SharpShooter®

Turf Sprayer Edition

Operator and Maintenance Manual

CAPSTAN AG SYSTEMS, INC.
SINCE 1893
APPLICATION SYSTEMS FOR PROFESSIONALS

P/N 118556-001 | Revised 06-2016 • © 2016 Capstan Ag Systems, Inc.

SERVICE CONTACT INFORMATION

If a problem arises with the SharpShooter Turf System that cannot be corrected with the information in this manual, please contact your dealer for service and technical assistance. If further assistance is needed, contact Capstan Ag Systems, Inc.

Dealer: _____

Contact: _____

Phone: _____

Address: _____

City / State / Zip: _____

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1.0 - INTRODUCTION

SharpShooter® - Turf Sprayer Edition with Blended Pulse™ is an innovative Capstan Ag patented process that combines a tip-management system with rate control technology to solve the greatest limitation of modern sprayer technology - ***spraying from one tip size at a time***.

As an aftermarket retro fit, SharpShooter® - Turf Sprayer Edition uses patented Blended Pulse-Width Modulation technology providing a simple solution of having exactly the right effective tip size to maintain both a set rate and a set pressure throughout the entire sprayer speed range.

SharpShooter® - Turf Sprayer Edition permits independent operator control over pressure, droplet size, rate and speed without ever changing tips. It may seem magical but the impact on operational efficiency, application quality, drift control and chemical savings is profound.

Since the spray function is controlled at the tip, spray shut off is instantaneous. The flow and pressure are retained in the boom at the tips so when the boom is turned on there is instant flow at the proper rate and pressure.

SharpShooter® - Turf Sprayer Edition enhances the physics of spraying to provide a foundation for today's advanced GPS rate controllers with 10-section nozzle spray control and mapping features to truly provide a Total Turf Application System.

SharpShooter® - Turf Sprayer Edition provides the right tip size at the right time automatically and instantaneously.

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2.0 - SAFETY

2.1 - Hazard Communications

This manual contains important information on how to safely, efficiently and correctly install, operate and maintain **SharpShooter Turf System**. Following these instructions will help keep personnel safe, reduce downtime and increase the reliability and life of the equipment, its components and related systems.

- Review the Safety Information in the Original Equipment Manufacturer (OEM) sprayer equipment manual(s).
- Follow the instructions (in this manual) for each step thoroughly to ensure safe work conditions in and around OEM sprayer equipment.
- It is important for all individuals working with chemicals to understand the potential risks, necessary safety precautions, and proper response in the event of accidental contact.
- Review the OEM sprayer equipment manual(s) for chemical safety information.
- Review, understand and read procedures and use Safety Data Sheets (SDS) and the required Personal Protective Equipment (PPE) for hazardous chemicals.

Make certain that all personnel have read this manual and thoroughly understand safe and correct operation and maintenance procedures.

Please keep this manual and all enclosed documentation in an accessible location known to all operators, installation, and maintenance personnel.

If you do not understand the Capstan Ag Systems, Inc. equipment after reading this manual, please obtain the proper training before working with equipment to ensure your own safety and well as your co-workers' safety.

- Do not attempt to operate any equipment or system until you completely understand why, when and how it operates. If you are uncertain after studying this manual, please contact Capstan Ag Systems, Inc.

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2.2 - Signal Words

Signal Words used in product safety messages (found in this manual) are based upon these standards:

- American National Standards Institute (ANSI) Z535.1-6
- American Society of Agricultural and Biological Engineers (ASABE) MS-23/14

2.3 - Definitions

The **DANGER** symbol indicates a hazardous situation, which if not avoided, will result in death or serious injury. This signal word is limited to extreme situations.

The **WARNING** symbol indicates a hazardous situation, which if not avoided, could result in serious injury or equipment damage.

NOTE: DANGER or WARNING signal words are not used for property damage accidents unless personal injury risk is appropriate to a specific hazardous situation level.

The ***NOTICE*** symbol addresses practices not related to personal injury and safety practices.

The **SAFETY INSTRUCTION** symbol explains safety practices and hazardous situations in detail, above what the **DANGER** and **WARNING** symbols can provide.

2.4 - Conformance

Safety Messages in this Capstan Ag manual conforms to the ANSI Z535 Standard:

- **Safety Color Code: (WARNING)**
- **Signal Word:** WARNING!
- **Hazard Statement:** Chemical Residues may be present in the OEM equipment.
- **Instructions Statement:** Release pressure on the liquid application system before servicing. Rinse the system with clean water prior to installing or servicing fittings, hoses, valves, or nozzles.
- **Consequences Statement:** Use proper PPE at all times to avoid personal injury.

2.5 - HCS Pictograms and GHS Safety Labels

OSHA's Hazard Communication Standard (HCS) places pictograms on labels to alert users of chemical hazard exposure **[Figure 1]**. You many find these pictograms on OEM sprayer equipment. Review the OEM sprayer manuals for further explanations on these pictograms.

Figure 1: HCS Pictograms

The HCS aligned its provisions with the United Nations' Globally Harmonized System (GHS) Classification and Labeling of Chemicals in 2012. **[Figure 2]** displays a GHS Safety Label example for a chemical hazard.

Figure 2: GHS Safety Label Example

Capstan Ag Systems, Inc. add-on spraying systems for OEM and retrofit sprayer equipment (Booms and Toolbars) may contain (where applicable) HCS pictograms and GHS safety labels (on our equipment) and safety "signal word" messages (in this manual) **[Figure 3]**.

These labels and safety messages warn all personnel about hazardous chemicals or potentially unsafe chemical conditions that may exist while working around sprayer equipment.

Figure 3: GHS Safety Warning Example

2.6 - Hazardous Energy

People working around OEM sprayer equipment may be exposed to hazardous energy in several forms and combinations during installation, operation or maintenance, of Capstan Ag equipment, such as:

- Kinetic (mechanical) - energy in the moving parts of mechanical systems (springs or spring-loaded).
- Potential (residual) - energy stored in pressure vessels, such as liquid application systems and hydraulic cylinders and hoses.
- Electrical energy - generated electrical power, static sources, or electrical storage devices (such as batteries or capacitors).
- Thermal (high or low temperature) - energy resulting from mechanical work, radiation, chemical reaction, or electrical resistance.

2.7 - Chemical Safety

Following these common handling practices for working safely around hazardous chemicals:

- Always have an ample water supply nearby.
- Never smoke or eat while working around chemical spraying equipment.
- Have qualified technicians that are familiar with all local, State or Province, and Country-specific laws install and service the equipment.
- Operate the equipment according to the Product, Operation or Maintenance Manual.
- Avoid chemical exposure by using the proper PPE. Remove contaminated clothing immediately and wash skin (and clothing) thoroughly with soap and water. Wash contaminated clothing after every use.
- Bleed off pressurized sprayer equipment and flush the chemical residue with clean water before servicing.
- If symptoms of illness occur during or shortly after working on or around spraying equipment, immediately call a physician or go to a hospital.

2.8 - Unsafe Equipment Use

- The use of the Capstan Ag equipment by non-qualified personnel.
- The use of unsuitable tools or replacing components or spare parts with ones other than those specified in this manual or by Capstan Ag personnel.
- Re-engineering Capstan's operating software so it changes the intended use of the Capstan Ag equipment without FIRST consulting Capstan Ag Systems, Inc.

2.9 - Battery Safety

Use the procedure in the appropriate sprayer equipment manual for connecting, disconnecting and jump-starting the machine's battery.

- Keep sparks and flames away from the battery. Battery gas can explode and cause serious injury. Do not smoke in battery charging area.
- Remove jewelry, which might make electrical contact and create sparks.
- Avoid chemical burns by not rubbing eyes or skin while working with the battery.
- Wash your hands immediately after completing the job.

2.10 - Extinguishing Fires

Fire extinguishing systems must meet the applicable OSHA requirements and all users of Portable/Fixed Fire Suppression Equipment must know the types, limitations, and proper uses of this equipment; including hazards involved with incipient stage firefighting.

Know where fire extinguishers and first aid kits are located and how to use them.

- Inspect the fire extinguisher and service the fire extinguisher regularly.
- Follow the recommendations on the instructions plate.
- Very small fires can be put out (extinguished) with a fire extinguisher. Use an appropriate method to extinguish a fire (water for paper fires, and chemical extinguishers for electrical or chemical fires.

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3.0 - PARTS IDENTIFICATION

3.1 - Pulse Generator

[Figure 4] - The Pulse Generator is located in the sprayer's cab.

The Pulse Generator contains two switches:

1. Rotary Switch.
2. Rocker Switch.

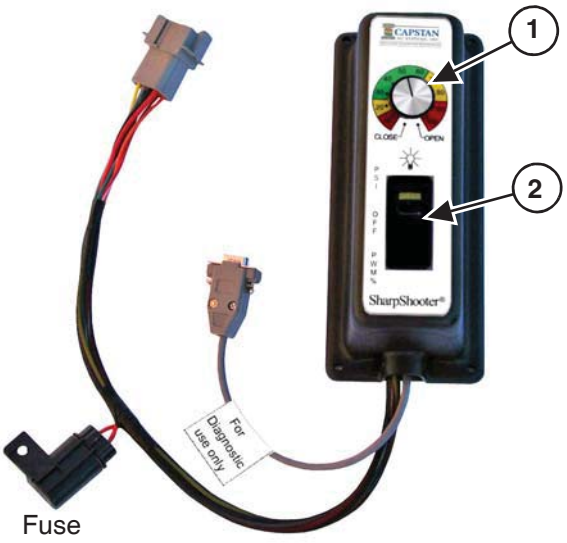
The rotary switch has twelve detent positions: Close, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100 and Open.

The rocker switch has three positions and an indicator light. The three rocker switch positions are PWM, OFF, and PSI.

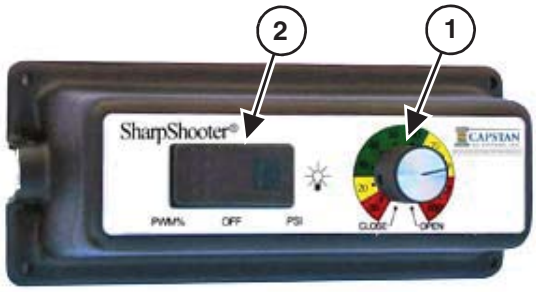
NOTICE The Pulse Generator has a 10A fuse in the power lead.

PART NO.	DESCRIPTION
118500-101	Pulse Generator, (Vertical)
118500-102	Pulse Generator, (Horizontal)

Figure 4: Pulse Generator



118500-101



118500-102

3.2 - Extension Harness, Pulse Generator

[Figure 5] - The Extension Harness routes from the Power Hub to the Pulse Generator.

PART NO.	DESCRIPTION
118600-110	Extension Harness, 14' for SmithCo / Toro
118600-106	Extension Harness, 18' for Jacobsen

Figure 5: Extension Harness, Pulse Generator

118600-110

3.3 - Power Hub

[Figure 6] - The Power Hub can usually be located at the center of the boom mast.

The Power Hub is a junction block where the battery power is routed to the Valve Drivers. The Power Hub also routes Pressure Sensor signals and Valve Driver signals to the Pulse Generator.

PART NO.	DESCRIPTION
118600-250	Power Hub, 9-Nozzle, 15’
118600-253	Power Hub, 11-Nozzle, 18’
118600-256	Power Hub, 12-Nozzle, 20’
118600-101	Power Hub, 13-Nozzle, Universal, 21’

The power hubs listed above replace the following power hub part numbers:

PART NO.	DESCRIPTION
118600-104	Power Hub, 9-Nozzle, SmithCo
118600-105	Power Hub, 11-Nozzle, Universal
118600-103	Power Hub,12-Nozzle, SmithCo

NOTICE

Left and right boom harnesses, power extension, display extension and pressure sensor extensions will also be required if replacing the older style power hubs.

Figure 6: Power Hub

118600-253

118600-102

3.4 - Left Boom Harness

[Figure 7] - Left Boom Harness (Driver's left-hand side) from the Power Hub.

PART NO.	DESCRIPTION
118600-251	Left Boom Harness, 3-Section, 9-Nozzle, 1-3, 15’
118600-254	Left Boom Harness, 3-Section, 11-Nozzle, 8-11, 18’
118600-257	Left Boom Harness, 3-Section, 12-Nozzle, 9-12, 20’

NOTICE Not needed for the Universal 13 nozzle 118600-101 Power Hub.

Figure 7: Left Boom Harness

118600-254

3.5 - Right Boom Harness

[Figure 8] - Right Boom Harness (Driver's right-hand side) from the Power Hub.

PART NO.	DESCRIPTION
118600-252	Right Boom Harness, 3-Section, 9-Nozzle, 7-9, 15’
118600-255	Right Boom Harness, 3-Section, 11-Nozzle, 8-11, 18’
118600-258	Right Boom Harness, 3-Section, 12-Nozzle, 9-12, 20’

NOTICE Not needed for the Universal 13 nozzle 118600-101 Power Hub.

Figure 8: Right Boom Harness

118600-255

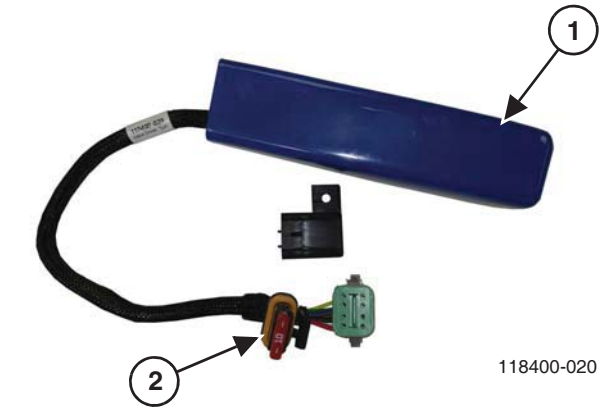
3.6 - Valve Driver Module

[Figure 9] - The ① Valve Driver Module(s) are usually located next to the Power Hub. Two are required. One is for the BOOST row of nozzles and one is for the non-boosted nozzles.

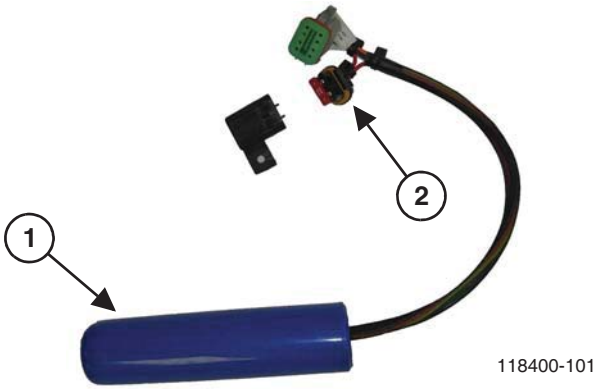
Each Valve Driver has a single connector that connects to the Power Hub. Each Valve Driver is equipped with a ② 10A fuse.

NOTICE 118400-020 replaces 118400-101.

Figure 9: Valve Driver Module



118400-020



118400-101

3.7 - Pressure Sensor

[Figure 10] - On most models the Pressure Sensor is located near the center section of the rear boom. On SmithCo models the Pressure Sensor is located at the machine center behind the seat.

NOTICE The Pressure Sensor must be installed in a vertical upright position. It should be located so product flow aways flows past it to avoid plugging. It must also be installed at a location that will allow an accurate reading when all, or only one boom section, is turned on.

The Pressure Sensor, 100 PSI, 0.5-5 VDC, provides pressure signals to the Pulse Generator.

Figure 10: Pressure Sensor

116301-001

3.8 - Extension Harness, Pressure Sensor

[Figure 11] - The Pressure Sensor Extension Harness connects the Pressure Sensor to the Power Hub.

NOTICE Pressure Sensor Extension Harness is used on SmithCo Sprayers only.

Figure 11: Extension Harness, Pressure Sensor

118600-108

3.9 - Power Harness

[Figure 12] - The Power Harness connects the Power Hub directly to the battery.

PART NO.	DESCRIPTION
118600-107	Power Harness, 14’ SmithCo / Toro
118600-109	Power Harness, 18’ Jacobsen (with 5A fuse)

Figure 12: Power Harness

118600-107

118600-109

3.10 - Boom Shutoff Adapter

Several Boom Shutoff Adapters are available depending on the sprayer model and boom configuration.

[Figure 13] - This style Boom Shutoff Adapter with the Deutsch connector services the following power hubs:

PART NO.	DESCRIPTION
118600-250	Power Hub, 9-Nozzle 15’
118600-253	Power Hub, 11-Nozzle 18’
118600-256	Power Hub, 12-Nozzle 20’

The boom shutoff adapter intercepts the signals from the rate controller section signals that open and close the boom section shutoff valves. Typically the machine boom section shutoff on SmithCo machines are removed and the Boom Section Adapters connect directly to the controller harness.

SharpShooter uses this signal to turn on and off the nozzle valve assemblies located on the boom nozzle bodies. These assemblies are located on the boom section spray tubes. When the signal wire is powered up, 12V, the nozzle valves open. When the signal wire has no power, the nozzle valves close.

Applicable Shutoff Adapter service parts include the following part numbers:

Figure 13: Boom Shutoff Adapters

118602-124

118602-120

9 and 10 Section Configurations		
118602-129	SmithCo / Toro	9-Section Raven Envizio; 9-Nozzle Boom
118602-118	Jacobsen	
118602-127	SmithCo / Toro	10-Section Raven Envizio; 11-Nozzle Boom
118602-120	Jacobsen	
118602-128	SmithCo / Toro	10-Section Raven Envzio; 12-Nozzle Boom
118602-122	Jacobsen	

3 Section Configurations		
118602-125	SmithCo / Toro	3-Section Raven 440; 9-Nozzle Boom (spade terminals)
118602-119	Jacobsen	3-Section Raven 440; 9-Nozzle Boom
118602-124	SmithCo / Toro / Deere	3-Section Raven 440; 11-Nozzle Boom (spade terminals)
118602-121	Jacobsen	3-Section Raven 440; 11-Nozzle Boom
118602-126	SmithCo / Toro	3-Section Raven 440; 12-Nozzle Boom (spade terminals)
118602-123	Jacobsen	3-Section Raven 440; 12-Nozzle Boom

[Figure 14] - This style of Boom Shutoff Adapter with the large round connector services the following older Power Hubs.

NOTICE These Hubs do NOT have separate boom and power harnesses.

PART NO.	DESCRIPTION
118600-104	Power Hub, 9-Nozzle Boom SmithCo
118600-105	Power Hub, 11-Nozzle Universal
118600-103	Power Hub, 12-Nozzle SmithCo
118600-101	Power Hub, 13-Nozzle Universal 21’

Figure 14: Boom Shutoff Adapter

118602-104

Replacements for this style of adapter includes the following part numbers:

10-Section Configurations	
118602-111	10-Section Raven Envizio; 11-Nozzle Boom (Packard weather-pack terminals)
118602-112	10-Section Raven Envizio; 12-Nozzle Boom (Packard weather-pack terminals)
118602-110	10-Section Raven Envizio; 13-Nozzle Boom (Packard weather-pack terminals)

3 Section Configurations	
118602-117	3-Section Raven 440; 9-Nozzle Boom (spade terminals)
118602-115	3-Section Raven 440; 11-Nozzle Boom (spade terminals)
118602-104	3-Section Raven 440; 11-Nozzle Boom (Packard weather-pack terminals)
118602-116	3-Section Raven 440; 12-Nozzle Boom (spade terminals)
118602-103	3-Section Raven 440; 13-Nozzle Boom (Packard weather-pack terminals)

3.11 - Y-Adapter

[Figure 15] - The Y-Adapter connects to the Boom Shutoff Adapter and allows two nozzle locations to be a single section.

Figure 15: Y-Adapter

118602-102

3.12 - Battery Power Cable

[Figure 16] - The Battery Power Cable (Envizio Pro) is required for aftermarket installations of advanced rate controllers. This 30A fused harness connects the battery to an aftermarket switch that controls an aftermarket fuse panel for the rate controller power and ground wires.

Figure 16: Battery Power Cable

118600-120

3.13 - Nozzle Valve Assembly

[Figure 17] - The SharpShooter pulses the Nozzle Valve Assembly to maintain a constant boom and tip pressure.

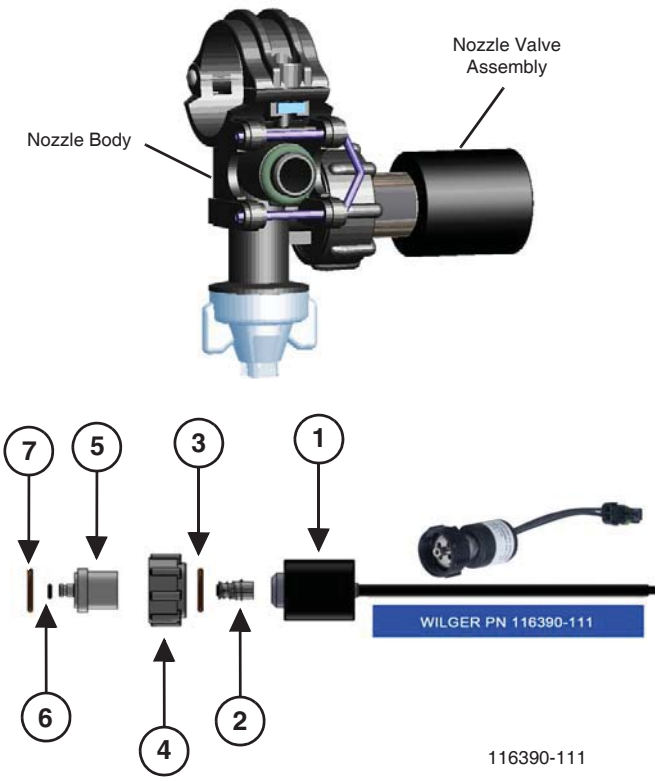
The Nozzle Valve Assembly screws onto the nozzle bodies replacing the standard diaphragm check valve. The 2-pin Packard connector plugs into boom harness from the Power Hub.

NOTICE

This part requires a Wilger brand nozzle body. Do not replace broken nozzle bodies with a brand other than Wilger as significant leaking will occur.

ITEM	PART NO.	DESCRIPTION
1	116189-111	Coil
2	716009-111	Plunger
3	715022-204	O-ring, Viton, -015
4	717101-007	Flynut
5	116188-111	Valve Body
6	715022-201	O-ring, Viton, -008
7	715022-206	O-ring Wilger, Viton, -016

Figure 17: Nozzle Valve Assembly



3.14 - Tips

[Figure 18] - Capstan offers Wilger pre-orifice drift reduction tips.

Depending on the top spraying speed desired, Capstan offers:

- SR110-10 - inside nozzle bodies.
- MR110-10 - outer BOOST nozzle bodies.

NOTICE

These tips have the same inlet orifice that determines the maximum flow. But the two tips have different exit orifices to allow a broader droplet spectrum.

- MR110-125 tips are used to replace the MR110-10 tips when application rates exceeding 2.0 gal/1000sf are consistently used. Additional tips may be ordered as necessary.
- SR110-06 tips are used to replace the SR110-10 tips when application rates less than 1.0 gal/1000sf are consistently used.

Figure 18: Tips

3.15 - Wilger Nozzle Bodies

[Figure 19] - Wilger Nozzle Bodies.

Figure 19: Wilger Nozzle Bodies

132017-001

132002-001

3.16 - Hypro Dry Boom Adapters

[Figure 20] - Hypro Dry Boom Adapters.

Figure 20: Hypro Dry Boom Adapters

132025-001

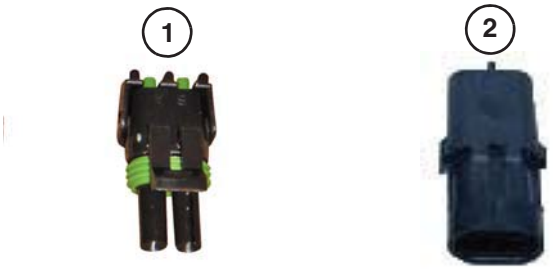
132026-001

3.17 - Electrical Connector Dust Plugs

[Figure 21] - Packard plugs are used to weatherproof any unused nozzle valve assembly pigtails or boom shutoff adapters.

ITEM	PART NO.	DESCRIPTION
1	706500-502	WP Plug 2-Pin tower
2	706510-502	WP Plug 2-Pin shroud

Figure 21: Electrical Connector Dust Plugs



3.18 - Pressure Sensor Breakout Harness

[Figure 22] - The Pressure Sensor Breakout Harness is a service tool used to evaluate the Pressure Sensor.

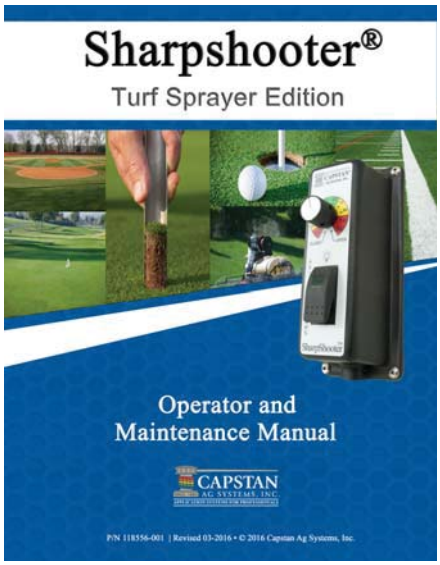
Figure 22: Pressure Sensor Breakout Harness

620185-001

3.19 - SharpShooter Turf Sprayer Edition Operator and Maintenance Manual

[Figure 23] - The SharpShooter Turf Sprayer Edition Operator and Maintenance Manual is supplied to aid the owner/operator in safety, operation, maintenance and troubleshooting of the SharpShooter system.

Figure 23: SS Operator and Maintenance Manual



18556-001

3.20 - OEM Kits

KIT NO.	SMITHCO KITS SHARPSHOOTER - TURF EDITION	QTY.	OEM Factory Installed	Retro-fit Aftermarket Customization
118600-202	Kit, Jacobsen 9-Nozzle, 3 & 9-Section,15' Boom, Turf SS		Jacobsen Kit (made by SmithCo for Jacobsen)	
118600-200	Kit, Jacobsen 11-Nozzle, 3 & 10-Section, 18' Boom, Turf SS		Jacobsen Kit (made by SmithCo for Jacobsen)	
118600-201	Kit, Jacobsen 12-Nozzle, 3 & 10-Section, 20' Boom, Turf SS		Jacobsen Kit (made by SmithCo for Jacobsen)	
118600-205	Kit, SmithCo 9-Nozzle 3-Section, 15' Boom, Turf SS		SmithCo Kit	Toro
118600-203	Kit, SmithCo 11-Nozzle 3-Section, 18' Boom, Turf SS		SmithCo Kit	John Deere/SDI
118600-204	Kit, SmithCo 12-Nozzle 3-Section, 20' Boom, Turf SS		SmithCo Kit	Toro

	Core Components			
118500-101	Kits (vertical), Pulse Generator, Turf SS		ALL	
118500-102	Kits (horizontal), Pulse Generator, Turf SS		Jacobsen only	
118400-020	Valve Driver Module		ALL	
118600-101	Power Hub, Turf, 13-Nozzle, Turf SS		Retro-fit	John Deere/SDI
118600-107	Power Harness, Turf, 14'		SmithCo	
118600-108	Extension Harness, Pressure Sensor		SmithCo	
118600-109	Power Harness, Turf, 18'		All except SmithCo	
118600-250	Power Hub, 9-Nozzle, Turf		ALL	
118600-251	LH Boom Harness, 3-Section, 9-Nozzle, 1, 2, 3		ALL	
118600-252	RH Boom Harness, 3-Section, 9-Nozzle, 7-9		ALL	
118600-253	Power Hub, 11 Nozzle, Turf		ALL	
118600-254	LH Boom Harness, 3-Section, 11-Nozzle, 1, 2, 3, 4		ALL	
118600-255	RH Boom Harness, 3-Section, 11-Nozzle, 8, 9, 10, 11		ALL	
118600-256	Power Hub, 12-Nozzle, Turf		ALL	
118600-257	LH Boom Harness, 3-Section, 12-Nozzle, 1, 2, 3, 4		ALL	
118600-258	RH Boom Harness, 3-Section, 12-Nozzle, 9, 10, 11, 12		ALL	
116301-001	Pressure Sensor Assy, 100 PSI, 0.5-5 VDC, 1/4" MNPT, WP		ALL	
118600-125	Extension, Turf SS, 8 cond x 25', 18 ga, Universal, DT		Retro-fit only	John Deere/SDI
116390-111	Valve Assy, Wilger OM Coil w/Grip Body, PFE		All	

KIT NO.	SHUTOFF HARNESSES	QTY.	OEM Factory Installed	Retro-fit Aftermarket Customization
118602-102	Harness, Shutoff, Y Adapter, Turf		ALL Sprayers using advanced Rate Controllers with more than 9 nozzles	
118602-103	Harness, Shutoff, Turf, 3-Section, 13 Pigtails, Universal		Retro-fit	John Deere/SDI
118602-104	Harness, Shutoff, Turf, 3-Section, 11 Pigtails, Universal			Toro, John Deere/ SDI
118602-110	Harness, Shutoff, Turf, 10-Section, 13 Pigtails, Universal		Retro-fit	John Deere/SDI
118602-111	Harness, Shutoff, Turf, 10-Section, 11 Pigtails, Universal			Toro, John Deere/ SDI
118602-115	Harness, Adapter, Turf, 3-Section Shutoff, 11-Nozzle w/ Spade Term		ALL older sprayers	Toro, John Deere/ SDI
118602-116	Harness, Adapter, Turf, 3-Section Shutoff, 9-Nozzle		ALL older sprayers	Toro, John Deere/ SDI
118602-117	Harness, Shutoff, 9-Nozzle, 9-Section Turf			Toro, John Deere/ SDI
118602-118	Harness, Shutoff, 9-Nozzle, 9-Section Turf		Jacobsen Kit	
118602-119	Harness, Shutoff, 9-Nozzle, 3-Section Turf		Jacobsen Kit	
118602-120	Harness, Shutoff, 11-Nozzle, 10-Section Turf		Jacobsen Kit	
118602-121	Harness, Shutoff, 11-Nozzle, 3-Section Turf		Jacobsen Kit	
118602-122	Harness, Shutoff, 12-Nozzle, 10-Section Turf		Jacobsen Kit	
118602-123	Harness, Shutoff, 12-Nozzle, 3-Section Turf		Jacobsen Kit	
118602-124	Harness, Shutoff, 11-Nozzle, 3-Section Turf		SmithCo Kit	Toro, John Deere/ SDI
118602-125	Harness, Shutoff, 9-Nozzle, 3-Section Turf		SmithCo Kit	Toro/SDI
118602-126	Harness, Shutoff, 12-Nozzle, 3-Section Turf		SmithCo Kit	Toro, John Deere/ SDI
118602-127	Harness, Shutoff, 11-Nozzle, 10 Section Turf			Toro, John Deere/ SDI
118602-128	Harness, Shutoff, 12-Nozzle, 10 Section Turf			Toro, John Deere/ SDI
118602-129	Harness, Shutoff, 9-Nozzle, 9 Section Turf			Toro, John Deere/ SDI

KIT NO.	ACCESSORIES and SERVICE PARTS	QTY.	OEM Factory Installed	Retro-fit Aftermarket Customization
116188-111	Valve Body, Wilger w/Grip		ALL	
116189-111	Valve, Coil Assy, 7W, OM		ALL	
706500-502	Harness, Dust Plug, 2-Pin Tower, WP		ALL	
706510-502	Harness, Dust Plug, 2-Pin Shroud, WP		ALL	
118600-120	Harness, Power, Turf, 2 cond x 12', 12ga		ALL	
118603-101	Ram Mount, Ball		ALL	
118703-001	Kit, Installation, SS		ALL	
132031-001	Harness, Power, Turf, 2 cond x 12ga, battery lugs x bare ends		Retro-fit only	Retro-fit Raven Epro
620185-001	Harness, Breakout, 3-Pin, WP		ALL	
706500-502	Packard Tower, 2-Pin		ALL	
706510-502	Packard Shroud, 2-Pin		ALL	
715022-201	O-Ring, Viton, -008		ALL	
715022-204	O-Ring, Viton, -015		ALL	
715022-206	O-Ring, Viton, -116, Wilger		ALL	
716009-111	Plunger Assy, PFE		ALL	
717101-007	Valve, Fly Nut, Wilger		ALL	
	Wilger Nozzle Bodies and Tips			
132002-001	Wilger ComboRate Nozzle Body, End Body		All sprayers, all customers	
132009-001	Wilger Combojet Tip, SR110-10		All sprayers, all customers	
132009-006	Wilger Combojet Tip, SR110-06		Parts service for lower rates (optional)	
132010-001	Wilger Combojet Tip, MR110-10		All sprayers, all customers	
132017-001	Wilger C/R II Saddle/Body 1” 1-Way 3/8 Inlet BP, BM		All sprayers, all customers	
132025-001	Dry Boom Adapter, Single, 1” x 3/4”		All sprayers, all customers	
132026-001	Dry Boom Adapter, Double, 1” x 3/4”		All sprayers, all customers	
132030-001	Wilger Combojet Tip, MR110-125		Parts service for higher rates (optional)	

3.21 - Capstan Parts Support - Non Kit Parts

PART NO.	DESCRIPTION	QTY.	SmithCo, Jacobsen, John Deere/SDI
132009-006	Combojet Tip, SR110-06 (replaces 132009-001 for low rates)		ALL
132030-001	Combojet Tip, MR110-125 (order with 132029-001)		ALL
132009-001	Combojet Tip, SR110-10 (order with 132010-001)		ALL
132010-001	Combojet Tip, MR110-10 (order with 132009-001)		ALL
716009-111	Plunger Assembly, PFE		ALL
717101-007	Fly Nut, Wilger		ALL
116188-111	Valve Body, Wilger w/Grip		ALL
715022-206	O-Ring Wilger, -116, Viton (Between Body and Nozzle)		ALL
715022-204	O-Ring, -015, Viton (Between Coil and Body, All Valves)		ALL
715022-201	O-Ring, -.008, Viton, Small		ALL
116189-111	Coil Assembly, 7-Watt, Overmolded		ALL
132020-001	Wilger Boom Clamp, High Reach C/R II 3/4” - 1 1/4”		Old Toro and John Deere Models

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4.0 - OPERATION

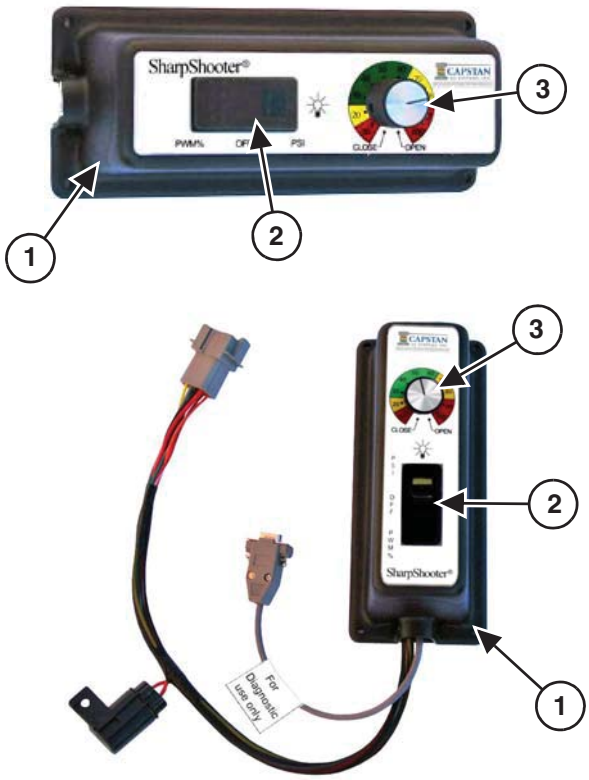
4.1 - Pulse Generator Controls

[Figure 24] - The ① SharpShooter Pulse Generator has one ② rocker switch and one ③ rotary switch.

