

July 31, 1945.

G. A. WAHLMARK

2,380,810

HYDRAULIC CIRCUIT

Filed July 5, 1941

2 Sheets-Sheet 1

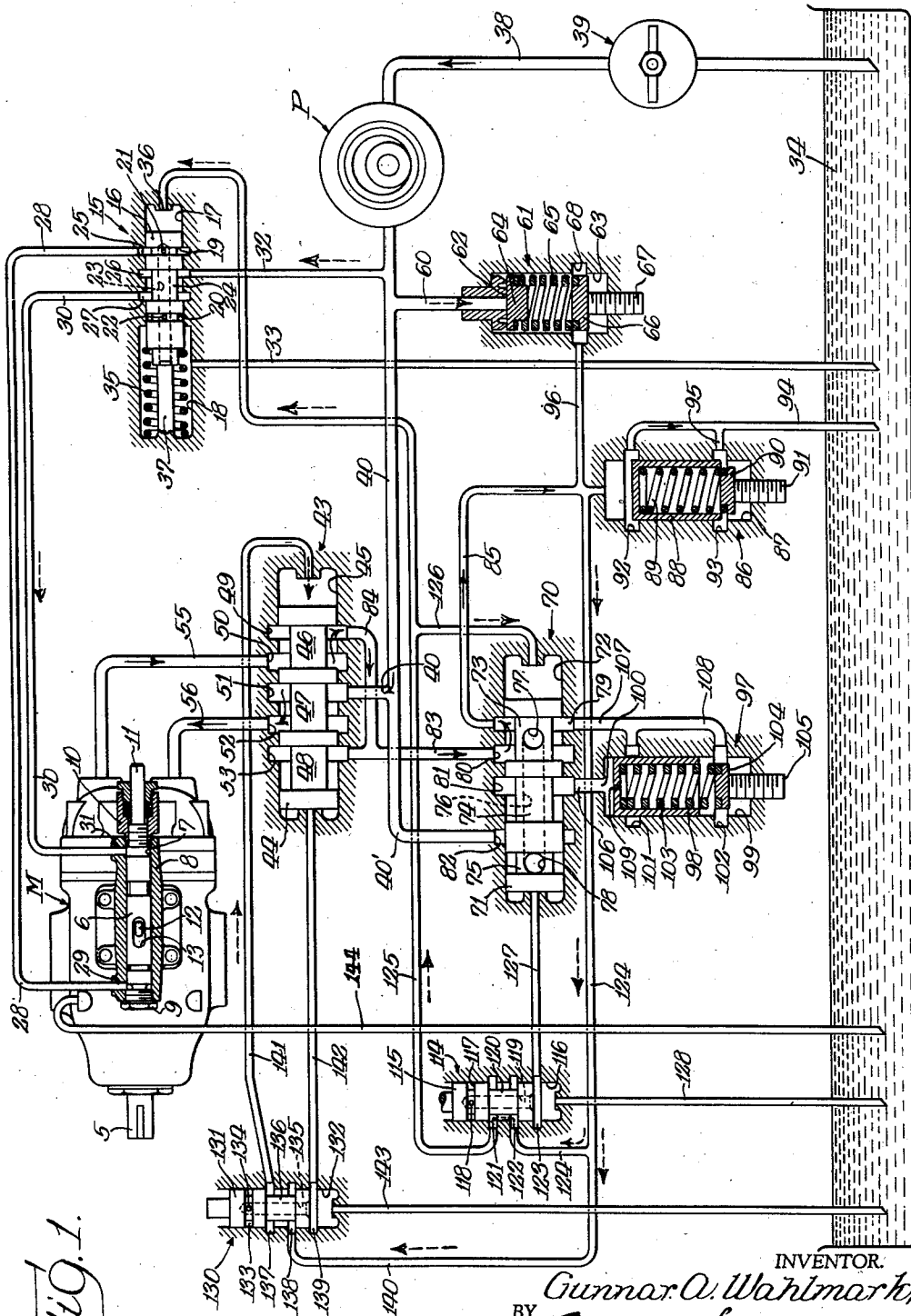


Fig. 1.

