

March 23, 1965

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3,174,409

PUMPS AND REGULATING MEANS THEREFOR

Filed Nov. 29, 1962

3 Sheets-Sheet 1

Fig. 1.

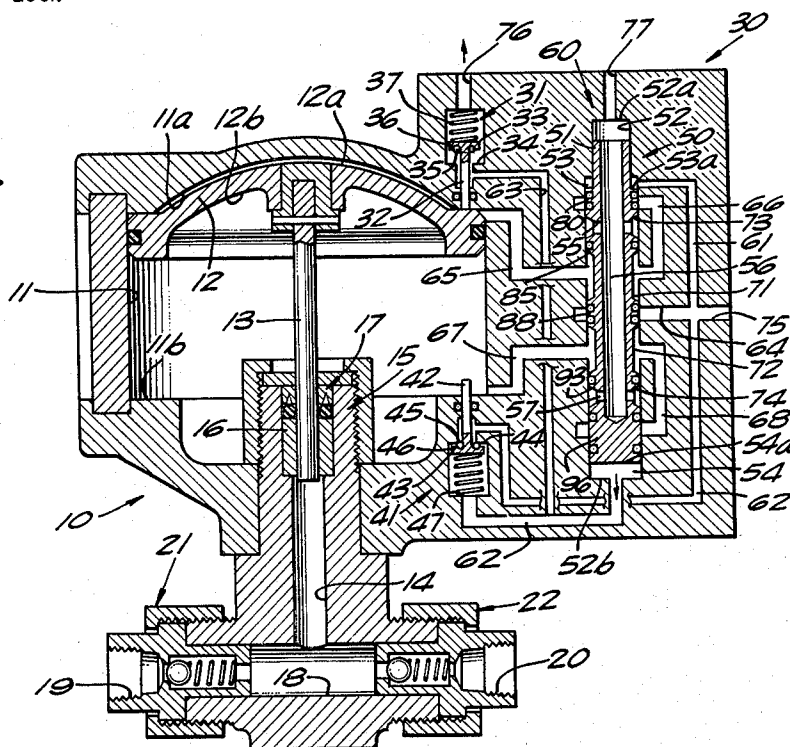
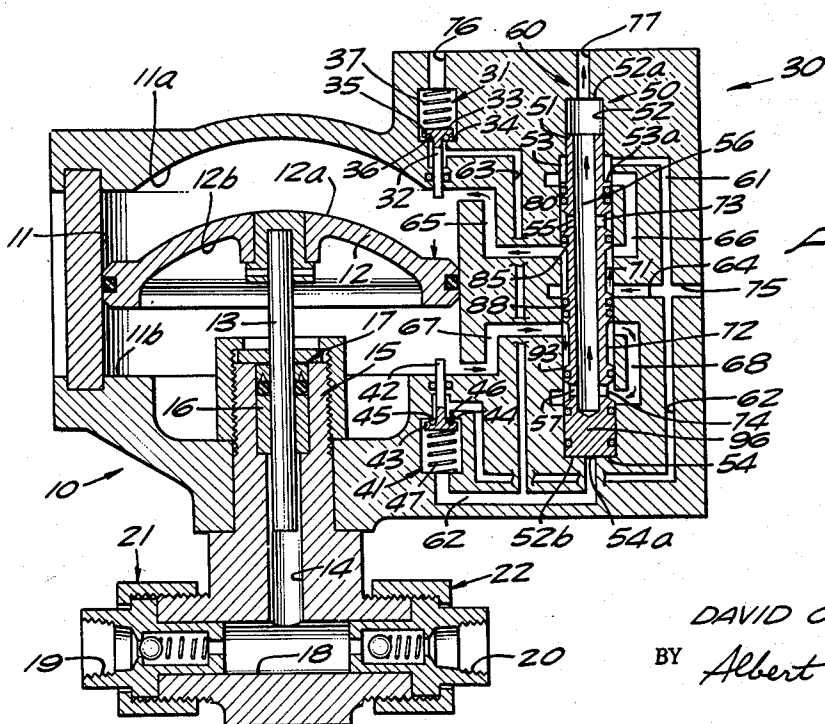


Fig. 2.



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Fig. 3.

