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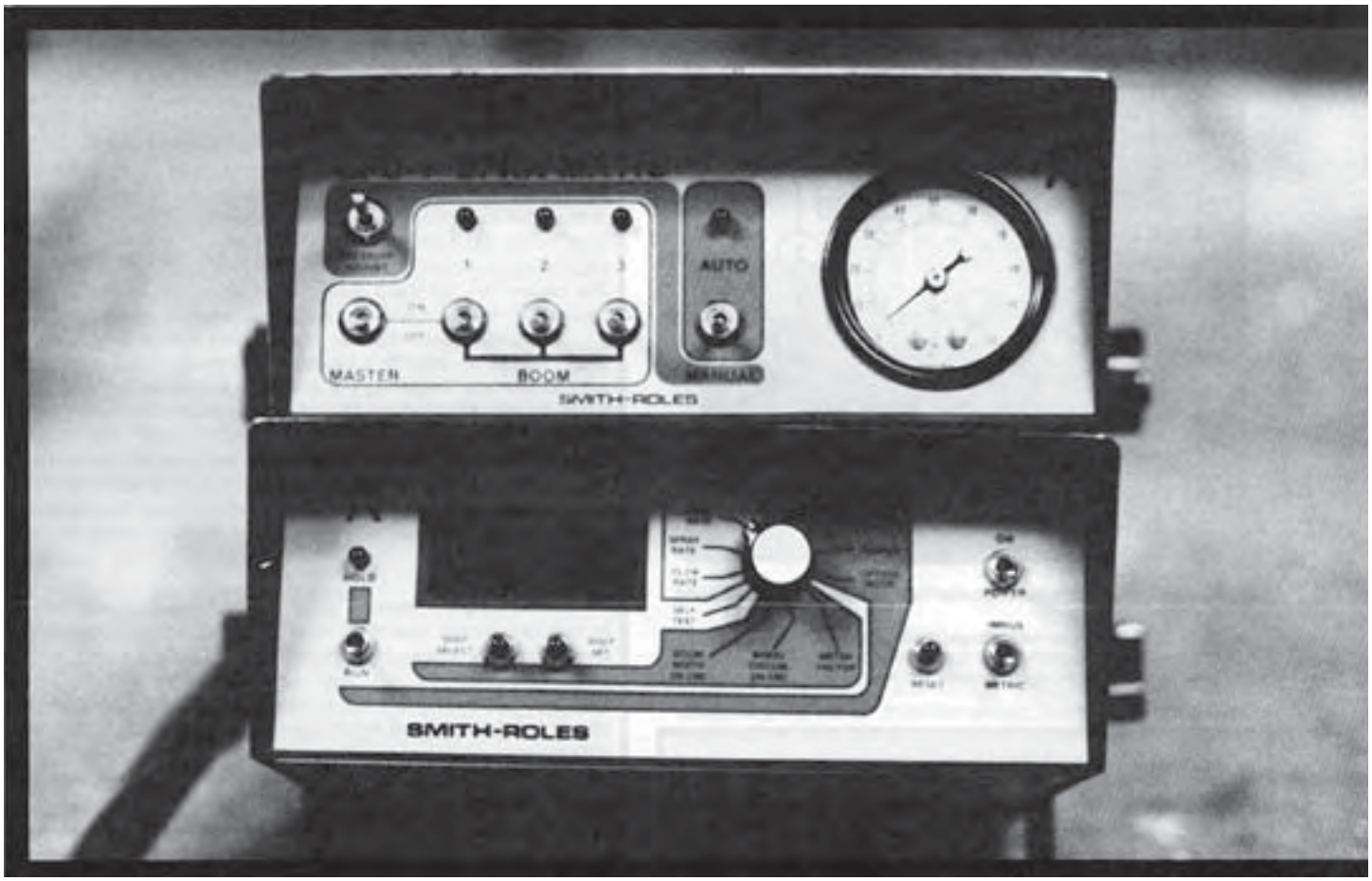

SMITH-ROLES AUTOMATIC SPRAYER CONTROL SYSTEM (MODEL SP-3A SPRAYER MONITOR AND SPC-1 CONTROLLER)

A Co-operative Program Between

ALBERTA FARM MACHINERY RESEARCH CENTRE
PAMI
PRAIRIE AGRICULTURAL MACHINERY INSTITUTE

SMITH-ROLES AUTOMATIC SPRAYER CONTROL SYSTEM

MANUFACTURER

Smith-Roles Limited
2401 Millar Avenue
Saskatoon, Saskatchewan
S7K 2Y4

RETAIL PRICE: (April, 1984, f.o.b. Lethbridge, Alberta).

