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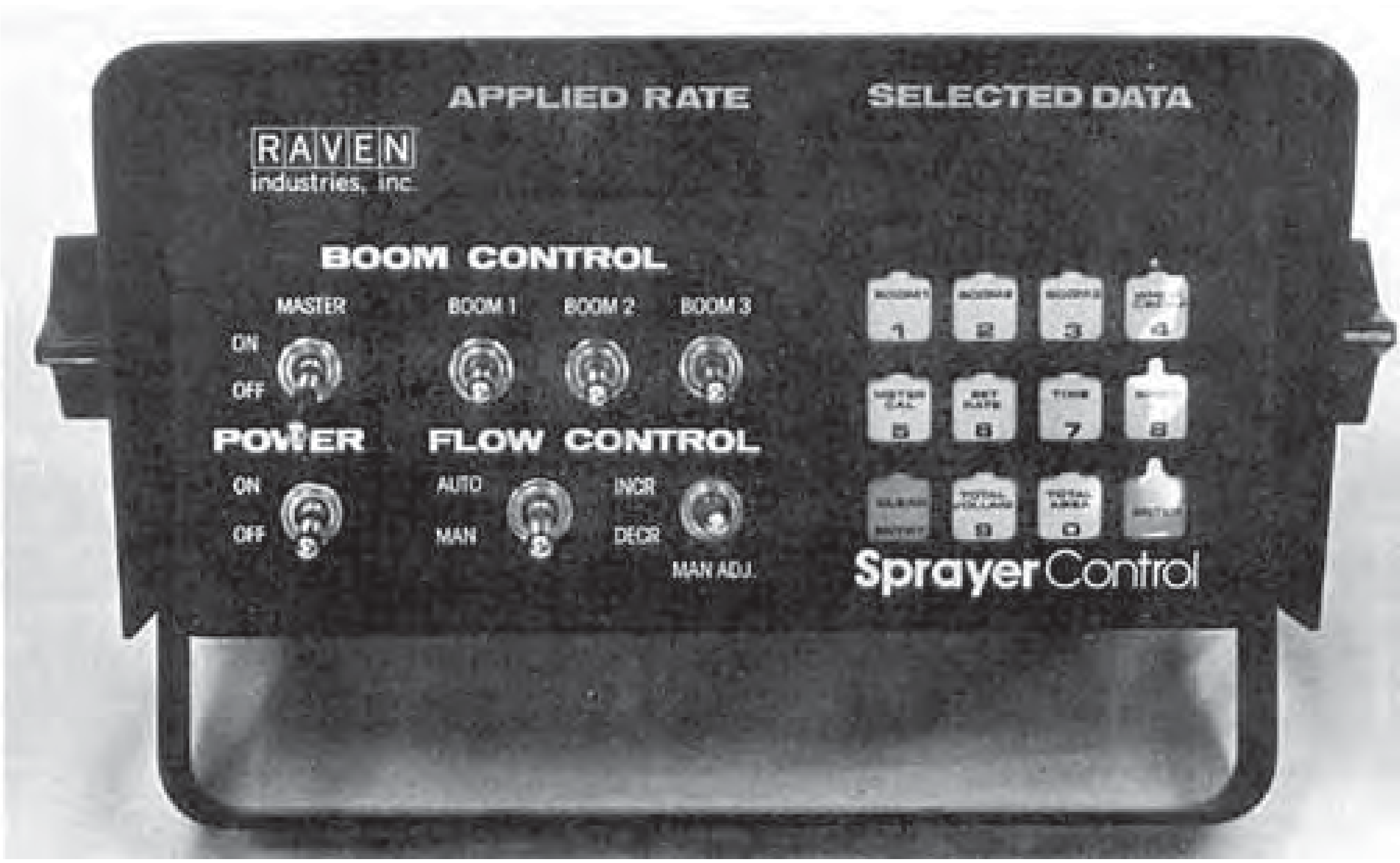

Raven Model SCS 400 Automatic Sprayer Control System

A Co-operative Program Between

ALBERTA FARM MACHINERY RESEARCH CENTRE

PAMI
PRAIRIE AGRICULTURAL MACHINERY INSTITUTE

RAVEN SCS 400 AUTOMATIC SPRAYER CONTROL SYSTEM

MANUFACTURER:
Raven Industries Inc.
Electronics System Division
P.O. Box 100
7205 E Sixth Street
Sioux Falls, South Dakota 57117