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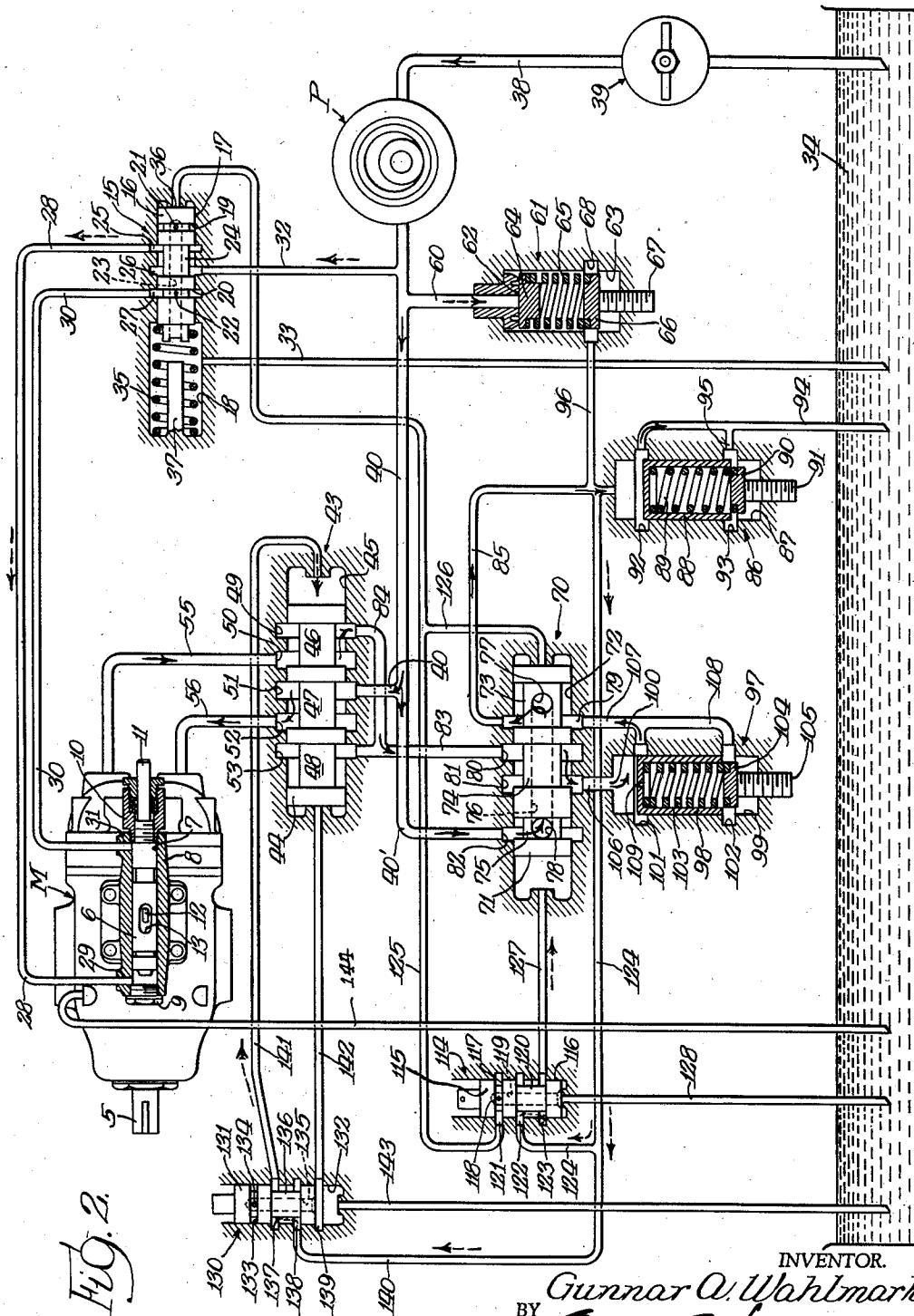
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2 Sheets-Sheet 2



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HYDRAULIC CIRCUIT

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14 Claims. (Cl. 60—53)

The invention relates to a hydraulic circuit particularly adaptable for use with a machine tool and has as a general object to provide a circuit of new and improved construction.

