) |
| 3. Wire connector | |

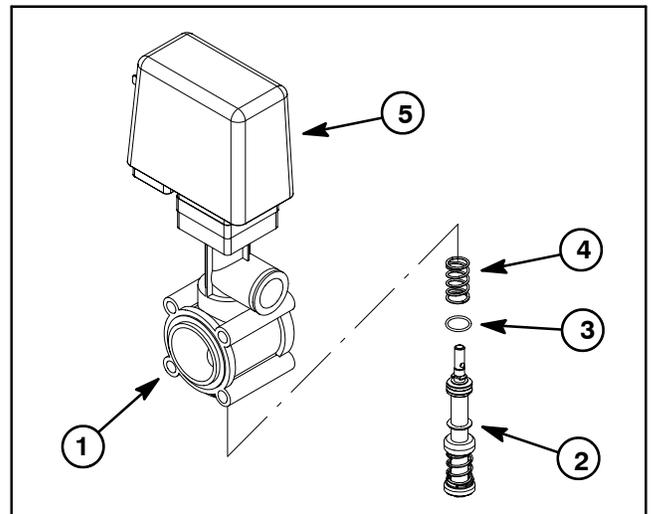


Figure 32.4

- | | |
|--------------------------|----------------------|
| 1. Valve motor assembly | 4. Spring |
| 2. Piston valve assembly | 5. Valve motor cover |
| 3. Valve seal | |

Spray System

Boom Bypass

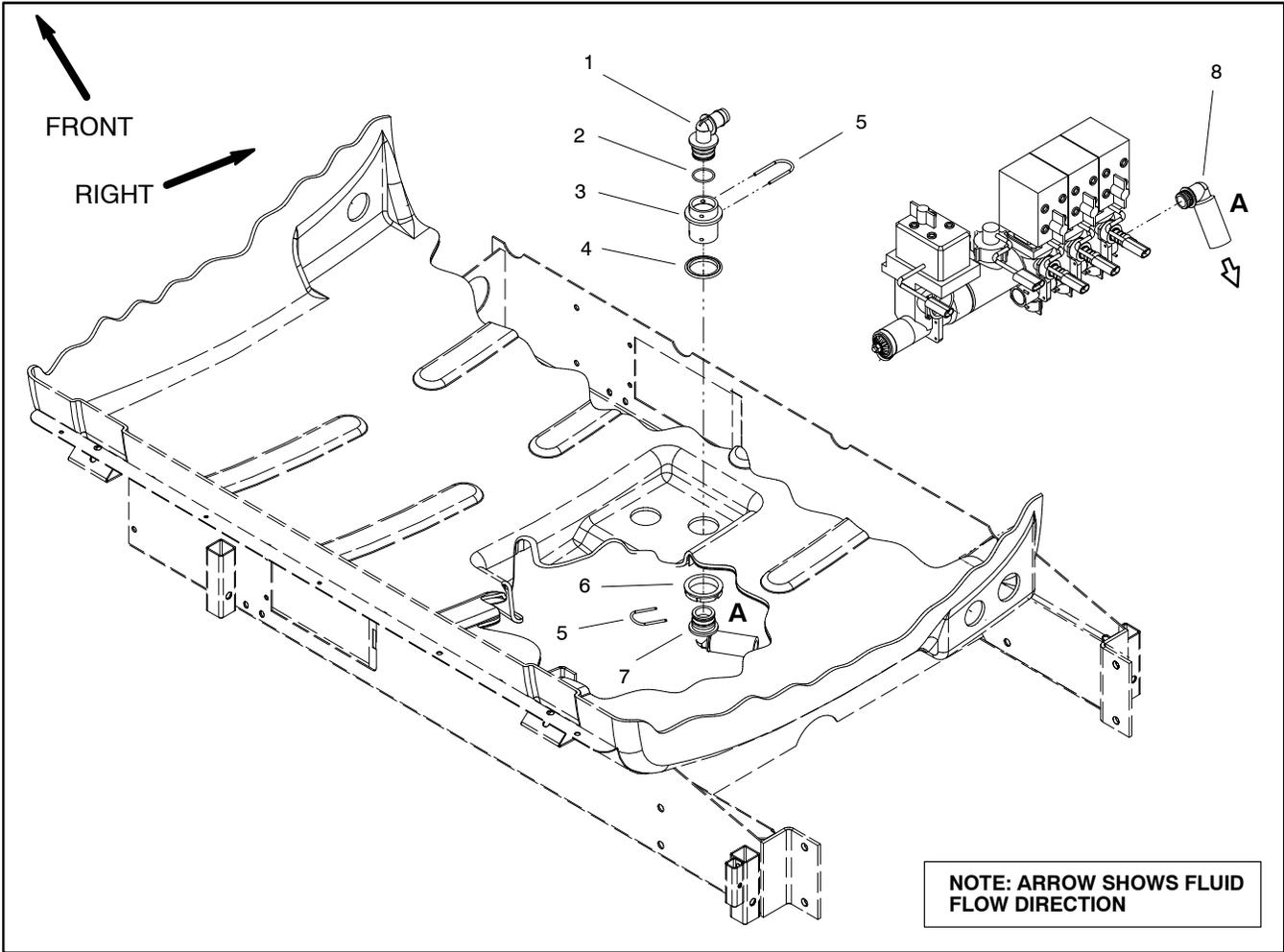


Figure 33

- 1. Boom bypass elbow
- 2. O-ring
- 3. Bulkhead fitting

- 4. Gasket
- 5. Fork
- 6. Bulkhead nut

- 7. Hosebarb/hose
- 8. Hosebarb/hose

Disassembly (Fig. 33)

IMPORTANT: Make sure to remove and neutralize chemicals from tank and spray components before disassembly. Wear protective clothing, chemical resistant gloves, and eye protection during repair.

1. Park machine on a level surface, stop engine, engage parking brake, and remove key from the ignition switch.
2. Drain spray tank (see Operator's Manual).
3. Disassemble boom bypass using Figures 33 and 34 as guides. Discard all removed o-rings and gaskets.

Assembly (Fig. 33)

NOTE: Coat all o-rings with vegetable oil before installation to reduce the chance of damage during assembly.

1. Assemble boom bypass using Figures 33 and 34 as guides. Replace all removed o-rings and gaskets.
2. Check spray tank for leaks.

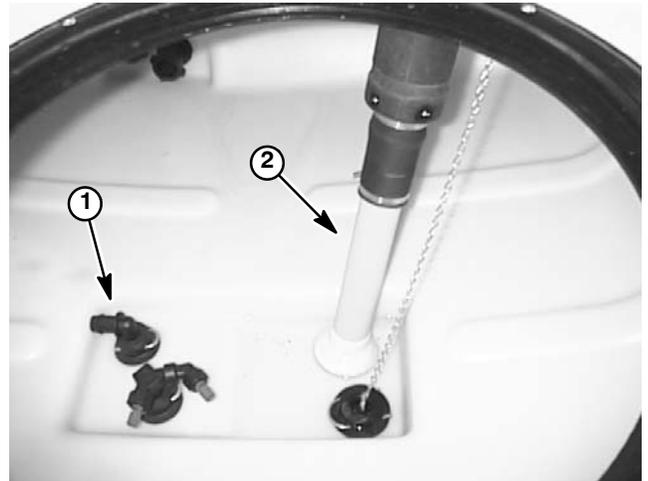


Figure 34

1. Boom bypass elbow
2. Tank suction tube

Tank Suction

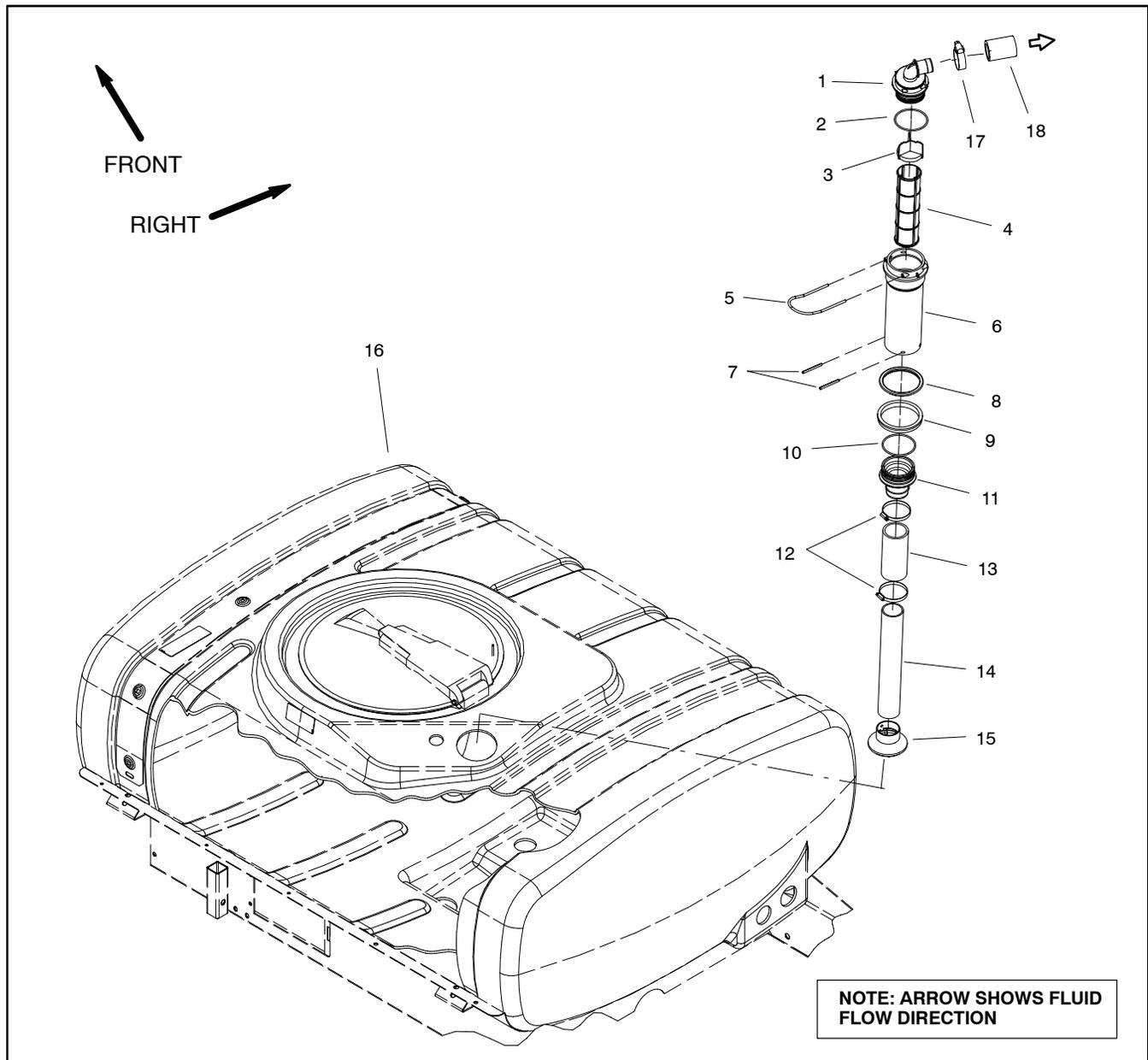


Figure 35

- 1. Suction hose barb
- 2. O-ring
- 3. Screen vane
- 4. Suction screen
- 5. Fork
- 6. Filter housing

- 7. Expansion pin
- 8. Bulkhead gasket
- 9. Bulkhead nut
- 10. O-ring
- 11. Hose barb
- 12. Hose clamp

- 13. Suction hose
- 14. Suction tube
- 15. Suction tube foot
- 16. Spray tank
- 17. Hose clamp
- 18. Suction hose (1 1/2")

NOTE: If suction tube in tank develops an air leak, spray performance will diminish when tank level reaches the leak.

Removal (Fig. 35)

IMPORTANT: Make sure to remove and neutralize chemicals from tank and spray components before disassembly. Wear protective clothing, chemical resistant gloves, and eye protection during repair.

1. Park machine on a level surface, stop engine, engage parking brake, and remove key from the ignition switch.
2. Remove suction strainer from spray tank (see Operator's Manual).
3. Raise tank lid and remove strainer basket to gain access to suction tube inside spray tank (Fig. 36).
4. Remove suction tube assembly from spray tank and disassemble tube using Figure 35 as a guide. Discard all removed o-rings and gaskets.

Assembly (Fig. 35)

NOTE: Coat all o-rings with vegetable oil before installation to reduce the chance of damage during assembly.

1. Assemble and install suction tube assembly using Figure 35 as a guide. Replace all removed o-rings and gaskets.
2. Check spray tank for leaks.

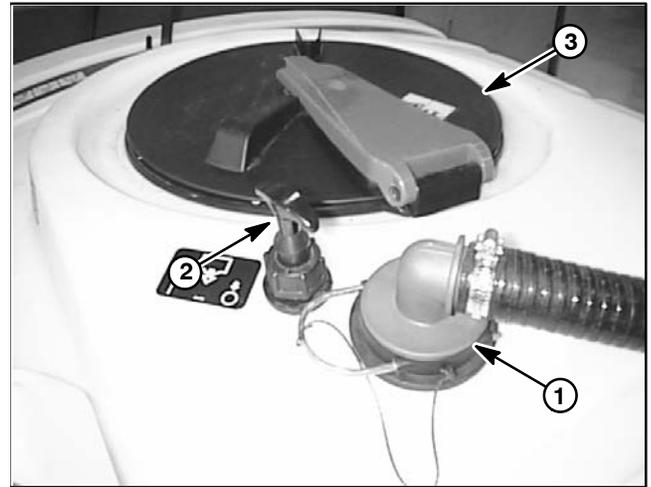


Figure 36

- | | |
|---------------------|-------------|
| 1. Suction strainer | 3. Tank lid |
| 2. Tank drain | |

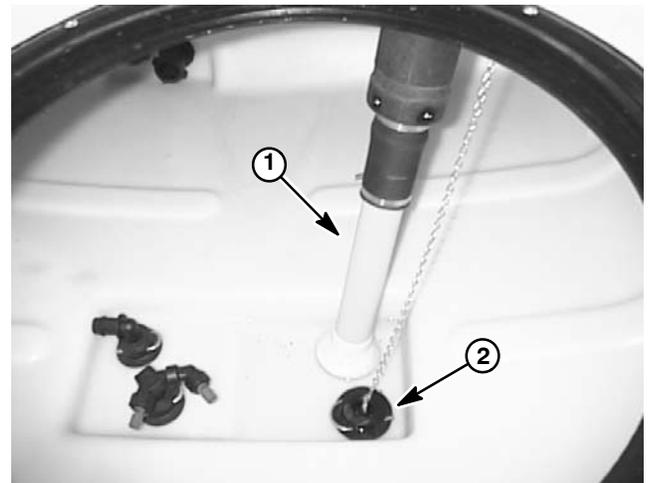


Figure 37

- | | |
|----------------------|---------------|
| 1. Tank suction tube | 2. Tank drain |
|----------------------|---------------|

Tank Drain

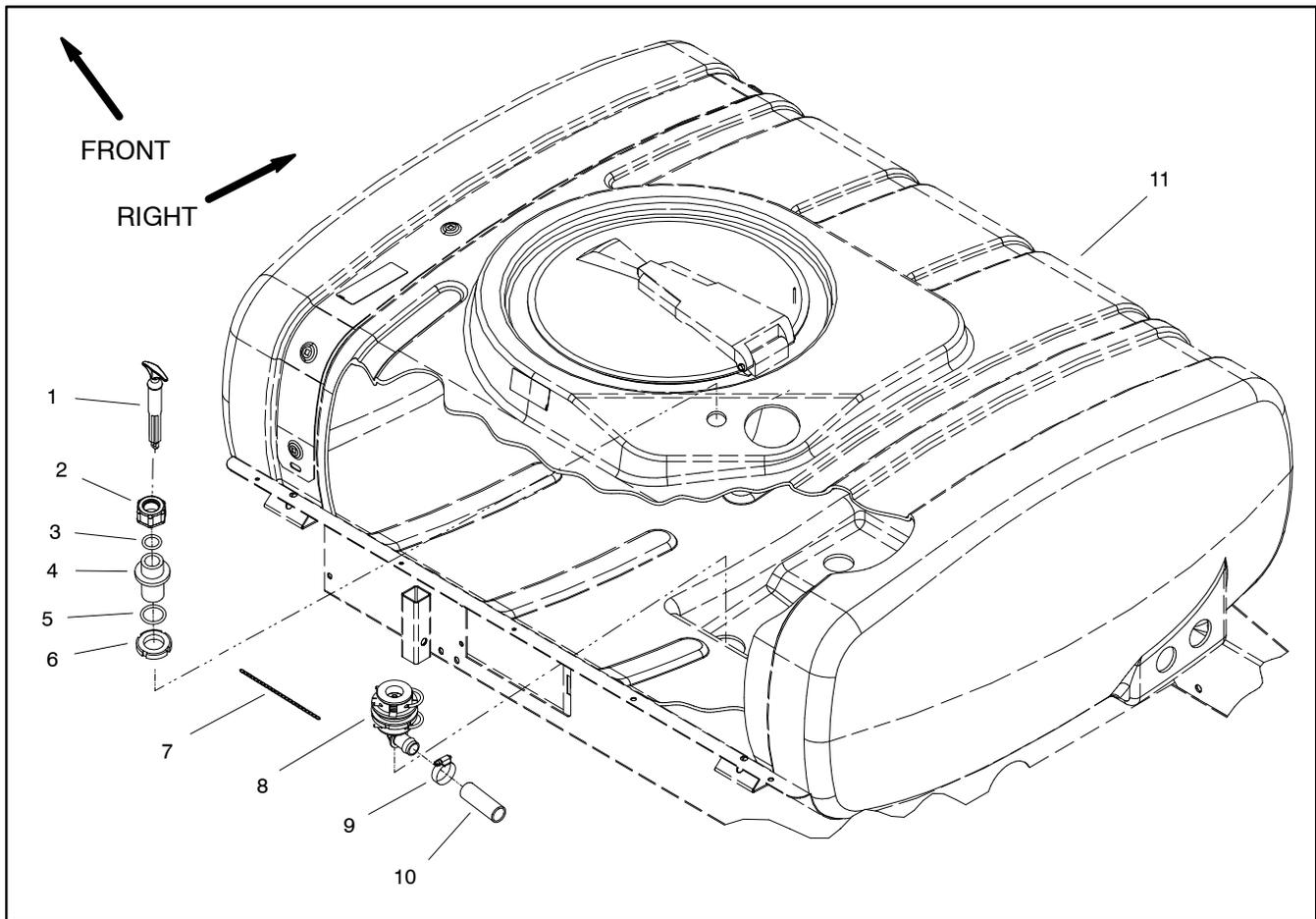


Figure 38

- 1. Drain handle
- 2. Nut
- 3. O-ring
- 4. Bulkhead

- 5. Gasket
- 6. Ringnut
- 7. Chain
- 8. Drain assembly

- 9. Hose clamp
- 10. Drain hose
- 11. Spray tank

Disassembly (Fig. 38)

IMPORTANT: Make sure to remove and neutralize chemicals from tank and spray components before disassembly. Wear protective clothing, chemical resistant gloves, and eye protection during repair.

1. Park machine on a level surface, stop engine, engage parking brake, and remove key from the ignition switch.
2. Drain spray tank (see Operator's Manual).
3. Raise tank lid and remove strainer basket to gain access to chain (item 7) that connects drain handle (item 1) to plunger in drain assembly (item 8). Disconnect chain from drain handle.
4. If necessary, remove drain handle and bulkhead using Figure 38 as a guide.
5. If necessary, remove drain assembly from tank:
 - A. Loosen hose clamp and slide drain hose from drain assembly hosebarb.
 - B. Remove fork from drain assembly to allow hosebarb to be removed from drain assembly.
 - C. Remove bulkhead nut that secures drain assembly to spray tank.
 - D. Lift drain assembly from bottom of tank.
6. Disassemble drain assembly using Figure 40 as a guide.
7. Discard all removed o-rings and gaskets.

Assembly (Fig. 38)

NOTE: Coat all o-rings with vegetable oil before installation to reduce the chance of damage during assembly.

1. Assemble drain tube using Figures 38 and 40 as guides. Replace all removed o-rings and gaskets.
2. Hosebarb of drain assembly should be orientated toward the rear of the spray tank. Make sure that clearance exists between drain assembly and sprayer frame.
3. Check spray tank for leaks.

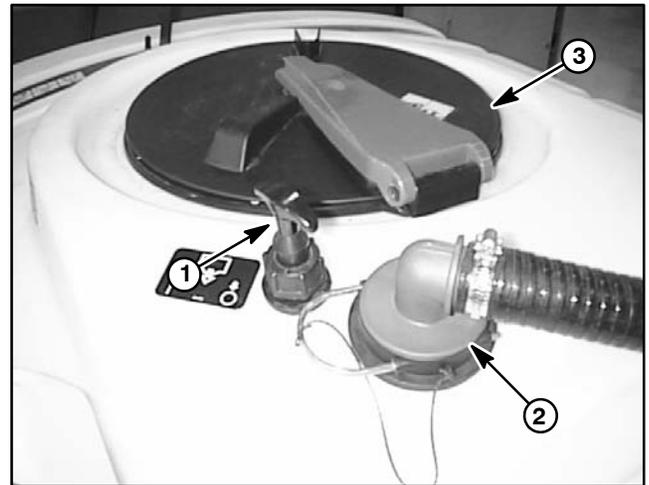


Figure 39

- | | |
|---------------------|-------------|
| 1. Tank drain | 3. Tank lid |
| 2. Suction strainer | |

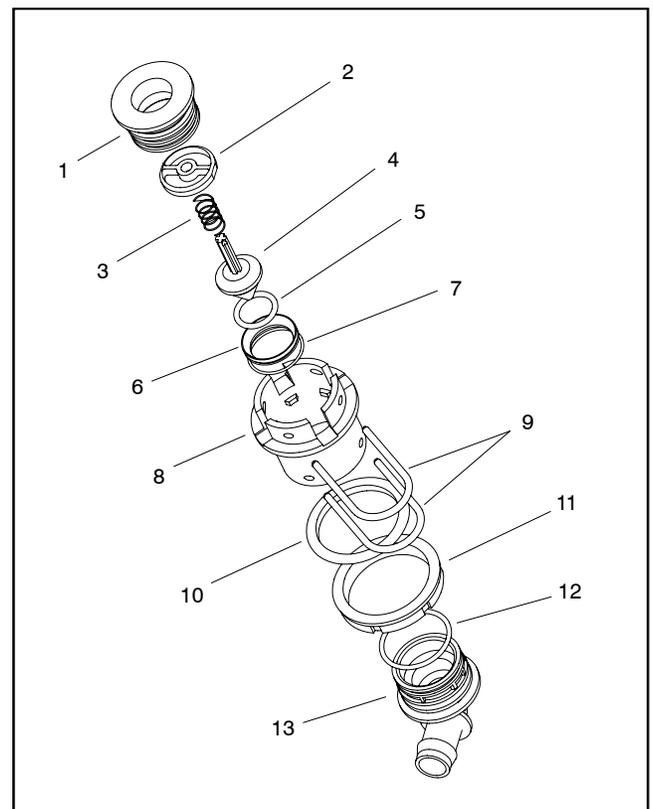


Figure 40

- | | |
|-------------------|-------------------|
| 1. Adapter | 8. Drain bulkhead |
| 2. Plunger holder | 9. Fork |
| 3. Spring | 10. Gasket |
| 4. Drain plunger | 11. Bulkhead nut |
| 5. O-ring | 12. O-ring |
| 6. Drain seat | 13. Hosebarb |
| 7. O-ring | |

Turret Bodies

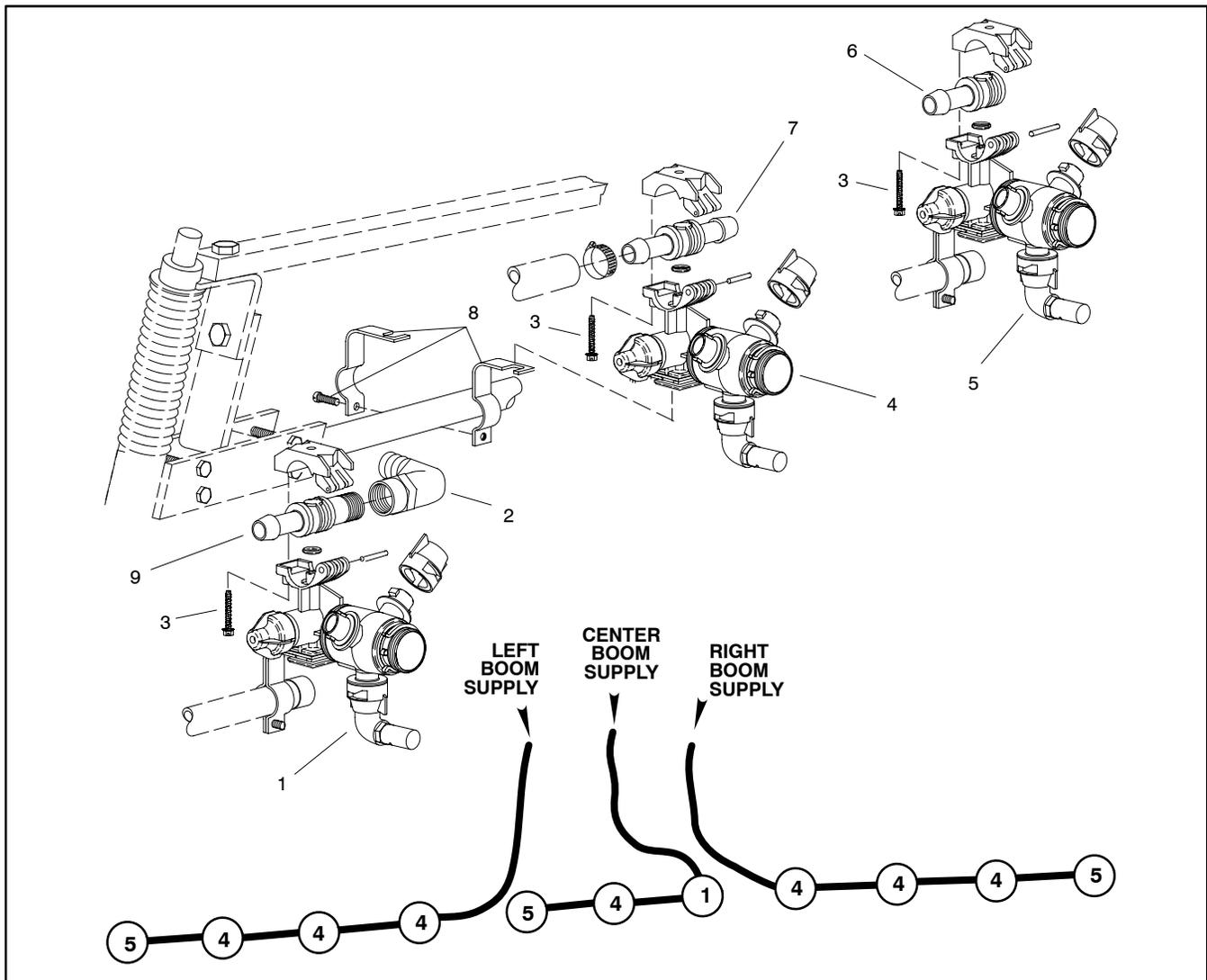


Figure 41

- | | | |
|------------------------------|-------------------------------------|------------------------------|
| 1. Turret body (w/90° elbow) | 4. Turret body (w/double hose barb) | 7. Double hose barb (7 used) |
| 2. 90° elbow (1 used) | 5. Turret body (w/single hose barb) | 8. Turret body clamp |
| 3. Screw | 6. Single hose barb (3 used) | 9. Hose barb (for 90° elbow) |

Removal (Fig. 41)

IMPORTANT: Make sure to remove and neutralize chemicals from spray components before disassembly. Wear protective clothing, chemical resistant gloves, and eye protection during repair.

1. Park machine on a level surface, stop engine, engage parking brake, and remove key from the ignition switch.
2. Loosen hose clamp(s) and remove supply hose(s) from turret body.
3. Remove screw that secures turret body clamp to spray boom. Separate clamp halves and remove turret body from machine.

Installation (Fig. 41)

NOTE: The type of hose barb on turret body determines turret location on spray boom. Refer to Figure 41 for turret position on booms.

1. Position turret body clamp halves to spray boom and turret body. Slide clamp halves together. Position turret so that spray nozzle and nozzle fan slot are parallel to ground. Tighten clamp screw to secure turret body.
2. Install supply hose(s) to turret body. Tighten hose clamp(s).

Turret Body Service

Disassembly (Fig. 42)

1. Pull e-clip from body and slide plug with o-ring from body.
2. Disassemble turret body using Figure 42 as a guide.
3. Discard all removed seals, gaskets, o-rings, and diaphragms.

Assembly (Fig. 42)

NOTE: Coat all o-rings with vegetable oil before installation to reduce the chance of damage during assembly.

1. Replace all removed seals, gaskets, o-rings, and diaphragms.
2. Assemble turret body using Figure 42 as a guide.
 - A. The turret (item 8) end with slightly larger bore and detent grooves needs to be orientated toward detent posts on body (item 4) (Fig. 43).
 - B. Make sure to align notch on plug (item 10) with groove in body (item 4) as plug is installed.
 - C. Install e-clip (item 5) into body to secure assembly.

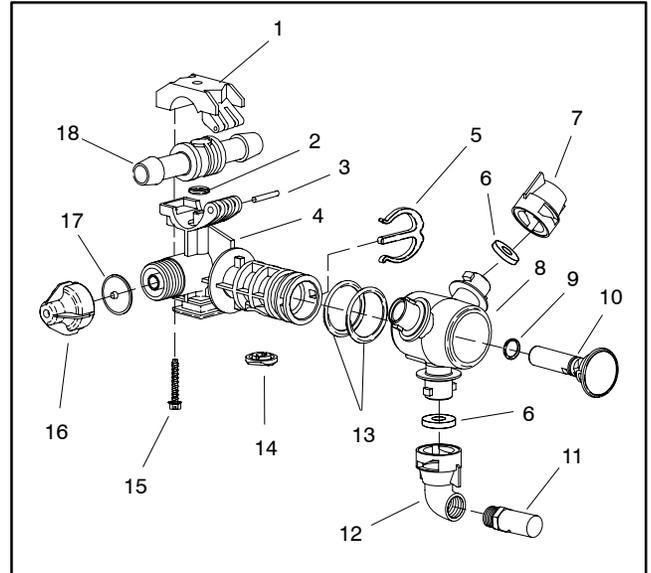


Figure 42

- | | |
|----------------------|----------------|
| 1. Upper clamp | 10. Plug |
| 2. O-ring | 11. Nozzle |
| 3. Pivot pin | 12. Nozzle cap |
| 4. Body | 13. O-ring |
| 5. E-clip | 14. Seal |
| 6. Gasket (3 used) | 15. Screw |
| 7. Dust cap (2 used) | 16. End cap |
| 8. Turret | 17. Diaphragm |
| 9. O-ring | 18. Hose barb |

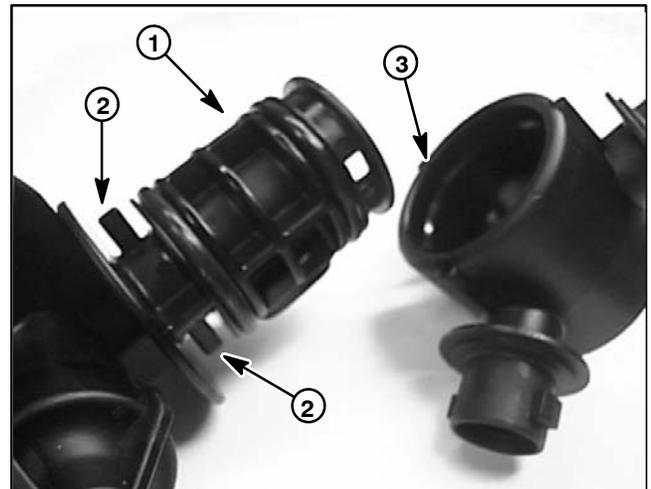


Figure 43

- | | |
|----------------|------------------|
| 1. Body | 3. Detent groove |
| 2. Detent post | |

Disassembly (Fig. 44)

1. Park machine on a level surface, lower booms, stop engine, engage parking brake, and remove key from the ignition switch.
2. Support boom to prevent it from falling. Remove cap screw and hex nut that secure boom support to breakaway assembly.
3. Remove hex nut, flat washer, and carriage screw that secure support bracket to breakaway pivot. Slide support bracket from breakaway assembly.

**CAUTION**

Spring in breakaway pivot is under tension. To prevent possible personal injury, compress spring before removing roll pin. Wear eye protection when removing roll pin.

4. Compress spring in breakaway assembly slightly. Drive roll pin from hinge (Fig. 46). Remove flat washer and spring from assembly.
5. Complete disassembly as required using Figures 44 and 45 as guides.

Assembly (Fig. 44)

1. Assemble breakaway pivot using Figures 44 and 45 as guides.
2. Lubricate grease fitting on breakaway pivot after assembly is complete (see Operator's Manual).

