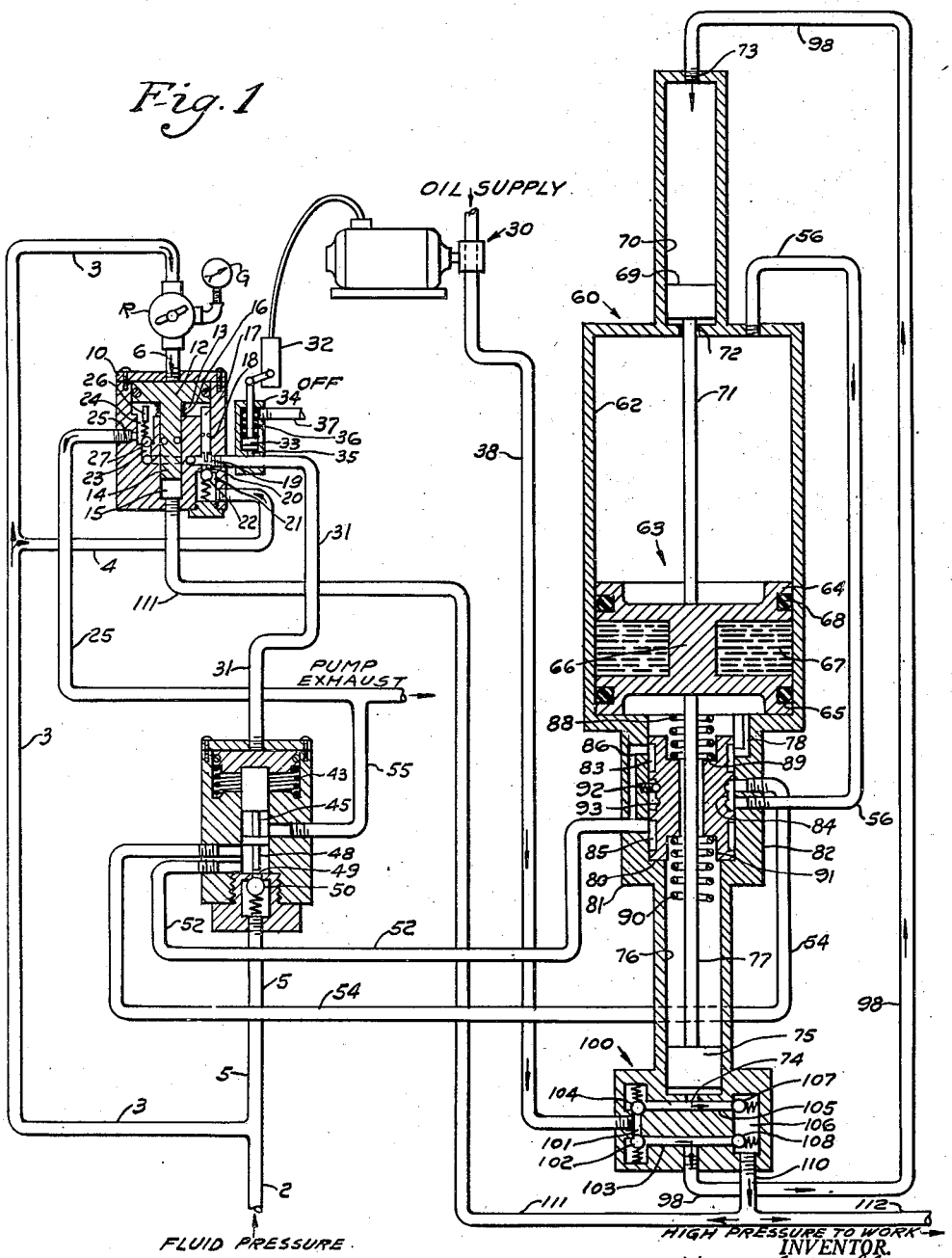
Sept. 16, 1947. W. F. MOHLER 2,427,616

FLUID PRESSURE SYSTEM

Filed Oct. 5, 1944 2 Sheets-Sheet 1

Fig. 1



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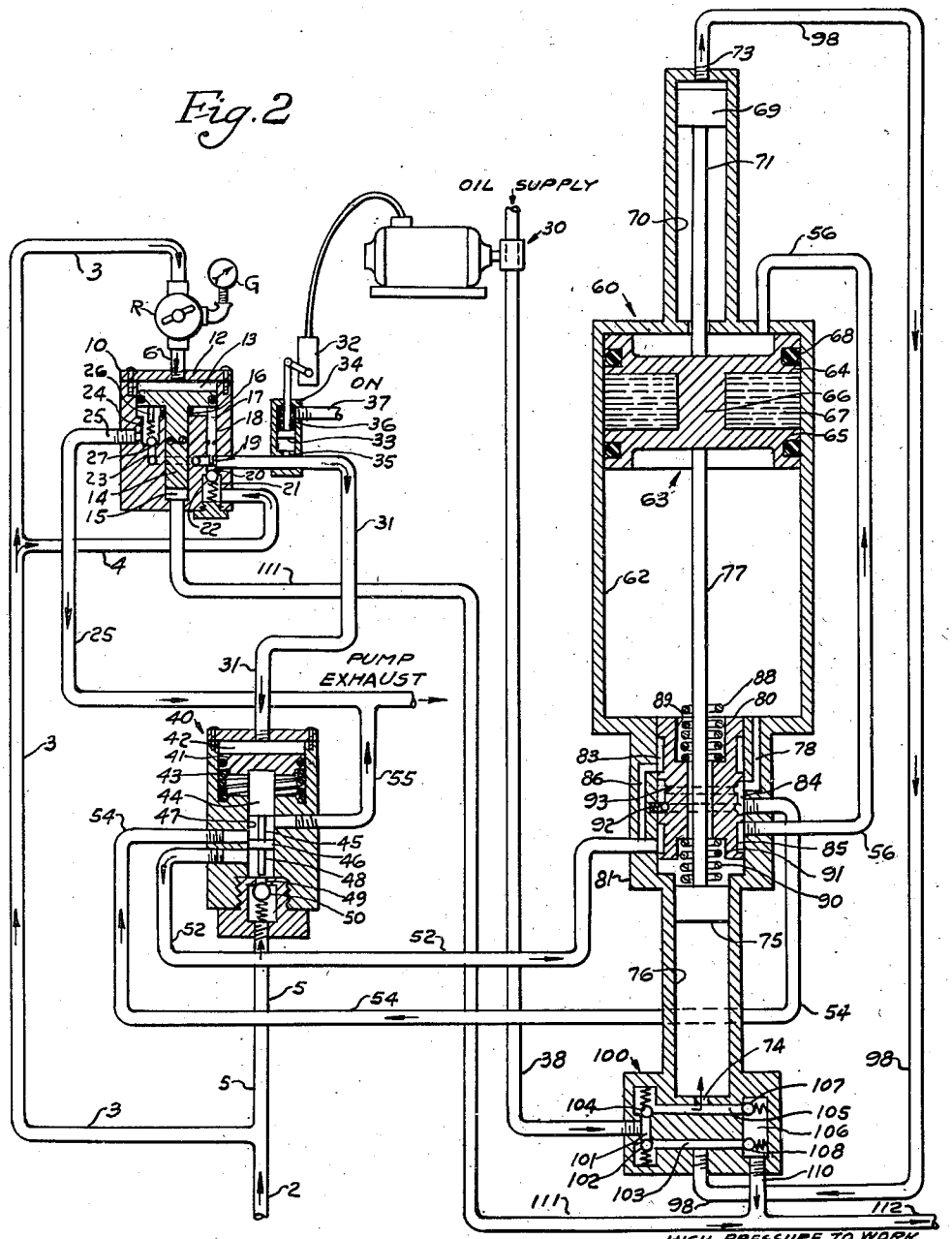
FLUID PRESSURE SYSTEM

Filed Oct. 5, 1944 2 Sheets-Sheet 2

Fig. 2

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2,427,616

## FLUID PRESSURE SYSTEM

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17 Claims. (Cl. 103—19)

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This invention relates to a simplified fluid pressure system for automatically boosting a relatively low unregulated oil pressure to a predetermined and relatively high regulated oil pressure. The oil or other liquid under regulated high pressure, can then be used for all types of press work, for flow testing and static testing of hydraulic units, for cable stretching, and for hydraulic jacks, for example.

The chief object of my invention is to provide a simplified fluid pressure system for automatically boosting a relatively low unregulated liquid pressure to a relatively high accurately regulated liquid pressure, and for automatically maintaining said high liquid pressure at the work.

A further object is to provide an improved form of hydraulic, self-lubricated, double acting booster pump operated by fluid pressure.

Another object of my invention is to provide an improved means for automatically starting and stopping the action of the booster pump by the reciprocating movement of two integrally connected control pistons, between a balanced position at one end of their movement, and a pump operating position at the other end of their movement. In my invention, said reciprocating movement is induced by making the ratio of the regulated high oil pressure, acting on the smaller control piston, and the regulated lower fluid pressure, acting on the larger piston, inversely proportional to the areas of said control pistons, whereby a drop in the high oil pressure upsets the balanced pressures acting on said pistons.

