Dec. 23, 1941. W. ERNST ET AL 2,267,644

HYDRAULIC MACHINE CIRCUIT

Filed July 1, 1937 2 Sheets-Sheet 1

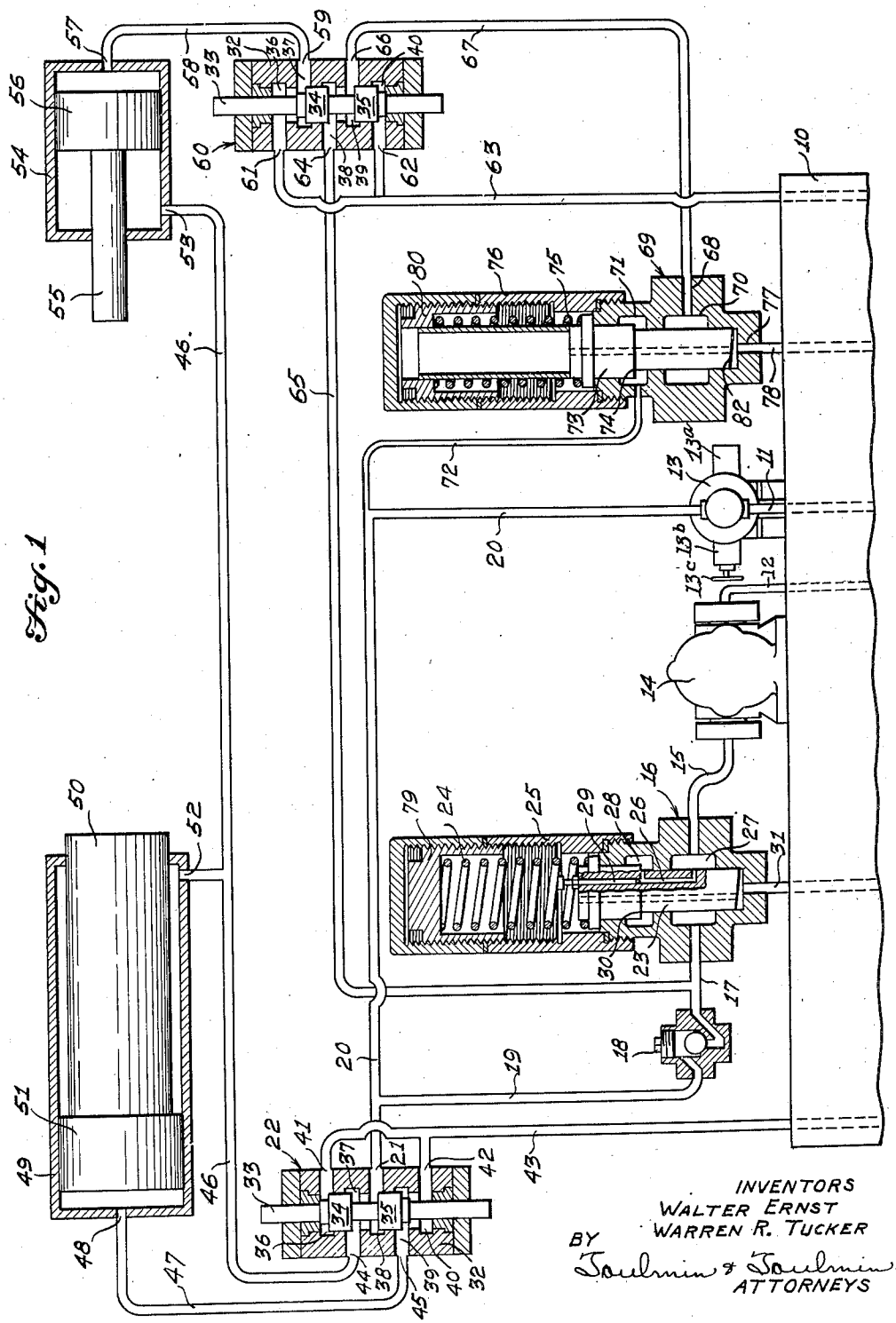

Fig. 1

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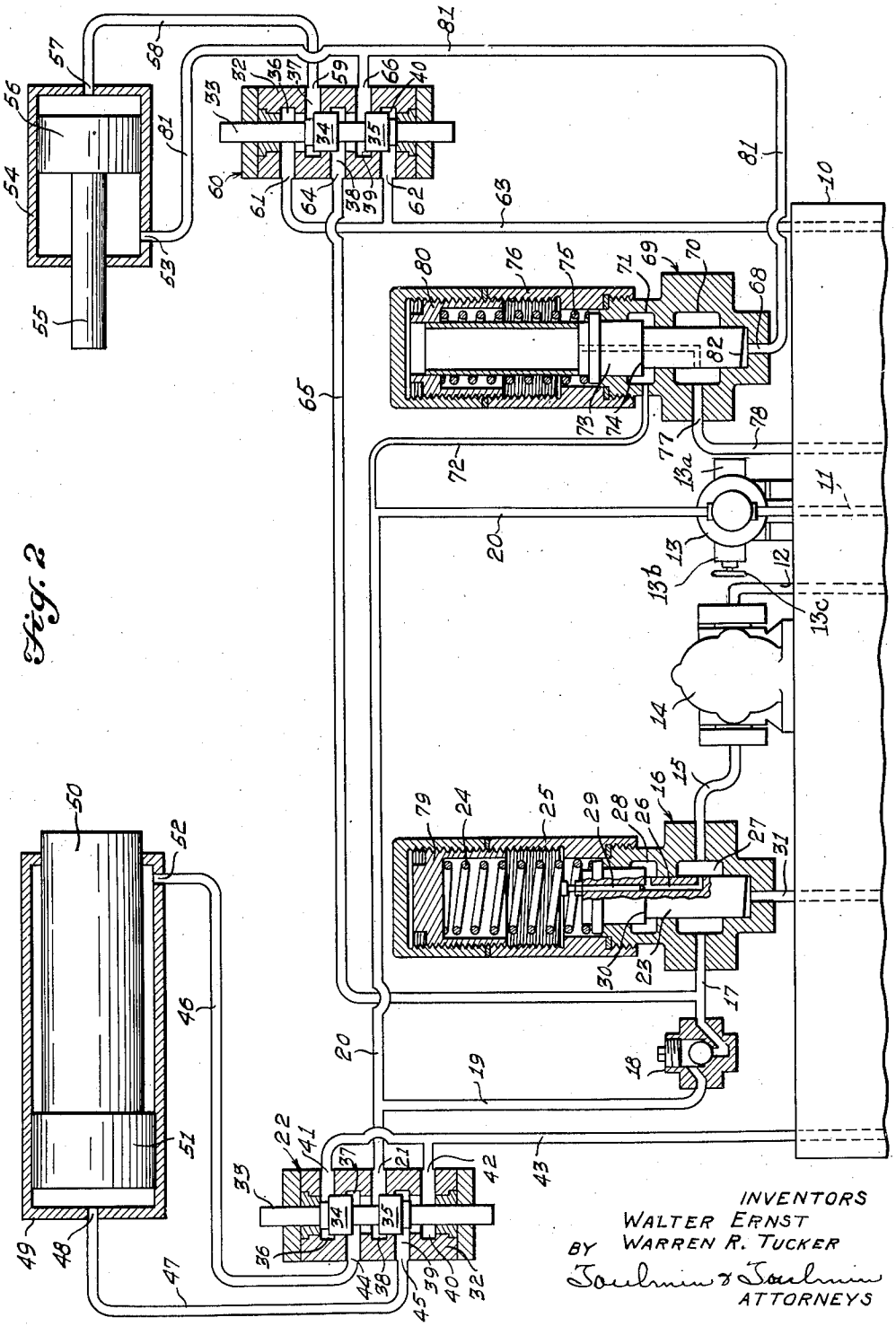

Fig. 2

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HYDRAULIC MACHINE CIRCUIT

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6 Claims. (Cl. 60—97)

This invention relates to hydraulic machine circuits, and in particular, to circuits for operating hydraulic machines having multiple cylinders and pistons, and is a variation of the hydraulic system disclosed in our copending application, Serial No. 151,470, which matured to Patent No. 2,211,370.

One object of this invention is to provide a hydraulic machine circuit for operating a hydraulic machine having one cylinder to which pressure is supplied, and then held constant while pressure is supplied to another cylinder.

