Feb. 8, 1966 P. HAMMELMANN 3,233,628

HYDRAULIC DEVICE FOR THE AUTOMATIC ACTUATION OF A PISTON

Filed Dec. 24, 1962 4 Sheets-Sheet 1

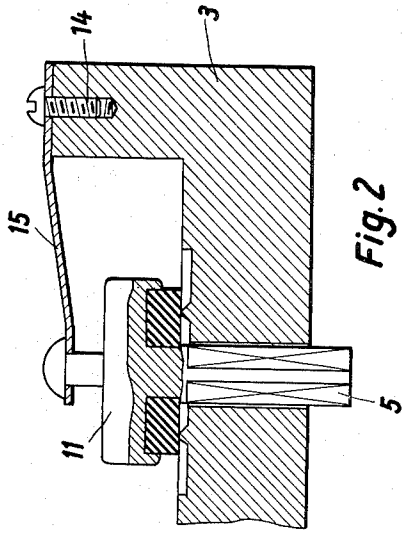

Fig.2

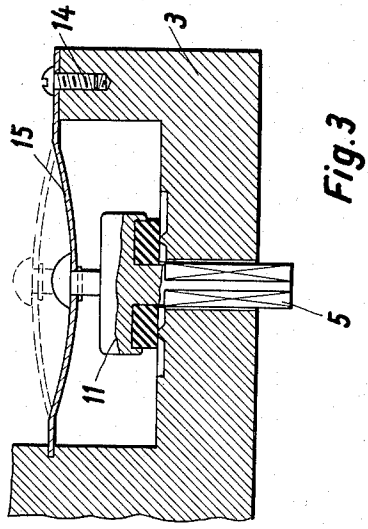

Fig.3

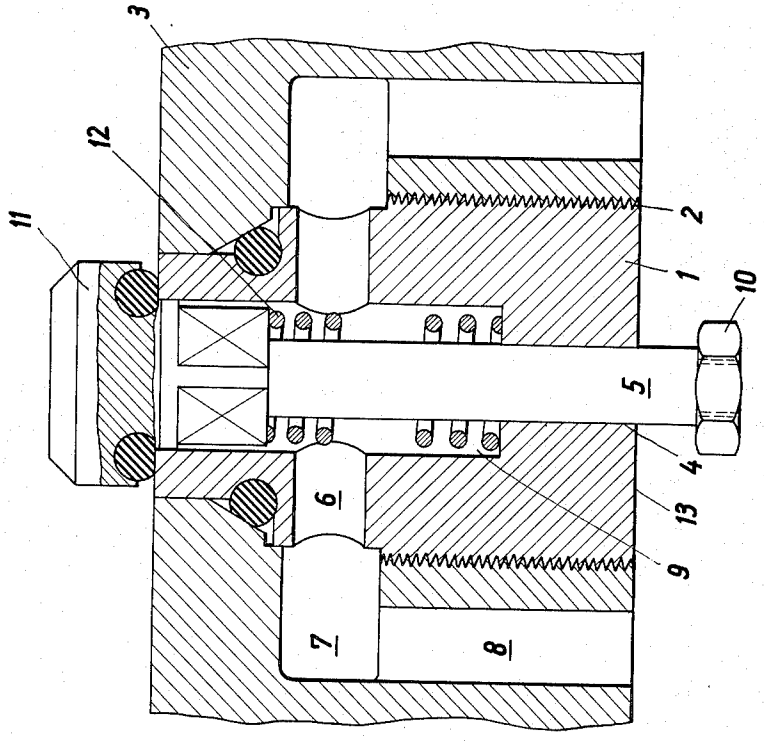

Fig.1

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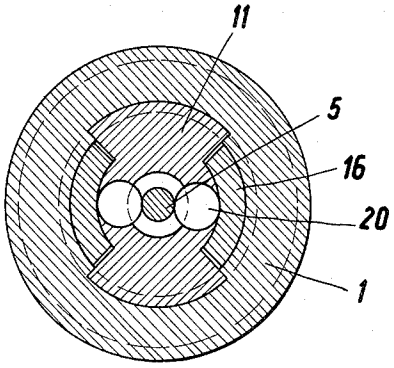
Fig. 5



