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ACCUMULATOR

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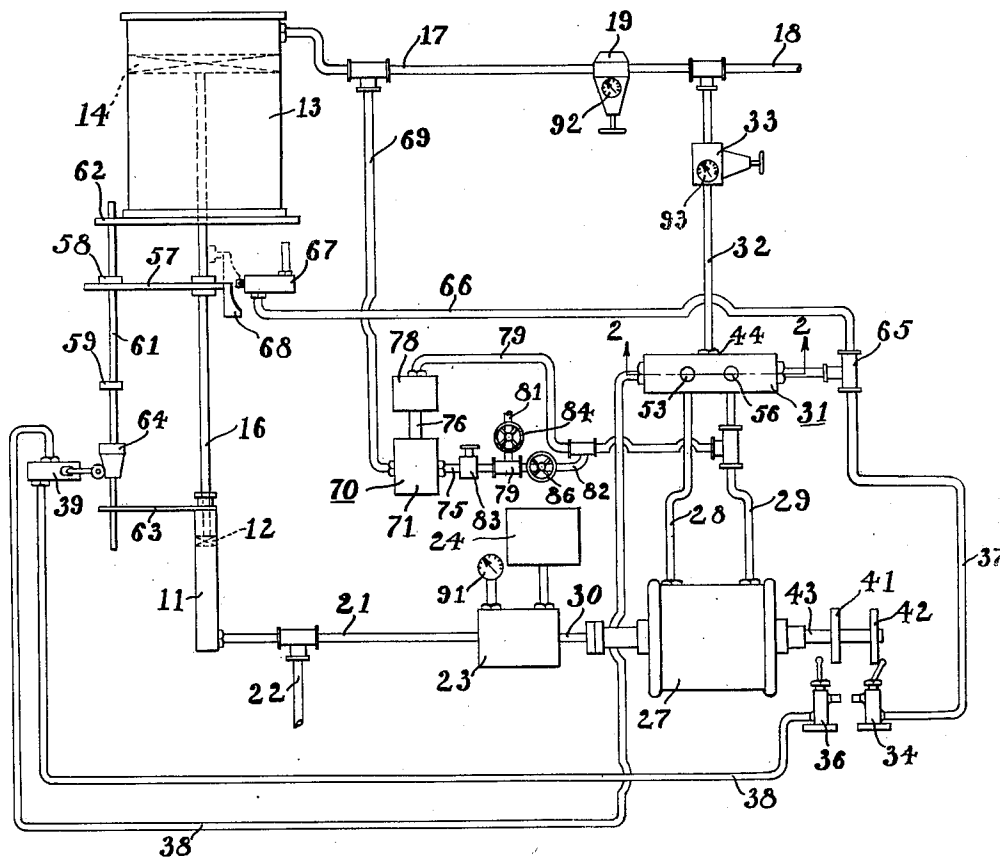


Fig 1

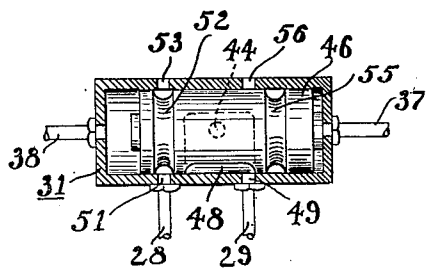


Fig 2

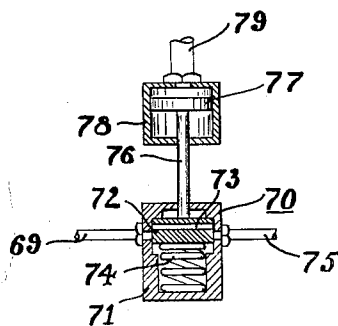


Fig 3

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ACCUMULATOR

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The invention disclosed in this application relates to processes of, and apparatus for maintaining a supply of liquid under relatively high pressure without any substantial variation in the uniformity of said pressure. The devices disclosed in illustration of my invention comprise generally a liquid cylinder and a fluid (air as shown) cylinder cooperating therewith, each cylinder having a piston connected with the piston of the other; and having associated therewith a pump for supplying liquid to the liquid cylinder and a motor for operating the liquid pump.

I provide means whereby as the pump on each stroke supplies a measured amount of liquid such as oil to the liquid cylinder coincidentally a measured amount of air is withdrawn from the air cylinder. Accordingly I am able to obtain a uniform fluid pressure in the fluid (air) cylinder and thus obtain a uniform pressure on the liquid in the liquid cylinder.

