Dec. 25, 1962 C. O. GLASGOW 3,070,023

FLUID OPERATED PUMP

Filed Sept. 28, 1959 4 Sheets-Sheet 1

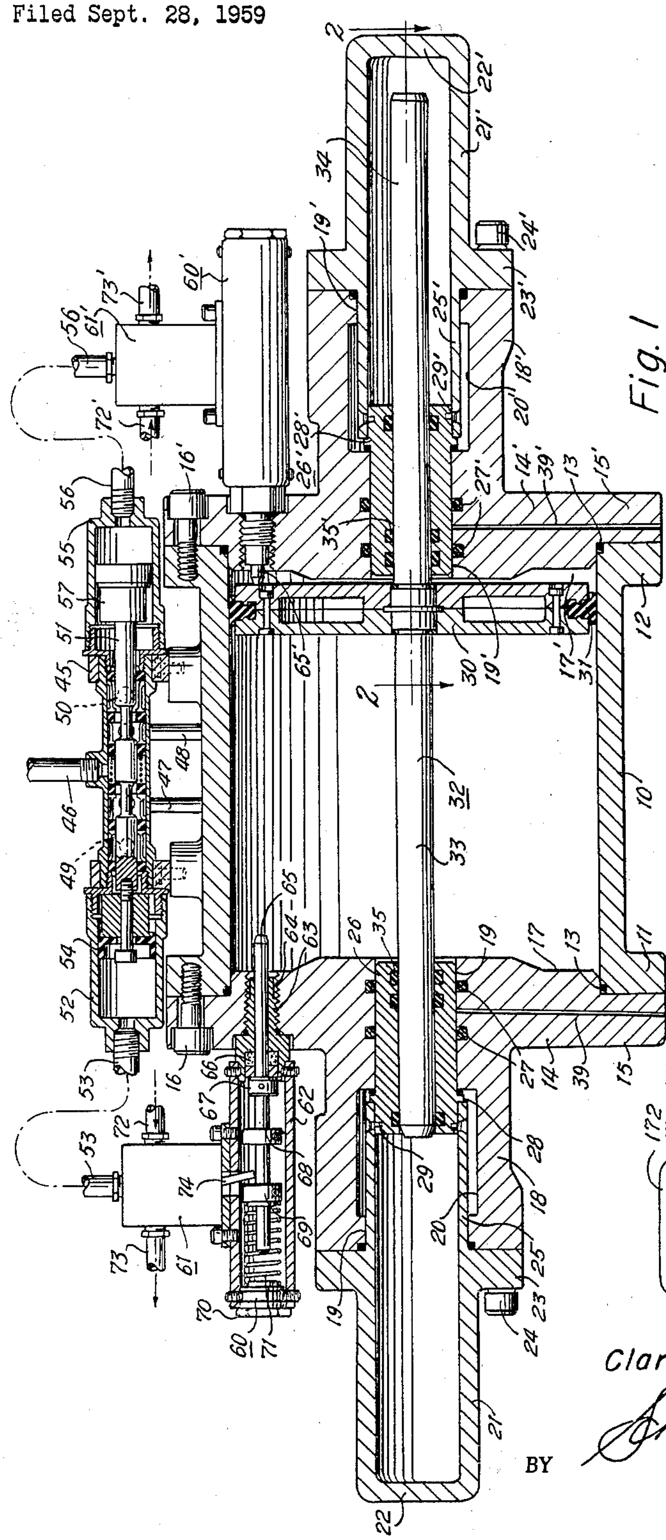

Fig. 1

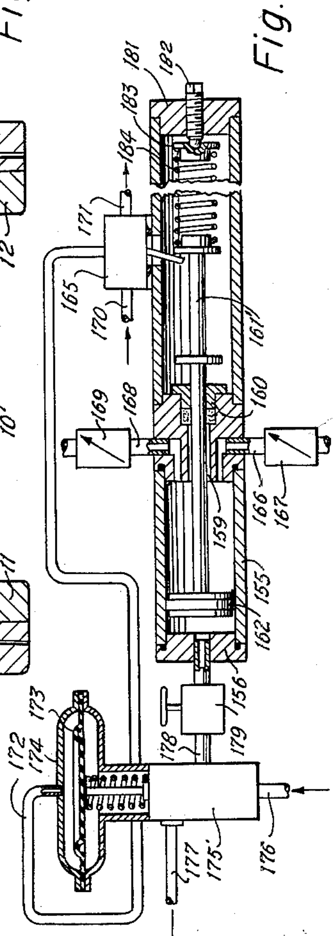

Fig. 7

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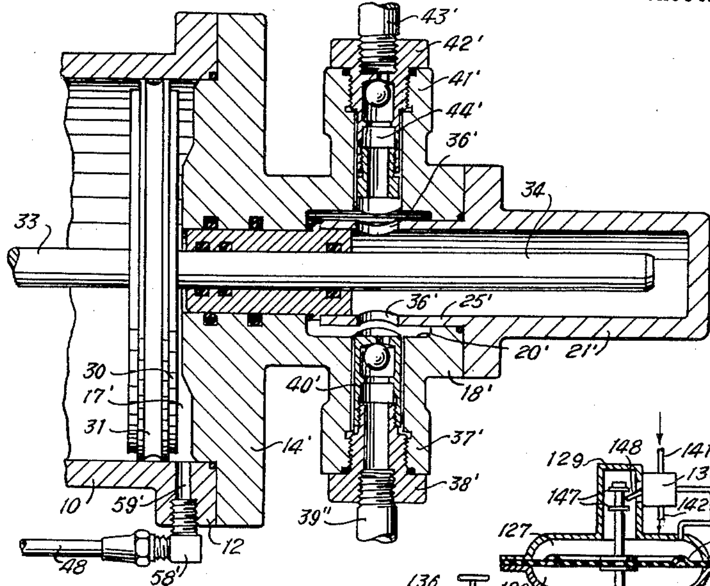

