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Huelskamp

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[54] **CONTROL VALVE MEANS FOR HYDRAULIC PRESS**

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Related U.S. Application Data

[63] Continuation of Ser. No. 237,085, March 22, 1972, abandoned.

[52] **U.S. Cl.** ..... **91/411 A;** 91/441

[51] **Int. Cl.²** **F15B 11/18;** F15B 13/06

[58] **Field of Search** ..... 91/441, 412, 411 A; 60/97 H, 426, 429; 251/63

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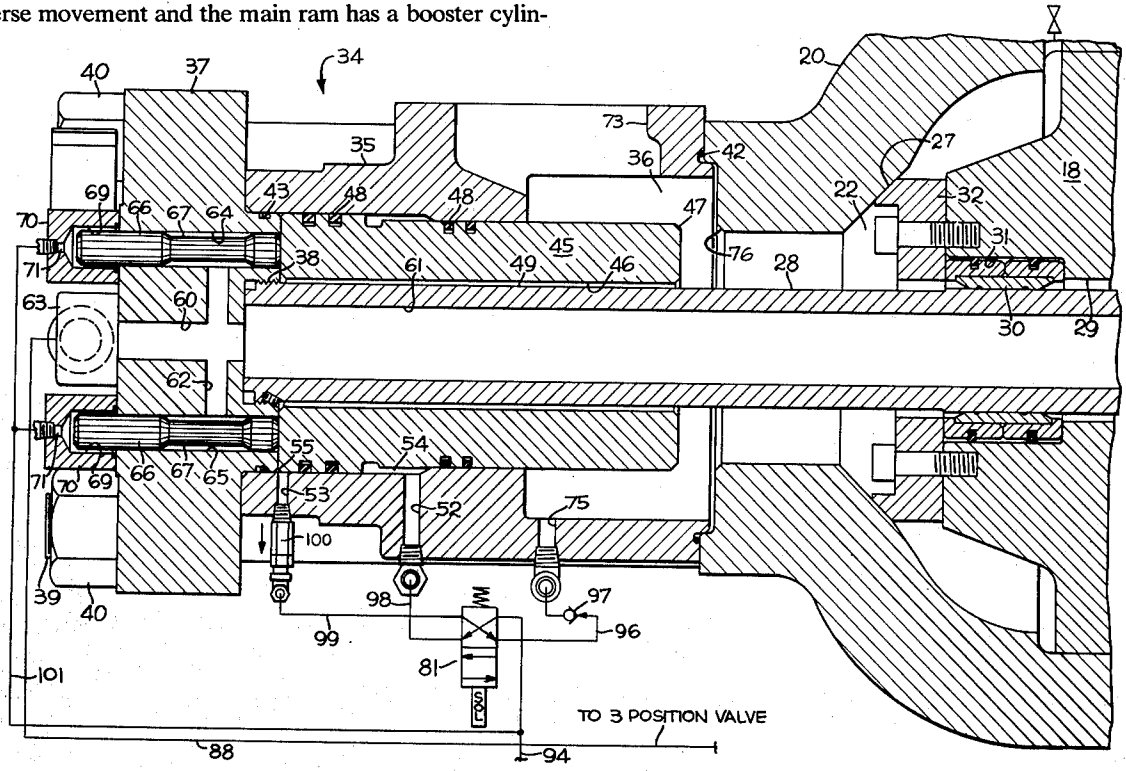
[57] **ABSTRACT**

A hydraulic molding press comprising a main cylinder in which a main ram is mounted for forward and reverse movement and the main ram has a booster cylinder therein into which a hollow stationary booster ram extends. A control valve comprising a valve housing is provided at the end of the main cylinder and the booster ram extends therethrough. The valve housing includes a removable portion called a booster ram cap which threads onto and supports the end of the booster ram. The booster ram cap is detachably secured to the valve housing and the latter is detachably secured to the end of the main cylinder by four studs. A prefill tank connects to the valve housing for supplying prefill fluid to the main cylinder as the main ram is moved rapidly forward by booster fluid supplied through the booster ram from a port in the booster cap. A prefill valve piston slideably mounted in the valve housing is movable to close off prefill fluid flow from the prefill tank.

The piston has a central opening through which the booster ram extends. The opening in the piston also serves as a fluid passage for supplying high pressure fluid to the main ram after the piston is moved forward to closed position. Fluid to this passage is supplied through a pair of prefill chambers in the booster ram cap which opens when the prefill pins are moved forward by pilot pressure to close the prefill valve piston.

The prefill valve piston is controlled by a two-position remotely operated valve. The prefill pins are continually under pilot pressure. Forward and reverse movement of the main ram is controlled by a three-position remotely operated valve. To effect reverse movement of main ram, the two-position valve operates to decompress the high pressure fluid behind the main ram and opens the prefill valve piston to allow free fluid flow to the prefill tank. Then the three-position valve operates to move the main piston in reverse.

