June 11, 1935. D. H. MONTGOMERY 2,004,793

HYDRAULIC APPARATUS

Filed Jan. 29, 1931 4 Sheets-Sheet 1

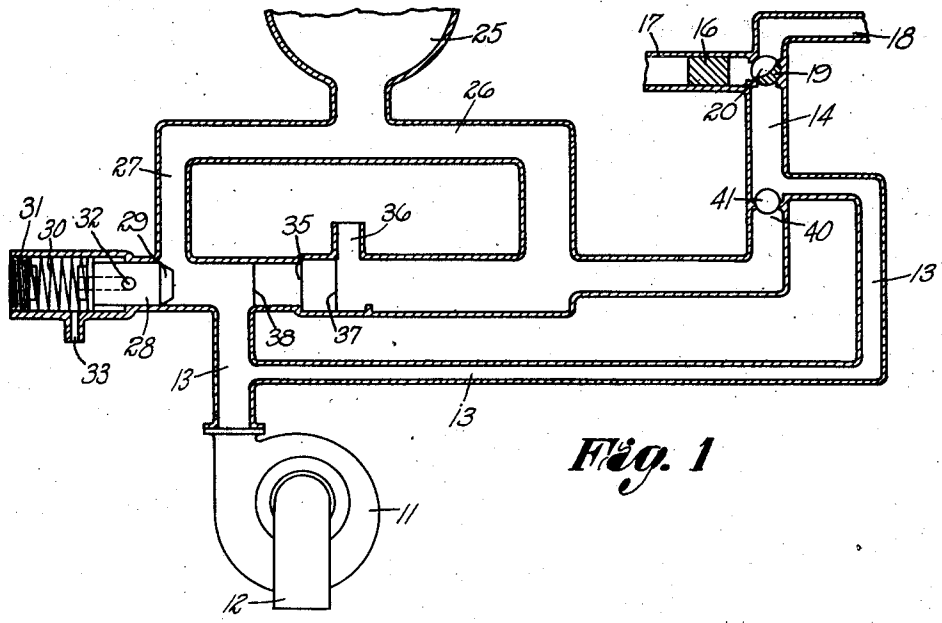


Fig. 1

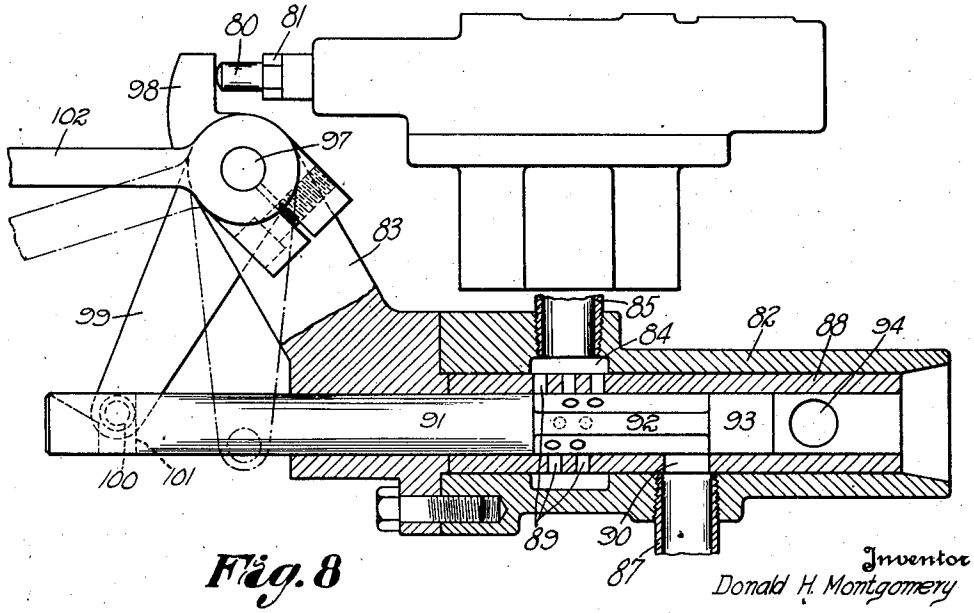


Fig. 8

Inventor
Donald H. Montgomery

By H. Clay Lindsey.

