

Feb. 21, 1956

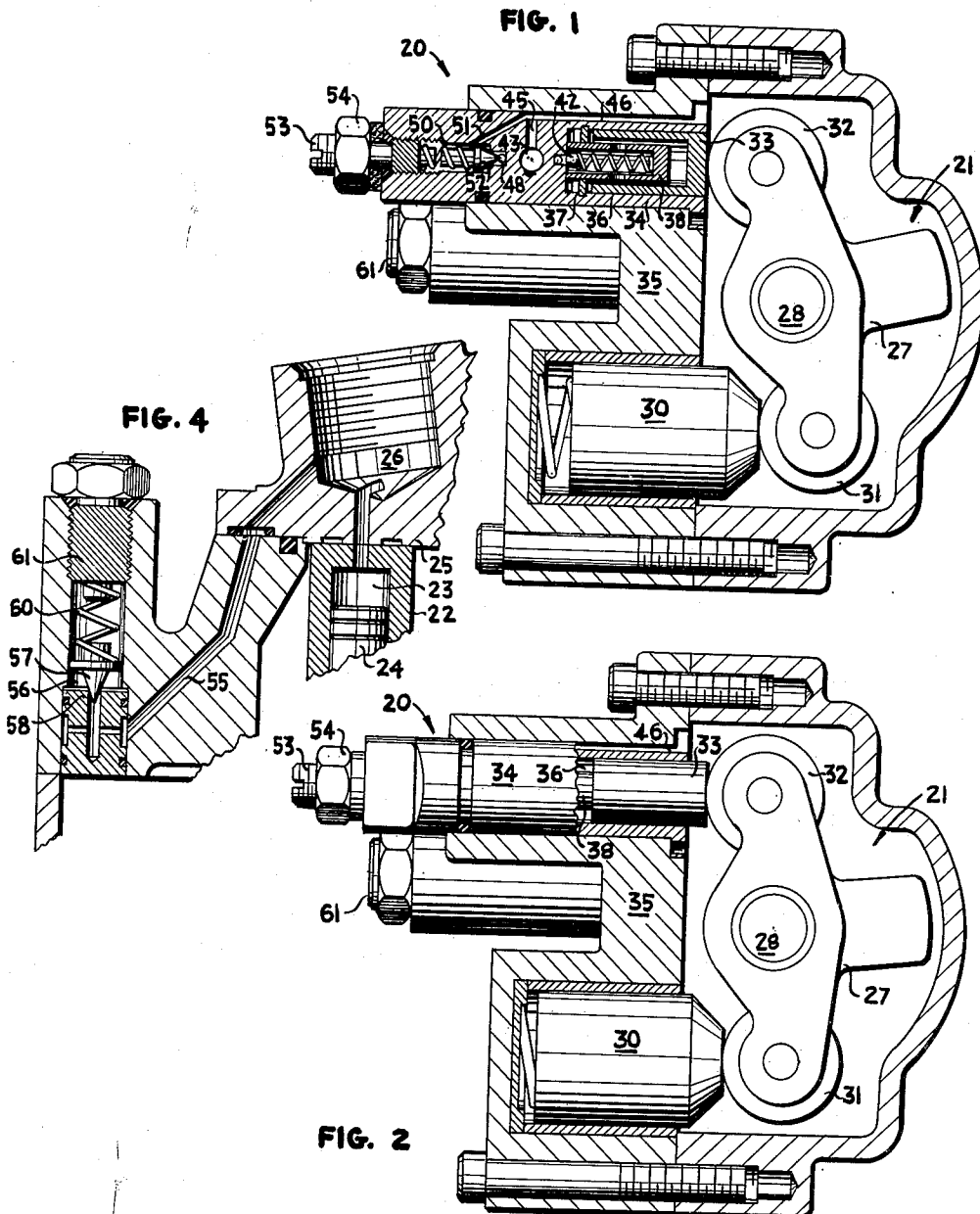
E. L. SHAW ET AL

2,735,374

PUMP COMPENSATOR

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3 Sheets-Sheet 1