Another object of my invention is to provide an improved means for automatically starting and stopping the action of an auxiliary oil supply pump, by the movement of the control pistons away from and back to their initial balanced position.

An additional object of my invention is to provide an improved valve means for controlling the automatic operation of the booster pump. My invention employs one source of unregulated fluid pressure controlled by the reciprocating movement of said control pistons both for automatically opening and closing said valve means, and for starting and stopping the auxiliary oil pump, and a second source of unregulated fluid pressure, controlled by said valve means, for operating said booster pump.

A further object of my invention is to provide in combination with the booster pump, an improved form of slide valve for reciprocating the connected pump actuating pistons and the oil pumping pistons, said slide valve being moved

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to its alternate positions by what I believe to be an improved arrangement of spring means interposed between the ends of the valve and the adjacent ends of one of the actuating pistons and one of the oil pumping pistons, and said slide valve being provided with detent means for retaining said valve in either of said alternate positions.

My invention also has for its objects to provide such means that are positive in operation, convenient in use, easily installed in a working position and easily disconnected therefrom, economical of manufacture, relatively simple, and of general superiority and serviceability.

The invention also comprises novel details of construction and novel combinations and arrangements of parts, which will more fully appear in the course of the following description. However, the drawings merely show and the following description merely describes one embodiment of the present invention, which is given by way of illustration or example only.

In the drawings, like reference characters designate similar parts in the several views.

Fig. 1 is a schematic layout of my pressure booster system showing most of the parts as they appear when the pumps are not operating.

