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APPARATUS FOR INTENSIFYING HYDRAULIC PRESSURE

Filed Oct. 1, 1956

3 Sheets-Sheet 1

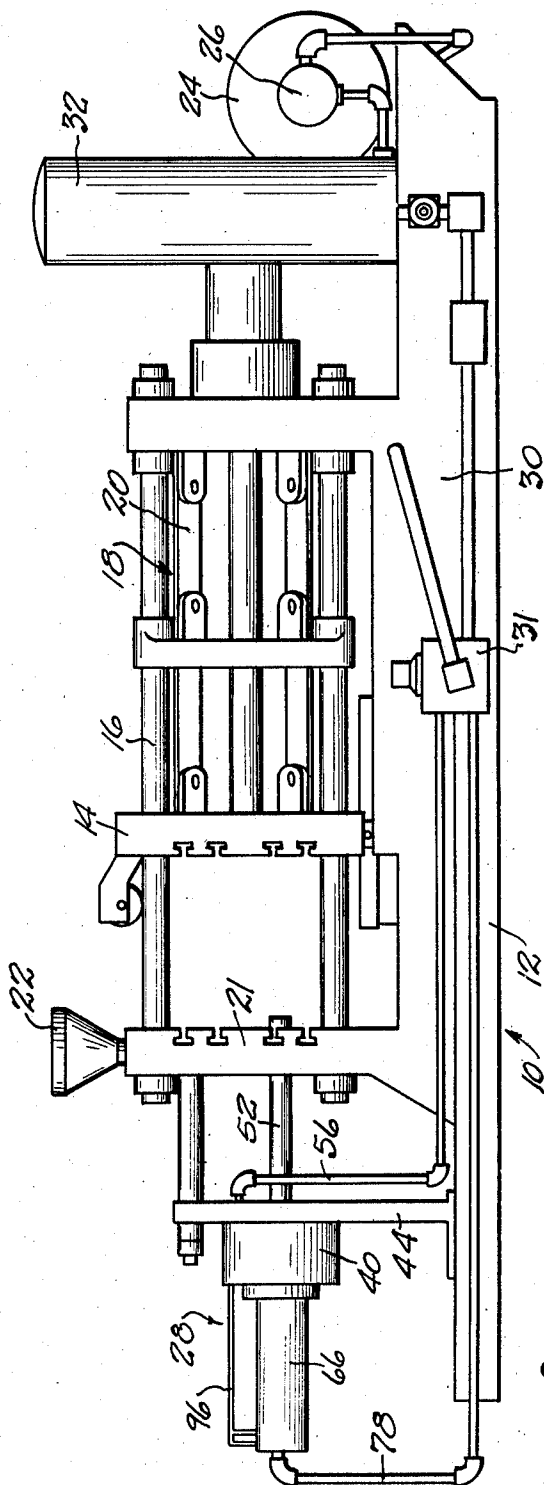


FIG. 1

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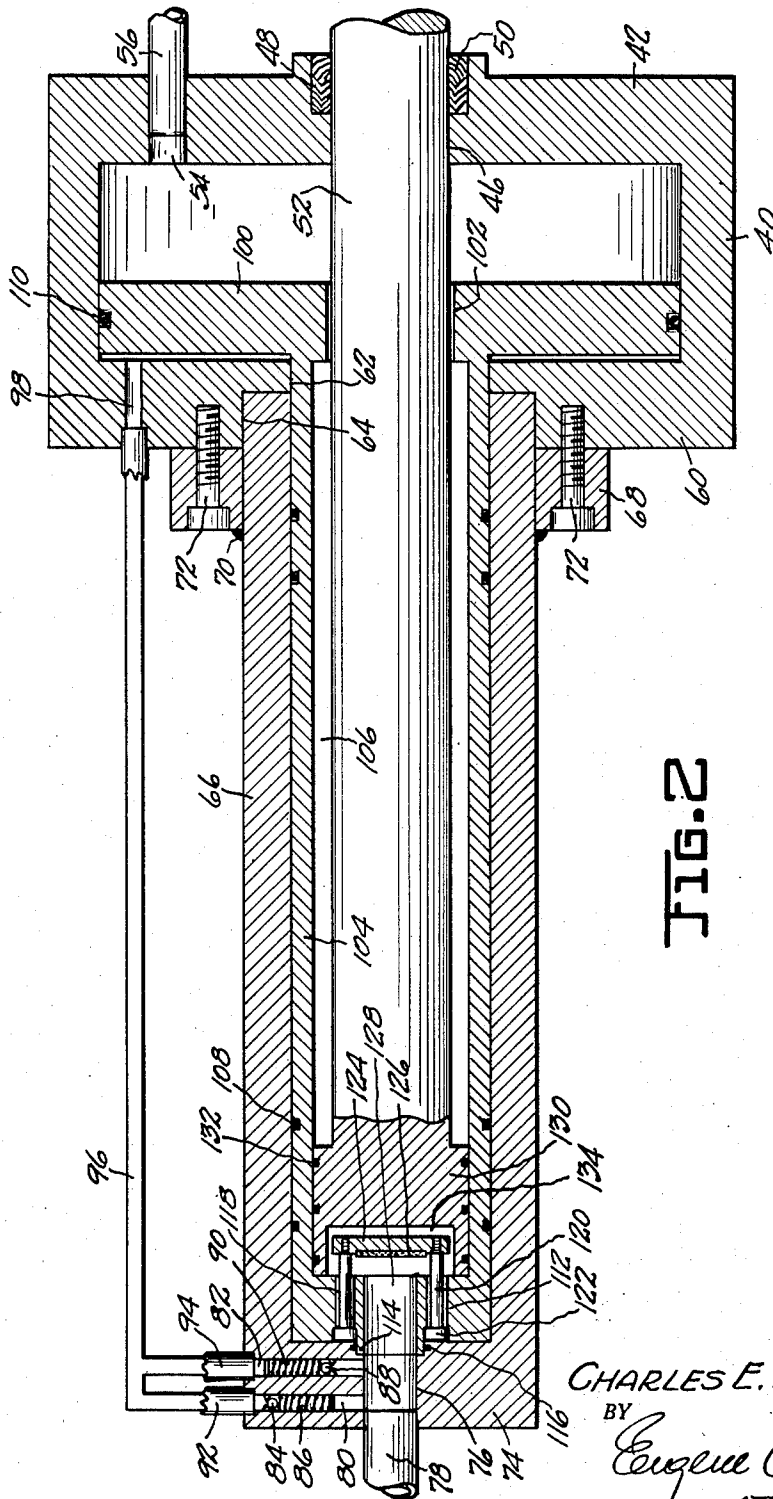
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3 Sheets-Sheet 2