The rocker switch has three positions and an indicator light. The three rocker switch positions are: PWM, OFF and PSI.

The twelve rotary switch detent positions are: Close, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100 and Open.

Figure 24: Pulse Generator Controls



4.1.1 - Rocker Switch Positions

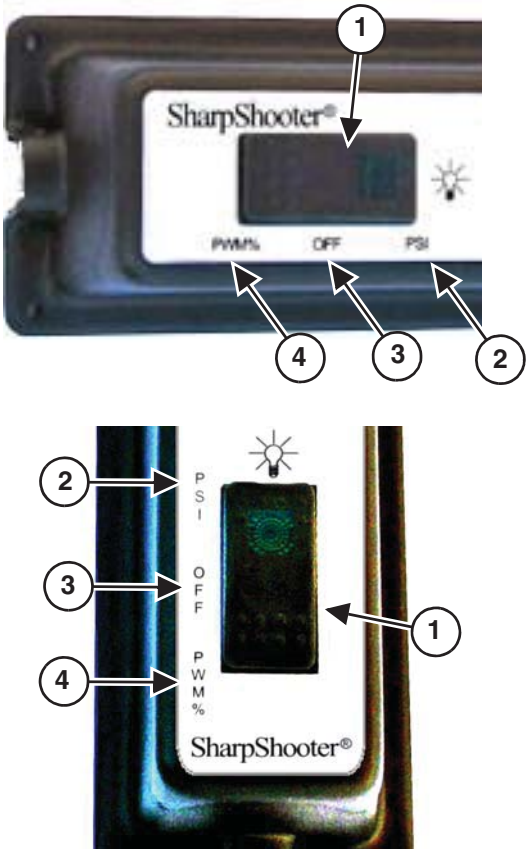
PSI Mode (Top) - **[Figure 25]** - The standard operating mode for the SharpShooter is the ② PSI Mode. When the ① rocker switch is in the PSI Mode the SharpShooter will pulse the nozzle valves at a Duty Cycle percentage to achieve the pressure set-point determined by the operator with the rotary switch setting.

OFF Mode (Center) - With the rocker switch in ③ OFF Mode, the sprayer will only operate as a conventional rate controller. The Nozzle Solenoids work as an electronic On / Off drip check and work with the boom section On / Off switches.

NOTICE Spraying with the SharpShooter in the OFF Mode, the conventional rate controller may require smaller tips to spray effectively.

PWM Mode (Bottom) - With the rocker switch in ④ PWM Mode, the SharpShooter will pulse the nozzle valves at the Duty Cycle percentage selected by the rotary switch. This mode known as the Rate Controller Only Mode, which is used to control pressure in the event that the SharpShooter PSI Mode fails to automatically control pressure. It is not necessary to change tips.

Figure 25: Rocker Switch Positions



Open / Close Valves - **[Figure 26]** - When the ① rocker switch is in either PSI Mode or PWM Mode and the ② rotary switch in the "OPEN" or "CLOSE" position, the nozzle valves will fully open or fully close.

This allows the operator to disable the pulsing of the valves. Pulsing may not be desired for row banding, drop nozzles, special applications, maintenance, troubleshooting, or in the event of a system failure.

Indicator Light - The ③ indicator light located in the rocker switch will be on when power is supplied to the SharpShooter system.

When the rocker switch is in PWM Mode, the indicator light will flash two times per second (2 Hz), this indicates that the nozzle valves are pulsing at the fixed Duty Cycle percentage, as selected on the rotary switch.

When the rocker switch is in PSI Mode, the indicator light will be on. This indicates that the nozzle valves are pulsing at a variable Duty Cycle percentage in order to achieve the pressure selected on the rotary switch.

The indicator light will flash slowly, one time per second (1 Hz), when the automatic pressure control is suspended.

[Figure 27] - The ① color graphic surrounds the rotary switch and indicates the Preferred (Green), Caution (Yellow) or Warning (Red) ranges of operation.

The SharpShooter control is suspended and the indicator light will flash slowly in the following positions:

1. Minimum Duty Cycle Limit
2. Maximum Duty Cycle Limit
3. Low Pressure Shutoff
4. Start-Up Delay
5. Run / Hold Delay

Figure 26: Open / Close Valves

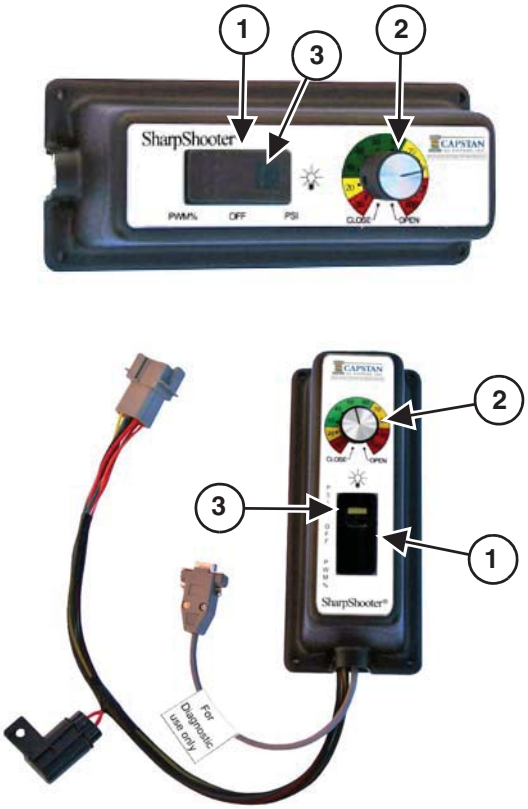
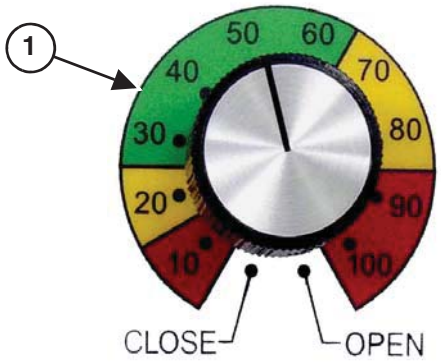


Figure 27: Rotary Switch Graphic



Twelve detent Rotary Switch positions:

1. CLOSE Valves
2. 10 (Red)
3. 20 (Yellow)
4. 30 (Green)
5. 40 (Green)
6. 50 (Green)
7. 60 (Green)
8. 70 (Yellow)
9. 80 (Yellow)
10. 90 (Red)
11. 100 (Red)
12. OPEN Valves

Open / Close Valves

- When the rocker switch is in either PSI Mode or PWM Mode and the rotary switch in the “OPEN” or “CLOSE” position, the nozzle valves will fully open or fully close. This feature allows the operator to control the nozzle valves.

NOTICE This control method is useful in emergency situations where an untrained person might need to stop the spray or empty the tank.

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5.0 - CONTROL FEATURES

5.1 - Control Features

Start-Up - In PSI Mode, the SharpShooter will begin pulsing at 50% Duty Cycle and will remain constant until the start-up delay time has lapsed. This allows the flow control system to establish itself before the SharpShooter begins to control the pressure. The rocker switch indicator light will flash slowly, to alert the operator that the initialization delay has been activated. The start-up delay time is equal to the Run / Hold delay time.

Low Pressure Shutoff - In PSI Mode, the SharpShooter will turn off the nozzle valves when the pressure falls below 8 PSI. This feature is intended to duplicate the effect of the nozzle drip checks found on sprayers. To alert the operator that the low pressure shutoff feature has been activated, the rocker switch indicator light will flash slowly. When the pressure rises above 10 PSI again, the SharpShooter will pulse at 50% Duty Cycle for the start-up delay period and then will resume pressure control.

The low pressure shutoff feature can be disabled through the DB9 serial port with the use of a computer and terminal emulator program.

When disabled, the SharpShooter will maintain a minimum Duty Cycle percentage equal to the pulse frequency regardless of either low or zero pressure.

Run / Hold - In PSI Mode, the SharpShooter will stop controlling pressure when the boom is turned off and the run / hold signal is removed. When the boom is turned on and the run / hold signal is returned, the SharpShooter will resume pulsing at the previous Duty Cycle before the boom was shutoff. This Duty Cycle will remain for a delay period of three seconds. This allows the flow control system to resume control. Once the delay period has elapsed, the SharpShooter will resume pressure control. The rocker switch indicator light will flash slowly, to alert the operator that the run / hold delay has been activated.

The run / hold feature can be disabled on the cab control circuit board by turning S1#2 to ON, see Circuit Board Setup on page 55. When disabled, the SharpShooter will attempt to control pressure, and will either modulate to the minimum or the maximum Duty Cycle. This modulation causes the SharpShooter, (when the boom is turned back on) to spike / dip the pressure or cause control instability until the system catches up and pressure control resumes.

The run / hold delay value can be adjusted from 0 to 20 seconds through the DB9 serial port with the use of a computer and terminal emulator program.

Control Parameters - The SharpShooter uses three control parameters to stabilize the pressure control algorithm in the control software:

1. Proportional Gain - Determines the speed that the SharpShooter drives the Duty Cycle toward the target value.

   Proportional gain can be adjusted from -20 to +20 through the DB9 serial port with the use of a computer and terminal emulator program.

   Factory setting for proportional gain is eight (8).

2. Integral Gain - Determines the acceleration.

   Integral gain can be adjusted from -20 to +20 through the DB9 serial port with the use of a computer and terminal emulator program.

   Factory setting for integral gain is two (2).

3. Derivative Gain - Determines the accuracy.

   Proportional, integral and derivative gains can be set through the DB9 serial port with the use of a computer and terminal emulator program.

   Factory setting for derivative gain is one (1).

Boost - The SharpShooter has a unique ability to turn on a second boom / row of nozzles when the capacity of the first row of pulsing nozzles has been exceeded.

The boost feature works by turning on a second boom when 80% pulse Duty Cycle is achieved with the first row of nozzles. When the boost is turned on, the pulse Duty Cycle immediately modulates downwards to 40% based on a value calculated on tip size. In addition, a transition time may be entered to account for the speed at which the boost boom turns on. Conversely when the Duty Cycle of all the nozzles drops to 20%, the boost boom is turned off, SharpShooter modulates upwards to 40% for the remaining row of nozzles. The tip sizes of the two booms dictate the amount of “thermostat” preventing the boost boom from turning on and off too much.

Boost settings can be set through the DB9 serial port with the use of a computer and terminal emulator program. Boost settings include PWM tip size, PWM valve size, boost tip size and boost transition time.

6.0 - EMERGENCY SPRAYING

6.1 - Component Failure During Operation

SharpShooter is designed with several features that allow the operator to continue spraying in the event of a SharpShooter component failure.

When the SharpShooter does not automatically control pressure and will not pulse:

Turn the SharpShooter Pulse Generator rocker switch to OFF.

NOTICE This returns the operator to the traditional rate controller mode. In this mode only the non-Boost nozzles will operate.

A conventional tip chart will be needed to select a proper tip based on pressure and rate. The SharpShooter solenoids are still powered and will act as electronic “drip checks” for On and Off spraying.

This feature will allow the operator to continue spraying until repairs can be made.

Install the re-sized tips on the non-BOOST solenoids.

When the SharpShooter does not automatically control pressure but still pulses:

With the pulsing still functioning, turn the SharpShooter Pulse Generator rocker switch to the PWM Mode.

NOTICE This also reverts the operator to the traditional rate controller functionality. Only the non-Boost nozzles will operate.

In this case the PWM Mode acts like an “electronic” rotary nozzle body, but with 10 different tip choices. Instead of rotating a 3-way or 5-way nozzle body on the back of the boom, the operator manually dials the Duty Cycle up or down to change the “effective” tip size. If the pressure goes too high, the operator dials up to a larger tip. If the pressure is too low, the operator dials down to a smaller tip.

The PWM Mode is typically used in the event of a SharpShooter pressure sensor failure. The PWM Mode will allow the operator to adjust the pressure range in which the Rate Controller operates. This pressure range can be changed on-the-go for varying spray conditions.

When the Rate Controller or flow meter fails, and the SharpShooter continues to pulse:

Put the Rate Controller in the MANUAL Mode. This locks the flow control valve to a single position and eliminates the need for the flow meter and control valve.

Put the SharpShooter Pulse Generator in the PWM Mode. This locks in to a tip size chosen by the operator. The tip size can be manually changed to select the tip needed.

NOTICE This reverts the operator back to the basic Speed and Pressure mode of application. Only the non-Boost nozzles will operate.

Referencing conventional tip charts, the operator selects a single speed (typically 3 MPH) and an operating pressure (typically 40 PSI). The operator then selects a tip size that delivers the desired rate at 3 MPH and 40 PSI.

To select the right tip, start spraying at 3 MPH. Change the SharpShooter Duty Cycle up or down until the machine is spraying at 40 PSI. This Duty Cycle is then the effective tip size needed to achieve the desired rate at 40 PSI and 3 MPH.

The operator must continue to spray only at 3 MPH to maintain the target rate.

The operator will need to do a test run checking the volume and area applied. Dividing the volume by the area will serve to verify the rate. It may be necessary to modify the tip size or speed to achieve the desired rate.

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7.0 - TIP SELECTION

It is important to adhere to the following rules:

1. Always use 110 degree spray angle tips and maintain the boom height at 24” or greater. However, if 80 degree spray angle tips are used, maintain the boom height at 36" or greater.

2. Never use Air Induction (AI) pre-orifice spray tips.

- While AI tips are a good solution to the limitations of rate controller spraying, the need for them is offset by the advancement of the SharpShooter and non-AI pre-orifice tips.

- The same droplet size control desired for drift managements is achieved with pre-orifice tips that are not air induced.

- Better canopy penetration is achieved with solid droplets of the same size as the air entrained droplets.

- The air entrained droplets are intended to improve coverage by causing the larger droplets to explode on contact into smaller droplets. This claim is important for low application rates below 10 GPA when the number of droplets is very low. It is less important as the number of droplets increases as in rates above 20 GPA. It has also been shown that this is less effective on grasses compared to broadleaf weeds and insects.

- The SharpShooter pulsing tends to squirt liquid out the air hole of the AI tips

3. For turf spraying with rates between 1.0 and 2.5 gallons/1000, Wilger SR110-10 and MR110-10 are provided. The SR tip is installed on the non-boosted row of nozzle bodies and the MR tip on the row of the boosted nozzle bodies. The non-boosted nozzle bodies are the most forward row of nozzles.

4. For turf spraying where rates are **consistently** sprayed at less than 1.0 gallons/1000 (43 GPA), it is recommended that Wilger SR110-06 tips be purchased to replace the SR110-10 tips. This allows for a larger number of droplets for the same rate and a more thorough coverage.

5. For turf spraying where rates are **consistently** sprayed at more than 2.0 gallons/1000 (86 GPA), it is recommended that Wilger MR110-125 tips replace the MR110-10 tips on the boosted nozzle bodies. The non-boosted nozzle bodies should be the row of nozzles to the rear of the machine. This allows a little bit larger combined orifice to utilize the full pump capacity of the machine at the top-end speeds.

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8.0 - MAINTENANCE

8.1 - Strainers and Screens

NOTICE Factory-built sprayers typically come with 50-mesh strainers. These will need to be changed to the 80-mesh strainers.

Check the mesh size of the strainers and replace the screens if they are too coarse.

[Figure 28] - Most sprayers are built with strainers to filter debris from the spray. An 80-mesh screen is required to *prevent nozzles from plugging*. When selecting a strainer DO NOT rely on the color coding. Check with the strainer manufacturer to be sure and select the 80-mesh strainer.

Plugged strainers will cause a reduction in system flow, which in turn, will affect rate, speed and pressure.

When replacing the mesh screen on TeeJet strainers, first install and set the mesh screen in the strainer head. Then install the strainer cap. Failure to do this will likely result in a damaged mesh screen and overall strainer failure.

Figure 28: Strainers and Screens

NOTICE Clean the strainers on a regular basis.

NOTICE Use 80-mesh or finer strainer screens. The filter manufacturer is specified only on the strainer housing. Only a color code identifies the strainer mesh size which is not consistent between filter suppliers.

NOTE: The following chart has been typical, but check with your local supplier for any changes or updates.

MESH	TEEJET	HYPRO	ARAG	BANJO
30	Yellow	Red	Red	Yellow
50	Red	Blue	Blue	Red
80	Blue	Yellow	Yellow	Blue
100	Green	Green	Green	Green

8.2 - Jump-Starting/Welding/Charging

- If jump-starting or charging the batteries on the sprayer, disconnect the rate controller and the SharpShooter power wires to prevent damage to the SharpShooter system.
- If welding on the equipment, disconnect the rate controller and the SharpShooter power wires to prevent damage to the SharpShooter system.

8.3 - Servicing the Spray System

- Before servicing the spray system or spray components, the spray tank and system should be emptied of chemical mixture and flushed with clean water. Clean the machine of all chemical residue.

8.4 - Inspecting the Spray System

- Inspect spray system hoses for cuts, nicks or abrasions before each use. Replace any damaged hoses immediately.
- Check for loose hoses, mounting hardware and components. Tighten if necessary.
- Verify all hoses and wiring are secure.
- Make sure boom strainers are clean.
- Check for damaged or missing decals. Replace decals if damaged or missing.

8.5 - Cleaning the Spray System

- Thoroughly clean the spray system with clean water after each use.
- Avoid high pressure spray when cleaning the spray system components, valves and wiring connectors.

8.6 - Product Tank and Boom Line Rinsing

At the end of the day and/or between chemical changes the following rinse procedure must be performed.

- Drain excess chemical from the tank according to standard safety practices of disposing of chemical.
- Using a hose or a tank rinse system integrated on the machine, rinse the product tank thoroughly with clean water and drain according to standard safety practices.
- Fill the turf product tank with 25 gallons of clean, fresh water. Spray the fresh water out the tank through the entire boom length making sure both nozzles at each location spray.

NOTICE Failure to do a proper rinse at the end of the day can cause unnecessary plugging/ dripping. Failure to rinse between chemical changes could leave residual chemical that could damage the turf in next application.

8.7 - Winterizing for Storage

DO NOT USE FERTILIZER TO WINTERIZE! The use of fertilizer for winterization will cause internal damage to the nozzle valves.

- Thoroughly clean the spray system before winter storage.
- Flush the spray system with clean water.
- Winterize the spray system with RV antifreeze for winter storage. Proper winterizing of the sprayer with a Capstan system installed on it is essential. Make sure the booms are completely full of antifreeze at 100% strength and that the solenoids are pulsed (sprayed) for a few minutes to ensure the antifreeze remaining in the solenoids is at full strength.

NOTICE Improper winterizing procedure could result in damage to the internal components of the solenoids.

9.0 - TROUBLESHOOTING

9.1 - Setup

Programming Parameters

Once all of the components are installed, the next step is to validate the SharpShooter electronic programming for proper setup.

The tools required are:

- A computer.
- A 9-pin pigtail to USB serial cable purchased at a local electronics store.

  This should come with an installation disc. Follow included instructions. Note the computer COM port number that the USB cable is plugged into. You will need the COM port ID for the Capstan Diagnostic software tool.
- Capstan diagnostic software tool. See instructions below to acquire this software.

Capstan Diagnostic Software Tool

This software tool may be downloaded from the Capstan website at www.capstanag.com

- Log in at the dealer log-in.
- Look for the Capstan Diagnostic Tool, and double click to download.
- Select the “Save As” option to store at a desired location on your computer.
- When the save is complete, select the “Open Folder” option.
- In the folder, double click the Capstan Diagnostic file to “unzip” and save it as an icon on the computer’s main screen.

If not done already, connect the serial cable into both the 9-pin pigtail on the SharpShooter Pulse Generator and the USB port to the computer. If the Pulse Generator is an older version without the 9-pin pigtail, remove the cover to locate the 9-pin connector.

If you did not identify the COM port number in the cable install, locate which computer communication port the USB cable is using, by viewing the “Devices”. Typically, you can use the “Control Panel” selection on your computer to view “Devices”. From here, you should be able to see the computer COM Port that the USB cable is using. Click on the Capstan Diagnostic Tool and enter the proper COM port number from the drop-down menu.

Enter the COM Port number.

The Baud Rate should be 19200.

You are now able to run the programming diagnostics.

9.1.1 - Program Information

Once the Capstan Diagnostic Tool is running and the SharpShooter Pulse Generator is powered up in the PWM Mode, a header file should open and display a message that the EEPROM information is valid.

```
==  TermTestEEprom ()  ==
-Valid Data in EEPROM
```

Next, the header file should describe the program version data and hour meter value.

```
Module Type……..:     SharpShooter
Software Rev……..:     Rev  1.04  -
Compiler Version……...:    612
Compile Date……..:    Jul 20 2006
Compile Time……..:    15:51:35

Current Run Time……..:   120:25
```

9.1.2 - Circuit Board Setup

To access the Pulse Generator circuit board setups, remove the four screws from the Pulse Generator and lift the lid away from the back panel.

① S1 Dip Switch

- #1:OFF = DB9 Power
- #2:OFF = Run / Hold
- #3:ON = Odd Resistor
- #4:ON = Even Resistor

② S4 Dip Switch (Item 2)

- #1:ON = Freq. x Multiplier
- #2:OFF = Invert
- #3:OFF = PSI Shutoff
- #4:OFF = Boost

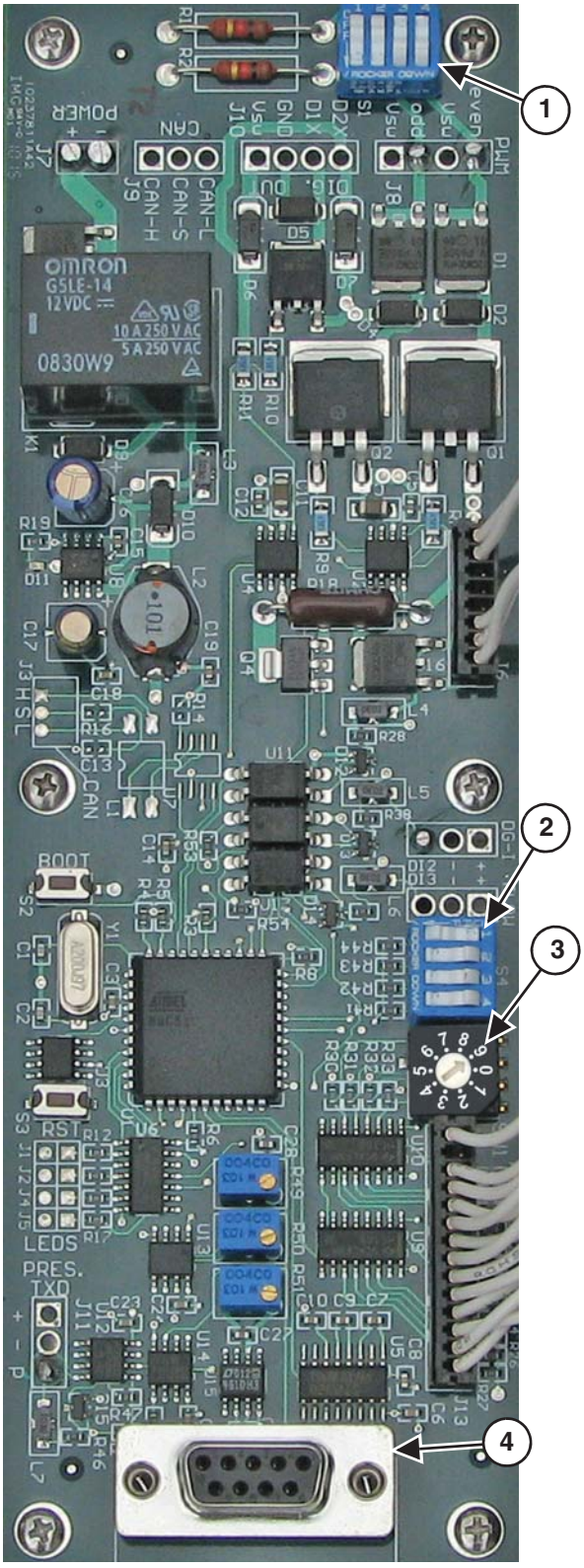
③ SW1 Rotary Detent Switch

- #1: = 1 Hz
- #2: = 2 Hz
- #9: = 9 Hz
- #0: = 10 Hz

Etc.

NOTE: The Rotary Switch is set to “9” for Turf.

④ DB9 = Serial Port



Next, a header file will scroll forward to confirm the hardware switch position on the SharpShooter Pulse Generator circuit board. The file should display as seen below: (Values may not be correct, see the default values below):

S1.x	.....	switches 1, 3, and 4 are not monitored
S1.1	.....	NA - DB-9.9 Power (default = OFF)
S1.2	.....	OFF - Run/Hold ENABLED
S1.3	.....	NA - PWM Odd Pullup (default = ON)
S1.4	.....	NA - PWM Even Pullup (default = ON)
SW1	.....	9
S4.1	.....	ON - Tmr Freq = 19 Hz
S4.2	.....	OFF - Output is NOT inverted
S4.3	.....	OFF - Low Pressure Shutoff: ENABLED
S4.4	.....	OFF - Boost: ENABLED

To change the dip switches, remove the SharpShooter Pulse Generator cover, locate the switches on the circuit board and make the proper changes.

9.1.3 - Validating Software Calibration Values

The header file will then confirm that the software calibration values are present on the EEPROM.

== Pressure Control Mode ==	
== PID Parameters ==	
P_GAIN.....	8
I_GAIN.....	2
D_GAIN.....	0.00
K_GAIN.....	-0.10
== Pressure Txd Parameters ==	
Txd MIN Press.....	0.0
Txd MAX Press.....	100.0
Txd MIN Output.....	0.5
Txd MAX Output.....	5.0
Calc Slope.....	22.2
== Other Parameters ==	
Print Limit.....	2
Controller Rate [mS].....	100
Hold Timeout [mS].....	500
Pressure Shut Off [PSI].....	8.0
Pressure Turn On [PSI].....	10.0

9.1.4 - PWM Mode

In PWM Mode, the SharpShooter prints a line of data each time the set-point knob is turned to a new position, as shown below:

PwmMode: New Pos: 4 EVEN: 39.84 ODD: 39.84
PwmMode: New Pos: 5 EVEN: 49.61 ODD: 49.61
PwmMode: New Pos: 6 EVEN: 59.77 ODD: 59.77
PwmMode: New Pos: 5 EVEN: 49.61 ODD: 49.61
PwmMode: New Pos: 4 EVEN: 39.84 ODD: 39.84
PwmMode: New Pos: 3 EVEN: 29.69 ODD: 29.69
PwmMode: New Pos: 4 EVEN: 39.84 ODD: 39.84

“PWM Mode:” indicates that the SharpShooter system is running in PWM Mode.

“New Pos: 4” indicates that the knob is turned to position number 4.

“EVEN: 39.84” indicates the pulse Duty Cycle of the even nozzles.

“ODD: 39.84” indicates the pulse Duty Cycle of the odd nozzles.

9.1.5 - PSI Mode

In PSI Mode, data will scroll in columns, with column labels every 50 lines.

Act	SP	DC	Freq	R/H	RunTime	Tmo	Gp,	Gi,	Flow
41.5	40.0	46.3	10.0	RUN	0:01	1.0	8.0	2.0	4.7
41.0	40.0	46.3	10.0	RUN	0:01	1.0	8.0	2.0	4.7
39.6	40.0	45.9	10.0	RUN	0:01	1.0	8.0	2.0	4.5
42.7	40.0	46.7	10.0	RUN	0:01	1.0	8.0	2.0	4.8
44.1	40.0	47.1	10.0	RUN	0:01	1.0	8.0	2.0	4.9
42.2	40.0	46.7	10.0	RUN	0:01	1.0	8.0	2.0	4.8
41.1	40.0	46.7	10.0	RUN	0:01	1.0	8.0	2.0	4.7
39.6	40.0	46.3	10.0	RUN	0:01	1.0	8.0	2.0	4.6
39.6	40.0	46.3	10.0	RUN	0:01	1.0	8.0	2.0	4.6
39.6	40.0	46.3	10.0	RUN	0:01	1.0	8.0	2.0	4.6

- “Act” = actual pressure in PSI, that SharpShooter reads on the Pressure Sensor.
- “SP” = pressure set point in PSI, that SharpShooter controls.
- “DC” = pulse Duty Cycle (percentage) of the SharpShooter pulsing nozzle.
- “Freq” = frequency of nozzle pulses in Hz.
- “R/H” = state code of the software.
- “Run Time” = hour meter. Shows hours and minutes of pulse operation.
- “Tmo” = run/hold delay time used in the control algorithm.
- “Gp” = proportional gain value used in the control algorithm.
- “Gi” = integral gain value used in the control algorithm.
- “Flow” = calculated flow used to compare with the flow meter.

With the cursor positioned in the scrolling date, pushing the “M” key will display a menu of setup information.

9.1.6 - Software Calibration Values

The Software Calibration Values may now be modified from the menu that appears as follows:

Menu:
1. PID Parameters
2. Pressure Txd Parameters
a. Read Potentiometers
c. Clock
$. Clock Reset
f. Flow Setup
g. Gains & Tmo on Pots
h. Run-Hold Timeout
m. PWM Test
o. Toggle Digital Output
p. Pressure Shutoff Limit
q. Quit

Pressure control is suspended whenever the SharpShooter is in menu mode. To re-establish control, exit the menu mode by pressing “q” for quit, and data will begin scrolling as previously described.

9.1.7 - PID Parameters Menu

Pressing “1” in the main menu brings up the first line of the PID Parameters menu. Pressing “Enter” will bring up the next line. Default values are shown in parenthesis. To change a value, type the new value and press “Enter”.

The complete menu is shown below:

```
Setup PID Parameters
-PID Proportional Gain.(8.0).....    8.000     NEW:
-PID Integral Gain.(2.0).....        2.000     NEW:
-PID Derivative Gain.(0.).....       0.000     NEW:
-PID System Gain.(-0.1).....        -0.100     NEW:
-Print Limit.(2).....                2         NEW:
-Controller Rate[mS].(100).....      100       NEW:
-Pots Enabled (YES).....             YES       NEW (Y/N):
          Pots = Disabled

Press a key to exit
```

- “PID Proportional Gain” establishes the speed in which the SharpShooter changes the pressure. A higher number results in faster control.
- “PID Integral Gain” establishes the acceleration in which the SharpShooter changes the pressure. A higher number results in faster control.
- “PID Derivative Gain” establishes the accuracy in which the SharpShooter changes the pressure. A higher number results in faster control.
- “PID System Gain” establishes the sensitivity of the control algorithm.
- “Print Limit” establishes the rate in which the SharpShooter scrolls data.
- “Controller Rate” establishes the rate in which the SharpShooter runs the control algorithm.
- “Pots Enabled” allows the PID Proportional Gain, PID Integral Gain and Run-Hold Timeout to be controlled by adjusting the potentiometers located on the SharpShooter Pulse Generator circuit board. Pots should be disabled. This allows modifications to be made and saved via a computer interface.

9.1.8 - Pressure Txd Parameters

Pressing “2” in the main menu brings up the first line of the Pressure Transducer Parameters menu.

Setup Pressure Transducer		
-Txd MIN Press(PSI)(0.0).....	0.0	NEW:
-Txd MAX Press(PSI)(100).....	100.0	NEW:
-Txd MIN Output(V)(0.5).....	0.5	NEW:
-Txd MAX Output(V)(5.0).....	-0.100	NEW:
-Print Limit.(2).....	5.0	NEW:
-Calc Slope(PSI/V).....	22.2	NEW:
Press a key to exit		

- “Txd MIN Press(PSI)” is the minimum pressure read by the Pressure Sensor.
- “Txd MAX Press(PSI)” is the maximum pressure read by the Pressure Sensor.
- “Txd MIN Output(V)” is the Pressure Sensor signal voltage when at minimum pressure.
- “Txd MAX Output(V)” is the Pressure Sensor signal voltage when at maximum pressure.
- “Calc Slope(PSI/V)” is automatically calculated by the SharpShooter.

9.1.9 - Flow Setup

Pressing “f” on the main menu brings up the flow setup menu. The flow setup parameters are required for boost and flow meter calculations.

Setup Flow Calculation Parameters		
-PWM Valve Size (15.5).....	15.50	NEW:
-Tip Size (8).....	10.000	NEW:
-Number of Valves (54).....	11.000	NEW:
-Specific Gravity (1.0).....	1.000	NEW:
-Boost Valve Size (15.5).....	15.50	NEW:
-Boost Tip Size (8).....	10.00	NEW:
-Boost Timeout (3000).....	3000.000	NEW:
-Boost Nozzles Pulse	Enable	NEW:
-Boost Polarity.....	LOW	NEW:
Press a key to exit		

- “PWM Valve Size” refers to the size, or flow parameter, of the pulsing valve. That value for Ag applications is 15.5.
- “Tip Size” refers to the size, or flow parameter, of the spray tip downstream of the pulsing valve. Capstan uses the flat fan tip size based on the flow at 40 PSI. This size is generally printed on the tip. If the tip shows “110-10”, then the tip size is 0. In Turf, either a 110-10 tip or a 110-125 is used. Enter 10 for 12.5 in the tips size.
- “Number of Valves” refers to the number of SharpShooter pulsing nozzles on the boom.