1 Claim, 4 Drawing Figures



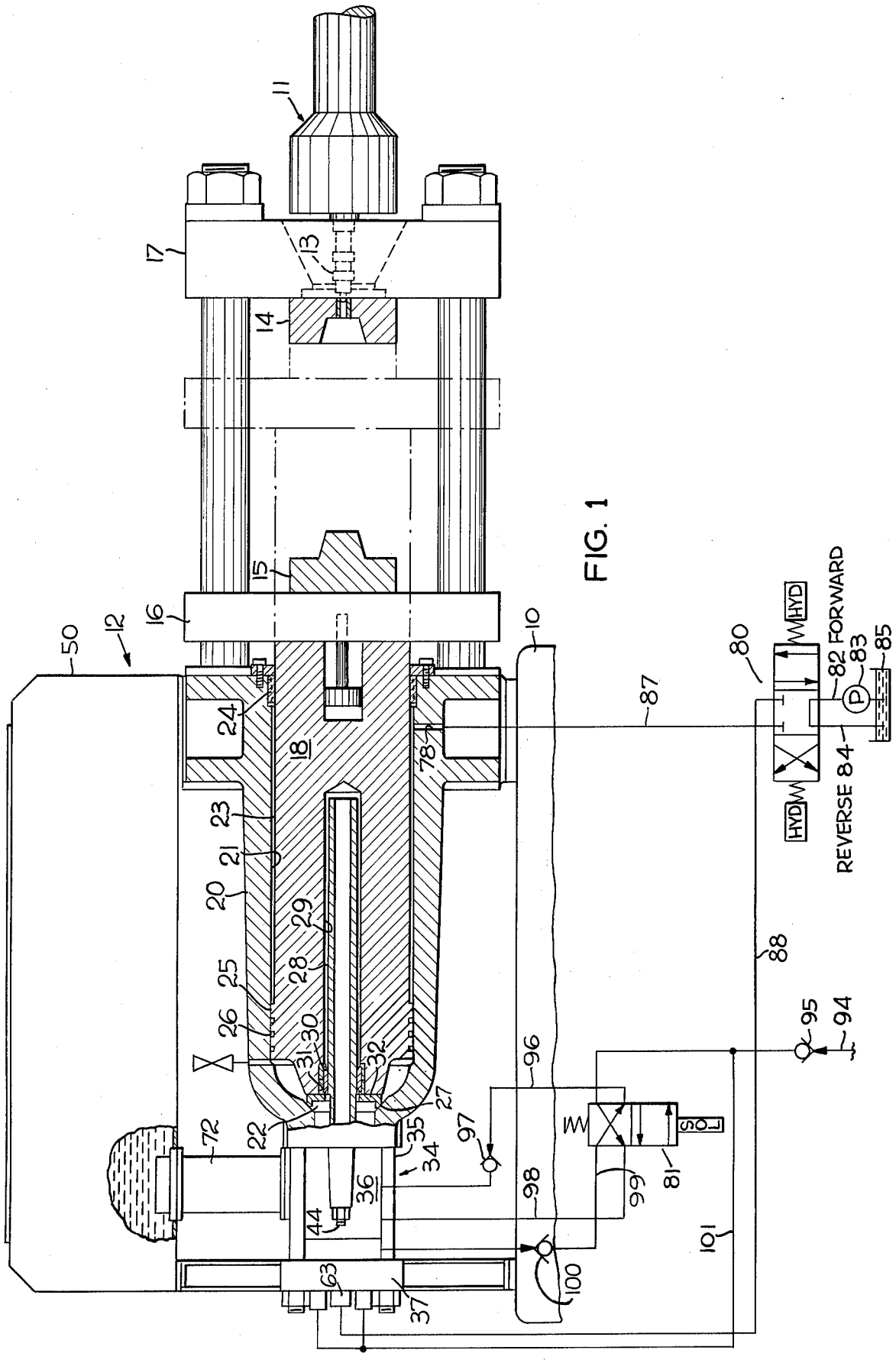
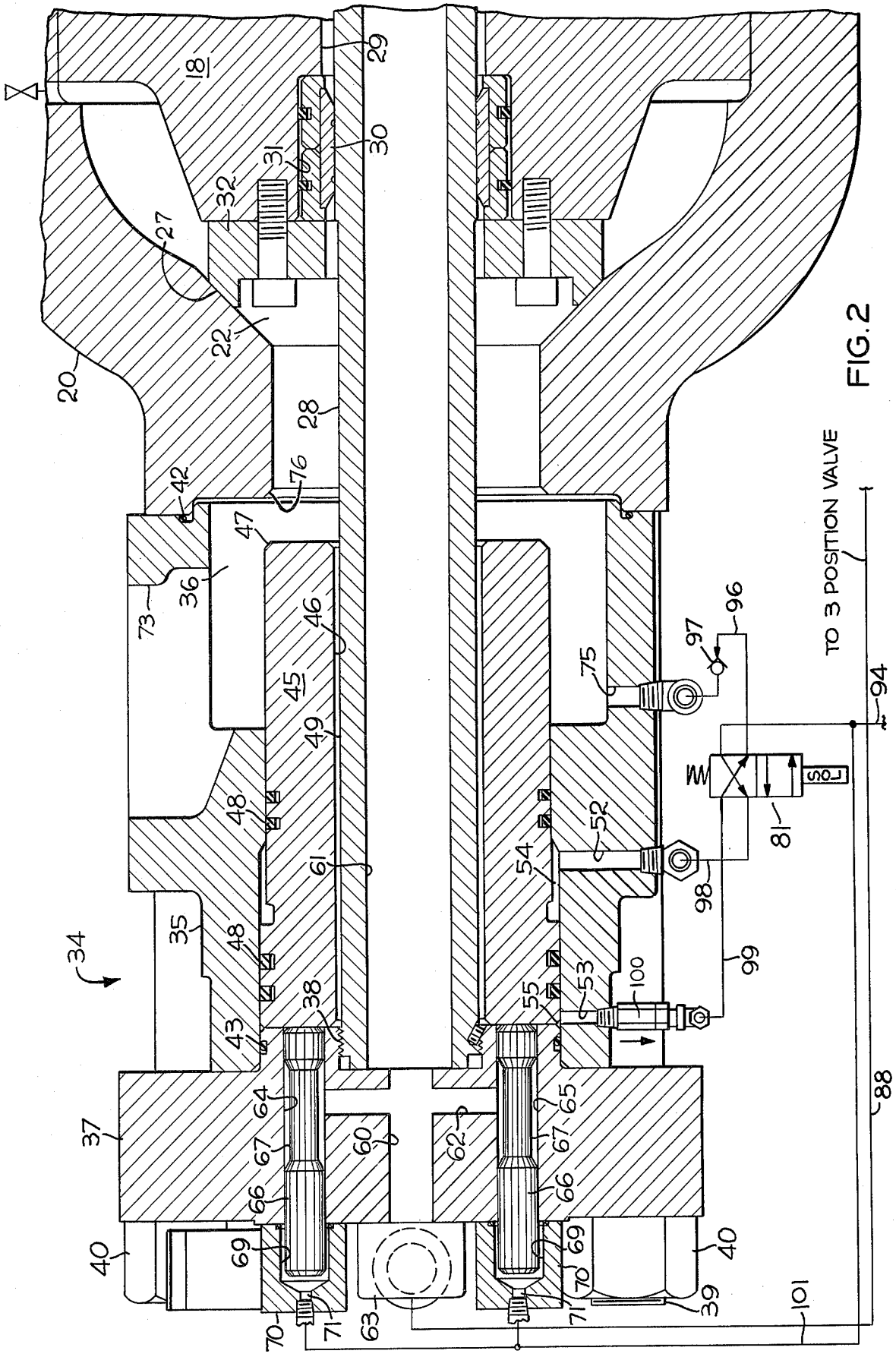