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3 Sheets-Sheet 3

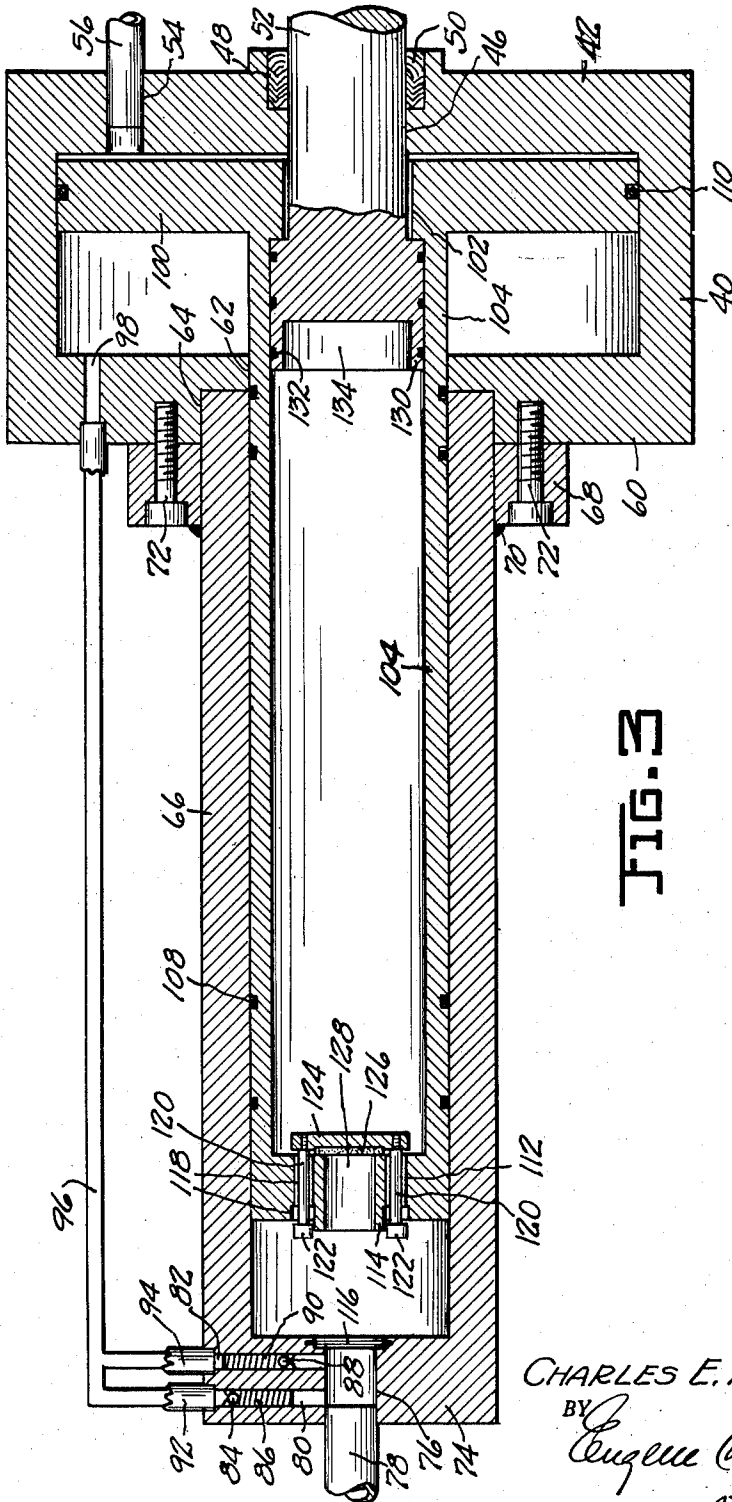


FIG. 3

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2,829,499

APPARATUS FOR INTENSIFYING HYDRAULIC PRESSURE

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Application October 1, 1956, Serial No. 613,339

12 Claims. (Cl. 60—54.5)

The invention relates to improvements in apparatus for intensifying hydraulic pressure. More particularly, it relates to a device of the general type and character illustrated in my co-pending application, Ser. No. 591,883, filed June 18, 1956.

Various machines which are operated by hydraulic pressure require application of a very high final operating force at the end of a stroke or actuation thereof which is started and carried on to its final part by application of a comparatively small amount of force.

Examples of apparatus which may require application of a high final operating force are aircraft landing gear, hydraulic vehicle brakes, hydraulically operated punch presses, hydraulically operated earth-moving equipment, hydraulically operated forging equipment, and hydraulically operated die casting machines.

It is the primary object of this invention to provide a novel, simple device for automatically increasing a fluid-pressure-generated force at the end of an operating stroke or cycle of a pressure operated device to accomplish assured operating results of the device.

A further object is to provide a device of this character applicable to a die casting machine to permit filling of the molding cavity of the machine at low pressure so as to allow air to escape from said cavity during filling, and wherein the final cavity-filling operation of the machine occurs at increased force or pressure to insure the production of dense and non-porous castings in the die cavity.

A further object is to provide a device of this character having a pressure responsive member presenting a small pressure responsive area during a portion of the stroke of the device in which low resistance is encountered and which automatically increases the pressure responsive area thereof upon the development of resistance of a predetermined value in the operating device.

