

[54] **FLUID ACTUATING MECHANISM HAVING  
ALTERNATIVELY SELECTABLE FAST AND  
SLOW MODES OF OPERATION**

[75] Inventor: **James A. Kime**, Columbus, Ohio  
[73] Assignee: **Hydron, Inc.**, Columbus, Ohio  
[22] Filed: **Jan. 29, 1973**  
[21] Appl. No.: **327,697**

**Related U.S. Application Data**

[63] Continuation of Ser. No. 194,752, Nov. 1, 1971,  
abandoned.  
[52] U.S. Cl. .... **91/411 B, 91/422, 91/437,**  
60/484, 60/488  
[51] Int. Cl. .... **F15b 11/16**  
[58] Field of Search ..... 91/411 R, 411 B, 422, 170,  
91/171; 60/97 E, 97 L, 484

[56] **References Cited**  
**UNITED STATES PATENTS**

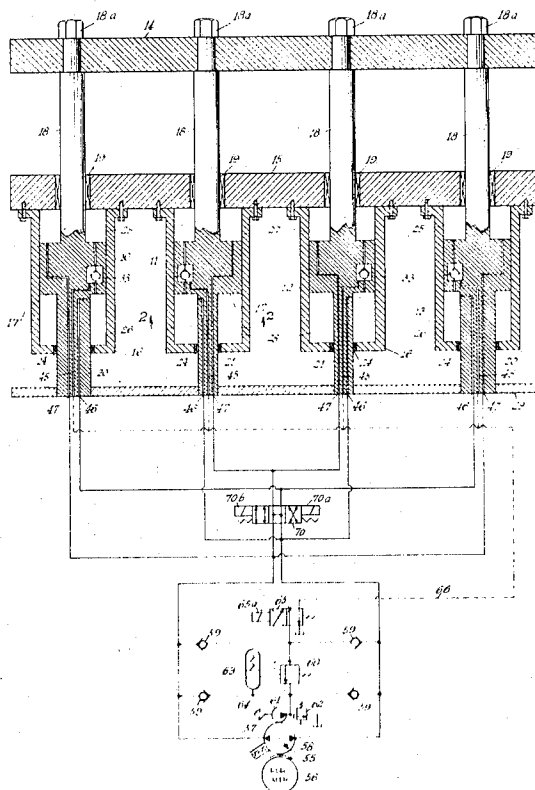
2,935,852	5/1960	Russell.....	91/172
2,986,123	5/1961	Augustin.....	91/422 X
3,390,616	7/1968	Hammer.....	91/436
3,476,016	11/1969	Dixon et al.....	91/422

Primary Examiner—Edgar W. Geoghegan  
Attorney, Agent, or Firm—Mahoney, Miller & Stebens

[57] **ABSTRACT**

A fluid actuating mechanism is provided having mechanically intercoupled first and second piston and cylinder units coupled with a fluid source and control circuit to selectively enable fast or slow modes of operation in either direction. The piston and cylinder units are of a double acting type with double-ended piston rod and having selectively operable valving to permit fluid flow between the two cylinder chambers. The piston rods of each unit are of relatively different diameters and are inversely oriented as between the two units, such that a fast mode of operation may be effected by directing a small pressurized fluid flow to one cylinder with the bulk of the fluid merely transferred between the chambers through the opened selectively operable valving. A slow mode of operation capable of exerting a substantial force is obtained by closing the selectively operable valving and directing a small pressurized fluid flow to one chamber of each cylinder. In one embodiment of this invention, the selectively operable valving is located in the pistons to reduce fluid transfer conduits required externally of the apparatus.

