April 16, 1946. G. S. LIGHT 2,398,542

HYDRAULIC VALVE

Filed Jan. 16, 1942 3 Sheets-Sheet 1

Fig. 1

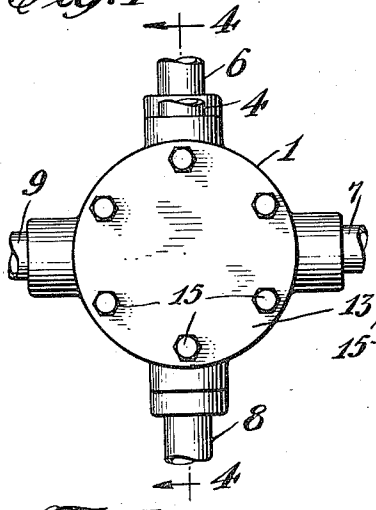



Fig. 2

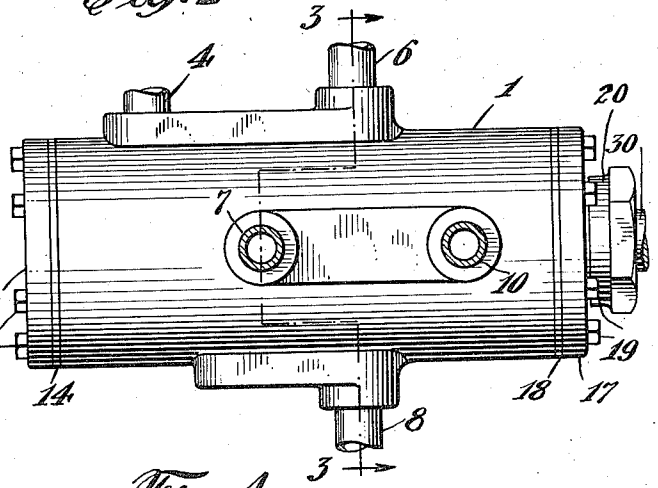



Fig. 3

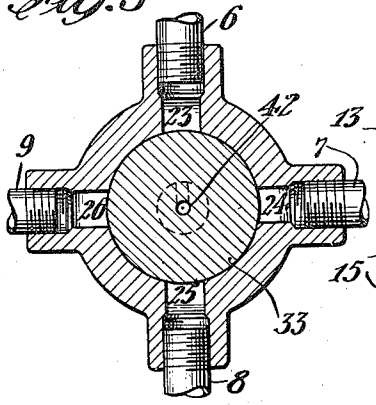



Fig. 4

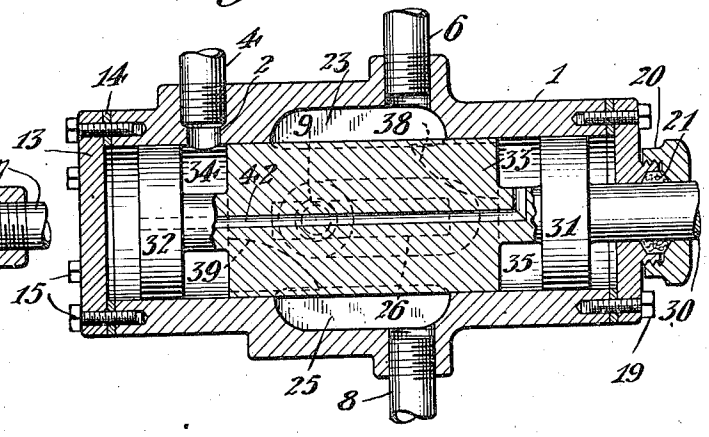



Fig. 6

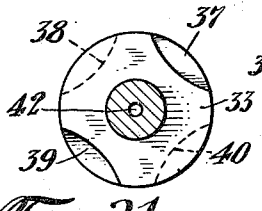



Fig. 5

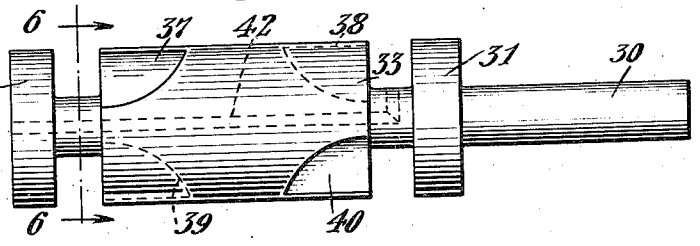



Fig. 21

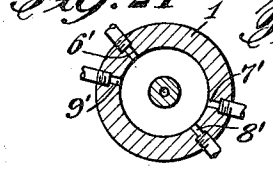



Fig. 22

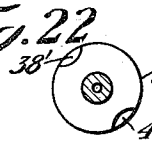
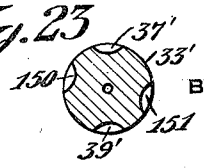



