United States Patent

Barlow

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[54] **SPRAYING APPARATUS AND CONTROL SYSTEM THEREFOR**

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[52] **U.S. Cl.** **239/171,** 239/455, 239/551

[51] **Int. Cl.**.....**B05b 17/02,** B64d 1/18

[58] **Field of Search**.....239/551, 571, 124, 537, 569, 239/570, 534, 546, 455, 171

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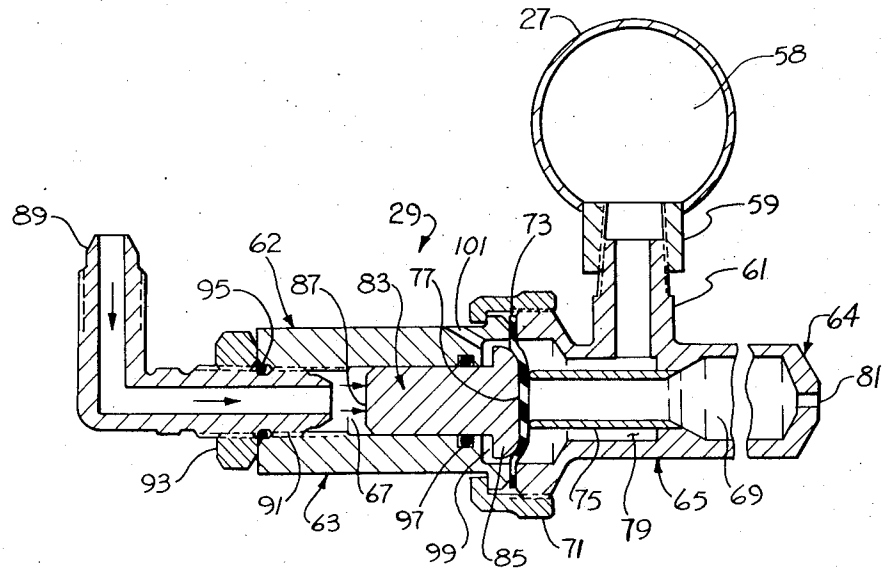
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[57] **ABSTRACT**

A spraying device comprising a spray boom, a plurality of nozzles attached to the spray boom and a pressure responsive valve for each of the nozzles. Each of the valves has an open position and a closed position for, respectively, permitting and preventing the flow of sprayable fluid through the associated nozzle. The valves are actuated hydraulically and when opened, sprayable fluid is supplied through the boom and the valves to the nozzles.

12 Claims, 5 Drawing Figures



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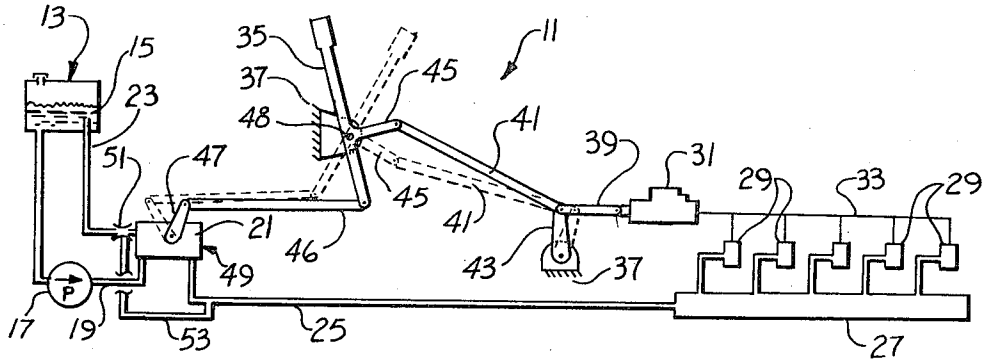