  There are 22 pulsing solenoids on an 18 foot 11-nozzle location Turf boom. Enter 11 for number of valves.

  There are 24 pulsing solenoids on a 20 foot, 12-nozzle location Turf boom. Enter 12 for the number of valves.

  There are 26 pulsing solenoids on a 21 foot, 13-nozzle location Turf boom. Enter 13 for the number of valves.
- “Specific Gravity” is the density of the product being applied, this is expressed as a ratio to water. Although the specific gravity of water is 1.0, liquid fertilizer can vary significantly, generally it is around 1.2.
- “Boost Valve Size” refers to the size, or flow parameter, of the pulsing valve. That value for Ag and Turf applications is 15.5.
- “Boost Tip Size” is the tip size used on the boost boom (See Tip Size above). SharpShooter assumes that the boost boom is a conventional boom without pulsing nozzles. If the boost feature is enabled, the SharpShooter assumes that there are the same number of boost nozzles as pulsing nozzles. If fewer boost nozzles are in use, then the boost tip size can be “faked” for an equivalent flow. In Turf, the default boost tip is 10.
- “Boost Timeout” refers to the time required to turn on the boost boom and is expressed in milliseconds. If a 1 second ball valve is used, then the boost timeout would be 1 second or 1000 milliseconds. If solenoid valves are used, the boost timeout might be ¼ second or 250 milliseconds.
- Boost Pulse enables the Boost nozzles to function.
- Boost Polarity determines when the boost function engages. A LOW polarity activates the Boost after a minimum flow is achieved. A HIGH polarity shuts off the Boost after a minimum flow is achieved. For Turf applications, LOW is the proper setting.

9.1.10 - Run-Hold Timeout

Pressing “h” on the main menu brings up the hold timeout menu. Hold timeout is the time required for the flow controller to establish rate control and is expressed in milliseconds. If the rate controller takes 5 seconds to establish rate control, then the hold timeout should be set at 5000. **The turf recommended setting is 500 milliseconds.**

```
Setup Hold Timeout
-Hold Timeout [mS] (3000)….: 500    New:

Press a key to exit
```

The hold timeout value is used by the SharpShooter whenever pressure control is suspended. Pressure control is commonly suspended for power-up, run/hold, open/close valves, low pressure shutoff, etc.

9.1.11 - Pressure Shutoff Limit

Pressing “p” on the main menu initiates the pressure shutoff limit menu. The pressure shutoff limit is the pressure value below which the SharpShooter will shut off the pulsing nozzles. This allows the SharpShooter to work very much like diaphragm drip checks. The pressure turn-on value is different than the shutoff limit. In many cases, a pressure spike is seen when the boom turns off. The turn-on pressure value should be set higher than the spike value to prevent inadvertent boom turn-on.

The low pressure shutoff feature must be enabled on the SharpShooter Pulse Generator circuit board. This may be accomplished by flipping the DIP switch S4-3 to OFF.

```
Setup Pressure Shut Off
-Pressure Shut Off [lbs] (8.0)…...:   8.0      New:
-Pressure Turn On [lbs] (10.0)....:   10.0     New:

Press a key to exit
```

9.2 - SYSTEM TESTING AND TUNING

9.2.1 - Service Troubleshooting

Capstan recommends a three-step process in servicing a SharpShooter and Rate Controller system:

1. Base-line the machine, regardless of the service issue, to eliminate any simple root causes and to ensure that any further evaluation is not compromised by the obvious.

2. Component trouble shooting.

3. Address the customer performance complaint by evaluating the known root causes of the possible performance issue and validating it through the Base-line testing.

With the SharpShooter, the primary service tool will be the sprayer itself and a simple multi-meter that can measure voltage and resistance.

9.2.2 - 6 Step Base-line Procedure

1. Track the supply voltage to the SharpShooter and Rate Controller through the fuses, starting at the battery and working toward the cab and boom.

2. Do a visual check of wire harness wear and connector integrity.

3. KEY: Verify the Rate Controller Calibration Numbers.

4. Check “Most Common” issues.

5. Do a like-component swap.

6. Verify SharpShooter programming with the Capstan Diagnostic Tool.

9.2.3 - Most common Issues

1. Strainer and Filter:

    - Verify the strainer and filter are clean and the flow direction arrow on the filter head is orientated correctly.

    - Verify the strainer is an 80 mesh strainer.

    - Verify that the strainer has not been crimped by improper installation. On a TeeJet filter, the strainer must first be installed and seated in the filter head. Then the filter cap is installed. If the strainer is installed in the cap first, it will not seat properly in the filter head.

NOTICE To ensure trouble-free usage, the filter and strainer must be cleaned at the end of every day.

2. Solenoid Assembly:

    - If the solenoids are stuck open or closed, then there has been either a filter failure or an incomplete cleansing after an application. Disassembly the solenoid and clean. Check the solenoid plastic for damage or an excessive wear groove and replace if necessary. Check the coil to 19-23 ohms specification.

    - If the solenoids are dripping, then either the filter has failed and debris is preventing the solenoid to completely close, or there is an O-ring failure, particularly the small O-ring on the tip of the solenoid.

3. Tips: Check for incorrect or damaged tips. The SR110 tips should be on the front row of solenoids. The MR110 tips should be on the rear or Boosted solenoids.

4. Pressure Sensor: Using the Pressure Breakout Harness, check the input voltage (12V) and the output signal (2.5V), when the SharpShooter is in the PWM Mode and adjusted to attain a boom pressure of 50 PSI (2.5V).

9.3 - TROUBLESHOOTING TESTS

The SharpShooter and the rate controller can be isolated from each for evaluation purposes. By putting the SharpShooter in the PWM (Manual) Mode, the rate controller can be evaluated independently The PWM Mode removes the automatic tip function and “locks in” a specific tip size (Duty Cycle).

Likewise putting the rate controller in the MANUAL Mode removes the automatic rate control by locking the flow control valve. The SharpShooter can then be evaluated independently.

The following tests will use this strategy to isolate key components:

9.3.1- SharpShooter Dry Test

This confirms that the Pulse Generator fuse is functioning, the rocker switch is functioning, and that power is being received by the circuit board.

1. Turn on the rate controller with the section switches ON and the Master Switch OFF.

2. **[Figure 29]** - Turn the SharpShooter Pulse Generator ① rotary switch to 50.

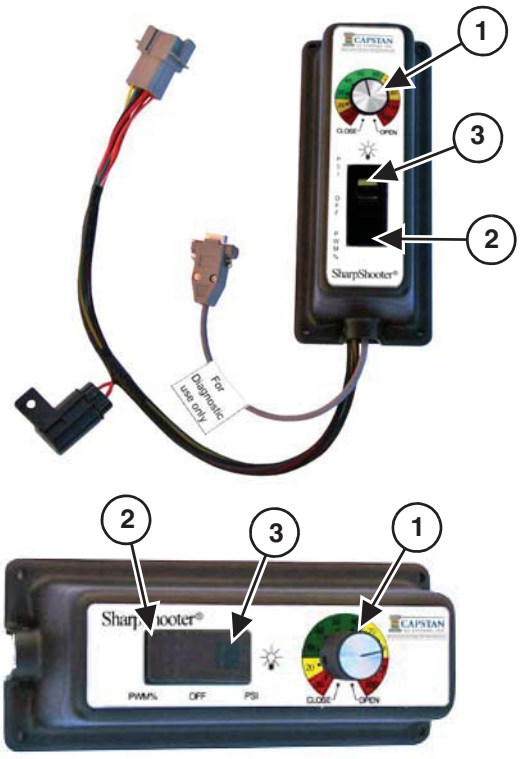
3. Place the SharpShooter Pulse Generator rocker switch in the ② PWM Mode.

4. Observe that the SharpShooter Pulse Generator ③ rocker switch light is flashing two times per second.

Service Actions:

1. If the SharpShooter Pulse Generator does not power on, check the fuse and/or trace the power from the battery. Check pins, connectors and wires for proper contact and/or damage

Figure 29: Pulse Generator Power Check



9.3.2 - SharpShooter Pulse Check and Boom Section Control Dry Test

This test verifies the pulse circuit is working, only the front row of solenoids activate in the PWM Mode, and that the SharpShooter solenoids match the rate control section switches

Verify that the SharpShooter solenoids match the rate controller section switches.

1. Turn the SharpShooter Pulse Generator rocker switch to the PWM (manual) Mode and rotate the dial to the 50% Duty Cycle.
2. Turn the Rate Controller ON and place the rate controller in MANUAL Mode. Verify the rate controller is in the MANUAL Mode.

NOTE: An advanced rate controller will require starting a job.

3. Toggle ON all the section switches.
4. Toggle ON the Master Switch.
5. Note that the FRONT row of solenoids ONLY should start clicking in the PWM Mode. The Boost or rear row of solenoids should not be clicking. If not, switch the harness pigtails so that only the front rows of nozzles pulse.
6. Set the Pulse Generator rotary dial to 100% duty cycle or OPEN. Solenoids should lock open and stop clicking.
7. Set the Pulse Generator rotary dial to 0% duty cycle or CLOSED. As you move from OPEN the solenoids should start clicking again. When you reach CLOSED the solenoids should lock shut and the clicking should again stop.

Service Actions - If all the solenoids do not start clicking or will not stop clicking:

a. If the solenoid pulse does not stop at 0% or 100% duty cycle, the dial or the pulse generator may have failed. Replace the pulse generator and return the faulty pulse generator for possible repair.
b. Check the fuses on the valve driver.
c. If the SharpShooter does not pulse. Test the Run/Hold +/- 12V signal in the rate controller harness to the Capstan Boom Section Adapter. If the signal voltages are correct, check that the Boom Section Adapter is connected to the signal pin of the harness. If correct, then trace the pulse circuit from the solenoids back through the valve drivers, power hub and to the source at the Pulse Generator. See this process in the component test section. Check component and connectors.

8. Toggle OFF all rate controller boom sections.
9. Toggle ON boom section 1.

NOTICE Solenoid valve on boom section 1 should start clicking. Some boom sections may have more than one solenoid assigned to it.

10. Repeat steps 6 and 7 for each boom section.

Service Actions:

If solenoid valves on a different boom section click on instead, the shutoff adapter is not properly connected to the appropriate rate controller harness boom section wires. Redo the connections until the proper section clicks.

9.3.3 - Wet Test 1 Flow Control

This test evaluates the rate controller flow control independent of the SharpShooter.

Fill the sprayer with at least 100 gallons of water for these tests.

1. Power up the SharpShooter Pulse Generator to the PWM Mode at 50% Duty Cycle. (This locks in a particular Duty Cycle or tip and removes the SharpShooter impact on flow).
2. Power up the rate controller to the AUTOMATIC Mode with all section switches ON and the Master switch OFF.
3. Set a test speed of 5.0 MPH and set the emergency brake to prevent movement that might reset the test speed to 0.0 MPH.
4. Check the rate controller on the UNITS selection. If TURF UNITS, set a rate of 1.5 gallons/thousand. If US UNITS, set a rate of 64 GPA.
5. Verify that any Chem Loader attachment valves are closed.
6. Turn on the sprayer product pump. Throttle the sprayer to maximum throttle.
7. Switch Master Switch to ON. Both rows of nozzles should begin to pulse and spray.
8. Once the spray stabilizes, note the resulting boom pressure. Increase or decrease the SharpShooter Duty Cycle (effective tip size) until the pressure is near 40 PSI.
9. Increase the rate to 2.0 gal/thousand or 84 GPA.
    a. Observe that the rate controller achieves that rate.
    b. Observe that the pressure increases beyond 40 PSI and stabilizes.
10. Decrease the rate to 1.0 gal/thousand or 42 GPA.
    a. Observe that the rate controller achieves that rate.
    b. Observe that the pressure decreases below 40 PSI and stabilizes.
11. Return the rate to 1.5 gal/thousand.
    a. Observe that the rate controller returns to 1.5 gal/thousand.
    b. Observe that the pressure returns to the original value.
12. If all performs as stated, then the rate control side, including the flow control valve, flow meter, pump and rate controller are all working. Now proceed to evaluate the SharpShooter, (9.3.4 - Wet Test 2 Pressure Control page 57).

Service Actions:

If the rate does not stabilize or achieve the target rate:

1. Verify that the rate controller speed calibration is set correctly and not to zero.
2. Verify that rate controller is getting a speed signal.
    a. If doing a static test, verify that the test speed did not go to 0.0 MPH. If so, reset the test speed.

b. If moving, verify that there is a GPS signal of adequate signal strength. You may need to move the sprayer away from buildings or from under trees. If the issue persists, contact your GPS dealer for support.

3. Verify that the pump is ON, the machine is at full throttle and valves for a Chem Loader attachment are closed.

4. If using a Test Speed, verify that the advanced rate controller boom section switches are switched to manual ON and not to ACCUBOOM (Raven SwitchPro) control.

5. You may have reached the pump output limit, if a newer pump, or if the pump is older and its performance is decreasing.

6. The BOOST feature may not be working. Verify that both rows of nozzles are spraying. If one row only is spraying, check the Duty Cycle. Increase either your speed or rate toward 80% Duty Cycle. At 80% Duty Cycle the BOOST nozzles should start spraying. Then decrease the Duty Cycle toward 20%. At 20% Duty Cycle the BOOST nozzle should stop spraying and the Duty Cycle should jump to 40% and then settle in at the appropriate Duty Cycle for that rate and speed.

7. Evaluate the pump impeller and pump bearing components. If the sprayer cannot achieve normally applied rates, speed or pressure, the issue is possibly a worn or damaged pump impeller.

   a. Lower the speed or rate and set if the applied rate is achieved. If so, check and service the pump impeller.

   b. You should also see plastic impeller debris in the filter.

   c. Bad pump bearings will cause rate instability.

8. Calculate theoretical flow (GPM) using the GPA or GPT rate, and the test speed.

   GPM = (GPA x speed x nozzle spacing x number of nozzles)/5940
   or
   GPM = (GPT x speed x nozzle spacing x number of nozzles)/136

   GPA = gallons per acre

   GPT = gallons per thousand square feet

Example: Rate of 1.0 GPT, (or 43.5 GPA) with a speed of 5 mph, 20” nozzle spacing and 11 nozzles.

GPM = 8.0 GPM = (1 x 5 x 20 x 11)/136

GPM = 8.0 GPM = (43.5 x 5 x 20 x 110/5940

9. Locate the rate controller screen/button with which you can observe the GPM flow reading as the machine sprays in the rate controller AUTOMATIC Mode. Adjust the SS Duty Cycle until a pressure of 40 PSI is achieved. Tips are rated at 40 PSI. This will allow the theoretical flow to better match the actual flow

10. Compare the theoretical flow with the rate controller value. Considering actual flow:

    a. If the GPM reading is unstable, switch the rate controller to the MANUAL Mode. This locks the flow control valve or PWM pump valve and isolates the flow meter.

    b. If the GPM stabilizes, the flow control valve or PUMP PWM control valve is likely defective.

    c. If the sprayer rate is unstable at ALL rates, speeds and pressures, the issue is likely the flow meter.

Further Flow Control Valve Evaluations:

1. For a centrifugal pump: With the engine off and rate controller ON and in MANUAL Mode, toggle the rate controller INC/DEC switch.

    a. Note if you can see or hear the flow control valve respond, then at least a voltage signal is getting to the valve from the rate controller.

2. Disconnect the flow control valve harness from the rate controller harness.

    a. Using a Voltmeter, this test should yield a +12/ -12 volt reading. If the voltage is not correct, the INC/DEC switch, Raven harness and connections should be evaluated. If no defect is found, then the rate controller itself needs to be repaired.

3. Test the flow control valve under load.

    Put the rate controller on and in MANUAL Mode, and the SharpShooter in the PWM Mode at 50% Duty Cycle. Turn on the pump and booms. Note the rate and pressure:

    a. Using the rate controller INC/DEC switch increase the flow and release the switch. The pressure should go up with the increased flow. Both the rate and pressure should stabilize.

    b. Decrease the flow and release the switch, the pressure should decrease. Both the flow and pressure should stabilize.

    c. Replace the flow control valve if it does not perform as stated.

4. The rate controller may work under load in MANUAL Mode, but not in the AUTOMATIC Mode. Using a test speed, set the sprayer up to begin spraying. In the AUTOMATIC Mode toggle the INC/DEC switch. Tap into the signal wire and again measure voltage to the control valve. If inadequate voltage, repair or replace the rate controller.

5. For PWM driven diaphragm pump:

    a. With the rate controller in the MANUAL Mode, check the harness to the PWM valve for a 0 to 12V signal. If no voltage occurs, check the rate controller harness and connectors for issues. Ultimately it could be an issue with the rate controller.

    b. With the rate controller in AUTOMATIC Mode with a test speed and spraying, toggle the INC/ DEC switch. Observe the pump shaft for related change in RPM. If shaft does not spin, then the issue is likely with the rate controller. If the shaft spins, but does not change in rpm with the INC/DEC, the issue could be either the PWM valve or the rate controller.

9.3.4 - Wet Test 2 Pressure Control

This test evaluates the pressure side control of the SharpShooter with the flow control held constant.

1. If not started already, power up the rate controller and put in the MANUAL Mode. This locks the flow control to a constant position. If not already, power up the SharpShooter and put the Pulse Generator in PWM mode at 50% Duty Cycle.
2. Set a test speed of 5.0 MPH, turn on the pump and section switches. Toggle the master switch to initiate boom spraying. Using the rate controller INC/DEC switch adjust the rate to an acceptable value. Allow the sprayer to get to a functional rate and pressure. The SharpShooter should be pulsing. Note the boom pressure.
3. Starting with the Pulse Generator at a 50% Duty Cycle:

    a. Increase the Duty Cycle. The pressure should decrease.

    b. Decrease the Duty Cycle. The pressure should increase.

    If so the SS MANUAL Mode is working. If not, the SS dial or switch may be defective. Otherwise, trace pulse circuit at the solenoid back through the valve drivers, power hub, connectors and to the Pulse Generator.

4. Put the Pulse Generator in the PSI Mode at 50 PSI.

    a. Increase the test speed to 7.0 mph. The pressure should increase. The SharpShooter should return the pressure to 50 PSI.

    b. Decrease the speed to 3.0 mph. The Pressure should decrease. The SharpShooter should return the pressure to 50 PSI.

Service Actions:

In the PSI mode, if the pressure does not return to 50 PSI:

Perform the following steps:

a. Verify that the pump is on and the machine is at full rpm.

b. Verify that the solenoids are not plugged

c. Using the TEST SPEED mode, verify that the boom section switches are set to Manual ON and not set to automatic section controls.

d. Verify that the Duty Cycle is changing. If the Duty Cycle is not changing:

i. Test the Pressure sensor for proper input and output signal voltages. (See pressure sensor tests on pages 72 and 73). Replace the pressure sensor if bad.

ii. Trace the SharpShooter pulse signal back from the solenoid pigtail harness back through the valve drivers and power hub back to the Pulse Generator. (See Component Testing on pages 67 thru 79).

9.3.5 - Test 3 Integrated Pressure and Flow Control

If both the flow and pressure independent tests were successful, this test evaluates if the rate controller and sharpshooter are working together to achieve both flow and pressure control.

NOTICE This integrated test can also be used as the SharpShooter DEMO. In this case use a TEST SPEED instead of actual speed.

INITIAL STEPS:

1. Fill the sprayer tank with about 100 gallons or more of water.
2. Start the sprayer and achieve a speed (TEST SPEED or ACTUAL SPEED) of 5.0 MPH If using a TEST SPEED, set the emergency brake.
3. Power up the SharpShooter Pulse Generator and select PSI Mode at 40 PSI.
4. Power up the rate controller in the AUTOMATIC Mode with all section switches in the MANUAL ON position and the Master Boom switch OFF.
5. Set a rate of 1.0 gallons/thousand if the rate controller is set to TURF UNITS, or 42 GPA if the rate controller is set to US UNITS.
6. Turn on the sprayer pump and switch the rate controller switch to ON. Watch the SharpShooter Duty Cycle as the sprayer achieves the target rate and pressure.

    a. If the Duty Cycle doesn't reach 80%, only one row of nozzles will be spraying.

    b. If the Duty Cycle passes 80%, then the BOOST nozzles will spray and the Duty Cycle will initially drop to 40% and then settle at the value needed for rate and speed to maintain the 40 PSI.

7. BOOST TEST:

    a. If both sets of nozzles are spraying, decrease the speed and rate until Duty Cycle approaches 20%. When you pass 20% the BOOST nozzles will stop spraying and the Duty Cycle will initially climb to 40% and then settle at the value needed for rate and speed to maintain the pressure set point.

    b. If only one row of nozzles is spraying, observe the Duty Cycle. Increase the speed and/or rate and watch the Duty Cycle. Once the Duty Cycle reaches 80% the BOOST nozzles should spray.

    c. In both cases the rate controller will be working to maintain the target rate and the SharpShooter will be working to maintain the set pressure.

    If the BOOST is not working, trace the BOOST signal back through the valve driver and power hub to the pulse generator. (See Component Testing on pages 67 thru 79).

8. FLOW INTEGRATION TEST:

    a. Set the sprayer to 1.5 gallon/thousand or 64 GPA, 5.0 MPH and 50 PSI.

    b. Using the rate controller INC/DEC switch, increase the target rate to 2.0 gallons/ thousand. As the rate controller changes the applied rate to match the target rate, observe the pressure and the SharpShooter Duty Cycle. The pressure will increase. The Duty Cycle will also increase to create a large effective tip size and consequently bring the pressure back to 40 PSI.

c. Using the rate controller INC/DEC switch, decrease the target rate to 1.0 gallons/thousand. As the rate controller changes the applied rate to match the target rate, observe the pressure and the Duty Cycle. The pressure will decrease. The Duty Cycle will also decrease to create a smaller effective tip size and consequently bring the pressure back to 50 PSI.

d. Return to 1.5 gallons/thousand or 64 GPA and go to the next test.

If the applied rate does not stabilize or meet the target rate, return to TEST 1.

If the pressure does not stabilize or return to the target pressure, return to TEST 2.

9. SPEED TEST:

a. Set the sprayer to 1.5 gallon/thousand or 64 GPA, 5.0 MPH and 50 PSI and start spraying.

b. Increase speed to 9.0 MPH. Note that the applied rate changes and the rate controller works to match the target rate. Note that the pressure decreases and the SharpShooter Duty Cycle increases to create a larger effective tip size to return the pressure to 50 PSI.

c. In the rate controller, decrease the test speed to 3.0 MPH. Note that the applied rate changes and the rate controller works to match the target rate. Note that the pressure increases and the SharpShooter Duty Cycle decreases to create a smaller effective tip size to return the pressure to 50 PSI.

10. PRESSURE TEST:

a. Set the sprayer to 1.5 gallon/thousand or 64 GPA, 5.0 MPH and 50 PSI and start spraying.

b. Decrease the pressure to 20 PSI, but don't change the speed. Observe the rate controller working to maintain the target rate as the SharpShooter Duty Cycle increases to a larger effective tip size to drop the pressure. This is the DRIFT CONTROL feature of the SharpShooter. NOTE the larger droplets size and reduced drift.

c. Increase the pressure to 60 PSI, but again do not change the speed. Observe the rate controller working to maintain the target rate as the SharpShooter Duty Cycle decreases to a smaller effective tip size to increase the pressure. NOTE the smaller droplet sizes and increased drift.

d. During a DEMO you might want to raise the boom to further illustrate the drift impact of the SharpShooter.

Service Actions:

a. During a DEMO, if the rate completely falls off, verify that the test speed did not go to zero. Bumping the machine can fool the rate controller that the machine is moving and will override the TEST SPEED.

b. At the top speed, if the applied rate cannot achieve the target rate, the pump capacity may have been exceeded. Decrease the speed until the applied rate matches the target rate.

c. At the top speed, the applied rate achieves the target rate, but the pressure exceeds the pressure set point, the Duty Cycle will read 100%. The tips will have reached their limit and further speed will cause the pressure to increase. Unless there are drift concerns, it is still OK to spray.

9.3.6 - Test 4 Immediate ON/OFF

This test evaluates the solenoids ON/OFF response over the whole boom and by boom sections.

Perform the following steps:

1. Start the sprayer with about 100 gallons of water.
2. Power up the SharpShooter Pulse Generator and place the rocker switch to the PSI Mode at 50 PSI.
3. Power up the rate controller to 1.0 gallons/thousand or 42 GPA with the boom section switch ON and the Master boom switch OFF.
4. Turn on the pump and increase the engine to full rpm.
5. Achieve a speed (Actual or TEST) of 4 MPH.
6. Allow the booms to charge and the machine to settle in on the target rate and pressure.

TOTAL BOOM ON/OFF:

7. Turn the Master Switch OFF. Note that the nozzle solenoids stop spraying immediately. The pressure climbs to either the preset agitation value (typically 60-70 PSI), or the pump dead-head pressure depending on the particular sprayer.
8. Turn the Master Switch ON. Note that the nozzles start spraying immediately. The SharpShooter works the Duty Cycle to return the pressure to the target value. The rate controller works to return the rate to its target value.

INDIVIDUAL NOZZLES:

9. Repeat this test with one section at a time.
10. You will notice that the speed by which individual nozzles achieve rate when turned OFF or ON will affect the applied rate recovery to the target rate.

NOTICE The flow control valve is the limiting factor to the applied rate achieving and maintaining the target rate. Depending on how large the target rate is, the boom can be quickly depleted of liquid before the flow control valve can open far enough. To optimize its response, proceed to the Rate Optimization Test.

11. If all performs well, proceed to (9.3.7 - Test 5 Rate Optimization page 61).

Service Actions:

a. Check for any nozzles that are dripping.
   i. Check for debris keeping the plunger open.
   ii. Check for a damaged O-ring at the tip of the solenoid.
b. Check for plugged or damaged filter.
c. Slow flow recovery could also be systematic of a damaged flow control valve. See 9.3.3 - Wet Test 1 Flow Control on page 54.
d. Proceed to Test 5 Rate Optimization.

9.3.7 - Test 5 Rate Optimization

This test tunes the rate controller and SharpShooter operating parameters for optimum performance.

NOTICE Most of the 300 gallon sprayers have pumps and performance is optimized at 50 PSI. Different units may have a different optimum pressure.

NOTICE The sprayer must be running and spraying to affect this test protocol.

Perform the following steps:

For a PWM Drive Pump with 2 PWM Settings:

1. In the rate controller you will most likely find a MAX PWM value of 253 and a Minimum PWM value of 1.
2. The minimum PWM value needs to be set near 60, OR the value that makes the pump to rotate.
3. Typically there is also a choice of two Valve Types:
    a. PWM Valve: In this case when the boom is shut off, the pump operating PWM value drops to the minimum PWM value. This valve type creates an issue for diaphragm pumps if there is no pressure relief circuit to limit the pressure build up past 70 PSI or so.
    b. PWM Close Valve: In this case when the boom is shut off, the pump stops. This creates a large issue for consistent spraying and from spraying from a dead stop. It is done to prevent a diaphragm pump from continually building pressure that could ultimately burst hoses, etc. This is overcome by continually using an agitation circuit as a pressure relief circuit. Therefore the rate controller will have a Preset Agitation PWM setting to maintain a 60-70 PSI agitation pressure when the booms are off. Often users think the Preset Agitation is a pressure and set it too low. That PWM value is typically around 100 to achieve a 60-70 agitation pressure.

Advanced Rate Controllers with 3 PWM values:

The 3 PWM values are: Maximum (253), Minimum (~60) and Pre-Set which is a value you may want to change depending on a green, tee or fairway application. In general this is the value the PWM goes to when the booms stop spraying. The smaller the difference between the operating PWM value and the Preset Value is, the more optimum the sprayer response and performance.

To determine the Preset PWM value:

1. Find the location in the rate controller where you can monitor the PWM value while spraying.

    a. On fairways, using the maximum speed (typically 8-9 MPH) and your rate will determine the operating PWM value that determines the Preset Value you want to use. With any Preset Value you use, check the "boom-off" pressure. It should not exceed 100 PSI. If the pressure is too high, the Preset PWM will have to be lowered.

    b. Do the same with the greens and tees. Given that the rates are higher and speeds are lower for greens, it would not be unusual for the two PWM values to be close.

    c. If these two values are different, you consider editing the Preset Value for the two applications.

    The object is the minimize the recovery time of the pump to resupply the boom when changes to speed, boom section or rate occurs.

    In both cases above, it is then possible to adjust the rate controller valve calibration for a faster response, but yet stable response.

Engine Driven Centrifugal Pump with Inline Flow Control Valve:

1. Tune the valve calibration from 2123.
2. Try varying the second digit from the right "2" (deceleration timing). The larger lengthens time and is more stable. Try 2133, or 2143.
3. Then increase the third digit from the right "1" (velocity of change) one number at a time. Increasing the number makes the valve respond faster. For example: Change to 2143 to 2243, or 2343.
4. Test each setting for the balance of speed and stability. Typically when you increase the speed, you also need to increase the deceleration time.

SharpShooter Performance Optimization:

Timing and speed of control helps reduce issues with dead stop spraying, boom section changes and dramatic speed changes, that can affect application quality.

There are generally 3 parameters that are effective in tuning the SharpShooter control relative to a rate controller. All three are accessible via the MENU toggle:

1. Run/Hold Parameter: This value allows the rate controller to stabilize before the SharpShooter begins to control pressure. This delay (Hold) period prevents instability as the rate controller and the SharpShooter work to control rate and pressure, respectively.

    a. The default value is 3000 milliseconds or 3 seconds.

    b. Decreasing that time allows the SharpShooter to start controlling the pressure sooner.

    c. In most cases this value can be dropped to 125 to 150 milliseconds or 0.125 to 0.150 seconds.

    d. The new setting should be tested to make sure it does not cause the rate controller to become unstable.

2. System Gain: The value affects the response time of the SharpShooter to changes in pressure. The system gain changes two values (P gain and I gain) proportionally. The higher the number the quicker the response. Again any change to this value should be tested to avoid rate instability.

3. P gain: This value is addressed after the System Gain is optimized.

General Spray Operation Strategies:

Spray performance is more consistent when the flow control valve moves less in response to a change.

1. If the “Entry Speed” of a spray pass can be kept the same an the “Exit Speed” of the previous pass, the flow control valve does not need to move. Result: Less under or over application.

    a. Determine a comfortable “Turning Speed” as you target exit and entry speed between passes. Typically this is 5-6 MPH. Fairway speeds can be as high a 7-12 MPH. So the strategy is to slow down to the comfortable turning speed as you exit a pass and maintain that turning speed as you start the next pass.

2. Smaller areas are more challenging than larger areas. So to minimize flow control changes, it is best to spray greens and tees at a constant speed of 3-4 MPH.

3. The SharpShooter provides the option to turn the BOOST OFF if the operating Duty Cycle does not exceed 100%. This may be desirable when spraying greens or tees.

4. Boom section changes work the flow control valve. The largest challenge is going from a full boom to one nozzle spraying and vice versa. An experienced operator can manage these large swings in the number of sections spraying.

5. Dramatic speed changes work the flow control valve. Smooth speed changes are best to eliminate under or over applications.

9.4 - SWAPPING COMPONENTS

SharpShooter Turf systems are comprised of a number of components. Some of these components are used in multiples. Components with multiple usage are:

- Nozzle Valves.
- Valve Drivers.

When troubleshooting failed components, it can be helpful to swap the failed part with a working part at another location. If the problem follows the failed part to the new location, repair or replace the failed part.

If the problem does not follow the failed part, then the problem is likely elsewhere in the system and other troubleshooting means may be followed.

NOTICE Use caution when swapping failed components as in rare cases the failed component may cause other components to fail at the new location.

9.5 - COMPONENT EVALUATION

9.5.1 - Fuses

Blown fuses are indicators of a short or overload condition. Therefore, never replace a fuse with a larger fuse. Larger fuses may result in costly component failures.

9.5.1.1 - OEM Turf SharpShooter System Fuse Location

FUSE LOCATION	RATING	TYPE	COLOR
Power Harness	5A	ATO/ATC	TAN
Pulse Generator	10A	ATO/ATC	Red
Valve Drivers	10A	ATO/ATC	Red

NOTICE On OEM ***factory-installed*** units, the battery wire fuse may be located in a sprayer fuse bus instead of in the wire itself. See page 17 to view the factory-installed Power Harnesses.

9.5.1.2 - Turf Aftermarket Systems (Outside of SharpShooter) Fuse Location

FUSE LOCATION	RATING	TYPE	COLOR
Battery Power Cable	30A	ATO/ATC	Green

NOTICE On ***Aftermarket-installed*** units, the battery power cable with 30A fuse is required for aftermarket installations of advanced rate controllers and does not plug directly into the SharpShooter System. (See page 20 to view the aftermarket-installed Battery Power Harnesses).

9.5.2- Nozzle Valves

Plugged nozzle valves can be classified into two categories:

- Plunger blockage.
- Plunger stuck.

[Figure 30] - Plunger blockage results when larger debris catches between the ① orifice and ② plunger seal. This is the smallest flow passage within the nozzle valve.

Stuck plungers result when smaller debris collects around the ③ plunger barrel and binds the plunger in place.

Symptoms of a blocked or stuck plunger are:

- No spray.
- Constant spray.
- Dripping when the nozzle is shut off.

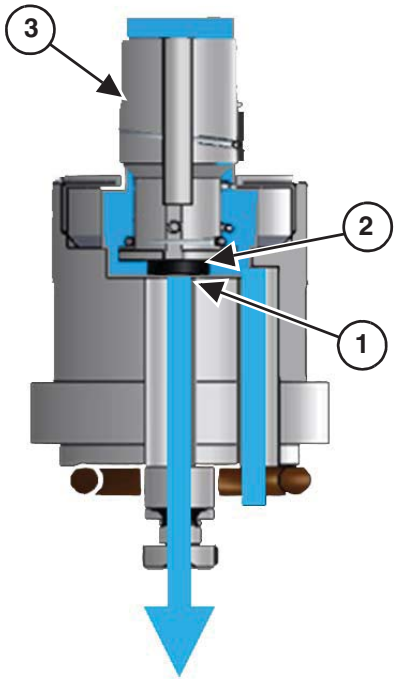
NOTICE Pinched or split O-rings will also cause nozzles to drip when shutoff.

