Sept. 14, 1965 W. V. BROWN 3,205,823

PUMP REGULATING SYSTEM

Filed March 18, 1963 4 Sheets-Sheet 1

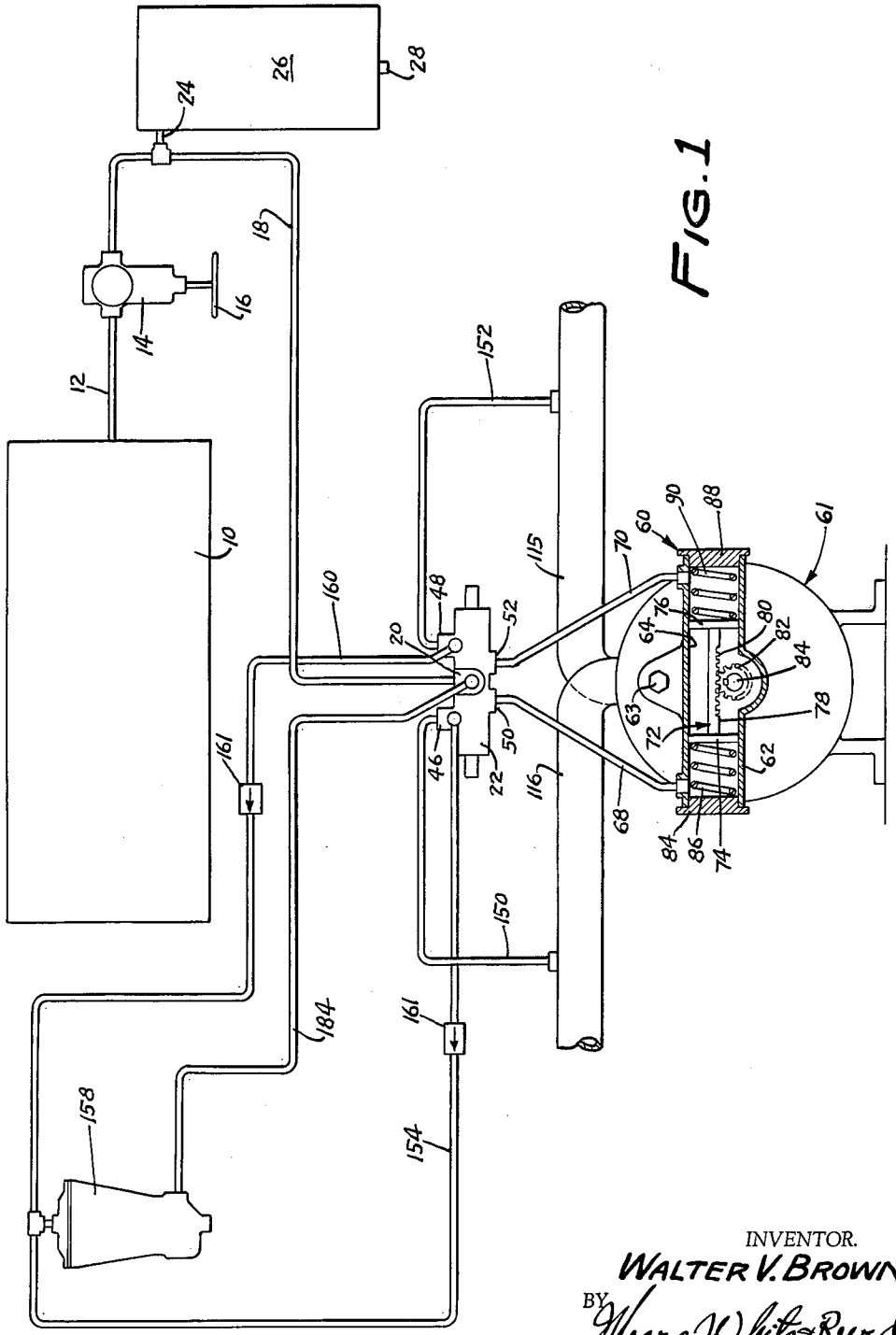


FIG. 1

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PUMP REGULATING SYSTEM

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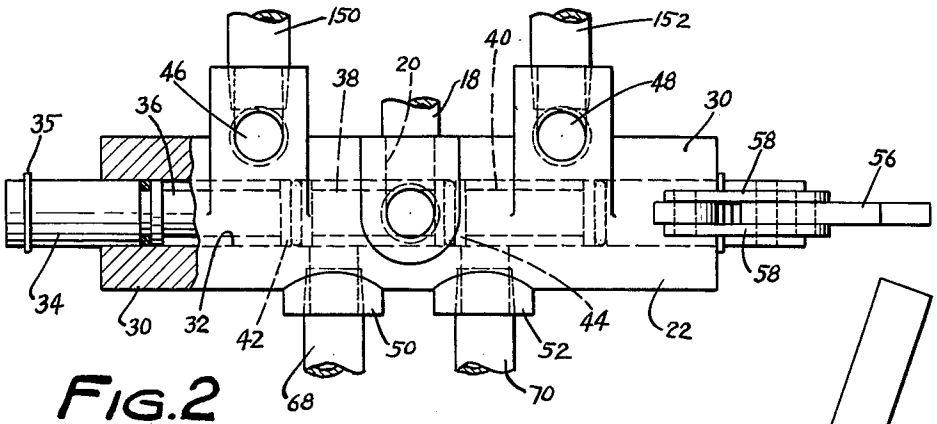