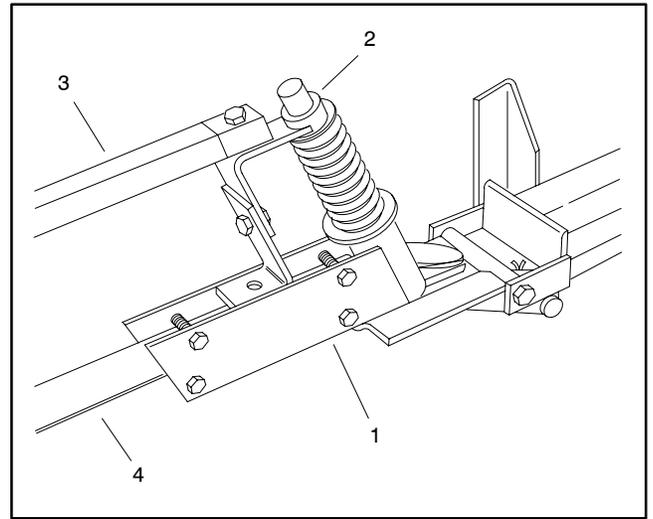


Figure 45

- | | |
|--------------------|------------------------|
| 1. Breakaway pivot | 3. Boom support |
| 2. Support bracket | 4. Boom extension pipe |

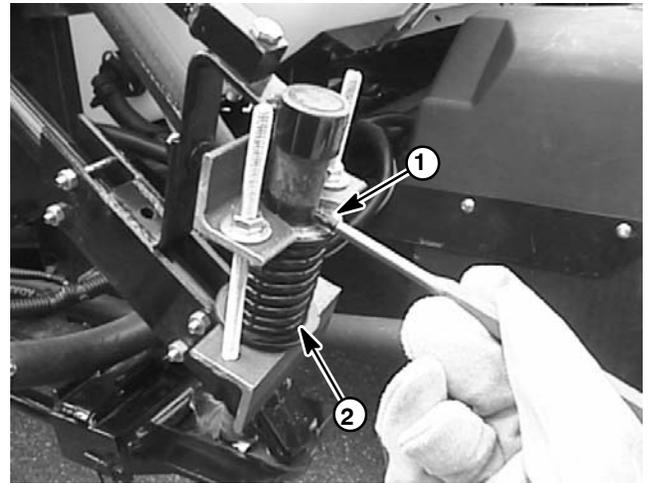


Figure 46

- | | |
|-------------|-----------|
| 1. Roll pin | 2. Spring |
|-------------|-----------|

Boom Hinge (Serial Numbers Above 26000000)

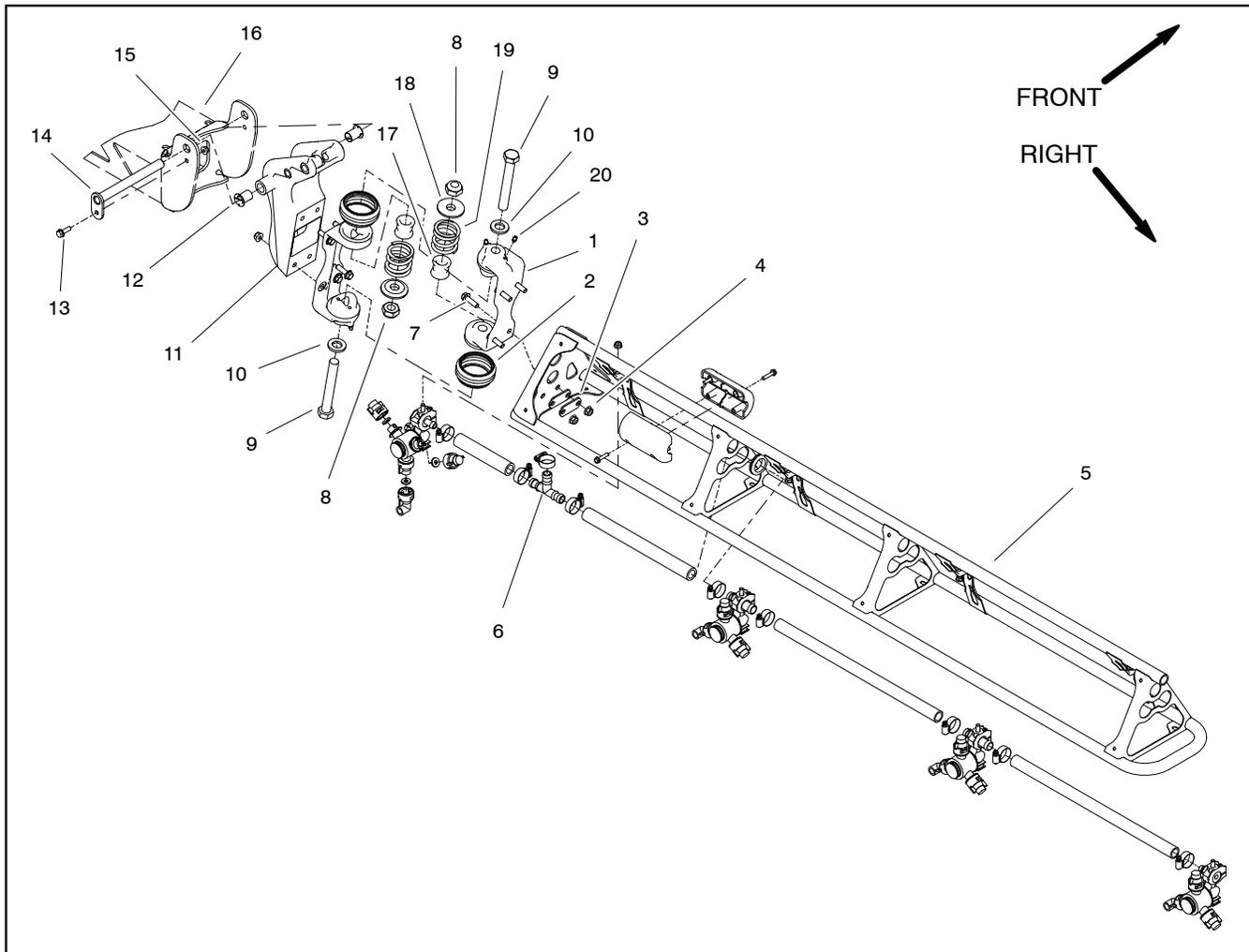


Figure 47

- | | | |
|---------------------------------------|--|--|
| 1. Hinge (2 used per boom) | 8. Lock nut | 15. Flange nut |
| 2. Rubber boot (2 used per hinge) | 9. Cap screw | 16. Boom frame |
| 3. Backing plate (4 used per hinge) | 10. Flat washer | 17. Tube (2 used per boom) |
| 4. Flange nut (4 used per hinge) | 11. Pivot bracket | 18. Spring retainer (2 used per boom) |
| 5. Boom (RH shown) | 12. Bushing (2 used per pivot bracket) | 19. Breakaway spring (2 used per boom) |
| 6. Tee fitting | 13. Flange head screw | 20. Grease fitting (2 used per hinge) |
| 7. Flange hd screw (4 used per hinge) | 14. Pivot pin | |

Disassembly (Fig. 47)

IMPORTANT: Make sure to remove and neutralize chemicals from spray components before disassembly. Wear protective clothing, chemical resistant gloves, and eye protection during repair.

1. Park machine on a level surface, lower spray booms, stop engine, engage parking brake and remove key from the ignition switch.
2. Loosen hose clamp and remove supply hose from tee fitting (item 6) on spray boom.
3. Support spray boom to prevent it from falling.

4. Loosen two (2) cap screws (item 9) and lock nuts (item 8) to allow breakaway springs (item 18) to fully extend.

5. Complete disassembly as required using Figure 47 as a guide. If pivot bracket (item 11) is to be removed from machine, disconnect boom actuator (not shown) from pivot bracket (see Boom Actuator Removal (Machines with Serial Numbers Above 260000000) in this section).

6. Clean all removed components. If pivot bracket was removed, inspect bushings and pivot pin for damage or wear.

Assembly (Fig. 47)

1. If pivot bracket (item 11) was removed from machine, lightly lubricate bushings (item 12) with motor oil before assembly. Connect boom actuator (not shown) to pivot bracket (see Boom Actuator Installation (Machines with Serial Numbers Above 260000000) in this section).

2. Make sure that hinges (item 1) are securely fastened to pivot bracket (item 11) and boom (item 5). The boom hinge uses four (4) backing plates between the boom and flange nuts.

3. Position boom hinge to pivot bracket hinge. Make sure that rubber boots (item 2) are placed at hinge junctions and that rib on boots are toward the top of the boom (Fig. 48).

4. Insert two (2) cap screws (item 9) through flat washers (item 10) and hinges. Place tube (item 17), breakaway spring (item 19), spring retainer (item 18) and lock nut (item 8) on each cap screw. Make sure that shoulder on spring retainer fits into breakaway spring.

5. Tighten lock nuts so there is 1.560" (39.6 mm) between the face of the spring retainer and the hinge casting (Fig. 49).

6. Connect supply hose to tee fitting on spray boom and secure with hose clamp.

7. Lubricate grease fittings on boom hinge (see Operator's Manual).

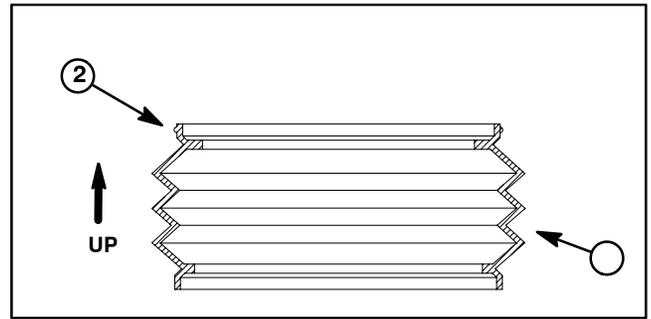


Figure 48

1. Rubber boot

2. Rib

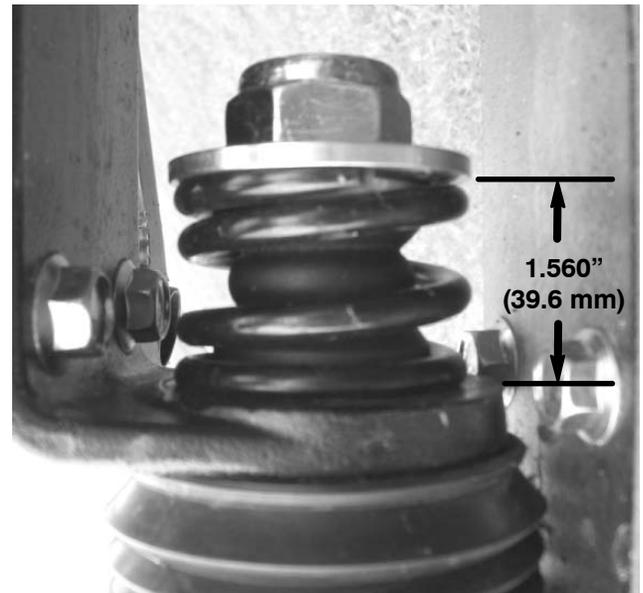


Figure 49

Spray
System

Boom Actuator (Optional) (Serial Numbers Below 26000000)

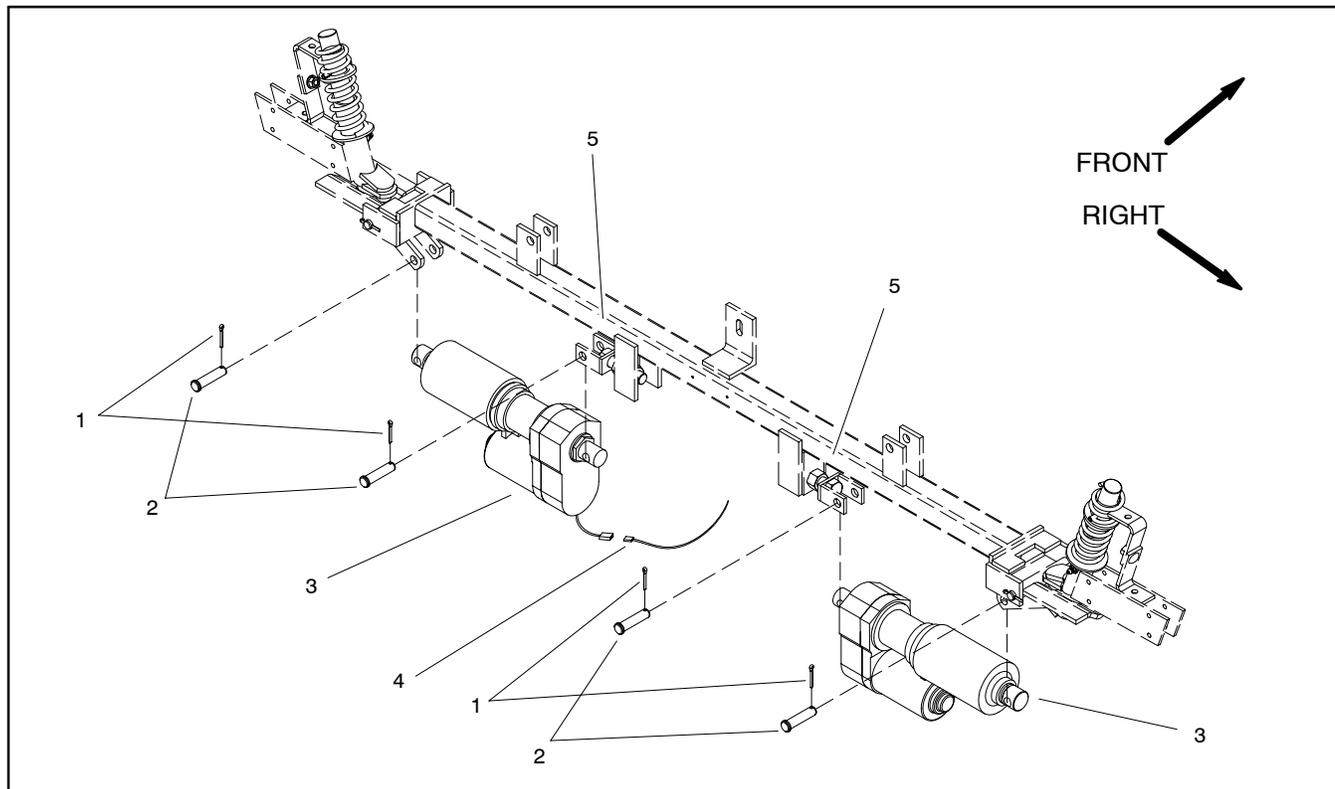


Figure 50

1. Cotter pin
2. Clevis pin

3. Boom actuator
4. Wire harness

5. Adjustable clevis

Removal (Fig. 50)

1. Park machine on a level surface, lower booms, stop engine, engage parking brake, and remove key from the ignition switch.
2. Label actuator electrical leads to ease reassembly. Unplug boom actuator connector wires from machine harness.
3. Support boom to prevent it from falling. Remove cotter pins and clevis pins that attach boom actuator to center and side boom.
4. Pull boom actuator from machine.

Installation (Fig. 50)

1. Position boom actuator to clevis attachment points on center and side booms.
2. Install clevis pins and cotter pins to secure actuator to boom assembly.
3. Plug actuator connector wires into machine harness. Make sure that operator switches engage correct actuator.
 - A. Left side actuator connector has orange and blue wires.
 - B. Right side actuator connector has yellow and green wires.

Adjustment

1. Loosen end nut that secures adjustable clevis to boom frame (Fig. 51). Position jam nut as close as possible to adjustable clevis. Tighten end nut to secure clevis.

2. Fully raise side boom with the boom actuator. The boom actuator should fully extend and ratchet.

3. With the boom actuator at full extension, the breakaway pivot gusset should just touch the center boom frame slot (Fig. 52).

4. If needed, loosen end nut that secures adjustable clevis and readjust jam nut on clevis to allow correct boom actuator extension. Tighten end nut to secure clevis adjustment.

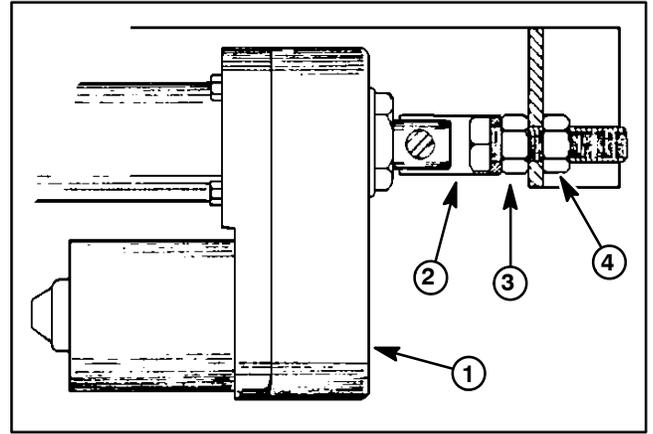


Figure 51

- | | |
|----------------------|------------|
| 1. Boom actuator | 3. Jam nut |
| 2. Adjustable clevis | 4. End nut |

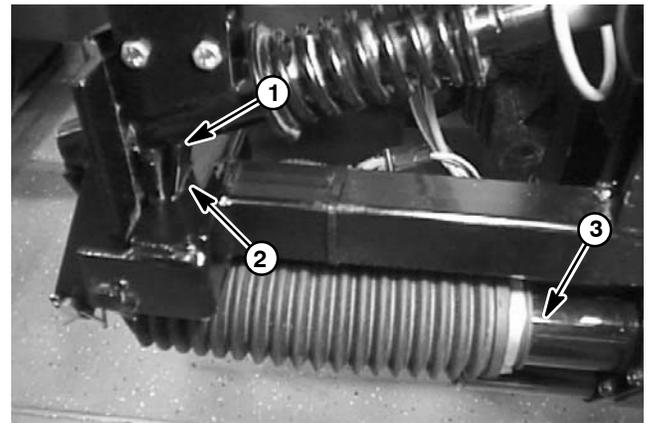


Figure 52

- | | |
|---------------------------|------------------|
| 1. Breakaway pivot gusset | 3. Boom actuator |
| 2. Boom frame slot | |

Boom Actuator Service (Serial Numbers Below 26000000)

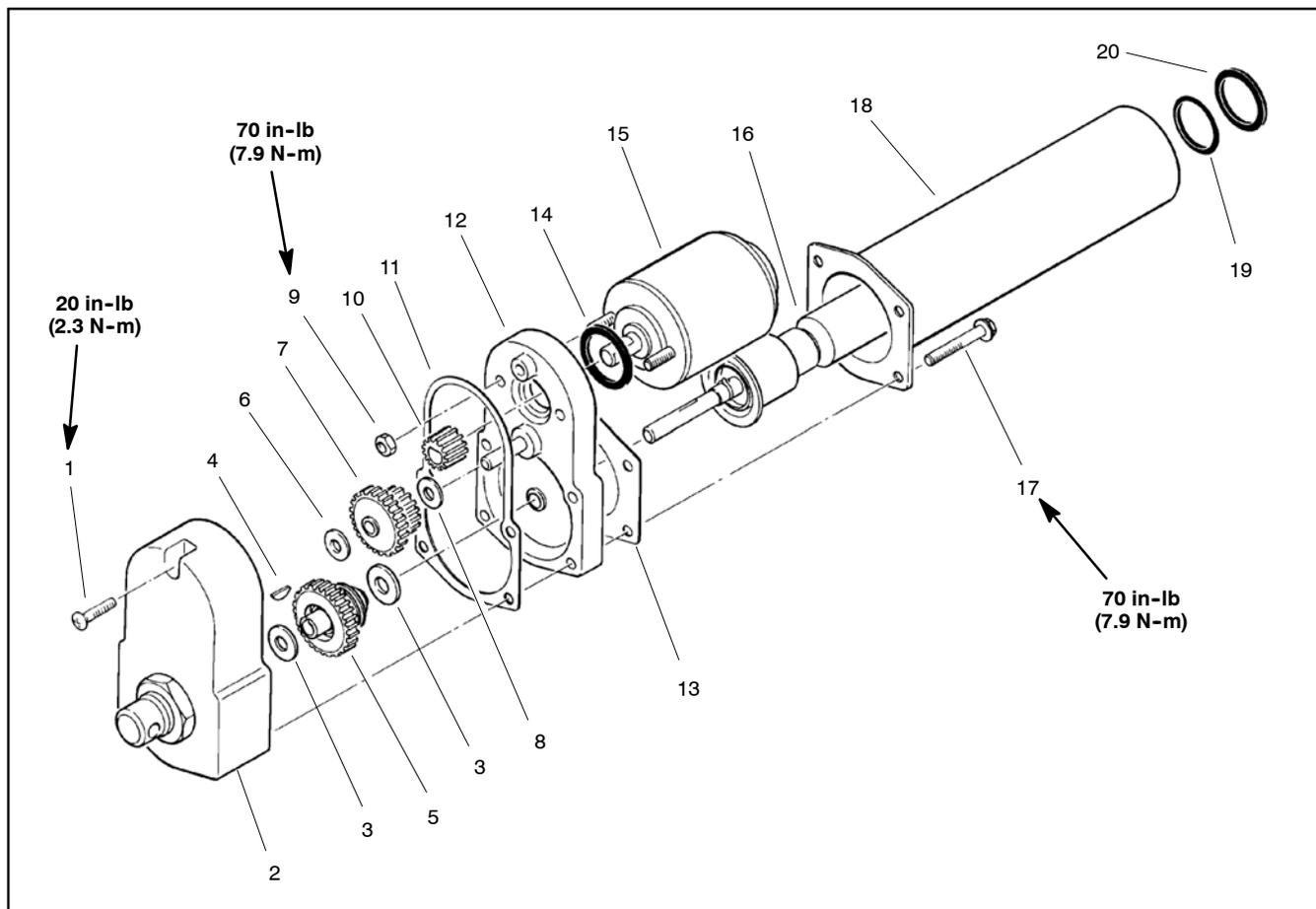


Figure 53

- 1. Screw
- 2. Rear housing
- 3. Washer
- 4. Woodruff key
- 5. Clutch
- 6. Thin washer
- 7. Intermediate gear

- 8. Thick washer
- 9. Hex nut (2 used)
- 10. Motor gear
- 11. Housing gasket
- 12. Front housing
- 13. Cover tube gasket
- 14. Motor seal

- 15. Motor assembly
- 16. Ball screw and brake assembly
- 17. Washer head screw (4 used)
- 18. Cover tube
- 19. O-ring
- 20. O-ring

Disassembly (Fig. 53)

1. Remove four (4) washer head screws that secure cover tube. Remove one (1) screw (item 1) that retains rear housing. Slide rear housing and housing gasket from assembly.
2. Slide thin washer, intermediate gear, and thick washer from front housing support pin.
3. In order, remove washer, clutch, woodruff key, and second washer from ball screw shaft.
4. Pull cover tube from front housing. Remove cover tube gasket.
5. Loosen and remove two (2) hex nuts that secure motor to front housing. Slide motor, motor gear, and motor seal from front housing.
6. Remove ball screw and brake assembly from front housing.
7. Clean actuator components. Replace worn or damaged parts.
8. Discard and replace all removed gaskets and o-rings.

Assembly (Fig. 53)

1. Position ball screw and brake assembly to front housing. Take care to not disturb brake components.
2. Slide motor, motor gear, and motor seal to front housing. Secure motor with two (2) hex nuts. Torque nuts to 70 in-lb (7.9 N-m).
3. Install new o-rings into rear of cover tube. Slide cover tube gasket and cover tube over ball screw.
4. Place washer on ball screw shaft. Position woodruff key and then slide clutch and second washer onto shaft.
5. Place thick washer, intermediate gear, and thin washer onto front housing support pin. Make sure that intermediate gear engages both motor gear and clutch.
6. Position housing gasket to front housing. Slide rear housing over gears.
7. Secure rear housing:
 - A. Thread one (1) screw (item 1) through rear housing and into front housing.
 - B. Install four (4) washer head screws through cover tube.
 - C. Torque screw (item 1) to 20 in-lb (2.3 N-m). Torque four washer head screws to 70 in-lb (7.9 N-m).

Boom Actuator (Serial Numbers Above 26000000)

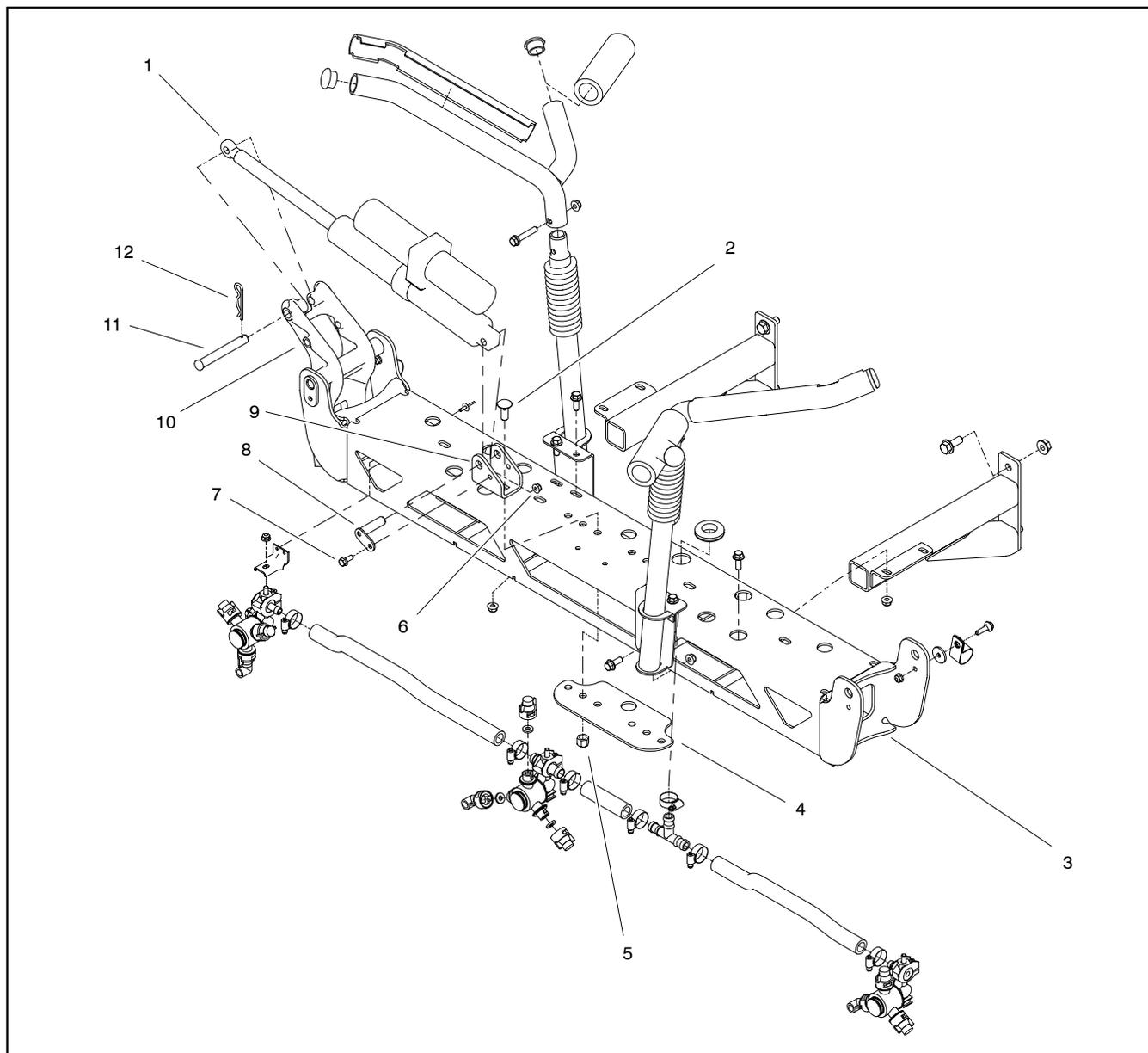


Figure 54

- 1. Boom actuator (2 used)
- 2. Carriage screw (4 used)
- 3. Boom frame
- 4. Washer plate

- 5. Lock nut (4 used)
- 6. Flange nut (2 used)
- 7. Flange head screw (2 used)
- 8. Pivot pin (2 used)

- 9. Clevis strap (2 used)
- 10. Boom pivot bracket
- 11. Clevis pin (2 used)
- 12. Cotter pin (2 used)

Removal (Fig. 54)

1. Park machine on a level surface, place spray booms in the transport (raised) position, stop engine, engage parking brake and remove key from the ignition switch.
2. Disconnect boom actuator from machine wire harness.
3. Remove pivot pin (item 8) that secures actuator to clevis strap (item 9) on boom frame.
4. Remove cotter pin (item 11) from clevis pin (item 12). Support boom actuator and slide clevis pin from boom pivot bracket. Remove actuator from machine.

Installation (Fig. 54)

1. Position boom actuator to boom frame and boom pivot bracket.
2. Secure actuator to boom pivot bracket with clevis pin and cotter pin.
3. Secure actuator to clevis strap on boom frame with pivot pin.
4. Connect boom actuator to machine wire harness.

Boom Actuator Service (Serial Numbers Above 26000000)

IMPORTANT: Do not dismantle, repair or modify the boom actuator. Internal components are not available for the actuator. If an actuator is damaged or worn, replace actuator.



CAUTION

During and after operation, the actuator may be very hot. To avoid possible burns, allow the actuator to cool before working on it.

Actuator Circuit Protection

Each boom actuator is protected internally by a thermal circuit breaker. In case of actuator overheating, the thermal breaker will trip, causing the actuator to cease functioning. Once the actuator cools to appropriate operating temperature, the actuator thermal breaker will reset to allow actuator operation to resume.

A separate 30 amp thermal breaker also protects each boom actuator circuit. These thermal breakers are located at the machine fuse panel and will prevent circuit operation if overloaded. The thermal breakers reset automatically.

Actuator Freeplay Inspection

Over time, actuator operation may be affected by air captured in the reservoir oil. An excessive amount of air in the actuator oil will allow excessive actuator freeplay. Excessive freeplay will allow spray boom bouncing when driving over severe terrain.

Measure actuator freeplay using the following procedure:

1. Move the vehicle to an open area and lower the spray booms to the spray position.
2. Lift up on the boom at the last triangular gusset with a 25 pound (11.4 kg) force. Support boom in that position.
3. Using a non-permanent felt tipped marker, mark the cylinder rod at the outside of the cylinder seal.
4. Release the spray boom and allow it to return to the spray (fully lowered) position.
5. Determine the actuator freeplay by measuring the distance from the mark on the cylinder rod to the cylinder seal. The freeplay should be less than 0.100" (2.5 mm). If excessive freeplay is found, bleed air from actuator.

Actuator Air Bleeding

If actuator freeplay is excessive, air bleeding of the actuator should be performed using the following procedure:

1. Thoroughly clean the exterior of the actuator to prevent contaminants from entering the actuator.
2. Make sure that the actuator cylinder is fully retracted.

IMPORTANT: To prevent actuator damage, use vise with protective jaws when clamping actuator.

3. Place the actuator in a vise making sure that actuator is clamped in the area identified in Figure 55. Use just enough clamping force to hold the housing securely. Make sure that the reservoir plug is orientated up.



CAUTION

The actuator reservoir is pressurized. If the reservoir plug is removed too quickly, oil under pressure can be ejected from the actuator.

4. Slowly loosen and remove the reservoir plug at the top of the reservoir.
 5. Using a light through the plug hole, confirm that the reservoir oil is clear. If the oil appears milky, air is entrained in the reservoir oil. Keep the actuator vertical with the plug removed for approximately 15 minutes to allow the air to separate from the oil.
 6. When oil appears clear, use a 12 volt DC power supply to power the actuator and extend the cylinder completely.
- IMPORTANT: To ensure proper reservoir pressure, make sure that cylinder is extended before installing reservoir plug.**
7. Install the reservoir plug and torque from 45 to 60 in-lb (5.1 to 6.8 N-m).
 8. If reservoir oil was milky, use power supply to contract and extend the actuator cylinder 3 times. Repeat steps 2 through 7 until oil is clear.
 9. When actuator oil is clear and plug has been installed, use power supply to fully contract the actuator cylinder. Remove actuator from vise and install on machine.

Actuator Oil Level

Under normal conditions, actuator oil level should remain constant. If any oil is spilled from the reservoir during air bleeding, the oil level in the actuator should be checked and adjusted.

1. Thoroughly clean the exterior of the actuator to prevent contaminants from entering the actuator.
2. Make sure that the actuator cylinder is fully retracted.

IMPORTANT: To prevent actuator damage, use vise with protective jaws when clamping actuator.

3. Place the actuator in a vise making sure that actuator is clamped in the area identified in Figure 55. Use just enough clamping force to hold the housing securely. Make sure that the reservoir plug is orientated up.

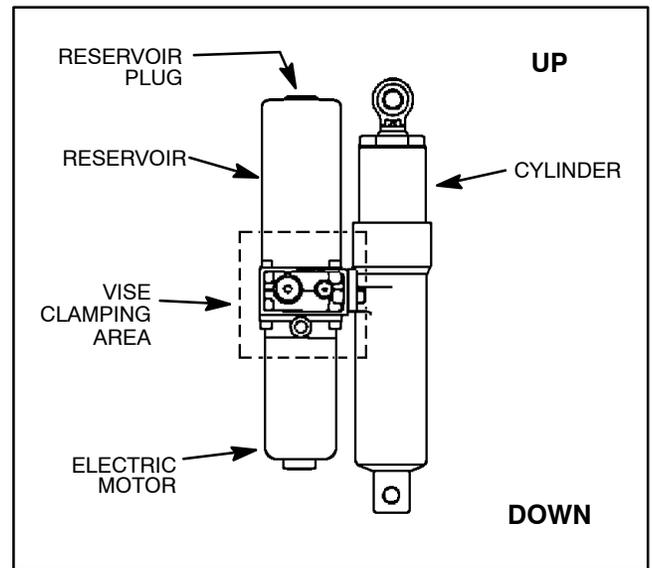


Figure 55

**CAUTION**

The actuator reservoir is pressurized. If the reservoir plug is removed too quickly, oil under pressure can be ejected from the actuator.

4. Slowly loosen and remove the reservoir plug at the top of the reservoir.
5. Using a light through the plug hole, confirm that the reservoir oil is clear. If the oil appears milky, perform actuator air bleeding procedure.
6. Use a clean rod to identify the level of oil in reservoir. Distance from plug fitting to oil level should be .984" (25 mm). If necessary, add ISO VG 32 mineral oil to actuator reservoir to adjust oil level.
7. When oil level is correct, use a 12 volt DC power supply to power the actuator and extend the cylinder completely.

IMPORTANT: To ensure proper reservoir pressure, make sure that cylinder is extended before installing reservoir plug.

8. Install the reservoir plug and torque from 45 to 60 in-lb (5.1 to 6.8 N-m).

Actuator Disposal

If actuator disposal is necessary, remove hydraulic oil from actuator before disposal.

1. Open actuator reservoir (see Steps 1 through 4 in Actuator Air Bleeding).
2. Drain oil from actuator.

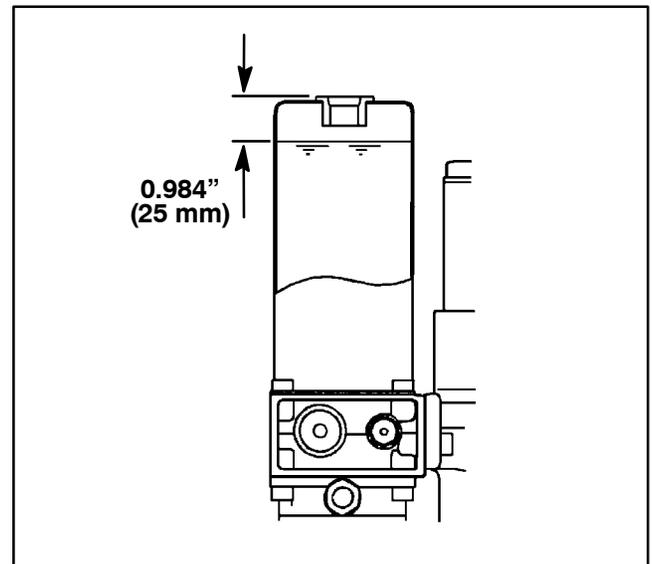


Figure 56

Spray System

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Sonic Boom System

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General Information

Installation Instructions

The Sonic Boom Kit Installation Instructions provides information regarding the installation, operation and general maintenance for your Sonic Boom System. Refer to that publication for additional information when servicing the machine.

Precautions Concerning Chemicals Used in Spray System

Chemicals can injure persons, animals, plants, soil and other property. To eliminate environmental damage and personal injury:

1. Select the proper chemical for the job.
2. Carefully read the directions printed on the chemical manufacturer's labels before handling chemicals. Instructions on chemical manufacturer's container labels regarding mixing proportions should be read and strictly followed.
3. Keep spray material away from skin. If spray material comes in contact with a person, wash it off immediately in accordance with manufacturer's recommendations (refer to container labels and Material Safety Data Sheets).
4. Always wear protective clothing, chemical resistant gloves, eye protection and other personal protective equipment as recommended by the chemical manufacturer.
5. Properly dispose of chemical containers, unused chemicals and chemical solution.

Precautions for Removing or Adjusting Spray System Components

1. Park vehicle on a level surface and apply the parking brake.
2. Shut off the vehicle's engine and remove the key from the ignition switch.
3. Disengage all power and wait until all moving parts have stopped.
4. Remove chemicals from pump, hoses and other spray components. Thoroughly neutralize and rinse spray system before loosening or removing any spray system component(s).
5. Make sure spray system pressure is relieved before loosening any system component.

Special Tools

Diagnostic Display

The Diagnostic Display (Fig. 1) can be connected to the Sonic Boom wire harness communication connector to verify correct electrical functions of the Sonic Boom System. Electronic control unit (ECU) inputs and outputs for the Sonic Boom System can be checked using the Diagnostic Display.

Toro Part Number for Diagnostic Display: **85-4750**

Toro Part Number for Overlay (English): **94-8604**

IMPORTANT: The Diagnostic Display must not be left connected to the machine. It is not designed to withstand the environment of the machine's every day use. When use of Diagnostic Display is completed, disconnect it from the machine and reconnect loopback connector to wire harness communication connector. Machine will not operate without loopback connector installed on wire harness. Store Diagnostic Display in a dry, secure, indoor location and not on machine.

