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(54) Slide valve drive in a reciprocating motor

(57) In a plant comprising an evaporator (1), Fig. 1 (not shown), a motor 3 to which a consumer, e.g. a pump 9, is connected, a condenser (14), and a condensate pump (16), the motor 3 is provided with a slide valve 4 and a cylinder 5 having a piston 8. To the slide 6 is secured an extension rod 7 which is connected to a piston rod 12 of the piston 8. In order to permit the valve to operate without vibrating at small pressure differences, the extension rod 7 is connected resiliently (as by spring 53) in the longitudinal direction of the rod to the piston rod 12 which is coaxial with the extension rod, and the valve 4 is provided with a spring-loaded locking means 56–61 cooperating with the slide 6 and permitting displacement of the slide from one extreme position to another only when the spring force between the extension rod 7 of the slide and the piston rod 12 exceeds a predetermined limit value. The forces transmitted via the springs 53 and 61 may instead be transmitted via gas cushions.

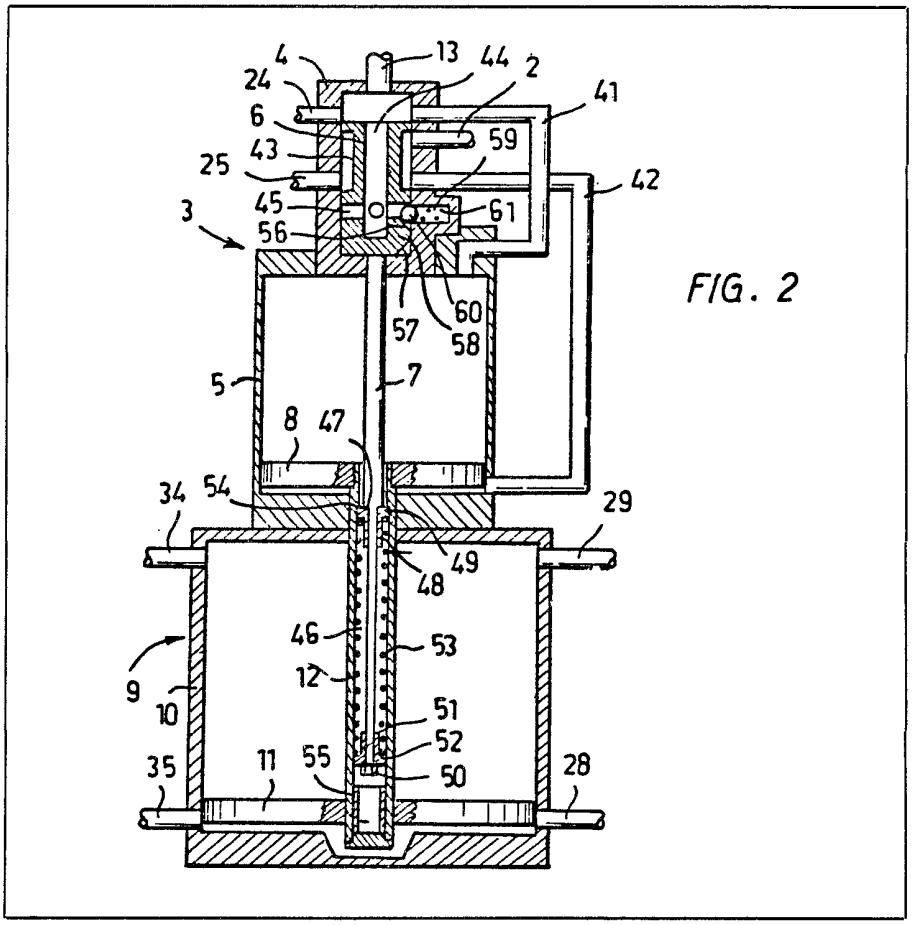

FIG. 2

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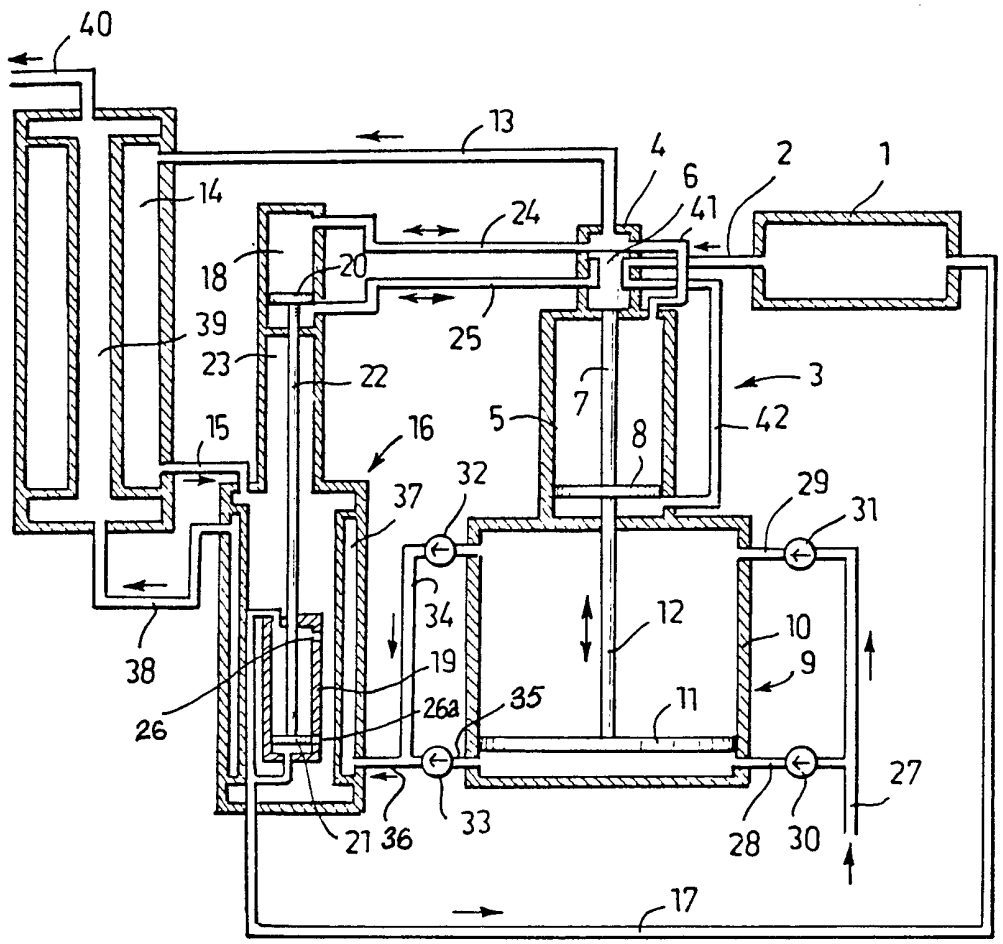
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26a
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FIG. 1

