

April 8, 1958

C. E. FERGUSON

2,829,498

HYDRAULIC PRESSURE INTENSIFYING APPARATUS

Filed June 18, 1956

3 Sheets-Sheet 1

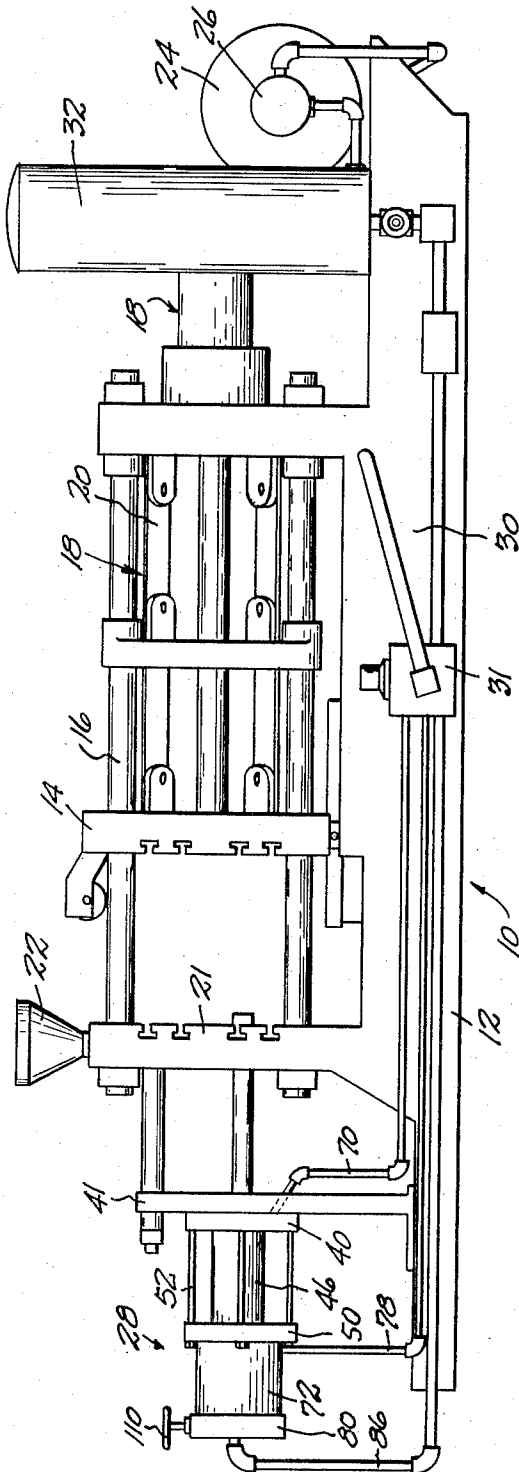


FIG. 1.

CHARLES E. FERGUSON.
INVENTOR.

BY
Charles C. Knoblock
ATTORNEY.

