Feb. 7, 1961 T. H. PARIS 2,970,579

HYDRAULIC REVERSING CONTROL

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FIG. 1

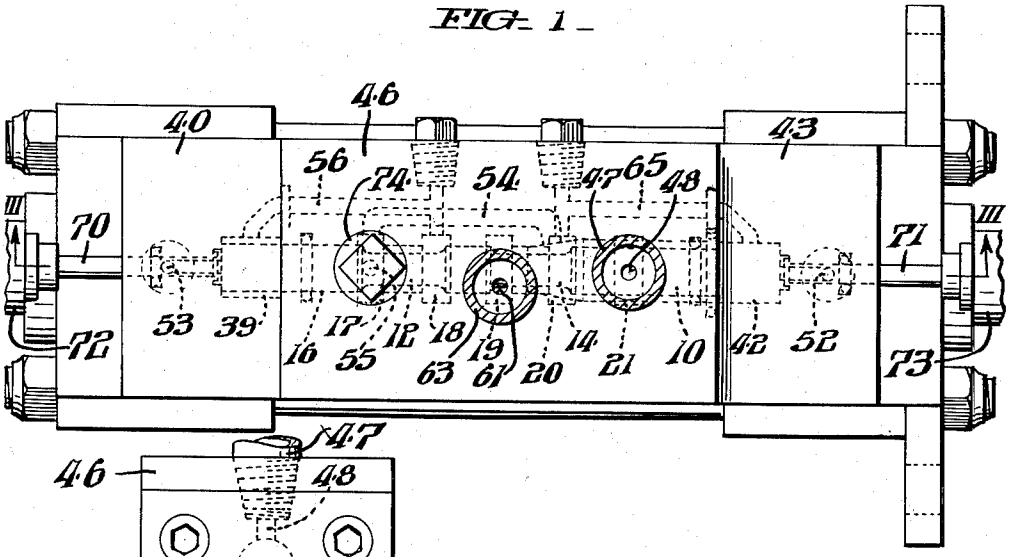


FIG. 2

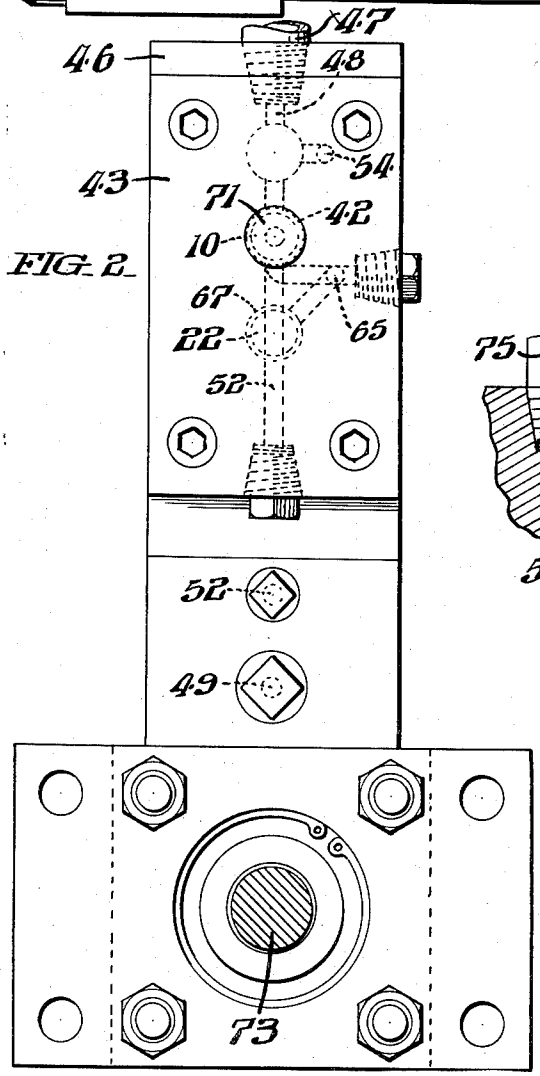
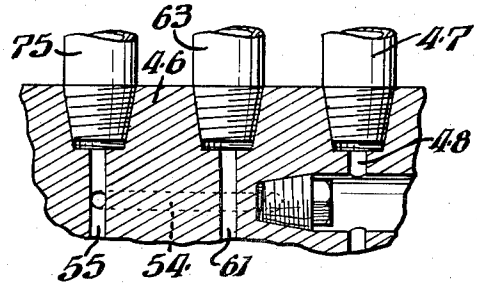