FIG. 2

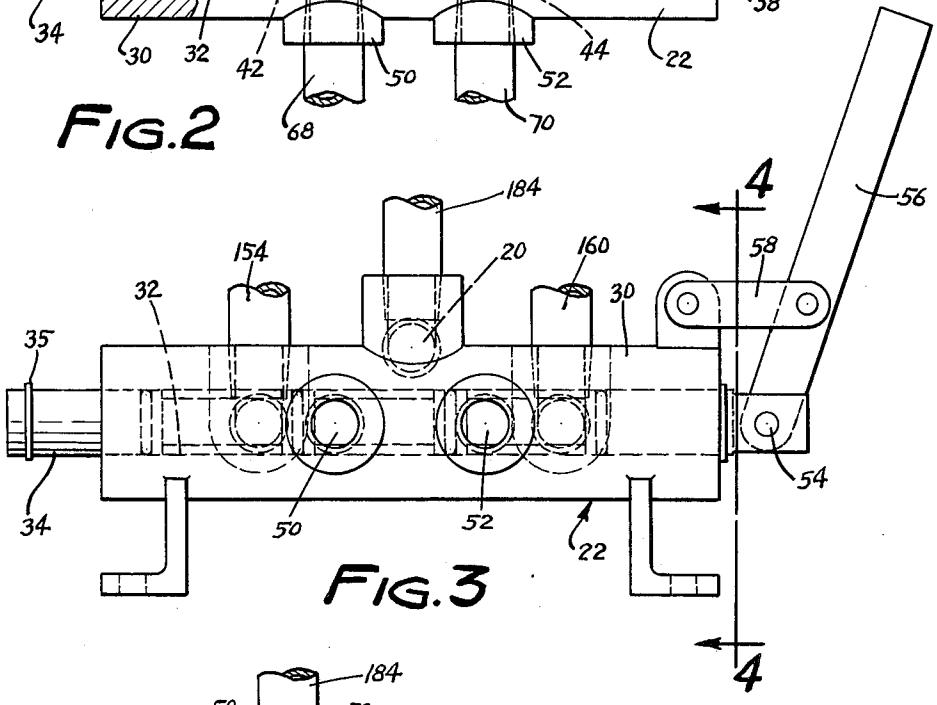


FIG. 3

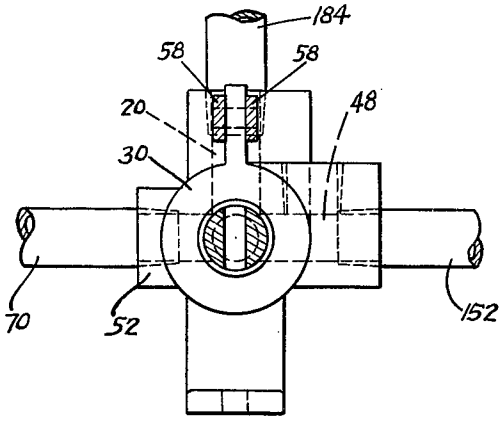


FIG. 4

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PUMP REGULATING SYSTEM

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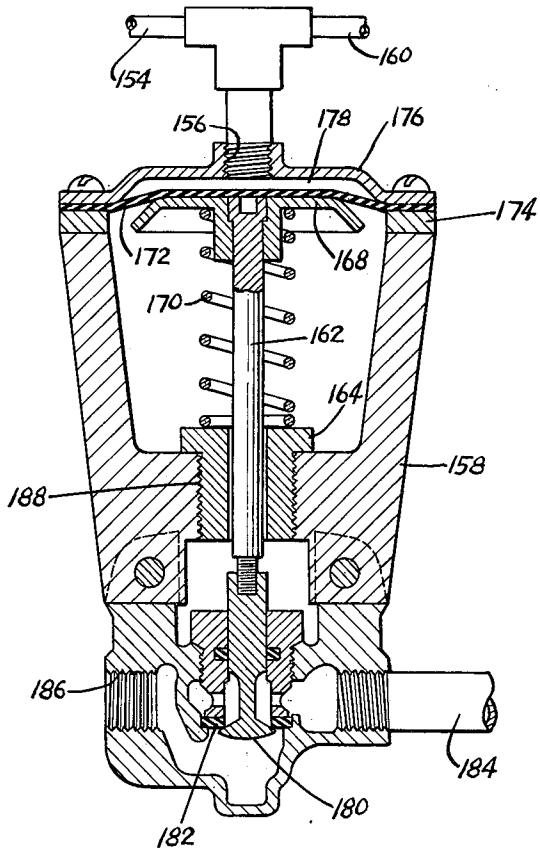