Fig. 23




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HYDRAULIC VALVE

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Fig. 7

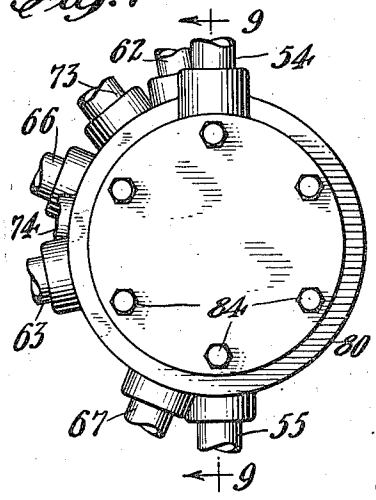



Fig. 8

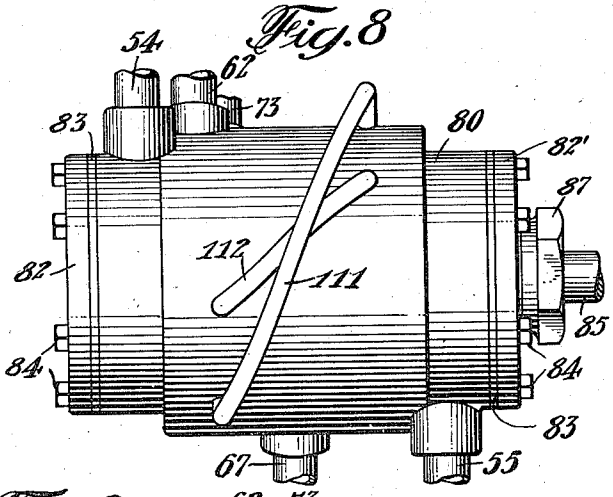



Fig. 9

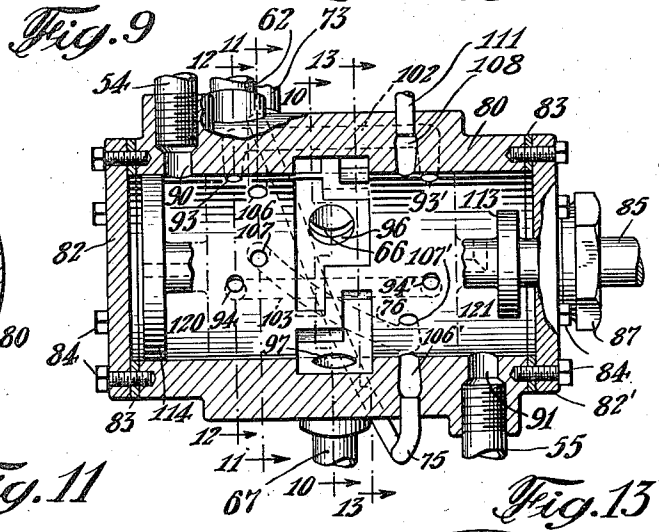



Fig. 10

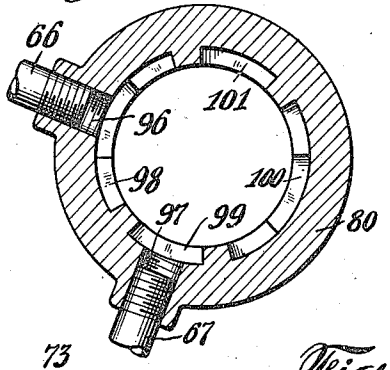



Fig. 11

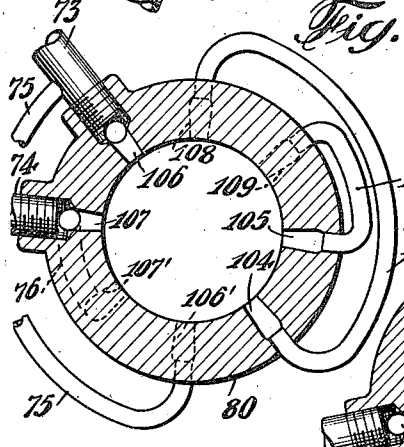



Fig. 12

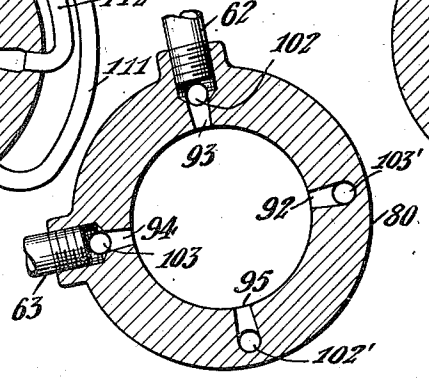
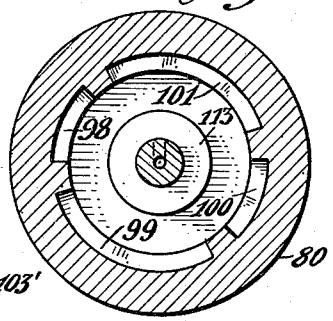