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FIG. 1


TO 3 POSITION VALVE
FIG. 2

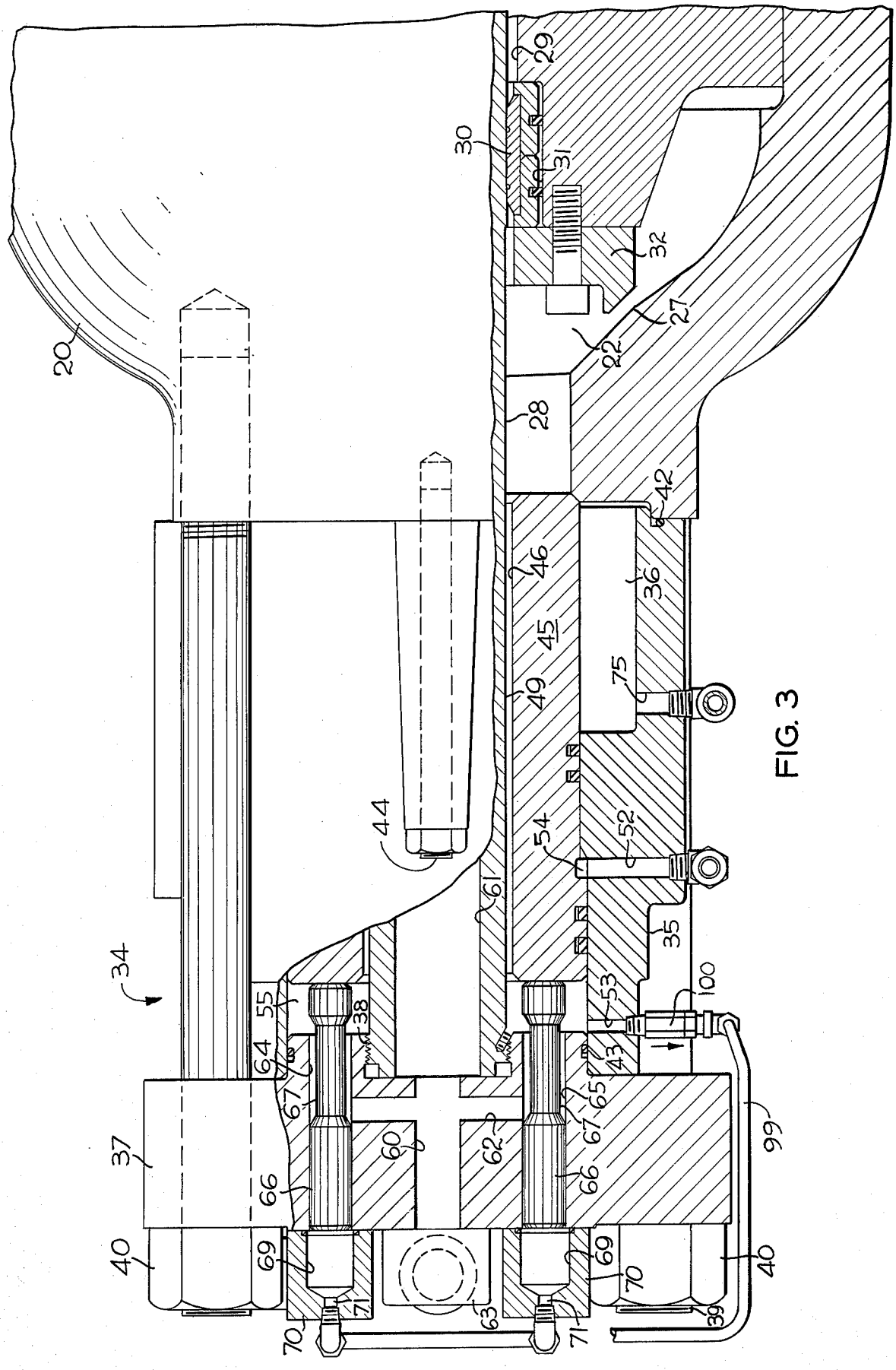

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FIG. 3

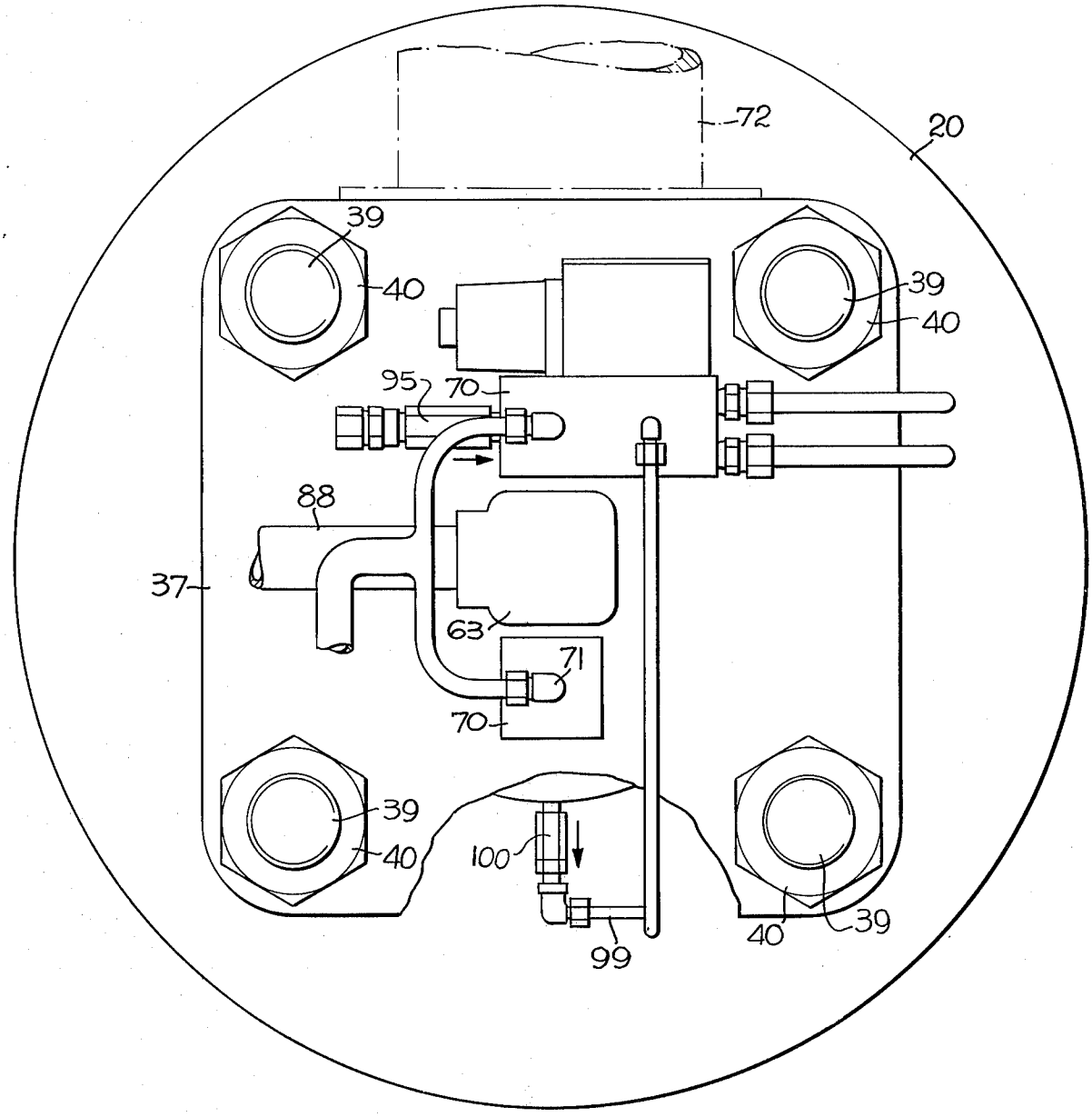


FIG. 4

CONTROL VALVE MEANS FOR HYDRAULIC PRESS

This is a continuation, of application Ser. No. 237,085, filed Mar. 22, 1972 now abondoned.

FIELD OF USE

This invention relates generally to hydraulic presses such as hydraulically actuated molding machines of the type having a mold clamp assembly for quickly closing, clamping and opening a mold. In particular it relates to control valves therefor, such as prefill valves.

DESCRIPTION OF THE PRIOR ART

My U.S. Pat. No. 3,084,512 issued Apr. 9, 1963 for "Hydraulic Molding Machines" discloses an injection molding machine wherein an initial high-speed movement of the main ram to mold closing position is accomplished by means of a smaller booster ram. The advantage of this is that a given amount of pressure fluid supplied to the booster cylinder will effect a much faster and greater ram movement than it would if supplied to the main ram cylinder. This construction however requires that fluid prefill means be provided for keeping the main ram cylinder filled with fluid as the main ram is moved under the action of the booster ram. It also requires that valve means be provided for shifting the flow of pressure fluid from the booster ram to the main ram when the latter reaches that point in its travel at which full ram pressure is desired. This construction further requires that valve means be provided for quickly closing the large prefill line to the main cylinder just before the shiftover of the high pressure fluid which is commonly at a pressure of 3000 lbs./sq. in. or higher.

In practice these machines are quite large and require much floor space for installation and to enable servicing. Also, since they are supplied with high pressure hydraulic fluid for operation, pressurized components therein, such as valves, require strong castings, numerous carefully fitted O-rings and other types of costly seals, and numerous studs or bolts to secure components together. Furthermore, most valve assemblies and components thereof are relatively complex and are