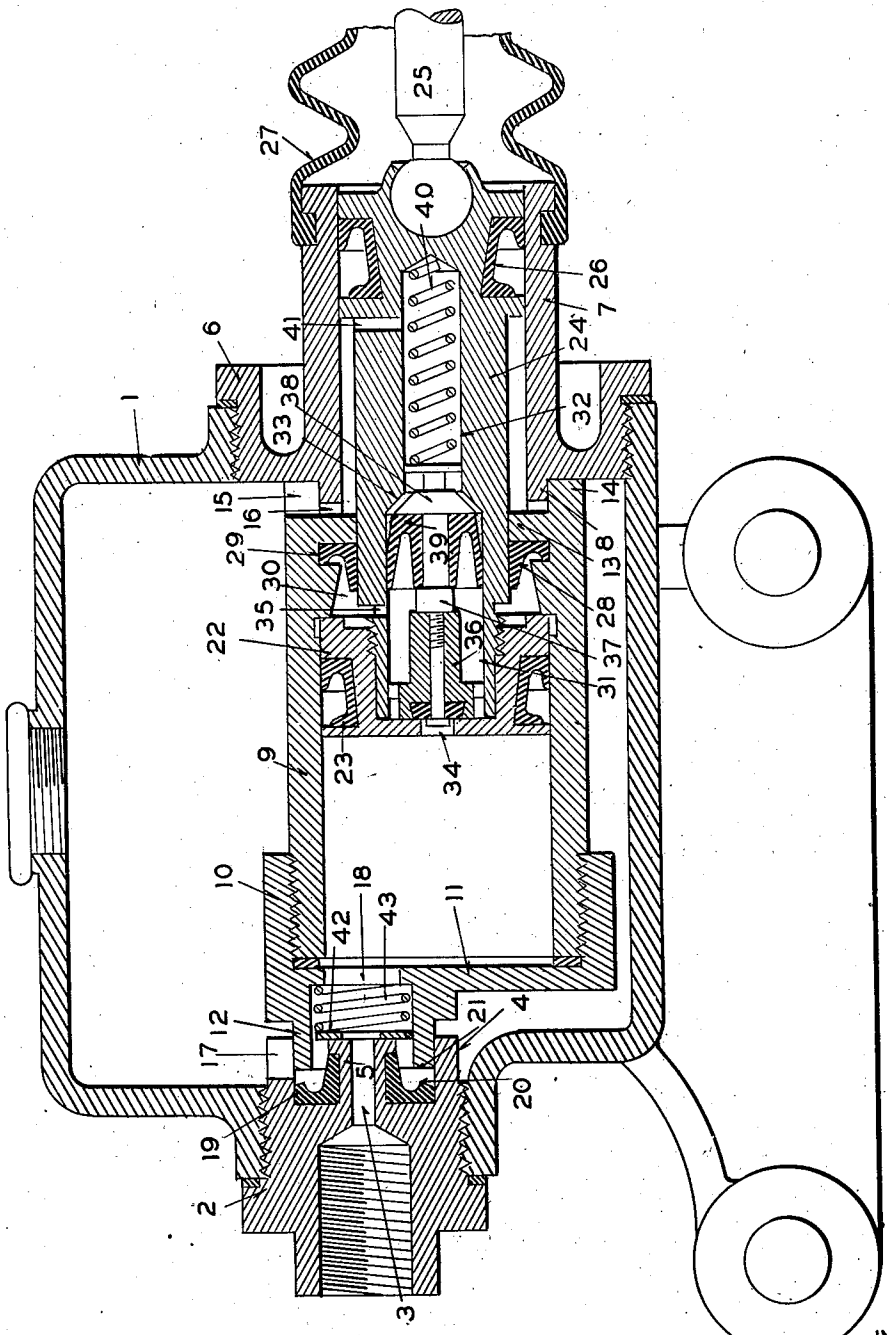
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COMPOUND MASTER CYLINDER

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COMPOUND MASTER CYLINDER

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My invention relates to master cylinder devices for fluid pressure actuated systems and more particularly to a compound master cylinder whereby the pressure created may be increased without proportionally greater increase in the applied operating force.

One of the objects of my invention is to provide an improved compound master cylinder wherein the transition from the low pressure producing means to the high pressure producing means may be effected in a smooth manner.

Another object of my invention is to produce a compound master cylinder wherein efficient compensation between the pressure producing system and the reservoir is permitted without employing compensating portholes which must be passed by the sealing cups.

Among other objects of my invention is to produce a compound master cylinder which can be economically manufactured and which will be simple in construction and efficient in operation.

