Aug. 31, 1948. E. A. ROCKWELL 2,448,467

POWER INTENSIFIER-TWO STAGE-UNIFORM FLOW

Filed Oct. 16, 1944 2 Sheets-Sheet 1

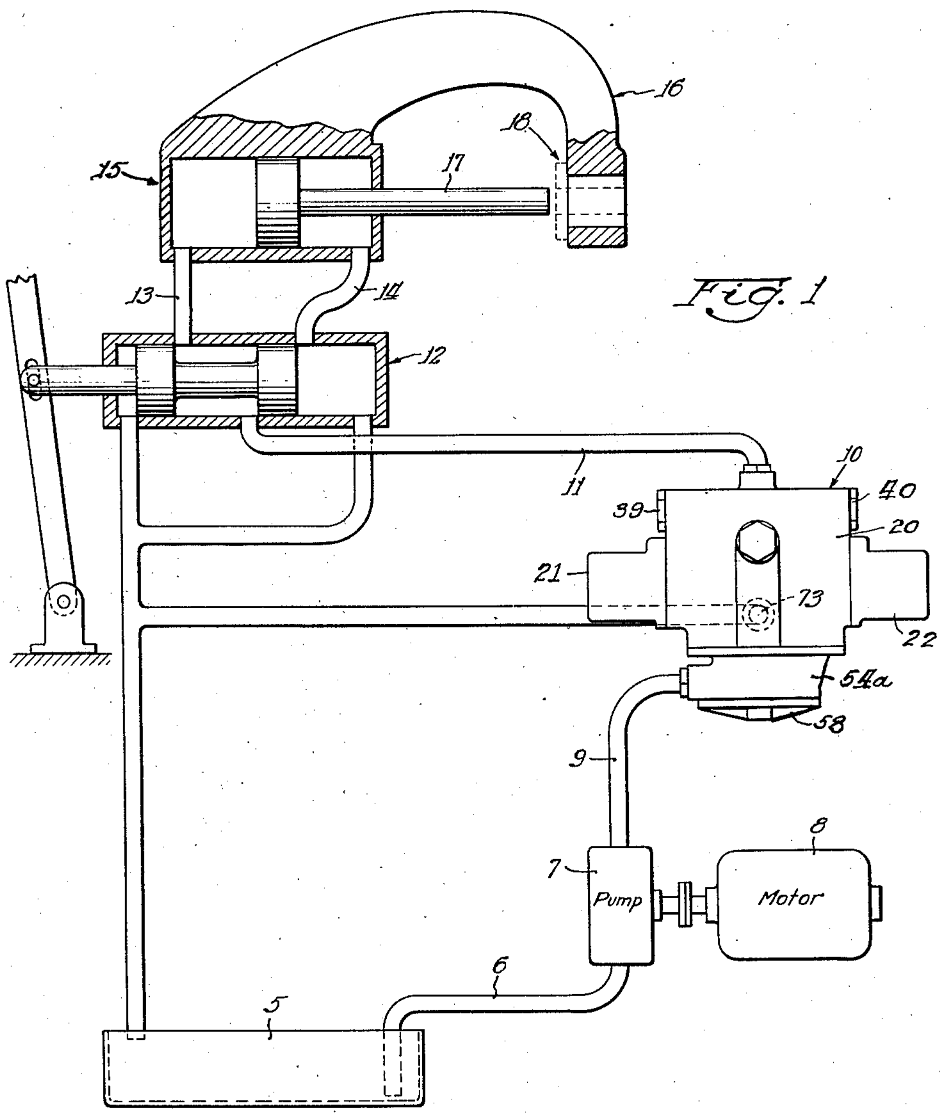


Fig. I

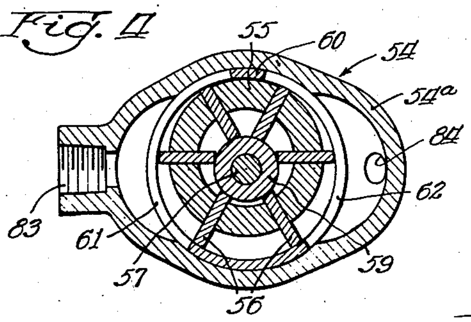


Fig. II

Inventor:
Edward A. Rockwell
By Edward C. Fritzkamp
Atty.