FIG. 5



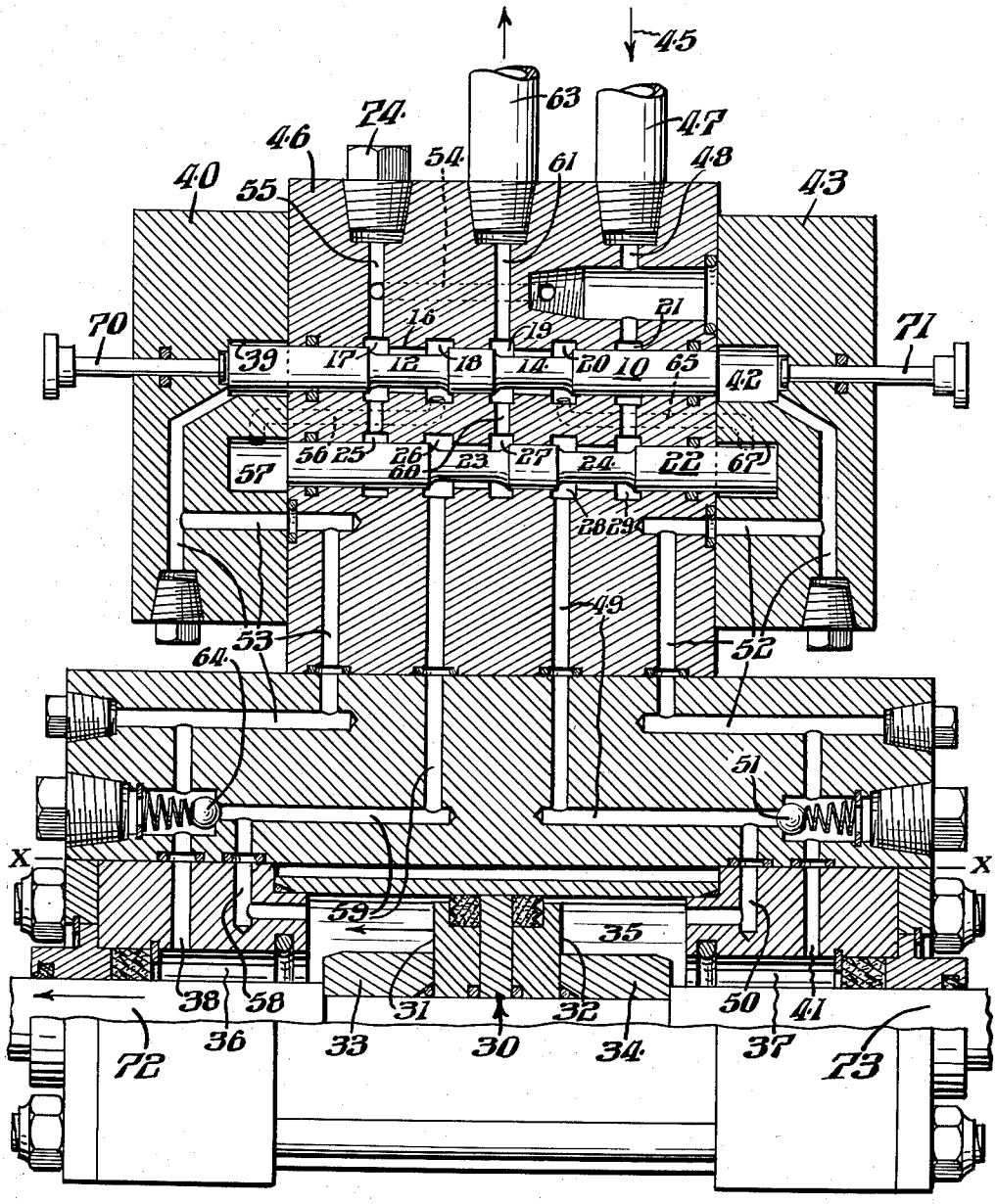
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HYDRAULIC REVERSING CONTROL

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FIG. 3.