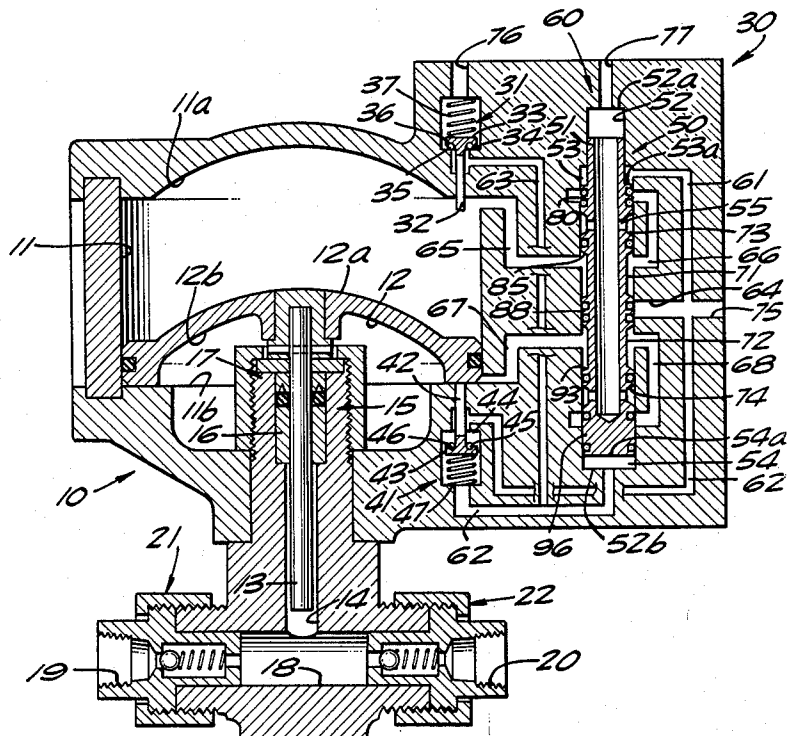
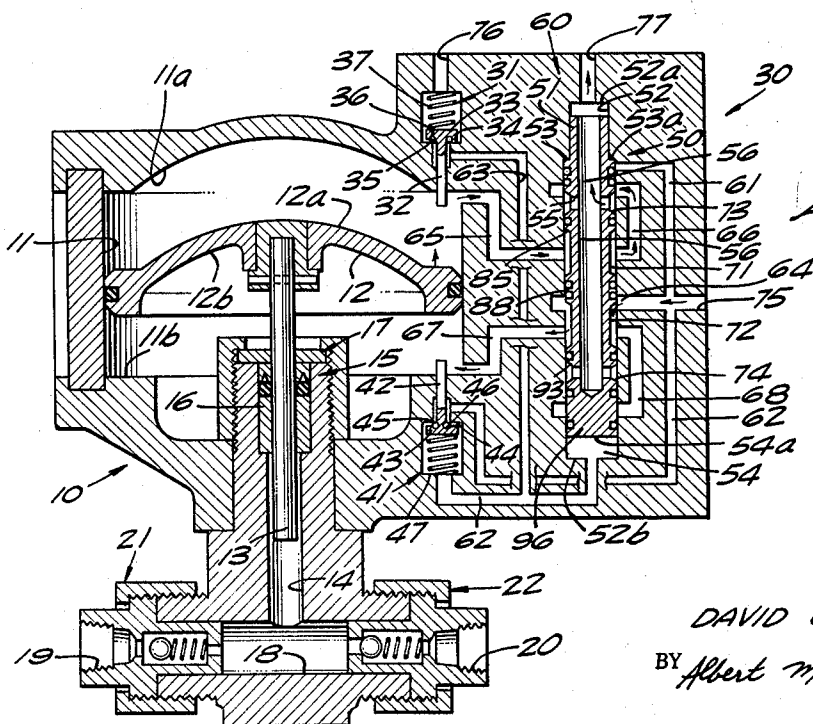


Fig. 4.