(a) Model SP-3A Monitor $910.00
(b) Model SPC-1 Controller $328.00
(c) Optional Solenoid Valves (each) $ 89.85

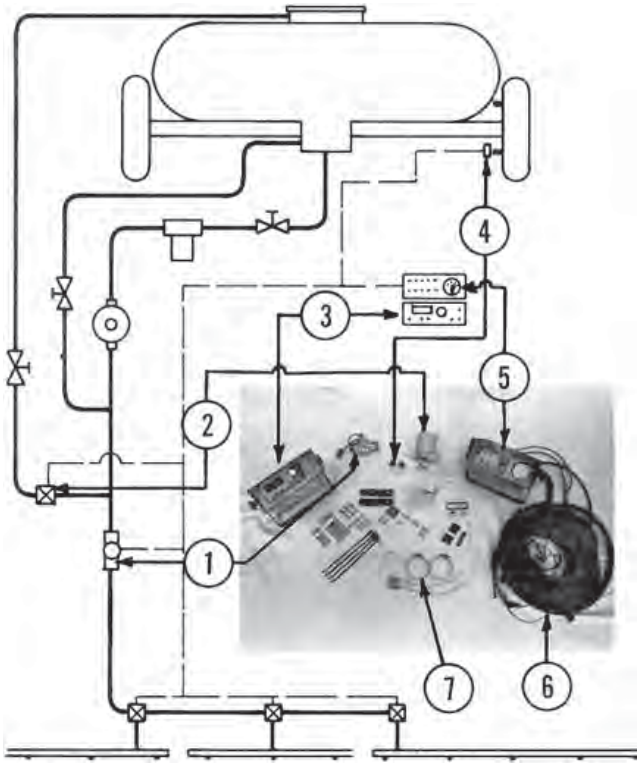

FIGURE 1. Smith-Roles Automatic Sprayer Control System: (1) Flow Meter (2) Motorized Control Valve, (3) SP-3A Sprayer Monitor, (4) Speed Sensor, (5) SPC-1 Sprayer Controller, (6) Cables, (7) Mounting Hardware and Accessories.

SUMMARY AND CONCLUSIONS

Functional Performance: The Smith-Roles automatic sprayer control system consisted of two individual consoles; the Smith-Roles model SP-3A sprayer monitor and the model SPC-1 sprayer controller. The two systems could be used individually or combined in a modular fashion as a system.

The performance of the Smith-Roles model SP-3A and SPC-1 were good. Some monitor and controller features of the system were considered very beneficial in providing the operator with the information and controls to manually make required changes from the tractor seat. The automatic rate controlling feature, to automatically control application rate, was deemed to be of less importance due to the narrow range of forward speeds over which the spraying rate could be effectively controlled automatically and due to the large and rapid pressure changes experienced over this narrow range of speeds.

Flow Meter: The flow meter was accurate above 2.9 gal/min (13 L/min), using the flow meter calibration number supplied by the manufacturer. The flow meter was reliable and repeatable.

Speed Sensor: When properly calibrated, the speed sensor was accurate above 1.2 mph (2 km/h) when using two magnets and above 2.5 mph (4 km/h) when using one magnet. The monitor application rate indication depended on the speed sensor calibration number. Therefore, it was very important to obtain the speed sensor calibration number in field conditions similar to those encountered during spraying, with sprayer tires properly inflated and with the sprayer tank half full of water.

Motorized Control Valve: In the automatic mode, the motorized control valve responded slowly to changes in forward speed and flow. It took about a minute to completely respond to a change in forward speed. As a result, the automatic rate control feature usefulness was reduced in hilly fields and after turning or cornering. In the manual mode, it was easy to obtain the desired pressure, however, it took up to a minute to do so.

Installation: The Smith-Roles system took 5 hours to install. Sprayer plumbing modifications were usually required to properly install the flow meter and solenoid valves. All wires were conveniently packaged into one cable for neat and convenient hook-up to the tractor and sprayer. Pull-apart connectors made unhitching the tractor from the sprayer quick and easy. The pressure gauge hose was too short to allow pressure to be measured at the nozzles.

Control Console: The 4-digit LED display screen was easy to see providing the console was not in direct sunlight. Readout was conveniently possible in both SI (metric) and Imperial units by positioning a switch. All controls were conveniently positioned and easy to use. The calibrating, operating and cumulative functions were conveniently distinguished in the monitor for easy understanding and use of the system. Four calibration numbers had to be entered in the console memory. The calibration numbers were easily obtained. Entering the calibration numbers was easy and convenient.

Automatic Control: Both Smith-Roles model SP-3A and SPC-1 had to be used to automatically control a preselected application rate. Preparing the system to automatically control a preselected application rate required proper nozzle selection and setting of pressure limits for proper nozzle operation. Although the procedure was somewhat complex, the detailed, step-by-step explanation in the operator's manual was easy to follow. Once the proper nozzles had been selected, the control console was easily programmed to automatically control a preselected application rate by simply entering the desired application rate.

Power Requirements: A good 12V battery was necessary to maintain proper operating voltage. No excessive electrical demands were made on a normal 12V tractor battery and charging system.

Operator's Manual: The operator's manual provided complete information on installation, operation, adjustment and calibration.

