United States Patent

Johnston

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[54] **FLOW CONTROL ASSEMBLY AND METHOD**

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[52] **U.S. Cl.**.....**239/62**, 137/51, 222/177, 239/156, 251/282

[51] **Int. Cl.**.....**B05b 3/16**

[58] **Field of Search**.....239/61, 62, 93, 155, 156, 157, 239/158, 11; 137/51, 57, 87; 111/6, 7; 222/177; 251/282

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Assistant Examiner—Michael Y. Mar
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[57] **ABSTRACT**

The present control structure is a centrifugal governor operated relatively low pressure diaphragm valve for a wheeled liquid applicator including a tank for liquid under applied air pressure, the governor being driven from a ground wheel of the applicator by a friction wheel-flexible cable drive, or a belt and pulley drive, or the like. This structure controls the applicator nozzle pressure so that the output, in gallons per minute, is proportioned to the speed, thereby providing a constant gallons per acre output, regardless of the speed. An adjustable drive assembly including a friction wheel-cone provides means for varying the rate of fluid output.

8 Claims, 13 Drawing Figures

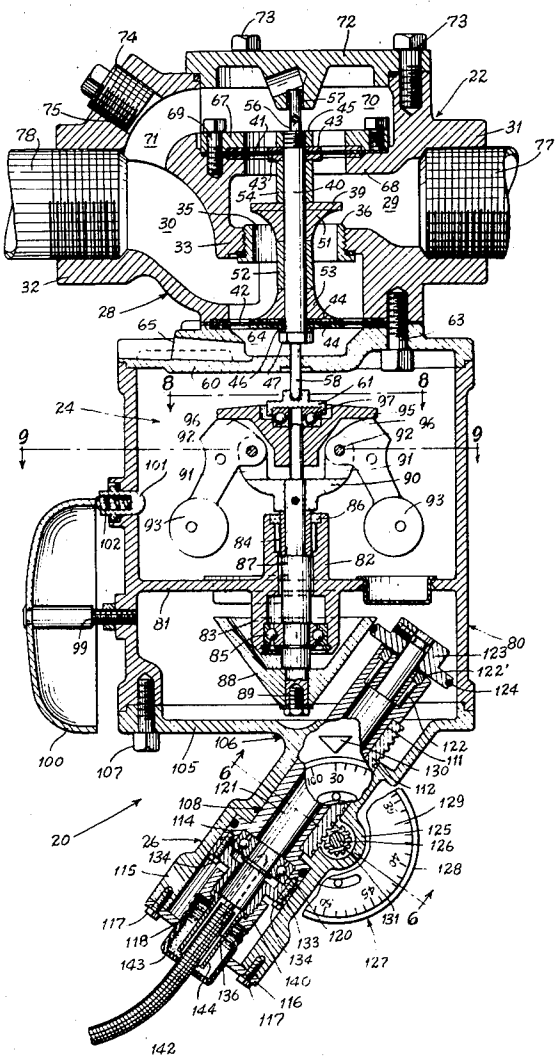
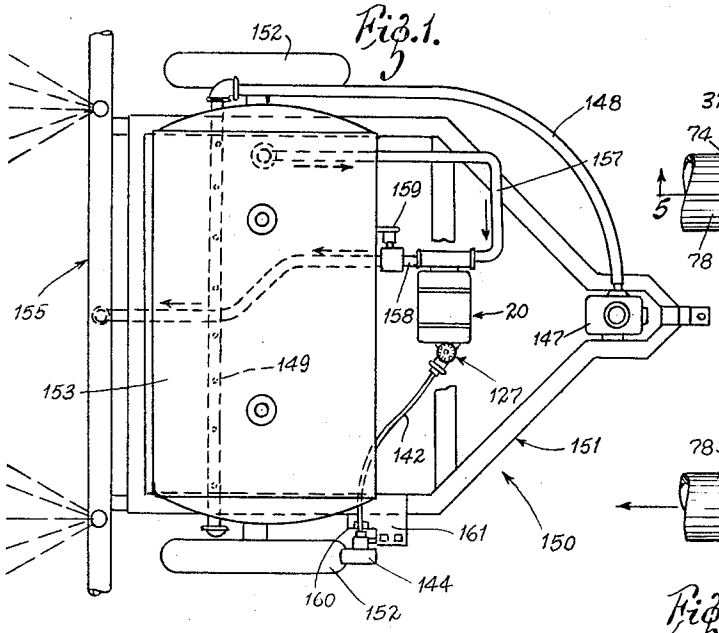


Fig. 1.



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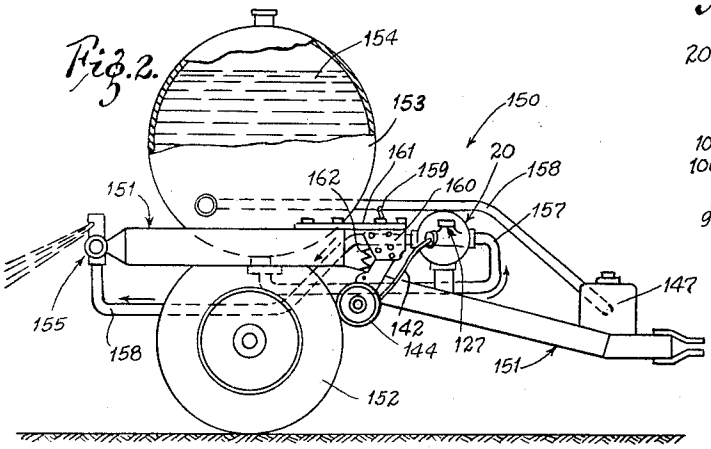

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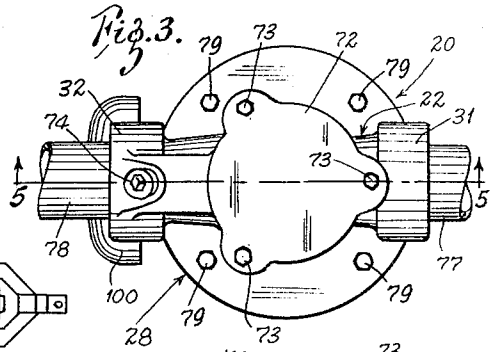