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3 Sheets-Sheet 2

FIG. 3

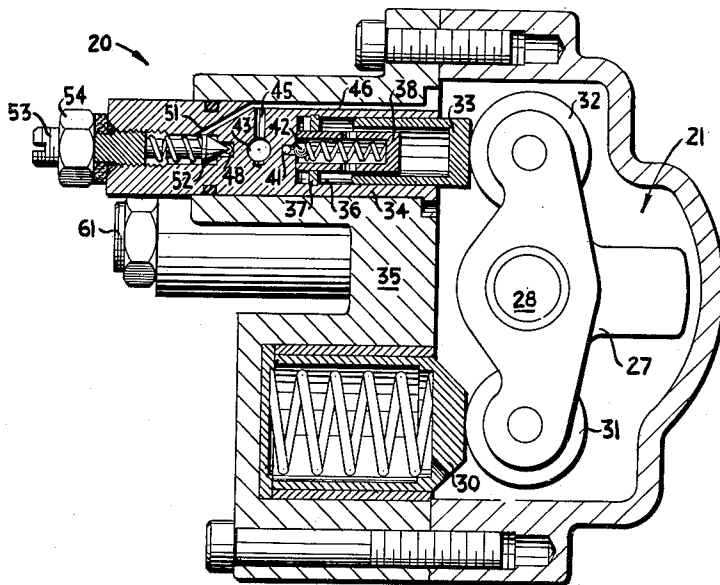


FIG. 5

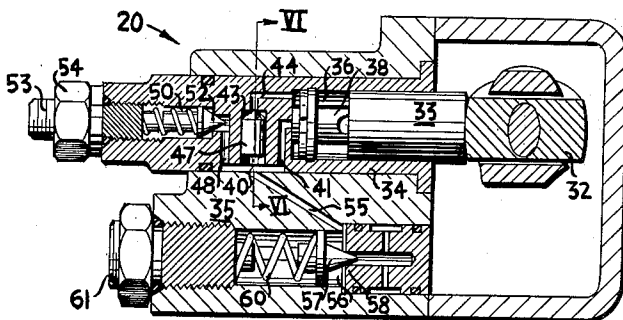
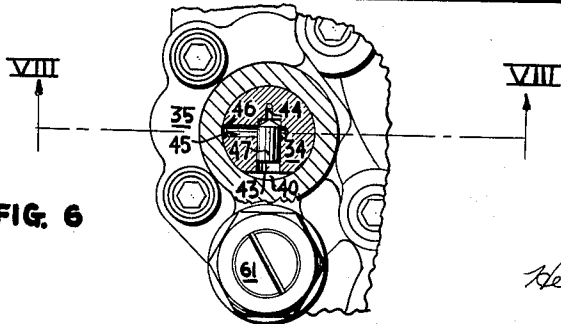


