

Nov. 12, 1968

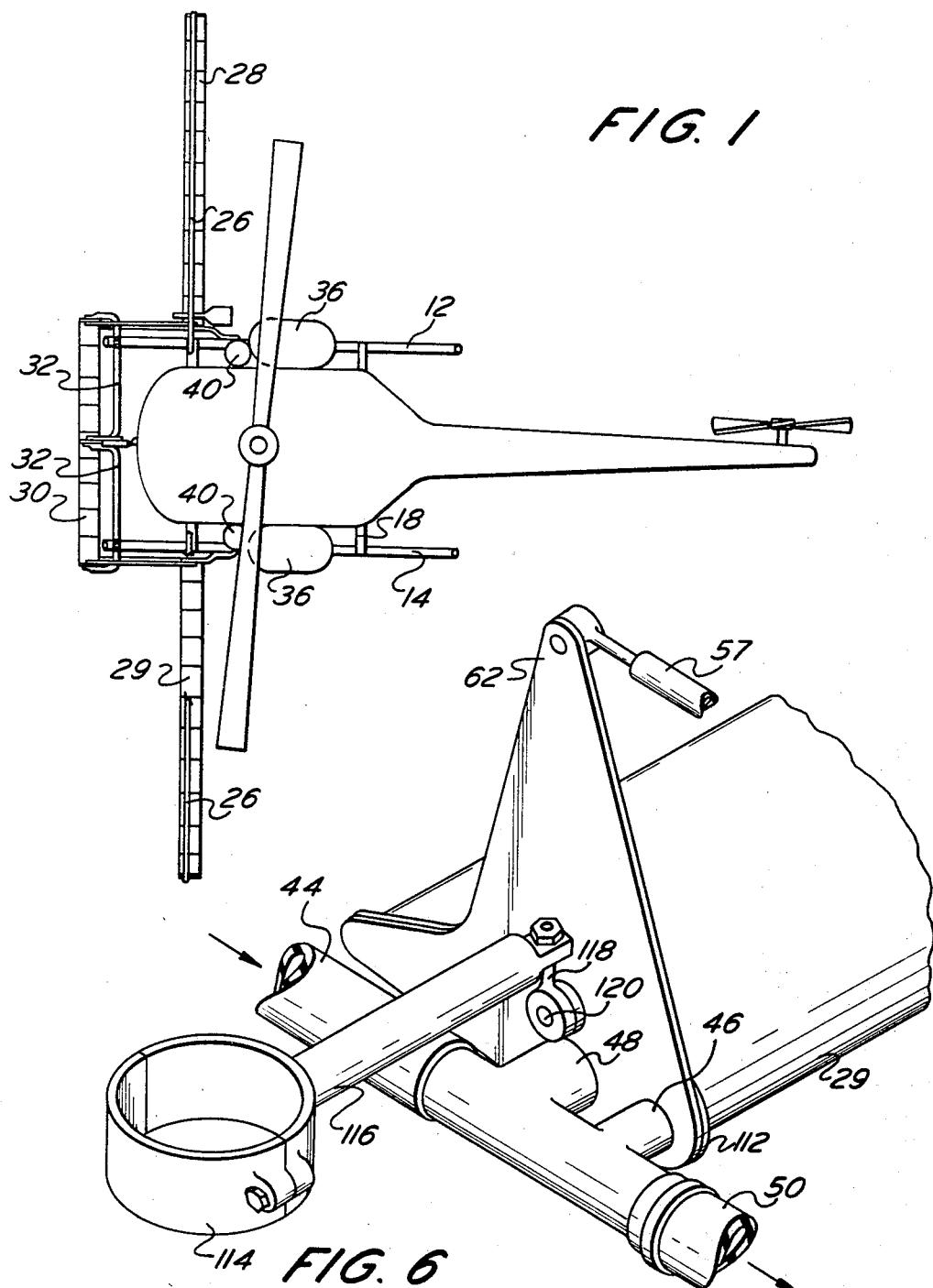
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3,410,489