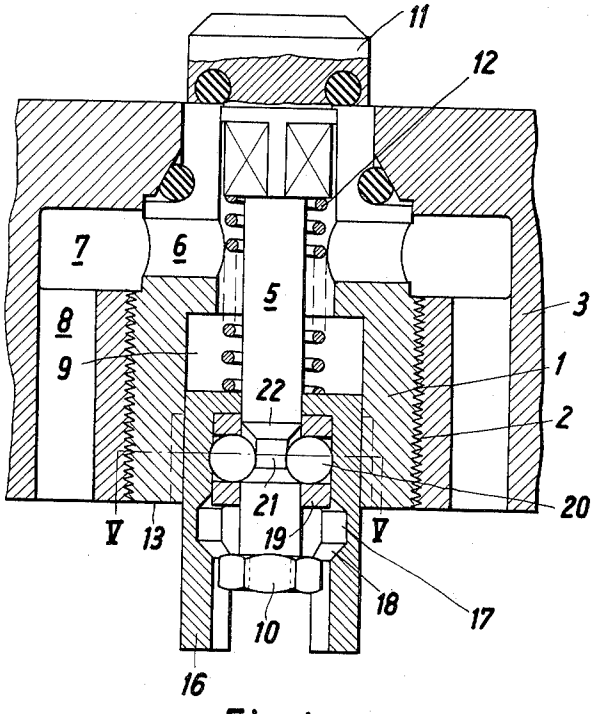


Fig. 4

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HYDRAULIC DEVICE FOR THE AUTOMATIC ACTUATION OF A PISTON

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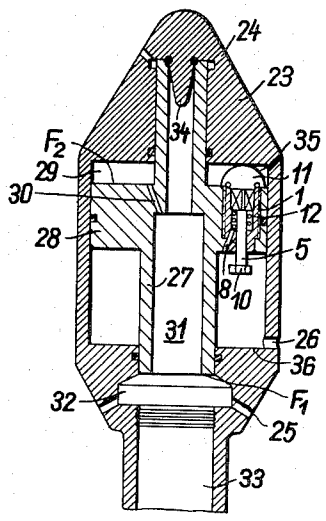