FIG. 5

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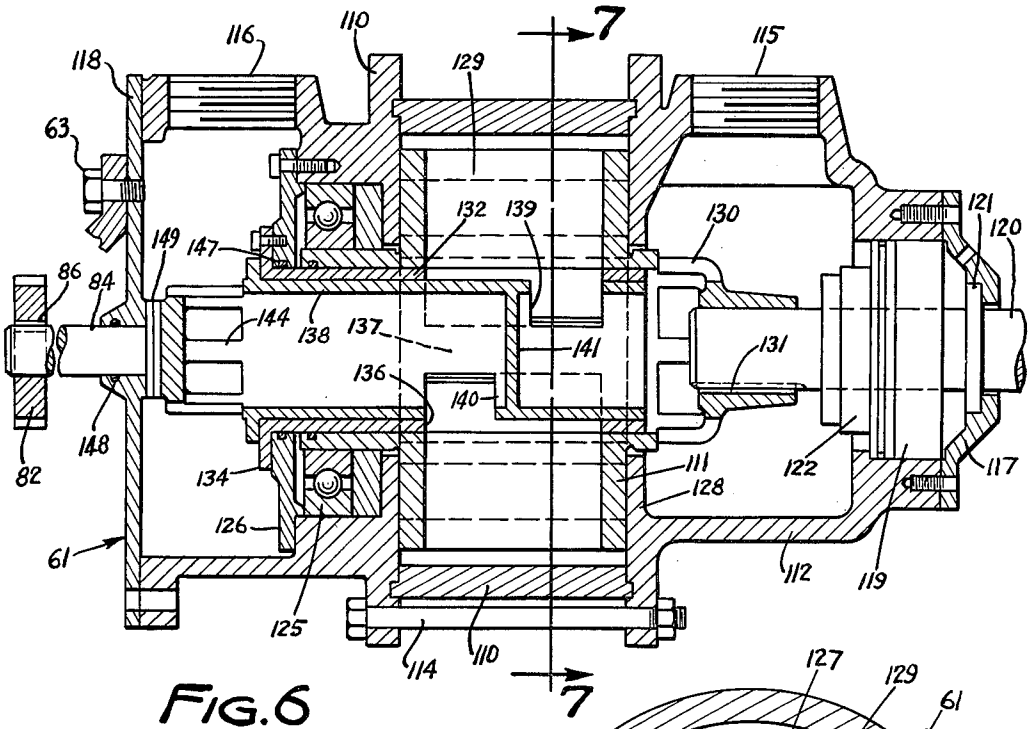


FIG. 6

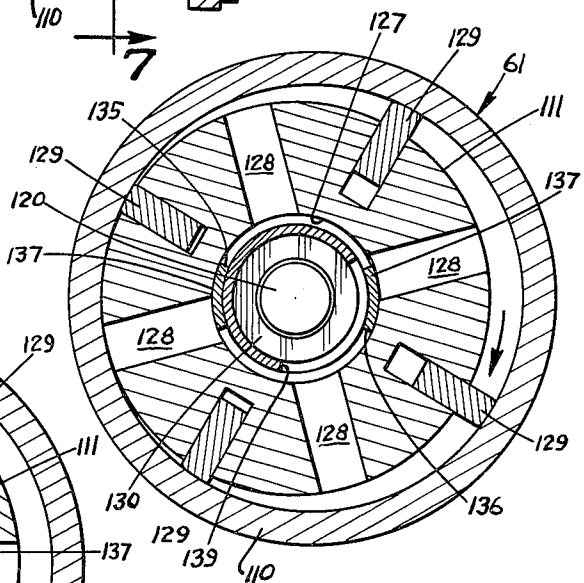


FIG. 7

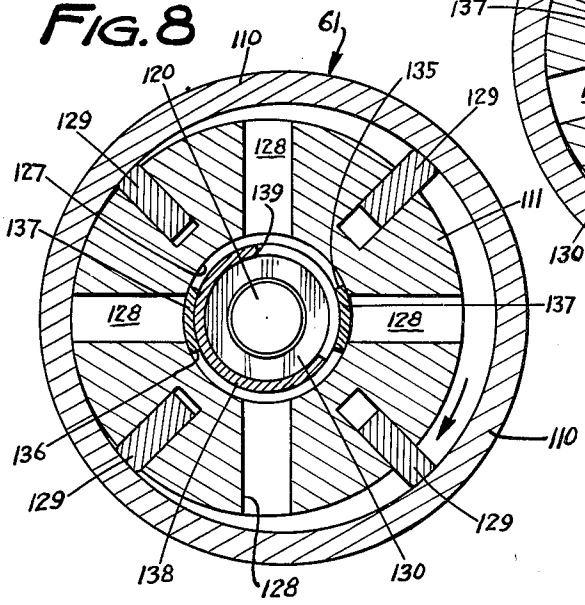


FIG. 8

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United States Patent Office 3,205,823 Patented Sept. 14, 1965

