April 4, 1950 C. E. ADAMS ET AL 2,502,547

HYDRAULIC APPARATUS

Filed May 11, 1948 3 Sheets-Sheet 1

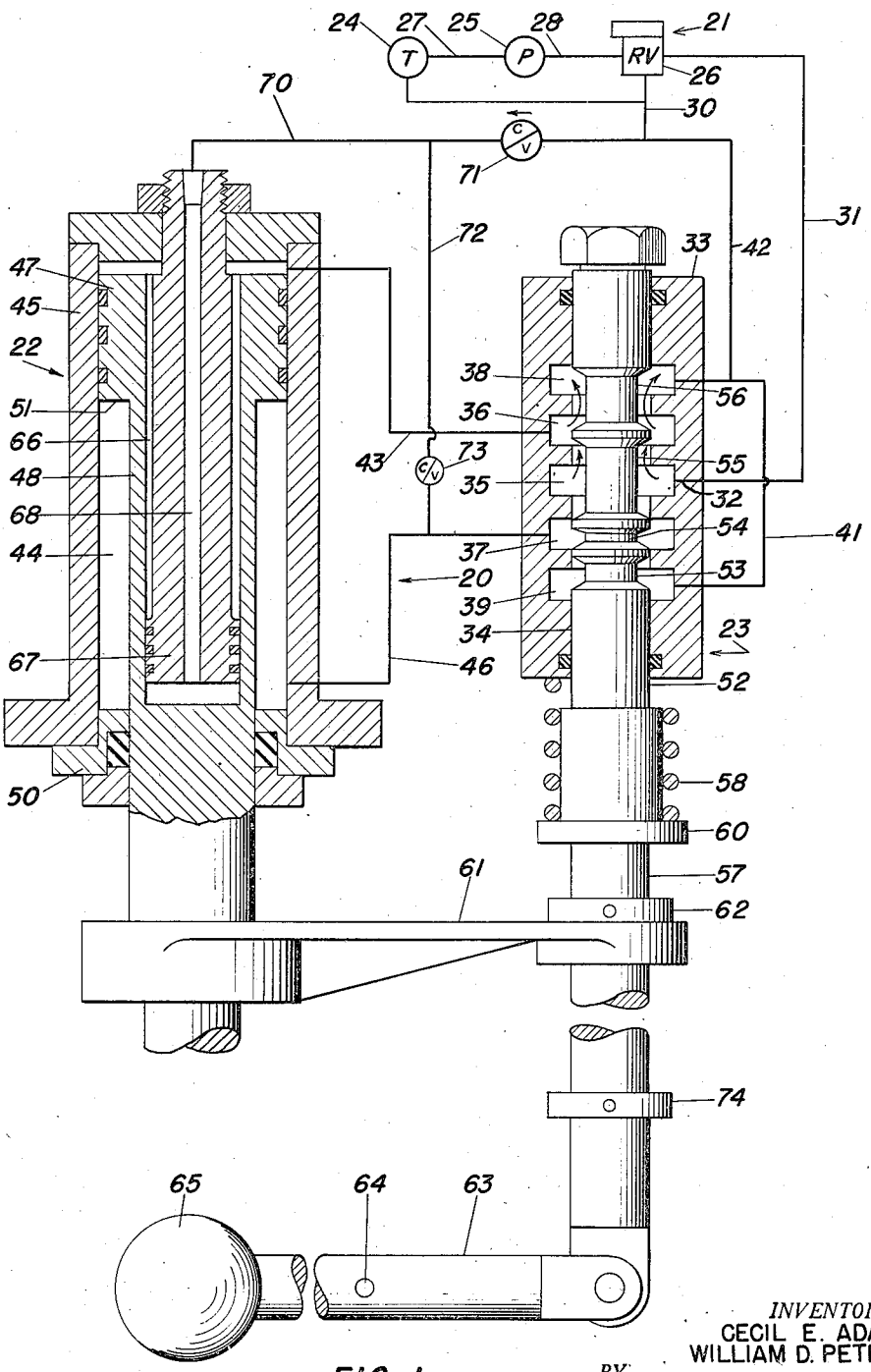


FIG. 1

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HYDRAULIC APPARATUS

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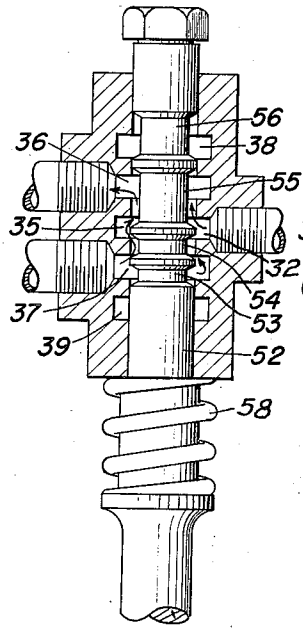