DISTRIBUTOR:
John Brooks Canada Limited
1260 Kamato Road
Mississauga, Ontario
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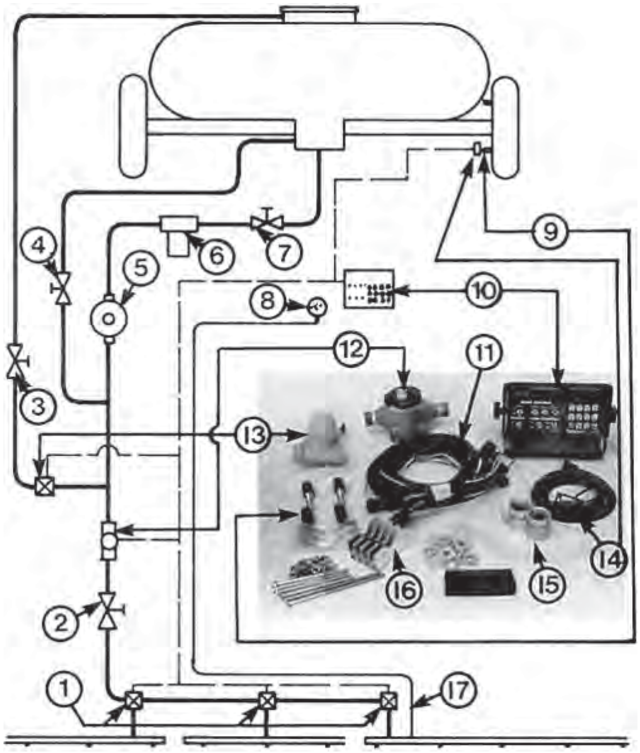

FIGURE 1. Raven Automatic Sprayer Control System: (1) Solenoid Valves, (2) Throttling Valve, (3) By-Pass Valve, (4) Agitator Valve, (5) Pump, (6) Filter, (7) Shut-Off Valve, (8) Pressure Gauge, (9) Speed Sensor Magnets (10) Control Console, (11) Cables with Pull-apart and Screw-on Polarity Connectors, (12) Flow Meter, (13) Motorized Control Valve, (14) Speed Sensor Switch Assembly, (15) Flow Meter Pipe Couplers, (16) Mounting Hardware, (17) Boom Pressure Line.

SUMMARY AND CONCLUSIONS

Overall functional performance of the Raven automatic sprayer control system was good. The monitoring and remote control 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 considerably 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.

The accuracy of the MVR50 and MVR30 flow meters was good at rates above 10 L/min (2.2 gal/min), using the meter constants supplied by the manufacturer. Reliability and repeatability of both flow meters was good.

The speed sensor was accurate and speed readings did not fluctuate if set up according to specifications.

The original motorized control valve had slow response to changes in forward speed and flow. It took in excess minute to completely respond to a change in forward speed. A replacement motorized control valve received at the end of the test, responded to changes in forward speed in less than 20 seconds.

The system took from 6 to 12 hours to install, depending on the sprayer plumbing system. Additional plumbing fittings, hoses and mounting hardware were required, especially on older sprayers not using 25 mm (1 in) plumbing. All wires were conveniently packaged into one cable for neat and convenient hook-up to the tractor. Screw-on and pull-apart connectors made hook-up quick and easy.

The control console was not weathertight and required covering to protect it from the rain if used on tractors without cabs.

The two digital display screens were visible to the operator providing the control console was not in direct sunlight. The control console was available calibrated in either metric (SI) or Imperial units,

The calibration numbers were generally easily obtained and conveniently entered into the control console.

Preparing the system to automatically control a pre-selected 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 proper nozzles had been selected, the control console was easily programmed to automatically control a pre-selected application rate by simply entering the desired application rate,

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

The operator's manual provided a complete parts list and information on installation, operation, adjustment, calibration, and maintenance.

The few failures encountered during the evaluation included leaking flow meter couplers and failure of the motorized control

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Supplying a pressure gauge as standard equipment, to allow for convenient setting of pressure limits.
2. Discontinuing the use of the original motorized control valve (serial number A-0427) and supplying, as standard equipment, the replacement motorized control valve (serial number D-3888) due to its faster response.
3. Modifications to weatherproof the control console.
4. Modifications to prevent the MVR 50 flow meter couplers from leaking.
5. Modifications to prevent motorized control valve failure.

Senior Engineer: E. H. Wiens

Project Technologist: L. B. Storozynsky

THE MANUFACTURER STATES THAT

With regard to recommendation number:

1. A pressure gauge is normally supplied as standard equipment with the SCS 400, however, it is supplied by Raven's distributors and not by Raven directly. Raven's distributors purchase gauges and other sprayer accessories direct from the manufacturer thus realizing cost savings, which can then be passed on to the farmer.
2. The original motorized control valve (serial number A-0427) was discontinued in June, 1981 and replaced with a high speed control valve (serial number D-3888) at that time. Our present motorized control valve can go from fully closed to open in 8 seconds, at normal tractor operating voltages.
3. Although Raven does not recommend that the control console be left out in the rain, the console in fact is fully gasketed and will function even if exposed to rain. According to U.S. National Electrical Code standards, the console would be defined as "rainproof". Since introducing the SCS 400 three years ago, Raven has never had a weather-related failure of the control console.

4. The MVR50 flow meter couplings are now installed with the swivel end toward the flow meter and with an adapter washer provided for use between the swivel and the flow meter threads. This has eliminated the problem with couplers leaking.
5. The new motorized control valve introduced in June, 1981 has several features to minimize failure:
   a. A new seal design which is held in place by a snap ring which has doubled seal life.
   b. An Iso-flange which protects the valve motor and electronics from moisture in the event of a seal failure.
   c. A 100% burn-in of all valve motors before shipment.