Still other objects will become apparent from the following description taken in connection with the accompanying drawing in which the single figure is a sectional view of a compound master cylinder embodying my invention and showing the parts in their inoperative positions.

Referring to the single figure in detail, 1 indicates a reservoir casing provided with a threaded plug 2 at its forward end and having an outlet passage 3 therein to which is connected the usual conduit leading to the fluid motor or other device to be actuated by fluid pressure. The inner end of the plug is provided with a cylindrical flange 4 and a central projection 5 through which the outlet passage extends. At the rear end of the casing there is also provided a threaded member 6 having a cylindrical extension 7 and an annular flange 8 extending into the interior of the casing.

Within the reservoir casing is positioned a cylinder 9 mounted for limited reciprocable movement. The forward end of this cylinder has threaded thereon a member 10 forming an end wall 11 for the cylinder. The member 10 is provided with a cylindrical extension 12 of smaller diameter than cylinder 9 which is slidably received in flange 4 of the forward plug 2 to thus constitute a support for the front end of cylinder 9. The rear end of the cylinder is provided with an inwardly extending end wall 13 and an annular flange 14 for receiving the flange 8 on the member 6 to thus constitute a support for the rear end of the cylinder. The flange 14 is provided with slots 15 and flange 8 with slots 16 to thus place the interior of the cylindrical extension 7 in constant communication with the interior of the reservoir casing.

The flange 4 is formed with one or more slots 17 which permit the reservoir to communicate with the outlet 3 and with the interior of cylinder 9 through the cylindrical extension 12 and an opening 18 in wall 11 when the cylinder 9 is in its rearmost position shown. Positioned in the annular space between flange 4 and extension 5 of plug 2 is a sealing member 19 of rubber or like material having an annular ridge 20 for cooperation with the end surface 21 on extension 12. It is thus seen that when cylinder 9 is moved forwardly, slot 17 will be closed and the sealing member 19 will be engaged and compressed to thereby prevent any communication between cylinder 9 or outlet 3 and the reservoir.

Positioned within cylinder 9 for reciprocation is a piston 22 having a sealing cup 23. The piston is threaded to the inner end of a plunger 24 passing through the cylindrical extension 7 and the rear wall 13 of cylinder 9. A piston rod 25 is connected to the rear end of the plunger for reciprocating it and piston 22. A sealing cup 26 seals the rear end of the plunger and the extension 7 and a dust boot 27 is provided between the piston rod and the end of the extension. A sealing cup 28 is also carried in a groove 29 at the rear end of cylinder 9 adjacent wall 13 for preventing fluid from escaping past the wall and plunger from chamber 30 at the rear of piston 22.

The plunger is provided with communicating stepped bores 31 and 32 at the juncture of which is a valve seat 33. The bore 31 communicates with cylinder 9 ahead of piston 22 by an opening 34 (smaller than the diameter of bore 31) through the piston and with chamber 30 by a passage 35. Within the bore is a valve element 36 carried by a valve rod 37 and cooperating with the piston 22 to control passage 34. The rear of the valve rod carries a second valve element 38 for cooperation with the valve seat 33 and associated with this valve element is a cup 39 for preventing fluid from flowing from bore 31 to bore 32 but capable of collapsing sufficiently that fluid can flow in the opposite direction. A spring 40 in bore 32 normally biases the valve rod so that valve element 36 closes opening 34 and valve element 38 is unseated. A passage 41 constantly places bore 32 in communication with the cylindrical extension 7 and the reservoir by way of slots 15 and 16.

The friction between sealing cup 23 and cylinder 9 and the friction between sealing cup 28

and the plunger insures that cylinder 9 will be moved with the piston and plunger when they are initially moved. Thus the valve means at the forward end of cylinder 9 can be closed before relative movement between the piston and cylinder takes place. In order to prevent any rapid flow of fluid from cylinder 9 to the reservoir in the event the piston should be moved quickly and thus have some relative movement with respect to the cylinder before the valve means at the forward end is closed, there is provided a washer 42 of slightly less diameter than the internal diameter of the cylindrical extension 12. A weak spring 43 maintains this washer in engagement with the end of projection 5. Thus it is seen that the washer restricts flow from cylinder 9 to the reservoir when the valve means is open. Fluid may flow from the reservoir to cylinder 9 without appreciable restriction as the washer can be moved away from the end of the projection by compressing weak spring 43.

