



Jan. 11, 1955

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2,699,153

REVERSING VALVE MECHANISM

Filed Aug. 29, 1952

2 Sheets-Sheet 2

FIG. 3

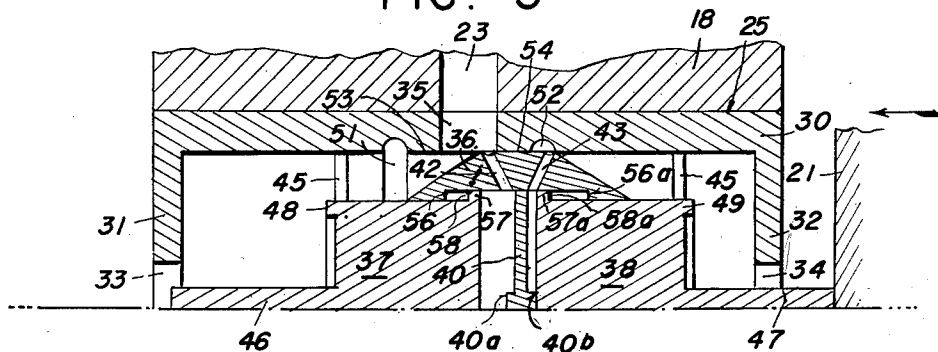


FIG. 4

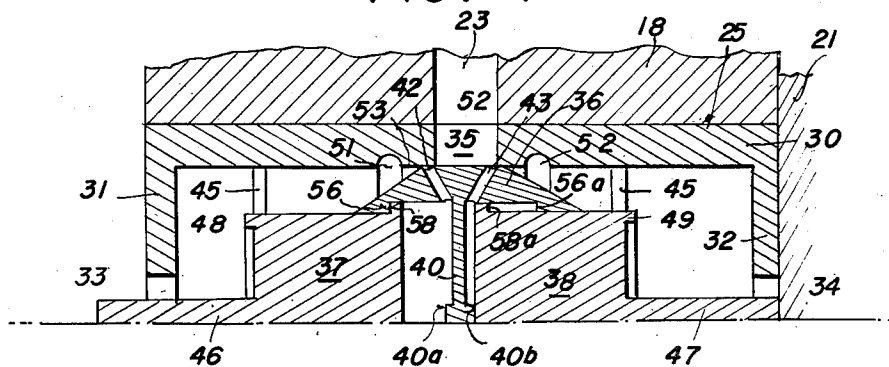
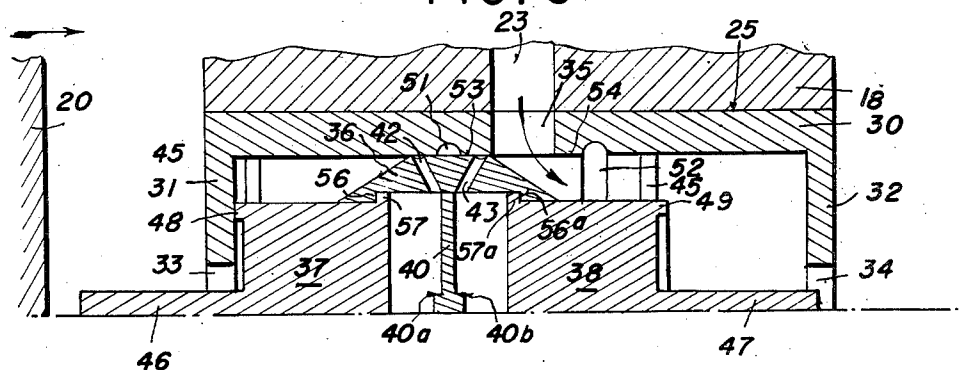


FIG. 5



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2,699,153

## REVERSING VALVE MECHANISM

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Application August 29, 1952, Serial No. 307,150

5 Claims. (Cl. 121—152)

This invention relates to improvements in reversing valve mechanism of the type disclosed and claimed in my copending application Serial No. 215,950, filed March 16, 1951, and is more particularly directed to an improved construction of such a reversing valve mechanism designed to enhance the precision and surety of its operation.