POWER INTENSIFIER-TWO STAGE-UNIFORM FLOW

Filed Oct. 16, 1944 2 Sheets-Sheet 2

Fig. 2

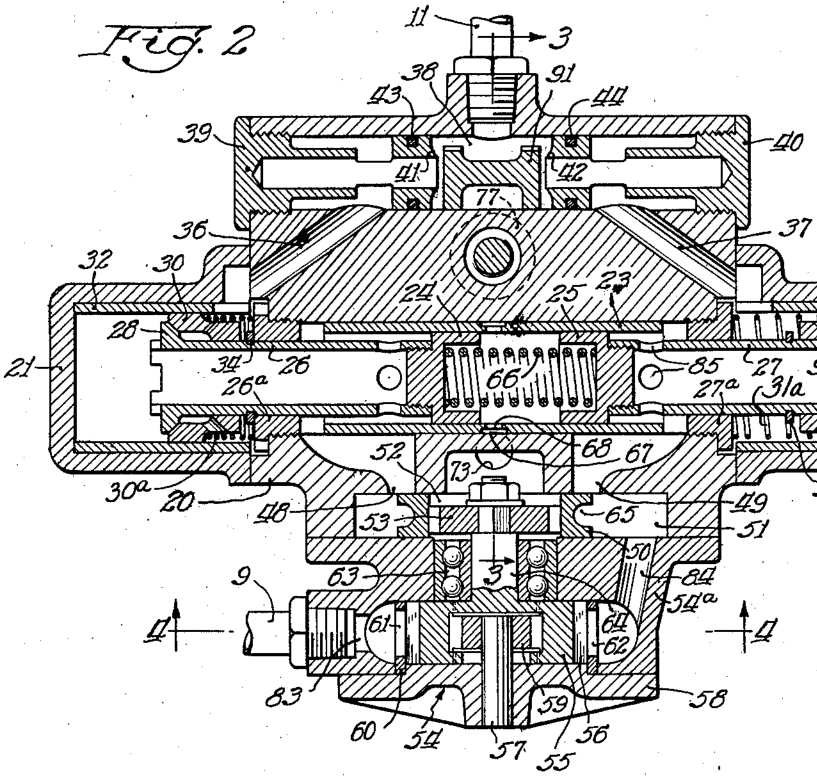
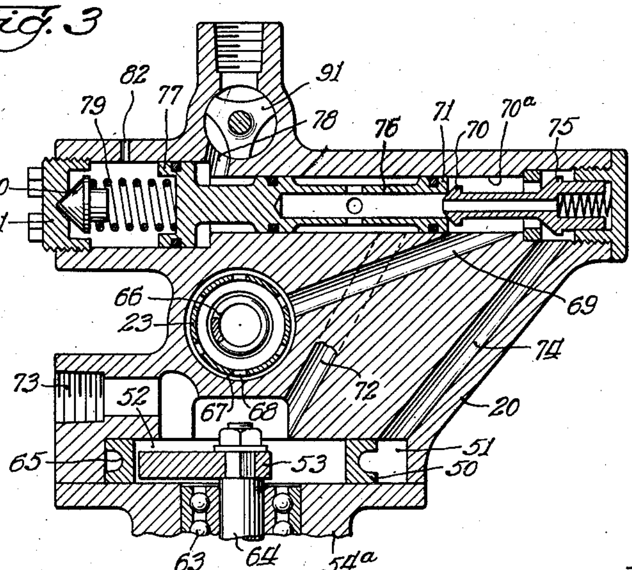


Fig. 3



Inventor:
Edward A. Rockwell
By Edward C. Fitzhaugh
Atty.

Patented Aug. 31, 1948

2,448,467

UNITED STATES PATENT OFFICE

2,448,467

POWER INTENSIFIER TWO STAGE UNIFORM FLOW

Edward A. Rockwell, Cleveland, Ohio, assignor, by mesne assignments, to Borg-Warner Corporation, Chicago, Ill., a corporation of Illinois

Application October 16, 1944, Serial No. 558,929

6 Claims. (Cl. 103—49)

1

This invention relates to a hydraulic system wherein there is a requirement for rapid operation of a work cylinder at low pressure and a slower operation of the work cylinder at a higher pressure.