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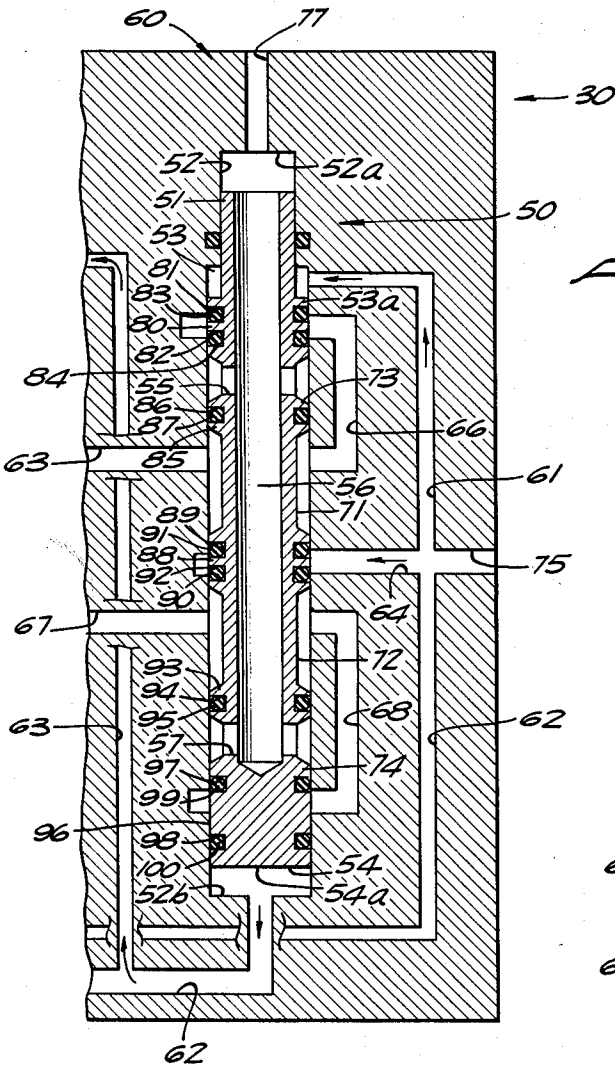


Fig. 5.

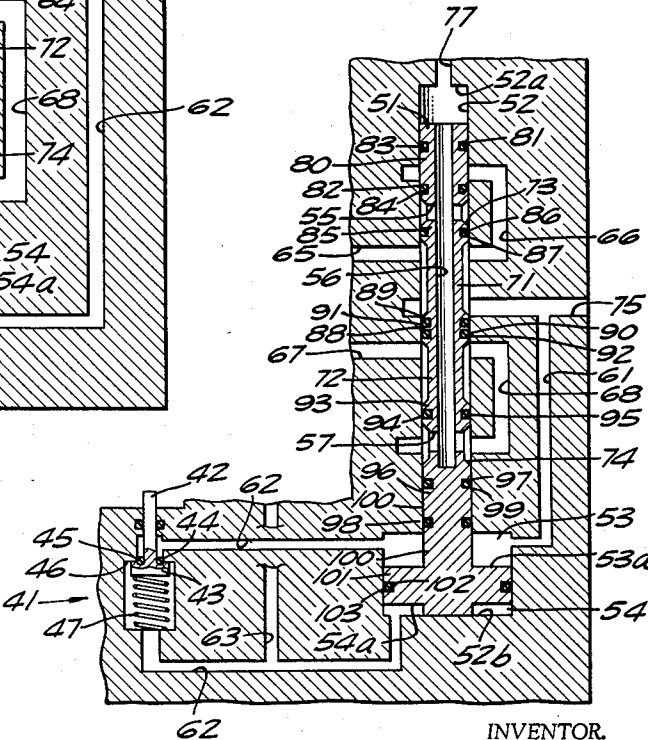


Fig. 6.

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PUMPS AND REGULATING MEANS THEREFOR
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4 Claims. (Cl. 91-306)

In general, the present invention relates to air or gas-driven fluid pumps and regulating means for such pumps. More specifically, the present invention relates to air or gas-driven fluid pumps and regulating means therefor adapted to utilize a dry driving gas without a lubricating fluid added thereto and yet having a long service life and adapted to permit replacement of all parts subject to wear without disturbing external gas and fluid connections.

