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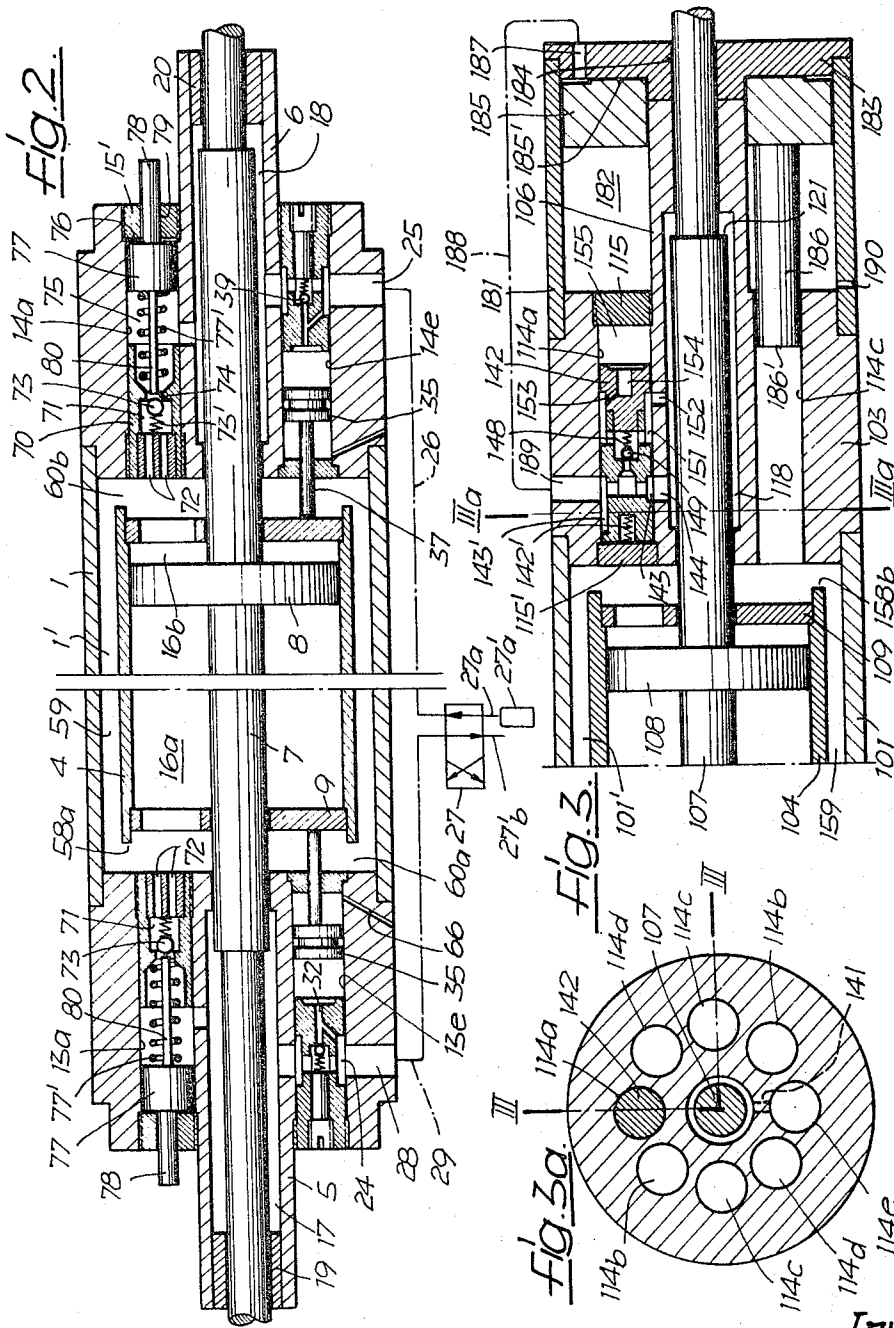
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3,301,196

PISTON MACHINE

Filed Jan. 29, 1965

5 Sheets-Sheet 2



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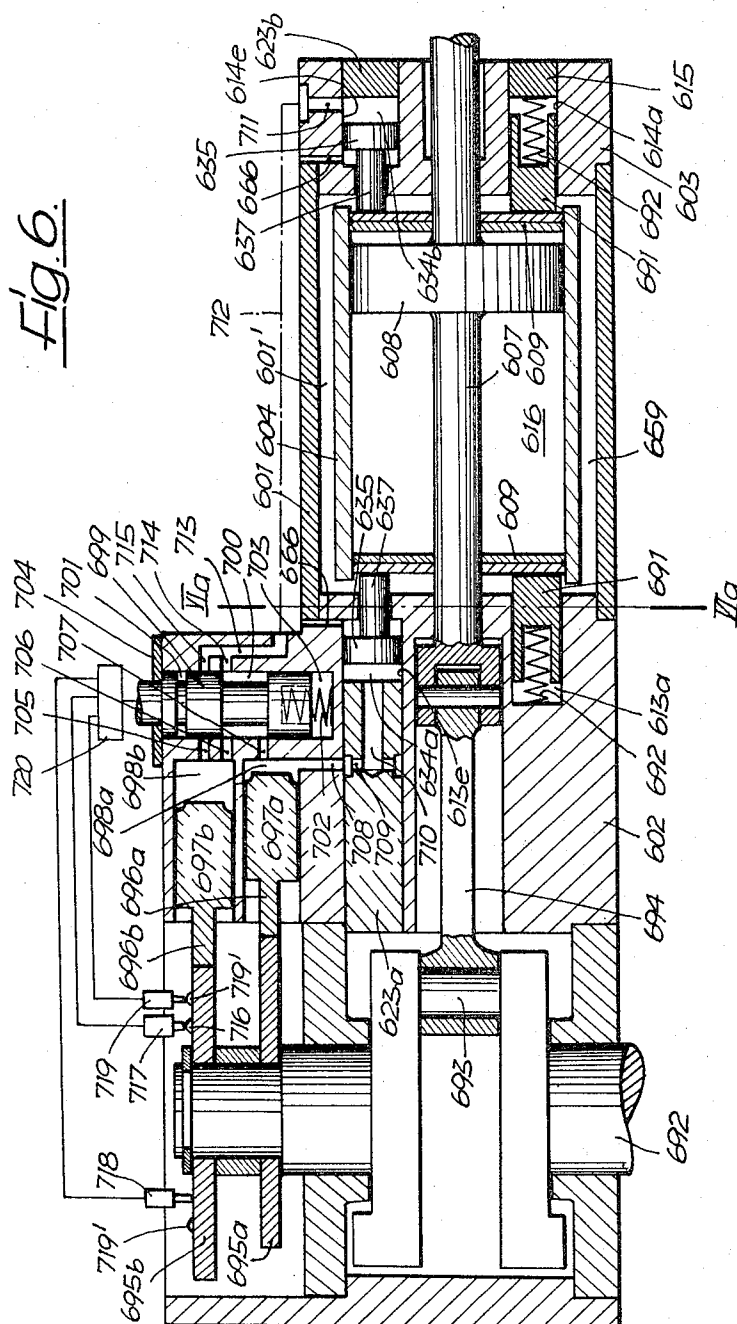
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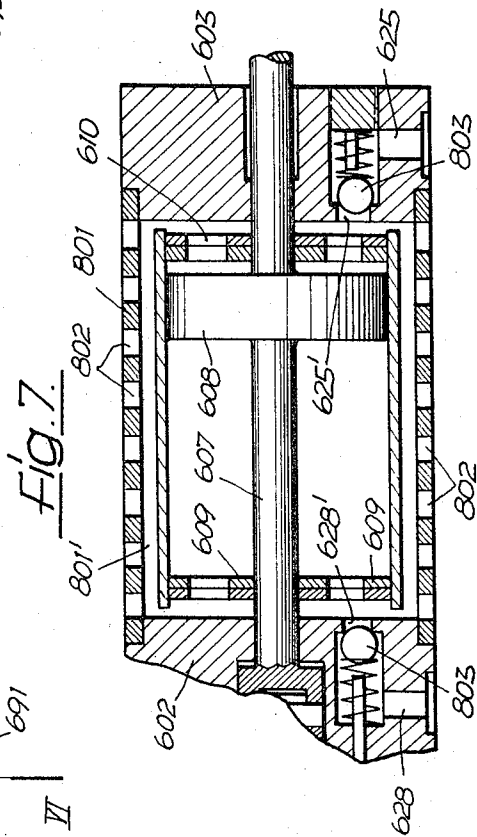
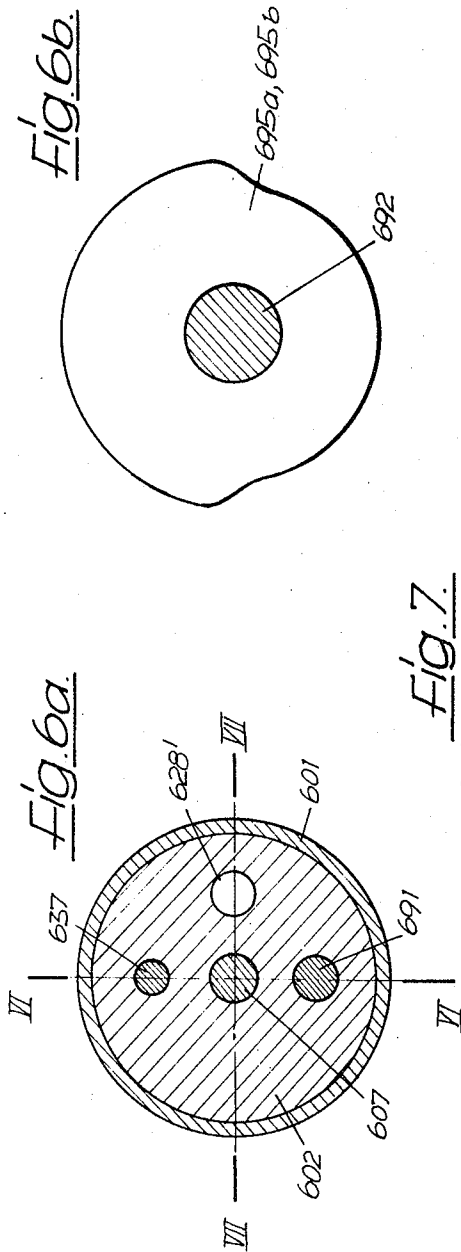
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5 Sheets-Sheet 5