While continuing experience with reversing valve mechanisms as disclosed in my aforesaid application has amply demonstrated that its principle of operation is sound, it was learned that the uniformity and precision of its performance suffered from absence of any positive control of the outward movement of the timing plungers with reference to the sleeve valve whose bore provides the cylinders in which the plungers operate. For example, when no control of the outward movement of the plungers is exercised, it is possible for the plunger operating in the end of the sleeve past which the working fluid is being distributed to a cylinder end space to move completely out of its cylinder under the differing pressures effective on its opposite end faces. This excessive plunger travel may result in out-of-step motion of the sleeve valve and the said plunger when reversing movement of the sleeve valve takes place, which renders the sleeve valve movement sluggish and uncertain.

It is a principal object of the invention to improve the uniformity and surety of performance of a reversing valve mechanism according to my aforesaid patent application through the provision of means effective between sleeve valve and timing plungers for positively preventing uncontrolled outward movement of plungers with respect to the sleeve valve.

A more specific object of the invention is the provision of a reversing valve mechanism of the stated character, wherein the sleeve valve and timing plunger components thereof are provided with coacting means for preventing uncontrolled outward movement of the plungers with respect to the sleeve valve under pressure conditions tending to give rise to such plunger movement, without in any way interfering with the ability of the plungers to partake of their normal movement (stroke) within their cylinders as formed by the bore of the sleeve valve.

Yet another object of the invention is to improve the performance of a reversing valve mechanism of the stated character through the provision of simple internal and external stop shoulders formed on the sleeve valve and timing plungers, respectively, and which are so arranged as to permit predetermined relative movement between the sleeve valve and plungers, but to limit excessive outward movement of the plungers with respect to the sleeve valve as might result in complete separation of the plungers from their cylinders.

The above and other objects and advantages of the improved reversing valve mechanism of the present invention will be apparent from the following detailed description thereof, taken with the accompanying drawings, wherein:

Fig. 1 is a longitudinal section taken through a motor-compressor unit of the connected-piston type powered by elastic working fluid, which illustrates one application of the improved reversing valve mechanism of the invention; and

Figs. 2-5 are enlarged part-sectional views taken through the reversing valve mechanism, illustrating the relative positions assumed by the sleeve valve and associated timing plungers forming components of said

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mechanism throughout one-half cycle of sleeve valve and piston travel.

Referring to the drawings, the improved reversing valve mechanism according to the present invention will be described as a means for effecting distribution, i. e. alternate admission of the working fluid, to the opposite ends of a cylinder of a motor-compressor unit of the interconnected or tandem piston type disclosed in my prior application Serial No. 68,141, filed December 30, 1948, and now Patent No. 2,637,981 issued May 12, 1953, wherein the reversing valve mechanism is mounted in a partition which divides the cylinder into opposite end spaces in which the pistons are mounted for reciprocatory travel. It is to be understood, however, that the improved reversing valve mechanism of the present invention may also be employed as a means for distributing a work fluid such as water to the opposite ends of the cylinder of a double-acting water motor of the type disclosed and claimed in my copending application Serial No. 144,738, filed February 17, 1950, and now Patent No. 2,655,966 issued October 20, 1953, or for distributing power oil to the opposite ends of a sub-surface engine-pumping unit as disclosed in my prior application Serial No. 222,695, filed April 24, 1951, in which latter apparatus the working fluid is supplied to the valve mechanism through the piston interior and distributed alternately to the opposite ends of the working cylinder through the piston faces.