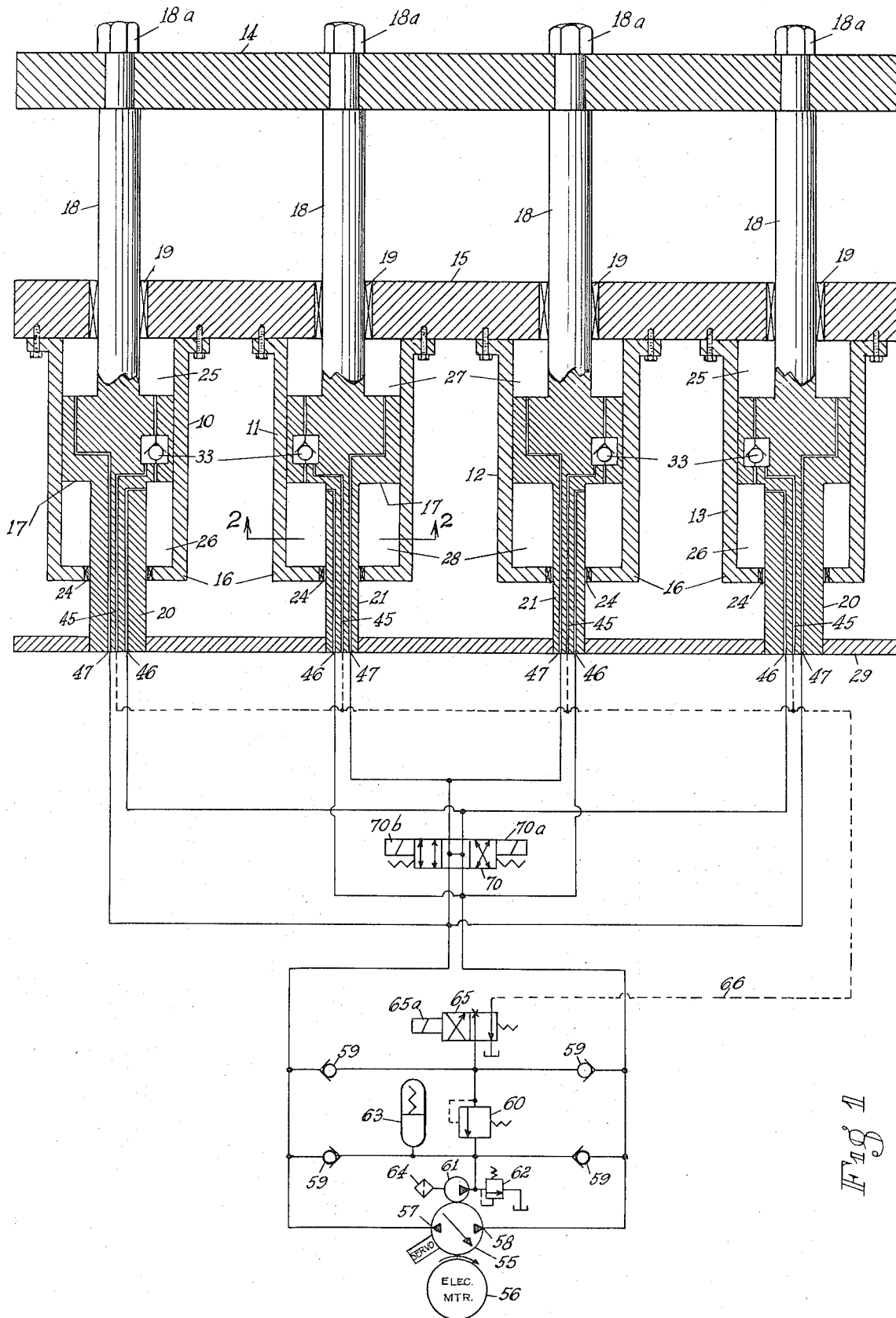
**8 Claims, 4 Drawing Figures**



PATENTED JUN 25 1974

3,818,801

SHEET 1 OF 3