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PISTON MACHINE

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32 Claims. (Cl. 103—158)

The present invention relates to a piston machine which comprises a main piston which is adapted to be acted upon from both sides, a cylinder in which this piston is slidable and which is provided with supply and discharge lines for a gaseous and/or liquid pressure medium, and at least one movable valve member for controlling the flow of the pressure medium.

It is an object of the present invention to provide a piston machine of the above-mentioned type which is of a very simple design and construction, only requires very few movable parts, and is provided with control valves with movable valve members and with flow channels from one side of the main piston to the other, and in which these valves and channels may be opened to a considerably larger cross-sectional size than those in the known kinds of piston machines so as to permit the pressure medium to flow with as little friction as possible when the main piston of the machine runs idle or is to be returned rapidly to its basic position.

Another object of the invention is to provide a piston machine which may be employed either as a drive engine or as a pump for liquid or gaseous pressure media.

A further object of the invention is to provide a machine of the mentioned type which is designed so that its main elements may be employed for many different purposes and may be of numerous different constructions.

Another object of the invention is to provide a machine of this type, the movable main elements of which, especially the valve members and the like, are of such a simple construction that they may be produced very easily and at a low cost.

The principal features of the invention for attaining these objects consist in designing and mounting the cylinder in which the main piston is guided so as to be slidably adjustable to different positions within a completely enclosing jacket, in designing the cylinder so as to define a channel for the flow of the pressure medium from one side of the piston to the other, and in designing it so that the cylinder together with the main piston form the movable valve member for controlling the flow of pressure medium through the mentioned channel.

A preferred embodiment of the invention is designed so that the mentioned jacket and the cylinder which acts as a slide valve form the outer and inner walls of an annular chamber which forms a part of the mentioned channel leading from one side of the piston to the other, that this slide valve is mounted so as to be slidable in the axial direction relative to the jacket, that at least one end of the slide valve is adapted to shut off or to free the flow of pressure medium through the channel, and that suitable control means are provided which are adapted to act upon the ends of the slide valve for adjusting the position thereof. The piston machine may in this manner be of a very simple construction since essentially it consists merely of a jacket and a slide valve which may consist of a simple cylinder and is movable in the axial direction within this jacket, and the ends of which form the movable valve members of the valves. A machine of this design also has the advantage that the annular channel-forming chamber between the jacket and the slide valve may have a large cross-sectional size for the flow of the pressure medium from one side of the main piston to the other and that for the same purpose the valve which may be formed, for

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example, by the outer edges of the slide valve may also be opened to a very large size.

A very advantageous feature of the invention consists in mounting the slide valve so as to be slidable on the piston rod and in employing the outer edges of the slide valve in cooperation with the end walls of the jacket for controlling the flow of the pressure medium from one side of the main piston to the other.

According to another preferred embodiment of the invention, the main piston is driven by an outside driving force and is double-acting for conveying a liquid or gaseous pressure medium. The piston machine according to the invention may then be employed as a pump. This pump may also be designed so as to permit the movement of the slide valve to be delayed relative to the movement of the main piston, so that the amount of pressure medium which is to be conveyed by the pump will be reduced. Thus, even though the actual stroke of the piston remains the same, it is possible in a very simple manner to vary the length of its effective stroke.

Another very advantageous embodiment of the invention provides that the piston rod which passes at least out of one end wall of the jacket to the outside and may be connected to a suitable tool is connected to a quick-traverse piston which is movable within an auxiliary cylinder parallel to the axis of the main piston and piston rod. Such a quick-traverse piston may be formed, for example, at both sides of the main piston by providing the main piston rod with additional piston surfaces each of which may be acted upon by the pressure medium and is movable within an auxiliary quick-traverse cylinder which is formed in each end wall of the jacket by a bore which extends coaxially to the piston rod. In this manner it is possible in a very simple manner to attain a machine of a very compact design which, due to the large cross-sectional area of flow of the pressure medium from one side of the main piston to the other is capable of carrying out a quick-traverse stroke with very little energy and as rapidly as could not be attained by previously hydraulic piston machines of this type.

According to a further modification of the invention, at least one end wall of the jacket may be provided with a connection to the pressure medium which communicates with a bore which extends parallel to the axis of the main piston rod and forms a cylinder in which a thrust piston is slidable which is adapted to act upon the slide valve. This connection also communicates with the quick-traverse cylinder and with a further cylinder which contains at least one pressure-transmission piston which acts upon the main piston. If the machine is designed in this manner, the advantage is attained that by means of a single source of pressure medium a greatly increased force may be produced for carrying out the power stroke of the main piston.

The above-mentioned as well as numerous other features and advantages of the present invention will become more clearly apparent from the following detailed description thereof which is to be read with reference to the accompanying drawings, in which—

FIGURE 1 shows a centrally interrupted axial section which is taken along the line I—I of FIGURE 1b and illustrates a first embodiment of the piston machine according to the invention which is provided with removably inserted control elements for its operation with a liquid pressure medium;

FIGURES 1a and 1b show cross sections which are taken along the lines Ia and Ib—Ib of FIGURE 1, respectively;

FIGURE 2 shows an axial section similar to that according to FIGURE 1 of the same piston machine which, however, is provided with removably inserted control elements for its operation with a gaseous pressure medium;

FIGURE 3 shows an axial section which is taken along the line III—III of FIGURE 3a of the right part of the same piston machine which is equipped for its operation by pressure transmission;

FIGURE 3a shows a cross section which is taken along the line IIIa—IIIa of FIGURE 3;

FIGURE 4 shows a partial longitudinal section of a modification of the machine according to FIGURES 1 and 2;

FIGURE 4a shows a cross section which is taken along the line IVa—IVa of FIGURE 4;

FIGURE 5 shows an axial section similar to that as shown in FIGURE 1 of a further modification of the invention;

FIGURE 6 shows an axial section which is taken along the line VI—VI of FIGURE 6a and illustrates the piston machine according to the invention in the form of a pump for fluids;

FIGURE 6a shows a cross section which is taken along the line VIa—VIa of FIGURE 6;

FIGURE 7 shows a partial axial section which is taken along the line VII—VII of FIGURE 6b and illustrates the slide valve part of a pump which is similar to the pump according to FIGURE 6 but is modified for its operation with a gaseous pressure medium.