Fig. 2 is a schematic layout similar to Fig. 1 showing most of the parts as they appear when the pumps are operating. For clarity of illustration, the parts of the booster pump are shown as they would appear with the pistons at the opposite end of their stroke from their position shown in Fig. 1.

*General description of system*

It will be understood that all of the operating parts of my invention are operative in any position, so that such terms as upper and lower, lifting, vertical, etc., are employed merely to simplify the description, and not to limit the separate parts to the positions adopted for illustration.

My pressure booster system generally employs a housing **10** for the high pressure control pistons **12**, **14** and the auxiliary fluid pressure control piston **17**; an auxiliary oil or liquid supply pump **30**, driven by an electric motor having a control switch **32**; a booster pump control valve **40**; a booster pump **60** having a slide valve **80**; and a chamber **100** for keeping the low pressure supply liquid being admitted to pump **60**, separated from the high pressure oil being directed to the work.

Operating fluid, either air, gas or liquid, is supplied from line or conduit 2, to a pressure

regulator R by conduit 3, to the housing 10 by conduit 4, and to the valve 40 by conduit 5. When the auxiliary pump 30 is employed in the system, oil is supplied to pump 60, by conduit 38 and chamber 100, at the relatively low pressure of 50 lbs. to 500 lbs. Pump 60 then boosts this pressure to any predetermined amount between 500 lbs. and 4000 lbs., and then delivers the oil under this high pressure through chamber 100, conduits 110 and 112 to the work, and through conduit 111 to control piston 14. The oil used at the work is returned to the supply reservoir (not shown) for recirculation into oil supply conduit 38.

*Description of high pressure control*

The pressure regulator R, having a gauge G, converts the line pressure of approximately 100 lbs. as received from supply conduit 3, to a regulated pressure of any predetermined quantity between 0 lbs. and 100 lbs. This regulated fluid pressure is delivered by conduit 6 to the top of a large control piston 12, which is integrally connected to a small control piston 14. This predetermined or regulated pressure, acting on the top of piston 12, is normally balanced by the pressure acting on the bottom of piston 14. This latter pressure is also predetermined or regulated by the relative areas of pistons 12 and 14. When normally balanced, the ratio of the high oil pressure and the low fluid pressure, is inversely proportional to the areas of the respective pistons 14 and 12. Said pistons 12, 14 are normally maintained in the upper part of their respective cylinders 13 and 15, by a spring 16, which surrounds piston 14 and presses upwardly against piston 12, and downwardly against the bottom of cylinder 13 with sufficient force to counteract the weight and friction of said pistons. In most designs, this force can be disregarded, but in any case in which it is substantial, the area of pistons 12 and 14 will not be exactly inversely proportional to the fluid and liquid pressures, as described.

An auxiliary piston 17 is located in a cylinder 18 beneath piston 12. In the raised position of piston 17, its upper end projects into the lower part of cylinder 13, while its lower end projects into a passageway 19, which communicates by a port 20, with a fluid pressure inlet chamber 21. Said port 20 and inlet chamber 21 are vertically aligned with said piston 17, the lower end of which is shaped to be projected through port 20 for unseating ball check valve 22, which is assembled in housing 10 in vertical alignment with cylinder 18.

Passageway 19 communicates with exhaust conduit 25 by the outlet port 23 and a passageway 24. Said passageway 24 opens into the bottom of cylinder 13, is vertically aligned with said port 23, and receives and guides a pin 26. The upper end of pin 26 projects into the lower part of cylinder 13 from said passageway 24, while the lower end carries a ball check valve 27 which normally rests lightly upon or just above port 23, when there is no exhaust pressure in passageway 19, and the piston 12 is in the position shown in Fig. 1.

*Description of supply pump*

An electric motor driven auxiliary pump 30, of any desired type, is automatically started and stopped by switch 32, which is actuated by piston 33 operating in cylinder 34. To start the pump, fluid from conduit 31 is admitted through port 35 for raising piston 33 against the resistance of return spring 36, thereby moving switch 32 to the "on" position. The air trapped above piston 33 is relieved through exhaust port or conduit 37. When the fluid pressure in conduit 31 is relieved through passageways 19, 23, 24 to exhaust port or conduit 25, spring 36 returns piston 33 to its inactive position, thereby opening switch 32 and stopping pump 30. This auxiliary pump 30 need not be used in those installations where booster pump 60 can furnish the required pressure in conduit 112, since pump 60 has sufficient suction to draw liquid from a supply reservoir (not shown), through conduit 38, if desired.

*Description of control valve*

Control valve 40 opens and shuts off the flow of operating fluid to booster pump 60. Fluid pressure from conduit 31 moves valve operating piston 41 downwardly in cylinder 42 against the action of return spring 43. Upper and lower valve pistons 44 and 46 are connected in axially spaced relation by rod 45, and are shifted in cylinder 47, from the closed position in Fig. 1, to the open or pump starting position shown in Fig. 2, by operating piston 41. In said open piston, a stem 48 projecting from the bottom side of lower piston 46, extends through port 49 for unseating ball check valve 50, which is secured in the bottom of valve 40 in vertical alignment with cylinder 47. When said valve 50 is held open by valve stem 48, fluid pressure is free to flow from conduit 5, via port 49 and conduit 52, to pump 60. Simultaneously, fluid pressure is exhausted from pump 60 via conduit 54, the upper part of cylinder 47, and conduit 55. After the fluid pressure is exhausted from conduit 31, valve 40 is closed by the lifting force of the fluid pressure in conduit 5 acting on the bottom of valve piston 46 and stem 48. This force continues to act fully until the rise of stem 48 out of port 49 allows valve 50 to close and shut off the pressure from conduit 5, thereby stopping pump 60. Spring 43, together with any residual lifting force acting on said piston 46, will then return pistons 41, 44 and 46 to their fully closed position.

