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2,699,152

VALVE MECHANISM

Filed March 16, 1951

2 Sheets-Sheet 1

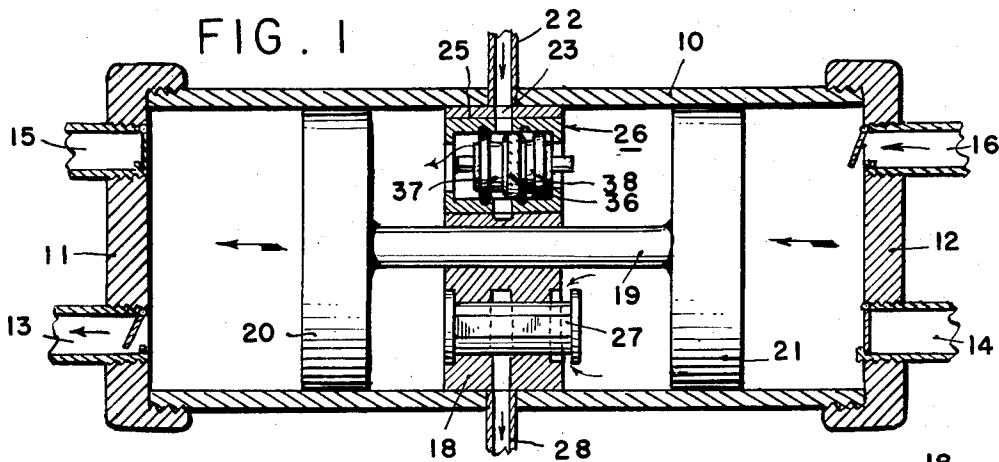


FIG. 6

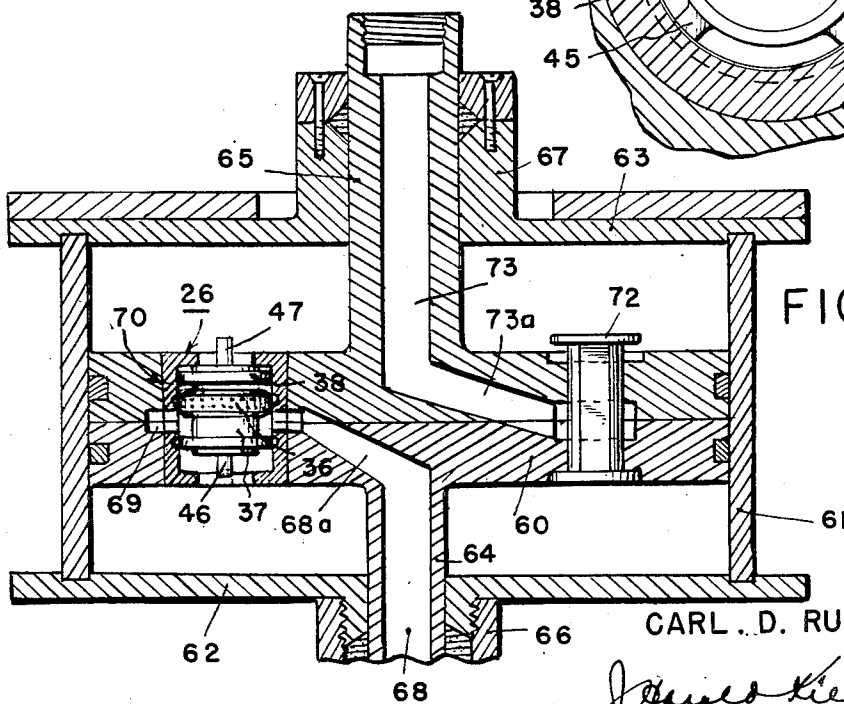
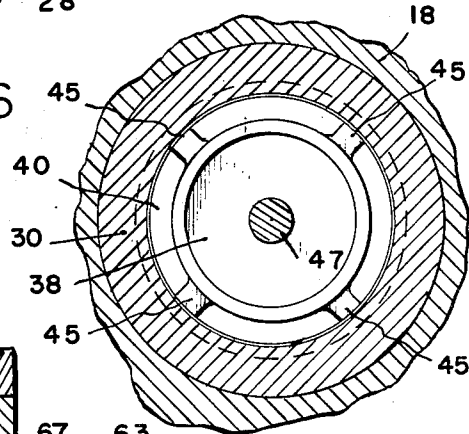