A further object is to provide a device of this character having a primary piston of small area and a secondary piston of comparatively large area, wherein the small area piston is initially actuated alone and wherein actuation of the piston of large area occurs after the small piston reaches a predetermined position, so that a preselected portion of the stroke of a pressure responsive member will take place under a small operating pressure, and the remainder of the stroke will take place under a larger or intensified pressure, and wherein the return stroke of the pressure responsive members commences under positive pressure actuation effective against the large area piston so as to provide adequate force to assuredly start the return stroke against retarding forces acting against the mechanism.

Other objects will be apparent from the following specification.

In the drawings:

Fig. 1 is a view illustrating the application of the device to a die casting machine;

Fig. 2 is an axial sectional view of the device in its starting or low static pressure operating position; and

Fig. 3 is an axial sectional view of the device illus-

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trating the parts at the end of the high pressure operating stroke of the device.

Referring to the drawings which illustrate the preferred embodiment of the invention as applied to a die casting machine, the numeral 10 designates a die casting machine having a base 12 upon which is slidable a traveling die plate 14 shiftable upon parallel horizontal tie bars 16 by any suitable mechanism illustrated generally at 18. The machine actuating mechanism preferably includes toggles 20 for locking the traveling die plate in casting position with the die (not shown) carried thereby abutting a second die part (not shown) which is mounted upon a fixed die carrying plate 21 having a passage through which molten metal may be fed to the die in the manner well understood in the art, as from the funnel part 22. The machine preferably includes electric motor 24 for operating a liquid pump 26, and this pump is preferably connected with a nitrogen loaded accumulator 32 which supplies liquid under pressure to the actuating mechanism 18 for the traveling die 14 and to the injector or charge loading device 28.

A sump 30 for storage of liquid at low pressure connected with the inlet of the pump 26 and of any suitable construction is also provided in the device.