A more particular object of the invention is to provide a circuit including a motor and new and improved means for braking the motor when the element driven thereby is to be brought to rest.

Another object is to provide a circuit including a motor and means for causing the motor to operate against a high back pressure for rapid deceleration of the motor when it is desired to arrest movement of the element driven by the motor.

Another object is to provide a circuit including a motor, means for maintaining a normal low back pressure on the discharge side of the motor and means providing a high back pressure on the discharge side of the motor during deceleration of the element driven by the motor.

Still another object is to provide a circuit including a variable stroke motor, means for maintaining a normal low back pressure on the discharge side of the motor and means adjustable to provide a high back pressure during deceleration of the element driven by the motor, the motor stroke being adjusted simultaneously with the adjustment to obtain the higher back pressure to increase the torque of the motor.

Other objects and advantages will become apparent from the following detailed description taken in connection with the accompanying drawings, in which:

Fig. 1 is a diagrammatic view showing a circuit embodying the features of this invention. The circuit is shown in running position.

Fig. 2 is a diagrammatic view similar to Fig. 1, but showing the circuit in braking position.

The circuit shown in the drawings for purposes of disclosing an exemplary embodiment of the invention comprises generally a variable displacement motor M, a pump P for supplying operating fluid to the motor, means for controlling the displacement of the motor, and means for controlling the supply of operating fluid by the pump to the motor. The motor M is a wobbler type piston motor of the general character disclosed in my Patent No. 2,344,432 issued March 14, 1944. The wobbler plate is non-rotatably mounted on a shaft 5 which projects at one end from the motor casing so as to permit coupling to an element to be driven by the motor. The wobbler is pivotally mounted on the shaft 5 so as to be adjustable in its angular position with respect to the shaft, thereby to govern the length of stroke of the

pistons and hence the displacement and torque of the motor. Herein the wobbler is under the control of hydraulic displacement varying means comprising a piston 6 reciprocable in the bore 7 of a cylinder 8 secured to the motor casing externally thereof. One end of the bore 7 is closed by a screw plug 9 while the other end is closed by a suitable cap 10, including a threaded pin 11 forming an adjustable abutment for limiting movement of the piston 6 in one direction. The wobbler has projecting radially therefrom a finger or arm 12 which is received in an appropriately formed socket 13 in the piston 6, so that shift of the piston varies the tilt of the wobbler. Herein minimum stroke of the motor pistons is obtained when the piston 6 is shifted to the left, as shown in Fig. 1, while an increased stroke is obtained when the piston 6 is shifted to the right, this stroke being variable to a degree by adjustment of the pin 11.

Supply of fluid to shift the piston 6 and thus vary the displacement of the motor is under the control of a valve means, generally designated 15, which will hereinafter be known as the displacement control valve means. This valve means comprises a valve 16 of the cylinder type reciprocable in a valve bore 17 having an enlarged portion 18 at one end. Spaced inwardly from the ends of the valve are annular grooves 19 and 20 connected by radial ports 21 and 22, respectively, with an axial passage 23 opening only through the left end of the valve so as to be in communication with the enlarged portion 18 of the valve bore. Intermediate the grooves 19 and 20 the valve is formed with a reduced portion 24. The bore 17 has opening therein three annular grooves 25, 26 and 27, the grooves being equally spaced and spaced to permit bridging of adjacent grooves by the reduced portion 24 of the valve 16. Groove 25 is by a conduit 28 connected to a port 29 opening to the left hand end of the cylinder 8, while groove 27 is by conduit 30 connected to a port 31 opening to the right hand end of the cylinder 8. Groove 26 is, as will later become more apparent, connected by a conduit 32 to the main fluid supply conduit, while the enlarged portion 18 of the valve bore is by a conduit 33 connected to the tank or reservoir 34.

The valve 16 has two operative positions, namely, that shown in Fig. 1 wherein the grooves 26 and 27 are bridged, and the other, wherein the valve is shifted to the right to the position shown in Fig. 2, wherein the grooves 26 and 25 are bridged. The valve is constantly urged to the second mentioned position, namely, that shown

in Fig. 2, by a light compression spring 35 positioned in the enlarged portion 18 of the valve bore and bearing against the end of the valve so as to urge the same to the right, the extent of movement being limited by abutment of the valve with the end of the valve bore. The valve is shifted to the first mentioned position, namely, that shown in Fig. 1, by fluid under pressure which is discharged to the bore through an end port 36. Movement of the valve to the left is limited by a pin 37.