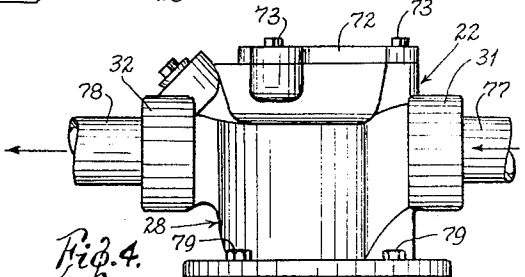

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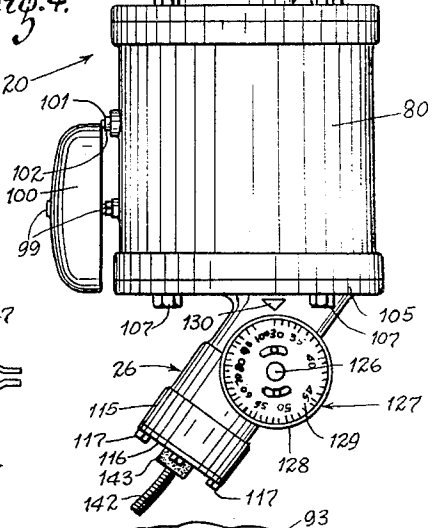

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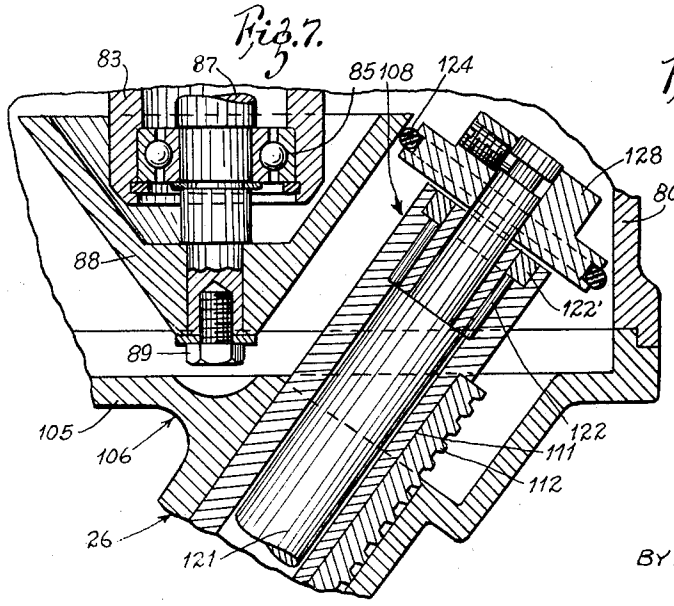

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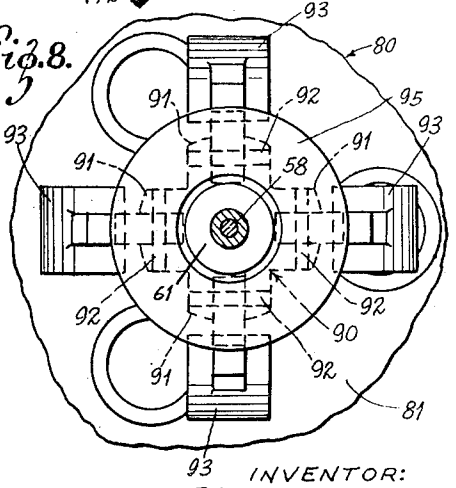

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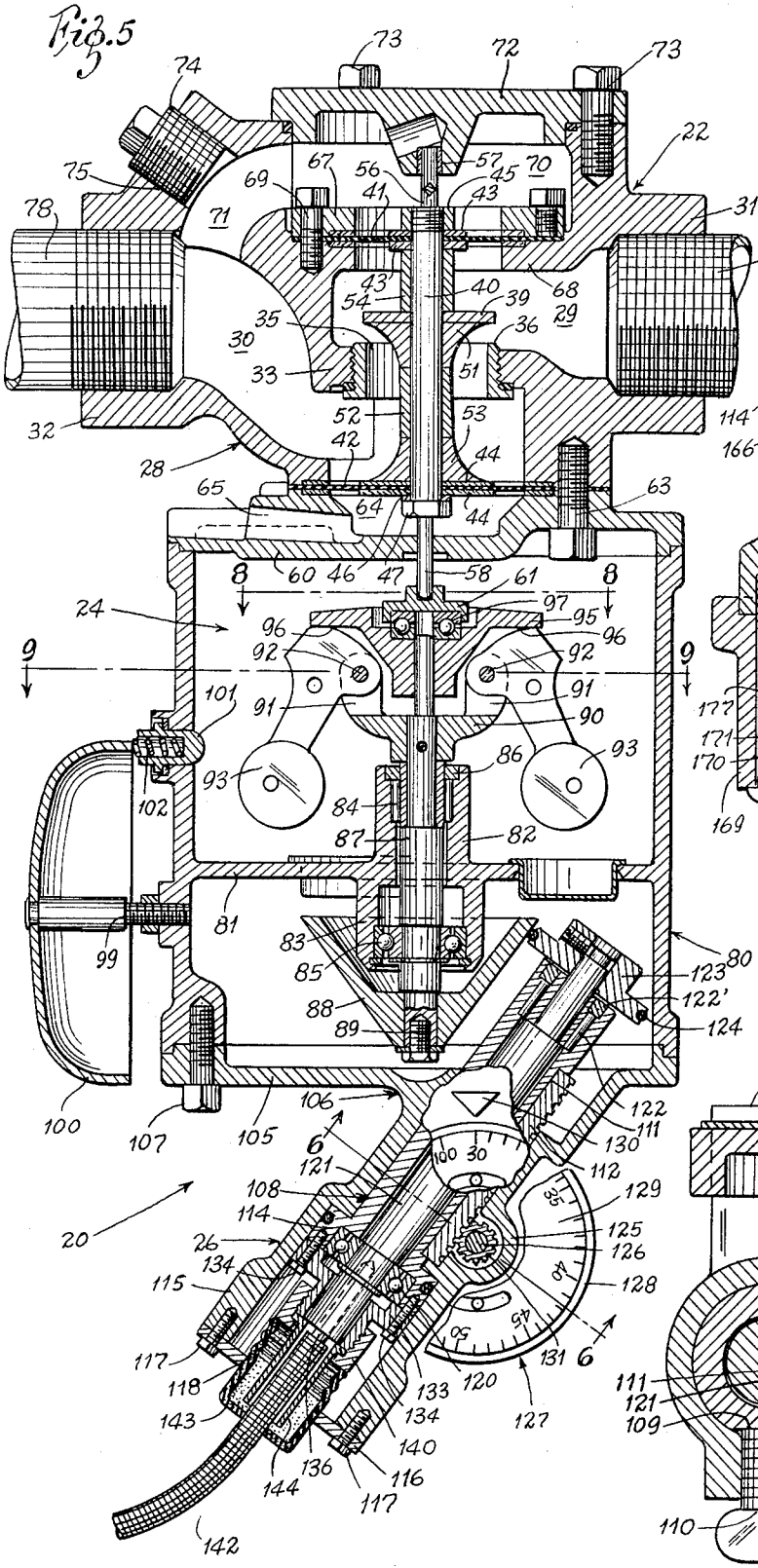
Fig. 5



