June 18, 1940. A. E. HAMBLY 2,204,854

PUMPING APPARATUS

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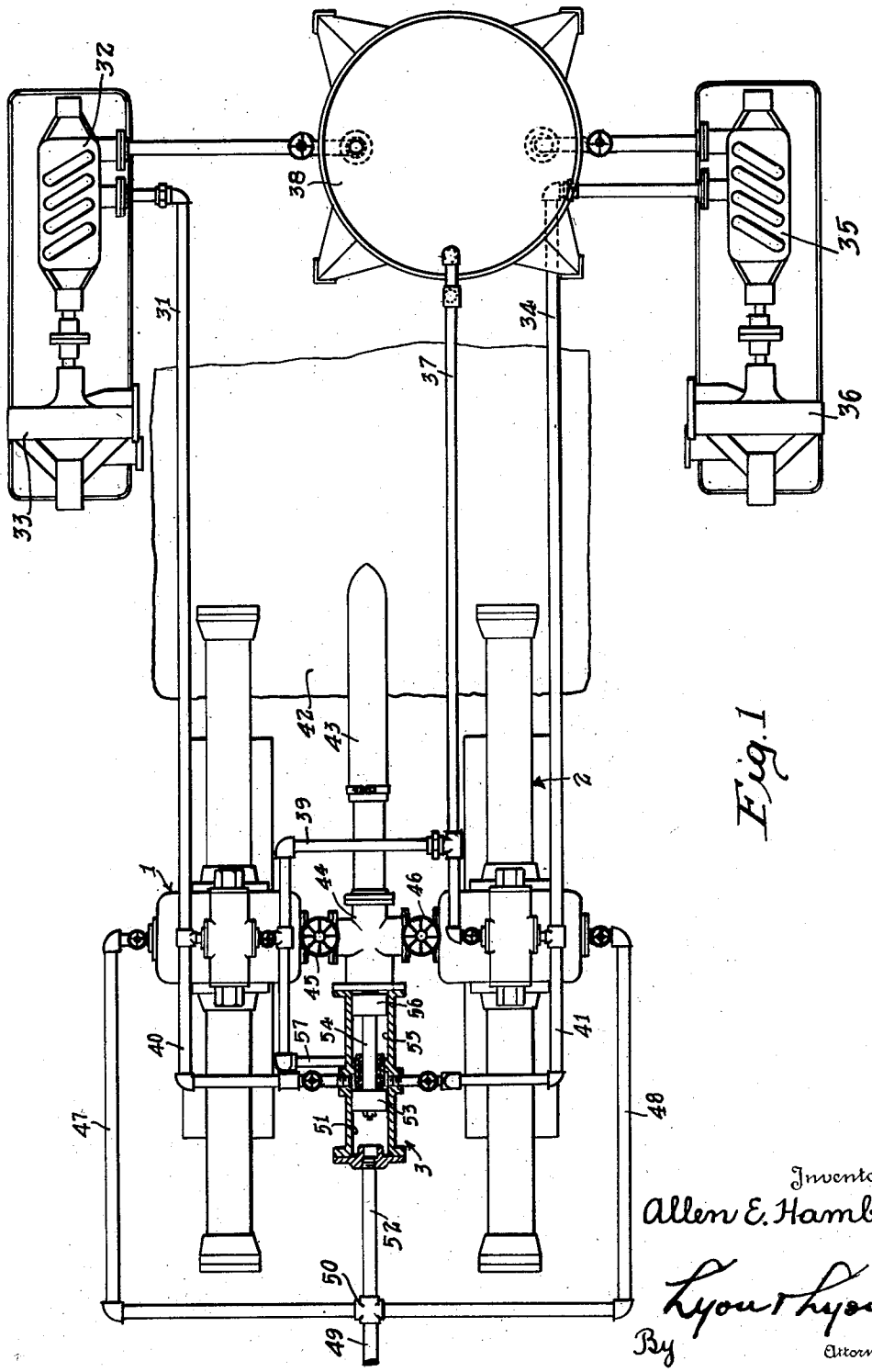