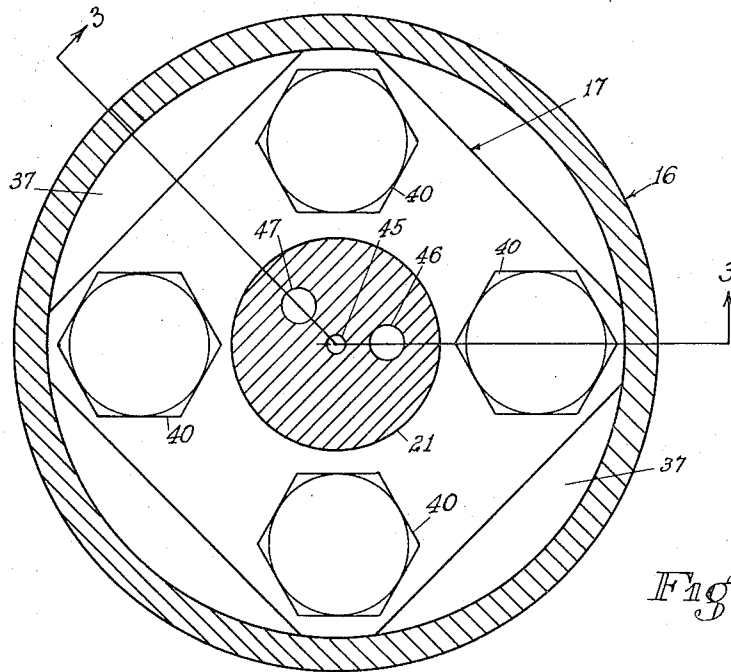


Fig 2

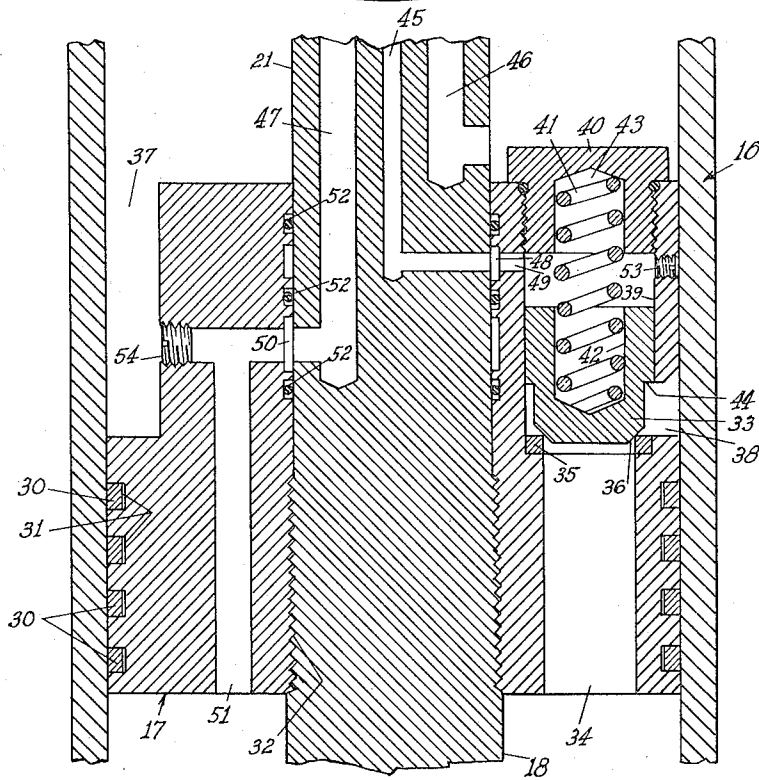
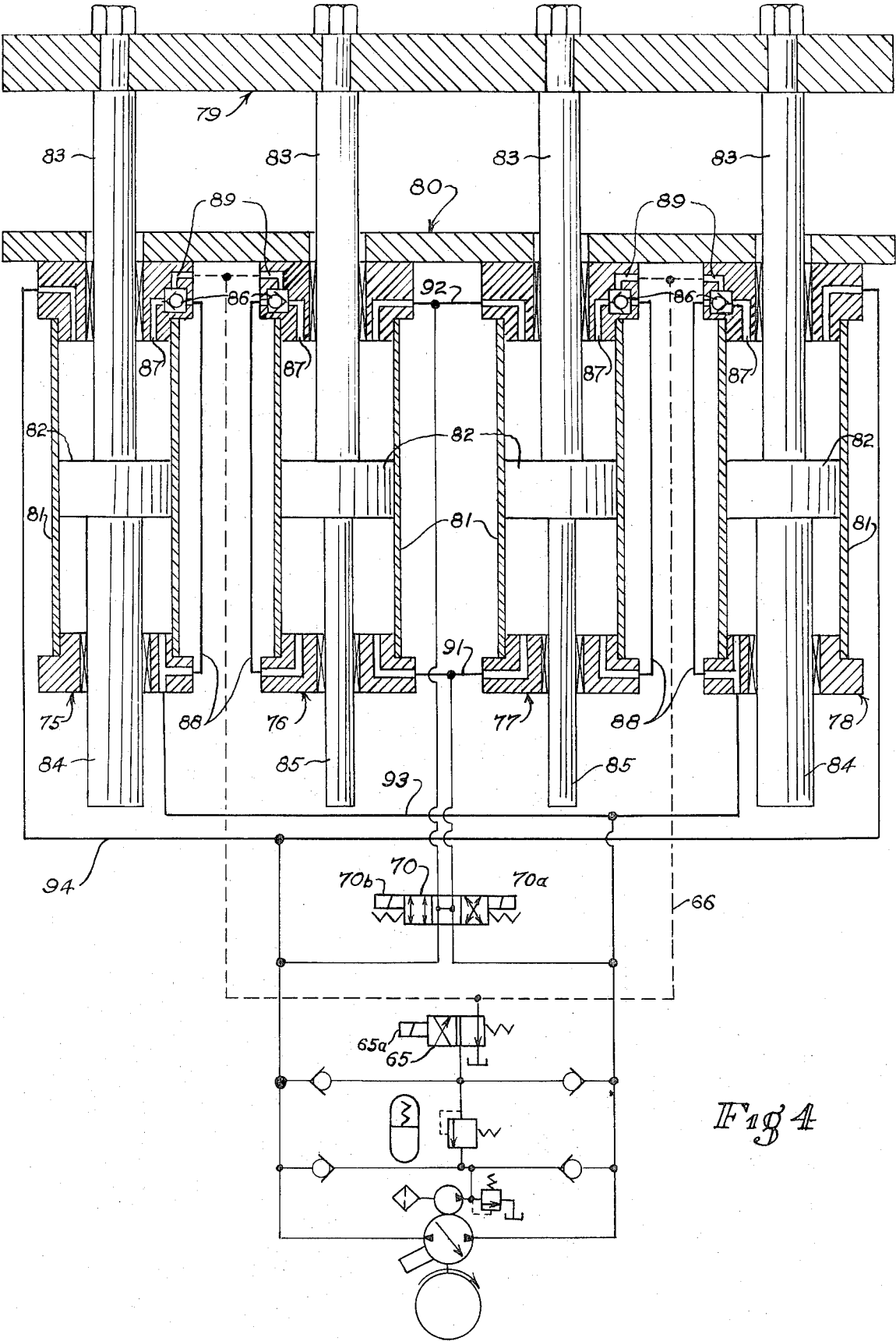