Fig.6

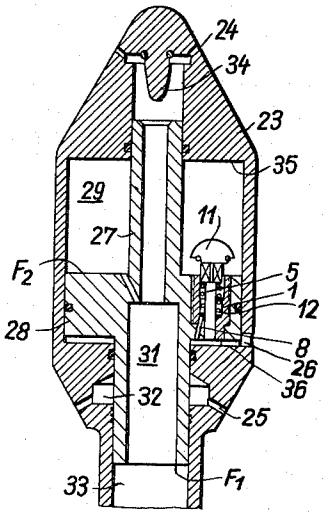

Fig.7

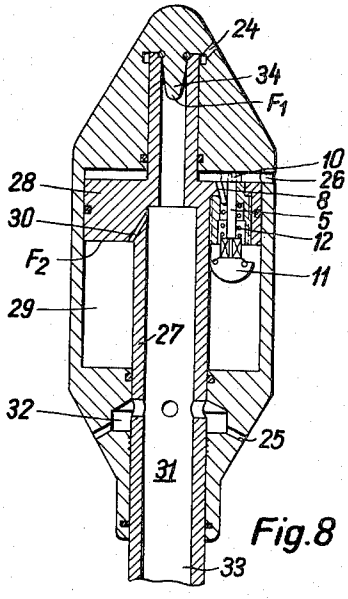

Fig.8

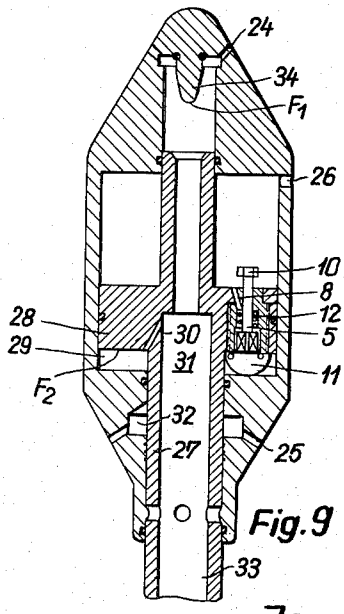

Fig.9

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Fig. 10

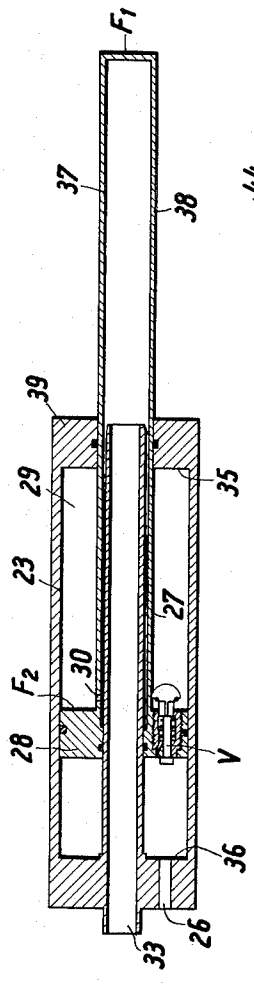


Fig. 11

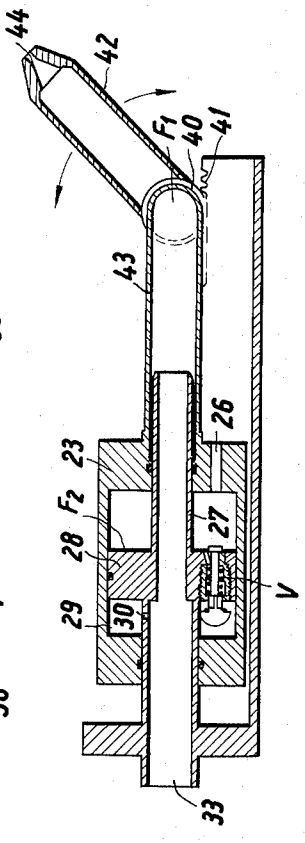
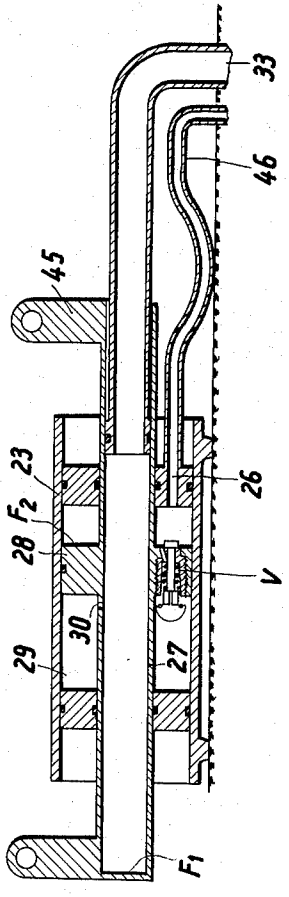


Fig. 12



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HYDRAULIC DEVICE FOR THE AUTOMATIC ACTUATION OF A PISTON

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Filed Dec. 24, 1962, Ser. No. 246,689
5 Claims. (Cl. 137—624.14)

This invention relates to hydraulic steering devices and refers more particularly to a hydraulic steering device of the type wherein uniform liquid flow is used to attain automatic actuation of a piston within a cylinder.

Some of the prior art hydraulic steering devices operate by the use of two currents of liquid having different pressures, whereby movement of the member being actuated is changed by the greater pressure of one of the two current. Other prior art devices use only one current of liquid which is introduced with variable pressure into the device. In such constructions the piston is pressed in one direction against the force of a spring which moves it back when pressure is diminished.

All these devices have the drawback, however, that they can not be used for a completely automatic steering with non-varying pressure. Furthermore, prior art devices require more or less complicated actuating constructions which on many occasions do not operate properly and often fail when they are not any more under the direct control of an operator.

An object of the present invention is to eliminate these drawbacks of prior art devices.

Other objects of the present invention will become apparent in the course of the following specification.

In accomplishing the objects of the present invention it was found desirable to provide a device having the following characteristic features:

(a) A valve is located in a piston between its operating chamber and its outflow chamber. (The two chambers are by no means equivalent.)

(b) The central portion of the piston having a smaller load-receiving surface is always subjected to the pressure of the inflowing liquid. (Gas pressure is unusable.)

(c) An auxiliary current branches off continuously from the piston to the operating chamber of the cylinder. (Therefore, they are no two separate connections for the outflowing pressure medium.)

(d) When the valve is closed, the auxiliary current develops in the operating chamber a pressure acting upon a large area for the movement of the piston, i.e. for increasing the size of the operating chamber.