Fig. 1

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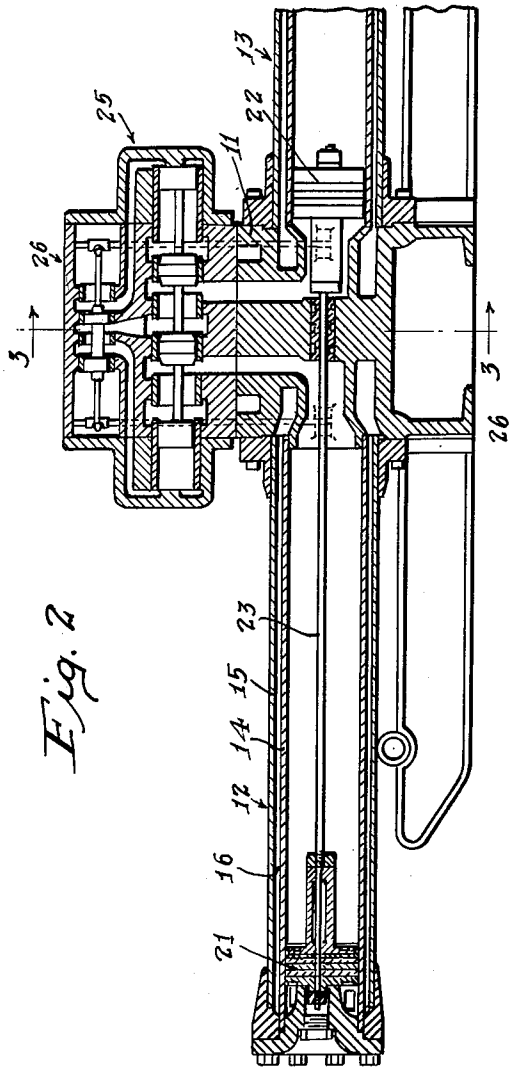