Mechanical Failures: No failures were encountered during the evaluation.

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Supplying a longer hose to allow pressure to be measured at the nozzles.
2. Modifications to improve motorized control valve response.
3. Modifications to eliminate pressure oscillations caused by large changes in forward speed.

Senior Engineer: E. H. Wiens

Project Technologist: B. Storozynsky

THE MANUFACTURER STATES THAT

With regard to recommendation number: 1, 2, & 3. All recommendations have been noted and appropriate changes are under consideration.

GENERAL DESCRIPTION

The Smith-Roles automatic sprayer control system consists of a model SP-3A sprayer monitor, a model SPC-1 sprayer controller, a turbine flow meter, a speed sensor (FIGURE 1), and a motorized control valve. The SP-3A in conjunction with the flow meter and speed sensor is used to monitor sprayer performance. When combined in a modular fashion with the SPC-1 and motorized control valve, it becomes an automatic application rate control system.

The Smith-Roles model SP-3A sprayer monitor indicates application rate, ground speed, area sprayed, workrate, flow to the

booms, distance travelled, and fluid pumped, in either SI (metric) or Imperial units. The Smith-Roles model SPC-1 sprayer controller automatically controls application rate when changes in forward speed occur. In addition, the controller monitors boom pressure and controls the boom solenoid valves. The control consoles mount near the operator's station. The speed sensor, to measure ground speed, consists of two magnets that mount on a non-driven wheel of the tractor or sprayer wheel and a pickup assembly that mounts on a frame near the wheel and magnets. The turbine flow meter mounts in the sprayer plumbing circuit to measure the amount of fluid going to the nozzles. The motorized control valve is located in the sprayer plumbing and either automatically or manually opens or closes to maintain a preset application rate.

The Smith-Roles sprayer control system is powered by the tractor electrical system and will operate on either a positive or negative ground.

Detailed specifications are given in APPENDIX I while FIGURE 1 shows major components and a schematic of their location in a typical sprayer plumbing system.

SCOPE OF TEST

The Smith-Roles automatic sprayer control system was used for 55 hours while spraying about 939 ac (380 ha). It was evaluated for ease of installation, ease of operation and adjustment, quality of work and suitability of the operator's manual.

RESULTS AND DISCUSSION

EASE OF INSTALLATION

Installation Time: It took about 5 hours to install the Smith-Roles on a Sprafoil model PT4583 sprayer. Installation instructions were clear and adequate. The Sprafoil was already equipped with solenoid valves and 1 in (25 mm) plumbing, which made installation quick and easy. Other sprayers, without solenoid valves or 1 in (25 mm) plumbing, may require more time and additional plumbing fittings and material.

Control Consoles: Mounting hardware and enough cable were provided to mount the control consoles near the operator station and connect them to the tractor electrical system.

Flow Meter: The flow meter had to be installed in the sprayer plumbing system so the entire flow going to the nozzles passed through it. As a result, modifications to the original sprayer plumbing system were usually required. The existing plumbing had to be either cut, shortened, re-routed or replaced to provide the recommended straight length of inlet hose to ensure flow meter accuracy. The flow meter was heavy and had to be properly secured. Replacing the existing rubber hoses with metal piping provided adequate support for the flow meter.

Motorized Control Valve: Location of the motorized control valve depended on the existing plumbing and operator preference. The motorized control valve could be installed in either the main boom line or in the by-pass line. Only the bypass location was discussed in the operator's manual. Installation was easy and simple and involved cutting or separating the main boom or by-pass line and inserting the valve. The valve was small and light and didn't have to be supported.

Solenoid Valves: No remote control boom valves were supplied with the Smith-Roles system. To make the system totally operational from the tractor seat, solenoid valves are available as an option.

Speed Sensor: The speed sensor magnets were easily fastened to the rim of a wheel (FIGURE 2). The pickup assembly was a little more difficult to install since it required fastening to a stationary part of the sprayer in close proximity to the sensor magnets. The pickup had to be placed no more than 11/16 in (18 mm) from the magnets. When installing the speed sensor on a front tractor wheel, caution was required to ensure the wheel could be turned to its extreme without magnet and pickup interference and still maintain the 11/16 in (18 mm) gap.

Wiring Harness: All wires in the wiring harness were conveniently combined into one cable, making it tidy and easy to fasten to the sprayer and tractor. Pull-apart connectors made unhitching the tractor from the sprayer convenient. The ground speed sensor wire had to be removed from the main cable when installing the speed sensor on a front tractor wheel.

The hose supplied to monitor pressure was only long enough to monitor system pressure at the front of the sprayer. For accurate system operation, pressure should be monitored at the nozzles. It is recommended that enough hose be supplied to allow pressure to be measured at the nozzles.