Referring to the operation of the master cylinder device, the parts will be in the positions shown in the figure when the master cylinder is inoperative. Under these conditions the reservoir will be filled with fluid as will also the cylinder 9 ahead of piston 22 and chamber 30. The bore 32 will also be filled with fluid since it is in constant communication with the reservoir. The cylinder 9, as well as the outlet passage, will be in communication with the reservoir to thus permit compensation for any expansion and contraction of the fluid since the surface 21 on the extension 12 will be disengaged from the sealing member 19 and slot 17 uncovered. It is also to be noted that in the inoperative position of the master cylinder, the valve element 36 closes the opening 34 and the valve element 38 is off the valve seat 33. If the fluid in chamber 30 contracts, additional fluid can flow thereto from the reservoir by passing sealing cup 39. Any expansion of the fluid in chamber 30 will be compensated for by the opening of the valve element 36 by the pressure of the fluid in chamber 30 acting on cup 39. It is to be noted that the cross-sectional area of cup 39 is considerably greater than the cross-sectional area of valve element 36 which is subject to fluid pressure tending to hold it closed.

When the piston rod 25 is moved to the left to operate the master cylinder, piston 22 and plunger 24 are simultaneously moved forwardly therewith. The friction between the cup 23 and the cylinder wall and the friction between cup 28 and the plunger will also cause cylinder 9 to move forwardly with piston 22 and the plunger until the surface 21 on extension 12 engages the ridge 20 of the sealing member 19. The reservoir will now be cut off from communication with the portion of cylinder 9 ahead of piston 22 and also with the outlet passage 3. As piston 22 is caused to continue to move forwardly, it will have relative movement with cylinder 9 and pressure will be developed in cylinder 9 whereby fluid under pressure will be forced out of the outlet passage to operate the fluid motors which are connected by a suitable conduit with said outlet passage. As soon as pressure is developed in cylinder 9 ahead of piston 22, it will act upon the wall 11 and produce a force tending to hold surface 21 in engagement with the sealing member 19. The sealing member 19 will not be excessively compressed due to the engagement of member 10 with the flange 4. This force will increase as the pressure in cylinder 9 increases and, therefore, surface 21 will be held against the sealing member under all conditions.

If the piston rod 25 should happen to be moved quickly from its inoperative position shown in the figure, the inertia of the cylinder may result in piston 22 having relative movement with the cylinder before surface 21 on extension 12 engages the sealing member 19 to cut off communication with the reservoir. This relative movement, however, will be very slight since as the piston moves relatively to the cylinder, pressure will be immediately developed in the portion of the cylinder ahead of the piston due to the fact that washer 42 will restrict flow of fluid to the reservoir. The pressure developed in cylinder 9 ahead of the piston will act upon the end wall 11 and immediately cause the cylinder to move forwardly so that the surface 21 will engage the sealing member 19 to cut off communication with the reservoir.

As piston 22 moves forwardly after communication with the reservoir is cut off and fluid pressure is being developed, chamber 30 at the rear of piston 22 will increase in volume and a sub-atmospheric pressure will be developed. This will result in fluid flowing from the bore 32 in the plunger past the open valve element 38 and the periphery of the sealing element 39 and into the chamber 30. It is thus seen that this chamber, although increasing in volume, will continue to be filled with fluid.

When the pressure being developed by piston 22 reaches a predetermined value which will be determined by the strength of spring 40 and the area of opening 34, valve element 36 will be forced off its seat to thus place the portion of the cylinder ahead of piston 22 in communication with chamber 30. The pressures of the fluid in the cylinder and chamber 30 will now be equalized. The pressure in chamber 30 will now be effective on the sealing cup 39 and the sealing cup and valve element 38 will be quickly forced rearwardly against the action of spring 40 so as to cause the valve element 38 to become seated on seat 33. Due to the larger cross-sectional area of cup 39, the pressure in chamber 30 will now maintain valve element 36 unseated and also prevent it from fluttering. The pressure in chamber 30 will continue to maintain the valve element 38 seated so that valve element 36 will be held unseated.

With the valve element 36 held open, continued movement of the piston rod 25 will now result in plunger 24 developing pressure in the cylinder. Pressure will no longer be developed by piston 22 since fluid can flow past the piston. Since plunger 24 has a cross-sectional area effective to develop pressure which is less than the cross-sectional area of piston 22, continued movement of the piston rod will develop pressure at a higher ratio. With a smaller area becoming effective to develop pressure, less manual force will be necessary to increase the fluid pressure being developed than would be the case if the piston 22 continued to develop the pressure alone.

