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[54] **MASTER CYLINDER CONSTRUCTION AFFORDING AUTOMATIC RE-PHASING OF MASTER AND SLAVECYLINDERS**

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Related U.S. Patent Documents

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[51] **Int. Cl.²** **F15B 7/00**

[58] **Field of Search** 60/533, 546, 535, 543, 60/542, 544, 591, 592; 91/393, 443; 92/61, 162, 163; 417/386

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EXEMPLARY CLAIM

6. A hydraulic actuator assembly comprising:
an elongated cylinder;
first and second longitudinally spaced fluid inlet and outlet fittings in the cylinder wall;
first and second longitudinally spaced fluid inlet and outlet ports through the cylinder wall communicating respectively with the first and second inlet and outlet fittings;
first and second longitudinally spaced fluid escape orifices through the cylinder wall communicating respectively with the first and second inlet and outlet fittings, one orifice adjacent each of said ports, the longitudinal spacing between the orifices being less than the longitudinal spacing between said ports, and the fittings, ports and orifices being in substantial longitudinal alignment along the cylinder wall;
a piston having limited reciprocable movement in the cylinder; and
an annular seal or packing carried by the piston for sealing between the piston and the internal wall of the cylinder, and for thus dividing the cylinder into first and second fluid pressure chambers,
the location of the piston at each end of its permitted stroke and the spacing between and location of the ports and the orifices being so related, each to the other, that:
a. when the piston is at one end of its stroke the piston seal is located between the first port and the adjacent first orifice, the first cylinder chamber is in open communication with the first fitting through the first port, and the second cylinder chamber is in restricted communication with the first fitting through said first orifice; and
b. when the piston is at the other end of its permitted stroke the piston seal is located between the second port and the adjacent second orifice, the second cylinder chamber is in open communication with the second fitting through the second port, and the first cylinder chamber is in restricted communication with the second fitting through the second orifice.