Attorney

June 11, 1935. D. H. MONTGOMERY 2,004,793

HYDRAULIC APPARATUS

Filed Jan. 29, 1931 4 Sheets-Sheet 2

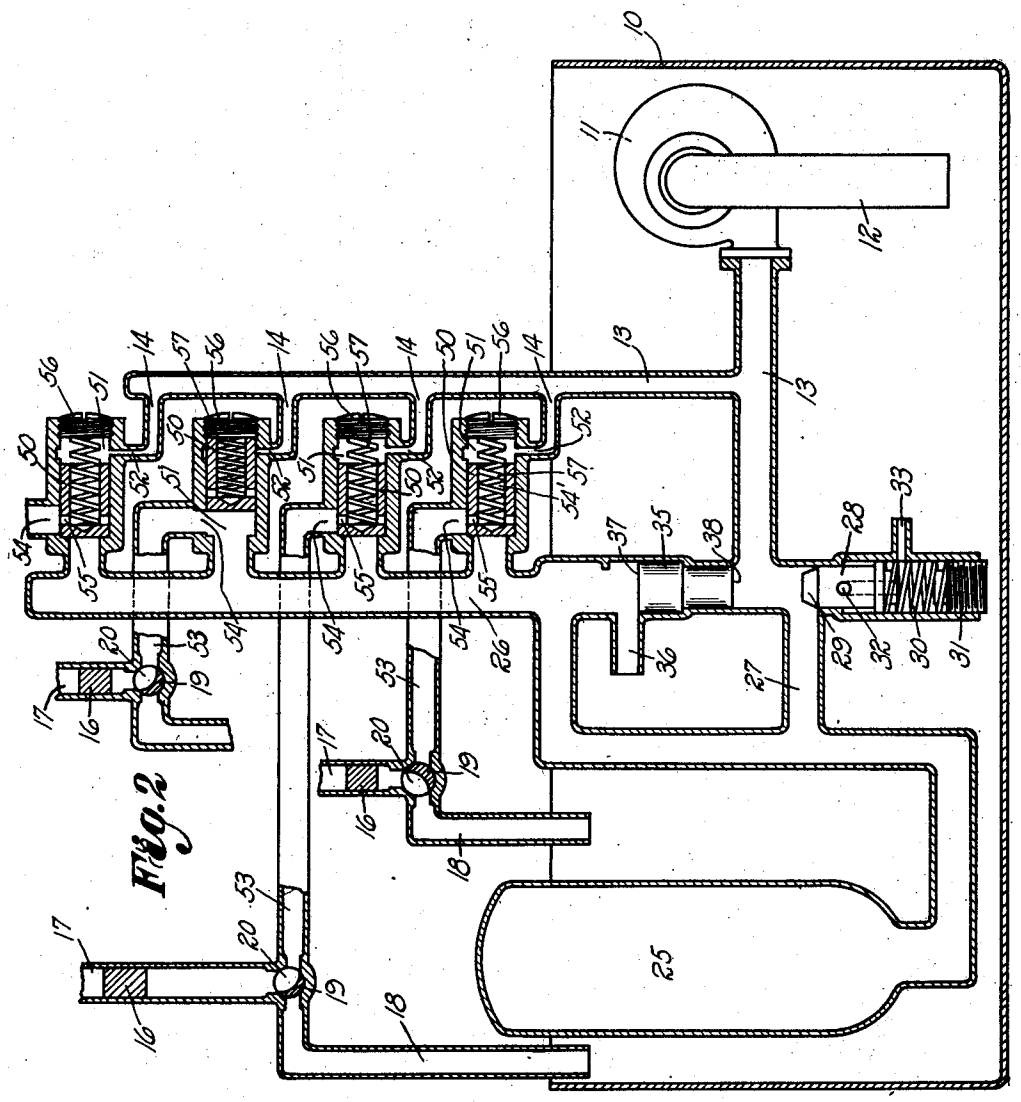


Fig. 2

Inventor
Donald H. Montgomery

By K. Clay Lindsey.

Attorney

June 11, 1935. D. H. MONTGOMERY 2,004,793

HYDRAULIC APPARATUS

Filed Jan. 29, 1931 4 Sheets-Sheet 3

Fig. 3

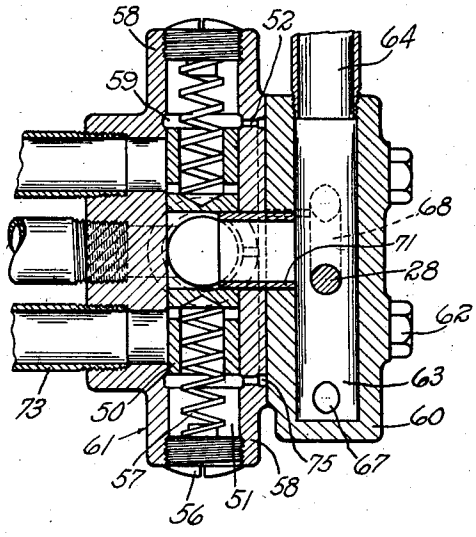


Fig. 4

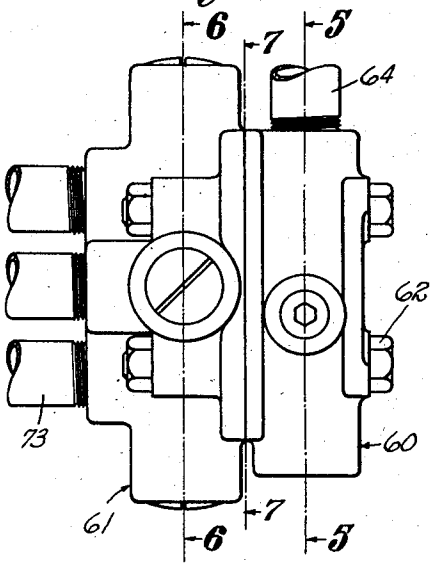
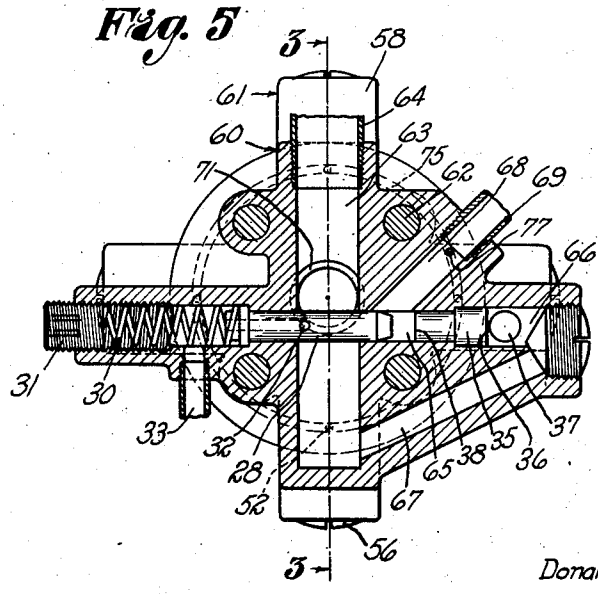