To illustrate the first of the above described applications, reference is had to Fig. 1 wherein reference numeral 10 designates an elongated cylinder closed at its ends by heads 11, 12 into which discharge lines 13, 14 extending to and suction lines 15, 16 extending from a compressor (not shown) 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, either 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 10 may be supplied through a line 22 connected into an annular passage 23 formed in the partition 18 to encircle and open into a cylindrical partition bore 25 in which is mounted the improved reversing valve mechanism generally designated 26 which forms the subject-matter of the present invention. When the parts of the valve mechanism are positioned as shown in Fig. 1, the 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, which leftwise movement is imparted to the piston 21 via piston rod 19. 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 the under face of piston 21, which latter is now acting as a compression face, to a line 28 connected to exhaust, i. e. condenser. As will be understood from my aforesaid prior Patent No. 2,637,981, the line 28 may extend direct to the condenser or it may connect with the cylinder discharge lines 13, 14 leading to condenser.

The general arrangement and construction of the aforesaid reversing valve mechanism is that disclosed in my aforesaid application Serial No. 215,950 and comprises a cylindrical valve body or casing 30 mounted in the partition bore 25 and having axial length corresponding to the thickness of the partition, so that its ends are flush with the opposite faces of the partition. As shown, the valve body may be formed at both ends with radially inward flanges 31, 32 which define fluid admission openings 33, 34 to the cylinder spaces to the opposite sides of the partition 18. The working fluid entering through line 22 is supplied to the interior of the valve body through an annular port 35 in its middle length portion which registers with the aforesaid annular passage 23 of the partition. Preferably, the port 35 extends substantially throughout the full circumference of

the valve body so as to provide more or less uninterrupted admission of the working fluid to valve body interior throughout its full circumference.

Distribution of the working fluid entering the valve body interior 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 in the form of a cylindrical ring or sleeve 36, having sliding fit within the valve body 30, and operating in conjunction with piston-controlled timing plungers 37, 38 which function to initiate reversing movement of the sleeve valve upon the working piston (20, Fig. 1) approaching its outermost limit of travel and the interconnected piston 21 approaching its innermost limit of travel. As disclosed in my aforesaid application Serial No. 215,950, the sleeve valve is divided interiorly by a transverse wall 40 which closes its bore and divides its interior space into two oppositely disposed cups or cylinders in which the timing plungers 37, 38 have sliding fit. As shown, the end edges of the sleeve valve are oppositely chamfered so that it has substantially greater axial length along its interior surface than along its outer surface, which latter has somewhat greater axial length than the width dimension of the inlet passage 35 in the valve body. Working fluid is supplied to said plunger cylinders through two circular series of ports 42, 43 extending between outer and inner surfaces of the sleeve valve, the ports of the series converging towards one another at an angle such that they open into the plunger cylinders adjacent their relatively inner or closed ends.

Preferably, the transverse wall 40 which divides the interior space of the valve sleeve into plunger cylinders as aforesaid is provided with central hubs 40a, 40b which project a short distance axially into the plunger cylinders, thus to permit the working fluid to become effective against the working faces of the plungers when the latter are actuated to their innermost position within their cylinders. By reference to Fig. 4, it will also be observed that the outer (inlet) ends of the two series of sleeve valve ports 42, 43 are spaced axially from one another a distance which is slightly less than the width dimension of valve body inlet passage 35, with the result that even though the unit is cut out of operation with the sleeve valve 36 in its dead center position, one or the other series of ports 42, 43 is in communication with said inlet passage. Hence, working fluid will be supplied to either one or the other of the plunger cylinders immediately upon resumption of the supply of working fluid, thus assuring re-starting of the unit without resort to extraneous starting means.

The timing plungers 37, 38 are oppositely arranged as shown and comprise cylindrical heads which may be provided adjacent their under faces with radial arms or spokes 45 giving a spider form of support for the outer ends of the plungers within the valve body 30. The plungers are also provided on their under faces 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 their outermost position and with circular sealing ribs 48, 49 which seal against the inner surfaces of the flanges 31, 32 formed at the ends of the valve body 30 in said outermost position; it being understood that "outermost position" refers to the position of the plunger (38, Fig. 2 and 37, Fig. 5) opposite to that past which the working fluid is supplied to an end of the cylinder.