AUTOMATICALLY ADJUSTABLE AIRFOIL SPRAY SYSTEM WITH PUMP

Filed Jan. 5, 1967

5 Sheets-Sheet 1



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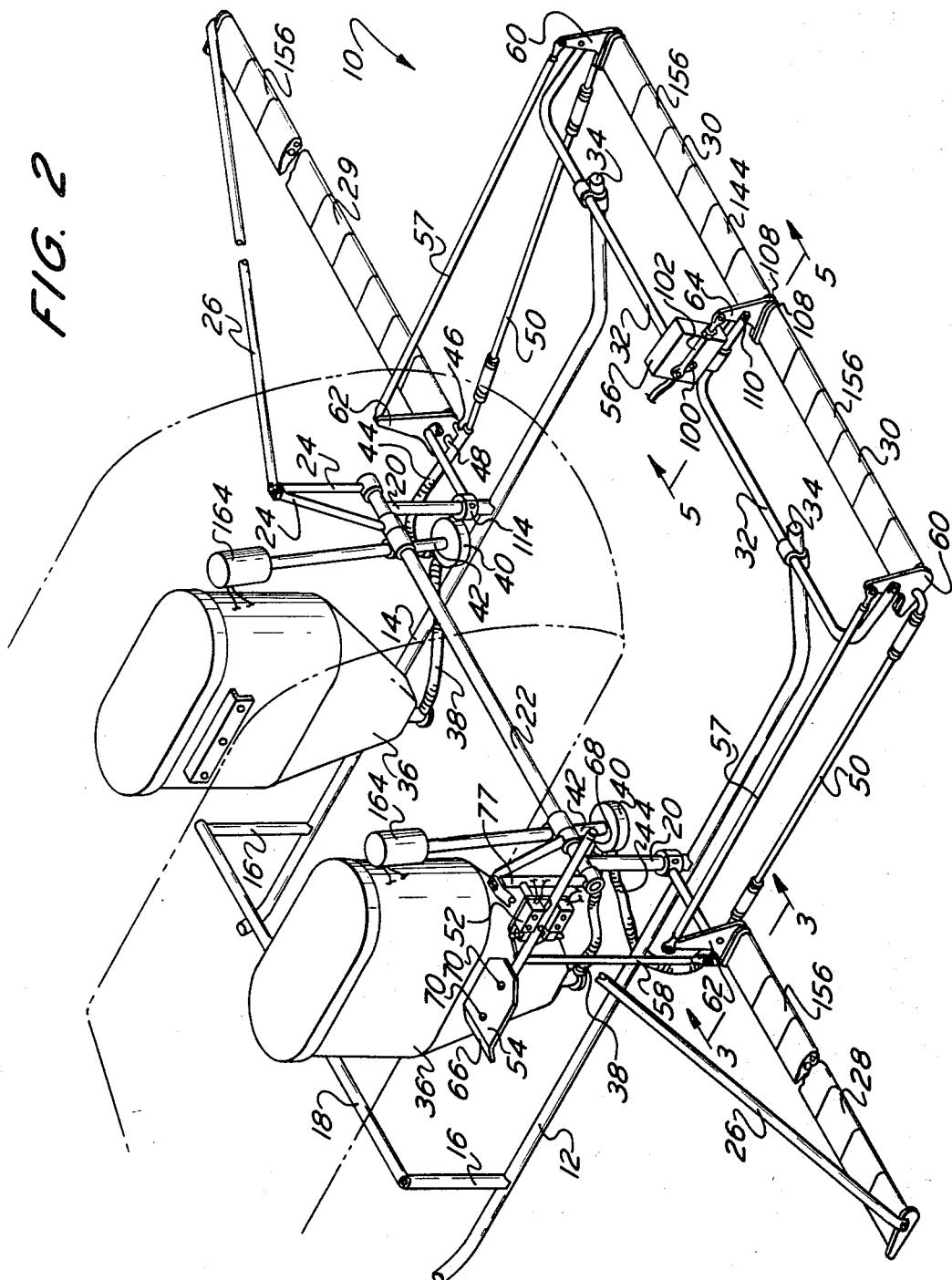
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## AUTOMATICALLY ADJUSTABLE AIRFOIL SPRAY SYSTEM WITH PUMP