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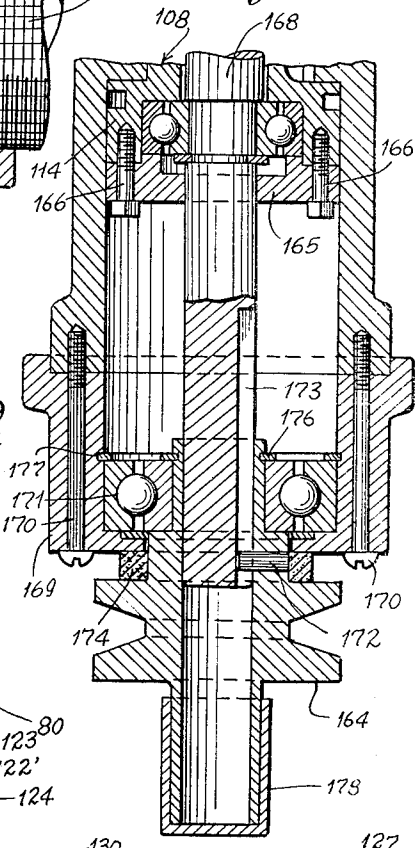

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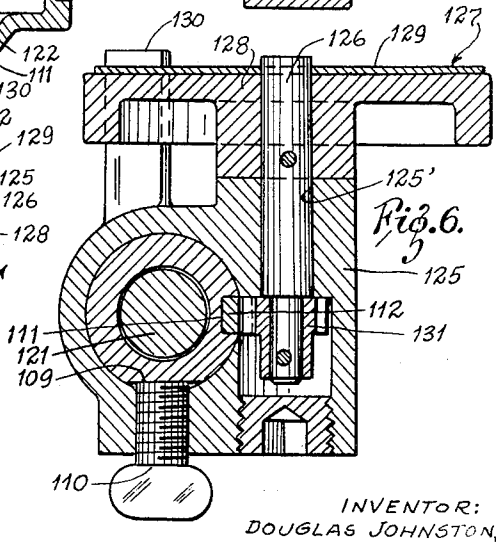

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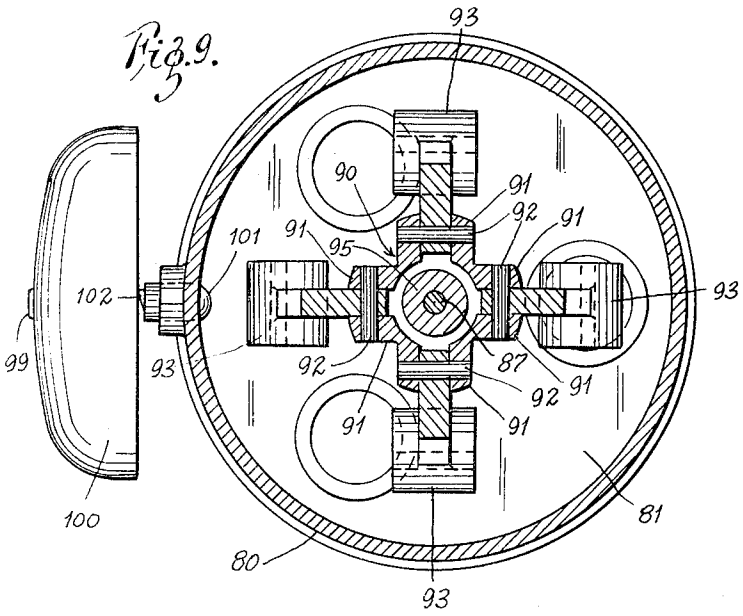
Fig. 9.



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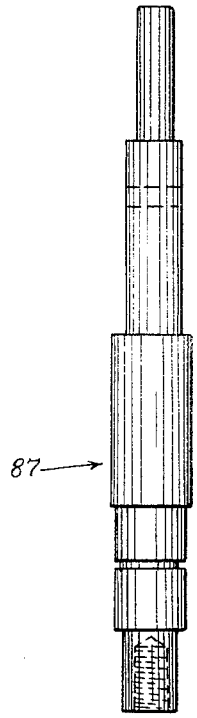

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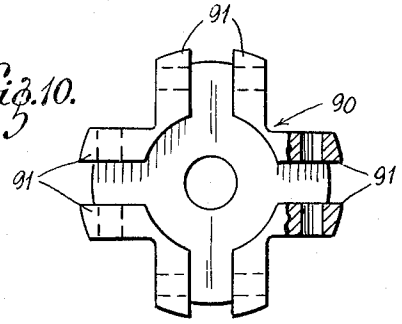
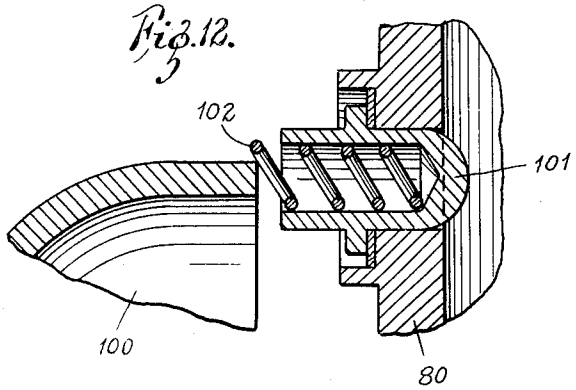


Fig. 12.



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FLOW CONTROL ASSEMBLY AND METHOD

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to flow control, and more particularly to a novel flow control assembly for and a novel method of controlling the fluid pressure on nozzles or orifices in an applicator so that the output rate of the applicator per acre remains constant, regardless of the ground speed of the applicator.

The present invention, preferably a ground wheel actuated pressure control, but adaptable to power take-off, is especially suited for the application of all types of agricultural chemicals such as nitrogen fertilizer solutions, mixed liquid fertilizer solutions, aqua ammonia, suspension fertilizers, slurry fertilizers, herbicides, insecticides, fungicides, fumigants, and others.

It is also well suited for controlling the rate of application of water or any other type of liquid where it is desirable to have a constant rate per increment of forward travel regardless of the speed of the vehicle. As an example, the application of water, oil, and tar in highway construction could be applied from a tank on a truck at a preselected and fixed rate per foot of highway, regardless of the speed of the truck.