My invention provides a continuous flow pressure converter for increasing the output pressures from a constant source of relatively low pressure fluid which will initially pass the fluid through the converter to the output at a capacity and pressure of the fluid being pumped; to automatically increase the pressure when the pressure of the output reaches a predetermined value; and to return the excess volume of low-pressure fluid which has been used to do the necessary work to produce the higher pressure fluid flow.

More specifically, my invention contemplates the use of a multiple piston intensifier pump, which will be relatively free of pumping impulses in the reciprocation of the pumping members, so as to secure a continuous uniform flow.

An object of my invention is to provide a uniformly rotating valve operating device which is driven by the flow of the fluid passing through the converter.

A further object of my invention is to provide a valve device with a negative lap so that both pistons, for a short duration, will feed at the same time so as to avoid undesirable impulses from the output of the converter.

Still another object of my invention is to provide a pressure-responsive valve for cutting in and out the operation of the converter at a predetermined level of pressure and to provide a double check valve in connection with the distribution of the output flow of the converter.

A further object is to provide an arrangement wherein a spring return is used for the plungers for filling and exhausting the intensifier cylinders so as to avoid the use of the usual inlet and outlet check valves wherein it is not necessary to have an independent intake stroke of the intensifier plungers.

A further object is to employ a vane motor for operating the valve mechanism so as to avoid any dead-center problem in the operation of a valve means for the operation of the plungers.

A further object of the invention is to provide an externally adjustable valve device for predetermining the pressure at which the intensified pressure is cut in. More specifically, the valve device is arranged to trap hydraulic fluid on the breathing side of the reciprocating plungers to prevent their operation until the valve device

2

vents the same so as to permit the reciprocation of the intensifier pistons.

It has heretofore been proposed to provide a plurality of positive displacement pumps driven at the same speed in combination with a circuit and an automatically controlled valve to furnish a variable flow of fluid so as to minimize the loss of power otherwise required by a single pump. It is one of the objects of this invention to accomplish a similar saving of power as could be obtained by a high and a low pressure pump, with the advantage that the present invention provides the second stage operation, that is to say, the high pressure operation, with a piston pump having a high volumetric efficiency. Another advantage in the present invention is that different high pressure units having any desired cut-in point and input to output ratio can be used effectively in a wide variety of applications.

These and other objects and features of this invention will become apparent from the following description when taken together with the accompanying drawings in which:

Fig. 1 is a schematic arrangement showing the application of the present invention to the hydraulic system of a hydraulic press;

Fig. 2 is a vertical section through the high and low pressure device for controlling the hydraulic system, the view showing the flow of the fluid from the input to the output of the control device;

Fig. 3 is a vertical transverse section, taken along the plane of line 3—3 on Fig. 2, looking in the direction of the arrows, showing the exhaust port and control valve, as well as the passageways leading thereto;

Fig. 4 is a horizontal section, taken along the plane of line 4—4 on Fig. 1, looking in the direction of the arrows, showing the vane motor for operating the valve.

The drawings are to be understood as being more or less of a schematic character for the purpose of disclosing a typical or preferred embodiment of my invention, and in these drawings like reference characters identify the same parts in the different views.

The hydraulic system shown in Fig. 1 comprises a supply reservoir **5** with an intake connection **6** to a pump **7** that is driven by an electric motor **8**, the pump in turn having a connection **9** to the intensifier and control unit **10**, that embodies the instrumentalities of the present invention. There is an output connection **11** from the unit to a manually operable four-way valve **12**, having connections **13** and **14** leading to opposite ends of a work cylinder 15 that may comprise a portion of any suitable mechanism. The example of such mechanism shown in Fig. 1 is a hydraulic press 16 wherein the reciprocating plunger 17 is actuated by the fluid in the cylinder 15, approaches the work or press bed 18 rapidly under the action of low pressure, applies a higher pressure while performing the work, and then withdraws from the work at high speed under the action of low pressure. In a typical arrangement such as shown, the cylinder 15 and piston 17 may be said to function in the manner of a Servo work motor or Servo-generator.