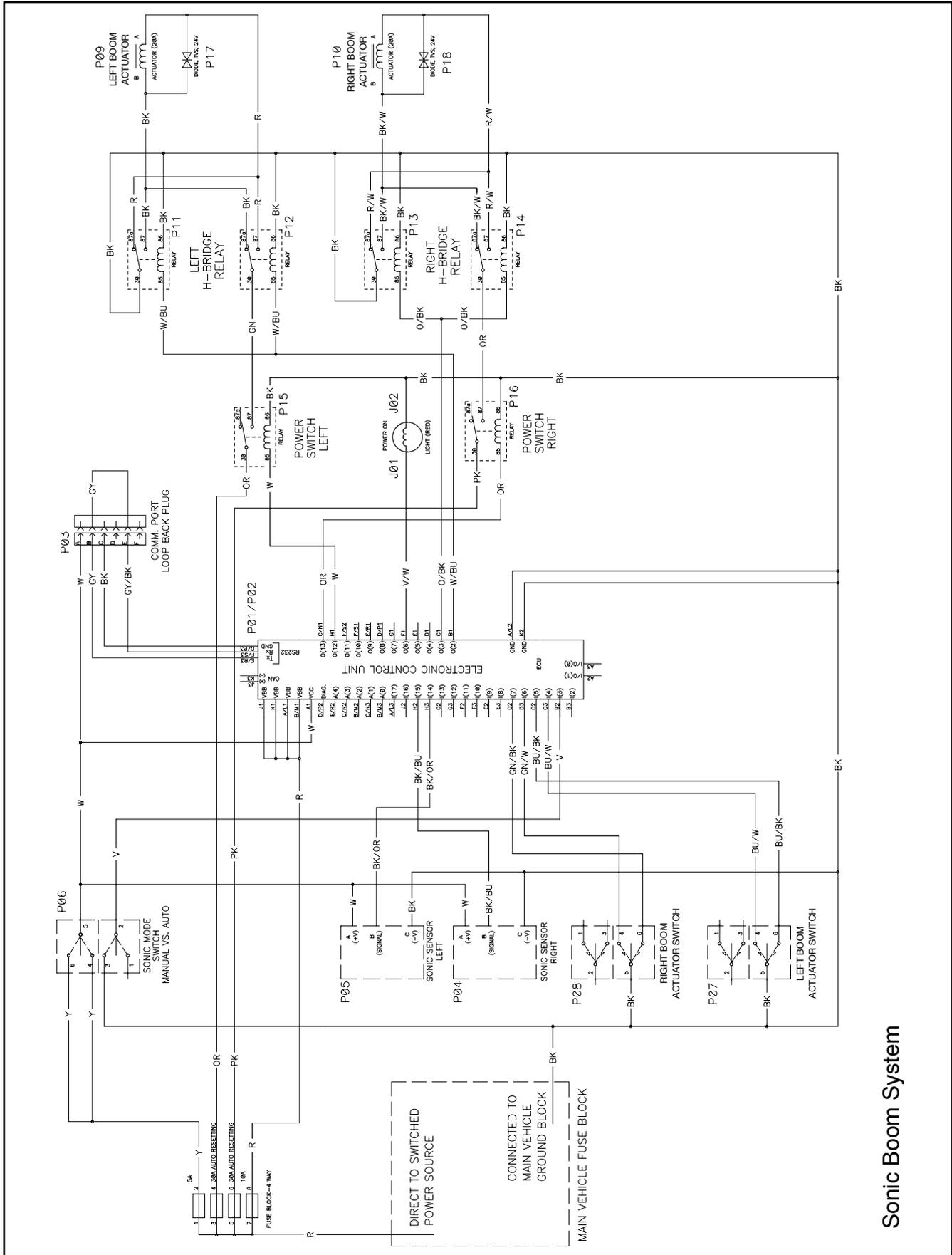


Figure 1



Figure 2

Electrical Schematic



Sonic Boom System

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Sprayer Operation on Level Turf

During sprayer operation with the sonic boom switch in the automatic position (sonic boom light is illuminated), the boom mounted sonic boom sensors continually send impulse signals and then receive echos as the signals bounce off the turf. The electronic control unit (ECU) determines the sensor distance from the ground based on the elapsed time between the sensor signal generation and the received echo. As long as the sensor height remains the same as the calibrated height, the spray boom will remain at a fixed height from the ground for spraying accuracy.

On level turf, the boom sensors continually send signals and receive echoes that determine that the booms sections are at the calibrated height. Thus, there is no need to change boom height. The boom actuators will not be energized and the boom sections remain at the correct, level position.

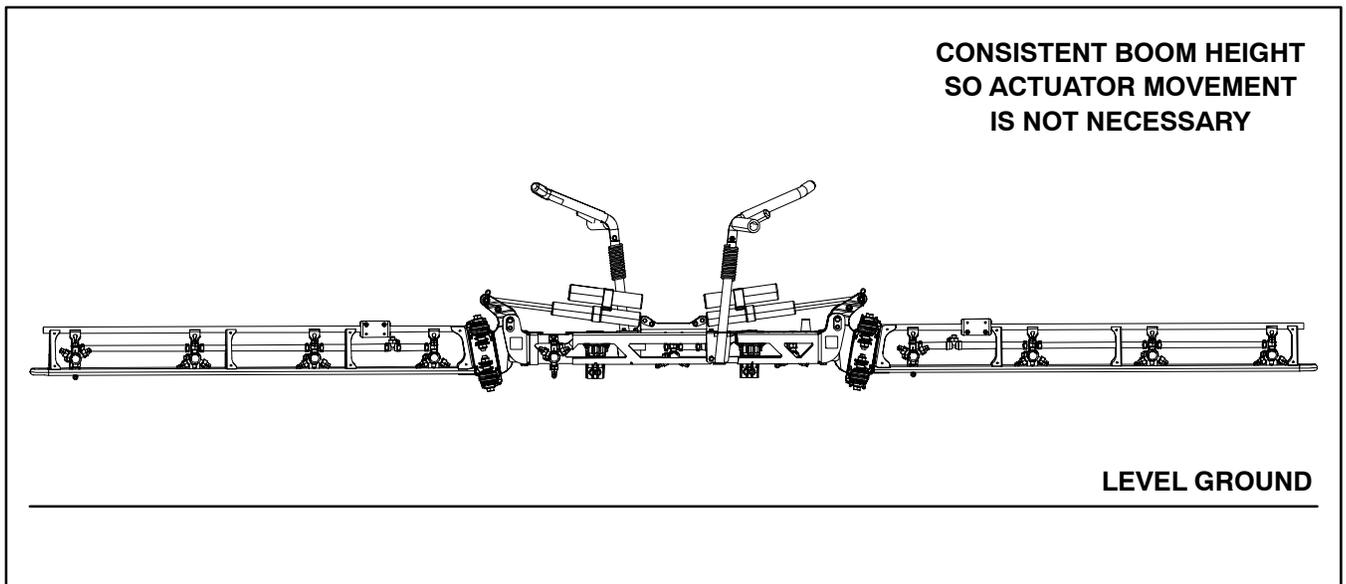


Figure 3

Downward Slope in Turf Encountered

During sprayer operation with the sonic boom switch in the automatic position (sonic boom light is illuminated), the boom mounted sonic boom sensors continually send impulse signals and then receive echos as the signals bounce off the turf. The electronic control unit (ECU) determines the sensor distance from the ground based on the elapsed time between the sensor signal generation and the received echo. As long as the sensor height remains the same as the calibrated height, the spray boom section will remain at a fixed distance from the ground for spraying accuracy.

When a spray boom section encounters a downward slope in the turf, the time necessary for the sensor to receive the signal echo is longer than the calibrated timeframe. This change in time causes the ECU to energize the appropriate power switch relay. The energized relay provides a current path to the boom actuator causing the actuator to extend and the boom section to lower. This maintains the boom height at the calibrated distance from the ground. Once the boom section is lowered to the calibrated distance, the elapsed time between the sensor signal generation and the received echo returns to the correct timeframe and the boom stops lowering.

The boom sensor target distance is initiated during initial sonic boom calibration and is typically set at twenty (20) inches. When in automatic mode, the booms will not move if the target distance change is three (3) inches or less (inner dead band). Once the target distance exceeds five (5) inches (outer dead band), the ECU will energize the appropriate power switch relay. The energized relay will lead to a change in boom actuator length and ultimately a change in boom height.

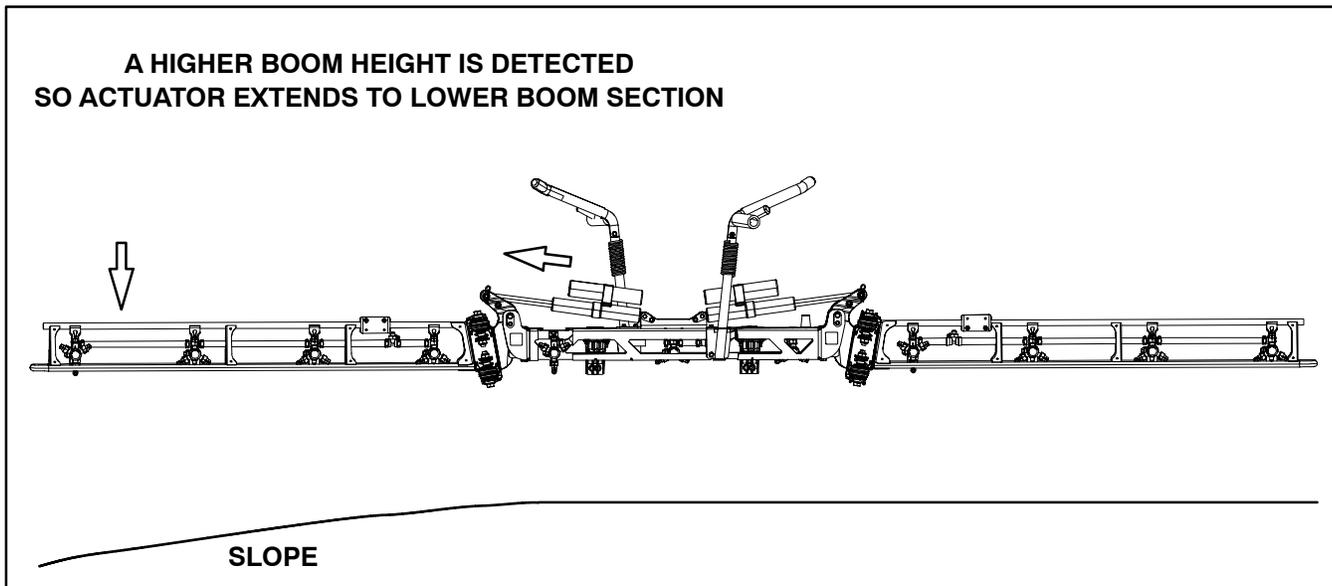
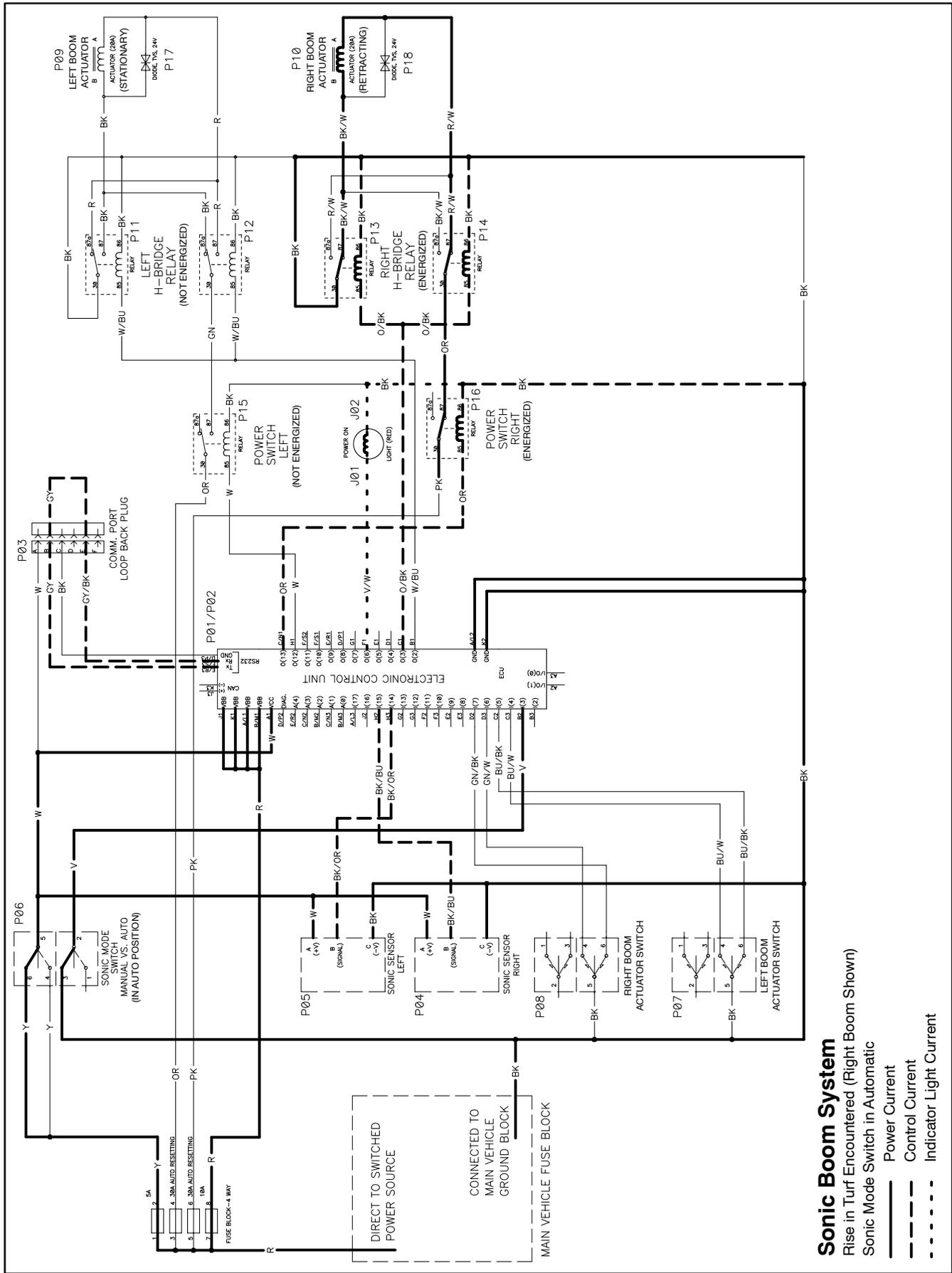


Figure 4



Rise in Turf Encountered

During sprayer operation with the sonic boom switch in the automatic position (sonic boom light is illuminated), the boom mounted sonic boom sensors continually send impulse signals and then receive echos as the signals bounce off the turf. The electronic control unit (ECU) determines the sensor distance from the ground based on the time between the sensor signal generation and the received echo. As long as the sensor height remains the same as the calibrated height, the spray boom section will remain at a fixed distance from the ground for spraying accuracy.

When a spray boom section encounters a rise in the turf, the time necessary for the sensor to receive the signal echo is shorter than the calibrated timeframe. This change in time causes the ECU to energize the appropriate power switch relay and H-bridge relays. These energized relays provide a current path to the boom actuator causing the actuator to retract and the boom section to raise. This maintains the boom height at the calibrated distance from the ground. Once the boom section is raised to the calibrated distance, the elapsed time between the sensor signal generation and the received echo returns to the correct timeframe and the boom stops raising.

The boom sensor target distance is initiated during initial sonic boom calibration and is typically set at twenty (20) inches. When in automatic mode, the booms will not move if the target distance change is three (3) inches or less (inner dead band). Once the target distance exceeds five (5) inches (outer dead band), the ECU will energize the appropriate power switch relay. The energized relay will lead to a change in boom actuator length and ultimately a change in boom height.

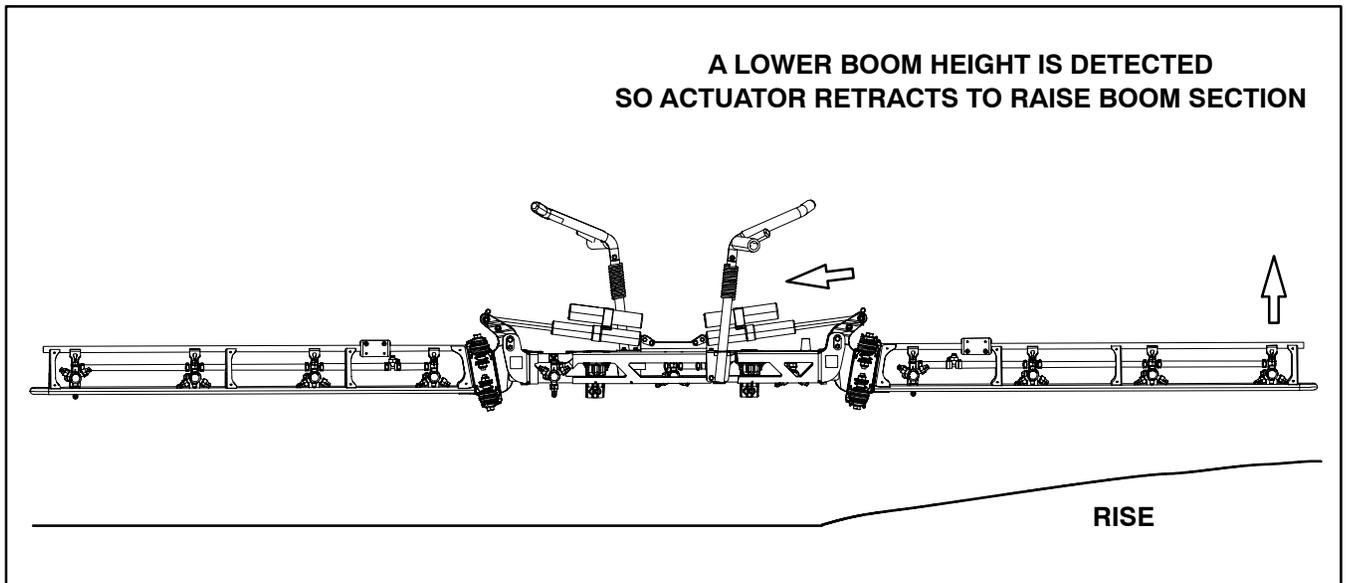
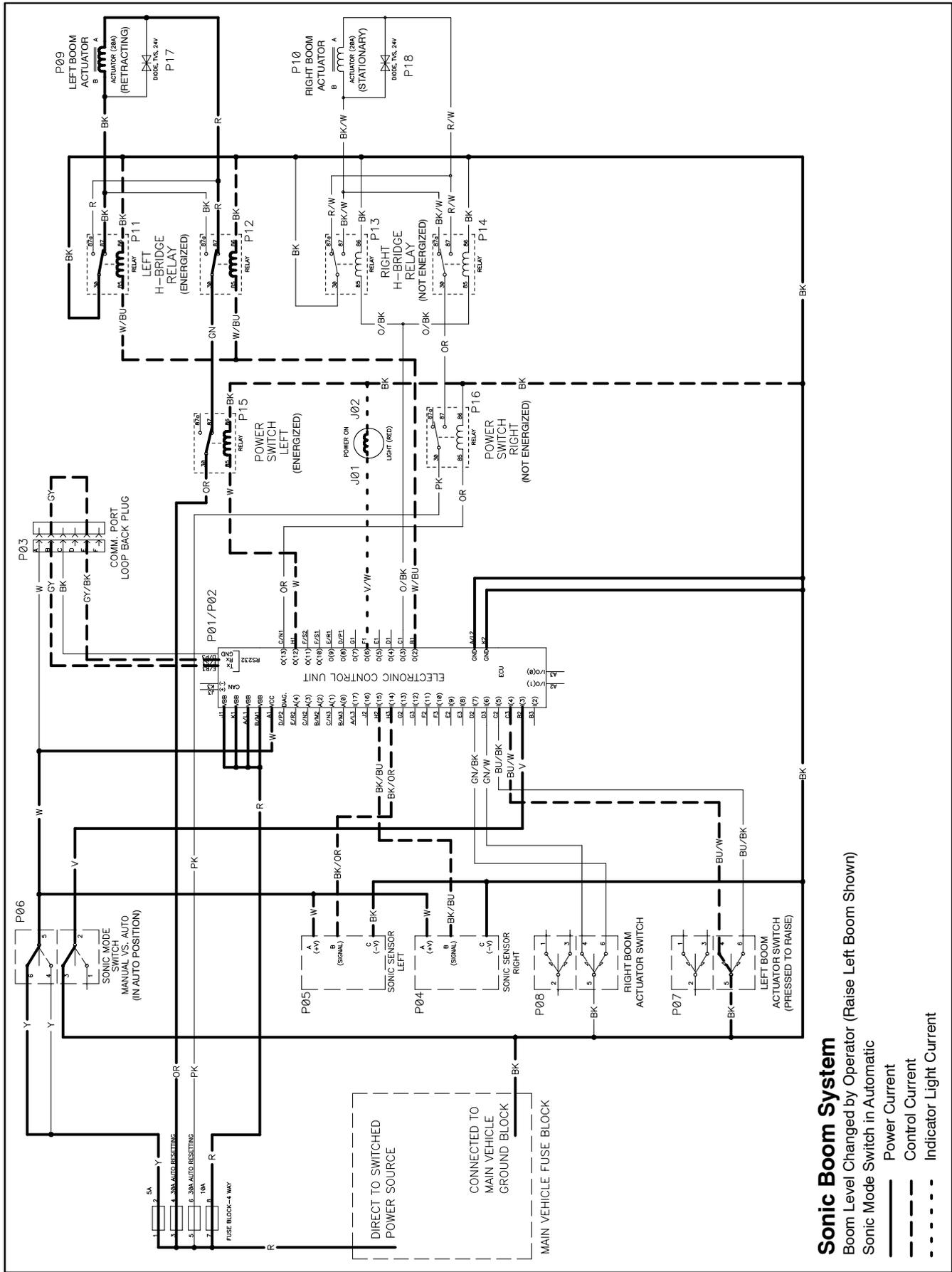


Figure 5



Sonic Boom System

Boom Level Changed by Operator (Raise Left Boom Shown)

Sonic Mode Switch in Automatic

Power Current

Control Current

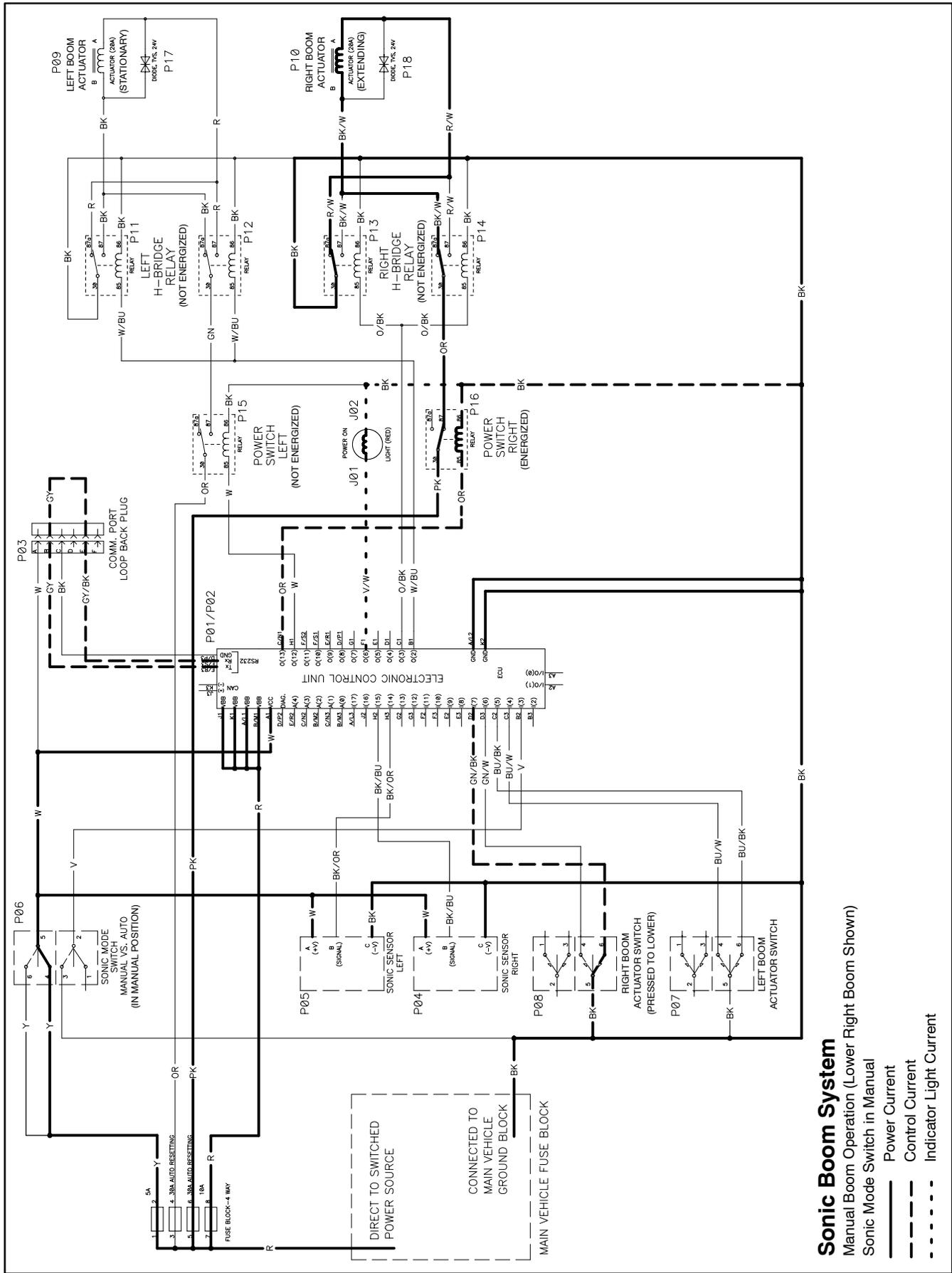
Indicator Light Current

Boom Level Changed by Operator During Automatic Operation

During sprayer operation with the sonic boom switch in the automatic position (sonic boom light is illuminated), the boom mounted sonic boom sensors continually send impulse signals and then receive echos as the signals bounce off the turf. The electronic control unit (ECU) determines the sensor distance from the ground based on the time between the sensor signal generation and the received echo. As long as the sensor height remains the same as the calibrated height, the spray boom will remain at a fixed distance from the ground for spraying accuracy.

If the sprayer operator should press a boom actuator switch while in automatic operation, the ECU energizes the necessary power switch relay and H-bridge relays to raise or lower the appropriate boom. The energized relay(s) provides a current path to the requested boom actuator to raise or lower the boom. The boom actuator will stay energized as long as the operator keeps the boom actuator switch pressed. The sonic boom light will flash as long as the boom actuator switch is pressed.

If a boom is raised by the operator while the Sonic Boom System is in automatic operation, the boom will remain in the raised position until it is lowered halfway with the boom actuator switch to re-engage automatic sonic boom operation. If one boom is moved by the operator, the other boom continues to function automatically.



Manual Boom Operation

During sprayer operation with the sonic boom switch in the manual position, the spray booms will remain in position unless the operator presses a boom actuator switch. When the sonic boom switch is in the manual position, the sonic boom light should be illuminated. The operator will control the boom position with the boom actuator switches.

Raise Boom

When a boom actuator switch is pressed to raise a boom section, the electronic control unit (ECU) energizes the power switch relay and both H-bridge relays for the requested boom section. The energized relays provide a current path to the boom actuator causing the actuator to retract which will raise the boom section. The boom will continue to rise until the operator releases the boom actuator switch.

Lower Boom

When a boom actuator switch is pressed to lower a boom section, the electronic control unit (ECU) energizes the power switch relay for the requested boom section. The energized relay provides a current path to the boom actuator causing the actuator to extend which will lower the boom section. The boom will continue to lower until the operator releases the boom actuator switch.

Troubleshooting

For effective troubleshooting and repairs, there must be a good understanding of the electrical circuits and components used on the Sonic Boom System (see Sonic Boom System Operation in this chapter).

NOTE: When troubleshooting an electrical problem on your Sonic Boom System, refer to information regarding the sonic boom light in this section. Also, use the Diagnostic Display (see Special Tools in this chapter) to test electronic control unit (ECU) inputs and outputs.

Sonic Boom Light

The Sonic Boom System is designed to automatically adjust the sprayer boom height if changes in the turf surface are detected. The sonic boom light should be illuminated whenever the vehicle ignition switch is ON and the sonic boom switch is in either the automatic or manual position.

The sonic boom light flashing quickly indicates that the Sonic Boom System is in the calibration mode. This mode allows the spray booms to be adjusted for the desired boom height. The calibration mode lasts for twenty (20) seconds after which the boom light should quit flashing.

NOTE: A sequence of switch movements is necessary to engage the calibration mode. Refer to the Sonic Boom Kit Installation Instructions for this sequence.

The sonic boom light flashing slowly indicates that a system error has been encountered. If the boom light is flashing slowly, lower the affected boom(s) with the boom actuator switch(es) to clear the error. If the error continues, there may be an issue with the Sonic Boom System electronic control unit (ECU). If this occurs, see Diagnostic Display and Troubleshooting Chart in this section.

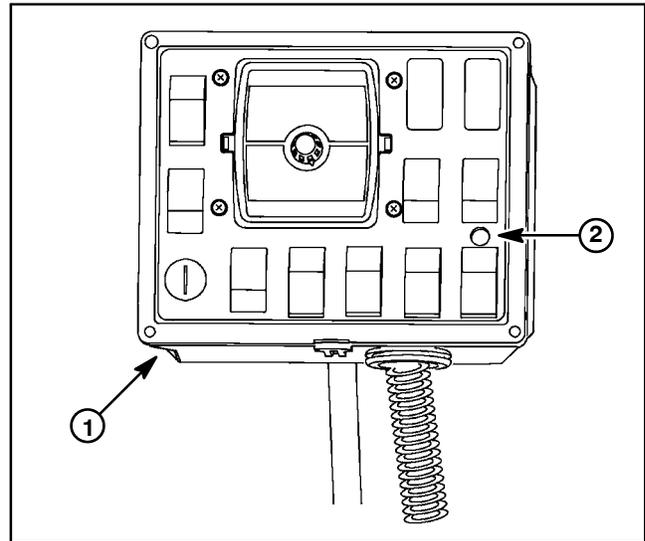


Figure 6

- 1. Spray control console
- 2. Sonic boom light

Sonic Boom Calibration

The Sonic Boom sensor calibration process is critical to the correct operation of the Sonic Boom System. The calibration process establishes the sensor target distance between the boom and the turf surface. Typically, this distance is approximately twenty (20) inches. Steps needed for proper calibration are identified in the Sonic Boom Kit Installation Instructions.

While calibrating the Sonic Boom sensors, it is best to perform the calibration process on turf. A shiny surface (e.g. cement shop floor) can skew sensor signals. Also, ensure the calibration area is free of buildings, trees, underground plumbing and other machines that could interfere with sensor signals.

Diagnostic Display

The Sonic Boom System is equipped with an electronic control unit (ECU) which controls machine sonic boom electrical functions. The ECU monitors various input switches (e.g. boom actuator switches, sonic boom sensors) and energizes outputs to actuate relays for appropriate machine functions.

For the ECU to control the machine as desired, each of the inputs (switches and sensors) and outputs (relays) must be connected and functioning properly.

The Diagnostic Display (see Special Tools in this chapter) is a tool to help the technician verify correct electrical functions of the machine.

IMPORTANT: The Diagnostic Display must not be left connected to the machine. It is not designed to withstand the environment of the machine's every day use. When use of the Diagnostic Display is completed, disconnect it from the machine and reconnect loopback connector to harness connector. The machine will not operate without the loopback connector installed on the harness. Store the Diagnostic Display in a dry, secure, indoor location and not on machine.

Verify Diagnostic Display Input Functions

1. Park vehicle on a level surface, stop the engine and apply the parking brake.

2. Locate Sonic Boom wire harness communication port and loopback connector under the vehicle dash panel. Carefully unplug loopback connector from harness connector.

3. Connect the Diagnostic Display connector to the wire harness connector. Make sure correct overlay decal is positioned on the Diagnostic Display (Fig. 7).

4. Turn the vehicle ignition switch to the ON position, but do not start vehicle.

NOTE: The **red** text on the Diagnostic Display overlay decal refers to input switches and the **green** text refers to ECU outputs.

5. Make sure that the "INPUTS DISPLAYED" LED, on lower right of the Diagnostic Display, is illuminated. If "OUTPUTS DISPLAYED" LED is illuminated, press the toggle button on the Diagnostic Display to change to "INPUTS DISPLAYED" LED.



CAUTION

When testing ECU inputs with the Diagnostic Display, boom actuators may be energized causing the spray booms to move. Be cautious of potential sprayer component movement while verifying inputs with the Diagnostic Display.

6. The Diagnostic Display will illuminate the LED associated with each of the inputs when that input switch is closed. Individually, change each of the switches from open to closed (e.g. toggle sonic mode switch), and note that the appropriate LED on the Diagnostic Display will illuminate when the corresponding switch is closed. Repeat on each switch that is possible to be changed by hand (see Inputs and LED Operation chart on following page).

7. If appropriate LED does not toggle on and off when switch state is changed, check all wiring and connections to that switch and/or test switch. Replace any defective switches and repair any damaged wiring.

8. After input functions testing is complete, disconnect the Diagnostic Display connector from the harness connector and plug loopback connector into wire harness.



Figure 7

Diagnostic Display Inputs	Diagnostic Display LED Operation
AUTO MODE	Sonic mode switch in auto position: LED ON Sonic mode switch not in auto position: LED OFF
L RAISE	Left boom actuator switch in raise position: LED ON Left boom actuator switch not in raise position: LED OFF
L LOWER	Left boom actuator switch in lower position: LED ON Left boom actuator switch not in lower position: LED OFF
R RAISE	Right boom actuator switch in raise position: LED ON Right boom actuator switch not in raise position: LED OFF
R LOWER	Right boom actuator switch in lower position: LED ON Right boom actuator switch not in lower position: LED OFF
L NO SNSR DATA	ECU has detected an invalid reading from left sensor: LED ON Left sensor operating normally: LED OFF
L NOT TRACKING	Left boom not tracking to target within 5 seconds: LED ON Left sensor operating normally: LED OFF
R NO SNSR DATA	ECU has detected an invalid reading from right sensor: LED ON Right sensor operating normally: LED OFF
R NOT TRACKING	Right boom not tracking to target within 5 seconds: LED ON Right sensor operating normally: LED OFF
L - SNSR FEEDBACK	ECU receiving signal from left sensor: LED ON ECU not receiving signal from left sensor: LED OFF
R - SNSR FEEDBACK	ECU receiving signal from right sensor: LED ON ECU not receiving signal from right sensor: LED OFF

NOTE: When the vehicle ignition switch is in the OFF position, all Diagnostic Display LED's should be OFF.

NOTE: Initial calibration of the Sonic Boom sensors is required for proper operation of ECU inputs. Refer to your Sonic Boom Kit Installation Instructions for information on initial sensor calibration.

NOTE: Right and left side Sonic Boom sensors are identical so they can be exchanged to assist in troubleshooting. If a problem follows the exchanged sensor, an electrical problem likely exists with the sensor. If the problem remains unchanged, something other than the sensor is the problem source (e.g. switch, circuit wiring).

Verify Diagnostic Display Output Functions

The Diagnostic Display also has the ability to detect which output solenoids or relays are energized by the electronic control unit (ECU). This is a quick way to determine which electrical component is malfunctioning.

NOTE: An open output (e.g. an unplugged connector or a broken wire) cannot be detected with the Diagnostic Display.

1. Park vehicle on a level surface, stop the engine and engage the parking brake.
2. Locate Sonic Boom System wire harness and loopback connector under the vehicle dash panel. Carefully unplug loopback connector from harness connector.
3. Connect the Diagnostic Display connector to the harness connector. Make sure correct overlay decal is positioned on the Diagnostic Display (see Special Tools in this chapter).
4. Turn the ignition switch to the ON position.

NOTE: The **red** text on the Diagnostic Display overlay decal refers to input switches and the **green** text refers to ECU outputs.

5. Make sure that the “OUTPUTS DISPLAYED” LED, on lower right column of the Diagnostic Display, is illuminated. If “INPUTS DISPLAYED” LED is illuminated, press the toggle button on the Diagnostic Display to change the LED to “OUTPUTS DISPLAYED”.

NOTE: It may be necessary to toggle between “INPUTS DISPLAYED” and “OUTPUTS DISPLAYED” several times to perform the following step. To change from inputs to outputs, press toggle button once. This may be done as often as required. **Do not press and hold toggle button.**

6. Attempt to operate the desired function of the machine. The appropriate output LED’s should illuminate on the Diagnostic Display to indicate that the ECU is turning on that function. The outputs can be checked with the vehicle ignition switch in the ON position and the engine not running.

A. If the correct output LED’s do not illuminate, verify that the required input switches are in the necessary positions to allow that function to occur.

B. If the output LED’s are on as specified, but the booms do not function properly, suspect a failed electrical component, an open in the tested circuit or a non-electrical problem (e.g. binding of the boom hinge). Repair as necessary.