Fig. 13




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HYDRAULIC VALVE

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Fig. 15

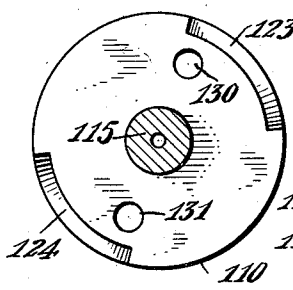



Fig. 14

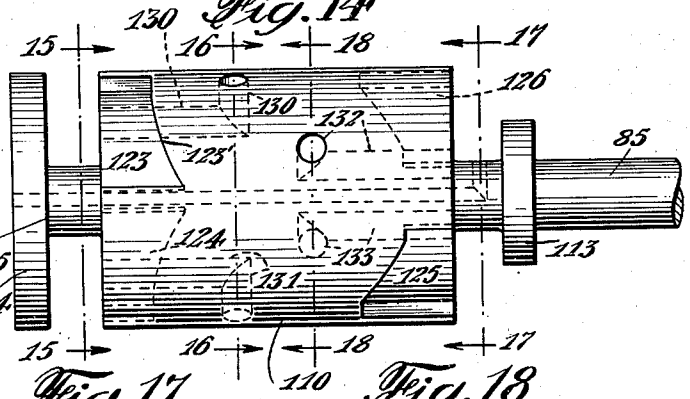



Fig. 16

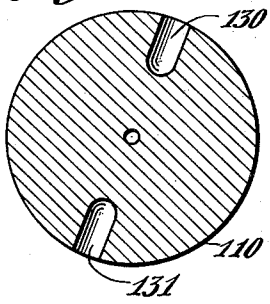



Fig. 17

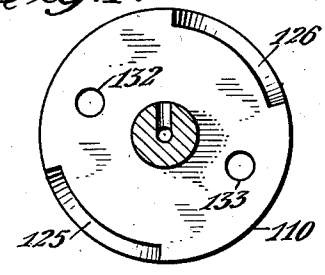



Fig. 18

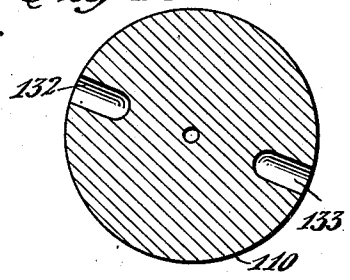



Fig. 19

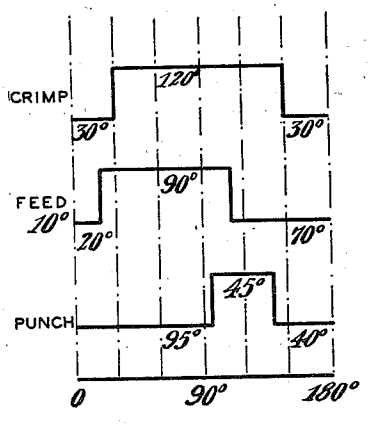
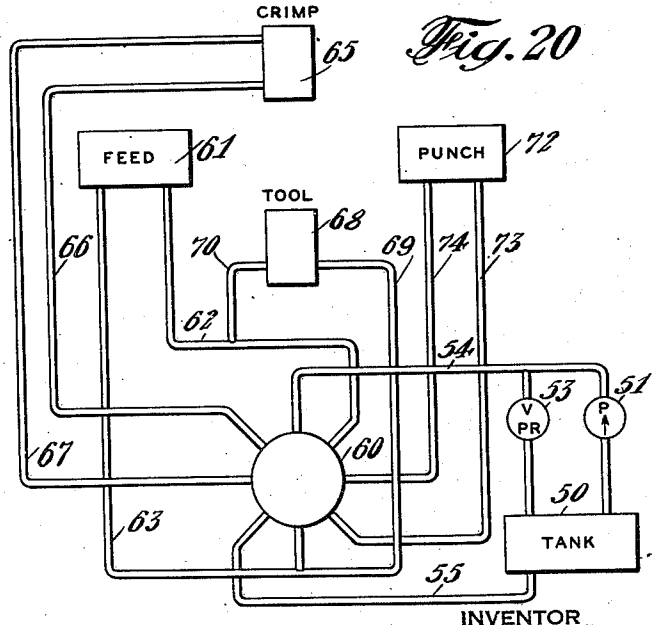



Fig. 20




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Patented Apr. 16, 1946 2,398,542

# UNITED STATES PATENT OFFICE

2,398,542

## HYDRAULIC VALVE

George S. Light, Winsted, Conn.

Application January 16, 1942, Serial No. 426,953

4 Claims. (Cl. 251—98)

This invention relates to hydraulic valves generally, and more particularly to hydraulic valves for use in fluid pressure systems including one or more hydraulically operated motors of various types to provide a hydraulic driving system as a substitute for the conventional forms of tool operating machinery, for changing speed and type or direction of motions between prime mover and tool. The subject of this invention, a new hydraulic valve, makes it possible to operate tools by a means of a hydraulic high pressure power system at the rate of hundreds of cycles per minute where conventional hydraulic power systems including conventional valves can operate them at only a few cycles per minute. It is also an object of this invention to provide a valve with a hydraulic balancing means of universal nature that does not interfere with the requirement of port size spacing or positioning.

Another object of this invention is to provide a hydraulic valve capable of converting a high speed motion of continuous rotation such as that provided by conventional prime movers into a motion of continuous oscillation. Another object of this invention is to provide a hydraulic valve for use in a high fluid pressure hydraulic power system which can be always in hydraulic balance to eliminate binding between moving parts and consequent failure of such system.

A still further object of this invention is to provide a hydraulic valve capable of providing a high rate of flow reversal in a number of high pressure hydraulic circuits, each of which includes means for operating a tool or other instrumentality. Such a valve should provide any desired time relation in and between the several circuits.

Further objects and advantages of this invention will be apparent to those skilled in the art after consideration of the following specification taken in conjunction with the accompanying drawings wherein;

Fig. 1 is an end view of a hydraulic valve including the subject-matter of this invention;

Fig. 2 is a side elevation of the valve shown in Fig. 1;

Fig. 3 is a cross section taken on line 3—3 of Fig. 2;

Fig. 4 is a cross section taken on line 4—4 of Fig. 1;

Fig. 5 is an elevation from the front of the rotor shown in cross section in Fig. 4;

Fig. 6 is an end view of the rotor shown in Figs. 4 and 5 and taken on line 6—6 of Fig. 5;

Fig. 7 is an end view of a modification of the valve comprising this invention;

Fig. 8 is a side elevation of the valve shown in Fig. 7;

Fig. 9 is a cross section on line 9—9 of Fig. 7;

Fig. 10 is a cross section on line 10—10 of Fig. 9;

Fig. 11 is a cross section on line 11—11 of Fig. 9;

Fig. 12 is a cross section on line 12—12 of Fig. 9;

Fig. 13 is a cross section on line 13—13 of Fig. 9;