FIG. 6



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3 Sheets-Sheet 3

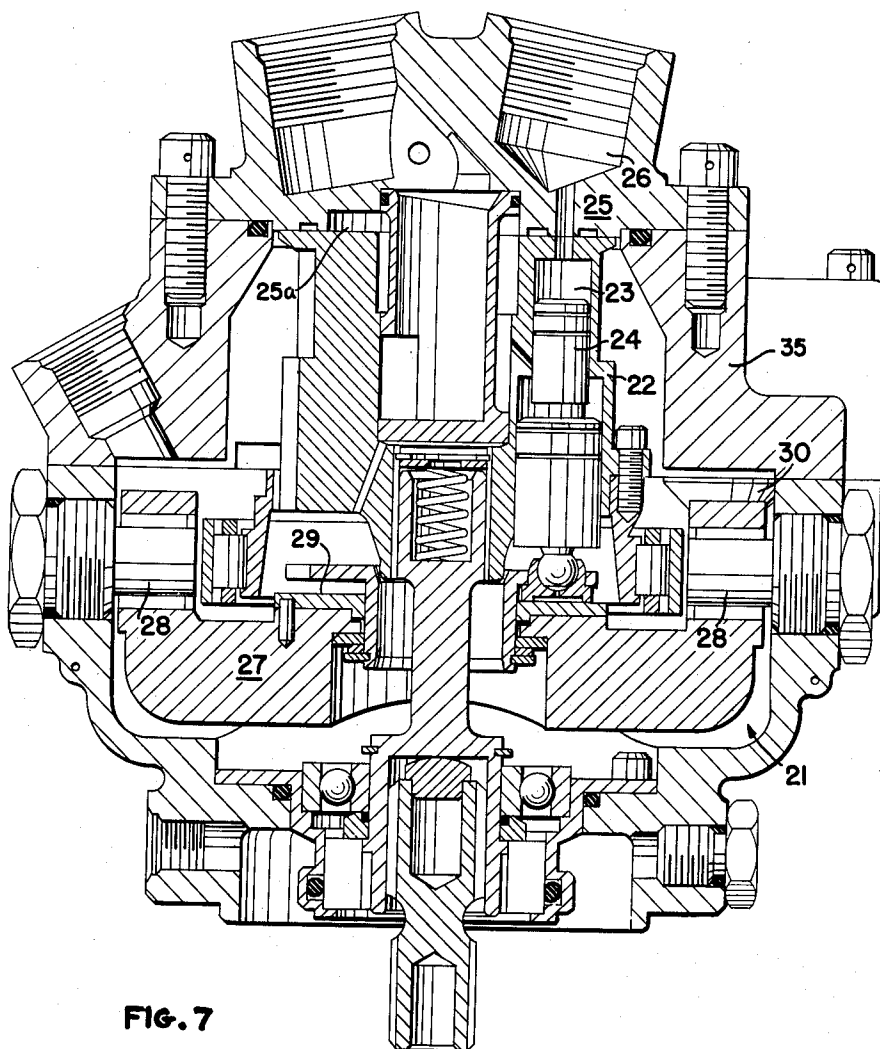


FIG. 7

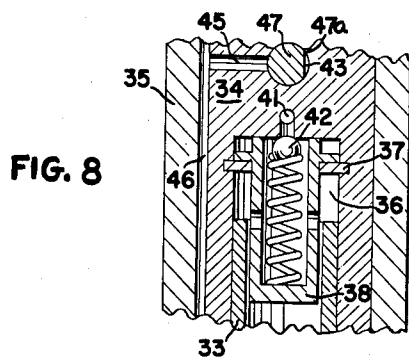


FIG. 8

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1

2,735,374

PUMP COMPENSATOR

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8 Claims. (Cl. 103—162)

This invention relates to control devices for variable volume hydraulic pumps.

An object of the invention is to provide a control mechanism which will permit the pump to deliver a maximum volume until a predetermined pressure is reached then reduce the volume to only that which is required to maintain the predetermined pressure.

Another object of the invention is to provide a pressure compensator for a variable volume pump which is responsive to fluid pressure developed by the pump, when that pressure reaches a predetermined value, to start to move the volume varying mechanism to reduce the volume and continue to move such mechanism as the pressure increases until the pump delivers only the volume necessary to maintain a maximum pressure just slightly higher than the predetermined pressure at which movement of the volume varying mechanism was started.

A still further object of the invention is to provide a pressure compensator which will operate rapidly to reduce the volume when a predetermined maximum pressure is reached, the mechanism also being operative to cause the volume varying mechanism to quickly return to full volume position when a demand for fluid occurs in the system served by the pump.

Another object of the invention is to provide a pressure compensator for a variable volume pump, the compensator having a pressure responsive valve which is operative when the fluid delivered by the pump reaches a predetermined pressure to admit fluid under pressure to a pressure responsive piston which serves to move the volume varying mechanism of the pump in a direction to reduce the volume of fluid delivered by the pump, a second pressure responsive valve being provided to control the rate of return of the pressure responsive piston toward a full volume position after the movement of the volume varying mechanism has served to reduce the volume and a demand for additional fluid is made upon the pump.

Another object of the invention is to provide a variable volume pump with a pressure responsive device for moving the volume varying mechanism, a hydraulic connection being provided between the pressure responsive means and an outlet of the pump, a pressure responsive valve being disposed in such hydraulic connection to govern the flow of fluid under pressure therethrough, a second pressure responsive valve having a differential piston being provided to control exhaust flow from the pressure responsive mechanism which serves to actuate the volume varying means.

Another object is to provide a mechanism of the type mentioned in the preceding paragraphs with a relief valve for establishing communication between the hydraulic connection and exhaust when the fluid in the hydraulic connection is subjected to sudden pressure surges.

An object of this invention is to provide a pressure

2

compensator for a variable volume hydraulic pump which compensator will function to cause the pump to deliver a maximum volume of fluid until a predetermined pressure is reached then swiftly and surely reduce the volume as the pressure increases until only sufficient fluid is pumped to maintain a predetermined maximum pressure, the compensator being so constructed and operated that the difference between the pressure at which the volume reduction is started and the desired maximum will be as little as possible and the action of the compensator in moving the volume varying mechanism of the pump will be smooth and without over-travel or oscillation frequently denominated in the trade as "hunting."