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FIG. 2



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AUTOMATICALLY ADJUSTABLE AIRFOIL SPRAY SYSTEM WITH PUMP

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5 Sheets-Sheet 3

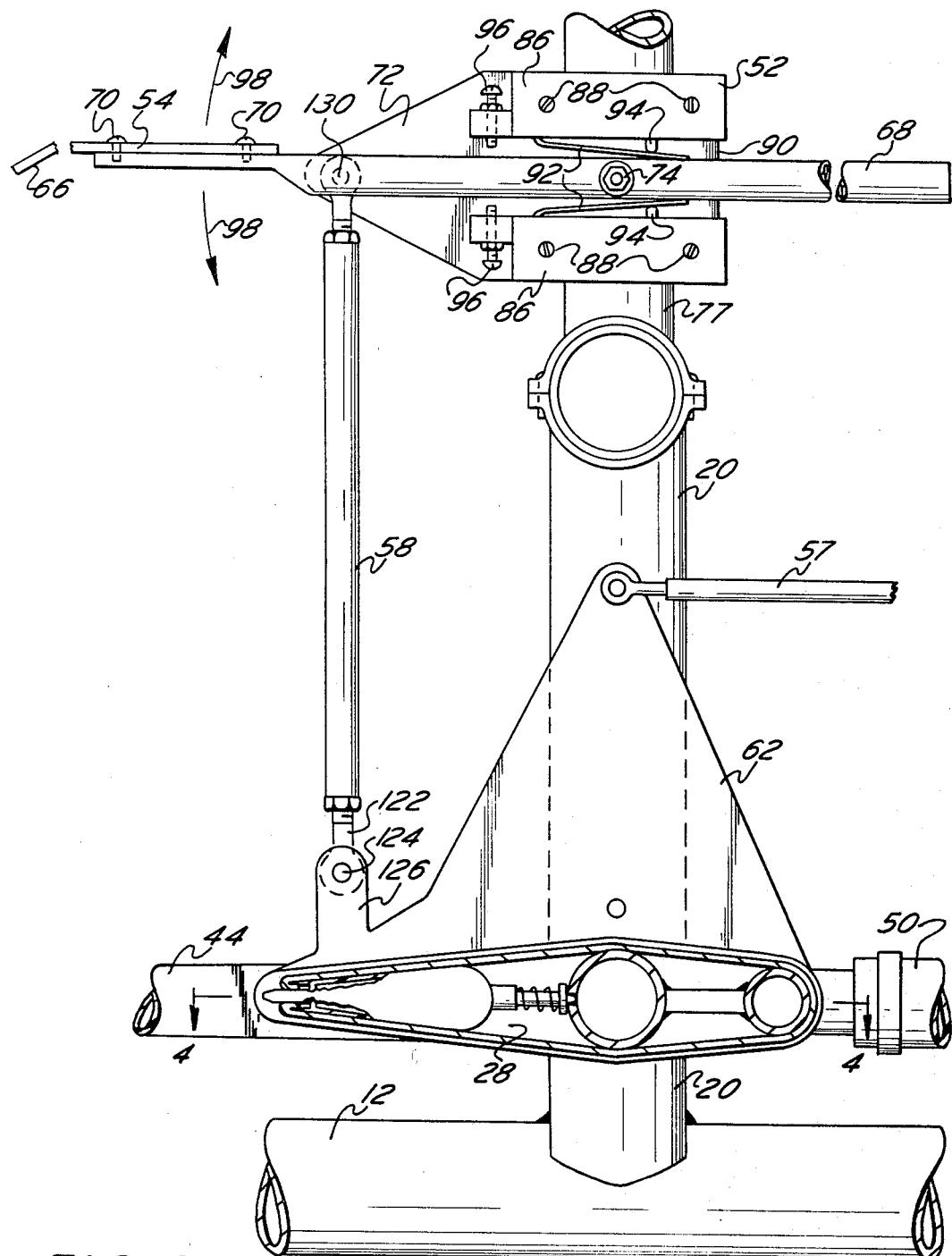


FIG. 3

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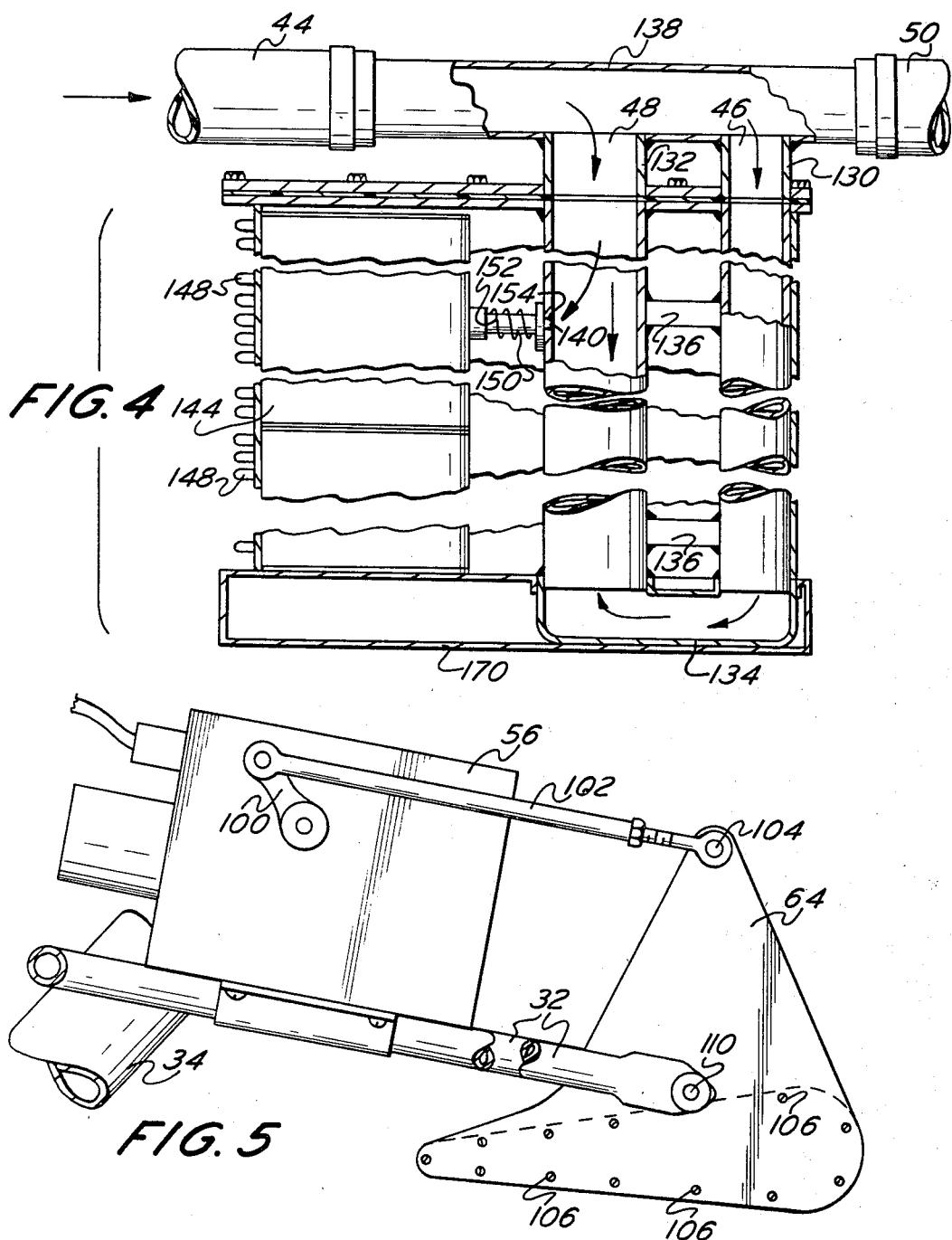
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AUTOMATICALLY ADJUSTABLE AIRFOIL SPRAY SYSTEM WITH PUMP