2. Description of the Prior Art

This invention provides the first practical means of applying suspension and slurry type fertilizers at a constant rate per acre, regardless of speed. By such means an operator with a trailer-type or a truck-type applicator will be able to cover twenty percent to forty percent more acreage per day than with a machine that would have to be driven at a constant speed, selected on the basis of the maximum speed practical in the roughest and wettest part of the field.

While it is theoretically possible to operate an applicator at a constant speed to get a continuously accurate output rate per acre, certain practical limitations make this all but impossible. Operators frequently encounter unforeseen conditions that make speed reduction mandatory, and safe operation of the machine and sound judgment require gradually slowing the machine down at the end of the rows, unless the farmer takes out of cultivation enough land to provide a slowing down corridor at the end of the rows on all of his fields.

A nationally recognized authority in the development and application of suspension fertilizers has publicly stated that the advantages of using suspension-type fertilizers are well recognized, but that the potential increase in use of these fertilizers, has been held back due to the limitations of present day application equipment. This authority was referring particularly to the fact that no system presently available provides a means of controlling output proportional to speed. He stated that the necessity for slowing down constant pressure applicators has in many cases so badly over-fertilized certain crops that the plants were either destroyed or stunted, causing the loss of not only the fertilizer, but part of the farmer's crop. The present flow control assembly solves many of the problems now encountered in the application of suspension-type fertilizers.

At present, non-pressure or low pressure liquid fertilizer solutions are applied by means of ground wheel driven positive displacement, variable stroke metering pumps, by centrifugal pump metering systems, and by air pressure systems in which an air compressor maintains a constant air pressure over the liquid in the tank, requiring a fixed and predetermined constant speed for accurate application.

Suspension-type fertilizers contain suspended crystals, sand, and various other types of abrasive and crystalline substances that tend to settle out and solidify during transport and application. The abrasive particles rapidly score cylinders and ruin valves and piston pumps, while in many cases only short periods of time allow sufficient settling out to fill suction lines and strainers and piping to such an extent that centrifugal pumps frequently loose their prime and stop pumping due to the heavy suction load.

The nature of a centrifugal pump is such that relatively minor restrictions in the suction line may cause them to lose their prime completely, and in this condition they will only apply a negligible suction to clean out the line. Self priming pumps cannot be used, because of the settling out and solidification of crystals and trash in the priming cavity.

While an unprimed centrifugal pump might be able to apply a suction equivalent to only two or three inches water pressure to a clogged-up suction line, a pressure of thirty pounds of air over the material will quickly force the sludge out of the line, and if the air is admitted through a tube running the length of the tank near the bottom, it will continuously and vigorously agitate the material by means of holes drilled along the length of the pipe, known as a sparging tube. It is for these reasons that air pressure is now being recognized as the most practical method of application for suspension-type fertilizers.

This invention provides the only known practical means of accurately metering suspension fertilizers at a rate independent of speed with air pressure applicators, and is equally satisfactory for metering any other type of liquid, whether the pressure over the liquid be supplied by air or whether the pressure to the control assembly be supplied by a pump.

SUMMARY OF THE INVENTION

In brief, the present novel flow control assembly comprises a valve assembly including a valve for controlling the flow of liquid from a tank, or the like, to discharge orifices or nozzles on an applicator, an operatively associated centrifugal governor assembly for positioning said valve which is designed so that at a given speed of an applicator the force developed thereby is constant, and an adjustable drive assembly for rotating said governor assembly in proportion to the ground speed of the applicator, so that the output rate of the applicator per acre remains constant, regardless of the ground speed of the applicator.

Hence, an object of the present invention is to provide a novel flow control assembly for and a method of dispensing liquid fertilizers and the like which fulfill the long existing need in the liquid fertilizer art; which accurately meters such liquids so that substantially the same amount is applied per selected ground increment regardless of the operating speed of the applicator; which is rugged in construction and adapted to perform the intended purpose in the dispensing of large gallonages; which are particularly effective in thus dispensing such agricultural chemicals as nitrogen fertilizer solutions, mixed liquid fertilizer solutions, suspension fertilizers, slurry fertilizers, herbicides, insecticides, fungicides, and others; and which are otherwise adapted to fulfill the objects and advantages sought, the foregoing and other objects and advantages being apparent from the description and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic plan view of a simple two-wheeled applicator, showing the present novel flow control assembly operatively mounted thereon;

FIG. 2 is a side elevational view thereof;

FIG. 3 is an end elevational view of the present novel flow control assembly;

FIG. 4 is a plan view thereof;

FIG. 5 is an enlarged horizontal cross-sectional view taken on substantially the line 5—5 of FIG. 3;

FIG. 6 is a further enlarged vertical cross-sectional view taken on substantially the line 6—6 of FIG. 5;

FIG. 7 is a further enlarged fragmentary view of a portion of FIG. 5 showing the friction wheel-cone and its drive pulley;

FIG. 8 is a vertical transverse cross-sectional view taken on substantially the line 8—8 of FIG. 5;

FIG. 9 is a vertical transverse cross-sectional view taken on substantially the line 9-9 of FIG. 5;

FIG. 10 is a plan view of the spider, parts being broken away for illustration of details, which pivotably supports the governor weights;

FIG. 11 is a plan view of the governor spindle;

FIG. 12 is a further enlarged fragmentary view of a portion of FIG. 5 showing the warning bell striker; and

FIG. 13 is a further enlarged cross-sectional view illustrating an alternate structure for powering the governor assembly.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings more particularly by reference numerals, the present novel flow control assembly is designated generally by the reference numeral **20**, which broadly includes a valve assembly **22** for controlling the flow of liquid from a tank or other source of supply to discharge orifices or nozzles on an applicator, a centrifugal governor assembly **24**, and an adjustable drive assembly **26** for rotating the centrifugal governor assembly **24** (FIG. **5**).

The valve assembly **22** includes a casing **28** having an inlet chamber **29** and outlet chamber **30** (FIG. **5**). A threaded inlet **31** is provided for the inlet chamber **29** and a threaded outlet **32** for the outlet chamber **30**. A partition wall **33** separates the inlet and inlet chambers **29** and **30** in which is formed an opening threadedly receiving an annular valve seat element **35** having a valve seat **36** at one end and a flange **37** at the other end sealingly engaging a gasket **38**. An outlet valve **39** is mounted on a diaphragm stem or spindle **40** for movement therewith and for cooperation with the valve seat **36**. The stem **40** extends between and through a balance diaphragm **41** at one end and a main diaphragm **42** at the other end, washers **43** engaging the two sides of the former and washers **44** engaging the two sides of the latter. A nut **45** engages the outer washer **43** and an adjustment shim **46**, and integral bolt flange **47** engages the outer washer **44**. The valve **39** is positioned on the stem **40** by means of a first cone **51**, a cone spacer **52**, and a second cone **53** on one side, and a valve spacer **54** on the other side. None, or more than one, shim **46** may be used, as required. An outer reduced end **56** of the stem **40** has sliding support in a bushing **57** and an inner reduced end **58** has sliding support in an end plate **60** and is engaged by a thrust cap **61** forming part of the centrifugal governor assembly **24**.