Another object is to provide a hydraulic machine circuit, wherein two hydraulic cylinders are operated from cooperating constant delivery and variable delivery pumps in such a manner that one of the pumps is caused to idle at substantially zero pressure when it is not needed for supplying pressure fluid.

Another object is to provide a hydraulic machine circuit having a pair of cylinder and piston assemblies operated by a pair of pumps, means being provided to unload one of the pumps when the pistons are in their retracted positions, such as when the machine is at rest.

Another object is to provide a hydraulic machine circuit, wherein two pumps are caused to cooperate and supply pressure fluid to two hydraulic piston and cylinder assemblies in such a manner that one of the pumps is fully unloaded when the machine is at rest with its pistons in a retracted position, and wherein the two pistons may be operated simultaneously or independently, both on their retraction and advancement strokes.

Another object is to provide a hydraulic machine circuit for operating two independent cylinder and piston assemblies from cooperating high pressure and low pressure pumps, wherein the high pressure pump causes the low pressure pump to be unloaded, or substantially unloaded, when the low pressure pump has performed its desired functions.

In the drawings:

Figure 1 is a diagrammatic view of a hydraulic machine circuit according to one form of the invention, wherein two hydraulic motors are operated from two different pumps, both pistons of the motors being retracted simultaneously.

Figure 2 is a view similar to Figure 1, but of a slightly modified circuit in which one of the pistons may be retracted independently of the other.

General arrangement

In general, the hydraulic machine circuits shown in the two diagrams have the same purpose of enabling the operation of two independent rams or motors from a pair of high and low pressure pumps, wherein the high pressure pump always unloads, or substantially unloads, the low pressure pump when the latter has performed its work. Hitherto, attempts to do this have been unsuccessful for the reason that when it was attempted to operate two hydraulic cylinders from one source of supply, it was impossible to unload the pump and still have pressure fluid available to work either one of the two cylinders.

The two hydraulic machine circuits shown in Figures 1 and 2 are substantially identical in the left-hand half of each circuit, the variations occurring mainly in the right-hand half. In the circuit of Figure 1 a low pressure constant delivery pump and a high pressure variable delivery pump supply fluid to two independent hydraulic cylinders, the purpose of the variable pump being to maintain pressure upon one of the cylinders while the other cylinder is operated. This circuit causes the cylinder to which pressure fluid is first supplied to be held at constant pressure while pressure fluid is supplied to the second cylinder. In this circuit, however, both cylinders are retracted simultaneously, and the low pressure constant delivery pump is unloaded when both hydraulic cylinders are in their retracted position, namely, when the machine is standing open and idling. After one of the cylinders causes its piston to advance to its forward position, the circuit causes the constant delivery pump again to unload. The modified circuit shown in Figure 2 enables the second cylinder to be reversed before reversing the first cylinder, although the constant delivery pump is not quite fully unloaded when the machine is at rest.

Circuit simultaneously retracting both pistons

Referring to the drawings in detail, Figure 1 shows the hydraulic machine circuit of this invention as consisting of a tank **10** from which lines **11** and **12** lead to the variable delivery high pressure and constant delivery low pressure pumps **13** and **14**, respectively. From the low pressure constant delivery pump **14** the line **15** leads to the pressure relief valve, generally designated **16**, from which the line **17** leads to the ball check valve **18**, continuing in the line **19** joining the line **20**, which terminates at one end in the port **21** of the first operating valve, generally designated **22**. The variable delivery pump **13** discharges directly into the line **20**, and hence, both pumps **14** and **13** cooperate to supply pressure fluid to the port **21** of the first operating

valve 22. This is a conventional four-way piston valve.

The high pressure variable delivery pump 13 is of a conventional type, such as a radial piston type, wherein the eccentricity of the piston actuating ring may be varied relatively to the cylinder barrel, and thereby vary the strokes of the pistons to increase or reduce the output of the pump. This variable delivery pump 13 is provided with a control mechanism, of a type known to those skilled in the art, and forming no part of the present invention. According to the arrangement shown, a servomotor 13a has therein a piston (not shown) connected to the pump flow-control member or shift ring so as to shift the latter to a neutral or zero stroke position, and overcome the opposing urge of a coil spring within the spring casing 13b, thereby serving to maintain pressure in the circuit when this pressure is built up to a predetermined value. The thrust of the spring and hence the said predetermined pressure may be adjusted by turning the hand wheel 13c. A pump control of this type is disclosed in the Ernst Patent No. 2,039,893, issued May 5, 1936. The low pressure constant delivery pump 14 may likewise be of any suitable conventional type, such as the gear or vane type, and its details form no part of the present invention.