The control device 10 shown in detail in Fig. 2 comprises a main body portion 20 with two opposed cylinder heads 21 and 22 attached thereto by suitable flanges with screws (not shown), holding the same in place in axial alignment with the longitudinal bore in body 20. There is a sleeve tightly pressed into the bore of the main body portion, forming a cylinder 23 for two opposed intensifier motor pistons 24 and 25. Screw threaded onto each intensifier piston are tubular stems 26 and 27 with tapered valves 28 and 29 formed at their outer extremities. These valves 28 and 29 are adapted to seat against the heads of the respective pressure intensifier pistons 30 and 31, having light springs 30*a* and 31*a* for this purpose, respectively, which are guided for movement and have a sliding fit within sleeves 32 and 33 that are pressed into the opposed cylinder heads 21 and 22. On the outside of said tubular stems 26 andn 27 there are snap rings 34 and 35 limiting the motion of the pistons 30 and 31 in their reciprocation relative to the reciprocable tubular connections or stems 26 and 27. There are suitable guide bushings 26*a* and 27*a* for said hollow stem members which have a close fit therewith to be effective for preventing any appreciable flow of high-pressure fluid back to the low-pressure side of the bushings.

Oblique outlet passageways 36 and 37 are drilled in the main body portion 20, leading upwardly from the longitudinal bore into an elongated chamber 38 the ends of which are defined by two hollow bushings 39 and 40 screwed thereinto and forming seats 41 and 42 at their inner ends for the double check valve 91. At their inner ends these bushings have annular seals 43 and 44 for preventing leakage from the outlets 36 and 37.

Two spaced ports 48 and 49 are preferably cored into the body portion next to the longitudinal bore, said ports leading to the respectvie intensifier pistons. A rectangular D-valve 50 is adapted to slide back and forth in a valve cavity 51 extending past the ports 48 and 49, the movement of the valve being adapted to admit pressure to one of the intensifier pistons, while at the same time exhausting pressure fluid from the other intensifier piston. In Fig. 2 this valve 50 is shown slightly open to both ports and the respective intensifier pistons. There is a slot 52 through this valve 50 that is of proper width to accommodate a rotatable cam member 53 as shown in Fig. 2 and said slot has a length that permits the complete throw of the cam. The exhaust port 73, which is shown in Fig. 3, also communicates with the cam slot 52.

The valve-operating assembly 54 comprises a casting 54*a* having a mating flange which is secured by screws, not shown, to the main body portion 20 beneath the valve chamber. The driving elements, which are best shown in Fig. 4, include a vane motor 55 with six radial blades 56 and a center pin 57 arrangement fixed to a closure plate 58 which has provided thereon a rolling collar 59 for positioning the blades. There is a cylindrical sleeve or cage 60 in the rotor housing 54 which has slotted inlet and outlet ports 61 and 62 at radially opposite regions, as shown in Fig. 4. An anti-friction bearing 63 provides a journal for the motor shaft 64 and eccentric valve-operating cam 53. The rectangular sliding D-valve 50 has annular channels 65 extending around its periphery for the purpose of permitting the flow of the fluid so as to substantially balance the pressures on the valve.

As seen in Fig. 2, a spring 66 is interposed between and is adapted to normally urge the pistons in their opposed extended positions. Also it will be seen that the sleeve 23 for the intensifier pistons 24 and 25 within the main bore of the body portion 20 has an annular groove or recess 67 at its mid region that communicates through holes 68 with the centers of the pistons 24 and 25 to alow the breathing of the pistons while they are reciprocating. There is a radial communicating passage 69 from the annular recess 67 to one side of a valve member 70 in a bored valve chamber 70*a*, which, as shown in Fig. 3, is between the main bore 20 and the check valve chamber 38 and is arranged with its axis transverse to the axes of said bore and chamber. On the other side of this valve member 70 to the left thereof (Fig. 3), there is a tubular valve seat 71 slidable in bore 70*a* which when open provides a communicating passage 72 through the tubular valve seat member back to the exhaust port 73, this passageway being shown partly in dotted lines in Fig. 3.