The piston machine according to the invention as illustrated in FIGURE 1 comprises a cylindrical jacket 1 which encloses an annular flow channel 1' which is closed at both ends by a pair of covers 2 and 3, and an inner cylinder which forms a slide valve 4 and extends coaxially to the jacket 1 and has a length shorter than the distance between the covers 2 and 3. Each of these covers is provided with a central part 5 and 6 which has a hublike outer projection and supports a piston rod 7 which carries a piston 8 which is slidable within a main work cylinder 16 which is formed by the slide valve 4 and is, in turn, slidable on the piston rod 7. Slide valve 4 is for this purpose provided with end walls 9, each of which has a bearing bore 11 and apertures 10, as shown particularly in FIGURE 1a. Covers 2 and 3 are provided within the central parts 5 and 6 with coaxial bores 12 and 12' in which the piston rod 7 is slidable, and with diametrically opposite bores 13a, 13e and 14a of equal diameter around the central parts 5 and 6 and parallel to the axis of piston rod 7, as shown in FIGURE 1b which illustrates the cover 3. These bores which may be closed toward the outside, for example, by screw plugs 15 or the like are intended for receiving suitable control means. The central parts 5 and 6 of covers 2 and 3 are each provided with a cylindrical chamber 17 or 18, respectively, which serves as a quick-traverse cylinder and, except for the bearing bore 12 or 12', is closed toward the side facing the flow channel 1' and toward the outside by a bushing 19 or 20, respectively. Within cylinders 17 and 18 the outer parts of the piston rod 7 are made of a smaller diameter so as to form annular shoulders 21 and 22 each of which forms the piston surface of a quick-traverse piston.

Bores 13a and 14a contain control means for the main piston 8, while bores 13e and 14e contain control means for the slide valve 4. Since the piston machine according to the invention is double-acting and therefore of a substantially symmetrical design, it will only be necessary to describe the control means for one side of the machine.

If for operating the piston machine a liquid pressure medium, for example, oil, is used, these control means which are disposed within the bores 13a, 13e and 14a, 14e are designed in the manner as illustrated in FIGURE 1. Bore 14e of cover 3 contains, and is closed toward the outside by a cylindrical plug 23 which is provided in its outer peripheral surface with an annular groove 24 into which a radial bore 25 in the cover 3 terminates which forms a connection port and is connected to a pressure line 26, as indicated diagrammatically in FIGURE 1, which leads to a conventional switch valve 27 which is adjustable to three different positions. The corresponding pressure line which connects the connection port 28 of

cover 2 with the switch valve 27 is designated by the numeral 29. In the three different positions of the switch valve 27 these two pressure lines 26 and 29 may be either shut off or connected to a source of pressure medium 27a or a tank 27b, or vice versa.

At the inside of the cylindrical plug 23 a chamber 30 is provided which communicates through radial bores 31 with the annular groove 24 and through an axial bore 32 with bore 14e in the cover 3. Plug 23 and a bushing 33 which closes the bore 14e toward the flow channel 1' define within the bore 14e a cylinder 34 in which a thrust piston 35 is movable, the piston rod 37 of which extends through the bore 36 in bushing 33 and acts upon the end wall 9 and thus upon the slide valve 4. The part 34a of cylinder 34 through which the piston rod 37 of piston 35 extends communicates with the atmosphere through a bore 66. By means of a throttle bore 38, the annular groove 24 communicates directly with the axial bore 32. Chamber 30 contains a check valve which is formed by a ball 39 and a compression spring 40 which presses this ball upon the end of the bore 32 and thereby closes the same. The annular groove 24 communicates through a radial bore 41 with the quick-traverse cylinder 18 in the bushing 6.

FIGURE 1 further illustrates that the bore 14a in the cover 3 contains a control piston 42 which is slidable therein and has the purpose of throttling the supply of pressure medium to the main piston 8 as long as the latter is moved in quick traverse by the piston rod 42. The control piston 42 is shown in FIGURE 1 in its left end position after completing its throttling operation. In its basic position, the control piston 42 engages upon the plug 15, as illustrated at the left side of FIGURE 1, so that an annular groove 43 which is provided in the outer peripheral surface of the control piston 42 will then be located at the right of a radial bore 44 in bushing 6 which connects the quick-traverse cylinder 18 with bore 14a in the cover 3. The annular groove 43 communicates through radial bores 45 in the control piston 42 with an axial bore 46 in the latter, and this bore 46 leads at one end into the flow channel 1' and at the other end into a chamber 47 which is provided at the inside of the control piston 42. The other end of the axial bore 46 is closed by a check valve which consists of a ball 49 which is acted upon by a compression spring 48. Chamber 47 communicates through radial bores 50 with a further annular groove 51 which is provided in the outer peripheral surface of the control piston 42. This annular groove 51 communicates through a radial bore 52 in bushing 6 with the quick-traverse cylinder 18 and through a throttle bore 53 with an axial bore 54 in the control piston 42. Bore 54 communicates with a cylinder 55 which forms a part of the bore 14a. For effecting the return stroke of the control piston 42, a channel 56 is provided which leads from the flow channel 1' to the bore 14a and terminates therein at a point between the bushing 33 and a shoulder 57 on the control piston 42.

The manner of operation of the piston machine according to FIGURES 1, 1a, and 1b is as follows:

When the switch valve 27 is turned to the proper position, the pressure medium flows from its source 27a through the line 26 and the connection port 25 into the machine and from the latter through the connection port 28 and the line 29 to the tank 27b.

The pressure medium passes at the right side of the machine from the connection port 25 through the annular groove 24 and the radial bores 31 and the chamber 30 into the quick-traverse cylinder 18 while the axial bore 32 is closed, and in cylinder 18 the pressure medium acts upon the annular piston surface 22 so that the piston rod 7 and thus also the main piston 8 are moved rapidly toward the left of FIGURE 1. At the same time, the pressure medium also passes through the radial bore 52 into the annular groove 51 of the control piston 42 and further through the throttle bore 53 and the axial bore 54 into the cylinder 55. The control piston 42 is then

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located in its basic position which is farther toward the right than the position in which the piston is illustrated at the right side of FIGURE 1. The annular groove 43 of the control piston 42 is then still located at the right of the radial bore 44. Since the throttle bore 53 only permits a small amount of pressure medium to enter the cylinder 55, the control piston 42 is at first moved slowly toward the left. However, as soon as the annular groove 43 starts to communicate with the radial bore 44, the pressure medium passes from the quick-traverse cylinder 18 through the radial bore 44, the annular groove 43, the radial bores 45, and the axial bore 46 into the main cylinder 16, and it then passes through the entire cross-sectional area of this channel as soon as the control piston has reached its left end position, that is, as soon as the radial bore 44 is fully in alignment with the annular groove 43, as shown at the right side of FIGURE 1. During these proceedings, the right check valve which is formed by the ball 49 is closed.

The slide valve 4 which in its basic position engages with its control edge 58b upon the cover 3 is then slowly moved toward the left by the thrust piston 35 since the latter is at first acted upon by the pressure medium only through the throttle bore 38. Since at the beginning of this slow movement the control edge 58b of slide valve 4 separates from the cover 3, the pressure medium which is displaced from the cylinder chamber 16a by the rapid movement of the main piston 8 may pass through the apertures 10, the space 60a between the left control edge 58a of slide valve 4 and the cover 2, and further through the annular chamber 59 between cylinder 1 and slide valve 4 which forms a part of the flow channel 1', and through the space 60b between the right control edge 58b and the cover 3 into the cylinder chamber 16b. Consequently, during the quick traverse the pressure medium flows freely from one side of piston 8 to the other. The quick traverse generally serves for the purpose of moving a tool, not shown, which is connected to the piston rod 7 quickly toward a workpiece before the actual compression stroke is started, for example, for carrying out a cutting, stamping, or any other operation.