One of the objects of this invention is the provision of methods of supplying liquid under exactly uniform pressure at all times.

A further object of the invention is the provision of apparatus for supplying liquid at all times under a uniform relatively high pressure.

Features of the invention include in combination with a liquid pressure supply system including an accumulator cylinder, a pressure controlled, fluid relief valve of special design; a safety valve for preventing the pumping of too much liquid into the accumulator cylinder; the arrangement in combination of a shut-off valve, a pilot valve, toggle valves, a relief valve, and a safety valve; and the combination in such a system of appropriate pressure reducing valves.

Further objects, features and advantages of the present invention and of the details thereof will be apparent from the following description, reference being had to the accompanying drawings wherein a preferred form of embodiment of the invention is clearly shown.

In the drawings:

Fig. 1 is a diagrammatic showing of an air operated high pressure liquid accumulator system constructed in accordance with my invention;

Fig. 2 is a sectional view of the master valve; and

Fig. 3 is a sectional view of the fluid relief valve and its operating motor.

Referring now to the drawings for detailed description of the embodiment of the invention illustrated it may be seen that I provide an accumulator cylinder 11 having a piston 12. The ac-

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cumulator cylinder 11 is of relatively small diameter and the piston therein may, for instance, be of a diameter of $\frac{1}{8}$ of an inch.

Positioned above the accumulator cylinder 11 is a pressure operated means for driving the piston 12. The means shown comprises in general an air cylinder 13 having a piston 14. The air cylinder 13 and piston 14 have a relatively large diameter. For instance, the diameter thereof may be the order of four inches. Pistons 12 and 14 are connected by a piston rod as, for example, 16. The upper end of the air cylinder has connected thereto an air conduit 17 which leads to a source of air supply 18 there being interposed in said conduit 17 a pressure reducing valve 19. It is thus clear that air pressure flowing into the air cylinder 13 by the air conduit 17 exerts a total pressure on the liquid in the cylinder 11 corresponding to the air pressure in the conduit 17 multiplied by the square of the ratio of the piston 14 to the piston 12. Thus if there was an air pressure in the conduit 17 of about 100 lbs. per square inch, the piston 12 had a diameter of $\frac{1}{2}$ inch and the piston 14 had a diameter of 4 inches there would be a pressure exerted on the liquid in the accumulator cylinder 11 of approximately 6400 lbs. The lower end of the accumulator cylinder 11 is connected by a liquid conduit 21 to an outlet 22 and to an oil pump 23. The outlet may lead to any device which is desired to operate by the high pressure or to any place to which it is desired to supply liquid under high pressure. Connected to the inlet side of the oil pump 23 is a reservoir 24 for supplying additional oil.

I provide means including said oil pump 23 for supplying to the accumulator cylinder 11, liquid to replenish liquid which may be used up by the device to which the outlet 22 is connected. The oil pump 23 is designed to be operated by a fluid pressure motor 27 which as shown is an air motor and is operated from the source of air supply 18. Air is supplied to the opposite ends of the air motor 27 by conduits 28 and 29 which are connected with air conduit 17 by a master valve 31 and an air conduit 32. Interposed in the conduit 32 is a pressure reducing valve 33. The piston of the air motor 27 is connected by a piston rod 30 with the piston of the pump 23.

The master valve 31 is controlled by toggle pilot valves 34 and 36 which are connected by control conduits to the opposite ends of the master valve 31. For example, the toggle valve 34 is connected by the control conduit 37 with the right hand end of the master valve 31 and is

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designed to exhaust air from the right hand end of the master valve to allow the valve piston therein to move to the right. Likewise the toggle valve 36 is connected by a control conduit 38 with the left hand end of the master valve 31 and is designed to exhaust air from the left hand end of the master valve to allow the valve piston to move to the left. Interposed in the control conduit 38 is a shut-off valve 39 which is provided for purposes later to be described. The toggle valves 34 and 36 are operated by lugs 42 and 41 formed on the projecting end 43 of the piston rod 30 which protrudes from the right hand end of the air motor 27.

The details of construction of the master valve 31 are shown in Fig. 2. As may be seen the air conduit 32 leading from the source of air under pressure is connected to the port 44 of the master valve 31. With the movable valve element or piston 46 in the position shown, it may be seen that the inlet port 44 is connected through the groove 48 with the outlet port 49 which in turn is connected with the conduit 29 and the right hand half of the air motor 27. The left hand end of the air motor 27 is connected by the air conduit 28 with the port 51 and through the groove 52 with the exhaust port 53. When the piston 46 is moved to the left as will be described below, the groove 48 connects the inlet (air pressure) port 44 with the port 51 and the conduit 28 leading to the left hand end of the motor 27. At the same time the right hand end of the motor is connected to exhaust through the conduit 29, the port 49, the groove 55, and the exhaust port 56. The toggle pilot valves 34 and 36 control the master valve 31 to actuate the air motor 27 to operate the oil pump 23.