FIG. 2

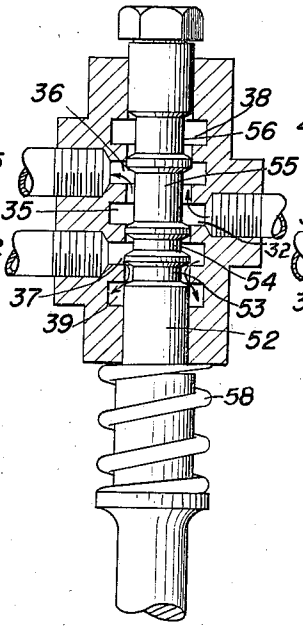


FIG. 3

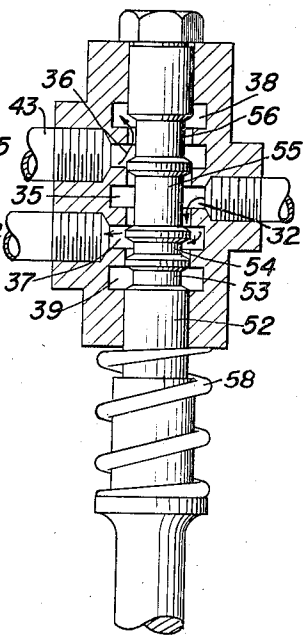


FIG. 4

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Filed May 11, 1948 3 Sheets-Sheet 3