Fig. 2

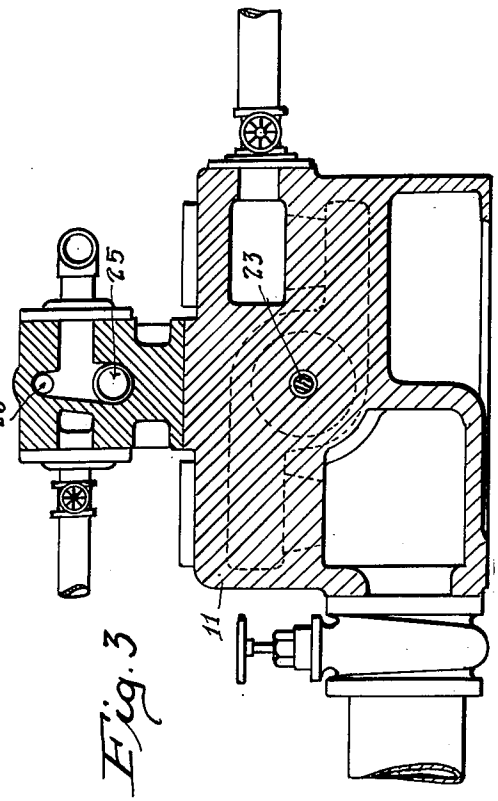


Fig. 3

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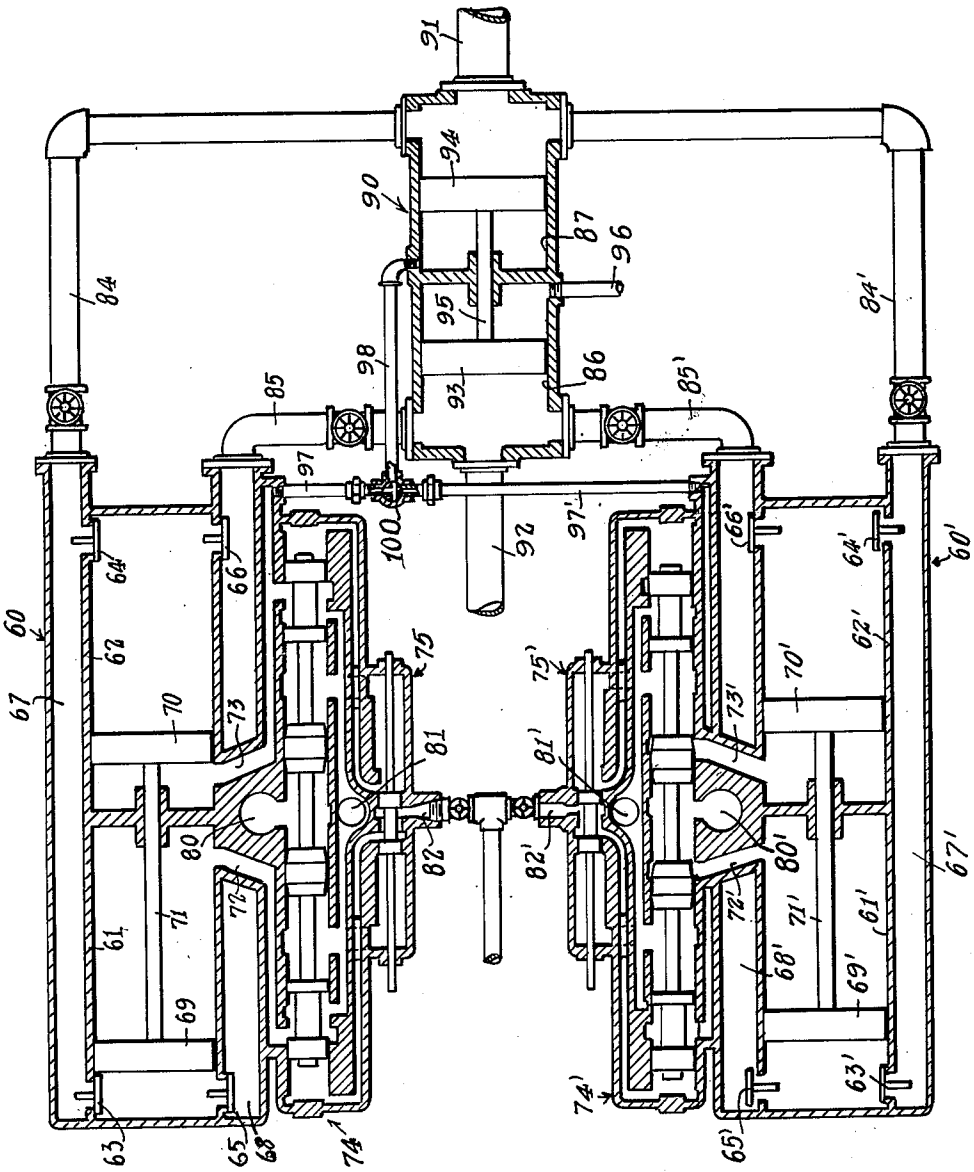


Fig. 4

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Patented June 18, 1940 2,204,854

UNITED STATES PATENT OFFICE

2,204,854

PUMPING APPARATUS

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Application July 18, 1938, Serial No. 219,799

12 Claims. (Cl. 103—52)

This invention relates generally to pumping apparatus, and particularly to a pumping system employing a plurality of simplex hydraulic pumps.

An object of the invention is to provide a simple and practicable pumping apparatus including a plurality of simplex pumps operated in parallel, capable of producing a continuous flow of fluid.

In the copending application of Aladar Hollander and Waldemar F. Mayer, Serial No. 197,140 filed March 21, 1938, for Pumping apparatus, and the copending application of Waldemar F. Mayer, Serial No. 197,142, filed March 21, 1938, for Pumping apparatus, there are disclosed several specific embodiments of simplex hydraulic pumps particularly adapted to circulate drilling mud during the drilling of deep wells by what is known as the rotary method. In each of the embodiments disclosed, the pump is of the simplex, double-acting type and one of the outstanding features thereof is the provision of a surge piston, actuated by the motive liquid which operates the pump, for continuing the discharge of pump liquid and the intake of motive liquid during reversal of the stroke of the pistons.

It is customary in well drilling practice to provide at least two mud pumps which may be connected in parallel when necessary, to furnish the required volume of mud. The pumps described in the above-mentioned applications are complete units in themselves, provision being made to continue the flow of discharge mud, as well as of motive liquid from each unit during reversal of the pistons in that unit. It is not always necessary, however, to provide surge means individual to each pump when a plurality of such pumps are connected in parallel, since each will function as a surge means for the other so long as the reversals are not simultaneous. In lieu of complex synchronizing mechanism for maintaining a plurality of such pumps in out-of-phase relationship, I propose to provide a single surge means serving two or more simplex pumps.