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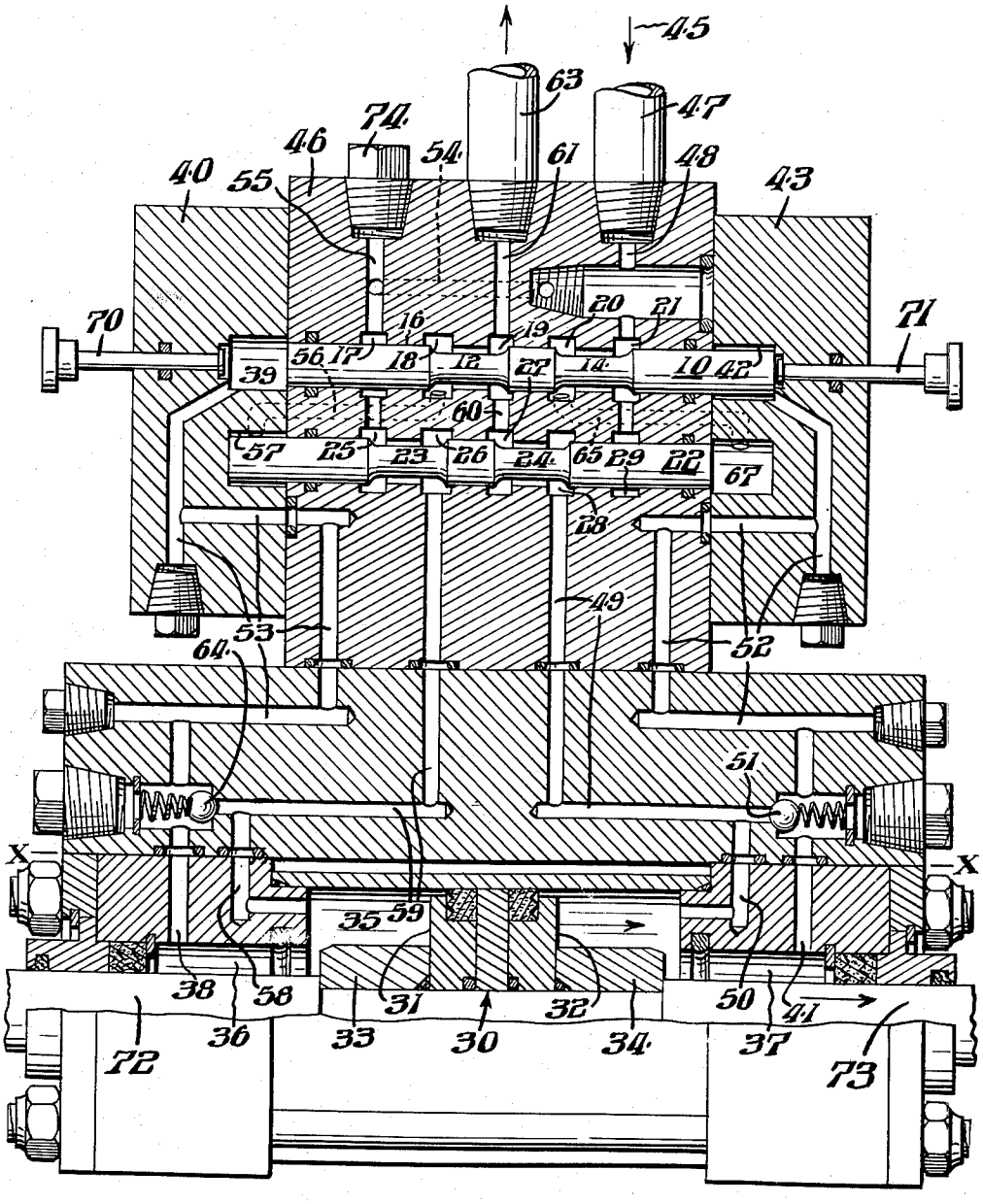
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3 Sheets-Sheet 3

FIG. 4.



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HYDRAULIC REVERSING CONTROL

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5 Claims. (Cl. 121—158)

This invention relates to a hydraulic system, and in particular to a hydraulically operated reversing control.

In accordance with my present invention, intensified fluid pressure is used for the signal which controls the valve mechanism, which in turn controls the reversing of the piston stroke.

The reversing control of my present invention has a number of advantages, including but not limited to the following: It has no external mechanical connections. It is adapted to operate a cylinder of any length. Its operation is not adversely affected by varying pressure created by cylinder load changes, nor by main cylinder piston or valve internal leakage. It may be mounted either integral with or separate from the cylinder. It is adapted to be operated from two-volume supplies so as to provide (when desired) different speeds in opposite directions. The means by which these advantages are achieved will become clear as the description proceeds.