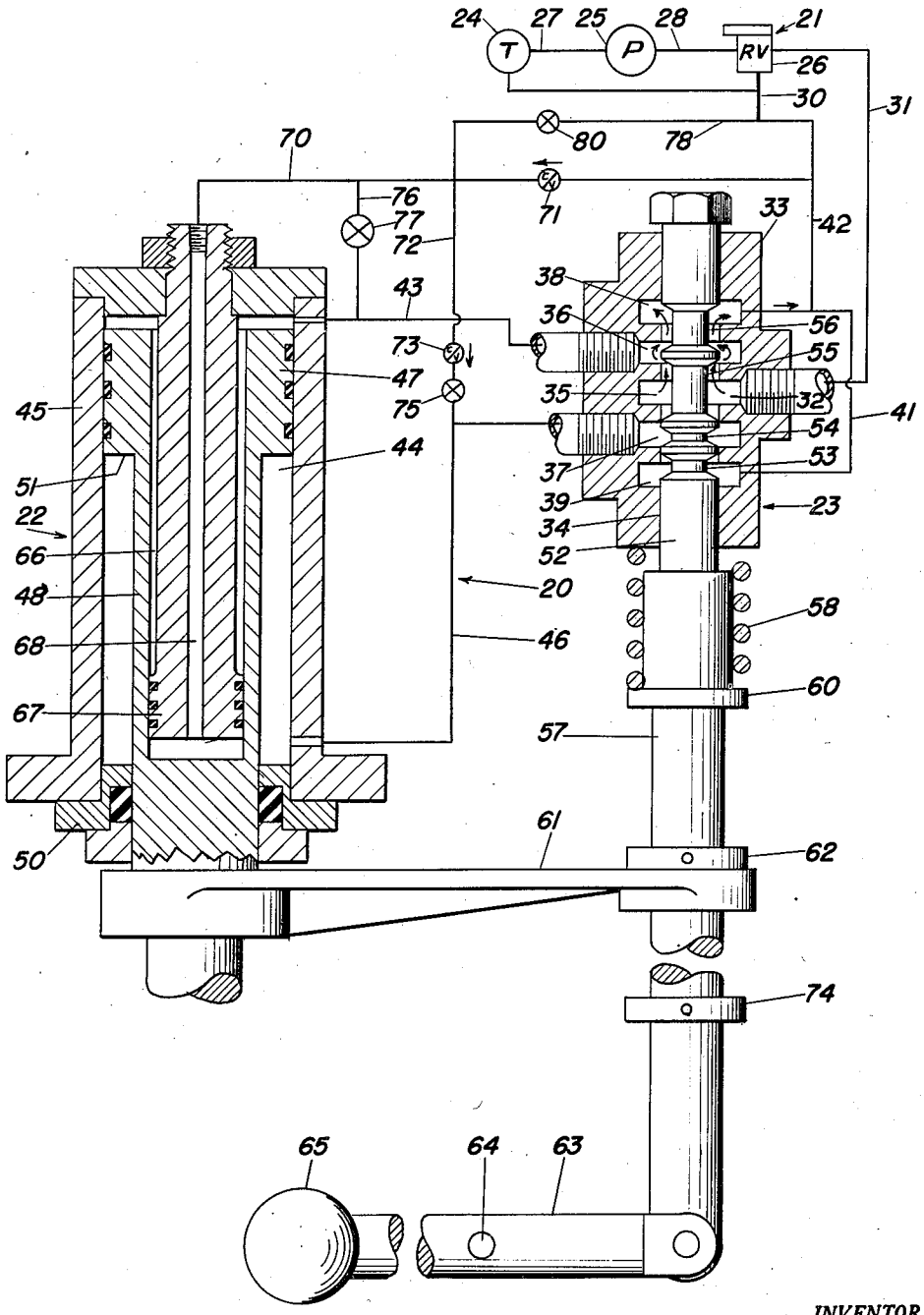


FIG. 5

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HYDRAULIC APPARATUS

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Application May 11, 1948, Serial No. 26,318

11 Claims. (Cl. 121—38)

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This invention relates generally to hydraulic apparatus and is particularly directed to hydraulic presses or other hydraulic equipment having a fluid motor of the piston and cylinder type and an element, such as a ram, operated by the piston of the fluid motor.

An object of the invention is to provide a hydraulic system having a fluid motor of the piston and cylinder type, a source of fluid pressure and a control mechanism for governing the flow of the pressure from the source to the fluid motor to cause rapid movement of the piston of the motor in both directions, the control mechanism being operable at any point in the motion of the piston in one direction to increase the force exerted by the piston, this increase in force being accompanied by a decrease in the rate of motion of the piston.

Another object of the invention is to provide a hydraulic system for hydraulic apparatus having a fluid motor of the piston and cylinder type, the motor being so constructed that it will include a plurality of piston surfaces of differing areas, the system including control mechanism by means of which fluid displaced by certain of the piston surfaces will be combined with fluid applied to other piston surfaces to decrease the effective areas of the piston thus increasing the rate of movement thereof.

Another object of the invention is to provide a mechanism of the character specified in the preceding paragraph and to so construct a control mechanism therefor that the combination of fluid displaced between certain piston surfaces may be interrupted, the displaced fluid then being directed to exhaust whereby the effective area of the piston surface to which fluid is being applied will be increased and thus increase the force exerted by the piston.

A still further object of the invention is to provide a fluid motor having a casing formed with a cylinder for the reception of a piston and ram, the piston and ram also being formed with a second cylinder for the reception of a second piston which is rigidly carried by the casing, fluid conducting and control mechanism being provided so that fluid under pressure may be applied to the first piston to effect movement thereof, the fluid displaced by such piston during movement being combined with fluid applied to effect its movement whereby the piston will be caused to move at a rapid rate, the second piston operating in the second cylinder serving as a pump during movement of the first piston in one direction to draw fluid from a suitable source

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and on the return movement of the first piston to combine this fluid with fluid from the pressure source applied to the first piston to increase the rate of return movement of the piston; by the telescopic arrangement of the pistons a high degree of compactness in the fluid motor will be secured.

Another object of the invention is to provide a hydraulic system having a source of fluid pressure, a fluid motor of the type mentioned in the preceding paragraph, a control valve mechanism between the fluid motor and the pressure source and conduits connecting the pressure source with the control valve mechanism and the latter mechanism with certain portions of the fluid motor, conduits also being provided to connect certain portions of the cylinders of the fluid motor to combine fluid exhausted by the pistons with fluid applied by the pressure source to decrease the effective areas of the pistons and cause rapid movement thereof, valved conduits also being provided so that the hydraulic system may be converted into a conventional system at will.

Further objects and advantages of the present invention 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 view of a hydraulic system formed in accordance with the present invention; a fluid motor and control mechanism therefor included in said system being shown in vertical section.

Figs. 2, 3 and 4 are vertical sectional views of the control valve mechanism showing the movable elements thereof, in different operative positions.