In one embodiment a surge device operable in response to a slight pressure drop in the discharge line, as described in the above-mentioned application Serial No. 197,140, may be connected to two or more pumps. In this case the surge means will operate only when all of the pumps reverse simultaneously, since otherwise one pump serves as a surge means for the one which is reversing. In another embodiment a controlled surge device similar to that described in the copending application Serial No. 197,142 may be connected to the mud suction and discharge lines of a plurality of pumps, being controlled, however, by only one of the pumps so as to function during reversal of the stroke of that pump. The latter will serve as surge means for the remaining pump or pumps, automatically speeding up momentarily during reversal of the latter. Connections may be provided whereby the surge means may be connected to any one of the pumps to permit operation thereof singly or in parallel with one or more additional pumps.

Other objects and advantages will be apparent from the following description, reference being had to the accompanying drawings, wherein:

Fig. 1 is a plan view of a complete pumping system embodying two hydraulic simplex pumps with a common surge means operable in response to pressure drop;

Fig. 2 is a central longitudinal vertical section through one of the pumps;

Fig. 3 is a central transverse vertical section taken on line 3—3 of Fig. 2; and

Fig. 4 is a schematic arrangement of an alternative construction embodying a controlled surge means.

Referring to Fig. 1, a pair of simplex hydraulic pumps 1 and 2 are disposed in parallel relation, on opposite sides of a surge device 3. The pumps are of identical construction and are generally similar to that described in the copending application Serial No. 197,140, and therefore, a brief description of one will suffice, reference being had to Figs. 2 and 3.

Secured to opposite sides of a central body 11 are aligned cylinders 12 and 13. Each cylinder comprises an inner cylinder 14 and an outer concentric sleeve 15 defining therebetween an annular passage 16 communicating at its outer end with the interior of the inner cylinder and at its inner end with a pump liquid passage in the central body. As described in detail in the aforementioned applications pump liquid suction and discharge valves are mounted in the central body in conjunction with each cylinder.

Pistons 21 and 22 secured to opposite ends of a piston rod 23 are reciprocable in the cylinders, being actuated by the alternate application of motive liquid directly to the inner faces of the pistons, under the control of a reversing valve 25. The latter is controlled by a pilot valve 26 mechanically actuated by the pistons as the latter approach the inner ends of their cylinders, all as described in the aforementioned applications.

Referring once more to Fig. 1, in the system illustrated therein each pump is supplied with

motive liquid from an individual centrifugal pump, pump 1 being connected by supply line 31 to a centrifugal pump 32 driven by a steam turbine 33, and pump 2 being connected by a supply line 34 to a centrifugal pump 35 driven by a steam turbine 36. A cross-connection is provided between the two supply lines by conduits 40 and 41 communicating with each other through the surge means 3. A common motive liquid discharge conduit 37 leads from pump 2 to a storage tank 38 and is connected to pump 1 by a branch conduit 39.

The system shown in Fig. 1 is particularly adapted to handling drilling mud at a well being drilled, recirculating the mud from a mud pit 42 down the drill pipe and back to the mud pit to remove cuttings from the well. A common suction line 43 extends from the mud pit to a cross-connection 44, from which connections are made at 45 and 46 to the suction inlets of the pumps 1 and 2. Mud is discharged under pressure from the pumps through discharge lines 47 and 48 which are connected to a common discharge line 49 at the cross-connection 50.

It will be apparent that with two simplex pumps connected to a common discharge line as described, there will be no pressure drop in the discharge during reversal of one of the pumps, provided the other pump does not reverse simultaneously. As such time the combined discharges of the two centrifugal pumps flow to one of the pumps, causing the pumping piston thereof to accelerate and double its discharge momentarily. However, in a pump of this type the piston speed is a function of several factors, such as the friction of the pistons, the amount of leakage across the pistons, etc., and without special synchronizing mechanism there is no assurance that any predetermined phase relationship would be maintained. Therefore, in order to assure continuous discharge, and to prevent water hammer in the motive liquid lines as the result of simultaneous reversal of both pumps, the surge device 3 is provided.