As air under pressure enters the port 44 of the master valve it passes (depending on the position of the movable valve element 46) mainly into the conduit 28 or the conduit 29. However a small portion leaks past the piston toward the ends of the casing of the master valve 31. Thus pressure in the ends of the valve is built up and is sufficient to move the piston to the opposite end of the valve whenever such opposite end is vented to the atmosphere by means of one of the pilot valves 34 and 36.

I provide means for stopping the operation of the air motor 27 and the oil pump 23 when a sufficient supply of oil has been supplied to the accumulator cylinder 11; and for again initiating the operation of the oil pump by the air cylinder when the supply of oil to the accumulator cylinder 11 becomes partially depleted. The piston rod 16 carries a projecting arm 57 which is adapted at times to contact with upper lug 58 and at other times to contact with a lower lug 59, both of said lugs being carried on a reciprocating rod 61. The rod 61 may be mounted in brackets 62 and 63 for reciprocation therein. It carries a cam 64 which is adapted to operate the shut-off valve 39. When the cam 64 is raised (as for example in the position shown) the shut-off valve 39 is closed but when in its downward travel, the projecting arm 57 strikes the lower lug 59 (as pistons 12 and 14 and the piston rod 16 are moved downward by reason of a partial depletion of the oil in the cylinder 11), the cam 64 operates the valve 39 to move it to open position so that the toggle valve 36 is effectively connected to the master valve 31. The toggle valve 36 thus becomes effective to control the operation of the master valve 31 and thus initiates operation of the air motor 27 and the oil pump 23.

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I provide additional means in the form of a safety valve for further insuring that the pumping mechanism shall not supply a too large quantity of liquid or oil to the accumulator cylinder 11 and that pressures may not be built up too high. The conduit 37 is connected to the right hand end of the master valve 31 by a T 65. Secured to the T 65 is a conduit 66 which leads to a safety valve 67. The projecting arm 57 is provided with a cam 68 which is designed to open the safety valve 67 and hold it open should the projecting arm 57 be moved above the position shown to the dotted line position. This situation will exhaust air from the right hand end of the master valve 31 and thus will prevent the piston in the master valve 31 from being moved to the left and consequently will prevent the continuation of the operation of the air motor 27.

Many of the parts described above are conventional and even though they are combined in a new way, nevertheless without the device now to be described they would be incapable of maintaining uniform air pressure in the cylinder 13. It is clear that as oil is pumped into the accumulator cylinder 11, the piston 12 thereof will be moved upward together with both the piston rod 16 and the air cylinder piston 14. The air trapped in the upper part of the air cylinder 13 would thus be compressed more and more in the upper part of said cylinder with the result that the air pressure therein would be increased above that which is desired and the oil pressure of the oil supplied to the outlet 22 would be increased above the uniform pressure desired. I provide means to prevent this lack of uniformity and to insure that the air pressure in the cylinder 13 always remains uniform. Connected either to the upper end of the air cylinder 13 or (as shown) to the conduit 17 leading thereto is a branch conduit 69 which leads to my relief valve unit 70 which is designed to exhaust from the upper portion of the air cylinder 13 an equivalent quantity of air with each stroke of the oil pump 23. This equivalent quantity of air under the air pressures maintained is exactly sufficient to compensate for the amount of oil supplied by one stroke of the oil pump 23.

Referring to Fig. 3, it may be seen that the relief valve unit 70 has a cylinder 71 which is provided with an apertured movable member 72. The member 72 is provided with a port 73 which is designed to connect the conduit 69 with conduit 75 when member 72 is in its lowermost position so as to let pass the exact quantity of air which it is desired to exhaust. The movable member 72 is urged to an upper position by a spring 74. It is connected by a rod 76 with the piston 77 of the supplementary air motor 78. The chamber of the supplementary air motor 78 is connected by conduit 79 with the air motor conduit 29 so that when the right hand end of the air motor 27 is exhausted, supplementary air motor 78 is also connected to the atmosphere. Thus the movable member 72 of the relief valve 70 is moved upward to disconnect the conduit 75 from the branch conduit 69. On the other hand when compressed air is supplied to the right hand end of the air motor 27 to cause a pumping stroke of the oil pump 23 air is also supplied to the supplementary air motor 78 to force the movable member 72 down to the position shown in which it is connected to the conduit 69 so that an additional quantity of air under pressure escapes from the cylinder 13 into the conduit 75.