The pressure relief valve 16 is of a conventional type, and a complete disclosure thereof will be found in the Ernst Patent No. 2,086,295 of July 6, 1937. The relief valve 16 is provided with a plunger 23, urged in a downward direction by the spring 24 within the screw cap 25. The plunger 23 contains a drilled passageway 26 interconnecting the main valve chamber 27 and the plunger-lifting chamber 28, the flow being adjustable by means of a needle valve 29. The plunger 23 within the plunger-lifting chamber 28 is provided with an annular shoulder 30, which serves as a piston area to lift the plunger 23 when the pressure exceeds a predetermined amount, as determined by the force of the spring 24. When this amount is exceeded and the pressure lifts the plunger 23, the fluid from the constant delivery pump 14 passes from the plunger-lifting chamber 27 downwardly, through the pipe 31, into the tank 10.

The first operating valve 22 consists of a longitudinally bored casing 32 having a valve rod 33 with twin spaced heads 34 and 35 thereon. These heads open into spaced chambers 36, 37, 38, 39 and 40. The chambers 36 and 40 open into the ports 41 and 42, connected by the line 43 to the tank 10. The chamber 38 opens into the port 21 and line 20, previously described. The chambers 37 and 39 open into the ports 44 and 45, to which are attached the lines 46 and 47, respectively. The line 47 leads to the port 48 in the main hydraulic cylinder 49. The latter has a piston 50 with a head 51 reciprocating therein. The line 46 is connected to the port 52 at the right-hand end of the cylinder 49, and is likewise connected to the port 53 at the left-hand end of the auxiliary cylinder 54. The latter is provided with a piston 55 having a head 56.

The opposite end of the cylinder 54 is provided with a port 57 connected by the line 58 to the port 59 of the second operating valve, generally designated 60. The latter is of a similar construction to the first operating valve 22, and its corresponding parts bear similar numerals. The outlet ports, however, are differently designated for purposes of clarity. From the end ports 61 and 62 the line 63 runs downwardly to the tank 10. From the middle port 64 the line 65 runs to a junction with the line 17, between the check valve 18 and the pressure relief valve 16. From the remaining port 66 the line 67 runs to the port 68 of the pilot-operated unloading valve, generally designated 69. The latter is provided with a valve chamber 70 and a plunger-lifting chamber 71, having pressure fluid supplied thereto by the pilot line 72 leading from the pressure line 20 of the high pressure variable delivery pump 13.

The unloading valve 69 contains a plunger 73 having an annular shoulder 74 forming a piston area within the plunger-lifting chamber 71, and urged downwardly by the coil spring 75 within the casing 76. From the remaining port 77 of the main valve chamber 70 the line 78 runs downwardly to the tank 10. The pressures at which the pressure relief valve 16 and unloading valve 69 open may be adjusted by turning the screw caps 79 and 80, with which these valves are equipped.

In the operation of the hydraulic machine circuit shown in Figure 1, the pumps 13 and 14 are started in operation, and take in fluid through their suction lines 11 and 12, respectively. At the outset it will be assumed that the pistons 50 and 55 are nearing the ends of their retraction strokes, so that the machine is approaching its position of rest. The constant delivery pump 14 discharges its fluid through the line 15, the pressure relief valve 16, the line 17, the ball check valve 18 and the lines 19 and 20, into the first operating valve 22 at the port 21. Pressure fluid also passes from the line 17, through the line 65, the second operating valve 60 and the line 67, into the valve chamber 70 of the unloading valve 69. The latter, however, is closed at this stage of the operation, hence, the pressure fluid cannot yet escape. The fluid reaching the first operating valve 22 passes outwardly, through the port 44 and line 46 to the ports 52 and 53 on the pull-back sides of the cylinder 49 and 54, thereby simultaneously retracting the two pistons 50 and 55. As the pistons are nearing their retracted positions but a slight pressure will exist in the system.