6 Claims, 3 Drawing Figures

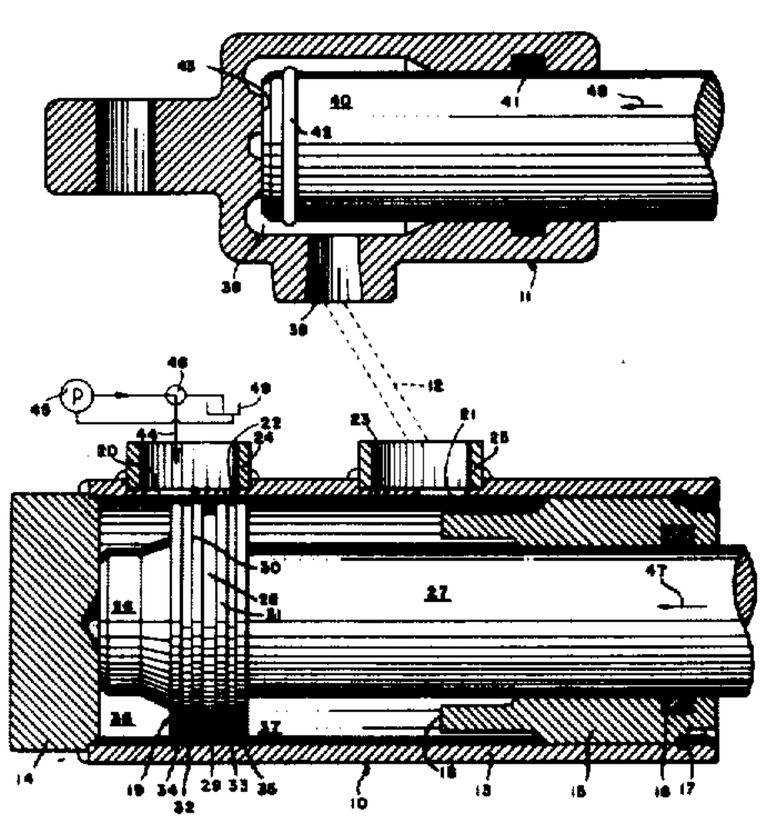

FIG. 1

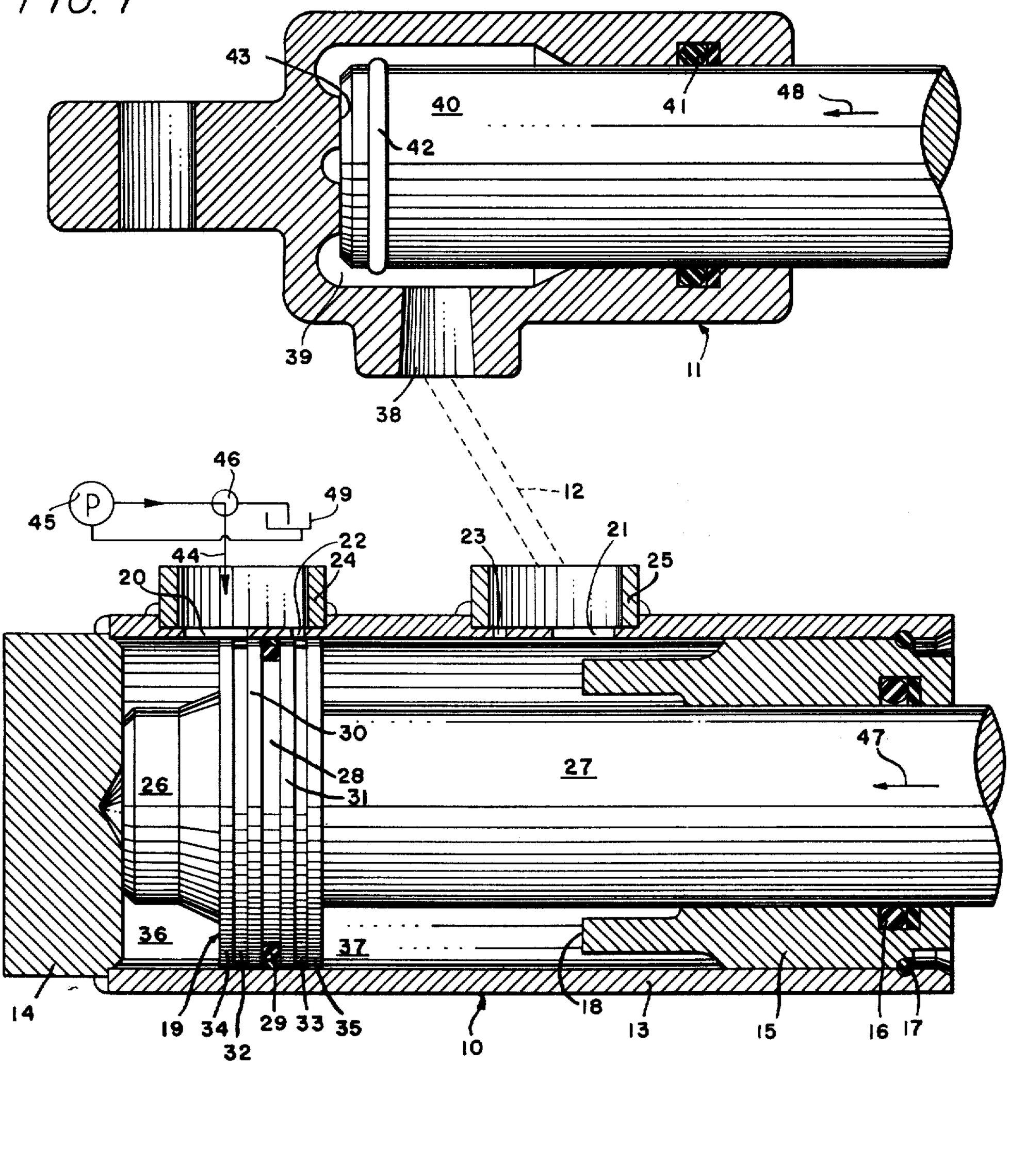