There is an oblique pressure port 74 leading from the valve chamber 51 to the right-hand side of a balanced valve 75, so that when open, this port 74 will deliver the pressure fluid to the passageway 69 leading into the center of the cylinder 23 between the two intensifier motor pistons 24 and 25. A tubular valve seat plunger 76 reciprocable in bore 70*a* has a piston head portion 77, which at one side has communication through a port 78 with the center of the chamber for double check valve 91, and on its other side said plunger is engaged by a spring 79 for normally holding the breather valve 70 seated and the balanced pressure valve 75 open. The relative positions of the elements are illustrated in Fig. 3. The outer end of this spring 79 engages a conical spring retained member 80 that is pressed against an adjusting plug 81 screwed into the end of bore 70*a* for adjusting the tension of the spring to determine the pressure at which the breather valve 70 will be held open. The portion of the chamber in which this spring operates which is between the piston head 77 and the plug 81 is vented to the atmosphere as at 82.

In the operation of the device, the pump 7 which is of suitable capacity and pressure for low pressure operation is connected to the inlet 83 leading to the vane motor or actuator and the pressure fluid will flow initially from the pump through the main valve bore and cylinder 23 and in its course will actuate the motor, which in turn will revolve the cam shaft 64 in a counterclockwise direction. This causes the cam 53 to move the D-valve 50 to the left and will continue to hold the D-valve port 49 open until the motor has turned 180°. During this time, fluid pressure from the main pump 7 will flow through a motor outlet passage 84 into the D-valve chamber 51 and through the cored passageway 49 into the right hand intensifier piston cylinder **33** through radial holes **85** in the plunger stem **27**, and then through the center of the stem. The flow of the fluid pushes the valve piston head **31** away from the valve **29** permitting the fluid to move past the seat and out through the series of holes **90** in the head of the piston to the high-pressure side of the intensifier piston. From the high-pressure side the fluid will flow through the outlet passageway **37** to the chamber of double check valve **91** and in so doing the fluid will pass through the central portion of seat member **42**, for discharge into outlet connection **11** leading by way of control valve **12** to the work cylinder **15**.

During the succeeding rotation of the valve motor through its next 180° of its cycle of operation, the other or left-hand piston **30** will allow a similar flow of the fluid. This alternate operation effects a shuttling movement of the double check valve **91** back and forth in its chamber. When the valve passes through a dead-center position, it will be seen that pressure fluid can flow through both ports or passageways **48** and **49** which are partly open as best shown in Fig. 2 thus practically eliminating pulsations. During the initial operation, when the flow is directly through the device, the return spring **66** will urge both pistons outwardly, and although there are alternate pressures applied to opposite sides of the intensifier pistons **30** and **31** tending to reciprocate them, the stiffness of the return spring will tend to prevent them from returning. In addition, the trapped or locked hydraulic fluid between the pistons which results from the fact that the balanced valve **75** in Fig. 3 is held open permitting the flow of high pressure fluid to pass through its valve seat and passageway **69** into the portion of the cylinder between the two intensifier motor pistons **24** and **25** is effective to lock the intensifier pistons against movement. During this time, the breather valve **70** is held closed by reason of the fact that the spring **79** biasing the control valve stem **76** is stronger than the output pressure acting on the valve actuating control plunger. Whenever there is sufficient resistance to the flow of the fluid in the output, then the pressure will build up sufficiently to allow the balanced pressure valve **75** to seat and the breather valve **70** will open. Both pistons will then start moving toward each other, but immediately the D-valve **50** (Fig. 2) will close off the port to the left, and the right-hand one will continue to move toward the center, and then immediately following this, the exhaust port **73** will open to the left-hand piston on stem **26**, and the spring **66** will move said left-hand piston back to the end of its stroke, leaving all the passageways up to the double check valve filled with the pressure fluid.

The volume of the valve motor **54** is selected so as to meter the required amount of fluid determined by the stroke of the piston assemblies. It will be seen that the pressure of the fluid from the pump **7**, after passing through the valve motor, will act on a low pressure inner piston area and this piston will in turn act on the head of its main piston. Thus the fluid on the high pressure side of the main piston will be intensified by reason of the smaller effective area and volume on the outlet side of the main piston, this being defined by a difference in the areas of the main piston head and the area of the tubular valve stem, as compared to the pressures applied, which are effective on the inner intensifier piston and the outlet main piston area.