Fig.2

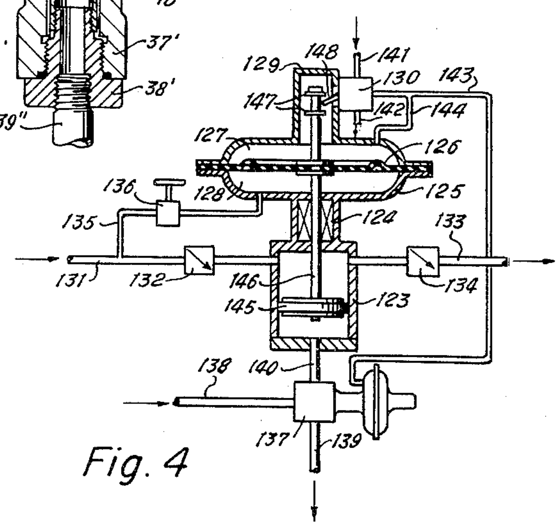

Fig. 4

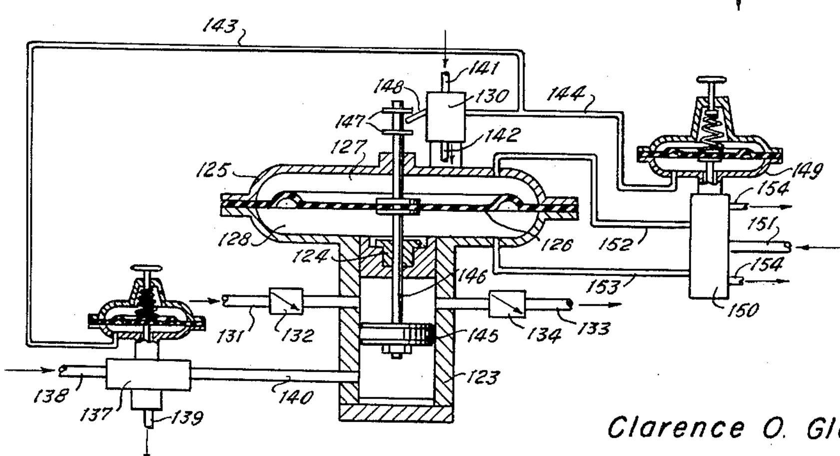

Fig.5

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FLUID OPERATED PUMP

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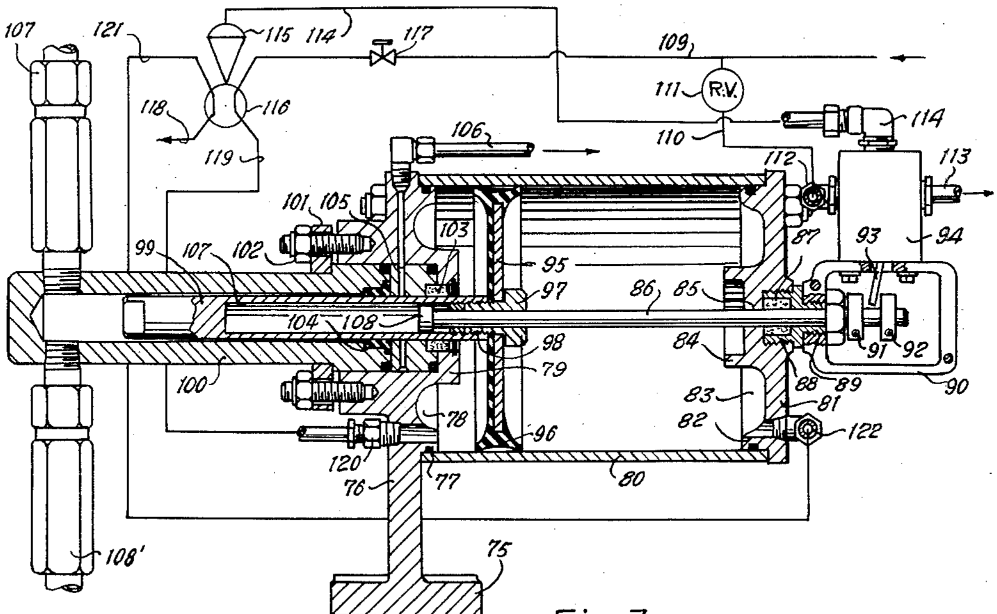

Fig.3

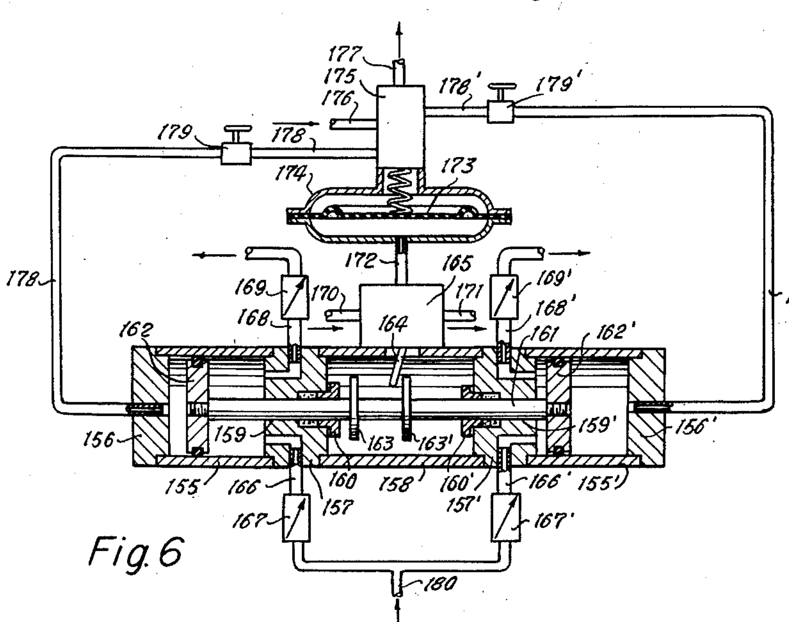

Fig.6

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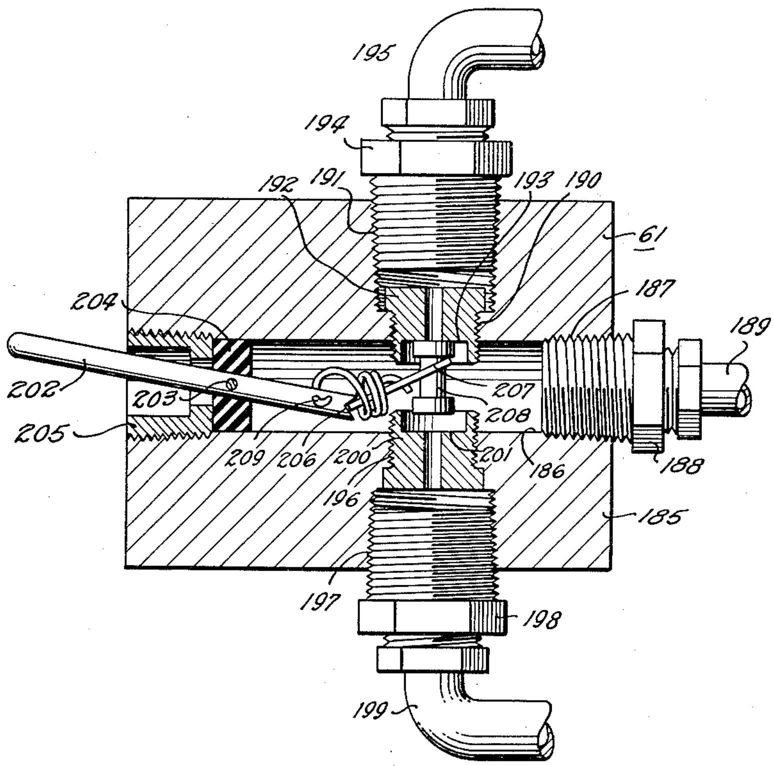

Fig. 8

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United States Patent Office

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FLUID OPERATED PUMP

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Filed Sept. 28, 1959, Ser. No. 842,831
11 Claims. (Cl. 103—51)

This invention relates to new and useful improvements in fluid operated pumps.

There are many instances in which it is necessary or desirable to pump a fluid, usually a liquid, into a vessel, conductor, or other enclosure under relatively high pressure utilizing a low or intermediately pressured fluid as a source of motive power. It is often necessary only to pump relatively small quantities of fluid or liquid into the high pressure system, usually under adjustable or predetermined rates, but under the high pressures involved, difficulties have been encountered involving leakage in the pumping system as well as accurate control of the quantities of fluid being pumped. In many cases, the fluid operated pump must function unattended for considerable periods of time and with relatively infrequent inspection. Under such conditions, it is preferable that the pump use a source of fluid under comparatively low pressure as a source of motive power, both for reasons of economy as well as reasons of continuity of operation and ability to function properly in remote locations where electric power and similar conventional sources of motive power may not be available.