3,205,823

PUMP REGULATING SYSTEM

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Filed Mar. 18, 1963, Ser. No. 265,734
11 Claims. (Cl. 103—3)

The present invention relates to pumping systems and more particularly to pumping systems including a provision for regulating either pumping pressure, flow direction or both direction and pressure as conditions require.

A variety of pumps and control systems therefor have been previously proposed. Many of these systems have been at least partially ineffective in operation particularly in exacting work such as the fueling or defueling of aircraft. In this type of service, it is important to pump fuel into the tank at a relatively high flow rate while at the same time avoiding the possibility of pressure surges which if present could seriously damage fuel tanks and lines. Moreover, in aircraft fueling systems, a shut off valve is provided at the outlet end of the fuel hose. After the fueling operation has been completed, this valve is closed even though the fuel pump continues to run. The system must therefore include a provision for effectively preventing surges which result from a sudden increase in fuel hose pressure as the shut off valve is closed.

Another defect in many prior art pumping systems is that while the pumping pressure can be reliably regulated with the fluid being pumped in one direction, there is either no provision for reverse pumping or if reverse pumping is provided, there is no reliable means for regulating the pressure achieved when pumping in reverse.

In accordance with a preferred form of the present invention, a positive displacement pump is employed. Pumping pressure is varied by by-passing all or part of the pump output. With the present invention it is possible to obtain high flow rates while at the same time mainaining pumping pressure below a predetermined limit.

In view of these and other defects in the prior art it is thus one object of the present invention to provide an improved pumping system including means for reliably maintaining the peak pumping pressure below a predetermined limit.

It is yet another object of the present invention to provide an improved pumping system including a means for controlling the output pressure by changing a manually adjustable setting.

It is a still further object of the present invention to provide an improved pumping control system including a provision for reversing the direction of fluid flow through the pump without reversing the direction of rotation of the pump.

Yet another object of the present invention is the provision of an improved pumping system including a positive displacement type pump having an adjustable by-pass and an improved control means for regulating the volume of fluid by-passed.

A further object is the provision of a pump control system which employs a single regulator means and a single relief means which function reliably to prevent pressure surges regardless of the pumping direction.

Other objects of the invention will become apparent as the description proceeds.

To the accomplishment of the foregoing and related ends, this invention then comprises the features hereinafter fully described and particularly pointed out in the claims, the following description setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of but a few of the various ways in which the principles of the invention may be employed.

The invention is illustrated by the accompanying drawings in which the same numerals refer to corresponding parts and in which:

FIGURE 1 is a semidiagrammatic schematic illustration of the control system according to the present invention;

FIGURE 2 is an enlarged plan view of the reversing valve employed in the present invention;

FIGURE 3 is a side elevational view of the reversing valve of FIGURE 2;

FIGURE 4 is a transverse vertical sectional view taken on the line 4—4 of FIGURE 3;

FIGURE 5 is a vertical sectional view of the pressure relief valve of the present invention;

FIGURE 6 is a longitudinal vertical sectional view of the pump;

FIGURE 7 is a transverse vertical sectional view taken on the line 7—7 of FIGURE 6 with the control sleeve set for normal pumping; and

FIGURE 8 is a view similar to FIGURE 7 but illustrating the pump control element in a position for reverse pumping.

Briefly stated, a preferred form of the present invention provides a control system for a pump including a control valve for regulating the output pressure of the pump and a pressure differential responsive means operatively connected with the control valve for regulating the movement thereof. The pressure differential responsive means is connected to an adjustable biasing means and also to the pump outlet. The control valve is in this way regulated by the pressure differential between the pump output and that exerted by the adjustable biasing means.

The invention will be best understood by reference to the accompanying drawings wherein the same numerals refer to corresponding parts of the several views.

Referring now particularly to FIGURE 1 there is shown a compressed air tank **10** communicating through a line **12** with an adjustable pressure regulating valve **14**. Valve **14** includes a hand wheel **16** for adjusting the pressure established by the regulator **14** in any well known and suitable manner. Since the pressure regulator **14** can be constructed in various ways and forms no part of the present invention per se, no detailed description thereof will be presented herein. The air passing out of the valve **14** flows through a line **18** and to a port **20** of a reversing valve **22**. It thus can readily be seen that the compressed air tank **10** and valve **14** cooperate to provide an adjustable source of air pressure.