Fig. 5 is a diagrammatic view of a modified hydraulic system, also including the features of the present invention, by which the operation of the hydraulic device may be modified.

Referring more particularly to the drawings the hydraulic system shown in Fig. 1 is designated generally by the numeral 20. In general the hydraulic system 20 includes a pressure source 21, a fluid motor 22 and control mechanism for said motor indicated generally by the numeral 23. The fluid source has been indicated only diagrammatically and includes a reservoir 24, a power operated pump 25 and a relief valve 26, this valve being of any desirable construction. Fluid conductors 27 and 28 extend between the reservoir and pump and between the pump and relief valve respectively. A return line 30 ex-

tends from the outlet of the relief valve back to the reservoir 24 to return fluid thereto when the relief valve spills due to the pressure in line 28 approaching a predetermined maximum. A fluid line 31 extends from the relief valve to the inlet port 32 of the control valve mechanism 23, the port 32 being formed in the body 33 of the valve mechanism.

This body 33 includes a vertical chamber 34 and a plurality of annular grooves 35 to 39, inclusive, spaced longitudinally of the body and communicating with the chamber 34, groove 35 also communicating with the port 32 and hereinafter being termed the inlet, or, pressure port. Grooves 36 and 37 are disposed at opposite sides of the groove 35 and are hereinafter designated as top and bottom cylinder ports. While grooves 38 and 39 are disposed between the top and bottom cylinder ports and the ends of the body 33; grooves 38 and 39 are designated as exhaust ports. These grooves 38 and 39 are connected by a line 41 which in turn is connected by a branch line 32 with reservoir 24.

The top cylinder port 36 is connected by a line 43 with the upper end of a cylinder 44 which is formed in the casing 45 of the fluid motor 22, the bottom cylinder port 37 being connected by line 46 with the lower end of the cylinder 44. Cylinder 44 receives for sliding movement, a piston 47, which has a ram 48 depending therefrom, this ram extending through a cover 50 employed to close the open lower end of the cylinder 44. The diameter of the ram 48 is smaller than the diameter of the piston 47, thus providing a downwardly facing surface 51, which is exposed to fluid supplied to the lower end of the power cylinder. When pump 25 is operated fluid will be drawn from the reservoir 24 and discharged through lines 28 and 31 to the inlet port 35 of the control valve mechanism. The application of the fluid from the pump to the fluid motor or power cylinder is controlled by a spool member 52, which is disposed for movement in the chamber 34.

The spool 52 in this instance is provided with four longitudinally spaced grooves 53 to 56, inclusive. These grooves serve to connect certain of the grooves 35 to 39 in various positions of adjustment of the spool 52. In the position shown in Fig. 1, spool 52 will direct the fluid supplied by the pressure source to the inlet port 32, to exhaust and permit the fluid motor to remain idle with the piston 47 retracted in the cylinder 44. The fluid will flow in the direction of the arrows to Fig. 1 from groove 35 to groove 36, through groove 56 to exhaust port 38, this fluid then flowing through lines 41 and 42 to the reservoir. When spool 52 is in position shown in Fig. 1, the groove 37 which is connected with the lower end of the power cylinder will be blocked off so that no fluid can be discharged therefrom the fluid then in the lower end of the cylinder 44 will retain the piston and ram in the elevated position.

To effect movement of the spool 52, a shipper rod has been provided, this rod depending from the spool 52. Under normal conditions, the rod 57 and spool 52 are urged in a downward direction by a coil spring 58 arranged between the lower end of the body 33 and a collar 60 secured to the shipper rod. When the piston 47 and ram are in an elevated position as shown in Fig. 1, the spool 52 will be held in a partially elevated position against the force of spring 58 by an arm 61, which is secured to the ram 48 and surrounds the shipper rod, this arm engaging a collar 62 adjustably carried by the rod 57.

In the form of the invention illustrated, an operating lever 63 is pivotally connected to the lower end of rod 57 and is pivoted for rocking movement as at 64, the lever 63 being provided with an operating knob 65. When it is desired to initiate the operation of the fluid motor, the knob 65 is depressed to move the spool 52 in an upward direction to the position shown in Fig. 2. In this position groove 55 in spool 52 will connect the inlet 35 with the top cylinder port 36 and fluid from the pressure source will then be applied to the upper end of the cylinder 44. This fluid will tend to move the piston 47 and ram 48 in a downward direction.