NOTE: This report has been prepared using SI units of measurement. A conversion table is given in APPENDIX Ill.

GENERAL DESCRIPTION

The Raven Model SCS 400 automatic sprayer control system monitors sprayer application rate, fluid pumped, ground speed, area sprayed, time of day and automatically controls application rate when changes in forward speed or flow occur. The Raven SCS 400 consists of a control console, speed sensor, flow meter and motorized control valve (FIGURE 1).

The control console mounts at the operator's station. The console consists of two, four-digit LED display screens, a master boom switch and three individual boom control switches, an on-off power switch, a pressure adjustment switch, an auto-man flow control switch and a keyboard with 12 function keys. The control console is available calibrated in either metric (SI) or Imperial units. The speed sensor, to indicate ground speed, consists of four magnets that mount on a non-driven wheel of the tractor or a sprayer wheel and a switch 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 booms. The motorized control valve is located in the sprayer plumbing and automatically opens or closes to maintain the preset application rate, when changes in forward speed or flow occur.

The Raven 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 Raven Model SCS 400 automatic sprayer control system, calibrated for read out in metric (SI) units, was used for 56 hours while spraying about 506 ha (1250 ac). 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 from 6 to 12 hours to install the Raven automatic sprayer control system on conventional field sprayers. Installation time depended on the existing sprayer plumbing system. With some older sprayers that were equipped with hoses and plumbing fittings smaller than 25 mm (1 in) and manual control valves with bypass and agitation lines attached, virtually complete replumbing was required. Installation on sprayers already equipped with solenoid valves and 25 mm (1 in) plumbing, required considerably less time and fewer additional plumbing fittings and material.

Installation instructions were clear and adequate.

Control Console: Mounting hardware and cables were provided to mount the control console on the tractor near the operator station and connect it to the tractor electrical system. The control console was not weathertight and had to be sheltered from rain if a tractor without a cab was used.

Flow Meter: The flow meter pipe couplers provided (FIGURE 1), assisted in the convenient installation of the flow meter. It had to be installed so the full flow going to the booms passed through the flow meter. With most sprayers, installation of the flow meter required modifications to the original sprayer plumbing system. Usually, the main line from the pump to the booms had to be cut, shortened, re-routed or replaced to provide the recommended straight lengths of inlet and outlet hose to ensure flow meter accuracy. Additional plumbing fittings were also required. The flow meter was heavy and had to be properly secured to the sprayer trailer hitch frame.

Speed Sensor: The speed sensor magnets were easily fastened to the rim of a wheel. The bevels and washers supplied made magnet positioning convenient (FIGURE 2). The speed sensor switch assembly was more difficult to install and required additional material not provided. The switch had to be positioned between 10 and 25 mm (0.4 and 1 in) from the magnets, making sure the magnets passed across the entire length of the switch. When installing the switch assembly on a front tractor wheel, caution was required to ensure the wheel could be turned to its extremes without magnet and switch interference and also that the required gap was maintained.

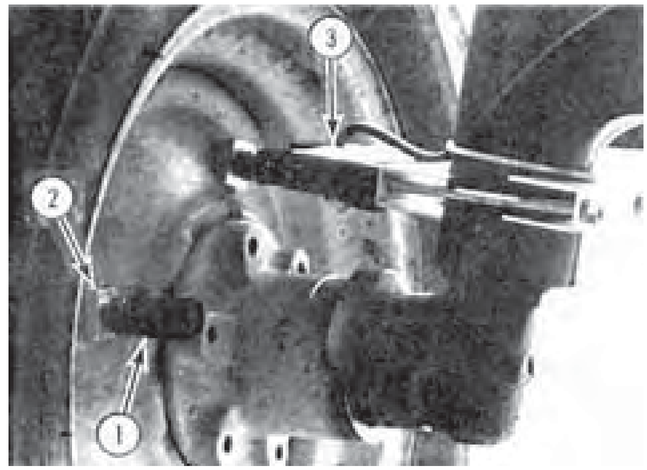

FIGURE 2. Speed Sensor: (1) Magnets, (2) Bevels, (3) Switch.

Motorized Control Valve: The motorized control valve could be installed in either the main boom supply line after the flow sensor or in the bypass line. Installing the valve in the main boom supply line was easy and simply involved cutting the hose and inserting the valve. The manufacturer, however, did not recommend this location and preferred installation of the valve in the by-pass line. Installing the valve in the bypass line was usually more difficult and required additional hose and fittings. The valve was too heavy for the hose to support and required additional support.

Solenoid Valves: No remote control boom solenoid valves were supplied with the Raven system. Spraying Systems Model 144 boom solenoid valves were purchased and installed to enable use of the controls on the Raven console. The solenoid valves were secured to the sprayer trailer frame with U-clamps.

Hoses with threaded hose adaptors were required to attach the solenoid valves to the boom inlets.