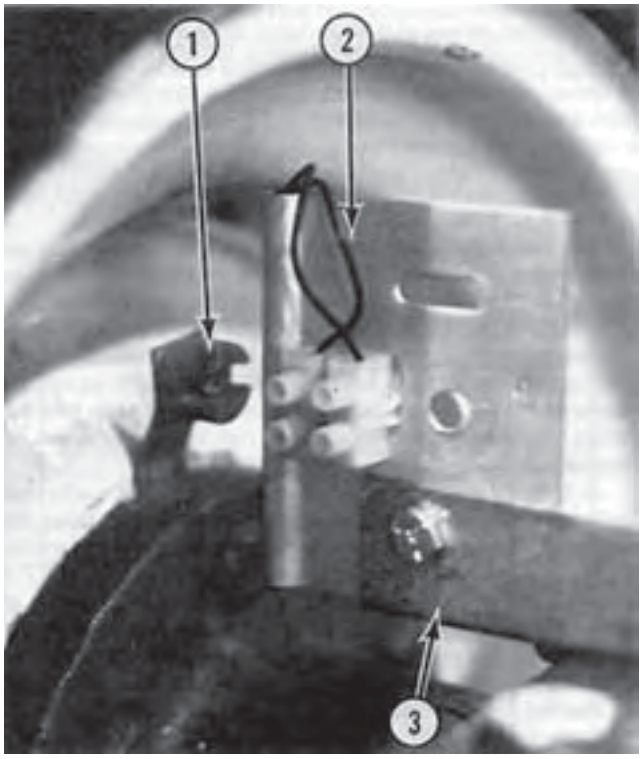

FIGURE 2. Speed Sensor: (1) Magnets, (2) Pickup Assembly, (3) Mounting Bracket.

EASE OF OPERATION AND ADJUSTMENT

Monitor Console: The Smith-Roles control consoles were easy to operate after reading the instructions in the operator's manual. The SP-3A sprayer monitor console was used for displaying and entering calibration numbers and indicating operating functions. The SP-3A console was equipped with a 12 function selection dial, a four-digit LED display screen, power on, Imp/metric and run/hold toggle switches and 3 push button switches, labelled digit select, digit set and reset (FIGURE 3).

The SP-3A sprayer monitor function selection dial allowed selecting 12 functions for display on the 4-digit LED screen. Four of the twelve functions were used to enter calibration numbers into memory. The calibration numbers were stored under the following functions:

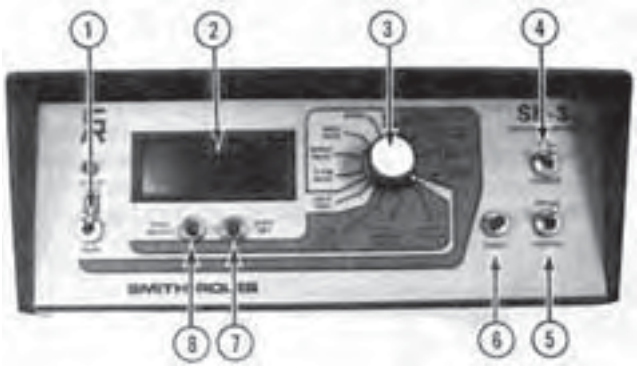

FIGURE 3. Monitor Console: (1) Run/Hold Switch, (2) Function Display Screen, (3) Function Selection Dial, (4) Power Switch, (5) Imp/U.S. - Metric Switch, (6) Reset Button, (7) Digit Set Button, (8) Digit Select Button.

1) Boom width - indicated the exact spraying width of the sprayer. The spraying width is the number of nozzles used times the nozzle spacing.
2) Wheel circum - indicated the circumference of the speed sensor wheel. The number is obtained by measuring the distance the speed sensor wheel travelled in ten revolutions. This

measurement had to be obtained in the same soil conditions encountered during spraying and with the tires properly inflated. If the speed sensor was installed on the sprayer wheel, the measurement had to be made with the sprayer tank half full, in order to obtain an average wheel circumference. This was not indicated in the operator's manual.

3) Meter factor - indicated the flow meter calibration number. This number was provided by the manufacturer. The number was written on a plastic band attached to the flow meter.
4) Option mode - indicated the desired application rate. This was the number the controller system maintained by automatically opening and closing the motorized control valve when changes in ground speed or flow occurred. The desired application rate number depended on the size of nozzles used and desired forward speed.

Once the calibration numbers were entered, the procedure did not have to be repeated unless the console was disconnected from the battery. The power on switch did not affect the console memory.

The self test function was used to check if the calibration numbers were entered correctly. The screen displayed "HELP" if the calibration numbers were not recorded in the memory.

The rest of the functions indicated operating conditions during spraying. These functions included:

1) Speed - displayed the actual ground speed.
2) Area rate - displayed the area sprayed per hour at the current ground speed.
3) Spray rate - displayed actual application rate.
4) Flow rate - displayed the total amount of spray solution flowing through the nozzles.
5) Area covered - displayed cumulative area sprayed.
6) Distance covered - displayed cumulative distance travelled.
7) Pumped - displayed cumulative amount of spray solution sprayed.