(e) At the end of a stroke of the piston, the valve of the piston is opened by engagement with the cylinder.

(f) The pressure medium flows out of the operating chamber through the open valve. The movement of the piston is reversed by the prevailing pressure of the inflowing medium, which is always present.

It is thus apparent that the present invention contemplates the provision of a hydraulically actuated device for automatically actuating a piston within a cylinder, said device being characterized by the provision of a valve in the piston between the operating chamber and the outflow chamber, and in that a secondary current is preferably continuously branched off to the operating chamber of the cylinder from the piston, the central portion of which having a smaller surface, is always subjected to the central pressure of the incoming liquid, whereby the secondary current builds up pressure upon a large surface in the operating chamber for moving the piston while the valve is closed, the valve being opened at the end of the stroke by engagement with the cylinder and the movement of the piston being reversed by causing an outflow of the pressure medium and by the prevailing incoming pressure.

The actuating piston with the piston ring and valve can be movably mounted in the casing. However, it may be made immovable, while the casing may be made movable relatively thereto.

It is advantageous to construct the valve in such manner that the valve body is firmly connected with the piston ring and is provided with a reciprocating valve rod having an end projecting out of the valve body and carrying a valve tappet while the other end carries a safety nut. In the closed position the valve rod is subjected to spring pressure, whereby it is possible to use a spiral spring enclosing the valve rod, or a leaf spring connected with the valve tappet.

The force of the spring must be such that when the valve is closed, the pressure of the liquid exerted upon the valve tappet will be greater than that of the spring, while when the valve is open the force of the spring must be greater than the action of the current of liquid pressing upon the valve tappet.

The invention will appear more clearly from the following detailed description, when taken in connection with the accompanying drawings showing, by way of example, preferred embodiments of the inventive idea.

In the drawings:

FIGURE 1 is a longitudinal section through a valve constructed in accordance with the principles of the present invention, and shows the valve in the closed position.

FIGURE 2 is a partial longitudinal section through a somewhat different construction, wherein the spiral spring is replaced by a leaf spring.

FIGURE 3 is a partial longitudinal section through another construction which also employs a leaf spring.

FIGURE 4 is a longitudinal section through a differently constructed valve.

FIGURE 5 is a section along the line V—V of FIG. 4.

FIGURE 6 illustrates in longitudinal section a valve similar to that shown in FIG. 1, in its closed position and mounted in a cleaning head of high pressure installations.

FIGURE 7 is similar to FIG. 6 and shows the valve in its open position.

FIGURE 8 illustrates in a longitudinal section a valve in its closed position in a different cleaning head.

FIGURE 9 is similar to FIG. 8 and shows the valve in its open position.

FIGURE 10 is a longitudinal section illustrating the use of a valve of the present invention in a spraying pipe for the cleaning of sieve bands.

FIGURE 11 is a longitudinal section illustrating the use of a valve of the present invention in a tank cleaning device.

FIGURE 12 is a longitudinal section illustrating the use of a valve of the present invention in a moving device for supports of machine tools.

Throughout the following description the same parts are designated by similar numerals.

As shown in FIG. 1, the valve V of the present invention has a valve body 1 provided with outer screw threads 2 and screwed into a valve casing 3 which is preferably constituted as a ring of an actuating piston. The center of the valve body 1 has a longitudinal bore 4 containing a reciprocating valve rod 5. Furthermore, the valve body 1 is provided with radial bores 6 which communicate with an annular channel 7 provided in the valve casing 3. Discharging passages 8 communicate with the annular channel 7. The vertical bore 4 of the valve body 1 has an enlarged portion constituting a valve chamber 9.

It is apparent that the operating liquid can flow out out the valve chamber 9 and through the radial bore 6, the annular channel 7 and die discharging passages 8 to the space at the bottom of the piston.

One end of the valve rod 5 carries a safety nut 10 which prevents the valve rod 5 from sliding out of the valve body 1. A valve tappet 11 is provided upon the other end of the valve rod 5. A spiral spring 12 is mounted around the valve rod 5 in the valve chamber 9.