The pump P is of the constant displacement, rotary element type well known in the art. The pump operates when driven by a suitable means (not shown) to draw fluid from the tank 34 through an intake conduit 38, which preferably has a filter or strainer 39 interposed therein, and discharge the fluid under pressure into a main supply line or conduit 40. Governing the direction in which fluid discharged by the pump P is supplied to the motor, and hence the direction of operation of the motor, is a directional control valve means generally designated 43. This valve means comprises a valve 44 of the cylinder type reciprocable in a valve bore 45 and having three reduced portions 46, 47 and 48 of equal length. The valve bore 45 has opening thereto five annular grooves 49, 50, 51, 52 and 53, all equally spaced and so spaced that adjacent grooves may be bridged by the reduced portions of the valve 44. The central groove 51 is connected to the supply conduit 40, while the grooves 50 and 52 on opposite sides of the groove 51 are, respectively, connected by conduits 55 and 56 to the main motor ports. These latter conduits 55 and 56 serve alternatively as supply or return conduits depending upon whether the valve is in the position shown in Fig. 1 or is shifted to the right, wherein the reduced portion 47 bridges the grooves 50 and 51.

Also connected to the main supply conduit 40 is a branch conduit 60 leading to a relief valve means, generally designated 61. The conduit 60 opens through means forming a valve seat 62 to discharge to a valve bore 63. Cooperating with this seat is a valve 64 urged to seated position by a strong compression spring 65 bearing at one end on the valve and at the other end on a washer 66 seated on an adjusting screw 67. The valve 61 is, by way of example, adjusted to maintain a pressure in the supply conduit 40 up to approximately 1000 pounds. The pressure maintained by this valve will hereinafter be known as working pressure. The valve bore 63 has opening thereto a single annular groove 68 which is eventually connected to tank through means presently to be described.

Means is provided for governing the supply of effective operating fluid to the motor and hence there is associated with the main supply conduit 40 a valve means, generally designated 70, which serves as a stop and running valve means. This valve means comprises a valve 71 of the cylinder type reciprocable in a valve bore 72. The valve 71 has two reduced portions 73 and 74 of equal length, and a reduced portion 75 of a length somewhat shorter than the portions 73 and 74. Extending axially of the valve is a bore 76 which, through radial ports 77 and 78 respectively opening to the reduced portions 73 and 75, connects those reduced portions. Formed in the valve bore and opening thereto are four annular grooves 79, 80, 81 and 82. Three of these grooves 79, 80 and 81 are equally spaced and are so spaced that any adjacent two may be bridged by either

the reduced portion 73 or the reduced portion 74. The groove 82 is spaced from the groove 81 and cooperates with the reduced portion 75 of the valve. The valve has two positions, namely, that shown in Fig. 1, which may be termed the running position, and the position which it assumes when shifted to the extreme right, shown in Fig. 2, which may be termed the stop position or the braking position. Groove 82 is connected with the main supply conduit 40 by a branch conduit 40' which at times (when valve 71 is shifted to the right as viewed in Fig. 2) in conjunction with the bore in the valve 71 forms a by-pass around the motor M for the fluid discharged by the pump. At this time the fluid in conduits 40 and 40' is no longer at working pressure but merely at the lower pressure maintained by the back pressure valve means 86. The intermediate groove 80 of the three equally spaced grooves is connected by a conduit 83 to the groove 53 of the directional control valve means, and by a branch conduit 84 to the groove 49 of the directional control valve means to form part of a discharge or return line from the motor.