Fig. 5



Inventor
Donald H. Montgomery

By H. Clay Lindsey

Attorney

June 11, 1935. D. H. MONTGOMERY 2,004,793

HYDRAULIC APPARATUS

Filed Jan. 29, 1931 4 Sheets-Sheet 4

Fig. 6

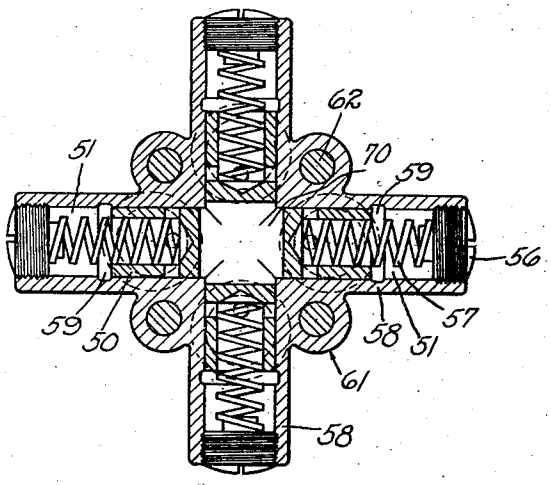
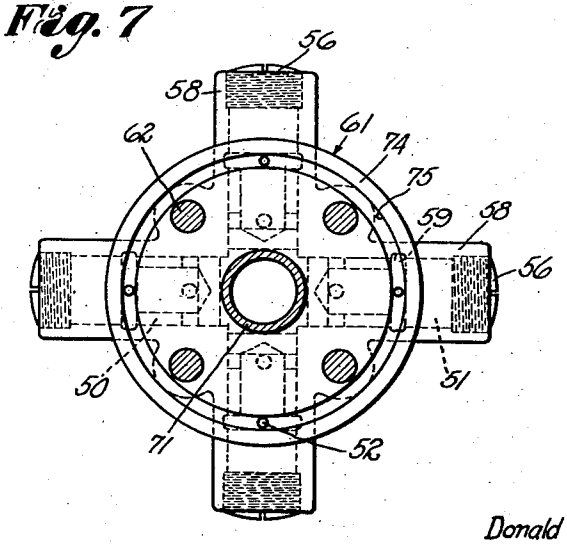


Fig. 7



Inventor
Donald H. Montgomery

By H. Blair Lindsay.

Attorney

Patented June 11, 1935 2,004,793

UNITED STATES PATENT OFFICE

2,004,793

HYDRAULIC APPARATUS

Donald H. Montgomery, Berlin, Conn., assignor to The New Britain-Gridley Machine Company, New Britain, Conn., a corporation of Connecticut

Application January 29, 1931, Serial No. 511,950

23 Claims. (Cl. 103—42)

This invention relates to a hydraulic apparatus or system of the character described and claimed in my co-pending application, Serial Number 206,910, filed July 16, 1927. As is therein stated, the apparatus finds special use in connection with mechanisms or devices adapted to be actuated with a relatively quick movement followed by a period during which substantially constant pressure is maintained.

The aim of the present invention is to provide an apparatus of this character having further various features of novelty and advantage.

More particularly, an aim of the invention is to provide an improved arrangement wherein the apparatus may be very quickly and easily adjusted, the setting being so simple that errors due to carelessness or ignorance on the part of the operator are substantially avoided. To this end, I provide an arrangement wherein there is no necessity of separately setting the relief valve for the system, the pressure with which that valve operates being automatically controlled by the setting of the pressure retaining valve which controls the flow of liquid from the pump pressure side to the accumulator pressure side.

A further aim of the invention is to provide an arrangement by means of which the system is automatically drained when the apparatus is shut down so that, when the apparatus is again put into operation, the proper amount of elastic fluid, such as air, will be present in the accumulator.

A further object of the invention is to provide an improved system or apparatus for effectively operating or controlling a plurality of actuated devices or instrumentalities. In accordance with the present invention, the arrangement is such that the actuation of one of the actuated devices will not affect or interfere with the operation of one or more of the other devices.

Another feature of the invention resides in an arrangement whereby the pressure may be changed during the normal operation of the apparatus and in timed relation to the actuated instrumentality or instrumentalities.

Other objects will be in part obvious, and in part pointed out more in detail hereinafter.

The invention accordingly consists in the features of construction, combination of elements and arrangement of parts which will be exemplified in the construction hereinafter set forth and the scope of the application of which will be indicated in the appended claims.