The operation is as follows:

The valve is shown in its normal position in FIG. 1. The valve is maintained in the closed position when pressure exerted upon the valve tappet 11 is greater than the pressure of the spring 12 acting in the opposite direction. The opening of the valve may take place when the pressure exerted upon the valve tappet 11 is diminished, so that the force of the spring 12 will overcome this pressure and move forward the valve rod 5. The valve can be also opened by pressing the safety nut 10 along with the valve rod 5 until the safety nut 10 is brought into engagement with the adjacent bottom surface 13 of the valve body 1.

FIGURE 2 illustrates a construction wherein the spiral spring is replaced by a one-sided leaf spring 15, one end of which is held by a screw 14 in the valve casing 3*a*, while its other end is attached to the tappet 11*a* of the valve rod 5*a*. The operation of this valve is the same as of the valve shown in FIG. 1.

FIGURE 3 illustrates a valve of the same construction as that of FIG. 2, but wherein the one-sided leaf spring is replaced by a two-armed spring 15*a* connected at both ends to the valve casing 3*a* and connected at its middle to the tappet 11*a*.

FIGURES 4 and 5 illustrates a locking device used to prevent the opening of a valve similar to that shown in FIG. 1 when pressure upon the valve tappet 11 is diminished. In this construction the valve casing 1*a* encloses a clamping socket 16. The inner wells of the socket 16 have recesses 17 which may be provided with conically slanting surfaces 18. A ball bearing 19 carrying balls 20 is also provided within the socket 16 and is firmly connected with the valve casing 1*a*. In this construction, the valve rod 5*b* is provided with a narrow portion 21 limited by preferably slanting surfaces 22.

The operation is as follows:

When pressure upon the valve tappet 11 is reduced, the valve will not open, since it is held by balls 20 and since the spring 12 is only weakly tensioned. The spring 12 will be subjected to substantial tension only when the socket 16 is moved so far that the balls 20 which are located in the position shown in FIG. 4 in the untensioned state of the spring, will be moved into the recesses 17 and will thus release the valve rod 5*b*, while at the same time locking the socket 16. Then the tension of the spring 12 becomes effective and the valve rod 5*b* can be shifted forward to open the valve.

A reverse procedure takes place when the valve is being closed. The spring 12 is again tensioned when the valve rod 5*b* is moved rearwardly. When the valve rod 5*b* reaches the position in which the balls 20 enter the recess formed by the rod portion 21, the socket 16 is unlocked and it will be moved quickly by pressure of the spring 12 into its initial position, whereupon the valve rod 5*b* will be locked again by the balls 20.

The described valve V of the present invention can be used for a great variety of purposes as a hydraulic automatic steering valve.

By way of example, FIGURES 6 to 9 illustrates the arrangement of this valve V in cleaning heads of high pressure cleaning machines.

The cleaning heads provided with the valve of the present invention are actuated only by the effect of two operational or acting surfaces F1 and F2 of different sizes.

As illustrated in FIGS. 6 and 7, the cleaning head includes a casing 23 having front nozzles 24 and rear nozzles 25, as well as an outlet 26. A valve peg 34 is located between the front nozzles 24. An actuating piston 27 is movably mounted within the casing 23. The piston 27 is hollow and is provided with a piston ring 28. The piston ring 28 moves jointly with the piston 27 within a chamber 29 of the casing 23. The interior 31 of the hollow piston 27 is connected with the chamber 29 by a passage 30 provided in the piston 27, and is also connected with the liquid inflow passage 33 by a chamber 32.

The piston ring 28 carries a valve V which is the same as that shown in FIG. 1 and described above. This valve has the valve body 1 carrying the movable valve rod 5 with the safety nut 10 and the valve tappet 11, as well as the spring 12. The passage 30 is restricted relative to the valved passage through the piston.

This cleaning head operates as follows:

The initial position of the cleaning head is illustrated in FIG. 7. Liquid flows through the inlet 33 into the space 31 and leaves through the front nozzles 24. While the cleaning liquid is supplied to the head and while it flows out of the front nozzles 24, a small part of the liquid forms a secondary current which continuously flows through the passages 30 into the chamber 29. Since the valve V is open, the liquid flowing into the chamber 29 through the passage 30, can leave the chamber 29 through the outlet passage 8 of the valve and to leave the head through the outlet 26. The spring 12 of the valve prevents the closing of the valve by the flow pressure of the current of the liquid.

