

[54] AIR OPERATED DIAPHRAGM PUMP

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[58] Field of Search 417/393, 326, 24,
417/464, 465, 404; 91/336, 435

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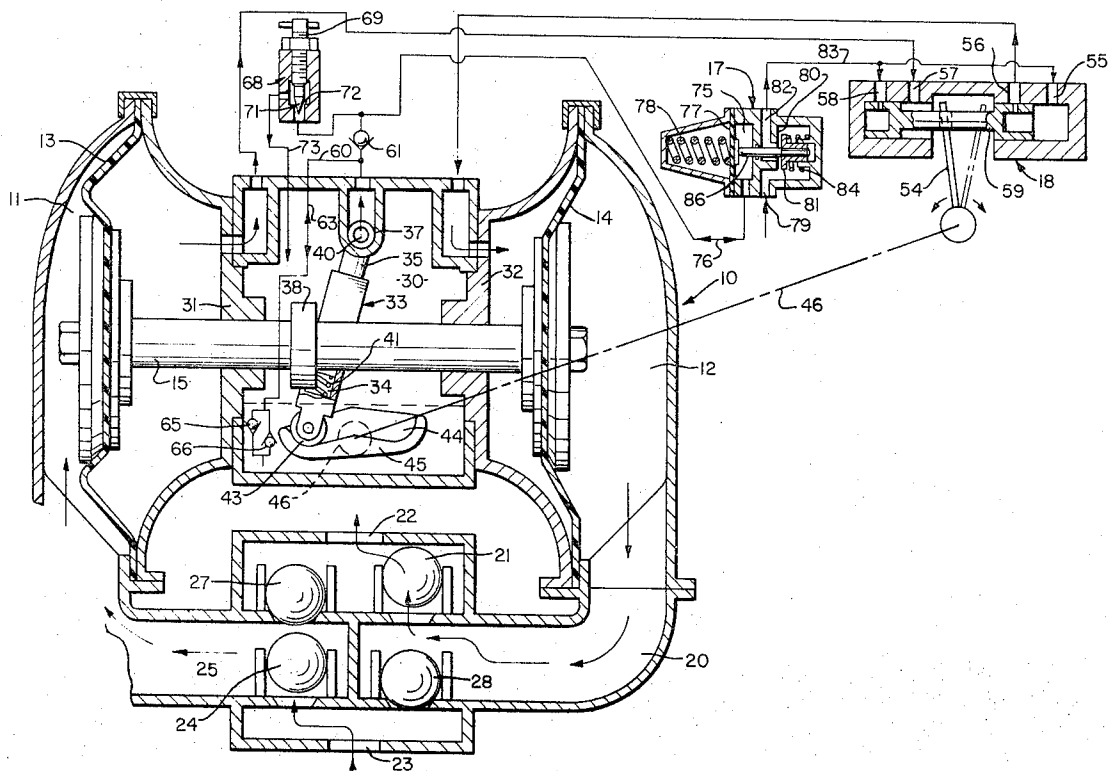
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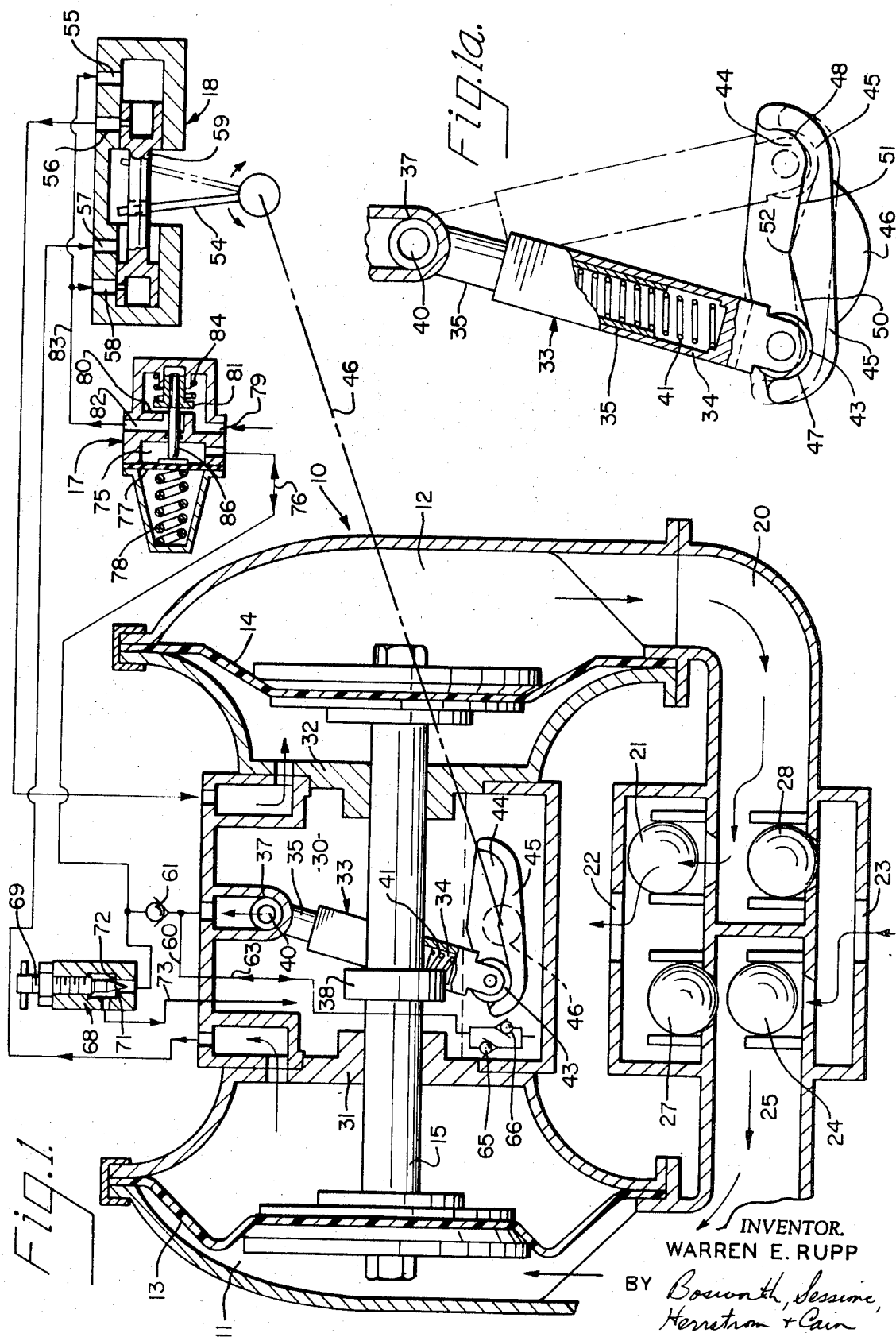
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ABSTRACT

An air-operated diaphragm pump and a governor for controlling its speed of operation. An auxiliary pump is driven by the diaphragm pump and pumps a separate fluid through an adjustable orifice. For a given setting of the orifice the pressure of separate fluid varies with the rate of operation of the auxiliary pump. The pressure of separate fluid is transmitted to a control valve which admits more or less air to the diaphragm pump actuator valve in response to changes in the pressure. The actuating valve directs air to the diaphragm pump to cause it to reciprocate. The actuating valve is snapped from one position to another by the mechanism that actuates the auxiliary pump.