C. If each input switch is in the correct position and functioning correctly, but the output LED’s are not correctly illuminated, this indicates an ECU problem. If this occurs, contact your Toro Distributor for assistance.

7. After output functions testing is complete, disconnect the Diagnostic Display connector from the harness connector and plug loopback connector into wire harness.

Diagnostic Display Outputs	Diagnostic Display LED Operation
L BOOM - RAISE	Left boom is rising: LED ON Left boom is stationary: LED OFF
R BOOM - RAISE	Right boom is rising: LED ON Right boom is stationary: LED OFF
POWER ON/ERROR	Power to ECU: LED ON No power to ECU: LED OFF System error: LED flashing slowly
L BOOM MOTOR	ECU output exists to energize left power switch relay: LED ON No ECU output to left power switch relay: LED OFF
R BOOM MOTOR	ECU output exists to energize right power switch relay: LED ON No ECU output to right power switch relay: LED OFF

Troubleshooting Chart

The chart that follows contains suggestions that can be used to assist in diagnosing Sonic Boom System performance issues. These suggestions are not all-inclusive. Also, consider that there may be more than one cause for a machine problem.

NOTE: When troubleshooting an electrical problem on your Sonic Boom System, refer to information regarding the sonic boom light in this section. Also, use the Diagnostic Display (see Special Tools in this chapter) to test electronic control unit (ECU) inputs and outputs.

Problem	Possible Cause
Sonic boom light is not illuminated.	<p>Sonic mode switch is in the OFF position.</p> <p>5 amp or 10 amp fuse in sonic boom fuse block is faulty.</p> <p>Electrical power from vehicle is not available (all sonic boom functions are affected).</p> <p>Sonic boom light or circuit wiring is faulty.</p> <p>Sonic mode switch or circuit wiring is faulty.</p>
LED on one of the sonic boom sensors is not illuminated.	Sonic boom sensor or circuit wiring is faulty.
LED on both of the sonic boom sensors is not illuminated.	<p>Sonic mode switch is in the OFF position.</p> <p>5 amp fuse in sonic boom fuse block is faulty.</p> <p>Sonic mode switch or circuit wiring is faulty.</p>
One of the boom actuators will not retract.	<p>30 amp auto resetting fuse for affected boom actuator is faulty.</p> <p>Power switch relay or circuit wiring for affected boom actuator is faulty.</p> <p>One or both of the H-bridge relays or circuit wiring for the affected boom actuator is faulty.</p> <p>Boom actuator switch or circuit wiring for affected boom actuator is faulty.</p> <p>Affected boom actuator or circuit wiring is faulty.</p>
Neither of the boom actuators will retract.	<p>Loop back connector is unplugged from wire harness connector.</p> <p>5 amp or 10 amp fuse in sonic boom fuse block is faulty.</p> <p>Electrical power from vehicle is not available (all sonic boom functions are affected).</p> <p>Both of the boom actuator 30 amp auto resetting fuses are faulty.</p> <p>ECU or circuit wiring is faulty.</p>

Problem	Possible Cause
<p>One of the boom actuators will not extend.</p>	<p>30 amp auto resetting fuse for affected boom actuator is faulty.</p> <p>Power switch relay or circuit wiring for affected boom actuator is faulty.</p> <p>Boom actuator switch or circuit wiring for affected boom actuator is faulty.</p> <p>Affected boom actuator or circuit wiring is faulty.</p>
<p>Neither of the boom actuators will extend.</p>	<p>Loop back connector is unplugged from wire harness connector.</p> <p>5 amp or 10 amp fuse in sonic boom fuse block is faulty.</p> <p>Electrical power from vehicle is not available (all sonic boom functions are affected).</p> <p>30 amp auto resetting fuse is faulty in both boom actuators.</p> <p>ECU or circuit wiring is faulty.</p>
<p>One of the booms does not automatically follow ground irregularities. Boom can be controlled with boom actuator switch.</p>	<p>On affected boom, the sonic boom sensor cover is on sensor or is hanging in sensor path.</p> <p>On affected boom, the sensor filter is dirty or damaged.</p> <p>Calibration of the Sonic Boom sensors is incorrect.</p> <p>On affected boom, the sonic sensor angle needs adjustment.</p> <p>Sonic sensor or circuit wiring for affected boom is faulty.</p> <p>ECU or circuit wiring is faulty.</p>
<p>Neither boom automatically follows ground irregularities. Booms can be controlled with boom actuator switches.</p>	<p>Sonic mode switch is not in the AUTO position.</p> <p>Sonic boom sensor covers are on both sensors or are hanging in sensor path.</p> <p>The filters on both sensors are dirty or damaged.</p> <p>Calibration of the Sonic Boom sensors is incorrect.</p> <p>The sonic sensor angle on both booms need adjustment.</p> <p>Both sonic sensors or circuit wiring are faulty.</p> <p>ECU or circuit wiring is faulty.</p>

Service and Repairs

Sonic Mode Switch

The sonic mode switch is used as an input for the ECU to activate the Sonic Boom System. This switch has three (3) positions: automatic, manual and off. The sonic mode switch is located on the console.

If the sonic mode switch is in the automatic position, the sonic sensors will be activated to allow automatic movement of the boom. The tips of the booms will remain at a constant distance from the ground. The boom switches can be used to raise/lower the booms when the sonic mode switch is in the automatic position.

If the sonic mode switch is in the manual position, the sonic sensors are disabled. The boom switches are used to raise/lower the booms when the sonic mode switch is in the manual position.

If the sonic mode switch is in the OFF position, the booms will remain in position. The boom actuators will not be energized regardless of sonic boom sensor activity or change in boom switch position.

Testing

1. Before disconnecting the sonic mode switch for testing, the switch and its circuit wiring should be tested as a ECU input with the Diagnostic Display (see Diagnostic Display in the Troubleshooting section of this chapter). If the Diagnostic Display verifies that the sonic mode switch and circuit wiring **are** functioning correctly, no further switch testing is necessary. If, however, the Display determines that the sonic mode switch and circuit wiring **are not** functioning correctly, proceed with test.

2. Park vehicle on a level surface, stop engine, engage parking brake and remove key from ignition switch.

3. Disassemble console to gain access to sonic mode switch.

4. Disconnect harness electrical connector from the sonic mode switch.

5. The switch terminals are marked as shown in Figure 9. The circuit logic of the sonic mode switch is shown in the chart to the right. With the use of a multimeter (ohms setting), the switch functions may be tested to determine whether continuity exists between the various terminals for each switch position. Verify continuity between switch terminals. Replace switch if testing identifies a faulty switch.

6. If the sonic mode switch tests correctly and circuit problem still exists, check wire harness (see Electrical Schematic and Wire Harness Drawings in this chapter).

7. After testing is completed, connect wire harness connector to the sonic mode switch.

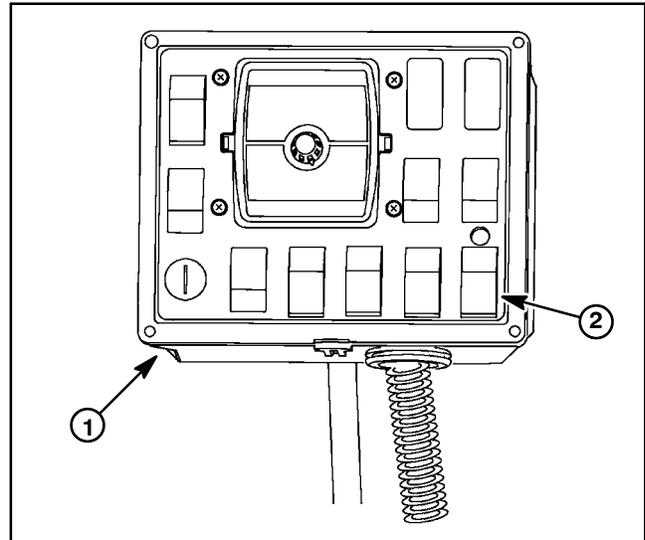
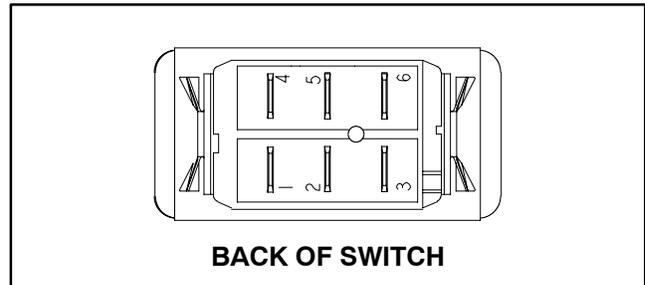


Figure 8

1. Spray control console 2. Sonic mode switch



BACK OF SWITCH

Figure 9

SWITCH POSITION	CLOSED CIRCUITS	OPEN CIRCUITS
AUTOMATIC	2 + 3 5 + 6	2 + 1 5 + 4
OFF	NONE	ALL
MANUAL	2 + 1 5 + 4	2 + 3 5 + 6

Relays

The Sonic Boom System uses six (6) identical relays to control the boom actuators and ultimately the boom height. Three (3) of the relays control the right actuator and the other three (3) relays control the left actuator. The electronic control unit (ECU) controls the operation of the relays. The relays are located on a mounting plate under the vehicle dash panel (Fig. 10) and can be identified by a label on the wire harness connector.

For each actuator, a power switch relay and two (2) H-bridge relays are used. The power switch relay is energized by the ECU whenever the actuator is to be energized to change boom height (either lowered or raised). Both H-bridge relays are energized by the ECU when a boom is to be raised. The energized bridge relays provide current flow to the actuator so the actuator retracts. The H-bridge relays are not energized when a boom is to be lowered. The non-energized bridge relays provide current flow to the actuator so the actuator extends.

Testing

1. Park vehicle on a level surface, stop engine, engage parking brake and remove key from ignition switch.
2. Locate relay to be tested and disconnect wire harness connector from relay. Remove relay from mount plate for testing.

NOTE: Prior to taking small resistance readings with a digital multimeter, short the meter test leads together. The meter will display a small resistance value (usually 0.5 ohms or less). This resistance is due to the internal resistance of the meter and test leads. Subtract this value from the measured value of the component you are testing.

3. Using a multimeter, verify that coil resistance between terminals 85 and 86 is from 71 to 88 ohms.
4. Connect multimeter (ohms setting) leads to relay terminals 30 and 87. Ground terminal 86 and apply +12 VDC to terminal 85. The relay terminals 30 and 87 should have continuity as +12 VDC is applied to terminal 85. The relay terminals 30 and 87 should not have continuity as +12 VDC is removed from terminal 85.
5. Disconnect voltage from terminal 85 and multimeter lead from terminal 87.
6. Connect multimeter (ohms setting) leads to relay terminals 30 and 87A. With terminal 86 grounded, apply +12 VDC to terminal 85. The relay terminals 30 and 87A should not have continuity as +12 VDC is applied to terminal 85. The relay terminals 30 and 87A should have continuity as +12 VDC is removed from terminal 85.

7. Disconnect voltage and multimeter test leads from the relay terminals. Replace relay if necessary.
8. Secure relay to mount plate and connect wire harness connector to relay.

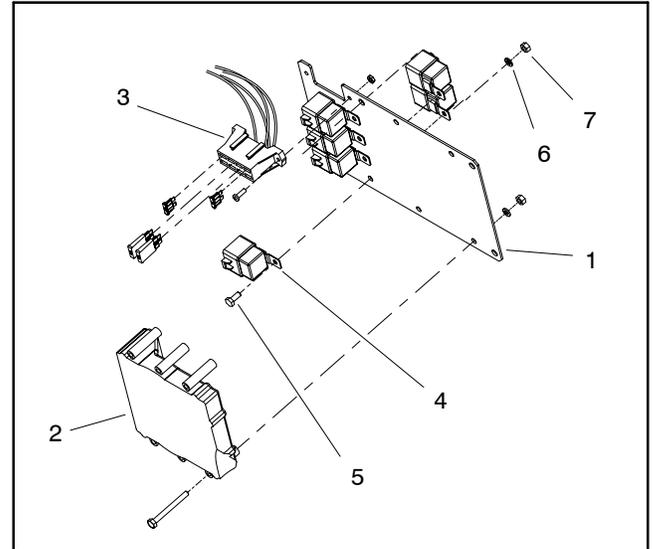


Figure 10

- | | |
|----------------------------|-------------------------|
| 1. Mount plate | 5. Cap screw (4 used) |
| 2. Electronic control unit | 6. Lock washer (4 used) |
| 3. Sonic boom fuse block | 7. Nut (4 used) |
| 4. Relay (6 used) | |

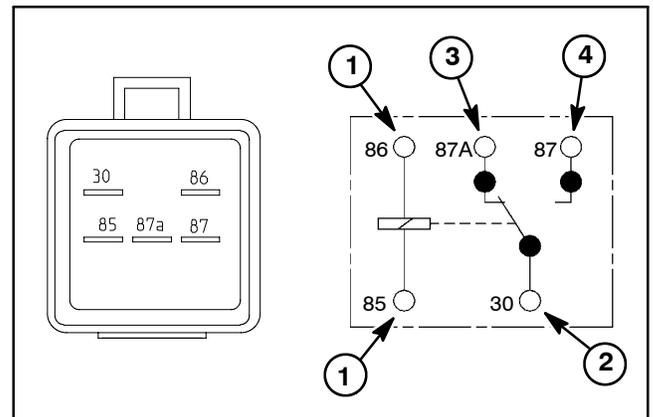


Figure 11

- | | |
|--------------------|--------------------------|
| 1. Coil terminal | 3. Normally closed term. |
| 2. Common terminal | 4. Normally open term. |

Electronic Control Unit (ECU)

The Sonic Boom System uses an electronic control unit (ECU) to control electrical system operation. The ECU is attached to a mounting plate under the vehicle dash panel (Fig. 12).

Power is provided to the ECU when the vehicle ignition switch is ON. A 5 amp fuse provides circuit protection for this logic power to the ECU. The fuse is located in the Sonic Boom System fuse block.

The ECU monitors the states of the following components as inputs: the sonic mode switch, the two (2) boom actuator switches and the two (2) boom sonic sensors.

The ECU controls electrical output to the sonic boom light and the six (6) relays that are part of the Sonic Boom System. Circuit protection for the ECU outputs is provided by a 10 amp fuse located in the Sonic Boom System fuse block.

Because of the solid state circuitry built into the ECU, there is no method to test it directly. The ECU may be damaged if an attempt is made to test it with an electrical test device (e.g. digital multimeter or test light).

IMPORTANT: Before performing welding on the machine, disconnect both cables from the battery and disconnect wire harness connector from the ECU. These steps will prevent damage to the machine electrical system.

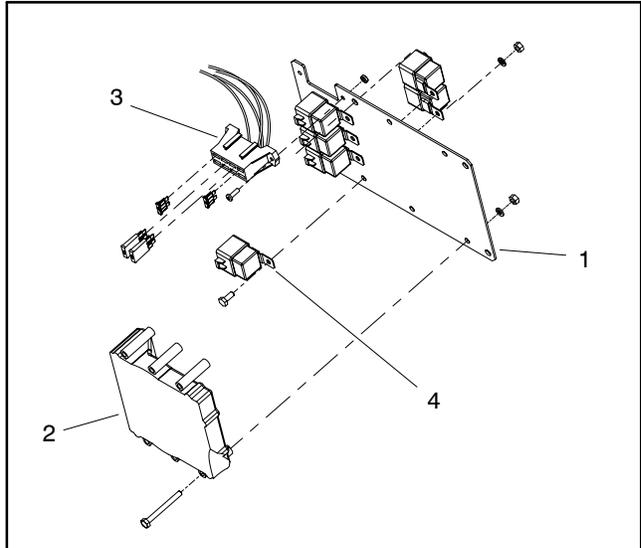


Figure 12

- | | |
|----------------------------|--------------------------|
| 1. Mount plate | 3. Sonic boom fuse block |
| 2. Electronic control unit | 4. Relay (6 used) |

Sonic Sensor

Two (2) identical sonic sensors are used in the Sonic Boom System. The sensors are mounted to the spray booms (Fig. 13). During sprayer operation with the sonic mode switch in the automatic position, the sonic sensors will provide inputs for the electronic control unit (ECU) to keep the booms at a constant distance from the ground.

During sprayer operation, the sonic boom sensor continually sends an impulse signal and then receives an echo as the signal bounces off the turf. The ECU establishes the sensor distance from the ground based on the time between the sensor signal generation and the received echo. The ECU then determines if the boom height is different than the calibrated height and, if necessary, energizes the appropriate boom actuator to change the boom height.

Sensors and protection tubes should be rotated above parallel with the ground for proper sonic sensor operation. Refer to the Sonic Boom Kit Installation Instructions for sonic sensor setup information.

The sonic sensor includes a LED that should be illuminated during sprayer operation regardless of whether the sonic mode switch is in manual or automatic mode. The intensity of the LED can be used to assure that the sensor is properly adjusted on the spray boom.

The sonic sensors and their circuit wiring can be tested as ECU inputs with the Diagnostic Display (see Diagnostic Display in the Troubleshooting section of this chapter). Because of the solid state circuitry built into the sensors, there is no method to test them directly. The sensors may be damaged if an attempt is made to test them with an electrical test device (e.g. digital multimeter or test light)

IMPORTANT: Do not spray water at or on the sensors. Water sprayed under even household pressure can damage the sensor. Always install sensor cover (item 7) on sensor before washing the sprayer. Also, install cover when sprayer is not in use.

As required, use a damp cloth to clean the sensors. Make sure that the sensor covers (item 7) are clean and dry before installing them on sensors.

The patch (item 13) that is adhered to the sensor is designed to allow moisture to escape from inside the sensor housing. The patch should be replaced if it is deteriorated or has loosened from the sensor.

Inspect the foam sensor filter (item 11) for damage or excessive debris buildup. Replace filter if necessary.

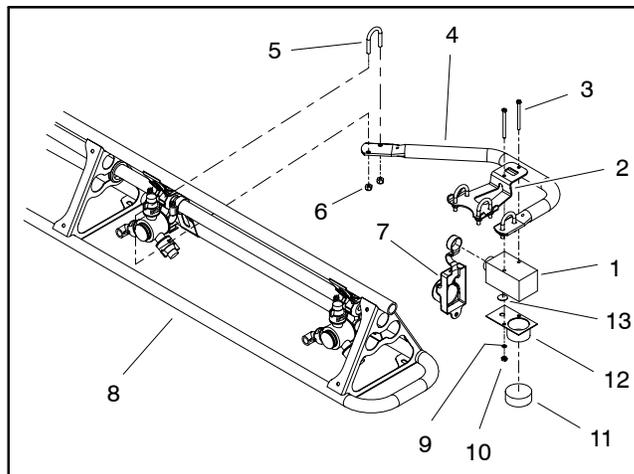


Figure 13

- | | |
|----------------------|--------------------------|
| 1. Sonic sensor | 8. Spray boom (RH shown) |
| 2. Sensor bracket | 9. Lock washer (2 used) |
| 3. Screw (2 used) | 10. Nut (2 used) |
| 4. Protection tube | 11. Foam sensor filter |
| 5. U-bolt (4 used) | 12. Sensor shield |
| 6. Lock nut (8 used) | 13. Patch |
| 7. Sensor cover | |

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Ultra Sonic Boom System (Optional Kit)

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General Information

Installation Instructions

The Ultra Sonic Boom Kit Installation Instructions provides information regarding the installation, operation and general maintenance for your Ultra Sonic Boom System. Refer to that publication for additional information when servicing the machine.

Precautions Concerning Chemicals Used in Spray System

Chemicals can injure persons, animals, plants, soil and other property. To eliminate environmental damage and personal injury:

1. Select the proper chemical for the job.
2. Carefully read the directions printed on the chemical manufacturer's labels before handling chemicals. Instructions on chemical manufacturer's container labels regarding mixing proportions should be read and strictly followed.
3. Keep spray material away from skin. If spray material comes in contact with a person, wash it off immediately in accordance with manufacturer's recommendations (refer to container labels and Material Safety Data Sheets).
4. Always wear protective clothing, chemical resistant gloves, eye protection and other personal protective equipment as recommended by the chemical manufacturer.
5. Properly dispose of chemical containers, unused chemicals and chemical solution.

Precautions for Removing or Adjusting Spray System Components

1. Park vehicle on a level surface and apply the parking brake.
2. Shut off the vehicle's engine and remove the key from the ignition switch.
3. Disengage all power and wait until all moving parts have stopped.
4. Remove chemicals from pump, hoses and other spray components. Thoroughly neutralize and rinse spray system before loosening or removing any spray system component(s).
5. Make sure spray system pressure is relieved before loosening any system component.

Special Tools

Diagnostic Display

The Diagnostic Display (Fig. 1) can be connected to the Ultra Sonic Boom wire harness communication connector to verify correct electrical functions of the Ultra Sonic Boom System. Toro electronic controller (TEC) inputs and outputs for the Ultra Sonic Boom System can be checked using the Diagnostic Display.

Toro Part Number for Diagnostic Display: **85-4750**

Toro Part Number for Overlay (English): **119-9431**

IMPORTANT: The Diagnostic Display must not be left connected to the machine. It is not designed to withstand the environment of the machine's every day use. When use of Diagnostic Display is completed, disconnect it from the machine and reconnect loopback connector to wire harness communication connector. Machine will not operate without loopback connector installed on wire harness. Store Diagnostic Display in a dry, secure, indoor location and not on machine.



Figure 1

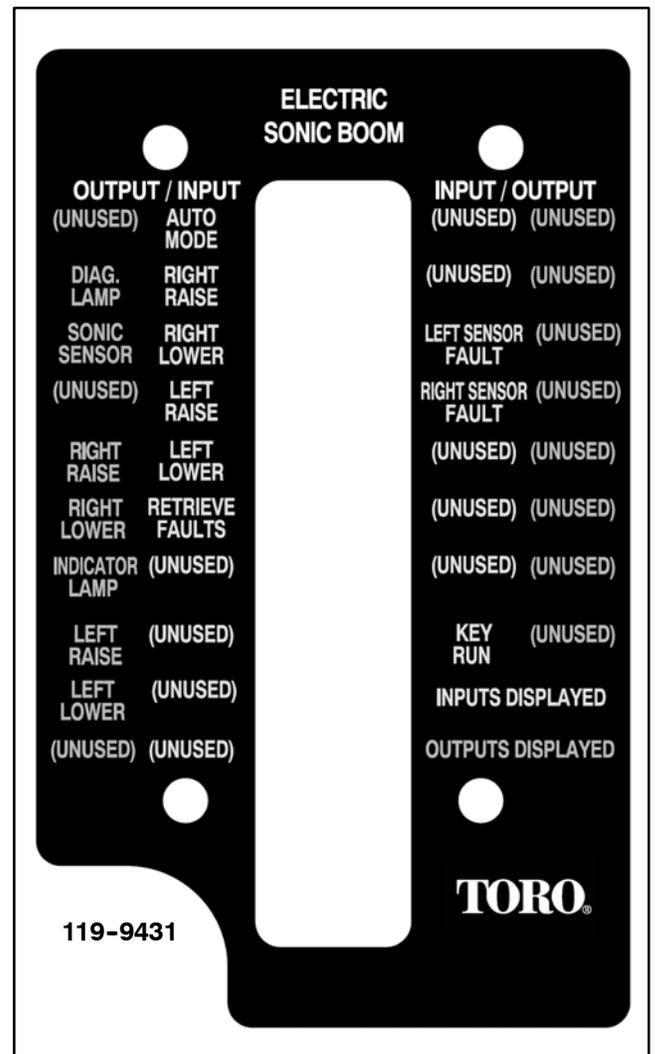
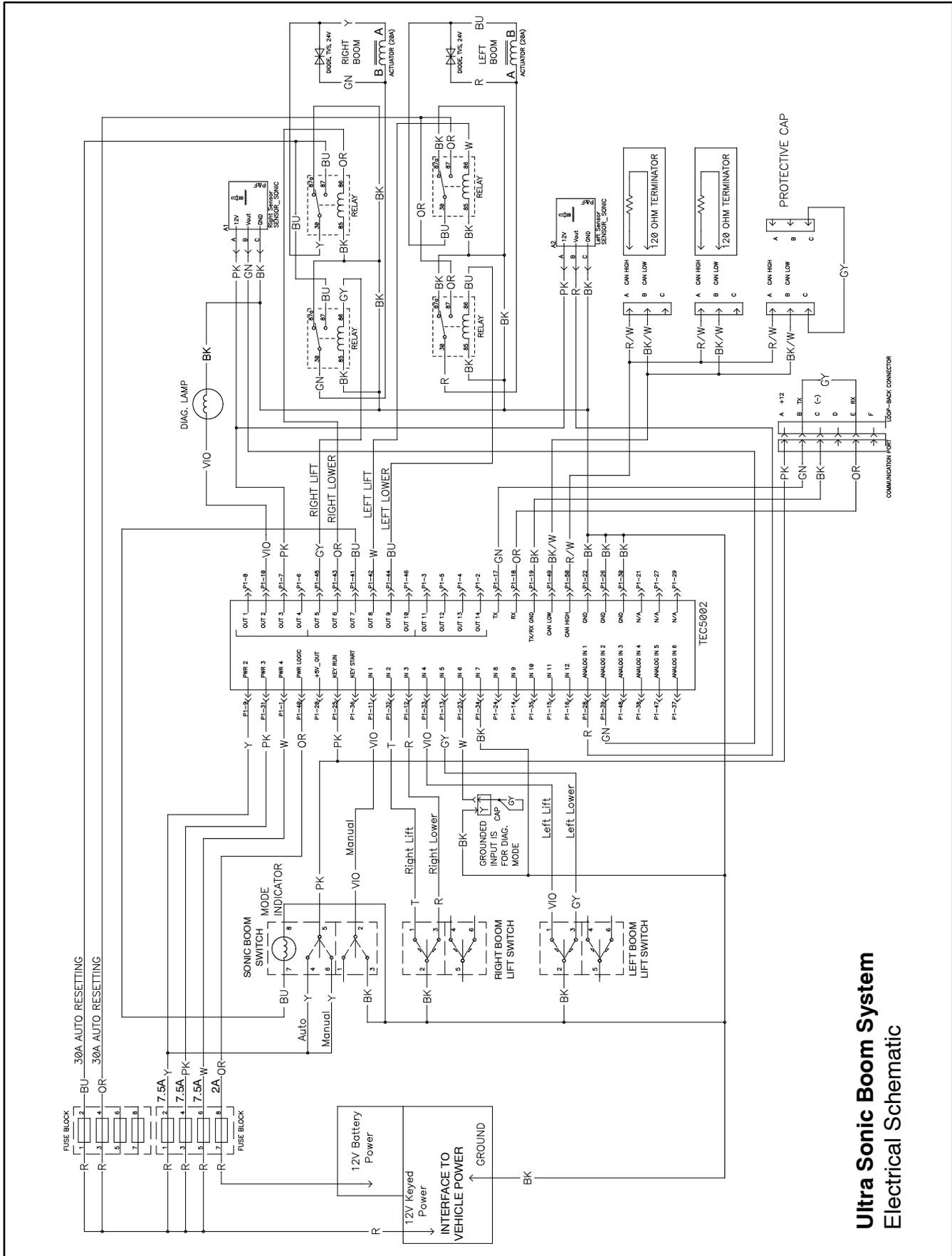


Figure 2

Ultra Sonic
Boom System

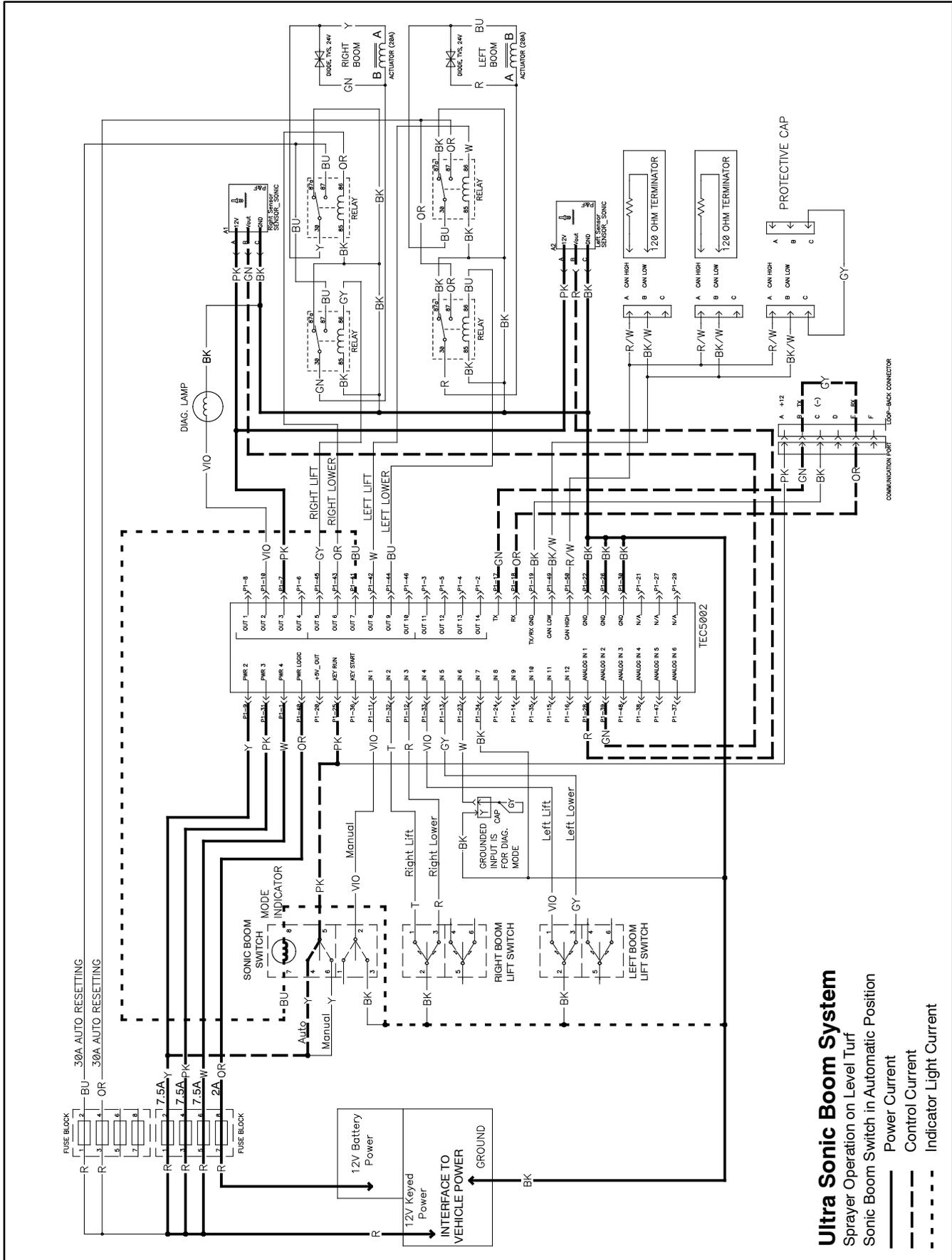
Electrical Schematic



Ultra Sonic Boom System
Electrical Schematic

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Ultra Sonic Boom System Operation



Ultra Sonic Boom System
 Sprayer Operation on Level Turf
 Sonic Boom Switch in Automatic Position
 Power Current
 Control Current
 Indicator Light Current

Sprayer Operation on Level Turf

During sprayer operation with the sonic boom switch in the automatic position (sonic boom light is illuminated), the boom mounted sonic boom sensors continually send impulse signals and then receive echoes as the signals bounce off the turf. The Toro electronic controller (TEC) determines the sensor distance from the ground based on the elapsed time between the sensor signal generation and the received echo. As long as the sensor height remains the same as the calibrated height, the spray boom will remain at a fixed height from the ground for spraying accuracy.

NOTE: During normal Ultra Sonic Boom system operation, there may be some slight movement of the booms.

On level turf, the boom sensors continually send signals and receive echoes that determine that the boom sections are at the calibrated height. Thus, there is no need to change boom height and the boom sections will remain at the correct, level position.

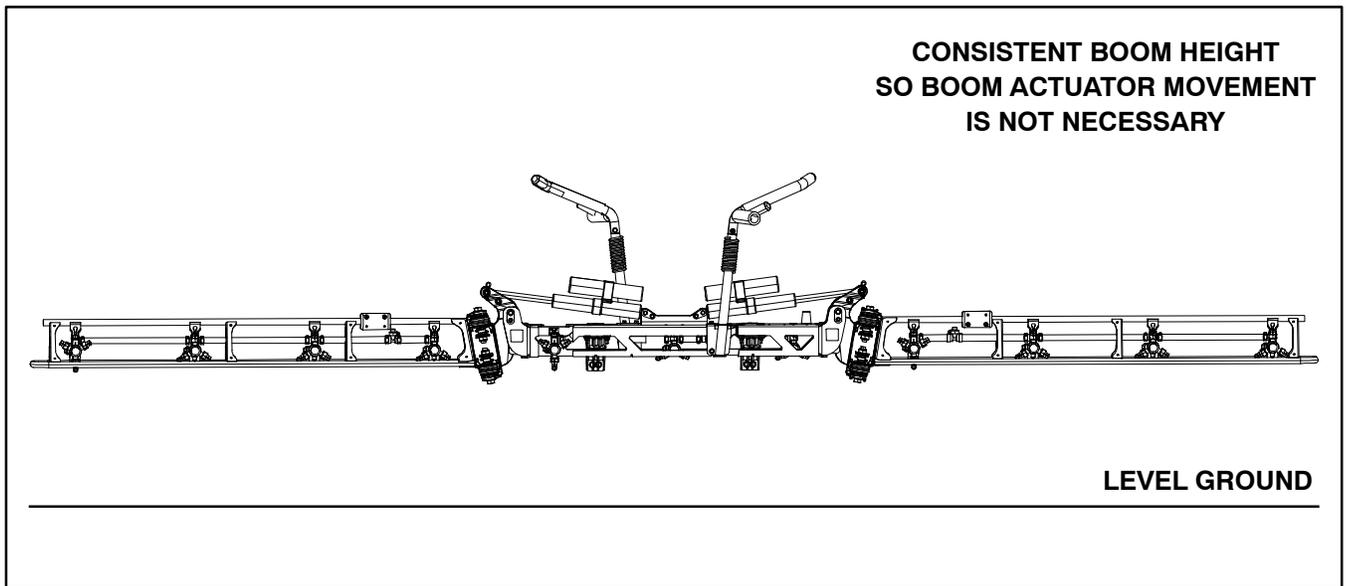
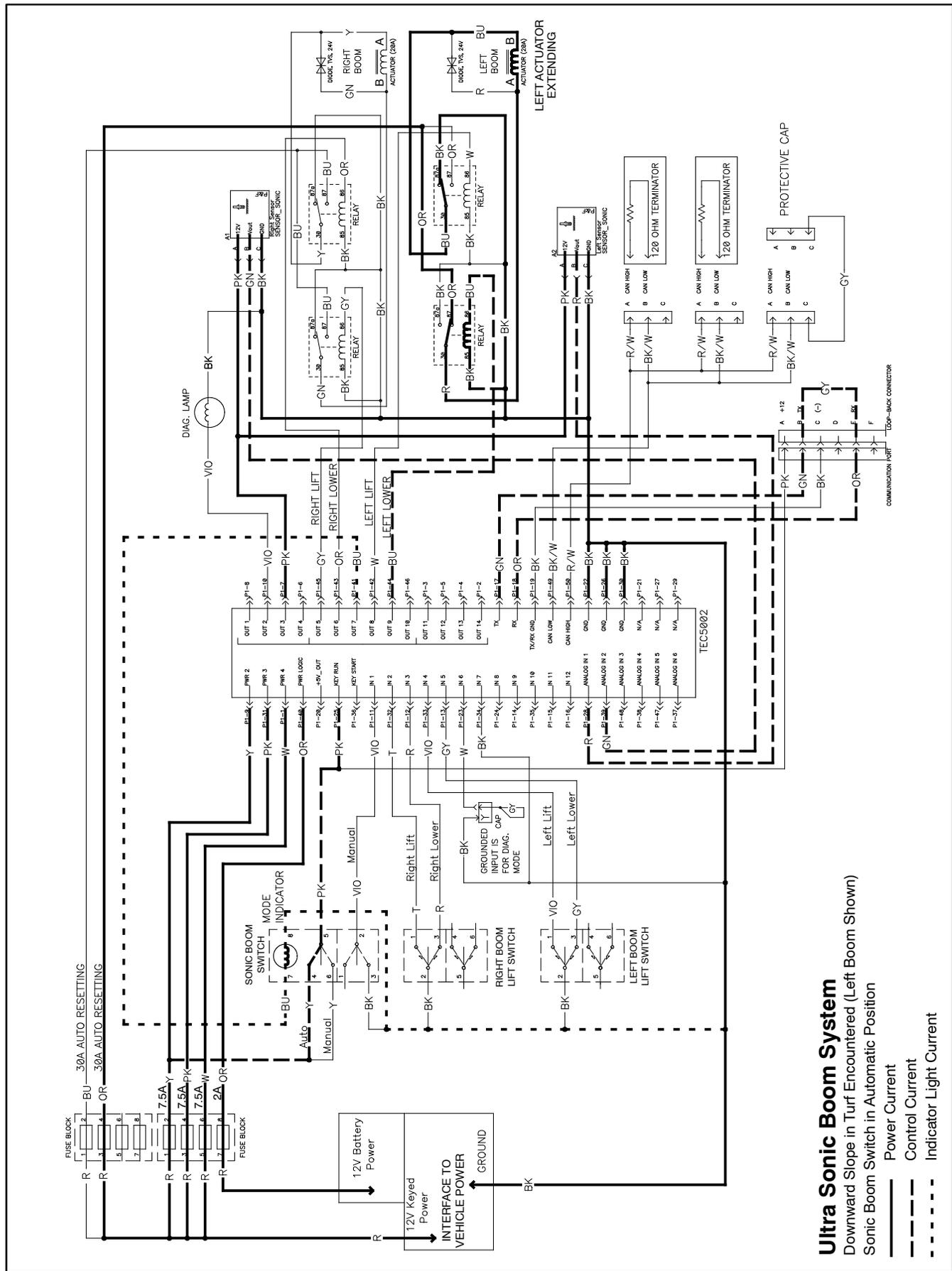


Figure 3



Ultra Sonic Boom System
 Downward Slope in Turf Encountered (Left Boom Shown)
 Sonic Boom Switch in Automatic Position
 Power Current
 Control Current
 Indicator Light Current

Downward Slope in Turf Encountered

During sprayer operation with the sonic boom switch in the automatic position (sonic boom light is illuminated), the boom mounted sonic boom sensors continually send impulse signals and then receive echoes as the signals bounce off the turf. The Toro electronic controller (TEC) determines the sensor distance from the ground based on the elapsed time between the sensor signal generation and the received echo. As long as the sensor height remains the same as the calibrated height, the spray boom section will remain at a fixed distance from the ground for spraying accuracy.