My new device forms a part of the injector 28 and preferably is constructed substantially as illustrated in Figs. 2 and 3. A cylinder 40 has an end wall 42 bearing against and preferably secured to a stationary member 44 adjacent to the stationary die carrier plate 21. End plate 42 has a central bore 46 therethrough of stepped character with an enlarged outer end portion adapted to receive a packing 48, such as a chevron packing, pressed upon by a follower ring 50. An elongated ram 52 is slidable in the aperture 46, and the packing 48 forms a fluid-tight seal around the ram. An aperture 54 is also formed in the cylinder wall 42 and has connected thereat a conduit 56 which communicates with a control valve 31 forming a part of the apparatus 10.

The cylinder 40 has a second end wall 60 with an aperture 62 therein of a diameter larger than the ram 52 and concentric with said ram. The aperture 62 is preferably of stepped form, having a large diameter outer end portion 64. An elongated cylinder 66 is provided with an inner diameter substantially equal to the diameter of the bore 62, and its outer diameter is substantially equal to the diameter of the bore portion 64 to fit in the latter. A ring 68, or annular flange, is carried by cylinder 66 and may constitute a member formed separately and welded thereto at 70. The member 68 is preferably apertured to accommodate cap screws or other securing means 72 for fixedly securing the cylinder 66 to the end wall 60 of the cylinder 40. The cylinder 66 has an end wall 74 provided with a central aperture 76 in which is secured the end of a conduit 78 which extends to the control valve 31.

A pair of passages 80 and 82 are formed in the end wall 74 of the cylinder 66 in spaced relation and communicate with the aperture 76 clear of the inner end of the conduit 78 and spaced from the inner face of the member 74. A check valve 84 is acted upon by a spring 86 and is located in the passage 80, the same being urged closed by fluid pressure from the passage 76 in addition to the spring-urged pressure of the spring 86 thereon. A valve 88 in passage 82 is spring-urged by spring 90 in a direction counter to the pressure exerted by fluid in the passage 76. Conduits 92 and 94 are respectively connected with the passages 80 and 82 and both are connected with a conduit 96 which communicates with a passage 98 formed in the cylinder wall 60 and communicating with the interior of the cylinder 40.

A piston 100 reciprocates in the cylinder 40 and has an aperture 102 therethrough receiving with clearance the

ram 52. A tube 104 is carried concentrically by the piston 100 and has a snug sliding fit within the interior of the cylinder 66. The inner diameter of the tube 104 is greater than the diameter of the aperture 102 so as to provide a chamber 106 between the tube 104 and the ram 52 positioned therein. Sealing means are provided between the cylinder 66 and the tube 104, the same preferably constituting annular resilient sealing rings 108, such as O-rings, which seat in circumferential grooves in the exterior surface of the tube 104 and which have a cross-sectional diameter preferably greater than the depth of the receiving grooves. Similar sealing means are preferably provided between the piston 100 and the cylinder 40, the same preferably constituting annular resilient sealing rings 110 preferably seated in circumferential grooves in the piston 100 and squeezed in said grooves into continuous contact with the interior wall surface of the cylinder 40.

The end of the tube 104 remote from the piston 100 is defined by an annular end wall 112 having an annular projecting lip or flange 114 adapted to seat in an enlargement of the inner end of the bore 76 and to engage a seal or O-ring 116 mounted in a groove in the enlarged part of bore 76 when in the position illustrated in Fig. 2. A plurality of spaced apertures 118 extend through the end wall 112 and preferably are countersunk. The apertures 118 slidably receive the shanks 120 of bolts or cap screws having enlarged heads 112 seating in the countersunk portions at the outer or free ends of the apertures 118. A plate or disk 124 is secured by bolts 120 and carries a sealing member 126 at the face thereof confronting the wall 112 and adapted to bear against the inner face of said wall to seal a central passage 128 in said wall 112 aligned with the passage 76. The spacing between the outer or left end face of the enlarged bolt head 122 and the same (left) surface of the disk 124 is greater than the thickness of the wall part 112, as best seen in Fig. 2.

The ram 52 has an enlarged head or piston portion 130 at the end thereof within the tube 104 and is preferably circumferentially grooved to receive annular resilient sealing members 132 to effect a seal between said piston 130 and tube 104. A recess 134 is formed in the end of the piston 130 confronting the wall 112 and is of a diameter to receive with clearance the plate 124. The depth of the recess 134 is such as to receive the plate 124 with clearance when the free or left end of the piston 130 abuts the wall 112 and when the plate 124 is spaced inwardly relative to the wall 112 to the maximum extent permitted by the bolts 120, 122 which carry the plate 124.