It will be noted from Fig. 1 that the fluid motor 22 embodies a peculiar construction in that the piston 47 and ram 48 have a cylinder 66 formed therein. This cylinder receives a second piston 67 which is rigidly secured to and depends from the upper end of the casing 45. The piston 67 is provided with a central bore 68, the outer end of which communicates with a line 70, this line being connected with the line 41 which is in turn connected with line 42 leading to reservoir 24. Line 70 contains a check valve indicated at 71. It will be seen that when piston 47 moves in a downward direction, the second cylinder 66 will move relative to piston 67 to cause latter to be withdrawn from the former; when this motion occurs fluid will be drawn through lines 42 and 70 into the inner end of the cylinder 66. A branch line 72 extends from line 70 to the bottom cylinder line 46, the line 72 also containing a check valve 73. Purpose of line 72 and check valve 73 will be presently set forth.

From Fig. 2, it will be apparent that when valve spool 52 is fully elevated, groove 55 therein will establish communication between grooves 35 and 36 and between grooves 37 and 35, in the valve body 33. It will also be apparent that the spool 52 at this time prevents communication between groove 37 and exhaust groove 39, therefore, fluid supplied by the pressure source will be directed to the upper end of the power cylinder to cause piston 47 to be moved in a downward direction. This movement of piston 47 will discharge fluid from the lower end of cylinder 44 through line 46 to port 37 from which it will flow through groove 54 to groove 35 where it will combine with the fluid from the pressure source and be conducted through grooves 55 and 36 and line 43 to the upper end of the cylinder 44. It will thus be seen that the fluid from the under side of piston 47 will be transferred to the upper side thereof, decreasing the effective area of the upper surface of the piston 47 to the difference between the diameter of piston 67 and the diameter of ram 48, the fluid introduced from the pressure source being effective over this reduced area. Due to the reduction in effective piston area the ram and piston 47 will be caused to move at a rapid rate.

When the ram approaches the work the control knob 65 on lever 63 may be elevated to place the spool valve 52 in the position shown in Fig. 3, wherein communication between grooves 37 and 35 will be interrupted and communication established between groove 37 and groove 39. The fluid then displaced by the piston 47 from the lower end of cylinder 44 will no longer be combined with the fluid applied to the upper end of cylinder 44 and the effective area of the upper surface of piston 47 will be increased, this area

now being equal to the difference between the diameter of the piston 47 and that of piston 67 this area being exposed to the fluid from the pressure source. The rate of movement of the piston 47 and ram 48 will then decrease but the force exerted by the ram will be increased. The distance traveled by the ram during the power stroke may be regulated through the adjustment of a collar 74 secured to the shipper rod below the arm 61. This collar when engaged by the arm 61 will cause the shipper rod to move in a downward direction moving with it the spool 52. When this spool is moved to the position shown in Fig. 1, wherein the inlet port 35 is connected through grooves 55, 36 and 56 with the exhaust groove 38, the fluid pressure from the pressure source will then be directed to the reservoir and will not serve to move the piston of the power unit. As previously mentioned, the line leading from the lower end of the power cylinder will then be blocked, so that there will be no escape of fluid contained therein. When the collar 74 is adjusted to secure this operation sufficient force will be supplied by the ram to the shipper rod to move the same even though the operator attempts to maintain the knob 65 on the actuating lever 63 depressed. After the ram stops moving it may be caused to retract by releasing the knob 65, or, elevating it, to locate the valve element 52 in the position shown in Fig. 4. Under normal conditions the collar 74 is disposed at a point beyond the limit of the desired travel and serves as a safety device to interrupt the downward movement of the ram. After the ram has completed the desired travel in a downward direction during normal operation the spool may be lowered to the position shown in Fig. 4, by releasing knob 65; spring 58 will then expand and move spool 52 to its lowermost position. When spool 52 occupies position shown in Fig. 4, groove 55 will establish communication between grooves 35 and 37, and fluid from the pressure source will then be applied to the lower end of cylinder 44. At this time, also, groove 56 will connect the top cylinder line 43 with exhaust port 38. The fluid then supplied to the lower end of the power cylinder will cause the piston 47 and ram 48 to move in an upward direction, the fluid exhausted from the upper end of the cylinder flowing to the reservoir 24. This upward movement of piston 47 and cylinder 66 causes piston 67 to displace fluid from the inner end of cylinder 66, this fluid flowing through passage 68, lines 70 and 72 to line 46 where it will combine with fluid from the pressure source. Through the introduction of the additional fluid, the effective area of the under side of piston 47 will be reduced in an amount equal to the area of piston 67 making the area of piston 47, which is exposed to the fluid from the pressure source quite small. Because this effective area on the under surface of the piston 47 is small the piston 47 and ram 48 will be caused to move upwardly also at a rapid rate.