Fig. 1

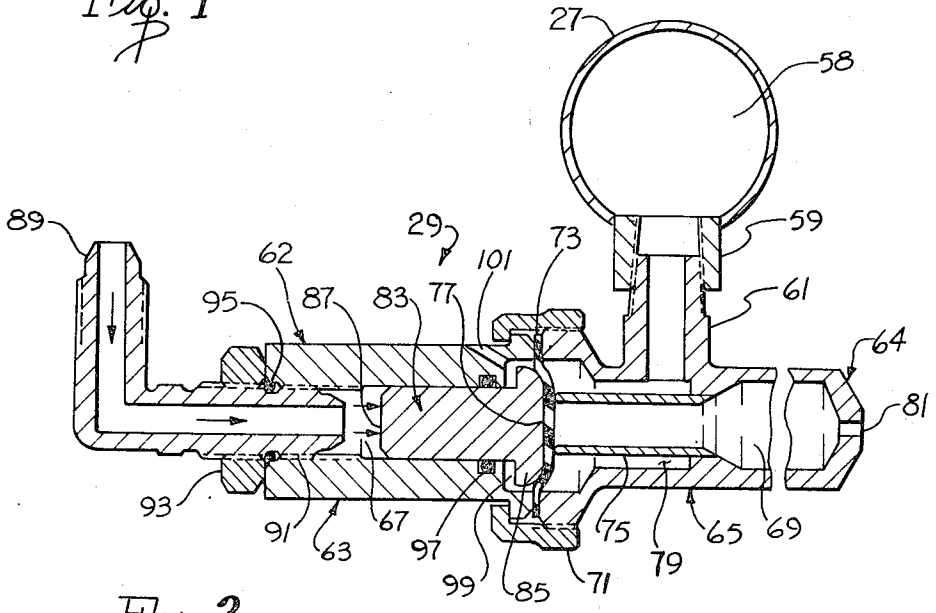


Fig. 2

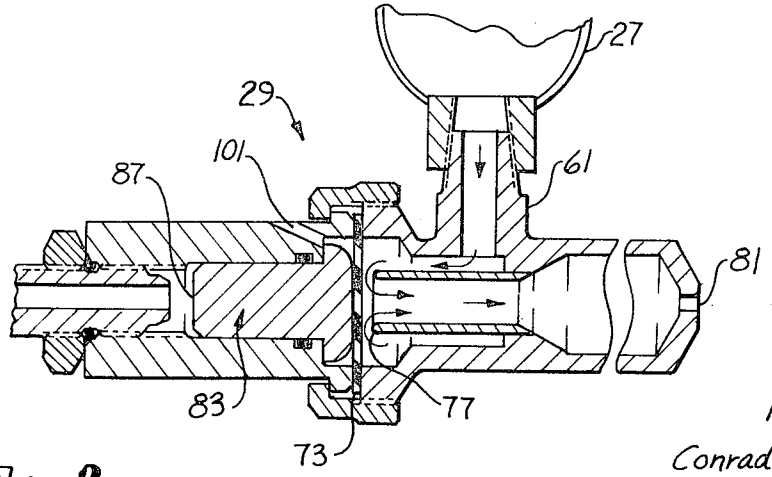


Fig. 2a

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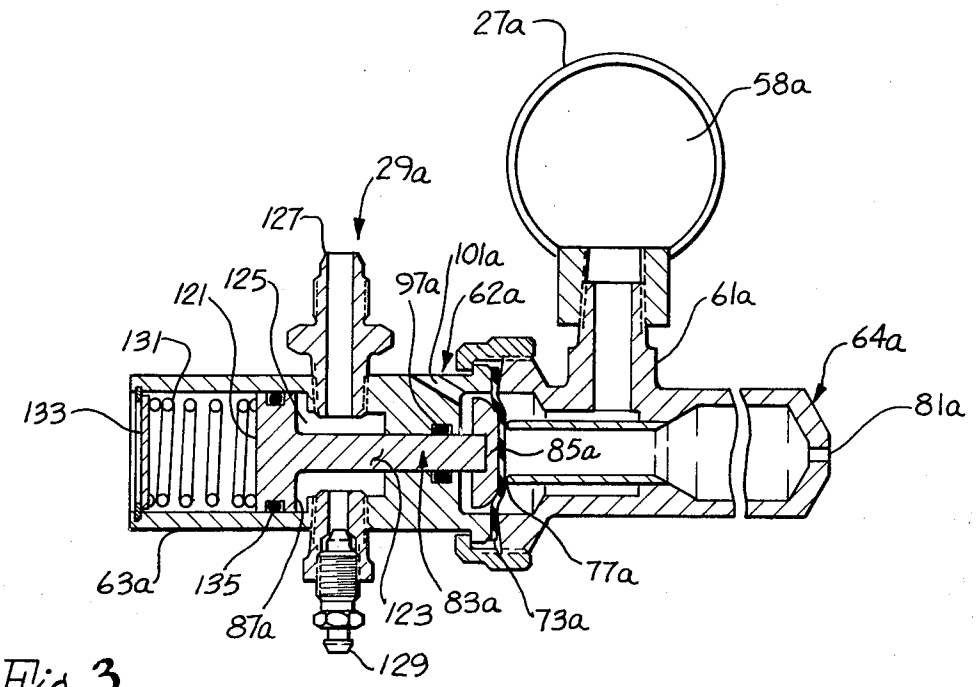


