April 27, 1948. F. J. WRIGHT 2,440,388

HYDRAULIC SYSTEM FOR RECIPROCATING BREAKER PLATES FOR REVERSIBLE ROTARY CRUSHERS

Filed July 10, 1945 2 Sheets-Sheet 1

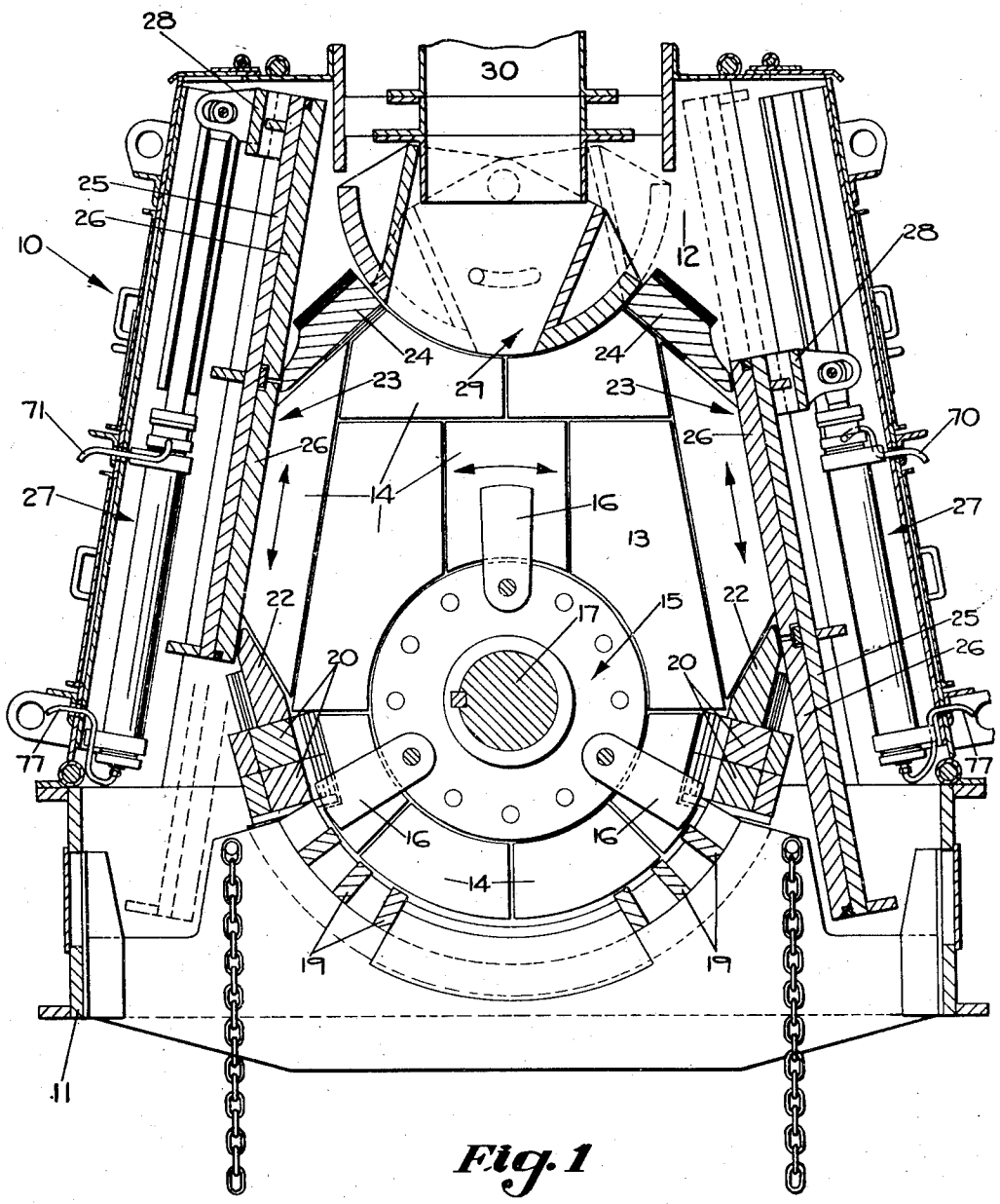


Fig. 1

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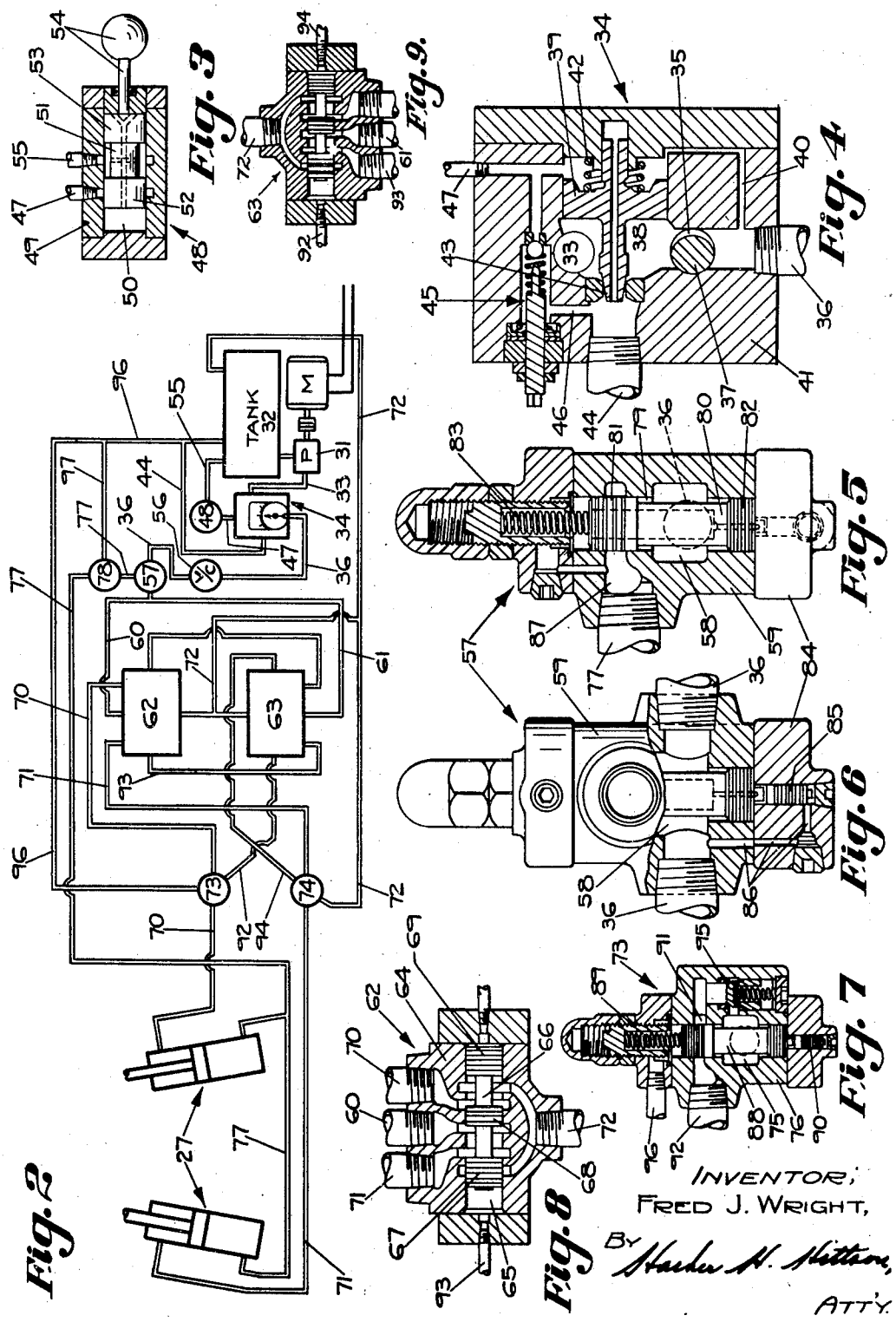


Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6

Fig. 7

Fig. 8

Fig. 9.

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2,440,388

HYDRAULIC SYSTEM FOR RECIPROCATING BREAKER PLATES FOR REVERSIBLE ROTARY CRUSHERS

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Application July 10, 1945, Serial No. 604,219

5 Claims. (Cl. 241—187)

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This invention relates to a hydraulic system and particularly to such a system, per se, and in combination with a reversible reciprocating breaker plate type of crusher.

An object of the invention therefore is to provide an improved hydraulic system which is particularly useful in connection with a crusher of the above mentioned type but which, in its broader aspects, may have other uses.

A further object of the invention is to provide a crusher with hydraulic apparatus for adjusting similar reciprocating breaker plates so that the breaker plates counterbalance each other and reciprocate oppositely simultaneously.