NOTICE Operating a plugged nozzle valve for extended periods of time may result in a nozzle valve coil failure. Clean any plugged nozzle valves immediately.

NOTICE If plugged nozzles are a frequent problem in a particular boom section, inspect the machine's boom filter screens for plugged or damaged screens. An 80-mesh screen is recommended to prevent nozzles from plugging. Check the mesh size of the strainers and replace strainers if they are too coarse.

NOTICE Before removal or installation of the nozzle valves, make sure that the pressure has been released from the boom tubes.

Figure 30: Nozzle Valve Debris



9.5.3 - Nozzle Valve Cleaning

WARNING

CHEMICAL RESIDUES MAY BE PRESENT IN THE EQUIPMENT. RELEASE PRESSURE ON THE BOOMS BEFORE SERVICING. RINSE THE SYSTEM WITH CLEAN WATER PRIOR TO INSTALLING OR SERVICING FITTINGS, HOSES, VALVES, OR NOZZLE VALVES. USE PROPER PPE AT ALL TIMES TO AVOID PERSONAL INJURY.

[Figure 31] - Rotate the ① coil CCW to remove it from the ⑤ valve body. Remove the ② plunger from the coil. Inspect the ③ O-ring on the coil and inspect the ⑥ O-ring and ⑦ O-ring on the valve body.

NOTICE Remove debris from the nozzle valve components items 2 thru 7 by washing with clean water.

Inspect the plunger for wear or damage, see page 67. Replace the plunger if it is worn or damaged.

Inspect the valve body. Make sure the orifice is not plugged with debris, worn or damaged. If orifice is worn or damaged replace valve body.

NOTICE Apply 40 in-lbs of torque to the ① coil when it threads into ⑤ valve body to properly seat the O-ring (Item 3).

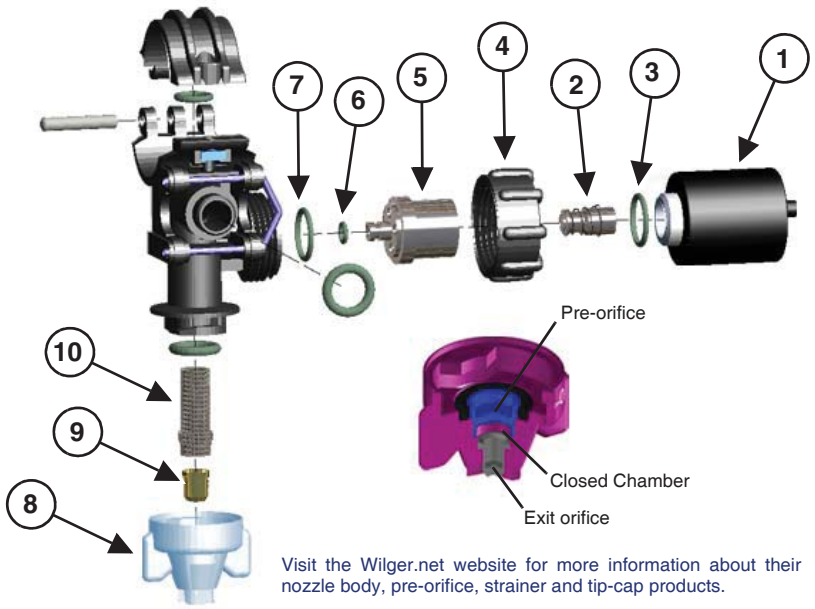
[Figure 31] - Remove the ⑧ tip-cap, ⑨ pre-orifice and ⑩ strainer.

NOTICE Remove debris from the Wilger nozzle body components items 8 thru 10 by washing with clean water. Replace any worn or damaged parts. (See Wilger.net for items 9 and 10).

Figure 31: Nozzle Valve Cleaning

ITEM	DESCRIPTION
1	Coil
2	Plunger
3	O-ring, Viton, -015
4	Flynut
5	Valve Body
6	O-ring, Viton, -008
7	O-ring, Viton, -016
8	Tip-cap, see page 21.
9	Pre-Orifice, see Wilger.net
10	Strainer, see Wilger.net

NOTE: See 3.13 - Nozzle Valve Assembly on page 21 for part numbers.



Visit the Wilger.net website for more information about their nozzle body, pre-orifice, strainer and tip-cap products.

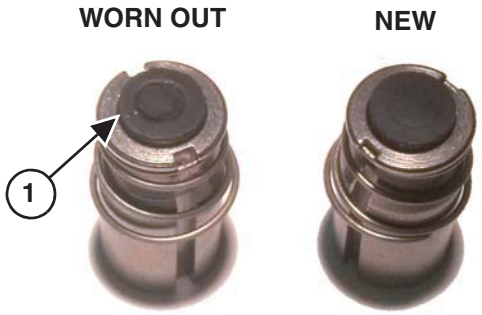
9.5.4 - Plunger Seal Inspection

[Figure 32] - After extended use the soft plunger seal will wear a groove where the seal impacts the hard orifice seat. Replace plunger if worn or damaged.

As the groove deepens the pressure capacity of the valve will decrease, until the pressure capacity interferes with the operating pressure of the SharpShooter system. The result is erratic pulsing, often described as “flickering”.

The SharpShooter system will operate normally at lower pressures until replacement parts can be acquired. High operating pressures and abrasive chemicals will accelerate the wear of the plunger seal material.

Figure 32: Plunger Seal Inspection



9.5.5 - Coil Failure Test

Coil failures are often the result of two factors:

1. Extended valve use with a plugged nozzle.
2. Extended use in corrosive environments.

NOTICE

Capstan recommends cleaning any plugged nozzle valves immediately. Capstan also recommends rinsing the inside of the Turf system with clean water and washing the outside of the coils with clean water as often as practical.

Disconnect the nozzle valve from the nozzle harness pigtail (connector) by unplugging the 2-pin Packard connector which is located on the spray boom.

[Figure 33] - Use a voltmeter to measure the ohms of resistance across pins A and B on the nozzle valve connector.

- 7 watt valve resistance of 21-23.5 ohms.

If proper resistance is not found:

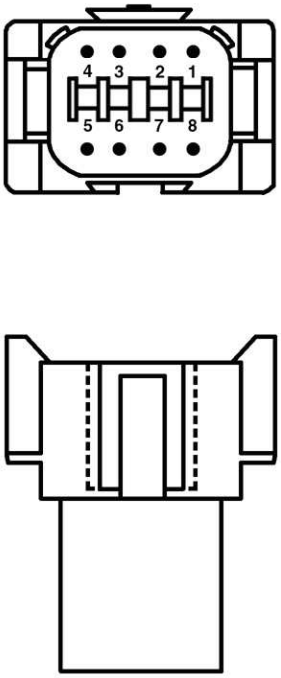
- Clean the connector terminals.
- Replace the coil.

Figure 33: Voltmeter Coil Check

9.5.6 - Pulse Generator Pinout Identification

1. POWER
2. GROUND
3. PSI
4. EVEN
5. ODD
6. RUN / HOLD
7. PSI POWER
8. BOOST

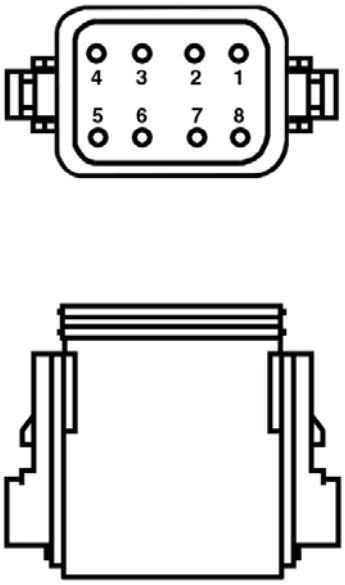
Figure 34: Pulse Generator Pinout Identification



9.5.7 - Valve Driver Pinout Identification

1. POWER
2. GROUND
3. BOOST
4. EVEN
5. ODD
6. RUN / HOLD
7. EVEN OUT
8. ODD OUT

Figure 35: Valve Driver Pinout Identification



9.5.8 - Battery Voltage Check

Disconnect the Pulse Generator from the Power Hub harness by disconnecting the 8-pin Deutsch connector. The connector is generally located in the cab.

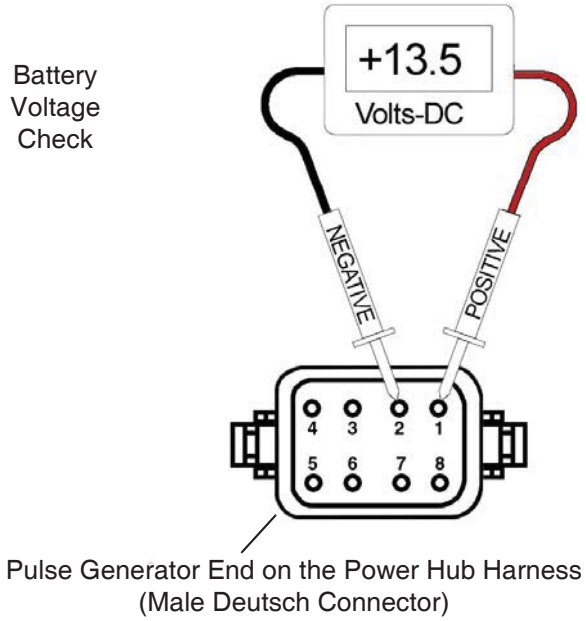
[Figure 36] - Use a voltmeter to observe that there is 13.5 VDC between pins 1 and 2 with the engine running, or 12.0 VDC without the engine running.

Be sure that the polarity is accurate by observing the positive voltage when the red (positive) probe is connected to pin 1 and the black (negative) probe is connected to pin 2.

If no voltage is present:

- Check the 30A fuse located at the sprayer fuse panel.
- Check the Power Hub battery connections.
- Check the condition of the battery.
- Check the condition of the alternator.

Figure 36: Battery Voltage Check



9.5.9 - System Load Capacity Check

Disconnect the nozzle valve 2-pin connector that is located on the spray boom farthest from the battery.

Turn OFF the SharpShooter Pulse Generator, and then turn ON all boom sections.

Start the engine and turn ON all electrical loads including air conditioning, foam markers, monitors, etc.

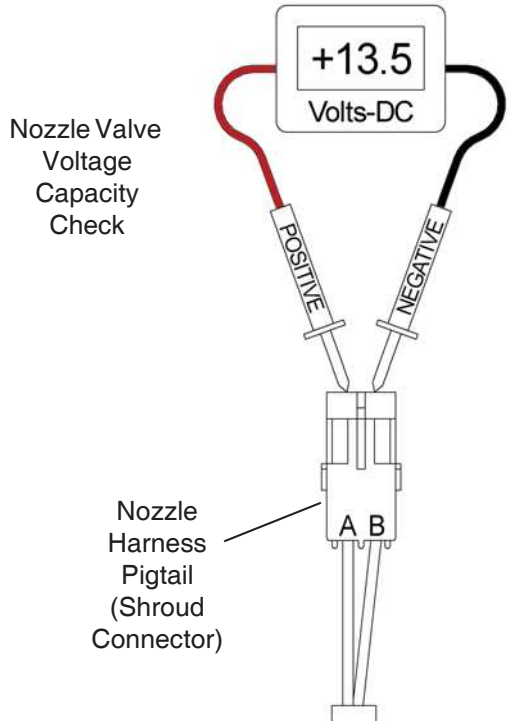
[Figure 37] - Use a voltmeter to observe the system voltage between pins A and B.

The SharpShooter nozzle valves operate best at 12 VDC or higher. Using less than 12 VDC will result in reduced pressure capacity. This will often result in erratic nozzle pulsing, sometimes described as “flickering”. Also, check nozzle valves for worn plunger seals. See 9.5.4 - Plunger Seal Inspection on page 67.

If low voltage is observed:

- Check and clean the battery terminals.
- Check the battery condition.
- Check the alternator condition.
- Check the condition of connections.

Figure 37: System Load Capacity Check



9.5.10 - Valve Driver Voltage Check

Disconnect the Valve Driver from the Power Hub harness by disconnecting the 8-pin Deutsch connector. The connector is generally located at each boom section.

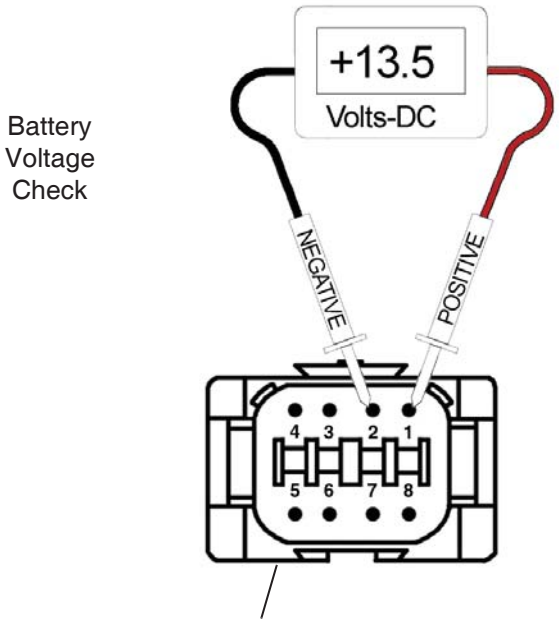
[Figure 38] - Use a voltmeter to observe that there is 13.5 VDC between pins 1 and 2 with the engine running or 12.0 VDC without the engine running.

Be sure the polarity is accurate by observing the positive voltage when the red (positive) probe is connected to pin 1 and the black (negative) probe is connected to pin 2.

If no voltage is present:

- Check the 30A fuse located at the sprayer fuse panel.
- Check the Power Hub battery connections.
- Check the Power Hub Valve Driver extension connection.
- Check the condition of the battery.

Figure 38: Valve Driver Voltage Check



9.5.11 - Boost Valve Driver Check

Boost function failures are usually exhibited by:

- Does not function at all
- Turns on at low speed and off at higher speed

Tests:

First check the non-boosted tip. If SR110-06 tips are being used for spraying rates consistently below 1.0 gal/1000, the boost may not come on. Raise the rate to greater than 1.0 gal/1000 and set a test speed of 5 MPH. The boost, if working should start. Otherwise:

With the serial test cable and the Capstan diagnostic tool, switch the SharpShooter to the PWM mode. Check to see that switch 4.4 is OFF. If necessary, remove the Pulse Generator cover and check Switch 4 and position 4. If it is already OFF, check for any physical damage to the switch.

Then switch to the PSI mode that exhibits scrolling date. Press "m" for the programming menu item. Select (f) flow parameters and check ALL the boost parameters for Boost Nozzle Size, Tip Size and Timeout values. Especially make sure the Boost Nozzle Pulse is enabled and the Boost Polarity is set on LOW.

Check the connection between the power hub and the valve driver. The power hub has two connectors that connect to the valve drivers. One connector has an additional wire (orange) which carries the boost signal voltage. Determine if there is a 12 V signal from the pulse generator through the power hub. If there is no signal:

- Check pins for improper contact or a bad harness wire.
- Swap valve drivers to see if the problem is corrected. Replace bad valve driver.
- The last option is to replace the pulse generator.

9.5.12 - Pressure Sensor Signal Check

Disconnect the pressure sensor from the pressure sensor harness. Connect one end of the pressure sensor breakout harness diagnostic tool into the pressure sensor shroud connector. Connect the other end into the pressure sensor harness tower connector.

NOTICE Make sure the Breakout Harness Diagnostic Tool is properly connected between the Pressure Sensor shroud connector and the Pressure Sensor harness tower connector. (See Figure 39).

NOTICE A poorly connected diagnostic tool is a frequent issue when trying to obtain voltage readings.

With the engine running and the pump turned on, use the rate controller to establish 40 PSI on the pressure gauge.

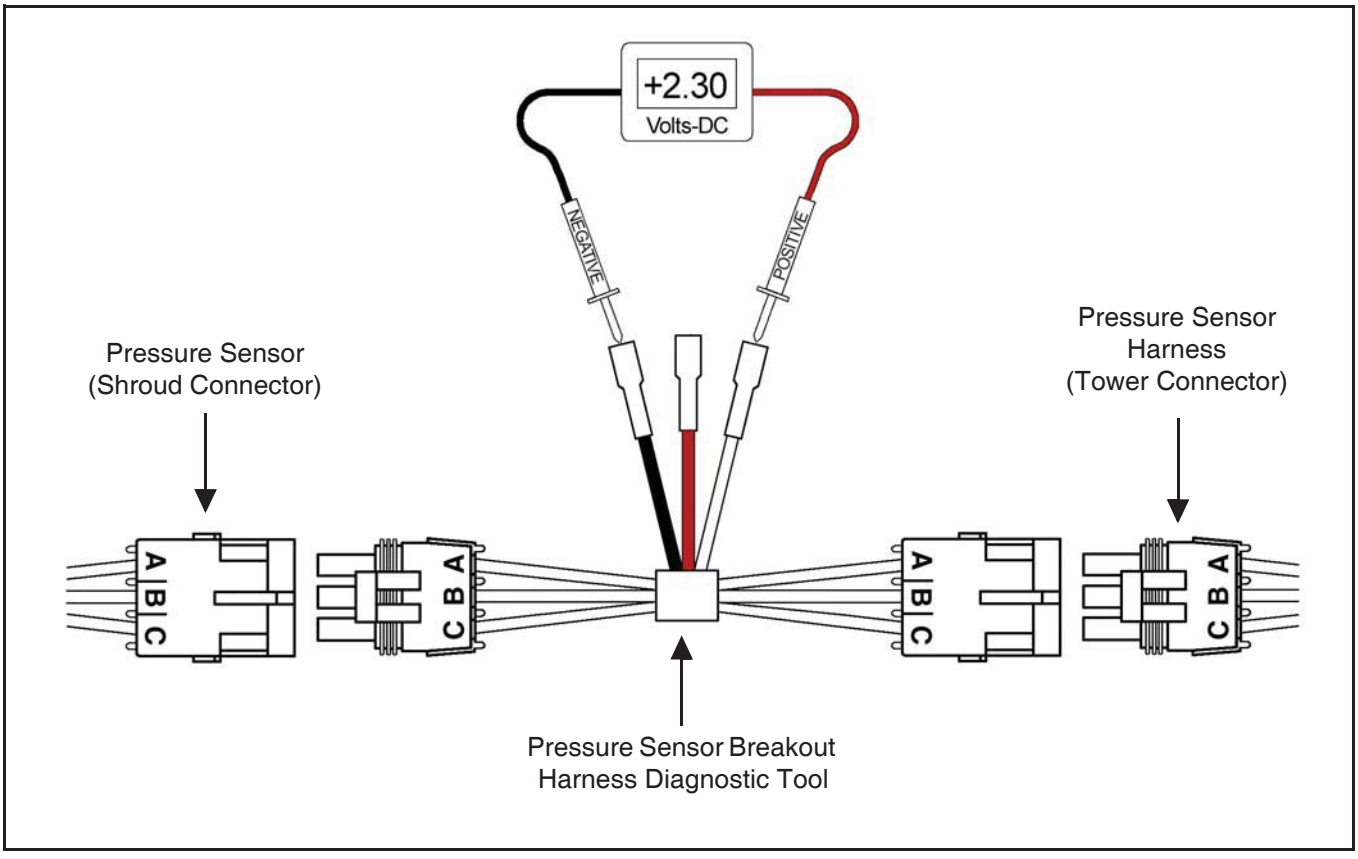
[Figure 39] - Use a voltmeter to observe that there is 2.30 VDC between the Black and White wire on the pressure sensor breakout harness.

Using the rate controller, adjust the pressure. Increasing the pressure should result into a higher output signal on the voltmeter (up to 5.0 VDC at 100 PSI). Decreasing the pressure should result in a lower output signal (down to 0.5 at 0 PSI).

If accurate voltage is not present:

- Verify the accuracy of the pressure gauge.
- Check for power to the pressure sensor. See 9.5.13 - Pressure Sensor Input Power Check on page 73.
- Replace the pressure sensor.

Figure 39: Pressure Sensor Signal Test



9.5.13 - Pressure Sensor Input Power Check

Disconnect the pressure sensor from the pressure sensor harness. Connect one end of the pressure sensor breakout harness diagnostic tool into the pressure sensor shroud connector. Connect the other end into the pressure sensor harness tower connector.

NOTICE Make sure the Breakout Harness Diagnostic Tool is properly connected between the Pressure Sensor shroud connector and the Pressure Sensor harness tower connector. (See Figure 40).

NOTICE A poorly connected diagnostic tool is a frequent issue when trying to obtain voltage readings.

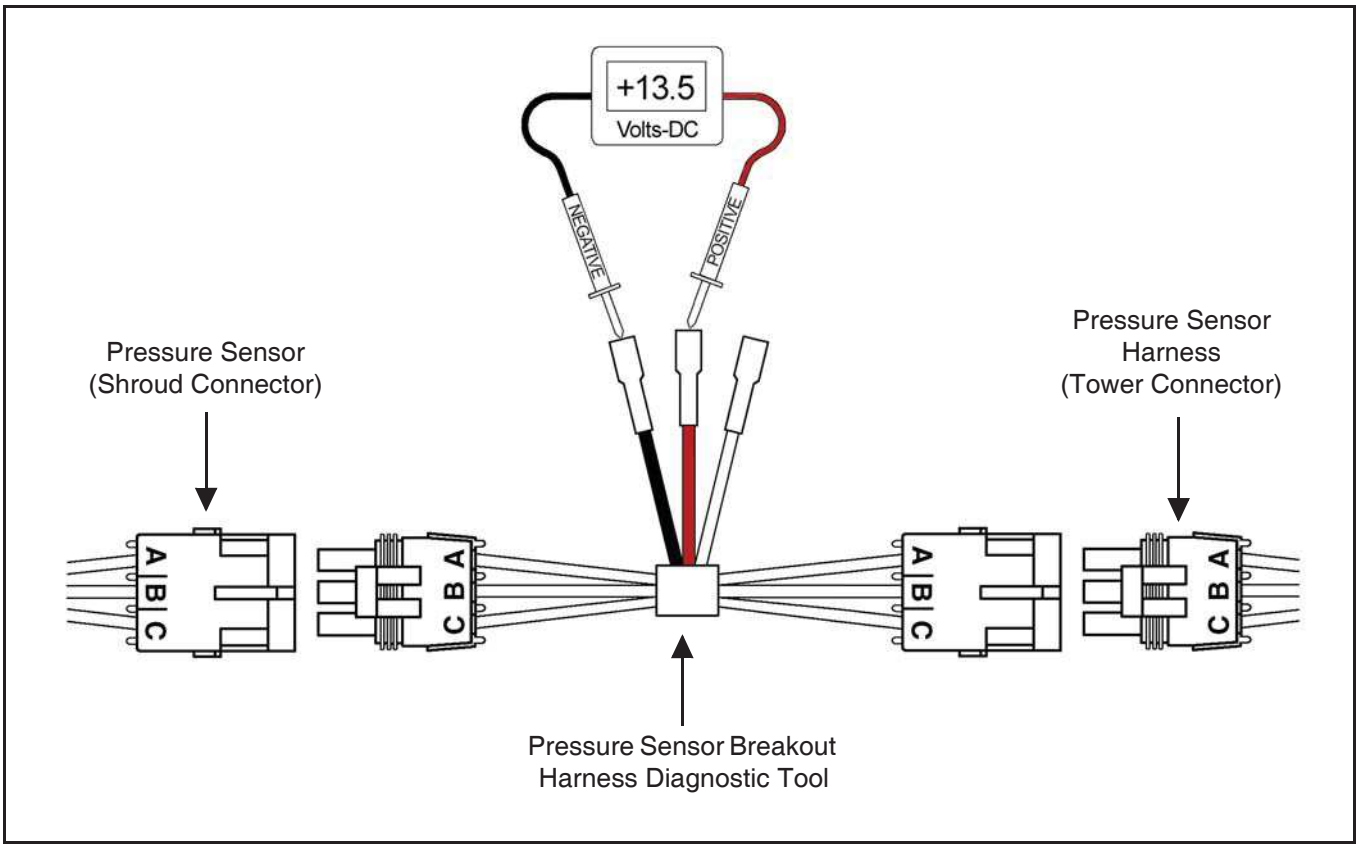
[Figure 40] - Use a voltmeter to observe that there is 13.5 VDC between the Red and Black wire on the pressure sensor breakout harness with the engine running, or 12.0 VDC without the engine running.

Be sure the polarity is accurate by observing that there is positive voltage when the Red (positive) probe is connected to Red pressure sensor breakout harness wire and the Black (negative) probe is connected to Black pressure sensor breakout harness wire.

If no voltage is present:

- Check the fuse located at the battery.
- Check the battery connections.
- Check the condition of the battery.
- Check the condition of the alternator.

Figure 40: Pressure Sensor Input Power Check



9.5.14 - Pulse Generator Output Check

Disconnect the Valve Driver from the Power Hub harness by disconnecting the 8-pin Deutsch connector. The connector is generally located on the center boom section.

Place the Pulse Generator in the PWM mode and then select 70 on the rotary switch. The rocker switch light should flash two times per second.

[Figure 41] - Use a voltmeter to observe that there is 4.05 VDC between pins 2 and 4.

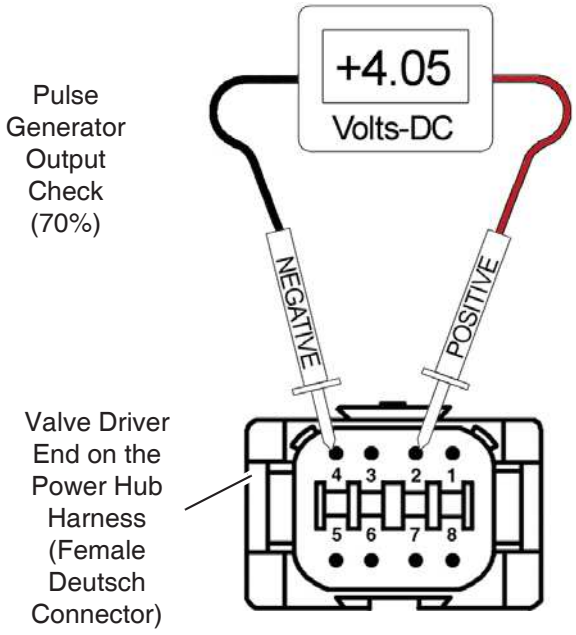
Most voltmeters measure signal as 12 VDC 10 Hz square wave which is a low voltage. In addition, the signal is inverted, so the 70% Duty Cycle selected on the knob will actually be a 30% duty signal at the Valve Driver. Measurements may vary depending on the voltmeter used. This tests the even pulse.

Make the same measurement between pins 2 and 5. This tests the odd pulse.

If accurate voltage is not found:

- Check the Valve Driver extension connections.
- Check the Pulse Generator extension connections.
- Check the Pulse Generator serial diagnostics.

Figure 41: Pulse Generator Output Check



9.5.15 - Valve Driver Output Check

Disconnect the desired nozzle valve 2-pin connector from the nozzle harness pigtail (connector) located on the spray boom.

Place the SharpShooter Pulse Generator in the PWM mode and select 70 on the rotary switch. The rocker switch light should flash two times per second. Turn ON the boom section, corresponding to the nozzle harness pigtail (connector) being tested.

[Figure 42] - Use a voltmeter to observe that there is 9.5 VDC between pins A and B.

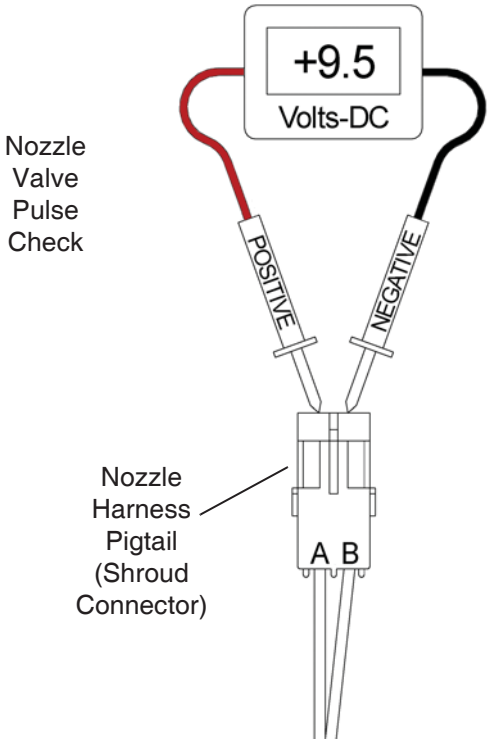
Most voltmeters measure signal as 12 VDC 10 Hz square wave which is a low voltage. Measurements may vary depending on the voltmeter used. Note the color of the wire in position B as either White or Green.

Make the same measurement on an adjacent nozzle harness pigtail shroud (connector). The wire color in position B should change from White to Green or from Green to White.

If accurate voltage is not found:

- Check the Nozzle harness extension connections.
- Check the Valve Driver extension connections.
- Check the Pulse Generator extension connections.
- Check the Pulse Generator serial diagnostics.

Figure 42: Valve Driver Output Check



9.5.16 - Valve Driver Input Check

Disconnect the Pulse Generator from the Power Hub harness by disconnecting the 8-pin Deutsch connector.

Start the engine, turn ON the pump and boom, then use the spray rate controller to establish 40 PSI on the pressure gauge. The boom should now be spraying.

[Figure 43] - Tap a jumper wire, several times per second, between pins 1 and 4 on the Power Hub harness 8-pin Deutsch connector. Observe that every even nozzle valve turns off as the jumper connects and turn on as the jumper disconnects.

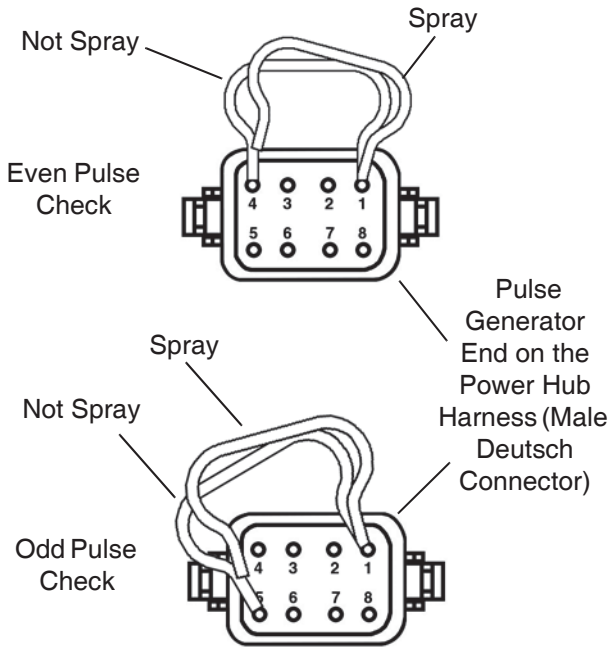
Tap a jumper wire, several times per second, between pins 1 and 5 on the extension harness connector. Observe that every odd nozzle valve turns on as the jumper connects and turn off as the jumper disconnects.

Observe the nozzle pulsing on each boom section.

If the boom sprays, but does not pulse, when the jumper wire is tapped:

- Check the Power Hub Pulse Generator extension connection.
- Check the Valve Driver extension connections.

Figure 43: Valve Driver Input Check



9.5.17 - Boom Shutoff and Run / Hold Signal Test

Disconnect the Pulse Generator from the Power Hub harness by disconnecting the 8-pin Deutsch connector.

Start the engine, then turn ON the pump and turn OFF the boom, then use the spray rate controller to establish 40 PSI on the pressure gauge. The boom should NOT be spraying.

Turn ON boom section number one to observe that the nozzle valves on boom section number one turn on and spray fully open.

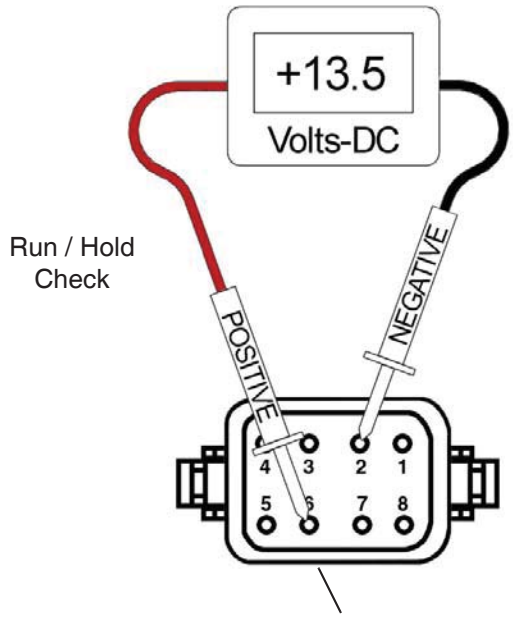
[Figure 44] - Use a voltmeter to observe that there is 13.5 VDC between pins 1 and 6 with the engine running, or 12.0 VDC without the engine running.

Turn OFF boom section number one and then observe the spray and voltage disappear. Repeat the test on remaining boom sections.

If no spray or voltage is observed:

- Check the boom shutoff adapter connections.
- Check the boom shutoff extension connections.
- Check the Valve Driver extension connections.

Figure 44: Boom Shutoff and Run / Hold Test



Pulse Generator End on the Power Hub Harness
(Male Deutsch Connector)

9.5.18 - Valve Driver Shutoff Signal Test

Disconnect the Valve Driver from the Power Hub harness by disconnecting the 8-pin Deutsch connector. The connector is generally located on the center boom section.

Turn ON the boom shutoff switch that corresponds with the Valve Driver extension being tested.