Fig. 14 is a front elevation of the rotor, parts of which are shown in Fig. 9;

Fig. 15 is an end view of the rotor looking from line 15—15 in Fig. 14;

Fig. 16 is a cross section taken on line 16—16 of Fig. 14;

Fig. 17 is another end view of the rotor taken from line 17—17 of Fig. 14;

Fig. 18 is a cross section of Fig. 14 on line 18—18;

Fig. 19 is a diagram illustrating the flow reversals with respect to the degrees of rotation of the valve shown in Figs. 7 to 18;

Fig. 20 illustrates the application of the valve shown in Figs. 7 to 18 to a hydraulic system for operating tools;

Fig. 21 is a cross section of the casing of a valve embodying the principles of this invention, the ports being spaced apart at an angle other than ninety degrees;

Fig. 22 is an end view of the high-pressure end of the rotor adapted for use in the casing of Fig. 21; and

Fig. 23 is an end view of the low-pressure end of the rotor shown in Fig. 22.

Figs. 1 to 6 of the drawings illustrate a basic form of hydraulic valve embodying the invention. The valve consists of an outer casing 1 provided with a supply pressure inlet port 2 having a suitable pipe connection 4 which may be connected to a source of fluid pressure such as a pump. Casing 1 also is provided with the fluid power connections 6, 7, 8 and 9, these connections being connected to a power converting mechanism, as for instance, a piston and cylinder for converting the fluid pressure into a desired useful motion or work. The return outlet 10 is provided for connection to the return line of the pressure source, as will be explained in more detail later on in the description.

Casing 1 is sealed at the left hand end by means of the head 13 and gasket 14 secured by bolts 15 or in any suitable fashion. The other end of the casing 1 is closed by a head 17 and gasket

18 secured by bolts 19, together with a stuffing box including a nut 20 and the packing 21. The interior of the casing includes port passages 23, 24, 25 and 26, these port passages connecting with the outlets 6, 7, 8 and 9.

The valving action of the mechanism is accomplished by a rotor, shown in Figs. 4, 5 and 6, which includes a drive shaft 30 extending through the stuffing box 20 and 21, sealing discs 31 and 32, together with the main portion 33 of the rotor which actually accomplishes the valving action. Chamber 34 is an inlet chamber into which inlet port 2 opens and chamber 35 is an outlet chamber into which outlet port 10 opens. The main element 33 of the rotor is a solid cylindrical member having the cutout channels 37, 38, 39 and 40, channels 37 and 39 permitting the passage of fluid under pressure from the inlet 2 and the inlet chamber 34 to the port passages 23, 24, 25 and 26 in the casing 1, and channels 38 and 40 permitting the passage of fluid from the passages 23, 24, 25 and 26 to outlet chamber 35. The rotor 33 may be provided with bore 42 connecting the space to the left of disc 32 with the outlet chamber 35 of the valve, this being provided for preventing pressure from building up in the space between the head 13 and disc 32 as might be caused by leakage of fluid under pressure from chamber 34. Thus, there can be no end thrust at either end of the rotor member. Disc 31 need not be the full diameter of the casing bore and both discs 31 and 32 may be closely fitted to elements 13 and 18 to prevent end play. It should be noted that the cylindrical surfaces of the rotor 33 are fitted to a close fit to the interior of casing 1 so that there will be no flow of fluid except as permitted by the channels and passages.

One of the principal features of this invention is the arrangement of the channels 37, 38, 39 and 40 on rotor 30, the channel 37 being opposed to and displaced 180 degrees from the channel 39 on the left end of rotor 33 and channel 38 being opposed to and displaced 180 degrees from channel 40 at the right hand end of rotor 33. The opposed channels at each end of the rotor always are under the same pressure, and channels 37 and 39 are equal in area as are channels 38 and 40. Therefore, it is evident that there can be no side thrust on the rotor which might cause it to bind with respect to the casing and regardless of the amount of pressure in the inlet chamber 34, the rotor 33 always rotates freely. A further reason for the hydraulic balance thus obtained is the fact that the port passages 23 and 25 are also directly opposite one another, as is the case with the port passages 24 and 26. The areas of opposed port passages 23, 25 are equal and identical as are passages 24 and 26 so that the areas of the rotor which are exposed to pressure, including the channels 37, 38, 39 and 40 and those exposed to pressure by the port passages, are always equal on either side of any diameter section. The provision of common inlet and outlet chambers together with the particular rotor channels and port passages makes possible a hydraulically balanced high speed rotary valve which will apply and relieve pressure with any desired time relation, as outlet passages 23 and 25 may be disposed at any desired angle with respect to the passages 24 and 26.

For the purpose of describing the operation of the valve it will be assumed that outlets 6, 7, 8 and 9 are connected to cylinders enclosing two double acting pistons or any other form of hydraulic motor so that pressure may be turned on and off to operate a tool or other instrumentality connected with the hydraulic motor. For purposes of illustration let it be assumed that channels 37, 38, 39 and 40 each subtend an angle of 40° at the circumference of the rotor and passages 23, 24, 25 and 26 each subtend an angle of 35° at the same circumference. As rotor 33 rotates, pressure fluid flow is applied from the chamber 34 through the channels 37 and 39 of the rotor through port passages 23 and 25 to outlets 6 and 8, through 75 degrees of rotation, for instance. At the same time, return flow is permitted from inlets 7 and 9 through port passages 24 and 26, channels 40 and 38, return chamber 35, and outlet 10. This permits motion in one direction of two double acting pistons, for example, with pressure being applied at one end of their cylinders and oil being discharged from the other end of each cylinder. Rotation beyond this point causes channels 37 and 39 of the rotor to pass beyond port passages 23 and 25 so that no pressure fluid can flow from chamber 34. After a total of 90 degrees of operation the channels 37 and 39 permit the application of pressure or pressure flow to the port passages 24 and 26 and outlets 7 and 9, while at the same time the channels 38 and 40 permit permit return flow from inlets 6 and 8 through port passages 23 and 25 to chamber 35.

