Nov. 12, 1968 J. E. WALDRUM 3,410,489

AUTOMATICALLY ADJUSTABLE AIRFOIL SPRAY SYSTEM WITH PUMP

Filed Jan. 5, 1967 5 Sheets-Sheet 1

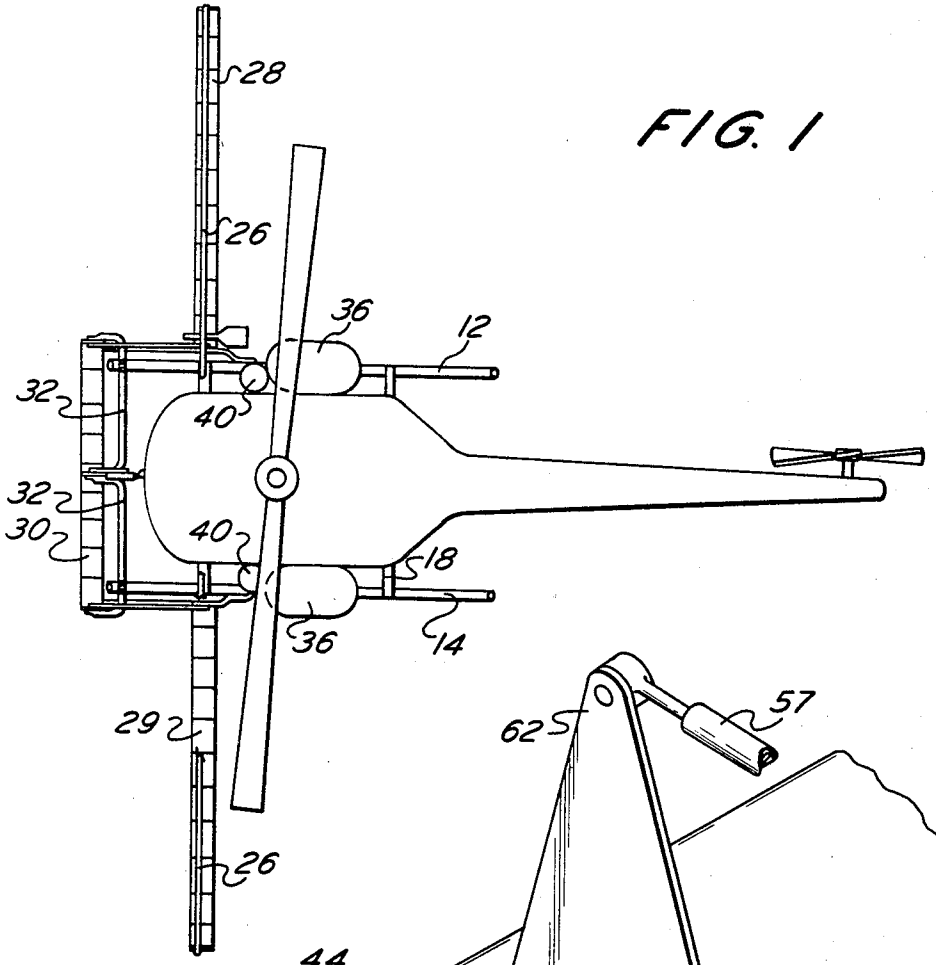

FIG. 1

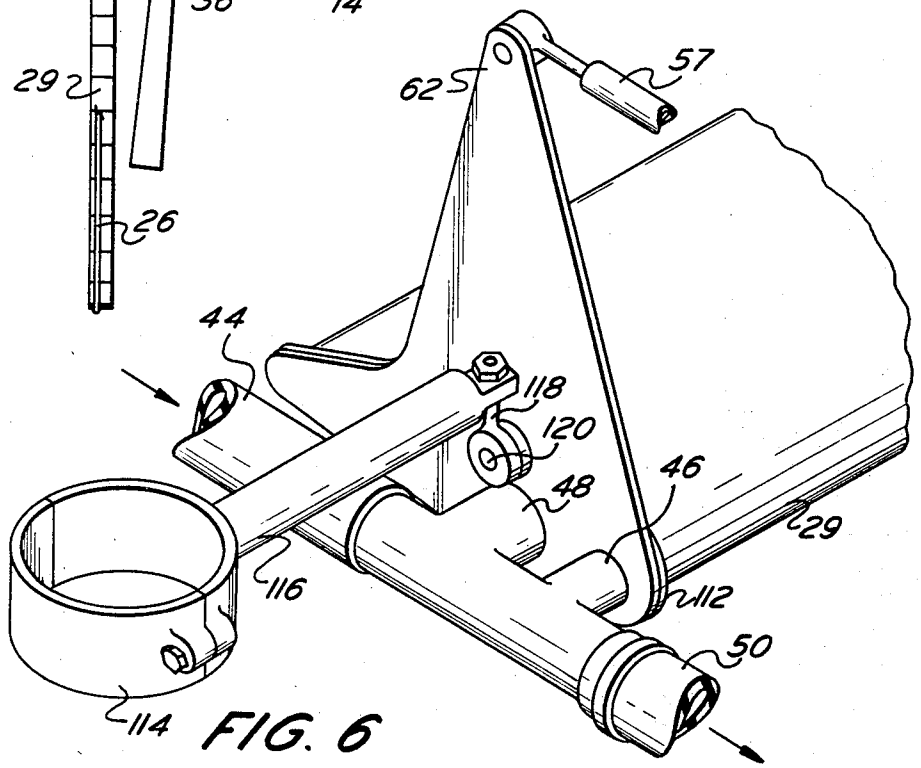