6 Claims, 10 Drawing Figures





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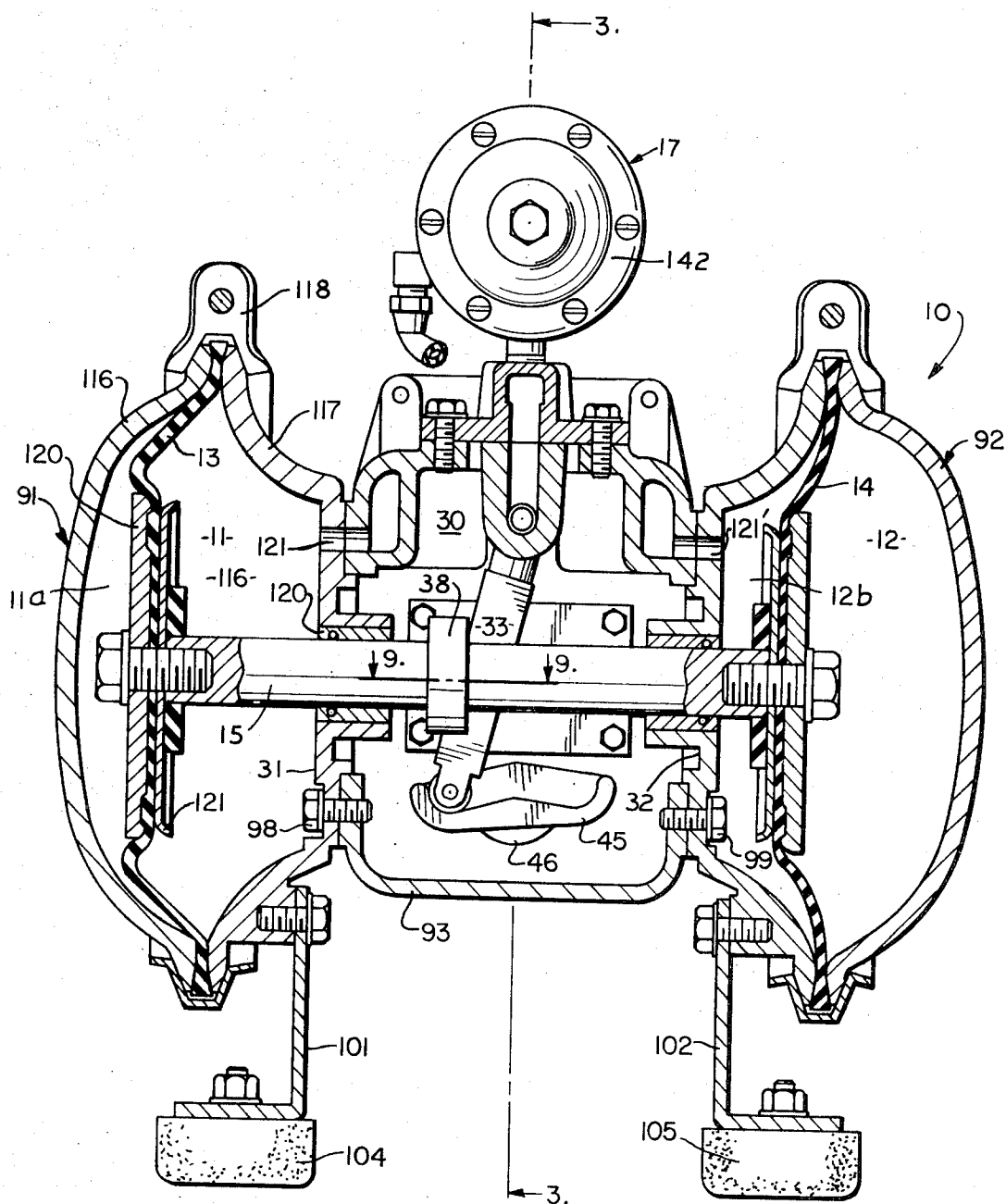


Fig. 2.

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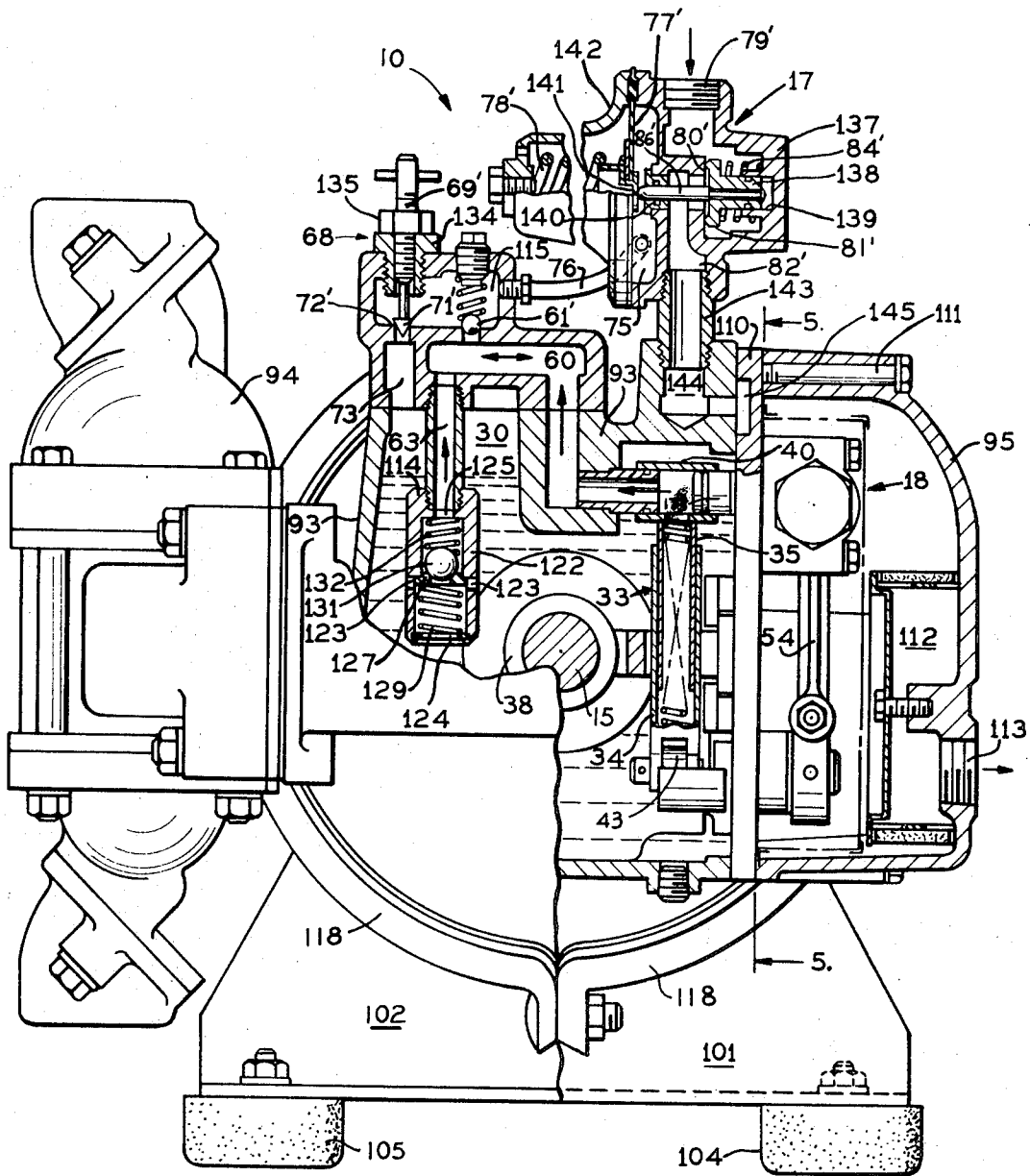


Fig. 3.