As shown, the valve body 30 is provided in its inner circumferential wall with two circularly arranged plunger-cylinder exhaust channels 51, 52 which are spaced axially from the valve body inlet passage 35 by a predetermined small distance. The channels 51, 52 open into the bore of the valve body and are each connected by a passage (not shown) to the cylinder end-space to the same side of the partition as each said exhaust channel is to the inlet passage 35. It will be observed that the inner surfaces of valve body between said channels 51, 52 and said inlet passage 35 form circular lands 53, 54 serving to cut off flow of the working fluid through ports 42, 43, respectively, to the plunger cylinders upon the sleeve valve being moved axially to positions in which said ports are covered by the lands.

As explained in my aforesaid prior application Serial No. 215,950, reversing movement of the sleeve valve 36 results from relative movement of the one of the plungers 37, 38 whose axial pin protrudes from the partition with

respect to the sleeve valve 36, both by the force of one of the pistons 20, 21 moving against the plunger pin, which initiates the reversing movement, and by the expansion of the working fluid within the cylinder in which said plunger operates, which completes such movement. During such reversing movement, uncontrolled outward movement of the opposite plunger may occur, with the result that when the latter plunger is called upon to initiate reversing movement of the sleeve valve in the opposite direction, it is not in a required position to perform this function or its action in the performance thereof is uncertain. Accordingly, it is a feature of the present invention that the sleeve valve 36 and plungers 37 are so coupled that the plungers can move outwardly with respect to the sleeve valve only a predetermined amount, which is such that the plunger which has moved outwardly the maximum permissible extent is always in a position to initiate the reversing movement of the sleeve valve, with the desirable end that reversing movement is initiated in properly timed relation.

To achieve this desirable purpose, the chamfer of the end edges of the sleeve valve 36 has lesser inclination than that of the end edges of the sleeve valve shown in my aforesaid application Serial No. 215,950, thus giving the valve substantially greater axial length along its inner surface than along its outer surface. This added length is availed of in providing thickened skirts 55, 55a at the ends of the sleeve valve, the bores of which have lesser diameter than that of the plunger cylinders and terminate inwardly in right-angled surfaces defining internal shoulders 56, 56a. Coupled with this shouldering of the valve sleeve 36, the plungers 37, 38 are provided along their head ends with thickened ribs or flanges 57, 57a, the outer radial faces of which form outwardly facing or external shoulders 58, 58a adapted to engage on the sleeve valve shoulders 56, 56a, respectively. Accordingly, it will be seen that the opposite shouldering of sleeve valve 36 and plungers 37, 38 positively precludes outward movement of the plungers in their cylinders beyond that resulting in the plunger shoulders 53 or 53a engaging against the valve shoulders 56, or 56a. Hence, the maximum outward movement of the plungers with respect to the sleeve valve is positively controlled, with the desirable result that the plungers cannot move outwardly with respect to the sleeve valve to positions in which their timing function is rendered uncertain.

While the operation of the reversing valve mechanism described above is generally the same as that described for the reversing valve mechanism disclosed in my aforesaid application Serial No. 215,950, it will be briefly repeated here, for the purpose of explaining the more certain and accurate operation and functioning of the valve mechanism incorporating the means for preventing uncontrolled outward movement of plungers with respect to sleeve valve forming the subject-matter of the present invention. Referring to Fig. 2, let it be assumed that the sleeve valve 36 is in its right-hand position to which it was actuated upon the piston 20 having earlier completed the limit of its travel to the right, and that the sleeve valve will maintain this approximate position due to the balance of the pressure effective on its inclined end faces, which will occur following righthand plunger 38 making sealing engagement with the end flange 32 of the valve body 30. When the sleeve valve is so positioned, working fluid from line 22 is being supplied through the valve body inlet passage 35 and thence past the lefthand plunger 37 to the lefthand power space of the cylinder, 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 but inward direction. It will be understood that the length of the plunger pin 47 is such that it projects from the right face of the partition 18 a predetermined amount corresponding to the inward travel of plunger 38 required to cause the plunger to abut the transverse wall 40 of the sleeve valve, plus the amount of valve travel required to bring the righthand series of ports 43 in registry with the inlet passage 35 of the valve body. It is also to be observed that in this position of the sleeve valve 36 the lefthand plunger 37 is in its full outward position with respect to sleeve valve to which the expansive force of the working fluid locked in its cylinder has actuated it, but that said plunger is held against any further outward movement beyond that position by the coaction of the left end valve sleeve shoulder 56 with plunger shoulder 53.