At present, a number of gas-driven fluid pumps for pumping liquids or gases, or both, are available. However, such presently available pumps have a number of significant limitations and disadvantages which have substantially impaired their usefulness. For example, the usual pump regulating means includes a control valve having a spool with circumferential grooves separated by circumferential ridges. Such ridges have circumferential channels containing annular gaskets, such as O-rings. The normal arrangement of such channels and gaskets on the control valve spool is such that the gaskets are subjected to pressure gradients tending to force them out of their channels. The result is that there is relatively high friction between the control valve spool and the bore in which it is seated and the gaskets are subjected to unduly high rates of wear. Also, in some cases, the protrusion of the gasket from the channel causes it to catch in the gas conduits leading to the control valve bore and thus cause the spool to stick completely. In order to minimize the high friction and high gasket wearing rates of the present pump regulating means, the presently available pumps require the use of a driving gas having a lubricating fluid added thereto. Furthermore, the presently used pump regulating means normally require a relatively tight gasket to prevent protrusion of the gasket from its channel. Another disadvantage of the presently available regulating means for gas-driven pumps is that the control valve spool frequently tends to stall in mid position because there is an equal balance of forces on it at that point. Also, the pump regulating means normally do not include means for automatically producing the cycling of the gas-driven pump.

In addition, the presently available gas-driven pumps normally require sliding contact between the fluid piston and fluid bore which actively moves the fluid through the pump. Such arrangement not only precludes long service life, but also prevents the replacement of the parts subject to wear without disturbing external air, gas and fluid connections.

Consequently, an object of the present invention is a gas-driven fluid pump and pump regulating means adapted to utilize dry driving gas without a lubricating fluid added thereto and yet having a long service life.

Another object of the present invention is gas-driven fluid pump and pump regulating means adapted to permit replacement of all parts subject to wear without disturbing external gas and fluid connections.

Still another object of the present invention is a pump regulating means adapted to automatically cycle a gas-driven pump.

Still another object of the present invention is a pump regulating means adapted to maintain a pressure difference on the control valve gaskets which tends to seat such gaskets in their channels irrespective of the position of the control valve spool on which gaskets are mounted.

Still another object of the present invention is a fluid piston movably mounted in a fluid bore without contacting the walls of such fluid bore.

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Other objects and advantages of the present invention will be readily apparent from the following description and drawings which illustrate a preferred exemplary embodiment of the present invention.

In general, the present invention involves a pump means comprising a cylindrical gas bore having a gas piston slidably mounted therein. Connected to said gas piston is a fluid piston which is movably mounted in a cylindrical bore without contacting the walls of the fluid bore. A seal-bearing separates the gas bore from the fluid bore and the fluid piston is slidably mounted in such seal-bearing. Such seal-bearing has sufficient length to preclude contact between the fluid piston and the fluid bore. The present invention also includes a pump regulating means which comprises a control valve, including a spool slidably mounted in a bore, said spool having a plurality of circumferential grooves. Such control valve includes a plurality of gas conduits with the gas conduits and spool grooves being adapted to selectively interconnect the ends of the gas bore and the control valve bore with a gas source and a gas outlet so that the gas piston automatically cycles between the ends of said gas bore. The grooves on the control valve spool are separated from each other by ridges having at least one circumferential channel containing an annular gasket. Such channels and gaskets are positioned with respect to the adjacent gas conduits so that the pressure difference between the adjacent gas conduits and the grooves always tend to seat the gaskets in the channels when they move across the adjacent gas conduits.

In order to facilitate understanding of the present invention, reference will now be made to the appended drawings of a preferred specific embodiment of the present invention. Such drawings should not be construed as limiting the invention which is properly set forth in the appended claims.

In the drawings:

FIG. 1 is an axial cross-section semi-schematic drawing of the pump means and pump regulating means of the present invention showing the gas piston at the first end of the cylindrical gas bore and the control valve spool at an intermediate position in the control valve bore.

FIG. 2 is the same view of the present invention as in FIG. 1 wherein the gas piston is in an intermediate position during the drive portion of its cycle and the control valve spool is at the second end of the control valve bore.

FIG. 3 is the same view as FIG. 1, except that the gas piston is positioned at the second end of the cylindrical gas bore and the control valve spool is at an intermediate position in the control valve bore.

FIG. 4 is the same view as FIG. 1, except that the gas piston is at an intermediate position in the cylindrical gas bore during the return portion of its cycle and the control valve spool is at the first end of the control valve bore.

FIG. 5 is an enlargement of the control valve portion of FIGS. 1-4.

FIG. 6 shows an alternate control valve configuration which may be utilized with the pump means illustrated in FIGS. 1-4.