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FIG. 2

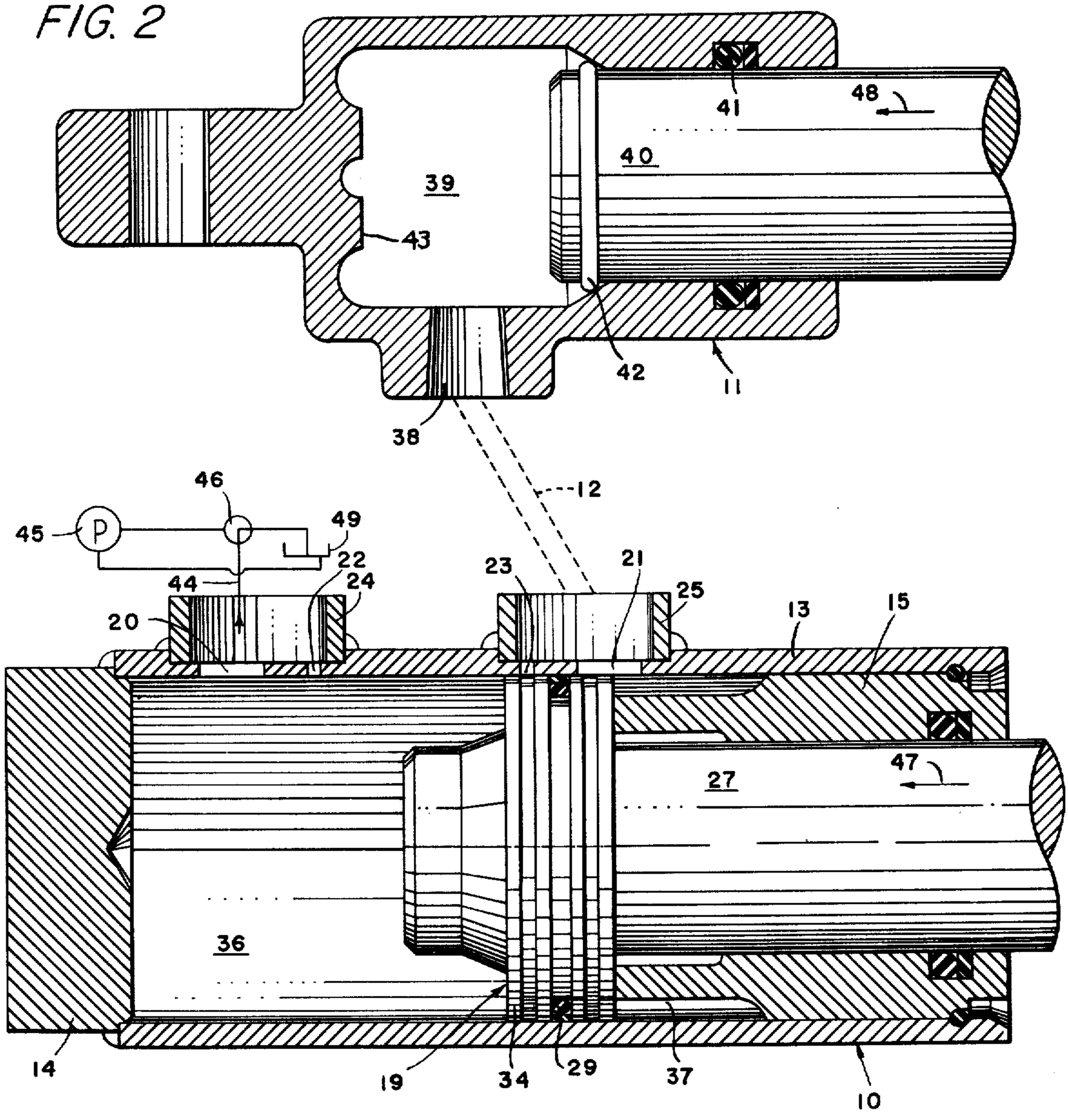
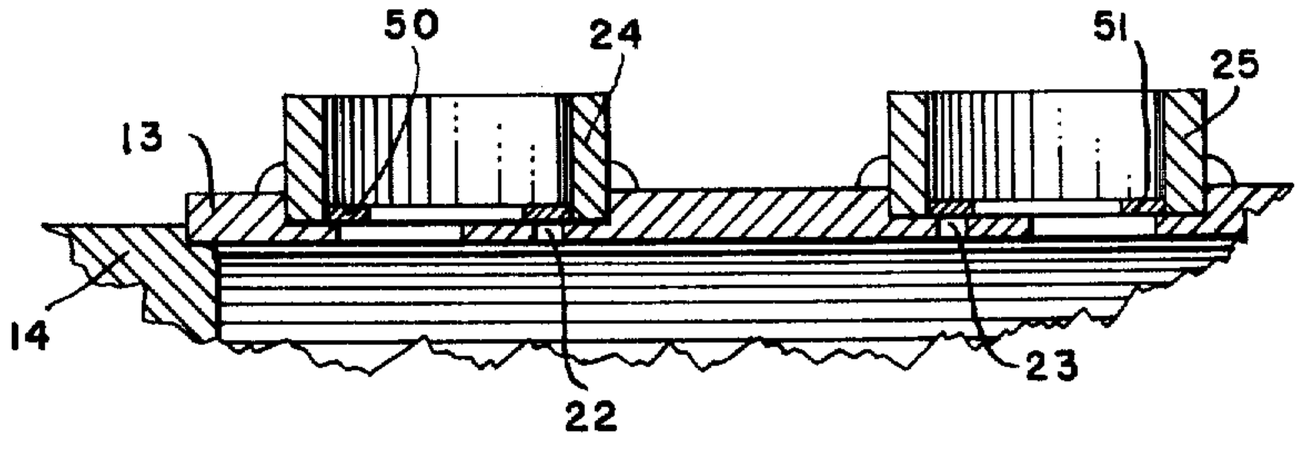