When a spray boom section encounters a downward slope in the turf, the time necessary for the sensor to receive the signal echo is longer than the calibrated timeframe. This change in time causes the TEC to energize the appropriate electrical relays causing the controlled boom actuator to extend and the boom section to lower. Once the boom section is lowered to the calibrated distance, the elapsed time between the sensor signal generation and the received echo returns to the correct timeframe, relays are de-energized and the boom stops lowering. This maintains the boom height at the calibrated distance from the ground.

The boom sensor target distance is initiated during initial sonic boom calibration and is typically set at twenty (20) inches. If the boom target distance changes when in automatic mode, the TEC will energize the appropriate electrical relays. The energized relays will lead to a change in boom actuator length and ultimately a change in boom height.

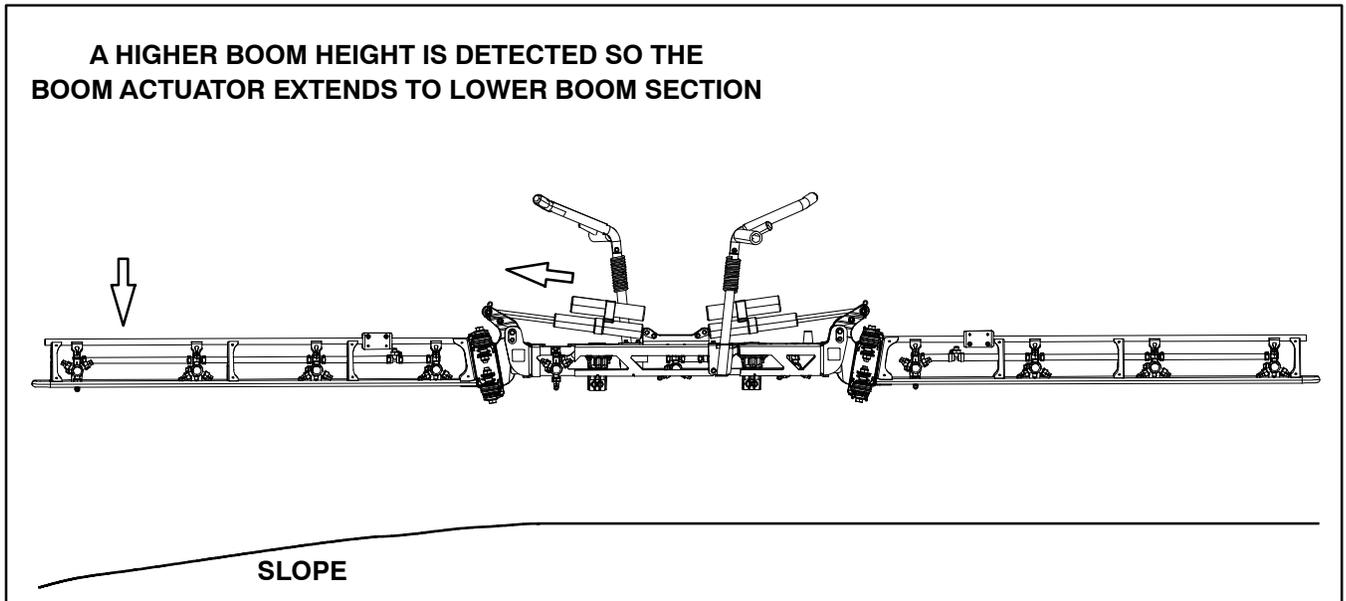
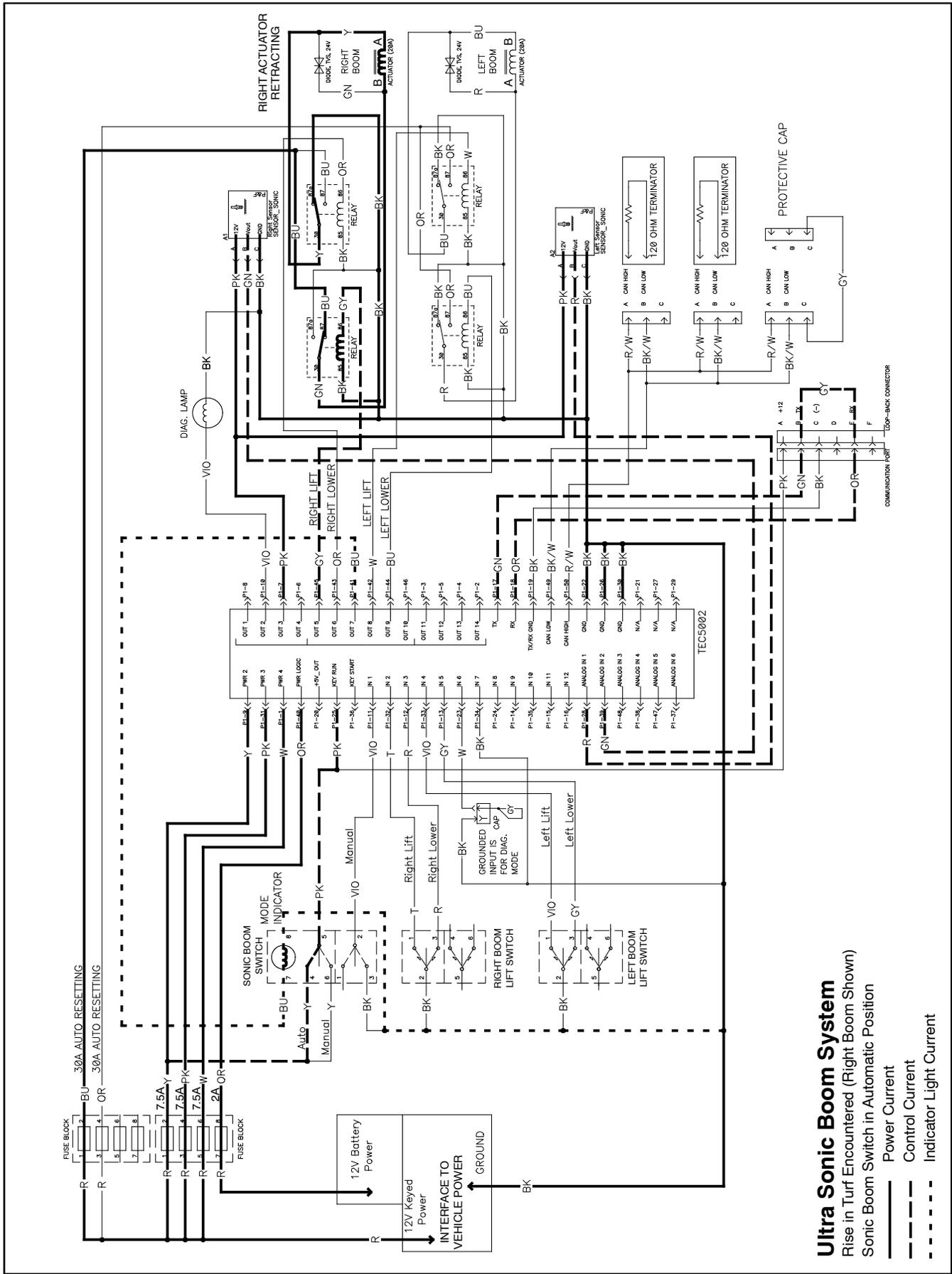


Figure 4



Rise in Turf Encountered

During sprayer operation with the sonic boom switch in the automatic position (sonic boom light is illuminated), the boom mounted sonic boom sensors continually send impulse signals and then receive echoes as the signals bounce off the turf. The Toro electronic controller (TEC) determines the sensor distance from the ground based on the time between the sensor signal generation and the received echo. As long as the sensor height remains the same as the calibrated height, the spray boom section will remain at a fixed distance from the ground for spraying accuracy.

When a spray boom section encounters a rise in the turf, the time necessary for the sensor to receive the signal echo is shorter than the calibrated timeframe. This change in time causes the TEC to energize the appropriate electrical relays causing the controlled boom actuator to retract and the boom section to raise. Once the boom section is raised to the calibrated distance, the elapsed time between the sensor signal generation and the received echo returns to the correct timeframe, relays are de-energized and the boom stops raising. This maintains the boom height at the calibrated distance from the ground.

The boom sensor target distance is initiated during initial sonic boom calibration and is typically set at twenty (20) inches. If the boom target distance changes when in automatic mode, the TEC will energize the appropriate electrical relays. The energized relays will lead to a change in boom actuator length and ultimately a change in boom height.

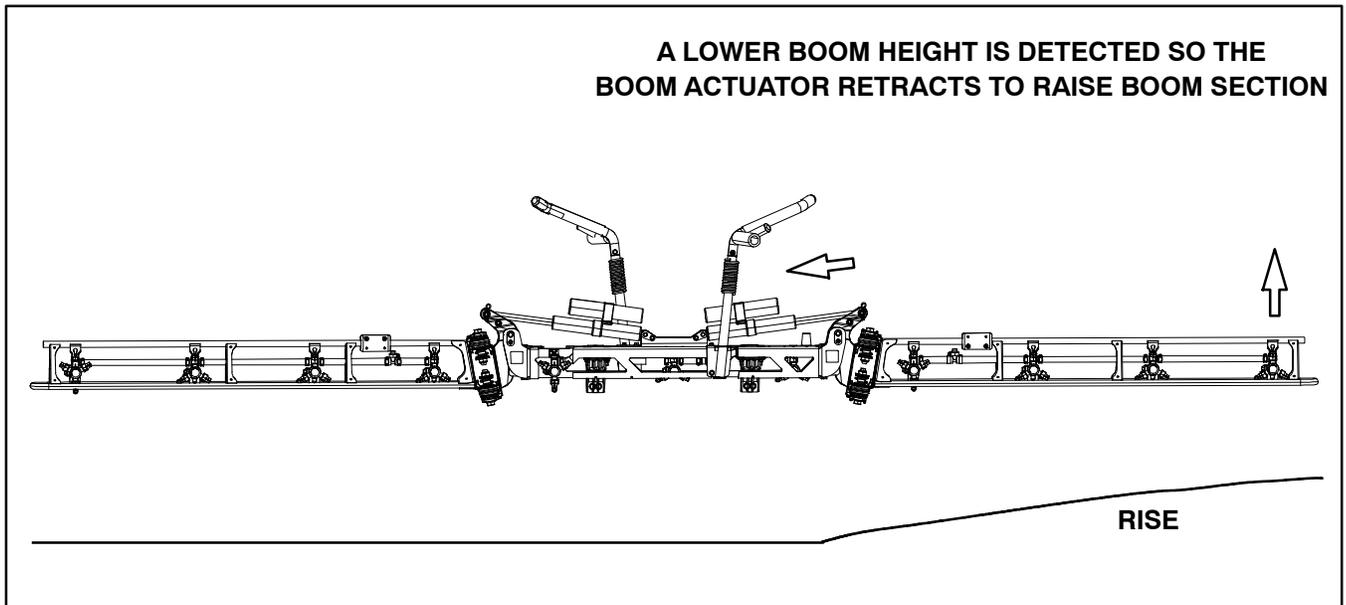
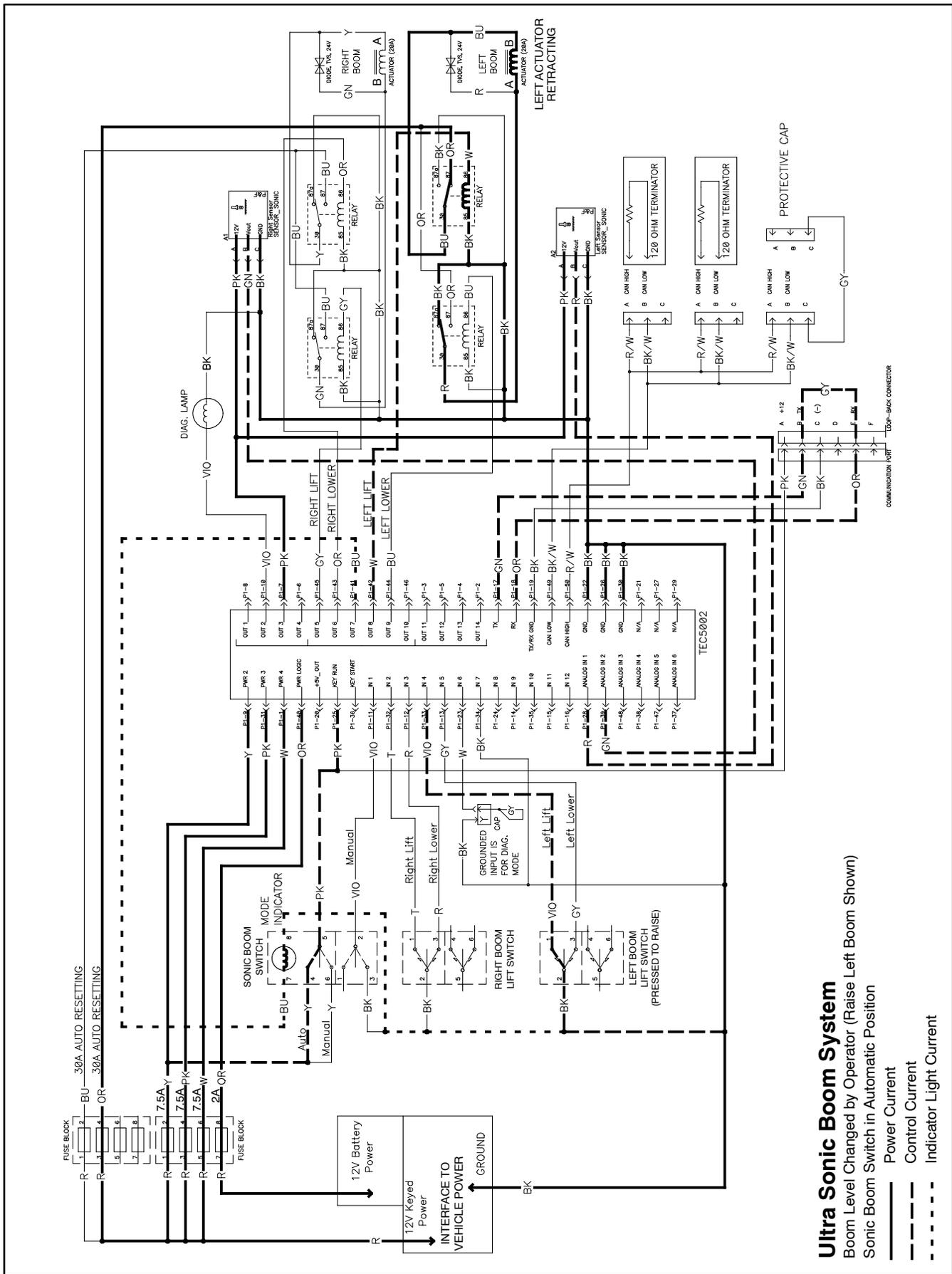


Figure 5



Ultra Sonic Boom System
 Boom Level Changed by Operator (Raise Left Boom Shown)
 Sonic Boom Switch in Automatic Position
 Power Current
 Control Current
 Indicator Light Current

Boom Level Changed by Operator During Automatic Operation

During sprayer operation with the sonic boom switch in the automatic position (sonic boom switch light is illuminated), the boom mounted sonic boom sensors continually send impulse signals and then receive echoes as the signals bounce off the turf. The Toro electronic controller (TEC) determines the sensor distance from the ground based on the time between the sensor signal generation and the received echo. As long as the sensor height remains the same as the calibrated height, the spray boom will remain at a fixed distance from the ground for spraying accuracy.

If the sprayer operator should press a boom lift switch while in automatic operation, the TEC energizes the appropriate boom lift control electrical relays. The energized relays cause the boom actuator to raise or lower the boom section. The relays will stay energized as long as the operator keeps the boom lift switch pressed. The sonic boom light will flash while the boom lift switch is being depressed. If one boom is moved by the operator, the other boom continues to function automatically.

If a boom is raised by the operator while the Ultra Sonic Boom System is in automatic operation, that boom will remain in the raised position until the boom lift switch is pressed to lower and released which will re-engage automatic sonic boom operation on that boom section.

If a boom is lowered by the operator while the Ultra Sonic Boom System is in automatic operation, that boom will lower until the boom lift switch is released. The automatic sonic boom operation will be re-engaged as soon as the lift switch is released from lower.

NOTE: To re-engage automatic sonic boom operation, the boom lift switch must be pressed to lower and released. Pressing the boom lift switch to raise will not re-engage automatic operation.

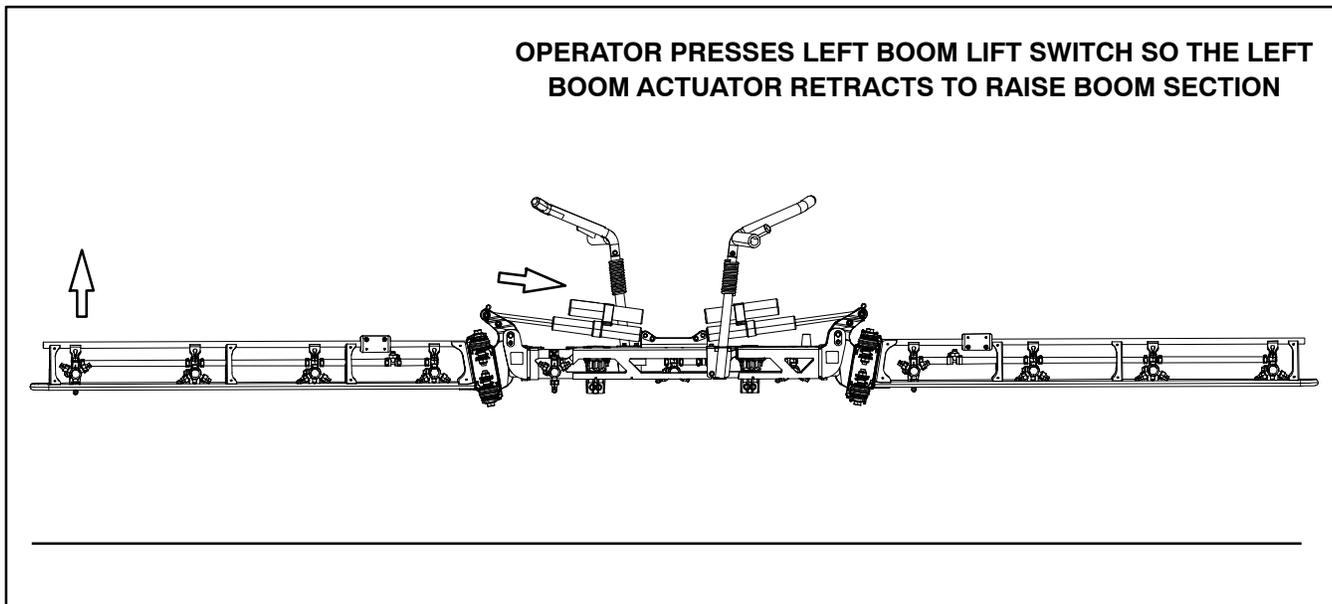
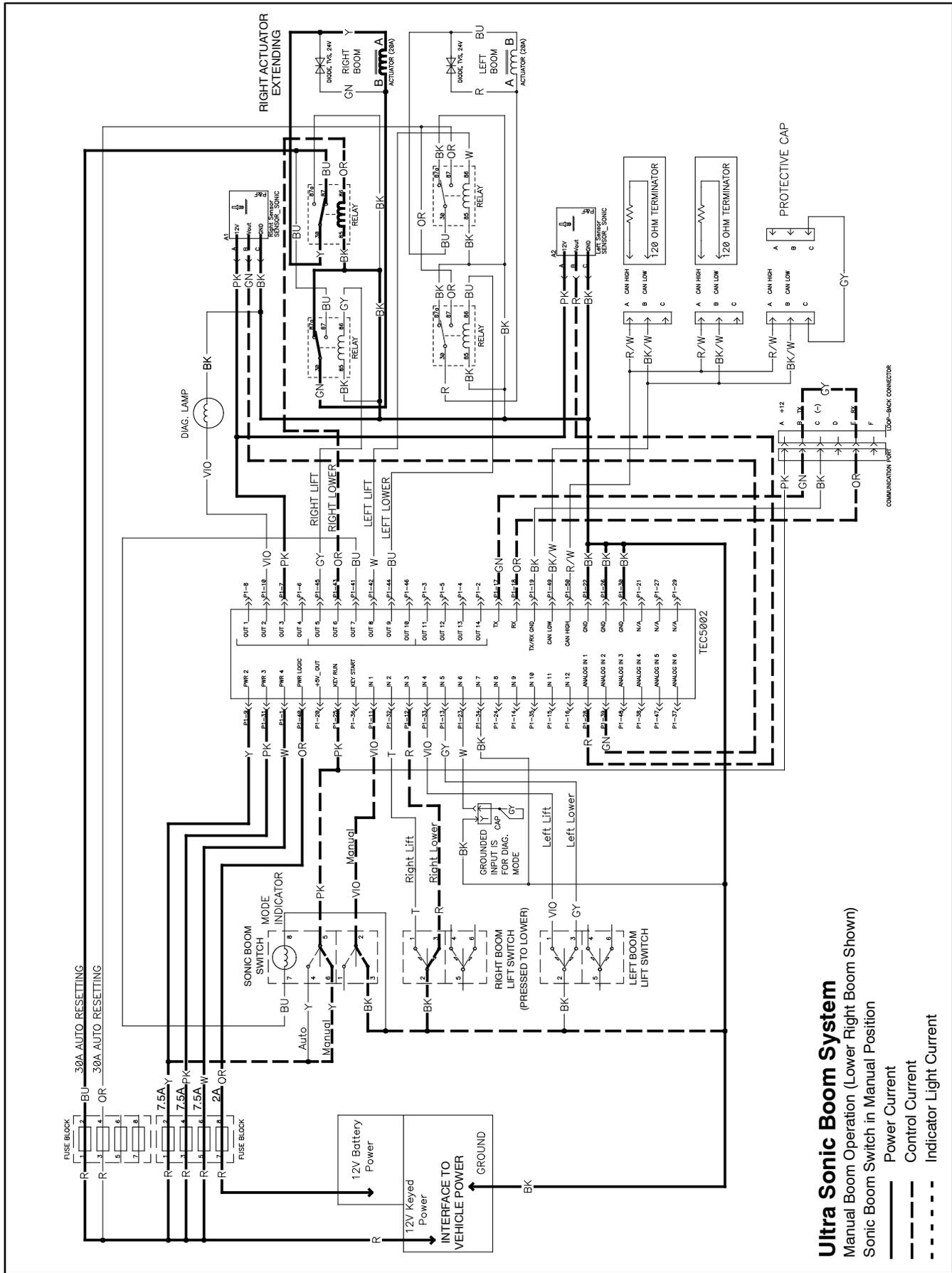


Figure 6



Ultra Sonic Boom System
 Manual Boom Operation (Lower Right Boom Shown)
 Sonic Boom Switch in Manual Position
 Power Current
 Control Current
 Indicator Light Current

Manual Boom Operation

During sprayer operation with the sonic boom switch in the manual position, the spray booms will remain in position unless the operator presses a boom lift switch. The sonic boom light should not be illuminated when in the manual position. The operator will control the boom position with the boom lift switches.

Lower Boom

When a boom lift switch is pressed to lower a boom section, the Toro electronic controller (TEC) energizes the appropriate electrical relays causing the controlled boom actuator to extend and the boom section to lower. The boom will continue to lower until the operator releases the boom actuator switch.

Raise Boom

When a boom lift switch is pressed to raise a boom section, the Toro electronic controller (TEC) energizes the appropriate electrical relays causing the controlled boom actuator to retract and the boom section to raise. The boom will continue to rise until the operator releases the boom lift switch.

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Troubleshooting

For effective troubleshooting and repairs, there must be a good understanding of the electrical circuits and components used on the Ultra Sonic Boom System (see Ultra Sonic Boom System Operation in this chapter).

NOTE: When troubleshooting an electrical problem on your Ultra Sonic Boom System, refer to information regarding the sonic boom light and diagnostic lamp in this section. Also, use the Diagnostic Display (see Special Tools in this chapter) to test Toro electronic controller (TEC) inputs and outputs.

Sonic Boom Light

The sonic boom light is included in the sonic boom switch on the spray control panel (Fig. 7). This light should be illuminated whenever the vehicle ignition switch is ON and the sonic boom switch is in the automatic position.

The sonic boom light flashing quickly indicates that the Ultra Sonic Boom System is in the calibration mode. This mode allows the spray booms to be adjusted for the desired boom height and continues for approximately twenty (20) seconds. The sonic boom light will then flash slowly for approximately two (2) minutes to finalize the calibration settings.

NOTE: A sequence of switch movements is necessary to engage the calibration mode. Refer to the Sonic Boom Kit Installation Instructions for this sequence.

The sonic boom light flashes slowly when the sonic boom switch is in the automatic position and a boom lift switch is pressed to manually change the boom height. The flashing light will return to being constantly ON and automatic operation will be re-engaged once the boom switch is manually pressed to the lower position.

A slowly flashing sonic boom light may also indicate that a system fault has been encountered. In the event that there is a fault in the Ultra Sonic Boom System (e.g. there is no signal coming from a boom sensor), the affected boom will raise briefly and then stop. The sonic boom light will begin to flash slowly and the diagnostic lamp on the console will also flash. If this occurs, refer to Diagnostic Lamp, Diagnostic Display and Troubleshooting Chart in this section.

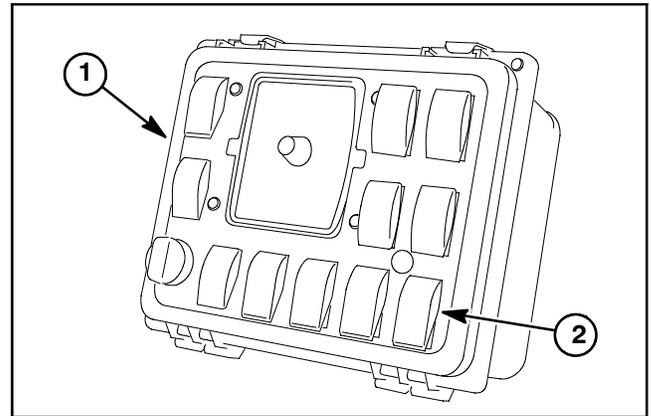


Figure 7

- 1. Spray control panel
- 2. Sonic boom switch

Ultra Sonic Boom Calibration

The sensor calibration process is critical to the correct operation of the Ultra Sonic Boom System. The calibration process establishes the sensor target distance between the boom and the turf surface. Typically, this distance is approximately twenty (20) inches. Steps needed for proper calibration are identified in the Ultra Sonic Boom Kit Installation Instructions.

While calibrating the Ultra Sonic Boom sensors, it is best to perform the calibration process on turf. A shiny surface (e.g. cement shop floor) can skew sensor signals. Also, ensure the calibration area is free of buildings, trees, underground plumbing and other machines that could interfere with sensor signals.

Diagnostic Lamp

The Ultra Sonic Boom System includes a diagnostic lamp that displays the status of the sonic boom system. The diagnostic lamp is located on the spray control panel (Fig. 8).

When the ignition switch is moved to the ON position and the Ultra Sonic Boom System electrical system is functioning properly, the diagnostic lamp will be illuminated for approximately three (3) seconds and then will turn off. The diagnostic lamp should remain off during normal sonic boom operation.

If the sonic boom system TEC controller detects an electrical system malfunction (fault) during operation (e.g. there is no signal coming from a boom sensor), the affected boom will raise briefly and then stop. The sonic boom light (in sonic boom switch) will begin to flash slowly and the diagnostic lamp will flash rapidly. The diagnostic lamp will stop flashing and will automatically reset when the ignition switch is turned to the OFF position. The fault, however, will be retained in controller memory and can be retrieved at a future time (see Retrieving Fault Codes below).

If the diagnostic lamp does not illuminate when the ignition switch is turned to the ON position, possible causes are:

- The loopback connector (6 pin connector) is not connected to the machine wire harness (Fig. 9). The loopback connector is near the TEC controller on the mounting plate under the dash panel.
- The diagnostic lamp (or circuit wiring) is faulty.
- TEC controller fuse(s) are faulty.
- The TEC controller is faulty.

Check electrical connections, controller fuses and the diagnostic lamp to determine malfunction. Make sure that the loopback connector is secured to the wire harness connector during machine operation.

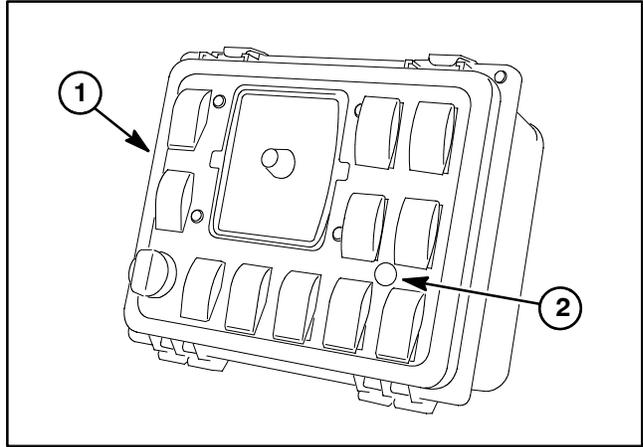


Figure 8

1. Spray control panel 2. Diagnostic lamp

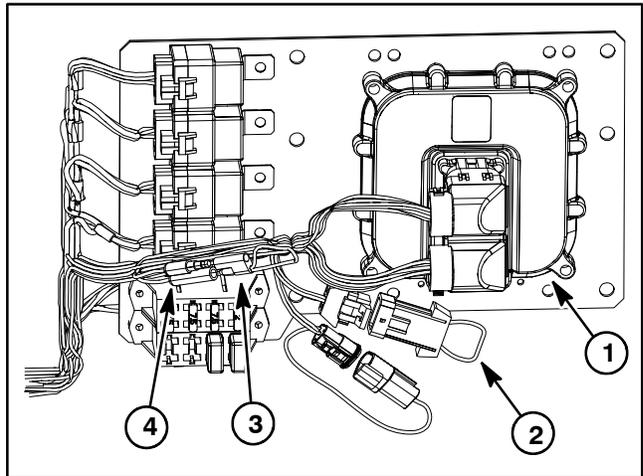


Figure 9

1. TEC controller location 3. Diagnostic tether cap
2. Loopback connector 4. Diagnostic shunt wires

Retrieving Fault Codes

All Ultra Sonic Boom System fault codes are retained in the TEC controller memory. The three (3) most recent fault codes that have occurred within the last forty (40) hours of operation can be retrieved using the diagnostic lamp. To retrieve these fault codes from the controller memory, perform the following steps:

1. Make sure that ignition switch is OFF.
2. Locate diagnostic tether cap that connects the two (2) diagnostic shunt wires located near the TEC controller on the mounting plate under the dash panel (Fig. 9).
3. Remove diagnostic tether cap from diagnostic shunt wires and connect the two (2) shunt wires together.
4. Turn ignition switch to the ON position.
5. Monitor the diagnostic lamp for fault code(s).

Fault codes displayed by the diagnostic lamp are two (2) digit numbers with no digit larger than five (5). Fault codes are listed in the chart below. There will be a one (1) second pause between the first and second digit of a code. Up to three (3) fault codes retained in controller memory will be displayed by the diagnostic lamp in order from the most recent fault to the oldest fault. If there are multiple faults in controller memory, there will be a three (3) second pause between codes. The fault codes will continually repeat after a five (5) second pause until the ignition key is turned OFF.

If there are no faults that have occurred within the last forty (40) hours of operation, the diagnostic lamp will flash continuously after performing the above steps.

If a fault code is not retrieved from the controller memory within forty (40) hours of machine operating time, the fault cannot be retrieved from controller memory using this procedure. If necessary, contact your Toro distributor to retrieve older fault codes.

After necessary service has been performed, disconnect diagnostic shunt wires and insert shunt leads into diagnostic tether cap. Lower operator seat.

Fault Code (Lamp Flashes)	Fault Description
1 - 2	Left sonic boom sensor fault occurred
1 - 3	Right sonic boom sensor fault occurred
1 - 6	TEC inputs are out of range (sonic boom operation will stop)
2 - 1	The extreme right 7.5 Amp fuse in boom supply fuse block is faulty
2 - 2	The middle right 7.5 Amp fuse in boom supply fuse block is faulty
2 - 3	The middle left 7.5 Amp fuse in boom supply fuse block is faulty
2 - 4	Main electrical power to sonic boom system was interrupted
3 - 4	Left boom raise function (output) is grounded or faulty
4 - 1	Right boom raise function (output) is grounded or faulty
4 - 2	Right boom lower function (output) is grounded or faulty
4 - 5	Left boom lower function (output) is grounded or faulty

Clearing Fault Codes

After fault codes have been retrieved, clearing of those faults can be completed using the following switch sequence:

1. Place sprayer in fault retrieval mode (see above). The diagnostic lamp should be displaying the fault codes.

2. At the same time, press the left boom switch to lower and the right boom switch to raise.

3. Monitor the diagnostic lamp for continuous flashing indicating that all faults have been cleared from the controller memory.

Diagnostic Display

The Ultra Sonic Boom System is equipped with the Toro electronic controller (TEC) which controls machine sonic boom electrical functions. The TEC monitors various input switches (e.g. sonic boom switch, boom lift switches, sonic boom sensors) and energizes outputs (e.g. boom actuators, diagnostic lamp) for appropriate machine functions.

For the TEC to control the machine as desired, each of the inputs (switches and sensors) and outputs (e.g. boom actuators) must be connected and functioning properly.

The Diagnostic Display (see Special Tools in this chapter) is a tool to help the technician verify correct electrical functions of the machine.