This particular arrangement of a casing having a number of outlets and port passages 23, 24, 25 and 26 together with the particular form of rotor provides a high speed balanced hydraulic radially actuated valve having a number of outlets which may be successively connected with a common inlet chamber and a common outlet chamber to thereby simplify the piping of the hydraulic system and still preserve hydraulic balance between the casing and the rotor. Furthermore, the invention as described and shown permits extremely rapid flow reversal and application of pressure.

It is evident from the foregoing description that this invention basically provides a hydraulically balanced valve capable of creating flow reversals in a hydraulic system for operating a number of hydraulic motors, but this valve, constructed in accordance with the principles of this invention, is capable of operating in a much more complicated hydraulic system, the hydraulic balance, and the single inlet and outlet chambers still being feasible. Figs. 7 to 18 of the drawings illustrate a valve for use in the hydraulic system shown in Fig. 20. This figure illustrates the fact that a single valve can be arranged to control machines or motors for performing at least three different steps in a manufacturing process.

Fig. 20 shows a source of hydraulic fluid under pressure including a supply tank 50, pump 51, and relief valve 53, valve 53 being connected across tank 50 and pump 51 for absorbing whatever excess pressure may occur. Valve 60, the development of this invention, is connected to the inlet pipe 54 and the outlet pipe 55 whereby a flow of pressure fluid is possible through the pump 51, valve 60 and tank 50. The particular work apparatus, shown for purposes of illustration only, includes a feed mechanism 61 connected with valve 60 by pipes 62 and 63. The crimp mechanism 65 is connected by pipe 66 and pipe 67, the tool mechanism 68 is connected to valve 60 by pipe 69 and pipe 70, and the driver mechanism 72 is connected by pipe 73 and pipe 74. The two pipes to each of the various tool mechanisms serve alternately as pressure flow and return flow pipes depending on the valve position. Thus as the

valve 60 rotates, the pressure from the tank 50 and pump 51 is successively applied to the various mechanisms and successively relieved to cause the mechanisms to perform their intended functions. Before this operation is described in detail, it will be necessary to explain the construction of the valve 60.

The details of valve 60 are shown in Figs. 7 to 18, and this modification of the invention differs from that illustrated in Figs. 1 to 6 only in that it illustrates the fact that a single valve rotor employing the fundamental principles of the invention demonstrated in Figs. 1 to 6 can be combined with a rotor having the channels and ports spaced in a predetermined manner to accomplish practically any desired timing of flow reversals with predetermined time relation between said reversals to thereby control and operate a number of different tools for performing a certain number of manufacturing operations. This does not mean that the utility of this invention is confined to use for controlling manufacturing operations, as it is obvious that the valve is equally adaptable for use in connection with heat engines, as for instance, single or multi-cylinder gasoline automobile engines. More particularly, the valve can control a hydraulic system for operating the intake and exhaust valves of a gasoline engine, thereby eliminating the necessity of providing a cam shaft and related parts. A still further use for the valve embodying this invention is in a distributing system where, for instance, only the high pressure half of the valve may be used to apply and relieve pressure to a series of pipes which could be used for supplying oil or other fluid to any form of mechanism requiring intermittent positive flow with a predetermined time relation between the periods of flow in each of the pipes.

Figs. 7 to 13 of the drawings illustrate the valve and arrangement of parts therein. The valve includes a rotor housing 80, the plates 82, and 82', gaskets 83, and the stuffing box 87 for providing an oil seal about the shaft 85 of the rotor. End plates 82 and 82' are secured to housing 80 by means of suitable bolts 84.

Housing 80 is provided with the inlet port 90 and outlet port 91 which are connected to inlet pipe 54 and outlet pipe 55, respectively, as illustrated in Fig. 20 of the drawings. The feed 61, shown in Fig. 20, is connected to ports 93 and 94, the port 93 being displaced counter-clockwise 5° from the reference plane, which is arbitrarily chosen as the vertical plane of the valve as shown in the drawings. The port 94 is displaced 90° from port 93 and 95° from the reference point, as illustrated in detail in Fig. 12 of the drawings. A hydraulic balance requires that the casing be provided with a balancing port 92 displaced 180° from port 94 and a balancing port 95 displaced 180° with respect to the port 93. Likewise, similar balancing ports must be provided at the low pressure end of the casing and connected with the ports 92 and 95 by the passages 102' and 103'. Thus the pressures on the exposed areas of the rotor 110 are all equal regardless of the position of the rotor, and therefore, since the ports are respectively opposed, there is no resultant pressure on the rotor and hydraulic balance is obtained. The crimp control illustrated in Fig. 20 receives its working pressure and return from ports 96 and 97 which are connected to the pipes 66 and 67 of Fig. 20. Fig. 10 is a cross section on line 10—10 of Fig. 9 and illustrates the ports 96 and 97 together with cut-away port passages 98 and 99. Port passages 98 and 99, which are specially shaped in relation to rotor ports to provide a predetermined time of flow as the rotor is caused to revolve, serve as passages from outlets 96 and 97 to the proper pressure or outlet chamber as the location of the rotor parts may determine. This section shows specifically the shape of the port passages 98 and 99 where they would be engaged by the rotor high pressure ports. The cut-away portion 98 starts at the point 15° displaced from the vertical and continues for 105°, after which there is an interval of 15°, and the cut-away portion 99 begins and continues for 45°. The casing 80 is also provided with cut-away port passages 100 and 101 which provide pressure compensating areas equal to the area of portions 98 and 99 and 180° displaced with respect thereto. Thus, the pressure on the surface of the rotor is equal at all times regardless of its angular position. Fig. 13 is a section on line 13—13 of Fig. 9, illustrating the shape of the cut-away portions at this cross section of the casing. This figure shows the cut-away port passages 98 and 99 at the point where the port of the rotor connecting to the low pressure chamber would engage. It will be noted in Fig. 9 that these port passages are composed of narrow and wide sections, which, in effect on their extreme sides, form passages on the low pressure side equal in space to the high pressure passages, but rotated 90°. This is a simplified construction which eliminates outside passages and simplifies the rotor construction. The punch mechanism 72 in Fig. 20 is connected through pipes 73 and 74 to the ports 106 and 107, respectively, which are shown in detail in Fig. 11, which is a cross section on line 11—11 of Fig. 9. It is to be noted that these ports are displaced axially toward the center with respect to ports 93 and 94, the reason for which will become apparent in the following description. The port 106 is displaced 35° from the vertical and the port 107 is displaced 35° from port 106.

