March 30, 1954 | J. E. LUCAS | 2,673,525

PUMP

Filed May 27, 1949

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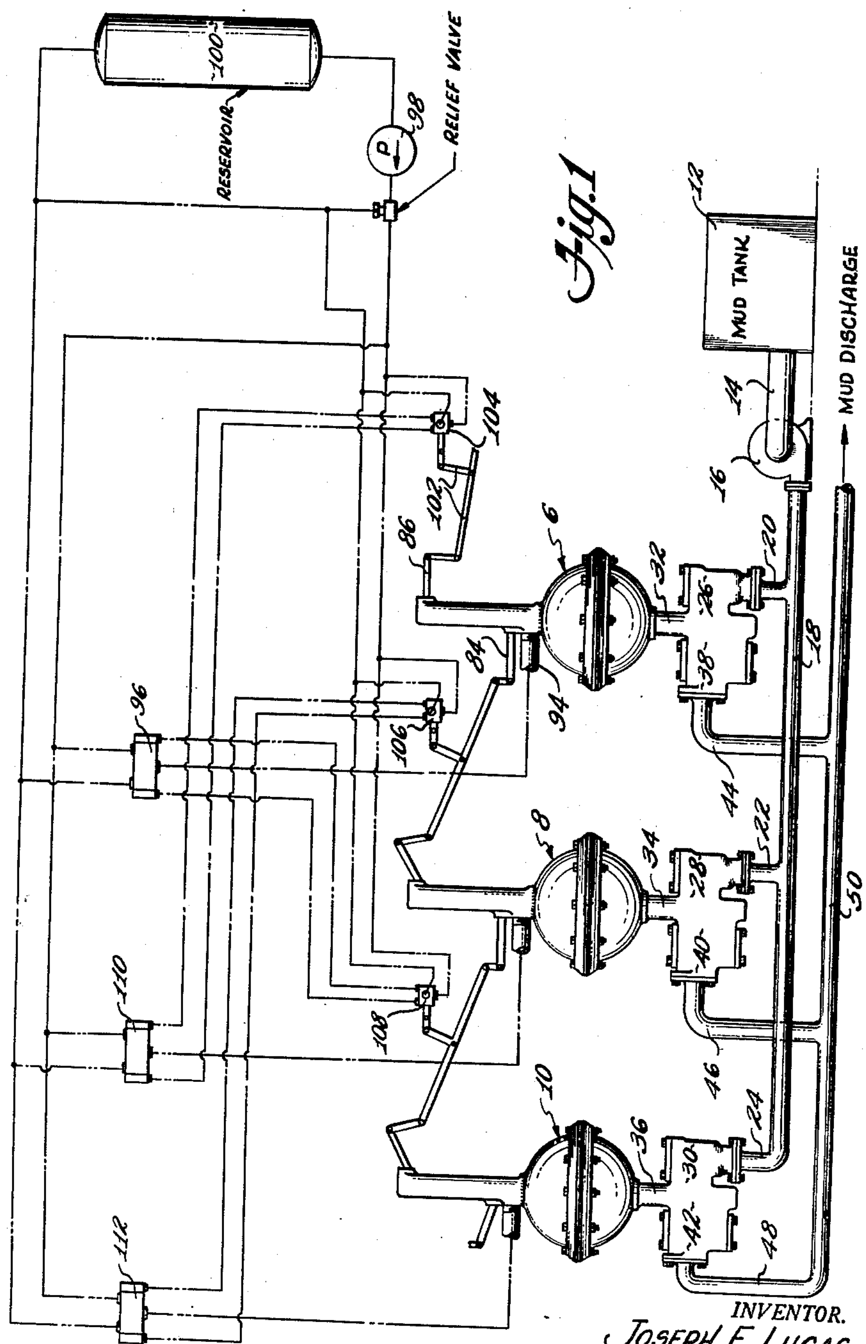