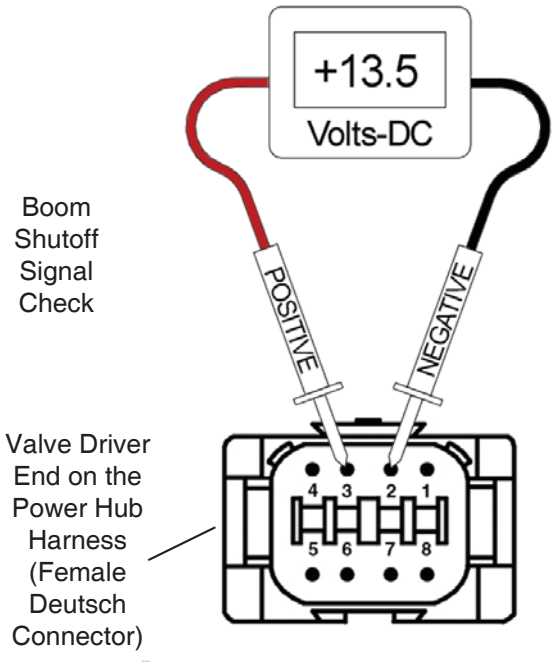
[Figure 45] - Use a voltmeter to observe that there is 13.5 VDC between pins 2 and 3 with the engine running or 12.0 VDC without the engine running.

Turn OFF the boom shutoff switch to observe the voltage disappear.

If no voltage is present:

- Check the boom shutoff adapter connections.
- Check the boom shutoff extension connections.
- Check the Power Hub Valve Driver extension connection.
- Check the boom shutoff switches.

Figure 45: Valve Driver Shutoff Signal Test



9.5.19 - Rocker Switch

Remove the Pulse Generator cover by removing the four corner screws. Disconnect the rocker switch from the circuit board by disconnecting the 8-pin connector.

[Figure 46] - Place the rocker switch in the OFF mode. Use a voltmeter to verify that there is no continuity between connector pins 7 and 8 (switch terminals 1 and 5) or between connector pins 6 and 7 (switch terminals 5 and 6). Verify that there is approximately 19 ohms resistance between connector pins 1 and 2 (switch terminals 7 and 8) **[Figure 46]**.

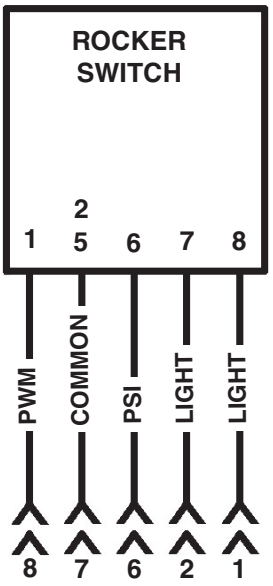
Place the rocker switch in the PWM mode. Use voltmeter to verify that there is continuity between connector pins 7 and 8 (switch terminals 1 and 5).

Place the rocker switch in the PSI mode. Use a voltmeter to verify that there is continuity between connector pins 6 and 7 (switch terminals 5 and 6).

If the switch does not function properly:

- Replace the rocker switch and connector assembly.

Figure 46: Rocker Switch



9.5.20 - Rotary Switch

Remove the Pulse Generator cover by removing the four corner screws. Disconnect the rotary switch from the circuit board by disconnecting the 14-pin connector.

[Figure 47] - Rotate the rotary switch to the OPEN position. Use a voltmeter to verify that there is continuity between connector pins 1 and 14 (switch terminals A and 1).

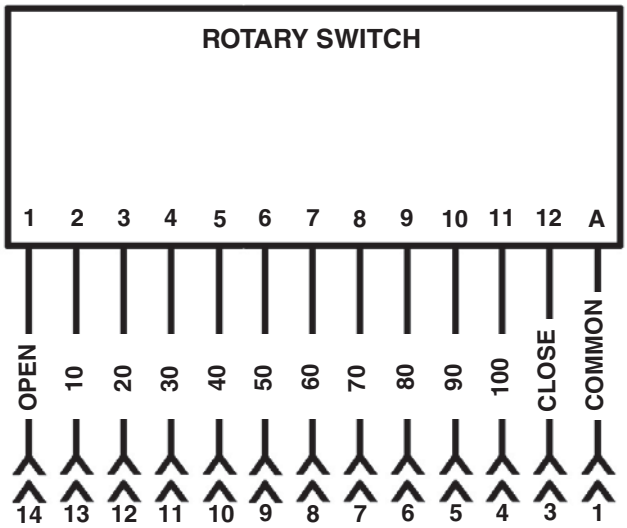
Rotate the rotary switch to the 10 position. Use a voltmeter to verify that there is continuity between connector pins 1 and 13 (switch terminals A and 2).

Use the diagram above to check each position of the 12-position rotary switch.

If the switch does not function properly:

- Replace the rotary switch and connector assembly.

Figure 47: Rotary Switch



9.5.21 - Rate Controller Troubleshooting

Basic Rate Controller

Symptom: Under Application

1. Tips too small.
   - Verify that all nozzle valves have correct tips, and are the correct size.
   - Verify the low rates with a Wilger Quick Calibrator or with a catch / time test at each nozzle.

   Oz / min per nozzle = GPA x Test Speed in MPH x Nozzle Spacing in inches / (5940 x 128).

   Oz / min per nozzle = G/1000 ft^2 x Test Speed in MPH x Nozzle Spacing in inches / (136 x 128).
2. Plugged filters.
   - Check the filters and replace any plugged or restricted filters.
   - Verify that each filter is correctly installed.
3. Plugged lines.
   - Verify that each line is clear and free of kinks.
4. Shut-off valves partially closed.
   - Verify that each shut-off valve is fully open.
5. Pressure set too low on flow by-pass lines (Toro 5700 models with diaphragm pumps only).
   - Verify settings on all pressure-controlled by-pass valves.
6. In-line servo flow control valve stuck.
   - Verify that each filter is correctly installed.
7. Electric servo valve pump control stuck.
   - Verify that the electric servo pump control is operating correctly.
8. Servo signal wire polarity switched.
   - Verify that the valve opens with a rate increase.
   - Verify that the valve closes with a rate decrease.
9. Top PWM value set too low.
   - Adjust the rate controller PWM valve to the desired setting.
10. PWM spool stuck.
    - Change the rate to observe whether the rate change is slow, limited or doesn't change at all. Replace as needed.

11. Worn flow meter.

    - Remove the rate smoothing feature.
    - Place the rate controller in manual mode at a test speed.

NOTE: Placing the rate controller in manual mode will lock the servo valve position (unless manually changed).

If the rate becomes stable, then it is either a worn servo valve or PWM valve.

If the rate continues to be unstable, it is likely flow meter signal instability.

- Manually increase the rate.

The rate and pressure should increase.

If the rate does not increase, then it is either a worn servo valve or PWM valve.

- Manually decrease the rate.

The rate and pressure should decrease.

If the rate does not decrease, then it is either a worn servo valve or PWM valve.

12. Worn pump.

    - Speed data error.

Incorrect speed calibration number.

Poor GPS satellite reception / number of satellites.

- Spraying too fast which outruns the liquid system capability.

Symptom: Over Application

1. Worn tips or tips too large.

    - Verify that all nozzle locations have the correct size and type of tips.
    - Verify the low rates with a Wilger Quick Calibrator or with a catch / time test at each nozzle.

Oz / min per nozzle = GPA x Test Speed in MPH x Nozzle Spacing in inches / (5940 x 128).

Oz / min per nozzle = G/1000 ft² x Test Speed in MPH x Nozzle Spacing in inches / (136 x 128).

- Incorrect speed calibration number.

Adjust the speed calibration setting.

Symptom: Rate Instability

1. Check the rate controller calibration numbers.

   Valve Type - Standard, Fast, PWM, PWM Close, etc.

   Valve Calibration - Check the calibration number for the valve type.

   - Change the Valve Calibration numbers one at a time (Standard Servo - 2123).

   4th digit - Dead-Band width around target rate (size of bulls-eye) (1 = 1% 9 = 9%).

   3rd digit - Percent away from target rate where the response is slowed (0 = 5% 1 = 1% 9 = 9%).

   2nd digit - Response Time (1 = Slow 9 = Fast).

   1st digit - Valve over-shoot correction response time (1 = Slow 9 = Fast)

   - Change the Valve Calibration numbers one at a time (PWM - 43).

   2nd digit - Dead-Band Width.
   1st digit - Response Time.

2. Worn or sticking servo valve.

   - Check the servo valve and replace if needed.

3. Worn or sticking PWM valve.

   - Check the PWM valve and replace if needed.

4. Flow meter signal instability.

   - Verify flow meter signal.

5. Hose integrity.

   - Check for plugged, kinked, or collapsed hoses. Replace as needed.

6. Controller Pressure Instability.

   Isolate the SharpShooter from the rate controller, put the SharpShooter in PWM mode at 50%.

   - Check controller pressure sensor.

   - Check the rate controller calibration numbers.

9.6 - SYMPTOM ANALYSIS

⚠ WARNING

Before operating or servicing system: Read and understand the machine's Operator Manual and the SharpShooter Turf Operator and Maintenance Manual. Follow the warnings and instructions in the manuals when making repairs, adjustments, or servicing. Check for correct function after adjustments, repairs or service. Untrained operators and failure to follow instructions can cause injury or death.

Use the following chart to locate and correct the problems which most often occur with the SharpShooter System.

PROBLEM	CAUSE	CORRECTION
Under application.	Tips too small.	Check for proper tip size.
	Plugged tips.	Clean or replace tips.
	Plugged filter(s).	Clean or replace filter(s).
	Filter(s) not installed correctly.	Check all filters for correct installation.
	Plugged, kinked or collapsed hoses.	Check all hoses and replace as needed.
	Pump not turned on.	Turn pump on.
	Outrunning sprayer liquid system capability.	Slow down.
		Run at optimum pressure (not too low, not too high).
	Incorrect rate settings.	Check and adjust rate settings.
	Incorrect calibration settings.	Check and adjust settings.
	Faulty radar.	Replace radar.
	Poor GPS satellite signal.	Verify that the GPS is working correctly.
	Faulty rate controller switch.	Locate bad switch(s) and replace switch.
	Servo valve not working correctly.	Check servo valve; replace if needed.
	Boost not working.	Check dip switch settings.
		Check for broken wires.
		Check Valve Driver(s); replace if needed.
Over application.	Tips too large.	Check for proper tip size.
	Worn tips.	Replace tips.
	Speed too slow.	Increase speed.
	Incorrect rate settings.	Check and adjust rate settings.
	Incorrect calibration settings.	Check and adjust settings.
	Servo valve not working correctly.	Check servo valve; replace if needed.

PROBLEM	CAUSE	CORRECTION
Rate instability.	Low voltage to rate controller.	Test voltage; repair as needed.
	Faulty flow meter.	Repair or replace flow meter if needed.
	Faulty pressure dampener on diaphragm pump(s).	Replace pressure dampener(s).
	Faulty speed sensor reading.	Check radar; replace if needed.
	Collapsed suction hose.	Replace suction hose.
	Inlet plugged.	Check and clean inlet if needed.
	Incorrect valve calibration settings.	Check and adjust settings. See the rate controller's manual.
	Incorrect SharpShooter PID Parameters.	Check SharpShooter PID Parameters; adjust as needed.
	SharpShooter Run / Hold Parameter too short.	Adjust SharpShooter Run / Hold Parameter.
	Faulty rate controller.	Replace rate controller.
Pressure instability.	Faulty rate controller.	Replace rate controller.
	Worn or sticky poppets.	Check and replace poppets as needed.
	Incorrect SharpShooter PID parameters.	Check SharpShooter PID parameters and adjust as needed.
	Faulty pressure sensor.	Replace pressure sensor.
Single nozzle valve drips when shutoff.	Plunger is lodged with debris.	Clean nozzle valve. See 9.5.3 - Nozzle Valve Cleaning on page 66.
	Plunger is worn.	Replace plunger. See 9.5.4 - Plunger Seal Inspection on page 67.
Single nozzle valve sprays erratically.	Plunger is worn.	Replace plunger. See 9.5.4 - Plunger Seal Inspection on page 67.
	Incorrect dip switch settings.	Check dip switch settings; adjust as needed.
Single nozzle valve will not shut off.	Plunger is lodged with debris.	Clean nozzle valve. See 9.5.3 - Nozzle Valve Cleaning on page 66.
Section will not spray.	Blown fuse on Valve Driver.	Replace fuse on Valve Driver.
	Faulty Valve Driver.	Replace Valve Driver.
Pulse generator not functioning properly.	Low voltage at Pulse Generator.	Perform system voltage checks.
		Check circuit board setups.
Every other nozzle pulses.	Faulty Valve Driver.	Replace Valve Driver.
	Incorrect dip switch settings.	Check dip switch settings and adjust as needed.
	Faulty harness.	Replace harness.
No pulse - PSI mode (PWM mode: Pulses).	Incorrect pressure sensor input and output settings.	Check and adjust settings.
No pulse - PSI mode (PWM mode: No pulse).	Faulty Pulse Generator.	Replace Pulse Generator.

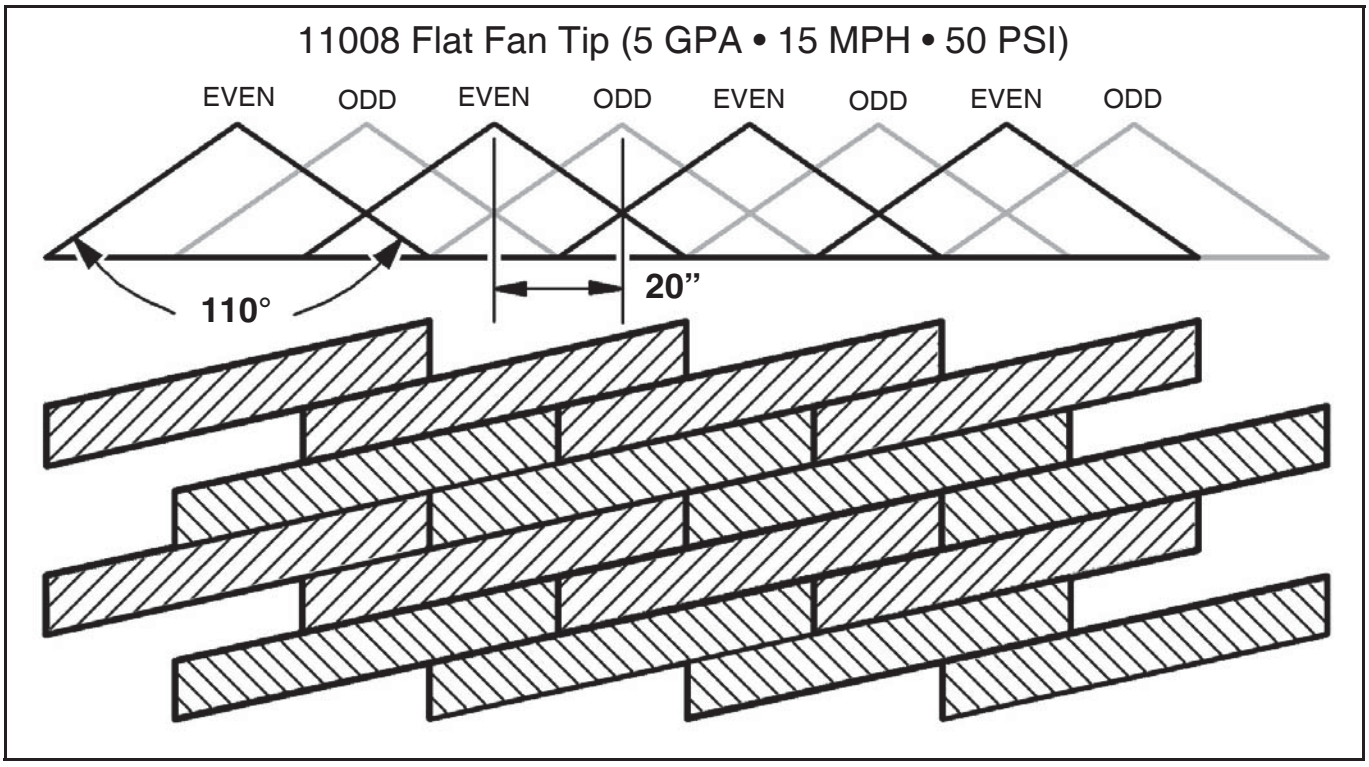
9.7 - TECHNICAL BULLETIN - JULY 11, 2001 (REVISED APRIL 12, 2006)

Spray Skips from Poor Pulse Blending

Over the years, Capstan's field engineers have received many questions about blended pulse spraying and its potential for causing skips in the field. In rare instances, skipping has been documented in the field. This technical bulletin is intended to explain pulse blending, and the techniques used to provide optimum spray coverage and to prevent skipping.

What is blended pulse spraying? Each nozzle in a blended pulse spray system emits 10 spray pulses per second. Adjacent nozzles have alternate timing. The alternating pulses, the overlapping spray patterns and the natural dispersing of droplets, blend together to provide consistent coverage of the target.

What makes the pulses blend? Below is an illustration of what a blended pulse spray pattern might look like if it were sprayed upon a flat surface. This spray pattern is similar to a #8 size flat fan spray tip (with a 110 degree fan angle) that is spraying 5 GPA at 15 MPH with a 50 PSI boom pressure. The nozzles are 20” apart. Each tip is rotated 12.5 degrees to prevent pattern interference between nozzles. The minimum boom height is 21” above the spray target.

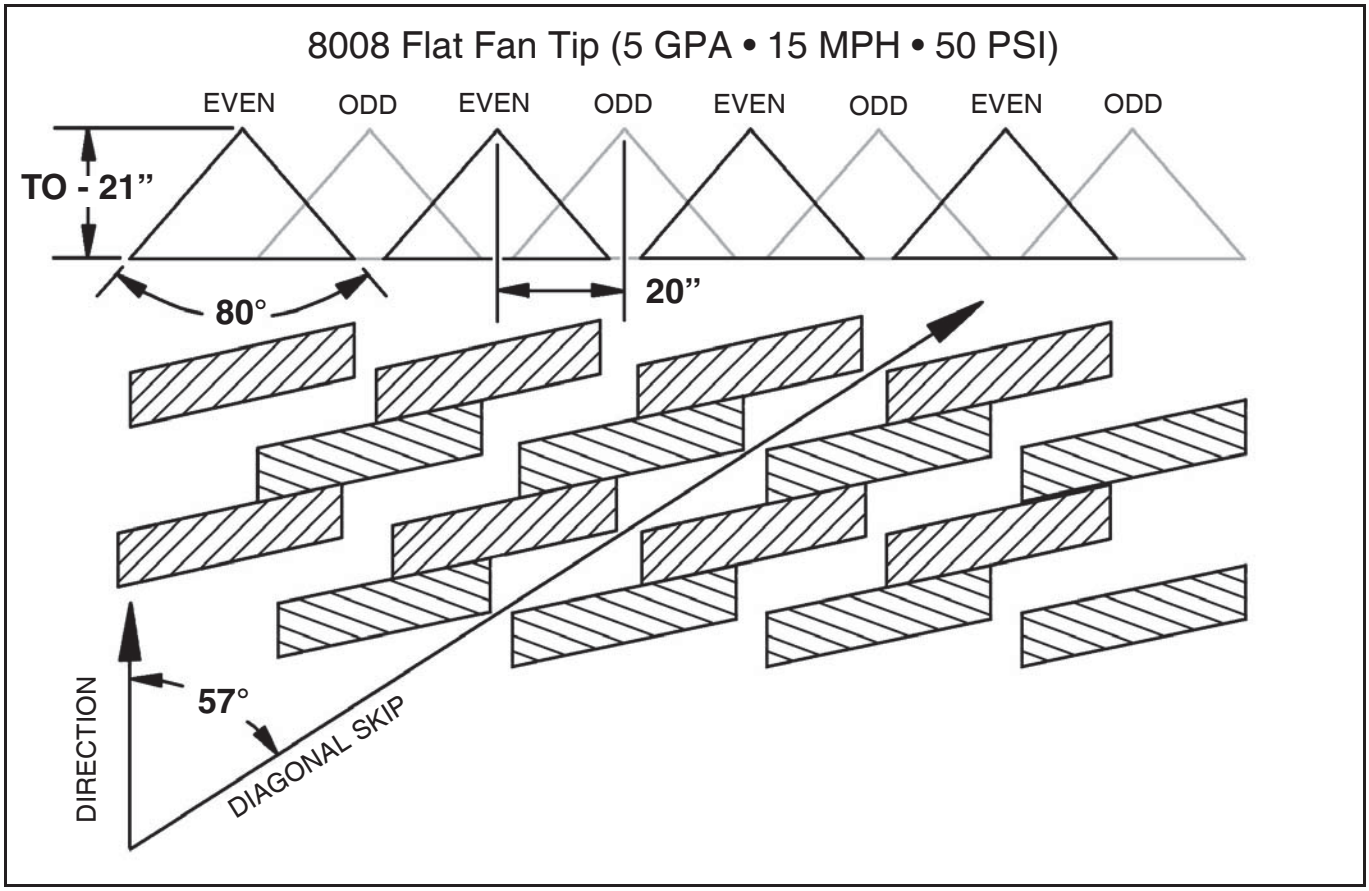


In this example, each nozzle sprays 1/3 of the time, but adjacent nozzles alternate and overlap to fill in areas between the nozzles. As the sprayer increases speed, rate, or boom height, the pulses become wider, this provides additional overlap, better pulse blending, and increased spray coverage.

As the sprayer decreases speed or rate, skips may begin to appear. For this example, a smaller tip size is recommended if slower speeds are desired.

Pattern width and natural droplet dispersion are not shown in the diagram. These factors help to smooth out the pulses and fill in skips. The amount of droplet dispersion depends upon the style of tip being used. For example, low-drift tips typically emit large droplets and provide minimal droplet dispersion.

What causes skipping? Below is the same illustration from the previous page except that 80 degree fan angle tips are used rather than 110 degree tips. In this case, the 21" boom height doesn't provide adequate nozzle overlap and skips can be seen. Tips emitting small droplets, with plenty of droplet dispersion, will fill in large skips. Large droplet tips may not fill in the skips, and this may result in poor coverage. The skips appear as diagonal lines in the direction of travel. The angle of the diagonal spray depends upon the speed of the sprayer.



To Prevent Skipping:

1. Use wide-angle spray tips and appropriate boom heights to provide 150% nozzle overlap.
   - For 80 degree tips, use 36" or greater boom height.
   - For 110 degree tips, use 24" or greater boom height.
   - Use pressures which fully develop the intended fan angle.
2. Avoid pulse Duty Cycles below 33%.
   - Use appropriately sized spray tips for the desired speed, rate, and pressure ranges.
   - Avoid speeds in the lower 1/3 of the speed range.
   - Avoid rates in the lower 1/3 of the rate range.
3. Use additional caution when using drift control tips or drift control additives which increase droplet size and reduce droplet dispersion. Carefully observe the boom height, Duty Cycle, and tip selection recommendations to ensure adequate spray coverage.
4. **Always read and follow chemical label instructions!** Agronomic and environmental factors significantly affect efficiency of the chemicals, and will magnify the adverse effects of poor coverage. Carefully observe boom height, Duty Cycle and tip selection recommendations for hot and dry field conditions, large / mature weed pressures, etc.
5. **Always apply blended pulse broadcast sprays using a 10 Hz or greater pulse frequency!** Capstan's "Commander" module and SharpShooter Pulse Generator allow the pulse frequency to be reduced for non-sprayer applications, when uniform coverage is not required.

10.0 - WARRANTY POLICY

LIMITED WARRANTY

Rev Date: 7/15/2014

A. What does the Limited Warranty cover?

The ultimate purchaser/user (“you”), by acceptance of seller Capstan Ag Systems, Inc.’s, (“our,” “we,” or “us”) product, assume all risk and liability of the consequences of any use or misuse by you, your employees, or others.

All replacement components furnished under this warranty, but shipped before the failed component is returned for evaluation, will be invoiced in the usual manner and warranty adjustments will be made after the component claimed to be defective has been returned to and inspected and deemed defective by us at our factory.

Upon determining that a component has failed under warranty, the repaired component or replacement component, furnished under this warranty, will be shipped at our expense, to your location. We will credit you an amount equal to the incoming freight you paid. We shall not be responsible for installation costs. (You shall be responsible for all customs and brokerage fees for all international transactions.)

If the component does not prove to be defective, you shall be liable for all freight, inspection and handling costs. In no event will any claim for labor or incidental or consequential damages be allowed for removing or replacing a defective product. Warranty will be denied on any component which has been subject to misuse, abuse, accidents, or alterations, or to improper or negligent use, maintenance, storage or transportation and handling.

Our liability under this warranty, or for any loss or damage to the components whether the claim is based on contract or negligence, shall not in any case exceed the purchase price of the components and upon the expiration of the warranty period all such liability shall terminate. The foregoing shall constitute your exclusive remedy and our exclusive liability.

The terms of this warranty do not in any way extend to any product which was not manufactured by us or one of our affiliates.

While necessary maintenance or repairs on your Capstan Ag Systems, Inc. product can be performed by any company, we recommend that you use only authorized Capstan Ag Systems, Inc. dealers. Improper or incorrectly performed maintenance or repair voids this warranty.

The foregoing warranty is exclusive and is in lieu of all other warranties expressed or implied. We shall not be liable for any incidental or consequential damages resulting from any breach of warranty.

Your exclusive remedy for breach of warranty shall be repair or replacement of defective component(s): Provided, if the component(s) are incapable of being repaired or replaced, your exclusive remedy shall be credit issued, but such credit shall not exceed the purchase price of the components.

On any claim of any kind, including negligence, our liability for any loss or damage arising out of, or from the design, manufacture, sale, delivery, resale, installation, technical direction of installation, inspection, repair, operation of use of any products shall in no case exceed the purchase price allocable to the components.

In no event, whether as a result of breach of contract or warranty or alleged negligence, shall we be liable for incidental or consequential damages, including, but not limited to: personal injury, loss of profits or revenue, loss of use of equipment or any associated equipment, cost of capital, cost of substitute equipment, facilities or services, downtime costs, environmental damage, crop losses, or claims of customers of you for such damages.

B. What is the period of coverage?

We warrant to you, that our products are free from defects in material and workmanship in normal use and service for a period of one year from date of purchase.

C. How do you get service?

Our obligation under this warranty shall be limited to the repairing or replacing at our option, the component which our inspection discloses to be defective, free of charge, return freight paid by us, provided you: (i) Notify us of defect within thirty (30) days of failure; (ii) Return the defective component to us, freight prepaid; (iii) Complete the Owner Registration Form and returned it to us; and (iv) Establish that the product has been properly installed, maintained and operated in accordance with our instructions or instructions contained in our operations or maintenance manuals and within the limits of normal usage.

Any claim for breach of our warranty must be in writing addressed to us and must set forth the alleged defect in sufficient detail to permit its easy identification by us. All breach of warranty claims must be made within thirty (30) days after expiration of the warranty period which is applicable to the defective product. Any breach of warranty claim not timely made will not be honored by us and will be of no force and effect.Any component that needs to be repaired or evaluated for warranty has to be authorized before return. Contact the factory (785-232-4477) to get a Return Materials Authorization (RMA #). This helps to track the part coming into the factory for repair or replacement.

Before returning any component to the factory, clean the component as well as possible to remove any dirt or chemical residue. Components received at the factory that are not clean, will be returned and warranty denied.

After receiving your RMA #, package the part, making sure to include the RMA #, your name, customer's name, your address and phone number and description of problems or failure. Then ship to:

Capstan Ag Systems, Inc.
Attn: Warranty/Repair
4225 SW Kirklawn Ave.
Topeka, KS 66609

Phone: (785) 232-4477
Fax: (785) 232-7799
Hours: 8:00 a.m. - 4:00 p.m. CST

D. How does state law relate to this Limited Warranty?

Some states do not allow limitations on how long an implied warranty lasts, so the above limitation may not apply to you.

Some states do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

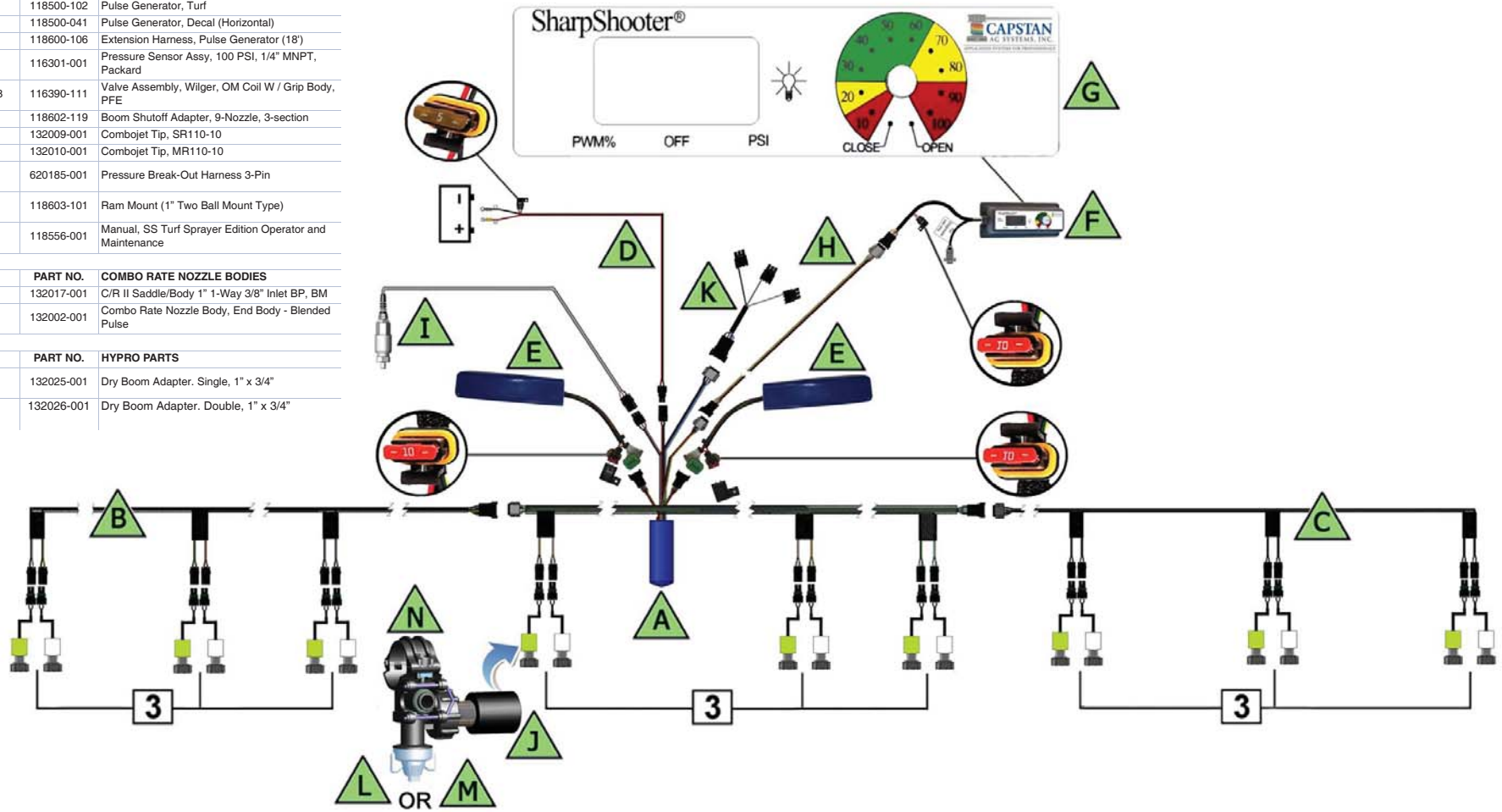
This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

11.0 - KIT JACOBSON 118600-202, 9-NOZZLE, 3-SECTION, (3-3-3), 15’ BOOM, TURF SS

ITEM	QTY.	PART NO.	CAPSTAN SHARPSHOOTER PARTS
A	1	118600-250	Power Hub, Turf, SmithCo 9-Nozzle, Center
B	1	118600-251	LH Boom Harness, (12 wire) Sections 1-3
C	1	118600-252	RH Boom Harness, (12 wire) Sections 7-9
D	1	118600-109	Power Harness (18’)
E	2	118400-020	Valve Driver Module
F	1	118500-102	Pulse Generator, Turf
G	1	118500-041	Pulse Generator, Decal (Horizontal)
H	1	118600-106	Extension Harness, Pulse Generator (18’)
I	1	116301-001	Pressure Sensor Assy, 100 PSI, 1/4” MNPT, Packard
J	18	116390-111	Valve Assembly, Wilger, OM Coil W / Grip Body, PFE
K	1	118602-119	Boom Shutoff Adapter, 9-Nozzle, 3-section
L	9	132009-001	Combojet Tip, SR110-10
M	9	132010-001	Combojet Tip, MR110-10
Not Shown	1	620185-001	Pressure Break-Out Harness 3-Pin
Not Shown	1	118603-101	Ram Mount (1” Two Ball Mount Type)
Not Shown	1	118556-001	Manual, SS Turf Sprayer Edition Operator and Maintenance

ITEM		PART NO.	COMBO RATE NOZZLE BODIES
N	9	132017-001	C/R II Saddle/Body 1” 1-Way 3/8” Inlet BP, BM
Not Shown	9	132002-001	Combo Rate Nozzle Body, End Body - Blended Pulse

ITEM		PART NO.	HYPRO PARTS
Not Shown	4	132025-001	Dry Boom Adapter. Single, 1” x 3/4”
Not Shown	5	132026-001	Dry Boom Adapter. Double, 1” x 3/4”