FIG. 6

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AUTOMATICALLY ADJUSTABLE AIRFOIL SPRAY SYSTEM WITH PUMP

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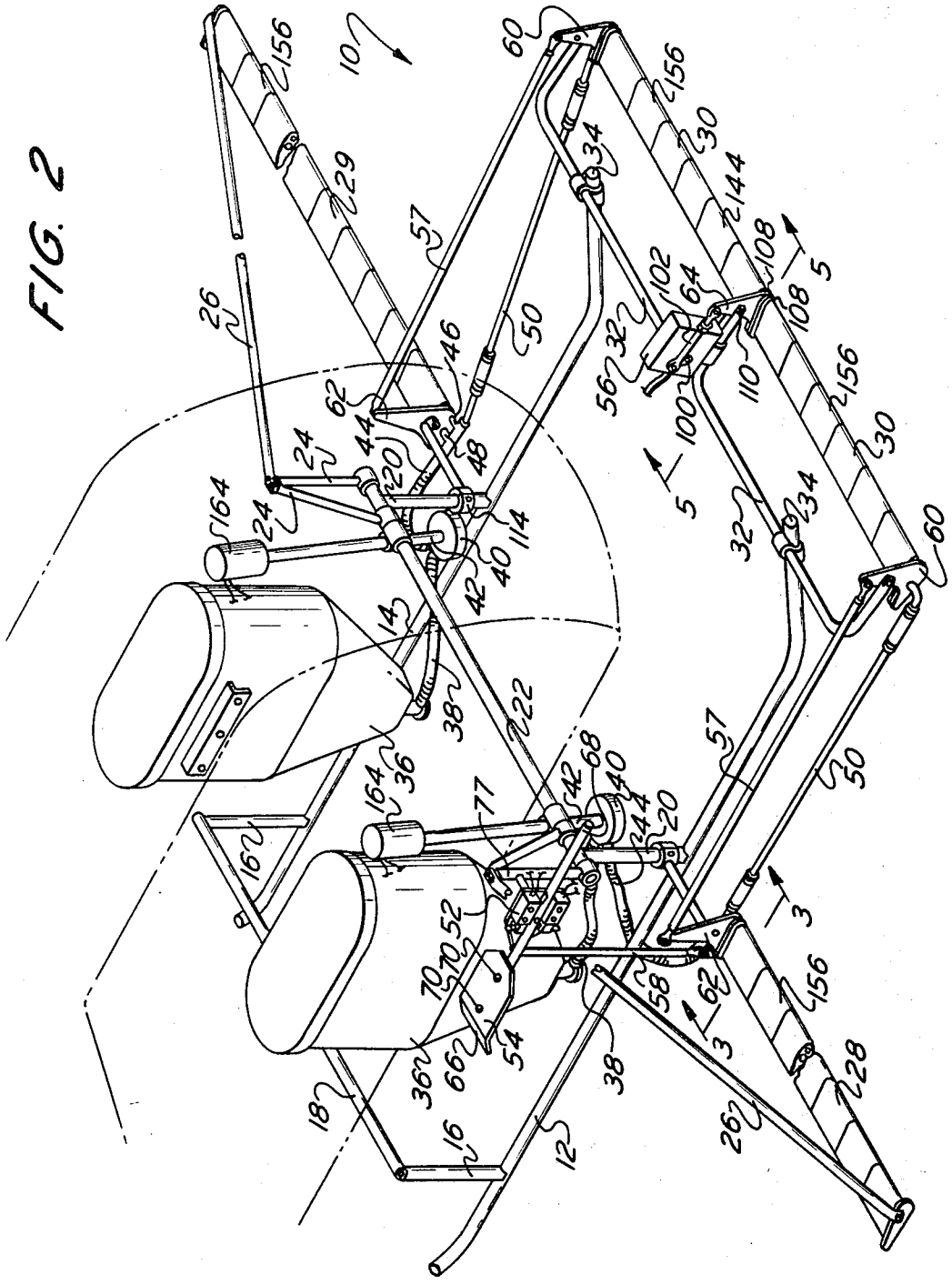
FIG. 2



