March 17, 1959 H. ZOLLER 2,877,624

FLUID OPERATED APPARATUS

Original Filed Aug. 27, 1953 4 Sheets-Sheet 1

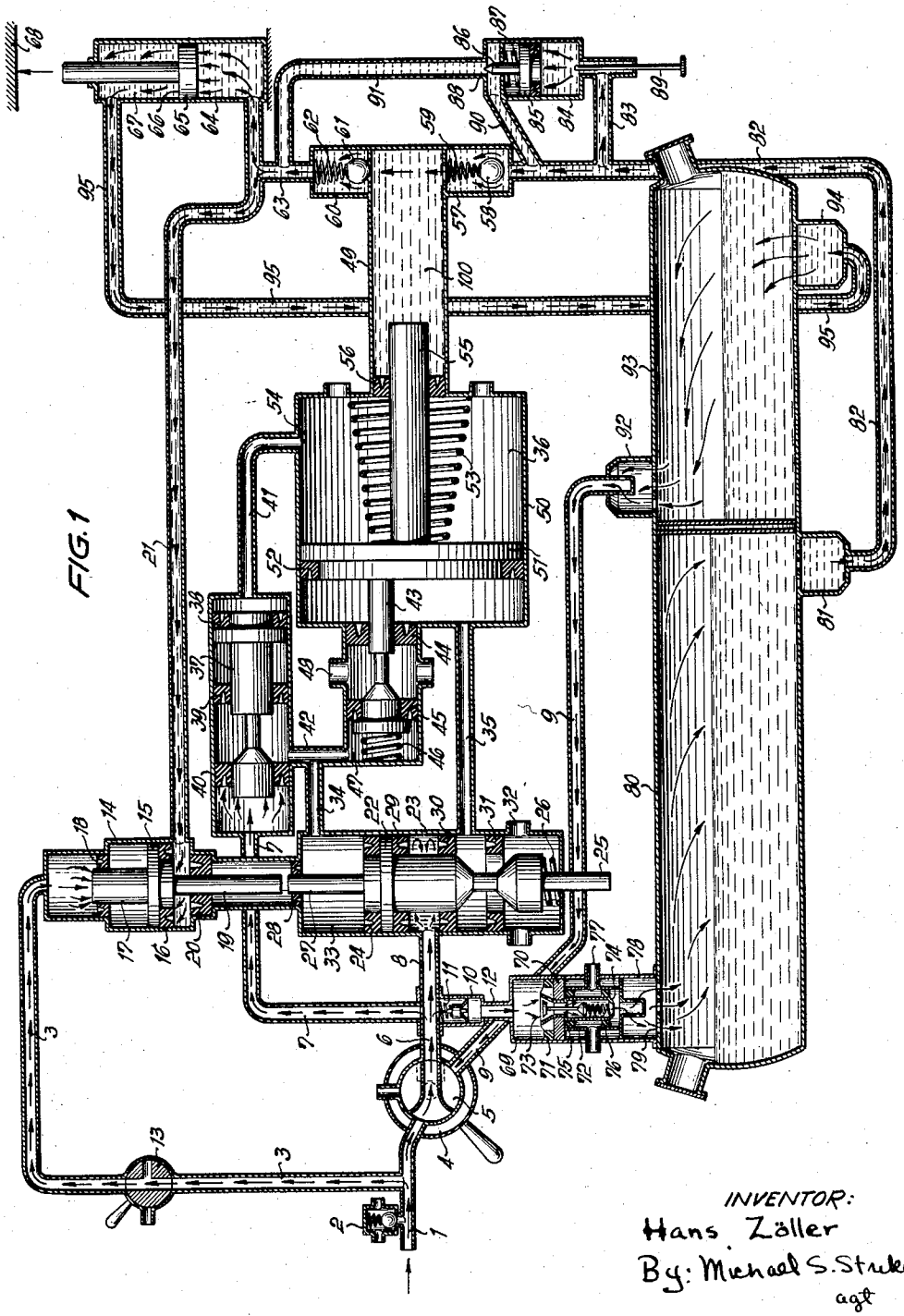


FIG. 1

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FIG. 6

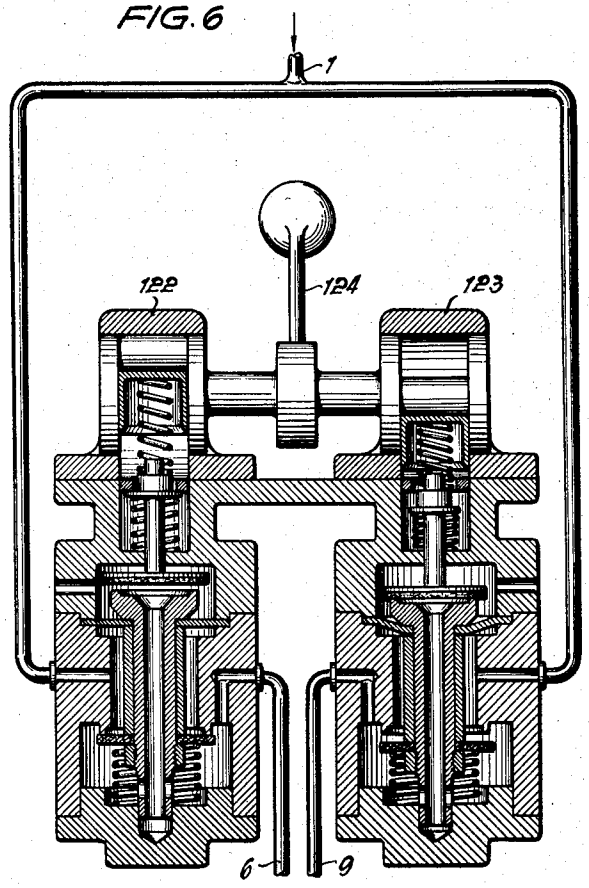


FIG. 2

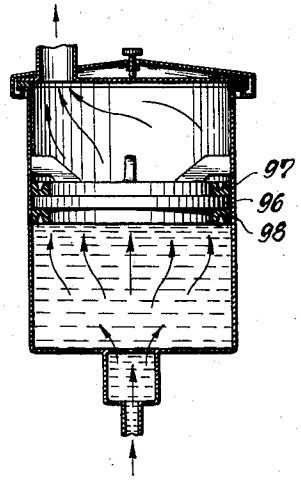
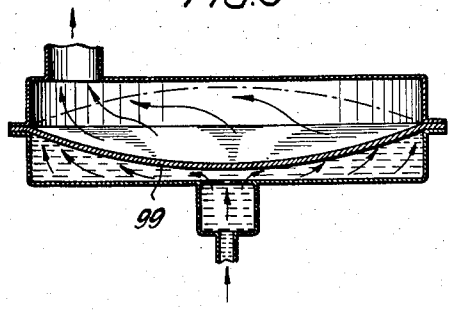