The main diaphragm **42** is clamped between the plate **60** and one side of the casing **28** by bolts **63**, there being a chamber **64** between diaphragm **42** and plate **60** exhausted to atmosphere by a passage **65**. The passage **65** also serves as a drip exit for any liquid that may leak past the diaphragm **42** which warns a user of a leak. The balance diaphragm **41** is clamped between a ring **67** and an inner wall **68** of the casing **28** by bolts **69**. A chamber **70** is thus provided which leads into the outlet chamber **30** by a passage **71**.

A closure plate **72** forms a wall of the chamber **70**, being secured to the casing **28** by bolts **73**. The plate **72** supports the bushing **57**, as shown in FIG. **5**. A threaded plug **74** closes a testing outlet **75**. Inlet and outlet hose line fittings **77** and **78**, respectively, are shown threaded into the inlet **31** and outlet **32**.

The centrifugal governor assembly **24** is operatively mounted in a housing **80** of cylindrical form, one end of which is closed by the plate **60** which is secured thereto by bolts **79** (FIG. **4**). Within the housing **80** is a partition wall **81**, integral with which are oppositely extending concentric bearing sleeves **82** and **83**, respectively, supporting a needle bearing unit **84** and a sealed ball bearing unit **85**. A grease seal **86** is provided for the needle bearing unit **84**. A governor spindle **87** of varying cross section, FIGS. **5** and **11**, is rotatably supported by the bearing units **84** and **85**. On the one end of the spindle **87** is secured a friction wheel-cone **88** by a bolt **89**, which is an element of the drive assembly **26**. On the other side of the wall **81** from the wheel-cone **88** and pinned to the spindle **87** is a governor spider **90** having four pairs of equally spaced arms **91**, each pair having aligned openings receiving a pin **92** on which is pivotally mounted a governor weight **93**. Freely rotatably mounted on the other end of the spindle **87** is a cam plate follower **95** which is in engagement with cam portions **96** of the weights **93**. Adjacent the cam plate follower **95** is a thrust bearing unit **97** which, in turn, is contiguous to the thrust cap **61**.

Mounted on the outside of the housing **80** by a threaded post **99** is a warning bell **100**. A bell striker or clapper **101** is reciprocably mounted in the wall of the housing **80** and is biased inwardly by a spring **102** into position out of contact with the edge of the bell **100**, as shown in FIG. **5**. When weights **93** swing too far outwardly, as on too great a speed of the applicator, they strike the bell striker **101** which, in turn, hits the bell **100** to warn the operator. Closing three openings in the wall **81** formed in casting the housing **80** are plastic sealing cups **104** which are employed to prevent grease or oil from the governor assembly **24** from leaking to the friction wheel-cone **88**.

The adjustable drive assembly **26** includes an oddly shaped housing **106** of the configuration shown in FIGS. **5–7**, which includes an end plate portion **105** closing the housing **80**, being secured thereto by spaced bolts **107**. Slidably mounted in the housing **106** is a spindle housing **108** having a flat side **109** (FIG. **6**) against which a thumb screw **110** releasably engages, and an axially extending groove **111** in which is disposed a rack **112**. The spindle housing **108** also includes an enlarged end portion **114** disposed in an enlarged end portion **115** of the housing **106**, said enlarged portions **114** and **115** having engageable annular shoulders limiting movement of the spindle housing **108** inwardly to the position of FIG. **5**. An end plate **116** secured to the housing **106** by bolts **117** limits movement of the spindle housing **108** in the opposite direction. The plate **116** has a large central opening **118** for a purpose described below. Mounted in the enlarged end portion **114** is a sealed ball bearing unit **120** which rotatably receives a segment of reduced diameter of a powered cable spindle **121**, thus also maintaining the spindle **121** against axial movement in respect to the spindle housing **108**. At the inner end of the spindle **121** is a supporting needle bearing unit **122** protected by a grease seal **122'**. Secured to the inner end of the spindle **121** against movement is a drive pulley **123** having an "O" ring tire **124** of rubber composition or other suitable material, which is in driving engagement with the wheel-cone **88**. At one side of the housing **106** is a boss **125** having a bore **125'** into which extends a post **126** (FIG. **6**). A calibrated dial **127** is provided which includes a disc member **128** pinned to the upper end of the post **126** and a calibrated disc plate **129** adjustably mounted thereon. A pointer **130** is disposed adjacent the dial **127**. Pinned to the post **126** at its lower end and in an enlargement of the bore **125'** is a pinion **131** which meshes with the rack **112**. It will be understood that the thumb screw **110** is loosened to permit adjustment of the position of the spindle housing **108**, hence, of the drive pulley **123** in respect to the driven wheel-cone **88**, by rotation of the calibrated dial **127** to a selected position. The thumb screw **110** is then re-secured.

A cable cap **133** is secured in the outer enlarged end **114** of the spindle housing **108** by screws **134**. A cable wire **136** with a square end extends into a square hole in the outer end of the cable spindle **121**. A fitting **140** threadedly engages the cap **133** and maintains a sleeve **141** is position extending through the opening **118** in the end plate **116**. The sleeve **141** guides the cable wire cover **142** in axial movement of the spindle housing **108**. The cable wire **136** and cover **142** are connected to a conventional friction speed sensor wheel **144** (FIGS. **1** & **2**). A rubber, or the like, bellows **143** engages the cover **142** and extends through the opening **116**, as shown, to protect the working parts from water, dirt and other foreign matter. The speed sensor wheel **144** preferably rides on the ground engaging portion of applicator wheels, or the like, but may be mounted to run against the side of a tire or wheel, if, for example, cleats or mud interfere.

FIGS. **1** and **2**, the present novel flow control assembly **20** is diagrammatically illustrated operatively mounted on a small two wheel applicator **150** which includes a frame or chassis **151**, wheels **152**, a tank **153** for liquid fertilizer **154**, and the like, under pressure in the tank **153**, a spray boom assembly **155**, a conduit **157** connecting the bottom of the tank with the flow control assembly **20**, and a conduit **158** connecting the flow control assembly **20** with the spray boom assembly **155**.