Fig 3



# FLUID ACTUATING MECHANISM HAVING ALTERNATIVELY SELECTABLE FAST AND SLOW MODES OF OPERATION

This application is a continuation of pending application Ser. No. 194,752 filed Nov. 1, 1971, now abandoned.

## BACKGROUND OF THE INVENTION

The fluid actuating mechanism of this invention is specifically adapted as a hydraulic press and the disclosure is in a press embodiment, but such a specific application is not to be considered limitative in any manner as to utilization and scope of this invention. In the press art, it is desirable to have both fast and slow operating modes as in the plastic molding industry since the greater portion of press travel time is merely opening or closing of the mold requiring a very small force, but often involving a substantial mold travel distance. Since the press force required for the actual molding operation is substantial in most cases, the fluid cylinders and pistons must be large and this necessitates a transfer of a large volume of fluid to effect the necessary press travel in the most basic prior art press apparatus having a piston and cylinder unit coupled with a fluid source and control system that merely forces fluid into the cylinder or withdraws fluid therefrom. A consequence of large fluid flow requirements is a large capacity system incorporating large fluid pumps, valves and conduits to attain a reasonable speed of operation.

Attempts to provide improved apparatus have not resulted in apparatus or mechanism that is capable of the desired fast and slow modes of operation in either direction without necessitating complex structure. An example of the prior art attempt is disclosed in U.S. Pat. No. 3,418,693 issued to Peter Franklin Harrison on Dec. 31, 1968. That patent disclosed a multiple-chamber piston and cylinder unit in which a rapid travel mode is achieved in one direction only by a differential cylinder chamber volume and a fast travel in the opposite direction is obtained by an effectively separate and independently operable cylinder and piston unit.

## BRIEF DESCRIPTION OF THE INVENTION

In accordance with this invention, a fluid actuating mechanism is provided having at least a pair of differential-volume cylinder and piston units with selectively operable valving in the piston to achieve the desired fast and slow modes of operation in either direction. The necessity for an auxiliary, effectively independent cylinder and piston unit is eliminated through the opposite orientation of the differential-volume cylinders and providing a fluid interconnection therebetween to accommodate a relatively small external fluid flow. The major portion of fluid flow is internally between the two chambers of each cylinder through the piston valving. A high press force is obtained by closing of the piston valves and the resultant slow travel is not a factor of importance at the press stage. Reduction of fluid flow in the fluid circuit externally of the cylinder and piston units reduces the fluid handling requirements for circuit components such as the fluid pump, valves and conduits with the resultant economic advantages. Operational advantages, in addition to the selective fast and slow operating modes in either direction, are in-

creased efficiency, reduction of fluid heating, and simplified operating mechanisms.

These and other objects and advantages will be readily apparent from the following detailed description of an embodiment of this invention and the accompanying drawings.

## DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram of a fluid actuating mechanism embodying this invention with the cylinder and piston units diagrammatically incorporated in a press apparatus.

FIG. 2 is a transverse sectional view of one of the cylinder and piston units taken along line 2—2 of FIG. 1.

FIG. 3 is a fragmentary sectional view through the piston taken along line 3—3 of FIG. 2.