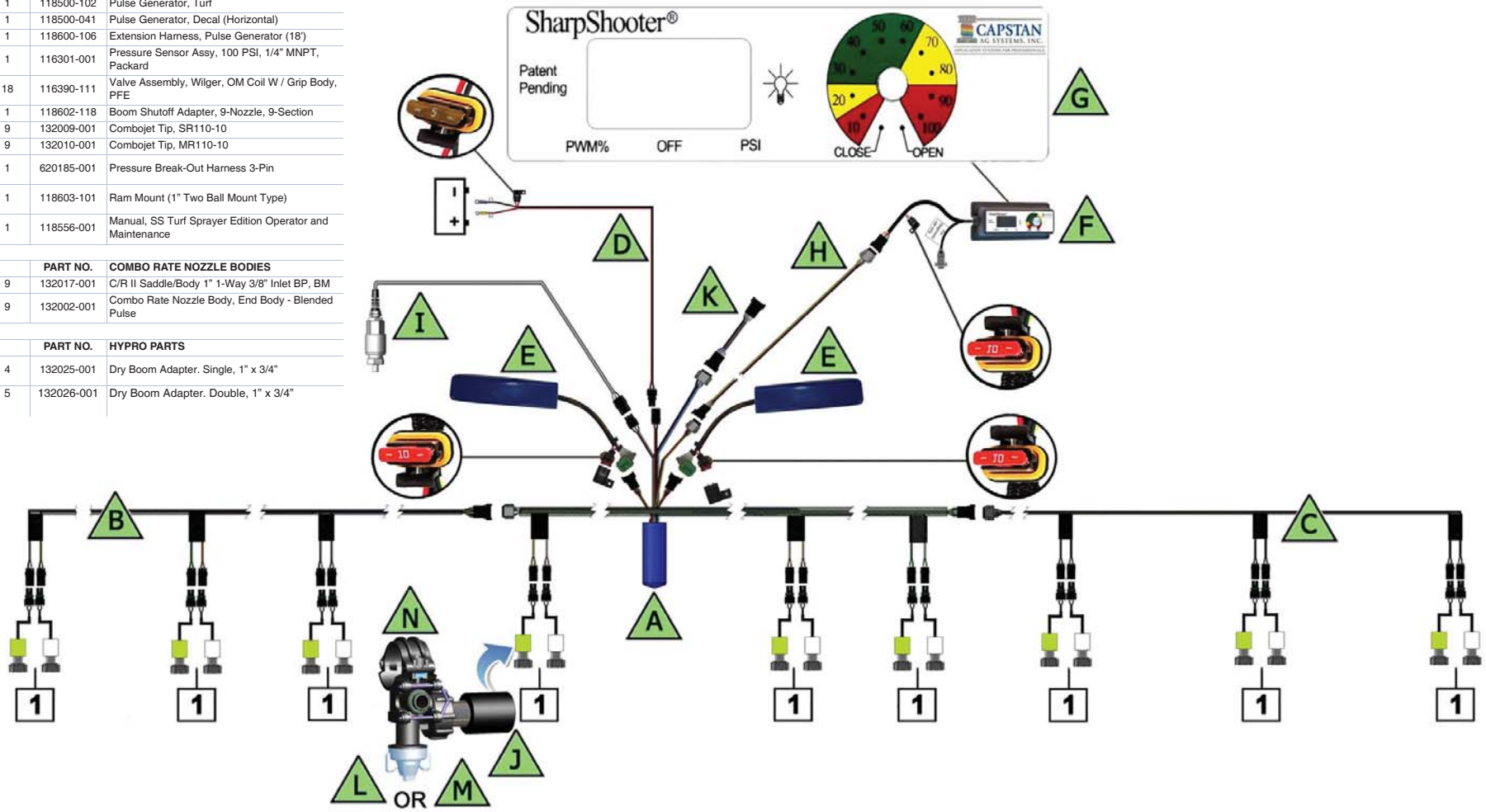


11.1 - KIT JACOBSON 118600-202, 9-NOZZLE, 9-SECTION, (1-1-1-1-1-1-1-1-1), 15' BOOM, TURF SS

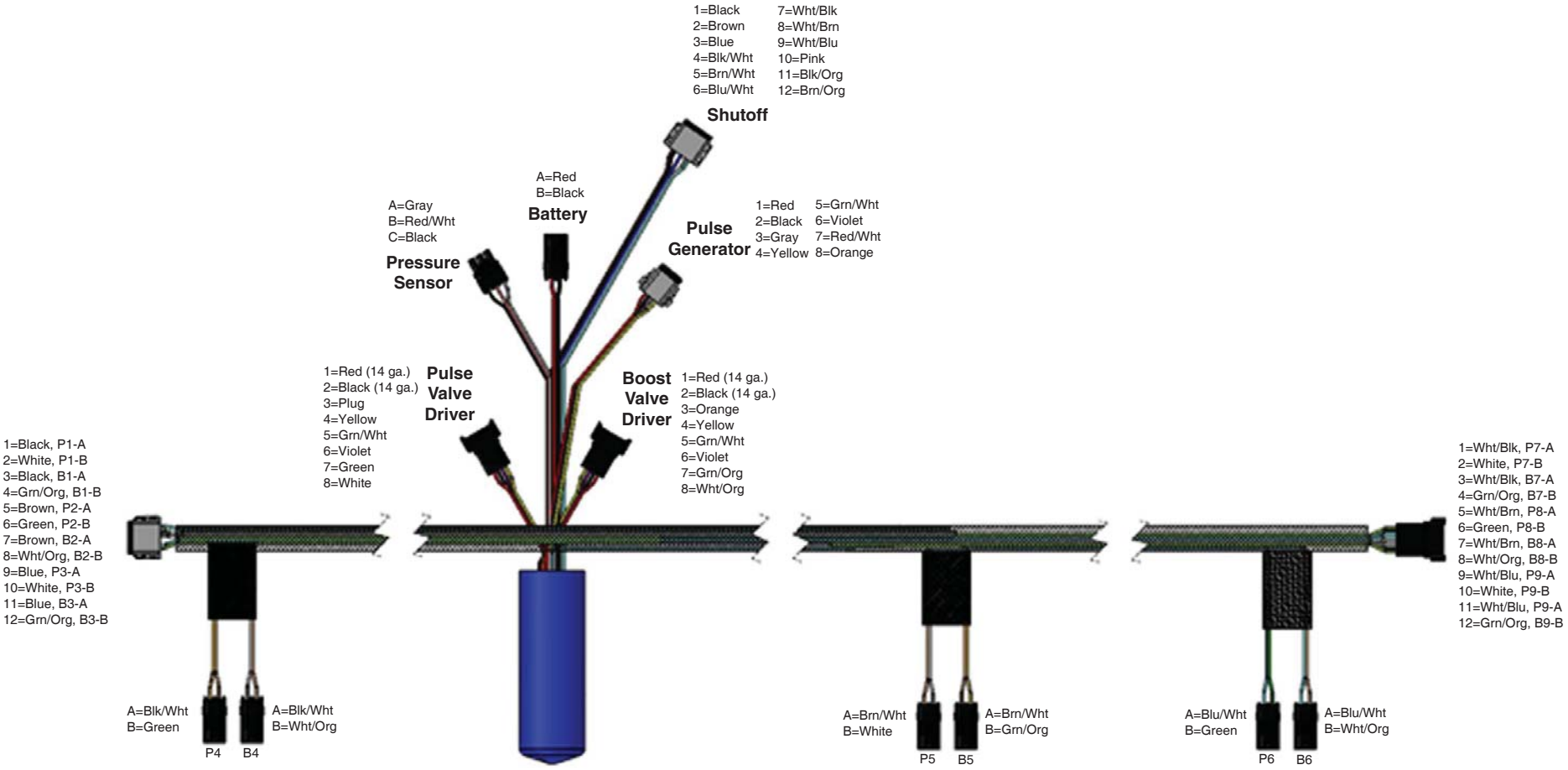
ITEM	QTY.	PART NO.	CAPSTAN SHARPSHOOTER PARTS
A	1	118600-250	Power Hub, Turf, SmithCo 9-Nozzle, Center
B	1	118600-251	LH Boom Harness, (12 wire) Sections 1-3
C	1	118600-252	RH Boom Harness, (12 wire) Sections 7-9
D	1	118600-109	Power Harness (18')
E	2	118400-020	Valve Driver Module
F	1	118500-102	Pulse Generator, Turf
G	1	118500-041	Pulse Generator, Decal (Horizontal)
H	1	118600-106	Extension Harness, Pulse Generator (18')
I	1	116301-001	Pressure Sensor Assy, 100 PSI, 1/4" MNPT, Packard
J	18	116390-111	Valve Assembly, Wilger, OM Coil W / Grip Body, PFE
K	1	118602-118	Boom Shutoff Adapter, 9-Nozzle, 9-Section
L	9	132009-001	Combojet Tip, SR110-10
M	9	132010-001	Combojet Tip, MR110-10
Not Shown	1	620185-001	Pressure Break-Out Harness 3-Pin
Not Shown	1	118603-101	Ram Mount (1" Two Ball Mount Type)
Not Shown	1	118556-001	Manual, SS Turf Sprayer Edition Operator and Maintenance

ITEM		PART NO.	COMBO RATE NOZZLE BODIES
N	9	132017-001	C/R II Saddle/Body 1" 1-Way 3/8" Inlet BP, BM
Not Shown	9	132002-001	Combo Rate Nozzle Body, End Body - Blended Pulse

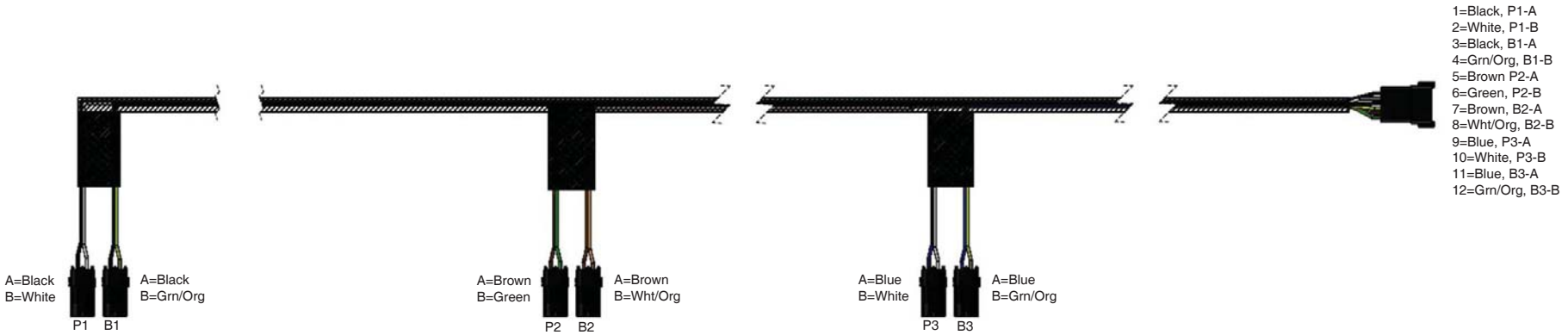
ITEM		PART NO.	HYPRO PARTS
Not Shown	4	132025-001	Dry Boom Adapter. Single, 1" x 3/4"
Not Shown	5	132026-001	Dry Boom Adapter. Double, 1" x 3/4"



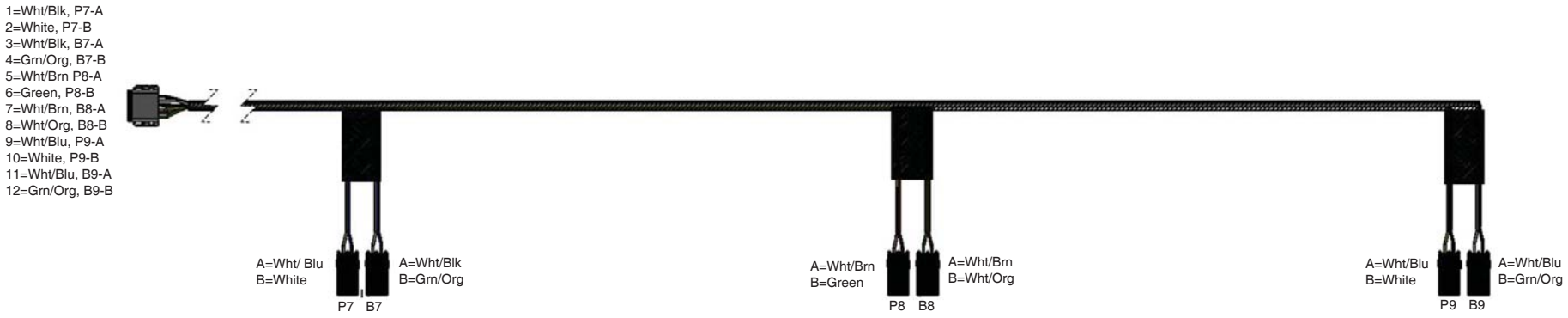
11.2 - Power Hub, 9-Nozzle, 3-Section, Boom 4, 5, 6 - P/N118600-250



11.3 - LH Boom Harness, 9-Nozzle, 3-Section, Boom 1, 2, 3 - P/N118600-251



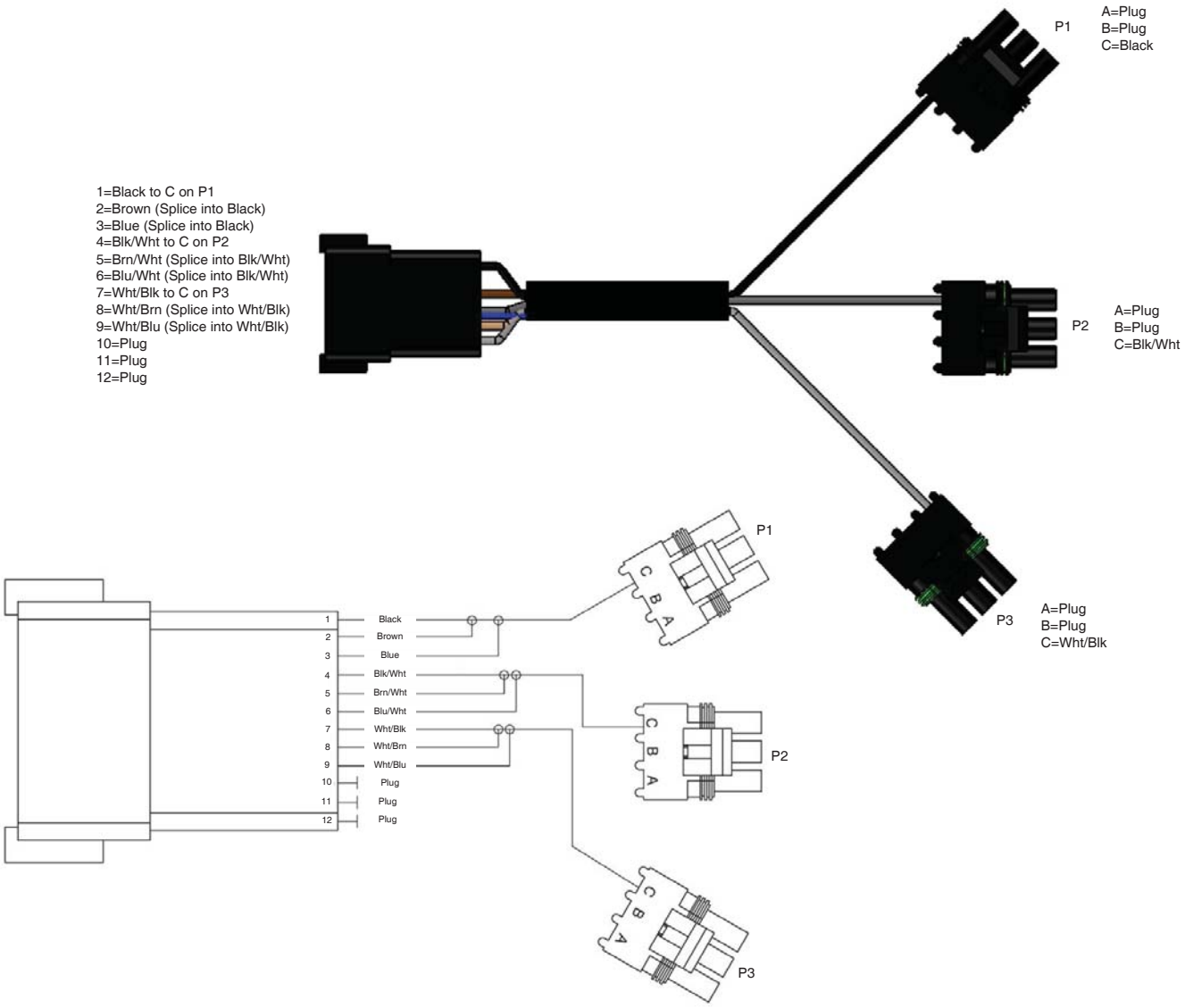
11.4 - RH Boom, Harness, 9-Nozzle, 3-Section, Boom 7, 8, 9 - P/N118600-252



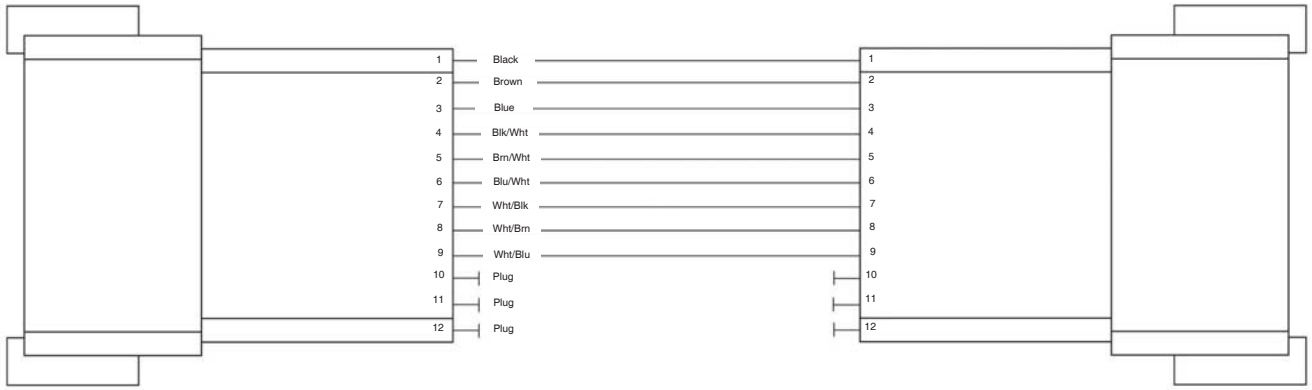
11.5 - Extension Harness, Pulse Generator, PN118600-106

11.6 - Power Harness, PN118600-109

11.7 - Boom Shutoff Adapter, 9-Nozzle, 3-Section, PN118602-119



11.8 - Boom Shutoff Adapter, 9-Nozzle, 9-Section, PN118602-118



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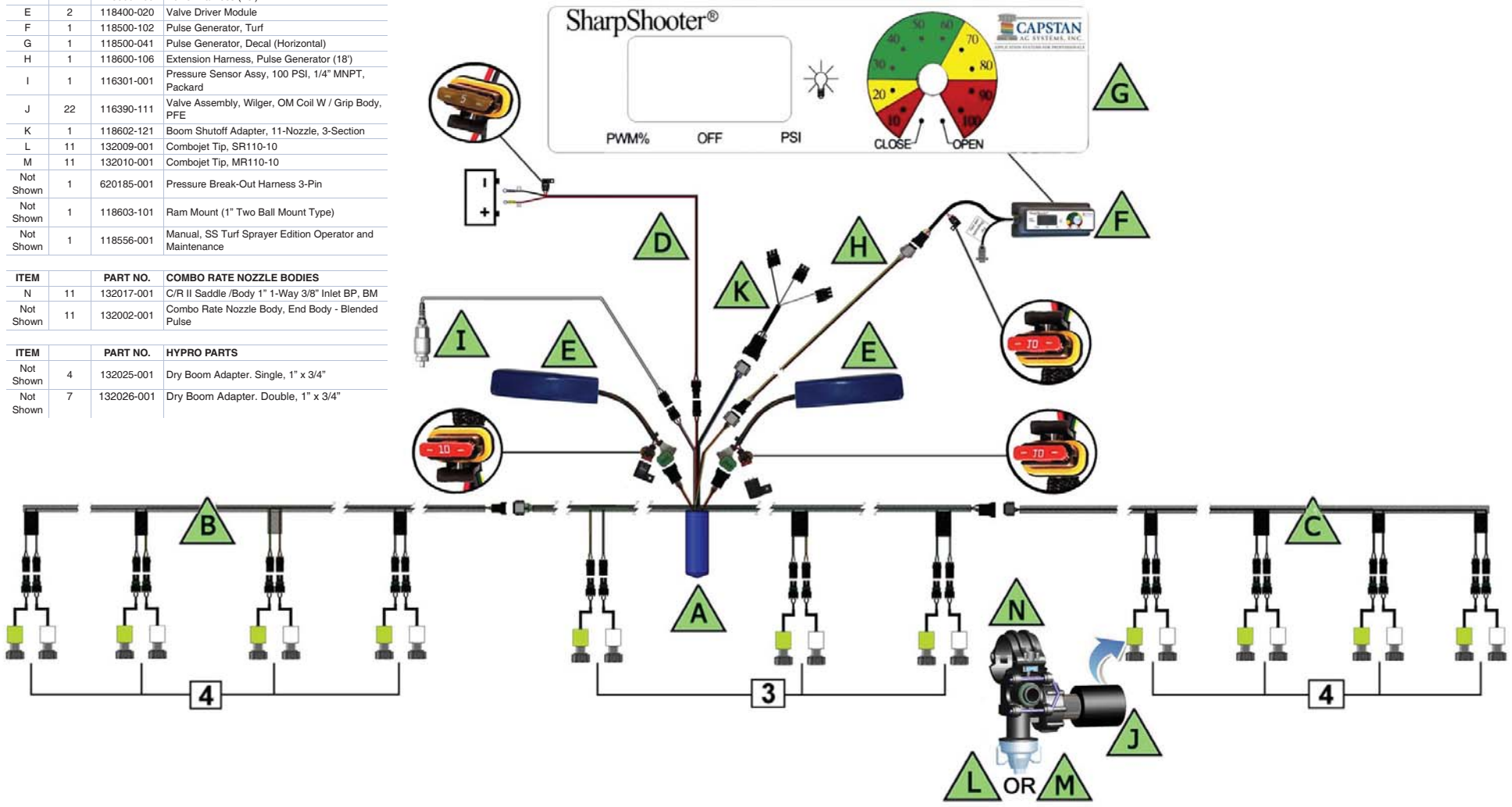
12.0 - KIT JACOBSEN 118600-200, 11-NOZZLE, 3-SECTION, (4-3-4), 18' BOOM, TURF SS

ITEM	QTY.	PART NO.	CAPSTAN SHARPSHOOTER PARTS
A	1	118600-253	Power Hub, Turf, SmithCo 11-Nozzle, Center
B	1	118600-254	LH Boom Harness, (16 wire) Sections 1-4
C	1	118600-255	RH Boom Harness, (16 wire) Sections 8-11
D	1	118600-109	Power Harness (18')
E	2	118400-020	Valve Driver Module
F	1	118500-102	Pulse Generator, Turf
G	1	118500-041	Pulse Generator, Decal (Horizontal)
H	1	118600-106	Extension Harness, Pulse Generator (18')
I	1	116301-001	Pressure Sensor Assy, 100 PSI, 1/4" MNPT, Packard
J	22	116390-111	Valve Assembly, Wilger, OM Coil W / Grip Body, PFE
K	1	118602-121	Boom Shutoff Adapter, 11-Nozzle, 3-Section
L	11	132009-001	Combojet Tip, SR110-10
M	11	132010-001	Combojet Tip, MR110-10
Not Shown	1	620185-001	Pressure Break-Out Harness 3-Pin
Not Shown	1	118603-101	Ram Mount (1" Two Ball Mount Type)
Not Shown	1	118556-001	Manual, SS Turf Sprayer Edition Operator and Maintenance

ITEM		PART NO.	COMBO RATE NOZZLE BODIES
N	11	132017-001	C/R II Saddle /Body 1" 1-Way 3/8" Inlet BP, BM
Not Shown	11	132002-001	Combo Rate Nozzle Body, End Body - Blended Pulse

ITEM		PART NO.	HYPRO PARTS
Not Shown	4	132025-001	Dry Boom Adapter. Single, 1" x 3/4"
Not Shown	7	132026-001	Dry Boom Adapter. Double, 1" x 3/4"

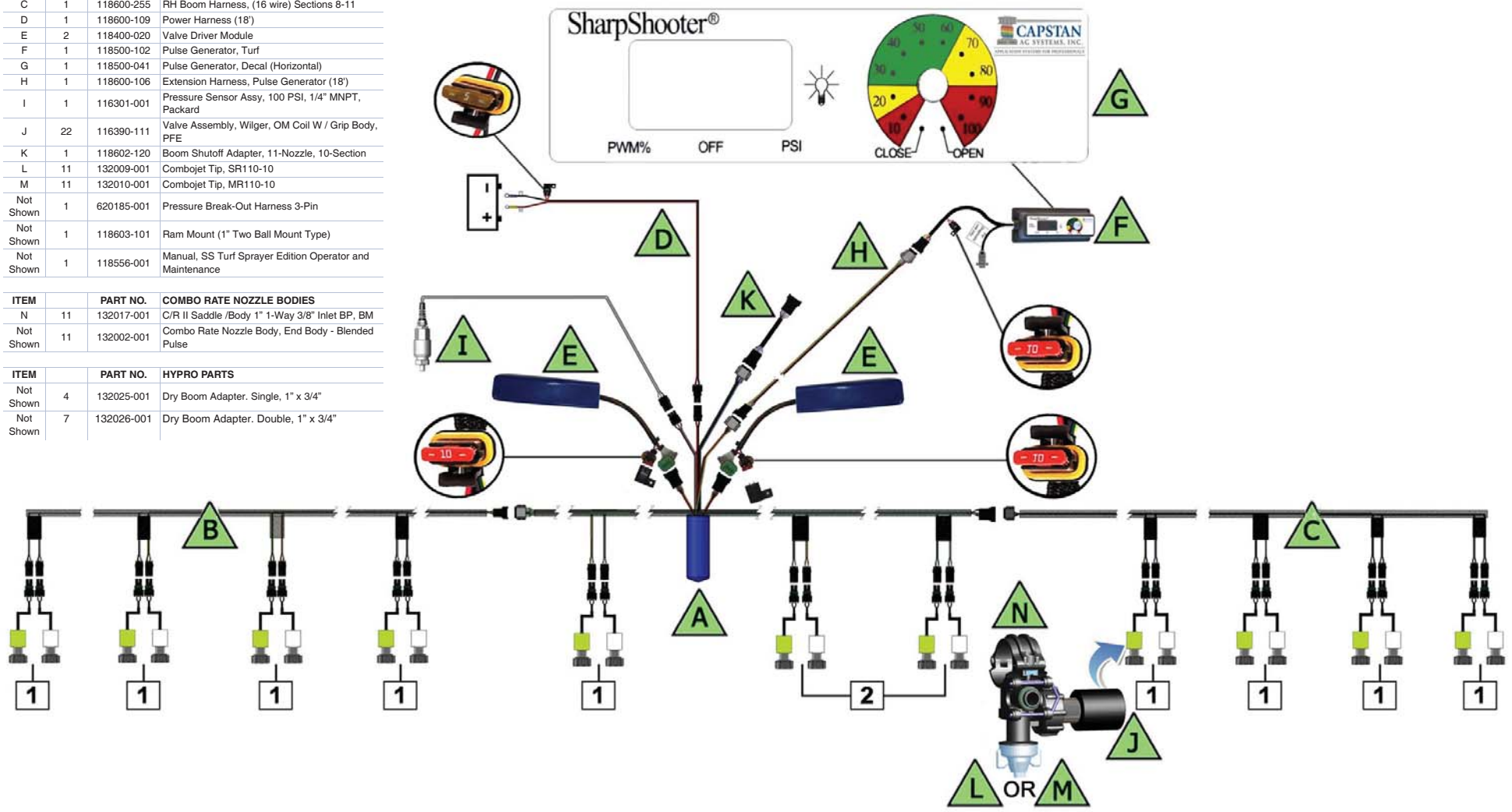


12.1 - KIT JACOBSEN 118600-200, 11-NOZZLE, 10-SECTION, (1-1-1-1-1-2-1-1-1-1), 18' BOOM, TURF SS

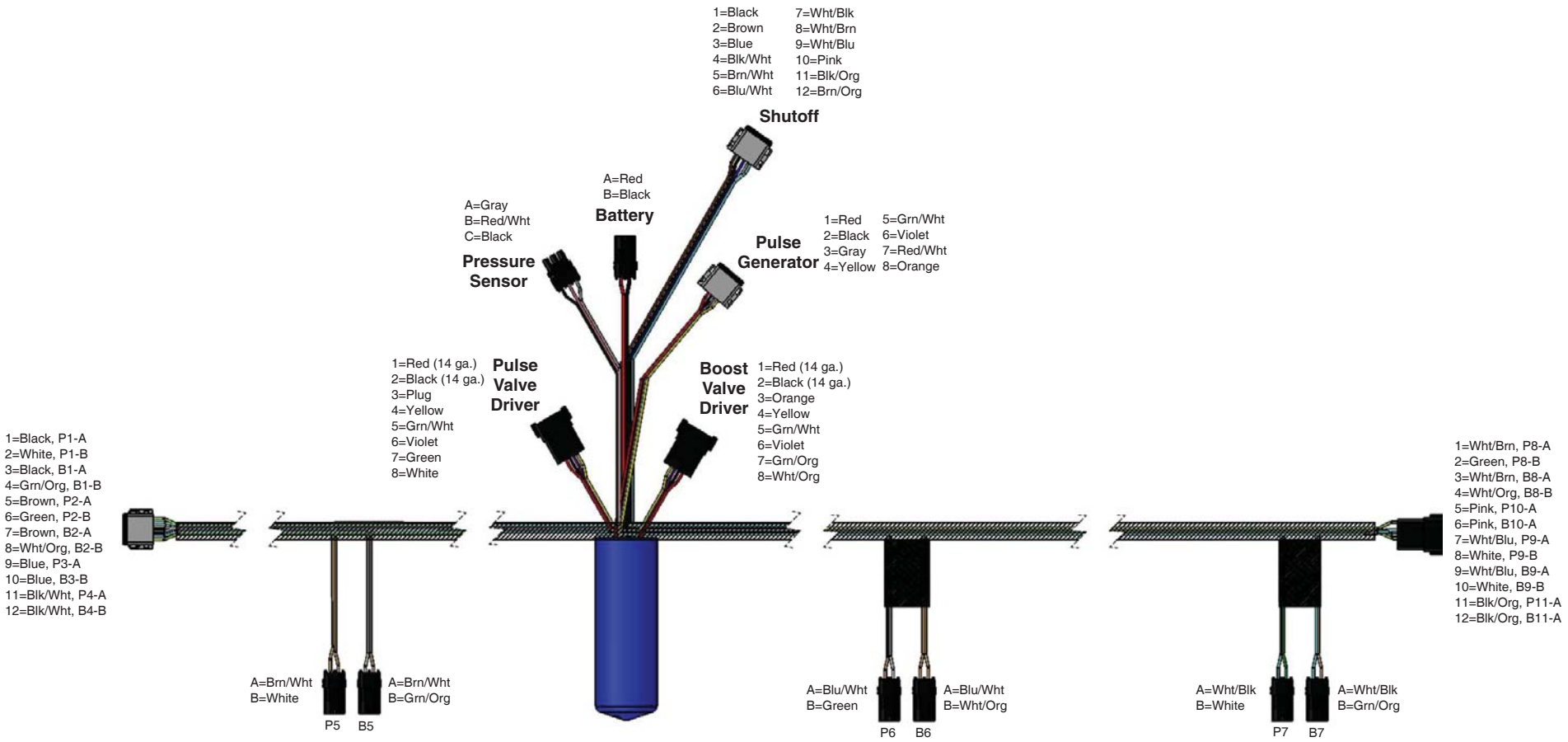
ITEM	QTY.	PART NO.	CAPSTAN SHARPSHOOTER PARTS
A	1	118600-253	Power Hub, Turf, SmithCo 11-Nozzle, Center
B	1	118600-254	LH Boom Harness, (16 wire) Sections 1-4
C	1	118600-255	RH Boom Harness, (16 wire) Sections 8-11
D	1	118600-109	Power Harness (18')
E	2	118400-020	Valve Driver Module
F	1	118500-102	Pulse Generator, Turf
G	1	118500-041	Pulse Generator, Decal (Horizontal)
H	1	118600-106	Extension Harness, Pulse Generator (18')
I	1	116301-001	Pressure Sensor Assy, 100 PSI, 1/4" MNPT, Packard
J	22	116390-111	Valve Assembly, Wilger, OM Coil W / Grip Body, PFE
K	1	118602-120	Boom Shutoff Adapter, 11-Nozzle, 10-Section
L	11	132009-001	Combojet Tip, SR110-10
M	11	132010-001	Combojet Tip, MR110-10
Not Shown	1	620185-001	Pressure Break-Out Harness 3-Pin
Not Shown	1	118603-101	Ram Mount (1" Two Ball Mount Type)
Not Shown	1	118556-001	Manual, SS Turf Sprayer Edition Operator and Maintenance

ITEM		PART NO.	COMBO RATE NOZZLE BODIES
N	11	132017-001	C/R II Saddle /Body 1" 1-Way 3/8" Inlet BP, BM
Not Shown	11	132002-001	Combo Rate Nozzle Body, End Body - Blended Pulse

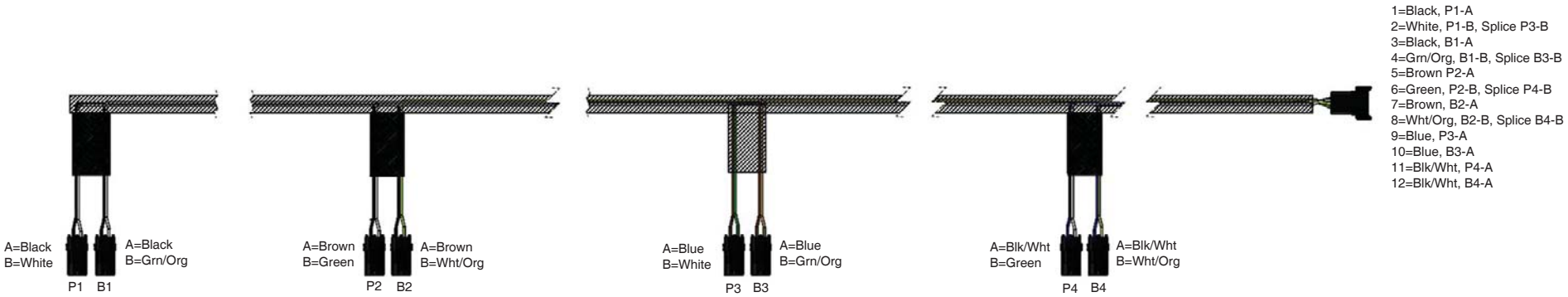
ITEM		PART NO.	HYPRO PARTS
Not Shown	4	132025-001	Dry Boom Adapter. Single, 1" x 3/4"
Not Shown	7	132026-001	Dry Boom Adapter. Double, 1" x 3/4"