Wiring Harness: All wires in the wiring harness were conveniently combined into one cable, making it tidy and easy to fasten to the sprayer. The cable included screw-on and pull-apart polarity connectors, making connections to the various components quick and easy. The wiring harness package included plastic hold-down ties for securing cables to the sprayer. There was a shortage of plastic ties, requiring the use of tape to properly secure the cable.

EASE OF OPERATION AND ADJUSTMENT

Control Console: The Raven control console had a 12 function keyboard (FIGURE 3) which allowed selecting various functions for display on the LED digital display screens. The keyboard was used for displaying and entering calibration numbers. The keys, when depressed, performed the following functions:

1. Boom 1, 2 and 3 -- these three function keys were used to enter the widths of up to three boom sections.
2. Wheel Crcmf -- used for entering the circumference of the speed sensor wheel.
3. Meter Cal -- used for entering the flow meter calibration number as provided by the manufacturer.
4. Set Rate -- used for entering the desired application rate, which

was to be automatically controlled.
5. Time -- used to enter and monitor the time of day.
6. Speed -- displayed actual ground speed.
7. Total Volume -- displayed the cumulative amount of fluid pumped.
8. Total Area -- displayed the cumulative area sprayed.
9. Enter -- depressed to enter above functions and calibration numbers.
10. Clear Entry -- used to switch from the "Enter Data" mode into the "Display Date" mode.

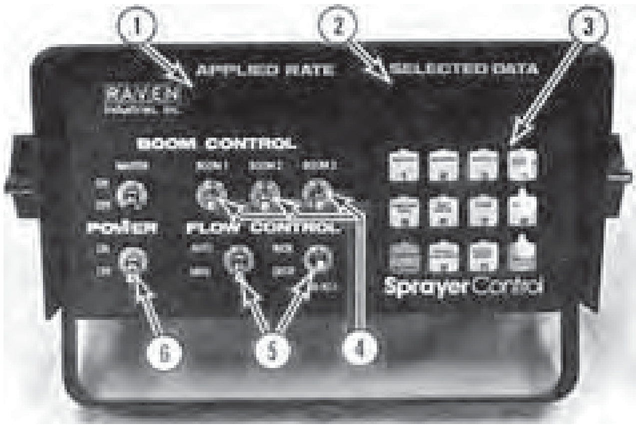

FIGURE 3. Control Console: (1) Application Rate Display Screen, (2) Function Display, (3) Keyboard, (4) Boom Switches, (5) Flow Control Switches, (6) Power Switch.

The display screens were easily read unless they faced directly into sunlight. The left screen constantly displayed the actual application rate being applied while the right screen displayed the different functions discussed above by simply depressing the appropriate key. The keyboard was convenient to operate.

The control console evaluated was calibrated in metric (SI) units. It was also available calibrated in Imperial units.

Five calibration numbers had to be obtained and stored in the control console in order to have the spraying rate automatically controlled. These numbers were stored in the control console under the following functions: "Boom", "Wheel Crcmf", "Meter Cal", "Set Rate", and "Time", as already discussed above. The calibration numbers were easily stored by depressing the appropriate function key and entering the number. The left application rate screen continually flashed "Cal" until all required calibration numbers were stored in the console. The application rate screen displayed "O" when the Raven system was completely programmed. Once programmed, the procedure did not have to be repeated unless the console was disconnected from the battery. The on-off power switch did not affect the console memory.

The "Boom 1, 2 and 3" functions were used to enter the exact spraying width of the sprayer boom sections. The boom spraying width is the number of nozzles used times the nozzle spacing. The number "0" was stored in boom 3 if the sprayer only had two boom sections. Most sprayers commonly used in the prairie provinces have three boom sections.

The "Wheel Crcmf" function was used to enter the circumference of the speed sensor wheel. This measurement, to be accurate, had to be obtained in soil conditions encountered during actual spraying and with the tires properly inflated. The procedure required measuring the distance travelled after ten wheel revolutions. If the wheel sensor was located on the sprayer wheel, the measurement should be made with the sprayer tank half full in order to obtain an average wheel circumference.

The "Meter Cal" function was the flow meter calibration number as provided by the manufacturer and engraved on a metal band attached to the flow meter. It was important to know whether the calibration number provided was for metric or Imperial units.

The "Set Rate" function was used to store the desired application rate. This was the number the automatic control system maintained by adjusting the motorized control valve when changes in ground speed or flow occurred.

The "Time" function was the time of day, based on a 24 hour clock.

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 used an example indicating a nozzle pressure range between 138 and 414 kPa (20 and 60 psi) could be used. For proper nozzle distribution patterns when using standard flat fan TeeJet nozzles, the Machinery Institute recommends that minimum pressure not be set below 200 kPa (29 psi), and to reduce spray drift, that the maximum pressure not be set above 300 kPa (45 psi).

The desired pressure limits were established with the pump operating at rated speed, the boom control valves open and the flow control switch in the "Man" position. The "Man Adj" 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 valve, pressure relief or by-pass valves when the motorized control valve was in the open or closed position.