It is believed that my invention, both as to structure and mode of operation, will be clearly understood from the following description of a preferred physical embodiment illustrated in the drawings in which:

Fig. 1 is a top view of apparatus embodying my present invention;

Fig. 2 is an end view of the apparatus;

Fig. 3 is a cross-sectional front-elevational view along the line and in the direction indicated by the arrows III—III of Fig. 1, Fig. 3 showing the position of the valve mechanism at a time when the piston is moving from right to left;

Fig. 4 is a view similar to Fig. 3 but showing the position of the valve mechanism at a time when the piston is moving from left to right; and

Fig. 5 is a detailed view showing a modification of a portion of Figs. 3 and 4.

In describing the preferred embodiment of my invention illustrated in the drawing, specific terminology has been resorted to for the sake of clarity. However, it is not my intention to be limited to the specific terms so selected, and it is to be understood that each specific term includes all technical equivalents which operate in a similar manner to accomplish a similar purpose.

Referring now to Fig. 3, this figure shows the details of the valve mechanism and of the cylinder mechanism. The valve mechanism (usually referred to in the art merely as the "valve") is that portion of Fig. 3 (and also of Fig. 4) above the line designated X—X, while the cylinder mechanism (usually referred to in the art merely as the "cylinder") is that portion below the line X—X.

As shown in Fig. 3, the "valve" includes a pilot spool 10 having two spaced-apart recessed portions 12 and 14. Pilot spool 10 is contained in a bore or cavity 16 of substantially the same diameter as the spool and having, at spaced apart intervals, annuluses 17, 18, 19, 20 and 21. As is well understod in the art, the function of each annulus having connections at both top and bottom (such as 17, 19 and 21) is to permit fluid to flow past the spool even when the full diameter of the spool is at the annulus. As is also well understood, the function of the recessed portions (such as 12 and 14) is to permit fluid communication between adjacent annuluses (such as 17 and 18; also 19 and 20), according to the position of the spool.

The valve shown in Fig. 3 also includes a main spool 22 located horizontally to but below pilot spool 10. As in the case of pilot spool 10, main spool 22 also has two recessed portions, 23 and 24, and the bore or cavity of the main spool also has five spaced apart annuluses 25, 26, 27, 28 and 29. Transverse movement of both the pilot spool and main spool in the direction of their respective axes is permitted by the fact that the respective bore or cavity of each spool is made longer than the length of the spool.

For convenience throughout this specification, the recessed portion of the spools 10 and 22 (such as 12, 14, 23 and 24) will be referred to as "open sections," this being a term used in the art, it being understood that the recessed portions of the spools, in cooperation with the bore or cavity in which the spool moves, form open sections for fluid communication.

Referring now to the lower or cylinder portion of Fig. 3, the main piston 30 is shown to have projecting from each of its opposite faces 31 and 32, extensions or plungers, 33 and 34, respectively, of substantially smaller diameter than the main piston diameter, and the main piston cylinder or bore 35 is shown to have at either end a cavity or chamber 36, 37 of substantially the same diameter as that of the plungers 33, 34 for receiving such plungers. A connection, passages 38, 53, is provided from plunger cavity 36 to the left end chamber 39 of cavity 16 of pilot spool 10, end chamber 39 being in the valve end cap 40. Similarly, a connection, passages 41, 52, is provided between the plunger cavity 37 and the right end chamber 42 of the pilot spool cavity in the valve end cap 43.

The remaining structure of the apparatus shown in the figures of the drawing will be clear from the following description of the operation of the device.

In Fig. 3 pilot spool 10 is shown all the way to the left in its cavity, while main spool 22 is all the way to the right. These are the positions which spools 10 and 22 occupy when the piston 30 is about to begin its movement from right to left, or when it is already moving from right to left, as, for example, when it is in the center of its travel (illustrated in Fig. 3) and before plunger 33 enters chamber 36.

It will be convenient to assume, for purposes of describing the operation, that the piston 30 has not yet started its movement from right to left and is located all the way to the right in the cylinder 35 with plunger 34 deep in cavity or chamber 37. Fluid under primary pressure from a supply of hydraulic pressure 45 (which will ordinarily but not necessarily include a pump) enters main valve body 46 at port 47, and primary pressure is exerted upon the right face 32 of main piston 30 through the fluid which flows through passage 48, annulus 21, open section 24, and passages 49, 50. This fluid enters the main bore of cylinder 35 urging piston 30 to the left.