*Description of booster pump*

Booster pump 60 is a double acting pump, and is operated by fluid pressure received through supply conduit 52 from any suitable source, and exhausted through conduit 54. Said pump 60 consists of a large diameter cylinder 62 in which a large diameter piston 63 is caused to reciprocate by alternately admitting fluid pressure through conduit 56 to one end of cylinder 62, while exhausting fluid pressure through passageway 76 from the other end of cylinder 62. Said piston 63 is advantageously divided into two piston sections 64, 65, connected in spaced relation by member 66, the intervening space being filled with lubricating material 67 which makes the pump self lubricating. Piston sealing rings 68 of any desired type may be employed, those illustrated being known to the trade as "O-rings" and formed of oil proof composition material.

A small diameter oil pumping piston 69 and cylinder 70 project from one end of cylinder 62. Said piston 69 is joined to the outer end of large diameter piston 64 by a rod 71 passing through an opening 72 between cylinders 62 and 70. A passageway 73 is provided in the outer end of cylinder 70. Liquid is supplied to, and removed from cylinder 70, by a conduit 98 which connects said passageway 73 to a passageway 103 in chamber 100.

A second small diameter oil pumping piston 75 and cylinder 76 project from the other end of large cylinder 62, the upper portion of cylinder 76 being enlarged where it is joined to cylinder 62, to form a housing 81 for slide valve 80. Piston 75 is joined to the outer end of piston section 65 by a rod 77. Rod 77 is made enough longer than corresponding rod 71 to accommodate a slide valve 80. A passageway 74, corresponding to passageway 73, connects cylinder 76 with a passageway 105 in chamber 100.

*Construction of the slide valve*

Slide valve 80 is loosely assembled on rod 77 but has a fluid tight fit with the inside surface of wall 82 of housing 81. Said valve 80 is generally cylindrical in shape and has three shallow annular grooves axially spaced on its outer surface, which cooperate with said wall 82 to provide annular passageways 82, 83, 84 for the flow of pump operating fluid.

Referring to Fig. 1, the upper annular passageway 82 is connected with conduit 52 by means of passageway 86 formed in housing wall 82, and with the bottom of cylinder 62 by means of passageway 78.

The middle annular passageway 84 joins the top of cylinder 62, and conduit 56, with exhaust conduit 54. The lower annular passageway 85 joins with supply conduit 52 but is not used with the parts in the position shown in Fig. 1.

Referring to Fig. 2, upper annular passageway 83 is not used with the parts shown in this position. The middle annular passageway 84 joins the bottom of cylinder 62 and passageway 78 with exhaust conduit 54. The lower annular passageway joins the top of cylinder 62 with supply conduit 52.

An upper spring member 88 is assembled on rod 77 between the large diameter piston section 65 and the bottom wall of a recess 90, formed in the top of valve 80. A lower spring member is assembled on rod 77 between oil pumping piston 75 and the top wall of a recess 91 formed in the bottom of valve 80. A spring operated detent member 92 is formed in wall 82 of said housing 81, and cooperates with either one of the two axially spaced shallow peripheral grooves 93 formed in the adjacent wall of valve 80, for holding said valve 80 in either one of its alternate positions of use.

*Construction of separation chamber*

A separation chamber 100 draws low pressure liquid from supply conduit 36, and directs it either to cylinder 70, through passageways 101, 103, conduit 98 and passageway 73, as shown in Fig. 1, or to cylinder 76, through passageways 101, 105, and 74, as shown in Fig. 2. At the same time, high pressure liquid is being directed from cylinder 76, via passageways 74, 105, 106, and conduits 110, 112 to the work, or by conduit 111 to control piston 14, as shown in Fig. 1, or, as shown in Fig. 2, is being directed from cylinder 70, via conduit 98, passageways 103, 106 and conduits 110, 112 to the work, or by conduit 111 to control piston 14. The arrangement and function of ball check valves 102, 104, 107, 108 is believed obvious from the drawing.

*Description of operation*

The high pressure control pistons 12, 14 are shown in their normally balanced position in Fig. 1. When the high pressure of the liquid in conduit 111 and 112 drops, due to leakage or to the liquid being consumed at the work, below the amount predetermined by the setting of regulator R and the design of the parts, said control pistons 12, 14 move to the position shown in Fig. 2, thereby depressing piston 17 to open inlet valve 22 and also depressing guide pin 26 to close exhaust valve 27.



The operating fluid, either air or liquid for example, under the pressure existing in the supply conduit 2, now flows through conduits 3, 4, chamber 21, port 19, conduit 31, and port 35 to cylinder 34, thereby moving piston 33 against the action of return spring 34, to close switch 32, and to start the motor and the auxiliary pump 30. Said pump circulates liquid under relatively low pressure, from the reservoir (not shown) to conduit 38, and to separation chamber 100. When the predetermined pressure required in conduit 112 for the work is relatively low, the auxiliary pump 30 can be disconnected, and the liquid supplied by conduit 38 directly from said reservoir to chamber 100 by the alternating suction action of the liquid pumping pistons 69 and 75.