Since it is necessary to apply pressure and return to each of the aforementioned ports, they must necessarily be connected to both the inlet and outlet sides of the valve, and therefore each of the ports 93, 94, 106 and 107 is provided with passages through the casing 80 to have outlets 93', 94', 106' and 107' in the return end of the valve. These passages may be cored through casing 80, as illustrated at 76, 102 and 103 in the drawings, or they may be in the form of pipes as 75 connected with the feed lines and to the suction side of the valve through drilled and tapped holes.

All of the ports 93, 94, 106, 107, 93', 94', 106' and 107', together with the associated balancing ports, subtend an angle of, for example, 10° at the circumference of the rotor 110. Thus they all expose the rotor area to equal pressures. Furthermore, ports 106 and 107 are opposed by 180°, displaced ports 104 and 105, respectively, and ports 106' and 107' are opposed by 180° displaced ports 108 and 109, respectively. Pipes 111 and 112 connect the balancing ports together so that here again the complete hydraulic balance is attained.

Figs. 15 to 18 show the form of rotor best adapted to the modification of this invention shown in Figs. 7 to 14. Rotor 110 comprises a shaft 85 which may be integral with rotor 110 or suitably secured thereto, collar 113, and sealing disc 114, together with its connecting shaft 115. The sealing disc 114 and end plate 82', to-

gether with rotor 110, as shown in the drawings, form inlet chamber 120 and outlet chamber 121, as illustrated by dotted lines in Fig. 9. This rotor is similar to that shown in Figs. 5 and 6 in that it also includes at its left hand end channel portion 123 and a similar portion 124 displaced 180° therefrom, as shown in Figs. 14 and 15. At the right hand end of the rotor there are the channel portions 125 and 126 180° apart and respectively displaced 90° with respect to portions 123 and 124. These portions subtend a total angle of 70° and are so dimensioned in width that they first connect with the ports 93, 94, 93' and 94' since these ports are closer to the ends of the casing 80 than are the ports 106, 107, 106' and 107'. However, 75° after portion 123, for instance, opens the port 93, the point 123' reaches the port 106 to open it. All of the portions 123, 124, 125 and 126 are of the same length and of equal area, and portion 123 is displaced 15° in a clockwise direction from the vertical, and therefore the other leading edges of the channel portions are also displaced 15° from the vertical and, in the case of portions 125 and 126, from the horizontal.

Rotor 110 is also provided with the ports 130 and 131 which are connected to the inlet or pressure end of the casing 80. These ports are displaced, as illustrated in Figs. 15 and 16, 15° from the vertical and are wide enough to subtend a 15° angle along the circumference of the rotor. Here again pressure on the rotor is equalized by providing a 180° displacement between these ports so that the relative pressure between the rotor and the casing is equalized. Figs. 17 and 18 show the outlet or return ports 132 and 133 displaced 180° apart with respect to one another and 90° from the ports 130 and 131. These ports 130 and 131, 132 and 133 are in alignment with the port passages 98 and 99, 100 and 101, respectively, and will apply pressure to the ports 96 and 97 in the manner to be described later.

Fig. 19 of the drawings is a graph representing a total of 180° of revolution of the rotor 110 in casing 80 and shows the intervals during which pressure and return flow act on the various tools shown in Fig. 20. Referring to Figs. 12 and 15 of the drawings, it will be seen that rotor 80 starting from rest must be rotated counter-clockwise through 15°, at which time the leading edge of channel 123 of rotor 110 reaches the vertical plane of the valve and after five more degrees of rotation, making a total of 20°, the leading edge of channel 123 meets the port 93 and applies fluid pressure from inlet 90 and chamber 120 through lines 62 and 70 to the feed and the tool 68. At the same time, channel 126 permits return flow through port 94'. Since the opening of port 93 subtends an angle of 10° at the surface of rotor 110 and since rotor channel 123 subtends an angle of 70°, pressure through port 93 will continue for 80° or a total of 100° of rotation when ports 93 and 94 will both be closed by the rotor. This accounts for a total of 100° of rotation of the rotor. Port 94 in the high pressure end is placed 95° beyond vertical or 110° from the start position of the rotor channel 123. Port 94' is similarly 110° displaced beyond the start position of channel 125. The next 10 degrees permit a period of dwell. There is no fluid flow, but whatever pressures exist on tool 68 are maintained.