IMPORTANT: The Diagnostic Display must not be left connected to the machine. It is not designed to withstand the environment of the machine's every day use. When use of the Diagnostic Display is completed, disconnect it from the machine and reconnect loopback connector to harness connector. The machine will not operate without the loopback connector installed on the harness. Store the Diagnostic Display in a dry, secure, indoor location and not on machine.

Verify Diagnostic Display Input Functions

1. Park machine on a level surface, stop the engine and apply the parking brake.
2. Locate Ultra Sonic Boom wire harness communication port and loopback connector (6 pin connector) located near the TEC controller on the mounting plate under the dash panel (Fig. 10). Carefully unplug loopback connector from harness connector.
3. Connect the Diagnostic Display connector to the wire harness communication port connector. Make sure correct overlay decal is positioned on the Diagnostic Display (Fig. 11).
4. Turn the machine ignition switch to the ON position, but do not start engine.

NOTE: The **red** text on the Diagnostic Display overlay decal refers to input switches and the **green** text refers to TEC outputs.

5. Make sure that the "INPUTS DISPLAYED" LED, on lower right column of the Diagnostic Display, is illuminated. If "OUTPUTS DISPLAYED" LED is illuminated, press the toggle button on the Diagnostic Display to change to "INPUTS DISPLAYED" LED.

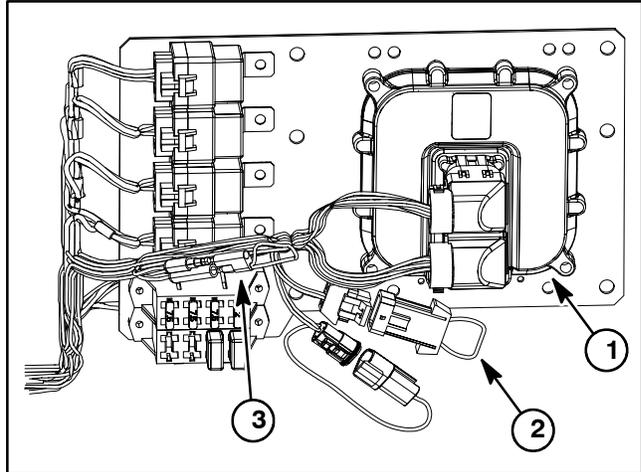


Figure 10

1. TEC controller location
2. Loopback connector
3. Diagnostic tether cap

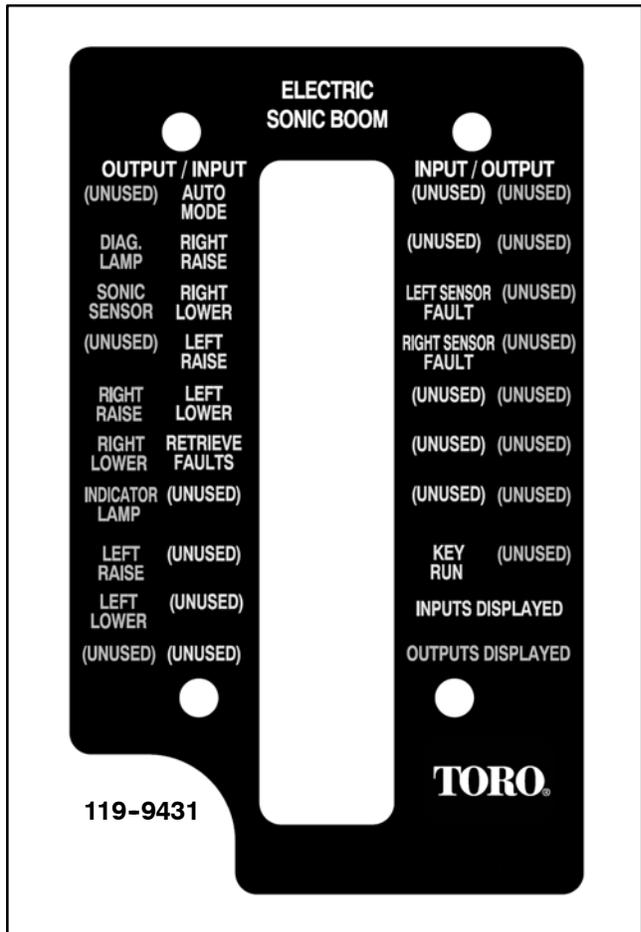


Figure 11



CAUTION

When testing TEC inputs with the Diagnostic Display, boom actuators may be energized causing the spray booms to move. Be cautious of potential sprayer component movement while verifying inputs with the Diagnostic Display.

6. The Diagnostic Display will illuminate the LED associated with each of the inputs when that input switch is closed. Individually, change each of the switches from open to closed (e.g. toggle sonic boom switch), and note that the appropriate LED on the Diagnostic Display will illuminate when the corresponding switch is closed. Repeat on each switch that is possible to be changed by hand (see Inputs and LED Operation chart below).

7. If appropriate LED does not toggle on and off when switch state is changed, perform test of switch and/or check all wiring and connections to that switch. Replace any defective switches and repair any damaged wiring.

8. After input functions testing is complete, disconnect the Diagnostic Display connector from the harness connector. Plug loopback connector into wire harness.

Diagnostic Display Inputs	Diagnostic Display LED Operation
AUTO MODE	Sonic boom switch in auto position: LED ON Sonic boom switch not in auto position: LED OFF
RIGHT RAISE	Right boom lift switch in raise position: LED ON Right boom lift switch not in raise position: LED OFF
RIGHT LOWER	Right boom lift switch in lower position: LED ON Right boom lift switch not in lower position: LED OFF
LEFT RAISE	Left boom lift switch in raise position: LED ON Left boom lift switch not in raise position: LED OFF
LEFT LOWER	Left boom lift switch in lower position: LED ON Left boom lift switch not in lower position: LED OFF
RETRIEVE FAULTS	Diagnostic shunt wires are connected for fault retrieval: LED ON Diagnostic shunt wires are not connected: LED OFF
LEFT SENSOR FAULT	The TEC has detected an invalid reading from left sensor: LED ON Left sensor operating normally: LED OFF
RIGHT SENSOR FAULT	The TEC has detected an invalid reading from right sensor: LED ON Right sensor operating normally: LED OFF
KEY RUN	Ignition key is in ON position: LED ON Ignition key is in OFF position: LED OFF

NOTE: When the vehicle ignition switch is in the OFF position, all Diagnostic Display LED's should be OFF.

NOTE: Initial calibration of the Ultra Sonic Boom sensors is required for proper operation of TEC inputs. Refer to your Sonic Boom Kit Installation Instructions for information on initial sensor calibration.

NOTE: Right and left side Ultra Sonic Boom sensors are identical so they can be exchanged to assist in troubleshooting. If a problem follows the exchanged sensor, an electrical problem likely exists with the sensor. If the problem remains unchanged, something other than the sensor is the problem source (e.g. switch, circuit wiring).

Verify Diagnostic Display Output Functions

The Diagnostic Display also has the ability to detect which output boom actuators or lights (sonic boom or diagnostic) are energized by the Toro electronic controller (TEC). This is a quick way to determine which electrical component is malfunctioning.

NOTE: An open output (e.g. an unplugged connector or a broken wire) cannot be detected with the Diagnostic Display.

1. Park machine on a level surface, stop the engine and engage the parking brake.
2. Locate Ultra Sonic Boom wire harness communication port and loopback connector (6 pin connector) located near the TEC controller on the mounting plate under the dash panel (Fig. 12). Carefully unplug loopback connector from harness connector.
3. Connect the Diagnostic Display connector to the harness communication port connector. Make sure correct overlay decal is positioned on the Diagnostic Display (see Special Tools in this chapter).
4. Turn the ignition switch to the ON position.

NOTE: The **red** text on the Diagnostic Display overlay decal refers to input switches and the **green** text refers to TEC outputs.

5. Make sure that the “OUTPUTS DISPLAYED” LED, on lower right column of the Diagnostic Display, is illuminated. If “INPUTS DISPLAYED” LED is illuminated, press the toggle button on the Diagnostic Display to change the LED to “OUTPUTS DISPLAYED”.

NOTE: It may be necessary to toggle between “INPUTS DISPLAYED” and “OUTPUTS DISPLAYED” several times to perform the following step. To change from inputs to outputs, press toggle button once. This may be done as often as required. **Do not press and hold toggle button.**



CAUTION

When testing TEC inputs with the Diagnostic Display, boom actuators may be energized causing the spray booms to move. Be cautious of potential sprayer component movement while verifying inputs with the Diagnostic Display.

6. Attempt to operate the desired function of the machine. The appropriate output LED's should illuminate on the Diagnostic Display to indicate that the TEC is turning on that function (see Outputs and LED Operation chart on next page). The outputs can be checked with the ignition switch in the ON position and the engine not running.

A. If the correct output LED's do not illuminate, verify that the required input switches are in the necessary positions to allow that function to occur.

B. If the output LED's are on as specified, but the booms do not function properly, suspect a failed electrical component, an open in the tested circuit or a non-electrical problem (e.g. binding of the boom hinge). Repair as necessary.

C. If each input switch is in the correct position and functioning correctly, but the output LED's are not correctly illuminated, this may indicate a TEC problem. If this occurs, contact your Toro Distributor for assistance.

7. After output functions testing is complete, disconnect the Diagnostic Display connector from the harness connector and plug loopback connector into wire harness.

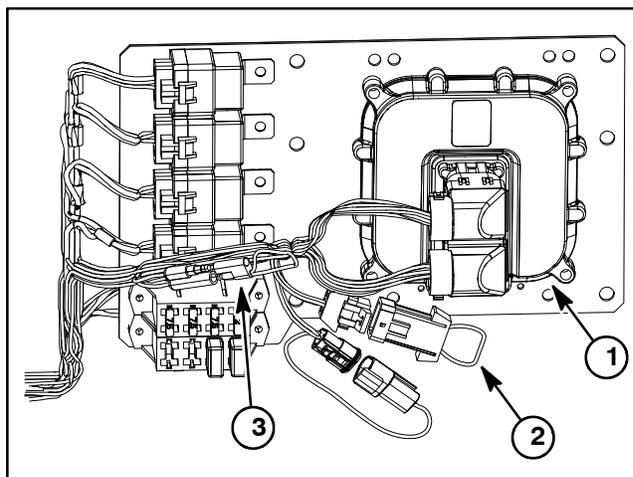


Figure 12

1. TEC controller location
2. Loopback connector
3. Diagnostic tether cap

Diagnostic Display Outputs	Diagnostic Display LED Operation
DIAG LAMP	Diagnostic lamp is ON or FLASHING: LED ON or FLASHING Diagnostic lamp is not ON or FLASHING: LED OFF
SONIC SENSOR	TEC output exists to sonic sensors: LED ON No TEC output to sonic sensors: LED OFF
RIGHT RAISE	TEC output exists to energize relays to raise right boom: LED ON No TEC output to energize relays to raise right boom: LED OFF
RIGHT LOWER	TEC output exists to energize relays to lower right boom: LED ON No TEC output to energize relays to lower right boom: LED OFF
INDICATOR LAMP	Sonic boom switch is in automatic position: LED ON Sonic boom switch is in manual position: LED OFF
LEFT RAISE	TEC output exists to energize relays to raise left boom: LED ON No TEC output to energize relays to raise left boom: LED OFF
LEFT LOWER	TEC output exists to energize relays to lower left boom: LED ON No TEC output to energize relays to lower left boom: LED OFF

Troubleshooting Chart

The chart that follows contains suggestions that can be used to assist in diagnosing Ultra Sonic Boom System performance issues. These suggestions are not all-inclusive. Also, consider that there may be more than one cause for a machine problem.

NOTE: When troubleshooting an electrical problem on your Ultra Sonic Boom System, refer to information regarding the sonic boom light in this section. Also, use the Diagnostic Display (see Special Tools in this chapter) to test Toro electronic controller (TEC) inputs and outputs.

Problem	Possible Cause
Light in sonic boom switch is not illuminated.	<p>Sonic boom switch is in the MANUAL position.</p> <p>2 Amp fuse in sonic boom fuse block is faulty (all sonic boom functions are affected).</p> <p>Upper, middle right fuse (7.5 Amp) in sonic boom fuse block is faulty.</p> <p>Loopback connector is unplugged from wire harness connector (all sonic boom functions are affected).</p> <p>Electrical power from vehicle is not available (all sonic boom functions are affected).</p> <p>Sonic boom switch or circuit wiring is faulty.</p>
One of the boom actuators will not extend or retract.	<p>Boom lift switch or circuit wiring for affected boom actuator is faulty.</p> <p>A problem exists with the affected boom actuator.</p>
Neither of the boom actuators will extend or retract.	<p>Loopback connector is unplugged from wire harness connector (all sonic boom functions are affected).</p> <p>Fuse(s) in sonic boom fuse block is faulty.</p> <p>Electrical power from vehicle is not available (all sonic boom functions are affected).</p> <p>A problem exists with both boom actuators.</p> <p>The Toro electronic controller (TEC) or circuit wiring is faulty.</p>
The LED's on one of the sonic boom sensors are not illuminated.	<p>Sonic boom sensor or circuit wiring is faulty.</p>
The LED's on both of the sonic boom sensors are not illuminated.	<p>Sonic boom switch is in the MANUAL position.</p> <p>Upper, middle left fuse (7.5 Amp) in sonic boom fuse block is faulty (diagnostic lamp also affected).</p> <p>Sonic boom switch or circuit wiring is faulty.</p>

Problem	Possible Cause
<p>One of the booms does not automatically follow ground irregularities. Boom can be controlled with boom lift switch.</p>	<p>On affected boom, the sonic boom sensor cover is on sensor.</p> <p>On affected boom, calibration of the sonic boom sensors is incorrect.</p> <p>The sonic boom sensor is incorrectly installed.</p> <p>Sonic boom sensor or circuit wiring for affected boom is faulty.</p> <p>The Toro electronic controller (TEC) or circuit wiring is faulty.</p>
<p>Neither boom automatically follows ground irregularities. Booms can be controlled with boom lift switches.</p>	<p>Sonic boom switch is not in the AUTOMATIC position.</p> <p>Sonic boom sensor covers are on both sensors.</p> <p>Calibration of the sonic boom sensors is incorrect.</p> <p>Both sonic boom sensors or circuit wiring are faulty.</p> <p>The Toro electronic controller (TEC) or circuit wiring is faulty.</p>

Service and Repairs

Sonic Boom Fuses

Fuses for the Ultra Sonic Boom system are included in the fuse blocks attached to the mounting plate under the dash panel (Fig. 13).

Fuse Identification and Function

The upper row of fuses protect circuits as follows:

1. The upper, extreme left 2 Amp fuse protects power supply for TEC logic.
2. The upper, middle left 7.5 Amp fuse is not used.
3. The upper, middle right 7.5 Amp fuse protects TEC output circuits (sonic boom switch light and boom actuator power supply).
4. The upper, extreme right 7.5 Amp fuse protects TEC output circuits (diagnostic light and sonic sensor power supply).

The lower row of fuses protect circuits as follows:

1. The lower, extreme left fuse position is not used.
2. The lower, middle left fuse position is not used.
3. The lower, middle right 30 Amp fuse (auto resetting) protects the left boom actuator circuit.
4. The extreme right 30 Amp fuse (auto resetting) protects the right boom actuator circuit.

Fuse Testing

Remove fuses from the fuse block for testing. Fuse should have continuity between fuse terminals.

NOTE: The auto resetting fuses should only be removed if they are faulty.

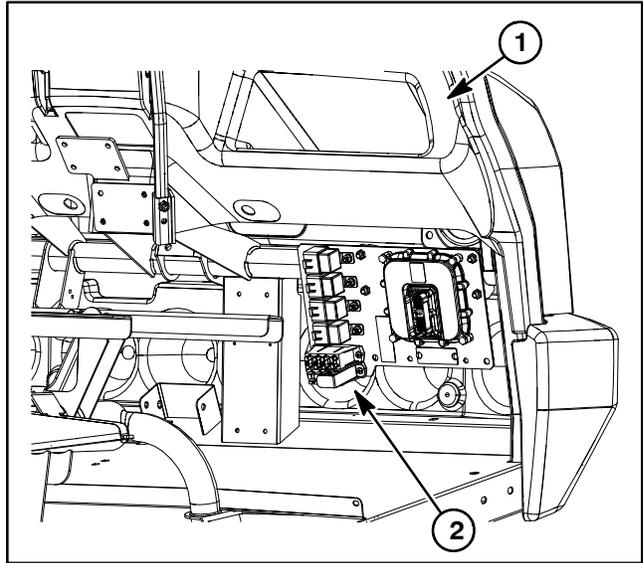


Figure 13

- 1. Dash panel
- 2. Fuse blocks

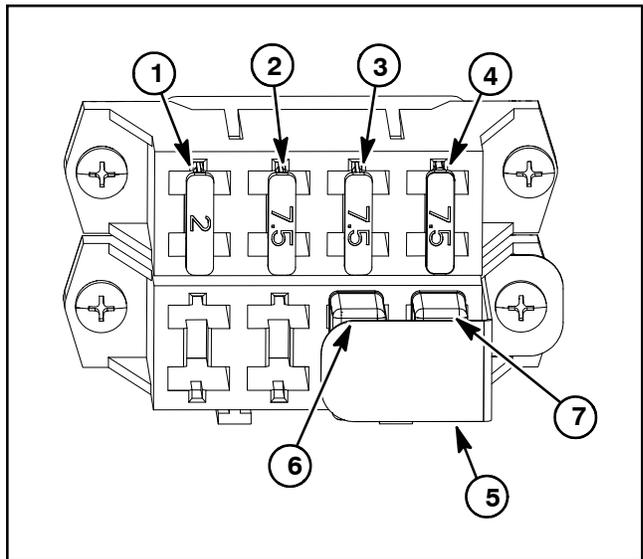


Figure 14

- 1. Upper, extreme left fuse
- 2. Upper middle left fuse
- 3. Upper, middle right fuse
- 4. Upper right fuse
- 5. Auto resetting fuse
- 6. Auto resetting fuse
- 7. Auto resetting fuse

Sonic Boom Switch

The sonic boom switch is used as an input for the Toro electronic controller (TEC) to activate the Ultra Sonic Boom System. This switch has two (2) positions: automatic and manual. The sonic boom switch is located on the spray control panel (Fig. 15).

If the sonic boom switch is in the automatic position, the sonic sensors will be activated to allow automatic movement of the booms. The tips of the booms will remain at a constant distance from the ground. The boom lift switches can be used to raise/lower the booms when the sonic boom switch is in the automatic position. The light in the switch should be illuminated when the switch is in the automatic position.

If the sonic boom switch is in the manual position, the sonic sensors are disabled. The boom lift switches are used to raise/lower the booms when the sonic boom switch is in the manual position.

Testing

NOTE: Before disconnecting sonic boom switch for testing, the switch and its circuit wiring should be tested as a TEC input with the Diagnostic Display (see Diagnostic Display in the Troubleshooting section of this chapter). If the Diagnostic Display verifies that the sonic boom switch and circuit wiring **are** functioning correctly, no further switch testing is necessary. If, however, the Display determines that the sonic boom switch and circuit wiring **are not** functioning correctly, proceed with switch test.

1. Park vehicle on a level surface, stop engine, engage parking brake and remove key from ignition switch.

2. Locate sonic boom switch, remove console panel and unplug wire harness connector from switch.

3. The switch terminals are shown in Figure 16. The circuit logic of the sonic boom switch is shown in the chart to the right. With the use of a multimeter (ohms setting), the switch functions may be tested to determine whether continuity exists between the various terminals for each switch position. Verify continuity between switch terminals. Replace switch if testing identifies a faulty switch.

4. To test switch light, apply 12 VDC to terminal 8 (+) and ground terminal 7 (-). The light should illuminate.

5. If the sonic boom switch tests correctly and circuit problem still exists, check sonic boom system wire harness.

6. After testing is completed, connect wire harness connector to the sonic boom switch. Install console panel to machine.

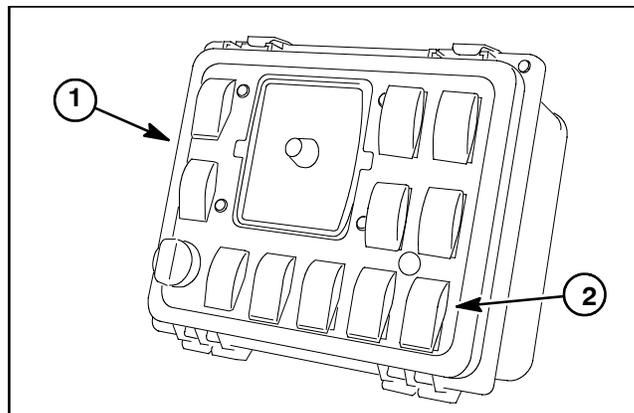


Figure 15

1. Spray control panel 2. Sonic boom switch

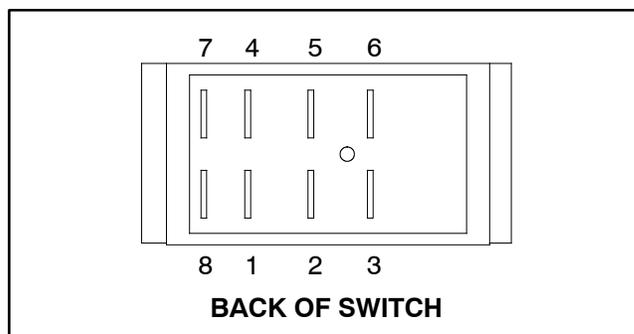


Figure 16

SWITCH POSITION	CLOSED CIRCUITS	OPEN CIRCUITS
MANUAL	2 + 3 5 + 6	2 + 1 5 + 4
AUTOMATIC	2 + 1 5 + 4	2 + 3 5 + 6

Sonic Sensors

Two (2) identical sonic sensors are used in the Ultra Sonic Boom System. The sensors are mounted to the spray booms (Figs. 17, 18 and 19). During sprayer operation with the sonic boom switch in the automatic position, the sonic sensors will provide inputs for the Toro electronic controller (TEC) to keep the booms at a constant distance from the ground.

During sprayer operation, the sonic boom sensor continually sends an impulse signal and then receives an echo as the signal bounces off the turf. The TEC establishes the sensor distance from the ground based on the time between the sensor signal generation and the received echo. The TEC then determines if the boom height is different than the calibrated height and, if necessary, energizes the appropriate boom actuator(s) to change the boom height.

Sensors should be secured to the spray booms correctly for proper sonic sensor operation. Refer to the Ultra Sonic Boom Kit Installation Instructions for sonic sensor installation and setup information.

The sonic sensors and their circuit wiring can be tested as TEC inputs with the Diagnostic Display (see Diagnostic Display in the Troubleshooting section of this chapter). Because of the solid state circuitry built into the sensors, there is no method to test them directly. The sensors may be damaged if an attempt is made to test them with an electrical test device (e.g. digital multimeter or test light)

IMPORTANT: Do not spray water at or on the sensors. Water sprayed even under household pressure can damage the sensor. Always install sensor cap on sensor before washing the sprayer. Also, install cap when sprayer is not in use.

As required, use a damp cloth to clean the sensors. Make sure that the sensor covers and caps are clean and dry before installing them on sensors. When the sprayer is not being used, it is recommended to have the caps installed on the sensors for sensor protection.

Each of the sonic sensor assemblies includes a programming plug for sensor accuracy. If a programming plug is removed from the sensor, make sure that the arrow below the sideways T on the plug is aligned with the notch on the top edge of the sensor (Fig. 20).

NOTE: The two (2) sonic sensors are identical. To assist in troubleshooting, sensors can be exchanged. If the problem follows the exchanged sensor, an electrical problem likely exists with the sensor. If the problem remains unchanged, something other than the sensor is the problem source.

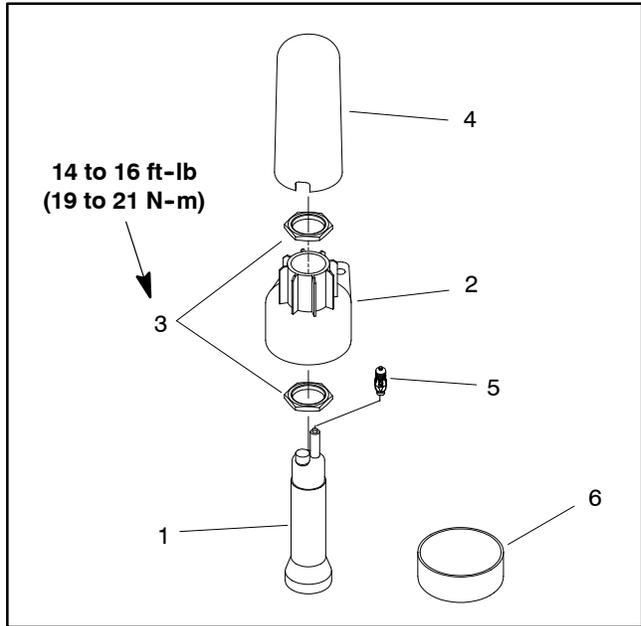


Figure 17

- | | |
|------------------|---------------------|
| 1. Sonic sensor | 4. Cover |
| 2. Lower housing | 5. Programming plug |
| 3. Nut (2 used) | 6. Cap |

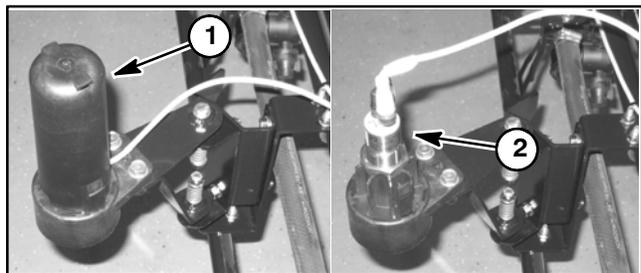


Figure 18

- | | |
|----------------------|-------------------------|
| 1. Sensor with cover | 2. Sensor without cover |
|----------------------|-------------------------|

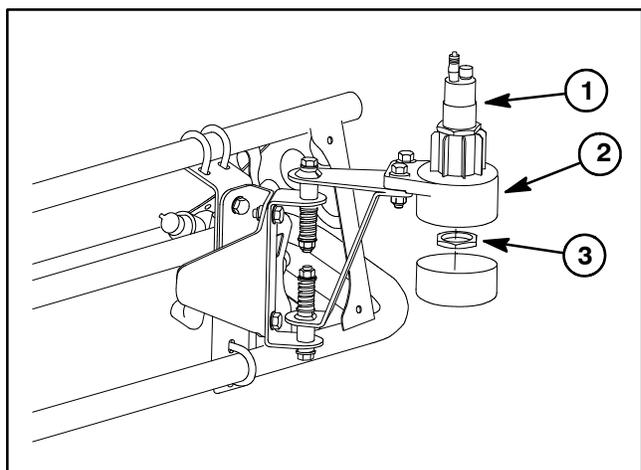


Figure 19

- | | |
|------------------|-----------------|
| 1. Sonic sensor | 3. Nut (2 used) |
| 2. Lower housing | |

Sonic Sensor LED Window

The sonic sensor includes a LED window that identifies sensor status during sprayer operation during operation of the Ultra Sonic Boom system (Fig. 21). To view the LED window, carefully remove cover from sonic sensor. The LED window includes four (4) LED's.

During normal operation, the green LED and both yellow LED's should be illuminated. The red LED will be off.

If there is some interference with normal sensor operation, the red LED will be flashing. The green LED will be off. The yellow LED's may flash, be illuminated or be off.

If the sensor programming plug is removed or is faulty, the red LED will be illuminated. The green LED will be off. The yellow LED's may flash, be illuminated or be off.

The status of the LED's on the sensors can be used to identify a faulty or unplugged programming plug. The LED's also can be used to identify the presence of interference that can affect Ultra Sonic Boom system operation. If the LED's do not illuminate correctly, a problem may exist with circuit wiring to the sensor or with the sensor itself.

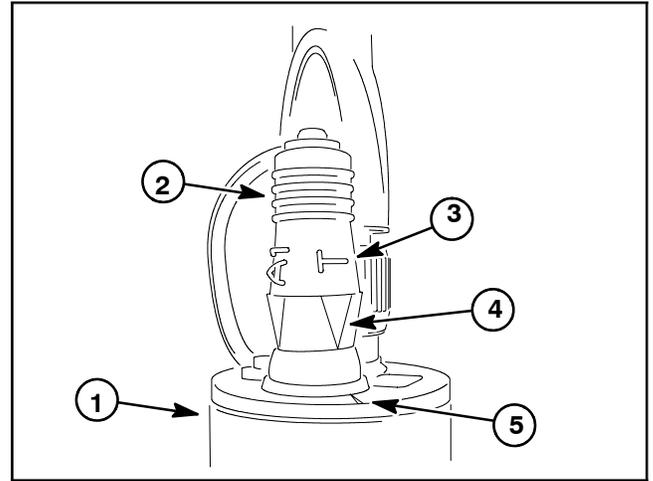


Figure 20

- 1. Sonic sensor
- 2. Programming plug
- 3. Letter T
- 4. Plug arrow
- 5. Sensor notch

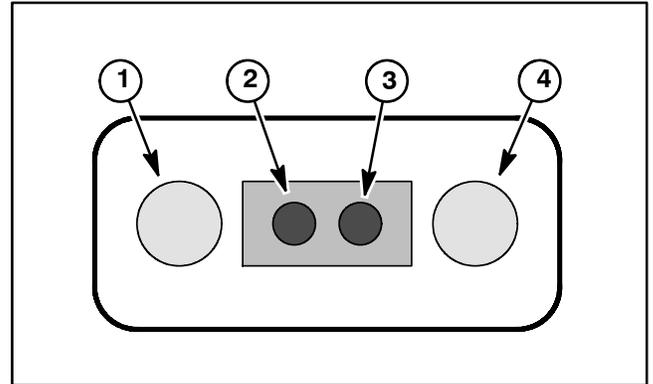


Figure 21

- 1. Yellow LED
- 2. Green LED
- 3. Red LED
- 4. Yellow LED

Relays

The Ultra Sonic Boom System uses four (4) identical relays to control the boom actuators and ultimately the boom height. Two (2) of the relays control the right boom actuator and the other two (2) relays control the left boom actuator. The Toro electronic controller (TEC) controls the operation of the relays. The appropriate relay is energized by the TEC to allow current flow to the boom actuators in the proper direction so that the actuator extends (boom raise) or retracts (boom lower).

The relays are located on a mount plate under the vehicle dash panel (Fig. 22) and can be identified by a label on the wire harness connector.

Testing

1. Park vehicle on a level surface, stop engine, engage parking brake and remove key from ignition switch.
2. Remove mount plate from under dash panel to allow easier relay access.
3. Locate relay to be tested and disconnect wire harness connector from relay. Remove relay from mount plate for testing.

NOTE: Prior to taking small resistance readings with a digital multimeter, short the meter test leads together. The meter will display a small resistance value (usually 0.5 ohms or less). This resistance is due to the internal resistance of the meter and test leads. Subtract this value from the measured value of the component you are testing.

4. Using a multimeter, verify that coil resistance between terminals 85 and 86 is from 71 to 88 ohms.

5. Connect multimeter (ohms setting) leads to relay terminals 30 and 87. Ground terminal 86 and apply +12 VDC to terminal 85. The relay should make and break continuity between terminals 30 and 87 as +12 VDC is applied and removed from terminal 85.

6. Disconnect voltage from terminal 85 and multimeter lead from terminal 87.

7. Connect multimeter (ohms setting) leads to relay terminals 30 and 87A. Apply +12 VDC to terminal 85. The relay should make and break continuity between terminals 30 and 87A as +12 VDC is applied and removed from terminal 85.

8. Disconnect voltage and multimeter test leads from the relay terminals. Replace relay if necessary.

9. Secure relay to mount plate and connect wire harness connector to relay. Secure mount plate to machine frame.

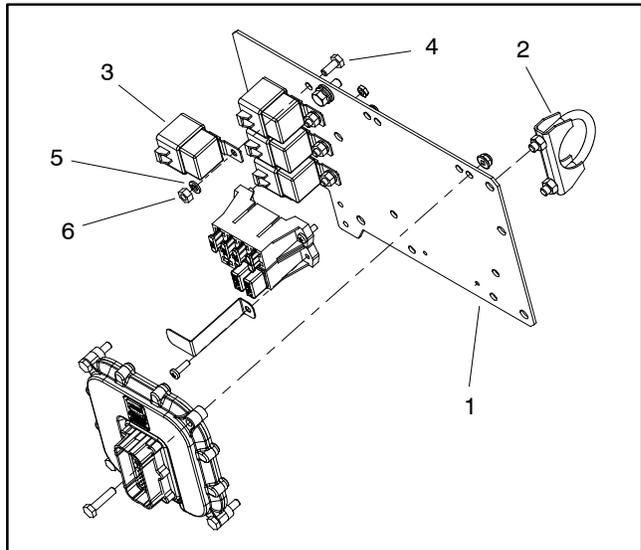


Figure 22

- | | |
|--------------------------|-------------------------|
| 1. Mount plate | 4. Cap screw (4 used) |
| 2. U-bolt clamp (2 used) | 5. Lock washer (4 used) |
| 3. Relay (4 used) | 6. Nut (4 used) |

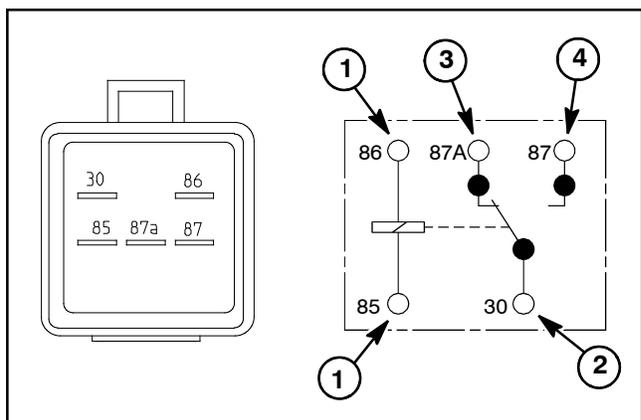


Figure 23

- | | |
|--------------------|--------------------------|
| 1. Coil terminal | 3. Normally closed term. |
| 2. Common terminal | 4. Normally open term. |

Toro Electronic Controller (TEC)

The Ultra Sonic Boom System uses the Toro Electronic Controller (TEC) to control electrical system operation. The TEC is attached to a mounting plate under the dash panel (Fig. 24).

Power is provided to the TEC when the vehicle ignition switch is ON. A 2 Amp fuse provides circuit protection for this logic power to the TEC. The fuse is located in the Ultra Sonic Boom System fuse block under the dash panel.

The TEC monitors the states of the following components as inputs: the sonic boom switch, the two (2) boom lift switches, the two (2) sonic boom sensors and the diagnostic shunt wires.

The TEC controls electrical output to the sonic boom light, the diagnostic lamp, the four (4) relays used to control the sonic boom system and the two (2) sonic boom sensors. Circuit protection for the TEC outputs is provided by three (3) 7.5 Amp fuses located in the Ultra Sonic Boom System fuse block.

Testing of the TEC inputs and outputs can be completed with the use of the Diagnostic Display (see the Special Tools and Troubleshooting sections of this chapter).

Because of the solid state circuitry built into the TEC, there is no method to test it directly. The TEC may be damaged if an attempt is made to test it with an electrical test device (e.g. digital multimeter or test light).

IMPORTANT: Before performing welding on the machine, disconnect both cables from the battery and disconnect wire harness connector from the TEC. These steps will prevent damage to the machine electrical system.