In the accompanying drawings wherein is shown, for illustrative purposes, one of the many embodiments which the present invention may take,

Fig. 1 is a sectional view showing my improved system or apparatus more or less diagrammatically, in combination with a single instrumentality or member to be actuated;

Fig. 2 is a view similar to Fig. 1 but showing the arrangement associated with a plurality of instrumentalities or devices to be actuated;

Fig. 3 is a sectional view taken substantially on line 3—3 of Fig. 5 and showing the arrangement disclosed in Fig. 2 embodied in a commercial or practical construction;

Fig. 4 is a side view of what is shown in Fig. 3;

Fig. 5 is a sectional view taken on line 5—5 of Fig. 4;

Fig. 6 is a sectional view taken on line 6—6 of Fig. 4;

Fig. 7 is a view taken on line 7—7 of Fig. 4 and shows the body section in which the check valves are located; and

Fig. 8 is a view showing the pressure retaining valve operatively associated with a valve which controls an actuated device.

Referring to the drawings in detail, the diagrammatic embodiment shown in Fig. 1 will first be described. This arrangement is generally similar to that disclosed in my said co-pending application, the main differences residing in the construction and arrangement of the pressure retaining valve and the relief valve. It will be understood that the apparatus may be positioned in a tank or reservoir containing a suitable liquid, such a tank being shown in Fig. 2 and being designated by the numeral 10. The numeral 11 designates a pump of any suitable construction having an inlet 12 and an outlet delivering to a chamber or confined space designated generally by the numeral 13. Leading from this confined space is a passage 14 which in effect forms with the chamber 13 a single chamber or confined space. This passage 14 leads to the actuated mechanism which is here shown for illustrative purposes as comprising a piston 16 located within a cylinder 17. Associated with this cylinder may be a work-holding chuck, the head of a ram, or other device to be actuated, all as described more fully in my said co-pending application. 18 designates a discharge pipe leading back to the tank. At the juncture of the passage 14, the cylinder 17, and the discharge pipe 18 is a control valve 19 which may be of any suitable construction, so long as it will permit of communication between the passage 14 and the cylinder when the valve is in one position, to result in actuation of

the piston, and communication between the cylinder and the discharge pipe 18 when the valve is in another position, so as to permit the fluid behind the piston, after the piston has been actuated, to flow through the discharge pipe. In the present instance, this valve is of the rotary type and it has a port 20. A spring or other suitable mechanism (not shown) may be employed for normally urging the piston to its normal or retracted position; that is to say, towards the right, referring to Fig. 1.

The numeral 25 designates a variable pressure accumulator in open communication with a confined space or chamber designated generally by the numeral 26. The pump pressure chamber 13 is adapted to communicate with the variable pressure chamber through a port or by-pass 27 which is controlled by a retaining valve. The retaining valve includes a sliding head 28, the forward end of which is preferably tapered, as at 29. Behind this valve is a spring 30 backed up by an adjustable screw 31. This spring normally urges the valve towards its closed position.

The numeral 35 designates a relief valve which controls communication from the accumulator to the reservoir or tank 10. This valve is so located as to control the exhaust port 36 leading from the variable pressure chamber 26. In the present instance, this valve 35 is a differential one, it having at one end a surface 37 against which the variable pressure is adapted to bear, and having at its other end a smaller surface 38 against which the pump pressure is adapted to bear. As the surface 38 is smaller than the surface 37, it will be apparent that the pressure within the variable pressure chamber 26 will be less than the pressure in the pump pressure chamber 13. Communication between the variable pressure chamber 26 and the passage 14 is had through a port 40 which is controlled by a check valve 41, as in my said application.

The operation of the mechanism so far described is similar to the operation of the structure shown in my said application, and which operation is fully explained in that application and, therefore, need not be repeated here. It is pointed out, however, that the setting or adjustment of the valve 28 determines not only the pressure on the pump pressure side of the system, but also determines the pressure in the accumulator side, and a separate setting of the relief valve 35 is not required. This is of advantage in that adjustment of the apparatus is greatly simplified and any danger of wrongly adjusting the mechanism, through ignorance or carelessness on the part of the operator, is guarded against. By way of example, it may be assumed that the valve 28 is set so as to maintain a pressure of 100 pounds on the pump pressure side and that the relative areas of the surfaces 38 and 37 are in a ratio of 4 to 5. Under this assumption, pressure within the accumulator may be built up to 80 pounds and up to that point the pump pressure acting on the surface 38 will maintain the relief valve in closed position; that is, in a position where the port 36 is blanked. When the pressure on the accumulator side goes above 80 pounds, the aggregate pressure against the face 37 of the relief valve is greater than that against the surface 38 so that the valve 35 is moved to open position, thus permitting the excess fluid to flow through the exhaust port back into the tank.

Referring again to the pressure retaining valve, the construction of the same is such as to permit of automatic draining of the system when the system is shut down. This is of advantage, as it has been found that if the fluid is maintained in the system, the air, within the air bell, may be partially dissipated so that when the system is again set into operation it may not function properly. The valve 28 has an opening 32 which, when the valve is in its completely closed position, is in registry with the port 27. The port or opening 32 leads to the outer end of the valve, and the chamber in which the coiled spring 30 is located has a waste opening 33. Now, when the system is closed down by shutting off the pump, the pressure in the system will fall so that the valve 28 will move to its full closed position; that is, as far as it can to the right, referring to Fig. 1. This position is shown in Fig. 5. The variable pressure side is then open to the atmosphere through the opening 32 and the waste opening 33, so that the fluid within the air bell will drain out, and the air bell will fill with air. When the system is started up, the pump will build up a pressure on the pump side, and when said pressure reaches a predetermined point, say 100 pounds, the valve 28 will open and the fluid will pass into the air bell, compressing that air. We thus have a fresh supply of air of the desired volume within the air bell.