A further object of the invention is to provide a crusher or other machine with a hydraulic system in which there are two reciprocating breaker plates or members operated by hydraulic motors, there being valve means provided to insure a predetermined travel of each breaker plate or member independently of the travel of the other one.

Other objects of the invention will appear hereinafter, the novel features and combinations being set forth in the appended claims.

In the accompanying drawings,

Fig. 1 is a sectional elevational view of a crusher incorporating reciprocating breaker plates which are controlled by the hydraulic system of my invention and which in combination therewith constitutes one aspect of the invention;

Fig. 2 is a piping diagram of the hydraulic system of my invention;

Fig. 3 is a sectional view of one of the control valves for starting and stopping the system;

Fig. 4 is a sectional view of a speed or hydraulic fluid volume control valve;

Fig. 5 is a sectional view of one of the control valves;

Fig. 6 is a view of the valve of Fig. 5, taken at right angles to the view of Fig. 5, with the lower portion shown in section;

Fig. 7 is a sectional view of another control valve;

Fig. 8 is a sectional view of a fluid pressure actuated four-way valve employed in the system; and

Fig. 9 is a sectional view of another fluid pressure actuated four-way valve employed in the system.

Referring first to Fig. 1 of the drawings, there is illustrated a crusher which incorporates structure disclosed in full detail in the application of Lloyd K. Knight, Serial No. 603,367, filed July 5, 1945, entitled Crusher.

Briefly described, the crusher includes a main frame 10 which is built up of a plurality of parts

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rigidly attached together and which provides a housing for the principal working parts of the crusher. Said main frame 10 includes a generally rectangular base 11 upon which is mounted a pair of side frame members 12 each formed by a plurality of attached plates or segments.

As best seen in Fig. 1 of the drawings, the main frame 10 provides a reducing chamber 13 within which reduction of the material takes place. The side walls of reducing chamber 13 are provided with removable wear plates 14 which are carried principally by the side frame members 12, some of the bottom wear plates 14, however, being carried by the base 11.

Mounted for rotation within the reducing chamber 13 is a rotor 15 which is shown as of the swing hammer type, being provided with a plurality of swing hammers 16. Rotor 15 includes a rotor shaft 17, the opposite ends of which are mounted on appropriate bearings carried in bearing boxes, said bearing boxes being mounted on pedestals provided by the base 11. On one end the shaft 17 carries a pulley or flexible coupling by which the rotor 15 may be rotated in reverse directions as desired.

Since the crusher is designed for selective reverse rotation, thus materially increasing its life without requiring the renewal of parts, it is generally symmetrical.

Adjacent the bottom portion of the reducing chamber 13 there is a pair of spaced screens 19, the bottom bars of which may be spaced apart to provide a free opening for the material to pass through and through the bottom of the open base 11. Adjacent the upper edge of each screen 19 I provide a pair of transversely extending breaker bars 20 which are mounted for adjustment toward and from the axis of the rotor 15 by adjusting means adjacent the opposite ends of each bar 20.

Positioned on top breaker bar 20 is a scraper 22, the upper edge of which defines the bottom limit or boundary of an exposed area at which an upwardly and inwardly extending traveling or reciprocable breaker plate 23 is provided and a portion of which is exposed as hereinafter described more completely. The upper limit or boundary of each exposed area is defined by the lower edge of an upper scraper 24.

Each breaker plate 23 includes a permanent backer or reinforcing plate 25 and a pair of removable wear plates 26. The wear plates 26 are preferably similar in construction and size and one is positioned directly above the other and removably attached to the backing or reinforcing plate 25, as clearly illustrated in Fig. 1 of the drawings.

As also clearly illustrated in Fig. 1 of the drawings, when a breaker plate 23 is in its uppermost position, which is the position illustrated at the left in Fig. 1, only one of the wear plates 26 is exposed to the chamber or, in other words, is in an operative position. This, of course, is determined by the scrapers 22 and 24. Similarly, when a breaker plate 23 is in its bottommost position, as illustrated at the right in Fig. 1, the other wear plate 26 alone is exposed or in operative position. As a consequence, by reciprocating the traveling breaker plates 23, the wear plates 26, or, in other words, the wearing surfaces or areas of said breaker plates 23, are successively exposed or brought into operative position.