When the pressure is being developed by plunger 24, the fluid pressure in chamber 30 will be effective on the rear wall 13 of the cylinder. However, since the area of this wall is much less than the area of the forward wall 11, there will continue to be a resultant force tending to hold the surface 21 on extension 12 engaged with the sealing member 19.

When it is desired to release the developed pressure, piston rod 25 is permitted to be retract-

ed. This will result in piston 22 and plunger 24 moving rearwardly under the force of the developed pressure. The valve 36 will remain open and the valve means at the forward end of cylinder 9 will remain closed. When piston 22 reaches its retracted position at the rear end of the cylinder, the fluid pressure in cylinder 9 acting on piston 22 will cause the cylinder to move rearwardly and disengage the surface 21 from the sealing member 19, thereby opening slot 17 so that the pressure can be relieved and any excess fluid flow into the reservoir. The movement of the cylinder 9 rearwardly to open the valve means at the forward end of the cylinder is brought about by a differential force acting on cylinder 9 through piston 22 which, it is noted, is engaged with a shoulder at the rear end of the cylinder. As soon as the valve means at the forward end of the cylinder is opened to relieve pressure in the cylinder, the valve means 36 will be closed under the action of the spring 40. The parts will then again be in their normally inoperative positions as shown in the figure. The cylinder 9, as previously stated, will not be moved rearwardly to open the valve means at the forward end of the cylinder until piston 22 reaches its retracted position. This is true as long as there is fluid pressure in the cylinder during the retracting movement of piston 22 and plunger 24, conditions which normally prevail. However, if piston 22 should be returned at a more rapid rate than fluid is returned through the outlet passage (due to the pull of a spring on the brake pedal or a restriction in a fluid line) the fluid pressure in cylinder 9 will drop below atmospheric pressure. Then under such conditions cylinder 9 will be pulled rearwardly by the friction of the cup 23, thus opening the valve means at the forward end of the cylinder and permitting fluid to flow from the reservoir. These conditions, however, will not normally be present as the fluid under pressure will usually be returned from the motors faster than the return movement of the piston 22, thus insuring that fluid under pressure will be maintained in cylinder 9 until the piston and plunger reach their retracted positions. If any fluid should be trapped in chamber 30, due to the closing of the valve 36 as a result of a rapid fall in pressure in cylinder 9, the continued return movement of piston 22 will result in pressure again rising in chamber 30 and thus again opening the valve so as to relieve this pressure.

If it is desired to relieve only part of the pressure developed then the piston rod need only be partially retracted. Since normally the valve means at the forward end of cylinder 9 remains closed until the piston reaches its retracted position, it is seen that a partial retraction of piston 22 and plunger 24 will permit a decrease in the previously developed pressure.

When the master cylinder is employed in bleeding the system with which it is associated, piston 22 will be moved forwardly and force fluid out of the system after the valve means at the forward end of the cylinder is closed due to the forward movement of cylinder 9 with the initial movement of piston 22. When the piston is initially retracted, the friction of the cup will pull the cylinder rearwardly and open the valve means to permit fluid to flow from the reservoir into the cylinder to replace the fluid which has been forced out through a valve in the system which has been opened to permit the bleeding. Fluid trapped in chamber 30 will open valve 36 and pass piston 22 during its return movement.

It is to be noted from the structure described that there is not present any compensating ports which are uncovered by a sealing cup when a piston is returned to its retracted position as is the usual present practice. By eliminating the compensating port, the life of the sealing cup is greatly increased since it will not be cut by the porthole. Consequently, the efficiency of the cup is greatly increased. Although the compensating ports have been eliminated, interchange of fluid between the reservoir and cylinder is nevertheless permitted to compensate for contraction and expansion of the fluid when the master cylinder is inoperative. Also, by means of the construction described the change-over from the low pressure producing means to the high pressure producing means will be smooth and without shock to the operator.

Being aware of the possibility of modifications in the particular structure herein described without departing from the fundamental principles of my invention, I do not intend that its scope be limited except as set forth by the appended claims.

Having fully described my invention, what I claim as new and desire to secure by Letters Patent of the United States is:

1. In fluid pressure apparatus, a support, a cylinder mounted on the support for limited reciprocable movement, means forming an outlet passage for the cylinder, a piston in said cylinder, a reservoir, means comprising valve means associated with the outlet passage and controlled by the reciprocable movement of the cylinder for controlling communication between the reservoir and both the cylinder and the outlet passage, means for moving the cylinder forward to close the valve means when the piston is moved forward, a second piston of smaller cross-sectional area than the first piston, means for connecting the pistons together for simultaneous movement at all times, means for moving the pistons, and means comprising valve means carried by the pistons and automatically operative upon the development of a predetermined pressure by the first piston for rendering said first piston ineffective to develop pressure and permitting additional pressure to be developed by the second piston.