FIG. 7

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FIG. 2

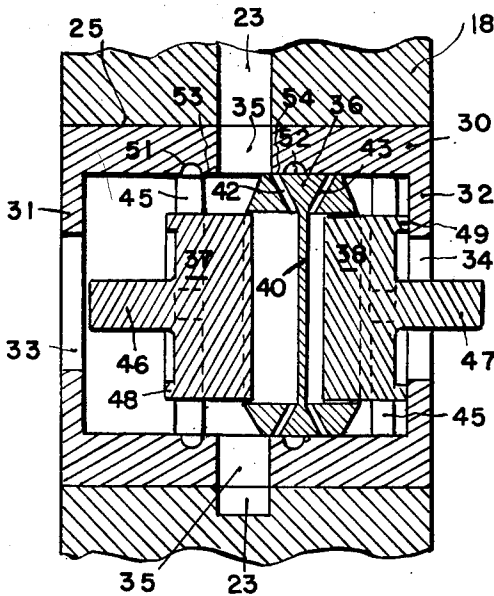


FIG. 3

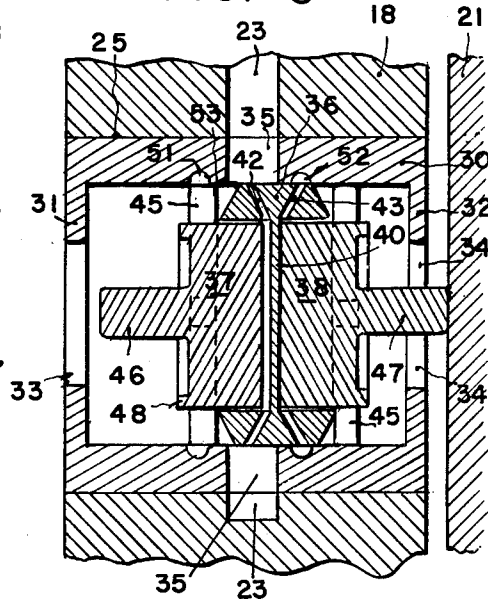


FIG. 4

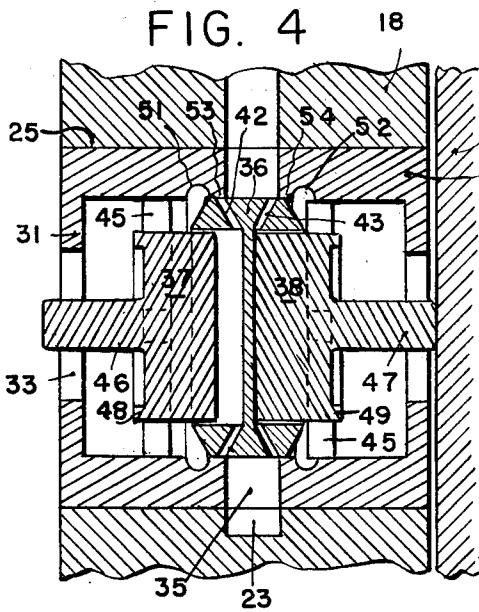
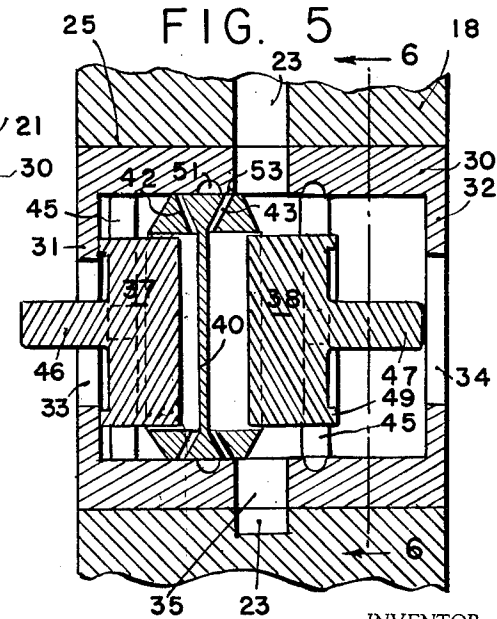