A power take-off driven air compressor **147** is mounted at the front of the chassis **151** which is connected into the tank **153** by a fluid line **148** and sparging tube **149**. It will be understood that a safety relief valve and pressure regulator (not shown) are used in the line **148**. A centrifugal pump may be used instead of the compressor **147**. The speed sensor wheel **144** is mounted on the frame **151** is depending pivotal relation by a bracket unit **160** and a plate **161**. A tension spring **162** biases the wheel **144** against the wheel **152** with several pounds force.

A rope operated cut-off ratchet valve **159** is located in the conduit **158**, as indicated in FIGS. **1** and **2**, between the outlet of the flow control assembly **20** and the boom assembly **155**. When the valve **159** is closed, tank pressure acts on the main diaphragm **42** to close the valve **39** and to push the governor weights **93** to the center. This prevents the governor weights **93** from swinging out and ringing the bell **100** at the end of a row in turning around or in travel.

In FIG. **13** a pulley **164** is illustrated as a modified structure for transferring rotation of the wheels **152** to the drive assembly **26**. The pulley **164** may be driven in the manner of the pulley **54** shown in FIGS. **1** and **2** of the applicant's U.S. Pat. No. 3,409,033. A cap **165** is secured by screws **166** to the outer enlarged end **114** of the spindle housing **108**. A pulley spindle **168** replaces the cable spindle **121**, the former being longer than the latter and receiving the pulley **164** on the outer end thereof. A sleeve member **169** is secured to the enlarged end portion **115** of the housing **106** by screws **170**. A ball bearing unit **171** is mounted in the sleeve member **169** and receives the spindle **168**, as shown. The pulley **164** is secured to the spindle **168** against relative annular movement, but permitting relative axial movement by a spring pin **172** and axial slot **173**. A felt ring **174** protects the parts from dust and dirt. Thus, the spindle **168** may be adjusted in and out as the dial setting is changed, but pulley **164** is held in a fixed position by the ball bearing unit **171** and snap rings **176** and **177**. A plastic or rubber dust cap **178** to keep water and dust from damaging steel parts is provided.

OPERATION

It is clear from the foregoing taken with the drawings that the drive pulley **144**, which turns a fixed and definite number of revolutions per revolution of the applicator wheel **152**, drives the wheel-cone **88**. The relative speed or number of revolutions per minute of the wheel-cone **88** obviously depends upon its radius at the point where it is contacted by the driven pulley **123**.

For the position in which the drive pulley **123** is shown in FIG. **5**, the dial pointer **130** points to 30 on the dial **127**. This is the slowest relative speed at which point the wheel-cone **88** turns 0.667 revolutions per turn of the drive pulley **123**. Assuming the dial **127** has been freed by loosening the thumb screw **110** and rotated to the left until the numeral **30** is opposite the pointer **130** and tightened, rotation of the dial **127** counterclockwise from 30 to 35, etc., to **100**, will bring the drive pulley **123** in a position to drive the wheel-cone **88** at its highest speed, which is 2.28 revolutions per revolution of the drive pulley **123**.

With these proportions, if one assigns a dial value of 100 to the maximum speed of the wheel-cone **88** in relation to the drive pulley **123**, at which position the former turns 2.28 revolution per revolution of the latter, then at the large diameter of the wheel-cone **88**, at which position it turns 0.667 revolutions per revolution of the drive pulley **123**, the slow speed of the wheel-cone **88** is 29.3 percent of its maximum speed. Rather than calibrate the dial **127** in fractions, it is calibrated from 30 to 100 and the calibrations represent the relative speed of the wheel-cone **88** in relation to the speed of the drive pulley **123**.

As the spindle **87** and spider **90** are rotated as the wheel-cone **88** is rotated, the centrifugal force swings out the weights **93** causing cam surfaces **96** to rotate about pins **92** and apply a force to the cam follower **95**, which, in turn, through thrust bearing unit **97** and thrust cap **61** applies a force to the diaphragm spindle **40** which tends to lift the valve **39** off the seat **36** to allow the fluid to flow from the inlet chamber **29**, which is approximately at tank pressure, to the outlet chamber **30**, which communicates through a hose **158** to the nozzles on the boom assembly **155**, the entrance pressure of which is approximately equal to that in outlet chamber **30**.

Assuming that the control assembly **20** is at rest with the valve **39** closed on the seat **36** with tank pressure of about 30 pounds per square inch in the inlet chamber **29**, and with the outlet chamber **30** at atmospheric pressure, having been drained through said nozzles or orifices, the force of the governor assembly **24** on the diaphragm **42** would have to be about 53 pounds to being lifting the valve **39** off the seat **36**. This is because in a preferred embodiment the area of the valve **39** (1½ inches diameter) is 1.77 square inches, which multiplied by thirty pounds per square inch would give a total force of 53 pounds.

However, the balance diaphragm **41** and its washers **43** are so proportioned that the effective area of this diaphragm **41** is exactly equal to the area of the outlet valve **39** (1.77 square inches). Therefore, while the 30 pound tank pressure applies a closing force of 53 pounds to the valve **39**, at the same time it applies an equal and opposite force against the balanced diaphragm **41**, so the difference between the tank pressure and the outlet pressure have no effect whatsoever on the force required to lift the valve **39** off of the seat **36** or to hold it open in any position. The outlet valve **39** is balanced by the diaphragm **41** at any nozzle pressure, since the pressures under the valve **39** and above the diaphragm **41** are equalized by passage **71**.

With reference to previously referred to Johnston U.S. Pat. No. 3,409,033, the diaphragm **41** is used to balance the outlet valve **39** exactly in the same manner that the piston **100** (FIG. **11** of the patent) is used to balance the outlet valve **92**. A piston could not be used in place of the diaphragm **41** to balance the outlet valve **39** for this control assembly **20**, because it is designed to handle highly corrosive and abrasive fluids containing sand, crystals, and other suspended solids that would quickly score and ruin a piston and the piston packings. Further, this control assembly **20** is designed to operate at maximum pressures of around 75 pounds per square inch, for which conventional diaphragms have adequate strength. On the other hand, the ammonia control shown in said U.S. Pat. No. 3,409,033 is designed for operating pressures of anhydrous ammonia, which may reach two hundred and fifty pounds per square inch, that would make the use of a diaphragm unsafe. It is to be noted that the use of diaphragms in this control assembly **20** has completely eliminated the necessity for seals or packings that might wear and leak.