When the piston heads 51 and 56 have reached the ends of their return strokes and halted, pressure will build up in the lines previously mentioned, causing a similar pressure to accumulate in the pilot line 72 and plunger-lifting chamber 71 of the unloading valve 69. When this becomes of a predetermined amount, it lifts the valve plunger 73 and opens communication between the main valve chamber 70 and the line 78, thereby permitting the fluid therein to escape back into the tank 10. This permits the low pressure constant delivery pump 14 to by-pass its flow through the line 15, the relief valve 16, the lines 17 and 65, the second operating valve 60, the line 67, the unloading valve 69 and the line 78, into the tank 10. The high pressure variable delivery pump meanwhile discharges its fluid through the line 20, and pressure backing up in the line 19 closes the check valve 18. This pressure continues to rise until the control mechanism of the high pressure variable delivery pump 13 has reached its critical pressure for which it is set, whereupon the flow-control member of the pump is shifted automatically into its neutral delivery position, in accordance with the well known principles of such pumps. The variable delivery pump 13, therefore, continues to

maintain pressure on the circuit while the low pressure constant delivery pump 14 is being by-passed or unloaded.

With the system at rest, therefore, and with both piston heads 51 and 56 retracted, as the pump 14 is being by-passed at substantially zero pressure and pump 13 is maintaining the pressure in the system at a substantially zero stroke, the machine is idling with its minimum power consumption. In this position the machine is in readiness for performing a subsequent working stroke. To perform a working stroke, the operator shifts the first operating valve 22 into the position opposite from that shown in the drawings. When this is done the pull-back line 46 will be connected through the valve 22 to the discharge line 43 so that fluid can escape back into the tank 10. The line 47, however, will be connected to the pressure lines 19 and 20, supplying pressure from the pumps 14 and 13, respectively. Under these conditions, the pressure in the line 20 will drop, likewise causing the pressure in the line 72 to drop, and permitting the spring 75 to close the plunger 73 of the unloading valve 69.

As the low pressure pump 14 can no longer by-pass its discharge through the unloading valve 69, in the manner previously described, it now supplies its pressure fluid through the line 19 to the line 20, which is already receiving pressure fluid from the high pressure variable delivery pump 13. The pressure fluid thus received in the line 47 from both pumps 13 and 14, acts against the piston head 51 and moves the piston 50 to the right upon its forward stroke. If the piston 50 is employed, for example, as a clamping piston for molding dies, the piston 50 now closes the dies and clamps them. This causes pressure to be built up in the line 47 and continued backward through the valve 22, the line 20 and pilot line 72 to the unloading valve 69, thereby opening the latter and again by-passing the discharge of the low pressure constant delivery pump 14, in the manner previously described. At this stage the piston 50 has reached the end of its forward stroke and is under pressure, but the piston 55 is still in a retracted position.

To advance the piston 55 to the left, the operator reverses the second operating valve 60, thereby cutting off the line 67 from communication with the line 65. The by-passing of the low pressure constant delivery pump 14 is thereby terminated, and it then discharges its fluid through the line 15, the relief valve 16, the lines 17 and 65, the second operating valve 60 and the line 58, into the right-hand end of the cylinder 54, where it acts against the piston head 56 and moves the piston 55 to the left upon its forward stroke. The piston 55 may be used to operate an injection plunger for injecting molding material into molding dies, which may be clamped by the action of the piston 50. When the piston 55 has reached its forward position, the pressure will be built up in the line 15. This pressure passes through the drilled passageway of the valve member 23, into the plunger-lifting chamber 28, where it acts against the annular piston area 30 and lifts the valve member or plunger 23. When this occurs the low pressure constant delivery pump 14 will discharge its fluid into the line 31, whence it escapes back into the tank 10.

To relieve the pressure in the cylinder 54, the operator shifts the second operating valve 60 into the position shown in Figure 1. Under these conditions the line 58 becomes connected to the line 63 leading back to the tank 10, hence, the pressure in the cylinder 54 drops. At the same time the line 65 is connected to the line 67. The plunger of the unloading valve 69 is still raised, however, because the pressure being maintained upon the piston 50 in the cylinder 49 continues to back up through the pilot line 72, into the plunger-lifting chamber 71, and to hold the unloading valve member 73 in its raised position. The low pressure pump 14 is therefore permitted to by-pass freely through the line 15, the relief valve 16, the lines 17 and 65, the second operating valve 60, the line 67, the unloading valve 69 and the line 78 leading back to the tank 10. Pressure will also be relieved from the chamber 28 of the pressure relief valve 16 through its passage 26, thereby permitting its valve plunger 23 to return to its closed position, as is shown in Figure 1.