After 10 degrees of rotation, the leading edge of the channel 123 meets port 94 and permits pressure fluid flow from inlet 90, chamber 120, through lines 63, to the tool piston of 68. At the same time, the leading edge of cut-away channel 125 meets port 93' and permits discharge return of fluid from the opposite side of the piston that actuates tool 18 through line 62, port 94', channel 125, chamber 121, and outlet pipe 55. Thus a reversal of flow is accomplished which causes a return motion of the piston on tool 18. The pressure flow and return flow to maintain a return motion or position of tool 68 continues for 80 degrees (this is the total of the 10 degrees opening of ports 94 and 94' and 70 degrees of channels 123 or 125). When the trailing edge of channel 123 has passed the edge of port 94, the trailing edge of 125 has passed 93', and the rotor will have rotated 180 degrees. Due to the fact that channel 124 is the same shape and 180 degrees displaced from channel 123, it will engage with ports 93 and 94, and channel 124 will engage ports 93' and 94' to duplicate the hydraulic cycle just described, and two complete identical cycles will result from one rotation of the rotor.

Fig. 16, together with Fig. 10, shows the effective portions of the valve in the crimping operation. Since port 130 in rotor 110 is displaced 15° clockwise from the vertical and since the port passage 98 connected with port 96 is displaced 15° in a counter-clockwise direction, there is a total of 30° of rotation, after which port 130 applies pressure from pressure chamber 120 to the port 96 and pipe line 66 of the crimping tool 65. This pressure continues through 105°, which is the arc subtended by port passage 98 at the surface of rotor 110. In the meantime 15° of rotation is added, since port 130 subtends an angle of 15° at the surface of rotor 110, making a total of 120° during which pressure is applied to port 96. At the same time return flow occurs through port passage 99 and channel 132.

At 150 degrees of rotation rotor port 130 has passed port passage 98; rotor channel 132 has passed port passage 99, so that flow or pressure direction are changed, as will be disclosed. It should be noticed that only part of port passage 98 opens to port 130, and only part of port passage 99 opens to port 132, and that during the time described the angles subtended by the exposed part of port passages 98 and 99 are the same and permit a pressure or fluid flow and return of 120°. After 150 degrees of rotation the motion of crimp tool 65 is reversed as the pipe 67 is now connected through port passage 99 and channel 130 to pressure chamber 120. Return flow is now through pipe 66, port passage 98, channel 133, and chamber 121. Flow or pressure is maintained through a period of rotation of 60 degrees, which is the sum of the angles subtended by the 15 degree port opening and the 45 degree port passage opening 98 on the low pressure side. The shape of the port passages is such that there is a pressure flow (and return) in one direction of 120 degrees and only 60 degrees in the others. Since port 131 is the same shape and 180 degrees removed from port 130; and port 133 is the same shape and 180 degrees removed from port 132, this cycle of 180 degrees of rotation will be duplicated for the second 180 degrees of rotation of the rotor, thus accounting for two complete identical cycles for 360 degrees of rotation. Here again radial hydraulic balance is obtained since ports 130 and 131 are displaced 180° apart as are ports 132 and 133. Furthermore, passage 98 is opposed by the balancing passage 100 180° displaced therefrom. Passage 97 is similarly opposed by passage 101. The areas of opposing pas-

sages are also equal and therefore the pressures exerted in passages 97 and 98 are balanced by the pressures in passages 101 and 100, respectively, so that equal pressures are diametrically opposed on the areas of the rotor exposed to the passages at any given angle of rotation.

The punch tool 72 is actuated by the ports shown in Fig. 11, which is a section on line 11—11 of Fig. 9. As described hereinbefore, ports 106 and 107 are farther from the end than are ports 93 and 94, and 95° of rotation must occur before channel 123 of rotor 110 can open the port 106. For a distance of 60° from vertical port passage 123 does not affect port 106 and, since this port is displaced 35° from the vertical, there must be a total of 95° rotation before pressure is applied to this port. Pressure is continued on port 106 for a total of 35° which is the sum of 25° the remaining area of channel 123 and 10° subtend by port passage 106.

There are 35° from the trailing edge of port 106 to the front edge of port 107. The effective portion of channel 123 is 25°, so that there will be a period of 10° before the channel makes connection with port 107. At the same time return flow is from punch 72, through pipe 74 and passage to port 107' in the low pressure end, channel 125 to return chamber 121. It will be noticed that port 107' is displaced 90° ahead of port 106. Channel 125 is displaced 90° ahead of channel 123, so that the time for return flow is as great as the time for pressure flow. At the rotation of 140°, channel 123 opens into port 107; channel 125 opens into port 106'; this causes a reversal of flows and pressures to the piston actuating punch 72. Pressure or pressure flow is from chamber 120 through channel 123, port 107, and pipe 74; return is from pipe 73, port passage 106, channel 125, to chamber 121. This will continue for 35 degrees, the sum of the space subtended by the face of the port 107 (15°) and effective channel surface 123 (25°). This accounts for a total of 175° of rotation. There will be a period of dwell of 5° to complete the 180° of rotation of the rotor. Because of the fact that channel 123 is 180° displaced beyond channel 124, a second and identical cycle will be made for punch 72 with a second 180° of rotation, thus completing 360° of rotation of the rotor.

It will be noticed especially in this cycle that the down position of the punch 72 will be during 45°, while the return position is 135°. This is accomplished by the fact that ports 106 and 107 are displaced less than 90° and, in turn, it is necessary to locate ports 106' and 107' with cross connecting pipes 75 and passage 76, as indicated.