difficult and costly to machine, assemble and service. In some instances construction of specially designed intricate fluid passageways in valve elements tends to weaken the part and necessitates the use of specially hardened expensive metals, as well as special tools and manufacturing techniques. Also, in some machines, special additional valve spools, choking devices and time-delay devices are required to effect decompression of the fluid in high pressure chamber before reverse movement of the main ram can occur. However, these means are only partially successful in effecting smooth decompression and sometimes allow pipe breakage and other problems to occur.

SUMMARY OF THE PRESENT INVENTION

A hydraulic press, such as a hydraulic molding machine, in accordance with the invention comprises a main ram cylinder, a main ram reciprocably movable in the ram cylinder, a booster ram cylinder formed in the main ram, and a hollow booster ram extending into the booster ram cylinder. A flow of pressurized hydraulic fluid through the hollow booster ram into the booster ram cylinder effects rapid closing movement of the main ram. Subsequent flow of pressurized fluid into the main ram cylinder behind the main ram effects a slow, powerful, final closing movement and holding of the main ram. A fluid reservoir or prefill tank supplies prefill fluid by gravity to the main ram cylinder as rapid closing movement occurs.

A control valve is provided to control fluid flow to and from the booster ram cylinder and the main ram cylinder and valve control means, including a hydraulic circuit, and multiposition valves, are provided to operate the control valve.

The control valve comprises a valve housing including a valve body, having a chamber therein and open at both ends, and an end portion. One end of the valve body lies adjacent the open end of the main ram cylinder. The other end of the valve body is provided with the aforesaid end portion which serves as a closure means and as a booster ram cap. The booster ram cap supports and seals one end of the hollow booster ram by making threaded engagement with the hollow booster ram. A plurality (preferably four) large bolts secure the booster ram cap to the valve body and the latter to the main ram cylinder.