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AUTOMATICALLY ADJUSTABLE AIRFOIL SPRAY SYSTEM WITH PUMP

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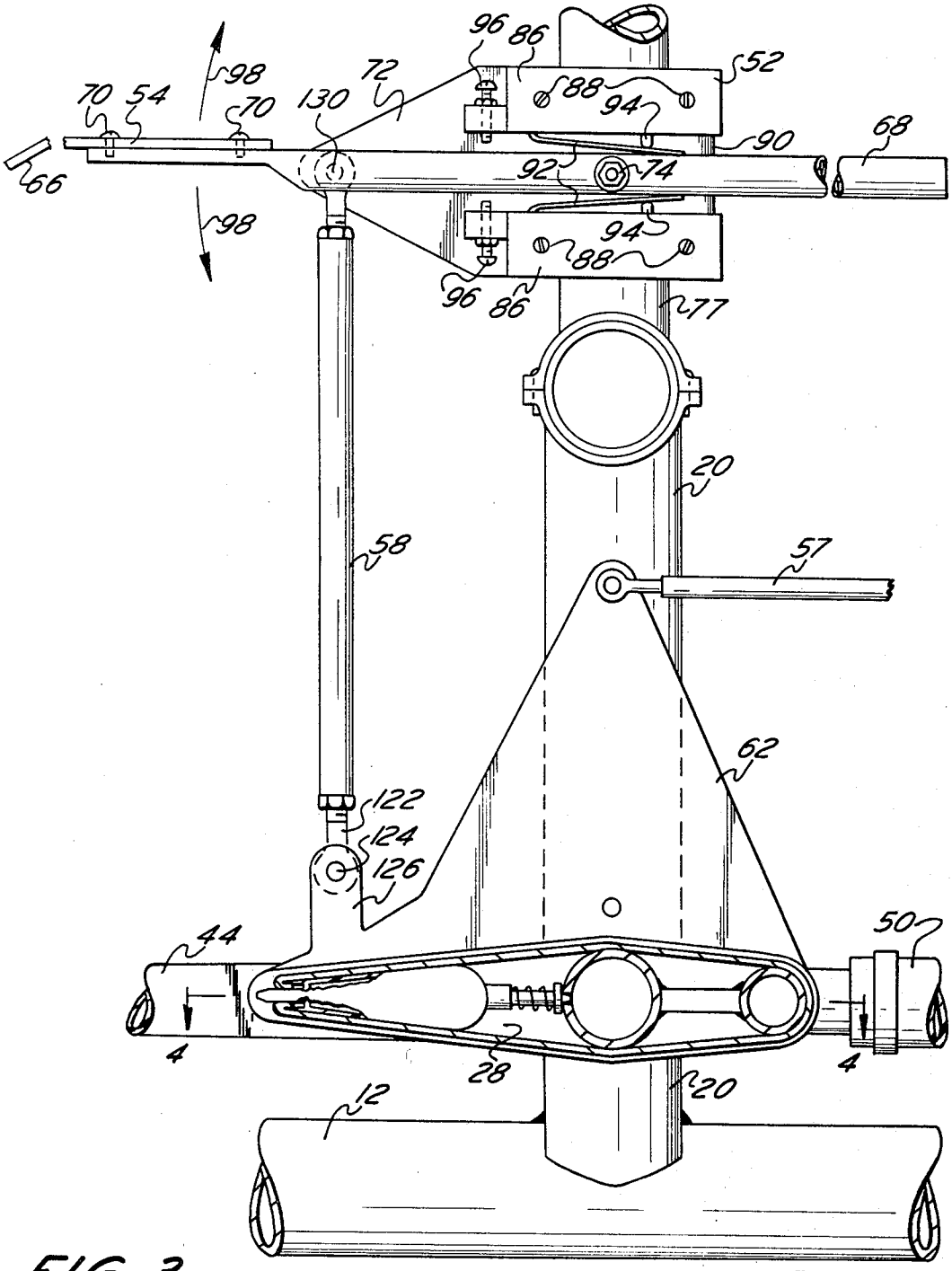