Fig. 3

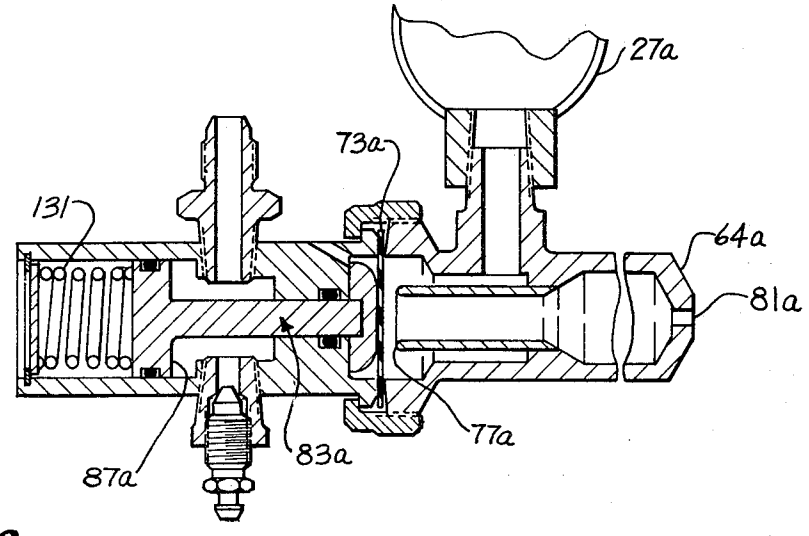


Fig. 3a

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SPRAYING APPARATUS AND CONTROL SYSTEM THEREFOR

BACKGROUND OF THE INVENTION

It is often necessary to spray various liquids such as insecticides, fungicides, etc. for agricultural purposes. This can be rapidly carried out by a spraying apparatus which is associated with a vehicle such as an airplane. In one such system, a spray boom is attached to a fixed wing airplane along the wing thereof, and the sprayable liquid is supplied to the boom. A plurality of nozzles are affixed to the boom to receive and spray the sprayable liquid. A main control valve controls the supply of sprayable fluid under pressure to the boom. A secondary valve is associated with each of the nozzles, and each of the secondary valves typically includes a diaphragm which is spring biased against a valve seat. The secondary valves are opened by the pressure of the sprayable fluid supplied through the spray boom when the main control valve is open.

One disadvantage of this system is that particulate matter may be trapped between the valve seat and the diaphragm. When this occurs, the valve leaks because the spring has insufficient force to completely close the valve when the particulate matter is trapped therein. The spring cannot be made stronger without increasing the pressure at which the sprayable liquid must be provided to open the valve. Leakage not only results in wasting of the sprayable fluid but also may cause damage if the sprayable fluid is a dangerous insecticide or fungicide or other chemical which may be incompatible with the object upon which it falls.

Another problem with this prior art system is that the spring may weaken through use, or due to manufacturing tolerances may not provide sufficient force on the diaphragm. When this occurs, the sprayable fluid which may, under certain circumstances, be under a small static head opens the secondary valve slightly and causes leakage.

SUMMARY OF THE INVENTION

The present invention solves the problems noted above by providing a secondary valve for a spraying system which is actuated by an actuating fluid under pressure such as a suitable hydraulic fluid. In one form of the present invention, the hydraulic fluid is used to close the secondary valve. This results in very tight closure of the valve and positively prevents leakage. Opening of the secondary valve is facilitated because the actuating fluid can be depressurized whenever it is desired to open the secondary valve. With the actuating fluid under substantially no pressure, the sprayable fluid, even at relatively low pressures thereof, can open the secondary valve, and it is not necessary to overcome any spring force.