To cause the piston 50 to return to its retracted position, as shown in Figure 1, the operator now shifts the first operating valve 22 into the position shown in Figure 1, whereby there will be a drop in pressure in lines 20 and 72 to permit the unloading valve plunger 73 to return to its closed position, as is shown in Figure 1. The pressure thereby supplied to the right-hand end of the cylinder 49 and left-hand end of the cylinder 54, causes both piston heads 51 and 56 to be moved in opposite directions away from one another, thereby causing the pistons 50 and 55 to be retracted. When the piston heads 51 and 56 have reached their retracted positions, as shown in Figure 1, the unloading valve 69 will again open, in the manner previously described, thereby unloading the low pressure constant delivery pump 14. The subsequent increase of pressure acts upon the control mechanism of the high pressure variable delivery pump 13, causing its shift ring to be shifted to its neutral position, and thereby shifting the pump itself to a zero delivery or neutral position. The machine and circuit are now at rest, awaiting the starting of a further operating cycle.

The feature of causing the low pressure constant delivery pump 14 to by-pass its discharge at substantially zero pressure when the pump delivery is not needed, results in a great reduction of power consumption. The low pressure pump 14 is the greatest power-consuming unit in the circuit, hence, much power is saved when its discharge is by-passed. The discharge of this low pressure pump 14 is needed only when advancing or retracting the pistons 50 and 55, but as soon as one of these pistons reaches a position of rest, the low pressure pump 14 is immediately unloaded. This unloading of the pump 14 occurs when both pistons 50 and 55 are in their retracted positions, as when the hydraulic machine is standing open and idling. It also occurs after the piston 50 has reached its extreme right-hand or advanced position. After the piston 55 has reached its extreme left-hand or advanced position, however, the low pressure pump 14 is not unloaded, but instead, by-passes its discharge through the relief valve 16. After the piston 55 is retracted, however, the pump 14 is again unloaded.

Circuit permitting independent retraction of both pistons

The circuit shown in Figure 2 permits the retraction of the piston 55 to be made while the

piston 50 is being maintained in its advanced or forward position. This operation is not possible with the circuit shown in Figure 1 because the retraction sides of the cylinders 49 and 54 are connected to the common push-back line 46. To permit this independent retraction of the piston 55, the circuit of Figure 2 employs slightly different connections to the right of the unloading valve 69. The circuit to the left of the unloading valve 69, however, remains substantially the same as in Figure 1. The line 46, which formerly led to the cylinder 54, is now severed and leads solely to the port 52 of the cylinder 49. The port 77 of the unloading valve 69 is now connected to the discharge line 78, and the port 68 is connected to a line 81 leading to the lower port 66 of the second operating valve 60, and thence to the port 53 at the left-hand end of the cylinder 54. The ports 61 and 62 remain connected to the discharge line 63, and the port 64 continues to receive pressure fluid from the line 65.

In the circuit of Figure 2 the piston heads 56 and 51 are again shown on their retraction strokes, and nearing the retracted positions thereof. In the operation of the circuit of Figure 2, as soon as the pistonheads 51 and 56 reach the ends of their return strokes, the consequent building up of pressure in the system causes pressure to pass through the pilot line 72 and raise the unloading valve plunger 73 in the manner previously described. Additional pressure, however, also passes through the line 65, the second operating valve 60, the line 81 and the port 18, into the unloading valve 69, where it acts against the lower end 82 of the valve plunger 73. The combined action of the pressure exerted on the annular piston area 74 and the end 82, causes the pressure plunger 73 to be lifted at a relatively low pressure, thereby permitting the constant delivery pump 14 to begin to by-pass its discharge through the unloading valve 69, into the line 78 and tank 10 at a relatively low pressure. In the circuit shown in Figure 2 the constant delivery pump is thus not fully unloaded when the machine is at rest. The actual pressure, however, is only high enough to be barely capable of retracting the piston head 56, hence, may be kept relatively low. At this low pressure the power consumed in driving the low pressure constant delivery pump 14 is relatively insignificant.