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings wherein a preferred form of embodiment of the invention is clearly shown.

In the drawings:

Fig. 1 is a detail sectional view taken through a pressure compensator, formed in accordance with the present invention, in assembled relationship with the volume varying mechanism of a hydraulic pump;

Fig. 2 is a similar view with parts shown in different positions of movement;

Fig. 3 is also a similar view showing the volume varying mechanism in a minimum volume position;

Fig. 4 is a detail sectional view taken through a portion of the pump casing showing a passage from the pump outlet to a control valve disposed in such passage;

Fig. 5 is a sectional view showing the hydraulic connection between the passage illustrated in Fig. 4 and the pressure responsive volume changing mechanism;

Fig. 6 is a detail sectional view taken through a portion of the compensator on the plane indicated by the line VI—VI of Fig. 5;

Fig. 7 is a longitudinal sectional view taken through a pump to which the pressure compensator, formed in accordance with the present invention is applied; and

Fig. 8 is a detail sectional view taken through a portion of the pressure compensator on the plane indicated by the line VIII—VIII of Fig. 6.

Referring more particularly to the drawings, the numeral 20 designates the pressure compensator in its entirety. This pressure compensator may be applied to pumps of various types but, for purposes of illustration, it is shown in the present drawings as applied to an axial piston pump, the compensator serving to actuate the volume varying mechanism, indicated generally by the numeral 21, of such pump. The pump includes a cylinder barrel 22 (see Figs. 4 and 7) in which cylinders 23 are formed for the slidable reception of pistons 24. As is usual in pumps of this character, the cylinder barrel moves relative to a port plate 25 or other valving surface and, as the cylinder barrel moves, the pistons 24 are reciprocated by a cam plate 29, in the cylinders 23 to transfer fluid from an inlet port 25A to an outlet port 26, this port being connected with the pressure section of a hydraulic system. In the event the flow of fluid in the system is opposed in any manner, pressure will be generated on the fluid in the port 26. The pressure compensator, forming the subject matter of this invention, is designed to vary the volume of the pump to control the pressure generated by the pump.

This operation is performed through the movement of a device hereinafter termed a yoke 27. This yoke is disposed for pivotal movement around an axis 28, the yoke carrying the cam 29 employed to impart reciprocatory movement to the pistons 24 when the cylinder

barrel 22 revolves. The angular relation of the cam is changed from a maximum volume position, when the hanger is in the position shown in Fig. 1, to a minimum or zero volume position as indicated in Fig. 3. In some instances, the hanger is capable of movement beyond the position shown in Fig. 3, in which case fluid may be withdrawn from the outlet port 26 by the pistons 24 and the pressure on such fluid will then be reduced. The pump is provided with a spring pressed plunger 30 which serves to urge the hanger toward the maximum volume position, the plunger engaging a roller 31 carried by the yoke 27 on the opposite side of the pivotal axis 28 from a second roller 32 which is engaged by the piston 33 of the pressure compensator. This piston 33 is disposed for movement in a cylinder 34 mounted in the casing 35 of the pump.

The cylinder 34 has a piston chamber 36 formed therein for the reception of the piston 33. When the hanger is moved by the plunger 30, the piston 33 will be moved into the chamber 36 until it engages a retaining ring 37 positioned in the chamber. This retaining ring, in addition to serving as a stop for the piston 33, also serves to retain a valve shell 38 in the chamber 36. The cylinder 34 has one side relieved, as disclosed in Figs. 5 and 6, to provide, in cooperation with the casing 35, a pocket 40 for the reception of fluid. The cylinder 34 is also provided with a passage 41 which extends from the pocket 40 to the inner end of the chamber 36. A ball type check valve 42 is disposed within the valve shell 38 and is urged into engagement with the surface of the end wall around the passage 41 to prevent the flow of fluid from the chamber 36 to the pocket 40 through the passage 41.

The cylinder 34 is also provided with a bore 43 which extends from the pocket 40 transversely into the cylinder 34 and communicates at its inner end with a passage 44 leading to the inner end of the chamber 36. A second passage 45 extends from the side of the bore 43 adjacent the inner end thereof to a groove 46 formed externally in the cylinder 34 and extending longitudinally thereof, this passage extending to the interior of the casing 35. This casing is connected in any suitable manner with the low pressure or exhaust section of the hydraulic system. The juncture between the bore 43 and the passage 44 forms a seat for engagement by a piston valve 47, this valve serving, when in a seated condition, to prevent the flow of fluid from the piston chamber 36 to the exhaust passage 46.