This discharge or return line also includes a conduit 85 and a pressure opened valve means, generally designated 86, operable at all times to maintain a low back pressure in the return line to steady the normal operation of the motor and to provide a convenient source of control fluid at a suitable pressure. The conduit 85 connects at one end to the groove 79 of valve means 70 and at the other end discharges to one end of the bore 87 of valve means 86. Reciprocable in the bore is a valve 88 of the piston type which is urged toward the end of the bore through which the conduit 85 opens by a light compression spring 89 bearing at one end against the valve and at the other end against a washer 90 seated on an adjusting screw 91. Opening through the side walls of the bore are widely spaced annular grooves 92 and 93. Communication between the conduit 85 and the groove 92 is controlled by the valve 88, but the groove 93 is constantly open to the valve bore 87. The return or discharge line of the circuit is completed by a conduit 94 leading from the groove 92 to the tank 34 and a branch conduit 95 leading from the groove 93 to the conduit 94. The back pressure valve means, by way of example, is adjusted to maintain up to 60 pounds per square inch pressure. To permit return to tank of any fluid flowing past the relief valve means 61, a conduit 96 is connected between the groove 68 and the conduit 85.

It is a feature of this invention to provide unique and improved means for rapidly decelerating the motor and the element driven thereby. Herein this is accomplished by compelling the motor to discharge fluid against a high back pressure during such deceleration. The means for accomplishing this function herein takes the form of a pressure opened valve means, generally designated 97, similar to the back pressure valve means 86 but capable of maintaining substantially higher back pressures. This valve means will hereinafter be termed braking valve means, in order more readily to distinguish the same from the low back pressure valve means 86. This braking valve means comprises a valve 98 of the piston type reciprocable in a valve bore 99. Opening to the valve bore 99 at one end is a port 100, while opening through the side walls of the bore 97 near the ends thereof are widely spaced annular grooves 101 and 102. Communication between the port 100 and the groove 101 is con-

trolled by the valve 98. Groove 102, however, is not controlled by the valve 98, but is in all positions of the valve open to the bore 99. The valve 98 is urged in a direction to cut off communication between the port 100 and the groove 101 by a strong compression spring 103 bearing at one end against the end of the valve and at the other end on a washer 104 seated on an adjusting screw 105. The pressure at which the valve means will open may thus be adjusted by the screw 105 and is herein, for exemplary purposes, considered adjusted to maintain a pressure of 1000 pounds per square inch.

In order that this valve means may be interposed in the return line of the circuit during deceleration of the motor, but not during normal operation, its connections to the circuit are governed by the running and stop or braking valve means 70. Thus port 100 is by a conduit 106 connected to the groove 81, while groove 79 of the valve means 70 is by conduit 107 and a branch conduit 108 connected respectively to the grooves 101 and 102. It is to be noted that the valve means 97 is thus connected in the return line in advance of the low back pressure valve means 86, and also in advance of the point of discharge of the by-pass line to the return line. The valve 98 is formed with a small bleed orifice 109 in its closed end, which orifice serves to permit manual operation of the motor when the valve 71 is in stop or braking position, as will later be more fully described.

It is also a feature of this invention to aid and abet the deceleration of the motor by the braking valve means to change the tilt of the wobbler, so as to obtain maximum torque of the motor during such deceleration. To that end, the valve 71 is shifted hydraulically and with the valve means 15 under the control of a common pilot valve means, generally designated 114. This valve means comprises a valve 115 of the cylinder type reciprocable in a valve bore 116. At one end the valve is formed with an annular groove 117 which, through a radial port 118, communicates with an axial bore 119 opening only through the end of the valve opposite that carrying the groove 117. Spaced from the groove 117 is a substantially wider groove formed by a reduced portion 120 of the valve. Opening to the valve bore are three annular grooves 121, 122 and 123, all equally spaced and so spaced as to permit the bridging of any two adjacent grooves by the reduced portion 120 of the valve. The valve is intended to be suitably actuated, most likely manually, and has two positions, namely, that shown in Fig. 1, which may be termed the start or running position, and that shown in Fig. 2, which may be termed the stop or braking position.