The 4-digit LED display screen displayed the function dialed and was easily read unless it faced directly into sunlight. Readout was conveniently possible in either Imperial or SI (metric) units by positioning the Imp/metric switch. Initial calibration was only necessary in one set of units.

The push buttons were convenient and easy to use. The reset button was used to clear cumulative or calibration function numbers. The digit select and set buttons were used to enter the calibration numbers into memory. The digit select button was used to select the position of the number on the 4-digit display screen and the digit set button was pushed until the desired number was displayed at the selected position.

The hold/run switch was used to stop the cumulative functions from measuring during turning or cornering in the hold position. This was convenient, since it resulted in more accurate area and distance measurements.

The power on switch was used to shut-off power from the battery to the console in order to conserve battery energy after spraying. The power on switch did not effect console memory in its off position.

Controller Console: The SPC-1 sprayer controller console included a pressure gauge, pressure adjust switch, automatic and manual mode switch with auto LED light, master and individual boom control switches with LED lights (FIGURE 4). The controller could be used by itself to remotely control the flow to the booms by opening and shutting solenoid valves and for remotely adjusting pressure. When used in conjunction with the SP-3A sprayer monitor, the controller automatically controlled the preset application rate by adjusting the motorized control valve when changes in forward speed or flow occurred.

Preparing the system to automatically control a preselected application rate required proper nozzle selection to apply the chosen application rate at the desired forward speed and at the appropriate pressures. A pressure range had to be established throughout which the nozzles would function properly. The operator's manual recommended that the pressure be set 10 psi (70 kPa) above and/or below the desired spraying pressure. This was adequate. The desired pressure limits were established with the pump operating at rated speed, the boom solenoid valves open and the auto-manual mode switch in the manual position. The pressure gauge supplied was convenient in setting pressure limits. The pressure adjust switch was used to open and close the motorized control valve to set the pressure range. The motorized control valve, if located in the by-pass line, had to be fully open to obtain the minimum pressure and fully closed to obtain the maximum pressure. The desired minimum and maximum pressures were obtained by adjusting the sprayer throttling, pressure relief and/or by-pass valves when the motorized control valve was in the open or closed position. The Machinery Institute recommends that, when using standard flat fan nozzles, minimum pressure, for proper distribution positions, not be set below 30 psi (207 kPa) and that maximum pressure, to avoid spray drift, not be set above 45 psi (300 kPa).

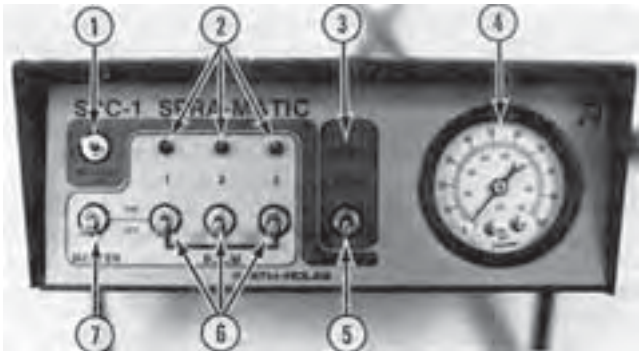

FIGURE 4. Controller Console: (1) Pressure Adjust Switch, (2) Boom Lights, (3) Auto Mode Light, (4) Pressure Gauge, (5) Auto-Manual Mode Switch, (6) Boom Switches, (7) Master Boom Switch.

Care had to be used when adjusting the pressure limits Using positive displacement pumps, to avoid excessive pressure that might damage solenoid valves and other plumbing components. A pressure relief valve must be installed in the bypass line to protect against component damage.

Having set the pressure limits, the desired application rate could be obtained manually or automatically. Placing the auto/manual switch in the manual mode required the forward speed and pressure be adjusted until the desired application rate was displayed on the digital screen. Placing the pressure control switch in the auto mode allowed the preselected application rate to be maintained by automatic adjustment of the motorized control valve when changes in forward speed or flow occurred.

The above procedure, although somewhat complex, was clearly outlined in the operator's manual in a detailed, step-by-step manner.

A new application rate could easily be entered in the option mode function of the control console. However, it was important to determine if the new application rate could be achieved with the same nozzles. Changing the application rate by more than 20% usually required different sized nozzles. Changing the application rate by less than 20% required the operator to change to a new nominal speed in order to operate at the desired nominal pressure. For example, at a nominal pressure of 35 psi (250 kPa), changing the application rate from 10 to 8 gal/ac (111 to 89 L/ha) required the speed to be increased from 5 to 6.2 mph (8 to 10 km/h). If only the application rate was changed and the speed was not changed, nozzle pressure changed. This was alright as long as the pressure remained within the desired range.

The controller could be set to apply lighter and heavier application rates in areas that required it. The application rate could be decreased or increased using the pressure control switch with the controller positioned in the manual mode. The new application rate remained until the pressure switch was adjusted again or the controller was returned to the "Auto" position.