FIG. 3

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AUTOMATICALLY ADJUSTABLE AIRFOIL SPRAY SYSTEM WITH PUMP

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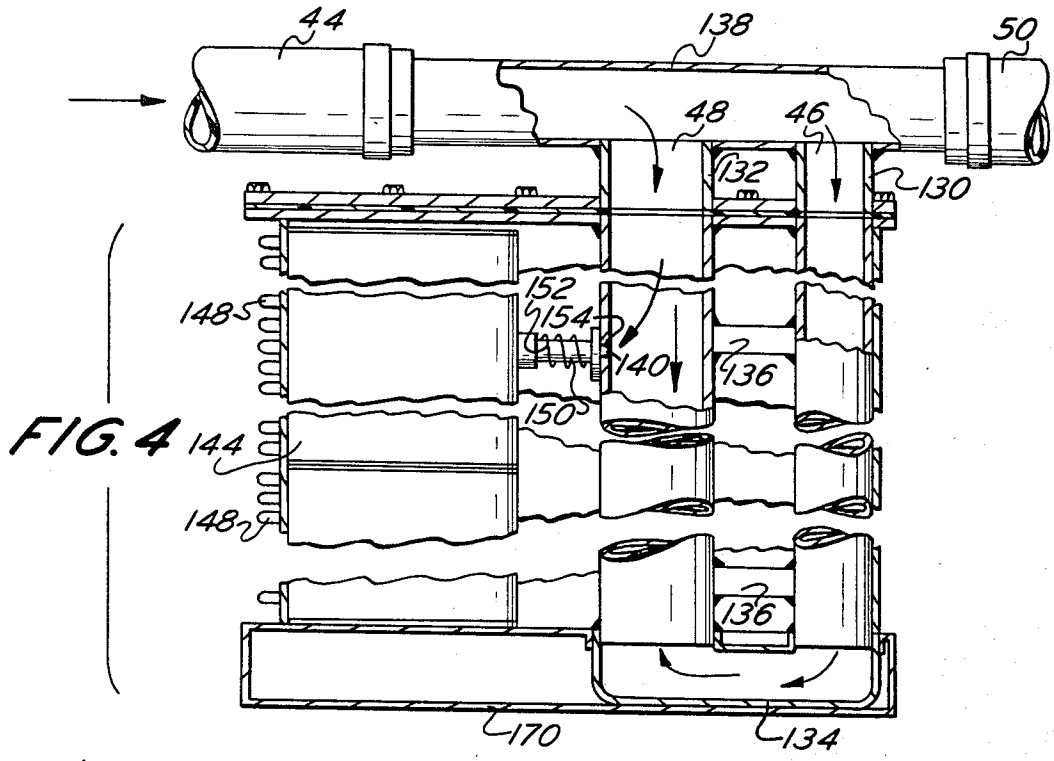