As illustrated in FIGS. 1-5, the present invention involves a pump means 10 and a pump regulating means 30. The pump means 10 comprises a cylindrical gas bore 11 having a gas piston 12 slidably mounted therein. The gas piston 12 is connected to the fluid piston 13. The fluid piston 13, in turn, is movably mounted in the cylindrical bore 14 without contacting the walls of the fluid bore 14. The fluid piston 13 is slidably mounted through the seal-bearing 15 which separates the gas bore 11 from the fluid bore 14. The seal-bearing 15 may comprise a bronze bearing 16 and a plurality of seals 17, such

as those described in applicant's copending application entitled High Pressure Seal being filed concurrently herewith. The seal-bearing 15 has sufficient length to preclude contact between the fluid piston 13 and the fluid bore 14. A fluid compartment 18 communicates with the fluid bore 14. Such fluid compartment 18 has at least one inlet fluid conduit 19 and at least one outlet fluid conduit 20. A first check valve 21 is positioned in the inlet conduit 19 and a second check valve 22 is positioned in the outlet conduit. Such pair of check valves 21 and 22 are oriented to move fluid through the fluid compartment 18 in one direction as set forth hereinafter.

The pump regulating means 30 comprises a pair of pilot valves 31 and 41, a plurality of gas conduits 50, and a control valve 60. Each of the pilot valves 31 and 41 have stems 32 and 42, respectively, extending into the gas bore 11. The stems 32 and 42 of the pilot valves 31 and 41, respectively, are connected to the valve heads 33 and 43, respectively. The valve heads 33 and 43 are sealed against the valve seats 34 and 44, respectively, by means of gaskets 35 and 45, respectively, such as O-rings. The gaskets 35 and 45 of the pilot valves 31 and 41, respectively, are mounted in circumferential channels 36 and 46, respectively, in the surface of the valve heads 33 and 43, respectively, adjacent to the valve seats 34 and 44, respectively. Each of the pilot valves 31 and 41 also include biasing springs 37 and 47, respectively, so that they are normally maintained in a closed position. The first pilot valve 31 is positioned adjacent to the first end 11a of the gas bore 11, and the second pilot valve 41 is positioned adjacent to the second end 11b of gas bore 11. Each of the pilot valves 31 and 41 are adapted to be opened by the movement of the gas piston 12 to its end of the gas bore 11, as illustrated in FIGS. 1 and 3.

Next, the pump regulating means 30 includes a control valve 50 which in turn includes a spool 51 slidably mounted in a bore 52. The control valve spool 51 is adapted to form with the control valve bore 52, a first chamber 53 located adjacent the first end 52a of the control valve bore 52, and a second chamber 54 located at the second end 52b of the control valve bore 52. The spool portion 53a of the first chamber 53 has substantially less area perpendicular to the axis of the control valve spool 51 than the spool portion 54a of the second chamber 54. As illustrated in FIGS. 1-5, the spool portion 53a of the first chamber 53 has approximately half the area perpendicular to the axis of the spool 51 of the second chamber 54.

Operatively associated with the control valve 50 is a plurality of gas conduits 60 which include a first gas conduit 61 connecting a gas source 75 to the first control valve chamber 53. A second gas conduit 62 connects the gas source 75 to the second control valve chamber 54 through the second pilot valve 41. A third gas conduit 63 connects the second control valve chamber 54 to a gas outlet 76 through the first pilot valve 31. A fourth gas conduit connects the gas source 75 to the control valve bore 52. A fifth gas conduit 65 connects the first end 11a of the gas bore 11 to the control valve bore 52. A sixth gas conduit 66 connects the control valve bore 52 to a gas outlet 77 when the control valve spool 51 is at the first end 52a of the control valve bore 52. As illustrated, specifically in FIG. 4, the sixth gas conduit 66 communicates with the gas outlet 77 through a third circumferential groove 73 in the control valve spool 51. The description of the first and second circumferential grooves 71 and 72, respectively, is set forth hereinafter. The third circumferential groove 73 in the control valve spool 51 has an aperture 55 connecting it with the hollow core 56 of the control valve spool 51 which in turn communicates with the gas outlet 77.

A seventh gas conduit 67 connects the second end 11b of the gas bore 11 to the control valve bore 52. An eighth gas conduit 68 connects the control valve bore 52 to the gas outlet 77 when the control valve spool 51 is

at the second end 52b of the control valve bore 52. As illustrated specifically in FIG. 2, the eighth gas conduit 68 communicates with a fourth groove 74 in the control valve spool 51. The fourth circumferential groove 74 has an aperture 57 connecting it with the hollow core 56 of the control valve spool 51. The hollow core 56 of the control valve spool 51 in turn communicates with the gas outlet 77.