The operating fluid in conduit 31 also enters the top of cylinder 42, thereby moving valve operating piston 41 against the action of return spring 43, and also moving valve pistons 44 and 46 from the closed position shown in Fig. 1 to the closed position shown in Fig. 2. This motion of said valve pistons 44 and 46 to open position, forces valve stem 48 through port 49 and unseats check valve 50, thereby allowing operating fluid to flow from supply conduits 2 and 5, through port 49, the lower part of cylinder 47 and conduit 52, to start the booster pump 60 operating. The exhaust fluids coming from said pump 60, flow through conduit 54, the upper part of cylinder 47, and conduit 55, either to the atmosphere or to a collecting reservoir (not shown).

By using control valve 40 to supply operating fluid to conduit 52 directly from supply conduit 5, it is possible to deliver large quantities of said fluid to pumps 69 and thereby obtain quiet, fast and economical operation of the entire system. In some installations, however, it may be preferable to omit the control valve 40 and to supply operating fluid to conduit 52 directly from conduit 31. My invention also contemplates supplying conduit 52 with fluid directly from a manually operated pump, whenever it is desired to use booster pump 60 alone, and without the benefit of either the predetermined pressure control, the control valve 40, or the auxiliary pump 30.

Referring to the booster pump 60 and separation chamber 100 in Fig. 2, the arrows in conduit 98 and passageway 103, and the open position of ball check 108, indicate that piston 69 has just delivered a quantity of liquid through passageway 73, conduit 98, passageways 103, 106 and conduit 110 to conduit 112; while the arrows in conduit 38 and passageway 105, and the open position of ball check 104, indicate that piston 75 has just drawn a charge of liquid from conduit 38 into cylinder 76, through passageways 101, 105 and 74. The parts of pump 60 are now ready to automatically return to the position shown in Fig. 1. Still referring to Fig. 2, operating fluid is admitted to the top of cylinder 62, from supply conduit 52, through passageways 85 and conduit 56, to begin one stroke of the connected pistons 69, 64, 65 and 75. The fluid in cylinder 62 beneath piston 63, is exhausted on this stroke to conduit 54, through passageways 78 and 84. Upon the completion of this stroke, the bottom of piston section 65, or other abutting means

carried by rod 77, engages and compresses spring 88, thereby overcoming the spring pressed detent 92 and shifting slide valve 80 to the position shown in Fig. 1.

Referring to Fig. 1, the arrows in passageways 73, conduit 98, passageway 103, and conduit 38, and the position of ball check 102, indicate that cylinder 70 has just received a charge of liquid; while the arrows in passageway 105 and conduit 110, and the piston of ball check 107, indicate that piston 75 has just delivered a quantity of liquid under high pressure to conduit 112. Pump 60 is now ready to return to the position shown in Fig. 2. Still referring to Fig. 1, operating fluid is admitted to the bottom of cylinder 62, from supply conduit 52, through passageways 86, 83 and 78 to begin the return stroke of piston 63. The fluid in cylinder 62 above piston 63 is exhausted on this stroke to conduit 54, through conduit 56 and passageway 84. Upon completion of this return stroke, the top of piston section 64, or other abutting means carried by rod 71, engages and compresses spring 90, thereby overcoming the spring pressed detent 92 and shifting valve 80 to the position shown in Fig. 2 for the start of another stroke. Since my pump delivers liquid with each stroke, it is double acting, thereby pumping a large quantity of liquid in a short time compared to other pumps of its size and weight, working with corresponding pressure.

Whenever the pressure of the liquid in conduit 112 is raised to the predetermined amount called for by the setting of the regulator R, the control pistons 12 and 14 are forced, by the pressure of liquid in conduit 111 on the bottom of piston 14, and by spring 16, to return to their balanced position in the top of their respective cylinders 13 and 15, thereby automatically stopping both the auxiliary pump 30 and booster pump 60, by shutting off the supply of operating fluid to conduits 31 and 52. When said control piston 12 is raised to the top of its cylinder 13, check valve 27 is free to open, while the bottom of piston 17 is lifted by the pressure of the fluid in inlet chamber 21 out of port 20, thereby allowing check valve 22 to close port 20, and the fluid in the top of cylinder 42, the bottom of cylinder 34, and in conduit 31, to exhaust through passageway 19, port 23, passageway 24 and conduit 25. Spring 43 and the pressure on valve piston 46 cooperate to shift valve pistons 41, 44 and 46 to the closed position of Fig. 1 to stop pump 60. Spring 36 returns piston 33 to the bottom of its cylinder 34, thereby moving switch 32 to its "off" position and stopping supply pump 30.

While I have illustrated and described what I now regard as the preferred embodiment of my invention, the construction is, of course, subject to modifications without departing from the spirit and scope of my invention. I, therefore, do not wish to restrict myself to the particular form of construction illustrated and described, but desire to avail myself of all modifications that may fall within the scope of the appended claims.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. A hydraulic pressure booster system comprising two control pistons connected together for movement in their respective chambers; a source of regulated low pressure fluid acting on one piston, and a source of high liquid pressure, which is to be kept regulated, acting on the other piston, for maintaining the connected pistons in a normally balanced position at one end of their motion; the ratio of the areas of the pistons being substantially inversely proportional to the ratio of the respective fluid pressure and liquid pressure acting on said pistons when in said balanced position, whereby a drop in said liquid pressure below its regulated amount, causes a movement of said pistons away from said balanced position toward the other end of their motion, while restoring said liquid pressure to its regulated amount restores said pistons to their original balanced position; a booster pump for restoring the high liquid pressure to its regulated amount means for controlling the flow of liquid to said booster pump, and means initiated by the movement of said connected pistons away from balanced position, for operating said means to open position, and by the movement of said pistons to their balanced position to close said means.