Before the annular groove 43 of the control piston 42 communicates with the bore 44 in bushing 6 or as soon as this occurs, slide valve 4 is moved by the thrust piston 35 to its end position in which the gap 60a between the control edge 58a of slide valve 4 and the cover 2 is closed so that the flow of pressure medium through the annular flow channel 59 is interrupted. Since the entire volume of the pressure medium then acts upon the main piston 8, the quick traverse of the piston and piston rod is terminated and the power stroke begins.

While these proceedings occur as have been described above, the following proceedings occur at the left side of the machine, the control means of which are arranged in the bores 13a and 13e symmetrically to those of the right side.

The control piston 42 and the thrust piston 35 are at first located in the position as shown in FIGURE 1. As long as the gap 60a is not as yet closed, that is, while the main piston is moving in quick traverse, the pressure medium flows in the manner as already described through the annular channel 59 from the cylinder chamber 16a into the cylinder chamber 16b and it also flows off through the axial bore 46 and the check valve 48, 49 which is opened by the pressure of the pressure medium, and further through the chamber 47, the radial bores 50, the annular groove 51, the radial bore 52, the quick-traverse cylinder 18, the bore 41, the annular groove 24 in the plug 23, the bore 31 of the latter, the connection port 28, and then through the line 29 and the switch valve 27. The pressure medium which is displaced by the thrust piston 35 flows off through an opening in the check valve which is formed by the ball 39 and the spring 40.

Thereupon the switch valve 27 is reversed so that the entire procedure as previously described will then occur

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in the reverse direction. The pressure medium is then released in the cylinder chamber 55 so that the control piston 42 in the right cover 3 is moved to its basic position by the direct action of the pressure which is still contained in the flow channel 1' and also by the pressure passing through the channel 56. As already described in connection with the check valve in the left cover 2, the pressure medium then flows off through the check valve 48, 49 in the right cover 3.

If the machine according to the invention is to be driven by a gaseous pressure medium rather than by a liquid medium as previously described with reference to FIGURE 1, controlled check valves will be inserted in place of the control pistons 42 in symmetrical positions into the bores 13a and 14a at both sides of the machine according to FIGURE 2. Bores 13e and 14e, however, are provided with thrust pistons and their control means in the same manner as shown in FIGURE 1.

The two machines as illustrated in FIGURE 1 and FIGURE 2 differ from each other merely by the fact that the parts which are inserted into the bores 14a and 14e of the machine according to FIGURE 1 are provided for its operation with a liquid pressure medium, while those which are inserted into these bores of the machine according to FIGURE 2 are provided for its operation with a gaseous pressure medium.

In FIGURE 2, the connection port 25 and 28 for the pressure medium are connected by the lines 26 and 29, respectively, with a switch valve 27 which alternately connects these lines with a source of pressure medium 27a or with an outlet 27'b to the atmosphere.

Bore 14a is closed toward the outside by the plug 15' and toward the inside by an insert 70 which is provided with a chamber 71 which is connected by axially parallel bores 72 with the flow chamber or channel 1'. Chamber 71 contains a ball 73 which is pressed by a spring 73' against the mouth of an axial opening 74 which extends into a cylinder chamber 75 and is closed by this ball. This chamber 75 and another cylinder chamber 76 are formed by the insertion of a control piston 77 into the area between the bore 14a of the cover 3 between the plug 15' and the insert 70, in which area this piston is slidable against the action of a spring 77'. This control piston 77 has on one end a pin 80 which is adapted to pass through the opening 74 and to act upon the ball 73. On its other end, piston 77 has a piston rod 78 which extends through a bore 79 in plug 15' to the outside and may be moved in the direction toward the ball 73 against the action of a spring 77' either by hand or by its engagement with a workpiece in order to open the check valve which is formed by the ball 73. Of course, in place of such a manual or mechanical actuation, it is also possible to provide an electromagnetic or hydraulic control for the actuation of piston 77 and piston rod 78.

The left side of the piston machine according to FIGURE 2 is again provided with the same parts as are shown at the right side.

The manner of operation of the piston machine according to FIGURE 2 is in principle the same as that of the machine according to FIGURE 1, except for the following difference:

The entire flow chamber 1' is held continuously under the pressure which is produced by the pressure source 27'a, and the required flow to and from the flow chamber is insured or prevented, as the case may be, by the two check valves 73 and 73'.

During its preceding return stroke, slide valve 4 has closed the gap 60b. The pressure source 27'a is then still connected with the connection port 28 on the left cover 2, while the connection port 25 of the right cover 3 is connected with the atmosphere. When the switch valve 27 is then reversed, these connections are likewise reversed. The pressure medium now flows through the line 26 to the right cover and at first moves the thrust piston 35 which shifts the slide valve 4 away from the

cover 3 so that the gap 60b is formed and the pressure medium can then flow freely through the annular chamber or channel 59 from one cylinder chamber 16a to the other chamber 16b and thereby permit the main piston 8 to carry out its quick-traverse stroke. Slide valve 4 is then slowly moved toward the left by the thrust piston 35 until the gap 60a is fully closed. When this occurs, the flow of pressure medium through the annular channel 59 immediately ceases and the quick-traverse of piston 8 is stopped and instead the power stroke thereof is started as soon as the check valve 73, 73' is opened by the actuation thereof as previously described, and the pressure medium can escape from the main cylinder chamber 16a which is then closed relative to the main part of the flow channel 1' by the engagement of the control edge 58a of the slide valve 4 against the cover 2. Since the pressure medium then acts only upon the right side of slide valve 4, its control edge 58a is pressed so firmly against the cover 2 that it is tightly sealed thereon. Thereafter the switch valve 27 is reversed and the entire operation as above described occurs in the opposite direction.

FIGURES 3 and 3a illustrate a modification of the machine according to FIGURES 1 and 1a, in which the main piston 8 is not driven directly by the pressure which is produced by the pressure source, but through a pressure transmission. All those parts in FIGURES 3 and 3a which substantially correspond to the parts as shown in FIGURES 1 and 1a are designated by reference numerals which are increased by 100 over those applied in FIGURES 1 and 1a.

This modified construction of the piston machine according to the invention which operates with a pressure transmission is likewise of a fully symmetrical design just as the machines according to FIGURES 1 and 2. It therefore also comprises two equal covers on the jacket 101, only one of which is illustrated in FIGURE 3, namely the cover 103. This cover 103 is not only provided with the bores 114a and 114e corresponding to the bores 14a and 14b in FIGURE 1, but also with further pairs of diametrically opposite bores 114b, 114c, and 114d in which the plungers 186 of pressure-transmission pistons 185, 186 are movable. Pistons 185, 186 may be provided with plungers 186 for each pair of the bores 114b, 114c, and 114d. If however, a higher rate of pressure transmission is desired, it is also possible to provide only one or two pairs of plungers. Those pairs of bores which are not occupied by plungers should then be closed by plugs similar to the plug 15.

Cover 103 carries on its outer end a cylinder 181 in which around the hublike central projection 106 of cover 103 an annular chamber 182 is formed. The outer ends of this chamber 182 and of hub 106 are closed by a common outer cover 183 which is provided with a bore 184 for the piston rod 107 and a further bore 187 which is connected by a line 188 with a radial bore 189 in the cover 103 which terminates into the bore 114a. The annular chamber 182 contains an annular piston 185 which is slidable therein and engages upon the outer ends of the pair or pairs of plungers 186. As already stated, the inner ends of these plungers engage into one or more of the pairs of bores 114b, 114c, 114d in the cover 103. Plungers 186 may also be rigidly secured to the annular piston 185, although this is not absolutely required for the operation of the machine.