The operation of the device will be explained with reference to its use in conjunction with a die casting machine as illustrated in Fig. 1. Assuming that the pump 26 is operating, that the hydraulic system is charged with an operating hydraulic pressure, that the traveling die carrier 14 has been moved to die-closing position by the mechanism 18, that a charge of molten metal has been introduced into the machine as through the funnel 22, and that the mechanism 28 is in the position illustrated in Fig. 2, the device is ready for operation. The valve 31 is then set in a position to direct liquid under pressure from the accumulator 32 through the conduit 78 into the passages 76, 128, and into the recess 134 of the inner small area piston 130. The liquid in the recess 134 acts against the piston 130 to force the same and the ram 52 toward the right, as viewed in Fig. 2. This movement of the ram serves to force into the molding cavity of the die or mold (not shown) the charge of molten metal introduced through the funnel 22.

The parts are preferably so proportioned that the discharging action of the ram 52 is substantially completed by the time the piston 130 engages the piston 100 in the position of the piston 100 as shown in Fig. 2. During this initial stroke of piston 130 the liquid in the chamber 106 behind the piston 130 will be displaced through the aperture 102 around the ram 52 into the cylinder 40 and will be discharged from cylinder 40 through the conduit 56 to

the sump 30. In other words, no resistance to the operation of the piston 130 by the liquid in the system occurs in either of the chambers 106 or 40, and the only resistance to the movement of the ram 52 in response to liquid pressure introduced through the conduit 78 results from the frictional engagement of the ram with its guides and seals and from the back pressure of the molten metal charge as it is forced by the ram into the molding cavity of the die casting machine to load or fill that cavity. It will be noted that the valve plate 124 has clearance within the piston recess 134 at the start of the piston stroke so that the liquid introduced through the conduit 78 flows freely around the plate 124 which is initially spaced from the wall 112 by an amount determined by the length of the stripper bolts 120.

The initial movement of the ram 52 against negligible resistance, as described above, occurs rapidly and the static pressure at inlet 76 is low compared to the pressure available through the accumulator 32. The spring 90 on the check valve 88 has a strength adequate to resist the low static fluid pressure within the passage 76 at this initial stage during which only the ram 52 operates. When the ram 52 approaches the end of its charging stroke the back pressure of the charge of molten metal increases rapidly, so that the static pressure at inlet 76 increases to substantially the full pressure in the hydraulic system. This increased pressure acts against the valve 88 to unseat the same and permit liquid to flow through passage 82 and conduits 94 and 96 to the passage 98 leading into the cylinder 40 for action against the large piston 100. The combined hydraulic action, that is, application of liquid pressure against both the small piston 130 and the large piston 100, shifts the piston 100 to the right in Fig. 2 and pulls the tube 104 with it to disengage the annular projection 114 from the seal 116. Thereupon the liquid pressure is permitted also to act against the area of the end 112 of the tube 104. When this condition occurs, the force effective on the piston 100 is equal to the applied liquid pressure multiplied by the area of the piston 100 externally of the tube 104 and the area of the end wall 112 which greatly exceeds the force effective on the ram piston 130.

As the tube 104 moves away from the end wall 74 of the small cylinder 66, the valve plate 124 remains substantially stationary until the seal 126 thereof bears against the inner face of the wall 112 of the tube 104. The seating of valve plate 124 on wall 112 serves to trap a solid column of liquid within the sleeve 104 to act against the end of the piston 130. This solid entrapped column of liquid constitutes means to transmit from the large area piston to the ram piston 130 the full force exerted upon the piston 100. Thus, whereas initially the liquid pressure exerted against the ram 52 is transmitted by the piston 130 to the piston 100 to aid in initially shifting the piston 100 and the tube 104 from the Fig. 2 position, the condition is reversed after the initial increment of movement of parts 100 and 104 sufficient to permit the valve plate 124 to seat in sealing relation against the wall 112. Thus, though there is no mechanical means for transmitting force from the large diameter piston 100 to the ram 52, that force nevertheless is effectively transmitted through the medium of the incompressible entrapped liquid within the tube 104 between the seated valve plate 124 and the end of the piston 130. This intensifies and increases the force effective upon the ram 52 far in excess of the effect upon said ram of the maximum static liquid pressure supplied at the inlet conduit 78. This pressure increased condition continues until the full end of the stroke of the ram 52 is reached.

The operation of the ram at highly intensified effective pressure at the end of its stroke insures formation of a dense or solid casting in a die casting machine, but also produces problems of release of the casting from the apparatus and release of cores from the castings. The operation of other types of machinery operating at a

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highly intensified effective working pressure at the end of a stroke produce similar problems. An example of another machine possessing such problem is a hydraulic punch press requiring exertion of high force to remove a punch from a work piece punched thereby. The present device meets and solves these problems by applying a high operating force to initiate the return stroke of the ram toward the position in which we have assumed that the parts start functioning, as described above.