The surge device is similar to that described in the copending application Serial No. 197,140, differing therefrom only in the fact that the stroke has been doubled to permit it to take care of the simultaneous reversal of both pumps. A high pressure surge cylinder 51 has connection at its outer end with the mud discharge line 49 through a conduit 52, and at its inner end with the motive liquid branch conduits 40 and 41. A surge piston 53 in the cylinder is secured to a piston rod 54 of greater cross-sectional area than that of the piston rods 23 of the pumps. Although the unit pressure of the discharge mud is slightly less than that of the motive liquid, the ratio of piston areas on opposite sides of surge piston 53 is such that the total pressure exerted on the piston by the discharge mud slightly exceeds that exerted by the motive liquid on the opposed face of the piston. Consequently the piston is held retracted in the position indicated except when the mud pressure decreases a predetermined amount, whereupon the piston is urged outwardly to maintain such slightly reduced pressure.

The piston rod 54 extends through a stuffing box in the inner wall of the cylinder 51 and into a low pressure surge cylinder 55. A second piston 56 is secured to the inner end of the piston rod, dividing the cylinder 55 into a low pressure water chamber and a suction mud chamber. The latter is in open communication with the cross-connection 44 in the mud suction line, and the low pressure water chamber is connected to the motive liquid discharge lines 39 through a branch line 57. By this arrangement the flow of spent motive liquid from the pumps and of suction mud in the suction line 43 will be continued during simultaneous reversal of both pumps.

As indicated in Fig. 1, shut-off valves are provided at suitable points in the various lines so that either pump may be cut out and the other may operate singly with the surge device, as in the aforementioned application.

Referring now to the modification illustrated schematically in Fig. 4, this form of the invention embodies a pair of pumps 60 and 60' and a single controlled surge piston operating on the same principle as that of the first-described form in the aforementioned copending application of Waldemar F. Mayer, Serial No. 197,142. Inasmuch as the pumps themselves may be of a construction identical with that shown in Figs. 2 and 3 of this application, or as shown in Figs. 1 to 7 of application Serial No. 197,142 with the surge piston omitted, they have been illustrated schematically in Fig. 4 in order to simplify the description thereof. Each pump and its valve mechanism corresponds to the pump shown schematically in Figs. 8 to 11 of the above-mentioned application, and hence it is believed that a brief description of one pump will suffice for both, primed reference characters being employed to designate similar parts on the other pump.

A pair of aligned cylinders 61 and 62 are connectible through suction valves 63, 64 and discharge valves 65, 66 with a suction header 67 and a discharge header 68, respectively. A pair of pistons 69, 70, connected by a piston rod 71, are reciprocable in unison in the cylinders. Motive liquid is admitted alternately to the cylinders on the inner sides of the pistons through ports 72 and 73 under the control of a reversing valve generally designated 74, which in turn is controlled by a pilot valve 75 mechanically reversed by the pistons as they approach the inner end of their stroke. The construction of the main and pilot valves and their mode of operation are identical with that described in detail in application Ser. No. 197,142, and reference is made thereto in lieu of a repetition herein of a detailed description.

It will be sufficient to point out that motive liquid at relatively high pressure is admitted at 80 to the main valve, spent motive liquid being discharged at 81. A control liquid at medium pressure is admitted to the pilot valve at 82 to actuate the main valve and to control the actuation of the surge device.

Suction and discharge lines 84, 84', and 85, 85' for pump liquid extend respectively from the suction headers 67, 67' and discharge headers 68, 68' to the high pressure surge cylinder 86 and to the low pressure surge cylinder 87 of a common surge device generally designated 90. A common suction line 91 extends from the cylinder 87 to a source of pump liquid such as a mud pit, and a common discharge line 92 extends from the high pressure cylinder 86 to the point of use. High and low pressure surge pistons 93 and 94 are mounted in the cylinders 86 and 87, respectively, being connected by a piston rod 95. High pressure motive liquid, at the same pressure as that admitted to the main valve at 80, is constantly admitted to cylinder 86 on the inner side of piston 93 through conduit 96. Medium pressure control liquid is alternately admitted to and exhausted from the low pressure cylinder 87 on the inner

side of piston 94, under the control of the main reversing valve of one of the pumps.