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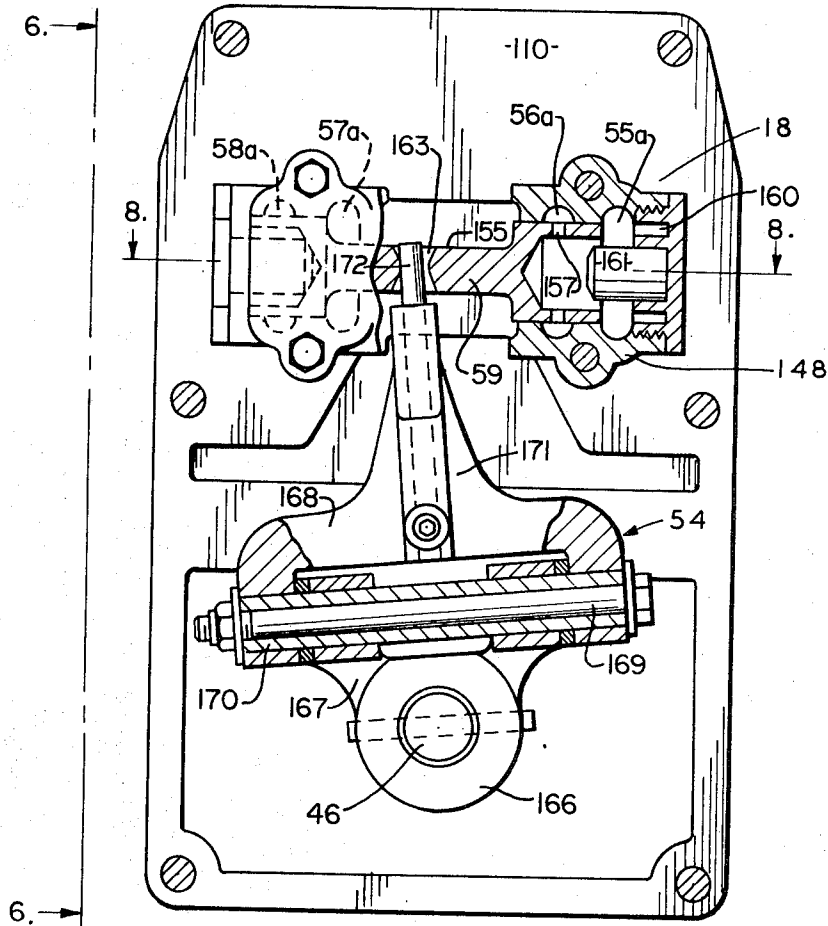


Fig. 5.

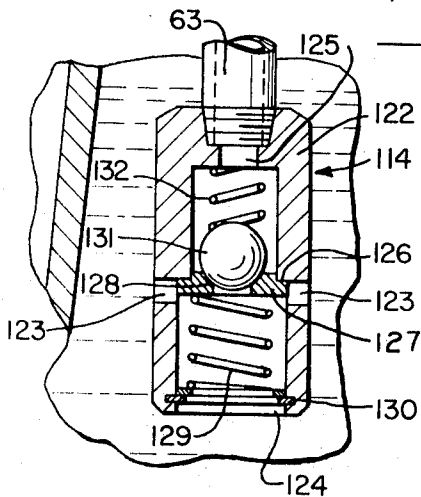
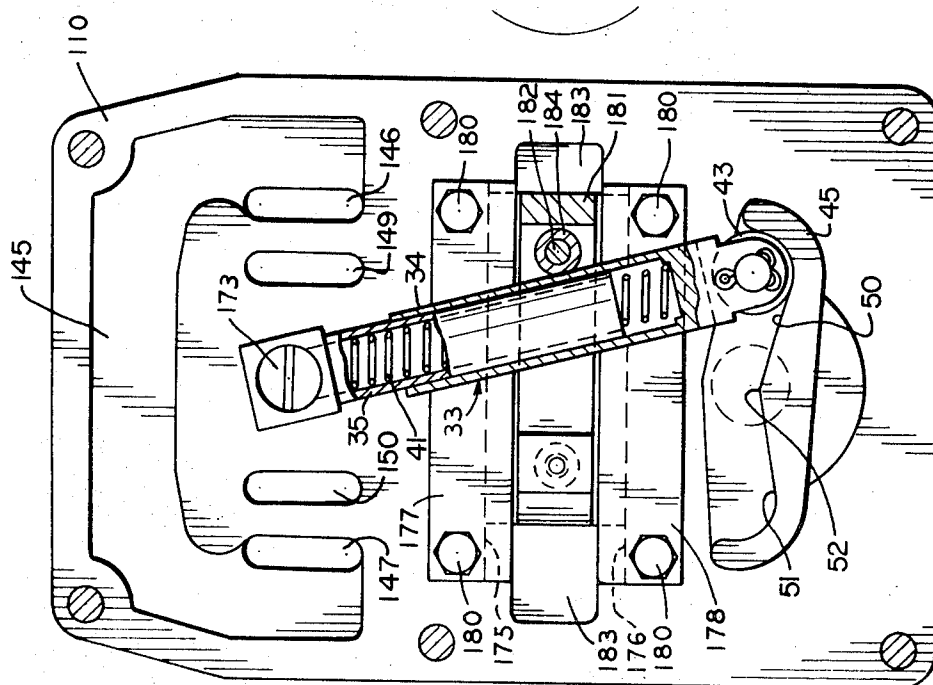
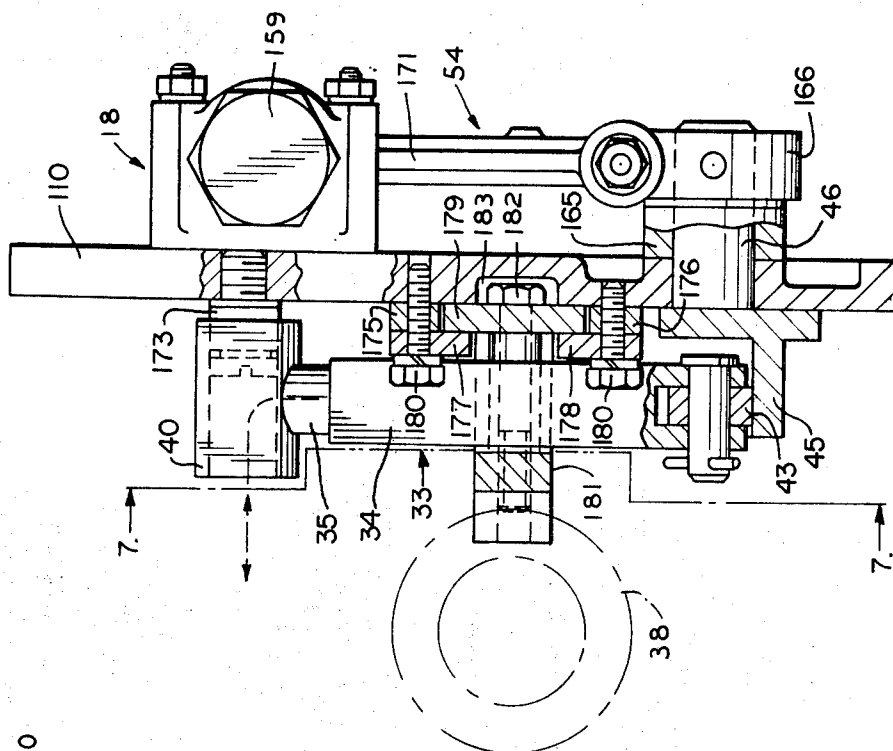


Fig. 4.