QUALITY OF WORK

Flow Meter: The flow meter, using the calibration number supplied by the manufacturer, was accurate above 2.9 gal/min (13 L/min) when using water. A flow rate of 2.9 gal/min (13 L/min), using a 60 ft (18 m) sprayer at 6.2 mph (10 km/h), represents an application rate of 3.6 gal/ac (40 L/ha). This was adequate for most spraying conditions encountered in the prairie provinces. The flow meter was not adequate when using Micro-max nozzles since these nozzles use very low flow rates.

Flow meter accuracy depended on sprayer plumbing. It was important that the flow meter be installed the recommended 6 in

(150 mm) from any elbow, regulator, or other plumbing fixture.

Repeatability is a measure of how consistently the flow meter gives the same reading repeatedly. Repeatability of the flow meter was very good.

The pressure loss created by installing the flow meter in the sprayer plumbing system was negligible at application rates commonly used in the prairie provinces.

Speed Sensor: Speed sensor accuracy depended on the calibration number obtained. Therefore, it was important to calibrate the sensor in field conditions similar to those encountered during spraying. The calibration number could vary as much as 5% in different field conditions. It was also important to obtain the speed sensor calibration number when the sprayer tank was half filled with water. The calibration number could change as much as 2% from a full to empty 150 gal (700 L) tank.

When properly calibrated, the speed sensor was accurate above 1.2 mph (2 km/h) when using two magnets and above 2.5 mph (4 km/h) when using one magnet. Speed readings were constant and consistent when set up according to manufacturer's specifications. The speed sensor did not operate when the pickup assembly was more than 11/16 in (18 mm) away from the magnets.

Motorized Control Valve: The motorized control valve adjusted the flow when changes in speed or flow occurred. The time required to make this adjustment was considered too long and a shortcoming of the system.

FIGURE 5 shows typical response curves for a 0.6 mph (1 km/h) change in forward speed when operating in the automatic mode. It usually took the valve up to a minute to adjust the pressure within 1.5 psi (10 kPa) of the final setting. This was considered inadequate since the valve could not maintain the desired application rate when momentary changes in forward speed occurred. This was usually the case when operating in hilly and rough fields and after turning or cornering. It is recommended that the manufacturer consider modifications to improve motorized control valve response.

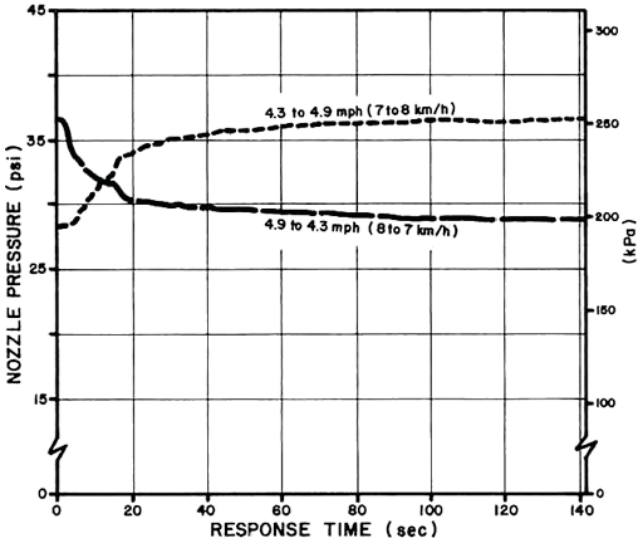

FIGURE 5. Response of the Motorized Control Valve to a Small Change in Forward Speed.

The pressure usually remained constant after the motorized control responded to small changes in forward speed or flow. With a larger change in forward speed, however, the pressure tended to oscillate between the set minimum and maximum pressures (FIGURE 6). These oscillations corresponded to fully open and closed positions of the motorized control valve and occurred since the valve continued to turn when attempting to compensate for the change in forward speed. It is recommended that the manufacturer consider modifications to eliminate pressure oscillations caused by large changes in forward speed.

In the manual mode, it took the motorized control valve over half a minute to fully open from the closed position or visa versa. This was convenient during spraying when adjusting nozzle pressure, since the desired nozzle pressure could easily be obtained. However, this was considered too long when setting the maximum and minimum pressure settings for operation in the automatic mode. Large volumes of water were used waiting for the valve to fully open or close.

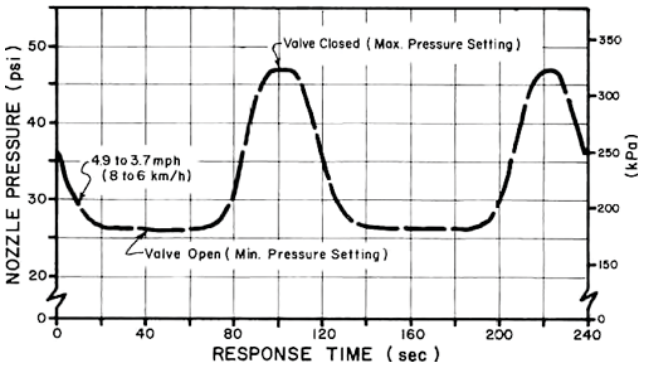

FIGURE 6. Response of the Motorized Control Valve to a Large Change in Forward Speed.