It will be noted that, when the piston valve 47 is seated, the valve end thereof is exposed to the pressure in the passage 44 and piston chamber 36. The other end of the piston valve is exposed to the pressure in pocket 40. In one operating model of the device shown herein, the relation of the areas of piston valve 47 exposed to pressure tending to move it in opposite directions is 3 to 1, the larger area being exposed to the pressure in pocket 40. As shown in Fig. 5, this pocket is also connected with a passage 48 which leads to a relief valve chamber 50, this chamber being connected by another passage 51, as shown in Figs. 1 and 3, to the exhaust passage 46. The chamber 50 has a valve seat surrounding the end of passage 48, the seat being engaged by a spring pressed poppet valve 52. This valve is of the conical type and may be adjusted by turning screw 53, the position of the screw being maintained by a locknut 54. It will be obvious that valve 52 will be responsive to pressure in pocket 40 determined by the setting of screw 53 to move to an open position to permit fluid under pressure to flow from the pocket 40 to exhaust.

Fluid under pressure is conducted from the outlet port 26 of the pump through a passage 55 see Fig. 4, to the pocket 40. The passage 55 communicates at an intermediate point with a chamber 56 containing a direct acting pressure responsive valve 57. This valve is also of the conical poppet type and is urged toward a seat 58 formed in the passage 55, by a coil spring 60, the tension

of this spring being varied through the adjustment of a screw 61. This screw is used to vary the pressure at which the compensator causes the volume of the pump to be reduced and consequently the maximum pressure developed by the pump. The force of the spring 60 is calculated to hold the valve 57 closed until a predetermined pressure for example 2700 p. s. i. is developed in the pump outlet port 26. When this pressure is reached, valve 57 will start to move away from the seat to permit limited fluid flow through passage 55 to pocket 40. This fluid will be under a pressure equal to the difference between that necessary to overcome the force exerted by the spring 60, i. e. 2700 p. s. i. and the pressure in the pump outlet port. This fluid under the reduced pressure will supplement the force of the spring 60 tending to close the valve 57. After passing the valve 57, the fluid will flow to the pocket 40 and through passage 41 to the interior of piston chamber 36. The fluid will also be applied to the large end of the piston valve 47 moving this element toward the inner end of the bore 43 and closing passage 44. Movement of the piston valve in this direction will take place due to the differential in areas exposed to the pressure in the pocket 40 and passage 44. As long as the pressure in these sections remains substantially the same or the pressure on the large end predominates, piston valve 47 will remain seated preventing communication between the inner end of the piston chamber 36 and exhaust. The pressure obtaining in pocket 40 will also be applied to the relief valve 52. The spring 50, however, will hold this valve in a closed position until the pressure in pocket 40 reaches a predetermined value determined by the setting of the valve spring adjusting screw 53.

As long as the pressure on the fluid being delivered by the pump is substantially lower than the pressure determined by the setting of spring 60, the spring pressed plunger 30 will hold the yoke 27 in position to cause the pump to deliver the maximum volume. When the pressure in the delivery port 26 reaches a value determined by spring 60, valve 57 will be moved in opposition to the spring 60 to permit fluid under pressure to flow through passage 55 to the pocket 40. As previously described, this fluid pressure will be admitted through passage 41 to the inner end of the piston chamber 36. Since the pressure in pocket 40 holds piston valve 47 closed, the fluid pressure will be confined in the piston chamber 36. When the pressure increases sufficiently, piston 33 will move in an outward direction in piston chamber 36 causing the yoke 27 to pivot about the axis 28 and move the piston reciprocating cam 29 toward a zero volume position. This movement will continue as the pressure in the outlet of the pump increases, continued movement of the yoke causing a corresponding reduction in the volume of fluid delivered by the pump. In all hydraulic pumps, a certain amount of leakage occurs and the pump must deliver enough volume to replace this leakage if the pressure is to be maintained. As the yoke 27 moves toward a zero volume position, it will approach the point at which the pump will deliver only sufficient volume to maintain the pressure and compensate for the leakage.

One of the objects of this invention is to provide a control mechanism which will cause the volume varying mechanism of the pump to be stable in its operation. In other words, it is desired to cause the pump to deliver full volume until a predetermined pressure is reached then reduce the volume to that necessary to maintain the pressure and make up for any leakage. It is desired to cause the volume varying mechanism to move rapidly but to avoid overtravel and to avoid reciprocation or an action known in the trade as "hunting."