In another form of the present invention, the actuating fluid is used to open the secondary valve. With this form of the invention, a relatively heavy spring normally maintains the valve in a closed position. The spring provides a much greater force than could reasonably be tolerated if the valve were to be open by the pressure of the sprayable fluid. This form of the invention has the advantage of failing safe in the event of a loss of hydraulic pressure. The pressure of the actuating fluid is sufficient to overcome the relatively heavy spring and open the valve so that the sprayable fluid need not perform the valve opening function. Of course, if desired, the pressure of the actuating fluid and the pressure of the sprayable fluid could be used simultaneously to open the valve.

For both forms of the invention, actuating fluid under pressure can be advantageously supplied by a master cylinder of the type typically used in an automobile braking system. Upon command of the operator, the master cylinder is operated to selectively pressurize or depressurize the actuating fluid to thereby control the action of the secondary valves. With this arrangement operation of the secondary valve is not dependent upon the aircraft hydraulic system.

The present invention employs a main control valve for controlling the flow of sprayable fluid to the spray boom. This main control valve can advantageously take the form of a three-way valve having an inlet connected to the supply tank of sprayable fluid and two outlets connected, respectively, to the spray boom and to the spray tank. The three-way valve receives sprayable fluid under pressure from a pump and either returns it to the supply tank or supplies it to the spray boom or proportions the flow therebetween.

Another feature of the present invention is the use of a common control member to simultaneously operate the main control valve and the master cylinder. With this arrangement, movement of the control member by the operator results in substantially simultaneously opening the main control valve and the secondary valves, or in closing the main control valve and the secondary valves. An over-center mechanism is used to advantage to maintain the master cylinder in the position in which it supplies fluid under pressure to the secondary valves.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a diagrammatic view of a spraying system constructed in accordance with the teachings of this invention.

FIG. 2 is a sectional view through the spray boom at one of the secondary valves showing one form of secondary valve constructed in accordance with the teachings of this invention with the valve being held in the closed position by hydraulic fluid under pressure.

FIG. 2*a* is a sectional view similar to FIG. 2 with the valve being in the open position.

FIG. 3 is a sectional view similar to FIG. 2 showing a second form of secondary valve with the valve being held in the closed position by a relatively stiff spring.

FIG. 3*a* is a sectional view similar to FIG. 3 with the secondary valve being held in the open position by hydraulic fluid under pressure.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawing and in particular to FIG. 1 thereof, reference numeral **11** designates a spraying system constructed in accordance with the teachings of this invention. The system **11** is carried by a vehicle such as a fixed wing aircraft (not shown). The system **11** includes a supply tank **13** for containing a supply of sprayable fluid such as insecticides, fungicides, or other fluids usually in liquid form usable for various agricultural purposes. A pump **17** which may be a wind driven pump carried by the airplane supplies sprayable fluid

15 from the tank 13 through a conduit 19 to a three-way, main control valve 21.

The main valve 21 directs the sprayable fluid supplied thereto by the pump 17 to, either or both of, the conduits 23 and 25. The sprayable fluid supplied to the conduit 23 is returned to the tank 13 and preferably to the lower regions thereof to maintain the sprayable fluid 15 properly mixed. The sprayable fluid 15 directed to the conduit 25 is supplied to a spray boom 27 which in turn distributes the sprayable fluid to a plurality of spray assemblies 29, any number of which may be utilized. As shown in the illustrated embodiment the spray assemblies 29 are arranged in parallel. The spray boom 27 may be attached to the wing of the airplane with the spray assemblies 29 appropriately arranged to spray the sprayable material 15 away from the boom.

The spray assemblies 29 can be maintained in an open or closed position by a master cylinder 31 which pressurizes or depressurizes hydraulic fluid in a conduit 33 leading from the master cylinder to each of the assemblies 29. The master cylinder 31 can be of any design which will pressurize hydraulic fluid in response to a predetermined input motion and as such may be of the type used in automobile braking systems. Such input motion is supplied by a control member 35 which is suitably pivotally mounted intermediate its ends to a fixed support member 37. The pivotal movement of the control member 35 is transformed into linear input motion to an input member 39 of the master cylinder by a pair of links 41 and 43. As shown in FIG. 1, the link 41 is pivotally connected to the link 43 and to a rigid link 45 which forms a part of the control member 35. The link 43 is pivotally connected to another portion of the fixed support 37. The linkage between the control member 35 and the input member 39 can be slotted as necessary to provide the desired input motion to the input member.