A specific example of a fluid operated pump of the nature set forth is to be found in the oil fields in which large flowing volumes of natural gas may require dehydration or other treatment prior to entry into a gas transmission pipe line. In particular, it is conventional to pass large volumes of natural gas through dehydration towers or dehydration equipment in which the gas is brought into intimate contact with a concentrated glycol solution, such as 96 percent or 98 percent diethylene or triethylene glycol, in order to remove from the natural gas virtually all of the moisture present so that the gas may subsequently be introduced into and flowed through a gas transmission pipe line without the danger of gas hydrates' occurring. In such an installation, it may be necessary to pump the glycol solution into a contactor tower operating at pressures of from 1500 to 2000 pounds per square inch or more, and yet, it is desirable to employ as a source of motive power natural gas or other fluid under moderate pressures up to the magnitude of 100 pounds per square inch. In connection with this particular example, it has been found in the past that existing pump structures present difficult leakage problems, especially in the glycol circuit, that they are not always positive in action so as to provide continuity of the pumping operation, and that the flow rates are not always too readily established and maintained at a pre-selected level. In a glycol dehydration system of this type, it is the usual practice to pump to the concentrated glycol into the contactor tower, to remove the dilute or spent glycol solution therefrom and subject it to a heating step in which excess moisture is removed so that the reconcentrated glycol may again be returned to the gas contacting tower. In this manner, the glycol flows in a continuous circuit, absorbing moisture from the natural gas stream and being relieved of such moisture in the heating or regenerating equipment.

Many other similar uses of fluid operated pumps are to be encountered, but for the purposes of brevity and clarity, the invention will be described largely with respect to utilization of the fluid operated pump in connection with the glycol system or circuit of a natural gas dehydration unit.

With the foregoing problems and malfunctions in view,

it is a principal object of this invention to provide an improved fluid operated pump adapted to utilize fluid under relatively low pressure as a source of motive power and to pump a second fluid into a high pressure system in a completely positive fashion with continuous and trouble free operation assured, and with elimination to a large degree of the problems of leakage, irregular or shifting pumping rates, as well as the maintaining of reliable and certain pumping operations in remote locations with very infrequent inspection and maintenance.

A particular object of the invention is to provide an improved fluid operated pump of the reciprocating type in which a quick and positive snap action is obtained in the valve or valves controlling the flow of motivating fluid under pressure so as to make certain the positive, quick, and exact reversal of movement of the driving piston at each end of its stroke.

An additional object of the invention is to provide an improved structure of the character described in which the same piston may be employed as both a driving piston and a driven piston, and which may be single or double acting in operation.

A further object of the invention is to provide an improved fluid operated pump particularly adapted for utilization in the glycol circuit of a natural gas dehydration system, and in which provision is made for simultaneous pumping of both the concentrated and dilute glycol solutions, and in which dilute glycol and/or natural gas under pressure may be employed as the motivating fluid under pressure.

Yet an additional object of the invention is to provide the new combination of a fluid operated pump employing unique snap action valves for the purpose of switching the motivating fluid under pressure as required for reciprocation of the driving piston of the pump with assurance of positive and very quick reversal of flow of the motivating fluid between different sides of the actuating piston.

Other and more particular objects of the invention will appear from a reading of the following description and by reference to the claims appended hereto.

A construction designed to carry out the invention will be hereinafter described, together with other features of the invention.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawings, wherein examples of the invention are shown, and wherein:

FIG. 1 is a longitudinal, horizontal, sectional view of a fluid operated pump constructed in accordance with this invention, certain of the parts having been rotated in the view in order to illustrate the structure more clearly,

FIG. 2 is a fragmentary view of one of the pump ends of the form of the invention shown in FIG. 1, the view being taken at right angles to FIG. 1 upon the line **2—2** thereof,

FIG. 3 is a longitudinal, vertical, sectional view of a modification of the pump of FIG. 1, certain of the operating connections being shown diagrammatically,

FIG. 4 is a schematic view of a further modification of the invention,

FIG. 5 is a schematic illustration of an additional modification of the invention,

FIG. 6 is a schematic view of a still further modification of the invention,

FIG. 7 is a schematic view of a single ended variation of the modification of FIG. 6, and

FIG. 8 is an enlarged cross-sectional view of the pilot valve.

In the drawings, the numeral **10** designates a motor cylinder of quite appreciable diameter and adapted to be supported upon any suitable type of pedestal or base for attachment to and mounting upon a foundation or other suitable supporting member (not shown). The cylinder **10** is formed with annular, outwardly extending flanges **11** and **12** at its left and right hand ends, respectively, an annular groove being cut in the inner periphery of the face of each of the flanges **11** and **12** for receiving suitable sealing O rings **13**. A head **14** projects a short distance into the left hand end of the cylinder **10** and is formed with a marginal flange **15** forming a shoulder enclosing the O ring **13**, the flange **15** being connected to the flange **11** by suitable bolts **16**. The inner face of the head **14** is chamfered and cut away to form an annulus **17** adjoining the inner wall of the cylinder **10** and to provide an annular clearance space for purposes to be described hereinafter. The head **14** carries a central, outwardly extending neck **18** formed integrally with the head and having an axial bore **19** opening into the interior of the cylinder **10**. Intermediate the end portions of the neck **18**, the bore **19** is enlarged to form a circumferential chamber **20** of greater diameter than the bore **19** and terminating short of the inner and outer ends of the neck **18**. A tubular pump chamber **21** having a closed outer end **22** is provided with an intermediate, outwardly extending flange **23** which abuts the outer end of the neck **18** and is secured thereto by suitable bolts **24**. The portion **25** of the pump enclosure **21** inwardly of the flange **23** is reduced in outside diameter and received within the outer portion of the bore **19**, the inner end of the reduced portion **25** terminating within the chamber **20** adjacent to the inner end thereof. A packing sleeve **26** is positioned in the inner portion of the bore **19** and sealed with respect thereto by a pair of spaced gasket members **27**, the sleeve being provided near its outer end with an external flange **28** disposed within the chamber **20** and abutting the inner end of the reduced portion **25**. Suitable screws or bolts, or other connecting elements **29** secure the outer end of the sleeve **26** to the inner end of the reduced portion **25**.

On the right end of the cylinder **10** upon the flange **12**, a cylinder head and pump assembly is mounted. The right hand assembly is substantially a mirror image of the left hand assembly described above, and the same numerals have been applied to similar elements with the numerals being primed.

Bleeder or tell-tale passages **39** and **39'** extend from between the gaskets **27** and the gaskets **27'** to the peripheries of the flanges **15** and **15'**, respectively, for discharging any fluid which may accumulate between the gaskets and conducting such fluid exteriorly to a suitable container or other enclosure in which the fluid may be detected and the presence of leakage between the respective sleeves and heads ascertained.

A motor piston **30** is disposed within the cylinder **10** between the heads **14** and **14'** and arranged for longitudinal movement within the cylinder, the piston being provided with a marginal piston ring **31**, preferably formed of some suitable elastomer and engaging the inner wall of the cylinder **10** in snug sliding relationship. The piston **30** is formed with opposed, substantially planar outer faces so that when the piston is closely adjacent either of the heads **14** or **14'**, the annuli **17** and **17'** will remain open. A plunger rod **32** is secured to the center of the piston **30** extending axially thereof and being formed with a left hand pump plunger **33** extending from the piston **30** through the sleeve **26** and into the pump enclosure **21**, the opposite end of the rod **32** forming a right hand pump plunger **34** which extends from the piston **30** through the sleeve **26'** and into the pump enclosure **21'**. Suitable sealing gaskets **35** and **35'** are provided between the sleeve **26** and the left hand pump plunger **33** and between the sleeve **26'** and the right hand pump plunger **34**. As may be observed in FIG. 1, the plungers **33** and **34** are of sufficient length that the outer extremities thereof are not completely withdrawn from the pump enclosures **21** and **21'** when the piston **30** is in either its extreme right hand or extreme left hand position.