As indicated above, the control valve spool 51 has a plurality of circumferential grooves which include a first groove 71 and a second groove 72. The first groove 71 connects the fourth gas conduit 64 to the fifth gas conduit 65 when the control valve spool 51 is at the second end 52b of the control valve bore 52 (note FIG. 2). The first groove 71 also connects the fifth gas conduit 65 to the gas outlet 77 through the sixth gas conduit 66 when the control valve spool 51 is at the first end 52a of the control valve bore 52 (note FIG. 4). The second groove 72 connects the seventh gas conduit 67 to the gas outlet 77 through the eighth gas conduit 68 when the control valve spool 51 is at the second end 52b of the control valve bore 52 (note FIG. 2). Also, the second groove 72 connects the fourth gas conduit 64 to the seventh gas conduit 67 when the control valve spool 51 is at the first end 52a of the control valve bore 52 (note FIG. 4).

As best illustrated in FIG. 5, the circumferential groove 71, 72, 73 and 74 and the first control valve chamber 53 and the second control valve chamber 54 are separated from each other by a plurality of ridges, each having at least one circumferential channel containing an annular gasket. More specifically, the first control valve chamber 53 is separated from the third circumferential groove 73 by a first circumferential ridge 80 having two circumferential channels 81 and 82, respectively, containing annular gaskets 83 and 84, respectively. The other side of the groove 73 is separated from the first groove 71 by a circumferential ridge 85 having a circumferential channel 86 containing an annular gasket 87. The other side of the first groove 71 is separated from one side of the second groove 72 by means of a circumferential ridge 88 having circumferential channels 89 and 90, respectively, containing annular gaskets 91 and 92, respectively. The other side of the second groove 72 is separated from one side of the fourth groove 74 by the circumferential ridge 93 having a circumferential channel 94 containing an annular gasket 95. Finally, the other side of the fourth groove 74 is separated from the second control valve chamber 54 by a circumferential ridge 96 having circumferential channels 97 and 98 containing annular gaskets 99 and 100, respectively. The channels and gaskets are positioned with respect to their adjacent gas conduits 66-69 so that the pressure difference between adjacent gas conduits and the grooves and control valve chambers always tend to seat said gaskets in said channels when they move across the adjacent gas conduits. For example, when the circumferential ridge 88 moves across its adjacent gas conduit 64 the gas pressure in the gas conduit 64 is always higher than the gas pressure in the first groove 71 or the second groove 72.

As illustrated in FIGS. 1-5, the operation of the pump 10 and the pump regulating means 30 may begin its cycle as shown in FIG. 1 by the gas piston 12 being located at the first end 11a of the gas bore 11. Such position of the gas piston 12 opens the first pilot valve 31 by raising the valve head 33 by pressing against the valve stem 32. The opening of the first pilot valve 31 exhausts the second control valve chamber 54 through the third gas conduit 63 and the gas outlet 76. Simultaneously, the gas pressure in the first control valve chamber 53 supplied through the first gas conduit 61 from the gas source 75 moves the control valve spool 51 to the second end 54b of the control valve bore 52, as shown in FIG. 2.

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As illustrated in FIG. 2, when the control valve spool 51 is at the second end 52b of the control valve bore 52, the first end 11a of the gas bore 11 receives pressure from the gas source 75 through the fourth gas conduit 64, the first groove 71 and the fifth gas conduit 65. Simultaneously, the second end 11b of the gas bore 11 is exhausted through the seventh conduit 67, the second groove 72, the eighth gas conduit 68, the fourth groove 74, the aperture 57, the spool core 56, and the gas outlet 77. Thus the gas pressure acts on the first side 12a of the gas piston 12 forcing it toward the second end 11b of the gas bore 11. Such movement in turn forces the fluid piston 13 further into the fluid bore 14 so that fluid is forced through the second check valve 22 and out of the fluid outlet 20. When the gas piston 12 reaches the second end 11b of the gas bore 11, as illustrated in FIG. 3, it opens the second pilot valve 41. The opening of the second pilot valve 41 supplies air pressure from the source 75 through the second gas conduit 62 to the second control valve chamber 54. Although the first and second control valve chambers 53 and 54, respectively, are at the same pressure at this point in the operating cycle since the second control valve chamber 54 has approximately twice the area perpendicular to the axis of the control valve spool 51 than the first control valve chamber 53, the control valve spool 51 is forced toward the first end 52a of the control valve bore. Also, under such conditions it is not possible for the control valve spool 51 to stall at an intermediate position since the larger resulting force from the second control valve chamber 54 will always force it to such position.