FIG. 5



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VALVE MECHANISM

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8 Claims. (Cl. 121—123)

This invention relates to improvements in valve mechanisms and more particularly to an improved reversing valve mechanism for controlling admission and distribution of a working fluid to the opposite ends of the power cylinder of a reciprocating motor, a motor-compressor unit, a motor-pump unit, and similar apparatus motivated by a fluid medium.

As conducive to an understanding of the invention, reference is had to my copending application Serial No. 68,141, filed December 30, 1948, now Patent No. 2,637,981, dated May 12, 1953, disclosing refrigeration apparatus employing a motor-compressor unit of the duplex piston type wherein admission and distribution of the working fluid to the opposite ends of the cylinder is controlled by a reversing valve mounted in a central partition, and to my copending application Serial No. 144,738, filed February 17, 1950, now Patent No. 2,655,966, dated October 20, 1953, disclosing waste disposal apparatus powered by a water motor of the valved piston type. In the case of the motor-compressor unit which employs the refrigerant in gaseous phase as its motive fluid, reliance is had on the expansive property of the fluid in the cylinder end then acting as the power cylinder to complete the reversing motion of the valve after it has been moved to an intermediate or dead center position by the piston then acting as a follower piston. While such an arrangement performs satisfactorily under normal working conditions, it is open to the objection that if the unit is cut out of operation with the admission valve in its dead center position, it can be re-started only by manually shifting the valve or by effecting slight further translation of the piston assembly.

In the case of the water motor, water being a non-elastic fluid, positive means (usually mechanical) must be provided to preclude against the possibility of the admission valve failing to move past its dead center position at the end of each stroke of the piston as would result in cessation of piston travel.

Broadly stated, the present invention contemplates and provides a reversing valve mechanism for use in the above and other like applications, in which valve reversal is effected in positive manner by the pressure of the working fluid itself and without reliance on the elastic properties thereof, or as in case of the non-elastic fluid motor, without recourse to mechanical valve reversing means.

Another important aim of this invention is the provision of a reversing valve mechanism for use with motors, compressors and like apparatus of the type employing both elastic and non-elastic working fluids characterized in that, even though the motor or similar apparatus is stopped with the admission valve in its dead center position, the valve will move to one or the other of its end positions upon working fluid being supplied thereto, thus insuring re-starting of the apparatus.

More detailed objects of the invention are the provision of a reversing valve mechanism of simple construction and design lending itself to ready installation in the dividing wall or partition of a motor-compressor unit of the duplex piston type, for example, or in the piston of a double-acting fluid motor, and which is further characterized by effective and thoroughly dependable operation.

The above and other objects and advantages of a reversing valve mechanism according to the invention will be apparent from the following description thereof, in conjunction with the accompanying drawings illustrating two typical applications of said valve mechanism, wherein:

Fig. 1 is a longitudinal section taken through a motor-

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compressor unit of the duplex piston type powered by an elastic working fluid, illustrating one application of a reversing valve mechanism according to the present invention;

Figs. 2-5 are enlarged longitudinal sectional views taken through the reversing valve mechanism of the invention illustrating the relative positions assumed by the sleeve valve and associated timing plungers forming the components of said mechanism throughout one-half cycle of valve reversing movement;

Fig. 6 is a section taken through the reversing valve mechanism on line 6-6 of Fig. 5; and

Fig. 7 is illustrative of the application of a reversing valve mechanism according to the invention to effect admission and distribution of a non-elastic working fluid to the opposite ends of the cylinder of a double-acting reciprocating motor, for example.