April 8, 1958

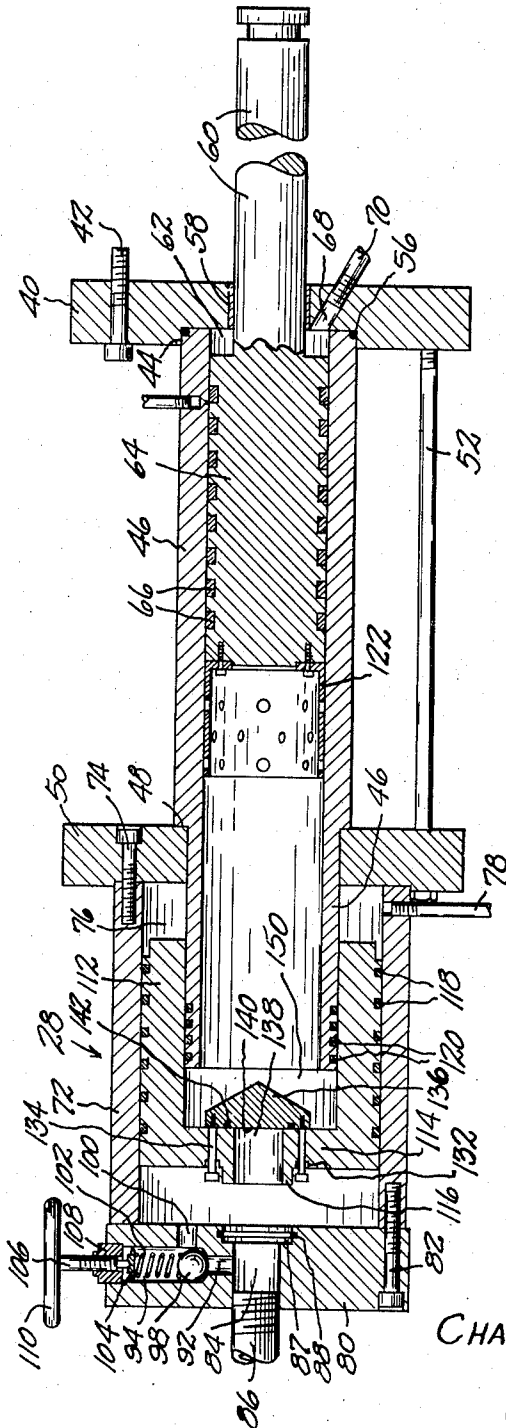
C. E. FERGUSON

2,829,498

HYDRAULIC PRESSURE INTENSIFYING APPARATUS

Filed June 18, 1956

3 Sheets-Sheet 3



INVENTOR.

CHARLES E. FERGUSON.

BY

Engel C. Knoblock.
ATTORNEY

ATTORNEY.

1

2,829,498

HYDRAULIC PRESSURE INTENSIFYING
APPARATUS

Charles E. Ferguson, Sister Lakes, Mich., assignor to
Roper Engineering Company, St. Joseph, Mich., a cor-
poration of Michigan

Application June 18, 1956, Serial No. 591,883

12 Claims. (Cl. 60—54.5)

This invention relates to improvements in hydraulic pressure intensifying apparatus.

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 cavity pressure to insure the production of dense and porous-free 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 fluid passage for directing fluid pressure against one part of a multiple part pressure-responsive member, and having a secondary passage controlled by a normally closed spring loaded valve and adapted to be opened in response to a predetermined pressure to direct fluid pressure against the entire multiple part pressure responsive member and thus increase the force exerted upon the pressure-responsive member in the final portion of its stroke.

A further object is to provide a device of this character having a primary piston with a supplemental large area apertured piston mounting a movable check valve at said aperture, wherein said supplemental piston is associated with a spring loaded pressure controlled valve in a passage branching from that leading to the check valve, so that the development of a static fluid pressure in the device adequate to overcome the spring loaded valve and thus shift the supplemental piston, will also be effective to close the check valve by movement in a direction counter to the direction in which the supplemental piston moves as a result of application of pressure thereto through the passage controlled by the spring loaded valve.

2

Other objects will be apparent from the following specification.

In the drawings:

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

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

Fig. 3 is an axial sectional view of the device illustrating the parts in the position thereof during which high operating force is exerted thereby.

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 by 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. An end plate 40 bears against a stationary member 41 adjacent to the stationary die carrier plate 21 and is anchored thereto by means of cap screws 42 or other suitable securing means. End plate 40 is preferably recessed at 44 at its outer face to snugly receive one end of tubular member 46. Member 46 has a circumferential shoulder 48 spaced from the opposite end thereof and engaged by an apertured plate or flange 50 which is connected in fixed relation to the end plate or flange 40, as by means of tie rods 52 in the manner well understood in the art. The end of the tubular member 46 which seats in the recess 44 is preferably circumferentially reduced or stepped at 54 to receive an annular resilient sealing member 56, such as an O-ring formed of rubber or synthetic rubber, whose cross-sectional dimension is slightly greater than the cross-sectional dimension of the annular socket receiving the same. Thus a sealed joint is provided between the end of the tube 46 and said end plate or flange 40.