The relief valve 52 has been provided to permit the escape of fluid from pocket 40 when the pressure therein exceeds a predetermined value which it may do even before the output of the pump can be reduced, because

of the inertia of the volume changing mechanism. The escape of fluid past relief valve 52 after the volume changing mechanism has been moved to the position in which the predetermined pressure is maintained tends to stabilize the compensator and limit the overtravel. In this manner, the hunting action will be avoided.

In the event the pressure outlet or portion of the system into which the pump discharges is blocked, the pressure will surge rapidly upward. This sudden pressure increase will be transmitted through passage 55 to the pocket 40. It will be applied to the compensator piston 33 and also to the relief valve 52. Due to the inertia of the yoke 27 and the resistance offered by the spring pressed piston 30, the compensator piston 33 will be prevented from moving too suddenly and relief valve 52 will open permitting the excess pressure to be exhausted through passage 46. When the pressure falls below the setting of the spring for valve 52, this valve will close confining the remaining pressure fluid in the pocket 40 and piston chamber 36. The piston 33 is prevented from returning to its retracted position too suddenly by the fluid which is confined in the inner end of the piston chamber 36 by the piston valve 47. This valve will remain closed until the pressure in pocket 40 decreases to approximately one-third, when the valve is constructed as illustrated, that of the pressure in the piston chamber 36.

As long as the pressure for which the spring 60 has been set exists in the outlet port 26 of the pump, the compensator piston 33 will hold the yoke 27 in a minimum volume position, that is, the position necessary to cause the pump to deliver sufficient fluid to maintain pressure and replace leakage. When the pressure in port 26 falls below the desired maximum pressure, however, valve 57 will be seated preventing the flow of fluid pressure through passage 55. When fluid pressure ceases to flow through passage 41 to the piston chamber 36, check valve 42 will close confining the fluid under pressure in the inner end of the piston chamber 36.

In the construction of the piston of valve 47, the external diameter thereof is made slightly less than the diameter of bore 43 or the valve may be provided with a flattened portion 47A as shown in Fig. 8 so that fluid may bleed past the piston of valve 47 from the pocket 40 to the exhaust passages 45 and 46. It will be seen that, after valve 57 closes, fluid between this valve and the check valve 42 will be under pressure. This pressure will be quickly dissipated, however, by the seepage of fluid past the piston of valve 47. After the pressure behind valve 47 drops enough, the fluid pressure in chamber 36 and passage 44 communicating therewith will be sufficient to move piston valve 47 to an open position. Fluid may then flow from chamber 36 to exhaust permitting piston 33 to be retracted or moved back into chamber 36 by spring pressed plunger 30.

It will be obvious to anyone familiar with the science of hydraulics that all of the passages, chambers, and pockets will be full of hydraulic fluid at all times and that pressure on such fluids may rapidly increase and diminish without an excessive volume of fluid flow. It has previously been pointed out that fluid may seep past piston valve 47. This seepage may be, for example, a matter of a few drops during a relatively long period of time yet the seepage is sufficient to permit a substantial reduction in pressure in the pocket 40 when fluid flow thereto through passage 55 is discontinued. It will be observed from the drawings that, when valve 57 closes, the fluid in chambers 56 and 40 and the passages communicating therewith will be under pressure but, since no fluid is then being supplied to these zones, the pressure may be quickly dissipated. By providing the check valve at the inner end of the piston chamber 36, the fluid in this chamber and passage 44 leading therefrom will be under pressure due to the action of the spring pressed plunger 30 which tends to force piston 33 into

the chamber 36. The spring for piston 30 is so calculated that the volume varying mechanism will be moved from maximum volume position to minimum volume position by the differential in pressure between the maximum pressure desired and the pressure at which valve 57 will first start to open. Partial variations in this differential will cause proportionate movements of the mechanism. This pressure is employed to open the exhaust valve 47 to permit the quick return of piston 33 when pressure in the outlet of the pump is decreased below the maximum desired.