The two ends of bore 114a are closed by plugs 115 and 115' relative to the annular chamber 182 and relative to the flow chamber or channel 101', respectively. The cylindrical chamber in bore 114a which is formed between these two plugs 115 and 115' contains a control piston 142 which is slidable therein in the axial direction against the action of a spring 242' which tends to press the control piston 142 into its basic position in which it engages upon the plug 115. The control piston 141 is otherwise of the same construction as the control piston 42 according to FIGURE 1 except that it is not provided

with the bore 46 which connects the check valve 48, 49 with the flow channel 1'. This control piston 142 therefore serves for the purpose of conducting the pressure medium from the quick-traverse cylinder 118 through the radial bore 152 in the central part 106, the annular groove 151, the throttle bore 153, and the axial bore 154 into the cylinder chamber 155. The control piston 142 is therefore subsequently moved against the action of spring 142' to its active position in which it engages upon the plug 115' and connects the radial bore 144 through the annular groove 143 with the radial bore 189 and thereby through the line 188 with the pressure chamber in the annular chamber 182 behind the annular piston 185. The annular groove 143 differs from the annular groove 43 in FIGURE 1 by being provided adjacent to the mouth of the radial bore 189 with a lateral extension which extends in the direction toward the plug 115' so as to insure during the entire stroke of the control piston 142 a return flow of the pressure medium from the annular chamber 182 through line 188, the radial bore 189, and the check valve which is formed by the ball 149 and the compression spring 148.

At the inner side of the annular piston 185 which is not acted upon by the pressure medium, the annular chamber 182 communicates with the atmosphere through at least one radial bore 190.

The machine according to FIGURE 3 is likewise provided in the bore 114 with a thrust piston, not shown, which is similar to the thrust piston 35 according to FIGURE 1. As shown in FIGURE 3a, the part of the bore 114e which forms the pressure chamber for the thrust piston is connected through the bore 141 which corresponds to the radial bore 41 in FIGURE 1 with the quick-traverse cylinder 118 and also with a connection port for the pressure medium which corresponds to the connection port 25 in FIGURE 1.

The manner of operation of the machine according to FIGURES 3 and 3a is as follows:

The liquid or gaseous pressure medium which enters the quick-traverse cylinder 118 in the same manner as described with reference to FIGURES 1 and 2 and acts upon the quick-traverse piston surface 121 of piston rod 107 and thereby moves the main piston 108 in quick traverse. The entire flow chamber or channel 101' as well as the bores 114b, 114c, and 114d are filled with a liquid pressure medium regardless of whether the machine is otherwise operated with a liquid or gaseous pressure medium. The pressure medium which flows from one side of the main piston to the other and also acts upon this piston during its power stroke therefore consists in either case of a liquid. Similarly as in the other machines as previously described, the thrust piston begins to move slowly in the bore 114 toward the left. At the same time, pressure medium enters from the quick-traverse cylinder 118 through the bore 152 and the throttle bore 153 into the cylinder chamber 155 so that the control piston 142 is moved slowly toward the left to its active position and the action upon the annular piston 185 is delayed for the length of time which is required for the quick traverse of the main piston 108. As soon as the quick traverse is completed and the slide valve 104 has shut off the flow of pressure medium through the annular channel 159, the control piston 142 has formed the connection between the radial bores 144 and 189 so that the surface 185' of the annular piston 185 will then be acted upon by the pressure medium which is supplied to the machine. Since this surface 185' of piston 185 is considerably larger than the sum of the area of the end surfaces 186' of plungers 186 which are facing the flow channel 101', a pressure transmission occurs during the power stroke of piston 108.

During this power stroke, the pressure medium flows off in the cover 102, not shown, at the other side of the machine because the plungers which correspond to the plungers 186 are forced back and because the pressure

medium which during the preceding power stroke was supplied to the pressure chamber of the annular chamber 182 is expelled by the annular piston 185 through the line 188 and the check valve 148, 149 in a similar manner as described with reference to FIGURE 1. The liquid pressure medium within the flow channel 101' and in the bores 114b, 114c, and 114d is not replaced but remains fully within these areas.

In the machine according to FIGURE 2, the slide valve 104 controls the flow of pressure medium through the annular channel 59 by means of its annular control edges 58a and 58b which are pressed against the cover 2 or 3, respectively, or are separated therefrom. FIGURES 4 and 4a illustrate a modification thereof, in which those parts which correspond to the parts in FIGURE 1 are designated by reference numerals which are increased by 200 over those applied in FIGURE 1.

The slide valve 204 according to FIGURES 4 and 4a is not slidable on the piston rod 207, but forms a cylinder without end walls. In this case, the thrust pistons 35 are omitted. The slide valve 204 is guided within an annular groove 261 which is provided between the cover 202 and the outer jacket 201 and is connected through a throttle bore 238 with a bore 213 in cover 202 which extends parallel to the axis of the piston rod so that the outer edges 258 of slide valve 204 carry out the same purpose as the thrust pistons 35 of the machines according to FIGURES 1 and 2. The cylindrical slide valve 204 is provided at a certain distance from its left end and within a plane transverse to its axis with sector-shaped slots 262 which are separated by webs 263. These slots 262 are arranged so that, when the slide valve 204 is located in its central position, as shown, or in its right end position, they will connect the chamber 216 of the main cylinder with the annular chamber 259, while when the slide valve 204 is moved to its left end position, these slots 262 are located within the annular groove 261 so that the mentioned connection is closed. The right end, not shown, of slide valve 204 is of a corresponding construction and for receiving it an annular groove similar to the groove 261 is provided. Slots 262 therefore have the same function as the openings 60a and 60b in FIGURES 1 and 2.

FIGURE 5 illustrates an apparatus according to the invention which has an axis of symmetry extending vertically to the axis of the apparatus and is provided with a continuous main piston rod, and in which the slide valve is likewise of a symmetrical design. The ends of the cylindrical jacket 501 are closed by covers 502 and 503 which are screwed into the jacket by means of screw threads 558 and 588. At the inside of jacket 501 between the covers 502 and 503, the symmetrical slide valve 509 is slidable, the ends of which are guided on the inner sides by the surfaces of recessed parts of the covers 502 and 503. Between these recessed parts of covers 502 and 503 and the jacket 501 annular cylindrical chambers 511 and 512 are provided in which the ends of the slide valve 509 are movable. Slide valve 509 is acted upon at both sides by compression springs 515 and 515' of equal strength which are inserted into the chambers 511 and 512, respectively. Slide valve 509 also forms the jacket for the main cylinder 508 which is closed by the covers 502 and 503. In these covers the piston rod 506 is guided which carries the main piston 507 which divides the cylinder 508 into the chambers 508a and 508b. Around the outside of cylinder 508 the jacket 501 is provided with an inner annular recess 513, the ends of which communicate through apertures 514a and 514b in slide valve 509 with the cylinder chambers 508a and 508b when the slide valve 509 is in its central position as shown.

Cover 503 is provided with a connection port 521 for the pressure medium which communicates with a transverse bore 523 which terminates into a longitudinal bore 593 in cover 503 which is closed toward the outside by a plug 592. This longitudinal bore 593 is connected by a coaxial bore 527 with the chamber 511 and contains a

check valve 526 which prevents the pressure medium from flowing into the bore 527. The transverse bore 523 is connected with the main cylinder chamber 508 by a longitudinal bore 525 which contains a check valve 524 which allows pressure medium to flow into the cylinder chamber 508a but not out of it. This bore 525 is connected by a throttling screw 593 and another longitudinal bore 534 with the cylinder chamber 511 of the slide valve 509. Cover 503 is further provided with two coaxial longitudinal bores 529 and 530, the first of which is connected at one end with the transverse bore 523, while the other bore 530 is connected at one end with the main cylinder chamber 508a. The other ends of these bores 529 and 530 are connected with inner annular grooves 544 and 545 in the slide valve 509 when the latter is located in its central position. These annular grooves 544 and 545 are provided in such a position that, when the slide valve 509 moves in one or the other direction from the central position, one or the other of these grooves 544 and 545 will connect the radial bores 531 and 532 with each other.