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5 Sheets-Sheet 4



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## AUTOMATICALLY ADJUSTABLE AIRFOIL SPRAY SYSTEM WITH PUMP

Filed Jan. 5, 1967

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FIG. 7

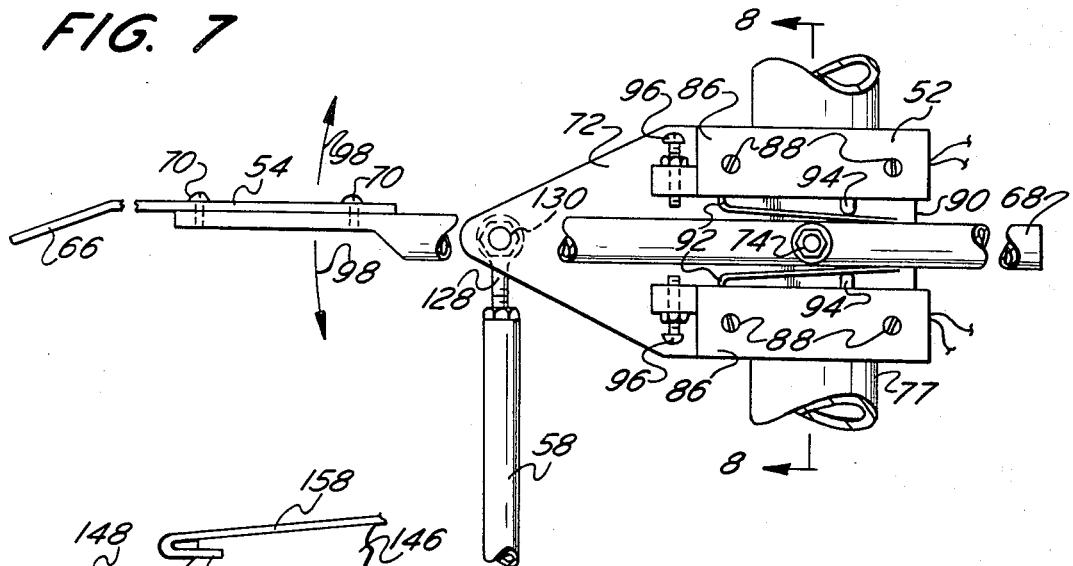


FIG. 10

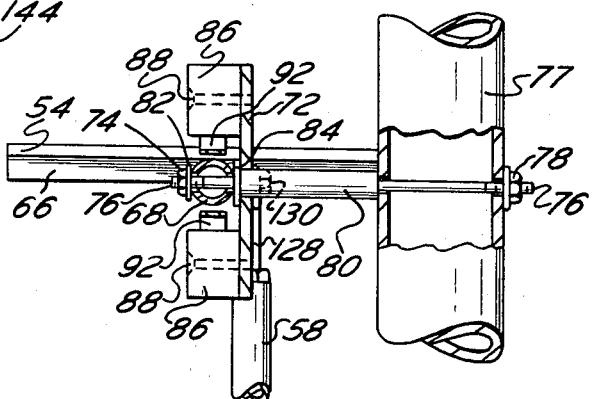


FIG. 8

FIG. 9

FIG. 9

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3,410,489  
**AUTOMATICALLY ADJUSTABLE AIRFOIL SPRAY SYSTEM WITH PUMP**  
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Filed Jan. 5, 1967, Ser. No. 607,488  
9 Claims. (Cl. 239—171)

## ABSTRACT OF THE DISCLOSURE

An automatically adjustable airfoil spray system with pump so constructed that the position of the spray boom can be changed automatically in accordance with changes in wind direction. This is accomplished by means of a vane that is sensitive to the wind direction such that changes in wind direction will actuate a microswitch device which in turn will actuate a motor to bring about a pivoting of the spray boom to align the boom with the new wind direction. It is preferred that the spray boom be in airfoil form and be composed of detachable segments to achieve flexibility and ease of repair. The material to be sprayed is pumped to the spray boom from storage tanks with the liquid level in the storage tanks being maintained at all times below the level of the pump motor, and in this way it is not necessary to provide liquid seals for the pump motor.

## Specification

This invention relates to an automatically adjustable airfoil spray system with pump, and has as its objective the provision of a novel and highly versatile device of this general class.