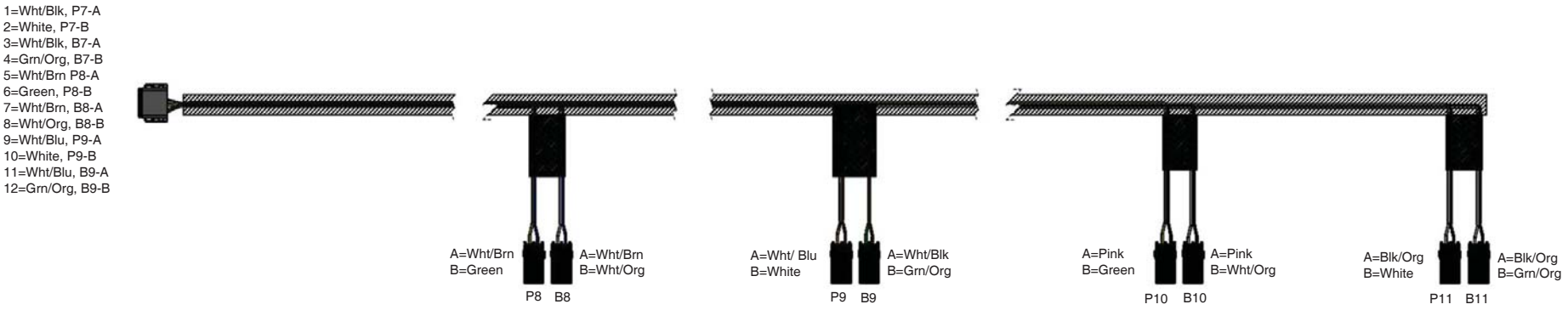
12.2 - Power Hub, 11-Nozzle, 3-Section, Boom 5, 6, 7 - P/N118600-253



12.3 - LH Boom Harness, 11-Nozzle, 3-Section, Boom 1, 2, 3, 4 - P/N118600-254



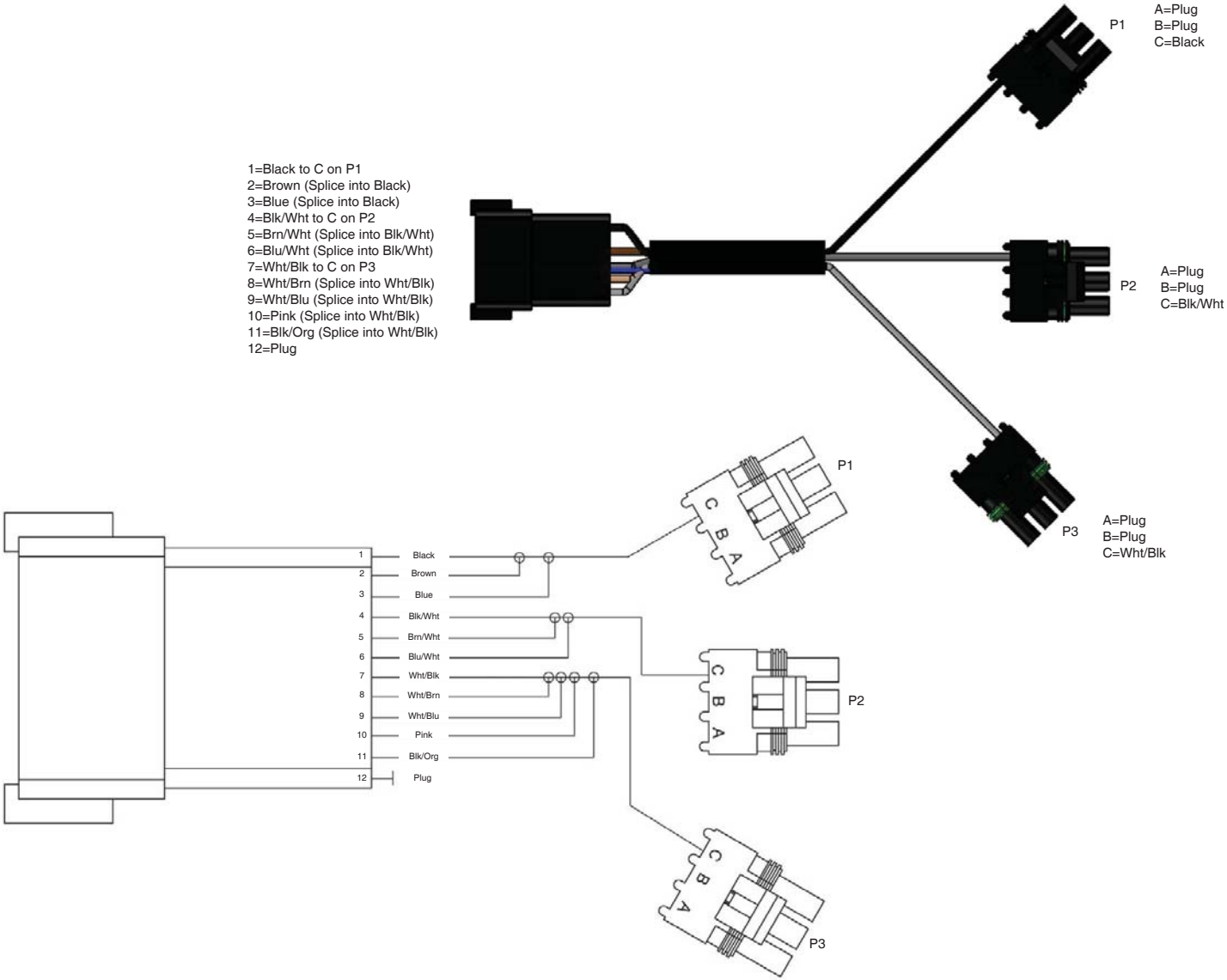
12.4 - RH Boom Harness, 11-Nozzle, 3-Section, Boom 8, 9, 10, 11 - P/N118600-255



12.5 - Extension Harness, Pulse Generator, PN118600-106

12.6 - Power Harness, PN118600-109

12.7 - Boom Shutoff Adapter, 11-Nozzle, 3-Section, PN118602-121

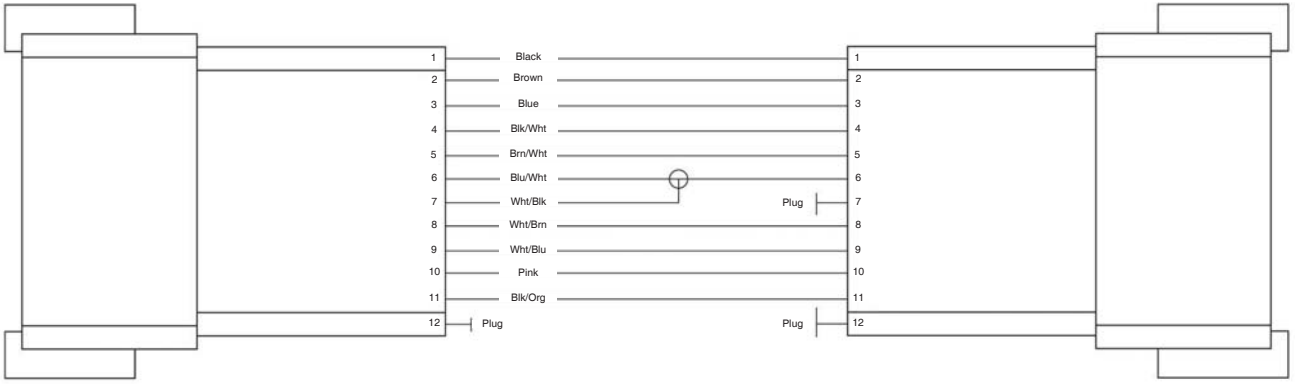


12.8 - Boom Shutoff Adapter, 11-Nozzle, 10-Section, PN118602-120

P/N118602-120 Jacobsen, Shutoff Turf, 11 Nozzle, 10 Section

1=Black
2=Brown
3=Blue
4=Blk/Wht
5=Brn/White
6=Blu/Wht
7=Wht/Blk (Splice into Blue/Wht)
8=Wht/Brn
9=Wht/Blu
10=Pink
11=Blk/Org
12=Plug

1=Black
2=Brown
3=Blue
4=Blk/Wht
5=Brn/White
6=Blu/Wht
7=Plug
8=Wht/Brn
9=Wht/Blu
10=Pink
11=Blk/Org
12=Plug



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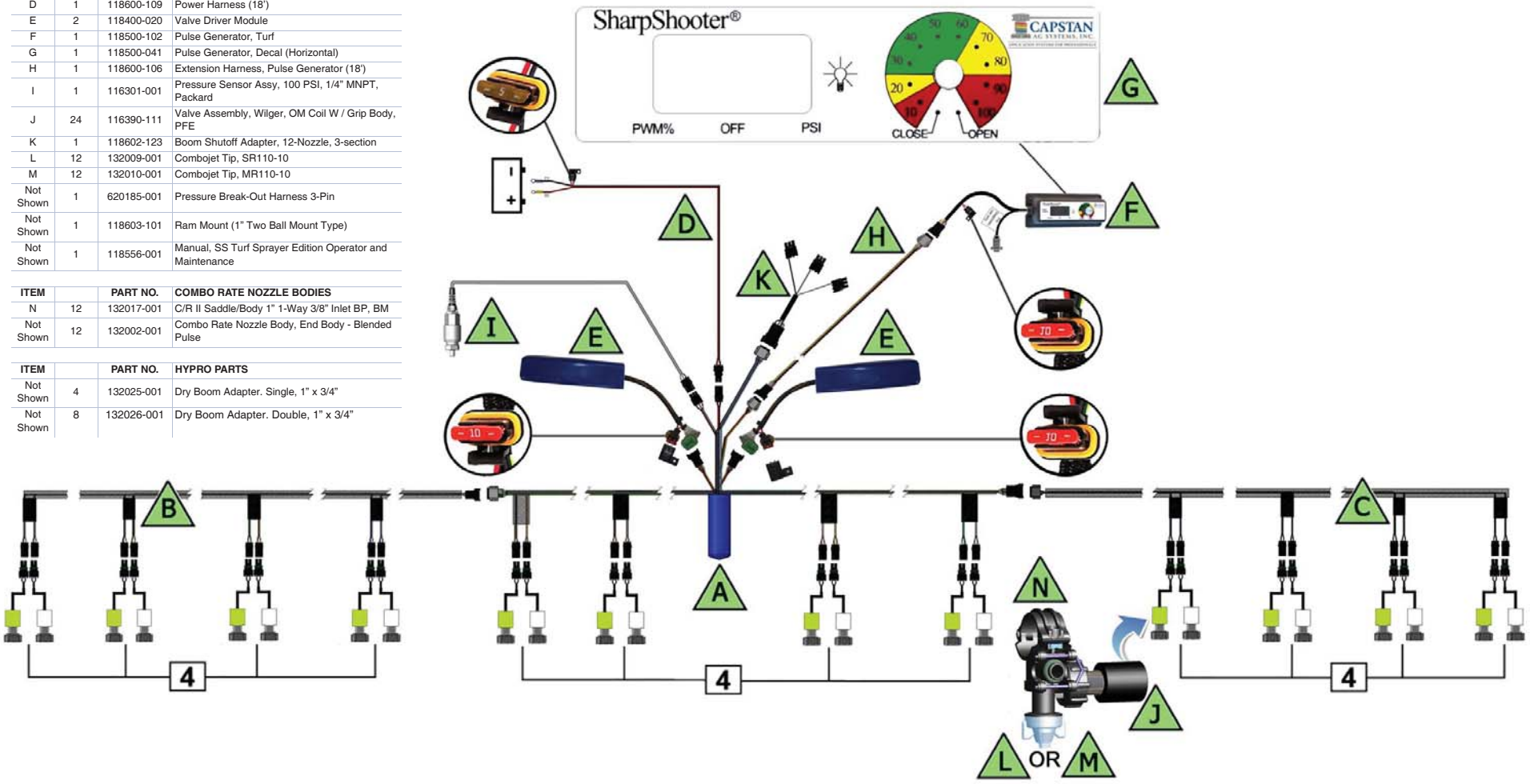
13.0 - KIT JACOBSEN 118600-201, 12-NOZZLE, 3-SECTION, (4-4-4), 20' BOOM, TURF SS

ITEM	QTY.	PART NO.	CAPSTAN SHARPSHOOTER PARTS
A	1	118600-256	Power Hub, Turf, SmithCo 12-Nozzle, Center
B	1	118600-257	LH Boom Harness, (16 wire) Sections 1-4
C	1	118600-258	RH Boom Harness, (16 wire) Sections 9-12
D	1	118600-109	Power Harness (18')
E	2	118400-020	Valve Driver Module
F	1	118500-102	Pulse Generator, Turf
G	1	118500-041	Pulse Generator, Decal (Horizontal)
H	1	118600-106	Extension Harness, Pulse Generator (18')
I	1	116301-001	Pressure Sensor Assy, 100 PSI, 1/4" MNPT, Packard
J	24	116390-111	Valve Assembly, Wilger, OM Coil W / Grip Body, PFE
K	1	118602-123	Boom Shutoff Adapter, 12-Nozzle, 3-section
L	12	132009-001	Combojet Tip, SR110-10
M	12	132010-001	Combojet Tip, MR110-10
Not Shown	1	620185-001	Pressure Break-Out Harness 3-Pin
Not Shown	1	118603-101	Ram Mount (1" Two Ball Mount Type)
Not Shown	1	118556-001	Manual, SS Turf Sprayer Edition Operator and Maintenance

ITEM		PART NO.	COMBO RATE NOZZLE BODIES
N	12	132017-001	C/R II Saddle/Body 1" 1-Way 3/8" Inlet BP, BM
Not Shown	12	132002-001	Combo Rate Nozzle Body, End Body - Blended Pulse

ITEM		PART NO.	HYPRO PARTS
Not Shown	4	132025-001	Dry Boom Adapter. Single, 1" x 3/4"
Not Shown	8	132026-001	Dry Boom Adapter. Double, 1" x 3/4"

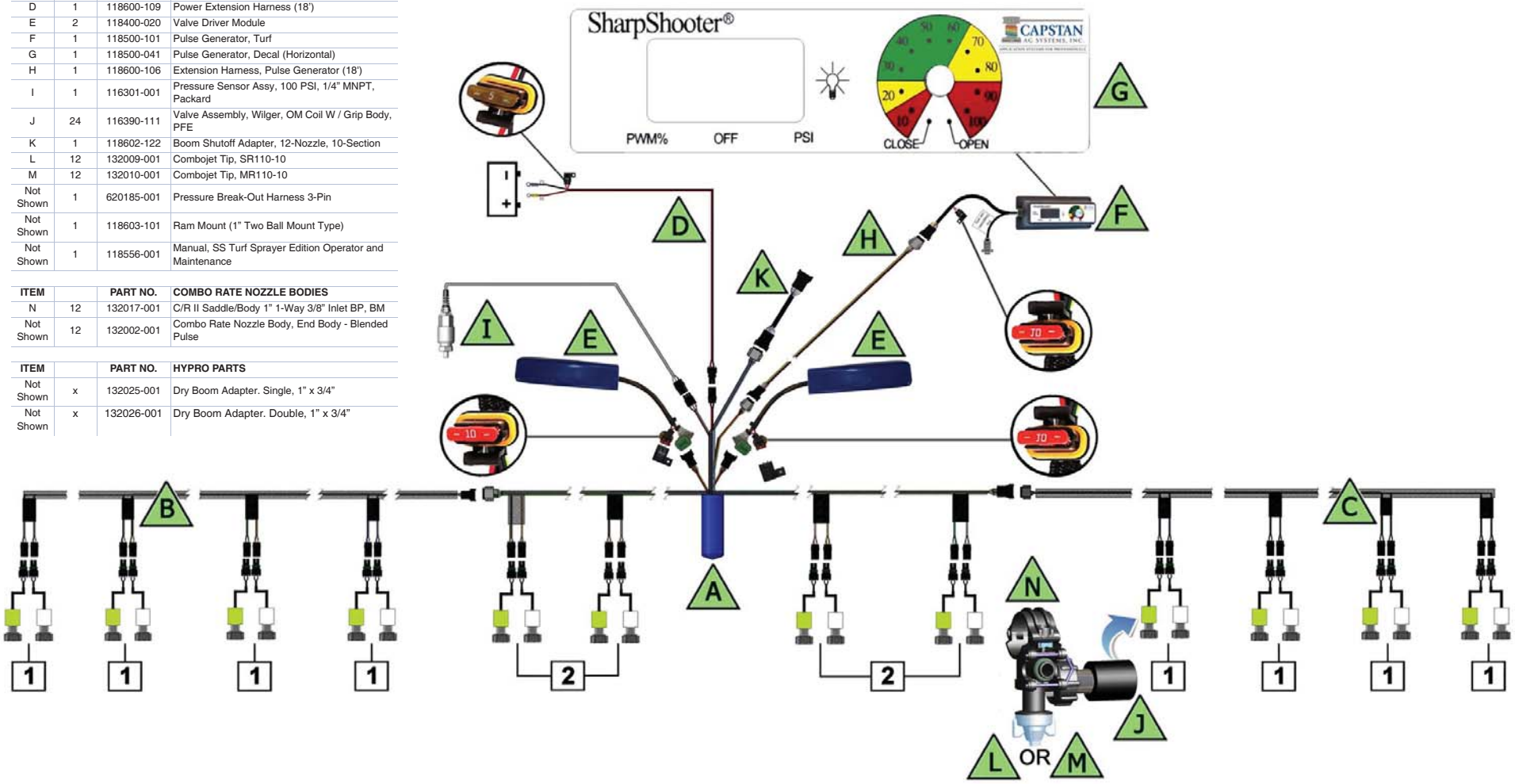


13.1 - KIT JACOBSEN 118600-201, 12-NOZZLE, 10-SECTION, (1-1-1-1-2-2-1-1-1-1), 20' BOOM, TURF SS

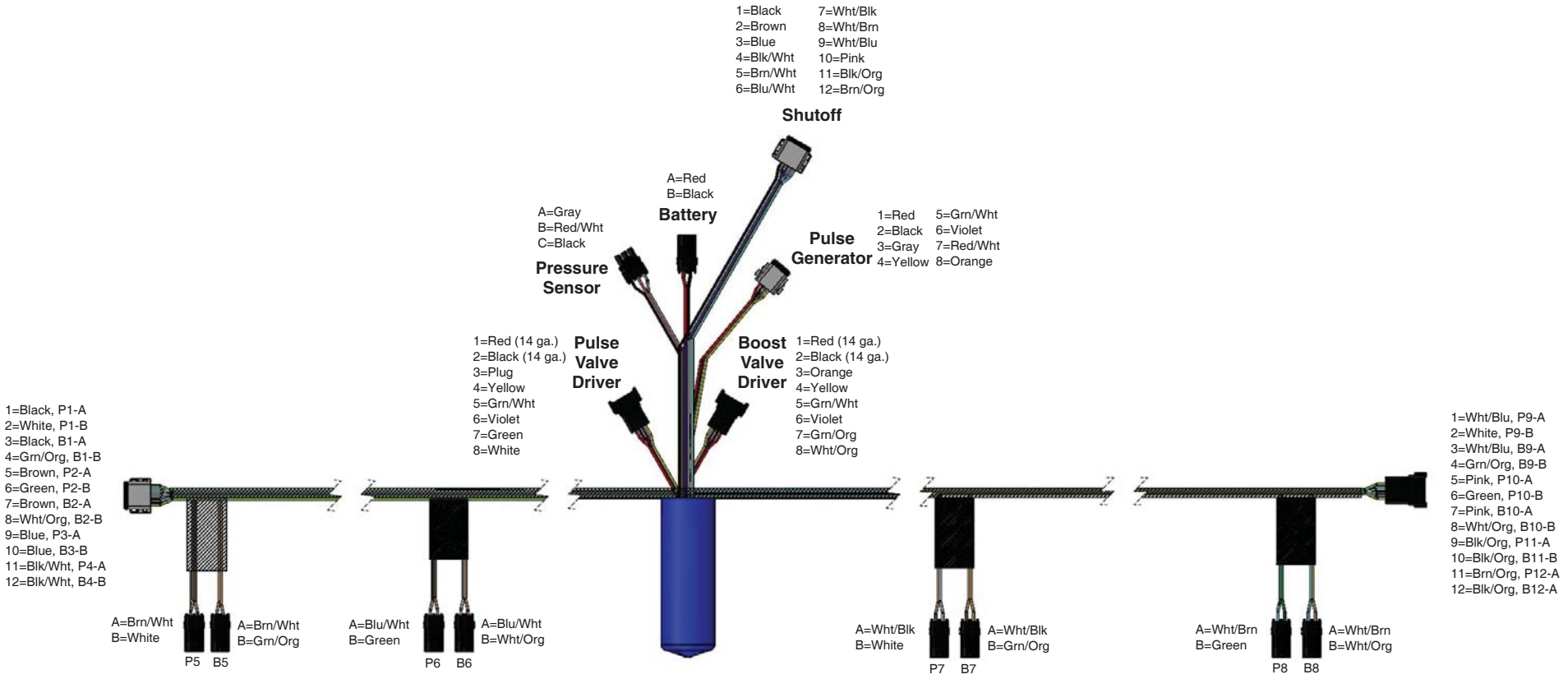
ITEM	QTY.	PART NO.	CAPSTAN SHARPSHOOTER PARTS
A	1	118600-256	Power Hub, Turf, SmithCo 12-Nozzle, Center
B	1	118600-257	LH Boom Harness, (16 wire) Sections
C	1	118600-258	RH Boom Harness, (16 wire) Sections
D	1	118600-109	Power Extension Harness (18')
E	2	118400-020	Valve Driver Module
F	1	118500-101	Pulse Generator, Turf
G	1	118500-041	Pulse Generator, Decal (Horizontal)
H	1	118600-106	Extension Harness, Pulse Generator (18')
I	1	116301-001	Pressure Sensor Assy, 100 PSI, 1/4" MNPT, Packard
J	24	116390-111	Valve Assembly, Wilger, OM Coil W / Grip Body, PFE
K	1	118602-122	Boom Shutoff Adapter, 12-Nozzle, 10-Section
L	12	132009-001	Combojet Tip, SR110-10
M	12	132010-001	Combojet Tip, MR110-10
Not Shown	1	620185-001	Pressure Break-Out Harness 3-Pin
Not Shown	1	118603-101	Ram Mount (1" Two Ball Mount Type)
Not Shown	1	118556-001	Manual, SS Turf Sprayer Edition Operator and Maintenance

ITEM		PART NO.	COMBO RATE NOZZLE BODIES
N	12	132017-001	C/R II Saddle/Body 1" 1-Way 3/8" Inlet BP, BM
Not Shown	12	132002-001	Combo Rate Nozzle Body, End Body - Blended Pulse

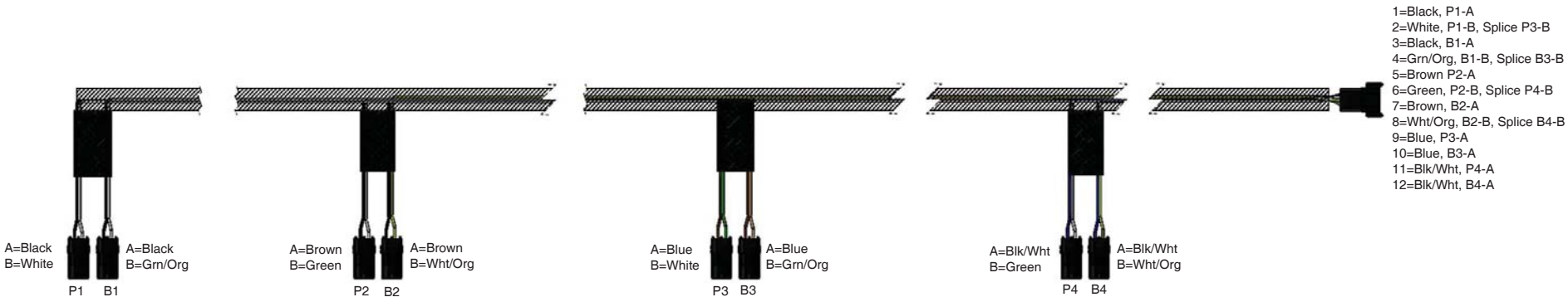
ITEM		PART NO.	HYPRO PARTS
Not Shown	x	132025-001	Dry Boom Adapter. Single, 1" x 3/4"
Not Shown	x	132026-001	Dry Boom Adapter. Double, 1" x 3/4"



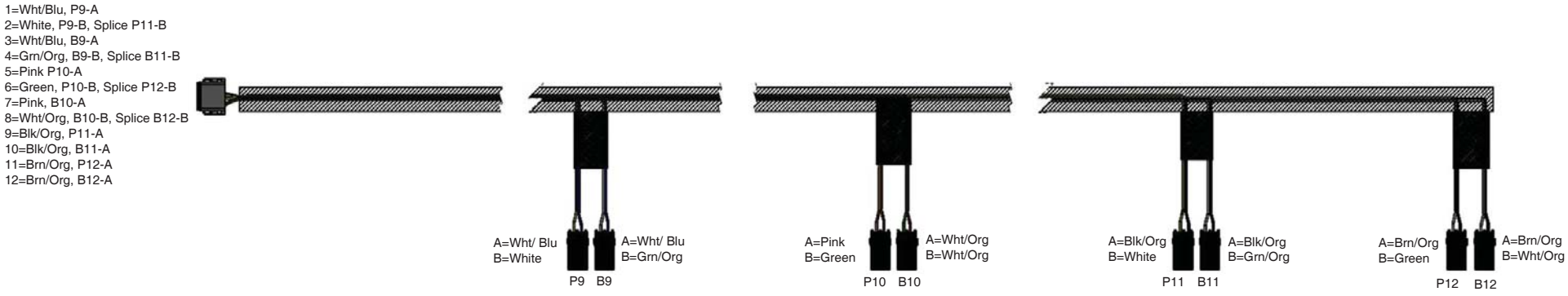
13.2 - Power Hub, 12-Nozzle, 3-Section, Boom 5, 6, 7, 8 - P/N118600-256



13.3 - LH Boom Harness, 12-Nozzle, 3-Section, Boom 1, 2, 3, 4 - P/N118600-257



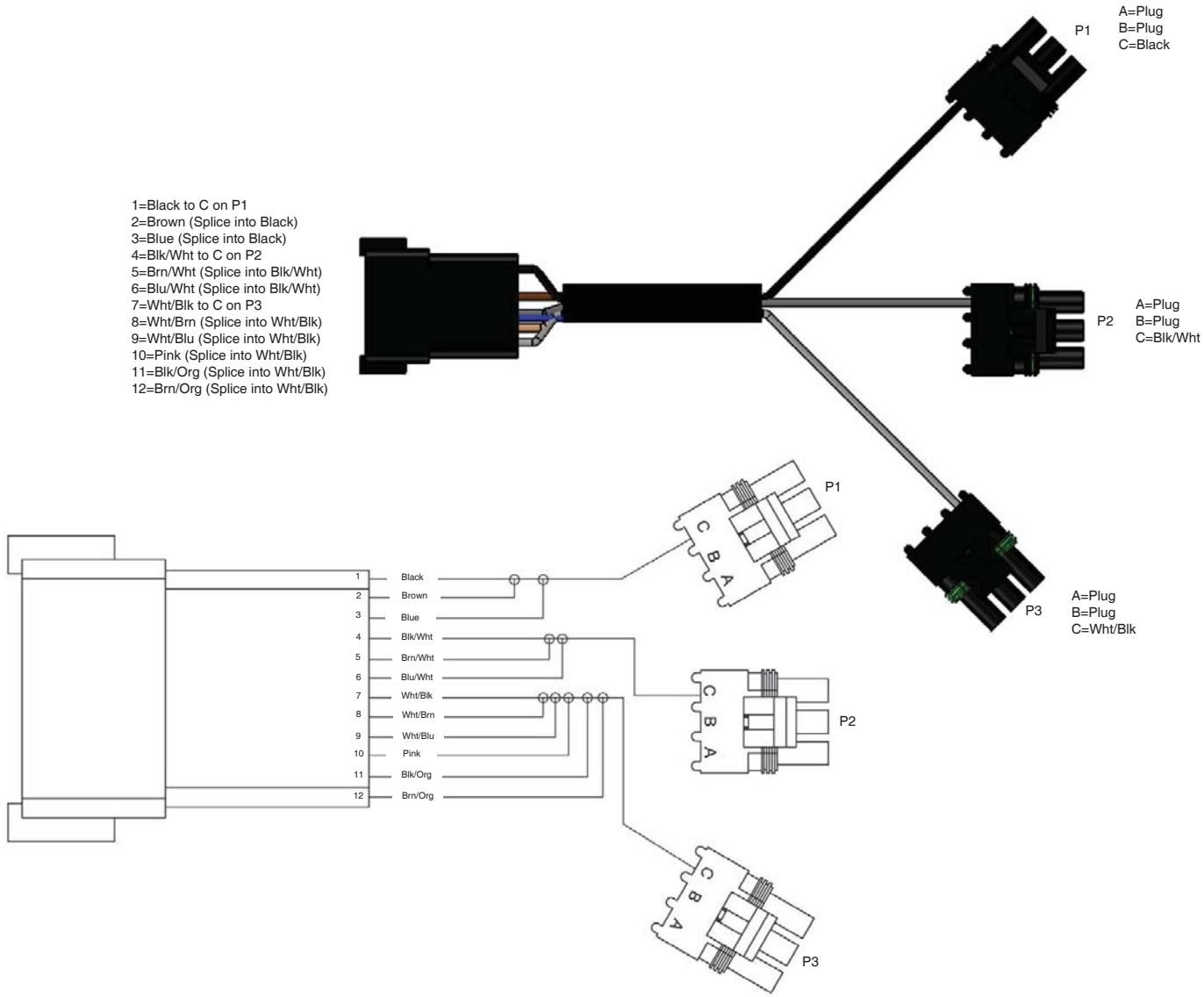
13.4 - RH Boom Harness, 12-Nozzle, 3-Section, Boom 9, 10, 11, 12 - P/N118600-258



13.5 - Extension Harness, Pulse Generator, PN118600-106

13.6 - Power Harness, PN118600-109

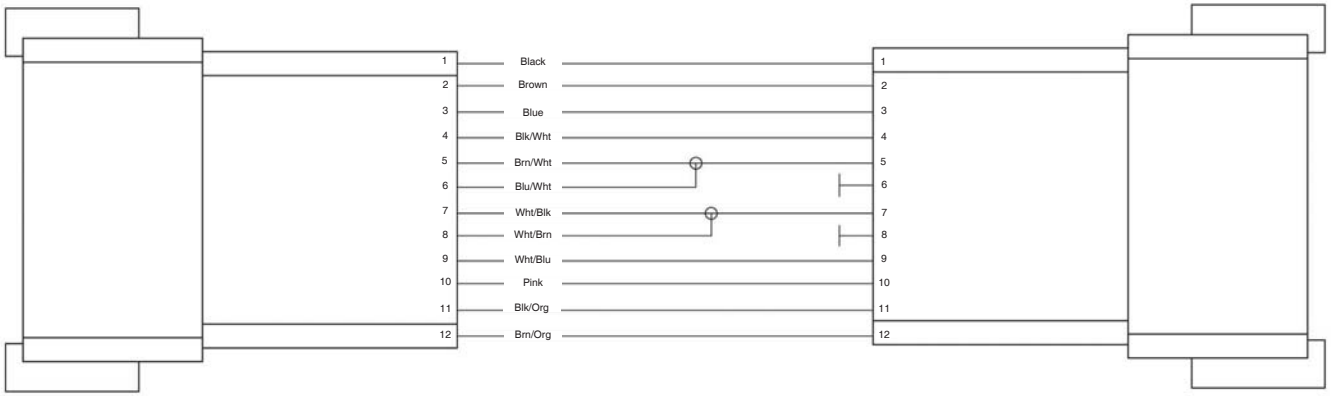
13.7 - Boom Shutoff Adapter, 12-Nozzle, 3-Section, PN118602-123



13.8 - Boom Shutoff Adapter, 12-Nozzle, 10-Section, PN118602-122

1=Black
2=Brown
3=Blue
4=Blk/Wht
5=Brn/White
6=Blu/Wht (Splice into Brn/Wht)
7=Wht/Blk
8=Wht/Brn (Splice into Wht/Blk)
9=Wht/Blu
10=Pink
11=Blk/Org
12=Brn/Org

1=Black
2=Brown
3=Blue
4=Blk/Wht
5=Brn/White
6=Plug
7=Wht/Blk
8=Plug
9=Wht/Blu
10=Pink
11=Blk/Org
12=Brn/Org