While the form of embodiment of the present invention as herein disclosed constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

We claim:

1. In a fluid energy translating device of the type having a casing with inlet and outlet ports, a cylinder barrel in said casing, said cylinder barrel having piston chambers alternately communicating with said ports, pistons disposed for reciprocation in said piston chambers and adjustable means in said casing for controlling the movement of said pistons; pressure responsive means for adjusting said piston movement controlling means comprising means on said casing forming a compensator piston chamber; a compensator piston disposed for reciprocation in said chamber and engaging said adjustable means; passage means connecting the outlet port and said compensator piston chamber; an unbalanced pressure responsive valve in said passage to control fluid flow there-through; an exhaust passage leading from said compensator piston chamber; a differential piston valve controlling the flow of fluid through said exhaust passage, the larger area of said piston valve being exposed to fluid pressure in said passage in advance of said compensator piston chamber to urge said differential piston valve toward exhaust passage closing position; and a restricted passage connecting said passage means at the larger area of said differential piston valve and exhaust.

2. In a fluid energy translating device of the type having a casing with inlet and outlet ports, a cylinder barrel in said casing, said cylinder barrel having piston chambers alternately communicating with said ports, pistons disposed for reciprocation in said piston chambers and adjustable means in said casing for controlling the movement of said pistons; pressure responsive means for adjusting said piston movement controlling means comprising means on said casing forming a compensator piston chamber; a compensator piston disposed for reciprocation in said chamber and engaging said adjustable means; a passage extending from said outlet port to said compensator piston chamber; an unbalanced pressure responsive valve in said passage to control fluid flow from said outlet port to said compensator piston chamber; an exhaust passage extending from said compensator piston chamber; a differential piston valve in said casing to control fluid flow through said exhaust passage, the larger area of said piston valve being exposed to the pressure in said first-mentioned passage between said pressure responsive valve and said compensator piston chamber and the smaller area of said piston valve being exposed to the pressure in said compensator piston chamber; and a relief valve in parallel relation with said differential piston valve and responsive to predetermined pressure in said first-mentioned passage between said pressure responsive valve and said compensator piston chamber to connect said first-mentioned passage to exhaust.

3. In a fluid energy translating device of the type having a casing with inlet and outlet ports, a cylinder barrel in said casing, said cylinder barrel having piston chambers alternately communicating with said ports, pistons disposed for reciprocation in said piston chambers and adjustable means in said casing for controlling the movement of said pistons; pressure responsive means for adjusting said piston movement controlling means compris-

ing means on said casing forming a compensator piston chamber; a compensator piston disposed for reciprocation in said chamber and engaging said adjustable means; a passage extending from said outlet port to said compensator piston chamber; a direct operating pressure responsive valve in said passage to control fluid flow from said outlet port to said compensator piston chamber; a check valve in said passage to prevent flow from said compensator piston chamber back into said passage; an exhaust passage extending from said compensator piston chamber; a valve in said exhaust passage responsive to pressure in the first-mentioned passage between said first-mentioned pressure responsive valve and said compensator piston chamber to control fluid flow through said exhaust passage; a second exhaust passage communicating with the first-mentioned passage in advance of said compensator piston chamber; and a second pressure responsive valve in said second exhaust passage to control fluid flow therethrough.

4. A fluid energy translating device of the variable displacement type comprising a casing having high and low pressure ports; a shiftable member for varying the displacement of the device; control mechanism for said shiftable member having a pressure responsive actuating element in engagement therewith; resilient means urging said shiftable member and element toward maximum volume position; passage means hydraulically connecting said pressure responsive actuating element with said high pressure port; a direct acting pressure responsive valve means in said passage means to control fluid flow therethrough; check valve means in said passage preventing reverse flow from said element through said passage; means in said casing forming an exhaust passage extending from said pressure responsive actuating element; and a differential pressure valve in said passage exposed and responsive to predetermined pressure differences at opposite sides of said check valve means to control fluid through said exhaust passage.

5. A fluid pressure energy translating device of the variable displacement type comprising a casing having high and low pressure ports a shiftable member associated with said casing for varying the displacement of the device; control mechanism for said shiftable member having a pressure responsive actuating element in engagement therewith resilient means urging said shiftable member and element toward maximum volume position; passage means hydraulically connecting said pressure responsive actuating element with said high pressure port; a valve in said passage means to control fluid flow therethrough, said valve having an area exposed to the pressure in said outlet port and tending to move said valve toward open position; resilient means tending to urge said valve toward a closed position; a check valve between said pressure responsive actuating element and said passage means to prevent reverse flow through said passage means; means forming an exhaust passage extending from said pressure responsive actuating element; exhaust valve means in said exhaust passage, said exhaust valve means having a large area exposed to the pressure in the first-mentioned passage means and tending to urge said exhaust valve means toward a closed position and a smaller area exposed to the pressure acting on said pressure responsive element and tending to open said exhaust valve; and a bleed passage extending around said exhaust valve from the first-mentioned passage to exhaust to reduce the force applied to the large area of said exhaust valve after the first-mentioned valve closes.