Referring now to FIG. 2 which is a sectional view of the right hand end of FIG. 1 but taken at right angles thereto, it will be seen that the reduced portion **25'** of the pumping enclosure **21'** is provided with a pair of diametrically opposed ports **36'** opening from the interior of the pumping enclosure around the pump plunger **34** to the circumferential chamber or enclosure **20'**. In alignment with one of the ports **36'** the neck **18'** is formed with an integral, laterally extending inlet collar **37'** having a bushing **38'** screw threaded into its outer end and receiving an inlet conductor **39''**. An inlet check valve **40'** is carried upon the inner end of the bushing **38'** and arranged to allow fluid to enter into the enclosure **20'** from the conductor **39'** but to prevent reverse flow of fluid from the enclosure **20'** to the conductor **39'**. Similarly, the opposite port **36'** is in registry with an outlet collar **41'** formed integrally of the neck **18'** and carrying a bushing **42'** in its outer end, the bushing being connected to an outlet conductor **43'**. An outlet check valve **44'** is carried by the inner end of the bushing **42'** and arranged to permit fluid to flow outwardly from the enclosure **20'** to the conductor **43'** but to prevent reverse flow of the fluid. Although it is not illustrated in the drawings, the opposite head **14** and neck **18** are provided with identical inlet and outlet collars and conductors carrying identical inlet and outlet check valves.

With this arrangement, as the piston **30** is reciprocated within the cylinder **10**, first the pump plunger **33** is caused to move to the left, as viewed in FIG. 1, into the pumping enclosure **21** so as to force fluid therefrom through the outlet conductor thereof while simultaneously the pump plunger **34** is withdrawn from the pump enclosure **21'** to draw fluid thereinto from the conductor **39'**. As the piston reverses its movement and returns to the position shown in FIG. 1, the plunger **33** is withdrawn from the enclosure **21**, drawing additional quantities of fluid thereinto, while the plunger **34** is moved into the enclosure **21'** forcing fluid therefrom outwardly under pressure through the outlet conductor **43'**. Of course, two different fluids may be pumped by the two pumping enclosures, but preferably the inlet conductors of the pumping enclosures **21** and **21'** are connected in manifold to draw fluid from a common source, and the outlet conductors of the enclosures may also be connected in manifold to direct the fluid under pressure to a common point. In this manner, the structure becomes a double acting pump in that fluid is pumped under pressure through the outlet conductors upon both strokes of the piston **30**. It is also be be noted that the diameter, and hence, the exposed area of the piston **30** is quite large in comparison with the diameters and exposed areas of the plungers **33** and **34**, and accordingly, a motive fluid under a pressure of possibly 100 pounds per square inch is entirely capable of pumping fluid from the enclosures **21** and **21'** at a pressure of the order of magnitude of several thousand pounds per square inch.

For supplying motive fluid under pressure alternately to opposite sides of the piston **30**, a conventional four-way valve **45** is mounted upon one outer wall of the cylinder **10**, the valve being of the springless variety adapted to have its switching plunger actuated through diaphragms, pistons, or other suitable devices. Such valves are well known in this art and need not be described at length except to point out that the valve has provision for connection to a pressure fluid inlet conductor **46**, a pair of outlet conductors **47** and **48** and vent ports **49** and **50**. The reciprocable plunger **51** is adapted to be shifted longitudinally of the valve structure to place the conductor **46** alternately in communication with the conductor **47** while exposing the conductor **48** to the vent **50**, and upon shifting of the plunger **51**, to place the conductor **46** in communication with the conductor **48**, while shutting off the vent **50** and exposing the conductor **47** to the vent **49**. In this manner, motivating fluid under pressure is alternately supplied to one of the conductors **47** or **48**, while the opposite one of the conductors 47 and 48 is exposed to a vent, the vent of the pressurized conductor being closed off while pressure fluid is being supplied thereto. For shifting the plunger 51 longitudinally, there is provided at the left hand end of the valve 45 a cylinder 52 communicating with an inlet conductor 53 and enclosing a piston 54 which is connected to one end of said plunger. At the right hand end of the four-way valve there is provided a cylinder 55 having a conductor 56 connected thereinto and enclosing a piston 57 connected to the right hand end of the plunger 51. Since no springs are included in the valve 45, it is apparent that supplying of fluid under pressure to the conductor 53 and venting of the conductor 56 will shift the plunger 51 to the right into the position shown in FIG. 1, while venting of said conductor 53 and pressurizing of said conductor 56 will shift the plunger 51 to the left to vent the conductor 47 and supply fluid under pressure to the conductor 48 from the conductor 46.

The conductors 47 and 48 are connected through the flanges 11 and 12 with the annuli 17 and 17′, the arrangement of the right hand end of the pump being shown in FIG. 2 in which the conductor 48 is connected to an elbow 58′ screw-threadedly mounted in the flange 12 in communication with a port 59′ leading to the annulus 17′. In this manner, as pressure fluid is supplied to the conductor 48 it is also supplied to the annulus 17′ and serves to drive the piston 30 to the left. As pressure fluid is alternately supplied to the conductor 47, such fluid will flow to the annulus 17 and drive the piston 30 to the right. Consequently, as the plunger 51 is shifted to the left and to the right, motivating fluid under pressure is alternately supplied to the conductors 47 and 48 to reciprocate the piston 30 within the cylinder 10.

For switching or shifting the four-way valve 45 from its right hand position to its left hand position and return, the heads 14 and 14′ carry pilot plunger assemblies 60 and 60′ respectively, snap action, toggle-type, pilot valves 61 and 61′ being mounted respectively upon the assemblies 60 and 60′. The pilot plunger assemblies 60 and 60′ are identical in structure, the assembly 60 being shown in detail in FIG. 1 and including an elongate housing 62 provided at one end with a screw-threaded nipple 63 secured in a screw-threaded bore 64 opening through the head 14 into the annulus 17. A pilot plunger 65 is reciprocable within the nipple 63 and extends through a suitable packing gland 66 into the interior of the housing 62. A stop member 67 is adjustably secured upon the plunger 65 within the housing 62 so as to abut the gland 66 and limit inward movement of the plunger 65, and a pair of inner and outer actuating rings 68 and 69 are adjustably positioned upon plunger 65 within the housing 62. The outer end of the housing is closed by a screw-threaded plug 70, a compression spring 71 being confined between the plug 70 and the outer ring 69 for urging the plunger 65 constantly inward.

The snap-action pilot valves 61 and 61′ are also substantially identical in structure and are desirably of the type disclosed and described in United States Letters Patent No. 2,860,660. The pilot valve 61 has connected thereto a pilot gas inlet conductor 72 and a vent conductor 73, the valve being adapted to place the conductors 72 and 73 alternately in communication with the conductor 53 which is connected to the cylinder 52 of the four-way valve 45. The actuating pin or arm 74 of the valve 61 extends into the pilot plunger housing 62 into the space between the rings 68 and 69 and is adapted to be swung to the right and to the left, as viewed in FIG. 1, by the rings 68 and 69 as the plunger 65 is reciprocated. The pilot valve 61′ is similarly arranged having a pilot gas inlet or supply conductor 72′, a vent conductor 73′, and being adapted to place the conductors 72′ and 73′ alternately in communication with the conductor 56 which is connected to the cylinder 55 of the four-way valve 45.