A prefill piston is slidably mounted within the valve body and has a central opening through which the booster ram extends. The booster ram does not touch the prefill piston but cooperates therewith to provide an annular fluid passage. A prefill fluid passage is provided in the valve body and serves as a means by which the resevoir is connected to the chamber in the valve body. The prefill piston is movable from an open position to a closed position wherein it bears against a valve seat provided in the main cylinder and closes off fluid flow between the prefill reservoir and the main ram cylinder. One of the fluid inlet ports in the valve body connects to a space behind the prefill piston and is pressurizable to move the prefill piston to an open position.

The booster ram cap is provided with a first fluid passage which communicates with the hollow interior of the booster ram. The booster ram cap is also provided with a second fluid passage which communicates between the first fluid passage and a pair of cylindrical prefill pin valve chambers in the booster ram cap, each of which has a slidably movable grooved prefill pin valve therein. A pilot pressure port is connected to each prefill pin valve chamber to move the prefill pin valves.

In a typical cycle of operation, the pilot pressure ports for the prefill pins are pressurized but pressurization of the fluid inlet port in the valve body causes the prefill piston to be maintained in open position against the force of the prefill pins. When the first fluid passageway in the booster ram cap is pressurized by operation of a forward-reverse valve, the main ram is moved forward rapidly by pressurized fluid which flows through the hollow booster ram into the booster ram cylinder. Since the prefill piston is open, prefill fluid can flow by gravity from the prefill reservoir to the main ram cylinder. After the main ram has traveled a predetermined amount, a shifter valve is operated to cause a shift to occur whereby the fluid inlet port in the valve body is depressurized. This allows the prefill piston to be moved to closed position by the prefill pins as the latter advance under the force of pilot pressure. As the prefill pins advance, pressurized fluid is able to flow from the first fluid passage, past the grooves in the prefill pins, and through the annular passage between

the prefill piston and booster ram into the main ram cylinder. When the prefill piston is moved to fully closed position, flow of prefill fluid from the prefill reservoir is cut off and fluid pressure builds up behind the main ram to slowly move it to clamped position and to hold it closed for a predetermined length of time, depending on the setting of the control valve means. To reverse the movement of the main ram and effect unclamping, the shifter valve is actuated to cause a second fluid port in the valve body to be depressurized and effect decompression of the fluid acting on the main ram by allowing fluid to flow back from the main ram cylinder, through the annual fluid passageway in the prefill piston, out through the second fluid port. This is essentially a metered flow and allows for a smooth transition to decompression. The prefill valve also returns to open position as this occurs. Shortly after operation of the shifter valve, the forward-reverse valve operates to cause rearward movement of the main ram and, with the prefill valve open, to allow flow from the main ram cylinder directly to the prefill reservoir as the prefill piston moves in reverse.

The valve control means includes hydraulic circuitry, electrically operated solenoid valves and limit switches, all hereinafter described in detail.

A hydraulic press, the control valve therefor and valve control means in accordance with the invention has the following advantages over the prior art apparatus. Valve construction and mode of operation allows for a substantially larger prefill fluid capacity. Fewer studs are required to secure the valve body and its end cover means (namely, the booster ram cap) to the main ram cylinder. The size of the working pressure surface area of the prefill piston is substantially reduced with an attendant reduction in the operating force required therefor. The valve seat on the prefill piston and on the main ram cylinder are move accessible for initial machining and subsequent inspection. At least one high pressure fluid seal is eliminated and no back-up rings are required. Numerous presicion-machined surfaces and intricate passageways are eliminated thereby reducing production efforts and costs while providing inherently more rugged valve components. Construction of the booster ram and its cap allow removal of the cap without removal of the ram itself, thereby allowing a reduction in installation and service space. Pilot pins are easily replaceable with others of a different type to allow for desired changes in shift-over positions. Other advantages will hereinafter appear.

DRAWINGS

FIG. **1** is a side elevation partially in section of a molding machine having control valve means embodying the present invention; with portions of the valve control means therefor shown schematically;

FIG. **2** is an enlarged cross-sectional view of the control valve means showing the prefill valve piston in open position before the main ram is moved by the booster ram;

FIG. **3** is a view similar to FIG. **2** but showing the prefill valve piston in closed position when high pressure fluid is first supplied to the main ram; and

FIG. **4** is an end view of control valve means in accordance with the present invention.

DESCRIPTION OF A PREFERRED EMBODIMENT

In FIG. **1** of the drawing, there is shown an injection molding machine embodying the present invention and having a frame **10** with an injection mechanism assembly **11** and a mold actuating or clamp mechanism assembly **12** on adjacent portions of the frame. The injection mechanism assembly **11** is of conventional form and includes an injection nozzle **13** through which plastic material passes in a well known manner into a cavity defined by mold halves **14, 15.**

In order to hold the mold halves in face-to-face contact during the injection of the plastic material and to permit subsequent removal of the molded piece, a horizontally movable platen **16** carries one mold half **15** toward and from a stationary die head **17** which supports the second mold half **14.** For this purpose the mold clamp assembly **12** is provided with a main ram **18** which is horizontally reciprocable in a ram cylinder **20** and which has secured to its outer end the movable platen **16.**

Means are provided for operating the main ram **18** to give rapid initial closing movement of main ram **18** with a slow but powerful final approach and clamping action. Such means comprises a main ram assembly, a booster ram assembly, a control valve and control means for the control valve.