No pressure gauge was supplied with the Raven control system. It is recommended that the manufacturer supply a pressure gauge to allow for convenient setting of pressure limits.

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 should be installed in the by-pass line to protect against component damage.

Having set the pressure limits, the desired application rate was obtained at the nominal forward speed, with the flow control switch on "Man", by adjusting the "Man Adj" switch until the nominal pressure was reached. Placing the flow 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 by a detailed, step-by-step procedure.

The digital displays flashed if the rate being applied was not within ±3 L/ha (0.27 gal/ac) of the set application rate. This provided a convenient warning of extreme changes in pressure due to such things as large changes in tractor speed, leaking hoses, plugged nozzles or plugged filters.

A new application rate could easily be entered in 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 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 250 kPa (35 psi), changing the application rate from 100 to 80 L/ha required the speed to be increased from 8 to 10 km/h (5 to 6.2 mph).

The Raven automatic sprayer control system could be set to apply lighter or heavier application rates in areas that required it. The application rate could be decreased or increased only in the "Man" position by using the manual override flow switch. In the "Man" position, the new application rate remained until the manual override flow switch was adjusted again or the flow control switch was returned to the "Auto" position.

QUALITY OF WORK

Flow Meter: Both the Raven model MVR30 and MVR50 flow meters were evaluated. The MVR30 was for use with flow rates from 4.5 to 135 L/min (1 to 30 gal/min) while the MVR50 was for flow rates from 4.5 to 205 L/min (1 to 50 gal/min). The MVR30 had a cast brass body while the MVR50 had a cast iron body for use with liquid fertilizers.

Flow meter accuracy depended on the meter constant supplied with each meter. The MVR30 flow meter was accurate between 10 and 200 L/min (2.2 and 44.0 gal/min) and the MVR50 flow meter was accurate between 10 and 300 L/min (2.2 to 66.0 gal/min) when using the manufacturer's meter constants. Neither meter was accurate at rates below 10 L/min (2.2 gal/min). A flow rate of 10 L/min (2.2 gal/min), using an 18 m (60 ft) sprayer at 10 km/h

(6.2 mph), represents an application rate of 33 L/ha (3 gal/ac), which is less than normally recommended application rates in the prairie provinces. Therefore, both meters were accurate for most spraying situations encountered in the prairie provinces.

The flow meter constants supplied by the manufacturer were based on water. Chemical mixtures, due to different density and viscosity, could result in other flow meter constants being more accurate. The flow meters could be recalibrated, if necessary, to obtain more accurate flow meter constants. Proper flow meter calibration would require proper calibration equipment and precise measurements.

Flow meter accuracy depended on sprayer plumbing. It was important that the flow meter be installed in a 25 mm (1 in) line and have the recommended length of straight pipe before and after the flow meter.

Repeatibility is a measure of how consistently the flow meter gives the same reading repeatedly. Repeatability of both flow meters 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: The speed sensor was accurate. Speed readings were constant and did not fluctuate when set up according to the manufacturer's specifications.

Effect of Forward Speed: The Raven automatic sprayer control system only effectively controlled application rates over a narrow range of forward speeds. For example, the control system was set to apply 100 L/ha (9 gal/ac) at 8 km/h (5 mph) at a nozzle pressure of 250 kPa (36 psi). The minimum and maximum pressures were set at 200 and 300 kPa (29 and 45 psi), respectively. Under these conditions, the application rate was maintained within ±3 L/ha (0.27 gal/ac) of the desired rate from 7 to 9 km/h (4.4 to 5.6 mph) (FIGURE 4). FIGURE 5 indicates how rapidly the nozzle pressure varied throughout this small range of forward speeds between the set pressure limits. At 7 km/h (4.4 mph) nozzle pressure was 200 kPa (29 psi), which if installed in the by-pass line, would result in the motorized control valve being in its fully open position. At 9 km/h (5.6 mph) the nozzle pressure increased to 300 kPa (45 psi) which would result in the motorized control valve being in its fully closed position.

Forward speeds outside this range would result in sprayer performance similar to that without an automatic control system. For example, as indicated in FIGURE 4, with the flow control switch set in the manual mode, the application rate would decrease with increased speed.

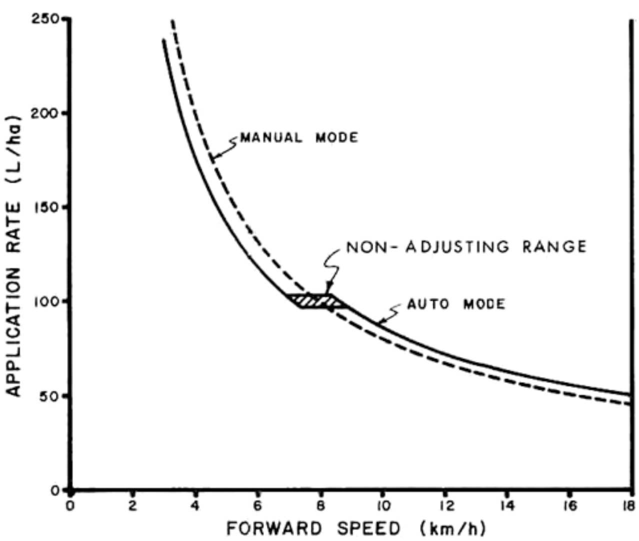

FIGURE 4. Application Rate at Various Forward Speeds with the Automatic Sprayer Control System in the Automatic and Manual Modes.