As illustrated in FIG. 4, when the control valve spool 51 is at the first end 52a of the control valve bore 52, gas pressure is supplied to the second end 11b of the gas bore 11 from the gas supply source 75 through the fourth gas conduit 64, the second groove 72, and the seventh gas conduit 67. Simultaneously, gas pressure is exhausted from the first end 11a of the gas bore 11 through the fifth gas conduit 65, the first groove 71, the sixth gas conduit 66, the third groove 73, the aperture 55, the spool core 56 and the gas outlet 77. The gas pressure thus acts on the second side of the gas piston 12 and forces it toward the first end 11a of the gas bore 11. Such movement retracts the fluid piston 13 from the fluid bore 14 and thus sucks fluid through the fluid inlet 19 and the inlet check valve 21. Such movement is continued until the position illustrated in FIG. 1 is attained and the cycle then automatically repeats for an indefinite period of time.

In FIG. 6, an alternate control valve configuration is illustrated wherein the first control valve chamber 53 and the second control valve chamber 54 are located at the second end 52b of the control valve bore 52. Such arrangement requires an additional circumferential ridge 101 on the control valve spool 51 to separate the first control valve chamber 53 from the second control valve chamber 54. The circumferential ridge 101 has a circumferential channel 102 containing an annular gasket 103.

Many other specific embodiments of the present invention will be obvious to one skilled in the art in view of this disclosure. For example, as noted, the first control valve chamber 53 may be located at either end of the control valve bore. Similarly, the second control valve chamber may be located at either end of the control valve bore. Also, the gas bore need not be exhausted by means of a hollow core control valve spool, but, rather, may be exhausted through a separate exhaust gas conduit. Of course, the particular pumping arrangement illustrated utilizing a pair of check valves is only one of a number of well known pumping arrangements requiring reciprocating longitudinal motion of a fluid piston. Any pumping arrangement may be utilized with the present invention which requires simply a reciprocating longitudinal movement of the fluid piston.

There are many features in the present invention which

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clearly show the significant advance the present invention represents over the prior art. Consequently, only a few of the more outstanding features will be pointed out to illustrate the unexpected and unusual results attained by the present invention. One of the features of the present invention is the utilization of ridges on the control valve spool separating its grooves and the control valve chambers, with such ridges having at least one circumferential channel containing an annular gasket. Such channels and gaskets are positioned with respect to adjacent conduits leading to the gas bore of the control valve bore so that the pressure difference between the gas conduits and the grooves or the control valve chambers always tends to seat the gaskets in the channels when they move across the gas conduits. With such arrangement using simple O rings, a leakproof valve is obtained with sufficiently low friction to permit running the pump with dry air.

Another feature of the present invention is a seal-bearing separating the gas fluid bore through which the fluid piston is slidably mounted. Such seal-bearing has sufficient length to preclude contact between the fluid piston and the fluid bore. Such arrangement obtains a long service life and in addition permits replacement of all parts subject to wear without disturbing external gas fluid connections. Another feature of the present invention is the utilization of pilot valves at each end of the gas bore to obtain automatic cycling of the gas piston between the ends of the gas bore. Still another feature of the present invention is the utilization of an unbalanced control valve spool to prevent such spool from stalling in mid position.

It will be understood that the foregoing description and examples are only illustrative of the present invention and it is not intended that the invention be limited thereto. All substitutions, alterations and modifications of the present invention which come within the scope of the following claims or to which the present invention is readily susceptible without departing from the spirit and scope of this disclosure are considered part of the present invention.