6. A fluid pressure energy translating device of the variable displacement type comprising a casing having high and low pressure ports; a shiftable member for varying the displacement of the device; control mechanism for said shiftable member having a pressure responsive actuating element in engagement therewith; resilient means urging said shiftable member and element toward maximum volume position; passage means hydraulically con-

necting said pressure responsive actuating element with said high pressure port; a poppet type valve in said passage means to control fluid flow therethrough; said valve having an area exposed to the pressure in said high pressure port and tending to open said valve; adjustable resilient means tending to urge said valve toward a closed position; a check valve between said pressure responsive actuating element and said passage means to prevent reverse flow through said passage means; means forming an exhaust passage extending from said pressure responsive actuating element; a piston operated exhaust valve controlling fluid flow through said exhaust passage, said exhaust valve piston having a first area exposed to the pressure acting on said pressure responsive actuating element and tending to open said exhaust valve and a second area substantially greater than said first area exposed to the pressure in said first-mentioned passage and tending to close said exhaust valve; and means forming a bleed passage around said piston valve from the second area to exhaust to reduce the force applied to such second area when said poppet type valve is closed.

7. A fluid pressure energy translating device of the variable displacement type comprising a casing having high and low pressure ports; a shiftable member for varying the displacement of the device; control mechanism for said shiftable member having a pressure responsive actuating element in engagement therewith; resilient means urging said shiftable member and element toward maximum volume position; passage means hydraulically connecting said pressure responsive actuating element with said high pressure port; a poppet type valve in said passage means to control fluid flow therethrough, said valve having an area exposed to the pressure in said high-pressure port and tending to open said valve; adjustable resilient means tending to urge said valve toward a closed position; a check valve between said pressure responsive actuating element and said passage means to prevent reverse flow through said passage means; means forming an exhaust passage extending from said pressure responsive actuating element; a piston operated exhaust valve controlling fluid flow through said exhaust passage, said exhaust valve piston having a first area exposed to the pressure acting on said pressure responsive actuating element and tending to open said exhaust valve and a second area substantially greater than said first area exposed to the pressure in said first-mentioned passage and tending to close said exhaust valve; means forming a bleed passage around said piston valve from the second area to exhaust to reduce the force applied to said second area when said poppet type valve is closed; and a relief valve for limiting the pressure in said first mentioned passage means.

8. A fluid pressure energy translating device of the variable displacement type comprising a casing having high and low pressure ports; a shiftable member for varying the displacement of the device; control mechanism for said shiftable member having a pressure responsive actuating element in engagement therewith; resilient means urging said shiftable member and element toward maximum volume position; passage means hydraulically connecting said pressure responsive actuating element with said high pressure port; a poppet type valve in said passage means to control fluid flow therethrough, said valve having an area exposed to the pressures in said high pressure port tending to open said valve; adjustable resilient means tending to urge said valve toward a closed position; a check valve between said pressure responsive actuating element and said passage means to prevent reverse flow through said passage means; means forming an exhaust passage extending from said pressure responsive actuating elements; a piston operated exhaust valve controlling fluid flow through said exhaust passage, said exhaust valve piston having a first area exposed to the pressure acting on said pressure responsive actuating element and tending to open said exhaust valve and a second area substantially greater than said first area exposed to the pressure in said first-mentioned passage and

tending to close said exhaust valve; means forming a bleed passage extending around said piston valve from the second area to exhaust to reduce the force applied to said second area when said poppet type valve is closed; and a pressure responsive valve between said first-mentioned passage means and exhaust, said last-mentioned pressure responsive valve being opened by a lower pressure than the valve in said first-mentioned passage.

5

References Cited in the file of this patent

UNITED STATES PATENTS

2,333,422	Higgins -----	Nov. 2, 1943
2,403,371	Ifield et al. -----	July 2, 1946
2,405,006	Ashton -----	July 30, 1946

FOREIGN PATENTS

557,480	Great Britain -----	Nov. 23, 1943
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