The breaker plates 23 are mounted for traveling or reciprocatory motion in guide means provided by the main frame 10 so that they may reciprocate between the two positions illustrated or indicated in Fig. 1 of the drawings, successively exposing the upper and lower wear plates 26. This reciprocatory motion is provided by a pair of hydraulic piston motors or jacks 27, one for each of the breaker plates 23. The piston motors 27 are carried in compartments provided by the main frame 10 behind the breaker plates 23 and the outer ends of their piston rods are connected by a loose or flexible connecting means 28 with the upper ends of the breaker plates 23.

The piston motors 27 are preferably interconnected so that there is a counterbalancing effect between the two breaker plates 23 in that one of them moves downwardly while the other moves upwardly. The apparatus or system for accomplishing this result is disclosed in full detail hereinafter.

Material to be crushed, such as iron ore, is fed to the feed chamber 13 by a pivoted or swingable feed chute 29 which is disclosed in full detail and claimed in the above mentioned application of Lloyd K. Knight. Feed chute 29 in turn is fed by a stationary feed pipe or chute 30 which is removably attached to the main frame 10.

Attention is now directed particularly to Figs. 2 to 8, inclusive, of the drawings, and to the hydraulic system which provides for reciprocation of the two motors 27 and through them the two breaker plates 23. The hydraulic system includes a motor driven pump 31 which derives hydraulic fluid from a tank 32 and delivers it by way of a pipe or conduit 33 to a combination volume control and high pressure relief valve 34, the interior details of which are shown in Fig. 4 of the drawings. This valve may be a standard valve having the above mentioned characteristics.

The mode of operation of such a valve is well known in the hydraulic art and, briefly described, is as follows. Fluid delivered to it through feed pipe or conduit 33 flows through a variable orifice 35 and out to the system by way of pipe or conduit 36. The volume which is delivered to the pipe 36 is determined by the size of the orifice 35 which may be varied by rotation of a shaft 37 upon which orifice 35 is formed. The hydraulic fluid delivered by the pipe or conduit 33 is received in a chamber 38 before flowing through the orifice 35 and a by-pass controlling piston 39 is reciprocably mounted in a cylinder communicating with the chamber 38.

A passageway 40 is formed in the body 41 of the valve 34 and communicates hydraulic fluid under pressure on the output side of orifice 35 to the opposite side of the piston 39 from that communicating with and subject to the pressure in chamber 38. A coil spring 42 urges a by-pass valve 43, attached to piston 39, to by-pass closing position. A by-pass or drain pipe or conduit 44 which is controlled by the valve 43 leads from the chamber 38 to tank 32.

For any given size orifice 35 the piston 39 will operate atuomatically, as determined by the pressure drop caused by the flow of hydraulic fluid through said orifice 35, to by-pass the excess oil delivered by the pump 31 to the pipe 44.

Also in communication with the passageway 40 is an adjustable high pressure relief valve 45 and this relief valve, of course, determines the maximum pressure which can appear in the feed pipe or conduit 36. In case this pressure is sufficient to open relief valve 45, the high pressure fluid is free to drain by passageway 46 into conduit 44 which, as above mentioned, leads to the tank 32.

Also communicating with said passageway 46 is a conduit or pipe 47 which leads to a start and stop valve 48 shown in detail in Fig. 3 of the drawings. This start and stop valve is a very simple spool type valve including a casing 49 having a cylindrical bore 50 in which there is a spool 51 having a pair of spaced lands 52 and 53. Spool 51 is provided with an actuating rod and handle 54. Pipe 47 leads to the bore 50, and a pipe or conduit 55 leads therefrom to tank 32.

When the spool 51 is in the position illustrated in Fig. 3, the system will be in operation because the drain pipe 47 will be sealed by the land 52. To stop the system the spool 51 is moved to the left, as viewed in Fig. 3, whereupon conduit 47 is connected to tank 32 by way of conduit 55, the two conduits being in communication by virtue of the reduced portion of spool 51 between lands 52 and 53. Under such conditions, substantially no pressure will be developed in the hydraulic system since the output of the pump 31 will be effectively by-passed and consequently there will be no hydraulic fluid under pressure available to operate the piston motors 27.

Under operating conditions, hydraulic fluid will be delivered, as above mentioned, at any one of a plurality of preselected volumes and at a maximum variable predetermined pressure to conduit 36 which includes a check valve 56 operating to prevent reverse flow of hydraulic fluid to the pump 31, thus prohibiting the possibility of regeneration which might cause damage. After passing through check valve 56, the hydraulic fluid is delivered to a pressure sequence valve 57 which is disclosed in detail in Figs. 5 and 6 of the drawings.