Reference will now be had to the embodiment shown in Fig. 2 and wherein a plurality of actuated devices are operatively associated with the system so that these devices may be operated in any order or sequence desired, and the operation of one or more will not materially affect or interfere with the operation of the others. In the embodiment shown in Fig. 2, the parts corresponding to similar parts of Fig. 1 bear corresponding reference numerals. In Fig. 2, there are a number of branch passages leading from the pump pressure chamber 13 to independent actuated devices, each of which may comprise a cylinder 17 and a piston 16 as in the preceding embodiment. Interposed in these branch passages are check valves 50, which respectively serve the same functions as the valve 41 of the preceding embodiment. Each of these valves is slidably mounted in a valve chamber 51, each of which is open at one end to the variable pressure chamber 26. Leading from the pump pressure chamber 13 to each valve chamber 51 is a restricted inlet port or passage 52. Also leading from an outlet port 54 of each valve chamber 51 to a respective valve 19 is a branch passage 53. Each of the valves 50 is recessed at its outer end, as at 54', and has a transverse opening 55 communicating with the recess 54' and also adapted to communicate with the port 54 when the valve is closed. The outer end of each valve chamber 51 is closed by a screw plug 56 against which abuts a coil spring 57, one end of which is bottomed in the recess of the valve 50. The pressure of the springs may be suitably adjusted, as by the plugs 56. The valve 50 may be of such length that when it is in normal position, the outer end of the same is just short of the inlet port 52. When the valve is in normal or closed position, the passage 53 is in open communication with the chamber 13 through the recess 54' in the valve and the cross opening 55 thereof.

The operation of this arrangement is briefly as follows: assuming that it is desired to operate one of the actuated mechanisms, the valve 19 of that mechanism will be turned to open position, whereupon the valve 50 moves instantly forwardly so as to blank the inlet port 52, because when the

valve 19 is initially opened, the pump pressure in front of the valve will drop slightly and momentarily to a point below the variable pressure on the rear end of the valve. During the forward movement of the valve the restricted port 52 is blanked off and communication is established directly between the variable pressure chamber 26 and the passage 53. The second valve 50 from the top of Fig. 2 is shown in a position where the port 52 is blanked off. When the variable pressure drops below a predetermined limit, the spring 57 will return the valve to normal position, thus closing off the variable pressure and permitting the pump pressure to become effective through restricted port 52 to slowly move or hold the actuated device, as shown in connection with the third valve from the top of Fig. 2. It will be apparent that since the port 52 is restricted and in addition that the valve 50 blocks off pump pressure when the associated actuated device is being acted upon by the variable pressure of the accumulator, the pump pressure will be maintained in the pump chamber 13 so that, if it is desired to actuate or hold one or more of the other actuated devices, the pump pressure on that device will not be affected; for example, in Fig. 2 the actuated device associated with the third valve from the top is shown as being moved slowly by the pump pressure. Now when the valve 19 associated with the second valve 50 is turned to open position, the valve 50 will prevent communication between the second cylinder 17 and the pump pressure chamber 13 so long as the variable pressure is moving the second piston 16 on the quick portion of its stroke, and therefore pump pressure on the actuated device associated with the third valve will not be decreased or changed.

Reference will now be had to Figs. 3 to 7, inclusive, and which figures show the arrangement of Fig. 2 embodied in a practical and commercial structure. It is, of course, obvious that this disclosure is by way of illustration. This mechanism includes a body portion formed of two castings 60 and 61 secured together by bolts 62. The casting 60 has a bore 63 to which is secured the pipe 64 leading to the accumulator. Extending transversely of the bore 63 is a bore 65 having an enlarged portion 66 at its right-hand end. The enlarged portion 66 has an exhaust port 36 and is connected to the bore 63 by an opening 67. Leading to the bore 65 is a bore 68 which is connected to a pipe 69 leading from the pump. The relief valve 35 and the pressure retaining valve 28 are located in the bore 65. The casting 61 has four sleeve-like portions or guides 58 constituting valve chambers 51 in which are respectively mounted check valves 50. Each sleeve portion 58 has an internal annular groove 59 adjacent the outer end of the valve when the latter is closed. At the juncture of the valve chambers 51 is a space 70 to which leads an axially disposed bushing 71 which communicates with the bore 63 of the casting 60. Leading from the respective chambers 51 are pipes 73, the bores of which correspond to the passages 53 of Fig. 2. The casting 61 has a face 74 adapted to abut in a fluid-tight manner against a corresponding face of the casting 60. This face 74 has an annular groove or channel 75. Leading from this channel to the respective grooves 59 of the valve chambers 51 are restricted ports 52. Also leading from the bore 68 of the casting 60 to this annular groove 75 is a port or passage 77.

Other elements shown in these figures bear reference characters corresponding to the reference characters for like parts in Figs. 1 and 2, and need not be further described. The operation of the mechanism shown in Figs. 3 to 7 is identical to that described in connection with Fig. 2 and need not again be reviewed. It is observed that the opening in the pipe 69, the bore 68, the port 77, and the annular groove 75 taken together correspond to the pump pressure chamber 13 of Fig. 2. The bore 63, the opening through the sleeve 71, and the space 70 constitute a variable pressure chamber corresponding to the chamber 26. The bores of the pipes 73 correspond to the passages 53.