The end plate or flange 40 also has a bore therethrough concentric with the recess 44 and is here shown as lined by a bushing 58. An elongated ram 60 is slidable in bushing 58 and is of smaller dimension than the interior diameter of the tubular member 46 so as to define an annular chamber 62 therearound within the tubular member 46. The ram 60 is preferably formed integrally with an enlarged piston-forming head 64 having a snug sliding fit within the bore of the tubular portion 46, which bore is preferably of uniform diameter throughout its length. The piston 64 has a plurality of circumferential grooves, each mounting a piston ring 66, and said rings seal the piston 64 to prevent leakage of fluid therepast. The end plate 40 has a bore 68 therein which communicates with the chamber 62 and a conduit 70 which leads to the low pressure reservoir 30. Piston 64 is one part of a multiple-part double-acting pressure responsive unit or structure.

A tubular member 72 of larger size than the tubular

member 46 is secured to the flange or plate 50 by means of cap screws 74 in concentric relation to the tube 46 and the piston 64 to cooperate with the tube 46 in defining a cylinder having large and small diameter parts. The reduced end of the tube 46 projects into the tube 72 with clearance to define an annular chamber 76 between said tubes. For purposes of convenience the tube 46 will sometimes be referred to as the inner tube, and the tube 72 will sometimes be referred to as the outer tube. The outer tube 72 has a bore therein adjacent to the plate 50 with which is connected a conduit 78 for establishing communication between the chamber 76 and the low pressure reservoir 30. An end plate or cylinder head 80 is fixedly mounted upon the outer end of the outer tube member 72, as by means of cap screws 82, and cooperates with said outer tube 72 and the flange or plate 50 to define a large cylinder part. The cylinder head 80 has a concentric bore 84 therethrough with which is connected a conduit 86 leading to the accumulator 32. At its inner end the bore 84 is enlarged at 87, and the enlarged bore portion is preferably interrupted by an annular groove intermediate its length which receives an annular resilient sealing member 88, such as a rubber O-ring whose cross-sectional diameter is preferably greater than the depth of the groove. The enlarged bore portion 87 defines an annular shoulder 90 intermediate the thickness of the cylinder head 80.

The cylinder head 80 is preferably of substantial thickness as shown and has formed therein, to extend substantially in the plane thereof, and intermediate and spaced from the shoulder 90 and clear of the inner end of the conduit 86, a by-pass 92 which is substantially concentric with a bore 94 extending to the edge of the cylinder head 80. A shoulder portion 96 between the by-pass 92 and the bore 94 defines a valve seat for a valve member 98. A transverse by-pass 100 communicates with the bore 94 adjacent to but spaced from the valve seat 96. The valve element 98 forms a part of a spring loaded valve which is engaged by the coil spring 102 within the bore 94 and its opposite end bears against an adjustable abutment, such as a plate 104 swivelled on the end of a shaft 106 threaded in a bushing 108 screw-threaded in the outer end of the bore 94. A hand wheel 110 is preferably carried by the screw 106.

A cup-shaped piston having a tubular skirt portion 112 and an end plate 114 is slidable in the chamber 76 and around the tube portion 46 and cooperates with piston 64 to constitute a multiple-part double-acting pressure responsive unit. The end plate 114 is located adjacent to and is adapted to bear against the inner face of the cylinder head 80 and has a central reduced diameter projecting tube or neck portion 116. The neck 116 is of a length substantially equal to the length of the enlarged bore portion 87 in said cylinder head and is of an outer diameter to have a snug sliding fit in said enlarged bore portion 87 and to effect a circumferential seal with the cylinder head by means of the annular sealing member 88. The skirt portion 112 is preferably provided with a plurality of external grooves receiving piston rings 118. The inner surface of the skirt portion 112 has slight clearance with the outer surface of the portion of the inner tube 46 which projects into the outer tube 72. Suitable sealing means are provided between the piston skirt 112 and the tube 46 and, as here shown, preferably constitute a plurality of piston rings 120 mounted in circumferential grooves in the end portion of the inner tube 46 which is encompassed by the skirt 112 in all operative positions of the device.