Assuming that the control assembly **20** is functioning, the orifice or nozzle pressure is chamber **30** acting on the main diaphragm **42** will exactly balance the force developed by the governor weights **93** acting against the nozzle pressure on diaphragm **42**. If the speed of the governor assembly **24** is increased due to the increase in speed on the applicator **150**, or if the speed of the governor assembly **24** is increased by increasing the dial **127** setting, the speed of the applicator **150** remaining constant, the force applied by the governor assembly **24** to the diaphragm spindle **40** to raise the valve **39** further off its seat **36** will raise this valve **39** off the seat **36** increasing the flow through the valve assembly **22** and the pressure in chamber **30** until the nozzle pressure and the pressure in chamber **30** have increased enough to act across the main diaphragm **42** to balance the increased force of governor assembly **24**.

Therefore, it can be readily seen that an increase in speed of the applicator **150** or increase in the dial **127** setting will increase the flow and pressure on the nozzles or orifices of the boom assembly **155**, and conversely a decrease in applicator **150** speed or dial **127** setting will decrease the flow and pressure on said orifices or nozzles.

Since the governor assembly **24** in this control assembly **20** is for practical purposes identical to the governor shown in the control assembly in U.S. Pat. No. 3,409,033, the force exerted by governor assembly **24** against the spindle **40** is a constant times the square of the speed (see col. 10, equation III of said patent). As explained in said patent, which is incorporated herein by reference, the force exerted by the governor assembly **24** is independent of the position of the weights **93**, determined by the position of the outlet valve **39**, and dependent only on the speed of the governor assembly **24**.

If a maximum speed were established for the governor assembly **24** and a maximum tank pressure were established for the tank **153**, the area of the diaphragm **42** should be so established that the area of the diaphragm **42** acted over by the maximum tank pressure would exactly equal the maximum force of the governor assembly **24**. From this, logic would make it necessary to establish the speed relationship of the tire friction wheel **144** so that when the applicator **150** is traveling at the maximum speed desired, the cable speed, with the dial **127** set on 100, would be such that the governor assembly **24** is turning at the maximum established revolutions per minute, and developing a force sufficient to exactly balance the tank pressure on the diaphragm **42**.

At 860 RPM, the governor assembly **24** develops a force of approximately 95.5 pounds. In order to exactly balance the force of the governor assembly **24** with a maximum tank pressure of thirty pounds per square inch, the diaphragm **42** should have an effective area of 3.18 square inches, i.e., 95.5 divided by **30**.

If the maximum desired speed of the applicator **150** with a control dial **127** set on 100 is assumed to be 3.51 miles per hour, the speed of the control cable **136** should be 107.5 revolutions per minute for each mile per hour ground speed, which would mean the cable **136** would turn 377 (3.51 × 107.5) revolutions per minute at 3.51 miles per hour. At maximum dial setting, it would turn the governor assembly **24** at 860 (377 × 2.28) revolutions per minute, since at a dial setting of 100, the wheel-cone **88** turns 2.28 revolutions per minute for each revolution of the drive pulley **123**.

Since it is obvious that the force of the governor assembly **24** cannot exceed the tank pressure times the area of the diaphragm **42** because, in this case, the governor weights **93** would continue to swing out with nothing to stop them and ultimately begin to drag against the inside of the housing **80** which would make the control assembly **20** inaccurate and very likely damage it severely, any increase in the maximum selected governor assembly **24** speed must be accompanied by an increase in tank pressure.

Since the force of the governor assembly **24** is proportional to the square of the speed, the increase in tank pressure required must also increase with the square of the speed. For example, if the governor assembly **24** speed were increased 50 percent from 860 to 1,290 RPM's, the tank pressure would have to be increased by 1.5 squared, which would be 2.25, and 2.25 times the original 30 pounds per square inch pressure would be 67.5 pounds per square inch pressure required for increasing the governor assembly **24** speed to one hundred and 50 percent of its original speed of 860 RPM.

As explained above, the speed relationship between the governor spindle **87** and the flexible cable wire **136** is proportional to the dial **127** setting. If a setting 100 gives a governor assembly **24** speed of 860 RPM at 3.51 miles per hour, than a dial **127** setting of 50 would give a governor assembly **24** speed of 430 RPM at 3.51 miles per hour. Therefore, it is seen that as the setting is decreased, the applicator **150** speed may be increased, and at a dial **127** setting of 50, the allowable speed of the applicator **150** would be 7.02 miles per hour, without exceeding the maximum governor assembly **24** speed of 860 RPM which, in turn, is based on a tank pressure of 30 pounds per square inch.

It will be noted in the example being considered that at dial **127** setting of 100, the maximum speed is 3.5 miles per hour, while at a dial setting of 30, the maximum allowable speed is 11.7 miles per hour. The output rate in gallons per acre at 3.5 miles per hour with the dial set on 100 is exactly double the output rate per acre at 7 miles per hour with the dial set on 50. Another way of saying this is that with a fixed and limited tank pressure and a given size of nozzle, the maximum rate of flow obtainable is fixed in gallons per minute and distributing this amount at 3.5 miles per hour applies twice as much to the ground as it does at 7 miles per hour.

In selecting the nozzle size one needs, the operator first determines the maximum speed at which he will operate. If he selects a maximum speed of 7 miles per hour and wishes to apply 60 gallons per acre, he would determine that for a speed of 7 miles per hour, his dial **127** cannot be set above 50 and he would select KSS 40 nozzles. To give him 60 gallons per acre, he would set the dial **127** at 41.5 (145 × 0.415 = 60.1), which would give him 60 gallons per acre, at any speed between 7 and 1.3 miles per hour. The minimum speed is merely the speed required to overcome the effect of gravity on the governor weights **93**. Were there no limit to the tank pressure available and no limit to the pressure capability of the control assembly **20**, one could operate the control assembly **20** at any speed or dial **127** setting desired as long as one were above the minimum allowable speed.

The governor assembly **24** as above pointed up, develops a force on the diaphragm spindle **40** proportional to the square of the governor assembly **24** speed which is a function of the ground speed with a given dial **127** setting. Therefore, for a given dial **127** setting, the governor assembly **24** force is proportional to the square of the ground speed. Inasmuch as the pressure on the diaphragm **42** multiplied by the area of the diaphragm **42** is equal to the governor assembly **24** force, it follows that the pressure on the diaphragm **42** is proportional to the force of the governor assembly **24**, the diaphragm **42** area being constant, and the pressure is, therefore, also proportional to the square of the ground speed.

Since the pressure on the diaphragm **42** is also substantially the pressure on the nozzles or orifices of the boom assembly **155** the flow in gallons per minute through said nozzles or orifices is proportional to the ground speed, for the flow through nozzles or orifices is proportional to the square root of the pressure, see mathematical explanation in said U.S. Pat. No. 3,409,033, column 11, equation VII.