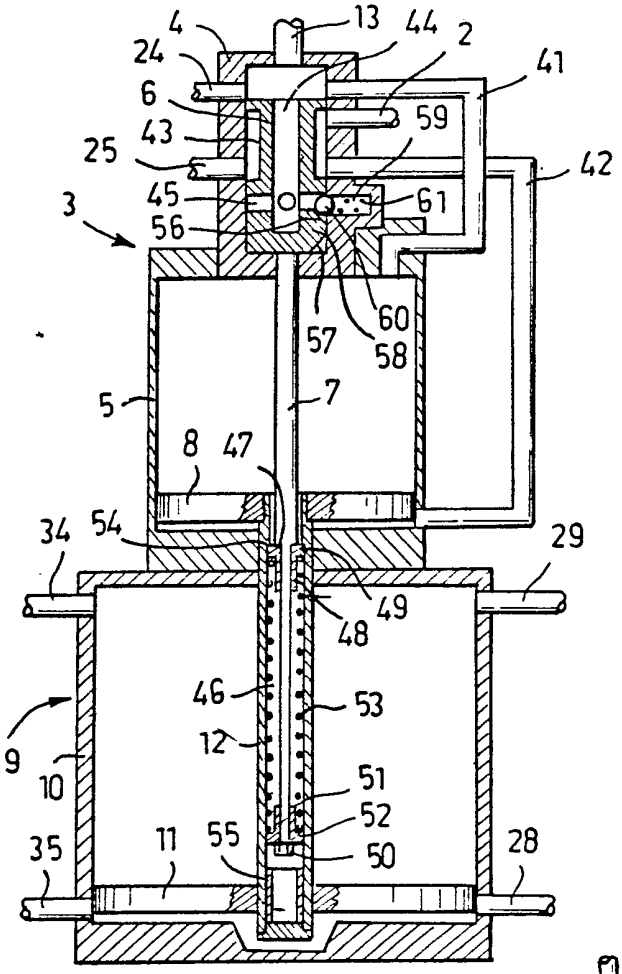
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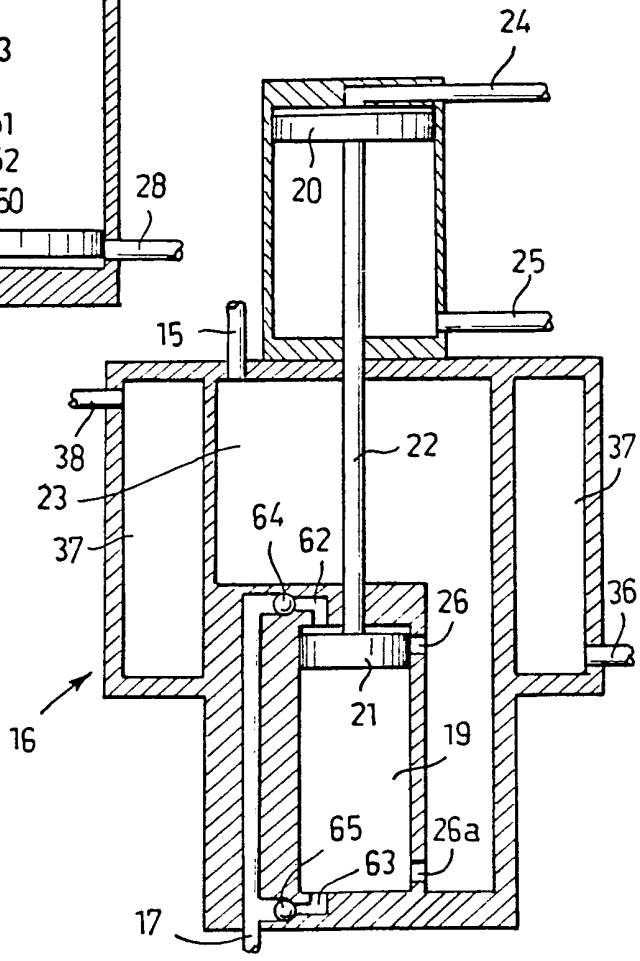
FIG. 2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62
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16
65
26a
63
17

FIG. 3

SPECIFICATION

Power machine operating by means of temperature differences

The present invention relates to a power machine operating by means of temperature differences and comprising an evaporator, a motor to which a working machine is connected, a condenser, and a condensate pump, which are connected to each other in said sequence to form a closed circuit for a working medium flowing from one device to another, said motor comprising a valve, a slide movable within said valve, a cylinder arranged in connection with said valve, a piston movable within said cylinder and provided with a piston rod, and an extension rod coaxial with said piston rod and connected to said slide and said piston rod.

As the price of energy increases, it is becoming more and more important to find means by which the small tempreature differences prevailing in nature can be exploited into mechanical energy. A previously known aggregate operating according to this principle operates by means of the temperarture difference occurring in oceans. The aggregate comprises an evaporator which heated by warm surface water and in which a working medium, for example, ammonia is evaporated. The vapour so formed in passed through a turbine to a condenser, which is cooled by means of colder water pumped from a depth. The condensate formed is by means of a condensate pump recirculated to the evaporator. The effective energy produced by the turbine can be converted, for example, into electricity by means of a generator connected to the turbine shaft. The surface water and deep water pumps as well as the condensate pump are driven by means of electric motors to which electricity is supplied from the generator. However, the efficiency of the aggregate remains low because under optimal conditions $n_{tot} = n_{turb} \times n_{gen} \times n_{motor} \times n_{pump} = 0.8 \times 0.9 \times 0.9 \times 0.8 = 51\%$. Thus, the energy required by the pumps is about 50% of the energy produced by the aggregate so that the total efficiency remains low.

Pumps and generators operating by means of solar heat are also previously known, and they have in recent years been developed for use in the tropical areas of the globe. As evaporator for one such known water pump, a solar collector is used from which Freon (TM) vapour is conducted through a valve to a motor consisting of a piston movable within a cylinder space, the piston rod of said piston driving a pump situated in a well. In order to cool the condenser, the water obtained from the well is made to flow through the condenser.