The two covers 502 and 503 are of identical construction and therefore all of the corresponding parts of the two covers are designated by the same reference numerals, except that a prime is added to each of the numerals designating the parts of the cover 502. The slide valve 509 is therefore also provided at the side of the cover 502 with inner annular grooves 544' and 545'. Piston rod 506 is also recessed symmetrically to the main piston 507 so as to form equal shoulders 595 and 595', which form the piston surfaces of the quick-traverse pistons 506 and 506' which are acted upon during the forward quick-traverse strokes. The quick-traverse cylinder 517a and the corresponding cylinder which is not indicated in FIGURE 5 because of the position in which the quick-traverse piston 506' is illustrated are formed by annular chambers which are defined by the parts 506a and 506b of the piston rod which have a reduced diameter and by the central bores in the covers 502 and 503. Each of these annular chambers forming the quick-traverse cylinders is connected with the respective transverse bores 523 or 523'.

The manner of operation of the apparatus according to FIGURE 5 is as follows:

Assuming that the apparatus is first in the position as shown in FIGURE 5, the pressure medium coming from its source enters the transverse bore 523' through the connection port 521' and acts upon the shoulder 595' on piston rod 506, that is, upon the quick-traverse piston 506', and thus also moves the main piston 507 forwardly, that is, toward the right of the drawing. At the same time, the pressure medium passes through the longitudinal bore 525', the throttle valve 593', and the longitudinal bore 534' and acts upon the slide valve 509 within the cylinder chamber 512' with a delayed action and moves the same forwardly, that is, toward the right, against the action of the compression spring 515. The pressure medium which is hereby displaced from the cylinder chamber 511 may then escape through the longitudinal bore 527 by opening the check valve 526 and then passing into the transverse bore 523 from which it may then flow off through the connection port 521 to a tank.

The pressure medium which is displaced from the cylinder chamber 508a by the forward movement of the main piston 506' may flow through the apertures 514a in slide valve 509, the inner annular recess 513 in the jacket 501, and the apertures 514b in slide valve 509 into the cylinder chamber 508b. The main piston 507 may also at any time draw in additional pressure medium through the longitudinal bore 525' and against the action of the check valve 524.

As soon as the inner annular groove 544 connects the radial bores 531' and 532' with each other, pressure medium can pass from the transverse bore 523' through the coaxial longitudinal bores 529' and 530' into the cylinder chamber 508b so that the actual power stroke

is started. In the meantime, the slide valve has moved so far that its apertures 514a have passed over and are closed by the inner end of the cover 503. After the apertures 514a are closed, the pressure medium which is displaced from the cylinder chamber 508a flows off through the longitudinal channels 530 and 529 to the transverse bore 523 since the annular groove 545 of the slide valve has in the meantime connected the radial bores 531 and 532 with each other.

After the direction of flow of the pressure medium has been reversed so as to enter through the connection port 521 and to leave through the connection port 521' the same proceedings as above described occur in the opposite direction. At this time, the radial bores 531 and 532 and the bores 531' and 532', respectively, will no longer be connected with each other by the inner annular grooves 545 and 545' of slide valve 509 but by its annular grooves 544 and 544'.

The piston machines as illustrated in FIGURES 1 to 5 are double-acting. If in such a machine the piston rod 7 extends through both jacket covers 2 and 3, both ends of the piston rod may alternately exert a force. In certain cases it may, however, occur that the forces which are alternately exerted in opposite directions during the reciprocation of the main piston 8 may be required only at one side of the machine. In this case it would not be necessary that the piston rod 7 extends through the cover at one side of the machine. At this side it will then not be necessary for the return stroke of the main piston to interrupt the flow of pressure medium from one side of the piston to the other.

The piston machine according to the invention may also be designed and employed as a pump. In this case, the main piston is driven by a separate drive and the slide valve serves for regulating the time of the start of the pumping of pressure medium in both directions or the time when the machine is changed over from idling to pumping or vice versa. The main piston then works as a pump piston in a pump cylinder which is formed by the slide valve. The movements of the slide valve for regulating the time of the start of the pumping action are controlled by special means which are actuated independently of the stroke and are adjustable.

FIGURE 6 illustrates the piston machine according to the invention which is designed in the form of a pump for conveying a liquid. Those parts of this pump which correspond to the parts of the machine as shown in FIGURES 1, 1a and 1b are designated in FIGURE 6 by reference numerals which are increased by 600 over those applied in FIGURES 1, 1a and 1b. Because of the similarity of these two embodiments of the invention, reference may to some extent also be made to the previous description of the machine according to FIGURE 1.

A cylindrical jacket 601 is closed at both ends by covers 602 and 603 in which the piston rod 607 of the pump piston 608 is slidably guided. Piston 608 is movable within a pump cylinder which forms the slide valve 604 and is mounted on piston rod 607 so as to be movable in the axial direction relative thereto. The end walls 609 of slide valve 604 are provided with apertures 610, as shown in FIGURE 7, which corresponds to the apertures 10 in FIGURE 1a. For adjusting the slide valve 604 to its idling position, both covers 602 and 603 are provided with axial bores 613a and 614a, the ends of which facing in the direction opposite to the flow channel 601' are closed. Thus, for example, bore 613a forms a socket bore, while bore 614a is closed by a plug 614a. These bores contain plungers 691 which are acted upon by centering spring 692 of equal strength and engage upon the opposite end walls 609 of slide valve 604 so as normally to maintain the latter in its central position. Diametrically opposite to the bores 613a and 614a, covers 602 and 603 are provided with further axial bores 613e and 614e in which thrust pistons 635 are slidable in the axial direction. The piston rods 637 of these pistons are operatively asso-

ciated with the end walls 609 of slide valve 604. The ends of the bores 613e and 614e are closed by plugs 623a and 623b. The chambers 634a and 634b between plugs 623a and 623b, respectively, and the thrust pistons 635 are connected with a pressure control mechanism as subsequently described. The chambers which are formed in the bores 613e and 614e at the other side of the thrust pistons 635 are connected by radial bores 666 with the atmosphere.

Cover 602 forms a bearing block for a crankshaft 692 which projects from one side of the cover 602 forming the bearing block carries two equally-shaped cam plates 695a and 695b which, however, are turned 180° relative to each other. These cam plates engage upon the piston rods 696a and 696b of control pistons 697a and 697b, respectively, which are slidable in the axial direction in cylindrical bores in the cover 602, the pressure chambers 698a and 698b of which are adapted to be connected by a control mechanism with the chambers 634a and 634b.

This control mechanism comprises a distributing slide valve 699 which is slidable in the axial direction in a cylindrical valve bore 703 in the cover 602 and is provided with a wide annular groove 700 and a narrow annular groove 701. This valve member 699 is normally maintained in a neutral position by the action of a spring 702 which presses it against a cover 704 which closes the valve bore 703 toward the outside. The bottom of the pressure chamber 698b is provided with two bores 705 and 706 which connect this pressure chamber with the valve bore 703, while the bottom of the other pressure chamber 698a is provided with one bore 707 which connects this last chamber likewise with the valve bore 703. A further bore 708 extends laterally from the bottom of pressure chamber 698a and is connected with the chamber 634a in bore 613e by two bores 709 and 710 which extend vertically to each other in the plug 623a. Chamber 634b in bore 614b of the other cover 603 is connected by a bore 711 and a line 712 with a bore 713 in the cover 602 which terminates by two branch bores 714 and 715 into the valve bore 703 which contains the valve member 699.

Bores 705, 706, 707, 714, and 715 and grooves 700 and 701 of the valve member 699 are located in such positions that, when the valve member 699 is in the position as shown in FIGURE 6, bores 705 and 715 are closed and bores 706, 707, and 714 are connected with each other by the wide annular groove 700. Consequently, the pressure medium which is contained in the pressure chambers 698a and 698b can circulate during the reciprocating movements of the control pistons 697a and 697b, and these pressure chambers are at the same time connected with the two chambers 634a and 634b which are formed in the bores 613e and 614e which contain the thrust pistons 635, so that the main slide valve 604 is not acted upon by any force which might move it out of its central position in which it is held by the centering springs 692. The above-mentioned bores and annular grooves are further arranged in such a manner that, when the valve member 699 is in its operative position in which it engages upon the bottom of the valve bore 703, this bore 703 is connected through the narrow annular groove 701 in the valve member 699 with the bore 715, while the connection between the other bores which terminate into the bore 703 is interrupted by the valve member 699. Consequently, the movement of the pressure medium which is caused by the piston 697 in the pressure chamber 698b is transmitted to the chamber 634b which forms the pressure chamber for the thrust piston 635. At the same time, pressure chamber 698a is connected with the chamber 634a which forms the pressure chamber for the thrust piston 635 in the cover 602.