The plungers 65 and 65′ are of such length as to project in their inward position into the cylinder 10 past the annuli 17 and 17′ so as to be in position for engagement by the piston 30 at each end of the stroke of the piston. Thus, in the position of the pump shown in FIG. 1, motivating fluid under pressure is being passed from the conductor 46 through the valve 45 to the conductor 47 and into the left hand side of the cylinder 10 to drive the piston 30 to the right hand end of its stroke and pump fluid under pressure from the enclosure 21′ outwardly through the outlet conductor 43′. As the piston 30 reaches the right hand end of its stroke, it engages the plunger 65′ to shift the right hand plunger assembly 60′ and the valve 61′, shutting off the venting of the conductor 56 to the vent 73′ and exposing the conductor 72′ to the conductor 56 to direct pilot fluid under pressure into the cylinder 55 to force the piston 57 and the plunger 51 to the left. As will appear more fully hereinafter, the pilot valve 61 is in a venting position so that the conductor 53 and cylinder 52 are vented to the atmosphere, and hence, there is no resistance offered to left hand movement of the plunger 51. Movement of the plunger in this direction will result in venting of the conductor 47 through the vent 49, thus venting the left hand portion of the interior of the cylinder 10, and the closing of the vent 50 while placing the motivating fluid inlet conductor 46 in communication with conductor 48. Fluid under pressure is thus admitted to the right hand end of the cylinder 10 and allowed to act upon the right hand face of the piston 30, commencing the left hand movement of the piston and the pumping of fluid under pressure from the left hand enclosure 21 while drawing additional supplies of fluid into the right hand enclosure 21′. As the piston moves away from the right hand pilot plunger assembly 60′, the plunger 65′ will move into the interior of the cylinder 10 under the influence of its spring, thus again shifting the pilot valve 61′ and exposing the conductor 56 and the cylinder 55 to the vent 73′. Since the four-way valve 45 is of the springless variety, however, no movement of the plunger 51 will result. The left hand movement of the piston 30 continues until it encounters the plunger 65 moving the plunger outwardly to momentarily shift the valve 61, closing off vent 73 and exposing the pilot fluid inlet conductor 72 to the cylinder 52 to drive the piston 54 and the plunger 51 to the right, venting the conductor 48 and pressurizing the conductor 47. In this manner, the snap-action pilot valves 61 and 61′ function to provide momentary supplying of fluid under pressure alternately to the cylinders 52 and 55 to reciprocate the plunger 51 and alternate the supply of motivating fluid under pressure to the left and right hand sides of the piston 30 while reciprocating the piston and alternately pumping the fluid under pressure from the enclosures 21 and 21′.

It is to be noted that the utilization of the snap-action pilot valves 61 and 61′ along with the provision of means whereby the valves are actuated only on a momentary basis and are then returned to a venting position, results in very quick and positive action of the switching or four-way valve 45, and the very positive and definite reciprocation of the piston 30 within the cylinder 10 regardless of the slowness with which the piston is moving and the slowness or the low rate at which fluid is being pumped from the enclosures 21 and 21′. Since the spacing between the rings 68 and 69 is considerably greater than the arc of movement of the arm 74, and since snap-action toggle-type, pilot valves are employed, the pilot valves will operate almost instantaneously regardless of the fact that the ring 68, in accordance with the movement of the plunger 65 and the piston 30, may be moving at a rate so slow as to be almost imperceptible. An ultimate point will be reached at which the arm 74 will snap past dead center, and the valve 61 will move almost instantaneously from a venting position to a pressurizing position, positively shifting the plunger 51 and ensuring certain reversal in movement of the piston 30. Similarly, as the piston 30 retreats from the plunger 65, a point will be reached at which the ring 69 will have moved the arm 74 sufficiently to cause the arm to snap the pilot valve 61, again, almost instantaneously, to a venting position so as to prepare the valve 61 for proper venting of the cylinder 52 upon subsequent reversal in movement of the piston 30. In this way, a new combination has been provided in utilizing positively actuated tripping means for snap-action pilot valves, the interconnection between the actuating means and the valves being such as not to impair the almost instantaneous action of the valves so that positive and reliable continuous operation of the pumping mechanism is ensured regardless of the slowness or the rapidity with which fluid is being pumped by the mechanism. All gradual opening and closing of valves is eliminated through the combining of the main pumping structure, the snap-action, toggle-type pilot valves, and the springless four-way valve 45.

Of course, any suitable type of needle or control valve may be incorporated into the conductor 46 or the conductors 47 or 48 for controlling the supply of motivating fluid under pressure and thus controlling the rate at which the piston 30 moves so as to control indirectly the rate at which fluid is pumped from the enclosures 21 and 21'.

In conjunction with a glycol type natural gas dehydrating system, the conductors 72 and 72' are desirably supplied with natural gas through a pressure reducing valve at a pressure of 5 to 30 pounds per square inch, the conductor 46 supplied with natural gas under a pressure of the order of magnitude of 100 pounds per square inch, and the inlet conductors to the enclosures 21 and 21' connected to the supply of concentrated glycol solution. The outlet conductors from the enclosures 21 and 21' will, of course, lead to the contacting or dehydration tower for supplying of concentrated glycol solution thereto for dehydration of the natural gas stream. The pilot gas and motivating gas under pressure may desirably be tapped from any suitable point in the dehydration system as, for instance, from the down stream side of the dehydration tower from which clean and dry natural gas may be withdrawn through suitable pressure reducing valves or pressure regulators for supply at the proper or desired pressure.

In the first form of the invention, the positive and certain snap-action of the pilot valves was obtained by mechanical abutment and direct mechanical movement between the piston 30 and the plunger rods 65 and 65'. In the remaining forms of the invention, however, the direct and certain mechanical movement of the snap-action pilot valves is obtained by direct actuation of the pilot valves from the piston rod or plunger itself. Thus, in FIG. 3, there is shown a single acting modification of the first form of the invention, this form including a base or support 75 having formed thereon an integral cylinder head 76 having a circular, laterally extending rib 77 surrounding a circular recess or annulus 78 enclosing a central hub 79. A cylinder 80 is mounted in sealing engagement with the periphery of the rib 77 and receives upon its opposite end a second cylinder head 81 also arranged in sealing engagement with the right hand end of the cylinder 80, both cylinder heads being suitably secured to each other or to the cylinder 80 for pressure tight enclosure. The head 81 is provided with an annular rib or flange 82 extending into the cylinder 80 in snug sealing engagement therewith and surrounding a concave, arcuate annulus 83 enclosing a central hub 84. An axial opening 85 extends through the hub 84 and the head 81 and receives an elongate pilot valve actuating rod 86 for reciprocal movement. A packing 87 is provided in the outer face of the head 81 encircling the rod 86, and is urged into packing position by a screw threaded packing gland 88 having a screw threaded nipple 89 extending therefrom and supporting an actuating ring housing 90. The rod 86 extends through the nipple 89 into the housing 90 and carries upon its extremity a pair of spaced, adjustable, inner and outer actuating rings 91 and 92, respectively, for engaging the actuating arm 93 of a pilot valve 94 similar to the valves 61 and 61'.

A piston 95 is positioned for reciprocation within the cylinder 80, the piston being provided with a marginal sealing ring 96, formed of some suitable elastomer or other material and having a central, headed bushing 97 slidably engaging the rod 86. The bushing 97 has its head positioned upon the right hand face of the piston 95, as viewed in FIG. 3, and its screw-threaded shank 98 extending through the piston and into the screw-threaded hollow interior of an elongate pump plunger 99. The plunger 99 is reciprocable within a pump barrel 100 clamped to the head 76 by a suitable plate 101 and bolts 102, the inner end of the barrel 100 carrying suitable sealing rings or gaskets and being received in a cylindrical recess formed in the outer face of the head 76 and extending into the central hub 79. The hub carries a suitable packing or packing gland 103 adjoining the inner end of the barrel 100 and encircling the plunger 99 so as to prevent leakage therebetween. In addition, a secondary packing element 104 is recessed in the barrel 100 outwardly of the packing 103, and a seepage or telltale passage 105 extends from between the packings 103 and 104 through the hub 76 to an outlet conductor 106 directed to a suitable container for detection of leakage between the plunger 99 and the barrel 100. Suitable inlet and outlet conductors and check valves 107' and 108', respectively, are connected into the outer end of the barrel 100.

The hollow plunger 99 is formed with a cylindrical bore 107 extending from the threaded shank 98 of the bushing 97 to a point spaced from the outer end of the plunger. The rod 86 extends through the bushing 97 into the bore 107 and is provided on its outer end with a cylindrical head 108 having a relatively loose fit within the bore 107 so as to provide ample lateral clearance for unrestricted reciprocation of the head 108 within the bore 107. As will be seen more fully, hereinafter, the bore 107 is of a length slightly less than the stroke of the piston 95 for the purpose of actuating the pilot valve 94.