FIG. 3



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MASTER CYLINDER CONSTRUCTION AFFORDING AUTOMATIC RE-PHASING OF MASTER AND SLAVECYLINDERS

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

This invention relates to a unique construction for a master hydraulic cylinder of the type capable of performing useful work while simultaneously controlling the coordinated operation of associated slave cylinders, which also perform useful work. The cylinder construction is also capable of use in a hydraulic system in which it performs its work independent of any slave cylinder association or operation.

A master cylinder construction embodying my invention is illustrated and described herein associated with a single slave cylinder. In such a combination, where both master and slave cylinders are simultaneously performing useful work at widely separated locations, it is often required that the pistons and rods of the two cylinders start their movement simultaneously, travel at substantially the same velocity, travel the same distance, and reach the ends of their respective strokes at substantially the same time. This is true, for instance, when two such cylinders are connected to raise and lower the respective opposite ends of the reel on a combine or other harvester. Such coordinated action of the cylinders is required in order to maintain the elongated reel in a level position throughout the raising and lowering operation.

The difficulty of maintaining such coordinated action over an extended period of weeks is primarily due to uneven wear of the working parts of the two working cylinders, particularly the hydraulic fluid seals. Seal wear causes leakage, and due to this leakage the piston and rod of one cylinder may not complete its travel to the full end of its permitted stroke in either direction, resulting in a progressive shortening of the length of its stroke. In other words the pistons and rods of the two cylinders get out of phase.

It is a primary object of my invention to provide a master cylinder construction which automatically re-phases the piston positions of the master cylinder and the associated slave cylinder or cylinders at each end of their respective strokes, regardless of the relative degree of wear on the working parts of the respective associated cylinders over an extended period. By so re-phasing the positions of the respective pistons at each end of their respective strokes, assurance is provided that all pistons begin their return strokes simultaneously, and that all pistons travel to the full ends of their respective permitted strokes in each direction.

Another important object of the invention is to provide a master cylinder construction which automatically provides a relief against over pressurization of one cylinder due to the fact that the piston of that cylinder reaches the end of its permitted stroke prior to the time the piston of an associated cylinder reaches the end of its permitted stroke.

Another object is to provide a master cylinder construction which accomplishes the above described results without the use of poppet valves, manual valves, etc., which are commonly used to accomplish re-phasing of associated working cylinders, whether they are connected in series or in parallel.

An additional object of the invention is to provide a double acting working cylinder construction which provides relief against internal over pressurization of the cylinder at both ends of the piston stroke in case the control valve directing pressure fluid to either end of the cylinder is not closed just prior to or at approximately the instant the piston reaches the end of its stroke in either direction.