As already mentioned, the two cam plates 695a and 695b are of an identical size and shape. This is also apparent from the side view of these cam plates as shown in FIGURE 6b that each cam plate is made of such a shape that during one half of the revolution of crankshaft 692 it will maintain the associated piston 697a or

697b in its retracted position, while during the other half revolution of the crankshaft it will maintain the respective piston in the advanced position. Since the two cam plates 695a and 695b are turned at an angle of 180° relative to each other, the two pistons 697a and 697b will also always be in opposite positions to each other.

Cam plate 695b carries on its flat outer side a projecting cam member 716 which is adjustable to different positions on cam plate 695b along a circular line concentric to crankshaft 692. This cam member 716 is operatively associated with two electric switches 717 and 718 which are mounted diametrically opposite to each other with respect to this circular line. These two switches are connected with an electromagnet 720 which, when switched on by one of the switches, remains switched on until at the end of each stroke of the pump piston 608 it is switched off by a further switch 719 which is likewise connected with the electromagnet 720 and operatively associated with two cam projections 719' secured to cam plate 695b and are disposed thereon diametrically opposite to each other.

Covers 602 and 603 are provided with further axial bores 628' and 625', respectively, which are connected by radial connection ports 628 and 625 to pressure lines leading to an apparatus or tool, not shown, for example, to a piston machine of the kind as illustrated in FIGURE 1 in which the pressure medium may act in opposite directions.

The manner of operation of the pump according to FIGURES 6, 6a, and 6b is as follows:

In the position as illustrated in FIGURE 6, the distributing slide-valve member 699 is located in its neutral position and the main slide valve 604 is therefore centered so as to permit the pressure medium to circulate. If the crankshaft 692 is rotated, the pump piston 608 will be moved back and forth, but the pressure medium will flow merely from one side of the pump piston to the other through the annular flow channel 659. This flow occurs freely and without interference since, due to the inventive design of the slide valve 604, not only the valves which are formed by its ends, but also the annular flow channel 659 have a large cross-sectional size. Each time when the pump piston 608 starts a new power stroke, the control pistons 697a and 697b are moved by the cam plates 695a and 695b to their respective opposite positions.

When the circuit of the electromagnet 720 is then switched on, the valve member 699 is moved to its operative position at the moment when the adjustable cam member 716 actuates one of the switches 717 or 718. From this moment on the slide valve 604 will be moved by the respective thrust piston 635 in the same direction in which the pump piston 608 is then moving, so that the part of cylinder 616 which is then located in front of the pump piston will be closed and the pressure medium within this part of the cylinder will be forced out of it through the bore 625' or 628' and be passed at the same time into the part of cylinder 616 behind piston 608. By varying the adjustment of the cam member 716, it is possible to start this movement of the slide valve 604 which initiates the power stroke of pump piston 608 so as to occur at any desired time during any particular stroke of this piston. Thus, even though the actual stroke of piston 608 remains the same, it is possible to vary freely the length of its effective or power stroke. As soon as the pump piston 608 reaches the end of its power stroke, the electromagnet 720 is switched off by the actuation of switch 719 by the cam member 719' so that the valve member 699 is moved to its neutral position from which it will not be moved again to its operative position until one of the switches 718 and 719 is actuated by the cam member 716. If there is no need to adjust the length of the effective stroke of the piston, the control by the electromagnet 720 may be omitted and replaced by simple manually operated means for shifting the valve member 699 to its operative position.

FIGURE 7 finally illustrates a slight modification of the pump according to FIGURE 6. The jacket 801 of this pump is provided with apertures 802, and spring-loaded check valves 803 are also provided in the bores 625' and 628' so as to permit the pressure medium to pass out of the flow channel 801', but to prevent its return flow. In all other respects, this pump is of the same construction as that according to FIGURE 6.

This pump is adapted to be immersed with its entire jacket 801 into a pressure medium which may consist, for example, of air but may also consist of a liquid, and may be pumped by this pump into a container.

It is evident from the above description of the different embodiments of the invention and especially from the description of the machines according to FIGURES 1 and 2 that the same main elements of the machine, namely, the jacket 1, the covers 2 and 3, the slide valve 4, and the main piston together with the piston rod 7, may be employed for many different purposes. FIGURES 1 and 2 illustrate the application of these same parts for a piston machine which may be operated either with a liquid pressure medium or with a gaseous pressure medium. As evident from the drawings, it is, however, also possible to employ the same parts in the machine according to FIGURE 3 if the covers are provided with additional bores for the plungers. Quite obviously, the same components may also be employed in the other embodiments of the invention, including the pumps.

Although in the previous description the flow channel leading from one side of the main piston to the other has been described as consisting of an annular chamber, for example, the chamber 59 in FIGURE 1 which is simply formed by the space between the peripheral walls of the main slide valve 4 and the outer jacket 1, it is also possible to provide separate conduit means for connecting the two covers 2 and 3 with each other, provided the axial movements of the slide valve are capable of shutting off the flow of the pressure medium through these conduit means. Furthermore, as evident particularly from FIGURE 7, if the machine is used as an air pump or if at least the space between the two covers or even the entire apparatus is immersed in a bath of the same fluid which is to be pumped and which may be either liquid or gaseous, the jacket 1 may be omitted entirely and be replaced by any suitable means for supporting the two covers 2 and 3 and for spacing them at a fixed distance from each other. In such a case, the two covers 2 and 3 would no longer serve as covers but may form two separate bodies which serve as fixed valve elements which are operatively associated with the movable valve element which is formed by the slide valve 4 and the outer ends thereof.

Although my invention has been illustrated and described with reference to the preferred embodiments thereof, I wish to have it understood that it is in no way limited to the details of such embodiments but is capable of numerous modifications within the scope of the appended claims.

I claim:

1. In a piston machine including conduits for supplying fluid to said machine and for discharging the same therefrom, a cylindrical jacket defining an annular flow channel, a main cylinder defining an internal chamber and forming an internal wall in said flow channel, a piston reciprocating in said main cylinder within said internal chamber and dividing the latter into two separate chambers, two immovable valve members disposed at a distance from each other at both sides of said piston, a movable valve member constituted by said main cylinder and adapted to be moved relative to said immovable valve members for cooperation with the latter from an intermediate position, wherein both said separate chambers are connected with said flow channel, in order to carry out an idle stroke of said piston, in two operative positions thereof, one of said separate chambers being discon-

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nected from said flow channel in each of said operative positions, so as to carry out a power stroke of said piston, and control means for moving and retaining said main cylinder in one of said intermediate and said operative positions, respectively, and for controlling said piston.

2. The piston machine as defined in claim 1, wherein said main cylinder having at least one opening and moves in axial direction of said piston relative to said valve members, in order to open and close, respectively, at least said one opening intermediate a part of said cylinder and a part of at least one of said immovable valve members and thereby to open and close, respectively, said valve members, and said control means comprising means for shifting said main cylinder in axial direction.

3. The piston machine as defined in claim 2, in which said main cylinder has at least one annular end surface adapted to engage with and disengage from, respectively, one of said immovable valve members, so as to close and open, respectively, said valve members, when said main cylinder is moved in axial direction.

4. The piston machine as defined in claim 2, in which at least one of said immovable valve members has a cylindrical end portion, said main cylinder having an end portion slidable along and guided by said end portion of said one of said immovable valve members, at least one of said end portions having at least one aperture in its peripheral wall adapted to be opened and closed, respectively, by the sliding movement of said main cylinder, so as to open and close, respectively, said valve members.