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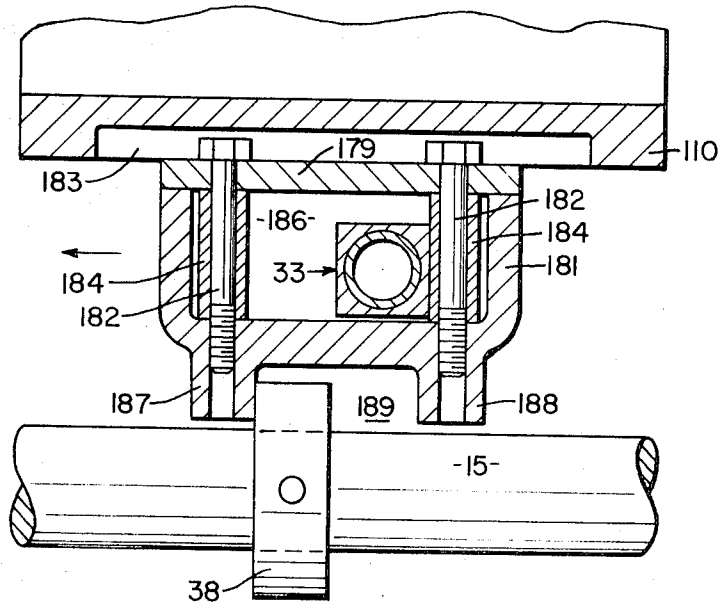
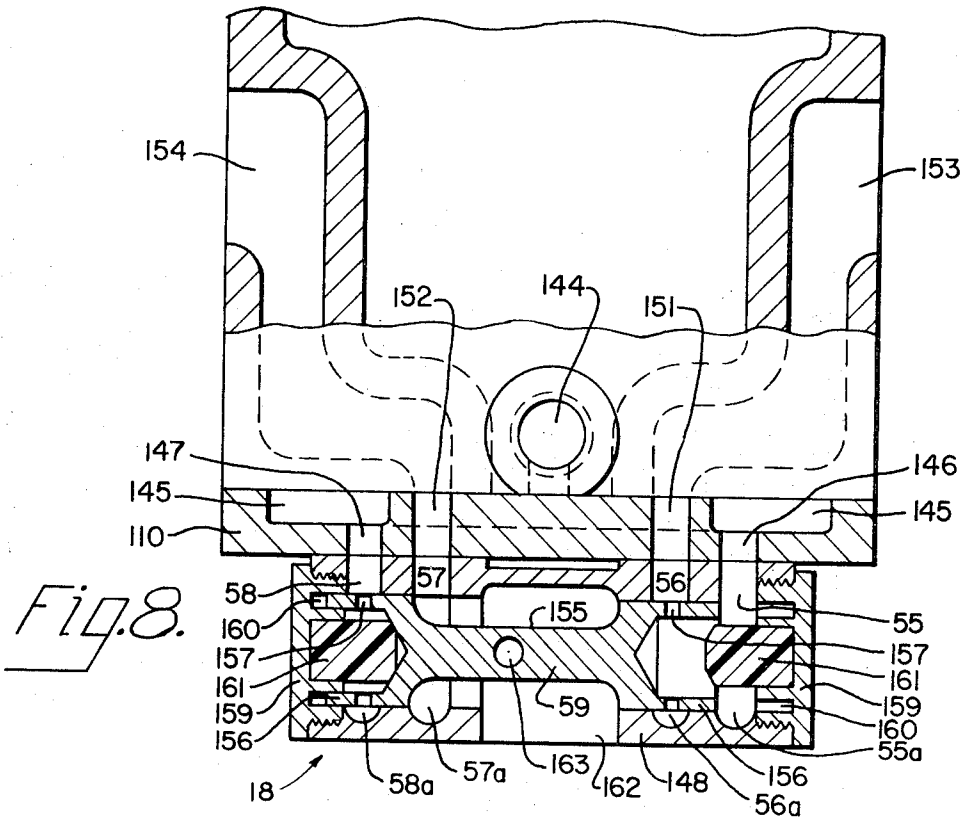


Fig. 9.

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AIR OPERATED DIAPHRAGM PUMP

BACKGROUND OF THE INVENTION

This invention relates to pumps of the reciprocating type and more particularly to a governor especially adapted for air-operated diaphragm type pumps and to a valve actuating mechanism for such pumps.

Air-operated diaphragm pumps are widely used, particularly for pumping liquids, solutions, viscous materials and slurries or suspensions containing substantial amounts of solids (the word "liquid" as used herein is intended to include all such materials). The pumps are frequently used under extremely severe operating conditions and the viscosity of the fluid being pumped, the head on the suction side of the pump and the back pressure on the pump discharge may all vary substantially as conditions under which the pump is operating vary. The usual practice has been to control the speed of such pumps simply by an adjustable valve in the air line leading to the pump. The result has been that unless the operation of the pump is kept under observation and the valve adjusted to suit different conditions, the speed of the pump will vary substantially depending upon conditions of operation. For example, if the back pressure on the pump should increase for any reason or if the viscosity of the liquid being pumped should increase, then the speed of operation of the pump and the quantity of liquid pumped per unit of time will decrease substantially. On the other hand, if the back pressure or viscosity decrease or, to take an extreme example, if the level of the liquid being pumped falls below the suction pipe of the pump, the speed of operation of the pump will substantially increase and under the last condition there would be a waste of compressed air. Therefore, in many installations a pump that is governed to operate at a substantially constant speed under varying conditions is highly desirable.

SUMMARY OF THE INVENTION

A general object of the present invention is to provide an improved governor for reciprocating pumps and especially air-operated diaphragm pumps. Another object is to provide such a governor that can be manufactured economically; that will be long-lived and reliable in service and that will control the pump with which it is associated to operate at a predetermined speed with a reasonable degree of accuracy. Another object is the provision of such a pump governor wherein the speed of operation of the pump can readily be adjusted. A further object is the provision of a pump of the air-operated diaphragm type in which a portion of the mechanism constituting the governor also constitutes a portion of the mechanism for operating the actuating valve for the air supply to the pump diaphragm chambers.

Briefly, the foregoing and other objects and advantages of the invention are attained by providing in association with a reciprocating member of the pump, such as the connecting rod of an air-operated diaphragm type pump, an auxiliary or governor pump that is arranged to discharge a substantially constant volume of a liquid such as oil for each stroke of the reciprocating member of the main pump. Thus, the rate of discharge of liquid by the auxiliary pump is directly proportional to the number of strokes per minute of the main pump. The flow of liquid discharged by the auxiliary pump is utilized, through an orifice that is preferably provided

by an adjustable discharge valve and a diaphragm operated air control valve, to control the air supply to the main pump. The arrangement is such that for a given orifice or a given setting of the adjustable discharge valve, an increase in the speed of operation of the main pump will result in an increase in the discharge pressure of the auxiliary pump. This pressure is applied to the diaphragm of the diaphragm operated air control valve and the increase in pressure results in a throttling of the air flow to the main pump. Conversely, a decrease in the rate of reciprocation of the main pump results in a decrease in the discharge pressure of the auxiliary pump that is applied to the diaphragm operated air control valve. A spring then opens the air valve to increase the supply of air to the main pump and bring its rate of reciprocation back to the rate desired. The auxiliary pump constitutes part of the mechanism that operates the actuating valve that controls the air supply to the pump diaphragm chambers.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring to the drawings:

FIG. 1 illustrates the general arrangement of a preferred form of air-operated diaphragm pump embodying the invention, the pump itself being shown in a somewhat diagrammatic vertical sectional view while the governor mechanism, the air valve actuating mechanism and associated piping and valves are all shown diagrammatically.

FIG. 1a is a fragmentary detail of the auxiliary pump, to an enlarged scale.

FIG. 2 is a vertical sectional view through a preferred form of air actuated diaphragm pump embodying the invention.

FIG. 3 is a transverse vertical sectional view taken approximately along the line 3—3 of FIG. 2.

FIG. 4 is a portion of FIG. 3 to an enlarged scale.

FIG. 5 is a sectional detail showing the actuating mechanism for the pump actuating valve, the section being taken along the line 5—5 of FIG. 3.

FIG. 6 is a view taken at right angles to FIG. 5, as indicated by line 6—6 of FIG. 5.

FIG. 7 is a vertical sectional detail showing the actuating mechanism for the auxiliary pump for the governor, the section being taken approximately as indicated by the line 7—7 of FIG. 6.

FIG. 8 is a horizontal section through the actuating valve for the pump, the view being taken as indicated by line 8—8 of FIG. 5; and

FIG. 9 is a sectional detail to an enlarged scale illustrating the operating mechanism for the auxiliary pump, the section being taken on line 9—9 of FIG. 2.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring to FIG. 1 of the drawings, the invention is disclosed herein as adapted to an air-operated diaphragm pump of a known type which is indicated in general at 10. The pump 10 embodies two diaphragm chambers 11 and 12. The diaphragm chambers are divided by diaphragms 13 and 14, respectively, the diaphragms being connected by a connecting rod 15 so that the diaphragms reciprocate together. Air is admitted alternately to the inner sides of the diaphragms 13 and 14, the air being supplied from any suitable source through a diaphragm operated control valve 17 to the pump actuating valve 18 that is operated at the end of each reciprocation of the connecting rod 15 to admit

air alternately to the inner sides of diaphragm chamber 11 and diaphragm chamber 12. The diaphragms are reciprocated in unison; in FIG. 1 the pump is shown with the chamber 12 at the beginning of its pumping stroke with both diaphragms and the connecting rod moving to the right as indicated by the arrow, air being admitted to the space on the inner side of the 14, 14 which space constitutes a motor chamber for the pump, and liquid being pumped being discharged from the space on the outer side of diaphragm 14, which space constitutes a pumping chamber, through the manifold 20 and discharge valve 21 to the port 22 which is connected to a suitable discharge pipe (not shown).