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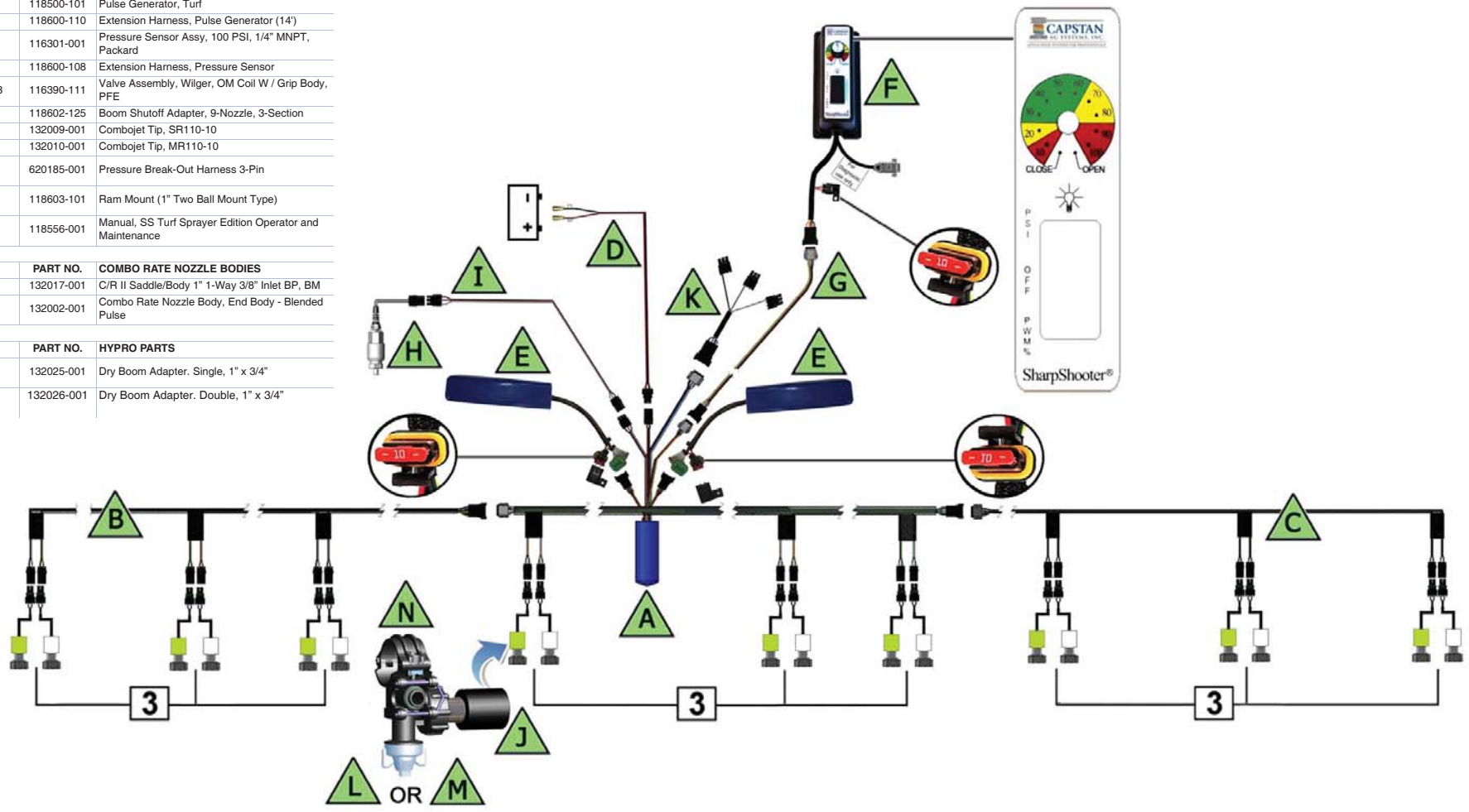
14.0 - KIT SMITHCO 118600-205, 9-NOZZLE, 3-SECTION, (3-3-3), 15’ BOOM, TURF SS

ITEM	QTY.	PART NO.	CAPSTAN SHARPSHOOTER PARTS
A	1	118600-250	Power Hub, Turf, SmithCo 9-Nozzle, Center
B	1	118600-251	LH Boom Harness, (12 wire) Sections 1-3
C	1	118600-252	RH Boom Harness, (12 wire) Sections 7-9
D	1	118600-107	Power Harness (14')
E	2	118400-020	Valve Driver Module
F	1	118500-101	Pulse Generator, Turf
G	1	118600-110	Extension Harness, Pulse Generator (14')
H	1	116301-001	Pressure Sensor Assy, 100 PSI, 1/4” MNPT, Packard
I	1	118600-108	Extension Harness, Pressure Sensor
J	18	116390-111	Valve Assembly, Wilger, OM Coil W / Grip Body, PFE
K	1	118602-125	Boom Shutoff Adapter, 9-Nozzle, 3-Section
L	9	132009-001	Combojet Tip, SR110-10
M	9	132010-001	Combojet Tip, MR110-10
Not Shown	1	620185-001	Pressure Break-Out Harness 3-Pin
Not Shown	1	118603-101	Ram Mount (1” Two Ball Mount Type)
Not Shown	1	118556-001	Manual, SS Turf Sprayer Edition Operator and Maintenance

ITEM		PART NO.	COMBO RATE NOZZLE BODIES
N	9	132017-001	C/R II Saddle/Body 1” 1-Way 3/8” Inlet BP, BM
Not Shown	9	132002-001	Combo Rate Nozzle Body, End Body - Blended Pulse

ITEM		PART NO.	HYPRO PARTS
Not Shown	4	132025-001	Dry Boom Adapter. Single, 1” x 3/4”
Not Shown	5	132026-001	Dry Boom Adapter. Double, 1” x 3/4”

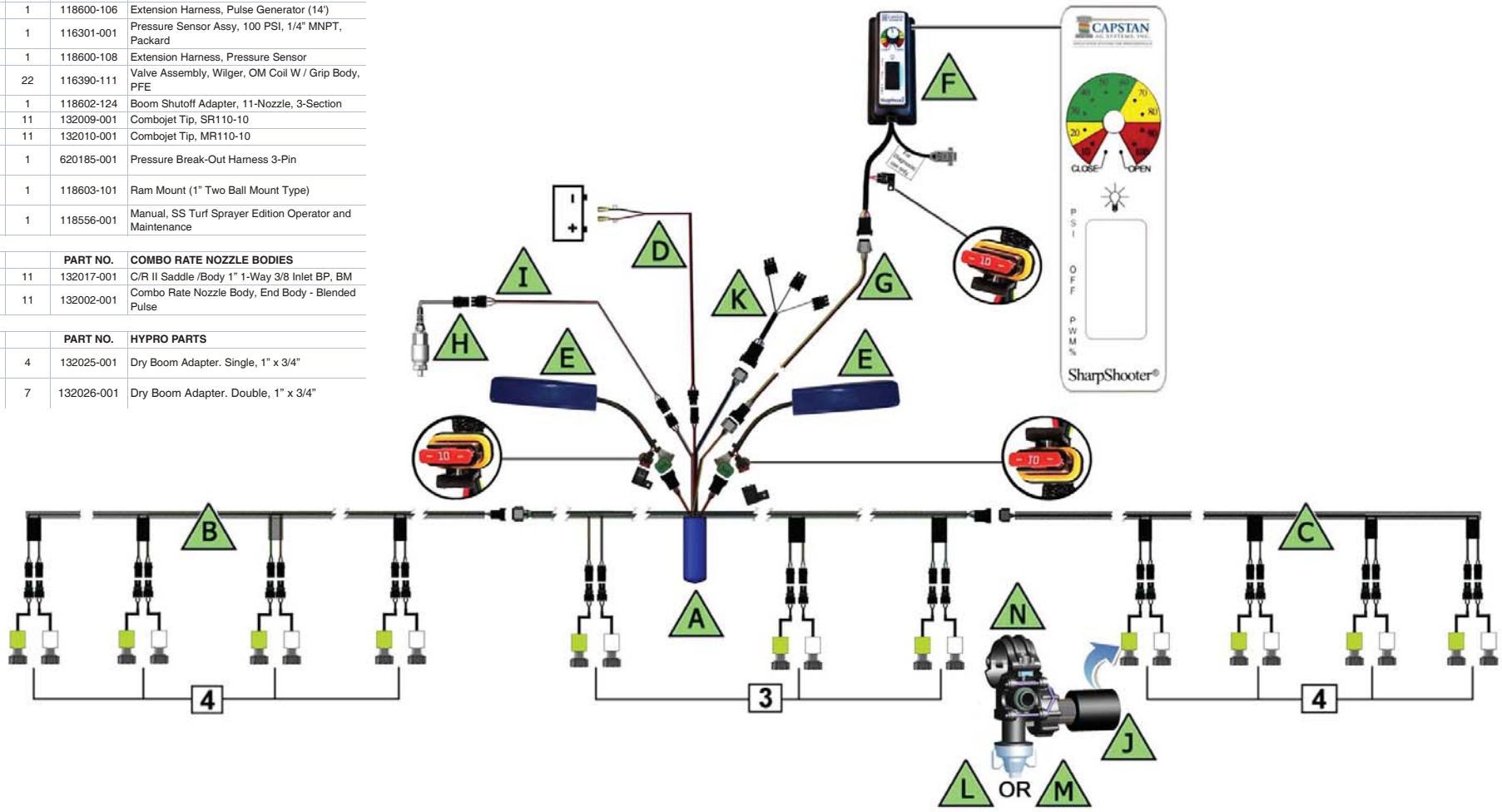


14.1 - KIT SMITCO 118600-203, 11-NOZZLE, 3-SECTION, (4-3-4), 18’ BOOM, TURF SS

ITEM	QTY.	PART NO.	CAPSTAN SHARPSHOOTER PARTS
A	1	118600-253	Power Hub, Turf, SmithCo 11-Nozzle, Center
B	1	118600-254	LH Boom Harness, (16 wire) Sections 1-4
C	1	118600-255	RH Boom Harness, (16 wire) Sections 8-11
D	1	118600-107	Power Harness (14’)
E	2	118400-020	Valve Driver Module
F	1	118500-101	Pulse Generator, Turf
G	1	118600-106	Extension Harness, Pulse Generator (14’)
H	1	116301-001	Pressure Sensor Assy, 100 PSI, 1/4” MNPT, Packard
I	1	118600-108	Extension Harness, Pressure Sensor
J	22	116390-111	Valve Assembly, Wilger, OM Coil W / Grip Body, PFE
K	1	118602-124	Boom Shutoff Adapter, 11-Nozzle, 3-Section
L	11	132009-001	Combojet Tip, SR110-10
M	11	132010-001	Combojet Tip, MR110-10
Not Shown	1	620185-001	Pressure Break-Out Harness 3-Pin
Not Shown	1	118603-101	Ram Mount (1” Two Ball Mount Type)
Not Shown	1	118556-001	Manual, SS Turf Sprayer Edition Operator and Maintenance

ITEM		PART NO.	COMBO RATE NOZZLE BODIES
N	11	132017-001	C/R II Saddle /Body 1” 1-Way 3/8 Inlet BP, BM
Not Shown	11	132002-001	Combo Rate Nozzle Body, End Body - Blended Pulse

ITEM		PART NO.	HYPRO PARTS
Not Shown	4	132025-001	Dry Boom Adapter. Single, 1” x 3/4”
Not Shown	7	132026-001	Dry Boom Adapter. Double, 1” x 3/4”

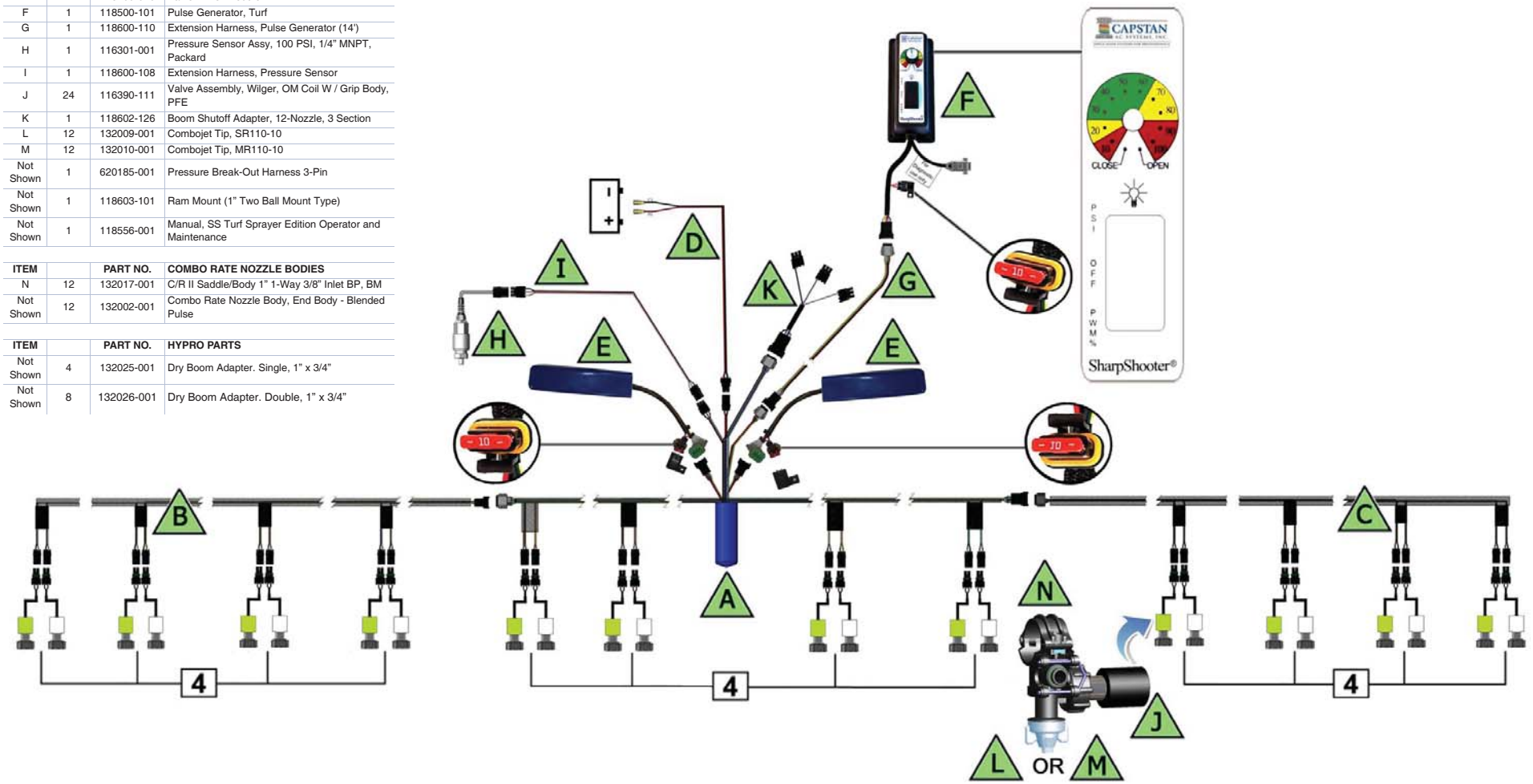


14.2 - KIT SMITHCO 118600-204, 12-NOZZLE, 3-SECTION, (4-4-4), 20’ BOOM, TURF SS

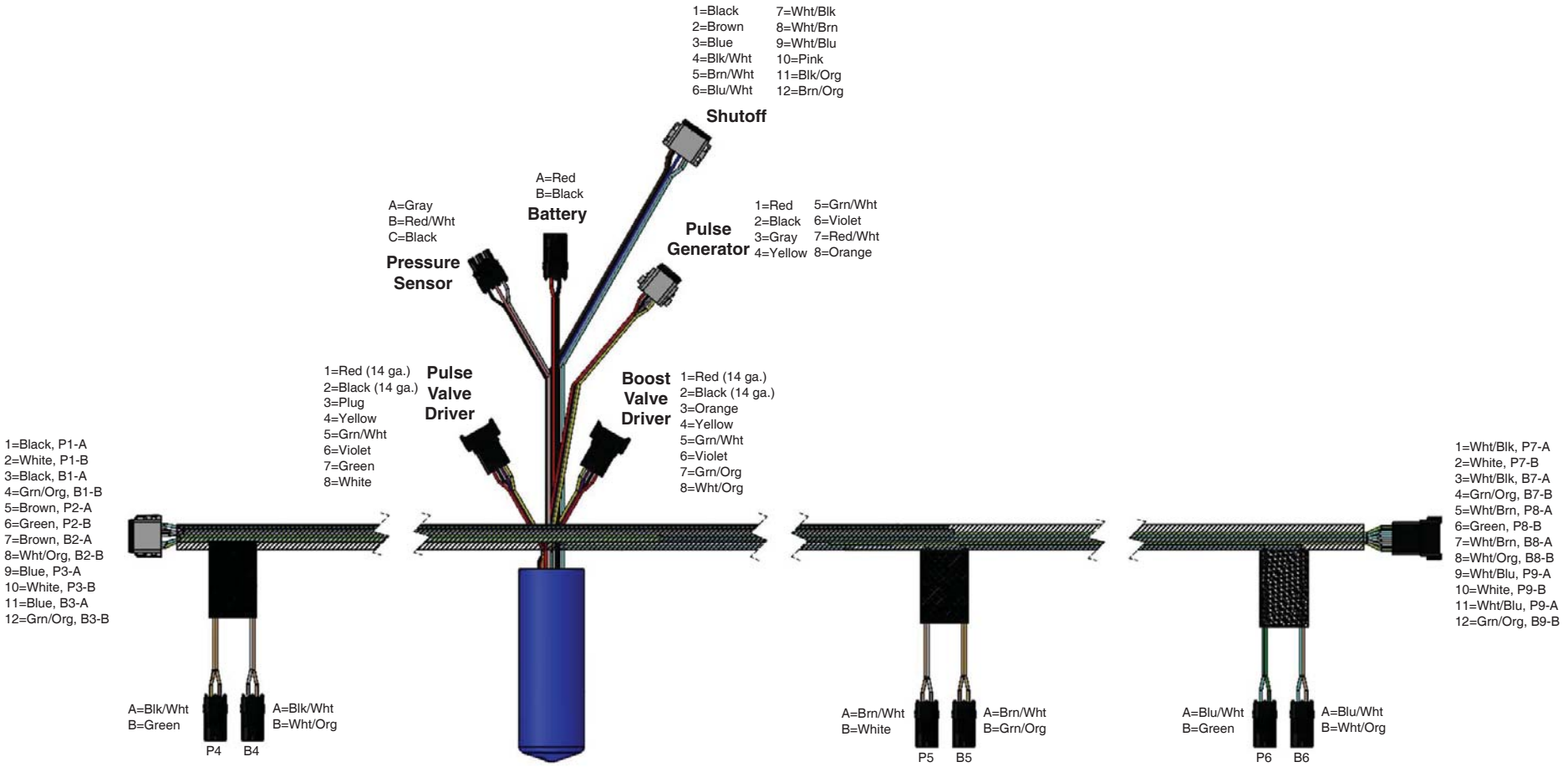
ITEM	QTY.	PART NO.	CAPSTAN SHARPSHOOTER PARTS
A	1	118600-256	Power Hub, Turf, SmithCo 12-Nozzle, Center
B	1	118600-257	LH Boom Harness, (16 wire) Sections 1-4
C	1	118600-258	RH Boom Harness, (16 wire) Sections 9-12
D	1	118600-107	Power Harness (14’)
E	2	118400-020	Valve Driver Module
F	1	118500-101	Pulse Generator, Turf
G	1	118600-110	Extension Harness, Pulse Generator (14’)
H	1	116301-001	Pressure Sensor Assy, 100 PSI, 1/4” MNPT, Packard
I	1	118600-108	Extension Harness, Pressure Sensor
J	24	116390-111	Valve Assembly, Wilger, OM Coil W / Grip Body, PFE
K	1	118602-126	Boom Shutoff Adapter, 12-Nozzle, 3 Section
L	12	132009-001	Combojet Tip, SR110-10
M	12	132010-001	Combojet Tip, MR110-10
Not Shown	1	620185-001	Pressure Break-Out Harness 3-Pin
Not Shown	1	118603-101	Ram Mount (1” Two Ball Mount Type)
Not Shown	1	118556-001	Manual, SS Turf Sprayer Edition Operator and Maintenance

ITEM		PART NO.	COMBO RATE NOZZLE BODIES
N	12	132017-001	C/R II Saddle/Body 1” 1-Way 3/8” Inlet BP, BM
Not Shown	12	132002-001	Combo Rate Nozzle Body, End Body - Blended Pulse

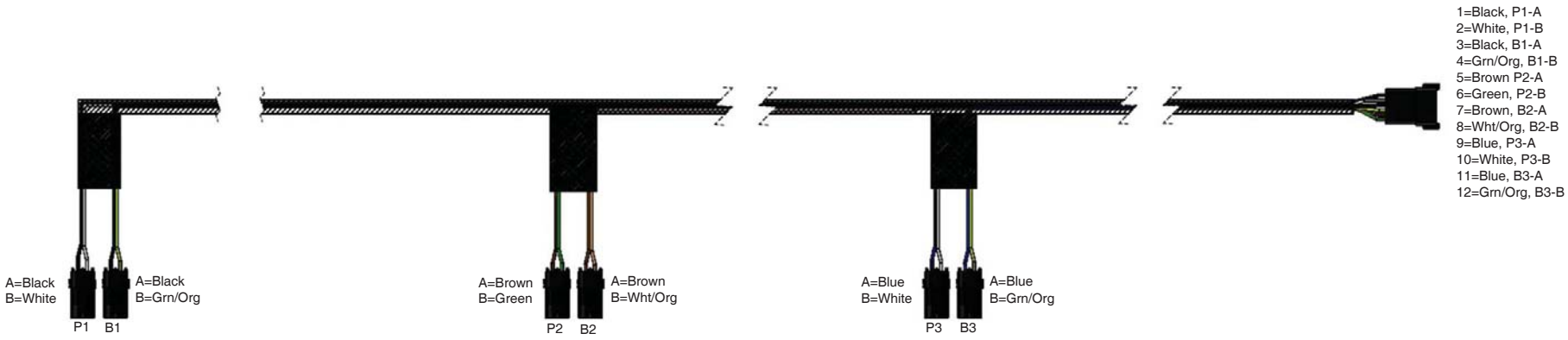
ITEM		PART NO.	HYPRO PARTS
Not Shown	4	132025-001	Dry Boom Adapter. Single, 1” x 3/4”
Not Shown	8	132026-001	Dry Boom Adapter. Double, 1” x 3/4”



14.3 - Power Hub, 9-Nozzle, 3-Section, Boom 4, 5, 6 - P/N118600-250



14.4 - LH Boom Harness, 9-Nozzle, 3-Section, Boom 1, 2, 3 - P/N118600-251



14.5 - RH Boom Harness, 9-Nozzle, 3-Section, Boom 7, 8, 9 - P/N118600-252

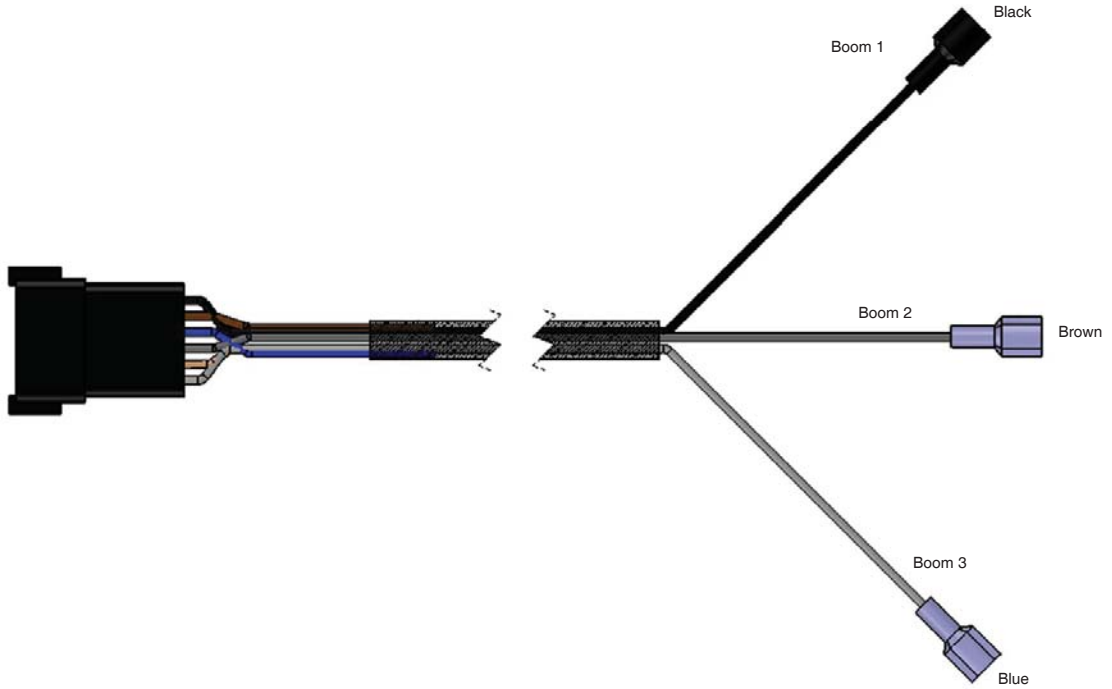
14.6 - Extension Harness, Pulse Generator, PN118600-110

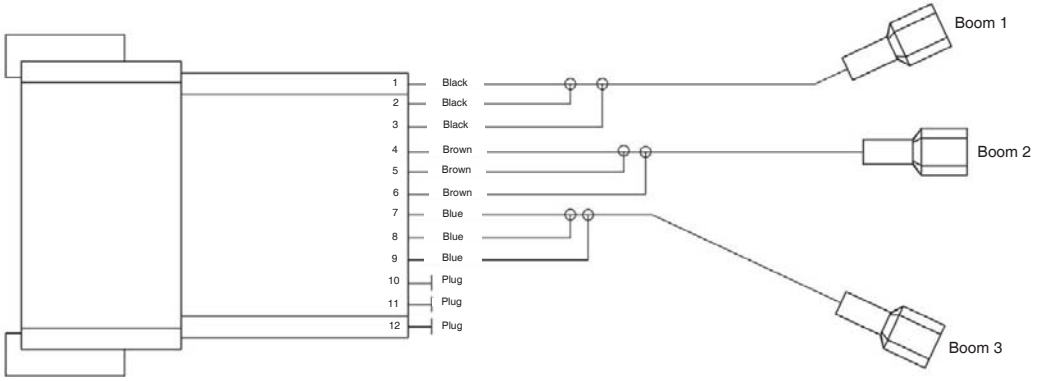
14.7 - Power Harness, PN118600-107

14.8 - Extension Harness, Pressure Sensor, PN118600-108

14.9 - Boom Shutoff Adapter, 9-Nozzle, 3-Section, PN118602-125

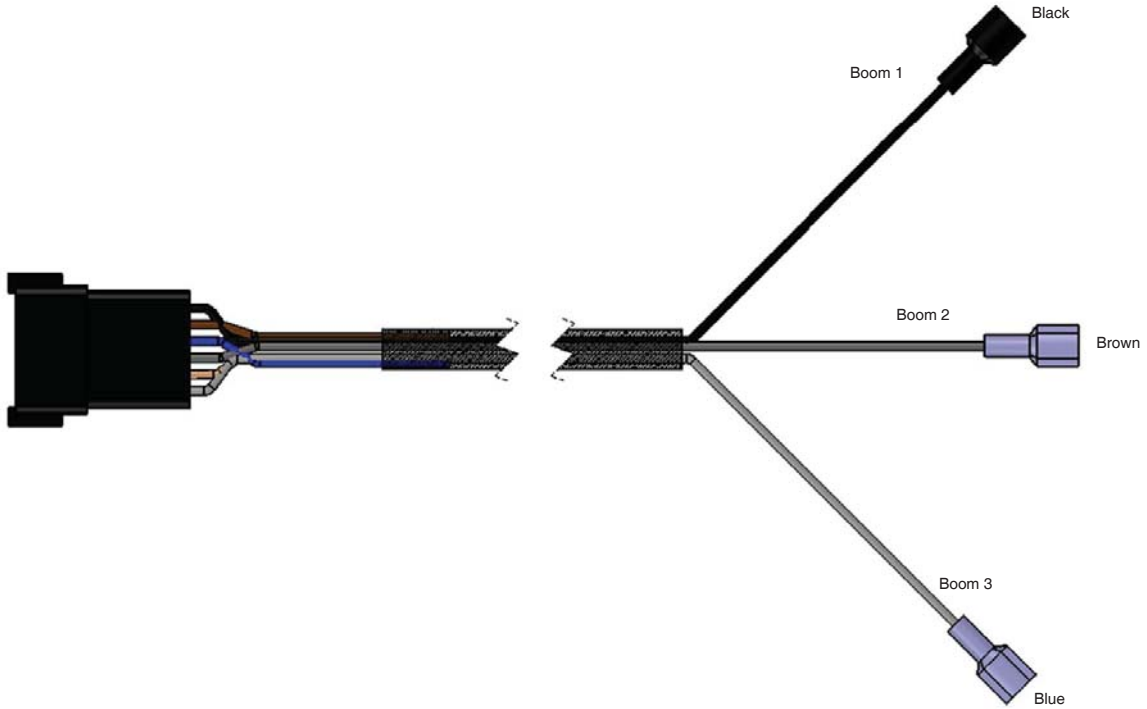
1=Black
2=Black (Splice into Black)
3=Black (Splice into Black)
4=Black (Splice into Black)
5=Brown
6=Brown (Splice into Brown)
7=Brown (Splice into Brown)
8=Brown (Splice into Brown)
9=Blue
10=Blue (Splice into Blue)
11=Blue (Splice into Blue)
12=Blue (Splice into Blue)

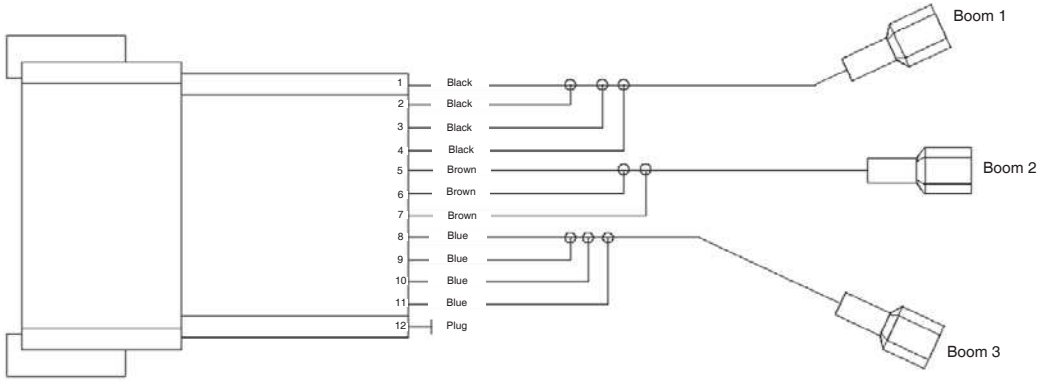




14.10 - Boom Shutoff Adapter, 11-Nozzle, 3-Section, PN118602-124

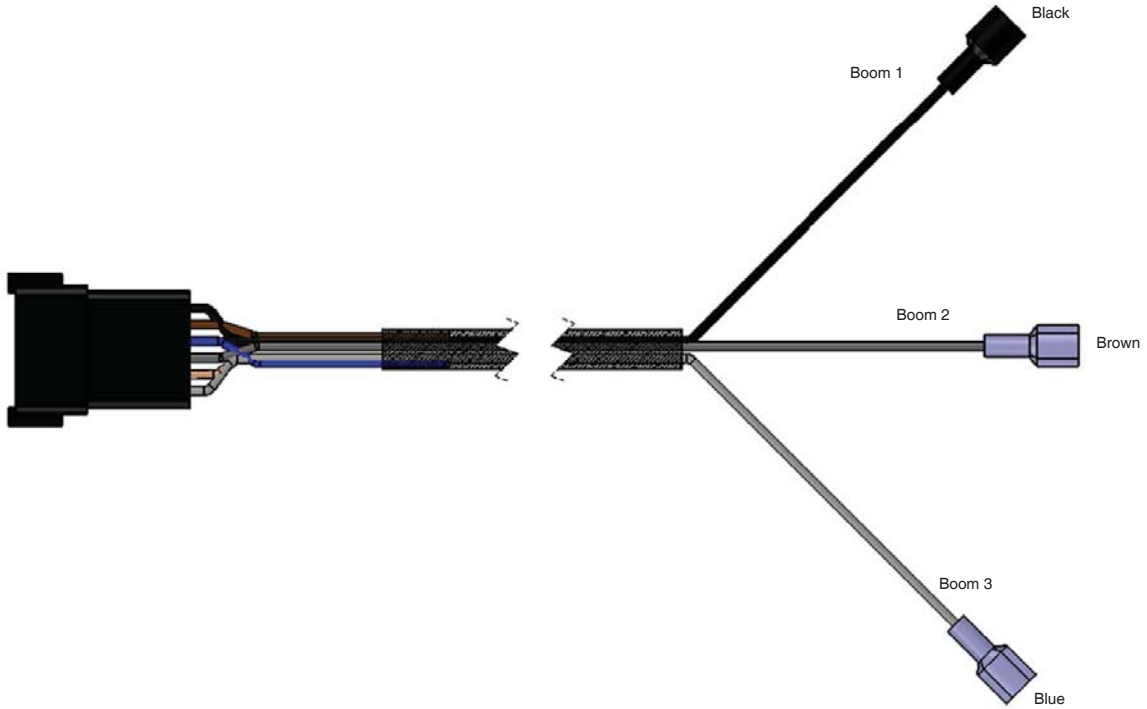
1=Black
2=Black (Splice into Black)
3=Black (Splice into Black)
4=Black (Splice into Black)
5=Brown
6=Brown (Splice into Brown)
7=Brown (Splice into Brown)
8=Blue
9=Blue (Splice into Blue)
10=Blue (Splice into Blue)
11=Blue (Splice into Blue)
12=Plug

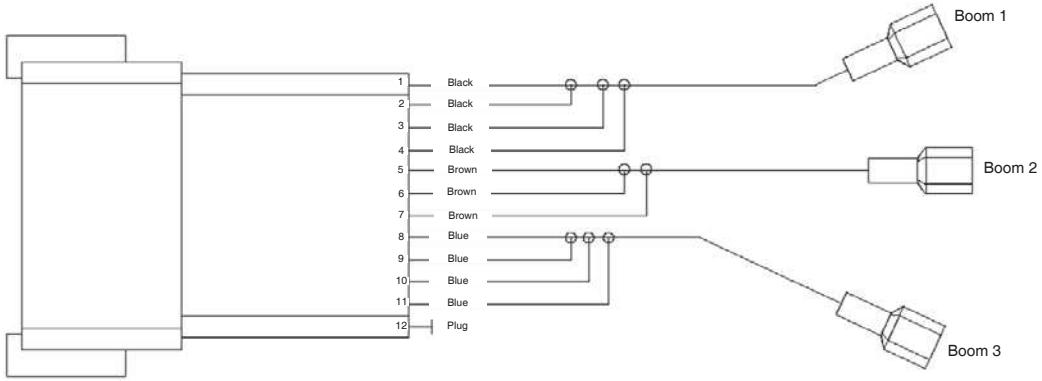




14.11 - Boom Shutoff Adapter, 12-Nozzle, 3-Section, PN118602-126

1=Black
2=Black (Splice into Black)
3=Black (Splice into Black)
4=Black (Splice into Black)
5=Brown
6=Brown (Splice into Brown)
7=Brown (Splice into Brown)
8=Blue
9=Blue (Splice into Blue)
10=Blue (Splice into Blue)
11=Blue (Splice into Blue)
12=Plug





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