In herbicide spraying operations, it is important that the herbicide be discharged upon target areas and that inadvertent spraying of unwanted areas be completely eliminated. This is particularly important where the spraying is done through the use of a helicopter where unpredictable air currents or drafts as well as wind changes may divert a properly delivered herbicide stream.

It is quite common during helicopter spraying for the helicopter to move in an upward and downward motion because of air currents and air drafts which naturally affect the flight pattern. This in turn has an adverse effect on the spray pattern that is being delivered from the trailing edge of the helicopter boom. For example where sudden movement is from a horizontal plane to an upward position, the boom will naturally tilt downward and the forward rushing air currents will then separate lighter weight spray particles from the heavier particles, thereby creating two distinct spray patterns.

The smaller particles will drift off over a wider range since they naturally stay in the air for a longer time and this improves the chances that such smaller particles will be diverted by air currents and drafts which arise from time to time.

The delivery of even small amounts of a herbicide to undesirable areas can create serious problems particularly where the herbicide is of the systemic type. In such herbicides only a few drops are required to kill a plant, and most systemic herbicides are effective against certain economic crops as well as exhibiting selective properties in attacking various weeds.

It is therefore an objective of the present invention to provide an automatically adjustable airfoil spray system with pump wherein the direction of spray discharge can be varied in accordance with changes in wind and draft direction.

Another objective of the present invention is to provide an automatically adjustable airfoil spray system with

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pump wherein the spray boom is preferably in the form of an airfoil and is composed of a series of segments for purposes of flexibility and ease of repair.

Yet another objective of the present invention is to provide an automatically adjustable airfoil spray system wherein the level of liquid in the herbicide storage tanks is maintained at all times below the level of the pump motor thereby avoiding the necessity of providing liquid seals for the pump motor.

Still another objective of the present invention is to provide an automatically adjustable airfoil spray system with pump which can be erected in a relatively simple manner in accordance with the dimension of the particular helicopter or other air, land or water vehicle involved.

Yet another objective of the present invention is to provide an automatically adjustable airfoil spray system with pump that is of relatively simple construction, of relatively low cost and is relatively simple to maintain.

The foregoing as well as other objectives of the invention are achieved by providing an automatically adjustable airfoil spray system with pump wherein the vane or other air direction detecting device is sensitive to changes in air direction or drafts to actuate a microswitch device which in turn drives a motor or other actuating device in a given direction to give rise to a corrective action to change the spray boom inclination and thereby vary the angle of spray discharge in accordance with the previous change in wind direction. When the corrective action has been completed, the motor is turned off and the spray boom will remain in its new position until there is another change in wind direction or drafts.

The spray boom itself is preferably in airfoil form and is comprised of a series of segments including protective snap-on covers such that a given segment may be removed at any time and, if necessary, replaced. In a preferred form of the invention, a helicopter is fitted with a front spray boom and two side spray booms through mechanical control links which in turn serve to terminate the corrective action when the spray boom position has been lined up with the new wind or draft direction. Another aspect of the present invention relates to maintaining the level of liquid in storage tanks at a point below the height of pump motors, such that it is not necessary to provide liquid seals in connection with the pump motors.

Other objectives and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIGURE 1 is a partly schematic top plane view of a helicopter equipped with the spray system of the present invention;

FIGURE 2 is an enlarged perspective view with portions eliminated or broken away for the sake of clarity which illustrates a system embodying the spray system of the present invention and in connection with certain helicopter structural members;

FIGURE 3 is an enlarged sectional view taken along the lines 3—3 of FIGURE 2;

FIGURE 4 is a sectional view taken along the lines 4—4 of FIGURE 3;

FIGURE 5 is an enlarged sectional view taken along the lines 5—5 of FIGURE 2;

FIGURE 6 is an enlarged fragmentary perspective view showing the inner end of one of the side spray booms;

FIGURE 7 is a fragmentary elevational view illustrating certain details of a microswitch device that is useable in the present invention;

FIGURE 8 is a sectional view taken along the line 8—8 of FIGURE 7;

FIGURE 9 is a perspective view showing a metallic

cover for a spray boom section about to be snapped into place; and

FIGURE 10 is an enlarged detailed view taken from FIGURE 9.

Referring now to the various figures of the drawings wherein like reference characters refer to like parts, there is shown at 10 in FIG. 1 an automatically adjustable airfoil spray system with pump embodying the present invention. The details of the system 10 are readily apparent by consideration of the other figures of the drawings with particular reference to FIG. 2.

As shown in FIGS. 1 and 2, the system 10 is adapted to be mounted upon certain conventional structural members of a helicopter. As shown in FIG. 2, the helicopter support members include skids 12 and 14 with rear uprights 16 extending from the skids to support rear cross member 18. Forward uprights 20 extend upwardly from the skids to support forward cross member 22. Strut brackets 24 support struts 26, with the struts 26 serving to support side spray booms 28 and 29. The front spray boom 30 is supported from support frames 32 that are mounted adjacent the front tips 34 of the skids 12 and 14.