FIG. 3



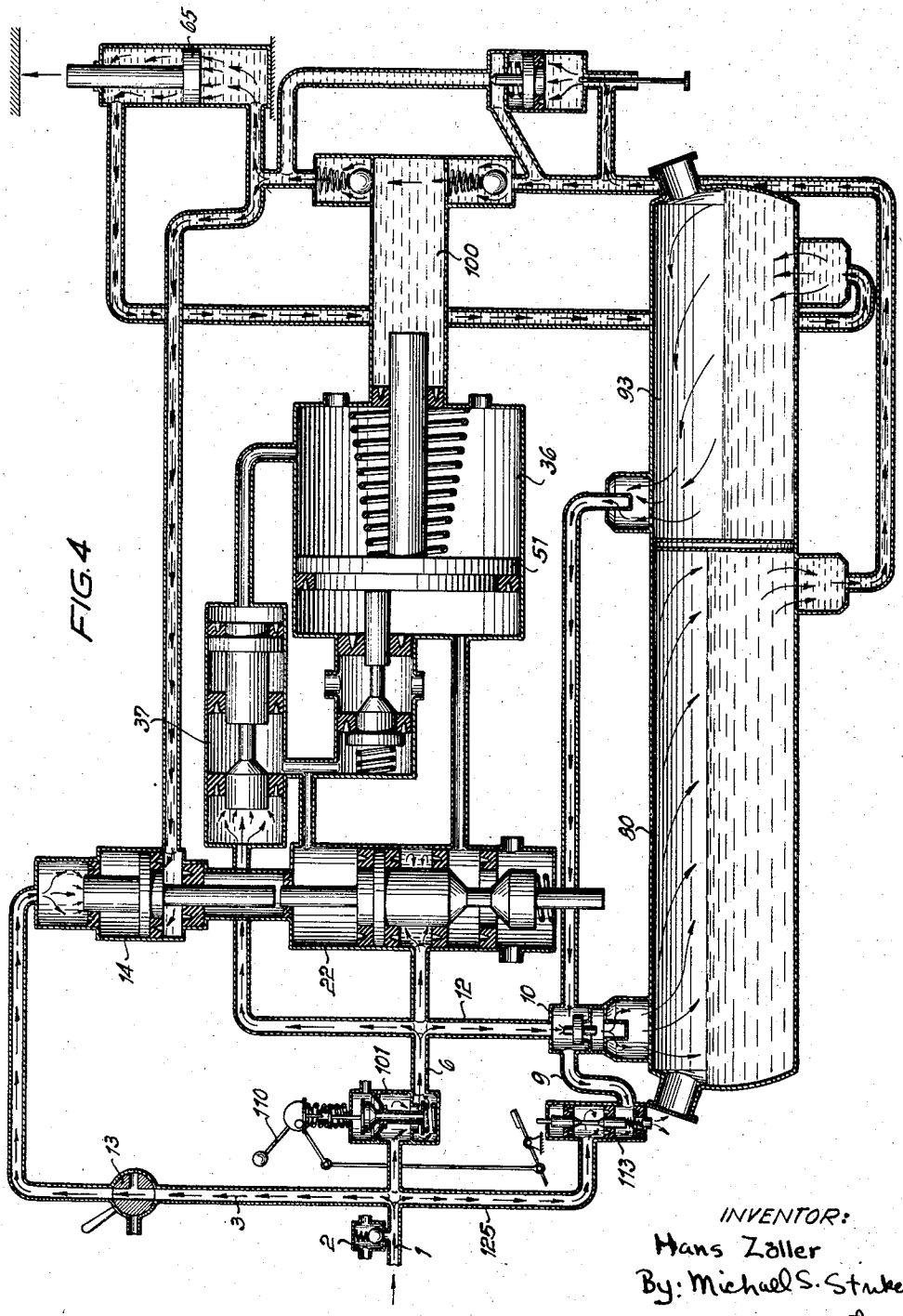
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FIG. 4



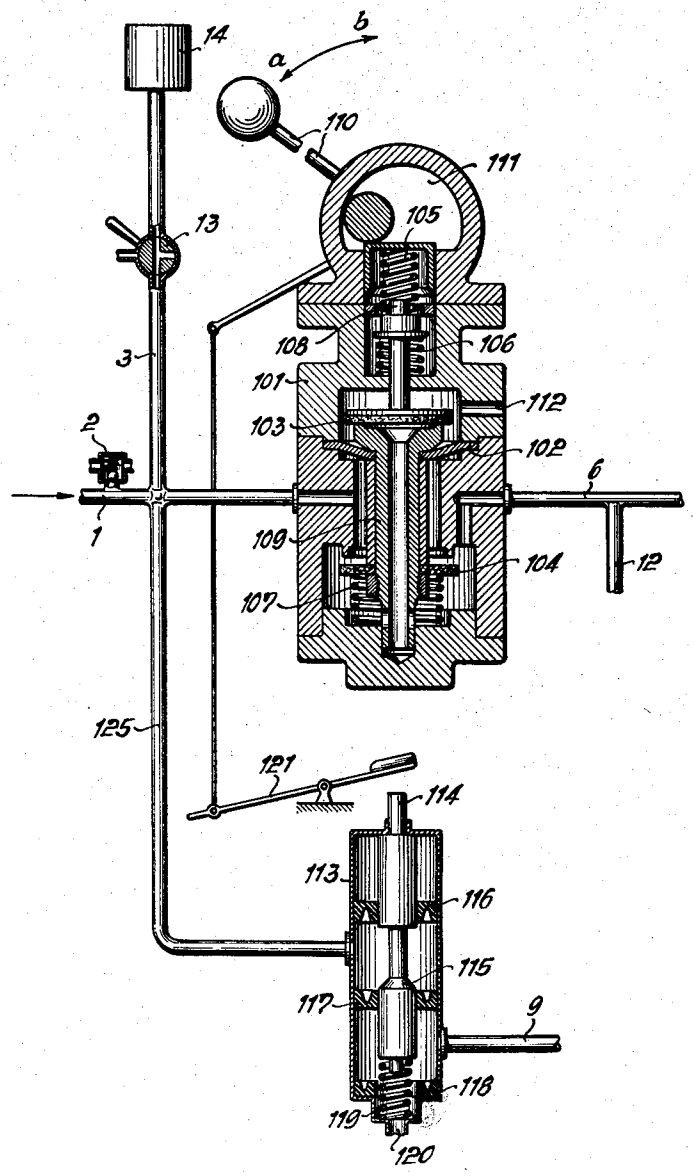
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Original Filed Aug. 27, 1953 4 Sheets-Sheet 4

FIG. 5



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2,877,624

FLUID OPERATED APPARATUS

Hans Zoller, Laubenheim, near Mainz, Germany

Continuation of abandoned application Serial No. 376,947, August 27, 1953. This application March 7, 1957, Serial No. 644,623

Claims priority, application Germany August 28, 1952

12 Claims. (Cl. 60—51)

The present invention relates to a fluid operated apparatus of the type where a hydraulic medium acts on a work member to move the same for pressing the work member with a desired, generally extremely large, pressure against an apparatus to be worked on.

This application is a continuation of my co-pending application Serial No. 376,947, filed August 27, 1953, and entitled "Fluid Operated Apparatus," now abandoned.

With such known constructions, great inefficiency and waste of energy is frequently involved because these known constructions are designed to operate at extremely high pressures. Therefore, their best efficiency is obtained when work requiring an extremely high hydraulic pressure is being performed. However, an extremely high pressure is not required during certain operations, as, for example, when a work member is being freely moved from an idle to an operating position. During operations of this latter type, known apparatus have an extremely low efficiency because they are not designed to operate at the low pressure required for moving a work member to an operative position, for example, and therefore a great waste of energy results.

One of the objects of the present invention is to overcome the above drawbacks by providing an apparatus which has one part capable of operating at an extremely high pressure and another part designed to operate at a much lower pressure and which uses the high pressure part only when high pressures are required.

A further object of the present invention is to provide a fluid operated apparatus having high and low hydraulic pressure means with a control for bringing the high pressure hydraulic means into play only after the low pressure hydraulic means moves working members into their operative position, for example.

Another object of the present invention is to provide an automatic control for automatically bringing a high hydraulic pressure means into play after a low pressure hydraulic means has moved a work member into its operating position.

An additional object of the present invention is to provide an apparatus of the above type which may be easily adapted to different conditions and which includes suitable replaceable or adjustable members for regulating the operating pressures.