As in the copending application Serial No. 197,142, the main reversing valve is so constructed that during the stroke of the main pistons control liquid is applied through conduits 97 and 98 to the inner face of the surge piston 94 to augment the pressure of the pump discharge applied to the outer face of surge piston 93, these combined pressures exceeding the motive liquid pressure exerted on the inner face of piston 93. The pistons 93 and 94 are thus held in their right-hand position, as viewed in Fig. 4, during the stroke of the main pistons 69, 70. During reversal of the main valve 74, however, the control liquid is exhausted from cylinder 87, allowing the higher motive liquid pressure exerted on the inner face of piston 93 to move the surge pistons to the left. The displacement from the cylinder 86 will compensate for the momentary interruption in displacement from the cylinders 61 and 62, and the flow of motive liquid into the surge cylinder will replace the flow to the main cylinders while the reversing valve is passing through the dead center position. After the valve has reversed, control liquid is again admitted to cylinder 87 to cause the surge pistons to return to their former position.

The mode of operation of pump 60 as described above is identical with that of the pump described in application Serial No. 197,142. In the present instance, however, another pump 60' is connected as described above, whereby the pump 60 functions as a surge means for pump 60'. During reversal of the latter the pistons 69 and 70 of pump 60 speed up momentarily because of the fact that the motive liquid which is normally divided between the two pumps is momentarily all directed to pump 60. It will be apparent, however, that pump 60' does not serve as a surge means for pump 60 during reversal of the latter, the surge device 90 performing this function. Accordingly, the time required for a complete cycle of pump 60 will be slightly less than that of pump 60', and the pistons 69 and 70 of pump 60 will be in a different position with each succeeding reversal of pump 60'. In order to provide for simultaneous reversal of both pumps, the stroke of the surge pistons is made approximately twice that of the surge pistons in the aforementioned copending application.

It will be observed that a control conduit 97' is provided extending from the main valve 74' of pump 60' to a three-way valve 100 at the intersection of conduits 97 and 98. In the position illustrated in Fig. 4, conduit 98 is connected to conduit 97 to put the surge device under the control of pump 60. By rotating the valve 100 through 180° the surge device will be controlled by pump 61', reversing the relationship of the two pumps. It will be understood that when both pumps are operating simultaneously, it is immaterial to which one the surge device is connected. By making it selectively connectible with either pump, however, either may be operated singly as a complete unit with the surge device. Suitable shut-off valves are provided wherever necessary to enable either pump to be cut out of service.

From the foregoing description of two preferred embodiments, it will be seen that material economies may be effected by eliminating one surge device when two pumps of the type described are connected in parallel, without sacrificing any of the advantages of two complete units. In both forms of the invention either pump may be cut out of service and the other pumps will function in a normal manner to deliver its rated capacity in a steady flow at steady pressure.

I claim:

1. Hydraulic pumping apparatus comprising a plurality of pumps, each of the type having a pair of cylinders and a piston in each cylinder with one face of each piston contacting motive liquid in one end of its associated cylinder and constituting a motor element and the other face contacting pump fluid in the other end of the cylinder and constituting a pumping element, the two pistons of each pump being interconnected for movement in unison, pump liquid suction and discharge connections to said other end of each cylinder, said discharge connections being interconnected, motive liquid inlet and outlet connections to said one end of each of said cylinders, the motive liquid inlet connections being interconnected, and a single surge means connected to said pumps, said surge means comprising a cylinder, a piston reciprocable therein, a connection between one end of said surge cylinder and said interconnected pump discharge connections and a connection between the other end of said surge cylinder and said interconnected motive liquid connections.

2. Hydraulic pumping apparatus as defined in claim 1, in which said surge means includes a second cylinder, a piston therein connected to said first-named surge piston, one end of said second cylinder being connected to said pump suction connections, and the other end of said second cylinder being connectible with said motive liquid outlet connections.

3. Apparatus as defined in claim 1, in which the piston area on the motive liquid side of said surge piston is reduced relative to the piston area on the pump discharge side thereof, whereby the full discharge pressure retains said surge piston at the motive liquid end of its cylinder, and said surge piston moves only in response to a drop in discharge pressure.

4. Hydraulic pumping apparatus comprising a plurality of pumps, each pump comprising a pair of main cylinders, a pair of interconnected main pistons reciprocable in each pair of cylinders, interconnected pump liquid suction connections and interconnected discharge connections to each of said pumps, interconnected inlet connections and interconnected exhaust connections for motive liquid to each of said pumps for reciprocating said pistons, and a single surge means connected to said pumps, said surge means comprising an auxiliary cylinder and a piston reciprocable therein, one end of said auxiliary cylinder being connected to said interconnected pump liquid discharge connections and the other end of said cylinder being connected to said interconnected motive liquid inlet connections, whereby said auxiliary piston is actuated by motive liquid to force pump liquid into said discharge connections.