Now, it will be seen that as these pistons reciprocate one of them will remain completely extended while the other is being pulled in during its intensifying stroke and for a short interval, as when its valve is in its negative lap position on dead center, this piston which has remained stationary will start to move before the other piston has completed its stroke. Thus both pistons will permit fluid to flow through the double check valve at the same time for a short initial interval, and thereafter one or the other of the pistons will pick up the flow and allow the valve to shuttle back and forth in a manner which will dampen out the pulsations of high-pressure fluid. When one or the other of the exhaust valves is open, the spring will return the piston and in so doing will exhaust the excess fluid to the return outlet.

While I have described my invention in detail with respect to a detailed embodiment thereof, I wish it to be understood that changes and modifications can be made therein without departing from the spirit of the same.

I claim:

1. In a continuous flow pressure converter comprising a housing, differential plunger means reciprocably mounted in said housing, a valve device having intake and exhaust ports leading to said differential plunger means for supplying pressure fluid thereto and effect the reciprocation thereof, rotatable means for shifting said valve device, a fluid motor acting on said rotatable means to shift said valve device, said motor having a selected volumetric capacity for imparting a predetermined stroke to said differential plunger means, whereby all of the fluid passing through said motor is transferred to act on the differential plunger means for the reciprocation thereof.

2. In a continuous flow pressure converter as defined in claim 1, wherein the fluid motor is a vane type motor.

3. In a continuous flow pressure converter comprising a housing, intensifier means including separate differential plungers reciprocably mounted in said housing, outlet valves leading from said plungers, a valve device having intake and exhaust ports leading to said plungers for controlling the reciprocation thereof, said valve device having means for shifting the same to alternately provide power and exhaust strokes for the respective plungers, said valve providing a short phase during the shifting thereof for effecting power strokes of the plungers whereby there will be a momentarily short period of overlapping of the power strokes during the continuous operation of the intensifier means so that a continuous rate of flow will result from the reciprocation of the plungers.

4. In a continuous flow pressure converter comprising a housing, intensifier means including two opposing differential plungers reciprocably mounted in said housing, a double check valve having communication with the respective plungers, and a valve device having intake and exhaust ports leading to the plungers for controlling the separate reciprocation thereof, said valve device having means for shifting the same to provide alternate power and exhaust strokes for the respective plungers, said valve device providing a short phase during the shifting thereof for effecting power strokes for the plungers whereby there will be a momentarily short period of overlapping of the power strokes during the continuous operation of the intensifier means so that a

continuous rate of flow will result from the reciprocation of the plungers.

5. In a continuous flow pressure converter comprising a housing, intensifier means including two axially aligned opposed differential plungers reciprocably mounted in said housing, a double check valve communicating with each of the plungers, a valve device having intake and exhaust ports leading to the plungers for controlling the reciprocatory movement thereof, said valve device having means for shifting the same to effect alternate power and exhaust strokes for the respective plungers, said valve device providing a momentarily short phase during the shifting thereof for effecting power strokes for the plungers whereby there will be a short period of overlapping of the power strokes during the continuous operation of the intensifier so that a continuous rate of flow will result from the reciprocation of the plungers, and a return spring between said opposed differential plungers for providing exhaust strokes thereof.

6. In a continuous flow pressure converter comprising a housing member having a bore therethrough, cylinders at the ends of said bore, opposed motor pistons guided for movement in said

housing bore, spring means urging said motor pistons in opposite directions, hollow stems for said motor pistons extending through bushings in the housing bore, intensifier pistons at the outer extremities of said stems adapted to reciprocate in said cylinders, inlet ports leading to the respective pistons, a communicating passageway leading through said hollow stem members to the extremity of the piston head for supplying pressure fluid to said motor pistons in opposition to said spring means, a one-way valve device controlling the flow through said pistons to permit the return of said pistons to their outer extremity of travel, a check valve, and passages exterior of said piston and one-way valve device and leading through said check valve to terminate in an outlet connection in said housing member.

EDWARD A. ROCKWELL.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,336,446	Tucker, et al.	Dec. 7, 1943