Still another object of the present invention is to provide a means for quickly returning a working member from its operating to its idle position.

A still further object of the present invention is to provide a hydraulic apparatus of the above type which uses one fluid to apply pressure to another fluid.

Yet another object of the present invention is to provide a hydraulic apparatus having two working fluids with a means for separating said working fluids from each other.

Still an additional object of the present invention is to provide an apparatus capable of accomplishing all of the above objects and at the same time being made up of

simple and ruggedly constructed parts which will operate efficiently for a long period of time.

With the above objects in view, the present invention mainly consists of a fluid operated apparatus which includes a work member and a low pressure hydraulic means operatively connected to the work member for moving the latter, with a pressure below a predetermined pressure, to an operating position. A high pressure hydraulic means is operatively connected through a portion of the low pressure hydraulic means to the work member for acting on the latter through the said portion of the low pressure hydraulic means with a pressure substantially higher than the predetermined pressure, and a control means is operatively connected to the low pressure and high pressure hydraulic means for setting the high pressure hydraulic means into operation to act on the work member after the low pressure hydraulic means has moved the work member into its operating position.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings, in which:

Fig. 1 is a diagrammatic view of an apparatus constructed in accordance with the present invention;

Fig. 2 is a diagrammatic, fragmentary view of a tank of Fig. 1, and shows a means for preventing contact between a pair of different working fluids;

Fig. 3 shows an apparatus similar to Fig. 2 with a different embodiment of a means for preventing direct contact between a pair of different working fluids;

Fig. 4 is a diagrammatic view of an embodiment of the invention which differs from Fig. 1 in that a reduction valve is employed to regulate the hydraulic pressure;

Fig. 5 is an enlarged fragmentary detailed view of a reduction valve used in Fig. 4 and a control apparatus associated therewith; and

Fig. 6 is a fragmentary enlarged view of a pair of reduction valves which may be used with the apparatus of Fig. 4 in place of the single reduction valve and control apparatus associated therewith.

Referring now to the drawings, and in particular to Fig. 1, it will be seen that a fluid under pressure, in this case a gas such as air, is derived from any suitable source (not shown) and fed along the conduit **1** past the pressure relief safety valve **2** which controls the maximum pressure of the gas in conduit **1**, shown at the left of Fig. 1. The conduit **1** communicates with a hand-operated multi-position control valve **4** which has a turnable valve member provided with a single passage extending therethrough and provided on opposite sides of this passage with open spaces communicating with a chamber **5** which communicates with the outer atmosphere so that any conduits communicating with chamber **5** also communicate with the outer atmosphere.

In addition to communicating with the conduit **1**, the valve **4** communicates with the conduit **6** and with the conduit **9**, and in the position shown in Fig. 1, the passage of the turnable valve member of valve **4** communicates with conduits **1** and **6** to feed the conduit **6** the gaseous medium under pressure in conduit **1**. In the position of Fig. 1 the conduit **9** exhausts through the chamber **5** to the outer atmosphere.

The conduit **6** in turn communicates with conduits **7**, **8** and **12**. Conduit **7** leads to a pressure-sensitive valve formed by a cylinder having fixed sealing rings **39** and **40** located therein and slidably engaging a valve member **37** which is adapted to reciprocate through the rings **39** and **40** and which is formed at its right hand

end, as viewed in Fig. 1, as a piston provided with its own sealing ring 38 which moves together with the valve member 37.

The conduit 8 communicates with a main control valve made up of the cylinder 23 having the sealing rings 28, 29, 30 and 31 fixedly located therein and having a valve member 22 slidable along the sealing rings 29, 30 and 31 and provided with its own sealing ring 24 engaging a piston portion of valve member 22 and being movable with the latter. A control bar 25 is fixed to the bottom end of valve member 22 and extends slidably through an opening in the bottom wall of cylinder 23, as viewed in Fig. 1, a spring 26 engaging this bottom wall in the interior of cylinder 23, being located about bar 25, and engaging valve 22 to urge the latter upwardly, as viewed in Fig. 1. A second bar 27 is fixed to the top end of valve 22, as viewed in Fig. 1, and extends slidably through sealing ring 28, the space in cylinder 23 between sealing rings 28 and 29 forming a pressure chamber 33 of variable volume. Beneath the sealing ring 31 the cylinder 23 is formed with exhaust ports 32 communicating with the outer atmosphere.

Before the valve 4 and after the safety valve 2, the conduit 1 communicates with the conduit 3 provided with a valve 13 having a vent which discharges to the atmosphere. The conduit 3 leads to a pressure-sensitive valve control 14, and in the position of valve 13 shown in Fig. 1 the gaseous pressure medium in conduit 1 moves along conduit 3 to the valve control 14. However, when the valve 13 is turned through 90° in a counter clockwise direction from the position shown in Fig. 1, the cylinder of valve control 14 will discharge to the atmosphere through the vent formed in the casing of valve 13.

Sealing rings 20 and 18 are fixed in the interior of the cylinder of valve control 14, and the valve operating and stop member 15 is provided with a piston portion slidable along the interior of this cylinder, this piston portion having a first bar 17 fixed thereto and extending slidably through the sealing ring 18 and a second bar 19 fixed thereto and extending slidably through the sealing ring 20.

The conduit 12, communicating with the conduit 6, leads to the tank 80. Adjacent to the conduit 6, the conduit 12 is provided with a special non-return valve 10 whose valve member is urged downwardly into the closed position shown in Fig. 1 by a spring, as shown in Fig. 1. This valve member is formed with a nozzle-shaped bore 11 so that the fluid from conduit 6 is throttled as it passes through the valve member of valve 10 when this valve member is in closed position thereof illustrated in Fig. 1. Thus, a throttled flow of fluid through the conduit 12 toward the tank 80 is provided by the valve 10. However, when the fluid flows in the reverse direction, through the conduit 12 toward the conduit 6, the valve member of valve 10 is lifted by the fluid against the action of the spring to an open position which allows fluid to flow at a much faster rate to the conduit 6 than toward the tank 80.

The conduit 12 communicates with the tank 80 through a relief valve formed by a cylinder 69 in which a valve member 70 is slidable, this valve member 70 being in the form of a piston having a sealing ring 71 movable therewith and having a piston rod 72 slidable through the fixed sealing rings 75 and 76 located in the cylinder 69, this cylinder 69 being provided with discharge ports 77 communicating with the outer atmosphere and being located between the sealing rings 75 and 76. The piston rod 72 and piston 70 are bored through their entire length and a non-return valve 73 is accommodated in this bore and urged to its closed position by a spring 74. The bottom end of the cylinder 69 communicates through a suitably apertured tube with the dome 78 which leads through apertures 79 in the top wall of tank 80 to the interior of this tank. In the position shown in Fig. 1, gaseous pressure medium flowing downwardly through conduit 12 automatically moves the valve 73 against the action of spring 74 to the open position illustrated where the fluid continues to flow through the bore of piston rod 72 and dome 78 into the interior of tank 80 to engage the top surface of a liquid located in the tank 80.

The tank 80 is provided at its bottom side with a filter outlet 81 communicating with the conduit 82 which leads to a non-return valve 57 having a ball valve member 58 urged to its closed position by a spring 59. Through this non-return valve 57, the liquid from conduit 82 communicates with a cylinder 49 and with a second non-return valve 60 having a ball valve member 61 urged to its closed position by the spring 62, this non-return valve 60 in turn communicating with a conduit 63 which communicates with a conduit 21 leading on the one hand to the cylinder of valve control 14, between the sealing ring 20 and the piston portion of valve operating and stop member 15, and on the other hand to a cylinder 64 having a piston 65 located therein and fixed to a work member which extends slidably through the top wall of cylinder 64, as viewed in Fig. 1, and which is adapted to contact the work 68 to apply a pressure against the same, as is diagrammatically shown at the top right part of Fig. 1.