Sprayer Monitor: The application rate indicated on the monitor display screen was entirely dependent on the flow meter and speed sensor accuracy. The operator had no control over flow meter accuracy since the manufacturer supplied the calibration number. Therefore, it was important to carefully calibrate the speed sensor as described in the operator's manual. Application errors up to 7% could result if speed sensor calibration procedures were not carefully followed.

The use of the sprayer monitor to provide the operator with a readout of spraying performance such as spraying rate, speed and area covered was very beneficial. This provided the operator with the information required to make necessary changes in pressure or tractor speed. The area sprayed per hour, flowrate, distance covered and pumped functions were useful but not essential.

Although not mentioned in the operator's manual, the flow rate function could be used to check the accuracy of the flow meter. The output of several nozzles could be measured with a container and stop watch, and this average flow rate compared with the indicated flow displayed on the monitor. If the difference in flow rates was significant, replacement of the flow meter should be considered. If the difference was small, a new calibration number should be entered until the indicated and measured flows matched.

Sprayer Controller: The Smith-Roles sprayer controller only effectively controlled the desired application rate over a narrow range of forward speeds. The range of forward speeds depended on the minimum and maximum pressure settings. For example, with the controller set to apply 10 gal/ac (110 L/ha) when using Teejet 8002 nozzles, and the minimum and maximum pressures set at 30 and 45 psi (207 and 310 kPa), respectively, the automatic rate controller maintained the application rate at the desired rate from 4.3 to 5.4 mph (6.9 to 8.7 km/h). At 4.3 mph (6.9 km/h) nozzle pressure was 30 psi (207 kPa) which, if installed in the by-pass line, would result in the motorized control valve being in its fully-open position and at 5.4 mph (8.7 km/h) the nozzle pressure increased to 45 psi (310 kPa) which would result in the motorized control valve being in its fully closed position.

Forward speeds outside this range resulted in the motorized control valve continuing to turn while attempting to compensate for the change in speed, causing the pressure to oscillate (FIGURE 6). Usually the display screen and auto indicator flashed when this occurred, warning the operator the application rate was 12% over or under the selected rate.

The 12% warning feature of the Smith-Roles also served as a convenient indicator of an empty tank or a burst hose.

Increasing the nozzle pressure range resulted in the application rate being controlled over a larger forward speed range. Increasing the minimum and maximum pressures to 15 and 60 psi (103 and 414 kPa), respectively, the automatic system controlled the application rate from 3.5 to 6.3 mph (5.7 to 10.1 km/h). Operating at pressures above 45 psi (310 kPa) is not recommended, due to excessive spray drift. Pressures lower than 30 psi (207 kPa) are not recommended, with standard flat fan nozzles, due to poor nozzle distribution patterns. Nozzle pressures throughout this expanded forward speed range greatly exceeded these pressure limitations, in essence reducing the effective controllable speed range.

Effect of Tractor Engine Speed: Momentary changes in

tractor engine speed, and consequently pump speed, in hilly fields could result in application rate changes up to 10%. Due to the slow response time of the motorized control valve, the controller usually was unable to compensate for these brief variations in pump speed.

Effect of Plugged Nozzles: When operating in the automatic mode, each plugged nozzle resulted in an increase in pressure. This pressure increase was used as a convenient indicator of plugged nozzles.

Effect of Boom Width: Shutting off part of the boom during spot spraying required setting the controller in the manual mode and adjusting to nominal spraying pressure. If left in the automatic mode, the controller adjusted the motorized control valve to increase the flow, since the monitor did not compensate for the change in spraying width. As a result, the pressure increased and the monitor indicated the application rate for the total width of the sprayer and not the reduced width. The reduced spraying width had to be entered into the monitor before the correct application rate would be indicated.

Environmental Effects: The dust common to normal spraying operations did not affect the Smith-Roles system performance. No moisture problems were encountered during the test with the consoles operated in a tractor cab. The operator's manual did not mention if the control consoles were weather tight.

Effect of Voltage: The monitor functioned well between 12 and 14 volts. Damage to the unit could result if subjected to voltages greater than 15 volts. Battery voltage drop, due to tractor starting, could result in loss of calibration numbers stored in the monitor memory. To avoid having to re-enter calibration numbers, the monitor should be in the off position during tractor starting.

Electrical Power Requirements: No excessive demands were made on the tractor battery or electrical charging system. The sprayer monitor drew up to 0.02A with the power switch off and up to 0.8A with the power switch on and all systems operating, when attached to a 12 volt electrical system. If solenoid valves were used the amperage required increased by 0.3A for each solenoid valve.