Note that the automatic control system did not react until the application rate varied by more than ±3 L/ha (0.27 gal/ac). This resulted in a 6 L/ha (0.54 gal/ac) non-adjusting range (FIGURE 4). This was considered a minimal change and thus an acceptable range before a correction was initiated.

Increasing the nozzle pressure range resulted in the application

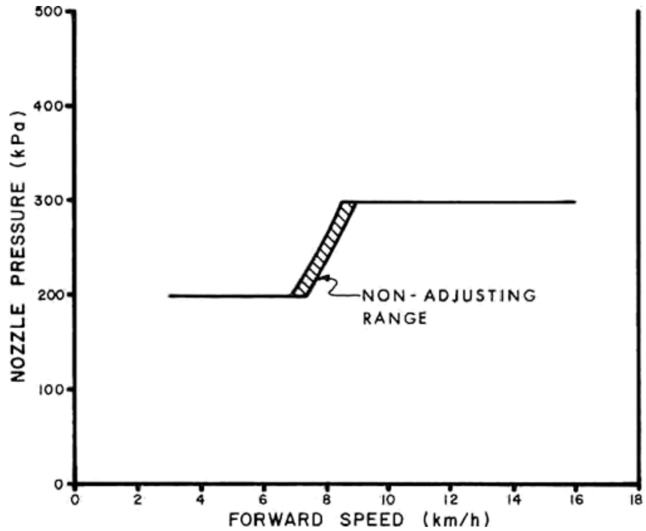

FIGURE 5. Nozzle Pressure at Various Forward Speeds with the Automatic Sprayer Control System in the Automatic Mode.

rate being controlled over a larger speed range. Increasing the minimum and maximum pressures to 100 and 400 kPa (15 and 60 psi), respectively, the automatic sprayer control system controlled the application rate from 5.1 to 10.3 km/h (3.2 to 6.4 mph) (FIGURE 6). FIGURE 7 shows the rapid increase in nozzle pressure over this range of speeds. Operating at pressures above 300 kPa (45 psi) is not recommended, due to excessive spray drift. Pressures lower than 200 kPa (29 psi) are not recommended with standard flat fan nozzles due to poor nozzle distribution patterns. Nozzle pressures throughout this expanded forward speed range exceeded these pressure limitations, in essence reducing the effective controllable speed range.

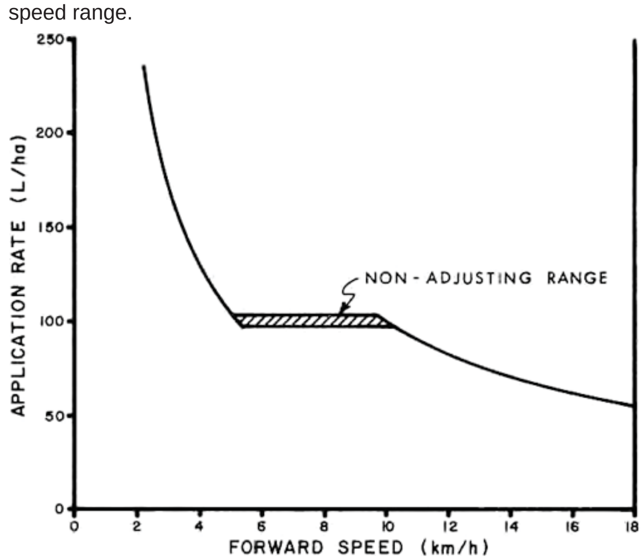

FIGURE 6. Application Rate at Various Forward Speeds with the Automatic Sprayer Control System in the Automatic Mode with an Increased Preset Pressure Range.

Motorized Control Valves: Two Raven motorized control valves were evaluated. The original valve received with the system (serial number A-0427) was used for the entire evaluation. Towards the end of the evaluation it malfunctioned and was replaced with another valve (serial number D-3888).

The motorized butterfly valve could be used either as a throttling valve in the boom supply line or as a flow control valve in the by-pass line.

The replacement valve responded considerably faster than the original valve. For example, in the manual mode, it took the replacement valve and original valve about 10 and 22 seconds, respectively, to fully open from the closed position or vise versa.
FIGURE 8 shows typical response curves for changes in forward speed for both valves, when operating in the automatic mode. It took the original valve more than a minute to completely respond, while the replacement valve responded completely in less than 20

seconds. Both valves held the pressure steady, with no hunting after the change in flow had been made.