5. The piston machine as defined in claim 2, in which said means for shifting said main cylinder are disposed on at least one of said immovable valve members and are adapted to act upon at least one end surface of said main cylinder.

6. The piston machine as defined in claim 2, further comprising a piston rod on at least one side of said piston, and means for mounting said main cylinder on said piston rod for movement thereon relative to said piston.

7. The piston machine as defined in claim 2, further comprising a piston rod on at least one side of said piston, and means for mounting said piston rod in at least one of said immovable valve members, so as to be movable in axial direction therein.

8. The piston machine as defined in claim 2, in which at least one of said immovable valve members forms a cover element removably secured to one end portion of said jacket.

9. The piston machine as defined in claim 2, in which at least one of said immovable valve members has at least one bore therein extending parallel to the axis of said main cylinder and piston, and said means for shifting said cylinder comprising a thrust piston axially slidable within said bore and adapted to engage with said main cylinder.

10. The piston machine as defined in claim 9, in which at least one of said thrust pistons is slidable in said bores in each of said valve members, and means for alternately connecting said thrust pistons to said fluid supply conduits containing a pressure medium.

11. The piston machine as defined in claim 1, further comprising means for reciprocating said piston, said piston being adapted to pump said fluid in at least one direction from said main cylinder when said valve members are closed.

12. The piston machine as defined in claim 11, in which said piston is adapted to pump said fluid alternately in opposite directions from said main cylinder.

13. The piston machine as defined in claim 11, in which said control means are adapted to act upon said main cylinder, so as to vary the effective pumping stroke of said piston.

14. The piston machine as defined in claim 11, in which said control means comprise actuating means, adapted to be connected to and driven by said reciprocating means for moving said main cylinder relative to said piston.

15. The piston machine as defined in claim 14, further comprising adjusting means for connecting said actuating means to said reciprocating means at different times during the continuous reciprocating strokes of said pistons for varying the effective length of each power stroke.

16. The piston machine as defined in claim 14, further comprising a piston rod on at least one side of said piston, said reciprocating means comprising a crankshaft connected to said piston rod, said actuating means comprising at least one control cylinder, a control piston slidable within said control cylinder for conveying a pressure medium, so as to act upon and move said main cylinder, and cam means on said crankshaft for moving said control piston.

17. The piston machine as defined in claim 16, in which said actuating means comprise a pair of control cylinders, and a control piston in each of said control cylinders for controlling the movements of said main cylinder during the strokes of said main piston in each direction, said cam means comprising a pair of substantially equal cam members mounted in opposite relation to each other on said crankshaft for reciprocating said control pistons in opposite directions to each other in a functional relation to the reciprocating movements of said main piston.

18. The piston machine as defined in claim 1, in which each of said immovable valve members has a bore therein, a source of pressure fluid, a control valve adapted to be connected to each of said bores, to said source, and to means at atmospheric pressure for supplying said fluid first to one of said bores and to release it from the other bore to said atmospheric pressure means for effecting a stroke of said main piston in one direction and for then reversing the direction of flow of said fluid for effecting a stroke of said main piston in the opposite direction.

19. The piston machine as defined in claim 1, further comprising a piston rod on at least one side of said piston and slidably guided within and projecting toward the outside of at least one of said immovable valve members, said projecting part being adapted to be connected to an apparatus for driving the same, at least one of said immovable valve members having a bore therein extending parallel to said piston rod and forming a cylinder, a quick-traverse piston connected to said piston rod and slidable within said bore for effecting a quick traverse of said main piston during a part of the stroke of said main piston in at least one direction, and means for conducting said fluid under pressure into said bore.

20. The piston machine as defined in claim 19, in which said bore extends coaxially with said piston rod, and said piston rod having a shoulder thereon forming said quick-traverse piston within said bore.

21. The piston machine as defined in claim 19, in which at least one of said immovable valve members has a further bore therein extending parallel to the axis of said piston rod, said means for shifting said main cylinder comprising a thrust piston slidable within said further bore and adapted to engage with said main cylinder, said fluid conducting means being adapted to conduct said fluid under pressure to both of said bores for acting upon said quick-traverse piston and upon said thrust piston.

22. The piston machine as defined in claim 21, in which at least one of said immovable valve members has a further cylindrical chamber therein extending parallel to said piston rod, and at least one pressure-transmitting piston slidable within said chamber and adapted to act upon said main piston, said fluid conducting means also being adapted to conduct said fluid under pressure into said chamber for moving said pressure-transmitting piston.

23. The piston machine as defined in claim 22, in which said further cylindrical chamber forms an annular chamber removably secured to the outer end of one of said immovable valve members, an annular piston slidable within said chamber, and at least two of said pressure-transmitting pistons secured at one end to said annular

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piston and slidable within bores in said valve member extending parallel to said axis.

24. The piston machine as defined in claim 1, in which at least one of said immovable valve members has at least one bore therein extending parallel to the axis of said cylinder and piston, a control piston slidable within said bore, throttling means in said immovable valve member and acting upon said control piston in only one direction, said control piston being adapted during the forward movement of said main piston to delay the supply of said fluid under pressure to said main piston, and a check valve connected to said control piston for permitting said fluid to be discharged during the return stroke of said main piston.

25. The piston machine as defined in claim 1, in which each of said immovable valve members has at least one bore therein extending parallel to the axis of said cylinder and piston, a check valve in each of said bores, means for opening each of said check valves in a direction toward said main piston, at least one of said check valves in one of said immovable valve members adapted to open automatically under the pressure of said fluid supplied to said main piston at the beginning of its power strokes through said immovable valve member and at least one of said check valves in the other immovable valve member adapted to be opened by said opening means during said power stroke.

26. The piston machine as defined in claim 10, further comprising throttling means in said fluid supply conduits in positions preceding said thrust pistons.

27. The piston machine as defined in claim 4, further comprising control means on said cylinder for controlling the flow of said fluid to said main piston.

28. The piston machine as defined in claim 27, in which said control means are formed by annular grooves in the inner side of said end portion of said cylinder slidable on said end portion of said immovable valve member, and by radial bores in said immovable valve member operatively associated with said annular grooves.

29. The piston machine as defined in claim 17, further comprising valve control means interposed between said control cylinders and said cylinder for effecting the movements of said cylinder.

30. The piston machine as defined in claim 29, further comprising electromagnetic means for actuating said valve control means, and means on at least one of said cam members and rotatable therewith for actuating said electromagnetic means.

31. In a piston machine adapted to be used at will as a drive unit and as a pump, comprising an outer first cylinder,

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der, a pair of cover members closing the ends of said first cylinder, an inner second cylinder extending coaxially to said first cylinder and radially spaced therefrom, so as to define an annular chamber between said cylinders and to define an internal chamber, a main piston adapted to reciprocate in said second cylinder and dividing said internal chamber into two separate chambers, means for supplying fluid into said internal chamber, said second cylinder adapted to reciprocate in its axial direction between said covering members, so as alternately to open said annular chamber at both ends for connecting it with both of said two separate chambers, so as to carry out an idle stroke of said piston or to close said annular chamber at one end, so as to carry out a power stroke of said piston, a piston rod secured to said piston and extending in opposite directions therefrom and guided within said cover members, first control means in said cover members for reciprocating said second cylinder, and second control means in said cover members for controlling the flow of said fluid in operative association with said main piston.

32. In a piston machine including conduits for supplying fluid to said machine and for discharging the same therefrom, a main cylinder defining an internal chamber and forming an internal wall of a passage chamber, a piston reciprocating in said main cylinder within said internal chamber and dividing the latter into two separate chambers, two immovable valve members disposed at a distance from each other at both sides of said piston, a movable valve member constituted by said main cylinder and adapted to be moved relative to said immovable valve members for cooperation with the latter from an intermediate position, wherein both said separate chambers being connected with said passage chamber in order to carry out an idle stroke of said piston, in two operative positions thereof, one of said separate chambers being disconnected from said passage chamber, so as to carry out a power stroke of said piston, and control means for moving and retaining said main cylinder in one of said intermediate and said operative positions, respectively, and for controlling said piston.

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