The tank 80 forms an extension of a tank 93, and these two tanks are separated from each other by a partition wall, as shown in Fig. 1. A dome 92 communicates through suitable apertures in the top wall of tank 93 with the interior of this tank 93, and a perforated end portion of conduit 9 extends into this dome 92 so that the gaseous medium on top of the liquid in tank 93 flows, in the position of the parts shown in Fig. 1, through the dome 92 and conduit 9 to the valve 4 to be discharged to the atmosphere through the chamber 5 of valve 4. The lower side of tank 93 is provided with a filter outlet 94 communicating with a conduit 95 which in turn communicates with cylinder 64 to thus receive the liquid 67 at the top face 66 of the piston 65. Liquid flowing through the conduits 63 and 21 engages the bottom face of piston 65, as viewed in Fig. 1.

A by-pass around the non-return valves 57 and 60 is provided by the conduits 90 and 91 which communicate with a valve 84 having a valve member 85 in the form of a piston slidably engaging the cylinder of valve 84 and having a projection 86 fixed thereto and provided therewith a conical top free end to engage the bottom end 88 of conduit 91 to close this conduit. A spring 87 engages the top face of valve member 85 to urge the latter to the open position where the bottom end of conduit 91 is not closed and an adjustable rod 89 extends into the cylinder of valve 84 to limit the movement of valve member 85 under the influence of spring 87. For example, this member 89 may be threaded through an apertured member fixed on the bottom wall of the cylinder of valve 84, this apertured member allowing fluid from conduit 82 to freely flow through conduit 83 and into the valve 84 to engage the underside of valve member 85. The bottom of conduit 91 forms valve seat 88 for member 85.

The cylinder 49 forms part of a high pressure pump 100 and is provided with a fixed sealing ring 56 through which a piston 55 of a high pressure pump is adapted to reciprocate. A second cylinder 50 of a drive 36 for the high pressure pump 100 is connected to the left end of cylinder 49, as viewed in Fig. 1, and is provided at its right wall, as viewed in Fig. 1, with ports communicating with the atmosphere. When the piston 55 moves in its suction stroke out of cylinder 49 it simultaneously moves into the cylinder 50, and a piston 51 having a sealing ring 52 movable therewith slidably engages the interior of cylinder 50 and is connected to the left end of piston 55, as viewed in Fig. 1, to actuate this piston 55, a spring 53 being located about the piston 55 in cylinder 50 and engaging the right wall of cylinder 50, as viewed in

Fig. 1, and the piston 51 to urge the piston 55 along its suction stroke. The cylinder 50 is further provided with a port 54 adapted to be covered and uncovered by piston 51 and communicating with a conduit 41 which leads to the pressure-sensitive valve member 37.

A conduit 42 communicates with the interior of this latter pressure-sensitive valve member between the fixed sealing rings 39 and 40 thereof, and this conduit 42 also communicates on the one hand with a conduit 34 leading to the chamber 33 of cylinder 23 and on the other hand with a cylinder 47 communicating with the left end of cylinder 50, as viewed in Fig. 1, and having fixed sealing rings 44 and 45 located therein and between which the cylinder 47 is provided with exhaust ports 48 communicating with the outer atmosphere. A combination control pin and valve member 43 extends slidably through the sealing rings 44 and 45 into the cylinder 50 to cooperate with piston 51 in a manner described below, and a spring 46 in the cylinder 47 engages the left wall of cylinder 47, as viewed in Fig. 1, and the member 43 to urge the latter to the right to the position shown in Fig. 1. A conduit 35 provides communication between the left end of cylinder 50, as viewed in Fig. 1, and the part of cylinder 23 located between sealing rings 30 and 31.

The above described apparatus operates as follows:

With the parts in the position shown in Fig. 1, the pressure fluid in the conduit 1 flows on the one hand through conduit 3 and valve 13 to the cylinder 14 to press on the top end of bar 17 so as to urge the valve operating and stop member 15 downwardly to the position shown in Fig. 1 where the bar 19 has its bottom free end located adjacent to the sealing ring 28, and on the other hand through the valve 4 and conduit 6 to the several conduits 7, 8 and 12, the pressure fluid being throttled as it flows through the nozzle 11 and the relief valve 69 into the tank 80. The pressure fluid flowing along conduit 7 engages the pressure-sensitive valve member 37 to maintain this valve member in the closed position shown in Fig. 1 where none of the gaseous pressure fluid can flow through the sealing ring 40. The fluid acting on the bar 17 causes the bar 19 to be maintained in such a position that the bar 27 cannot move upwardly under the influence of spring 26, which is weaker than the pressure provided by the gas acting against the top end of bar 17, so that the main control valve 22 is in the closed position where none of the gaseous fluid from conduit 8 can flow through the sealing ring 30 to the conduit 35 which provides a communication between cylinder 23 and cylinder 50, as shown in Fig. 1. It should be noted that in this position, the part of the main valve 22 which cooperates with the sealing ring 31 is in its open position where the conduit 35 communicates with the outer atmosphere through ports 32. Thus, no pressure fluid can reach the left side of piston 51 to move the latter against the action of spring 53 so as to move piston 55 into cylinder 49.

The pressure fluid which flows downwardly through the nozzle 11 moves along the conduit 12 and moves the non-return valve 73 against the action of spring 74 so that this pressure fluid moves through the bore of piston rod 72 and dome 78 into the tank 80 to press against the liquid hydraulic fluid in the tank 80. It should be noted that the pressure of the gaseous fluid in the top part of cylinder 69 maintains the valve 70 in the position shown, where the piston rod 72 extends through both sealing rings 75 and 76 to prevent the interior of tank 80 from communicating with the outer atmosphere through the exhaust ports 77.

The pressure of the gaseous medium in the tank 80 presses downwardly on the liquid therein and moves this liquid along the conduit 82 to the non-return valve 57 and to the conduits 83 and 90. The spring 87 is weaker than the pressure produced by the liquid acting against the underside of valve 85 so that at this time the piston 85 moves upwardly to locate the valve member 86 against the seat 88 to close the conduit 91 and it is believed to be apparent that due to the extremely small cross section of the top end of member 86, a very high pressure would be required to move the member 86 away from the seat 88 to open conduit 91 against the action of the fluid engaging the underside of piston 85. The conduit 90 remains filled with the liquid and the liquid in conduit 91 simply remains therein and cannot open the passage through seat 88. The fluid from conduit 82 flows through the non-return valve 57, through the cylinder 49, through the non-return valve 60, through the conduit 63, and through the conduit 21 to the cylinder 64 and to the cylinder of valve control 14.

The pressure of the gaseous medium engaging the liquid medium is relatively low so that the liquid medium in conduit 21 and the cylinder of valve control 14 cannot at this time move the piston 15 upwardly against the force of the gaseous medium acting on the bar 17. Also, nothing resists the movement of the work member connected to the piston 65 so that this piston 65 moves upwardly very easily and quickly, and the liquid 67 simply moves downwardly along conduit 95, out of cylinder 64 and into tank 93 which at this time communicates with the outer atmosphere through the conduit 9 and chamber 5 of valve 4, in the manner described above, so that the liquid 67 engaging the top face 66 of piston 65 also does not materially resist the movement of piston 65 to locate the work member in its operating position against the work 68. Thus, at this time the relatively low pressure of the gaseous medium is used by itself to move the work member from its idle to its operating position, and the high pressure pump 100 does not operate.