To advance the piston 50 the operator reverses the first operating valve 22, as in the case of Figure 1. When this occurs the fluid passes from the pump pressure lines 19 and 20, through the first operating valve 22 and the line 47, into the left-hand end of the cylinder 49, causing the piston 50 to move to the right under the combined action of both of the pumps 13 and 14. The drop in pressure in lines 20 and 72 when the valve is shifted permits the unloading valve plunger 73 to return to its closed position, as shown in Figure 1. As the pressure is built up in the system, the unloading valve plunger 73 is subjected to pressure from both pumps on both of the areas 74 and 82. This combined action causes the valve plunger 73 to be lifted and the unloading valve 69 to be opened at a mederate pressure. Assuming this moderate pressure, for example, to be 600 pounds per square inch, the valve plunger 73 will lift and begin to partially by-pass the discharge of the low pressure constant delivery pump 14 by way of the line 15, the pressure relief valve 16, the lines 17 and 65, the second operating valve 60, the line 81, the unloading valve chamber 70 and the line 78 leading back to the tank 10.

The pressure fluid coming from the high pressure variable delivery pump 13 causes the check valve 18 to close, as before, and pressure continues to be built up by the high pressure pump 13. The consequent building up of pressure in the pilot line 72 continues to lift the unloading valve plunger 73, thereby causing a further drop in the pressure line 81. This action proceeds until the maximum pressure is reached for which the control arrangement of the high pressure variable delivery pump 13 is set. Assuming this to be 1500 pounds, for the sake of an example, then a residual pressure of about 200 pounds remains in the line 81 after the maximum by-passing effect is obtained. In this manner, therefore, while the low pressure constant delivery pump 14 does not by-pass at a zero pressure, it nevertheless by-passes at a very low pressure which causes the operating motor of the pump 14 to consume very little power.

To advance the plunger 55 the operator reverses the second operating valve 60, thereby connecting the pressure line 65 to the line 58, and connecting the line 63 to the line 81. When this occurs pressure under the end 82 of the unloading valve plunger 73 is released through the line 81, the valve 60 and the line 63 leading to the tank 10, closing the unloading valve 69 so that the low pressure constant delivery pump 14 is no longer subject to the action of the unloading valve 69 because the pressure in the chamber 71 is now insufficient to maintain the valve plunger 73 raised in its open position. The pressure relief valve 16 now assumes control of the low pressure pump 14, the pressure fluid from which causes the piston head 56 and piston 55 to be moved to the left at full pressure. At the end of the forward stroke of the piston 55, the consequent accumulation of pressure in the line 15 passes from the chamber 27 of the pressure relief valve 16, through the drilled passageway 26, into the plunger-lifting chamber 28, where it acts against the annular piston area 30 and lifts the relief valve plunger 23 when a predetermined pressure has been reached. Thenceforth, the low pressure constant delivery pump 14 is by-passed back to the tank 10 by way of the line 31.

To reverse the action of the piston 55 and cause it to return to its retracted position, the second operating valve 60 is again shifted into the position shown in Figure 2, whereupon the unloading valve 69 comes into action again to unload the low pressure pump 14 when the piston head 56 reaches the end of its retraction stroke. Assuming, as previously stated, that a pressure of 1500 pounds per square inch, for example, is maintained on the piston 50 and applied under these conditions to the plunger-lifting area 74 of the unloading valve 69 by way of the pilot line 72, the valve plunger 73 is nevertheless not lifted. In order to lift this plunger 73 and open the unloading valve 69, an additional pressure, such as about 200 pounds per square inch, for example, must be also applied through the line 81 and port 68 against the lower end 82 of the unloading valve plunger 73. The pressures stated are purely by way of example, and not critical.

While the piston 55 is moving backward upon its retraction stroke, the necessary pressure is not built up. When the end of the retraction

stroke is reached, however, the additional pressure builds up in the line 81 against the end 82, until the necessary additional amount is reached, such as the 200-pound pressure previously referred to. The combined action of the pressure from the pilot line 72 upon the annular piston area 74, and from the line 81 upon the plunger end 82, then lifts the valve plunger 73 and causes the low pressure constant delivery pump 14 to be by-passed into the line 78 and tank 10, in the manner previously described. In this way, the low pressure pump 14 is by-passed at a relatively low pressure when the machine is running idle. With the circuit shown in Figure 2, the piston 55 is operable independently of the piston 50 and can be retracted or advanced at will. In the circuit of Figure 1, however, the piston 55 cannot be retracted independently, but only simultaneously with the piston 50. While, furthermore, in the circuit of Figure 2 the piston 55 is advanced and retracted by only the low pressure pump, according to the circuit of Figure 1, only the advancing stroke of piston 55 is effected by the low pressure pump alone, whereas the retraction stroke of piston 55 is effected by joined action of the low pressure pump and the high pressure pump. The high pressure pump 13 always unloads or substantially unloads the low pressure pump 14, under the conditions mentioned.