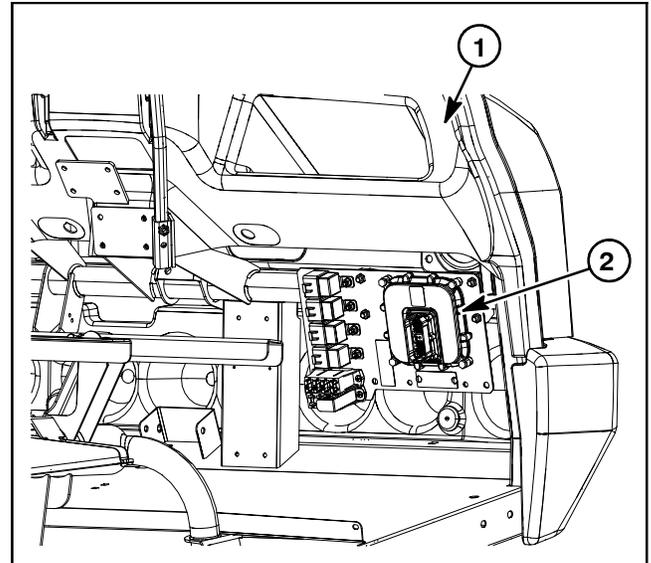


Figure 24

- 1. Dash panel
- 2. TEC controller

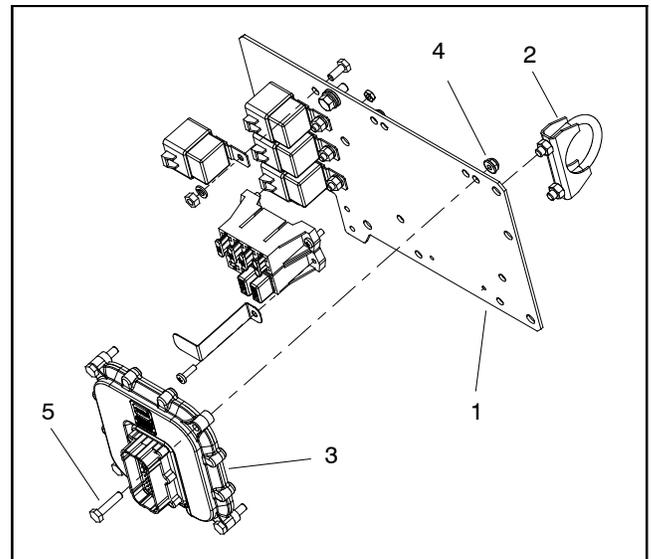


Figure 25

- 1. Mount plate
- 2. U-bolt clamp (2 used)
- 3. TEC controller
- 4. Nut (4 used)
- 5. Cap screw (4 used)

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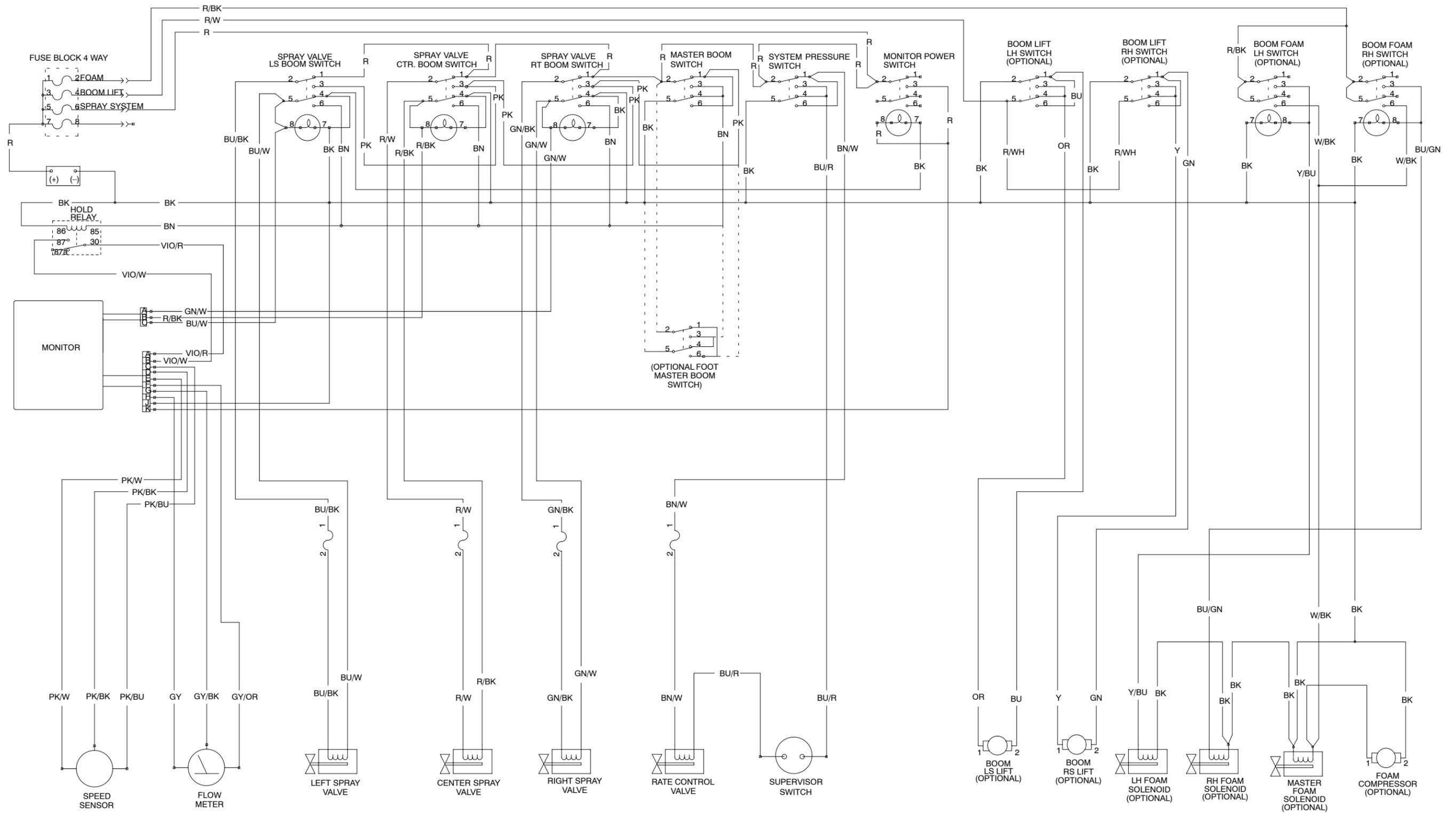
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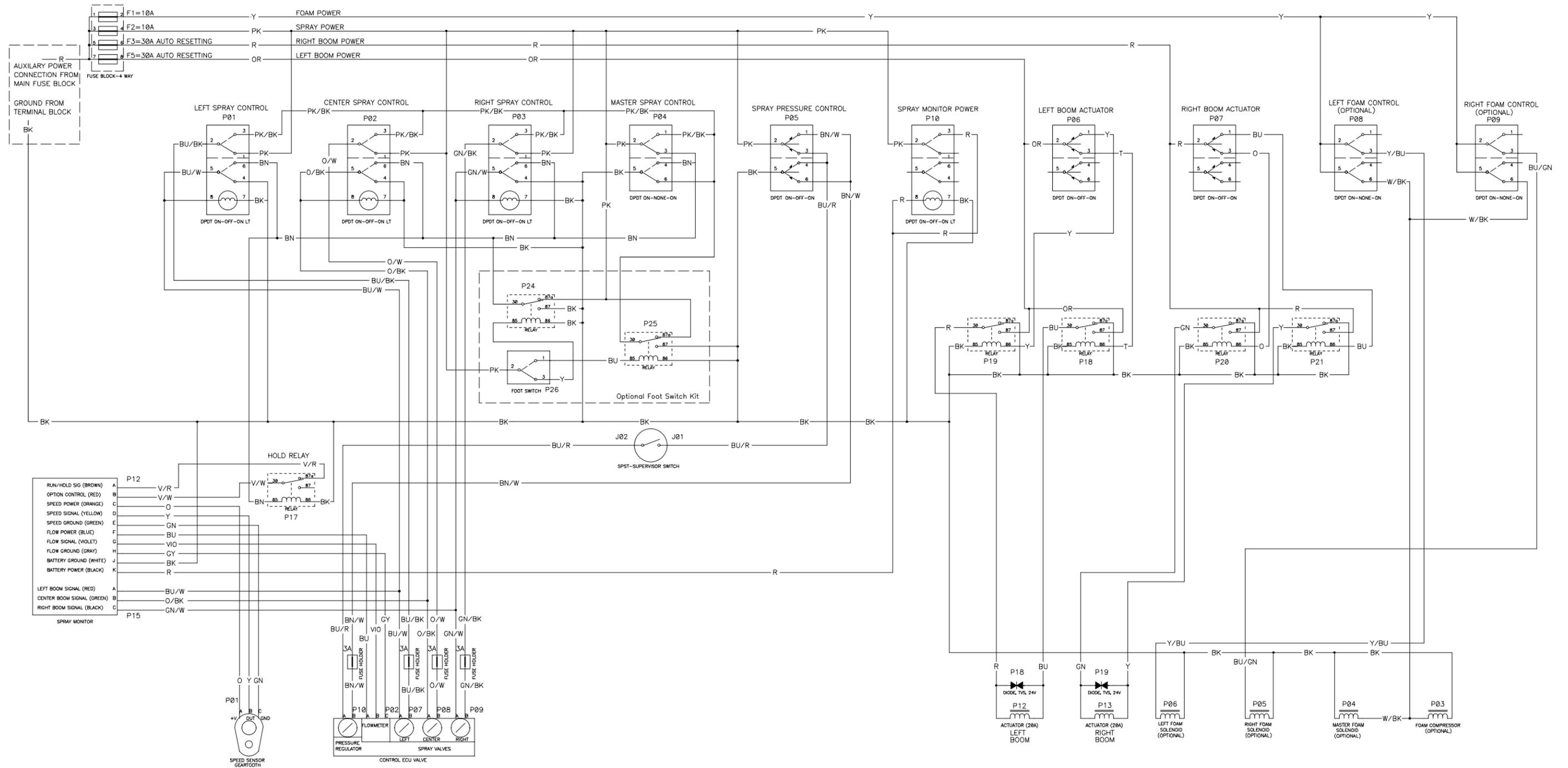
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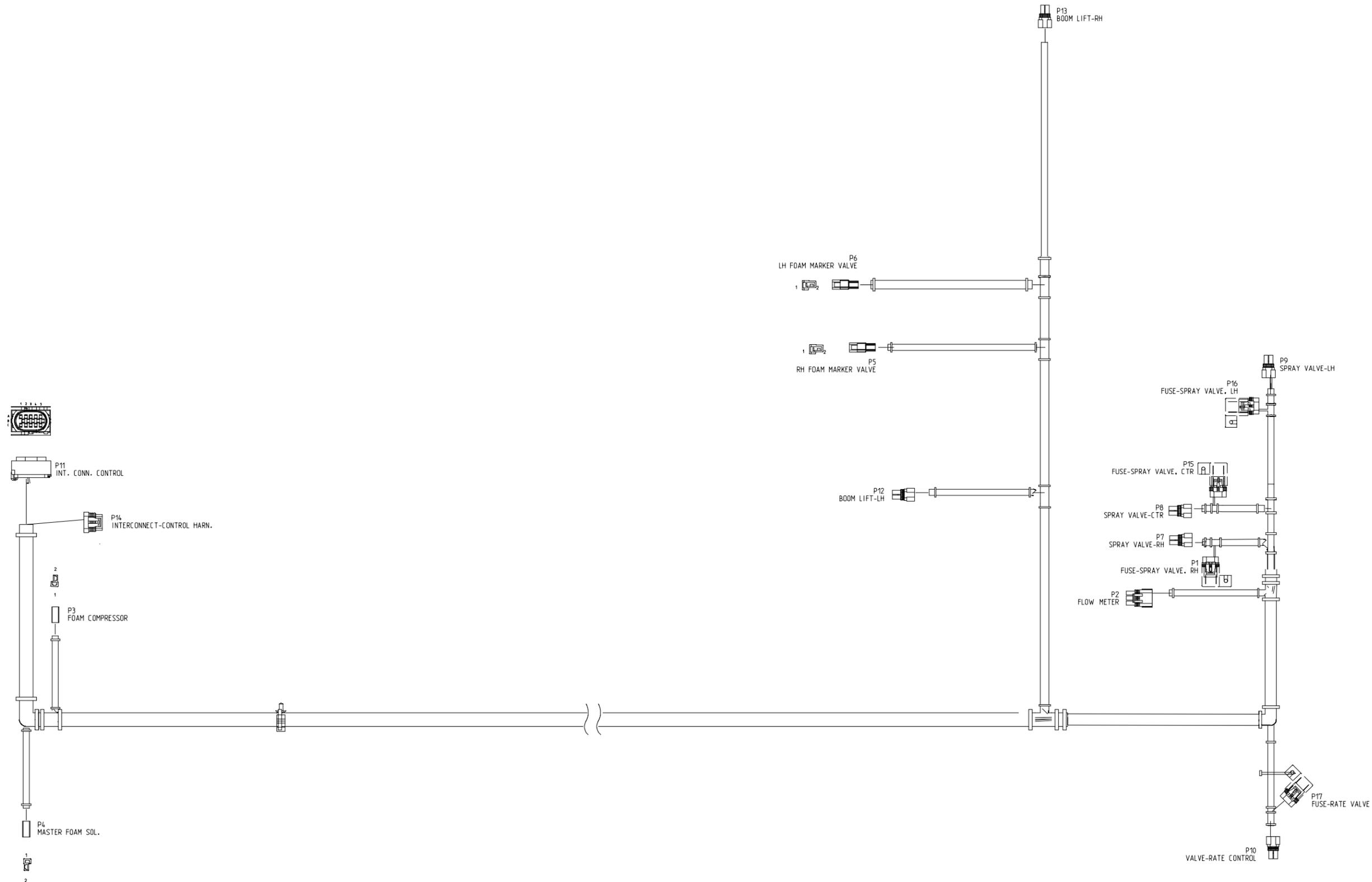


Workman 200 Spray System
Electrical Schematic
 (Serial Numbers Below 26000000)

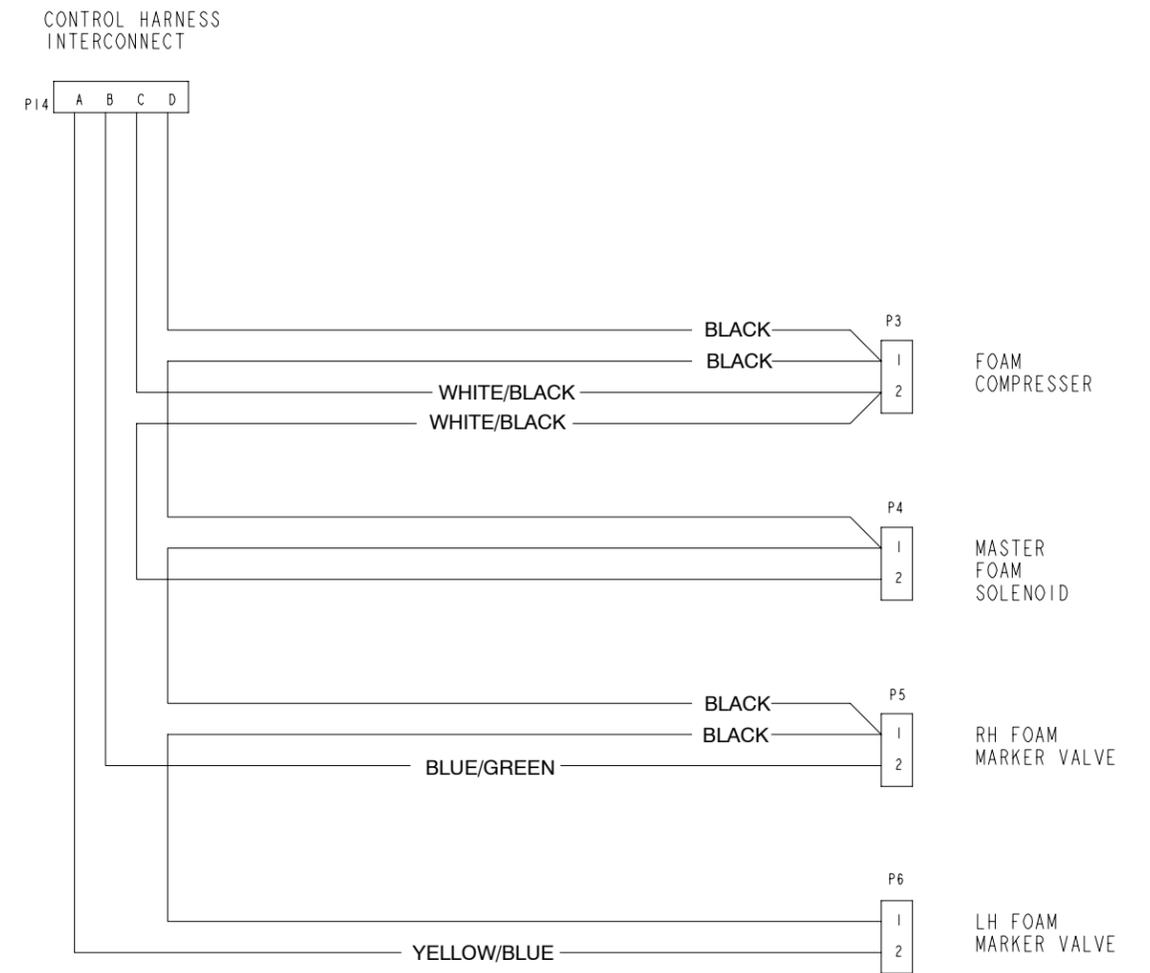
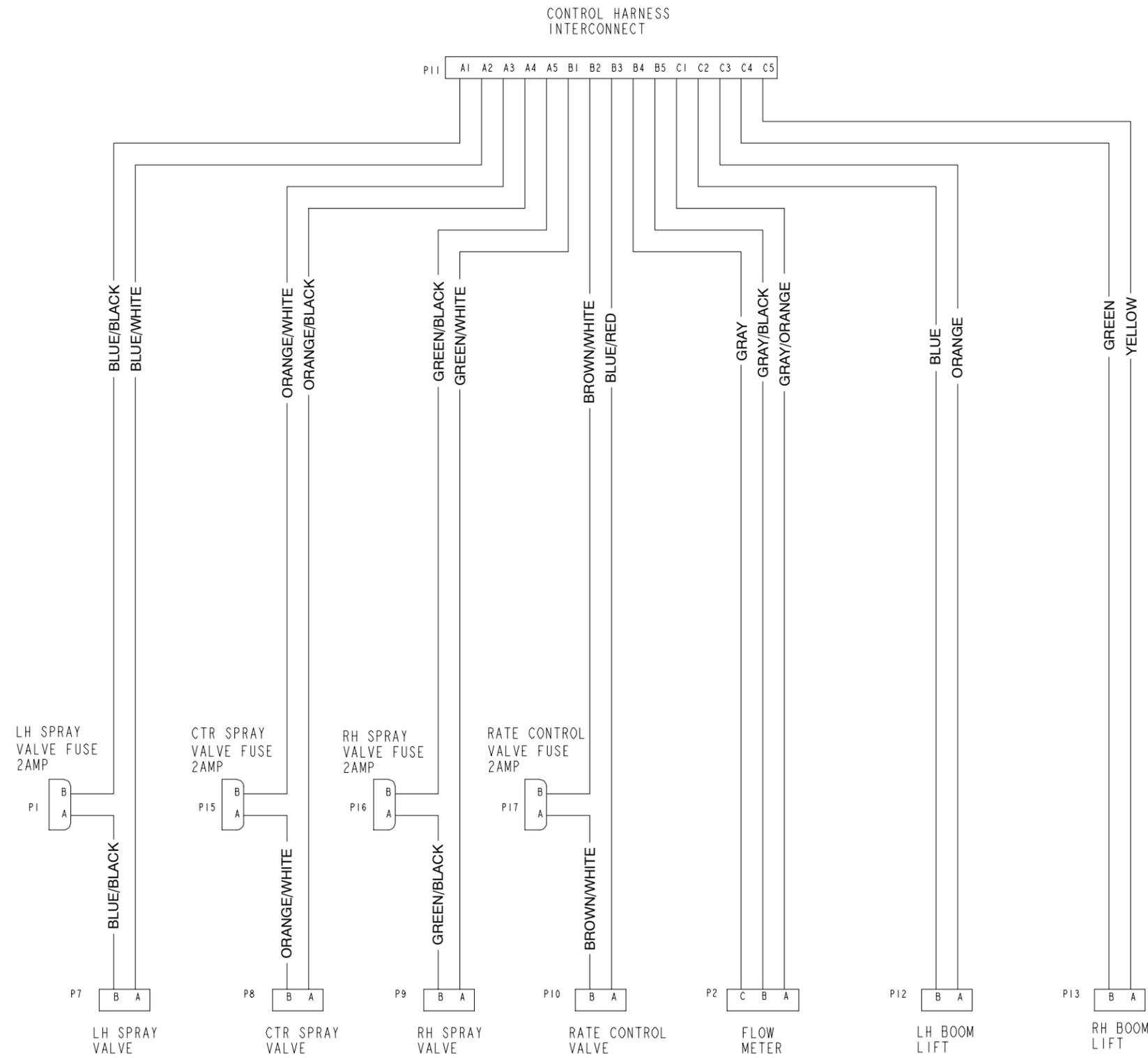