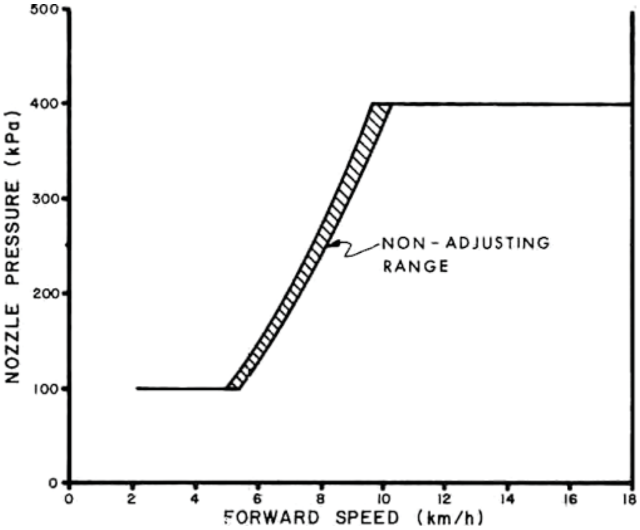

FIGURE 7. Nozzle Pressure at Various Forward Speeds with the Automatic Sprayer Control System in the Automatic Mode with an Increased Preset Pressure Range.

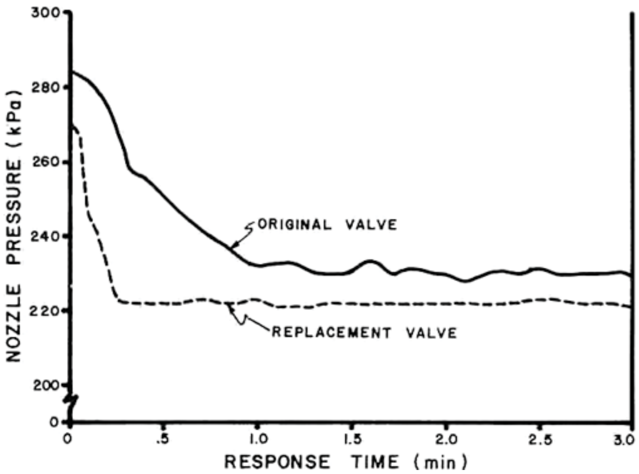

FIGURE 8. Response Time for Two Motorized Control Valves to Changes in Forward Speed.

Longer response times were encountered with the original valve when operating at or near its fully open or closed position and with the replacement valve when operating at or near its open position. This was normally the case, since as shown in FIGURE 5, small changes in forward speed called for relatively large changes in pressure and consequently flow, which resulted in the valves frequently operating at or near their open or closed position.

Due to the slow response time of the original motorized control valve, it is recommended that it be discontinued and that the replacement motorized control valve be supplied as standard equipment.

When operating the motorized control valve in the by-pass line, an additional 18.4 L/min (4.1 gal/min) passed through the motorized control valve before any adjustment occurred. It was therefore important to have a pump with adequate capacity.

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 original motorized control valve, the automatic rate 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 could be used as a convenient indicator of plugged nozzles. The automatic sprayer control system kept the application rate at the desired rate for each plugged nozzle until the preset maximum nozzle pressure was reached.

Effect of Boom Width: With the motorized control valve installed in the by-pass line, the set application rate was automatically maintained when part of the boom was shut off during spot spraying or when completing a field. However, with the motorized control valve installed in the main boom line, application rate could not always be automatically adjusted. For example, the set application rate could not be automatically adjusted if the flow through the motorized control valve when completely closed was greater than the required flow to the boom.

Environmental Effects: The control console was not sealed and therefore had to be covered from rain if installed on a tractor without a cab. The dust common to normal spraying operations did not affect the monitor's performance. It is recommended that the control console be weatherproofed to avoid the inconvenience of having to cover it.

Effect of Voltage: The monitor functioned well between 7 and 17 volts. Damage to the unit could result when subjected to voltages greater than 18. The monitor had to be recalibrated if the voltage supply dropped below 7 volts. It was therefore important that a good battery be used to supply adequate voltage to the system at all times.

Starting the tractor normally lowered the battery voltage supply. If the voltage decreased below 7 volts, the system had to be recalibrated, unless the monitor was in the off position during starting.

COMPARISON OF MANUAL AND AUTOMATIC SPRAYER CONTROL SYSTEM FUNCTIONS

The use of the sprayer control system 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 feature, allowing pressure to be manually adjusted and various sections of the boom to be controlled from the operator's position on the tractor was also considered beneficial. The automatic feature, to automatically maintain a preselected application rate when changes in forward speed or flow occurred, was considered to be of considerably less importance, particularly since effective automatic control was only possible over such a narrow range of forward speeds and resulted in such rapid changes in nozzle pressure.

ELECTRICAL POWER REQUIREMENTS

No excessive demands were made on the tractor battery or electrical charging system. The control console drew up to 0.2 A with the power switch off and up to 0.6 A with the power switch on when attached to a 12-volt electrical system. The Raven automatic sprayer control system, with two solenoid boom valves and with the motorized control valve, drew up to 4.8 A. The original and replacement motorized control valves drew 0.7 and 0.2 A, respectively.