Assuming now that the work member has engaged the work 68, it will be seen that the liquid medium engaging the underside of piston 65 can no longer move the piston 65 unless the pressure of this liquid medium is greatly increased, and as a result the gaseous medium which continues to flow into the tank 80 builds up its pressure and therefore builds up the pressure of the liquid medium so that the pressure of the liquid medium in conduit 21 increases. It will be seen that the working face at the underside of piston 15 in the cylinder of valve control 14 is of a larger area than the cross-section of bar 17, so that as the pressure of the liquid in conduit 21 builds up the force of the gaseous medium acting against the bar 17 is no longer capable of maintaining this bar 17 in the position shown in Fig. 1 and the liquid at higher pressure moves into the cylinder of valve control 14 and moves the piston 15 upwardly so as to move the bar 19 upwardly away from the bar 27, this action taking place automatically as soon as the work member fixed to piston 65 engages the load 68.

The upward movement of bar 19 frees the main valve member 22 to the influence of spring 26 which moves this main valve member upwardly so as to close the passage through sealing ring 31 and so as to open the passage through sealing ring 30. Thus, an automatic means is provided to operate the main valve 22 so that the gaseous pressure medium flows through the sealing ring 30 to the conduit 35 and cylinder 50 after the work member engages the work.

Due to the large area of piston 51, the gaseous medium entering cylinder 50 through conduit 35 is capable of moving the piston 51 to the right against the influence of spring 53 and also is capable of moving the piston 55 through the sealing ring 56 into the cylinder 49 so as to move the piston 55 along its pressure stroke which closes the non-return valve 57 and which opens the non-return valve 60, so that in this way fluid under a much higher pressure is pumped by the pump 100 along the conduit 63 to the cylinder 64 so that fluid at a much higher pressure is applied against the underside of piston 65 to perform the work which requires a high hydraulic pressure. The cylinder 14 limits, with its top end wall where the sealing ring 18 is located, the upward move-

ment of piston 15 so that no more fluid can flow to the cylinder 14, and, as was mentioned above, the cross-section of the member 86 is so small that the high pressure from pump 100 acting along conduit 91 is incapable of opening valve 84 against the action of the liquid located against the underside of piston 85. Thus, a liquid under high pressure is pumped to the underside of piston 65 as the piston 51 moves to the right, the air in cylinder 50 to the right of piston 51 discharging through the exhaust ports located on the right wall of cylinder 50, as viewed in Fig. 1.

As the piston 51 approaches the end of its stroke, it first covers and then uncovers the port 54 so that this latter port is now located on the left side of piston 51, and at this moment the gas under pressure in the cylinder 50 at the left side of piston 51 flows through the conduit 41 to the right hand end of valve member 37, which is of a larger area than the left end thereof, so that this valve 37 now automatically moves to the left through the sealing rings 39 and 40 to open the passages through the sealing ring 40 so that the gaseous pressure fluid now flows from conduit 7 through sealing ring 40 and conduit 42 into conduit 34 and chamber 33 to move the main control valve member 22 downwardly against the action of spring 26 back to the position shown in Fig. 1 where the passage through the sealing ring 30 is closed and the passage through sealing ring 31 is open. Also, this pressure fluid in conduit 42 is transmitted to the cylinder 46, but the member 43 has already been moved to the position shown in Fig. 1 by the spring 46. Thus, the gaseous fluid flowing through the port 54 has automatically operated the valve member 37 to cause the main valve member 22 to be moved to its closed position where the passage through the sealing ring 31 is open, and therefore the gaseous medium under pressure in cylinder 50 escapes through conduit 35 and sealing ring 31 to the exhaust ports 32 and the outer atmosphere so that the driving pressure of the apparatus 36 is released and the spring 53 now returns the piston 51 to the left, as viewed in Fig. 1, to cause piston 55 to move outwardly of the cylinder 49 so that non-return valve 60 becomes closed and non-return valve 57 becomes open, the piston 55 thus moving along its suction stroke and drawing additional liquid into the cylinder 49.

As the piston 51 approaches its left dead center position, as viewed in Fig. 1, it moves the member 43 to the left from the position shown in Fig. 1, the spring 53 being much stronger than the spring 46, so that the passage through the sealing ring 45 becomes open and the gaseous medium under pressure in the chamber 33 of cylinder 23 may now escape through conduit 34, conduit 42, cylinder 47, sealing ring 45, and exhaust ports 48 to the outer atmosphere. Therefore, the spring 26 is now capable of moving main valve member 22 upwardly to close the passage through the sealing ring 31 and to open the passage through the sealing ring 30 so that the gaseous medium under pressure may now again move through the conduit 35 to the cylinder 50 to again move piston 51 so as to again move piston 55 in its pressure stroke. In this way, the cycle of operations are automatically repeated to continuously operate the pump 100 to pump the liquid pressure medium at a high pressure against the underside of the piston 65 so that this piston 65 and the work member attached thereto move upwardly with a relatively large force. During upward movement of the piston 65 the liquid 67 is displaced from the top of cylinder 64 through the conduit 95 to the tank 93 which communicates with the outer atmosphere through conduit 9 and chamber 5 of valve 4, in the manner described above.

The size of the nozzle 11 which is arranged in the double-acting valve 10 depends upon different factors, for example the viscosity of the hydraulic medium, the dimensions of the hydraulic press cylinder 64, the friction of the press piston 65 and its packings, and the like.

When the press piston 65 moves out quickly without the drive 36 of the hydraulic pump 100 being set in operation, the nozzle 11 allows only so much pressure medium to pass that there is only a slight increase of pressure in the conduit 63 and control conduit 21.

Assuming now that the work member attached to piston 65 has been moved through a desired distance to perform the desired work on the work piece 68, then the operator moves the valve 4 manually to an intermediate position where the flow of gaseous pressure medium from the conduit 1 is cut off and where both conduit 6 and conduit 9 communicate with the chamber 5 and through the latter with the outer atmosphere. In this position of the parts no more gaseous pressure medium will flow through the conduit 35 even if the passage through the sealing ring 30 is open, so that the pump 100 will cease to operate and no more liquid pressure medium will be supplied to the cylinder 64. Also, the pressure of the gaseous medium in the top part of the tank 80 will at first discharge through the bore of piston rod 72 to move upwardly along the conduit 12, so as to open the valve 10 against the action of its spring and discharge through conduit 6 and chamber 5 to the outer atmosphere. This discharge will very quickly take place, and the non-return valve 73 will close in a very short time under the influence of spring 74, and then the pressure of the gaseous medium in the tank 80 will act on the bottom end of valve 73 and the bottom end of the piston rod 72 to move the piston 70 upwardly so as to open the passage through sealing ring 76 to provide a communication between the exhaust ports 77 and the tank 80 which causes the pressure in this tank to quickly drop to atmospheric pressure. In this way the pressure of the liquid medium in tank 80 and in conduit 82 drops so that the pressure in conduit 83 drops to enable the piston 85 to be lowered by the pressure in conduit 91 and the force of spring 87 so that the by-pass 91 is opened and the liquid beneath the piston 65 is capable of flowing back to the tank 80.

The same is true of the liquid in conduit 21 which also flows back through the conduits 63 and 91 to the conduit 82 and tank 80, so that the piston 15 moves downwardly under the influence of the gaseous pressure medium which is still located in the conduit 3 and the cylinder valve control 14. Thus, the bar 19 will engage bar 27 to move the main valve member 22 to the position shown in Fig. 1 even though the pressure in the chamber 33 is the same as atmospheric pressure, so that the parts in their position of rest will have the position shown in Fig. 1 except that the piston 55 and piston 51 will be located further to the left with the passage through sealing ring 45 open to the atmosphere through the discharge ports 48. In order to completely release the apparatus from all pressures, the valve 13 may be turned in a counter-clockwise direction through 90°, as viewed in Fig. 1, to exhaust the gaseous medium to the outer atmosphere from the cylinder 14.