Control fluid is derived from the return conduit 85, such fluid at all times being maintained at a suitable pressure by the back pressure valve means 86. Such control fluid is supplied to the pilot valve means 114 through a conduit 124 connected at one end to the return conduit 85 and at the other end to the groove 122 which is the intermediate one of the three grooves 121, 122 and 123. Groove 121 is in turn connected to the port 36 of the valve means 15 by a conduit 125 and to the right hand end of the bore 72 of the valve means 70 by a branch conduit 126. The left hand end of bore 72 is by conduit 127 connected to the groove 123 and a conduit 128 connects the end of the bore 116 to the tank. It will thus be seen that the valve 71 and the valve 16 will be shifted simultaneously and that thus

the wobbler of the motor M will be tilted to obtain the maximum motor stroke simultaneously with the connection of the braking valve means in the return circuit.

The directional control valve means 43 is also hydraulically shifted and is, therefore, under the control of a reversing pilot valve means, generally designated 130. This valve means is identical with the valve means 114 comprising a valve 131 of the cylinder type reciprocable in a valve bore 132. The valve is formed with an annular groove 133 near one end which, through a radial port 134, communicates with an axial bore 135 opening only through the end of the valve remote from the groove 133. Intermediate its ends the valve is formed with a reduced portion 136. Opening to the bore are three annular grooves 137, 138 and 139, the intermediate groove 138 being by conduit 140 connected to the conduit 124. Grooves 137 and 139 are by conduits 141 and 142, respectively, connected to the right and left hand ends of the bore 45. A conduit 143 connects the end of the bore 132 to the tank.

For a more ready understanding of the invention, the operation of the circuit will now be described briefly. The features of the invention will most readily be understood and appreciated if the operation is considered in transition from a condition of the circuit in which the motor is operating normally to one in which the motor will be at rest. Thus, let it be assumed that the motor is already running, in which case the various valve means will assume the positions shown in Fig. 1. More particularly, the start and stop pilot valve means 114 will be in its upper or start position wherein control fluid is supplied to the right hand ends of both the displacement control valve means 15 and the running-braking valve means 70. The valve 16 will then be shifted to the left against the stop 37, thereby bridging the grooves 26 and 27 and permitting the supply of pressure fluid to the right hand end of cylinder 8. This will shift the piston 6 to the left and thus will, as previously mentioned, place the wobbler in such position as to produce minimum stroke of the motor pistons, thereby giving high speed operation at low torque of the motor. The fluid supplied to the right hand end of the valve means 70 will shift the valve 71 to the left, thereby blocking the groove 82 closing the by-pass line 40' and bridging the grooves 79 and 80 completing a return line which does not include the braking valve means 97. The return circuit does, however, include the back pressure valve means 86 which maintains at all times a low back pressure. This constant low back pressure, first of all, steadies the operation of the motor M in that it resists tendencies on the part of the driven element to overrun, and, secondly, provides a source for the control fluid. Under this condition, the directional control valve means 43 may be shifted back and forth under the control of the reversing pilot valve means 130 to reverse the operation of the motor, but no further change takes place with such reversal of motor operation.

If now the start-stop pilot valve means 114 is shifted downwardly to its stop position, shown in Fig. 2, the improved and unique circuit arrangement herein provided will come into play quickly to decelerate the motor and the element driven thereby. With this shift of the valve 115 to its stop position, grooves 122 and 123 are now bridged, thereby supplying control fluid to the left hand end of the valve bore 72. At the same

time, groove 117 now registers with groove 121 to connect the conduit 125 to tank, thereby permitting the valve 71, under the influence of the control fluid supplied to its left hand end, and the valve 16, under the influence of the spring 35, to be shifted to the right to the position shown in Fig. 2. In this position, the reduced portion 75 of the valve 71 registers with the groove 82, thereby connecting the branch conduit 40' to the return conduit 85 completing the by-pass passage around the motor, and permitting the fluid discharged by the pump to discharge to the tank through the back pressure valve means 86. The grooves 80 and 81 are now bridged, thereby connecting the braking valve means 97 in the return line of the circuit. The fluid discharged by the motor M now must overcome the valve means 97 and thus there will be set up a high back pressure counteracting the inertia tendency of the motor and the element driven by the motor to continue to operate in the same direction. The circuit arrangement here shown has the additional advantage that though, in the stop or braking position of the valve 71, fluid supplied by the pump is not effective to drive the motor, yet it is not completely cut off from the motor, but still may be drawn into the motor to maintain operation with the cylinders full of fluid and the piston held against the wobbler.