Referring to the drawings, Fig. 1 illustrates a motor-compressor unit of the duplex piston type generally as disclosed in my aforesaid Patent No. 2,637,981. As shown, such a unit comprises an elongated cylinder 10 closed at its ends by heads 11, 12 into which discharge lines 13, 14 to and suction lines 15, 16 from compressor are connected. The interior space of said cylinder is divided by a central partition 18 in which a connecting rod 19 has sliding bearing, the connecting rod mounting at its ends the pistons 20, 21 which accordingly reciprocate in unison; that is to say, as one of the pistons 20, 21 is motivated in outward direction by working fluid effective on its under face, motion in like (but inward) direction is imparted to the other piston through connecting rod 19.

The working fluid to be distributed to one or the other power spaces of the cylinder is supplied through line 22 connected into an annular passage 23 formed in the partition to encircle and open into a cylindrical partition bore 25, in which is mounted the reversing valve mechanism generally designated 26 forming the subject-matter of the present invention. When positioned as shown in Fig. 1, the aforesaid valve mechanism is effecting admission of the working fluid to the power space to the left of the central partition 18, with the result that the piston 20 is moving to the left and through piston rod 19 is imparting corresponding leftwise motion to the piston 21. An exhaust valve 27, also mounted in the partition 18, is shown in its rightwise position, in which it closes said power space to exhaust and opens the opposite space, namely, that between the partition and under face of piston 21, which latter is now acting as a compression face, to a line 28 connected to exhaust, i. e. condenser. Said line 28 may extend direct to condenser or it may connect with the cylinder discharge lines 13, 14 leading to condenser.

According to the invention, the aforesaid reversing valve mechanism 26 comprises a cylindrical body 30 mounted in the partition 25 and having axial length corresponding to the thickness of the partition. Preferably, the valve body is formed at both ends with radially inward flanges or skirts 31, 32 which define fluid admission openings 33, 34 to the cylinder spaces to the sides of the partition 18. The working fluid is supplied to the interior of the valve body by a circular series of ports 35 in its middle portion which provide an inlet passage in register with the annular passage 23 of the partition. Alternately, the valve body 30 may be formed in two longitudinal half-sections whose adjacent ends are spaced the width of the annular passage 23 so that the latter opens directly into valve body interior throughout the full circumference of said body.

Distribution of the working fluid entering the valve body to one or the other ends thereof, and thence to one or the other of the power spaces of the cylinder 10, is controlled by a reversible valve element 36 contained within the bore of the valve body. It is a principal feature of the present invention that the aforesaid valve element is actuated in its reversing movement by the pressure of the working fluid, in conjunction with piston-controlled timing plungers 37, 38 whose operation is such as to insure proper positioning of said valve element for initiation of its reversing movement responsively to the working piston approaching its outermost limit of travel.

As seen in Figs. 2-5, the valve element 36 comprises a cylindrical sleeve having sliding fit within the valve

body 30, the sleeve being divided interiorly by a transverse wall 40, whereby the sleeve forms two oppositely disposed cups or cylinders in which timing plungers designated 37, 38 have sliding fit. Preferably, the end edges of the sleeve valve are oppositely chamfered, thus to give the valve greater axial length interiorly than in its outer surface, which latter has axial length greater than the width dimension of the inlet passage 35. Working fluid is supplied to said plunger cylinders through two circular series of ports 42, 43, the ports of the series converging towards one another by an angle such that they open into said cylinders adjacent their relatively inner or closed ends.