Communicating with the line **18** through a line **24** is a reservoir **26** having a drain opening **28** at the lower end for purposes hereinafter described.

As best seen in FIGURES 2, 3 and 4, the reversing valve **22** includes a casing **30** having an elongated cylindrical bore **32** extending longitudinally therethrough and a movable valve element such as plunger **34** slidably mounted within the bore **32**. Plunger **34** includes three longitudinally spaced circumferentially extending recesses **36**, **38** and **40** separated by sealing elements **42** and **44**. A stop ring **35** is mounted upon the left end of plunger **34**. Spaced longitudinally of the center port **20** are end ports **46** and **48**. Intermediate port **46** and port **20** is a port **50**. Intermediate ports **20** and **48** is a port **52**. Pivotally connected at **54** to one end of the spool **34** is a vertically extending control lever **56**. Pivotally connected between the lever **56** of the casing **30** are a pair of links **58**.

With the control handle **56** positioned as shown in FIGURES 2 and 3 and the plunger **34** moved fully toward the left in the figures, the port **20** will communicate with the port **50** and the port **48** will communicate with the port **52**. The port **46**, however, will be sealed from the other ports by the sealing element **42**. When the plunger

34 is moved toward the right in FIGURES 2 and 3 until the stop 35 hits the casing 30, the port 46 will communicate with port 50 and the port 20 will communicate with port 52. The port 48 will under these conditions be sealed from the remaining ports by the sealing element 44.

As can best be seen in FIGURE 1, there is provided a pressure differential responsive regulator or pressure sensing assembly 60 including a hollow generally cylindrical casing 62 having a cylindrical bore 64 therein. The regulator 60 is supported upon a pump 61 in any suitable manner as by bolt 63. Communicating between the port 50 and one end of the chamber 64 is a duct 68. Communicating between the port 52 and the opposite end of the chamber 64 is a duct 70. Slidably mounted within the chamber 64 intermediate the ends thereof is a movable sensing element 72 including a pair of longitudinally spaced sealing members 74 and 76 and a center portion 78 of a reduced diameter. On the lower surface of the portion 78 is a rack 80 connected in driving engagement with a gear 82. The gear 82 is affixed to a pump control shaft 84 in any suitable manner as by a key 86. The movable sensing element 72 is in this manner operatively connected to operate the pump control shaft 84.

As can clearly be seen in FIGURE 1 the left end of the casing 62 is sealed by a plug 84. Between the plug 84 and the head 74 is mounted a helical spring 86. The right end of the housing 62 is sealed by a plug 88. Positioned between the plug 88 and the head 76 is provided a helical spring 90. The sensing element 72 is in this manner resiliently held in the center of the housing 62.

Refer now particularly to FIGURES 1, 6, 7 and 8 which illustrate a preferred form of pump employed in connection with the present invention. The pump 61 includes a housing 110 within which a rotor 111 is eccentrically and rotatably mounted. As each side of the housing 110 are provided right and left pump chambers 112 and 113 respectively. The housing 110 is secured between the chambers 112 and 113 by a suitable connecting means such as bolts 114.

The chamber 112 has an internally threaded port 115 and the chamber 113 is provided with a similar port 116. Suitable end caps 117 and 118 are secured to the respective chambers 112 and 113. A bearing 119 provides support for a rotor shaft 120 which is rigidly associated with rotor 111. Suitable seals 121 and 122 are positioned adjacent the bearing 119 on either side thereof. A bearing 125 supports the other end of the rotor 111 and rotor shaft assembly.

As best seen in FIGURES 7 and 8, the rotor 111 is provided with a cylindrical center opening 127 which communicates with the periphery of rotor 111 through radially extending and circumferentially spaced passageways 128. The rotor 111 is also provided with conventional sliding vanes 129 which may be biased outwardly in any convenient and well known manner. A spider 130 including a sleeve 131 mounted securely upon shaft 120 is affixed to the right end of rotor 111 and extends between the rotor shaft 120 and the rotor 111. During operation, the shaft 120 is of course connected to a suitable drive motor (not shown).

Within the center opening 127 of rotor 111 is the pump flow control assembly composed of a slotted sleeve 132 and a control valve or sleeve 138, both of which communicates with chambers 112 and 113.

The sleeve 138 is rotatably mounted within the sleeve 132, the latter being secured by means of a radially extending flange 134 at one end thereof to a stationary plate 126 which is itself fastened by any suitable means such as screws to the housing 110 of pump 61. Sleeve 132 is provided with a pair of ports 135 and 136 spaced 180° apart. Web portions designated 137 extend intermediate ports 135 and 136. A substantially fluid tight seal is formed between the outside of sleeve 132 and the opening 127 of rotor 111.