When the piston 47 approaches the upper limit of its travel the arm 61 will engage the collar 62 and move the shipper rod 57 and spool 52 in an upward direction until communication between grooves 35 and 37 is interrupted at which time piston 47 will cease to move. The spool 52 will then occupy the position shown in Fig. 1 wherein the fluid from the pressure source is directed to the reservoir to decrease the load on the pump. The ram will remain in this elevated position until the spool 52 is again moved either to the position shown in Fig. 2, or, that shown in Fig. 3, at which time a cycle of movement will again be initiated. When the spool occupies the position shown in Fig. 2 the ram will move rapidly as described previously. After the spool occupies the position shown in Fig. 3 the ram will move at a slower rate, but with increased force.

It will be observed that in moving from the position shown in Fig. 1 to that shown in Fig. 2, the spool 52 will pass through the position shown in Fig. 3. It will be obvious from the drawing that the cylinder 66 and piston 67 function as a pump when piston 47 reciprocates in cylinder 44. On the suction stroke, which is accomplished during the downward movement of piston 47, fluid will be drawn into cylinder 66 from the reservoir, check valve 71 permitting fluid flow in this direction. Check valve 73 prevents the flow of fluid from line 46 and the bottom of cylinder 44 during this movement of the piston 47. On the return stroke of piston 47 check valve 71 prevents fluid exhausted from cylinder 66 from flowing to the reservoir 24, while check valve 73 permits this exhaust fluid to flow into line 46.

In some instances it may be desired to operate the press ram in the conventional manner, that is, without combining the discharge from certain portions of the cylinder with fluid flowing to other portions of the same or other cylinders. To secure this varied form of operation the hydraulic system may be modified as illustrated in Fig. 5 wherein line 72 is provided with a valve 75 which in the previously described operation of the system is maintained in an open position. A connecting line 76 containing a normally closed valve 77 is disposed between the lines 43 and 70. When it is desired to operate the system in a conventional manner, valve 75 is closed and valve 77 is opened. At this time the control valve spool 52 should be placed in the position shown in Fig. 3 to effect a pressing operation of the ram. When the spool 52 is so positioned fluid under pressure from the pressure source will flow from the inlet port 35 through groove 55 to groove 36 from which it will flow through lines 43, 76 and 70 into the upper end of cylinder 44 and the inner end of cylinder 66. This fluid will urge the ram in a downward direction, the effective area of the piston being the total area of piston 47 and piston 67. Due to the increased effective area the movement of the ram will be slow, but the force will be increased. When the pressing stroke has been completed the valve spool 52 may then be moved to the position shown in Fig. 4, wherein line 43 will be connected with the reservoir while line 46 is connected with the pressure source. Fluid from the pressure source will thus be introduced to the lower end of cylinder 44 which will cause piston 47 to move in an upward direction. Fluid expelled by pistons 47 and 67 will pass through lines 43 and 42 to reservoir 24. The rate of return of piston 47 will be at the conventional rate.

Also in some instances of operation it may be desired to cause the ram to move at the conventional rate during the initial portion of the return stroke and then at an increased rate during the balance of return stroke. To provide for such operation a second shunt line 78 containing a normally closed check valve 80 is provided. This shunt line is connected at its ends with line 70 at opposite sides of valve 71. Valve 80 may be opened during the initial portion of the ram return stroke to cause the ram to move at the conventional rate and then closed during the re-

maining portion of such stroke. When valve 80 is open, fluid discharged from cylinder 66 will flow directly to reservoir 24. After the valve is closed, this exhaust fluid will be combined with fluid flowing to the lower portion of the cylinder 44 to increase the rate of return travel of the piston 47. During the operation of the system in this manner valve 77 will be closed while valve 75 will remain open. It is obvious that the operation of the system may be modified through the provision and operation of valves 75, 77 and 80.

While the form of embodiment of the present invention as herein disclosed constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow:

We claim:

1. In a hydraulic system, a source of fluid pressure; a power unit having piston means with at least three pressure responsive areas of different sizes; and fluid conducting and controlling mechanism between said power unit and pressure source, said mechanism being operative in one position to combine fluid displaced by the first piston area with fluid from said source and apply the same to the second piston area to move said piston means in one direction and operative in another position to combine fluid displaced by the third piston area with fluid from said source and apply the same to the first piston area to move said piston means in the opposite direction.