The control member 35 also operates the main valve 21. This is accomplished by a link 46 interconnecting the lower end of the control member 35 and an operating handle 47 of the main valve.

The control member 35 is pivotal about an axis between the full line position and the dotted line position shown in FIG. 1. In the full line position, the master cylinder does not pressurize the hydraulic fluid, and according to the first embodiment of the invention, the spray assemblies 29 are open in this condition. The main valve 21 is also open so that the main valve 21 supplies all of the sprayable fluid 15 supplied thereto by the pump 17 to the spray boom 27 via the conduit 25. Accordingly, in this position of the control member 35, the sprayable fluid is discharged from the assemblies 29. In this position of the control member 35, there are substantially no forces tending to move the control member toward the dotted line position, and accordingly, no stop or latching mechanism is necessary to retain the control member in this position; however, a stop may be provided, if desired.

In the dashed line position shown in FIG. 1, the input member 39 is moved axially to the right relative to the remainder of the master cylinder 31 thereby causing the latter to pressurize, in a conventional manner, the hydraulic fluid which is supplied to the spray assemblies 29. According to the first embodiment of this invention, this results in closing of the spray assemblies 29. In addition, the operating handle 47 is moved so that all of the sprayable fluid 15 supplied thereto by the pump 17 is returned via the conduit 23 to the supply tank 13.

In the dashed line position, the reaction force resulting from pressurization of the hydraulic fluid by the master cylinder 31 tends to move the input member 39 to the left as viewed in FIG. 1. It should be noted, however, that the links 41 and 45 are over-center in this position. Moreover, the main valve 21 has a stop 49 which prevents further over-center movement of the links 41 and 45. Accordingly, once placed in the off or dashed line position, the control member 35 remains there until moved by the operator.

The main valve 21 can also proportion the flow of sprayable fluid between the conduits 23 and 25. Accordingly, the control member 35 may be maintained in a position intermediate the dashed and full line positions shown in FIG. 1 by the operator or a suitable adjustable stop (not shown) can be provided to retain the control member 35 in the selected position. The control linkage is arranged so that the pressure of the hydraulic fluid is reduced by the master cylinder 31 to allow opening of the assemblies 29 at the position of the control member 35 at which the main control valve 21 supplies minor quantities of the sprayable fluid to the assemblies 29. Further movement of the control member 35 toward the open or full line position results in increasing the flow rate of sprayable fluid through the spray boom 27.

A venturi 51 is located in the conduit 23 and a conduit 53 interconnects the conduit 25 with the constricted region of the venturi. With the main valve 21 turned off, the low static pressure at the constricted region of the venturi 51 applies suction to the conduit 25 tending to pull the liquid therein into the conduit 23.

FIGS. 2 and 2*a* show the details of a typical one of the assemblies 29 affixed to the boom 27. The spray boom 27 in the embodiment illustrated is a substantially cylindrical pipe having a passage 58 extending therethrough and one bushing 59 suitably mounted thereon as by welding for each of the assemblies 29. The assemblies 29 are identical, and accordingly, only one of the assemblies 29 is illustrated in detail. The assembly 29 has an inlet section 61 received within and attached to the bushing 59 with screw threads.

The assembly 29 generally includes a secondary valve 62 and a nozzle 64. The assembly 29 includes body sections 63 and 65 having passages 67 and 69, respectively. The body sections 63 and 65 are held together in coaxial relationship by a retainer 71 which engages an annular shoulder on the body section 63 and which is affixed to the body section 65 by screw threads. A flexible, resilient diaphragm 73 is clamped between the confronting end faces of the body sections 63 and 65.

The body section 65 has a sleeve 75 therein which terminates in an annular valve seat 77. An annular passage 79 surrounds the sleeve 75. The passage 69 terminates in one or more orifices 81 formed in the nozzle 64.

A plunger 83 having an enlarged head 85 and a pressure responsive face 87 is mounted for sliding movement in the passage 67. Hydraulic fluid under pressure is supplied through a fitting 89 to the pressure respon-

sive face **87**. The fitting **89** is mounted on the body section **63** by screw threads **91** and a nut **93** with the interface between the fitting and the body section **63** being sealed by an annular seal **95** such as an O-ring. Another annular seal **97** which may also be an O-ring is mounted in an annular groove in the body section **63** and isolates the pressure responsive face **87** from a chamber **99** in which the head **85** is positioned. The chamber **99** is vented to atmosphere by a port **101** which extends through the wall of the body section **63**.