The function and structure of the valve 57 will be described more completely hereinafter. For the time being it is sufficient to say that under most conditions the hydraulic fluid simply flows through this valve, the inlet and outlet portions of which are connected by virtue of a central chamber 58 formed in a body 59 thereof. From the valve 57 the conduit 36 branches into two pipes or conduits 60 and 61. Conduit 60 leads to a main four-way reversing valve 62, and conduit 61 leads to a control four-way valve 63 which, as hereinafter described, controls the reversing movement of the four-way valve 62. The construction of valve 62 is shown in detail in Fig. 8 of the drawings, and valve 63 is of substantially identical construction, as shown in Fig. 9.

Valve 62 includes a body 64 provided with a central cylindrical bore 65 within which there is a spool 66 provided with three spaced lands 67, 68 and 69. Communicating with the bore 65 are five successive chambers, the center one of which com-

municates with conduit 60, the next two of which on opposite sides of the center one communicate with cylinder or motor pipes or conduits 70 and 71, respectively, and the two end chambers are connected in parallel and both connected to a drain or tank pipe or conduit 72 which leads back to the tank 32.

It is obvious from Fig. 8 of the drawings that hydraulic fluid under pressure delivered to the pipe or conduit 60 may be delivered selectively to the pipes 70 and 71; the other of said pipes 70 and 71 being connected to tank or drain. Consequently, by shifting the spool 66, the direction of flow of hydraulic fluid through pipes 70 and 71 may be reversed and, as hereinafter described, the spool 66 is shifted to effect reversal or reciprocation of the two motors 27 which are connected in series and which are preferably operated in reverse directions; that is, one of them is expanding while the other is contracting and consequently one of the breaker plates 23 is moving upwardly while the other is moving downwardly and vice versa.

Pipe 70 leads to the piston rod end of the right-hand hydraulic piston motor 27, as viewed in Figs. 1 and 2, through a control valve 73 which is shown in some detail in Fig. 7 of the drawings. The pipe 71 leads to the piston rod end of the left-hand hydraulic piston motor 27, as viewed in Figs. 1 and 2, through a control valve 74 which is similar to control valve 73. The structure of these valves 73 and 74 is described in detail hereinafter, but, for the time being, it is sufficient to note that under most operating conditions the hydraulic fluid merely flows through a central chamber 75 formed in a body 76 thereof.

The piston motors 27 are of the double acting type and the head ends are connected together by pipe or conduit 77 which leads to a pressure sequence valve 78 which is similar in construction to the valve 57.

Hydraulic fluid which is delivered to the conduit 60, as above described, will flow through the reversing valve 62, when the spool 66 is in the position illustrated in Fig. 8, and be delivered to the conduit 71, flowing through it and through the valve 74 to the piston rod end of the left-hand hydraulic piston motor 27. This hydraulic fluid entering the cylinder of said motor 27 will cause the piston and piston rod to move downwardly and thus cause the associated left-hand breaker plate 23 of the crusher to move downwardly. The downwardly moving piston will force oil or hydraulic fluid from the bottom of the cylinder to the conduit 77 and into the bottom of the cylinder of the right-hand piston motor 27. This, of course, will move the piston of right-hand cylinder upwardly and the hydraulic fluid on the piston rod side of the piston will flow through conduit 70 and valve 73 back through the four-way valve 62 and to the tank or drain pipe 72 with which it is in communication. This flow of hydraulic fluid will, of course, produce downward movement of the left-hand piston 27 and the left-hand breaker plate 23 and upward movement of the right-hand piston 27 and the right-hand breaker plate 23.

It is to be particularly noted that the portion of the conduit 77 which interconnects the two piston motors 27 provides a hydraulic coupling so that the weight of each breaker plate 23 or other mechanisms supported by the piston motors 27 counterbalances each other. Obviously, if these breaker plates or other mechanisms are not of the same weight the counterbalancing effect will not

be complete, but in the particular machine herein disclosed the counterbalance will be substantially complete as the two breaker plates 23 are substantially identical.

This counterbalancing feature is an important contribution of my invention as it reduces materially the amount of work that the pump 31 and its driving motor must perform, since they need only overcome friction to produce reverse reciprocatory motion of the two breaker plates 23.