A piston extension is mounted upon the end of the piston 64 and is adapted to bear against the piston end wall 114, as seen in Fig. 2. This piston extension preferably constitutes a tubular member 122 having an in-turned flange 124 anchored by securing means 126, such as cap screws, to the piston 64 in concentric relation to that piston. The tube 122 has a plurality of apertures

128 formed therein, here shown as being arranged in a plurality of circumferential series.

A plurality of spaced stepped bores 130 are formed in the piston end wall 114 with the enlarged end part 132 thereof open at the face confronting the cylinder head 80. These bores 130 slidably receive headed stripper bolts 134 fixedly secured to a check valve member 136. The check valve member is preferably in the nature of a plate or plug of a size larger than a bore 138 in the center of the piston wall 114 and slightly smaller than the inner diameter of the piston extension member 122. The valve member 136 has a flat face 140 adapted to bear against the inner face of the cylinder end wall 114. A circumferential groove is formed in the face 140 concentric with bore 138 and has an inner diameter larger than the diameter of the bore 138. Within this circumferential groove is mounted a resilient annular sealing member 142, such as a rubber O-ring whose cross-sectional diameter is greater than the depth of the groove which receives it, so that upon abutment of the face 140 of the valve 136 with the inner face of end wall 114 of the supplemental piston part a seal is provided which prevents leakage of fluid between said abutting surfaces.

As seen in Fig. 1, a valve 31 forms a part of the die casting machine and is adapted to be operated in a predetermined sequence to determine the operating cycle of the mechanism. The various conduits 86, 78 and 70 are preferably controlled by the valve 31.

In the operation of the die casting machine, assuming that the travelling carrier 14 has been moved to die-closing position by the mechanism 18 which operates it, and that a charge of molten metal has been introduced into the machine, as through the funnel 22, while the intensifier mechanism 28 is in the condition illustrated in Fig. 2, operation of the valve 31 will first be made in a manner to introduce oil under pressure from the accumulator 32 through the conduit 86 into the passages 84, 138 and into the chamber or cavity 150 within the interior of the supplemental piston 112, 114. Oil under pressure in the chamber 150 acts against the piston 64 to force the same and the ram 60 toward the right as viewed in Fig. 2. Movement of the ram 60 serves to force the charge of molten metal into the die cavity and continues until such time as the resistance of the metal within the die cavity retards or stops the piston and the ram. During this time oil within the chamber 62 will be discharged through conduit 70 in a path controlled by the valve 31 which leads it to the low pressure sump 30. The setting of the valve 31 during that same period will also be such as to open the conduit 78 to the low pressure reservoir 30. In other words, no resistance to the operation of the piston 64 by fluid entering the conduit 86 occurs in either of the chambers 62 or 76, and the only pressure which is developed occurs as a result of the movement of the ram 60 to displace the molten metal charge for the purpose of loading or filling the die. It will be noted that the apertures 128 in the piston extension 122 permit the free flow of oil around the check valve 136 which is spaced from the end wall 114 by an amount determined by the length of the stripper bolts 134. The apertures 128 eliminate any possibility of creating an oil trap between the piston extension 122, the piston skirt 112, the piston base 114 and the end of the inner tube 46.

When the movement of the ram 60 approaches its limit, that is, moves to within a small fraction of an inch of its total desired movement, resistance to further movement is encountered by the charge of metal in the die cavity. In normal die casting machine operation the original or effective charging pressure which produces the movement of the piston 64 may be in the order of 25 pounds per square inch, as determined by the resistance of the various parts to motion and the force required to push the charge into the die cavity. In other words, though the oil pressure in the accumulator is