Thus the equivalent quantity of air escapes

from the cylinder 13 at the same time that oil is being supplied to accumulator 11 by the pump 23. The conduit 75 is connected to a T 79. Branch conduit 81 leads from the T to the atmosphere. Branch conduit 82 also leads from the T to a connection with conduit 79. Interposed in conduit 75 is an adjustable throttle valve 83. Interposed in conduits 81 and 82 are shut-off valves 84 and 86 respectively. By means of the valve 83 I can control the amount of air which escapes on each stroke of the pump. Thus I can set the valve 83 so that on each stroke of the pump 23, an amount of air escapes equivalent in volume to the amount of oil being pumped in. I could set the valve 83 so that less air escapes than the volume of oil being supplied. With such a setting the pressure in cylinder 13 would gradually build up. I can set the valve 83 so that on each stroke a slightly greater volume of air escapes than the volume of oil being pumped in. In such case the deficiency in air for maintaining the pressure constant is supplied by air from the source 18 past the valve 19. One of the valves 84 and 86 is always closed. During operation, the other of these valves is maintained open. When the valve 84 is open, the air escaping from the conduit 69 escapes to the atmosphere. When the valve 86 is open, the escaping air is utilized as an aid in the operation of the pump 23.

Suitable gauges may be provided if desired. For instance, I provide a gauge 91 to show the oil pressure in the accumulator cylinder 11 and in the conduits 21 and 22 leading therefrom. I provide an air pressure gauge 92 to show the pressure in the air cylinder 13 and in the conduit 17 leading thereto. This gauge as shown may be associated with the pressure reducing valve 19. An air gauge also may be provided which may as shown at 93 be associated with the pressure reducing valve 33 to show the air pressure being supplied to the master valve 31 and through it to air motor 27.

The operation of the embodiment of my invention illustrated is as follows:

Assuming that the reservoir 24 is filled with oil and that accumulator 11 and oil lines 21 and 22 are empty and that all of the air lines are at atmospheric pressure. When air under pressure (as for instance at the pressure of about 150 lbs. per square inch) is introduced at the air supply 18, this air under pressure immediately flows through the conduit 17 to the top of the air cylinder 13 and fills that cylinder with air under pressure. Inasmuch as it flows through the reducing valve 19 the pressure in the air cylinder 13 will be that for which the reducing valve 19 is set as for example 100 p. s. i. Air under pressure also flows through the reducing valve 33 and thence into the master valve 31. Assuming that the master valve is in the position shown, it will flow through the entrance port 44, groove 48, the outlet port 49, the conduit 29 and into the right hand end of the air motor 27. This will move the air piston to the left carrying with it, the piston rod 30 and its extension 43 and causing the oil pump 23 to force to the accumulator 11 a measured quantity of oil. The lug 41 will strike the toggle pilot valve 36 opening the valve and allowing air to flow from the left hand end of the master valve 31 through the conduit 38 and the toggle valve 36 to the atmosphere. It must be here noted that because the pistons 12 and 14 and the piston rod 16 are in their lowered positions due to the absence of oil in the accumulator cylinder 11, the cam 64 is holding the valve

39 open and air may flow freely through the conduit 38. The evacuation of air from the left hand end of the master valve 31 allows the piston 46 to be moved to the left closing off the air pressure connection to the right hand end of the air motor 27 and connecting that portion of the air motor through the groove 55 with the exhaust port 56. At the same time the air conduit 32 supplies air under pressure through the groove 48 to the conduit 28 and to the left hand of the air motor 27. This reciprocates the piston in the air motor to the right moving the piston rod 30 and operating the oil pump to draw in a measured quantity of oil from the reservoir 24. As the piston rod 43 moves to the right the toggle valve 36 is allowed to close. Later the lug 42 contacts with the toggle valve 34 and that valve is opened allowing air to escape from the right hand end of the master valve 31 and the movable element 46 of the master valve 31 is again reciprocated to the position shown in the drawing with the result that the right hand end of the air motor 27 is connected to compressed air while the left hand end thereof is connected to exhaust. Each time that the right hand end of the air motor 27 is connected to compressed air the upper end of the supplementary motor 79 is also connected to compressed air and the piston therein is forced down to align the port 73 of the movable member 72 thereof with the conduits 69 and 75 to exhaust a quantity of compressed air.