2. A hydraulic pressure booster system comprising two control pistons connected together for movement in their respective chambers; a source of regulated low pressure fluid acting on one piston, and a source of high liquid pressure, which is to be kept regulated, acting on the other piston, for maintaining the connected pistons in a normally balanced position at one end of their motion; the ratio of the areas of the pistons being substantially inversely proportional to the ratio of the respective fluid pressure and liquid pressure acting on said pistons when in said balanced position, whereby a drop in said liquid pressure below its regulated amount, causes a movement of said pistons away from said balanced position toward the other end of their motion, while restoring said liquid pressure to its regulated amount restores said pistons to their original balanced position; and a fluid pressure operates hydraulic booster pump for restoring the high liquid pressure to its regulated amount, valve means for controlling the flow of fluid to said pump, and means for operating said valve means the operation of said means being automatically started by the movement of said pistons away from balanced position, and being automatically stopped by the return movement.

3. A hydraulic pressure booster system comprising two control pistons connected together for movement in their respective chambers; a source of regulated low pressure fluid acting on one piston, and a source of high liquid pressure, which is to be kept regulated, acting on the other piston, for maintaining the connected pistons in a normally balanced position at one end of their motion; the ratio of the areas of the pistons being substantially inversely proportional to the ratio of the respective fluid pressure and liquid pressure acting on said pistons when in said balanced position, whereby a drop in said liquid pressure below its regulated amount, causes a movement of said pistons away from said balanced position toward the other end of their motion, while restoring said liquid pressure to its regulated amount restores said pistons to their original balanced position; means for restoring the high liquid pressure to its regulated amount, said means comprising a fluid pressure operated hydraulic booster pump, and fluid pressure operated valve means for controlling the flow of operating fluid to said booster pump; and means automatically operated by the movement of said pistons away from balanced position, for opening said valve means, and automatically operated by the movement of said pistons back to balanced position, for closing said valve means.

4. A hydraulic pressure booster system comprising two control pistons connected together for

movement in their respective chambers; a source of regulated low pressure fluid acting on one piston, and a source of high liquid pressure, which is to be kept regulated, acting on the other piston, for maintaining the connected pistons in a normally balanced position at one end of their motion; the ratio of the areas of the pistons being substantially inversely proportional to the ratio of the respective fluid pressure and liquid pressure acting on said pistons when in said balanced position, whereby a drop in said liquid pressure below its regulated amount, causes a movement of said pistons away from said balanced position toward the other end of their motion, while restoring said liquid pressure to its regulated amount restores said pistons to their original balanced position; means for restoring the high liquid pressure to its regulated amount, said means comprising a fluid pressure operated hydraulic booster pump, and a fluid pressure operated valve for controlling the flow of operating fluid to said booster pump; said valve comprising a valve control piston, a valve operating piston connected thereto, and two separate sources of fluid pressure for moving said connected valve pistons to their pump starting and pump stopping positions; means for admitting fluid pressure from one of said sources to the valve operating piston chamber for opening said valve, said means being automatically operated by the movement of said connected control pistons away from said balanced position; means for admitting fluid pressure from the other of said sources into the valve control piston cylinder for operating said booster pump while the valve is held open, and for closing said valve when the fluid pressure acting on said valve operating piston is allowed to exhaust by the return movement of said control pistons to balanced position.

5. A hydraulic pressure booster system comprising two control pistons connected together for movement in their respective chambers; a source of regulated low pressure fluid acting on one piston, and a source of high liquid pressure, which is to be kept regulated, acting on the other piston, for maintaining the connected pistons in a normally balanced position at one end of their motion; the ratio of the areas of the pistons being substantially inversely proportional to the ratio of the respective fluid pressure and liquid pressure acting on said pistons when in said balanced position, whereby a drop in said liquid pressure below its regulated amount, causes a movement of said pistons away from said balanced position toward the other end of their motion, while restoring said liquid pressure to its regulated amount restores said pistons to their original balanced position; means for restoring the high liquid pressure to its regulated amount, said means comprising a fluid pressure operated hydraulic booster pump, and fluid pressure actuated valve means for controlling the flow of operating fluid to said booster pump; means for automatically opening said valve means comprising a source of fluid pressure cut off from said valve means by a check valve, an auxiliary piston actuated by the movement of said control pistons away from balanced position for opening said check valve; and means for automatically closing said valve means, said means comprising an exhaust port, a valve for said port, and means actuated by said movement of the control pistons away from balanced position, for holding said exhaust valve closed until the return movement of said control pistons allows said exhaust valve to open and said check valve to close, thereby automatically exhausting the fluid pressure holding said valve means open.