As is further shown in FIG. 2, saddle tanks 36 are also supported from the skids 12 and 14 by brackets (not shown) with the herbicide being contained in the saddle tanks 36. The herbicide flows through flexible hoses 38 to the impeller 40 of pumps 42 and then is discharged through flexible hoses 44 into the side spray booms 28 and 29 through connections 46 and 48 and also forwardly through line 50 to front spray boom 30.

As is further shown in FIG. 2, a microswitch mechanism 52 (microswitch means) is provided and actuated by changes in direction of vane 54 (air direction detecting means) that is sensitive to changes in air direction. Should the vane 54 be deflected upwardly or downwardly by changes in air direction, the microswitch 52 will be actuated to turn on motor or actuator 56 (actuating means) that causes the front spray boom 30 to pivot in a particular direction and thereby give rise to a corrective action.

There is a simultaneous pivoting of the side spray booms 28 and 29 through control links 57. As the side spray boom 28 pivots under the corrective action, a control rod 58 is also moved upwardly or downwardly and this ultimately turns off the microswitch device 52 which in turn stops the action of the actuator 56. Thus spray booms 28, 29 and 30 are held in their new position until there is another change in wind direction.

With particular reference to the front spray boom 30 as shown in FIG. 2, it will be seen that at each end of the spray boom 30 there is provided a pivot plate 60.

A similar pivot plate 62 is found at the interior end only of each of the side spray booms 28 and 29 with a somewhat similar pivot plate 64 being associated with actuator 56.

Reference is now made to the microswitch device 52, the vane 54 and control rod 58, the details of which are best seen in FIGS. 3, 7 and 8. The vane 54 is a flat plate terminating in inclined rear edge 66. The vane 54 is secured to a pivot link 68 (pivot link means) which extends through and beyond the microswitch device 52.

As is further shown in FIGS. 3 and 7, the pivot link 68 is pivotally secured to the switch plate 72 by means of floating pivot 74. In other words, the pivot link 68 is secured to the switch plate 72 in such a manner that when the pivot link 68 moves in either a clockwise or counterclockwise sense, such movement will not cause any corresponding movement of switch plate 72.

Thus the pivot link 68 in essence moves independently of the switch plate 72. In a similar way when the switch plate 72 moves, as will be discussed hereinafter, such movement will not cause any movement of the pivot link 68.

The actual connection of the pivot link 68 and the switch plate 72 can be observed in FIG. 8 wherein it can be observed that an elongated stem 76 passes through the pivot

link 68 and then continues to pass through the forward upright 20 with a nut 78 being employed to secure the stem 76 against the upright 20 as shown in FIG. 8. Appropriate spacer members such as the sleeve 80 are employed, and also appropriate washers 82 and 84 are used to allow the relative movement of the pivot link 68 and with respect to the switch plate 72 and vice versa.

As is further shown in FIG. 8, blocks 86 are secured to the switch plate 72 by means of screws 88.

The blocks 86 are spaced from each other to define a passageway 90 through which pivot link 68 passes. Also positioned in the passageway 90 are resilient springs 92 which extend from the opposing inner surfaces of the blocks 86. The springs 92 are also in bearing contact with the pivot link 68 as shown in FIGS. 3 and 7.

Contact points 94 of the microswitch device 52 also extend from the opposing interior surfaces of the blocks 86 with a spring 92 being pressed against a contact 94 by virtue of the resilient pressure of a spring 92 with the pivot link 68 in the manner as shown in FIGS. 3 and 7.

In other words the pivot link 68 snugly passes between the opposed springs 92 or is gripped thereby. This has the effect of forcing the springs 92 against their bias into bearing relationship with the contacts 94. However, the contacts 94 are so set that they will remain open until a somewhat greater force is exerted upon them as when the pivot link pivots upwardly or downwardly. Limit bolts 96 are provided to prevent the pivoting of the pivot link 68 beyond a given point.

It is therefore seen with a change in wind direction or draft the vane 54 will be caused to move upwardly or downwardly in the direction of the arrows 98. This will have the effect of pivoting the pivot link 68 about pivot point 74, either in a clockwise or counterclockwise sense. In either event, the movement of the pivot link 68 will automatically apply added pressure upon one of the springs 92, and in effect press such spring against a given contact 94. This will soon supply sufficient pressure (as determined by the setting of the control) to cause a particular contact 94 to close and send a signal which will turn on the actuator 56.

As shown in FIG. 5, the actuator 56 includes an arm 100 which will thereby be driven in either a clockwise or counterclockwise sense, and this will have the effect of urging rod 102 either forwardly or backwardly as can be observed in FIG. 5. Since the rod 102 is connected at 104 to the plate 64, the movement of the rod 102 will be directly reflected in a corresponding movement of the central plate 64. The central plate 64 is in turn coupled to the two main sections of the forward spray boom 30 by means of bolts 106 which pass through couplers 108.

Hence the actuator 56 and in particular the rod 102 will cause the plate 64 to pivot about a pivot point 110 which is the connection of the support frame 32 to the plate 64. Since the support frames 32 are stationary, and since the top portion of the plate 64 is being moved by actuation of the rod 102, this will give rise to a pivoting action about the pivot point 110.