It will be observed, by reference to Fig. 4, that the outer (inlet) ends of the two series of ports 42, 43 are spaced from one another a distance which is less than the width of the valve body inlet passage 35, with the result that even though the sleeve valve 36 is in its dead center position, one or the other series of ports 42, 43 is in register with said inlet passage and hence working fluid will pass to either one or the other of the plunger cylinders, for the purpose to be later explained.

The timing plungers 37, 38 are oppositely arranged as shown and comprise cylindrical heads which may be provided adjacent their outer faces with radial arms 45 (Fig. 6) giving a spider form of support for the outer ends of the plungers within the valve body 30, and with axial pins or stems 46, 47 of length such that they protrude a fixed distance outwardly from the partition 18 when the plungers are in the outermost position. On their under faces, the plungers may be provided with circular sealing ribs 48, 49 which are adapted to seal against the inner faces of the valve body end flanges 31, 32 when the plungers are in their aforesaid outermost position.

In its inner circumferential wall, the valve body 30 is provided with two circularly arranged exhaust channels 51, 52 which open into the bore thereof and are spaced axially from the valve body inlet passage 35 by a predetermined small distance. It will be observed that the inner wall surfaces of the valve body which extend between the exhaust channels 51, 52 and said inlet ports 35 form circular lands 53, 54. The purpose and functioning of the aforesaid exhaust channels and lands will be seen from the following explanation of the operation of a valve mechanism as described in the foregoing.

Briefly detailing this operation, let it be assumed that the sleeve valve 36 and timing plungers 37, 38 are in their relative positions shown in Fig. 2, to which they were actuated upon the piston 20 reaching the limit of its travel to the right. It will be observed that the position of sleeve valve 36 and plunger 37 is such that the working fluid from supply line 22 passes freely through the annular partition passage 23 and the valve body inlet passage 35, and thence past plunger 37 to the left-hand power space of the cylinder 10, i. e. to the under face of the piston 20, resulting in actuation of said piston to the left, and travel of the piston 21 in like direction.

As the pistons 20, 21 near the end of their leftwise stroke, piston 21 engages the protruding pin 47 of plunger 38 and forces same to the left, that is to say, into its cylinder. Upon the plunger consequent to such movement compressing any fluid locked within its cylinder to a pressure exceeding that of the working fluid effective on the sleeve valve, said sleeve valve moves to the left until its then rearward series of ports 43 register with the exhaust channel 52 which is in communication with the low-pressure side of the partition. Thereupon, the plunger 38 collapses, i. e. moves freely into the sleeve valve in response to further leftwise movement of piston 21, until it engages against the transverse dividing wall 40 of the valve, as is indicated in Fig. 3. When such engagement occurs, the plunger 38 in its further leftwise movement positively pushes the sleeve valve to the left, causing the ports 43 of said righthand series thereof first to be covered by the land 54, and thereupon to come into registry with the supply passage 35. At the instant of said registry, reference being had to Fig. 4, the working fluid is admitted to the right-end plunger cylinder into which the plunger 38 has fully moved as aforesaid and becomes immediately effective against the inner end face of said plunger. Since the plunger 38 cannot move to the right, and in fact is being positively actuated to the left by continued leftwise movement of piston 21, the pressure of the working fluid forces the sleeve valve 36 to the left

to the approximate position shown in Fig. 5, in which said valve ports 43 are covered by the land 53 between the lefthand exhaust channel 51 and the inlet passage 35.