With the above described operations, the piston 65 and the work member therewith will return to their rest positions rather slowly. In order to provide a speedy return of the piston 65 and the work member therewith to their idle position, the valve 4 need only be turned in a clockwise direction, as viewed in Fig. 1, to place conduit 9 in communication with conduit 1 so that the gaseous pressure medium will flow through conduit 9 to the interior of tank 93 and will act on the liquid medium in tank 93 to move liquid along conduit 95 into the top part of cylinder 64 against the top face 66 of piston 65 so as to positively move this piston 65 at a much faster rate back to its idle position. When the idle position is reached, the valve 4 may again be manually moved to an intermediate position where both conduits 6 and 9 communicate with the outer atmosphere through chamber 5, and this is the rest position of the apparatus.

It will be noted that with the above-described arrangement, the gaseous and liquid mediums are in direct contact with each other, and it is possible for droplets of the

liquid medium to become entrained with the gaseous medium and to flow therewith to the outer atmosphere, which results in an undesirable loss of liquid. In order to prevent this, the arrangements of Figs. 2 and 3 may be provided. According to Fig. 2 the tanks 80 and 93 may be provided with a piston 96 which rests by gravity on the liquid medium and which is provided with sealing rings 97 and 98, so that the gaseous and liquid mediums act on each other only through the piston 96 to make it impossible for liquid droplets to be entrained with the gaseous medium.

The arrangement of Fig. 3 is capable of accomplishing the same results. According to this arrangement a flexible fluid-proof diaphragm 99 is connected at its outer periphery to both of the tanks 80 and 93 so that this diaphragm 99 has its botom face in engagement with the liquid and its top face in engagement with the gas. Thus, the diaphragm 99 is easily deformable to permit the liquid and gas to interact with each other, and at the same time it is impossible for liquid droplets to become entrained with the gas.

Fig. 4 of the drawings shows an embodiment of the invention which is different from that of Fig. 1 in that the valve 4 is omitted and the valve 10 is located directly over the tank 80. In place of valve 4 an adjustable pressure-reducing valve 101 is provided, and this pressure-reducing valve 101 is operatively connected to a control valve 113 for controlling the movement of the gaseous pressure medium to and from the tank 93. As may be seen from Fig. 4, the tank 93 communicates with the conduit 9 which in turn communicates with the control valve 113, the latter communicating with the conduit 125 which communicates with the conduit 1 at a point between the safety valve 2 and the pressure reducing valve 101, the latter being operated by a handle 110 which through a suitable linkage automatically operates the valve 113. The rest of the apparatus of Fig. 4 is identical with that of Fig. 1 and operates in the same way.

The details of the pressure-reducing valve 101 and valve 113 as well as the interconnection therebetween is shown in Fig. 5 in a partly diagrammatic manner. The valve 101 includes several interconnected parts which form a housing, and between two of these parts a flexible diaphragm 102 is fixed at its outer periphery, this diaphragm 102 acting on a tubular member 109 to urge the same upwardly from the position shown in Fig. 5. This tubular member 109 is engaged by a sealing member 103 so that the passage through the tubular member 109 is closed when the parts are in the position shown in Fig. 5, and the sealing plate 104 is fixed to the tubular member 109 for movement therewith so as to open and close the annular space located about member 109 between plate 104 and diaphragm 102. A spring 107 also engages plate 104 to urge the latter upwardly, as viewed in Fig. 5, and the member 109 is formed adjacent its bottom end with one or more lateral ports communicating with the inner bore of member 109. The tube 1 communicates with the annular space located about member 109 between diaphragm 102 and sealing member 104, and the conduit 6 communicates with the space beneath the member 104, as is evident from Fig. 5. An exhaust port 112 provides a communication between the space on the top side of diaphragm 102 and the outer atmosphere. A pair of springs 105 and 106 act on a collar fixed to a shaft 108 to determine the position of this shaft which is connected to the sealing member 103. The handle 110 is connected to an eccentric 111 which acts on a cup-shaped member into which the top side of spring 105 extends so that in accordance with the turning of the handle 110, the springs 105 and 106 will act on shaft 108 to move the sealing member 103 up or down.

A suitable linkage interconnects the handle 110 with the member 121 which is pivoted to act on the operating end 114 of the valve member 115 of valve 113, this valve member 115 slidably extending through the sealing rings 116 and 117 which are fixed in the interior of the outer casing of valve 113. Also, a third sealing ring 118 is fixed in the valve 113 and a spring 119 urges the valve member 115 upwardly to the position shown in Fig. 5. The bottom end of valve 113 is provided with an exhaust port 120 communicating with the outer atmosphere and the conduit 9 communicates with the valve 113 at a point between sealing rings 117 and 118, while the conduit 125 communicates with the valve 113 at a point between the sealing rings 116 and 117. The member 121 may be in the form of a foot pedal for foot operation of valve 113 together with valve 101.

In the position of the parts shown in Fig. 5 the conduit 9 communicates with the outer atmosphere through sealing ring 118 and exhaust port 120. Also, the pressure medium from conduit 1 flows downwardly about the plate 104 to communicate with the conduit 6, so that the apparatus in Fig. 5 is in the position which corresponds to the position of the valve 4 of Fig. 1, and the apparatus of Fig. 4, with the control structure of Fig. 5 in the position shown in Fig. 5, will operate, in the manner described above, to automatically move the work member and piston 65 from their idle to their operating position and to then automatically set the pump 100 into operation.

With the embodiment of Figs. 4 and 5, it is possible to control the pressure of the gaseous medium which drives the piston 51 and therefore it is possible to control the pressure of the high pressure hydraulic medium obtained with the pump 100. In the position shown in Fig. 5, the valve operating lever 110 has been moved in the direction of arrow *a* to one extreme position where the full force of the gaseous pressure medium flows along conduit 6 to the tank 80 so that a very quick movement of the piston 65 from its idle to its operating position is provided. In order to provide a reduced pressure to act on the pump 100, after the piston 65 has arrived almost at its operating position the hand lever 110 is turned in the direction of arrow *b* to a vertical position, as viewed in Fig. 5, and the valve 13 is turned through 90° in a counter-clockwise direction, as viewed in Fig. 4, to the position which exhausts the cylinder of valve control 14 so that the main control valve 22 is no longer blocked by the valve control 14. Now the lever 110 is slowly moved in the direction of arrow *a* so as to allow only a part of the gaseous medium in conduit 1 to leak past the sealing plate 104 to the conduit 6, and thus the gaseous medium will reach the piston 51 at a reduced pressure which may be regulated by the position of lever 110.

If the reduced pressure is, for example, 0.3 atmosphere, the pump, in the case of a transmission ratio of 1:60, will supply hydraulic pressure to the press piston up to a maximum of 18 atmospheres, which, when the lever is in this position, can be maintained for any desired length of time. This adjusted pressure can however be increased by shifting the hand lever 110 a corresponding distance in the direction of arrow *a*. If on the other hand, the hand lever 110 is moved in the direction of arrow *b* the pressure will be reduced.