The return stroke of the ram is started by reversal of the setting of the valve 31 at the end of the working stroke of the ram to connect the conduit 56 with the high pressure side of the hydraulic system and connect the conduit 78 with the low pressure side of said system, as to sump 30. Liquid pressure is then applied against the piston 100 at the right thereof when the parts are in the position shown in Fig. 3. The high pressure of the liquid is exerted against the piston 100 through an area equal to the area of piston 100 less the area of the ram 52. The force so exerted is sufficient to commence withdrawal of the ram 52 from the end of its working stroke to accommodate withdrawal of a core from the casting in a die casting machine or withdrawal of a punch from the punched hole of a work piece in a punch press or the like. As the piston 100 moves from the position shown in Fig. 3 toward the position shown in Fig. 2, it pushes the ram piston 130 ahead of it. Simultaneously, the liquid between the piston 100 and the cylinder wall 60 within the cylinder 40 is displaced through port 98, conduit 96, conduit 92 and passage 80 at which it unseats the valve 84 and then flows into the passage 76 and the conduit 78 for return to the low pressure side of the hydraulic system. It will be apparent that as the piston 100 moves to the left from the position shown in Fig. 3 toward that shown in Fig. 2, the oil displaced from the bore of the cylinder 66 ahead of the end wall 112 of the tube 104 is likewise free to pass through the passage 76 and into the conduit 78.

The parts are so proportioned that by the time the piston 100 reaches the end of its return stroke within the cylinder 40, the end wall 112 of tube 104 will reach the end of its return stroke within the small cylinder 66, causing the heads 122 of the bolts 120 to strike the end wall 74 of cylinder 66 and unseat the valve plate 124 from its sealing engagement with the inner face of the well 112. Simultaneously, the annular projection 114 on the tube end wall 112 will enter the enlarged inner portion of the recess 76 and be engaged within the annular resilient seal 116, as illustrated in Fig. 2. By the time this return movement of piston 100 and connected parts has been completed, the ram 52 will have been shifted through a part of its return stroke sufficient to release it from that condition or position in the machinery with which the pressure intensifier is employed requiring high force in the return stroke. Consequently, the application of the pressure from the high pressure side of the system through conduit 56 is thereafter directed through the bore 102 in the piston 100 around the ram 52 for entry into the chamber 106 and against the inner or right-hand end of the piston 130 as viewed in Figs. 2 and 3. This operation continues until the ram 52 has been fully withdrawn to the starting position at the left-hand end of the member 104, as illustrated in Fig. 2. The device is then ready for another charging stroke upon reversal of the setting of the valve 31 to connect the conduit 78 to the high pressure side of the system, and the conduit 56 to the low pressure side of the system, as first explained.

While the device has been described in association with a die casting machine, and its operation has been explained in association with that machine, it will be understood that the utility of the device is not limited to such service. Instead, the device is useful for other services and operates in each such instance in the same manner. In other words, initial flow of liquid under pressure through the conduit 78 while the device is in the position

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shown in Fig. 2, produces a rapid motion of the ram 52 as long as that ram encounters only a small resistance to its movement. Thus the flow of liquid is characterized by a low static pressure acting upon the check valve 88 insufficient to unseat that check valve.

As soon as increased resistance to the continued movement of the ram 52 is encountered, so that the static pressure in the inlet 76 increases, the valve 88 opens in response to the pressure increase and liquid at the increased static pressure flows through passage 82 and conduits 94 and 96, to passage 98 and the cylinder 40 for action against the large area piston 100. As explained previously, this preferably occurs substantially at the time that piston 130 strikes the piston 100, but that relation of parts is not critical or essential, and the valve 88 may open prior to the time that the piston 130 strikes the piston 100 if that is desired. As soon as the valve 88 is open, the piston 100 pulls the wall 112 away from the end wall 74 of the cylinder 66 and permits the closing of the valve plate 124 to entrap a solid body of liquid within the chamber 106 between the piston 130 and the wall 112. As soon as this occurs, the force effective against the ram 52 is intensified or increased to a force equal to that generated by the application of the high static pressure at the inlet 78 against the total area of the piston 100 plus the area of the wall 112. Consequently, the final increment of movement of the ram 52 toward the right, as viewed in Fig. 2, occurs at extremely high operating pressures. The return stroke of the ram occurs after reversal of the setting of the control valve to connect the conduit 56 with the high pressure side of the hydraulic system and the conduit 78 with the low pressure side, and serves to restore the parts from the Fig. 3 position representing substantially the end of the charging phase of the cycle toward the Fig. 2 position representing the commencement of a new charging phase of the cycle.