5

very high, resistance to the expansion of the chamber 150 in the device is only in the order of 25 pounds per square inch until the device has substantially completely filled the die cavity with the molten metal charge. When the latter condition occurs, pressure in the conduit 86, the passages 84 and 138, and in the chamber 150, increases according to the pressure available in the accumulator 32 which preferably is in the order of 1000 pounds per square inch. Since the by-pass 92 is in free and open communication with the passage 84 at which increase in oil pressure occurs, that by-pass exposes the valve element 98 to the increased pressure to unseat the valve element 98 against the action of the spring 102 when the force exerted exceeds that which the spring 102 has been adjusted to withstand. Unseating of the valve 98 opens by-pass 100 into communication with by-pass 92 and applies the oil under high pressure against the end wall 114 of the supplemental large area piston to bodily move the piston 112, 114 to the right from the position illustrated in Fig. 2. This movement of the piston 112, 114 occurs while the resistance in the line to discharge from chamber 62, plus the resistance of the metal charge within the die acting against the ram 60, as compared to entire lack of resistance in the chamber 76, holds the ram 60 stationary.

After movement of the supplemental piston 112 and its tubular extension 116, a short distance, for example a distance of approximately one-eighth of an inch, the piston extension 116 will pass clear of the annular seal 88 so that oil may flow around the extension 116 into the space between piston wall 114 and cylinder wall 80 to continue movement of the supplemental piston toward the right from the position shown in Fig. 2. During this movement the check valve 136 remains substantially stationary because pressure of liquid at both sides thereof is balanced. Therefore, during the initial movement of the supplemental piston 112, the heads of the stripper bolts 134 will continue to bear against the cylinder head 80 until such time as the piston wall 114 advances into engagement with the surface 140 of the check valve 136 to effect a seal between those parts at the annular sealing member 142. Note that as movement of the piston 112 occurs, no resistance to such movement occurs in chamber 76 which is connected to the reservoir 30, whereas the resistance acting on the ram 60 continues.

It is important to observe that during the movement of the supplemental piston 112, no drop in pressure applied against the small piston 64 occurs. As soon as the check valve 136 seats against the piston wall 114 and a seal is effected by the sealing member 142, the chamber 150 is closed or sealed. The continued application of pressure through line 86 thereupon acts through or upon the piston wall 114 to increase the force exerted upon the ram 60 in proportion to the increase in the effective area of the multiple part piston unit. In particular, the area against which oil pressure is now effective is the area of the end wall 114 minus the area of the annular space at the end of the inner tube 46 and plus the area of small piston 64. This pressure increase is sufficient to move the ram through the slight distance remaining to insure complete filling of the die cavity and to insure the formation of a dense and void-free metal casting in the forming die.

Fig. 3 illustrates the position of the parts at the end of the charging cycle, and it will be noted therefrom, by comparison with the position of the parts as seen in Fig. 2, that the stroke of the cup-shaped supplemental piston 112, 114 is short compared with the stroke of the small piston 64. Also, it will be noted that, because the check valve 136 is sealed and the chamber 150 is filled with liquid which is not compressible, trapped liquid in chamber 150 constitutes means for transmitting force exerted upon the large area piston 114 to the comparatively small piston 64 to secure the final movement of the ram. The final component of the movement of the ram will preferably be exerted after the die or mold has been opened to eject the "biscuit" of the formed metal

6

from the part of the die carried by the stationary die carrier plate 21.

The description of pressure application and intensification set forth above has referred particularly to the operation of my improved device when applied to a die casting machine. As previously indicated herein, the device is useful for other services than attachment to die casting machines and operates in each such instance in the following general manner. Initial flow of fluid through the inlet conduit 86 into the device while the device is in the Fig. 2 position produces a rapid motion of the small piston 64 in the inner tubes or cylinder 46 during the time that the piston 64 encounters only small resistance to its movement. Thus the flow of liquid is characterized by a low static pressure acting upon the spring pressed valve 98. During this time the seal 88 is effective to exclude delivery of fluid pressure against the wall 114 of the cup-shaped supplemental piston 112, 114. The pressure of the piston rings 118 and 120 will preferably be sufficient to provide a frictional resistance to movement of the cup-shaped supplemental piston 112, 114 by fluid at low static pressure acting against the annular end surface 90 of the tubular projection 116 of the piston wall 114.