6. A hydraulic pressure booster system comprising two control pistons connected together for movement in their respective chambers; a source of regulated low pressure fluid acting on one piston, and a source of high liquid pressure, which is to be kept regulated, acting on the other piston, for maintaining the connected pistons in a normally balanced position at one end of their motion; the ratio of the areas of the pistons being substantially inversely proportional to the ratio of the respective fluid pressure and liquid pressure acting on said pistons when in said balanced position, whereby a drop in said liquid pressure below its regulated amount, causes a movement of said pistons away from said balanced position toward the other end of their motion, while restoring said liquid pressure to its regulated amount restores said pistons to their original balanced position; means for restoring the high liquid pressure to its regulated amount, said means comprising a fluid pressure operated hydraulic booster pump, fluid pressure actuated valve means for controlling the flow of operating fluid to said booster pump; an auxiliary liquid supply pump, fluid pressure actuated means for starting said auxiliary pump; means for automatically opening said valve means and for starting said auxiliary pump, said means comprising a source of fluid pressure cut off from said valve and starting means by a check valve, an auxiliary piston actuated by the movement of said control pistons away from balanced position for opening said check valve; and means for automatically closing said valve means and for stopping said auxiliary pump, said means comprising an exhaust port, a valve for said port, means actuated by said movement of the control pistons away from balanced position, for holding said exhaust valve closed until the return movement of said control pistons allows said exhaust valve to open and said check valve to close, thereby automatically exhausting the fluid pressure which held said valve means open and prevented the auxiliary pump from stopping.

7. A hydraulic pressure booster system comprising two control pistons connected together for reciprocatory movement in their respective cylinders; a source of regulated low pressure fluid acting on one piston, and a source of high liquid pressure, which is to be kept regulated, acting on the other piston, for maintaining the connected pistons in a normally balanced position at one end of their stroke; the ratio of the areas of the pistons being substantially inversely proportional to the ratio of the respective fluid pressure and liquid pressure acting on said pistons when in said balanced position, whereby a drop in said liquid pressure below its regulated amount causes a movement of said pistons away from said balanced position toward the other end of their stroke, while restoring said liquid pressure to its regulated amount returns said pistons to their balanced position; means for restoring said liquid pressure to its regulated amount, said means comprising an auxiliary liquid supply pump, a fluid pressure operated hydraulic booster pump, and fluid pressure operated valve means for controlling the flow of operating fluid to said booster pump; means automatically operated by the movement of said pistons away from balanced position for starting said auxiliary pump and for opening said valve means; and means automati-

cally operated by the movement of said pistons back to balanced position for stopping said auxiliary pump and for closing said valve means.

8. A hydraulic pressure booster system comprising a conduit for containing liquid at a predetermined high pressure; a booster pump for supplying liquid to said conduit at said predetermined pressure; an auxiliary pump for supplying liquid to said booster pump; fluid pressure operated means for actuating said booster pump; valve means for controlling the flow of fluid pressure to said pump actuating means, means actuated by fluid pressure for starting said auxiliary pump; valve means for automatically opening the flow of fluid pressure to said booster pump actuating means and to said auxiliary pump starting means, said flow opening means being actuated by means responsive to a pressure drop in said conduit below said predetermined pressure; and means for automatically cutting off the flow of fluid pressure to said booster pump actuating means and auxiliary pump starting means, when said predetermined high pressure has been restored in said conduit.

9. A hydraulic pressure booster system comprising a conduit for containing liquid at high pressure; a double acting booster pump for supplying liquid to said conduit at said pressure; said pump comprising a relatively large diameter pump actuating piston and cylinder; a relatively small diameter liquid pumping piston and cylinder projecting from each end of said large piston and cylinder, respectively; means for alternately supplying liquid at low pressure to the outer end of one of the small cylinders, and for alternately removing liquid at high pressure from the outer end of the other of the small cylinders, with each stroke of the pistons; means for directing the removed high pressure liquid to said conduit; and means for reciprocating said pistons.

10. A hydraulic pressure booster system comprising a conduit for containing liquid at high pressure; a double acting booster pump for supplying liquid to said conduit at said pressure; said pump comprising a relatively large diameter pump actuating piston and cylinder; a relatively small diameter liquid pumping piston and cylinder projecting from each end of said large piston and cylinder, respectively; a single passageway in the outer end of each small cylinder; means for alternately supplying a quantity of liquid at low pressure through said passageway in one cylinder, and for alternately removing a quantity of liquid at high pressure through the corresponding passageway in the other cylinder, with each stroke of the pistons; means for directing the quantity of high pressure liquid, removed alternately through said passageways, to said conduit.

11. A hydraulic pressure booster system comprising a conduit for containing liquid at high pressure; a double acting, self-lubricating booster pump for supplying liquid to said conduit at said pressure; said pump comprising two relatively large diameter actuating pistons connected to each other in axially spaced relation, a cylinder for said connected pistons, the space between said pistons being substantially filled with lubricating material, a relatively small diameter liquid pumping piston projecting from the outer face of each of said large pistons, a cylinder for each of said small pistons projecting from the opposite ends of said large cylinder; means for alternately supplying liquid at low pressure to the outer end of one of the small cylinders, and for alternately removing liquid at high pressure from the outer end of the other of the small cylinders, with each stroke of the pistons; means for directing the removed high pressure liquid to said conduit; and means for reciprocating said pistons.

12. A hydraulic pressure booster system comprising a conduit for containing liquid at high pressure; a double acting booster pump for supplying liquid to said conduit at said pressure; said pump comprising a relatively large diameter pump actuating piston and cylinder; a first, relatively small diameter liquid pumping piston and cylinder projecting from one end of said large piston and cylinder, respectively; a piston rod projecting from the other end of said large piston; a second, relatively small diameter liquid pumping piston on the outer end of said rod; a slide valve assembled on said rod; spring means also assembled on said rod at each end of said slide valve; a housing for said slide valve and said spring means, said housing projecting from the other end of said large cylinder; a cylinder for said second piston projecting from said housing; means for alternately forcing one of said spring means against the adjacent end of said slide valve, at the end of each stroke of said pistons, for shifting said valve in said housing to its alternate positions of operation; and means for alternately directing fluid pressure to, and exhausting fluid pressure from, opposite ends of said large cylinder, with each stroke of said pistons, said directing means comprising connecting inlet and outlet passageways in said housing, slide valve and large cylinder.