The main ram assembly comprises a ram cylinder **20** which takes the form of a generally cylindrical housing having a longitudinally positioned, open-ended cylindrical bore **21.** To actuate ram **18** in the forward direction, pressure fluid is applied to a pressure chamber **22** behind the ram. To actuate ram **18** in the reverse direction, pressurized fluid is applied to an annular cavity **23** surrounding the ram. The forward or outer end of ram cylinder **20** has suitable seals, such as ring seals **24,** to prevent escape of pressurized fluid, and to permit reciprocation of main ram **18.** The rear or inner end of main ram **18** has an enlarged portion or flange **25** forming an annular area against which the pressurized fluid acts to return the ram. The enlarged portion **25** has suitable fluid seals, such as piston rings **26,** which likewise permit reciprocation of main ram **18.** Return movement of main ram **18** is limited by an internal abutment or shoulder **27** formed in the inner wall of the main ram cylinder **20.** Forward movement of main ram **18** is limited by engagement of the mold halves **14, 15.**

To provide for rapid closing movement of main ram **18,** and a slow, powerful final approach and clamping action thereof, fluid pressure is applied to differential areas on the rear or inner end of main ram **18.**

The booster ram assembly for rapid traverse applies fluid pressure to a relatively small area of main ram **18.** The booster ram assembly includes a stationary booster ram **28** of cylindrical shape which projects forwardly into an axial bore or compartment **29,** called the booster ram cylinder, formed centrally in the rear or inner end portion of main ram **18.** The booster ram cylinder **29** is of sufficient length to allow axial clearance between the forward end of booster ram **28** and the closed end of the cylinder **29** when main ram **28** is fully retracted. The forward closed end wall of booster cylinder **29** provides a first differential, or booster, area against which pressurized hydraulic fluid acts to force main ram **18** forwardly in rapid forward or closing movement. A second differential pressure area on main ram **18** is provided by the remaining annular area on the rear end face surrounding booster ram cylinder **29,** and includes the annular retaining plate **32.** The fluid applied to the second differential pressure area of main

ram **18** is received in chamber **22** formed by the rear section of main ram cylinder **20** and the forward end of valve body **35.** The chamber, of course, includes the interior portion of the main ram cylinder **20** as ram **18** moves forward.

Referring also to FIGS. **2** and **3** of the drawings, sealing the open rear end of booster cylinder **29** and maintaining the booster and main rams in substantially coaxial sliding relationship, is a tubular collar **30** seated in a counterbore **31** in the rear end portion of main ram **18.** The tubular collar **30** has an inner diameter which permits sliding engagement with booster ram **28** and is held in position by an annular plate or retaining ring **32.** Retaining plate **32** is secured to the rear face of main ram **18** and has its inner edge portion extending radially inwardly over the exposed end of collar **30** blocking rearward displacement of the latter.

A control valve **34** is provided to control fluid flow to and from the main ram and booster ram assemblies.

As FIGS. **2** and **3** show, control valve **34** comprises a valve housing including a valve body **35** having a chamber **36** therein and open at both ends. The valve housing also comprises an end portion **37** thereinafter described. One end of valve body **35** lies adjacent the open end of main ram cylinder **20.** The other end of valve body **35** is provided with end portion **37** which serves as a closure means for chamber **36.** Portion **37** takes the form of a booster ram cap which makes threaded engagement as at **38** with one end of booster ram **28** and supports the latter. The booster ram **28** can be unthreaded from booster ram cap **37** when dissassembly of the valve is required. Thus the booster ram tube **28** can be left in the machine during servicing and the allowance of extra floor space for tube removal is not required. As FIGS. **2, 3** and **4** show, a plurality (preferably four) large studs **39** having nuts **40** thereon secure booster ram cap **37** to valve body **35** and the latter to main ram cylinder **20.** The studs **39** extend through suitable holes in end cap **37,** past valve housing **35** and take into threaded holes in main cylinder **20.** O-ring seals **42** and **43** are provided between valve body **35** and cylinder **20** and between valve body **35** and booster ram cap **37,** respectively. Two auxiliary studs **44,** one of which is shown in FIG. **1,** are used to hold valve body **35** against main cylinder **20** and are for convenience in holding the valve body in position when booster ram cap **37** is removed. The four main studs **39** resist the high pressure forces applied in the interior of the valve housing.

As FIGS. **2** and **3** show, a prefill valve piston **45** is slidably mounted within valve body **35** and has a central opening **46** through which booster ram **28** extends. Prefill valve piston **45** has a bevelled valve surface **47** at one end which seats against a bevelled valve seat **76** provided in the end of main ram cylinder **20.** Valve seats **47** and **76** are thus accessible for ease of machining and exposed for inspection when valve body **35** is detached. The prefill piston **45** is precision-fitted to valve body **35** but does not touch booster ram **28.** Therefore, the inside bore or hole **46** in piston **45** may be rough machined to a size sufficient to provide a fluid passage **49.** The machining of booster ram **28** in the prefill valve area is also rough turning with no precision required. Piston **45** preferably is made of cast iron requiring no heat treatment, and the bursting strength of which is adequate since no thru-drilled holes are provided therein. Prefill piston **45** is provided with suitable piston rings **48** on the exterior thereof and is movable from an open position, shown in FIG. **2,** to a closed position, shown in FIG. **3,** wherein it bears against valve seat **76** provided in main cylinder **20** and closed off fluid flow from a prefill fluid reservoir **50,** shown in FIG. **1,** which otherwise can flow through valve body chamber **36** and main ram cylinder pressure chamber **22.**

First and second fluid ports **52** and **53** are provided in valve body **35** and connect to spaces **54** and **55** ahead and behind prefill piston **45,** respectively.

The booster ram cap **37** is provided with a fluid passage **60** which communicates with a hollow interior or passage **61** in booster ram **28.** Passage **60** is provided with a fluid supply by means of a fluid supply fitting **63** attached to the exterior of booster ram cap **37.** The booster ram cap **37** is also provided with another fluid passage **62** in the form of a cross-drilled hole which communicates between fluid passage **60** and a pair of cylindrical prefill pin valve chambers **64** and **65** in the booster ram cap. Each chamber **64** and **65** has a slidably movable prefill pin valve **66** therein. Each pin **66** has a circumferential groove **67** therein. Passage **62** directs shiftover fluid to the prefill pin chambers **64** and **65.** The outer end of each prefill pin **66** extends into the pilot pressure chamber **69** of a pilot pressure housing **70** which is secured to the outer face of booster ram cap **37,** as FIGS. **2, 3** and **4** make clear. Each pilot pressure chamber **69** is provided with a pilot port **71.** The two prefill pins **66** are movable by pilot pressure in the chamber **69** to bear against and close prefill piston **45.** The pins **66** have the grooves or reduced diameter portions **67** which are used to conduct shiftover fluid from passages **60** and **62** when the pins are shifted forward. Because of the bored construction of booster ram cap **37,** pins **66** of different type can be installed easily if experiment shows that the shifover position should be changed.