One of the important characteristics of the device is the connection of the tube or sleeve 104 with the large area piston 100. This tube or sleeve forms a guide for the small area piston 130 with the ram 52. In other words, the large area piston 100 carries a chambered part 104 in which the ram piston 130 reciprocates, which part 104 moves within the cylinder 66. Thus the cooperative relationship of the parts entails an initial low pressure actuated travel of the small piston 130 in part 104 of the large piston. This operation continues until the ram 52 encounters increased resistance in the performance of its work resulting in the development of an increased static pressure at the inlet to the piston chamber 104 adequate to open the pressure responsive spring pressed valve 88 to direct liquid under pressure against the large area piston 100 to move the same and the chamber-defining member 104 in which the ram piston 130 travels.

Another important characteristic of the device is the closing of the chamber-defining tube 104 to entrap liquid in the tube 104 between said valve 124 and the piston 130. Consequently, continued actuation of the large area piston 100 shifts the small area piston 130 and the ram 52, due to the hydraulic interlock of the pistons effected by the entrapped liquid.

It is also interesting to observe that the closed condition of the pressure-balanced liquid-trapping valve 124 continues during the return stroke of the mechanism incident to application of high liquid pressure to the large piston 100 through the line or conduit 56. During this part of the movement there may be a positive mechanical abutment between the ram piston 130 and the large area piston 100 during the stroke of the piston 100 to perform initial withdrawal travel of the ram to disengage it from any retained or tightly clamped relation with the working parts, such as the casting within the die cavity. It will also be observed that as the piston 100 returns to the position illustrated in Fig. 2 from the position illustrated in Fig. 3, the heads 122 of the bolts 120 engage the end wall 74 of the cylinder 66 to unseat the valve 124. Inas-

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much as the valve plate 124 fits with clearance within the recess 134 in the leading face of the piston 130, unseating movement of the valve plate 124 occurs freely because the liquid displaced by movement of the valve plate 124 from the Fig. 3 position abutting the end wall 112 to the Fig. 2 position clear of the wall 112 flows around the valve plate as soon as the seal 126 disengages the wall 112. To the extent that entrapment of liquid between the end wall 74 of the cylinder 66 and the end wall 112 of the tube 104 occurs after the annular end projection 114 engages the seal 116, it is necessary to provide means for bleeding the liquid so entrapped. This is readily accomplished by providing a clearance between the bolts 120 and the bolt-receiving passages 118 in the end wall 112. This clearance must be sufficient to insure escape of liquid from the cylinder 66 as the parts 104, 112 advance toward the Fig. 2 position after the leading edge of the projection 114 engages the annular seal 116.

While the preferred embodiment of the invention has been illustrated and described, it will be understood that changes in the construction may be made within the scope of the appended claims without departing from the spirit of the invention.

I claim:

1. A hydraulic device comprising a cylinder having a pair of cavities of large and small cross-sectional sizes, respectively, a piston in said large cavity, a chambered projection carried by said piston and shiftable in said small cavity, a ram shiftable carried by said cylinder and including a piston portion shiftable in said chambered piston projection, liquid conduits communicating with the outer ends of said cylinder cavities, normally closed by-pass means opening in response to development of a pressure of predetermined value in the small cavity to direct liquid from said small cavity to the inner end of the large cavity, and a second normally closed by-pass means opening the inner end of said large cavity into communication with the outer end of said small cavity in response to entrapment of liquid in the inner end of said large cavity upon application of piston-actuating pressure at the outer end of said large cavity.

2. The construction defined in claim 1, and valve means entrapping a body of liquid within said chambered projection during movement of said piston in one direction for hydraulically interlocking said ram piston with said first piston to increase the force exerted on said ram at a selected point in the stroke of said ram in said one direction.

3. The construction defined in claim 1, and a normally open pressure balanced valve associated with said chambered projection and adapted to close at a predetermined point in the stroke of said projection in one direction to trap liquid in said projection between said valve and said ram piston.

4. The construction defined in claim 1 wherein said chambered projection has a passage in its end communicating with the adjacent conduit for directing liquid against said ram piston, and sealing means at said passage for excluding liquid from said small cylinder portion while said chambered projection is at one end of its path of travel in said cylinder.

5. A hydraulic device comprising a large cylinder, a small cylinder connected to and communicating with said large cylinder, a piston in said large cylinder, a hollow piston connected to said first piston and located in said small cylinder, a ram shiftable in said large cylinder and in said hollow piston, means for directing liquid under pressure into said small cylinder and hollow piston and against said ram, means responsive to a predetermined back pressure acting on said ram for directing liquid under pressure to move said first piston in said one direction, and means for transmitting to said ram the force exerted by movement of said first piston.