The piston 27 which is subjected to the pressure of the cleaning liquid, is moved in the direction toward the front nozzles 24 with a force which is equal to the area of the operational surface F1 multiplied by the pressure exerted per unit area by the cleaning fluid. This will result, firstly, in the closing of the front nozzles 24 with the help of the valve peg 34, and in the opening of the rear nozzles 25 through the chamber 32. During further movement of the piston 27 the valve tappet 11 will press against the wall 35 of the chamber 29, so that the valve will close. Liquid which continues to flow into the chamber 29 through the passage 30, will promptly develop a pressure which will be effective upon the larger area of the piston surface F2. This pressure of the continuously inflowing liquid will push the piston 27 rearwardly, while the valve remains closed, since pressure upon the valve tappet 11 is greater than the force of the spring 12. During the rearward movement of the piston 27 the front nozzles 24 are opened again and the rear nozzles 25 are closed. The valve is opened again only when the end 10 of the valve rod 5 strikes the bottom 36 of the head casing; then the liquid can flow out of the chamber 29 through the passage 8 and the outlet 26. Pressure in the chamber 29 will drop and the piston 27 will move forward again, whereby the operation is repeated.

FIGURES 8 and 9 show a cleaning head which is different from the one just described and illustrated in FIGS. 6 and 7, in that in the head of FIGS. 8 and 9 the operational piston which is extended to provide connection for the liquid, is made immovable, while the casing 23*a* is made movable relatively to the piston.

The operation of this cleaning head which is similar to the one just described, is as follows:

The cleaning fluid flows through the interior 31*a* of the piston 27*a* to the front nozzles 24. In the course of this flow the liquid presses forwardly the casing 23*a* of the head, so that it will assume the position shown in FIG. 9. The actuating force is again the product of the operational area F1′ times liquid pressure per unit area. In this position the cleaning liquid can flow out of the front nozzles 24. At the same time, a secondary current flows through a passage 30*a* into the chamber 29. Since the valve V is closed, pressure is developed in the chamber 29 which, due to the larger operational area F2, is greater than the pressure upon the area F1′, so that finally the casing is pushed rearwardly; when the end of the valve rod 5 strikes the casing bottom 36, the valve is opened. Then the liquid in the chamber 29 can escape

through the valve passage 8 and out of the outlet **26***a* (FIG. 8). Pressure is thereby diminished and the valve remains open under its spring action even after the subsequent movement of the casing, until the valve tappet **11** strikes the casing bottom **35**.

In this construction the front and rear nozzles are also alternately opened and closed, so that an automatic reversal of the direction of the sprays is provided, but this is attained by the sliding reciprocation of the casing of the cleaning head.

It is apparent that this operation of the nozzles can be applied to an automatic actuation of any other hydraulic transmission.

FIGURE 10 illustrates the use of the valve V of the present invention for steering the flow of a liquid in a spraying pipe for the cleaning of sieve bands, suction rollers or the like.

The operation is in principle the same as those already described and is as follows:

The cleaning liquid flows through the inlet **33***a* into the spraying pipe **37** provided with several spraying nozzles **38**. The pipe **37** which is firmly connected with the steering piston **27***b*, is reciprocated by the operation of the valve V within the immovable support **39** in the above described manner.

The embodiment of FIGURE 11 refers to a swingable tank-cleaning device wherein the valve V steers the device in such manner that the gear wheel **40** is reciprocated while meshing with a rack **41**, thereby producing a swinging movement of the head member **42** having an outlet nozzle **44**; this swinging movement may amount to about 180°. The rack **41** is connected with the immovable actuating piston **27***c*, while the gear wheel **40** is mounted in an inflow pipe **43**; the pipe **43** is connected to the reciprocating casing **23***c*.

The operation is otherwise the same as those already described.

It is also possible to provide a construction with toggle levers (not shown) for the release of the swinging movement.

The embodiment of FIGURE 12 illustrates another application of the basic principle of the present invention, namely, its use for the automatic steering, preferably reversal, of the movements of a support of a machine tool or the like. In this case the liquid serves only for the actuation of the valve V and for the release of the movement. On the other hand, no spraying is intended in this construction, so that the liquid which has not been utilized, is removed through an outflow tubing **46** and can be reintroduced under pressure into the machine whereby a closed flow cycle is provided.

The operation is the same as those previously described.

While the above described examples have indicated the many-sided applications of the subject of the present invention, it is apparent that the same steering principle of the invention can be used in other variations and modifications. All such variations and modifications are to be included within the scope of the present invention.