At this same time, primary pressure is exerted against the right end of pilot spool 10 through the fluid which flows past spring-loaded check valve 51 (which opens in response to the primary pressure), through passage 52 and into pilot end chamber 42 in valve end cap 43. As a result, pilot spool 10 is urged to the left. Check valve 51 now being open, primary pressure is also applied at this time against the right end of plunger 34 by the fluid which flows through passage 41 and into the chamber 37.

Primary pressure is also being exerted at this time against the left end of main spool 22 by the fluid which flows through passages 54, 55, open section 12, and passage 56 into end chamber 57 in valve end cap 40. Thus, main spool 22 is urged to the right.

As the main piston 30 in the cylinder portion of the apparatus moves from right to left under the influence

of the primary pressure which is being applied to its entire cross-sectional area (i.e. including the area of plunger 34), fluid flows out of the system through passages 58, 59, open section 23, passage 60, annulus 19 and passage 61, leaving the system at port 63 of the main valve body 46 to return to the reservoir. Since the source of primary pressure is vented, the pressure in the exit passages is low and check valve 64 remains closed. The pressure in passages 38, 53, leading from plunger cavity 36 to end chamber 39 of the pilot spool cavity is likewise low.

As the movement of piston 30 from right to left continues, plunger 33 enters the chamber 36 and, when this occurs, fluid under intensified pressure is forced through passages 38, 53, and into pilot end chamber 39. This pressure is substantially greater than that of the primary pressure being exerted against the right end of the pilot spool 10 in end chamber 42. The magnitude of the intensified pressure relative to that of the primary pressure is a function of the relative cross-sectional areas of the plunger and main piston. For example, the intensified pressure may be from 4 to 10 times the primary pressure, but, of course, these values are merely illustrative and not limiting. Since the intensified pressure being exerted against the left end of pilot spool 10 is substantially greater than the primary pressure being exerted against the right end, the pilot spool 10 moves from left to right.

Early in the movement of pilot spool 10 from left to right, open section 12 is shut-off, terminating primary pressure in passage 56, but main spool 22 remains in the position shown in Fig. 3.

As the movement of piston 30 continues and plunger 33 enters more deeply into chamber 36, pilot spool 10 continues its movement to the right under the influence of the intensified pressure in passages 38, 53, and end chamber 39. Soon after spool 10 passes center, open section 14 arrives at the position shown in Fig. 4 thereby establishing communication between annulus 21 and annulus 20. When such communication is established, primary pressure is exerted, through open section 14 and the fluid in passage 65 and end chamber 67, against the right end of main spool 22, and main spool 22 is urged to the left.

Early in the movement of main spool 22 from right to left, and before it passes center, primary pressure to the entire right hand portion of the "valve" below the main spool is cut off by the removal of open section 24 from annulus 29. Hence, movement of piston 30 to the left ceases, and piston 30 has completed its right-to-left stroke. It is to be observed, however, that primary pressure continues against the right end of main spool 22 by reason of the primary pressure applied to passage 48, open section 14, and passage 65. Thus, main spool 22 continues its movement to the left, and open sections 23 and 24 take up the positions shown in Fig. 4. In these positions, communication is established between annulus 25 and annulus 26 through open section 23; similarly, communication is established between annulus 27 and annulus 28 through open section 24. As a result, primary pressure is now exerted on the left face 31 of piston 30 (now at the extreme left end of the main cylinder bore) through the fluid moving in passages 54, 55, annulus 17, open section 23, and passages 59, 58; and an exit passage is established between the right end of the cylinder 35 and the reservoir through passages 50, 49, open section 24, passage 60, annulus 19, passage 61 and port 63. Consequently, piston 30 is urged to the right and the reverse portion of the piston stroke has now begun.

Attention is called to the fact that when piston 30 arrived at the end of its stroke from right to left, the intensified pressure applied against the left end of pilot spool 10 terminated. However, since open section 14 had reached the position shown in Fig. 4 and was effective to shift main spool 22 to the left, substantially instantly after termination of the intensified pressure primary pressure is applied to the same left end of the pilot spool through the fluid in passages 54, 55, annulus 17, open section 23, passage 59, open check valve 64, passage 53 and end chamber 39. Thus, pilot spool 10 continues to be urged to the right, and the pilot spool is held in the position shown in Fig. 4.