With the front boom sections 30 directly coupled to the plate 64, the pivoting of the plate 64 in turn causes a corresponding pivoting of the sections comprising the front boom 30. This in turn automatically gives rise to a corresponding pivoting action in the pivot plates 60 that are similarly coupled to the sections of the front boom 30 at the ends thereof. The aforesaid pivoting action of the pivot plate 60 is conveyed through control links 57 backwardly through the pivot plates 62 that are associated with the interior ends of the side booms 28 and 29.

As is shown in greater detail in FIG. 6, the side boom 29 is coupled to the pivot plate 62 through coupler 112 and associated bolts (not shown).

As is further shown in FIG. 6, a collar 114 is provided which encircles upright 20 (see FIG. 2). A connecting rod 116 extends from the collar 114 toward pivot plate 62 with a link 118 actually making a pivotal connection 75 between rod 116 and pivot plate 62.

Thus with the urging of control link 57 in a given direction, this will cause the plate 62 to pivot about pivot point 120 by virtue of the aforesaid connection. It is to be noted that herbicide fluid connections 46 and 48 must also pass through the plates 62 as further shown in FIG. 6. However, the presence of the connections 46 and 48 does not retard the pivoting action of plate 62 because of the presence of flexible hose 44. This actually allows the connections 46 and 48 to pivot along with the plate 62.

It is thus seen that the pivoting action of the front boom 30 gives rise to a corresponding pivoting action in side booms 28 and 29, since pivoting of plates 62 is directly conveyed to side booms 28 and 29. Obviously, more or less booms can be actuated in accordance with the foregoing principles as will be readily apparent to those skilled in the art.

However, it is necessary to stop the aforesaid pivoting action when the booms 28, 29 and 30 have been pivoted to a new position that is generally aligned with the new wind direction or draft which caused the initial movement of the vane 54. This stopping action can be achieved through control rod 58 which extends upwardly from the spray boom 28 and is actually connected to switch plate 72. Particular attention is referred to FIG. 3 which shows lower end 122 of the control rod 58 secured at 124 to a tab 126 which extends from pivot plate 62 that is associated with side spray boom 28.

The upper end 128 of the control rod 58 is secured at 130 to the switch plate 72. It thus can be seen that as the plate 62 is pivoted in a given direction that the control rod 58 will in turn be correspondingly raised or lowered. Since the control rod 58 is directly connected at 130 to the switch plate 72, the raising or lowering of the control rod 58 will result in a corresponding pivoting of switch plate 72 about point 74.

As the switch plate 72 pivots, it will tend to realign the blocks 86 in such a way that the control link 68 will again run in the equidistant manner between the blocks 86. This will have the effect of reducing pressure on a particular contact 94 which had been initially actuated by the movement of vane 54 that was occasioned by a change in wind direction or draft.

It is thus seen that the movement of the control rod 58 is in essence a way of sending a corrective signal to the microswitch device 52, and the movement of the control rod 58 is in essence an accurate reflection of the pivoting of the spray booms 28, 29 and 30. It can be seen that when the switch plate 72 is realigned with respect to the pivot link 68 a point will be reached that the contacts 94 will be opened, and this will stop movement of actuator 56. Spray booms 28, 29 and 30 will therefore remain in their new positions until there is another change in wind or draft which causes a new tilting of the vane 54, and in turn causes new movement of the pivot link 68 to close one of the contacts 94.

The liquid herbicide is contained in saddle tanks 36, and may flow through flexible hoses 38 to the impeller 40 of pumps 42 with the pressurized herbicide then being discharged through flexible hoses 44 into the side spray booms 28 and 29 by means of connections 46 and 48 as best shown in FIG. 4. However, a certain proportion of the herbicide will pass forwardly through line 50 to enter at either one of the outer ends of front spray boom 30.

As is shown in FIG. 2, there is a line 50 entering from each end of the spray boom 30, and this minimizes undesirable pressure drop towards the central portion of the spray boom 30. The aforesaid undesirable pressure drop is also minimized by virtue of the herbicide connections 46 and 48 to the side booms 28 or 29 as shown in greater detail in FIG. 4. The connection 46 essentially comprises a run of pipe 130 with the connection 48 comprising another length of pipe 132 that are joined together at one end by connection 134. Bridging structural links 136 are provided.

It can be seen from the arrows of FIG. 4 that the herbicide liquid enters both of connections 46 and 48 through pipe link 138. The liquid entering connection 48 moves directly toward closely located discharge openings 140 in the pipe 132. The liquid passing through connection 46 runs to the opposite end of the spray boom and then enters the pipe 132 to travel in a direction opposite to the direction of the herbicide flowing directly through connection 48. In this manner, a pressure drop in the herbicide liquid supply is essentially eliminated.