What is claimed is:

1. A hydraulic actuating device comprising, in combination, a single cylinder member formed with an operating chamber and an inlet chamber of a diameter smaller than that of said operating chamber; inlet passage means communicating with said inlet chamber; a differential piston member located in said chambers axially slidable relative to said cylinder member and having a pair of oppositely directed acting faces, one of said faces being wider and located in said operating chamber and the other of said faces being narrower and bounding said inlet chamber so that any fluid pressure in said inlet chamber urges said differential piston member in a first direction relatives to said cylinder member toward a first end position and any fluid pressure in said operating chamber urges said piston member in a second direction relative to said

cylinder member toward a second end position; passage means in said piston member connecting said operating chamber with the atmosphere; valve means in said passage means movable between a closed and an open position; actuating means for said valve means and cooperating within said cylinder member for automatically moving said valve means to said open position when said piston member has reached said second end position, maintaining said valve means in open position while said piston member is moving in said first direction from said second toward said first end position and closing said valve means when said piston member reaches said first end position, said valve means remaining in said closed position while said piston member is moving back in said second direction; a passage in said piston member restricted relative to said passage means and permanently connecting said inlet chamber with said operating chamber; and first and second outlet port nozzle means in said cylinder member constructed and arranged and cooperating with said piston member in such a manner that said first outlet port nozzle means are open when said piston member moves in said first direction and closed when it moves in said second direction, and vice versa, said second outlet port nozzle means are open when said piston member moves in said second direction and are closed when said piston member moves in said first direction.

2. A hydraulic actuating device as set forth in claim **1**, wherein said valve means includes a valve member and biasing means biasing said valve member to said open position, said valve member arranged to be urged to said close position by fluid pressure in said operating chamber.

3. A hydraulic actuating device as set forth in claim **2**, wherein said actuating means comprises locking means for positively maintaining said valve member in said closed position against the force of said biasing means, said locking means constructed and arranged to release said valve member for movement to said open position when said piston member reaches said second end position.

4. A hydraulic actuating device as set forth in claim **1** and including a valve housing fixed to said piston member, and wherein said valve means includes a valve member axially movable in said valve housing, and spring means cooperating with said valve member and biased to yieldably hold the latter in said open position, wherein said actuating means include a valve head fixed to said valve member and projecting from said wider face of said piston member into said operating chamber and adapted to engage one end wall of said cylinder member when said piston member is in said first end position, and a valve stem projecting through said passage means beyond the other face of said piston member and adapted to engage with a free end thereof an opposite end wall of said cylinder member when said piston member is in said second end position, and locking means cooperating with said valve means for preventing moving of the latter to the open position under the force of said spring means when fluid pressure on the valve head is smaller than the force of said spring means, said locking means comprising a locking sleeve about said valve stem and guided in axial direction in said valve housing, said sleeve having an inner and an outer end and being formed between said ends at the inner surface thereof with a first annular groove, said stem being formed with a second annular groove axially displaced from said first annular groove, a plurality of balls located in said second annular groove and engaging the inner surface of said sleeve so as to lock said stem in a position in which said valve means is in said closed position, said spring means engaging said inner end of said sleeve and tending to maintain the latter in a locking position, said outer end of said sleeve in said locking position extending beyond said free end of said stem, and said first annular groove being closer to the free end of said stem than said second annular groove, said outer end of said sleeve engaging said opposite end wall during movement of said piston member toward said

second end position thereof to move said sleeve to a releasing position in which the annular groove thereof is aligned with that in said stem permitting said balls to move out of the annular groove in said stem and permitting thereby the valve member to move to its open position; and means fixed to such a valve housing and operatively engaging said balls so as to prevent axial movement thereof while permitting said balls to move in radial direction from said first annular groove into said second annular groove and vice versa.

5. A hydraulic actuating device as set forth in claim 1, wherein said first outlet port nozzle means communicate with said inlet chamber and wherein said second outlet port nozzle means are located in a bore provided at the end of said cylinder member opposite said first outlet port nozzle means, and including hollow conduit means connected to said piston member in fluid communication with said inlet chamber and arranged to cooperate with said second outlet nozzle means to close the latter upon

movement of said piston member in said first direction and to open said second outlet port nozzle means upon movement of said piston member in said second direction.

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