FIG. 4

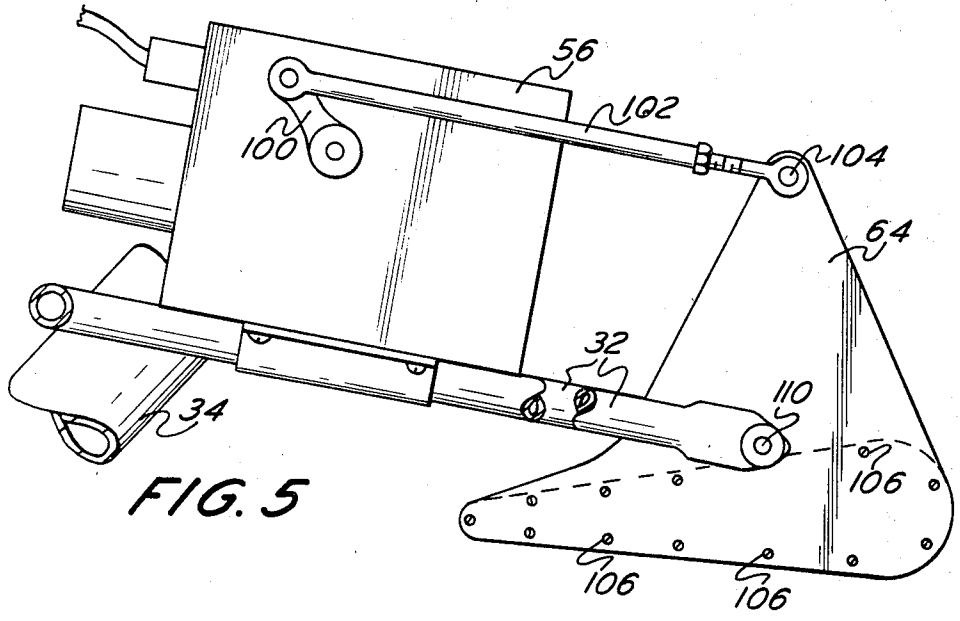

FIG. 5

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AUTOMATICALLY ADJUSTABLE AIRFOIL SPRAY SYSTEM WITH PUMP

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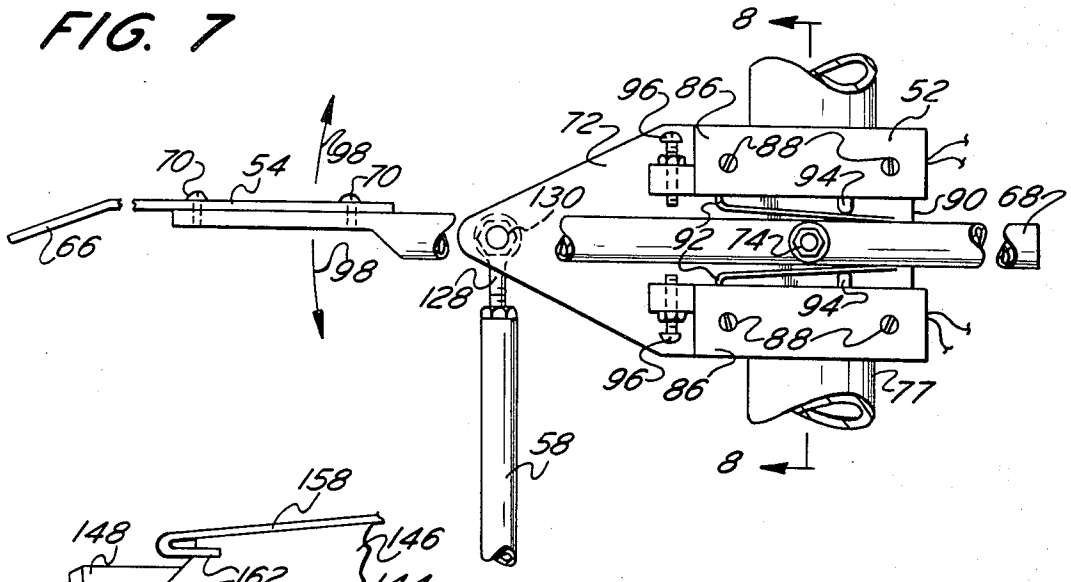
FIG. 7



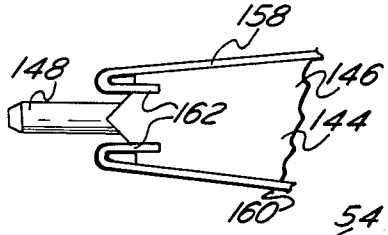


FIG. 10

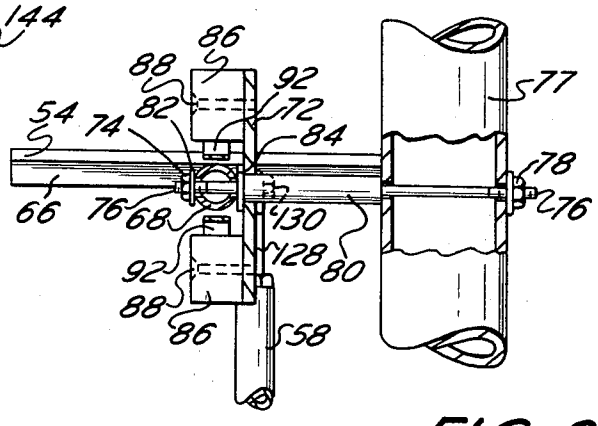


FIG. 8

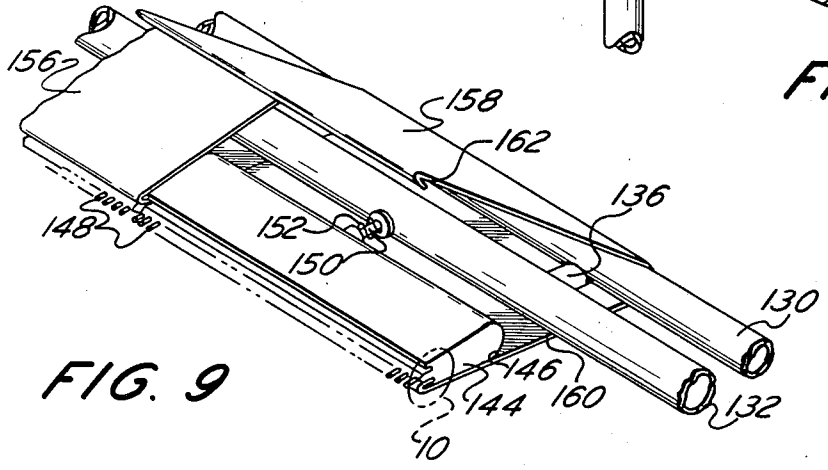


FIG. 9

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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 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 aobut 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 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 presure 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 **154** 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 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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EVERETT W. KIRBY, *Primary Examiner.*