Fig. 4 shows, then, the positions of the pilot spool 10 and main spool 22 when the piston 30 is about to begin, or is moving through, its left-to-right stroke. The action taking place during the left-to-right stroke is similar to that already described with respect to the right-to-left stroke but employs complementary facilities, as will be briefly described.

Referring again to Fig. 4, it will be seen that when the piston 30 has moved sufficiently to the right to cause plunger 34 to enter chamber 37, intensified pressure is exerted against the right end of pilot spool 10 through the fluid in passages 41, 52, and end chamber 42. As already discussed, this intensified pressure is substantially greater than that of the primary pressure being exerted against the left end of pilot spool 10 (through the fluid in passages 54, 55, annulus 17, open section 23, passage 59, check valve 64, passage 53 and end chamber 39) and, accordingly, pilot spool 10 begins to move from right to left.

Soon after the pilot spool 10 has started its movement from right to left, open section 14 is blocked off at annulus 21, thus shutting off primary pressure to the fluid in passage 65 and thus removing primary pressure against the right end of main spool 22.

When pilot spool 10 has moved sufficiently to the left so that the open sections 12 and 14 again take up the position shown in Fig. 3, primary pressure is again applied through passages 54, 55, open section 12, passage 56, and pilot chamber 57 upon the left end of main spool 22, and main spool 22 is urged to the right. When spool 22 moves to the right, the flow of fluid through the open section 23 into passage 59 is blocked and when this occurs all primary pressure in the entire left hand portion of the valve below main spool 22 is terminated, and piston 10 ceases to move. However, primary pressure against the left end of main spool 22 continues (through passages 54, 55, open section 12, passage 56, and end chamber 57) and main spool 22 continues its movement to the right.

At the time pressure is cut off below main spool 22, as mentioned above, piston 30 has completed its stroke from left to right. The intensified pressure against the right end of pilot spool 10 (through passages 41 and 52) has now terminated. Primary pressure, however, is now applied against the same right end of pilot spool 10 by reason of the primary pressure from source 45 applied through the fluid flowing into port 47, passage 48, annulus 21, open section 24, passage 49, open check valve 51, passage 52, and end chamber 42. Thus, pilot spool 10 continues to be urged to the left.

Primary pressure is now being exerted against the left end of main spool 22 through the fluid in passages 54, 55, open section 12, passage 56, and end chamber 57.

A complete cycle has now been completed and piston 30 is again ready to be moved from right to left.

The means by which the advantages recited in the introduction to this specification are achieved are by now probably clear. However, a few comments will be made.

It is apparent that the apparatus, once started, is adapted to run continuously without need of any external adjustments. For start-up purposes, however, a couple of external manually-operated plungers are used, these being identified in Figs. 3 and 4 of the drawing by reference numerals 70, 71. These plungers are provided merely for the purpose of assisting in purging air from the system during initial start-up. They are used to move the pilot spool 10 back and forth until all air in the system has been exhausted.

It is also believed to be apparent that the apparatus is adapted to operate a cylinder of any length, since the reversing control is not actuated until a pilot plunger, **33** or **34**, enters its respective chamber **36**, **37**, and this is independent of cylinder length.

It has been stated that the operation of the apparatus is not affected by varying pressure created by changes in the cylinder load, the cylinder load being represented in Figs. 3 and 4 by the shafts **72**, **73** which extend in opposite directions and are movable in a reciprocating manner by the piston **30**. With changes in cylinder load, the time period of the piston cycle changes, but the length of the stroke does not change, at least not significantly. If the cylinder load is so great as to stop the piston before the plunger (**33**, **34**) enters its respective chamber (**36**, **37**), the piston merely stops. This is in contrast to prior art apparatus of which I am aware in which stopping of the piston in one direction triggers the reversing control mechanism with the undesirable result that the piston reciprocates back and forth through a much shorter stroke, thus failing to accomplish the work, yet continuously operating to the detriment of the prior art apparatus involved.

It will also be apparent that fluid leakage past the cylinder will but alter the period of the reciprocating action.

An advantage of my present invention which is believed to be important is that the valve mechanism may be mounted either integral with, or separate from, the cylinder mechanism. For example, the valve mechanism lying above the line X—X in Figs. 3 and 4 may, if desired, be mounted remote from the cylinder mechanism lying below the line X—X, the lengths of the connecting conduits therebetween being of little consequence.