2. In a hydraulic system, a source of fluid pressure; a power unit having piston means with pressure responsive surfaces of large, intermediate and small areas; fluid conducting and controlling mechanism between said power unit and said pressure source, said mechanism having a valve member operative in one position to simultaneously direct fluid from said source and fluid displaced by the piston surface with the intermediate area to the piston surface with the large area and operative in another position to selectively direct the fluid from said source to the piston surface with the large area and the fluid displaced by the intermediate area to exhaust, said valve member also being operative in still another position to direct fluid from said source to the piston surface with the intermediate area and fluid displaced by the larger piston surface to exhaust, said fluid conducting means being operative to combine the fluid displaced by the small piston area with the fluid from said source applied to the intermediate piston area.

3. In a hydraulic system, a source of fluid pressure, a power unit having a cylinder and piston, the opposite surfaces of said piston having different effective areas; a control mechanism between said pressure source and said power unit, said mechanism having a movable valve operative in one position to simultaneously direct fluid from said pressure source and fluid discharged by the smaller piston surface to the larger piston surface to cause rapid movement of said piston in a predetermined direction, said valve being operative in another position also to direct fluid from said source to said smaller piston surface and from the larger piston surface to exhaust to cause movement of said piston in the opposite direction; and a pump device operated by said piston when moving in said opposite direction to add fluid to that supplied by said pressure source to said smaller piston surface to increase the rate of movement of said piston in said opposite direction.

4. In a hydraulic system, a source of fluid pressure, a power unit having a plurality of cylinders of different diameter and a plurality of pistons disposed therein, said cylinders and pistons being relatively movable; control mechanism between said pressure source and said power unit; a movable valve in said mechanism, said valve being operative in one position to selectively connect both ends of one cylinder with said pressure source to cause rapid movement of the pistons in one direction and operative in another position to connect one end of said one cylinder with said pressure source and the other end to exhaust to cause movement of said pistons in such direction with increased force and operative in a third position to connect said other end to said pressure source and said one end to exhaust to cause reverse movement of said pistons; and a valved fluid conductor extending between the second of said cylinders and said pressure source, said conductor being operative when said other end of said one cylinder is connected with said pressure source to combine fluid exhausted from said second cylinder with fluid from said pressure source.

5. In a hydraulic system, a source of fluid pressure, a power unit having a plurality of cylinders of different diameters and a plurality of pistons disposed in said cylinders for movement relative thereto, said pistons being movable in unison; control mechanism between said pressure source and said power unit, said mechanism being operative in one position to selectively connect both ends of one cylinder with said pressure source and in other positions to connect either end thereto and the opposite end to exhaust; and fluid conducting means extending between another of said cylinders and said pressure source, said conducting means being operative when a predetermined end of said one cylinder is connected with said pressure source to combine fluid exhausted from another of said cylinders with fluid from said pressure source.

6. In a hydraulic system, a fluid pressure source having a reservoir; a power unit having a casing with a cylinder; a piston disposed for reciprocation in said cylinder, said piston having a second cylinder formed therein; a second piston stationarily supported by said power unit casing and disposed in said second cylinder; conduit means extending between certain ends of said cylinders and said reservoir; check valve means in said conduit means, said check valve means permitting fluid flow only from said reservoir to the second cylinder and from the latter to an end of said first cylinder; and control mechanism between said pressure source and said power unit, said control mechanism being operative to selectively connect both ends of the first cylinder with said pressure source or either end thereof with said pressure source and the opposite end with said reservoir.

7. In a hydraulic system, a source of fluid pressure including a reservoir; a power unit having a casing provided with a cylinder; a piston disposed for reciprocation in said cylinder, said piston having a cylinder formed therein; a second piston disposed in the cylinder in the first piston, said second piston being supported by said casing; control mechanism for said power unit, said control mechanism having an inlet port communicating with said pressure source and cylinder ports communicating with opposite ends of the first-mentioned cylinder; conduit means connecting the inner ends of said cylinders; a

check valve in said conduit means limiting fluid flow to a direction from the cylinder in said piston to the first-mentioned cylinder; a second conduit means connecting the second-mentioned cylinder with said reservoir; a check valve in said second conduit means limiting fluid flow to a direction from said reservoir to said second cylinder, and a movable valve spool in said control mechanism selectively operative to connect both ends of the first-mentioned cylinder with said power source simultaneously when in one position or either end with said power source and the other end with said reservoir when in other positions.