FIG. 4 is a schematic diagram of a modified fluid actuating mechanism embodying this invention.

## DESCRIPTION OF ILLUSTRATIVE EMBODIMENT OF INVENTION

Having reference to FIG. 1, four piston and cylinder units 10, 11, 12 and 13 are shown assembled with a pair of relatively movable press platens 14 and 15 to form a fluid press apparatus. Although not shown, it will be understood that one of the press platens, 14 for example, would be supported in a fixed position with the molds (not shown) disposed and supported between the platens in any conventional and well known manner. Since this invention is directed to the cylinder and piston units and the associated fluid circuit, it is believed that a specific application of this invention will be clearly understood from the diagrammatic illustration of the platens 14 and 15.

It will also be understood that in this illustrative embodiment, the piston and cylinder units 10—13 are horizontally disposed and would preferably be positioned in a quadrangular pattern for symmetrical force distribution. The illustrated linear pattern also provides a symmetrical distribution of forces and presents a more clear illustration. While a four unit apparatus is shown, it will be apparent from the following description that only two units, 10 and 11 or 12 and 13, are necessary for a working embodiment of the invention assuming that any asymmetrical forces developed during a fast travel, low force mode of operation are of minor consequence.

Each of the piston and cylinder units 10—13 comprises a fluid cylinder 16 and a piston 17 having a double ended piston rod extending outwardly from either end of the respective cylinder. One end of the piston rods, designated by the numeral 18, of each unit is of the same diameter and extends through a fluid seal and bushing 19 in the movable platen 15 to which each of the cylinders 16 is secured or mounted. The terminal portions of the rods 18 are rigidly secured to the fixed platen 14 as by the shoulder and nut arrangements 18a with the piston rods also forming the tensile members of the press. The opposite ends of the piston rods 20 and 21 project through fluid seals and bushings 24 in the opposite ends of the respective cylinders 16. In this embodiment, the piston rods 20 are of equal diameter and greater than that of the opposite piston rods 18 while the piston rods 21 are of equal diameter but less than that of the rods 18. Thus, each cylinder 16 is divided into two chambers 25 and 26 in the case of units

10 and 13 and chambers 27 and 28 in the case of units 11 and 12 with the maximum volumes of the chambers in each cylinder being relatively different. A structural member 29 rigidly interconnects the piston rods 20 and 21 of each unit and is supported on the press structure to provide vertical support for the piston rods.

The pistons 17 are of identical construction and the enlarged sectional views of FIGS. 2 and 3 are applicable to the description of each with the only difference being that the piston rods 21 of the units 11 and 12 being of a smaller diameter than the piston rods 20 of the units 10 and 13. As a preferred construction, the piston rods 18, 20 and 18, 21 are fabricated as a unitary member with the piston 17 being secured on the rod as by interengaging threads 32. A plurality of piston rings 30 are disposed in respective grooves 31 extending around the piston and form the necessary fluid seal between the cylinder chambers. Four poppet valves 33 are assembled in each piston with a fluid passageway 34 extending axially from the chambers 25 and 27 through the piston body to a valve seat 35 cooperating with the poppet valve's face 36. This passageway 34 effectively communicates with the chamber, 26 or 28, at the opposite side of the piston through shaping of the piston to form the recesses 37 that are enlarged into a porting space 38 in region of the valves 33. Consequently, if the valves 33 are spaced from their respective seats 35, there may be free fluid flow between the chambers.

Each poppet valve 33 is axially slideable in its respective cylinder 39 with this cylinder being closed by a cap nut 40 threaded into the piston 17. A compression spring 41 extending between the cap nut 40 and valve 33 with the ends thereof retained in respective sockets 42 and 43 normally biases the valve 33 to a closed position, but the valve 33 may be unseated by the force of pressurized fluid exerted from either chamber of the cylinder 16 at opposite sides of the piston 17. A shoulder 44 formed on the valve enables fluid from the chamber 26 or 28 to also unseat the valve. In accordance with one mode of operation of this apparatus, it is necessary that the poppet valves 33 be held in a closed position and this is readily accomplished through the application of pressurized fluid to the cylinder 39.