During this reciprocatory action and before either motor 27 has reached the end of its stroke, the branch 77 which leads to valve 78 is effectively blocked, as hereinafter described, and has no immediate function.

When the left-hand piston motor 27 reaches the end of its stroke it is obvious that pressure will be built up in the pipe or conduit 71 and this pressure is employed to control the valves 74 and 63 so as to reverse the four-way valve 62 by moving the spool 66 in the opposite direction from that illustrated in Fig. 8. When such a condition is realized, it is obvious that hydraulic fluid delivered to the conduit 60 will be directed to conduit 70, and conduit 71 will be connected to tank, thus producing a reverse travel of the two piston motors 27 from that previously described. This reverse travel will continue until right-hand motor 27 reaches the end of its stroke, whereupon valve 73 will control valve 62 again to reverse the spool 66 of valve 62. The manner in which these reversals take place is as follows.

Assuming right-hand piston motor 27 has reached the end of its stroke, pressure will immediately build up in the pipe 70 and this will actuate valve 73. In order to understand the operation of valve 73 it is necessary first to understand the operation of valve 57 since it is similar thereto, except for two differences which will be pointed out. The body 59 of valve 57 has an upright cylindrical bore 79 which extends through the previously mentioned central chamber 58. A spool 80 reciprocates in the bore 79 and is provided with upper and lower lands 81 and 82. An adjustable spring 83 provides downward pressure on the top of the spool 80 and adjustment of its compression determines the pressure at which this valve opens.

In a removable base 84 of valve 57 there is a small piston 85, reciprocable in a bore, the bottom of which communicates with the chamber 58 by way of passageway 86. Thus the pressure of the hydraulic fluid in the chamber 58 is communicated to push upwardly on the piston 85 and in turn on the spool 80 against the spring 83. Whenever this hydraulic pressure reaches a predetermined value, as variably determined by the adjustment on the spring 83, the spool 80 will be moved up sufficiently to unseal a chamber 87 in the body 59 and place it in communication with the chamber 58 by way of bore 79.

The chamber 87 is connected to the pipe or conduit 77 leading between the valve 57 and the valve 78. In other words, conduit 77 has the valve 78 connected between input and output branches thereof in a manner similar to that in which valve 57 is connected between branches of conduit or pipe 36. Stated another way and in accordance with a previous suggestion, that portion of conduit 77 between the right-hand motor 27 and the valve 57 has valve 78 connected therein and the passageway of conduit 77 is normally unobstructed by the valve 78. However, with the spool of valve 57 in the position illustrated in Figs. 5 and 6, conduit 77 is blocked by the spool 80 thereof and consequently the hydraulic fluid which is

forced from the left-hand piston motor 27, as it is forced down to the right-hand piston motor 27, cannot be by-passed through the branch of pipe 77 leading through the valve 78 to the valve 57.

Any leakage of hydraulic fluid past the land 81 to the area above it will be drained into chamber 87.

As previously mentioned, the valve 73 is substantially the same construction as valve 57, except for two added features. That is, valve 73 has a spool 88 with top and bottom lands, the spool being urged downwardly by an adjustable spring 89 and being urged upwardly by a small piston 90 which is urged upwardly by hydraulic fluid delivered thereto through a bore, not shown, communicating with the central chamber 75. Whenever the pressure in the chamber 75 reaches a predetermined value, sufficient to move the spool 88 upwardly, chamber 75 will communicate with an upper chamber 91 and deliver hydraulic fluid to a conduit or pipe 92 which is connected to the left-hand end of the four-way valve 63. Whenever this valve 73 is thus actuated and fluid is delivered to the left-hand end of four-way valve 63, it will have its spool moved to the right.

Under such conditions the hydraulic fluid delivered to the branch or conduit 61 is directed by the four-way valve 63 to a pipe or conduit 93 which communicates with the left-hand end of the bore 65 of four-way valve 62 and thus actuates the spool 66 thereof to the right, as viewed in Fig. 8 of the drawings.

Also under such conditions the hydraulic fluid under pressure is diverted from pipe 70 to the pipe 71 and the piston motors 27 are actuated in their reverse directions, with the left-hand one moving downwardly or contracting and the right-hand one moving upwardly or expanding. This will continue until the piston of the left-hand motor 27 reaches the end of its stroke, whereupon pressure will build up in valve 74 and hydraulic fluid under pressure will be by-passed by said valve 74 to a pipe or conduit 94 and delivered to the right-hand end of four-way valve 63, shifting its spool and directing the hydraulic fluid under pressure from the conduit 61 to a conduit similar to 93 which leads to the right-hand end of the four-way valve 62 and will move the spool 66 thereof to the left.