The invention will be more clearly understood when the following description is read in connection with the accompanying drawings, in which:

FIG. **1** is a central longitudinal sectional view through a hydraulic working cylinder embodying my invention, shown connected in series to an associated hydraulic slave cylinder, the hydraulic system for actuating both cylinders being shown schematically, the respective pistons and rods of both cylinders being shown at the inner ends of their permitted strokes;

FIG. **2** is a view similar to FIG. **1,** with the respective pistons and rods of both cylinders being shown at the outer ends of their permitted strokes; and

FIG. **3** is a fragmentary view of a portion of the cylinder shown in the lower part of FIG. **2,** and includes optional check valves which are not included in the other drawing figures, yet which constitute a part of my invention.

A cylinder construction which embodies my invention is shown in the lowr portion of FIG. **1,** and is designated as a whole by the numeral **10.** For clarity in description cylinder **10** is shown connected in series to a slave cylinder **11** by means of a conduit **12.** Cylinder **10** will be referred to herein as a master cylinder, although it should be understood that this cylinder may be used in any hydraulic system as a double acting working cylinder, completely disassociated from any slave cylinder.

Construction—FIGS. 1 and 2

Referring to FIG. **1,** master cylinder **10** includes a barrel **13** having a fixed head **14** at one of its ends and a removable piston rod bearing **15** at its other end. Bearing **15** carries seals **16** and **17.** The head **14** and the inner end **18** of bearing **15** serve as travel limit stops for a piston **19.**

Barrel **13** is provided with relatively large longitudinally spaced ports **20** and **21,** and a pair of respectively associated fluid escape orifices **22** and **23.** Port **20** and orifice **22** both communicate with a conduit attachment fitting **24,** while port **21** and orifice **23** both communicate with a similar conduit fitting **25.**

Piston **19** carries an integral stop **26,** and is connected to a reciprocable rod **27.** Piston **19** is provided with a central annular groove **28** which seats an annular wall seal **29,** adjacent annular lands **30** and **31** which are of a diameter to fit the barrel wall snugly, grooves **32** and **33,** and outside lands **34** and **35.** Piston **19,** of course, divides the interior of barrel **13** into two pressure fluid chambers **36** and **37.**

The length of permitted travel of piston **19** between stops **14** and **18,** and the relative locations of ports **20** and **21** and orifices **22** and **23** with respect to the location of seal **29** on the piston are such that when piston **19** is at the inner end of its stroke, as in FIG. **1,** port **20** is located between seal **29** and head **14** and openly communicates with chamber **36.** With the piston in this position orifice **22** is located between seal **29** and

:hamber **37**, and if the fluid pressure in chamber **37** is ;reater than the pressure in chamber **36** and fitting **24**, luid from chamber **37** may leak past land **35** and es- :ape through orifice **22** into fitting **24**. Any flow of fluid hrough escape orifice **22** in the opposite direction due o a higher pressure in fitting **24** than in chamber **37**, is ncidental and immaterial in the illustrated series hook- p of master and slave cylinder, because the least out- ard movement of piston **19** causes seal **29** to pass rifice **22**, thus cutting off the fluid escape route into hamber **37**.

In the same manner, when piston **19** is located at the uter end of its permitted stroke, as in FIG. **2**, port **21** ; located outside seal **29** and openly communicates ith chamber **37**. At the same time escape orifice **23** is ocated inside seal **29**. If fluid pressure in chamber **36** is igher than in fitting **25** and chamber **37**, fluid can leak ast land **34**, through orifice **23** and into fitting **25**. eakage of fluid through orifice **23** in the opposite irection, due to the existence of a higher pressure in tting **25** than in chamber **36**, is inconsequential.

In the hydraulic system illustrated, master cylinder tting **25** is connected by conduit **12** to a port **38** in a all of single acting slave cylinder **11**. Port **38** commu- icates with a pressure chamber **39**, within which a ombination piston and rod **40** is reciprocable. The hambers **37** and **39** have equal volume capacities, gardless of the permitted length of stroke of the pis- n rods **27** and **40**. A piston rod seal **41** normally revents leakage from slave cylinder chamber **39** as the d reciprocates. A snap ring **42** is seated in an annular roove near the inner end of rod **40**, and serves as a op to limit outward movement of the rod in its cylin- er. Inward movement of rod **40** is limited by contact f the inner end of the rod with an inwardly projecting outment **43**, integral with the cylinder end wall.