At the same time air on the inner side of the diaphragm 13 of chamber 11 is permitted by valve 18 to discharge to atmosphere and liquid to be pumped is drawn in through the inlet port 23, which is connected to a suitable suction pipe (not shown), past the inlet valve 24, into the manifold 25 and thence to the outer side of the diaphragm 13 in the chamber 11.

At the end of the stroke the valve 18 is quickly moved to its opposite position by mechanism to be described. The air connections are reversed; air under pressure then being supplied to the inner side of the diaphragm 13 so that both diaphragms are moved to the left. Liquid is then discharged through the manifold 25 past the discharge valve 27 and through the discharge port 22 to the discharge pipe while liquid to be pumped is drawn in through the inlet port 23, past the inlet valve 28 and through the manifold 20 into the chamber on the outer side of the diaphragm 14 in the diaphragm chamber 12. It will be evident that the spaces on the inner and outer sides of the diaphragm 13, like the spaces on the inner and outer sides of diaphragm 14, constitute motor and pumping chambers, respectively.

According to the present invention the connecting rod 15 which reciprocates at a rate that is functional of the discharge of the pump is utilized to control the valve 17 and hence the supply of air to the valve 18 and the pump. The arrangement is such that if the speed of the pump increases above the desired value, the valve 17 functions to throttle the air flow to the valve 18 to bring the speed of the pump operation back to the desired value, while if the speed of the pump is reduced below the desired value, the valve 17 is opened to increase the supply of air to the valve 18 and the pump, thus increasing the speed of operation of the pump to the desired value.

A preferred form of mechanism and fluid circuits for obtaining this result are illustrated somewhat diagrammatically in FIG. 1. As there shown, the pump 10 is provided with an intermediate chamber 30 that contains oil or other appropriate liquid. Connecting rod 15 passes through and reciprocates within this chamber, being supported in aligned openings in the inner walls 31 and 32 of the diaphragm chambers 11 and 12, respectively, appropriate seals being provided to prevent leakage around the connecting rod 15 where it passes through the members 31 and 32. An auxiliary pump 33 is made up of telescoping tubular members 34 and 35 and is also supported within the chamber 30. Pump 33 is pivotally supported at its upper end as indicated at 37. As described below the outer portion 34 of the pump is operatively engaged by a collar 38 secured to the connecting rod 15 so that as the connecting rod reciprocates the auxiliary pump 33 is swung pendulum fashion about its pivot 37. There is lost motion in the

connection between the collar and the pump so that the pump is moved near the end of each stroke of the connecting rod. As appears in greater detail below, the outer part 34 of the pump 33 constitutes the cylinder portion thereof and inner member 35 constitutes a tubular piston. The interior passage of the member 35 is connected through the tubular connection 40 to the external hydraulic control circuits to be described, and the telescoping members 34 and 35 are urged apart by a spring 41 within the cylinder member 34 engaging the end of member 35.

In order to provide pumping action by the pump 33 with each reciprocation of the connecting rod 15 as well as to provide for actuation of the pump actuating valve 18, the end of the cylinder member 34 is provided with a roller 43 that rides in a track 44 on a rocker 45 that is supported within the chamber 30 on a rock shaft 46. The track 44 has end portions 47 and 48, see FIG. 1a, that limit the movement of the auxiliary pump 33 and has ramp portions 50 and 51 that form an inverted V and intersect at a point 52 above the center of rock shaft 46. With this arrangement, as the connecting rod 15 moves to the right in the arrangement shown in the drawings, the pump 33 is swung pendulum fashion to the right and the roller 43 of the pump climbs the ramp 50, telescoping the outer cylinder member 34 of the pump over the inner piston member 35 thereof and reducing the internal volume of the pump so that oil is discharged from the pump through the tubular connection 40. When the swinging motion of the pump 33 continues to a point where the roller has moved just past the apex 52, the spring 41 immediately forces the members 34 and 35 apart, the roller 43 promptly rolls down the ramp 51 and the rocker is rapidly moved to the dotted line position shown in FIG. 1a so that the pump 33 takes the dotted line position shown in FIG. 1a. This increases the volume within the pump 33 so that oil is drawn into the pump for discharge on the subsequent stroke. When the connecting rod 15 moves to the left the same action takes place except that the parts move in the opposite direction.

The auxiliary pump mechanism, rocker 45 and rock shaft 46 not only provide for operation of the auxiliary pump from the connecting rod 15 but also provide a rapid snap action for reversing the pump actuating valve 18 at the end of each stroke of the connecting rod. This is accomplished by the shaft 46 which carries a wand or operating lever 54 that operates the valve 18. When the parts are in the position shown in FIG. 1, air is admitted from the control valve 17 through the port 55 of the valve 18 and flows through port 56 as indicated by the arrows to the inner side of the diaphragm 14 in chamber 12, starting the movement of the diaphragm and the connecting rod 15 to the right as shown in the drawing. At the same time, air is being exhausted from the inner side of the diaphragm 13 in chamber 11 through the port 57, the port 58 being closed by the valve member 59. This condition is continued until the auxiliary pump 33 is moved beyond the apex 52 of the rocker, which occurs very near the end of the stroke of the connecting rod 15 to the right, whereupon the valve operating lever 54 takes the dotted line position shown in FIG. 1, moving the valve member 59 to the right so that the connections are reversed to admit air under pressure to the inner side of the diaphragm 13 in chamber 11 to move the connecting rod and both diaphragms to the left and permitting air to be exhausted

from the inner side of diaphragm 14 through the port 56 to atmosphere. Thus, a quick acting valve actuating mechanism is provided to quickly reverse the connections to the air sides of the diaphragms 13 and 14 at the end of each stroke of the connecting rod 15.

In order to utilize the pumping action of the auxiliary pump 33 to control the flow of air to the pump actuating valve 18 and thence to the pump, the fluid connections diagrammatically illustrated in FIG. 1 are employed. The pump connection 40 leads to a conduit 60 to which is connected a check valve 61. The check valve 61 permits oil to flow from the conduit 60 to an adjustable discharge valve (discussed below) and to the control valve 17 while preventing return flow. A conduit 63 leads from the conduit 60 to an inlet check valve 65 and a pressure relief valve 66.

The pressure in the discharge conduit 60 is established for a given speed of auxiliary pump 33 by a manually adjustable variable-orifice discharge valve 68 by adjusting the position of the threaded member 69 which is provided with a convenient handle. Member 69 is provided at its lower end with a needle valve member 71 which, with valve seat 72, provides a smaller or larger orifice for passage of oil in accordance with the adjustment of threaded member 69. The auxiliary pump 33 thus circulates oil from the chamber 30 through the conduit 60, the outlet check valve 61, the discharge valve 68 and the conduit 73 back to the chamber.

Movement of the needle valve 71 toward or away from its seat 72 varies the size of the valve orifice and, therefore, the pressure drop across the valve 68 and the pressure in conduit 60.

It will be evident that for a given setting of the valve 68 and with a constant speed of operation of the auxiliary pump 33, the back pressure developed across the adjustable discharge valve 68 and hence in the line 60 will be substantially constant. However, if the rate of operation of the main pump 10 increases, the rate of operation of the auxiliary pump 33 will also increase, the pressure drop across the valve 68 will increase and a higher pressure will be reflected in the conduit 60. Similarly, if the rate of operation of the main and auxiliary pumps decreases, the pressure drop across the valve 68 will decrease and that reduced pressure will be reflected in conduit 60.