The sleeve 138 includes a pair of ports 139 and 140

which are spaced 180° apart and are also displaced axially from each other. A transverse partition 141 is positioned within sleeve 138 intermediate the ports 139 and 140. A spider 144 connects the shaft 84 and the sleeve 138. The pump 61 per se is described more fully in my copending application entitled Rotary Fluid Device filed December 26, 1961, Serial No. 161,919 and now bearing Patent No. 3,191,541.

During operation, with the rotor 111 turning in a clockwise direction and with the sleeve 138 in the position shown in FIGURE 7, fluid will be drawn into the pump through port 116 and will be exhausted through port 115. For the sake of convenience these conditions will hereinafter be referred to as normal operation. On the other hand, with sleeve 138 in the position of FIGURES 6 and 8 and with the rotor 111 rotating in a clockwise direction as seen in FIGURE 8, fluid will flow from port 115 to port 116, for convenience, hereinafter referred to as reverse flow.

Referring now to FIGURES 1 and 5 it will be seen that a duct 150 is connected between the duct 116 and the port 46 of reversing valve 22. A similar duct 152 extends between the port 115 of the pump 61 and the duct or port 48 of valve 22. A line 54 communicates between the port 46 of valve 22 and the inlet 156 of a pressure relief valve 158. Another line 160 communicates between the port 48 and the inlet 156 of valve 158. In each of lines 154 and 160 is provided a check valve 161 to allow fluid within each line to flow from the valve 22 towards the pressure relief valve 158 but not in the reverse direction.

The relief valve 158 includes a movable valve member 162 which is slidably mounted at the center of the valve within a sleeve 164. The member 162 includes a head 168 at the upper end and is biased in an upward direction by means of a spring 170 positioned between head 168 and sleeve 164. A flexible and impermeable sealing member such as a flat rubber sheet 172 is mounted between a valve member 174 and a valve cap 176 to confine fluid from lines 154 and 160 in a space 178 above the valve head 168. The fluid in the lines 154 and 160 if excessive will force the valve member 162 downwardly within the sleeve 164 thereby moving a valve head 180 at the lower end of member 162 off of an annular valve seat 182 which communicates between an inlet line 184 and an exhaust vent 186. Downward movement of member 162 will in this way allow fluid to flow from line 184 out through the exhaust port 186. The pressure at which the valve 158 will open can be adjusted by regulating the tension of spring 170. To accomplish this, the sleeve 164 is threadedly mounted within the valve casing at 188. By turning the sleeve 164 upwardly the spring 170 can be further compressed thereby requiring more pressure in chamber 178 to open the valve seat 182.

As best seen in FIGURES 1 and 2, the end of line 184 opposite that connected to the valve 158 is connected to the port 20 of valve 22 which of course communicates with the line 18. If the pressure in either of lines 150 or 152 becomes excessive, as may result, for example, from a surge in one of the ducts 115 or 116, the pressure increase in one of the lines 154 or 160 will be transmitted to the pressure relief valve 158. The resulting downward pressure upon the valve head 168 will if of sufficient force, move the head 180 from seat 182 thereby allowing the fluid within line 18 to escape through line 184 and port 186.

Operation

For the purpose of describing the operation of the control apparatus according to the present invention it will be assumed that the air tank 10 has been pressurized with compressed air or the like and that the pressure regulating valve 14 is set to maintain the air pressure within line 18 at a predetermined selected value.

With the control handle 56 of valve 22 in the position shown in FIGURES 2 and 3 the compressed air present

in line 18 will pass through valve 22 from port 20 to port 50. From port 50 it will pass through line 68 to the left end of the movable element 72 thereby biasing the shaft 84 in a clockwise direction as seen in FIGURE 1. The pressurized tank 10 and valve 14 thus serve as an adjustable biasing means for urging the element 72 toward one end of casing 62. The pressure exerted upon the element 72 by air from tank 10 will, however, be balanced by the fluid pressure exerted upon element 72 through line 70, port 52, port 48 and line 152.