It is to be understood that upon the piston 21 moving to a position about that shown in Fig. 3, it contacts the exhaust valve 27 (Fig. 1) and shifts same to the left, thus opening the cylinder space to the left of partition 18 to exhaust. Since the left end of the valve body now becomes the low pressure end, the aforesaid leftwise motion of the sleeve valve is easily achieved, because of the substantially higher pressure of the working fluid effective on the right face of its dividing wall 40. It will be moreover seen that during the course of sleeve valve travel from its Fig. 4 to its Fig. 5 positions, the inlet ports 42 to the left-end plunger cylinder have moved through registry with the lefthand exhaust channel 51, thus permitting a quick release of any fluid locked in said cylinder by the plunger 37, so that the sleeve valve in effect collapses with respect to the plunger 37. However, upon the ports 42 moving past said exhaust groove 51, said ports are again closed, and the fluid effective between the inner end of said plunger and the left face of the dividing plate 40 expands to cause the plunger 37 to move outwardly and seal against the valve body flange 31, as in Fig. 5.

It will be observed at this point that the piston 21 in its leftwise movement positively actuated the right-end plunger 38 axially inwardly from its outermost (Fig. 2) position to the extent that the end face of its protruding pin 47 is flush with the right face of the cylinder partition 18, as in Fig. 4. Slight further inward or retracting movement of said plunger 38 into the valve body to its position shown in Fig. 5 may result, due to the tendency of said plunger to move with the sleeve valve upon the inlet ports 43 thereof being closed off by the land 53. However, when the plunger 38 assumes its position aforesaid, it maintains such position due to the equality of the pressure of the working fluid on its opposite faces. In said position, the working fluid passes freely to the right-end power space of cylinder 10, driving piston 21 to the right and imparting corresponding motion to piston 20 through connecting rod 19.

Upon piston 21 approaching the limit of its outward (power) stroke, piston 20 moves inwardly against pin 46 of plunger 37 which is now protruding from the left face of partition 18, as in Fig. 5, and moves same to the right, thus initiating the reverse motion of the sleeve valve 36 in the opposite direction from that previously described, whereupon the sleeve valve and timing plungers return to their position illustrated in Fig. 2, thus completing the cycle of one complete stroke of the main pistons.

It is noteworthy that this cycle is repeated so long as the supply of the working fluid is maintained since reversing motion is imparted to the sleeve valve 36 by the pressure of the working fluid itself rather than because of its property of expanding under compression. The reversing valve mechanism as described has the further advantage that should the supply of working fluid be cut off when the sleeve valve is in dead center position, restarting with resumption of working fluid supply is assured due to the spacing of the two series of inlet ports 42, 43 of the sleeve valve, according to which one or the other series of said ports is always open to the working fluid, as generally shown in Fig. 4. Hence, upon resumption of working fluid supply, the sleeve valve is immediately shifted from its dead center position in the appropriate direction.

The reversing valve mechanism of the invention is of course not limited to applications wherein it is mounted in a fixed partition, with reliance being had on moving pistons to initiate actuation of the timing plungers. On the other hand, a reversing valve mechanism as described may be mounted in the piston of a double-acting water motor of the type shown in my Patent No. 2,655,966 aforesaid, with actuation of the timing plungers being effected by their engagement with the cylinder ends upon the piston approaching the outermost limits of its reciprocatory travel. Such an application of my reversing valve mechanism is illustratively shown in Fig. 7, wherein a double-acting piston 60, which may be of two-part construction as shown, is mounted to reciprocate within a cylinder 61 closed at its ends by heads 62, 63. The illustrated piston is provided with axial stems 64, 65 which are bored or formed tubular for the purpose to be de-

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scribed, said stems having sliding bearing in stuffing boxes 66, 67 formed in the cylinder heads as is conventional. The bore 68 of the one cylinder stem 64, which is connected by any suitable means to a source of water or similar non-elastic fluid under pressure, joins with a laterally offset piston passage 68a delivering to an annular piston passage 69 encircling a through bore 70 in which is mounted a valve reversing mechanism 26 similar to that previously described, and which functions to distribute the working fluid supplied through the valve stem bore 68 and connecting piston passages 68a, 69 to one or the other ends of the cylinder 61. The piston 69 also mounts an exhaust valve 72 corresponding to the exhaust valve 27 shown in Fig. 1, for exhausting the end of the cylinder not being supplied with working fluid through a laterally offset piston passage 73a connecting with the bore 73 of the piston stem 65 which leads to exhaust.