A motive gas supply conductor 109 has a branch conductor 110 connected through a reducing valve 111 to the inlet fitting 112 of the pilot valve 94, the latter valve also having a vent conductor 113 and an outlet conductor 114 leading to the diaphragm housing 115 of a motor operated, four-way valve 116. The supply conductor 109 extends through a control or regulating valve 117 to one inlet of the four-way valve 116, the valve 116 being provided with a vent or outlet 118, a first supply conductor 119 leading to an inlet fitting 120 extending through the head 76 into communication with the recess 78, and a second outlet conductor 121 leading to an inlet fitting 122 connected into the annular recess 83 of the head 81.

In the operation of this second form of the invention and assuming that the structure is in the position shown in FIG. 3 in which the piston 95 has just reached the left hand end of its stroke so that the ring 92 has tripped the arm 93 of the valve 94 to move it into the position in which the inlet conductor 112 is placed in communication with the outlet conductor 114, gas or other suitable motive fluid under reduced pressure is supplied to the diaphragm housing 115 to shift the valve 116 into the position shown in FIG. 3. In this position, motive fluid under pressure is supplied from the conductor 109 to the fitting 120 and into the space to the left of the piston 95 so as to drive the piston to the right. To be exact, the piston 95, in the position shown in FIG. 3, has just commenced its right hand travel. Since the rod 86 is slidable within the bushing 97, it is immaterial whether gas or other fluid leaks through the bushing into the bore 107 which is effectively sealed from the left hand side of the piston 95 by the engagement of the inner end of the plunger 99 with the left hand side of the piston 95. Under pressure of the motive fluid the piston will move to the right, but the rod 86 will remain stationary due to the frictional resistance exerted by the packing 87. The plunger 99 is thus withdrawn from the cylinder 100, drawing additional fluid into the cylinder from the inlet conductor 107', and this action continues until the piston 95 approaches the right hand end of its stroke, at which time the bottom of the bore 107 will engage the head 103 of the rod 86 to shift the rod to the right and cause the ring 91 to engage the arm 93 and snap-actuate the pilot valve 94 for switching the valve into a position in which the inlet 112 is isolated from the outlet 114 and the latter is connected to the vent 113. Pressure gas is thus vented from the diaphragm housing 115, and the valve 116 is switched to place the inlet conductor 109 in communication with the conductor 112 while the conductor 119 is vented to the outlet 118. The space within the cylinder 80 to the left of the piston 95 is thus vented to the atmosphere while pressure is supplied through the fitting 122 to the right hand side of the piston to drive the piston in a reverse direction to the left and force the plunger 99 into the cylinder 100, pumping fluid under high pressure outwardly through the outlet conductor 108'. This action continues until the piston 95 reaches the left hand end of its stroke, at which time the shank 98 of the bushing 97 engages the head 108 to shift the rod 86 to the left and bring the ring 92 into engagement with the arm 93 to return the valve 94 to its original position and again commence admission of fluid under pressure to the space enclosed between the head 76 and the piston 95 for movement of the piston to the right. Obviously, this action continues alternately and indefinitely. It is to be noted that the hubs 79 and 84 limit the left and right hand movement of the piston 95, and that the annular recesses 78 and 83 ensure sufficient clearance for admission of motivating fluid under pressure to either side of the piston 95 so that the apparatus may not become locked in any fashion. Again, the spacing between the rings 91 and 92 is sufficient as to permit full snap-action of the arm 93 and snap-operation of the valve 94 for substantially instantaneous reversal in the movement of the piston 95. The piston is not directly or rigidly connected to the actuating rings which engage the pilot switch arm 93, but at the desired times of actuation there is a direct mechanical connection or mechanical abutment between the several parts for positive and certain shifting of the pilot valve.

A further modification of the invention is shown in FIG. 4, this latter modification involving direct controlling of the pilot valve by the pump and motor rod, and also making provision for pumping two fluids, as, for instance, in the case of a natural gas dehydration tower utilizing a glycol solution, the pumping structure makes provision for pumping concentrated glycol solution to the tower while simultaneously pumping spent or dilute glycol solution from the tower to the reconcentration apparatus. The structure includes an enclosed cylinder 123 carrying a packing gland 124 upon its upper end and supporting a diaphragm housing 125 having therein a flexible diaphragm or other pressure responsive element 126 dividing the housing 125 into an upper chamber 127 and a lower chamber 128. A reduced diameter enclosure 129 extends upwardly from the diaphragm housing and supports a pilot valve 130 similar in all respects to the pilot valves 61 and 61' hereinafter described. A concentrated glycol solution, or other fluid, inlet conductor 131 extends through a check valve 132 into the upper portion of the cylinder 123, an outlet conductor 133 extending from the upper end of the cylinder 123 through a check valve 134. A branch conductor 135 communicates between the inlet conductor 131 up stream of the check valve 133 with the chamber 128 through a needle valve or other type of flow control valve 136.

A three-way diaphragm or motor operated valve 137 has a fluid inlet conductor 138 connected thereto, as, for instance, a dilute glycol solution conductor leading from the bottom of a dehydration tower, the valve also being provided with an outlet conductor 139 and a third conductor 140 connected into the lower end of the cylinder 123 and adapted to be placed into communication with either the conductor 138 or the conductor 139 through switching of the valve 137.

The pilot valve 130 has a pilot gas supply conductor 141 connected thereto along with a vent conductor 142 and an actuating conductor 143 leading to the diaphragm or other actuating mechanism of the valve 137 and having a branch conductor 144 communicating with the chamber 127. Within the cylinder 123, a piston 145 is reciprocally positioned and carries a piston rod 146 extending upwardly through the packing gland 124 and through the diaphragm 126 into the enclosure 129. The rod 146 is secured to the diaphragm 126 so as to move therewith, the upper extremity of the piston rod carrying a pair of spaced actuating rings 147 adapted to engage alternately the operating arm or lever 148 of the pilot valve 130, said arm projecting from the pilot valve through the sidewall of the enclosure 129 and into position between the rings 147. It is to be noted that the entire underside of the piston 145 is exposed to the lower end of the cylinder 123 while the area of the upper side of the piston exposed to the upper portion of the cylinder is reduced by an amount equal to the cross-sectional area of the piston rod 146.

In the operation of this form of the invention and assuming that the piston 145 has just commenced its upward stroke, the pilot valve 130 being in a venting position so as to vent the conductors 143 and 144 and remove pressure from the upper side of the diaphragm 126 while depressurizing the diaphragm operator of the valve 137 and placing the conductors 138 and 140 in communication, dilute glycol solution and gas will flow under the pressure of the dehydrator tower into the cylinder 123 below the piston 145 forcing the piston upwardly and expelling concentrated glycol solution, or other fluid from the space above the piston 145 through the outlet conductor 133 and into the dehydrator tower or other point of delivery. As stated above, the differential areas between the upper and lower sides of the piston 145 will permit this action to take place, the diaphragm 126 offering no resistance to movement other than the rate at which fluid can be drawn into the chamber 128 through the conductor 135 in accordance with the setting of the valve 136. When the piston reaches the upper end of its stroke, the lower actuating ring 147 will contact the arm 148 to shift the valve 130, placing the pilot gas supply conductor 141 in communication with conductors 143 and 144, thus applying pressure to the top of the diaphragm 126 and switching the valve 137 to place the conductor 140 in communication with the conductor 139. The diaphragm 126 is of a sufficient area as to force the piston 145 downwardly, delivering dilute glycol solution or other fluids from beneath the piston through the outlet conductor 139 to the dehydration apparatus or other point of delivery while drawing a fresh quantity of concentrated glycol solution or other fluid into the upper part of the cylinder 123 through the inlet conductor 131. The rate at which this action takes place will again be dependent upon the setting of the valve 136 since fluid must be exhausted from the chamber 128 through the conductor 135 and into the conductor 131 so that concentrated glycol solution or other fluid, in actuality, surges in and out of the chamber 128 at a rate determined by the setting of the valve 136 so as to control the rapidity of movement of the piston 145 on both its upward and downward strokes and thus control the overall rate of pumping of both the fluid entering through the conductor 131 as well as the fluids entering through the conductor 138.