As the pistons 20, 21 near the end of their leftwise

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stroke, piston 21 engages the plunger pin 47 and forces same to the left, that is to say, into its cylinder. Upon the plunger 38 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 is forced to the left until its righthand series of ports 43 register with the exhaust channel 52 which is then in communication with the low pressure side of the partition 18. Thereupon, the plunger 38 collapses, i. e. moves freely into the sleeve valve, in response to further leftwise movement of piston 21 and engages against the hub 40b of the sleeve valve wall 40, as is indicated in Fig. 3. When such engagement occurs, the plunger 38 in its further leftwise movement positively pushes the sleeve valve 38 to the left, whereupon at about its dead center position said righthand series of ports 43 come into registry with the supply passage 35, as shown in Fig. 4. In Fig. 3, it will be noted that the sleeve valve 36 has moved to the left independently of the plunger 37, but ultimately said plunger will follow the sleeve valve due to the fact that the working fluid is now effective on the inner or head end face of said piston which has slightly larger effective area than the outer or under face thereof against which the high pressure working fluid is also effective.

Upon the righthand series of ports 43 registering with the inlet passage 35 as in Fig. 4 aforesaid, the working fluid now becomes effective in the space between the inner face of plunger 38 and the right-side face of the sleeve valve wall 40. Considering that the plunger 38 cannot move to the right as piston 21 has not yet begun its outward travel, and that expansion of the working fluid begins to occur in said space immediately upon the working fluid being admitted thereto, the sleeve valve 36 is activated further to the left to its Fig. 5 position in which admission to the cylinder in which the plunger 38 operates is cut off, consequent to the ports 43 of the righthand series thereof coming beneath the previously described land 53. When such cut-off occurs, plunger 38 is moved to the right by the expansive force of the working fluid locked in its cylinder, but only to the extent that plunger shoulder 58a engages on the sleeve valve shoulder 56a at the right end of the valve sleeve, as generally illustrated.

During the course of travel of the valve sleeve from its Fig. 4 to Fig. 5 positions, the lefthand series of ports 42 has passed under the exhaust channel 51, thus opening the space between the inner face of the plunger 37 and the left side of the sleeve valve wall 40 to the now low pressure side of the cylinder partition 18. However, upon said ports 42 being cut off by slight further sleeve valve movement to the left, expansion takes place in said space, with the result that piston 37 moves to the left until it seals against the left end valve body flange 31, which establishes the lefthand end position of the sleeve valve due to balanced pressures then becoming effective on its opposite end faces. In the sealing position of the plunger 37 as aforesaid, its pin 46 projects beyond the left face of the cylinder partition 18 the predetermined amount described above in connection with the extension of plunger pin beyond the right face of said partition, and the piston 38 moves outwardly to the right with respect to the sleeve valve 36 the controlled amount permitted by engagement of plunger and sleeve valve shoulders as aforesaid. Accordingly, it will be seen that under all of the various conditions of operation of a reversing valve mechanism as described, the outward movement of the timing plungers 37, 38 with respect to the valve sleeve 36 is positively controlled, with the result that said plungers cannot move outwardly to positions likely to impair their performance in initiating the reversing movement of the sleeve valve 36 in timed relation to working piston approaching the outermost limit of its working stroke and the related piston approaching the innermost limit of its stroke.