Reference will now be had to the construction shown in Fig. 8 and wherein the pressure retaining valve of the system is operatively associated with the controlling valve for the actuated mechanism in such manner that when this controlling valve is operated beyond a predetermined point, the setting of the retaining valve is automatically changed. Only a portion of the system is illustrated, as it is understood that the arrangement may be associated either with the mechanism described in Fig. 1 or in Fig. 2. The controlling valve, as shown in Fig. 8, is to take place of the controlling valves 19 in Fig. 1 or one of such valves in Fig. 2. Controlling valves of this type may be substituted for all of the valves 19 in Fig. 2.

Referring to Fig. 8 more specifically, the retaining valve 28 may be of the same construction as that shown in the preceding figures, except that behind the spring 31 is a plunger 80 adapted to slide in a hollow nut 81. The controlling valve may be of any suitable kind, but it is here shown as including a casing 82 fixed to a bracket 83 which in turn is fixed to a suitable support (not shown). The casing 82 has an inlet opening 84 to which leads a pipe 85. This pipe leads from the pump pressure side and may be considered as being the passage 14 of Fig. 1 or one of the branch passages 53 of Fig. 2. The casing 82 has an outlet port to which is connected a pipe 87 which leads to a device to be actuated and which is not shown. This actuated device may be a brake cylinder, such as provided on automobiles having hydraulic brakes. The opening through the pipe 87 may be considered as the equivalent of the cylinder 17 of the preceding embodiments. The valve casing has a lining or sleeve 88 having a plurality of spirally arranged openings 89 communicating with the inlet opening or passage 84. It also has an outlet port 90 registering with the pipe 87. The valve is in the form of a plunger or reciprocating bar having a body portion 91, a stem 92, and a head 93, the body portion and head closely but slidably fitting in the sleeve. Leading from the valve casing is an exhaust opening or port 94 which corresponds to the pipes 18 of the preceding embodiment. Journaled in the bracket 83 is a pin or shaft 97 to which is fixed an arm 98 having a shoulder adapted to abut against the outer end of the plunger 80. Also fixed to this shaft 97 is an arm 99 having on its lower end an anti-friction roller 100 operating in a vertical groove 101 in the valve 91. The numeral 102 designates a handle fixed to the pin 97 for rocking the lever which is composed of arms 98 and 99.

The operation of the construction shown in Fig. 8 is briefly as follows, it being assumed that the controlling valve is associated with a brake mechanism. This assumption is by way of exemplification only. When the parts are in the

normal position, that is, when no pressure is desired in the brake cylinder, the lever 102 is in the dotted line position and the valve 91 is in its extreme right-hand position so that openings or ports 89 are closed by the body portion 91 of the valve and communication is established between the pipe 87 and the exhaust 94 through the space about the stem 92. When it is desired to apply the brakes, the lever is raised, thereby moving the valve 91 to the left and when this is done, the exhaust port is closed off and the openings 89 are uncovered in sequence. It will be observed that when the valve 91 is in full closed position there is a space between the arm 98 and the plunger 80 so that during a predetermined portion of the opening movement of the valve 91 the setting of the pressure retaining valve 28 is not affected, and during this time service application of the brakes is had. If a slight braking action is desired, the valve 91 is moved to a position where only a few of the openings 89 are uncovered, and when a greater pressure is desired the valve is further opened. When the controlling valve 91 is opened, the accumulator pressure is first effective in quickly moving the cylinder to which the pipe 87 leads, and then the pump pressure comes into play to slowly move the cylinder and hold it in actuated position. When emergency application of the brakes is desired, the valve 91 is rapidly moved to the full open position shown in Fig. 8, and when this is done the arm 98 moves the retaining valve to closed or partially closed position. When the valve 91 is first opened, the accumulator pressure will quickly bump the cylinder to which the pipe 87 leads and then the pump pressure comes into play, as in the case of a service application. But in case of emergency application, a higher pressure than that normally maintained on the pump side is set up on that side because the pressure retaining valve has been closed, or partially closed. As soon as the pressure on the pump side is increased, this increase is immediately effective on the cylinder because the passages leading to the cylinder are completely filled with liquid which is substantially not compressible.

As many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the language used in the following claims is intended to cover all of the generic and specific features of the invention herein described and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

What is claimed is:

1. In an apparatus of the character described, a pump pressure chamber or passage, a pump for delivering liquid under pressure to said chamber, a variable accumulator, a port between said chamber and accumulator and through which said accumulator receives the liquid from said chamber, a port between said accumulator and chamber and through which said accumulator is adapted to discharge into said chamber, a pressure retaining valve for preventing liquid from flowing through said first mentioned port until a predetermined pressure is built up on the pump pressure side, means for closing said second mentioned port while the pressure on the pump pressure side is above that of the accumulator pressure side, an exhaust port for the system, and a relief valve for controlling said exhaust port and arranged to be moved to closed position by pressure on the pump pressure side and to be moved to open position by pressure on the accumulator side.

2. In an apparatus of the character described, a chamber or passage, variable pressure means, means for delivering fluid under pressure to said chamber and said variable pressure means, a pressure retaining valve for preventing fluid from flowing into said variable pressure means until a predetermined pressure is built up in said chamber by said fluid delivering means, and means for establishing communication from said variable pressure means to said chamber when the pressure in said chamber falls below that of said variable pressure means, said retaining valve including means for automatically draining said variable pressure means of fluid when the apparatus is shut down.