The reversing control of my present invention is also adapted to operate the piston at different speeds in opposite directions, or at the same speed when the piston loads in opposite directions are different. This may be readily accomplished by modifying slightly the apparatus shown in Figs. 3 and 4 of the drawing by removing plug **74**, and, as illustrated in Fig. 5, blocking passage **54** and applying a different volume rate of fluid pressure at port **75** than is applied at port **47**.

While the preferred embodiment of this invention has been described in some detail, it will be obvious to one skilled in the art that various modifications may be made without departing from the invention as hereinafter claimed.

Having described a preferred form of my invention, I claim:

1. A hydraulic reversing control for controlling the conversion of primary fluid pressure into a reciprocating mechanical motion, comprising; fluid-directing means; means for applying primary fluid pressure to said fluid-directing means to establish said fluid-directing means in one of two conditions; means for applying primary fluid pressure by way of said fluid-directing means to one face of a movable piston as determined by the condition of said fluid-directing means, thereby to move said piston in one direction; means responsive to said piston passing a selected point in its stroke for developing an intensified fluid pressure substantially greater than the applied primary fluid pressure, said means for developing said intensified pressure comprising a plunger extending from the face of said piston and of substantially smaller cross-sectional area than said piston, and a chamber for receiving said plunger; and means, including a coupling from said chamber to said fluid-directing means, for applying said intensified fluid pressure to said fluid-directing means to over-ride the primary fluid pressure applied thereto and to change said fluid-directing means to its other condition, thereby to direct primary fluid pressure to the opposite face of said movable piston and thereby to effect reversal of movement of said piston.

2. Apparatus as claimed in claim 1 characterized in that said piston has a plunger extending from each of its two faces, that a chamber is provided for each plunger, and that a coupling is provided from each chamber to said fluid-directing means.

3. A hydraulic reversing control comprising at least two fluid-carrying conduits; means for connecting each of said conduits to a source of primary fluid pressure; a cylinder having a two-face piston adapted for reciprocating motion therein, said piston having a plunger extending from each face thereof, each of said plungers having substantially smaller diameter than said piston, said cylinder having at each end a cavity for receiving said plunger, said cylinder also having at one end a coupling to one of said conduits and at the other end a coupling to the other said conduits; a main spool movable transversely with respect to said conduits and adapted to permit the flow of fluid through one of said conduits to one end of said cylinder and to block the flow of fluid through the other conduit according to the position of said main spool; a pilot spool movable transversely with respect to said conduits and adapted to permit the flow of fluid in one of said conduits to one end of said main spool and to block the flow of fluid through the other conduit; and means extending from each plunger chamber to opposite ends of said pilot spool for applying intensified pressure to one end of said pilot spool according to the direction of movement of said piston to move said spool transversely against the primary pressure applied at its opposite end, thereby to change the position of said main spool, and thereby to reverse the open and blocked conditions of said conduits.

4. Apparatus as claimed in claim 3 further characterized in that first and second sources of primary fluid pressure of different volumes are provided and in that one of said conduits is connected to said first source and the other to said second source, thereby to apply a different volume of fluid to one face of said piston than is applied to the other.

5. A hydraulic reversing control for controlling the conversion of fluid pressure into a reciprocating mechanical motion, comprising; a main fluid-directing element; a pilot fluid-directing element; means for applying primary fluid pressure to one end or the other of said pilot fluid-directing element to establish the position thereof; means for applying primary fluid pressure to one face or the other of a movable piston depending upon the position of said main fluid-directing element for moving said piston in one direction or the other; means responsive to said piston passing a selected point in its stroke for developing an intensified fluid pressure substantially greater than said applied primary pressure, said last mentioned means comprising a plunger extending from each face of said main piston having substantially smaller cross-sectional area than said piston, a chamber extending in opposite directions from each end of the piston cylinder for receiving its respective plunger after the piston has travelled past said selected point in its stroke, and conduit means coupling each of said plunger chambers to said pilot fluid-directing element; means for utilizing said intensified fluid pressure to over-ride the primary pressure applied to said pilot fluid-directing element to change the position thereof; and means responsive to the change in position of said pilot fluid-directing element for changing the position of said main fluid-directing element, thereby to direct application of said primary fluid pressure to the opposite face of said movable piston and thereby to effect movement of said piston in the opposite direction.

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