With the pump 61 in operation and the sleeve 138 positioned as shown in FIGURE 7, fluid within line 115 will be transferred through line 152, valve 22 and line 70 to bias the movable element 72 toward the left in FIGURE 1. The position of the element 72, shaft 84 and sleeve 138 is however determined by the pressure differential between the left and right sides of the movable element 72. Thus, if the handle 16 of pressure regulator 14 is moved in such direction as to increase the air pressure in line 18, the element 72 will temporarily move toward the right in FIGURE 1, thereby turning the sleeve 138 in a clockwise direction from the position shown in FIGURE 7. As the sleeve 138 moves in a clockwise direction with respect to sleeve 132, the size of the opening between port 139 and the top of web 137 at the right in FIGURE 7 will decrease thus reducing the volume of fluid by-passed through the rotor 111 from bottom to top. It will thus be understood that the pump output pressure will in this way be increased. When, on the other hand, handle 16 is moved to reduce the pressure in line 18, the relatively higher pressure in line 152 and line 70 will force the element 72 toward the left in FIGURE 7, thereby turning the shaft 84 in a counterclockwise direction so as to increase the size of the opening between port 139 and web 137 at the right in the figure, so as to cause a greater amount of fluid to be by-passed whereby the pressure at port 115 will again be reduced.

When the pumping direction of the pump 22 is to be changed, the lever 56 of valve 22 is pivoted so as to move the plunger 34 toward the right in FIGURES 2 and 3. The port 116 of pump 61 and line 150 will then communicate through valve 22 with the line 68 and line 18 will communicate through valve 22 with line 70. As this is done, the valve element 72 will be forced quickly toward the left by the pressure within line 70. As this takes place, the control shaft 84 will of course turn correspondingly so as to move port 139 to the position shown in FIGURE 7. Under these conditions, fluid will be drawn through the port 115 and will be expelled through port 116. In this way, the pump 61 will function for pumping in either direction without reversing the rotation of the rotor 111. It should be carefully noted that even when fluid is pumped in the reverse direction i.e., out through port 116, the pressure established by the pressure regulator 14 will accurately and reliably control the pump output pressure in line 116 by regulating differential pressure condition on opposite sides of the movable sensing element 72. For example, with the pump 61 operating in reverse as described and predetermined pressure established in line 18, if the pressure at port 116 increases, the pressure in line 150 and line 168 will also increase thereby driving the element 72 toward the right in the figures and in this way opening the gap between port 139 and the right web 137 as seen in FIGURE 8, thereby reducing the pressure increase in the line 116.

After the reversing valve 22 has been operated, any fuel or other liquid wich has accumulated within the casing 62 on one side of element 72 will be free to pass through one of lines 68 or 70 and through line 18 to the reservoir 26. When required, fluid which has accumulated in tank 26 can be emptied by removing plug 28.

It is apparent that many modifications and variations of the invention as hereinbefore set forth may be made without departing from the spirit and scope thereof. The specific embodiments described are given by way of example only and the invention is limited only by the terms of the appended claims.

What is claimed is:

1. A control system for a pump comprising in combination a source of air pressure, a pressure regulator communicating with the outlet of said source of air pressure, a pressure sensing assembly including a pressure responsive element movably mounted therein, a flow control assembly connected to said pump for controlling the flow of fluid therefrom, said pressure responsive element being operatively connected to said flow control assembly, a line interconnecting said source of air pressure and said pressure sensing assembly via said pressure regulator, said pump having inlet and outlet ports, first duct means communicating between one of said ports and said pressure sensing assembly on one side of said pressure responsive element, and a second duct means communicating between said source of air pressure and said pressure sensing assembly on the other side of said pressure responsive element.

2. A control system for a pump having inlet and outlet ducts comprising a flow control assembly communicating with one of said ducts for regulating the output pressure from said pump, an adjustable biasing means, a pressure differential responsive sensing means having a casing and a sensing element mounted therein for movement along a predetermined axis, a line communicating between said sensing means and one of said ducts to urge said element in one direction along said axis, a line communicating between said sensing means and said adjustable biasing means for urging said element to move along said axis in the opposite direction and means connecting said sensing element with said flow control assembly, whereby said flow control assembly is positioned responsive to the movement of said sensing element.

3. The combination of a reversible flow pump, said pump having first and second ducts for transferring fluid therefrom and a flow control assembly communicating with the ducts of said pump, said flow control assembly being movable between first and second positions for reversing the flow of fluid through said ducts; a pressure differential responsive regulator means, said pressure differential responsive regulator means including a casing having a chamber therein and a movable sensing element in said chamber, said movable sensing element being connected to said flow control assembly; an adjustable means yieldably biasing said sensing element in a first direction and conduit means communicating between one of said ducts and said chamber to bias said element in the opposite direction, said movable element thereby positioning said control valve responsive to the pressure differential between said adjustable means and the fluid pressure within said one duct.

4. The combination of a reversible flow pump, said pump having first and second ducts for transferring fluid therethrough and a flow control assembly communicating with the ducts of said pump, said control valve being movable between first and second positions for reversing the flow of fluid through said ducts; pressure differential responsive regulator means, said pressure responsive regulator means including a casing having a chamber therein and a movable sensing element in said chamber, said movable sensing element being operatively connected to said control valve; an adjustable source of fluid pressure, a reversing valve having first and second positions to provide communication between said first duct and a portion of the chamber on one side of said sensing element and between said source of fluid pressure and a portion of said chamber on the opposite side of said sensing element when in said first position and when in said second position for connecting said second duct with a portion of said chamber on the opposite side of said sensing element and for connecting said source of fluid pressure to the portion of said chamber on said one side of said sensing element.