In power machines of this type the operation takes place with very small pressure differences of the working medium, about 1 to 5 bar, for which reason conventional slide valves requiring pressure differences of several bar are unable to displace the piston and instead stop at the dead point. They may also remain oscillating around their central position and thereby waste working medium gas.

In order to avoid this disadvantage, the piston rod in the above mentioned known water pump is by means of rods connected to a flywheel which drives the pump. Under the action of the torque of the flywheel the valve slide does not stop at the dead point so that a conventional slide valve can be used in the pump. The flywheel suffers from the disadvantages of requiring a large space and a great weight which requires a robust frame construction. In addition, enviromental impurities, such as sand, may penetrate into the bearings of the flywheel and the rods connected thereto which would decisively reduce the efficiency of the machine.

The object of the present invention is to provide a power machine in which the operation of the valve is ensured in a simple and functionally reliable manner. The invention is characterized in that the connection between said extension rod of said slide and said piston rod is resilient in the longitudinal direction of said rods, and said valve is provided with a spring-loaded locking means cooperating with said slide and permitting the displacement of said slide from one extreme position to another only when the compressive force between said extension rod and said piston rod exceeds a predetermined limit value. Because of the locking means, the slide can be located only in its extreme positions which prevents the valve from stopping at the dead point.

Due to the flexible connection between the piston rod and the extension rod, the piston is able to displace the slide, even under a small pressure difference, from one extreme position to another because the force applied on the slide increases uniformly before the slide is displaced from one extreme position to another. The flexible connection between the piston rod and the extension rod and the locking means are small in size and simple in construction, and because they are located within the motor, enviromental impurities or any other ambient conditions are unable to act on them.

One embodiment according to the invention is characterized in that the locking means comprises a locking ball which is pressed against the slide by means of a spring secured in the valve housing, and in that the slide is provided with two axially spaced recesses for the ball, a ridge being provided between the recesses. This construction prevents in a simple manner the valve from vibrating because it always forces the slide to the extreme position.

The flexible connection between the piston rod and the extension rod can preferably be constructed so that the extension rod of the slide projects into a central bore in the piston rod, that the extension rod is surrounded by a helical spring located between two stops in the extension rod, and that also the central bore in the piston rod is provided with two spaced-apart stops, whereby, when the piston is located close to its extreme positions, the helical spring is compressed between one stop in the extension rod and one stop in the piston rod while resiliently pressing the extension rod in the direction of the extreme position. This construction is very simple and, accordingly, reliable in operation.

One preferred embodiment of the invention will be described in the following in more detail with reference to the accompanying drawing, in which

Figure 1 is a principal drawing of a power machine operating by means of temperature differences,

Figure 2 is a longitudinal section of a motor according to the invention for use in connection with this power machine, and

Figure 3 is a longitudinal section of a condensate pump for use in connection with this power machine.

In Fig. 1, reference numeral 1 denotes an evaporator, for example, a solar collector in which a pressure medium, for example, Freon is evaporated. The evaporator is, through a pipe 2, in communication with a motor 3 comprising a valve 4 and a cylinder 5. The valve 4 is provided with a slide 6 which via an extension rod 7 is connected to a piston 8 in the cylinder 5. Under the cylinder is shown a piston pump 9 consisting of a cylinder 10 and a piston 11 which is secured to a piston rod 12 of the piston 8 of the cylinder 5.

The motor 3 communicates through a pipe 13 with a condenser 14 which, in turn, is connected through a pipe 15 to a condensate pump 16. From the condensate pump, a pipe 17 leads back to the evaporator 1.

The condensate pump is provided with two cylinders 18 and 19 of which the first-mentioned has a larger diameter than the cylinder 19. Also the pistons movable within the cylinders are of different sizes, whereby the piston having a larger diameter and located within the cylinder 18 is denoted by reference numeral 20 and the other one by reference numeral 21. The pistons are connected by a piston rod 22 which, between the cylinders, passes through a space 23 in the condensate pump 16 into which space the pipe 15 from the condenser opens. The cylinder 18 is connected to the valve 4 of the motor 3 by pipes 24 and 25 which open into the cylinder on different sides of the piston 20.

The inner space of the cylinder 19 communicates with the space 23 of the condensate pump via openings 26, 26a and with pipe 17 via openings in both ends of the cylinder. The openings 26, 26a are provided with back valves (not shown) allowing condensate to flow only into the cylinder 19.