Reference is now made to FIGS. 9 and 10 which relate to the manner of building up a particular spray boom to achieve desired dimensions. As shown in FIG. 9, the spray boom is comprised of a series of spray sections 144. Reference is hereby made to co-pending application Ser. No. 558,539, filed May 31, 1966, entitled "Uniform Sprayer and Method" and in particular to FIGS. 7, 8 and 9 thereof which show the details of a spray head having an internally contained sponge or other absorptive means as well as to the descriptive portions of the specification in connection therewith. Such a spray head is usable in the present invention. As further shown in FIGS. 4 and 9 the spray sections 144 are built up to provide a particular spray boom. Each spray section 144 includes a plastic body 146 having discharge openings 148 as well as a backwardly extending stem 150 with a telescoped spring 152.

As shown in FIG. 4, the stem 150 terminates in a tip 154 that is positioned in an appropriate opening 140 in pipe section 132. Thus the liquid herbicide can travel through an opening in the tip 154 and then through a connecting opening in the stem 150 into the body of the spray head 146 which, as stated previously, is filled with an absorptive material. The liquid herbicide finally is discharged through openings 148.

It will be seen that the stem 150 is preferably integral with the body 146, so that when the tip 154 is pushed toward pipe section 132 the spring 152 will be compressed the spray sections 144 may be built along pipe section 132 to cover the length thereof.

Each spray section 144 will be held in place by means of an individual cover 156 which is essentially U-shaped to include an upper section 158 and a lower section 160 that are integral with each other.

As is shown in further detail, both the upper section 158 and the lower section 160 terminate in opposed lips 162 that may be seated in a corresponding slot in the body 146 of the spray section 144. The actual application of the cover 156 is illustrated in FIG. 9 wherein the lower lip 162 has already been seated in place with the lower section 160 of the cover 156 being brought beneath the particular spray section 144 as well as pipes 130 and 132. Then the upper section 158 of the cover is brought above the pipes 130 and 132 as well as above the spray section 144, and finally the upper lip 162 is seated or snapped in place. In order to permit the final seating or snapping of the upper lip 162, it is a simple matter to press the spray head 144 against the bias of spring 152 to compress the spring and thereby create the necessary clearance.

It is thus seen that there is provided an automatically adjustable airfoil spray system wherein the position of the spray boom can be changed automatically in accordance with changes in wind direction.

The various segments of the spray boom can be built up as desired using the spray sections 144 and covers 156. As shown in FIG. 4, an end plate 170 is also utilized to cap off the modular structure at any desired length of spray boom. The spray sections 144 are preferably in airfoil shape to give additional control of the spray pattern in creating uniform air currents.

Finally, it is to be noted that the pump motor is positioned at an elevation above the level of herbicide liquid in the tanks 36, and in this way it is not necessary to provide liquid seals for the pump motor.

Without further elaboration, the foregoing will so fully illustrate my invention that others may, by applying current or future knowledge, readily adapt the same for use under various conditions of service.

What is claimed as the invention is:

1. An automatically adjustable spray system comprising at least one spray boom having discharge openings, and means to deliver liquid to said spray boom, said spray boom being moveable by actuating means, air direction detecting means sensitive to changes in wind direction and drafts which give rise to a new wind direction, said air direction detecting means being adapted to turn on microswitch means in response to changes in wind direction, said microswitch means thereby turning on said actuating means to drive said spray boom in a corrective action to align said spray boom in accordance with the new wind direction, and control rod means associated with said microswitch means and said spray boom to turn off said microswitch means when said spray boom has been substantially aligned with said new wind direction.

2. The invention of claim 1 wherein said spray boom is pivotable about a horizontal axis.

3. The invention of claim 2 including a front spray boom and two side spray booms, said front spray boom being driven by said actuating means and mechanical control links connecting said front spray boom and side spray booms whereby the pivoting of said front spray boom is conveyed to said side spray booms.

4. The invention of claim 1 wherein said spray boom 30 is in airfoil form.

5. The invention of claim 1 wherein said air direction detecting means is a vane which extends from a pivot link that is moveably attached to a switch plate which carries the contact points of said microswitch means with said pivot link being moveable independently of said switch plate and said switch plate being moveable independently of said pivot link.

6. The invention of claim 5 wherein said pivot link extends through and beyond said microswitch means with said vane projecting from a free end of said pivot link,

whereby in the event of a change in wind direction, movement of said vane also causes movement of said pivot link to apply sufficient pressure to said contact points thereby turning on said microswitch means and in turn turning on said actuating means.

7. The invention of claim 6 wherein said control rod means are moved in accordance with movement of said spray boom with said control rod means being attached to said switch plate whereby movement of said spray boom urges said control rod means to move said switch plate and thereby relieve the pressure exerted by said pivot link against at least one of said contact points to the extent necessary to turn off said microswitch means when said spray boom has been substantially aligned with said new wind direction.

8. A spray boom comprising a length of pipe having a plurality of spaced openings, and spray sections adapted to be individually received in said openings, said spray sections each including a body having discharge openings and a stem terminating in a tip that is received in one of the pipe openings, said stem and said tip having a continuous internal bore to permit liquid to pass from said pipe and into said body and thereafter be sprayed through said discharge openings, a spring telescoped about said stem and a cover for each of said spray sections, said cover including opposed lips that are seated in corresponding slots in said body.

9. The invention of claim 8 wherein said spray section is in airfoil form and is made of plastic and said cover is also in airfoil form and is made of metal.

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