When it is desired to stop the operation of the pump 100, the lever 110 is turned in the direction of arrow *b* to the opposite extreme position from that shown in Fig. 5, the lever 110 extending vertically as viewed in Fig. 5, in this position of the apparatus. In this position of the parts the spring 107 and diaphragm 102 will have moved the member 109 upwardly to locate the plate 104 against the bottom of the annular passage located about member 109 so as to cut off communication between conduits 1 and 6. Also in this position of the parts the sealing member 103 is located above the member 109 which thus communicates with the outer atmosphere through the exhaust port 112. The conduit 6 communicates with the axial bore of

member 109 through the lateral ports adjacent the bottom of this member so that conduit 6 and tank 80 communicate with the outer atmosphere to cause the piston 65 to return to its idle position, and the valve 13 may be returned to the position shown in Fig. 4 to cause the valve control 14 to locate the main slide valve 22 in the position shown in Fig. 4 where the left side of piston 51 communicates with the outer atmosphere in the manner described above.

The movement of lever 110 in the direction of arrow *b* to a vertical position, which causes the tank 80 to be placed in communication with the atmosphere, also causes the lever 121 to turn in a clockwise direction, as viewed in Fig. 5, so as to engage the operating end 114 of valve member 115 to move this valve member downwardly, as viewed in Fig. 5, against the action of spring 119 so as to close the passage through sealing ring 118 and so as to open the passage through sealing ring 117. In this way the gaseous medium flows from conduit 125 through the sealing ring 117, through the conduit 9, and from the latter to the tank 93 to provide a quick return of the piston 65, in the manner described above.

A still further embodiment of the invention is illustrated in Fig. 6 where the conduit 6 communicates with the conduits 12 and 7 and where conduit 9 communicates with the tank 93 in the manner described above. The only difference between the embodiment of Fig. 6 and that of Figs. 4 and 5 is that the valve 113 is replaced by a pressure-reducing valve 123 identical with pressure reducing valve 101, and a second pressure-reducing valve 122 also identical with valve 101 is interconnected with the valve 123 through the medium of a lever 124 which maintains the valves 122 and 123 out of phase and in directly opposed positions at all times. Thus, in the position of the parts shown in Fig. 6, the valve 122, which controls communication between conduit 1 and conduit 6, is closed to cut off communication between these conduits and to permit conduit 6 to communicate with the outer atmosphere, while the valve 123 is open to provide communication between conduits 1 and 9 so as to produce the quick return of the piston 65 in the manner described above. In the opposite position of the apparatus of Fig. 6, where the valve 122 is open and the valve 123 is closed, the conduit 9 communicates with the outer atmosphere and the conduit 6 communicates with the conduit 1. Thus, with the embodiment of Figs. 4 and 5 it is possible to control the pressure derived from the pump 100, and with the embodiment of Fig. 6, it is possible to control the pressure of pump 100 and in addition it is possible to control the pressure of the liquid medium which returns the piston 65 to its fully retracted-or-idle position.

If several hydraulic press cylinders are inter-connected by the conduits 63 and 95, the hydraulic pump, after the press pistons have moved out quickly, starts up automatically as soon as the last press piston has touched the load.

Also, although gaseous and liquid mediums have been referred to above, it is possible to use a pair of liquid mediums, if desired, and any fluid may replace the gaseous medium, while any suitable liquid mediums may be used in the apparatus.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of fluid operated apparatus differing from the types described above.

While the invention has been illustrated and described as embodied in adjustable and automatic fluid operated apparatus, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. A fluid operated apparatus comprising, in combination, a cylinder; a piston located in said cylinder; a work member connected to said piston for movement therewith; first conduit means communicating with said cylinder at one side of said piston and having a first fluid therein engaging said one side of said piston; second conduit means communicating with said first conduit means for leading a second fluid to said first conduit means to act on said first fluid with the pressure of said second fluid so as to move said first fluid against said piston to move the latter in said cylinder so as to move said work member from an idle position to an operating position; a pump comprising a second cylinder communicating with said first conduit means and having said first fluid located therein and a second piston mounted for reciprocating movement into and out of said second cylinder for pumping said first fluid in said first conduit means; first valve means mounted in said first conduit means on opposite sides of said second cylinder for compelling said pump to pump said first fluid in said first conduit means in the same direction that said first fluid moves under the influence of said second fluid; a third cylinder located next to said second cylinder to receive said second piston when the latter moves out of said second cylinder; a third piston slidably mounted in said third cylinder and being connected to said second piston; spring means located in said third cylinder and being operatively connected to the side of said third piston adjacent said second cylinder for urging said third piston away from said second cylinder so as to move said second piston in its suction stroke outwardly of said second cylinder; a third conduit means communicating with said second conduit means and with said third cylinder on the side of said third piston opposite from said second cylinder for conveying said second fluid to said third cylinder for moving said third piston against the action of said spring means so as to move said second piston in its pressure stroke into said second cylinder; second valve means mounted in said third conduit means and having a closed position where said second fluid is cut off from said third cylinder and where the fluid located in said third conduit means between said second valve means and third piston is discharged from said third cylinder; second spring means operatively connected to said second valve means for urging the latter to the open position thereof; pressure sensitive valve control means communicating with said second conduit means and being operatively connected to said second valve means for holding the latter in said closed position thereof against the action of said second spring means with the pressure of said second fluid in said second conduit means, said pressure-sensitive valve control means communicating with said first conduit means at a part thereof located between said first valve means and first cylinder to be moved by said first fluid against the action of said second fluid to an inoperative position where said second valve means is freed to the influence of said second spring means to be moved by the latter to said open position where said second fluid flows through said third conduit means to said third cylinder to act on said third piston to move the latter against the action of said first spring means for moving said second piston in its suction stroke into said second cylinder.

2. A fluid operated apparatus as defined in claim 1 and wherein a fourth conduit means communicates with said second conduit means, with said second valve means to move the latter against the action of said second spring means to the closed position thereof, and with said third

cylinder to receive said second fluid therefrom when said third piston has moved said second piston almost to the end of said pressure stroke thereof; and pressure-sensitive third valve means located in said fourth conduit means to open and close the communication between said fourth conduit means and second valve means, to be acted on by said second fluid from said second conduit means to be maintained in its closed position, and to be acted on by said second fluid received from said third cylinder to be moved to its open position for admitting said second fluid from said second conduit means to said second valve means for moving the latter against the action of said second spring means to the closed position of said second valve means so that said first spring means will act on said third piston to move said second piston in its suction stroke outwardly of said second cylinder.

3. A fluid operated apparatus as defined in claim 2 and wherein a discharge means is operatively connected to said fourth conduit means for discharging said second fluid therefrom to permit said second valve means to be moved to its open position by said second spring means, said discharge means being mounted on said third cylinder and extending partly into the same to be engaged and activated by said third piston when the latter has been moved by said first spring means through a distance sufficient to locate said second piston almost at the end of its suction stroke, whereby said second valve means is automatically opened and closed to reciprocate said third piston for operating said second piston to pump said first fluid against said first piston for acting on the latter with a pressure substantially higher than that of said second fluid.

4. A fluid operated apparatus as defined in claim 3 and wherein a fifth conduit means communicates with the side of said first cylinder located on the side of said first piston opposite from said first conduit means, said fifth conduit means having said first fluid located therein; sixth conduit means leading to said fifth conduit means for supplying said second fluid thereto for acting on said first fluid in said fifth conduit means with said pressure of said second fluid; and a manually operable valve means operatively connected to said second and sixth conduit means and being movable between a first position where said sixth conduit means discharges and said second fluid flows through said second conduit means and a second position where said second conduit means discharges and said second fluid flows along said sixth conduit means to act on said first fluid in said fifth conduit means to move said first fluid into said first cylinder so that first fluid acts on said first piston to move said work member toward its idle position.