As soon as resistance to the continued movement of the piston 64 is encountered, so that a high static pressure develops in the inlet passage and acts against the valve 98 to open the by-pass 92, 100, the area against which the increased static pressure is effective is enlarged to be substantially coextensive with the diameter of the end wall 114 of the large piston, thereby increasing the effective force exerted by the liquid supplied through the inlet 86, and in turn transmitted from the supplemental piston 112 to the small piston 64 by the liquid trapped between said parts by the check valve 136. This principle permits the completion of the stroke of the piston 64 under highly intensified pressure or force-exerting conditions. The high intensification of pressure effective on the multiple part piston can be used in any hydraulic device requiring such intensification, as of the types hereinafter mentioned.

The return of the device to its starting position is controlled by the operating valve of the device, such as the valve 31. The return setting will be such as to connect the conduit 70 to the source of liquid under pressure and to connect the conduit 86 to the low pressure reservoir. As liquid under pressure passes through conduit 70 to enter the chamber 62, the small piston 64 is returned toward the cylinder head 80. This movement is transmitted to the large supplemental piston by the liquid trapped in the chamber 150 between the small piston 64 and the outer large piston 112, 114 so that the latter piston moves with the piston 64 toward the position shown in Fig. 2. After the heads of the stripper bolts 134 strike the cylinder head 80, continued movement of the supplemental piston breaks the seal between the check valve 136 and the inner face of the end wall 114 of the cup-shaped piston at the sealing ring 42, and liquid in the chamber 150 is then released for discharge through the conduit 86 along with the liquid remaining in the large cylinder portion 72 between the cylinder head 80 and the piston wall 114. The extension 122 of the small piston 64 will strike the end wall 114 of the supplemental piston as the multiple-part piston approaches the end of its return stroke and will positively and mechanically press the supplemental piston to the Fig. 2 position.

After the extension 116 of the supplemental piston has engaged the seal 88, the flow of fluid from the space between the piston wall 114 and the cylinder head 80 occurs through the clearance space in the apertures 130, 132 around the stripper bolts 134 which fit loosely in said apertures. Thus entrapment of liquid under pressure in the large diameter cylinder part during the return stroke is prevented and no resistance to return of the parts to the Fig. 2 position is encountered.

The application of fluid under pressure at the chamber 62 may be continued for the purpose of maintaining the device in the Fig. 2 position until such time as the next working stroke of the device is to occur, for example, as determined by reversal of the setting of the control valve, such as valve 31, for the purpose of connecting the conduit 86 to a source of liquid under pressure and the connection of the conduit 70 to a reservoir or other low pressure container.

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 pressure intensifying device comprising a cylinder having a large diameter portion and a small diameter portion, a piston in said small cylinder portion and adapted to project into said large cylinder portion, a large cup-shaped piston in said large cylinder portion having a normal inoperative position and adapted to receive said first piston therein, said cylinder having an inlet passage at the end of its large diameter portion and a passage branching from said inlet and confronting the end of said large piston, a normally closed valve in said branch passage adapted to be opened in response to attainment of a static pressure of predetermined value in said inlet, said large piston having a passage therethrough communicating with said inlet, seal means cooperating with said large piston in one position to isolate said inlet from said large cylinder portion, and a valve in said piston passage responsive to the position of said large piston to be open when said branch passage is closed and to be closed after predetermined movement of said large piston from said inoperative position.

2. A hydraulic pressure intensifying device comprising a cylinder having a large diameter portion and a small diameter portion, a piston in said small cylinder portion and adapted to project into said large cylinder portion, a large cup-shaped piston in said large cylinder portion having a normal inoperative position and adapted to receive said first piston therein, said cylinder having an inlet passage at the end of its large diameter portion and a passage branching from said inlet and confronting the end of said large piston, a normally closed valve in said branch passage adapted to be opened in response to attainment of a static pressure of predetermined value in said inlet, said large piston having a passage therethrough communicating with said inlet, a valve in said piston passage responsive to the position of said large piston to be open when said branch passage is closed and to be closed after predetermined movement of said large piston from said inoperative position, and a seal between said cylinder and said large piston to prevent impingement upon said large piston by fluid from said inlet while said large piston is in said inoperative position.