13. A hydraulic pressure booster system comprising a conduit for containing liquid at high pressure; a double acting booster pump for supplying liquid to said conduit at said pressure; said pump comprising a relatively large diameter pump actuating piston and cylinder; a first, relatively small diameter liquid pumping piston and cylinder projecting from one end of said large piston and cylinder, respectively; a piston rod projecting from the other end of said large piston; a second, relatively small diameter liquid pumping piston on the outer end of said rod; a slide valve assembled on said rod; spring means also assembled on said rod at each end of said slide valve; a housing for said slide valve and said spring means, said housing projecting from the other end of said large cylinder; a cylinder for said second piston projecting from said housing; means for alternately forcing one of said spring means against the adjacent end of said slide valve, at the end of each stroke of said pistons, for shifting said valve in said housing to its alternate positions of operation; and means for alternately directing fluid pressure to, and exhausting fluid pressure from, opposite ends of said large cylinder, with each stroke of said pistons, said directing means comprising connecting inlet and outlet passageways in said housing, slide valve and large cylinder; means for alternately supplying liquid at low pressure to the outer end of one of said small cylinders, and for alternately removing liquid at high pressure from the outer end of the other of said small cylinders, with each stroke of the pistons; and means for directing the removed high pressure liquid to said conduit.

14. A hydraulic pressure booster system comprising a conduit for containing liquid at high pressure; a double acting booster pump for supplying liquid to said conduit at said pressure; said pump comprising a relatively large diameter

pump actuating piston and cylinder; a first, relatively small diameter liquid pumping piston and cylinder projecting from one end of said large piston and cylinder, respectively; a piston rod projecting from the other end of said large piston; a second, relatively small diameter liquid pumping piston on the outer end of said rod; a slide valve assembled on said rod; spring means also assembled on said rod at each end of said slide valve; a housing for said slide valve and said spring means, said housing projecting from the other end of said large cylinder; a cylinder for said second piston projecting from said housing; means for alternately forcing one of said spring means against the adjacent end of said slide valve, at the end of each stroke of said pistons, for shifting said valve in said housing to its alternate positions of operation; means for alternately directing fluid pressure to, and exhausting fluid pressure from, opposite ends of said large cylinder, with each stroke of said pistons, said directing means comprising connecting inlet and outlet passageways in said housing, slide valve and large cylinder; a single passageway in the outer end of each small cylinder; means for alternately supplying a quantity of liquid at low pressure through said passageway in one cylinder, while removing a quantity of liquid at high pressure through the corresponding passageway in the other cylinder, with each stroke of the pistons; and means for directing the quantity of high pressure liquid, removed alternately through said passageways, to said conduit.

15. A hydraulic pressure booster system comprising a conduit for containing liquid at high pressure; a double acting booster pump for supplying liquid to said conduit at said pressure; said pump comprising a relatively large diameter pump actuating piston and cylinder; a first, relatively small diameter liquid pumping piston and cylinder projecting from one end of said large piston and cylinder, respectively; a piston rod projecting from the other end of said large piston; a second, relatively small diameter liquid pumping piston on the outer end of said rod; a slide valve assembled on said rod; spring means also assembled on said rod at each end of said slide valve; a housing for said slide valve and said spring means, said housing projecting from the other end of said large cylinder; a cylinder for said second piston projecting from said housing; means for alternately forcing one of said spring means against the adjacent end of said slide valve, at the end of each stroke of said pistons, for shifting said valve in said housing to its alternate positions of operation; spring pressed detent means in the adjacent sidewalls of said housing and slide valve for retaining said



valve in one of said alternate positions of operation during each stroke of said pistons; and means for alternately directing fluid pressure to, and exhausting fluid pressure from, opposite ends of said large cylinder, with each stroke of said pistons, said directing means comprising connecting inlet and outlet passageways in said housing, slide valve and large cylinder.

16. A hydraulic booster system comprising two control pistons for movement in their respective chambers, a source of low pressure fluid acting on one piston and a source of high fluid pressure acting on the other piston for maintaining the pistons in normally balanced position, a fluid pressure operated hydraulic booster pump for restoring the high liquid pressure to regulated amount when a pressure drop unbalances the pistons, valve means for controlling the flow of operating fluid to the booster pump, and means operated by the movement of said pistons for operating said valve means, said means including an auxiliary piston.

17. A hydraulic pressure booster system comprising a pair of control pistons movable in their respective chambers, a source of low pressure fluid acting on one piston, and a source of high liquid pressure acting on the other piston for balancing said pistons, means for restoring the high liquid pressure to its regulated amount to balance said pistons, said means comprising a booster pump, a source of fluid pressure for operating said pump, a fluid pressure operated valve for controlling the flow of operating fluid to said booster pump, including a valve control piston and a valve operating piston, means automatically operated by the movement of said control pistons from balanced position for admitting fluid pressure to the valve operating piston chamber for opening said valve, means for admitting fluid pressure into the valve control piston cylinder for operating said booster pump while the valve is open, said valve closing when the fluid pressure acting on the said valve operating piston exhausts by return of said control pistons to balanced position.

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