For conducting pressure fluid from passage **60** in booster ram cap **37** to the operative ram areas, booster ram **28** is provided with the conduit means or passage **61** extending axially from the rear to the forward end thereof. Thus, when pressurized fluid is applied to passage **61** the pressure is applied continuously to the first or booster pressure area of booster cylinder **29** in main ram **18.**

Because of the relatively small cross-sectional area of booster ram **28** and booster ram cylinder **29,** only a small volume of pressurized fluid need be supplied to move main ram **18** forward. Consequently, for a given rate of supply of pressure fluid, main ram **18** is pushed forward rapidly to provide rapid traverse for closing the mold. It will be appreciated, however, the force moving the ram is relatively small because of the small pressure area at the end of booster ram cylinder **29.**

As FIG. **1** shows, prefill tank **50** is mounted above clamping assembly **12** and contains hydraulic fluid of the same kind as that to be used in the high pressure conduits. A short pipe **72** leads from the bottom of the prefill tank to a suitable opening **73** in the top of valve housing **35.** The prefill fluid flows by gravity from the prefill tank through pipe **72** into chamber **36** in valve housing **35.** The forward end of chamber **35** is open for communication with chamber **22** at the rear face of main ram **18.** Consequently, as main ram **18** moves forwardly under the action of booster ram **28,** prefill fluid flows rapidly into the expanding space behind the main

ram keeping that space full of fluid at little or no pressure. This arrangement minimizes the amount of pressure fluid which must be delivered when applying clamping pressure, and, at the cessation of rapid traverse, rapidly permits increasing the pressure in the main ram chamber to clamp the molds together. Thereafter pressure fluid is supplied to main ram **18** through fluid passage **49** between booster ram **28** and the inside surface of the prefill valve piston **45** from passage **60** in booster ram cap **37**.

As FIGS. **1** and **2** show, chamber **36** in valve housing **35** is provided with a fluid port **75** and main ram cylinder **20** is provided with port **78** which communicates with cavity **23** therein.

The control means for control valve **34** and for the booster ram assembly and the main ram assembly of the injection molding machine or press in accordance with the invention comprise the multiposition valves **80** and **81** and hydraulic circuitry shown in FIGS. **1, 2** and **4** as well as limit switches (not shown) which effect operation of these multiposition valves.

FIG. **1** shows valve **80** to be a conventional hydraulic control valve having three positions (neutral, forward and reverse) which is pilot operated in response to hydraulic signals. Operation of valve **80** effects forward and reverse movement of main ram **18**. Valve **80**, which is shown in neutral position, is supplied with hydraulic fluid through a supply line **82** connected to a hydraulic pump **83**. Valve **80** is also provided with a fluid return line **84** which connects to a reservoir **85**. Valve **80** is connected by a fluid line **87** to port **78** in cavity **23** of main cylinder **20**. Valve **80** is also connected by a fluid line **88** to fluid supply fitting **63** on booster ram cap **37**. Valve **80**, pilot operated, is controlled by another valve, solenoid operated, not shown.

FIG. **1** also shows valve **81** to be a conventional hydraulic control valve having two positions (normal and shift) which is solenoid operated and effects shifting of fluid to main cylinder **20**. Valve **81**, which is shown in normal position, is supplied from a pilot pressure fluid line **94** having a check valve **95** therein. Valve **81** is also connected by a fluid line **96** having a check valve **97** therein to port **75** in control valve **34**. Valve **81** is also connected by fluid lines **98** and **99** to ports **52** and **53**, respectively, in control valve **34**. Line **99** has a check valve **100** therein. A fluid line **101** is connected between the fluid line **94** and the ports **71**.

OPERATION

Operation of a typical cycle of the apparatus shown in FIGS. **1** through **4** will now be described. First assume that all operative components, including valves **80** and **81**, are in the position or condition shown in FIGS. **1** and **2**. Also assume that fluid line **94** is pressurized, and that pump **83** is in operation and that fluid line **82** is pressurized. In this condition, pilot pressure is acting on the rear of the pins **66**. However, because valve **81** is in the position shown, fluid line **98** pressurizes chamber **54** in valve housing **35**. Therefore, valve piston **45** is held open because the pressurized area on piston **45** is larger than the pressurized area of the pins **66**.

To advance main ram **18** rapidly forward toward mold clamping position, operating valve **80** is moved leftward from the neutral position shown to its "forward" position to effect pressurization of fluid line **88**, port **63** of control valve **34**, fluid passages **60** and **62** in booster ram cap **37**, pin chambers **64** and **65** and passage **61** in booster ram **28**. Pressurization of passage **61** causes main ram **18** to advance rapidly forward. Prefill fluid flows rapidly and unimpeded from prefill tank **50**, through pipe **72**, through prefill port **73** in valve body **35**, through chamber **36** in the valve body, and into region **22** of the main ram cylinder **20** behind main ram **18**.

When main ram **18** has advanced a predetermined distance and is near the end of its stroke, it effects tripping of a limit switch (not shown) which operates the solenoid of shift valve **81** and causes valve **81** to shift upwardly from the position shown in FIGS. **1** and **2** to a position wherein fluid line **94** is connected to and blocked against check valve **100** and fluid line **98** is connected to line **96**. This permits fluid to flow from chamber **54** in valve body **35** to chamber **36** thereof and to prefill tank **50**. Under these conditions, the main cylinder shift occurs, i.e., the shiftover from rapid operation of the main ram **18** by booster ram **28** to slower, high powered clamping movement and operation.

More specifically, with chamber **54** depressurized, the prefill pins **66** move forwardly under the force of the pilot pressure applied thereto effect forward movement of prefill valve piston **45** toward its valve closed position. As the prefill pins **66** advance, the grooved regions **67** thereof extend into chamber **55** in valve body **35** and allow pressurized fluid to flow from port **63**, through the passages **60** and **62**, through the prefill pin chambers **64**, into the region or chamber **55** behind prefill valve piston **45**, as shown in FIG. **3**. Such fluid flow continues from chamber **55**, through the annular passages **49** into chamber **22** behind main ram **18**.