3. A hydraulic pressure intensifying device comprising a cylinder having a large diameter portion and a small diameter portion, a piston in said small cylinder portion and adapted to project into said large cylinder portion, a large cup-shaped piston in said large cylinder portion having a normal inoperative position and adapted to receive said first piston therein, said cylinder having an inlet passage at the end of its large diameter portion and a passage branching from said inlet and confronting the end of said large piston, a normally closed valve in said branch passage adapted to be opened in response to attainment of a static pressure of predetermined value in said inlet, said large piston having a passage therethrough communicating with said inlet, a valve in said piston passage responsive to the position of said large piston to be open when said branch passage is closed and to be closed after predetermined movement of said large piston from said inoperative position, said cylinder inlet being stepped, a tubular projection on said large piston seating in said

stepped inlet in said inoperative position, and a seal between said inlet and said piston projection.

4. A hydraulic pressure intensifying device, comprising a cylinder having a large diameter portion and a small diameter portion, a piston in said small cylinder portion and adapted to project into said large cylinder portion, a large cup-shaped piston in said large cylinder portion having a normal inoperative position and adapted to receive said first piston therein, said cylinder having an inlet passage at the end of its large diameter portion and a passage branching from said inlet and confronting the end of said large piston, a normally closed valve in said branch passage adapted to be opened in response to attainment of a static pressure of predetermined value in said inlet, said large piston having a passage therethrough communicating with said inlet, means for sealing said inlet from said large cylinder portion when said large piston is at inoperative position, and a valve in said piston passage responsive to the position of said large piston to be open when said branch passage is closed and to be closed after predetermined movement of said large piston from said inoperative position, said first piston having a longitudinal apertured tubular projection within and engaging the cup-shaped piston during the inoperative position of said first piston.

5. A hydraulic pressure intensifying device comprising a cylinder having a large diameter portion and a small diameter portion, a piston in said small cylinder portion and adapted to project into said large cylinder portion, a large cup-shaped piston in said large cylinder portion having a normal inoperative position and adapted to receive said first piston therein, said cylinder having an inlet passage at the end of its large diameter portion and a passage branching from said inlet and confronting the end of said large piston, a normally closed valve in said branch passage adapted to be opened in response to attainment of a static pressure of predetermined value in said inlet, said large piston having a passage therethrough communicating with said inlet, seal means between said large cylinder and large piston at the inoperative position of the latter, a valve in said piston passage responsive to the position of said large piston to be open when said branch passage is closed and to be closed after predetermined movement of said large piston from said inoperative position, said small diameter cylinder portion projecting into said large diameter cylinder portion to define an annular chamber and said cup-shaped piston including a skirt projecting into said annular chamber, and a vent for said annular chamber.

6. A hydraulic pressure intensifying device comprising a cylinder having a large diameter portion and a small diameter portion, a piston in said small cylinder portion and adapted to project into said large cylinder portion, a large cup-shaped piston in said large cylinder portion having a normal inoperative position and adapted to receive said first piston therein, said cylinder having an inlet passage at the end of its large diameter portion and a passage branching from said inlet and confronting the end of said large piston, a normally closed valve in said branch passage adapted to be opened in response to attainment of a static pressure of predetermined value in said inlet, said large piston having a passage therethrough communicating with said inlet and a sealed engagement with said cylinder around said inlet at said inoperative position, a valve plate in said cup-shaped piston adapted to span and seal said piston passage, and means guiding said valve plate for movement between an open position when said cup-shaped piston is in inoperative position and a closed position when said cup-shaped piston has moved a predetermined distance from said inoperative position.