The functioning of the exhaust valve 27 (Fig. 1) has not been detailed above, but it will be understood that as the piston 21 moves inwardly to a position in which it initiates reversal of the sleeve valve 36, it also initiates shift of the exhaust valve in the partition 18 to the left, thus opening the cylinder space to the left of the partition 18 to exhaust and simultaneously therewith closing the cylinder space to the right of said partition to exhaust. Thus, the working fluid admitted to the cylinder space to the right side of the partition immediately becomes effective upon the under face of the piston, thereby to power it

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on its outward or working stroke. When the piston 21 is driven in outward direction, piston 20 moves inwardly and upon the latter approaching the innermost limit of its travel, it engages the pin of the lefthand plunger 37, thus initiating the reversing motion of the sleeve valve 36. During the last half-cycle of valve operation, i. e. as the sleeve valve is actuated from its Fig. 5 to its Fig. 2 positions, the operation is the same as that previously described but in the reverse order.

As above explained, a reversing valve mechanism as aforesaid may be applied as the distributing means of a water motor such as that disclosed in my copending Patent No. 2,655,966 or of a sub-surface pumping unit of the type disclosed in my copending application Serial No. 222,695. In such latter applications, the reversing valve is mounted in the piston of a double-acting piston-cylinder unit, the working fluid being supplied through the piston and being distributed alternately through the opposite faces of the piston to the cylinder end spaces; and the plunger pins 46, 47 accordingly protrude from said opposite faces. In such an arrangement of parts, the one or the other plunger pin which points in the direction of piston travel is engaged by the cylinder head upon the piston approaching the end of its working stroke, such engagement initiating valve reversal as explained in the foregoing, which is completed by the pressure of the working fluid (non-elastic) becoming effective on the inner or head-end face of the plunger 37 or 38 temporarily held by its engagement with the cylinder head. Otherwise, the valve operation is similar to that described above.

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 reversing valve mechanism for alternately distributing a working fluid to the opposite ends of a cylinder, comprising an open-ended cylindrical valve body having in its middle-length portion a substantially circumferential inlet passage to its interior, a sleeve valve mounted within and having sliding fit on the inner surface of the valve body, said sleeve valve having an interior transverse wall preventing flow of the working fluid through its bore and dividing its said bore into oppositely disposed plunger cylinders and being operative to control distribution of the working fluid from said inlet passage to one or the other ends of the valve body upon limited axial movement thereof to one or the other side of said inlet passage, said sleeve valve being provided with two axially spaced port-means for supplying working fluid from the inlet passage to said plunger cylinders alternately in response to axial movement of the sleeve valve, oppositely disposed plungers reciprocable in said plunger cylinders and being actuable in relatively outward direction with respect to said sleeve valve upon working fluid being supplied to said cylinders, each plunger having an axially disposed stem which is adapted to project through the corresponding open end of the valve body a predetermined amount upon said sleeve valve and said plunger being actuated to the limit of their respective axial and outward movements in the direction of said open end, in which position of sleeve valve the working fluid is distributed to the other end of the valve body, and means operative between the sleeve valve and the plungers for controlling the outward movement of said plungers with respect to said sleeve valve.

2. A reversing valve mechanism as set forth in claim 1, wherein said last means is operative to limit the outward movement of the other plunger with respect to the sleeve valve under the differing fluid pressures effective on its opposite faces.

3. A reversing valve mechanism as set forth in claim 1, wherein said last means comprises coacting means on the sleeve valve and plungers which are adapted to engage one against the other upon a plunger moving outwardly within its plunger cylinder a predetermined amount.

4. A reversing valve mechanism as set forth in claim 1, wherein said last means comprises internal shoulders on the outer end portions of said sleeve valve and an external shoulder on the inner end of each said plunger, said internal and external shoulders coacting to limit out

ward movement of the plungers within their plunger cylinders.

5. A reversing valve mechanism as set forth in claim 1, wherein the valve body is provided at its ends with internal circular flanges defining the valve body end openings through which the plunger pins are adapted to project, and wherein said flanges form stop surfaces engageable by the under faces of the plungers, the engagement of a plunger on its stop surface determining the extent of outward movement of said one plunger and thereby the limit of axial movement of the sleeve valve

in the direction of the end opening defined by said flange.

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