In order to utilize the pressure in conduit 60 to control the flow of air to the valve 18 and the pump, the diaphragm operated control valve 17 is employed. This valve comprises a body having an oil chamber 75 connected by conduit 76 to the conduit 60 through the check valve 61, the chamber 75 being closed by a spring pressed diaphragm 77 that is urged inwardly by a spring 78. The body of the valve 17 also includes an inlet passage 79 for compressed air from any suitable source, a valve seat 80, an air valve 81 and an outlet passage for air 82 connected by conduit 83 to the ports 55 and 58 of the valve 18. The air valve 81 is urged toward its seat by a spring 84 and is urged away from its seat by the diaphragm 77 acting through plunger 86. With this arrangement, if the output pressure of the auxiliary pump 33 increases, either due to an increase in speed of the pump or to an adjustment of the discharge valve 68, the increased pressure will deflect the diaphragm 77 to the left in the embodiment shown against the action of the spring 78 and the spring 84 will act to move the air valve 81 toward its seat 80 reducing

the flow of air to the valve 18 and to the pump. Conversely, if the pump discharge pressure is reduced, the diaphragm 77 will move to the right under the influence of the spring 78 and, acting through plunger 86, will move the valve 81 away from its seat 80, allowing the flow of air through the outlet port 82 to the valve 18 to increase.

In the extreme position with the adjusting screw 69 screwed down so that the needle valve member 71 is fully seated in the adjusting valve 68, the output pressure of the auxiliary pump 33 will move the diaphragm 77 to the left to such an extent that valve 81 will engage the seat 80 and the air supply to the valve 18 will be shut off or nearly so and the main pump will stop or operate very slowly. Conversely, if the adjusting screw 69 is backed off as far as possible, the output pressure of the pump in the line 60 will be reduced to a minimum and the spring 78 will urge the diaphragm plunger 86 and the valve 81 to their maximum positions to the right resulting in the maximum amount of air available being supplied to the valve 18 and to the pump. Intermediate positions of adjusting screw 69 make it possible to govern the pump to any desired speed between zero or very slow and maximum and the pre-selected speed will be maintained with a reasonable degree of accuracy under widely varying conditions of operation.

In order to prevent development of undue pressure in the system the pressure relief valve 66 is provided and is connected in parallel with the intake valve 65.

Overall Construction

As shown in FIGS. 2 and 3 a preferred form of pump embodying this invention includes diaphragm housings 91 and 92 that provide the diaphragm chambers 11 and 12, an intermediate housing 93 providing the intermediate chamber 30, a manifold assembly 94 and a valve housing 95 for the pump actuating valve (FIG. 3). The manifold assembly 94 provides the liquid inlet and discharge passages and valves diagrammatically shown in FIG. 1. The manifold assembly as such, is of a known type and is not disclosed in detail. The diaphragm housings 91 and 92 are secured to the intermediate housing 93 by means of cap screws 98 and 99 and the entire pump assembly is supported by means of foot mounting brackets 101 and 102 which are connected to rubber foot supports 104 and 105. The housing 95 for the pump actuating valve 18 is secured to the intermediate housing 93 through a valve plate 110 by means of screws 111 as shown in FIG. 3. The housing 95 encloses the pump actuating valve 18, the actuating mechanism for the valve 18 and a muffler assembly 112 which muffles the sound produced by air being exhausted through exhaust port 113 in the valve housing 95.

The chamber 30 within intermediate housing 93 is substantially filled with oil. Housing 93 also has passages by which the auxiliary pump 33 pumps oil from the inlet check and relief valve 114 (representing inlet and relief valves 65 and 66 in FIG. 1) to the adjustable discharge valve 68, and through outlet check valve 61 to control valve 17. The actuating mechanism for auxiliary pump 33 is also within chamber 30.

In operation, connecting rod 15 reciprocates in the manner described with reference to FIG. 1 and causes auxiliary pump 33 to move from one to the other of its extreme positions. The intake or suction stroke of the auxiliary pump 33 occurs when the inner member 35 of pump 33 is extended from the outer member 34 and

causes oil to be drawn from chamber 30 through inlet valve assembly 114 and conduits 63 and 60 into the pump. The output stroke occurs when member 35 is telescoped into member 34, causing oil to be pumped through conduit 60 and outlet check valve 61 through adjustable valve 68 back to chamber 30. The pressure developed on the output stroke depends upon the pressure drop across valve 68 as described above. This pressure is applied to oil chamber 75 of the control valve 17. As the auxiliary pump 33 moves from one to the other of its stable positions, it tips rocker 45 and through rock shaft 46 causes the actuating operating lever 54 to snap pump actuating valve 18 to its alternate position. Compressed air is thereupon transferred through valve 18 to the appropriate diaphragm chamber 11 or 12 to drive the corresponding diaphragm 13 or 14 to its opposite position.

Diaphragms and Diaphragm Chambers

The diaphragm housings 91 and 92 are alike and contain like diaphragms and diaphragm chambers. Only housing 91 is described. Corresponding parts of housing 92 are referred to when necessary by corresponding primed reference numerals. Housing 91 comprises an outer member 116 and an inner member 117 that clamp the diaphragm 13 therebetween and are held by means of a V-clamp 118. The members 116 and 117 define the diaphragm chamber 11 which is divided by the diaphragm 13 into an outer diaphragm chamber 11a and an inner diaphragm chamber 11b. The middle portion of diaphragm 13 is secured to the connecting rod 15 in a conventional manner as shown. The connecting rod 15 extends through a sleeve bearing 120 in the inner wall of diaphragm chamber 11. Chamber 11b communicates with air passages in intermediate housing 93 through air inlet and exhaust port 121. O-rings or other suitable fluid seals are provided where needed and are not referred to specifically. Chamber 126 communicates with similar passages through port 121'.

Inlet Check and Relief Valve

The inlet check and relief valve 114 (FIGS. 3 and 4) comprises a valve body 122 having a relief port 123 about midway of its length, an inlet 124 at its lower end and with an outlet 125 at its upper end connected to a nipple that defines conduit 63. In order to provide the pressure relief valve 66 of FIG. 1, a shoulder 126 is formed in the valve body. A valve member 127 having a valve seat 128 is held against the under side of the shoulder 126 by a spring 129 within the lower portion of valve body 114, the spring being supported by a washer that rests upon a snap ring 130 disposed in a groove in the valve body. The inlet check valve 65 is constituted by a valve ball 131 and a spring 132.

On the intake or suction stroke of auxiliary pump 33 oil is drawn through the inlet port 124 and lifts ball 131 off its seat against the action of spring 132. Oil is thereby drawn into auxiliary pump 33. On the output stroke of auxiliary pump 33 ball 131 prevents oil from flowing through valve seat 128. However, if the pressure should exceed an amount determined by spring 129, valve member 127 will be forced downwardly against the force of spring 129 and will allow oil to flow through ports 123 into chamber 30. Valve assembly 114 thus constitutes the inlet check valve 65 and pressure relief valve 66, permitting oil to flow into chamber

30 if the pressure in passage 63 becomes excessive for any reason.

Adjustable Discharge Valve

Discharge valve 68 is shown in FIG. 3 and functions to provide a particular pressure of oil in conduit 60 for a particular speed of operation of auxiliary pump 33 and to provide greater or lesser pressures of oil as the pump speed increases and decreases, respectively. The size of a variable orifice in the valve is manually adjusted to provide the particular pressure of oil at the particular speed of auxiliary pump 33. Increases or decreases in auxiliary pump speed provide corresponding increases or decreases in the flow rate of oil through the orifice, resulting in increases or decreases in oil pressure in conduit 60. The valve is preferably constructed substantially as shown somewhat diagrammatically in FIG. 1 and corresponding primed reference characters have been applied to corresponding parts in FIG. 3. The valve comprises a valve seat 72' in a valve chamber that communicates with conduit 60 formed in the upper part of housing 93 through outlet check valve 61'. A needle valve member 71' is adjustable closer to or farther from the valve seat 72' and defines with it a variable orifice which controls the flow of oil between conduit 60 and conduit 73 which leads to chamber 30. The upper end of the valve body is closed by a member 134 into which an adjusting screw 69' is threaded. Needle valve member 71' is connected at its upper end to the lower end of adjusting screw 69'. The size of the orifice between valve member 71' and valve seat 72' may be varied by turning the adjusting screw in the threaded bore of the member 134. A knurled nut 135 is provided to lock adjusting screw 69' in position.