I claim:

1. A gas-driven fluid pump regulator adapted to utilize a dry driving gas without a lubricating fluid added thereto and yet having a long service life and adapted to permit replacement of all parts subject to wear without disturbing external gas and fluid connections, said pump regulator comprising:

(a) a cylindrical gas bore having a gas piston slidably mounted therein;

(b) a pair of pilot valves with the first of said pilot valves being positioned adjacent to the first end of said gas bore and the second of said pilot valves being positioned adjacent to the second end of said gas bore, each of said pilot valves being adapted to be opened by the movement of said gas piston to its end of said gas bore;

(c) a control valve, including a spool slidably mounted in a bore, said spool being adapted to form with said bore a first and second chamber, the spool portion of said first chamber having substantially less area perpendicular to the axis of said spool than the spool portion of said second chamber;

(d) a plurality of gas conduits including:

(I) a first gas conduit connecting a gas source to said first control valve chamber,

(II) a second gas conduit connecting said gas source to said second control valve chamber through said second pilot valve,

(III) a third gas conduit connecting said second control valve chamber to a gas outlet through said first pilot valve,

(IV) a fourth gas conduit connecting a gas source with said control valve bore;

(V) a fifth gas conduit connecting the first end of said gas bore to said control valve bore,

(VI) a sixth gas conduit connecting said control

- valve bore to a gas outlet when said spool is at the first end of said control valve bore,
- (VII) a seventh gas conduit connecting the second end of said gas bore to said control valve bore, and
- (VIII) an eighth gas conduit connecting said control valve bore to a gas outlet when said spool is at the second end of said control valve bore; and
- (e) a plurality of circumferential grooves in said control valve spool including:
- (I) a first groove connecting said fourth and fifth gas conduits when said spool is at the second end of said control valve bore and connecting said fifth and sixth gas conduits when said spool is at the first end of said control valve bore, and
- (II) a second groove connecting said seventh and eighth gas conduits when said spool is at the second end of said control valve bore and connecting said fourth and seventh gas conduits when said spool is at the first end of said control valve bore,
- said grooves being separated from each other and said control valve chambers by ridges, each of said ridges having at least one circumferential channel containing an annular gasket, said channels and gaskets being positioned with respect to the adjacent gas conduits so that the pressure difference between said adjacent gas conduits and said grooves always tends to seat said gaskets in said channels when they move across said adjacent gas conduits.
2. A pump regulator as stated in claim '1 wherein said control valve spool has a hollow core communicating with a gas outlet and the circumferential grooves on said control valve spool include:
- (a) a third groove having an aperture connecting it with the spool core and connecting said spool core with said sixth gas conduit when said spool is at the first end of said control valve bore, and
- (b) a fourth groove having an aperture connecting it with the spool core and connecting said spool core with said eighth gas conduit when said spool is at the second end of said control valve bore,
- said grooves being separated from said first and second grooves and said control valve chambers by ridges having at least one circumferential channel containing an annular gasket, said channels and gaskets being positioned with respect to the adjacent gas conduits so that the pressure difference between said adjacent gas conduits and said grooves always tends to seat said gaskets in said channels when they move across the adjacent gas conduits.
3. A pump regulating means adapted to automatically cycle a gas-driven pump means, including a cylindrical

gas bore having a gas piston slidably mounted therein, comprising:

- (a) a pair of normally seated pilot valves with the first of said pilot valves being positioned adjacent to the first end of said gas bore and the second of said pilot valves being positioned adjacent to the second end of said bore, each of said pilot valves including a valve seat and a valve head and being adapted to be unseated by the movement of said gas piston to an associated end of said gas bore;
- (b) a control valve including a spool slidably mounted in a bore, said spool being adapted to form with said bore a first and a second chamber, the spool portion of said first chamber having substantially less area perpendicular to the axis of said spool than the spool portion of said second chamber;
- (c) a plurality of gas conduits, including:
- (I) a first gas conduit connecting a gas source to said first control valve chamber,
- (II) a second gas conduit connecting said gas source to said second control valve chamber through said second pilot valve seat, and
- (III) a third gas conduit connecting said second control valve chamber to a gas outlet through said first pilot valve seat; and
- (d) a plurality of circumferential grooves in said control valve spool, said gas conduits and grooves being adapted to selectively interconnect the ends of said gas bore and said control valve bore with the gas source and a gas outlet so that said gas piston automatically cycles between the ends of said gas bore.
4. A pump regulating means as stated in claim 3 wherein said grooves are separated from each other and said control valve chambers by ridges having at least one circumferential channel containing an annular gasket, said channels and gaskets being positioned with respect to the adjacent gas conduits so that the pressure difference between said adjacent gas conduits and said grooves always tends to seat said gaskets in said channels when they move across said adjacent gas conduits.

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