3. In an apparatus of the character described, a chamber or passage, a variable pressure accumulator, a pump for delivering fluid under pressure to said chamber, a pressure retaining valve for preventing fluid from flowing into said accumulator until a predetermined pressure is built up in said chamber by said pump, and means for establishing communication from said accumulator to said chamber when the pressure in said chamber falls below that of said accumulator, said retaining valve including a valve head and a spring normally urging said head to closed position, said head having an opening normally out of communication with said accumulator and said head being moved to a position where said opening is in communication with said accumulator when the system is shut down whereby said accumulator may drain through said opening.

4. In an apparatus of the character described, a chamber, a pump for delivering liquid under pressure to said chamber, a variable accumulator, a pressure retaining valve for preventing fluid from flowing into said accumulator until a predetermined pressure is built up in said chamber by said pump, a plurality of passages adapted to be respectively associated with devices to be actuated, and a plurality of check valves, one for each passage, each check valve in one position establishing communication between said chamber and the respective passage and in another position establishing communication between the accumulator and the respective passage, each check valve being moved to the latter position when the pressure normally tending to move the valve to the first position becomes less than the accumulator pressure.

5. In an apparatus of the character described, a chamber, a variable pressure accumulator, a pump for delivering fluid under pressure to said chamber and said accumulator, a pressure retaining valve for preventing fluid from flowing into said accumulator until a predetermined pressure is built up in said chamber by said pump, a plurality of passages adapted to lead to respective actuated devices and each adapted to communicate with said chamber and accumulator, a check valve for each passage, and means for normally urging each check valve to a position where communication is established between said chamber and the respective passages.

6. In an apparatus of the character described, a chamber, a variable accumulator, a pump for delivering liquid under pressure to said chamber

and accumulator, means for preventing liquid from flowing into said accumulator until a predetermined pressure is built up in said chamber by said pump, a plurality of passages each adapted to communicate with said chamber and said accumulator, and a plurality of valves, one for each passage, each valve controlling communication between its passage and said chamber and accumulator respectively.

7. In an apparatus of the character described, a chamber, a variable accumulator, a pump for delivering liquid under pressure to said chamber and accumulator, a retaining valve for preventing liquid from flowing into said accumulator until a predetermined pressure is built up in said chamber by said pump, a plurality of passages each adapted to communicate with the chamber and the accumulator, and a plurality of valves one for each passage and normally urged to a closed position for preventing communication between the accumulator and the respective passage, each of said valves being arranged to establish communication between the chamber and the respective passage when the valve is in closed position, the pressure on the accumulator side normally tending to urge said valve to an open position, each valve being so arranged that when in open position it closes off communication between said chamber and the respective passage.

8. In an apparatus of the character described, a chamber, a variable accumulator, a pump for delivering liquid under pressure to said chamber and accumulator, means for preventing liquid from flowing into said accumulator until a predetermined pressure is built up in said chamber by said pump, a plurality of individual valve mechanisms each having a valve chamber communicating with said accumulator and said chamber and each having an outlet passage, a check valve in each valve chamber, means associated with each check valve for urging the same to a closed position where communication between the accumulator and the respective passage is prevented and communication is had between the first chamber and said passage, said valve being constructed to prevent communication between the first chamber and said valve chamber when the valve is in open position.

9. In an apparatus of the character described, a chamber, a variable accumulator, a pump for delivering liquid under pressure to said chamber and accumulator, a pressure retaining valve for preventing liquid from flowing into said accumulator until a predetermined pressure is built up in said chamber by said pump, a plurality of passages each adapted to communicate with said chamber and said accumulator, a plurality of valves one interposed between each passage on the one hand and the accumulator and chamber on the other hand, and a spring normally urging each valve to closed position where communication between the respective passage and accumulator is shut off, the pressure in said chamber normally tending to urge the valve to closed position and in which position communication is established between said chamber and passage and the pressure in the accumulator acting in opposition to the springs.

10. In an apparatus of the character described, a chamber, a variable accumulator, a pump for delivering liquid under pressure to said chamber and accumulator, a pressure retaining valve for preventing liquid from flowing into said accumulator until a predetermined pressure is built up in said chamber by said pump, a plurality of passages adapted to communicate with said chamber and said accumulator, a plurality of check valves, one for each passage, means normally urging each check valve to closed position where communication between the accumulator and the respective passage is shut off and communication between the chamber and the respective passage is established, the pressure in said chamber acting on said valve when in closed position in opposition to the pressure of the accumulator on said valve, the pressure of the chamber on said valve being discontinued when the pressure of said accumulator has moved the valve to open position and in which position communication is established between the accumulator and the passage.

11. In an apparatus of the character described, a chamber, a variable accumulator, a pump for delivering liquid under pressure to said chamber and accumulator, a pressure retaining valve for preventing liquid from flowing into said accumulator until a predetermined pressure is built up in said chamber by said pump, a plurality of individual valve mechanisms, each having a valve chamber provided with an opening communicating with the accumulator, an inlet port communicating with said first chamber, and an outlet passage between said opening and port, a check valve in each valve chamber, a spring associated with each check valve for urging the same to closed position where said opening is closed, each valve when in closed position being subjected to accumulator pressure and the pressure of said chamber in opposition and communication being established between the chamber and said outlet passage, each valve when in open position blanking said inlet port and establishing communication between said accumulator and the respective outlet passage.