With the spraying system **11** attached to an aircraft, the operation of the spraying system can be controlled by the pilot by manually moving the control member **35**. With the control member **35** in the off or dashed line position shown in FIG. **1**, hydraulic fluid under pressure from the master cylinder **31** acts on the pressure responsive face **87** and urges the plunger **83** to the position shown in FIG. **2**. In this position, the head **85** of the plunger **83** urges the resilient diaphragm **73** into substantially fluid-tight sealing contact with the valve seat **77**. Accordingly, any sprayable fluid in the passage **58** of the spray boom **27** cannot flow through the valve **62** to the orifice **81**.

With the control member **35** in the off position, the main control valve **21** blocks flow of the sprayable fluid through the conduit **25** to the spray boom **27**. Accordingly, the fluid supplied by the pump **17** is returned to the tank **13** via the conduit **23**. The flow of the sprayable fluid **15** through the venturi **51** produces a region of low static pressure at the constricted region of the venturi to cause the sprayable fluid trapped in the conduit **25** and the spray boom **27** to be drawn or sucked into the conduit **23** and returned to the tank **13**. Notwithstanding the use of the venturi **51**, some of the sprayable fluid may remain in the spray boom **27**. Moreover, if the pump **17** is shut down as when the aircraft is on the ground, the flow, if any, through the venturi **51** is not sufficient to create or to maintain a low static pressure region in the venturi. Accordingly, the sprayable fluid **15** flows from the tank **13** through the conduits **23**, **53** and **25** to the spray boom **27**. Under these circumstances the sprayable fluid in the spray boom **27** is under a static head depending upon the height of the fluid **15** in the tank **13** above the spray boom. Under these conditions, it is very important that the plunger **83** cause the diaphragm **73** to form a tight seal against the valve seat **77**. The hydraulic system of this invention provides such a tight seal and the seal thus provided is not dependent upon operation of the aircraft hydraulic system.

When the pilot wishes to spray the fluid **15**, he merely moves the control member **35** to the on or full line position shown in FIG. **1**. This simultaneously causes the master cylinder **31** to depressurize the hydraulic fluid acting against the pressure responsive faces **87** and moves the three-way valve so that it supplies the sprayable fluid **15** to the spray boom **27**. The pressure drop at the pressure responsive face **87** allows the sprayable fluid **15** in the boom **27** and/or the resilience of the diaphragm **73** to easily move the diaphragm **73** and the plunger **83** to the left as shown in FIG. **2a** thereby opening the valve and permitting flow to the nozzle **81**. The control member **35** need only be moved toward the off position sufficiently to depressurize the hydraulic fluid so that the pressure of the sprayable fluid can open the plunger **83**. Once the diaphragm **73** separates from the valve seat **77**, the pressure of the sprayable fluid acts over the whole area thereof. By moving the control member **35** further toward the on position, the valve **21** is caused to supply greater portions of the sprayable fluid **15** to the spray boom **27**. The diaphragm **73** is closely adjacent the valve seat **77** in the open position of the valve **62**. The diaphragm lies intermediate the plunger **83** and the valve seat.

FIGS. **3** and **3***a* show a second embodiment of spray assembly **29***a* which is quite similar to the spray assembly **29** except that the former is maintained in a closed position by a relatively heavy spring and is opened by hydraulic fluid under pressure. Portions of the spray assembly **29***a* corresponding to portions of the spray assembly **29** are designated by corresponding reference numerals followed by the letter *a*.

In FIG. **3**, the plunger **83***a* includes a head **85***a* and a piston **121** interconnected by a rod **123**. One side of the piston **121** defines a pressure responsive face **87***a* with the pressure responsive face **87***a* being sealed from the head **85***a* and the chamber **99***a* by an O-ring seal **97***a*. The plunger **83***a* and the body section **63***a* define an annular chamber **125** to which hydraulic fluid is supplied by a pair of fittings **127** and **129** which are connected to the master cylinder **31** substantially as shown in FIG. **1**.