COMPARISON OF SPRAYER MONITOR AND SPRAYER CONTROLLER FUNCTIONS

The use of the SP-3A sprayer monitor to provide the operator with a readout of spraying performance (i.e. spraying rate, speed and all other displayed functions) was considered very beneficial. This provided the operator with the information required to make necessary changes in pressure or tractor speed.

The remote control features, allowing pressure to be adjusted and various sections of the boom to be controlled from the operator's position on the tractor, were considered beneficial aspects of the SPC-1 sprayer controller. The automatic feature, to automatically maintain a preselected application rate, eliminated the need for the operator to make minor adjustments to tractor speed and pressure, when speed or flow changed for long periods of time. The automatic feature, when short term or large changes in forward speed or flow occurred, was considered to be less beneficial since motorized control valve response was slow and since automatic control was only possible over a narrow range of forward speeds.

OPERATOR'S MANUAL

The operator's manual provided good information on monitor installation, operation, calibration and adjustment.

DURABILITY RESULTS

The Smith-Roles sprayer control system was operated in the field for 55 hours. The intent of the test was evaluation of functional performance and an extended durability evaluation was not conducted. No mechanical problems were encountered during the test.

APPENDIX I
SPECIFICATIONS

MAKE:	Smith-Roles Sprayer Monitor	Smith Roles Sprayer Controller
MODEL:	SP-3A	SPC-1
SERIAL NUMBER:	3278	3357
CONTROL CONSOLE:		
-- size	8.1 x 9 x 3.1 in (207 x 229 x 79 mm)	8.1 x 9 x 3.1 in 207 x 229 x 79 mm)
-- controls	selection dial, digit set, digit select and reset push buttons, run/hold, Imp/metric and power switches	pressure control, master, boom and Auto/Manual switches
-- display	4-digit LED display screen, LED light	pressure gauge, 3 boom LED lights
-- alarm	flashing spray rate if rate ±12% from normal	flashing auto LED light
FLOW METER:		
-- type	turbine	
-- serial number	1S1001	
-- size	1 in (25.4 mm) NPT - male	
MOTORIZED CONTROL VALVE:		
-- type	butterfly	
-- serial number	13162D	
-- size	3/4 in (19 mm) NPT - female	
CONNECTORS:	pull-apart connectors between tractor and sprayer	
WEIGHT:		
-- sprayer monitor console	4.01 lb (1.82 kg)	
-- sprayer controller console	6.06 lb (2.75 kg)	
-- flow meter	2.15 lb (0.98 kg)	
-- motorized control valve	0.49 lb (0.22 kg)	
-- speed sensor assembly	0.16 lb (0.07 kg)	
-- extension cable	1.36 lb (0.62 kg)	
-- hardware	2.18 lb (0.99 kg)	
-- other material	0.09 lb (0.05 kg)	
Total	16.51 lb (7.50 kg)	

APPENDIX II
MACHINE RATINGS

The following rating scale is used in PAMI Evaluation Reports:

Excellent	Very Good
Good	Fair
Poor	Unsatisfactory

APPENDIX III
CONVERSION TABLE

acres (ac) x 0.40	= hectares (ha)
gallons (gal) x 4.55	= litres (L)
gallons/acre (gal/ac) x 11.23	= litres/hectare (L/ha)
inches (in) x 25.4	= millimetres (mm)
miles/hour (mph) x 1.61	= kilometres/hour (km/h)
pounds (lb) x 0.45	= kilograms (kg)
pounds force per square inch (psi) x 6.89	= kilopascals (kPa)

SUMMARY CHART
SMITH-ROLES AUTOMATIC SPRAYER CONTROL SYSTEM

RETAIL PRICE:	$1327.85 (May, 1984, f.o.b. Lethbridge)
COMPONENTS:	monitor console, controller console, speed sensor, flow meter and motorized control valve
INSTALLATION:	about 5 hours
MONITOR CONSOLE:	
-display	sprayer application rate, ground speed, area sprayed per hour, total flow rate through the nozzles, area sprayed, distance covered and amount of fluid pumped
-calibration	four numbers have to be stored into memory: boom width, speed sensor wheel circumference, flow meter factor and desired application rate
-features	automatically controls desired application rate when used in conjunction with controller console
CONTROLLER CONSOLE:	
-display	nozzle pressure
-features	shuts off flow to booms remotely adjusts nozzle pressure
SPEED SENSOR:	accurate when properly calibrated
MOTORIZED CONTROL VALVE:	very slow response time inadequate for adjusting to momentary changes in tractor speed
FLOW METER:	accurate, reliable and repeatable above 2.9 gal/min (13 L/min)
APPLICATION RATE ACCURACY:	depended largely on the speed sensor calibration application was not always constant in hilly and rough fields changed with sprayer tank fluid level
POWER REQUIREMENTS:	12 volt system - draws 0.8 A
OPERATOR'S MANUAL:	provided the required information
MECHANICAL PROBLEMS:	none

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