For a fixed given ground speed, the RPM of the governor assembly **24** is proportional to the dial **127** setting, but since the force developed by the governor assembly **24** is proportional to the square of the speed, and since the pressure developed on the diaphragm **42** is proportional to the governor assembly **24** force, the pressure is proportional to the square of the dial **127** setting, and the flow through said orifices and nozzles is directly proportional linearly to the dial setting.

Hence, it is clear that the current invention provides a control assembly **20** that regulates the nozzle or orifice pressure so that the output rate per acre remains constant regardless of speed, and provides a means of adjusting the output rate with a dial such that the output rate is proportional to the dial **127** setting.

A further word about the warning bell **100** is appropriate. If the pressure supplied to the control assembly **20** should become too low in chamber **29** above the valve **39** so that the flow through the valve **39** is not sufficient to maintain adequate pressure on the diaphragm **42**, which is approximately the same as the pressure on the nozzles of the boom **155**, the governor assembly **24** will continue to open the valve **39**, allowing the governor weights **93** to swing out until they being striking the bell clapper **101**. The clapper **101** is driven out against the bell **100**, which rings and warns the operator that there is insufficient tank pressure to maintain accuracy of the control assembly **24**.

Conversely, if the tank pressure has been maintained at the proper value, and the operator drives the applicator **150** above the maximum recommended speed, the governor assembly **24** force will increase beyond its normal value, for which the tank pressure is set, and it will again swing the weights **93** out to ring the bell **100**.

With reference to FIGS. 1 and 2, there is diagrammatically shown an air pressure applicator **150**. It is understood that an air compressor is mounted on the tongue of the applicator **150** which may be driven through a slip tube-type of propeller shaft that has a universal joint at each end, and is connected to the power take-off of the pull tractor. The compressor discharge line is connected to a pressure regulator attached to the tank **153** in conventional manner and by this means maintains a constant and pre-set pressure in the tank.

It is also conceived that a power take-off driven centrifugal pump may be mounted on the front of the tongue of the applicator **150**, in which case, the outlet of the tank **153** would be connected to the inlet of the centrifugal pump and the discharge of the centrifugal pump would be connected to the inlet **31** of the control assembly **20**. One may interpose a bypass or a relief valve between the discharge of the pump and the control assembly **20** which may be used to limit the pressure admitted to the control assembly **20** and/or also for returning by pass fluid to the tank **153** for agitation.

It is clear from the foregoing that there have been provided a novel structure for and a novel method of fulfilling the objects and advantages sought therefor.

It is to be understood that the foregoing description and the accompanying drawings have been given by way of illustration and example. It is also to be understood that changes in form of the several parts, substitution of equivalent elements or steps, and rearrangement of parts or steps, which will be readily apparent to one skilled in the art, are contemplated as within the scope of the present invention, which is limited only by the claims which follow.

What is claimed is:

1. In combination, a centrifugal governor operated diaphragm valve for controlling the spray nozzle pressure of a liquid applicator so that the output in gallons per minute is proportional to the applicator speed to provide a constant gallons per acre output and the like, regardless of the speed of the applicator within its predetermined operating range comprising a flow passage for liquids, a valve in said passage, a pressure balancing yieldable diaphragm operatively connected with said valve for movement therewith, said balancing diaphragm having an effective area subjected to inlet pressure substantially equal to the effective area of said valve subjected to inlet pressure, and an effective area subjected to outlet pressure substantially equal to the effective area of said valve subjected to inlet pressure, a centrifugal governor operatively connected with said valve for positioning the same in accordance with the speed of an applicator, and means for effecting operative rotation of said governor including rotatable means adapted to be driven at speeds proportional to speeds of an applicator on which said valve is mounted.

2. The combination of claim **1**, in which said means for effecting operative rotation of said governor further includes adjustable means to vary the preselected gallonage per acre, said adjustable means comprising a friction wheel-cone operatively connected to said governor for movement therewith, and a driven drive pulley operatively engaging said friction wheel-cone, at least one of said pulley and wheel-cone being adjustable in respect to the other to vary preselected gallonage per acre, said pulley being adjustable, and a calibrated rotatable disc member integrated with said pulley, rotation of said disc member in preselecting the required gallonage effecting the required movement of said pulley in respect to said wheel-cone, means for driving said pulley including rotatable means adapted for operative relation with wheels and the like of an applicator, said rotatable means comprising a friction speed sensor wheel adapted to engage the wheel tire of an applicator, said speed sensor being operatively connected to said pulley, and alarm means operatively mounted to warn a user that the governor is swinging on a radius greater than its preselected operating radius.

3. In combination a centrifugal governor operated diaphragm valve for controlling the spray nozzle pressure of a liquid applicator so that the output in gallons per minute is proportional to the applicator speed to provide a constant gallons per acre output and the like, regardless of the speed of the applicator within its predetermined operating range comprising a flow passage for liquids, a valve in said passage, a centrifugal governor operatively connected with said valve for positioning the same in accordance with the speed of the applicator, and means for effecting operative rotation of said governor including rotatable means adapted to be driven at speeds proportional to speeds of the applicator on which said valve is mounted and adjustable means to vary the preselected gallonage per acre.

4. The combination of claim **3**, in which said adjustable means comprises a friction wheel-cone operatively connected to said governor for movement therewith, and a driven drive pulley operatively engaging said friction wheel-cone, at least one of said pulley and wheel-cone being adjustable in respect to the other to vary preselected gallonage per acre.

5. The combination of claim **4**, in which said pulley is adjustable, and a calibrated rotatable disc member integrated with said pulley, rotation of said disc member in preselecting the required gallonage effecting the required movement of said pulley in respect to said wheel-cone.

6. The combination of claim **5** and including means for driving said pulley including rotatable means adapted for operative relation with wheels and the like of an applicator.

7. The combination of claim **6**, in which said rotatable means comprises a friction speed sensor wheel adapted to engage the wheel tire of an applicator, said speed sensor being operatively connected to said pulley.

8. In combination, a centrifugal governor operated diaphragm valve for controlling the spray nozzle pressure of a liquid applicator so that the output in gallons per minute is proportional to the applicator speed to provide a constant gallons per acre output and the like, regardless of the speed of the applicator within its predetermined operating range comprising a flow passage for liquids, a valve in said passage, a centrifugal governor operatively connected with said valve for positioning the same in accordance with the speed of the applicator, an alarm means operatively mounted to warn a user that the governor is swinging on a radius greater than its preselected operating radius, and means for effecting operative rotation of said governor including rotatable means adapted to be driven at speeds proportional to speeds of the applicator on which said valve is mounted.

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