Port passages 98 and 99 indicate another method of getting a similar result in relation to the crimp tool. These illustrations indicate some, but not all, of the possible variations of locating the ports.

In some applications of this invention it is desirable that the application of pressure to the operated device be timed to occur at intervals other than 90° apart in the operating cycle. Figs. 21, 22 and 23 illustrate a method of adapting the invention to such circumstances. In Fig. 21 casing 1 is tapped to provide ports such as 6', 7', 8' and 9' which are spaced apart as illustrated. The remaining features of this modification of the valve are similar to those shown in Figs. 1 to 6 except as illustrated in Fig. 23. The rotor 33' includes a pair of channels 38' and 40' which are spaced apart by 180° in a manner similar to the rotor of Fig. 6. However, it is necessary at the low pressure end of the rotor to provide channels 37', 39' spaced apart by 180° and displaced clockwise from ports 38 and 40 by the same angle as there is between 6' and 9' and channels 150 and 151 also spaced apart by 180° and displaced in a counter-clockwise direction from channels 37' and 39' by an angle equal to twice the angle between ports 6' and 7' shown in Fig. 21. Here again the principle of the invention has been applied to maintain hydraulic balance by making all ports and channels of equal areas and opposed to one another as taught hereinbefore. The operation of this modification of the valve is obvious from the description given hereinbefore in connection with Figs. 1 to 6.

From the above it is evident that this invention enables the use of a valve having a single rotor, a single inlet port and a single outlet port for, first, feeding a piece of wire, then grasping the wire to hold it firmly in its advanced position, and then driving a tool to punch a head on the end of the wire. Not only does this single valve enable these operations, but it also returns the tools to their normal position for a subsequent operation. This modification of the valve embodying the invention described hereinbefore illustrates the feasibility of providing a high speed hydraulic system for performing a series of operations at predetermined time intervals. Not only is such operation feasible, but it is accomplished by a rotating valve having a single inlet port and a single outlet port, and perfect hydraulic balance is maintained throughout the rotation of the valve.

It is not intended that this invention shall be limited to a valve embodying the specific structural details shown in the drawings, as it is obvious that there are many ways of sealing the ends of the casing, and there are several alternative methods of providing passageways between the pressure end of the valve and the suction end of the valve. For instance, the valve casing 80 may be cored to provide passages, or it may be merely drilled and tapped for external pipe connections. Thus, it is intended that the valve may be constructed in accordance with well known methods. Further modifications of this invention will occur to those skilled in the art, and therefore it is desired that this invention shall be limited only as required by the prior art and the appended claims.

What I claim is:

1. A rotary valve comprising a casing having a substantially cylindrical chamber therein, said casing having an inlet port, an exhaust port, and a supply port opening into said chamber, said ports being located in planes axially spaced from each other, a plug rotatably mounted in said chamber, a pair of substantially similar and diametrically opposed ports in said plug extending into the plane of said supply port and in constant communication with the inlet, a second pair of substantially similar and diametrically opposed ports in said plug extending into the plane of said supply port and in constant communication with the exhaust port, said casing being provided with a recess substantially similar and diametrically opposed to said supply port.

2. A rotary valve comprising a casing having a substantially cylindrical chamber therein, said casing having an inlet port, an exhaust port, and supply ports opening into said chamber, said inlet port and said exhaust port being located in planes axially removed from each other and said supply ports being in other axially spaced planes.

a plug rotatively mounted in said chamber, pairs of substantially similar and diametrically opposed ports of said plug extending into the planes of said supply ports and in constant communication with the inlet, pairs of substantially similar and diametrically opposed ports in said plug extending into planes of said supply ports and in constant communication with the outlet, said casing being provided with recesses substantially similar and diametrically opposed to said supply ports.

3. A valve adapted for uniform rotation, comprising a casing, having a substantially cylindrical chamber therein, said casing having an inlet port an exhaust port and supply ports opening into said chamber, said inlet port and said exhaust port being located in planes axially removed from each other and said supply ports being in other axially spaced planes, a plug rotatably mounted in said chamber, an annular space around said plug in constant communication with the inlet port, pairs of substantially similar and diametrically opposed ports in said plug extending into planes of said supply ports and in constant communication with said annular space, a second annular space around said plug in constant engagement with the outlet port, pairs of substantially similar and diametrically opposed ports in said plug extending into planes of said supply ports and in constant communication with said second annular space, said casing being provided with recesses substantially similar and diametrically opposed to said supply ports, a passage connecting an end surface of the plug and the second annular space.

4. A rotary valve comprising a casing having a substantially cylindrical chamber therein, said casing having an inlet port, an exhaust port, and supply ports opening into said chamber, said inlet port and said exhaust port being located in planes axially removed from each other and said supply ports being in still another plane, one of said supply ports comprising a circumferentially elongated portion along one of its sides and an interconnected shorter portion along its other side, said casing being provided with a recess substantially similar and diametrically opposed to said port, a second one of said supply ports also comprising long and short interconnected portions similar to the first one but arranged with its short offset portion in circumferential alignment with the long portion of the first supply port and its long portion in such alignment with the short portion of such first supply port, said casing being provided with a recess substantially similar and diametrically opposite the second mentioned supply port, a plug rotatably mounted in said chamber, a pair of substantially similar and diametrically opposed ports in said plug, in constant communication with the inlet, and aligned circumferentially with the aligned long and short portions on one side of the supply ports, a second pair of substantially similar and diametrically opposed ports in said plug in constant communication with the outlet and aligned circumferentially with the long and short portions on the other side of said supply ports.

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