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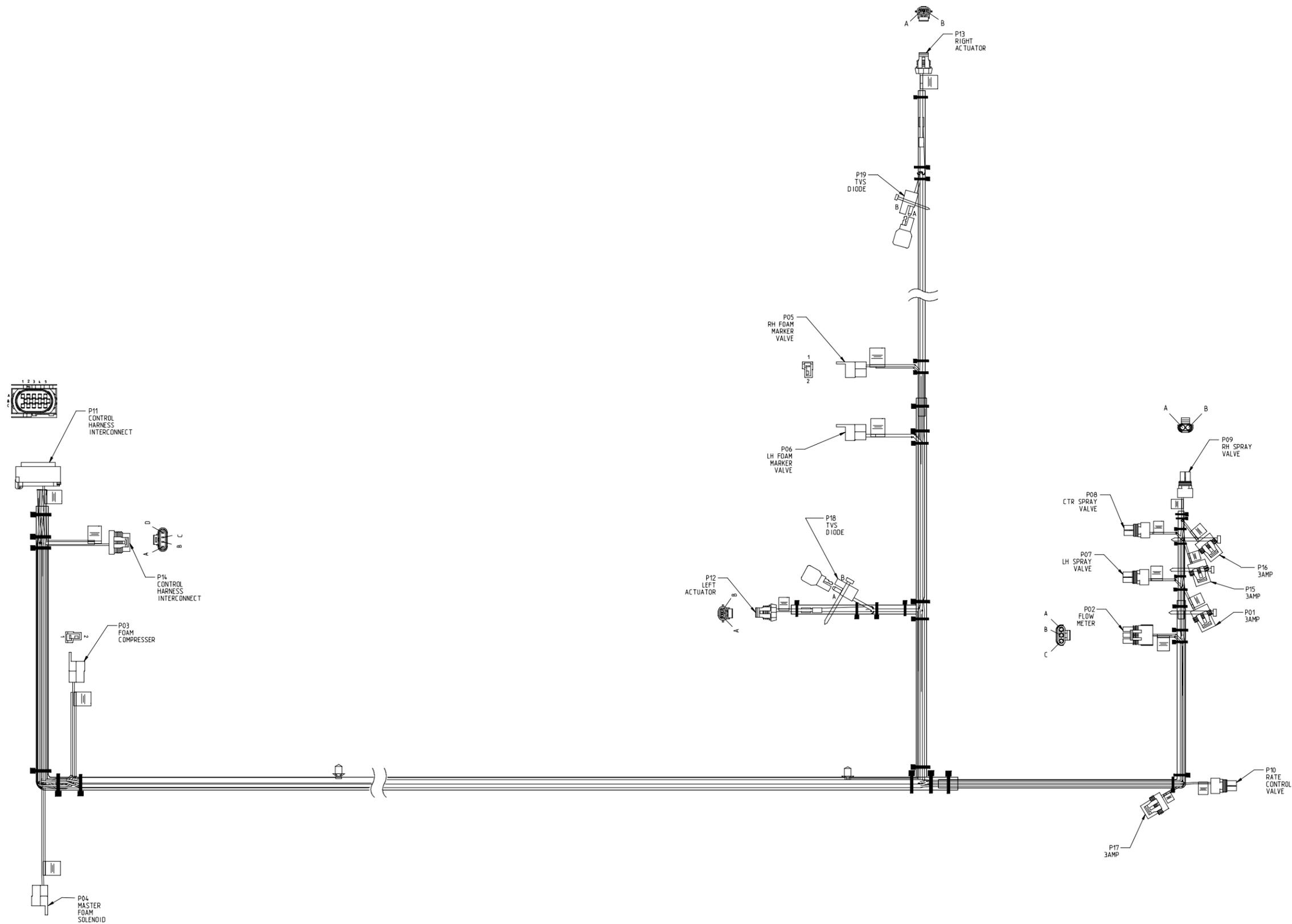
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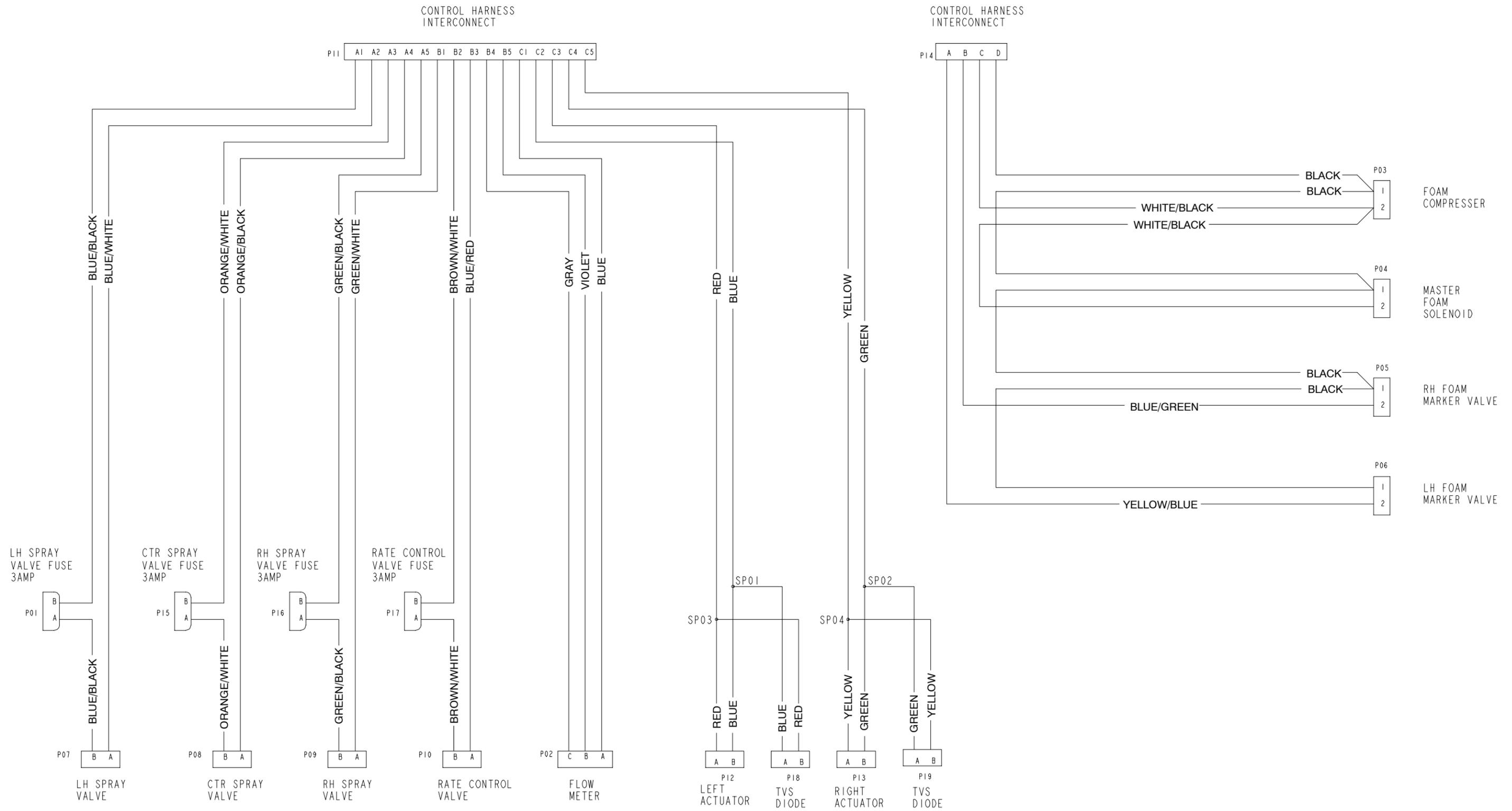
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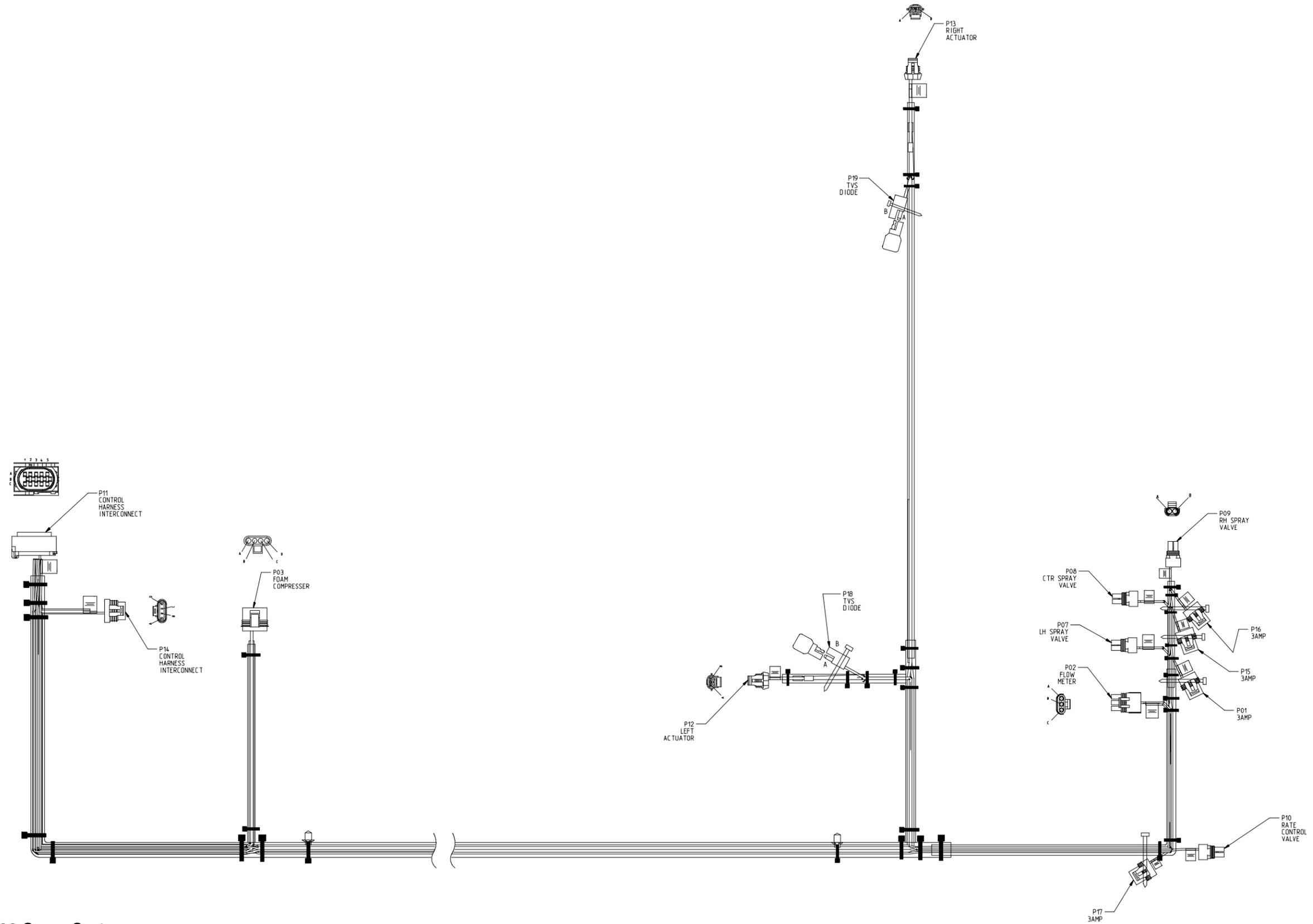
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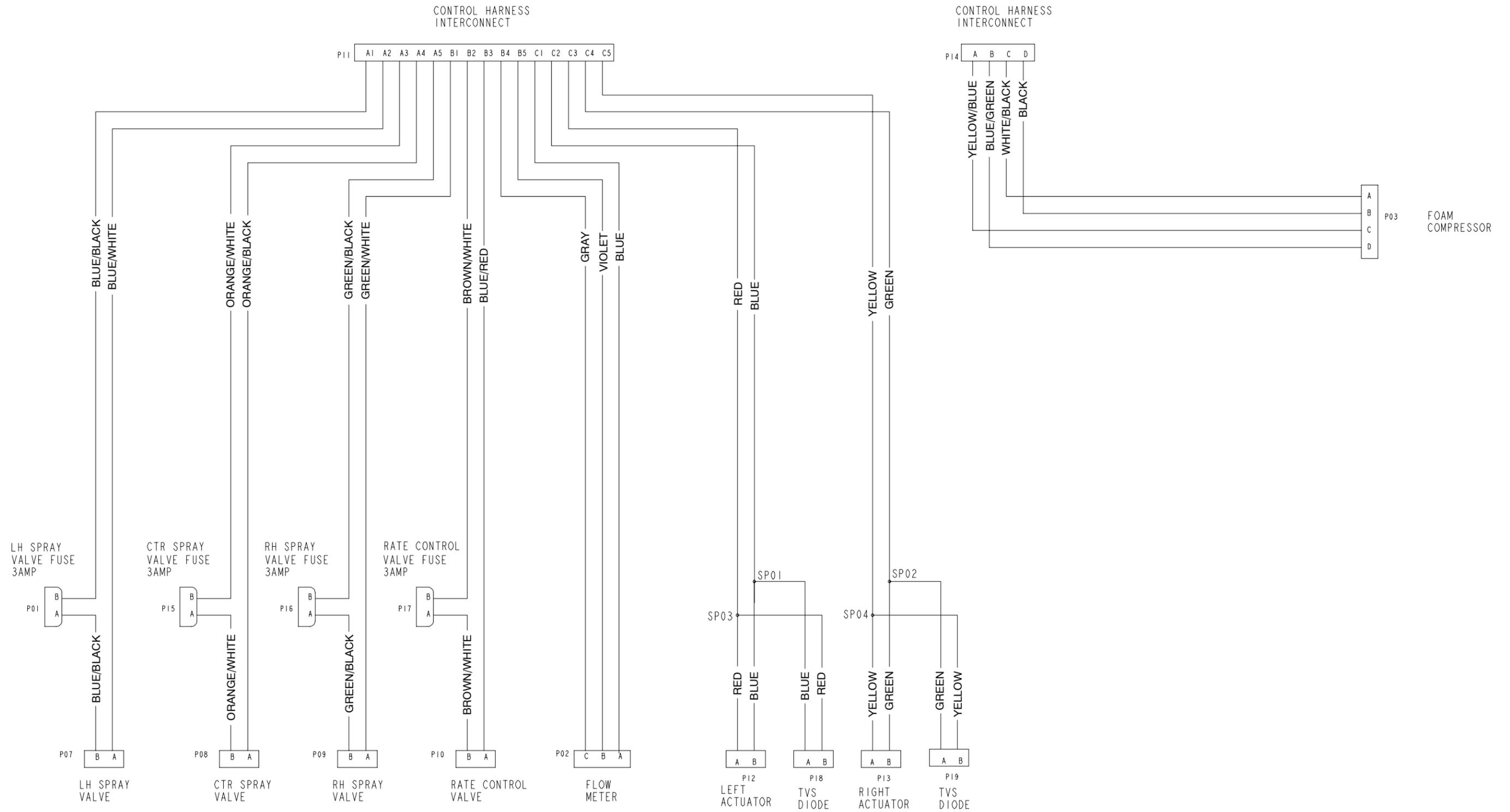
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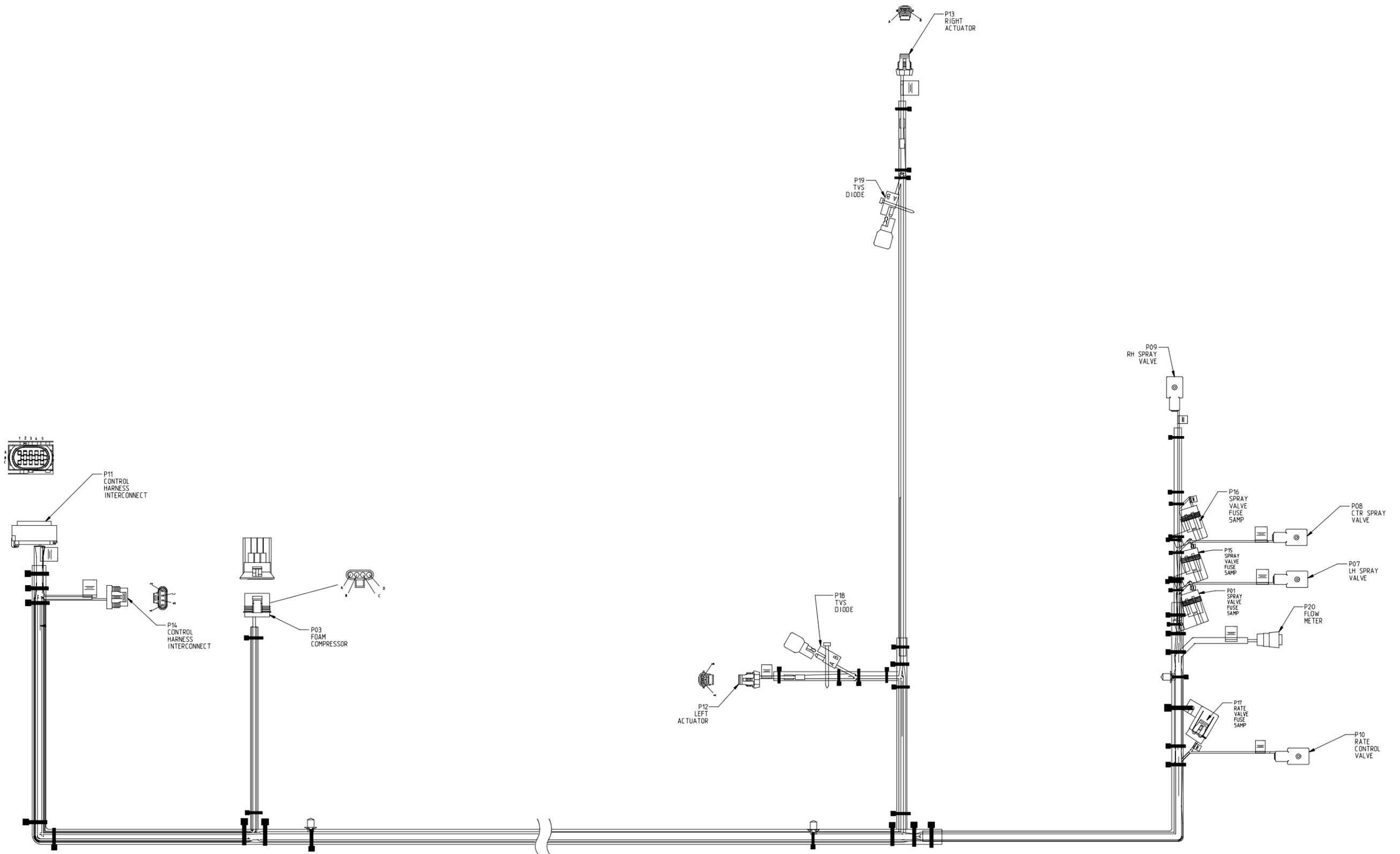
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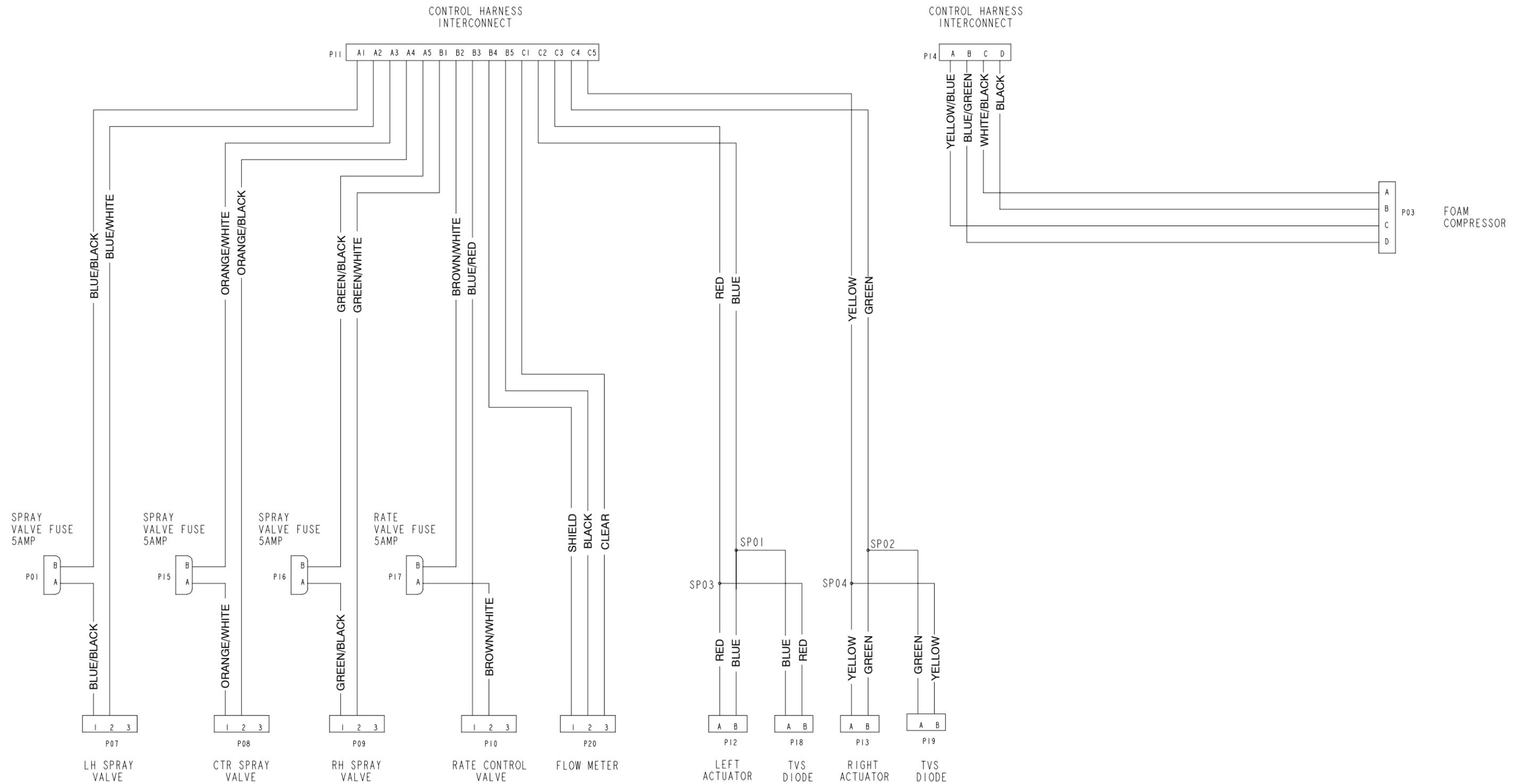
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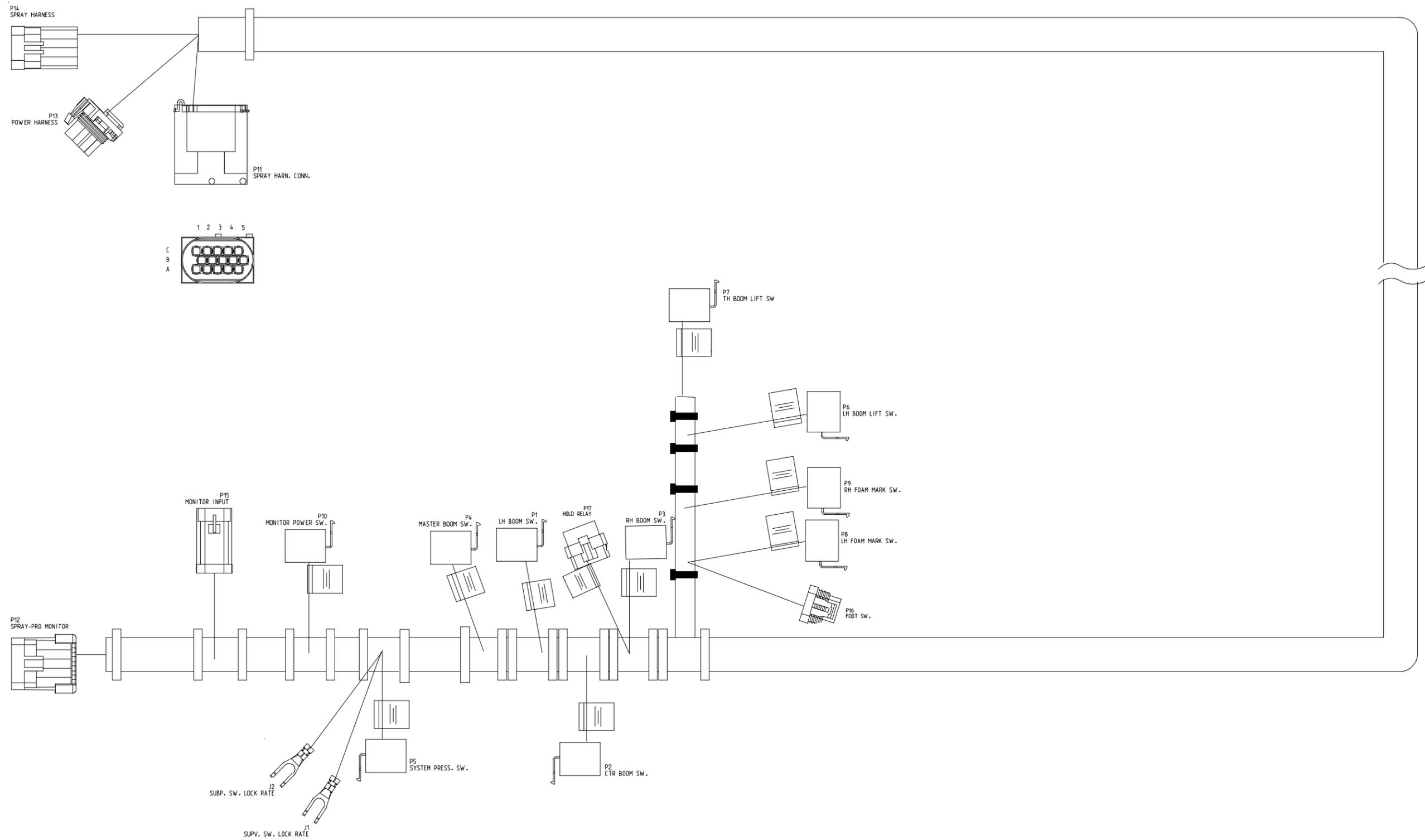
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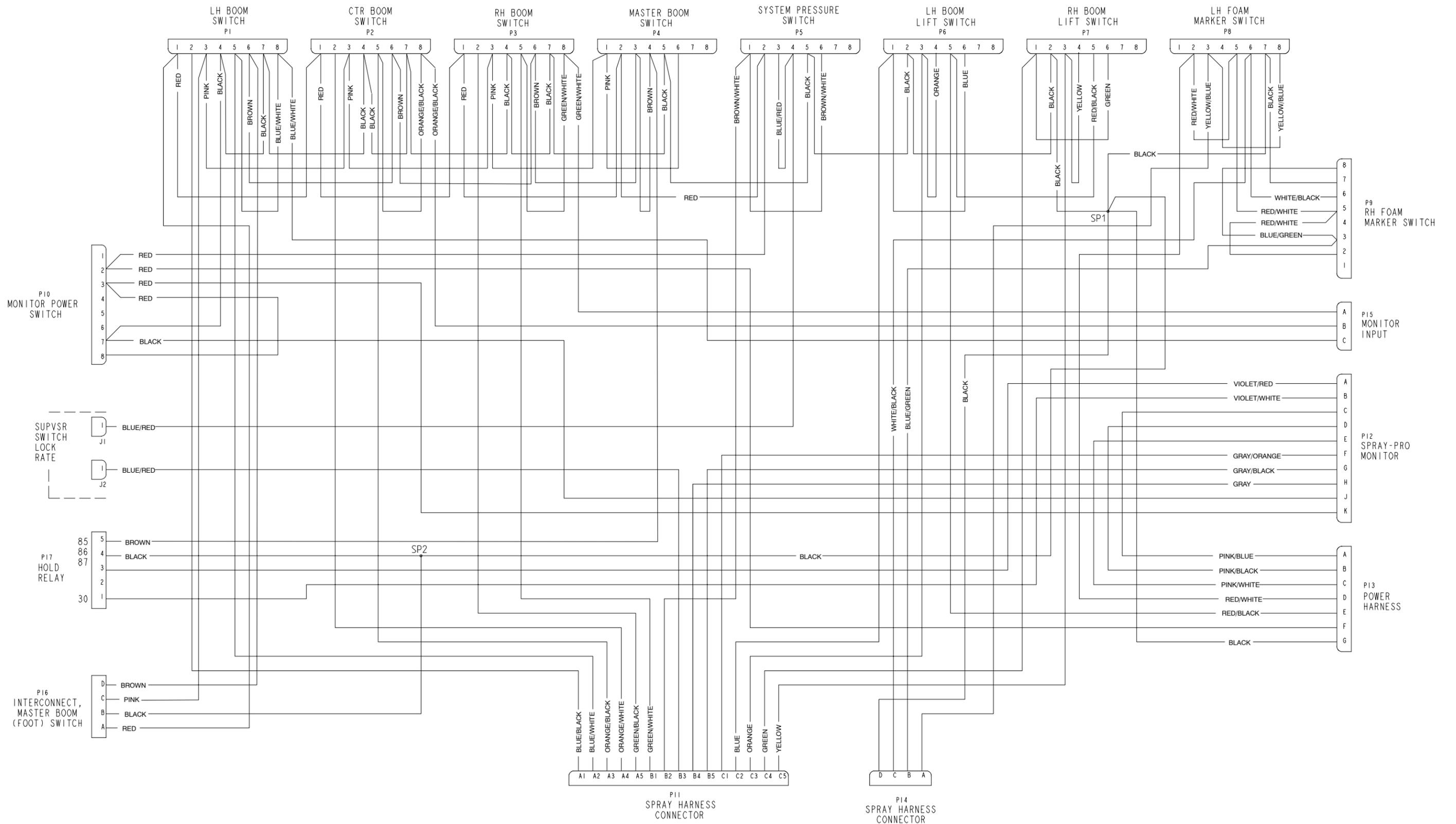
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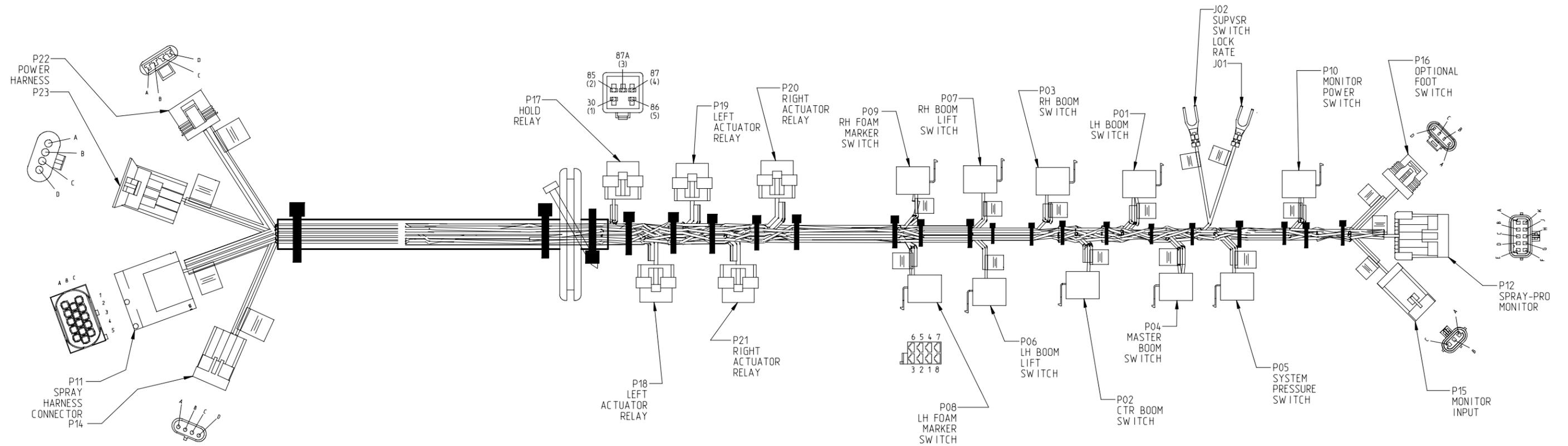
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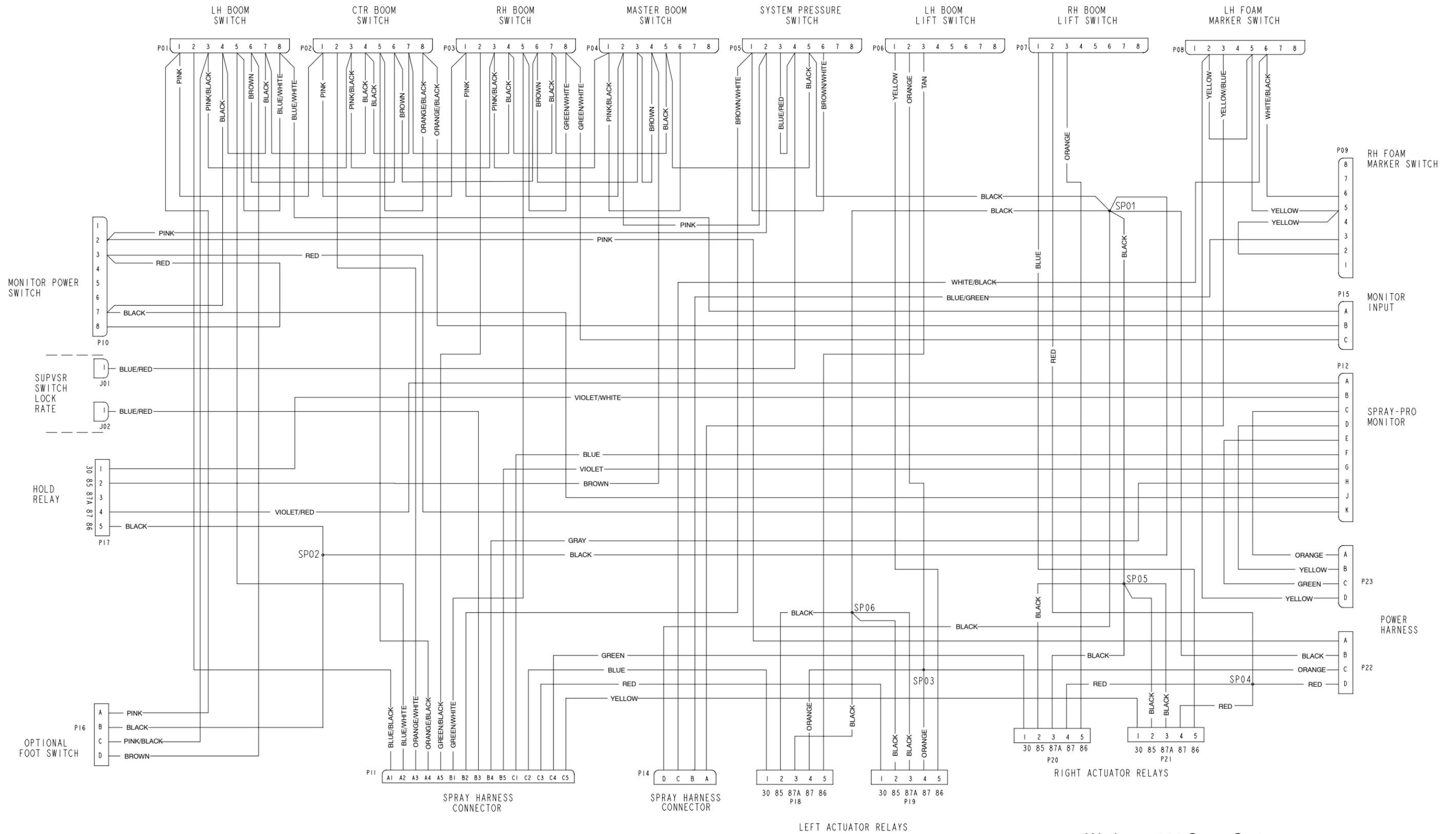
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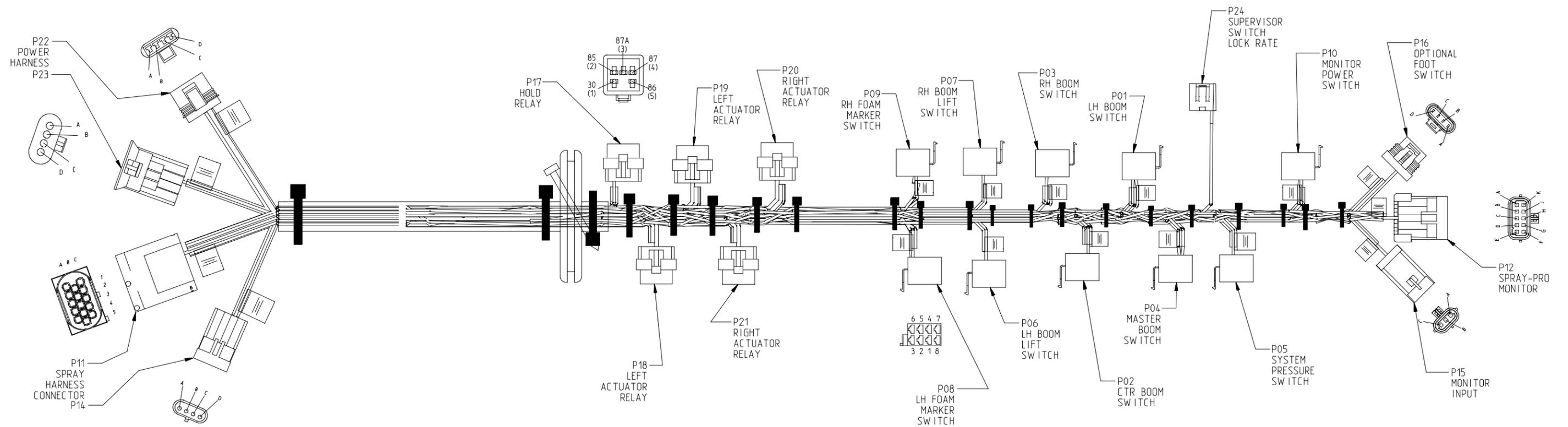
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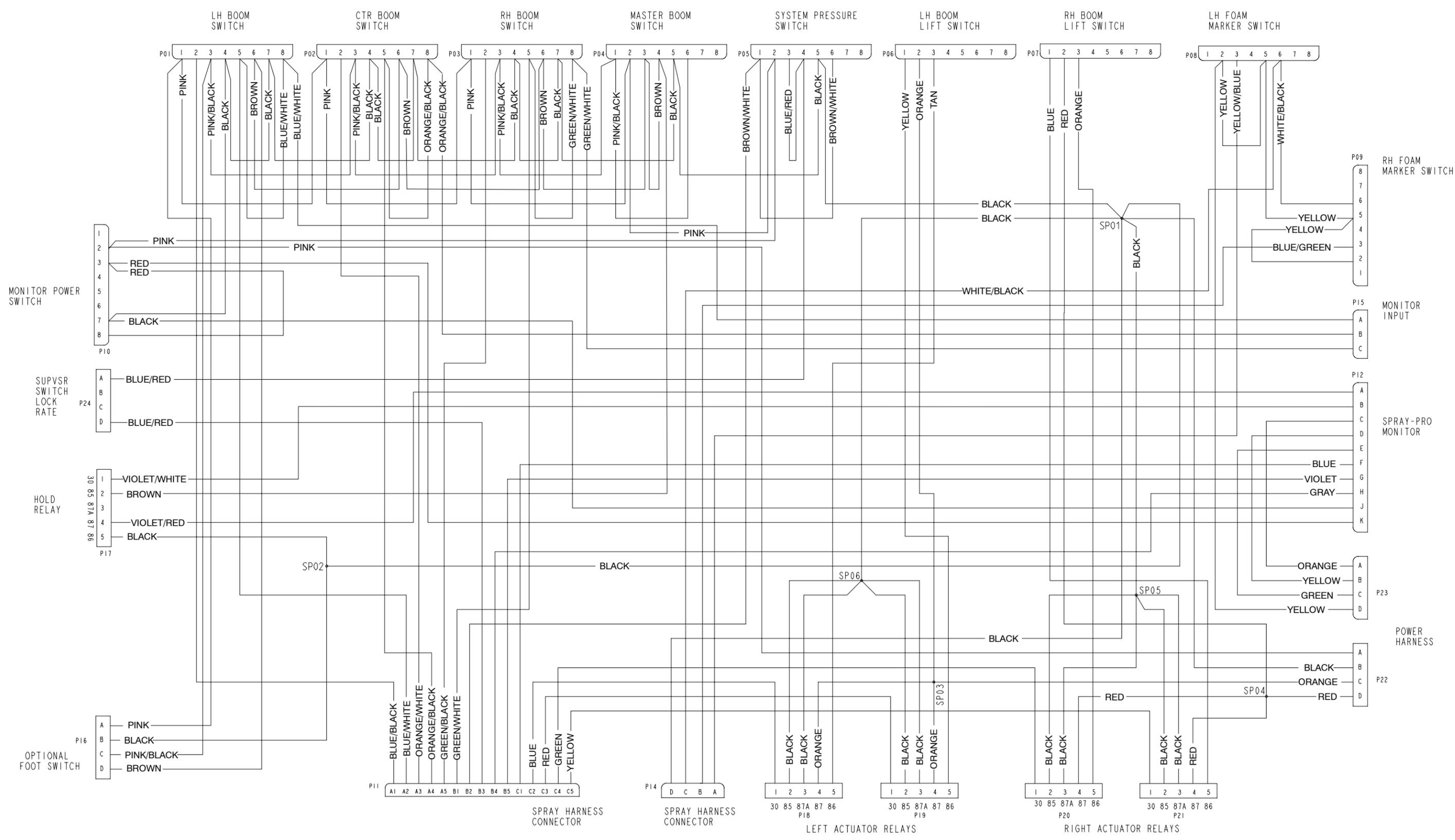
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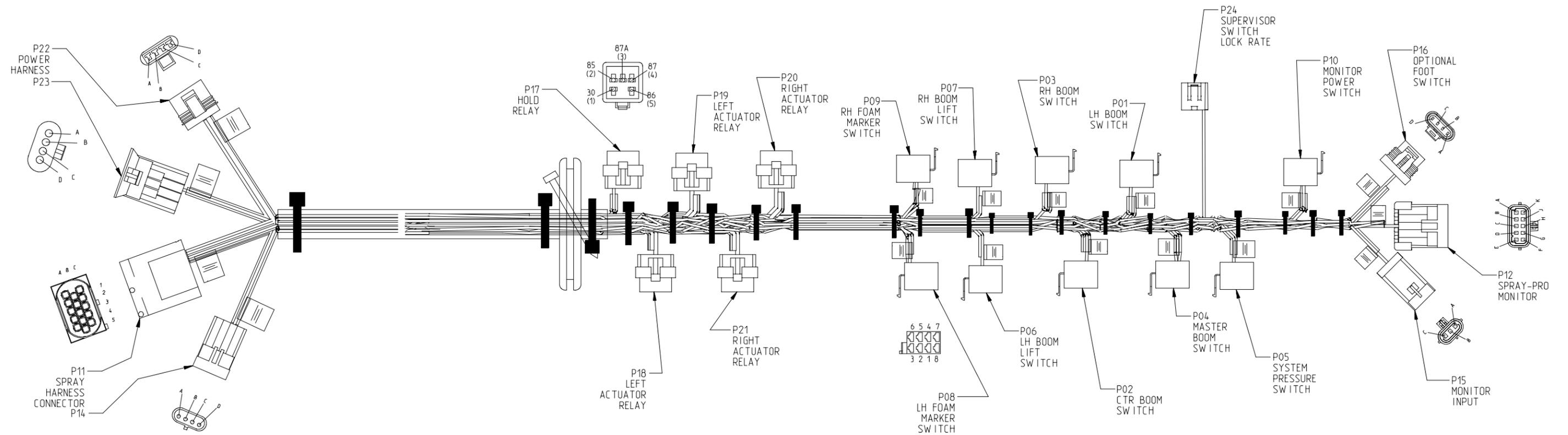
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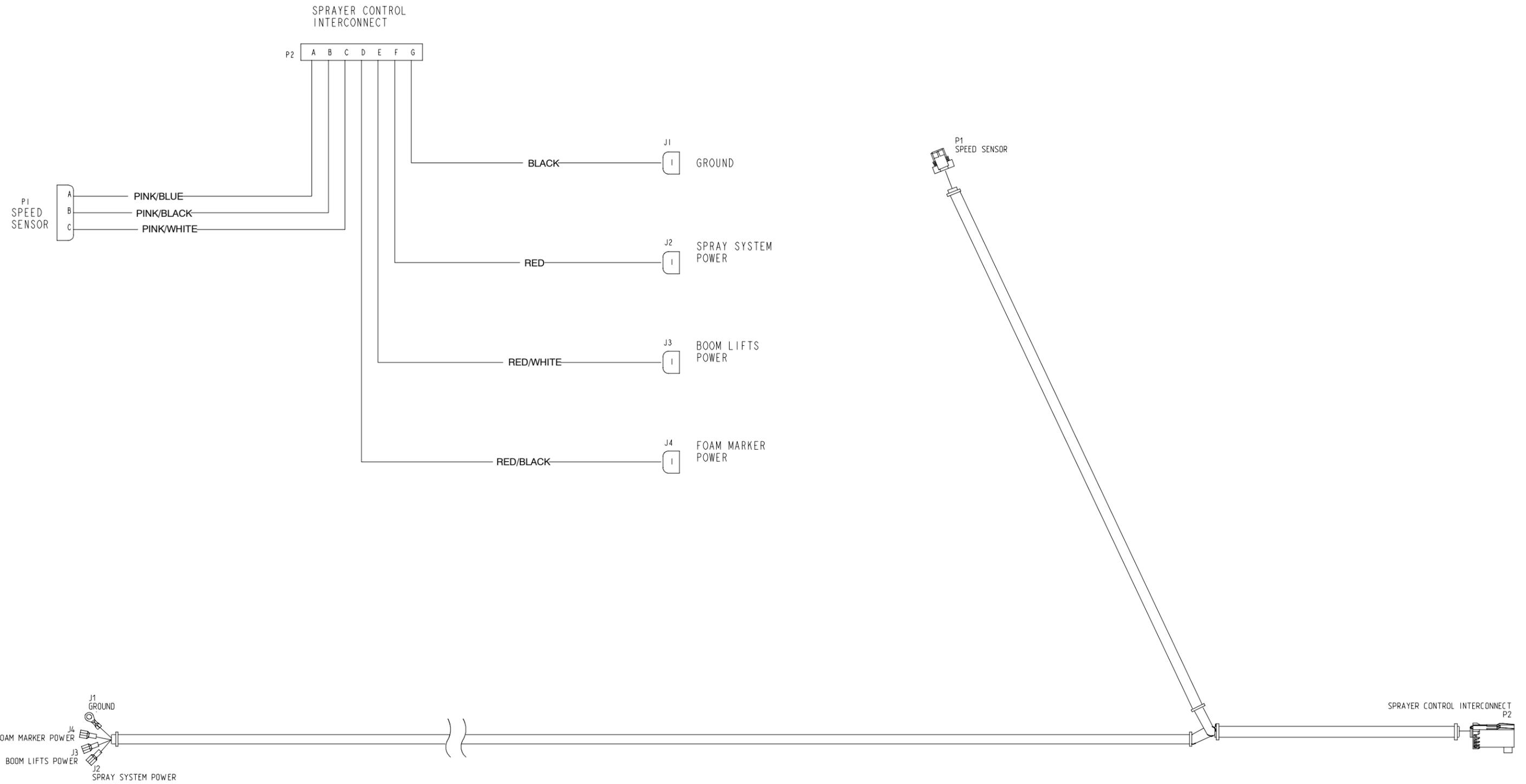
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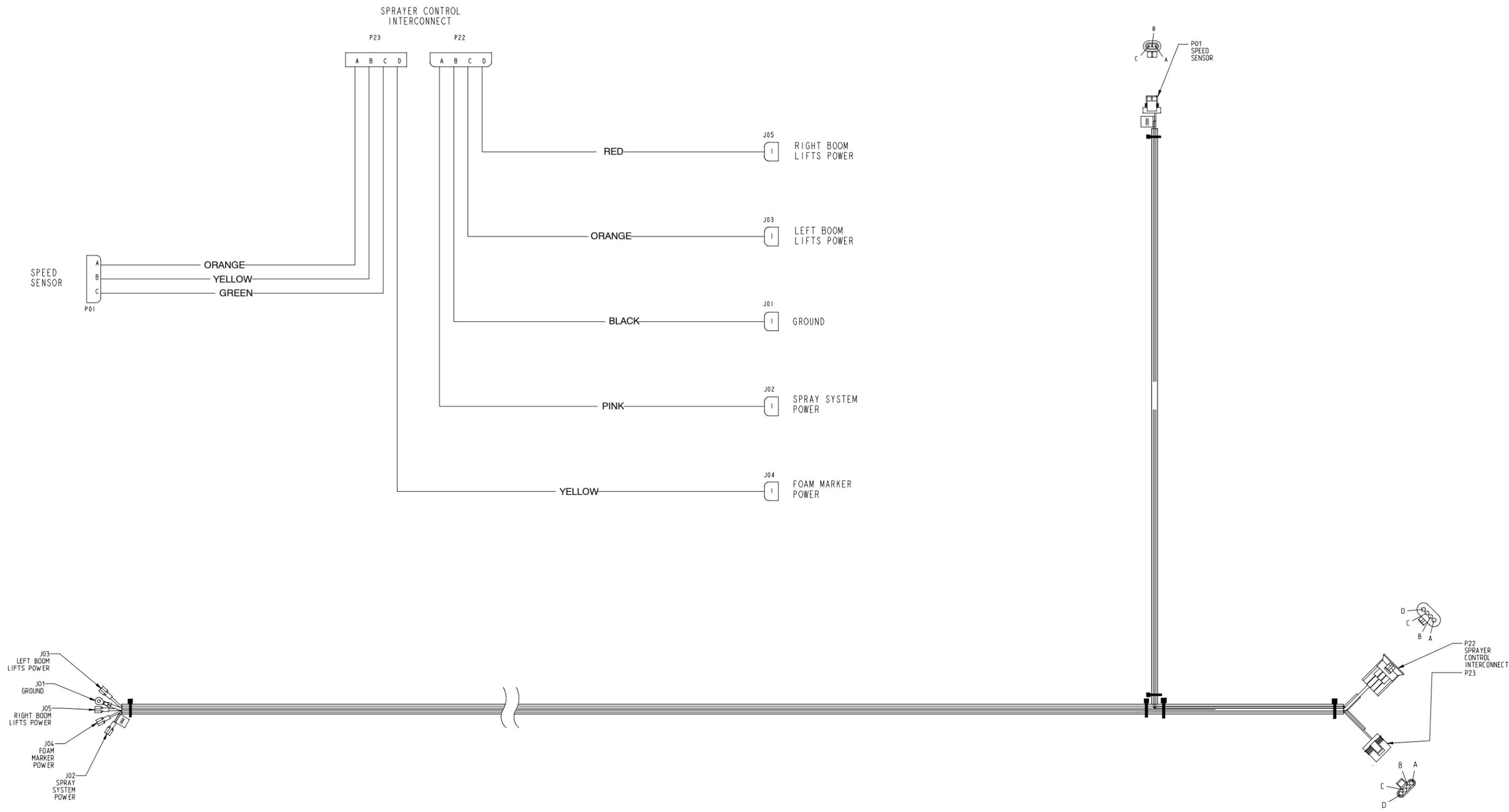
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Workman 200 Spray System
Spray Console Wire Harness
 (Serial Numbers Above 310000000)



**Workman 200 Spray System
Sprayer Power Harness**
(Serial Numbers Below 260000000)



Workman 200 Spray System
Sprayer Power Harness
 (Serial Numbers Above 260000000)