In operation, on the output stroke of auxiliary pump 33 oil in passage 60 is pumped through check valve 61 and through the orifice in valve 68. The area of the orifice in the valve can be controlled by positioning the valve member 71' with respect to the valve seat 72'. Thus the pressure of the oil in the passage 60' which is ultimately transmitted to the control valve 17, can be varied by adjustment of screw 69'.

Outlet Check Valve

This valve, shown at 115 in FIG. 3, constitutes the check valve 61 described in conjunction with FIG. 1. Valve 115 is screwed into the upper part of housing 93 and provides substantially unrestricted passage for oil from passage 60 into adjustable valve 68 and into oil chamber 75 of control valve 17 on the output stroke of auxiliary pump 33. The valve preferably takes the form of a conventional ball check 61' as shown. The valve body has a portion extending at right angles to the main body which communicates with the valve chamber of valve 68. The valve body also is connected by a conventional fitting to a hose assembly forming the conduit 76 which leads into the chamber 75 of control valve 17. The operation is as described with respect to FIG. 1.

Diaphragm Operated Control Valve

The diaphragm operated control valve 17 is mounted on the housing 93 as shown in FIGS. 2 and 3 and is constructed and operates essentially as shown and described with reference to FIG. 1. Corresponding primed reference characters are applied to corresponding parts. The valve comprises a valve body 137 having the inlet port 79' which is connected to a suitable

source of air under pressure (not shown) and leads to a valve chamber containing the valve seat 80', valve member 81' and spring 84'. Valve member 81' has a cylindrical portion 138 that slides in a cylindrical recess 139 in the inner wall of the valve body 137 and is provided with a fluid seal.

A plunger 86' is connected to the cylindrical portion 138 of the valve member as shown, having one end passed through a central opening in the cylindrical portion. Clearance is provided between the wall of the central opening and the portion of plunger 86' received therein so that air can pass from the valve chamber through the central opening and into the recess 139. The valve is thereby balanced under varying air pressures.

The plunger 86' extends from the front face of valve member 81' and through a sealing member 140 into the oil chamber 75'. The oil chamber 75' is defined on one side of the wall of the valve body and at the left (as viewed) end by the flexible diaphragm 77'. Diaphragm 77' is provided at its center with a metallic member 141 that acts as a guide and seat for spring 78' and also provides a contact face for the plunger 86' on the valve member 81'. The spring 78' is housed within a conventional housing 142 that is secured to the valve body and clamps the diaphragm in place. The spring chamber is vented to atmosphere pressure. The outlet port 82' is connected to a nipple 143 and communicates with a passage 144 in the intermediate housing which leads through the valve plate 110 and then to the inlet ports 55 and 58 of pump actuating valve 18, thus constituting the conduit 83 described with reference to FIG. 1.

The operation of the valve 17 is as described above, the oil in chamber 75' exerting a force on the diaphragm 77' that depends upon the pressure of oil within the chamber 75' which is determined by the setting of regulator valve 68. Valve 17 thus operates as a throttling valve, being opened more or less according to the pressure in chamber 75' so that more or less compressed air is supplied to pump actuating valve 18 to increase or decrease the speed of the governed pump as required.

Pump Actuating Valve and Actuating Mechanism Therefor

Preferred constructions of the pump actuating valve 18 and its actuating mechanism are shown in FIGS. 3 to 8. Referring first to FIGS. 3, 7 and 8, air is supplied from the control valve 17 to the passage 144 in the intermediate housing 93 and from there to the valve plate 110 which has parts that function as a manifold for air supplied to pump actuating valve 18. The passage 144 communicates with a recessed portion 145 in valve plate 110 which directs air to two openings 146 and 147 (FIG. 7). Openings 146 and 147 communicate with the inlet ports 55 and 58 in the valve body 148 of actuating valve 18. In FIG. 8 the passage 144 in intermediate housing 93 is shown in dashed outline. Air from pressure control valve 17 passes downwardly through passage 143 and through passage 144 to recessed portion 145 and from there to openings 146 and 147 in valve plate 110. Valve plate 110 is also provided with passages 151 and 152 which communicate at one end with the valve body 148 and at their other ends with passages 153 and 154 in intermediate housing 93. Passages 153 and 154 communicate with the openings

to the diaphragm chambers 11 and 12 in the diaphragm housings 91 and 92.

The pump actuating valve 18 is substantially as shown somewhat diagrammatically in FIG. 1. As shown in FIGS. 5 and 8 the ports 55 and 58 are formed in the body 148 and align with openings 146 and 147 in valve plate 110. The ports 56 and 57 are also formed in the valve body; these align with openings 151 and 152 in the valve plate 110. Annular grooves 55a, 56a, 57a and 58a in the valve body communicate with ports 55, 56, 57 and 58, respectively. The valve member 59 which is spool-shaped has a central necked down portion as shown at 155 and end portions 156 with openings 157 therein adapted to be aligned with the passages in valve body 148. Each end of valve body 148 is closed by a threaded fitting 159 having an annular slot 160 into which an end portion 156 of the valve member 59 is adapted to project. A rubber stop member 161 is disposed in the central portion of each fitting 159. These act as stops for the valve member 59 as it reciprocates. The valve body 148 is also provided with a centrally located opening 162 which serves as an exhaust port for exhausting air to atmosphere. The valve member 59 is provided with a central hole 163 which receives the end of the actuating lever 54 that moves the valve member 59 from one to the other of its positions.

With the valve member 59 in the position shown in FIG. 8, operation is as described with reference to FIG. 1. The air from pressure control valve 17 flows into inlet 55 of valve 18. The path of air is then past the end of valve member 59 and stop member 161, through opening 157 in valve member 59 and through port opening 56 in the valve body to opening 151 in valve plate 110 and into passage 153, which leads to the inner diaphragm chamber 12b to exert pressure on diaphragm 14. At the same time air from inner diaphragm chamber 11b flows through passage 154 through opening 152 in valve plate 110 and port 57 in valve body 59 and is exhausted to atmosphere through opening 162. In this position, the valve member 59 blocks flow of air through the port 58.

In the opposite position of the valve 17 the valve member 59 is moved to the right and air flows from openings 146 and 147 in valve plate 110, through port 58 in valve body 59, opening 157 in the left end of valve member 59 and port 57 in valve body 59, and ultimately through passage 152 to inner diaphragm chamber 11b to exert pressure on diaphragm 13, causing the pump to reciprocate in the opposite direction. At the same time, air from diaphragm chamber 12b is exhausted through passage 153 and ultimately to port 56 in valve body 148 which communicates with exhaust opening 162.

It will be noted that holes 157 in valve member 59 are small in comparison with the openings in valve body 148 and in valve plate 110. This is done to maintain nearly equal pressure on the two ends of the spool-type valve member 59 so that it is substantially balanced and requires little force to be shifted from one position to the other. A minimum of pressure drop is felt at the ends of the spool-type member because the pressure drop is radially directed across the ports 157.

As described in connection with FIG. 1, the valve actuating lever 54 is moved rapidly from one extreme position to the other by the rock shaft 46 that rocks as the auxiliary pump 33 moves from one to the other of its positions. This shifts the valve member 59 from one to

the other of its extreme positions. As shown in FIGS. 5 and 6, the rock shaft 46 extends through an opening in the lower part of valve plate 110 that forms a closure for one side of intermediate chamber 30 and through a bearing 165 and into a collar 166 that is pinned to the shaft.

In order to operatively secure collar 166 to the arm 54, the collar and the arm 54 are provided with yokes 167 and 168 (FIG. 5) that have aligned openings through which a bolt 169 and sleeve 170 extend to provide a hinged connection that prevents binding of the arm 54 and the valve member 59 in the event of misalignment.

The arm 54 is completed by an upward extension 171 that adjustably supports a rod 172, the upper end of which extends into the openings 163 in the valve member 59. By this mechanism the actuating arm and valve member 59 are shifted every time the rock shaft is moved from one position to the other by operating mechanism for the auxiliary pump 33.