Operation

With both pistons **27** and **40** positioned at the inner ds of their respective strokes, as in FIG. **1**, and with e chambers **36**, **37** and **39**, and conduits **12** and **44** mpletely filled, fluid under pressure is delivered from pump **45** or other source, through conduit **44** and rt **20** into master cylinder chamber **36**, when a con- ol valve **46** is properly adjusted. The instant piston **19** arts to move outward, fluid is forced from chamber 7 through conduit **12** and into slave chamber **39**, and ston **40** simultaneously starts to move outward. It will assumed that both piston rods are operating against ad forces applied in the directions indicated by the rows **47** and **48**.

Case No. 1—Extension

Assuming that there is fluid leakage from slave cham- r **39** past seal **41** due to a worn seal or because of a eater load on piston rod **40**, rod **40** would normally op traveling before reaching the outer end of its roke, while master piston **19** would continue to travel the full end of its stroke. This could occur because of sufficient fluid in master chamber **37** to completely l slave chamber **39** after fluid had leaked from that amber (FIG. **2**).

Under this condition supplemental fluid under pres- re from source **45** would leak past land **34** (FIG. **2**), rough orifice **23**, through conduit **12** and into slave amber **39**, thus forcing piston **40** to the full outer end its stroke, regardless of leakage from chamber **39**. e pistons and rods of both master and slave cylinders

are thus re-phased at the outer ends of their respective strokes, each time the movement cycle is repeated.

Case No. 2—Retraction

With both pistons at the outer ends of their respective strokes, as in FIG. **2**, control valve **46** can be adjusted to its FIG. **2** condition, which connects master chamber **36** to a system reservoir **49**, and allows both pistons to simultaneously start their inward travel under the influence of their respective loads.

If master piston **19** reaches the full end of its permitted inward travel before slave piston **40** does, excess fluid can pass from chamber **39** (FIG. **1**) through chamber **37**, past land **35**, and through escape orifice **22** into conduit **44** and to the reservoir, thus permitting piston **40** to travel to the full inner end of its stroke.

If slave cylinder piston **40** reaches the inner end of its stroke before master piston **19** has completed its stroke, and a void is created in chamber **37** as piston **19** continues to the end of its stroke, that void is filled through escape orifice **22** by pressure fluid from the pump before either piston again starts its outward travel during the next cycle. The pistons and rods of the two cylinders are thus re-phased at each of the ends of their respective strokes.

FIG. 3 Construction

The construction shown in FIG. **3** differs from the previously described master cylinder construction only by the inclusion of flat washers **50** and **51**, of metal or other material, which seat in conduit fittings **24** and **25**, and act as check valves to prevent the flow of fluid in one direction through escape orifices **22** and **23**, respectively.

Operation—FIG. 3

The washer type check valves **50** and **51** are useful in preventing uneven extension or retraction of the two piston rods **27** and **40** in case rod **27** is loaded much more heavily than rod **40**.

Under such a condition, with both pistons at the inner ends of their respective strokes as in FIG. **1**, check valve **50** prevents pressure fluid from traveling through escape orifice **22**, chamber **37**, and to slave chamber **39**, and moving piston **40** outward while master piston **27** remains stationary under its heavier load.

With both pistons at the outer ends of their respective strokes, with piston rod **40** loaded much higher than master rod **27**, and with control valve **46** open only slightly to provide slow inward movement of the pistons, check valve **51** prevents fluid from being forced from slave cylinder chamber **39** through escape orifice **23** and conduit **44** to reservoir. Rod **40** is thus prevented from moving inward in its cylinder under its greater load, while the pressure build up in master chamber **36** temporarily prevents rod **27** from moving inward under its lighter load. Uneven retraction or extension of the unequally loaded piston rods is thus prevented.

It will be understood from the above description of the master cylinder construction that a number of master cylinders could be connected in series, and that the first master would extend and retract the pistons of all the cylinders in unison. By varying cylinder capacities the the rate and extent of rod movement in the various cylinders can also be varied to meet requirements. It will also be understood that the fluid escape orifices **22** and **23** in each master cylinder of the series would

accomplish rephasing of all pistons at each end of their respective strokes.