In a source of the liquid to be pumped, such as a water well, is placed a suction pipe 27 which is divided into two branches 28 and 29 which are each provided with a back valve 30 and 31 and open into the inner space of the cylinder 10 on different sides of the piston 11. The cylinder 10 is, moreover, via pipe branches 34 and 35 provided with back valves 32 and 33 and a common pipe 36 for these branches in communication with an after-cooler 37 which partly surrounds the condensate pump 16 and which by means of a pipe 38 is connected to a space 39 in thermal connection with the condenser 14. A pipe 40 extending from the space 39 functions as the outlet pipe of the pump device.

In addition, Fig. 1 shows pipes 41 and 42 between the valve 4 and the cylinder 5 as well as the flow directions of the vapour and liquids by means of arrows.

In the following, the motor 3, shown in more detail in vertical section in Fig. 2, will be discussed.

The outer surface of the slide 6 in the valve 4 is provided with an annular recess 43 for distributing the vapour from the evaporator into different pipes. The slide is also provided with a central bore 44 which opens onto the upper surface of the slide and the lower part of which communicates with the outer surface of the slide by means of radial bores 45. To the lower end of the slide is firmly connected the extension rod 7 which extends through the piston 8 of the cylinder 5 into the inner space of the cylinder 10 and the lower part of which is located in a central bore 46 in the piston rod 12 rigidly secured to the pistons 8, 11. At a distance from the free end of the extension rod 7 there is formed, in the extension rod, a shoulder 47 against which a support ring 48 surrounding the extension rod abuts. The support ring 48 is provided with a flange 49 extending outside the surface of the extension rod.

The free end of the extension rod is provided with a nut 50 on which a second support ring 51 is provided slideably on the extension rod, said support ring being provided with a flange 52 having approximately the same diameter as the flange 49. Between the flanges 49, 52, is arranged a helical spring 53 surrounding the extension rod.

Close to the upper end of the central bore 46 in the piston rod 12 is a shoulder 54, the part of the central bore located under said shoulder having approximately the same diameter as the flanges 49, 52, whereas the part located above said shoulder has a smaller diameter. At the lower end of the central bore the diameter is again reduced by means of a sleeve 55.

The outer surface of the lower part of the slide 6 is provided with two axially spaced-apart recesses 56 and 57 between which a ridge 58 having inclined sides is provided. The wall of the valve 4 is provided with a transverse recess 59 in which a ball 60 is arranged which a helical spring 61 presses against the bottom of one of the recesses 56, 57.

The condensate pump 16 is shown in more detail in Fig. 3. In addition to the details appearing from Fig. 1, Fig. 3 shows that the pipe 17 is, within the condensate pump, divided into two branches 62 and 63 each of which is provided with a back valve 64, 65, respectively. The branches open into the end surfaces of the cylinder 19.

The power machine according to invention operates in the following manner.

The pressurized working medium, gasified in the evaporator 1, is conducted to the valve 4 along the pipe 2. The slide 6 guides the gas along the pipe 42 to the lower end of the cylinder 5 whereby the piston 8 starts to rise upwards from the position shown in Fig. 2. The gas located above the piston can flow out through the pipes 41 and 13 into the condenser 14. At the same time, gas flows through the pipe 25 into the cylinder 18 of the condensate pump whereby pistons 20 and 21 are displaced upwards in Fig. 1 and force the condensate in the cylinder 19 into the evaporator through the branch pipe 62 and the pipe 17. At the same time, new condensate flows from the space 23 through the opening 26a into the lower part of the cylinder 19.

As the piston 8 of the cylinder 15 is lifted upwards, the piston rod 12 is also displaced upwards, whereby the extension rod 7 of the slide extends more and more into the central bore 46 in the piston rod. This goes on until the upper edge of the sleeve 55 abuts the lower surface of the flange 52. Now the piston 8 strives to lift the slide upwards via the spring 53 but the locking ball 60 and the ridge 58 prevents the movement of the slide until the tensional force of the spring 53 overcomes the locking force of the spring 61 and the slide jumps to its upper position as the ball 60 is displaced over the ridge 58. As the piston 8 is displaced upwards, the piston 11 of the pump 9 is also lifted, whereby the liquid above the piston 11 flows through the branch pipe 34 and the pipe 36 into the after-cooler 37, from there along the pipe 38 into the space 39 and finally into the outlet pipe 40. At the same time, fresh liquid is sucked through the pipes 27, 28 into the space under the piston 11.