5. Apparatus as defined in claim 4, in which said surge means includes a second auxiliary cylinder and a piston therein connected to said last-named piston, and a connection between one end of said auxiliary piston and said pump liquid suction connections.

6. Apparatus as defined in claim 4, in which the piston area on the motive liquid side of said surge piston is reduced relative to the piston area on the pump discharge side thereof, whereby the full discharge pressure retains said piston at the motive liquid end of its cylinder, and said piston

moves only in response to a drop in discharge pressure.

7. A hydraulic pumping apparatus comprising a plurality of pumps, each of the type having a pair of cylinders and a piston in each cylinder dividing the cylinder into a pump liquid chamber and a motive liquid chamber, one face of each piston contacting motive liquid and constituting a motor element, and the other face contacting pump liquid and constituting a pumping element, said two pistons of each pump being interconnected for movement in unison, pump liquid suction and discharge connections to the pump liquid chamber of each cylinder, said suction connections being interconnected and said discharge connections being interconnected, motive liquid inlet and outlet connections to the motive liquid compartment of each cylinder, the inlet connections being interconnected and the outlet connections being interconnected, and a single surge means actuated by said motive liquid and connected to said pump liquid discharge connections for maintaining continuous discharge of pump liquid during reversals of said pumps.

8. Apparatus as defined in claim 7, and including shut-off valves in said fluid connections whereby any one or more of said pumps may be operated with said surge means while one or more remain idle.

9. Apparatus as defined in claim 7, and including valve means individual to each pump for controlling the flow of motive liquid thereto, and control means for said surge means connected to one of said valve means for actuating said surge means in predetermined timed relation to the actuation of said one valve means.

10. Hydraulic pumping apparatus comprising a plurality of pumps, each pump comprising a pair of cylinders each having a piston therein dividing it into a pump liquid compartment at one end and a motive liquid compartment at the other end and means interconnecting the pistons of each pair for movement in unison, valve means individual to each pump for successively applying motive liquid to the motive liquid compartments and exhausting spent motive liquid therefrom, valve means for admitting pump liquid to and discharging pump liquid from the pump liquid compartment of each cylinder in response to movement of the piston therein, and common surge means for said pumps comprising an auxiliary cylinder having a piston therein dividing it into a pump liquid compartment and a motive liquid compartment, a connection between the pump liquid discharge of each of said pumps and the pump liquid compartment of said auxiliary cylinder, and a connection between the motive liquid inlet of each of said pumps and the motive liquid compartment of said auxiliary cylinder, whereby during out-of-phase operation of said pumps motive liquid flows from the inlet of one pump, during its reversal period, into the inlet of the other pump, and during simultaneous reversal of both pumps motive liquid flows from the inlets of both pumps to the motive liquid compartment of said auxiliary cylinder to move the piston therein in a direction to discharge pump liquid from the pump liquid compartment thereof.

11. Hydraulic pumping apparatus comprising a pair of pumps, each comprising a pair of cylinders and each cylinder having a piston therein dividing it into a pump liquid compartment at one end and a motive liquid compartment at the other end, means interconnecting the pistons in each pair of cylinders for movement in unison, valve means individual to each pump for successively applying motive liquid to the motive liquid compartment and exhausting spent motive liquid therefrom, valve means individual to each pump for admitting pump liquid to and discharging pump liquid from the pump liquid compartment of each cylinder in response to movement of the piston therein, and common surge means comprising a surge cylinder, a surge piston therein having opposed faces, one exposed to the common discharge from both of said pumps and the other exposed to motive liquid in communication with the motive liquid inlets of both pumps, said motive liquid normally exerting a greater force than said pump discharge liquid on said surge piston, means to apply an auxiliary control force to said surge piston to supplement the force of said pump discharge liquid thereon, and means actuated at the end of each stroke of the pistons of one of said pumps for releasing said auxiliary control force during the reversal of stroke of said one pump.

12. Hydraulic pumping apparatus as described in claim 11, in which said means to apply an auxiliary control force to said surge piston comprises an auxiliary pressure face on said surge piston, and a source of auxiliary pressure liquid, and said means for releasing said auxiliary control force comprises valve means actuated in predetermined time relation with the motive liquid valve means of said one pump for controlling said auxiliary pressure liquid.

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