With the valve 16 shifted to the right the grooves 25 and 26 will now be connected while groove 27 will, through groove 20, be connected to tank. Thus fluid under pressure will be supplied to the left end of the cylinder 8, thereby shifting the piston 6 to the right into abutment with the adjusting screw 11. This will tilt the wobbler so as to increase the stroke of the pistons and thereby increase the torque of the motor. As a consequence, the high back pressure in conjunction with the increased torque of the motor will quickly bring the motor and the element driven thereby to rest.

In this condition, the motor will remain at rest until, through shift of the start-stop pilot valve means, the valve means 70 and the valve means 15 are again shifted in the opposite direction. Though the motor is at rest, it may be manually actuated for adjustment purposes. Such manual actuation is permitted because of the bleed orifice formed in the end of the piston valve 98. This bleed orifice permits fluid to flow from the conduit 83, grooves 80 and 81 which are now bridged by the reduced portion 74, conduit 106, groove 102, and conduits 108 and 107 to the groove 79 at a rate at which fluid is displaced by manual operation of the motor M. Any excess of fluid accumulating in the casing of the motor overflows to tank through conduit 144.

I claim as my invention:

1. In a hydraulic circuit, a motor, a pump for supplying operating fluid to said motor, a supply line leading from said pump to said motor, a return line leading from said motor, a high back pressure valve means, and means operable in effect to exclude said back pressure valve means from the return line and cause fluid from said pump to be supplied to said motor at working pressure or alternatively to discontinue the supply of fluid at working pressure to said motor and to interpose said back pressure valve means in the return line of the circuit.

2. In a hydraulic circuit, a motor, a pump for supplying operating fluid to said motor, a supply line leading from said pump to said motor, a return line leading from said motor, a by-pass

line connected between said supply line and said return line, a fluid pressure opened valve means, and control valve means having a plurality of positions in one of which the by-pass line is closed and the pressure opened valve means excluded from the return line and in another of which the by-pass line is open and said pressure opened valve means is interposed in the return line in advance of the connection therewith of the by-pass line.

3. In a hydraulic circuit, a motor, a pump for supplying operating fluid to said motor, a supply line leading from said pump to said motor, a return line leading from said motor, a first fluid pressure opened valve means permanently connected in the return line of the circuit, a second normally closed valve means adapted to be opened by the pressure of the fluid flowing therethrough, said second valve means operating at a substantially higher pressure than said first valve means, and means for alternatively interposing said second valve means in or disconnecting the same from the return line of the circuit.

4. In a hydraulic circuit, a motor, a pump for supplying operating fluid to said motor, a supply line leading from said pump to said motor, a return line leading from said motor, a first fluid pressure opened valve means permanently connected in the return line of the circuit, a second fluid pressure opened valve means, said second valve means operating at a substantially higher pressure than said first valve means, and a control valve means having a stop and running position, said control valve means in running position disassociating said second valve means from the circuit and in stop position connecting the pump to the return line and interposing said second valve means in the return line in advance of the point of connection of the supply line therewith.

5. In a hydraulic circuit, a variable displacement motor, a pump for supplying operating fluid at working pressure to said motor, valve means governing the supply of fluid by the pump to the motor, and simultaneously operable hydraulic means governing the displacement of said motor to obtain maximum displacement of said motor when the supply of fluid at working pressure is discontinued.

6. In a hydraulic circuit, a variable displacement motor, hydraulically actuated means for varying the displacement of said motor, a pump for supplying operating fluid to said motor, valve means having a stop position and a running position governing the supply of fluid by said pump to said motor, and means governing said hydraulically actuated displacement varying means to adjust said motor to maximum displacement when said valve means is in stop position.

7. In a hydraulic circuit, a variable displacement motor, hydraulically actuated means for varying the displacement of said motor, a first hydraulically controlled valve means governing said displacement varying means, a pump for supplying fluid to said motor, a second hydraulically actuated valve means having a stop position and a running position governing the supply of fluid by said pump to said motor, and pilot valve means governing said first and second valve means to obtain maximum motor displacement when said second valve means is shifted to stop position.