As oil is pumped into the accumulator cylinder 11, piston 12 together with piston rod 16 and the piston 14 of the air cylinder 13 are raised. This continues until the projecting arm 57 strikes the upper lug 58 and raises the cam 64 to close the shut-off valve 39. With the shut-off valve 39 closed it becomes impossible for air trapped in the left hand end of the master valve 31 to escape, and consequently the master valve piston 46 cannot be moved to the left so that air under pressure cannot be supplied to the left hand end of the air motor 27. Reciprocation of the air motor 27 and of the oil pump 23 are stopped and no further oil is supplied to the accumulator cylinder 11.

Should the valve 39 fail to close for any reason, the pistons 12 and 14 and the piston rod 16 would continue upward until the cam 68 operated the safety valve 67. Operation of the safety valve 67 exhausts the right hand end of the master valve 31 so that there is no force effective to move the master valve piston 46 to the left. In such case, air under pressure cannot be supplied to the left hand end of the air motor 27 with the result that no further oil can be pumped.

I wish to emphasize again that by my metering relief valve unit 70 I remove from the air cylinder 13 the equivalent quantity of air needed to balance the amount of oil supplied to the lower end of the accumulator cylinder 11 so that the air pressure acting on the oil in the accumulator cylinder 11 remains always constant at the exact pressure desired.

It is to be understood that the above described embodiments of my invention are for the purpose of illustration only and various changes may be made therein without departing from the spirit and scope of my invention.

I claim:

1. A system for maintaining liquid under pressure comprising a liquid pressure cylinder; a gaseous fluid pressure cylinder cooperating therewith; means for pumping liquid to the liquid cylinder; and means operated on each stroke of

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the pumping means for releasing a portion of the gaseous fluid from said gaseous fluid cylinder.

2. A system for maintaining liquid under pressure comprising a liquid pressure cylinder; a piston therein; a gaseous fluid pressure cylinder; a piston in the fluid pressure cylinder, said latter piston being directly connected with the piston in the liquid pressure cylinder; means for pumping liquid to the liquid cylinder; and means operated on each stroke of the pumping means for releasing a portion of the gaseous fluid from said gaseous fluid cylinder.

3. Apparatus for supplying liquid under pressure comprising a liquid pressure cylinder, an air pressure cylinder cooperating therewith; means comprising a reciprocating air motor for pumping liquid to said liquid cylinder; means for supplying air under pressure to said air cylinder and to said air motor; valves controlling said air supply means; and means for releasing air from said air cylinder on each stroke of the air motor.

4. Apparatus for supplying liquid under pressure comprising a liquid pressure cylinder, a piston therein, an air pressure cylinder; a piston therein connected to the piston in the liquid pressure cylinder; means comprising a reciprocating air motor for pumping liquid to said liquid cylinder; means for supplying air under pressure to said air cylinder and to said air motor; valves controlling said air supplying means; and means for releasing air from said air cylinder on each stroke of the air motor.

5. A system for supplying liquid under pressure comprising a liquid cylinder; a liquid piston in said cylinder; a gaseous fluid cylinder; a piston in said gaseous fluid cylinder, a piston rod connecting said two pistons; means comprising a gaseous fluid motor and a liquid pump operated thereby for supplying liquid to said liquid cylinder below said liquid piston; conduits for supplying gaseous fluid to said gaseous fluid cylinder and said gaseous fluid motor; and means for relieving said gaseous fluid cylinder of a portion of the gaseous fluid therein as liquid is pumped into said liquid cylinder comprising a valve connected to said gaseous fluid cylinder and to the atmosphere, a supplementary gaseous fluid motor for controlling said valve, and a gaseous fluid conduit connecting said pump operating gaseous fluid motor and said supplementary gaseous fluid motor for operating said motors synchronously.

6. A system for maintaining liquid under pressure comprising a gaseous liquid pressure cylinder; a fluid pressure cylinder cooperating therewith; means for pumping liquid to the liquid cylinder; means including a conduit and pressure reducing valve contained therein for supplying gaseous fluid under predetermined pressure to said gaseous fluid pressure cylinder; and means operated on each stroke of the pumping means for releasing a portion of the gaseous fluid from said gaseous fluid cylinder.