5. Fluid operated apparatus comprising, in combination, a cylinder; a piston located in said cylinder for movement therein; a work member connected to said piston to be moved thereby from an idle to an operating position; a tank; a first conduit leading from a lower part of said tank to a part of said cylinder located on one side of said piston; a liquid located in said tank and first conduit and contacting one side of said piston; a second conduit communicating with an upper part of said tank for leading a gas into said tank to act on said liquid therein with the pressure of said gas so as to move said liquid through said first conduit into said cylinder to act on said piston for moving said work member from said idle to said operating position thereof; first valve means mounted in said second conduit and having an open position where gas in said tank discharges therefrom and a closed position where said gas flows through said second conduit into said tank, said first valve means having a movable valve member having means thereon connected to be acted on by the pressure of the gas in said tank to be moved to the open position of said valve means, said valve member being formed with a bore through which gas flows into said tank; and non-return valve means located in said bore of said valve member for preventing gas from flowing through said bore of said valve member out of said tank, so that when the flow of gas along said second conduit is stopped, said non-return valve means closes and said gas in said tank acts on said first valve means to move the latter automatically to said open position thereof so that the gas discharges from said tank and so that the pressure of said liquid diminishes.

6. Fluid operated apparatus comprising, in combination, a cylinder; a piston located in said cylinder for movement therein; a work member connected to said piston to be moved thereby from an idle to an operating position; a tank; a first conduit leading from a lower part of said tank to a part of said cylinder located on one side of said piston; a first fluid located in said tank and first conduit and contacting one side of said piston; a second conduit communicating with an upper part of said tank for leading a second fluid into said tank to act on said first fluid therein with the pressure of said second fluid so as to move said first fluid through said first conduit into said cylinder to act on said piston for moving said work member from said idle to said operating position thereof; first valve means mounted in said second conduit and having an open position where said second fluid into said tank discharges therefrom and a closed position where said second fluid flows through said second conduit into said tank, said first valve means having a movable valve member having means thereon connected to be acted on by the pressure of said second fluid in said tank to be moved to the open position of said first valve means, said valve member being formed with a bore through which said second fluid flows into said tank; and non-return valve means located in said bore of said valve member for preventing said second fluid from flowing through said bore of said valve member out of said tank, so that when the flow of said second fluid along said second conduit is stopped, said non-return valve means closes and said second fluid in said tank acts on said first valve means to move the latter automatically to said open position thereof so that the second fluid discharges from said tank and so that the pressure of said first fluid diminishes.

7. A fluid operated apparatus as defined in claim 6 and wherein a plate is located in said tank in slidable sealing engagement with the walls thereof and resting on said first fluid to transmit pressure of said second fluid to said first fluid while separating said first and second fluids from each other.

8. A fluid operated apparatus as defined in claim 6 and wherein a flexible membrane is fixed in said tank in engagement with the top surface of said first fluid to transmit pressure of said second fluid to said first fluid while separating said first and second fluids from each other.

9. Fluid operated apparatus as defined in claim 6, and wherein an additional valve means is located in said second conduit on the opposite side of said first valve means from said tank, said third valve means having an open position where said second fluid may freely flow through said second conduit in a direction away from said tank, said third valve means having a valve member formed with a nozzle-shaped bore passing therethrough, so that in the closed position of said third valve means the flow of said second fluid to said tank through said conduit means is throttled by said bore of said valve member.

10. Fluid operated apparatus comprising, in combination, a work member; low pressure hydraulic means operatively connected to said work member for moving the latter with a pressure below a predetermined pressure to an operating position; high pressure hydraulic means operatively connected to said work member for acting on the latter with a pressure substantially higher than said predetermined pressure; control means operatively connected to said low pressure and high pressure hydraulic means for setting said high pressure hydraulic means into operation to act on said work member after said low

pressure hydraulic means has moved said work member into said operating position thereof; a third hydraulic means communicating with said work member for moving the latter away from said operating position thereof back to an idle position; first reduction valve means operatively connected to said high pressure hydraulic means for regulating the pressure thereof; second reduction valve means operatively connected to said third hydraulic means for regulating the pressure thereof; and means interconnecting said first and second reduction valve means for simultaneously operating the same and for maintaining said first and second reduction valve means out of phase with each other and in directly opposite positions at all times.

11. A gas-liquid operated apparatus, comprising, in combination, a first cylinder; a first piston located in said first cylinder; a work member connected to said first piston for movement therewith; a first conduit means communicating with said first cylinder at one side of said piston and having a liquid therein engaging said one side of said piston; a pump communicating with said first conduit means for pumping said liquid therein against said one side of said piston; gas operated means operatively connected to said pump for operating the same and including a valve member movable along a predetermined path between a first position releasing gas under pressure from said gas operated means and a second position admitting gas under pressure to said gas operated means for driving said pump along its pressure stroke; a second cylinder and a second piston slidable therein; a stop member fixed to said second piston and located in said path to prevent movement of said valve member from said first to said second position thereof when said second piston is in an end position thereof; second conduit means communicating with said first conduit means for leading a gas to said first conduit means to act on said liquid with the pressure of said gas so as to move said liquid against said first piston to move the latter in said first cylinder so as to move said work member from an idle position to an operating position, said second conduit means also communicating with said gas operated means for supplying the latter with gas under pressure and second conduit means also communicating with said second cylinder for applying the force of the gas under pressure to the face of said second piston directed away from said stop member for maintaining said second piston in said end position thereof and thus preventing movement of said valve member from said first to said second position thereof; and third conduit means communicating with said first cylinder at said one side of said first piston and communicating with said second cylinder at the side of said second piston directed toward said stop member for directing the liquid in said first cylinder into said second cylinder, so that when the pressure of the liquid increases upon engagement of the work member with a workpiece, the increased liquid pressure will cause said second piston to move said stop member away from said path and thus release said valve member automatically for movement from its first to its second position whenever the work member engages the work.

12. In a gas-liquid operated apparatus, a gas operated arrangement for automatically reciprocating a pump piston of a high pressure liquid pump, said arrangement comprising, in combination, a cylinder having an apertured end wall communicating with the outer atmosphere and having a side wall portion formed with a port adjacent said end wall; a second piston slidable in said cylinder and connected to said pump piston so that the latter reciprocates with said second piston, said second piston being movable in said cylinder to and from an end position located between said port and end wall; first spring means acting on said second piston for urging the same away from said end wall; first gas operated valve means communicating with said cylinder at a side of said second piston opposite from said end wall and having an operating position admitting gas under pressure into said cylinder to drive said second piston toward said end wall and a rest position placing said side of said piston in communication with the outer atmosphere to permit said first spring means to move said piston away from said end wall; second spring means cooperating with said first valve means for urging the same to said operating position thereof; second gas operated valve means communicating with said first valve means for admitting a gas under pressure thereto, for moving said first valve means to its rest position, when said second valve means is in an operating position thereof, said second valve means having a rest position cutting off the supply of gas under pressure to said first valve means, and said second valve means communicating with said port to be acted on by gas from said cylinder when said second piston is in said end position thereof for moving said second valve means to said operating position thereof; gas conduit means communicating with said second valve means for supplying the latter with gas under pressure which moves said first valve means when said second valve means is in said operating position thereof and which moves said second valve means to its rest position when said port is between said piston and end wall so that said second valve means communicates through said port and end wall with the outer atmosphere; and third valve means communicating with said first valve means and having an open position releasing the gas supplied to said first valve means from said second valve means to the outer atmosphere and a closed position preventing the escape of the latter gas to the outer atmosphere, said third valve means including an elongated valve member located in the path of movement of said second piston and engaged by the latter as it approaches a position distant from said end position to be moved by said second piston to said open position; and third spring means acting on said third valve means to urge the latter to its closed position.

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