Upon reaching the bottom of the piston stroke, the apparatus functions to switch the arm 148 downwardly by engagement therewith of the upper ring 147, again switching the pilot valve 130 to vent the chamber 127 and return the conductor 138 to communication with the conductor 140.

It is quite apparent that by reason of the larger piston area exposed and consequently the larger volume in the lower portion of the cylinder 123 as compared with the upper portion thereof, the unit cannot continue to operate solely by the flow of glycol solution or other liquid but must also utilize the flow of some gas or other fluid through the conductor 138 into the space below the piston 145. The unit will thus function, in the case of the natural gas dehydration tower utilizing glycol solution, to maintain the drainage chamber or enclosure of the dehydrator tower substantially free of glycol solution, or in any event to remove the glycol solution as fast as it accumulates therein. Thus, the unit is functioning under the motive force of the pressure existent within the glycol tower or source of fluid under pressure which constantly drives the glycol or other fluid from the tower and in reality utilizes a portion of the gas as well as the pressure of the gas present within the tower for motivation.

A modification of the above arrangement is shown in FIG. 5 of the drawings in which the pressure under which the dilute glycol solution or other fluid flows to the assembly is not necessarily critical, there being provided an outside source of motive power for driving the pumping unit. Although appearing slightly different from a schematic view point, in essence the structure is the same as that shown in FIG. 4, the same numerals being utilized to identify substantially the same elements or their equivalents, with the exception that the conductor 144, instead of being connected into the chamber 127 of the diaphragm housing 125 is connected to the diaphragm housing 149 of a four-way valve 150. A conductor 151 leads to the valve 150 for supplying motivating fluid under pressure thereto, the valve having a first outlet conductor 152 leading to the chamber 127 of the diaphragm housing 125, and a second conductor 153 leading to the chamber 128 of the diaphragm housing 125. The valve 150 is, of course, adapted to place the conductor 151 alternately in communication with the conductors 152 and 153. The operation of this modification of the invention is substantially the same as that previously described with the exception that the pilot valve 130 functions, in addition to switching the valve 137 as previously described, also to switch the valve 150 and alternately pressurize the chambers 127 and 128 while venting the opposite chamber through one of the vents 154 of the four-way valve 150.

The modification of FIG. 6 includes a left hand cylinder 155 and a right hand cylinder 155′ having their outer ends closed by heads 156 and 156′. Inner heads 157 and 157′ close the inner ends of the cylinders 155 and 155′, respectively, and are joined by a tubular connection member 158. The heads 157 and 157′ are provided with axial bores 159 and 159′ carrying packing glands 160 and 160′ through which a double ended piston rod 161 is reciprocable. A piston 162 is secured to the left hand end of the rod 161 and is freely slidable in the cylinder 155, a similar piston 162′ being carried by the right hand end of the rod 151 and being freely slidable within the cylinder 155′. Within the tubular connection member 158, a pair of spaced actuating rings 163 and 163′ are mounted upon the rod 161 to the left and right hand sides respectively, of the operating arm or pin 164 of a pilot valve 165 similar in all respects to the pilot valves 61 and 61′.

The inner heads 157 and 157′ are provided with inlet ports and inlet conductors 166 and 166′ having therein check valves 167 and 167′, the inner heads also having outlet ports and conductors 168 and 168′ also carrying check valves 169 and 169′. Thus, by reason of the presence of the several check valves, as the pistons 162 and 162′ are reciprocated within the cylinders 155 and 155′, fluid will be pumped from the conductors 166 and 166′ through the spaces between the pistons and the inner heads and outwardly through the outlet conductors 168 and 168′.

For reciprocating the piston rod 161 and the pistons 162 and 162′, the pilot valve 165 is provided with a pilot fluid inlet supply conductor 170, a venting conductor 171, and a controlled fluid conductor 172 leading to the underside of a diaphragm 173 enclosed in a diaphragm housing 174 and adapted to operate a four-way valve 175. The valve 175 carries an inlet supply conductor 176 for motive fluid admitted under pressure, an outlet conductor 177, and a pair of controlled fluid conductors 178 and 178′. The conductor 178 is connected through a needle valve or other suitable type of control valve 179 to the head 156 and to the interior of the cylinder 155 outwardly of the piston 162, while the conductor 178′ is connected through a control valve 179′, similar to the valve 179, to the head 156′ and to the interior of the cylinder 155′ outwardly of the piston 162′.

Here again, the areas of the pistons 162 and 162′ exposed to the conductors 178 and 178′ are greater than the areas exposed to the conductors 166 and 166′ as well as the conductors 168 and 168′ by reason of the presence of the piston rod 161. Accordingly, although fluid under pressure may be admitted to the outer faces of the pistons from a source of fluid under a given pressure, and another fluid pumped through the conductors 168 and 168′ into the same source, the differences in area of the two sides of each of the pistons as well as the differences in the volumes of fluid being pumped, will permit the unit to operate. Assuming that the pumping structure is being employed in a glycol type dehydration unit for natural gas and that both the concentrated and dilute glycol solutions are being pumped, in the position of the structure illustrated in FIG. 6, dilute glycol solution will be flowing from the conductor 176 through the valve 175 to the conductor 178 and to the outer face of the piston 162 to drive that piston, the rod 161, and the piston 162′ to the right. This action will pump concentrated glycol solution from the right-hand portion of the cylinder 155 through the outlet conductor 168 to the dehydration tower, will draw a fresh quantity of concentrated glycol solution into the left-hand portion of the cylinder 155′ from the inlet conductor 166′, and will pump dilute glycol solution from the right-hand portion of the cylinder 155′ through the conductor 178′ and the valve 175 to the outlet conductor 177 leading to the glycol regeneration or reconcentration unit. As the rod and piston assembly approaches the right-hand end of its stroke, the left-hand actuating ring 163 will engage the arm 164 to switch the pilot valve 165, closing the vent 171 and admitting pilot gas under pressure from the conductor 170 through the conductor 172 onto the underside of the diaphragm 173 thus switching the four-way valve 175 to vent the conductor 178 and pressurize the conductor 178′. Of course, upon reaching the left-hand end of the stroke of the piston and rod assembly, the arm 164 will be switched to the left, again reversing the operation and pressurizing the conductor 178 while venting the conductor 178′. As mentioned in connection with the discussion of the modification of FIG. 4, some quantities of gas or other fluid will also be admitted through the valve 175 to the conductors 178 and 178′ and will ultimately be exhausted through the outlet conductor 177. The concentrated glycol solution inlet conductors 166 and 166′ are shown as manifolded into a common inlet conductor 180, but it is apparent that the inlet conductors may remain isolated so as to pump two different fluids through the two cylinders of the assembly. Of course, the outer conductors 168 and 168′ may also be manifolded in a similar fashion, and this would be preferable in most instances when the pumping unit is being employed in conjunction with a gas dehydration unit.