8. In a hydraulic system, a source of fluid pressure, a fluid motor having a cylinder and a piston disposed for reciprocation therein; control mechanism between said pressure source and said motor, said control mechanism having a casing with a chamber and inlet, top and bottom cylinder and exhaust ports communicating therewith; fluid conducting means connecting said inlet port with said pressure source and said cylinder ports with the ends of said cylinder; a valve element disposed in said chamber for movement to one position to establish simultaneous communication between said cylinder ports and said inlet and to other positions to establish communication between either of said cylinder ports and said inlet port and the other cylinder port and exhaust; a pump device operated by movement of said piston, said pump drawing fluid thereinto during movement of said piston in one direction and discharging fluid therefrom during movement of said piston in the opposite direction; and passage means for conducting the fluid discharged from said pump to the end of said cylinder connected with said bottom cylinder port.

9. In a hydraulic system, a source of fluid pressure, including a reservoir; a fluid motor comprising a casing having a cylinder formed therein; a piston with a ram disposed for reciprocation in said cylinder, said ram projecting through the end of said cylinder; a second cylinder formed in said piston and ram; a second piston carried by said casing and disposed in said second cylinder; a control mechanism having a body with a chamber and inlet, inner and outer cylinder and exhaust ports communicating with said chamber; fluid conductor means connecting said inlet port with said pressure source and the ends of said first cylinder with said inner and outer cylinder ports; a valve element disposed in said chamber for movement to one position to connect both cylinder ports with said pressure source to cause a rapid projection of said ram from said casing, said valve element also being movable to another position to connect the outer cylinder port with said pressure source and the inner one with exhaust to cause the projection of said ram under increased force, said valve element being movable to a third position to connect the inner cylinder port with the pressure source and the outer cylinder port with exhaust to cause the retraction of said ram; passage means connecting the inner end of said second cylinder with the conductor leading from the inner cylinder port to the inner end of said first cylinder; additional passage means connecting the aforementioned passage with said reservoir; and check valve means in said passages to limit the direction of fluid flow therethrough.

10. In a hydraulic system, a source of fluid pressure; a power unit having piston means with at least three pressure responsive areas; a control mechanism between said pressure source and said power unit, said control mechanism having a casing with a chamber and inlet, top and bottom cylinder and exhaust ports communicating therewith; a spool element disposed for movement in said chamber, said element having a plurality of spaced grooves and being operative in a first position to establish communication between said inlet and an exhaust port and to block said bottom cylinder port, said element being operative in a second position to establish communication between the bottom and top cylinder ports and said inlet port, the element being operative in a third position to connect said inlet and top cylinder ports and said bottom cylinder and exhaust ports, a fourth position of said spool element serving to connect said inlet and bottom cylinder ports and said top cylinder and exhaust ports; and check valve equipped conduit means for combining fluid displaced by one of the piston areas with fluid flowing from the pressure source when the spool element is in said fourth position.

11. In a hydraulic system, a source of fluid pressure having a reservoir; a power unit having a casing with a piston chamber; a piston and ram disposed for movement in said chamber, said piston and ram having a cylindrical chamber formed therein; a second piston carried by said casing and disposed in the chamber in said piston and ram, movement of the first-named piston causing relative movement of the second piston in its chamber; mechanism for controlling fluid flow from the pressure source to said power unit and from the latter to exhaust, said mechanism having a casing with a bore and inlet, top and bottom cylinder and exhaust ports communicating therewith; fluid conducting means connecting said inlet port with said pressure source and said top and bottom cylinder ports with opposite ends of the first-mentioned chamber; a spool member disposed for movement in said bore, said spool serving in one position to connect said inlet and an exhaust port and in a second position to connect said inlet with both cylinder ports, said spool serving in a third position to connect said inlet with the top cylinder port and said bottom cylinder port with an exhaust port, a fourth position of said spool reversing the connections made in the third position; a conductor extending from the chamber in said piston to said reservoir; a check valve in said conductor to limit flow to the direction from said reservoir to said chamber; a conductor communicating with the last-named conductor and the conductor extending from the bottom cylinder port to said first-mentioned chamber; and a check valve in the last-mentioned conductor to limit flow in a direction toward the first-mentioned chamber.

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