OPERATOR'S MANUAL

The operator's manual provided adequate information on monitor operation, installation, adjustment, calibration and maintenance. A complete illustrated parts list was included.

DURABILITY RESULTS

The Raven automatic sprayer control system was operated in the field for 56 hours. The intent of the test was evaluation of functional performance and an extended durability evaluation was not conducted. TABLE 1 outlines the failures that occurred during functional testing.

Table 1. Mechanical History

Item	Operating Hours
-The MVR50 flow meter couplers leaked at	beginning of test
-Moisture entered the original motorized control valve motor housing	throughout the test
-The original motorized control valve failed and was replaced at	end of test

DISCUSSION OF MECHANICAL PROBLEMS

Flow Meter Couplers: The flow meter pipe couplers (FIGURE 1) provided with the MVR50 flow meter leaked at the beginning of the test and could not be tightened sufficiently to stop the leaking. It is recommended that modifications be made to prevent the couplers from leaking.

Motorized Control Valve: The micro-switch that stopped the butterfly valve inside the motorized control valve at its open and closed positions failed, allowing the butterfly valve to turn continuously. It is recommended that modifications be made to prevent butterfly valve failure.

Moisture entered the motorized control valve motor housing throughout the test. At the end of the test the metal parts of the motorized control valve were slightly corroded.

APPENDIX I
SPECIFICATIONS

MAKE:	Raven Automatic Sprayer Control System	
MODEL:	SCS 400	
SERIAL NUMBER:	063-0159-449	
CONTROL CONSOLE:		
-- size	267 x 171 x 185 mm	
-- controls	power on-off switch, dual function keyboard, master on-off and individual boom control switches, auto-manual flow switch and manual adjust flow switch	
-- alarm	flashing LED digital display screens	
-- display	2, 4-digit LED display screens, application rate and function display	
CONNECTORS:		
-- console	screw-on polarity connectors	
-- battery	crimp-on connectors	
-- solenoid valves	crimp-on connectors	
-- flow meter	screw-on polarity connector	
-- motorized control valve	pull-apart connector	
-- tractor and sprayer hitch	screw-on and pull-apart connectors	
-- speed sensor	wire molded to switch	
SPEED SENSOR:		
-- type	magnetic pick-up	
-- magnets	4, 48 mm long thread, 44 x 25 mm diameter	
-- switch	62 x 20 x 28 mm	
FLOW METERS:	<u>MVR 50</u>	<u>MVR 30</u>
-- serial number	0267-A	0669C
-- type	turbine	turbine
-- size-inlet	32 mm NPT (M)	19 mm NPT (M)
-- body	230 mm long x 104 mm wide x 140 mm high	191 mm long x 91 mm wide x 105 mm high
-- weight	3.2 kg	2.4 kg
MOTORIZED CONTROL VALVE:	<u>Original</u>	<u>Replacement</u>
-- serial number	0427A	D3888
-- type	butterfly	butterfly
-- size-inlet	25 mm NPT (F)	25 mm NPT (F)
-- body	126 mm long x 175 mm high x 75 mm diameter	126 mm long x 181 mm high x 75 mm diameter
-- weight	0.91 kg	0.93 kg
-- power	12 volts DC	12 volts DC
BOOM SOLENOID VALVES:		
-- make	Spraying Systems Co.	
-- model	144	
-- power	12 volt DC, 30 watt	
-- size	19 mm NPT (F)	
-- number		
WEIGHTS:		
-- Monitor control console	2.19 kg	
-- MVR 50 flow meter	3.22 kg	
-- Motorized control valve	0.91 kg	
-- Speed sensor switch and cable	0.51 kg	
-- Control console cable	0.44 kg	
-- Flow meter, motorized control valve and solenoid valve cable	0.89 kg	
-- Speed sensor magnets	0.58 kg	
-- Solenoid valves (3)	2.22 kg	
-- Mounting hardware -- ties, clamps, unions, brackets, bolts, nuts, screws, etc.	<u>3.86 kg</u>	
Total	14.86 kg	

APPENDIX II
MACHINE RATINGS

The following rating scale is used in Machinery Institute Evaluation Reports:

(a) excellent	(d) fair
(b) very good	(e) poor
(c) good	(f) unsatisfactory

APPENDIX III
CONVERSION TABLE

1 kilometre/hour (km/h)	= 0.6 miles/hour (mph)
1 hectare (ha)	= 2.5 acres (ac)
1 litre per hectare (L/ha)	= 0.09 Imperial gallons per acre (gal/ac)
1 kilopascal (kPa)	= 0.15 pounds per square inch (psi)
1 kilogram (kg)	= 2.2 pounds mass (lb)
1 litre per second (L/s)	= 13.2 Imperial gallons per minute (gal/min)
1 litre (L)	= 0.22 Imperial gallons (gal)
1 meter (m)	= 3.3 feet (ft)
1 millimetre (mm)	= 0.04 inches (in)
1 horsepower (hp)	= 0.75 kilowatt (kW)

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