12. In an apparatus of the character described, a chamber, a variable pressure accumulator, continuously operating means for delivering liquid under pressure to said chamber and said accumulator, an adjustable pressure retaining valve for preventing liquid from flowing into said accumulator until predetermined pressures are built up in said chamber by said continuously operating means, a controlling valve for controlling the discharge of liquid from said chamber, and an operative connection between said controlling valve and said pressure retaining valve, whereby the setting of the latter is automatically changed after the controlling valve is operated beyond a predetermined point.

13. In an apparatus of the character described, a chamber, a variable accumulator, a pump for delivering liquid under pressure to said chamber and accumulator, a pressure retaining valve for preventing liquid from flowing into said accumulator until predetermined pressures are built up in said chamber by said pump, a controlling valve for controlling the discharge of liquid from said chamber at varying rates depending upon the extent to which the controlling valve is opened, and means for operating said controlling valve and also for changing the setting of said pressure retaining valve during at least a portion of the operating stroke of said controlling valve.

14. In an apparatus of the character described, a chamber, a variable accumulator, a pump for delivering liquid under pressure to said chamber and accumulator, an adjustable pressure retaining valve for preventing liquid from flowing into said accumulator until predetermined pressures are built up in said chamber by said pump, a con-

trolling valve for controlling the discharge of liquid from said chamber and accumulator at varying rates, means for operating said controlling valve, and means between said operating means and said pressure retaining valve for changing the setting of the latter after said controlling valve has been moved to a predetermined extent.

15. In an apparatus of the character described, a chamber, a variable accumulator, a pump for delivering liquid under pressure to said chamber and accumulator; a pressure retaining valve for preventing liquid from flowing into said accumulator until a predetermined pressure is built up in said chamber, said valve having a member, a spring normally urging the member to closed position, and a plunger behind the spring; a controlling valve for controlling the discharge of liquid from said chamber and accumulator and having a valve chamber provided with a plurality of openings adapted to be opened in sequence and a valve head controlling said openings, and means for simultaneously moving said valve head and said plunger after the valve head has been moved to a predetermined extent.

16. In an apparatus of the character described, a chamber, variable pressure means, means for delivering fluid under pressure to said chamber and said variable pressure means, adjustable means for preventing fluid from flowing into said variable pressure means until a predetermined pressure is built up in said chamber by said fluid delivering means, means for establishing communication from said variable pressure means to said chamber when the pressure in said chamber falls below that of said variable pressure means, and a relief valve for the system and arranged to be moved to closed position by pressure acting directly on said valve on the pump pressure side and to be moved to open position by pressure acting directly on said valve on the accumulator side, the operation of said relief valve automatically varying in accordance with the setting of said adjustable means.

17. In an apparatus of the character described, a chamber or passage, a variable pressure accumulator, continuously operating means for delivering fluid under pressure to said chamber and said accumulator, a pressure retaining valve for preventing fluid from flowing into said accumulator until a predetermined pressure is built up in said chamber by said continuously operating means, means for establishing communication from said accumulator to said chamber when the pressure in said chamber falls below that of said accumulator, and a relief valve for the system and arranged to be moved to closed position by pressure acting directly on said valve on the pump pressure side and to be moved to open position by pressure acting directly on said valve on the accumulator side, the operation of said relief valve being controlled by the ratio of pressures exerted against said relief valve on the pump pressure and accumulator sides thereof.

18. In an apparatus of the character described, a pressure chamber or passage, a pump for delivering fluid to said chamber, an accumulator, a pressure retaining valve between said accumulator and chamber for maintaining a predetermined pressure in said chamber and including a valve head, a spring normally urging the valve into closed position, and means for adjusting the spring; a check valve between said chamber and accumulator and opened by the pressure of the accumulator, and a differential relief valve for the system and including a member arranged to be moved to closed position by pressure acting directly on said member on the pump pressure side and to be moved to open position by pressure acting directly on said member on the accumulator side.

19. In an apparatus of the character indicated, a pump device, an accumulator device connected thereto to be charged thereby, and means for discharging an excess of fluid from one of said devices, said means including a relief port and differential valve means for controlling said port, said differential valve means being open to accumulator pressure at one side to tend to open said port and being open to pump pressure at the other side to tend to close said port.

20. In an apparatus of the character indicated, a pump, an accumulator connected thereto to be charged thereby, means for preventing a flow of fluid from said pump to said accumulator until a predetermined pressure is built up by said pump, and means controlled by the differential of pump and accumulator pressures for maintaining the ratio of maximum pump and accumulator pressures constant.

21. In an apparatus of the character indicated, a pump, an accumulator connected thereto to be charged thereby, means for preventing a flow of fluid from said pump to said accumulator until a predetermined pressure is built up by said pump, and means subject to pump pressure at one side and to accumulator pressure at the opposite side for maintaining constant the ratio of maximum pump and accumulator pressures.

22. In an apparatus of the character indicated, a pump, an accumulator connected thereto to be charged thereby, a plurality of fluid pressure actuated devices, and means for subjecting one of said devices to pump pressure and accumulator pressure at different times while subjection another of said devices to pump pressure alone, said means including restricted passage means to prevent a rapid flow of pump pressure fluid to said one of said devices, whereby pump pressure will not be substantially lowered on said another actuated device.

23. In an apparatus of the character indicated, a pump, an accumulator connected thereto to be charged thereby, means for draining the accumulator comprising valve and port means, said valve being open to pump pressure to hold said valve in port closed position, and means for urging said valve to port open position whereby upon failure of pump pressure said accumulator will be drained.

DONALD H. MONTGOMERY.