5. A control system for a reversible flow pump, said pump having first and second ports for transferring fluid therethrough and a flow control assembly communicating with the parts of said pump, said flow control assembly being movable between first and second positions for reversing the flow of fluid through said ports, the combination of a pressure differential responsive regulator means, said pressure responsive regulator means including a casing having a chamber therein and a sensing element movably mounted in said chamber, said movable sensing element being connected to said flow control assembly, an adjustable source of fluid pressure communicating with said chamber for yieldably biasing said sensing element in a first direction, conduit means communicating between one of said ports and said chamber to bias said sensing element in the opposite direction, said sensing element thereby positioning said control valve responsive to the pressure differential between said source of fluid pressure and the fluid pressure within said duct, a reversing valve including a control member movable between first and second positions, said reversing valve being connected to provide in said first position communication between said first port and a portion of the chamber on one side of said sensing element and also to provide communication between said source of fluid pressure and a portion of said chamber on the opposite side of said sensing element and when in said second position for connecting said second port with a portion of said chamber on said one side of said sensing element and for connecting said source of fluid pressure to a portion of said chamber on the other side of said sensing element.

6. A control system for a pump having inlet and outlet ports; said control system comprising in combination an adjustable source of gaseous pressure, a pressure sensing assembly including a pressure differential responsive means mounted therein, a flow control assembly communicating with said pump for controlling the flow of fluid therethrough, said pressure responsive means being connected to said flow control assembly, first duct means connected between said source of gaseous pressure and said pressure sensing assembly, second duct means communicating between one of said ports and said pressure sensing assembly whereby said flow control assembly operates responsive to the pressure differential between said one port and said adjustable source of gaseous pressure.

7. A control for a pump; said pump having inlet and outlet ports and a control sleeve rotatably mounted therein for regulating the fluid by-passed between said ports, an adjustable biasing means, a pressure differential responsive means having a casing and a movable element mounted therein for movement along a predetermined axis, said element being connected to said sleeve for regulating the position thereof, means operatively connecting said movable element with one said port to urge said element in one direction along said axis, means operatively connecting said movable element with said adjustable biasing means for urging said element to move along said axis in the opposite direction.

8. The combination of a reversible flow pump, said pump having first and second ports for transferring fluid therethrough and a flow control assembly therein, said flow control assembly being movable between first and second positions for reversing the flow of fluid through said ports, pressure differential responsive regulator means, said pressure responsive regulator means including a casing having a chamber therein and a movable sensing element slidably mounted in said chamber, said movable element being operatively connected to said flow control assembly; a source of compressed gas yieldably biasing said sensing element in a first direction, adjustment means connected to said source for regulating the pressure thereof and conduit means communicating between one of said ports and said chamber to bias said element in the opposite direction, said movable element thereby positioning said flow control assembly responsive to the pressure differential between said source of compressed gas and the fluid pressure within said one duct.

9. The apparatus according to claim 8 wherein a pressure relief valve is communicatively connected to one of said ports for sensing the pressure therein, said relief valve also being communicatively connected to said source of compressed gas and being adapted to allow the escape of gas when the pressure within said duct has reached a predetermined limit.

10. The combination of a reversible flow pump, said pump having an eccentrically mounted rotor, first and second ports for transferring fluid into and out of said pump and a control sleeve rotatably mounted within said pump, said control sleeve including diametrically opposed axally spaced ports movable between first and second positions for reversing the flow of fluid between said ports, pressure differential responsive regulator means, said pressure responsive regulator means including a casing having a chamber therein and a movable sensing element in said chamber, said movable sensing element being operatively connected to said control sleeve, an adjustable source of pressurized gas communicating with said chamber for yieldably biasing said sensing element in a first direction, conduit means communicating between one of said ports and said chamber to bias said sensing element in the opposite direction, said sensing element thereby positioning said control sleeve responsive to the pressure differential between said source of fluid pressure and the fluid pressure within said duct, a reversing valve including a control member movable between first and second positions, said reversing valve being adapted in said first position to connect said first duct, a portion of the chamber on one side of said sensing element and said source of fluid pressure to the other end of said chamber and when said control member is in said second position to connect said second duct with one end of said chamber on said source of fluid pressure to the other end of said chamber.

11. The apparatus according to claim 10 wherein a pressure relief valve is communicatively connected to one of said ports for sensing the pressure therein, said relief valve also being communicatively connected to said source of compressed gas and being adapted to allow the escape of gas when the pressure within said duct has reached a predetermined limit.

No references cited.

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