Having described the invention with sufficient clarity to enable those familiar with this art to construct and use it, I claim:

[1. A hydraulic actuator assembly comprising:
an elongated cylinder;
a piston having limited reciprocable movement within the cylinder, and dividing the cylinder into first and second chambers;
a first port through a wall of the cylinder affording open exterior fluid communication with said first chamber regardless of piston position in the cylinder;
a first fluid escape orifice through a wall of the cylinder located to afford restricted exterior communication with the second chamber only when the piston is at one end of its permitted stroke;
a second port through a wall of the cylinder affording open exterior communication with said second chamber regardless of piston position in the cylinder; and
a second fluid escape orifice through a wall of the cylinder located to afford restricted exterior communication with the first chamber only when the piston is at the other end of its permitted stroke.]

[2. The actuator described in claim 1, and:
fluid conducting means affording communication exterior of the cylinder between each of said ports and the respectively adjacent fluid escape orifice.]

[3. The actuator described in claim 1, and:
a check valve for each of said escape orifices affording flow of fluid outward only through the respective orifices.]

[4. In a hydraulic actuator which includes an elongated cylinder and a piston having limited reciprocatory movement therein, and which divides the cylinder into first and second chambers, said cylinder including separate means for conducting fluid into and from the respective chambers, the improvement in such an actuator which comprises:
a first fluid escape orifice through a wall of the cylinder located to afford restricted egress of fluid from said second chamber when the piston has moved to a position to reduce the first chamber to minimum volume capacity; and
a second fluid escape orifice through a wall of the cylinder located to afford restricted egress of fluid from said first chamber when the piston has moved to a position to reduce said second chamber to minimum volume capacity.]

[5. The actuator described in claim 4, and:
a check valve for each of said escape orifices affording flow of fluid outward only through the respective orifices.]

6. A hydraulic actuator assembly comprising:
an elongated cylinder;
first and second longitudinally spaced fluid inlet and outlet fittings in the cylinder wall;

first and second longitudinally spaced fluid inlet and outlet ports through the cylinder wall communicating respectively with the first and second inlet and outlet fittings;
first and second longitudinally spaced fluid escape orifices through the cylinder wall communicating respectively with the first and second inlet and outlet fittings, one orifice adjacent each of said ports, the longitudinal spacing between the orifices being less than the longitudinal spacing between said ports, and the fittings, ports and orifices being in substantial longitudinal alignment along the cylinder wall;
a piston having limited reciprocable movement in the cylinder; and
an annular seal or packing carried by the piston for sealing between the piston and the internal wall of the cylinder, and for thus dividing the cylinder into first and second fluid pressure chambers,
the location of the piston at each end of its permitted stroke and the spacing between and location of the ports and the orifices being so related, each to the other, that:
(a) when the piston is at one end of its stroke the piston seal is located between the first port and the adjacent first orifice, the first cylinder chamber is in open communication with the first fitting through the first port, and the second cylinder chamber is in restricted communication with the first fitting through said first orifice; and
(b) when the piston is at the other end of its permitted stroke the piston seal is located between the second port and the adjacent second orifice, the second cylinder chamber is in open communication with the second fitting through the second port, and the first cylinder chamber is in restricted communication with the second fitting through the second orifice.

7. The actuator described in claim 6, wherein the inlet and outlet fittings have an inside diameter overlapping its associated port and escape orifice which are in fluid communication.

8. The actuator described in claim 6 wherein the inlet and outlet fittings each comprise a cylindrical sleeve having an inside diameter overlapping its associated port and escape orifice which are in fluid communication.

9. The actuator described in claim 6 wherein the inlet and outlet fittings each comprise a cylindrical sleeve welded to the cylinder wall having an inside diameter overlapping its associated port and escape orifice which are in fluid communication.

10. The actuator described in claim 6, wherein the escape orifices are of a diameter less than the width of the annular seal.

11. The actuator described in claim 6, wherein the distance between each of said ports and its associated escape orifice is greater than the width of the annular seal.

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