As above mentioned, the valves 73 and 74 are of similar construction and thus the operation of each of them will be understood from the above description of valve 73.

The two differences between the valves 73 and 74 on the one hand and the valves 57 and 78 on the other hand are evident from a consideration of valve 73 as compared with valve 57. Said valve 73 has a built-in check valve 95 which permits a flow of fluid from chamber 91 to chamber 75, but not in the other direction. The function of this is to provide for release of hydraulic fluid in the bore of four-way valve 63 whenever its spool 66 is shifted, since hydraulic fluid forcing it in one direction will require fluid on the other end of the spool to be released. For example, if the spool of valve 63 is moved to the left, as viewed in Fig. 2, fluid will be free to flow through the pipe or conduit 92 to the chamber 91 and by check valve 95 to chamber 75 which is connected to pipe 70 which, under such conditions, is connected by four-way valve 62 to drain through pipe 72. Reverse movement of the spool of valve 63 is similarly accommodated by valve 74.

The second difference between valves 57 and 73 is that the latter is provided with a drain or tank pipe or conduit 96 for draining oil which accumulates above the upper land of spool 88. Valve 74 is similarly connected with tank or drain pipe 72.

From the above description it is obvious that the sequence valves 73 and 74 control the spool of four-way valve 63 which in turn controls the main four-way control valve 62 to respond automatically to movement of the hydraulic motors 27 to their expanded or contracted positions to cause a reversal of the flow of hydraulic fluid to them and thus provide for their continuous reciprocation. It is further evident that by controlling the volume of hydraulic fluid delivered to the main feed pipe 36 by volume control valve 34, the speed or rate of reciprocation of the motors 27 may be variably determined at any one of a plurality of different values. Furthermore, the valve 34 provides a high pressure relief, thus protecting the hydraulic system. The start and stop valve 48 provides for starting and stopping of the reciprocating apparatus.

The function of the valve 57 is to insure that if one of the motors 27 reaches the end of its stroke before the other one does when they are traveling in one direction, the second motor will complete its stroke, and the function of the valve 78 is similar except for the other motor.

Valve 57 operates as follows. It is set to open at a relatively low pressure. For example, it may be set at a pressure of fifty to one hundred pounds per square inch, where the relief valve 45 is set, for example, at approximately nine hundred pounds per square inch. Assuming that hydraulic fluid under pressure is being delivered to the pipe 71 and left-hand motor 27 reaches the end of its stroke before right-hand motor 27 has reached the end of its stroke; as above described, when left-hand motor 27 reaches the end of its stroke, pressure is developed in the line 71, which ultimately actuates valve 74.

Valves 73 and 74 are preferably set to open at about eight hundred pounds per square inch in the system described, it being understood that in all cases where pressures are given they are merely relative and illustrative of one working arrangement. Valve 57, however, operates at very low pressure; for example, from fifty to one hundred pounds, and consequently it will open before valve 74 opens. By virtue of its opening, hydraulic fluid flowing through a by-pass circuit provided by pipe 36 in chamber 58 will be free to flow through pipe 77 and valve 78, reaching the lower end of the cylinder of right-hand piston motor 27 and causing this piston motor to complete its travel before it is possible for the pressure in line 71 to build up to a high value to operate valve 74. In other words, valve 74 can only be operated in case left-hand piston motor 27 has reached its complete downward stroke, and right-hand piston motor 27 has reached its complete upward stroke.

If, during the movement above described, the right-hand motor 27 reached the upward end of its stroke before the left-hand motor 27 reached the end of its stroke, compensation takes place as follows, to the end that left-hand motor 27 may complete its stroke. Right-hand motor 27 having completed its stroke, it is no longer possible to feed hydraulic fluid from left-hand motor 27 to right-hand motor 27. Therefore, to complete the stroke of left-hand motor 27, the re-

maining fluid in it must be drained to tank. This is effected by the fluid flowing over a by-pass circuit including pipe 77 leading into valve 78. Valve 78 is set to open at a pressure of, for example, seven hundred and fifty pounds per square inch, or slightly below the pressure at which valves 73 and 74 open, which may be, for example, eight hundred pounds per square inch. Therefore, as the pressure builds up in pipe 71 which is communicated through left-hand motor 27 to pipe 77, the pressure in valve 78 will build up to a predetermined value which, in the illustration given, was seven hundred and fifty pounds, whereupon said valve will open and connect pipe 77 by way of a pipe or conduit 97 to drain or tank conduit 96.