Fluid may be conveniently transferred to or from the valve cylinder 39 or the cylinder chambers 25, 26, 27 or 28 by means of passages 45, 46 and 47 extending axially through the piston rods 20 or 21 with suitable connections being provided at the outer terminus of the respective rod for coupling with the fluid circuit. Passage 45 connects with a distributor ring 48 in the piston body with passage continuations 49 opening from the distributor ring to the respective valve cylinder 39. Passage 46 communicates directly with the associated cylinder chamber 26 or 28 at a point adjacent the piston 17 while the passage 47 connects with a distributor ring 50 formed in the piston body and then through a continuation passage 51 formed in the piston body to the associated cylinder chamber 25 or 27. Fluid seals 52 disposed in respective grooves maintain the fluid separation between the cylinder chambers and the poppet valve cylinders. Plugs 53 and 54 may be used to block drill holes required for fabrication. Fluid flow may be effected by the relatively small diameter passages since the volume of fluid transferred by these passages is relatively small and this also eliminates the usual external

interconnection with the walls of the cylinders by means of flexible conduits or hoses.

Pressurized fluid for operation of the illustrative embodiment of the invention is provided by a closed fluid system having a variable-volume, servo-controlled pump 55 of a reversible-flow type and which is driven by an electric motor 56. The pump 55 is provided with ports 57 and 58 that are connected with the conduits of the closed fluid system and which alternatively serve as inlet and outlet ports as determined by the pump operation. Electric control circuitry for the motor 56 is not shown as the necessary circuit is well known to those skilled in the art as is also the control of the pump operation. A fluid circuit comprising an arrangement of four check valves 59 with a relief valve 60 is connected across the pump ports 57 and 58 to enable the closed system to properly function. The relief valve 60 limits the maximum system pressure that may be attained to a prescribed value for a particular embodiment. A booster pump 61 also driven by the electric motor 56 and with its own relief valve 62 is interconnected with this check valve circuit to assure that a minimum system pressure is maintained at all times for protection of the pump 55 and irrespective of its operating mode at any particular instant. Compensation for variations in fluid volume requirements resulting from the volume differentials of the cylinders 16 is achieved by a spring-loaded accumulator 63 connected in this check valve circuit and the accumulator may be recharged by the booster pump 61. It will be noted that any fluid which escapes from the system through operation of the several valves may be routed to a common reservoir (not shown) with the inlet port of the booster pump 61 in fluid communication therewith by means of a strainer 64.

Pressurized fluid for operation of the several poppet valves 33 is obtained from the main fluid system pressurized by the pump 55. A two-position, spring biased valve 65 is interposed in a conduit 66 connecting the passage 45 in each of the piston rods 20, 21 to a conduit interconnecting a pair of the check valves 59 connected across the pump ports 57 and 58. The valve 65 is actuated by an electric solenoid 65a that is connected with an appropriate control circuit (not shown) of well known construction and the valve is of a configuration that the conduit 66 will be connected to a reservoir to relieve the fluid pressure from the poppet valves 33 when the solenoid 65a is deenergized. Energization of the solenoid 65a will operate the valve 65 to result in pressurization of the conduit 66 and connected poppet valve cylinders 39 to maintain the valves 33 in a closed position. It will be noted that the springs 41 biasing the valves 33 are primarily provided to prevent free floating of the valves and that pressurization of the fluid in either or both chambers of the cylinders 16 will result in opening of the valves.

Control of the cylinder and piston units 10-13 as to being stopped or in either a fast or slow travel mode in either direction is accomplished through a three-position, spring-centered valve 70 of the open-center type having the actuating solenoids 70a and 70b. One pump port 57 is connected to a port of the valve 70 and to the passages 47 of the piston rods 20 while the other port 58 is connected to a second port of valve 70 and to the passages 46 of piston rods 21. The other two ports of the valve 70 are connected to the respective pairs of passages 47 of piston rods 21 and passages 46

of piston rods 20. With neither solenoid 70a or 70b energized, the open center of the valve 70 results in interconnection of all cylinder chambers 25-28 and, with the pump 55 in idle operation and assuming a horizontally disposed press, there will not be any relative movement of the piston and cylinder units 10-13 and the platens 14 and 15 will remain in a stationary position. While the disclosed embodiment will be adequate for a horizontally disposed press, it will be apparent that for vertically oriented press apparatus safety factors would require additional valve means preventing fluid flow relative to the cylinders 16 to prevent inadvertent movement thereof as a consequence of gravity forces. Illustration thereof is not deemed necessary as their installation and structure will be readily understood.