7. A hydraulic pressure intensifying device comprising a cylinder having a large diameter portion and a small diameter portion, a piston in said small cylinder portion and adapted to project into said large cylinder portion, a large cup-shaped piston in said large cylinder portion hav-

ing a normal inoperative position and adapted to receive said first piston therein, said cylinder having an inlet passage at the end of its large diameter portion and a passage branching from said inlet and confronting the end of said large piston, a normally closed valve in said branch passage adapted to be opened in response to attainment of a static pressure of predetermined value in said inlet, said large piston having a passage therethrough communicating with said inlet and a sealed engagement with said cylinder around said inlet at said inoperative position, a valve plate in said cup-shaped piston, means guiding said valve plate for axial movement between seated position spanning said piston passage and open position, and sealing means for preventing flow of fluid through said piston passage when said valve plate is in seated position.

8. A hydraulic pressure intensifying device, comprising a cylinder having large and small diameter portions, means at opposite ends of said cylinder for selectively admitting and discharging fluid under pressure, a piston in said small cylinder portion normally responsive to fluid under pressure admitted at said large diameter portion, a second piston in said large cylinder portion, means normally sealing said last named piston against response to fluid under pressure admitted at the large cylinder portion, and means responsive to increase of static pressure at the fluid admission means of the large cylinder portion to a predetermined value for exposing said second piston to the influence of said increased pressure.

9. A hydraulic pressure intensifying device, comprising a cylinder, a double-acting multiple-part piston in said cylinder, means normally sealing one piston part from fluid pressure applied at one end of said cylinder when at an inoperative piston position, means responsive to an increase of resistance to movement of the normally responsive other piston part in said one direction for exposing said one piston part to pressure and thereby increase the pressure responsive area of said double-acting piston and means for trapping fluid between said piston parts at a predetermined position of said one piston part to transmit movement of said one piston part to said other piston part.

10. A hydraulic pressure intensifying device, comprising a cylinder, a double-acting multiple-part piston in said cylinder, said parts being of different cross-sectional sizes and being independently operable, means normally sealing the large piston part against response to fluid pressure applied at one end of said cylinder when said large piston part is in an inoperative position, whereby

fluid pressure initially actuates only the small piston part in said one direction, means responsive to increase in resistance encountered by said small piston part for exposing said large piston part to fluid pressure and means for trapping fluid between said piston parts at a predetermined point in the stroke of said large piston part.

11. A hydraulic pressure intensifying device, comprising a cylinder, a double-acting multiple-part piston in said cylinder, said parts being of different cross-sectional sizes and being independently operable, means normally sealing the large piston part from response to fluid pressure applied in one direction at an inoperative piston position, whereby fluid pressure initially actuates only the small piston part in said one direction, means responsive to increase in resistance encountered by said small piston part for exposing said large piston part to fluid pressure, said large piston part having a passage therethrough normally exposing said small piston part to pressure to produce movement in said one direction, and a valve carried by said large piston part and adapted to seal said passage when said large piston part is within a predetermined part of its stroke.

12. A hydraulic pressure intensifying device, comprising a cylinder, a double-acting multiple-part piston in said cylinder, said parts being of different cross-sectional sizes and being independently operable, means normally sealing the large piston part from response to fluid pressure applied in one direction at an inoperative piston position, whereby fluid pressure initially actuates only the small piston part in said one direction, means responsive to increase in resistance encountered by said small piston part for exposing said large piston part to fluid pressure, said large piston part being cup-shaped to receive said small piston part and having a passage centrally thereof to accommodate flow of fluid past said large piston part to actuate said small piston part in one direction, and a valve shiftably carried by said large piston part and adapted to close said passage after predetermined movement of said large piston part in said one direction from inoperative position.

References Cited in the file of this patent

UNITED STATES PATENTS

1,865,105	Houplain	June 28, 1932
2,351,872	Parker	June 20, 1944
2,452,292	Cousino	Oct. 26, 1948
2,453,785	Cousino	Nov. 16, 1948
2,608,059	Kux	Aug. 26, 1952