After the slide has been displaced to the upper position, the direction of the gas flow is reversed. Now the gas flows from the pipe 2 through the annular recess 43 in the slide into the pipe 41 and along it into the upper part of the cylinder 5. From the lower part the gas is able to flow out along the pipe 42 and further through the radial bores 45 in the slide into the central bore 44, the outlet pipe 13 and from there into the condenser 14 into which also the gas under the piston 20 in the condensate pump flows through the pipe 25, the radial bores 45 in the slide, the central bore 44 and pipe 13. At the same time, high-pressure vapour flows through the pipe 24 into the upper part of the cylinder 18 displacing the piston 20, 21 downwards. As the piston 8 is displaced downwards, the spring 53 is more and more compressed between the flanges 49, 52 of the support rings. When the compression force is so high that it overcomes the locking force of the spring 61, the spring 53 displaces, by means of the energy momentarily stored therein, the slide into the lower position shown in Fig. 2 whereby the ball 60 is displaced into the other recess. Thus, it is impossible for the slide to remain in an intermediate position. Condensate flows from the condenser 14 along the pipe 15 into the cylinder 19 of the condensate pump 16 through the hole 26 simultaneously as the condensate under the piston 21 in the cylinder is, through the pipes 63, 17, conveyed into the evaporator.

In the pump 9 the piston 11 is displaced downwards whereby the liquid under the piston flows through the pipe 35 into the pipe 36 and from this pipe in the same way as described above. Fresh liquid flows through the pipes 27, 29 into the space above the piston 11.

The above described interconnection of the gas cylinder 5 of the motor and the gas cylinder 18 of the condensate pump, causes them to operate in synchronism so that the recirculation of condensate back into the evaporator can be synchronized in accordance with the operating speed of the pump.

The power machine described above operates always when there is a sufficient temperature difference between the evaporator and the condenser, said temperature difference producing a pressure difference to lift water from a lower level to the desired level. If the temperature difference of a pump working on a constant lifting height increases, the operation of the pump is accelerated and, in a corresponding manner, the volume of the liquid pumped from the souce increases. If again the temperature difference and the pressure difference, respectively, are reduced under the pressure difference corresponding to a certain lifting height, the pump stops until the critical pressure difference is again reached. At this moment the operation of the pump is automatically restarted.

Instead of a piston pump, the working machine may comprise, for example, a membrane pump or an electrical generator in which case the reciprocating movement of the piston rod 12 must be converted into a rotary

movement. The pipes 24 and 25 leading to the condensate pump may alternatively communicate with the upper and lower part, respectively, of the cylinder 5. The spring force of the springs 53 and 61 may alternatively be produced e.g. by a gas cushion.

CLAIMS

1. A power machine operating by means of temperature differences and comprising an evaporator, a motor to which a working machine is connected, a condenser,and a condensate pump, which are connected to each other in said sequence to form a closed circuit for a working medium flowing from one device to another, said motor comprising a valve, a slide movable within said valve, a cylinder arranged in connection with said valve, a piston movable within said cylinder and provided with a piston rod, and an extension rod coaxial with said piston rod and connected to said slide and said piston rod, whereby said connection between said extension rod of said slide and said piston rod is resilient in the longitudinal direction of said rods, and said valve is provided with a spring-loaded locking means cooperating with said slide and permitting the displacement of said slide from one extreme position to another only when the compressive force between said extension rod and said piston rod exceeds a predetermined limit value.

2. A power machine according to claim 1, wherein said locking means comprises a locking ball which is pressed against said slide by means of a spring secured to a housing of said valve and said slide is provided with two axially spaced recesses for said ball between which a ridge is provided.

3. A power machine according to claim 1 or claim 2, wherein said extension rod extends into a central bore in said piston rod, said extension rod is surrounded by a helical spring located between two stops in said extension rod, and said central bore in said piston rod is provided with two spaced apart stops, whereby said helical spring is compressed when said piston is located close to its extreme positions between one stop in said extension rod and one stop in said piston rod while resiliently pressing said extension rod in the direction of one extreme position.

4. A power machine according to any preceding claim, in which said condensate pump comprises a cylinder having a piston, wherein said valve is via pipes connected to a cylinder of said condensate pump for driving a piston thereof in synchronism and with the same pressure medium as said piston of said cylinder of said motor.

5. A power machine substantially as hereinbefore described with reference to, and as illustrated in, the accompanying drawings.

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