Operation of the apparatus for slow travel in either direction as determined by pump operation would be effected by energization of solenoids 70b and 65a. This would shift the spool of valve 70 to connect all cylinder chambers 25 and 27 together and all chambers 26 and 28 together and the poppet valves 33 would be held closed to prevent fluid transfer between the chambers of each cylinder 16. It will be recognized that the hydraulic force developed in the poppet valve cylinders 39 will exceed that of the opposing forces developed by the fluid in the cylinders 16 due to the lesser fluid friction loss and the poppet valves will be held closed. With the pump 55 operated to make port 57 the pressure port, the platen 15 would move toward the fixed platen 14. Reversal of pump operation to make port 58 the pressure port would also reverse the direction of slow travel of the platen 15. In this slow travel mode, it will be seen that only the chambers 25, 27 or 26, 28 of the cylinders 16 will be pressurized and thereby produce a substantially greater force than is possible in a fast travel mode.

Rapid travel in either direction as determined by pump operation is controlled by energization of solenoid 70a of valve 70 while leaving solenoid 65a deenergized. With solenoid 65a deenergized, valve 65 will be positioned to vent conduit 66, to a reservoir thereby relieving all fluid pressure in the poppet valve cylinders 39. This permits the poppet valves 33 to operate and open as a consequence of the fluid pressure in the cylinders 16 permitting fluid flow between the two chambers of each cylinder 16. With the pump 55 operated to make the port 57 the pressure port, the platen 15 will move rapidly toward the platens 14. In this mode of operation, the cylinder chambers 25 and 26 of both units 10 and 13 are interconnected while the cylinder chambers 27 and 28 of both units 11 and 12 are interconnected in fluid flow relationship. Fluid under pressure provided at the pump port 57 will result in a greater net force in the chambers 25 than in the chamber 26 due to the difference in relative piston areas with consequent movement. At the same time, the pressurized fluid will open the poppet valves 33 against their respective springs 41 and permit the bulk of the required fluid to merely transfer from one chamber to the other of a cylinder 16.

While the pump 55 is supplying fluid to the cylinders 16 of units 10 and 13, it is also drawing fluid from cylinders 16 of the other units 11 and 12. Consequently, there will be a minimum pressure in the latter units but sufficient to maintain the poppet valves 33 in an open configuration for free transfer of the bulk of the fluid

between the cylinder chambers. Any fluid make up can be obtained from the accumulator 63 connected into the pump circuit.

The system disclosed is what is termed a closed system but an open type fluid system may also be adapted for control of operation of the fluid actuating mechanism of this invention. A specific advantage of the illustrative closed system is that energy developed through pressurization of the fluid in the cylinders 16 may be readily dissipated through the pump and electric motor 56. The electric motor will thus absorb energy obtained from decompression of the fluid following a high force, low speed operating sequence.

Although the valves 65 and 70 are illustrated and described as having electrical solenoids for operation thereof, it will be understood that these valves may be of the manually actuated type or the solenoids may be of the pilot fluid operated type as is determined best suited for a particular application. A factor for consideration in selection of valve actuation type is the structure arrangement such as remoteness of valve location to the operator's station or automation of the system.

A modified apparatus embodying this invention is schematically illustrated in FIG. 4. This modification differs from the previously described preferred embodiment in FIGS. 1, 2 and 3 only in respect to having the selectively operable valving removed from the pistons and having an external conduit interconnected with the two cylinder chambers. In addition, other external fluid conduits are provided for interconnection of the cylinder chambers. The apparatus functions in the same manner as the preferred embodiment but certain economies are achieved in fabrication of the apparatus through reduction in the number of passageways required to be drilled in the piston rods, as well as omission of the expensive valve construction in the pistons. This construction economy is of importance in relatively smaller capacity press apparatus.

With specific reference to FIG. 4, the modified apparatus comprises four piston and cylinder units 75, 76, 77 and 78 which are assembled in a press apparatus. This press apparatus includes platens 79 and 80 which are relatively movable with one being fixed. Each of the piston and cylinder units comprises a cylinder 81 secured to the movable platen 80 and a piston 82 provided with double ended rods. As with the preferred embodiment, all of the rod ends 83 at one side of each of the pistons are of the same diameter and are secured to the fixed platen 79. The rods at the opposite side of the pistons are of different diameters with the rods 84 of units 75 and 78 being relatively larger than the rods 83 and the rods 85 of units 76 and 77 being relatively smaller than the rods 83.

The cylinders 81 of these units are of a built up construction having cylinder heads and a pilot operated check valve 86 of the same operational construction as the previously described poppet valves 33. A single check valve 86 is provided for each cylinder and is built into one cylinder head with a passageway 87 connected with the adjacent cylinder chamber and an external conduit 88 connecting the opposite end of the valve with the opposite cylinder chamber. A passageway 89 connects with each check valve 86 for supply of pilot fluid under pressure from the fluid control system.