8. In a hydraulic circuit, a variable displacement motor, means governing the displacement of said motor, a pump for supplying operating

fluid to said motor, a supply line leading from said pump to said motor, a return line leading from said motor, means operable when connected in the return line to set up a high back pressure, and means operable to connect said last mentioned means in the return line of the circuit and simultaneously actuate said displacement governing means to obtain maximum displacement of the motor.

9. In a hydraulic circuit, a variable torque motor, means governing the torque of said motor, a pump for supplying operating fluid to said motor, a supply line leading from said pump to said motor, a return line leading from said motor, a fluid pressure opened valve means, control valve means having a plurality of positions in one of which the pressure opened valve means is excluded from the return line and fluid from said pump caused to be supplied to said motor at working pressure and in another of which the supply of fluid to the motor at working pressure is cut off and said pressure opened valve means is interposed in the return line, and means for simultaneously controlling said control valve means and said torque governing means to obtain maximum torque when said valve means is in its last mentioned position and minimum torque when said valve means is in its first mentioned position.

10. In a hydraulic circuit, a variable displacement motor of the wobbler type, hydraulically actuated means governing the displacement of said motor, a first hydraulically controlled valve means governing said displacement varying means, a pump for supplying operating fluid to said motor, a supply line leading from said pump to said motor, a return line leading from said motor, a by-pass line connected to said supply line, a fluid pressure opened valve means, a second hydraulically actuated valve means having a plurality of positions in one of which the by-pass line is closed and the pressure opened valve means excluded from the return line, and in another of which the by-pass line is connected to the return line and said pressure opened valve means is interposed in the return line in advance of the connection therewith of the by-pass line, and pilot valve means exercising common and simultaneous control over said first and second valve means to obtain maximum displacement of said motor when said fluid pressure opened valve means is connected in the return line.

11. In a hydraulic circuit, a variable displacement motor of the wobbler type, hydraulically actuated means governing the displacement of said motor, a first hydraulically controlled valve means governing said displacement varying means, a pump for supplying operating fluid to said motor, a supply line leading from said pump to said motor, a return line leading from said motor, a by-pass line connected to said supply line, a fluid pressure opened valve means, a second hydraulically actuated valve means having

a plurality of positions in one of which the by-pass line is closed and the pressure opened valve means excluded from the return line, and in another of which the by-pass line is connected to the return line and said pressure opened valve means is interposed in the return line in advance of the connection therewith of the by-pass line, pilot valve means exercising common and simultaneous control over said first and second valve means to obtain maximum displacement of said motor when said fluid pressure opened valve means is connected in the return line, a conduit leading from said return line to said pilot valve means to supply control fluid thereto, and a second low back pressure valve means permanently interposed in the return line beyond the point of connection thereto of said last mentioned conduit to maintain fluid at suitable control pressure.

12. In a hydraulic circuit, a motor, a pump for supplying operating fluid to said motor, a supply line leading from said pump to said motor, a return line leading from said motor, a by-pass line connected to said supply line, a fluid pressure opened valve means, and control means having a plurality of positions in one of which the by-pass line is closed and the pressure opened valve means excluded from the return line, and in another of which the by-pass line is open and said pressure opened valve means is interposed in the return line.

13. In a hydraulic circuit, a motor, a pump for supplying operating fluid to said motor, a supply line leading from said pump to said motor, a return line leading from said motor, a first fluid pressure opened valve means, a second fluid pressure opened valve means, said second valve means operating at a substantially higher pressure than said first valve means, and a control valve means having a stop and a running position governing the supply of fluid at working pressure to said motor, said first fluid pressure opened valve means being connected in said return line when said control valve is in running position, and said control valve being operable when in stop position to connect said second fluid pressure opened valve means in said return line and when in running position to disconnect the same therefrom.

14. In a hydraulic circuit, a variable torque motor, means governing the torque of said motor, a pump for supplying operating fluid to said motor, a supply line leading from said pump to said motor, a return line leading from said motor, means for creating back pressure in said return line, and means operable alternatively to reduce the pressure of the liquid supplied to said motor and simultaneously to increase the torque of said motor and the back pressure, or to increase the pressure of the fluid supplied to said motor and simultaneously to decrease the torque of said motor and the back pressure.

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