Valve 78 will, of course, stay open until left-hand motor 27 completes its travel, whereupon the pressure in the system and particularly in pipe 71 will increase to actuate valve 74 which, as previously described, will reverse the fluid flow to the motors 27, reversing their operation.

It may be stated that the valves 57 and 78 operate to insure complete travel of the two motors 27 in each of their extreme positions in a manner which will be obvious from the above description.

Therefore, in the operation of the crusher the breaker plates 23 or reciprocating members which are reciprocated by the double acting hydraulic piston motors 27, are interconnected by a fluid coupling so that they are normally in balance, moving in a teeter-totter fashion, with one traveling upward while the other travels downward, and vice versa. Their rate of reciprocation can be adjusted over a wide range by adjusting the valve 34. Furthermore, the system not only provides for automatic reversal of each piston motor or breaker plate, but also provides for their synchronization, or, in other words, insures that each shall make a complete travel through a predetermined distance.

It may be further stated that the valves 34, 62, 63, 73, 74, 57 and 78 are all standard valves, but insofar as applicant is aware the particular system herein disclosed and claimed has not heretofore been produced.

Obviously those skilled in the art may make various changes in the details and arrangement of parts without departing from the spirit and scope of the invention as defined by the claims hereto appended, and I therefore wish not to be restricted to the precise construction herein disclosed.

Having thus shown and described an embodiment of my invention, what I desire to secure by Letters Patent of the United States is:

1. A crusher including a rotor, a pair of reciprocably mounted breaker plates adjacent said rotor, hydraulic motor means for reciprocating said breaker plates in reverse directions simultaneously upwardly and downwardly, a hydraulic circuit for controlling reciprocation of said breaker plates including a reversible hydraulic motor for each plate, a hydraulic circuit for controlling said motors including means providing a hydraulic coupling between them whereby the weight of each breaker plate counterbalances the other and said breaker plates are moved in reverse directions as aforesaid, and valve means operable to reverse the direction of travel of said motors periodically and insure that each breaker plate moves through a full stroke.

2. A crusher including a rotor, a pair of reciprocably mounted breaker plates adjacent said rotor, hydraulic motor means for reciprocating said breaker plates in reverse directions simultaneously upwardly and downwardly, a hydraulic circuit for controlling reciprocation of said breaker plates including a reversible hydraulic motor for each plate, a hydraulic circuit for controlling said motors including means providing a hydraulic coupling between them whereby the weight of each breaker plate counterbalances the other and said breaker plates are moved in reverse directions as aforesaid, and valve means operable to reverse the direction of travel of said motors periodically.

3. A crusher including a rotor, a pair of reciprocably mounted breaker plates adjacent said rotor, hydraulic motor means for reciprocating said breaker plates in reverse directions simultaneously upwardly and downwardly, a hydraulic circuit for controlling reciprocation of said breaker plates including a reversible hydraulic motor for each plate, and a hydraulic circuit for controlling said motors including means providing a hydraulic coupling between them whereby the weight of each breaker plate counterbalances the other and said breaker plates are moved in reverse directions as aforesaid.

4. A crusher including a rotor, a pair of reciprocating members adjacent said rotor, a reciprocating double-acting hydraulic piston motor for operating each member, a hydraulic circuit for controlling said motors including piping connecting them in series, pumping means for supplying fluid to said motors, and pressure responsive means in said circuit operable to cause reciprocation of said motors and to insure that each motor travels a predetermined distance including a by-pass circuit having a low pressure responsive valve operable to connect said pumping means to similar ends of said motors and a high pressure responsive valve operable to drain said by-pass circuit.

5. A machine including a pair of reciprocating members, a reciprocating double-acting hydraulic piston motor for operating each member, a hydraulic circuit for controlling said motors including piping connecting them in series, pumping means for supplying fluid to said motors, and pressure responsive means in said circuit operable to cause reciprocation of said motors and to insure that each motor travels a predetermined distance including a by-pass circuit having a low pressure responsive valve operable to connect said pumping means to similar ends of said motors and a high pressure responsive valve operable to drain said by-pass circuit.

FRED J. WRIGHT.

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