Additional external conduits 91, 92 interconnecting the respective left and right chambers of units 76 and

77 and external conduits 93, 94 interconnecting the respective left and right chambers of units 75 and 78 permit omission of the other axial piston rod passageways as required in the preferred embodiment.

Operation of the modified apparatus is controlled through a fluid system of the same arrangement as that utilized with the FIG. 1 embodiment. In the FIG. 4 embodiment, the pilot fluid passageways 89 to each check valve are connected to the valve 65 in the same way conduit 66 performed this function and each of the conduits 91, 92, 93 and 94 to the valve 70 which controls the flow of fluid to the cylinders. Energization of solenoids 70b and 65a will result in slow travel in the direction as determined by the direction of pump operation. Energization of solenoid 70a only will result in rapid travel in the direction as determined by pump operation. In the latter case, the check valves 86 will be free to open under cylinder pressure to permit rapid transfer of fluid from one cylinder chamber to the other.

It will be readily seen that an improved fluid actuating mechanism is provided by this invention that is capable of the desired fast and slow travel with associated minimum and maximum developed force utilizing in the simplest form, two piston and cylinder units of substantially the same construction. The mechanism does not require apparatus external to the cylinder and pistons units 10-13 for handling large fluid volumes with consequent economy and efficiency of operation.

Having thus described this invention, what is claimed is:

1. A fluid actuating mechanism comprising first and second double-acting cylinder and piston units with the cylinder and piston unit of each relatively axially reciprocable, each said piston dividing the respective cylinder into first and second chambers and having a double-ended piston rod extending axially thereto through both cylinder chambers and mechanically coupled in fixed relationship with the other and said cylinders mechanically coupled in fixed relationship with each other, the diameter of the opposite ends of each piston rod being relatively different with said first and second cylinder and piston units being relatively oppositely oriented with respect to the larger and smaller piston rod ends, fluid valve means mounted in fluid communicating relationship between said first and second chambers, said valve means selectively operable to either a fluid conducting or a fluid blocking position, and

fluid circuit means connected in fluid flow relationship with said cylinder and piston units and operable to provide pressurized fluid to selected ones of said cylinder chambers resulting in relatively fast axial movement of said cylinder and piston units with low force when said fluid valve means is in a fluid conducting position and relatively slow axial movement with high force when said fluid valve means is in a fluid blocking position.

2. A fluid actuating mechanism according to claim 1 wherein said fluid valve means is mounted in said piston

rod and said piston rods are formed with first and second fluid passages externally connecting with said fluid circuit means, said first and second passages communicating with said first and second cylinder chambers respectively, at a point closely adjacent the associated piston.

3. A fluid actuating mechanism according to claim 1 wherein said fluid valve means of each of said cylinder and piston units is mounted in the respective piston and includes a movable valve element and valve seat cooperating therewith in a fluid passage and fluid means cooperating with said valve element to maintain said valve element in fluid blocking relationship to said seat when pressurized fluid is applied to said fluid means.

4. A fluid actuating mechanism according to claim 3 wherein said piston rods are formed with a fluid passage communicating with said fluid means and selectively connectable with an external source of pressurized fluid.

5. A fluid actuating mechanism according to claim 1 wherein said fluid circuit means includes valve means connected in fluid flow controlling relationship to said chambers of each of said cylinders, said valve means selectively operable to either connect both chambers of one cylinder to a source of pressurized fluid or to connect the chambers at the same end of both cylinders to a source of pressurized fluid.

6. A fluid actuating mechanism according to claim 1 having a plurality of said pairs of first and second cylinder and piston units connected in parallel relationship therewith with said fluid circuit means for concurrent operation.

7. A fluid actuating mechanism according to claim 1 wherein said fluid circuit means is selectively operable to provide fast or slow operation in either axial direction.

8. A fluid actuating mechanism comprising first and second double-acting cylinder and piston units with the cylinder and piston unit of each relatively axially reciprocable, each said piston dividing the respective cylinder into first and second chambers and having a piston rod extending axially thereto and mechanically coupled in fixed relationship with the other and said cylinders mechanically coupled in fixed relationship with each other, each of said pistons having fluid valve means mounted therein in fluid communicating relationship between said first and second chambers, said valve means selectively operable to either a fluid conducting or a fluid blocking position, and

fluid circuit means connected in fluid flow relationship with said cylinder and piston units and operable to provide pressurized fluid to selected ones of said cylinder chambers resulting in relatively fast axial movement of said cylinder and piston units with low force when said fluid valve means is in a fluid conducting position and relatively slow axial movement with high force when said fluid valve means is in a fluid blocking position.

\* \* \* \* \*