2. In a fluid power transmitting system comprising a conduit for supplying fluid under pressure and a fluid reservoir, a fluid pressure producing device comprising a reciprocable cylinder and a reciprocable piston therein having a fluid outlet port in communication with the fluid supply conduit and said fluid supply conduit and cylinder port being normally in communication with the fluid reservoir, valve means controlled by the reciprocable movement of the cylinder, means functioning when the piston moves forwardly for moving the cylinder forwardly to close the valve means and thereby prevent flow of fluid to the reservoir, said means permitting relative movement between the piston and the cylinder after the valve means is closed, means comprising valve means carried by the piston for automatically rendering said piston inoperative upon the creation of a predetermined pressure in the cylinder ahead of the piston and for placing the portion of the cylinder at the rear of the piston in communication with the outlet, means for continuing to apply pressure to the fluid after said piston becomes inoperative and

comprising a second piston having a smaller effective cross-sectional area than the first piston, and means for causing the valve means to be opened when the first piston is retracted.

3. In fluid pressure producing apparatus, a reservoir, a cylinder having a rear wall and being mounted for limited reciprocable movement, an outlet for the cylinder, valve means controlled by the reciprocable movement of the cylinder for controlling communication between the reservoir and the cylinder, means for developing a low pressure and comprising a piston reciprocable in said cylinder, means for closing said valve means by a movement of the cylinder when the piston is moved forwardly, other valve means carried by the piston and operable upon the development of a predetermined pressure ahead of said piston for placing the chamber at the rear of the piston in communication with the portion of the cylinder ahead of the piston, and means comprising a plunger at the rear of the first named piston for developing a high fluid pressure when said last named valve means is opened, said plunger being smaller than the cylinder and extending through the rear wall thereof, packing means for the plunger carried by the rear wall of the cylinder, and means for moving said piston and plunger simultaneously in a pressure producing direction.

4. In fluid pressure producing apparatus, a cylinder having a rear wall, an outlet for the cylinder, a piston reciprocable in said cylinder, a plunger secured to said piston for simultaneous movement therewith and extending rearwardly thereof through the rear wall of the cylinder, said plunger being of smaller diameter than the piston and cylinder, packing means for the plunger so positioned at the rear end of the cylinder as to permit the plunger to have relative movement thereto, means comprising a valve element carried by the piston for automatically rendering said piston inoperative upon the creation of a predetermined pressure in the cylinder ahead of the piston and for placing the portion of the cylinder at the rear of the piston in communication with the outlet, means for reciprocating the piston and plunger, valve means for permitting fluid to flow to the space at the rear of the piston when said piston is developing pressure, and means for closing the last named valve means by a movement of the valve element to its open position.

5. In fluid pressure producing apparatus, a reservoir, a cylinder reciprocable therein, an outlet for the cylinder, valve means controlled by the reciprocation of the cylinder for controlling communication between the reservoir and both the outlet and the cylinder, said valve means when closed permitting the cylinder to be in communication only with the outlet, a piston in the cylinder, a chamber at the rear of the piston, a second piston of smaller diameter than the first secured to said first piston and capable of applying pressure to fluid in the chamber, a conduit through the first piston for placing the chamber at the rear thereof in communication with the cylinder ahead of the piston, valve means for said conduit adapted to be opened when the pressure in the cylinder ahead of the piston reaches a predetermined value, means for reciprocating the pistons, and means for moving the cylinder forwardly with the pistons to thereby close the first named valve means when said pistons are initially moved from their inoperative positions.

6. In fluid pressure producing apparatus, a reservoir, a cylinder reciprocable therein, an outlet for the cylinder, valve means controlled by the reciprocation of the cylinder for controlling communication between the reservoir and both the outlet and the cylinder, said valve means when closed permitting the cylinder to be in communication with the outlet only, a piston in the cylinder, a chamber at the rear of the piston, a second piston at the rear of the first piston and reciprocable with the first piston to apply pressure to fluid in the chamber, said pistons being of different diameters, a conduit through the first piston for placing the cylinder thereahead in communication with the chamber, valve means for controlling the conduit, means for reciprocating the pistons, means for moving the cylinder forwardly with the pistons to thereby close the first named valve means when said pistons are initially moved from their inoperative positions, and means comprising valve means carried by the second piston for permitting fluid to flow from the reservoir into the chamber at the rear of the first piston during the time said first piston is effective to develop pressure.

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