By analysis of Fig. 7, it will be seen that the sleeve valve 36 of the reversing valve mechanism 26 is positioned so as to admit working fluid to the lower end of the cylinder, and that the upper end of the cylinder is exhausting through valve 72. Accordingly, the piston 60 is being motivated in upward direction by the working fluid effective on its under face. Upon the piston approaching the upper limit of its travel, axial pin 47 of the upper (right-end) plunger 38 engages the upper cylinder head 63 and initiates downward movement of said plunger, with the result that the sleeve valve 36 is shifted downwardly by the pressure of the working fluid as previously described to a position in which it closes off admission to the lower end of the cylinder and effects distribution to the upper end of the cylinder, such being timed to the piston reaching the limit of its upward travel. Simultaneously therewith, the exhaust valve 72 is shifted downwardly to open the lower end of the cylinder to exhaust, whereupon the piston 60 begins its downward stroke. Reversing motion of the sleeve valve 36 in the opposite direction is initiated upon the axial pin 46 of the plunger 37 engaging the lower cylinder head 62 as the piston approaches the lowermost limit of its travel, and the aforesaid cycle is continued so long as the supply of working fluid is maintained.

Due to the fact that the sleeve valve 36 is positively actuated past its dead center position by the pressure of the working fluid, no mechanical means are required to effect admission valve reversal as in prior motors employing a non-elastic working fluid, such as water, as the working medium. Even if the supply of working fluid is interrupted when the sleeve valve 36 is on dead center, resumption of the supply immediately results in the valve moving to one or the other of its end positions consequent to the predetermined spacing of the series of sleeve valve inlet ports 42, 43 in relation to the width of the inlet passage 23 of the valve body.

It follows, therefore, that a valve reversing mechanism as described achieves the desirable objectives of the invention set forth in the foregoing in simple yet readily effective and thoroughly dependable manner.

As many changes could be made in carrying out the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

I claim:

1. A reversible valve mechanism for controlling admission and distribution of a working fluid to the opposite ends of a power cylinder having a reciprocating piston therein, comprising an open-ended cylindrical valve body whose open ends are in communication with the opposite ends of the cylinder and having an inlet passage in its middle portion, a sleeve valve having sliding fit within said body and being disposed in controlling relation to said inlet passage, said sleeve valve having a transverse wall dividing its interior space into opposed cylinders and which is operative to prevent passage of the working fluid through said valve to one end of the valve body when the working fluid is being supplied to the other end thereof, and plungers operating in said opposed cylinders and being actuable responsively to the piston approaching the limits of its travel for moving said sleeve valve alternately to the opposite sides of the inlet passage, thereby to distribute the working fluid alternately to the opposite ends of the valve body.

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2. A reversible valve mechanism for controlling admission and distribution of a working fluid to the opposite ends of a power cylinder having a piston mounted therein for reciprocatory travel, comprising an open-ended cylindrical valve body whose open ends are in communication with the opposite ends of the cylinder and having an inlet passage in its middle portion, a sleeve valve slidably mounted within said valve body for effecting distribution of the working fluid to one or the other end of said valve body upon positioning thereof to the side of said inlet passage opposite that adjacent the end of said valve body being supplied with the working fluid, said sleeve valve having a transverse dividing wall which prevents passage of the working fluid through said valve and divides its interior space into oppositely disposed plunger cylinders, oppositely disposed timing plungers having sliding fit in said cylinders, the sleeve valve being provided with two port means, one for each plunger cylinder, for supplying the working fluid to said plunger cylinders, said port means being spaced axially an amount such that one or the other thereof registers with the inlet passage when the sleeve valve is in its dead center position with respect to said inlet passage, each said timing plunger being operative upon the piston approaching the end of its stroke to initiate movement of the sleeve valve from its then position in which it is effecting distribution of the working fluid to one end of the valve body to a position in which the rearward of its port means registers with said inlet passage, whereupon the pressure of the working fluid becomes effective on said plunger and causes further movement of the sleeve valve relative to said plunger to a position in which it effects distribution of the working fluid to the other end of said valve body.