6. A hydraulic device comprising a large cylinder, a small cylinder connected to and communicating with said

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large cylinder, a piston in said large cylinder, a hollow piston connected to said first piston and located in said small cylinder, a ram shiftable in said large cylinder and in said hollow piston, means for directing liquid under pressure into said small cylinder and hollow piston and against said ram, means responsive to a predetermined back pressure acting on said ram for directing liquid under pressure to move said first piston in said one direction, means for transmitting to said ram the force exerted by movement of said first piston, said liquid-directing means including an opening in the end of said hollow piston, and said force transmitting means including a normally open pressure balanced valve located at said opening and adapted to close at a predetermined point in the stroke of said hollow piston in one direction to trap liquid within said hollow piston.

7. A hydraulic device comprising a large cylinder, a small cylinder connected to and communicating with said large cylinder, a piston in said large cylinder, a hollow piston connected to said first piston and located in said small cylinder, a ram shiftable in said large cylinder and in said hollow piston, means for directing liquid under pressure into said small cylinder and hollow piston and against said ram, means responsive to a predetermined back pressure acting on said ram for directing liquid under pressure to move said first piston in said one direction, and means for transmitting to said ram the force exerted by movement of said first piston, said liquid-directing means including an opening in the end of said hollow piston, said force-transmitting means including a valve adapted to seat at said opening and means shiftable mounting said valve on said hollow piston and projecting from said hollow piston when said valve is closed and engageable with an end of said small cylinder to open said valve at one end of the stroke of said hollow piston toward the means for directing liquid to said small cylinder.

8. A hydraulic device comprising a large cylinder, a small cylinder connected to and communicating with said large cylinder, a piston in said large cylinder, a hollow piston connected to said first piston and located in said small cylinder, a ram shiftable in said large cylinder and in said hollow piston, means for directing liquid under pressure into said small cylinder and hollow piston and against said ram, means responsive to a predetermined back pressure acting on said ram for directing liquid under pressure to move said first piston in said one direction, and means for transmitting to said ram the force exerted by movement of said first piston, said back-pressure-responsive means constituting a by-pass between said cylinders and a spring loaded check valve in said by-pass.

9. A hydraulic device comprising a large cylinder, a small cylinder connected to and communicating with said large cylinder, a piston in said large cylinder, a hollow piston connected to said first piston and located in said small cylinder, a ram shiftable in said large cylinder and in said hollow piston, means for directing liquid under pressure into said small cylinder and hollow piston and against said ram, means responsive to a predetermined back pressure acting on said ram for directing liquid under pressure to move said first piston in said one direction, and means for transmitting to said ram the force exerted by movement of said first piston, means for directing liquid under pressure to move said first piston and ram in the opposite direction, and a by-pass connecting said cylinders and having a one-way valve therein to discharge liquid from said large cylinder upon movement of said piston in said opposite direction.

10. A hydraulic device comprising a large cylinder, a small cylinder connected to and communicating with said large cylinder, a piston in said large cylinder, a hollow piston connected to said first piston and located in said small cylinder, a ram shiftable in said large cylinder and in said hollow piston, means for directing liquid under pressure into said small cylinder and hollow piston and

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against said ram, means responsive to a predetermined back pressure acting on said ram for directing liquid under pressure to move said first piston in said one direction, and means for transmitting to said ram the force exerted by movement of said first piston, said liquid-directing means including an opening in the end of said hollow piston and a seal between said hollow piston and small cylinder at said opening and operative when said hollow piston is at one end of its stroke.

11. A hydraulic device comprising a large cylinder, a small cylinder connected to and communicating with said large cylinder, a piston in said large cylinder, a hollow piston connected to said first piston and located in said small cylinder, a ram shiftable in said large cylinder and in said hollow piston, means for directing liquid under pressure into one end of said small cylinder and hollow piston and against said ram, means responsive to a predetermined back pressure acting on said ram for directing liquid under pressure to move said first piston in said one direction, and means for transmitting to said ram the force exerted by movement of said first piston, said force-

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transmitting means including a normally open valve adapted to close to entrap liquid in said hollow piston upon movement thereof to a predetermined extent from the inlet end of said small cylinder.

12. A hydraulic device comprising a large cylinder, a small cylinder connected to and communicating with said large cylinder, a piston in said large cylinder, a hollow piston connected to said first piston and located in said small cylinder, a ram shiftable in said large cylinder and in said hollow piston, means for directing liquid under pressure into said small cylinder and hollow piston and against said ram, means responsive to a predetermined back pressure acting on said ram for directing liquid under pressure to move said first piston in said one direction, and means for transmitting to said ram the force exerted by movement of said first piston, said ram and said first piston having interengaging abutments abutting after predetermined initial movement of said ram in said one direction.

No references cited.