In FIG. 7, there is shown a single acting modification of the form of the invention illustrated in FIG. 6, this structure being identical in many respects to that shown in FIG. 6 and the same numerals being applied thereto, the only important differences in the structure being the elimination of the cylinder 155′ and the replacement of the inner head 157 with an end head 181 carrying an adjusting screw 182 and a spring follower 183 supported upon the adjusting screw and confining a compression spring 184 between the follower 183 and the end of the piston rod 161′. The four-way valve 175 is also replaced with a three-way valve 175′ since the control of fluid to and from only the single cylinder 155 is required. This further modification operates in substantially the same manner as the modification of FIG. 6, the pilot valve 165 being actuated to admit alternately dilute glycol solution or other fluid under pressure to the left hand end of the cylinder 155 through the inlet conductor 176 and thereafter exhausting said fluid through the outlet conductor 177 so as to pump concentrated glycol solution or other fluid through the right hand portion of the cylinder 155. The spring 184, of course, functions to return the piston 162 to its left hand position during the venting of the dilute glycol solution or other fluid.

Thus, a new combination has been disclosed, a combination employing one or more driving pistons and one or more driven pistons powered by the driving pistons with snap-action, toggle-type, pilot valves operated positively and reliably from the driving piston through either a direct or indirect but positive mechanical connection for the purpose of switching a suitable control valve which regulates the flow of motivating fluid under pressure to the piston for driving the pumping unit and reciprocating the piston for pumping operations. All possibility of the device failing to switch or reverse strokes due to extremely slow rates of operation are eliminated, and at the same time, positiveness and certainty of operation is assured regardless of the rapidity with which fluid is being pumped. The net result is a positive displacement pump adapted for the supplying of controlled quantities of fluid at controlled rates and at high pressures utilizing motivating fluids under relatively low pressures but assuring complete positiveness of operation and eliminating the possibility of pumping failure short of the physical failure of some component portion of the structure. Even at pumping rates at which movement of the several pistons may not be visually observed, a point will be reached in the stroke of the pump piston at which one of the snap-action valves, by reason of its toggle-type construction, will shift almost instantaneously from one position to another to provide positive and certain reversal of the pump stroke.

In FIG. 8 of the drawings there is illustrated a snap-action, toggle-type valve or pilot valve typical of the valves 61 and 61′, 94, 130, and 165, hereinbefore mentioned, the valve of FIG. 8 being identified as valve 61 for purposes of identification. This valve is constructed in accordance with U.S. Letters Patent No. 2,860,660, and includes a rectangular valve body 185 having a longitudinal bore or passage 186 with its right-hand end screwthreaded at 187 to receive a bushing 188 and control conductor 189. An upper screwthreaded passage 190 opens upwardly from the upper side of the bore 186 into a screwthreaded counterbore 191 and receives a bushing 192 having a valve face 193 on its lower end. The counterbore 191 receives a bushing 194 and a vent conductor 195. A second screwthreaded and lower passage 196 opens downwardly from the lower side of the bore 186 into a screwthreaded counterbore 197 which receives a bushing 198 and pilot fluid supply conductor 199. A bushing 200 is positioned in the passage 196 and has a valve face 201 on its upper end. An operating lever 202 is pivotally mounted intermediate its ends upon a pivot pin 203 spaced inwardly from the left-hand end of the passage 186, an annular packing 204 enclosing the medial portion of the pin 202 in snug surrounding and sealing relationship substantially in the plane of its pivotal mounting, and a hollow plug 205 being screwthreadedly received in the left-hand end of the passage 186 for maintaining the sealing member 204 in position. The inner end of the pin 202 is notched as shown at 206 to receive one end of a yoke or fork 207 having its opposite end engaging a spool-shaped, double ended valve core 208 positioned for reciprocal movement between the valve faces 193 and 201. A toggle spring 209 encompasses the yoke 207 and has one end connected to the inner end of the arm 202 while its opposite end is connected to the medial portion of the yoke 207 in order to provide a toggle or snap action when the pin 201 is swung in an arc about the pivot pin 203. Obviously, in the operation of the valve and starting in the position thereof shown in FIG. 8, as the outer and projecting end of the lever 202 is moved downwardly, the yoke 207, by reason of the presence of the spring 209, will continue to urge the valve core 208 upwardly against the valve seat 193 until such time that the pin 202 and yoke 207 have reached and passed a relative dead center position, at which time, the spring 209 will function through a toggle action to snap the yoke 207 quickly downwardly and thus almost instantaneously move the valve core from engagement with the seat 193 into engagement with the seat 201. The reverse action, of course, occurs upon the return upward movement of the pin 202. In this manner, the valve functions to shift the conductor 189 quickly from communication with the conductor 199 into communication with the conductor 195 and through a reverse action upon reverse movement of the pin 202.

The foregoing description of the invention is explanatory thereof and various changes in the size, shape and materials, as well as in the details of the illustrated construction may be made, within the scope of the appended claims, without departing from the spirit of the invention.

What I claim and desire to secure by Letters Patent is:

1. The combination with a fluid-operated pump including a cylinder, a driving piston in the cylinder, means for admitting a motive fluid under pressure to the cylinder for moving the driving piston therein, fluid-actuated valve means for controlling the admission of the motive fluid to the cylinder, and fluid pumping means connected to and driven by the driving piston, of a snap-action valve for controlling the admission of actuating fluid to the fluid-actuated valve means, and actuating means for the snap-action valve including an actuating rod operated by the piston, and spaced actuating elements carried by the rod for actuating the snap-action valve.

2. The combination with a fluid operated pump including a cylinder, a driving piston in the cylinder, means for admitting a motive fluid under pressure to the cylinder for moving the driving piston therein, fluid-actuated valve means for controlling the admission of the motive fluid to the cylinder, and fluid pumping means connected to and driven by the driving piston, of a snap-action instantaneously opening and closing valve for controlling the admission of actuating fluid to the fluid-actuated valve means, and actuating means for the snap-action valve including an actuating rod extending into the cylinder for engagement by the piston, and spaced actuating rings carried by the rod for actuating the snap-action valve.

3. The combination as set forth in claim 2 wherein the snap-action valve is provided with an actuating arm projecting between the actuating rings of the actuating rod, said rings being spaced apart a distance greater than the path of movement of the actuating arm.

4. The combination as set forth in claim 2 wherein the fluid-actuated valve means is a springless four-way valve.

5. The combination with a fluid-operated pump including a cylinder, a piston and rod assembly for pumping a fluid, at least the piston of said assembly being

disposed in the cylinder, means for admitting a motive fluid under pressure to the cylinder for moving the piston therein, and fluid-actuated valve means for controlling the admission of the motive fluid to the cylinder, of a snap-action instantaneously opening and closing valve for controlling the admission of actuating fluid to the fluid-actuated valve means, an actuating rod operated by the piston and rod assembly, spaced actuating elements carried by the actuating rod, and means having connection with the snap-action valve for alternate engagement with the actuating elements to instantaneously open and close said snap-action valve.

6. The combination set forth in claim 5 wherein the means having connection with the snap-action valve includes an arm positioned for direct engagement with and movement by the spaced actuating elements.

7. The combination set forth in claim 6 wherein the actuating elements are disposed on each side of the arm and are spaced apart a distance greater than the movement of said arm.

8. The combination set forth in claim 5 wherein the actuating rod has lost-motion connection with the piston and rod assembly.

9. The combination set forth in claim 5, including means for admitting and discharging a pumped fluid to and from the cylinder on the side of the piston opposite the side to which the motive fluid is admitted, and means connected to said piston for driving said piston in a direction opposite that in which it is moved by the motive fluid for pumping said motive fluid from said cylinder.

10. The combination set forth in claim 5 wherein the piston and rod assembly includes a pair of cylinders with a piston in each cylinder, the motive fluid being admitted to one side of each piston for moving the pistons in unison.

11. The combination set forth in claim 5, spring means urging the piston and rod assembly in a direction opposite to that in which said assembly is moved by the motive fluid, and means for admitting a second fluid to the cylinder on the side of the piston opposite the side to which said motive fluid is admitted and for discharging the second fluid.

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