3. A reversible valve mechanism for controlling admission and distribution of a working fluid to the opposite ends of a power cylinder having a piston mounted therein for reciprocatory travel, comprising an open-ended cylindrical valve body whose open ends are in communication with the opposite ends of the cylinder and having an inlet passage in its middle portion, a sleeve valve slidably mounted within said valve body for effecting distribution of the working fluid to one or the other end of said valve body upon positioning thereof to the side of said inlet passage opposite that adjacent the end of said valve body being supplied with the working fluid, and sleeve valve having a transverse dividing wall which prevents passage of the working fluid through said valve and divides its interior space into oppositely disposed plunger cylinders, oppositely disposed timing plungers having sliding fit in said cylinders, the sleeve valve being provided with two port means, one for each plunger cylinder, for supplying the working fluid to said plunger cylinders, said port means being spaced axially an amount such that one or the other thereof registers with the inlet passage when the sleeve valve is in its dead center position with respect to said inlet passage, said timing plungers being each provided with an axial pin on its outer face of length adapting it to project, when its plunger is in its outermost position, a fixed distance through the open end of the valve body and into the cylinder end opposite to that being supplied with the working fluid, the construction and arrangement of sleeve valve and timing plungers being such that with the sleeve valve positioned to one side of the inlet passage with its port means covered, and the pin of the plunger disposed to said one side extending through the corresponding end of the valve body into the related end of the cylinder, said pin is moved axially inwardly in response to the piston approaching the end of its stroke and through its plunger initiates movement of the sleeve valve to an intermediate position in which the now rearward port means registers with said inlet passage, and that upon such registry the pressure of the working fluid becomes effective on said plunger and causes further movement of the sleeve valve relative to said plunger to a position in which it effects distribution of the working fluid to the other end of the valve body.

4. A reversing valve mechanism as set forth in claim 3, wherein the valve body is provided in its inner face with a circular exhaust channel on each side of its inlet passage, whereby in the aforesaid initial movement of the sleeve valve its now rearward port means registers with the exhaust channel disposed to said one side of the inlet passage, and whereby such registry permits the moving plunger to collapse into its cylinder and there-

upon to positively push the sleeve valve to its intermediate position aforesaid.

5. A reversible valve mechanism as set forth in claim 1, wherein the action of a plunger in moving the sleeve valve as aforesaid is first to effect movement of said sleeve valve substantially in unison therewith to a predetermined sleeve valve position, and thereupon to assist in effecting movement of said sleeve valve independently thereof.

6. A reversible valve mechanism as set forth in claim 1, wherein the sleeve valve is provided with separate port means for supplying working fluid to the inner ends of the respective plunger cylinders, and wherein the action of a plunger in moving the sleeve valve as aforesaid is first to effect movement of said sleeve valve substantially in unison therewith to a position in which the port means for the cylinder in which said plunger operates is in registry with the valve body inlet passage, and thereupon to serve as a fixed end for said cylinder, against which the working fluid reacts to complete the movement of the sleeve valve.

7. A reversible valve mechanism as set forth in claim 2, wherein said cylinder valve body and contained valve

parts are mounted in a fixed partition dividing said power cylinder into separate end spaces, each containing a piston and said pistons being interconnected, said valve mechanism being operative to admit working fluid to said cylinder-end spaces alternately.

8. A reversible valve mechanism as set forth in claim 2, wherein said cylinder valve body and contained valve parts are mounted in said piston and are bodily movable therewith, said valve mechanism being operative to admit working fluid to the opposite ends of the power cylinder alternately.

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