The secondary valve **62***a* is normally urged to the closed position by a relatively heavy coil spring **131** which acts between the piston **121** and an end wall **133** of the body section **63***a*. This portion of the body section **63***a* is sealed from the chamber **125** by an annular seal **135**.

In operation of the assembly **29***a*, the spring **131** normally forces the plunger **83***a* to the right to urge the diaphragm **73***a* into substantially fluid-tight sealing engagement with the valve seat **77***a*. When the operator wishes to open the valve, he supplies hydraulic fluid under pressure through the fittings **127** and **129** to the chamber **125**. The hydraulic fluid under pressure acts on the pressure responsive face **87***a* to move the plunger **83a** to the left to the position shown in FIG. **3***a*. This allows the diaphragm **73***a* to separate from the valve seat **77***a* to thereby open the passage to the orifice **81***a*. In all other respects the spray assembly **29***a* may be identical to the spray assembly **29**.

If desired, the assemblies **29***a* can be utilized in the control system shown in FIG. **1** in lieu of the spray assemblies **29**. If this is done, the operation of the control system will be the opposite of that described hereinabove in that the dashed line position which results in pressurization of the hydraulic fluid will be the open position (FIG. **3***a*). This means that the valve **21** must be reversed so that it will supply the sprayable fluid **15** to the spray boom when the control member **35** is in the dashed line position.

Although illustrative embodiments of the invention has been shown and described, many changes, modifications, and substitutions may be made by one having ordinary skill in the art without necessarily departing from the spirit and scope of this invention.

I claim:

1. A spraying system for spraying a sprayable fluid and operable by an actuating fluid, said spraying system being attachable to an aircraft and comprising:

a spray boom having a passage therein through which the sprayable fluid can flow;

nozzle means attached to the spray boom for receiving sprayable fluid therefrom and for spraying such sprayable fluid;

pressure responsive valve means having an open position and a closed position for, respectively, permitting and preventing the flow of sprayable fluid through said nozzle means;

first means for supplying actuating fluid under pressure to the valve means to place the valve means in one of said positions thereof;

second means for supplying the sprayable fluid under pressure to the spray boom at least when said valve means is in said open position; and

said valve means including a valve body having a passageway therein, a valve seat in said body, a diaphragm mounted in said body adjacent said valve seat for movement toward and away from said valve seat, a plunger mounted in the passageway of said valve body with the diaphragm being intermediate said plunger and said valve seat, the actuating fluid under pressure being directed to the plunger to cause movement thereof, movement of the plunger toward the valve seat urging the diaphragm into substantially fluid tight sealing engagement therewith whereby said valve means is in said closed position thereof.

2. A spraying system as defined in claim **1** including a control member and means for mounting said control member for movement between first and second positions, said first means being responsive to the control member being in said first position thereof for supplying actuating fluid under pressure to the valve means to place the valve means in said one position thereof, said spraying system including third means responsive to the control member being in said second position thereof for permitting the valve means to be in the other position thereof, said second means being responsive to the control member being in the position thereof corresponding to the open position of said valve means for supplying sprayable fluid under pressure to the spray boom.

3. A spraying system as defined in claim **1** wherein said first means includes a master cylinder for pressurizing the actuating fluid to place the valve means in said one position thereof, said master cylinder also being capable of reducing the pressure of the actuating fluid to thereby permit the valve to be placed in the other position thereof.

4. A spraying system as defined in claim **1** wherein said one position of said valve means is said closed position and said first means supplies actuating fluid under pressure to the plunger to force the latter toward said valve seat.

5. A spraying system as defined in claim **1** wherein said one position of said valve means is said open position, said plunger having a face substantially isolated from said diaphragm, and said first means supplies actuating fluid under pressure to said face of said plunger to move said plunger away from said valve seat to thereby place said valve means in said open position, said spraying system including resilient means for urging the plunger toward the valve seat.