When prefill valve piston **45** advances to its fully closed position, as shown in FIG. **3**, its seating surface **47** is in fluidtight engagement with its mating valve seating surface **76** on main ram cylinder **20**. This causes fluid flow from prefill tank **50** into chamber **22** to be cut off. It allows pressurized fluid flow directly through passage **49** into chamber **22** and, with valve piston **45** closed, pressure builds up in chamber **22** to move main ram **18** forward slowly for its final length of travel. Such condition is maintained for whatever predetermined length of time is desired to maintain ram **18** in stationary clamping position.

To reverse main ram **18** and unclamp the press, the valves **80** and **81** are actuated simultaneously by suitable manual or automatic operating means (not shown). However, it is to be noted that effective operational movement of valve **80** is slower than that of valve **81**, resulting in effects explained hereinafter.

Upon release of the solenoid of valve **81** to effect movement thereof back to the normal position shown in FIGS. **1** and **2**, the biasing spring means in valve **81** carry out valve movement quickly. With valve **81** in the position shown in FIGS. **1** and **2**, chamber **55** in valve body **35** is connected through port **53**, check valve **100**, fluid line **99**, valve **81**, fluid line **96**, check valve **97** and port **75** in valve body **35** to chamber **36** in the valve body which is connected to prefill tank **50**. The immediate effect of this connection is to decompress or relieve the high pressure condition in the body of fluid directly in chamber **22** directly behind main ram **18**. Since the tubing involved is of relatively small diameter, there is essentially a metered flow which transfers the stored energy behind the main ram **18** smoothly and without shock to the fluid in chamber **36** of valve

housing 35 and prefill tank 50. Pilot pressure is still being applied to the prefill pins 66. Since chamber 54 ahead of prefill valve piston 45 is now pressurized, piston 45 begins to move rearward toward to its open position. The effect of this is to further relieve pressure conditions in the fluid behind main ram 18.

Subsequent to operation of valve 81, slower-acting valve 80 is moved rightward from "forward" to the "reverse" position. In "reverse" position, valve 80 connects pressurized fluid line 82 from pump 83 to fluid line 87 which is connected to port 78 for chamber 23 in main ram cylinder 20. Valve 80 also connects fluid line 88 from port 63 on booster ram cap 37 (and the passages 60 and 62 pin chamber 64 and 65 therein, as well as passage 61 in booster ram 28) to fluid return line 84 for reservoir 85. Under these conditions, reverse movement of main ram 18 occurs as pressurized fluid enters chamber 23 of main cylinder 20 ahead of the main ram. Since prefill valve piston 45 is now open, fluid behind main ram 18 is able to flow freely under the action of ram movement from chamber 22 in cylinder 20, through chamber 36 of valve body 35, through port 73 therein and through prefill pipe 72 back into prefill tank 50. When rearward movement of ram 18 is completed, limit switches (not shown) effect movement of forward and reverse valve 80 to its neutral position shown in FIG. 1.

This completes one cycle of operation and the apparatus is in readiness for the next cycle of operation.

I claim:

1. In a hydraulic press:

a main ram cylinder,

a main ram in said main ram cylinder and extendable to and retractable from a clamping position, said main ram having a rearwardly directed surface against which fluid pressure may act to extend said ram to its clamping position and a forwardly directed surface against which fluid pressure may act to retract said ram,

a booster ram cylinder in said main ram,

a hollow booster ram having a front end portion extending into said booster ram cylinder,

stationary support means connected to a rear end portion of said booster ram and having a first chamber therein communicating with the interior of said booster ram,

a source of prefill fluid,

a control valve body disposed in surrounding relationship to said booster ram in the zone between said main ram cylinder and said support means and having a fluid passage for communicating said source of prefill fluid with the interior of said main ram cylinder behind said main ram,

a prefill valve piston within said control valve body disposed in surrounding relationship to said booster ram and being movable between a first position in which said fluid passage is open and a second position in which said fluid passage is closed off to block the flow of prefill fluid between said main ram cylinder and said source of prefill fluid,

said stationary support means further including a generally cylindrical prefill pin chamber communicating intermediate the ends thereof with said first chamber in said stationary support means, communicating at its rear end with a pilot pressure port and communicating at its front end with the interior of said control valve body at a location in alignment with the path of movement of said prefill valve piston,

a one piece cylindrical prefill valve pin movably disposed in said chamber and comprising

a pilot pressure reaction surface at the rear end thereof,

a surface at the front end thereof for engaging said prefill valve piston to urge the prefill valve piston toward its closed second position, and

a circumferentially grooved portion in the periphery of said cylindrical pin intermediate the ends thereof of such length as to remain in communication with said first chamber in said stationary means throughout the range of movement of said prefill valve pin and to communicate with the space behind said prefill valve piston when the prefill valve pin reaches its forwardmost position,

a source of pressurized pilot fluid and means for applying said pilot fluid to said pilot pressure reaction surface,

means defining a fluid passage from said space behind said prefill valve piston to the interior of the rear end portion of said main ram cylinder when said prefill valve piston is in its said second position,

pressurized fluid source means,

a first multiposition valve external to said main and booster ram cylinders and being connected to said pressurized fluid source means,

conduit means operably connected to said first multiposition valve for directing pressurized fluid to said first chamber in said support means in a first position of said first multiposition valve and for directing pressurized fluid to the interior of said main ram cylinder ahead of said forwardly directed surface of said main ram in a second position of said first multiposition valve, and

means, including a second multiposition valve external to said main and booster ram cylinders and having a position it assumes just prior to actuation of said first multiposition valve to the said second position of said first multiposition valve, for communicating said space behind said prefill valve piston with said source of prefill fluid to relieve the pressure behind said main ram prior to application to said main ram of fluid pressure in a direction to retract said main ram.

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