7. A system for supplying liquid under pressure comprising a liquid cylinder; a piston in said cylinder; a gaseous fluid cylinder; a piston in said gaseous fluid cylinder, a piston rod connecting said two pistons; means comprising a gaseous fluid motor and a liquid pump operated thereby for supplying liquid to said liquid cylinder below said liquid piston; conduits for supplying gaseous fluid to said fluid cylinder and said fluid motor; a pressure relief valve associated with one of said supply conduits for limiting the pressure of gaseous fluid supplied there-

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to; and means for relieving said gaseous fluid cylinder of a portion of the gaseous fluid therein as liquid is pumped into said liquid cylinder comprising a valve connected to said gaseous fluid cylinder and to the atmosphere, a supplementary gaseous fluid motor for controlling said valve, and a fluid conduit connecting said pump operating fluid motor and said supplementary fluid motor for operating said motors synchronously.

8. A system of supplying a fluid under pressure comprising a liquid cylinder; a piston in said cylinder; a gaseous fluid cylinder; a piston in said second mentioned cylinder; a piston rod connecting said pistons; a pump for supplying liquid to said first cylinder; a gaseous fluid motor operating said pump; a master valve controlling the operation of said fluid motor; a first fluid conduit connected to one end of said master valve; a valve connected to said first fluid conduit and arranged to control said master valve; a second valve; and a second fluid conduit connecting said second valve with the end of said master valve opposite to its connection with the first fluid conduit for the control of said master valve.

9. A system of supplying a liquid under pressure comprising a liquid cylinder; a piston in said liquid cylinder; a gaseous fluid cylinder; a piston in said gaseous fluid cylinder; a piston rod connecting said pistons; a liquid pump for supplying liquid to said liquid cylinder; a gaseous fluid motor for operating said liquid pump; a master valve for controlling the operation of said fluid motor; a fluid conduit connected to one end of said master valve; an exhaust valve connected to said conduit and arranged to relieve pressure at times from said end of the master valve; a valve interposed in said conduit and operated by movement of the piston rod; a second exhaust valve; and a second conduit connecting said second exhaust valve with the opposite end of said master valve.

10. A system of supplying a liquid under pressure comprising a liquid cylinder; a piston in said liquid cylinder; a gaseous fluid cylinder; a piston in said gaseous fluid cylinder; a piston rod connecting said pistons; a liquid pump for supplying liquid to said liquid cylinder; a gaseous fluid motor operating said liquid pump; a master valve controlling the operation of said fluid motor; a first fluid conduit connected to one end of said master valve; a relief valve connected to said first fluid conduit and arranged to relieve pressure at times from said end of the master valve; a valve interposed in said first fluid conduit and operated by movement of the piston rod; a second relief valve; a second fluid conduit connecting said second relief valve with the end of said master valve opposite to its connection with the first fluid conduit; a safety valve operated by movement of said piston rod; and a third fluid conduit connected to said safety valve and to said second fluid conduit.

11. An apparatus for supplying oil under pressure comprising an oil accumulator cylinder; an oil piston arranged therein; an air cylinder associated with said oil accumulator cylinder; a piston in said air cylinder; a piston rod connecting said air cylinder piston and said oil piston; a source of air supply connected to said air cylinder; a pressure reducing valve positioned in the connection between said source of air supply and said air cylinder; an oil pump; means for operating said oil pump comprising a reciprocating air motor; a master valve for controlling said air motor; a pair of toggle valves for controlling

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said master valve; conduits connecting said toggle valves and the two ends of said master valve respectively; connections between said master valve and the opposite ends of said air motor; and means comprising a relief valve, a piston for controlling said relief valve, a cylinder therefor, and a conduit connecting one end of said air motor and said last named cylinder, for releasing air from said air cylinder on each stroke of said air motor.

12. An apparatus for supplying oil under pressure comprising an oil accumulator cylinder; an oil piston arranged therein; an air cylinder associated with said oil accumulator cylinder; a piston in said air cylinder; a piston rod connecting said air cylinder piston and said oil piston; a source of air supply connected to said air cylinder; a pressure reducing valve positioned in the

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connection between said source of air supply and said air cylinder; an oil pump; means for operating said oil pump comprising an air motor; a master valve for controlling said air motor; conduits connecting said toggle valves and the two ends of said master valve respectively; connections between said master valve and the opposite ends of said air motor; means comprising a relief valve for releasing air from said air cylinder on each stroke of said air motor; a piston controlling said relief valve; a cylinder therefor; a conduit connecting one end of said air motor and said last named cylinder; and a control valve operated by the movement of the piston rod for controlling the operation of said master valve.

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No references cited.