Auxiliary Pump and Operating Mechanism Therefor

The details of auxiliary pump 33 and its operating mechanism are shown in FIGS. 2, 6, 7 and 9. The pump comprises the cylinder 34 and the inner piston 35; a spring 41 is provided to urge the members apart. The cylinder 34 is rectangular and at its lower end supports the roller 43 that rolls on the track of rocker 45.

The upper end of plunger 35 is secured as by brazing or welding to the tubular connection 40 which connects the interior of the pump to passage 60 (FIG. 3) and also acts as a pivotal support for the pump, being pivotally supported on a stud 173 secured to the valve plate 110.

The operating connection between the connecting rod 15 and the auxiliary pump 33 comprises the collar 38, a pair of guide bars 175 and 176 and a pair of retainer bars 177 and 178 that together provide guide ways for a slide bar 179, FIG. 6. The spacer bars and the retainer bars are secured to valve plate 110 by means of screws 180. A yoke 181 (FIG. 9) is secured to the slide bar by means of screws 182 having their heads received in a slot 183 in valve plate 110. The screws 182 are encased in spacer sleeves 184. Yoke 181 has a central opening 186 through which auxiliary pump 33 extends and has projecting lugs 187 and 188 that define a space 189 that are alternately engaged by collar 38 on connecting rod 15.

In operation, as connecting rod 15 is driven in one or the other direction collar 38 will, toward the end of the connecting rod's travel, contact one of the projections 187 or 188 and cause yoke 181 and slide bar 179 to move in the direction of movement of the connecting rod. One of the sleeves 184 will engage auxiliary pump 33 and swing it about its pivot. However, no movement of the rock shaft 46 will take place until the roller 43 climbs up one of the ramps 50 or 51 and just passes the apex 52 of the ramps. When this point is reached, as described with reference to FIG. 1, the discharge stroke of pump 33 is completed and the spring 41 causes the roller to travel quickly down the other ramp and the pump to swing to its other extreme position, rocking the shaft 46 as it does so. This completes the intake stroke of the pump. The clearance space 186 permits the pump to swing rapidly and independently of the collar 38 and yoke 181.

Thus, as soon as the roller 43 passes the apex 52 in either direction of movement of the rocker, the rocker and shaft 46 are quickly moved to their other extreme positions and the lever 54 and valve member 59 of the actuating valve 18 are rapidly moved to their opposite extreme positions, reversing the air connections to the diaphragm chambers and initiating another stroke of the main pump, whereupon the above described operations are repeated in the opposite direction.

The dimensions of the parts are correlated so that, assuming the connecting rod 15 to be moving in the direction of the arrow in FIG. 9, the collar 38 engages the lug 187 sufficiently before the desired end of the stroke of the main pump so that the roller completes its movement up the ramp and just beyond the apex 52 of the rocker as the main pump very nearly reaches the desired end of its stroke in the indicated direction. At this point, the pump 33 moves rapidly to its extreme opposite position, the rock shaft, lever and valve member 59 are rapidly snapped to their opposite positions, and the motion of the main pump is quickly reversed. The same action then takes place at the end of the reverse stroke of the main pump.

It will be apparent from the foregoing that the present invention provides an improved governor for a fluid driven reciprocating pump that is simple in construction and will be long lived and reliable in operation and wherein the speed of operation of the governed pump can readily be adjusted. Numerous other advantages will be apparent to those skilled in the art to which the invention relates.

While a preferred form of this invention has been described and illustrated herein it will be apparent to those skilled in the art that changes and improvements may be made in the form herein specifically disclosed without departing from the scope and spirit of the invention. Accordingly, this invention is not to be limited to the form herein specifically disclosed nor in any other way inconsistent with the progress in the art promoted by this invention.

What is claimed is:

1. In combination, a fluid driven reciprocating pump having at least one motor chamber and an actuating valve for directing actuating fluid to said motor chamber to cause said reciprocating pump to reciprocate, and a governor for controlling the speed of said reciprocating pump, said governor comprising an auxiliary pump, means for driving said auxiliary pump from said reciprocating pump, a source of separate fluid to be pumped by said auxiliary pump, adjustable discharge valve means in the discharge line of said auxiliary pump for producing changes in the pressure of the separate fluid therein in response to changes in the rate of operation of said auxiliary pump, a control valve responsive to changes in the pressure of the separate fluid in said discharge line for varying the rate at which fluid is supplied to said reciprocating pump, and means comprising the auxiliary pump and the driving means therefor for operating said actuating valve.

2. The combination as claimed in claim 1 wherein said auxiliary pump is a piston and cylinder pump supported for pivotal movement about one end thereof, and further comprising means defining a track for the opposite end of said pump, said track having a central portion extending toward said pump, said piston being extended from said cylinder when said other end of said pump is at either end of said track and being retracted

within said cylinder when passing said central portion, whereby pumping action is produced as said pump travels from one to the other end of said track.

3. The combination as claimed in claim 2 wherein said means for changing the position of said actuating valve includes a shaft coupled to said track defining means, said track defining means being rockable about said shaft and being transferred from one to another position as said auxiliary pump is transferred from one to another position, and an arm coupled to said shaft for moving said actuator valve from one to the other of its positions, said auxiliary pump acting as, over center means for snapping said actuator valve from one to the other of its positions.

4. The combination as claimed in claim 2 wherein said fluid driven pump includes a reciprocating shaft and wherein said means for operating said auxiliary pump comprises a yoke slidably supported on said reciprocating shaft and adapted to contact said auxiliary pump, and a collar carried by said reciprocating shaft engageable with portions of said yoke to slide said yoke from one position to another and thereby transfer said auxiliary pump from one to the other end of said track.

5. The combination as claimed in claim 4 wherein said yoke and said collar are normally positioned with respect to said auxiliary pump to provide a lost motion connection.

6. An air-operated diaphragm pump having two diaphragm chambers and an intermediate housing between said diaphragm chambers, a diaphragm in each diaphragm chamber, a connecting rod connecting the diaphragms and reciprocating with the diaphragms and extending through said intermediate housing, an actuating valve for alternately connecting the inner sides of said diaphragm chambers to a source of air under pressure to cause said diaphragms and said connecting rod to reciprocate in unison, said actuating valve in one position admitting air under pressure to the inner side of one diaphragm chamber while permitting air to exhaust from the inner side of the other chamber and in another position permitting air to exhaust from the inner side of said one chamber and while admitting air under pressure to the inner side of said other chamber, and means

for quickly moving said actuating valve from one position to the other at the end of each reciprocation of said connecting rod to cause said pump to operate, said moving means comprising an operating lever mounted on a rock shaft supported by said intermediate housing, said operating lever engaging said actuating valve whereby rocking of said rock shaft causes said operating lever to shift said actuating valve from one position to the other, a rocker fixed to said rock shaft and having a track thereon, a member pivotally mounted in said housing at a point spaced from said rocker, said member having a portion engaging the track on the rocker, said member having resilient means biasing said portion that engages said track away from said pivotal mounting, said track being V-shaped and having ramp portions and a central apex between said ramp portions whereby when the track engaging portion of said member is moved from engagement with one of said ramps over said apex into engagement with the other of said ramps the rocker and rock shaft are quickly rocked, said operating lever is moved and said actuating valve is shifted from one position to the other, and operative connections between said connecting rod and said pivotally mounted member whereby said member is swung about its pivot to cause said track engaging portion thereof to move across the apex of said track near the end of each reciprocation of said connecting rod, thereby rocking said rocker and said rock shaft and causing said operating lever to shift said actuating valve from one position to the other, said pivotally mounted member comprising an auxiliary pump having a cylinder and a piston reciprocated within said cylinder as the member is swung about its pivot, said housing containing a supply of separate fluid to be pumped by said auxiliary pump, means defining an orifice in the discharge line of said auxiliary pump whereby for a given setting of said orifice the pressure in said discharge line varies with the rate of operation of said auxiliary pump, and a control valve responsive to changes in the pressure of separate fluid in said discharge line for varying the rate at which air is supplied to said air-operated diaphragm pump to thereby control the speed thereof.

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