6. A control system for a spraying device of the type which is attachable to an aircraft and sprays a sprayable fluid through a nozzle, said control system comprising:

a valve assembly attached to said nozzle;

said assembly including a body having a passage therein and means for connecting said body to the spraying device, said body having an inlet for receiving the sprayable fluid from the spraying device, said nozzle receiving the sprayable fluid from said passage;

a valve seat in said passage of said body;

a diaphragm in said passage of said body movable toward and away from the valve seat and engageable therewith to form a substantially fluid tight seal in said passage of said body downstream from said inlet to thereby shut-off the flow of sprayable fluid to the nozzle;

a plunger mounted in said passage of said body for movement between a first position in which said plunger urges said diaphragm into substantially fluid-tight sealing engagement with said valve seat and a second position in which said plunger does not urge said diaphragm into substantially fluid-tight sealing engagement with said valve seat, said diaphragm being intermediate said plunger and said valve seat, said plunger having a fluid pressure responsive face thereon; and

means for supplying actuating fluid under pressure to the fluid pressure responsive face of said plunger to thereby urge said plunger to one of said positions thereof.

7. A control system as defined in claim **6** wherein the supply of actuating fluid under pressure to said pressure responsive face urges said plunger toward said valve seat to shut-off the supply of sprayable fluid to the nozzle.

8. A control system as defined in claim **6** including a relatively heavy spring for normally urging said plunger toward said valve seat to thereby maintain the supply of sprayable fluid to the orifice shut-off, the supply of actuating fluid under pressure to said pressure responsive face of said plunger urging said plunger away from said valve seat to thereby permit the sprayable fluid to flow through the passage of the body to the nozzle.

9. A control system for a spraying device of the type which is attachable to an aircraft and sprays a sprayable fluid through nozzle means, said control system comprising:

pressure responsive valve means having an open position and a closed position for, respectively, permitting and preventing the flow of sprayable fluid through said nozzle means;

a control member;

means for mounting the control member for movement between first and second positions;

first means responsive to the control member being in said first position thereof for supplying an actuating fluid under pressure to the pressure responsive valve means to place the pressure responsive valve means in one of said positions thereof;

second means responsive to the control member being in said second position thereof for permitting the valve means to be in the other position thereof;

third means responsive to the control member being in the position thereof corresponding to the open position of said pressure responsive valve means for supplying sprayable fluid under pressure to the pressure responsive valve means; and

said first means including a master cylinder for pressurizing the actuating fluid and said third means including valve means for controlling the flow of sprayable fluid under pressure to the nozzle means, said control system also including linkage means for interconnecting said control member with said last mentioned valve means and said master cylinder, said linkage means including over center toggle means for retaining said control member in one of said positions thereof corresponding to the position in which the master cylinder pressurizes the actuating fluid.

10. A spraying system for a sprayable fluid, said spraying system being attachable to an aircraft and being operable by an actuating fluid, said spraying system comprising:

a plurality of nozzles arranged in parallel for discharging the sprayable fluid;

conduit means for supplying the sprayable fluid to the nozzles;

a plurality of pressure responsive valves for said nozzles arranged in parallel in said conduit means, each of said valves having an open position in which sprayable fluid can pass therethrough and through the associated nozzle and a closed position in which flow of the sprayable fluid is blocked;

first means for supplying actuating fluid under pressure to said pressure responsive valves to place said pressure responsive valves in one of said positions thereof;

a control valve for selectively allowing and blocking flow of the sprayable fluid through said conduit means to the pressure responsive valves; and

common control means for operating said first means and said control valve whereby the control valve and the pressure responsive valves can be opened and closed.

11. A spraying system as defined in claim **10** wherein said first means includes a master cylinder, said common control means includes overcenter toggle means for holding the master cylinder in the position in which it provides actuating fluid under pressure to the pressure responsive valves, said control valve being at least a three-way valve for receiving sprayable fluid from a source and directing the fluid to the pressure responsive valves or back toward said source.

12. A spraying system for a sprayable fluid, said spraying system being attachable to an aircraft and being operable by an actuating fluid, said spraying system comprising:

nozzle means for discharging the sprayable fluid;

pressure responsive valve means having an open position and a closed position for, respectively, permitting and preventing the flow of sprayable fluid through said nozzle means;

a master cylinder for supplying actuating fluid under pressure to said pressure responsive valve means to place said pressure responsive valve means in one of said positions thereof;

conduit means for supplying sprayable fluid to the nozzle means;

a control valve for selectively allowing and blocking flow of the sprayable fluid through said conduit means to the pressure responsive valve means;

common control means for operating said master cylinder and said control valve; and

said common control means including overcenter toggle means for holding the master cylinder in the position in which it supplies fluid under pressure to said pressure responsive valve means.

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