It will be understood that we desire to comprehend within our invention such modifications as come within the scope of the claims.

Having thus fully described our invention, what we claim as new and desire to secure by Letters Patent, is:

1. In a hydraulic machine circuit, a pair of piston and cylinder units, each unit having a piston-advancing area and a piston-retracting area, the piston-retracting areas of both units being connected with each other, a low pressure pump and a high pressure pump connected thereto, means for selectively directing the discharge from said pumps to either the advancing or retracting area of the first unit, means for directing the discharge of pressure fluid from one only of said pumps to the advancing area only of the second unit for advancing the pistons of said units separately and retracting said pistons simultaneously, and means responsive to the attainment of a predetermined pressure in said circuit for by-passing the discharge of said low pressure pump.

2. In a hydraulic machine circuit, a pair of piston and cylinder units, each unit having a piston-advancing area and a piston-retracting area, the piston-retracting areas of both units being connected with each other, a low pressure pump and a high pressure pump connected thereto, means for selectively directing the discharge from said pumps to either the advancing or retracting area of the first unit, means for directing the discharge of pressure fluid from one only of said pumps to the advancing area only of the second unit for advancing the pistons of said units separately and retracting said pistons simultaneously, and means responsive to the upbuilding of a predetermined pressure in said circuit behind one only of said pistons for by-passing the discharge of said low pressure pump.

3. In a hydraulic machine circuit, a pair of piston and cylinder units, each unit having a piston-advancing and a piston-retracting area, a low pressure pump, a high pressure pump, means for selectively directing the discharge of pressure fluid from said pumps to either of said areas of the first unit, means for directing the discharge of pressure fluid from the low pressure pump only to the advancing area of the second unit, said second unit being adapted to be advanced independently of said first unit, means for simultaneously supplying pressure fluid from both pumps to the piston retraction areas of both units, and means responsive to the attainment of a predetermined pressure in said circuit for by-passing the discharge of said low pressure pump.

4. In a hydraulic machine circuit, a pair of piston and cylinder units, each unit having a piston-advancing and a piston-retracting area, a low pressure pump, a high pressure pump, means for directing the discharge of said pumps simultaneously to the retracting areas of both units, means for directing the discharge of said low pressure pump first to the advancing area of the first unit and subsequently to the advancing area of the second unit, means responsive to the attainment of a predetermined pressure in said circuit for by-passing the discharge of said low pressure pump.

5. In a hydraulic machine circuit, a pair of piston and cylinder units, each unit having a piston-advancing area and a piston-retracting area, the retracting areas of both units being connected with each other, a low pressure pump, a high pressure pump, means for selectively directing the discharge of pressure fluid from said pumps to either of said areas of said first unit, means for directing the discharge of pressure fluid from only one of said pumps to the advancing area of the second unit, and means including a pair of valves responsive to the attainment of a predetermined pressure in said circuit for unloading the discharge of said low pressure pump, one of said valves being adapted to be opened in response to the development of a predetermined pressure by pressure fluid from said low pressure pump only.

6. In a hydraulic machine circuit, a pair of piston and cylinder units, each unit having a piston-advancing area and a piston-retracting area, the retracting area of both units being connected with each other, a low pressure pump and a high pressure pump, means for selectively directing the discharge of pressure fluid from said pumps to either of said areas of the first unit, means for directing the discharge of pressure fluid from only one of said pumps to the advancing area of the second unit, means including a pair of valves responsive to the attainment of a predetermined pressure in said circuit for unloading the discharge of said low pressure pump, one of said valves being adapted to be opened in response to the development of a predetermined pressure by pressure fluid from said high pressure pump only so as to allow unloading of said low pressure pump at substantially zero pressure thereof.

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