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2 Sheets-Sheet 2

Fig. 2

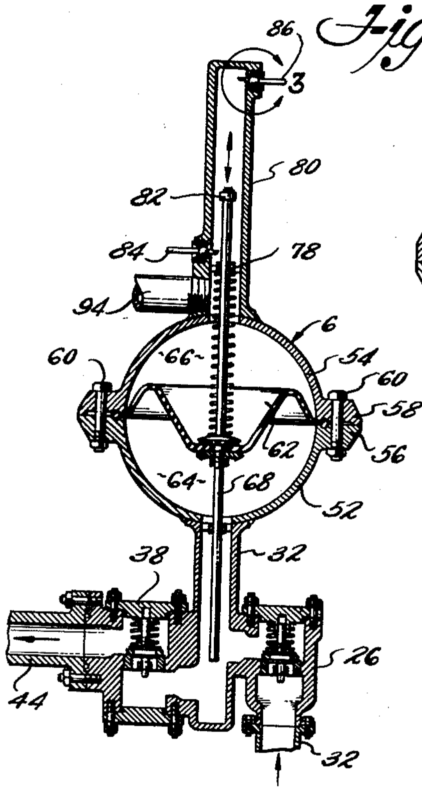


Fig. 4

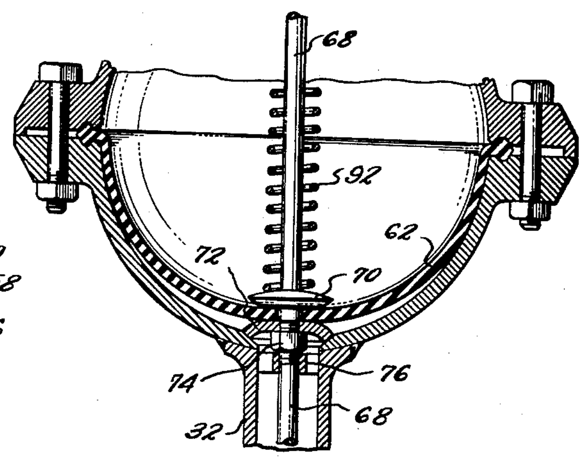


Fig. 5

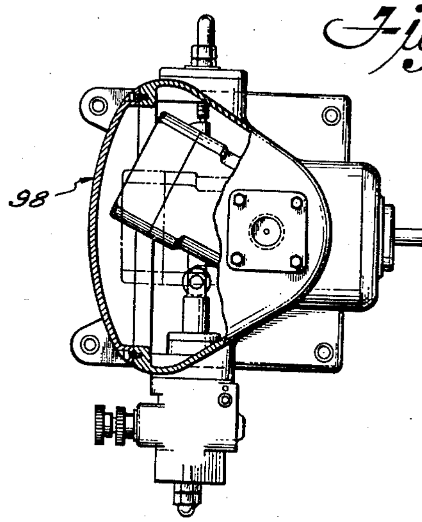
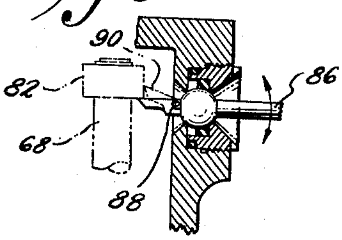


Fig. 3



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11 Claims. (Cl. 103—152)

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This invention relates to hydraulic pumping systems particularly suitable for circulating the mud or drilling fluid in the drilling of wells by the rotary type of drilling rig.

The main objects of this invention are: to provide a new and improved system of pumping the circulating or drilling fluid during the rotary drilling of oil wells; to provide an improved system of converting high speed, low torque energy into low speed, high torque pumping energy; to provide an improved mud pump which is charged with a low pressure pump, and discharged by a high speed, high pressure pump; to provide a diaphragm type of mud pump in which the cycling of its operation is controlled by the movement of the diaphragm; to provide a highly efficient mud pump whose weight and bulk are only a fraction of that of the standard type of mud pump of equal capacity which is now in common and extensive use; to provide a mud pump which can be, and preferably is, located remotely from its actuating pump; to provide a mud pump in which the fluid being pumped will be completely sealed from the actuating liquid and will not come in contact with the actuating mechanism, thereby eliminating cutting, scoring, and excessive wearing of the parts; and to provide a new and improved system of this character which will eliminate the expense of accurately aligning the mud pump with the driving mechanism as well as the expensive driving connections now in common use with such machinery.

Illustrative embodiments of this invention are shown in the accompanying drawings, wherein:

Fig. 1 is a diagrammatic view showing a multiple number of the improved mud pumps for producing a uniform and non-pulsating discharge of mud;

Fig. 2 is a vertical medial sectional view of the preferred form of my improved mud pump;

Fig. 3 is an enlarged fragmentary sectional view of the mechanism enclosed in the circle 3 of Fig. 2;

Fig. 4 is an enlarged fragmentary sectional view showing the diaphragm in full discharge position; and

Fig. 5 is a view, partly in elevation and partly in section, of a well-known variable discharge pump for use in my improved pumping system.

At the present time, it is customary in the drilling of oil wells and the like by the rotary method to use mud pumps for circulating the drilling fluid, and which pumps are of large size, expensive construction, require frequent main-

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tenance service with renewal and replacement of parts, and have a high initial cost.

Mud pumps now in use require very expensive drives from the prime mover. These drives are usually of the V-belt type, and due to the very high torque required to operate the pump, it requires a large number of the driving belts which, of course, must be housed-in, and which places certain limitations on the positioning of the units. In setting up such mud pumps it is, of course, necessary to have proper alignment or parallelism between the axes of the driving and driven pulleys of the V-belts, and such a drive necessarily requires the pump to be located closely adjacent to the driving belt pulley.

In the present construction, a mud pump of the same capacity as the standard type now in use would weigh only a small fraction as much as the present pumps, and would have no limitation as to location by reason of its being connected to its prime mover by a hydraulic line. There would, of course, be no problem of alignment between the units, as the hydraulic lines connecting the units may be run at any convenient place, and the prime mover may be, and preferably is, located remotely with respect to the mud pump itself. The present construction also eliminates the necessity for any form of reduction gearing, with the result that a mud pump of equal capacity to the standard type now in use would cost far less than half as much.

In the drilling of deep oil wells and the like, the deeper the well goes, the higher the pressure required for circulating the drilling fluid. When the well is first started, and for the first few thousand feet, a relatively low pressure will circulate the fluid in a satisfactory manner, but as the well goes down to greater depths, it requires a greater pressure to keep the drilling fluid in circulation, with the result that in the standard type of mud pump it is necessary, in the drilling of very deep wells, to change and replace the cylinders of the discharge end of the pump two or three times during the drilling operation.

Also, in a drilling operation sometimes the pressure becomes so high that the drilling fluid suddenly and unexpectedly stops circulating by reason of encountering resistance greater than can be handled by the mud pump. In the prior types of pumps, a period of time is required to dismantle the discharge end of the mud pump, remove the liners, replace with small sized liners, and reassemble the pump. During this period of time, the drill cuttings suspended in the drilling fluid may settle in the well so as to create a much higher resistance than the resistance which stopped the pumps.

When using a pump of the present invention, increased resistance to flow of the drilling fluid will be instantly and automatically met by increased pressure output, although of decreased volume, up to the limit of pressure of the apparatus. Thus the drill cuttings have no opportunity to settle, but are kept in constant movement.

Steam driven mud pumps of the past had great virtue in the matter of flexibility of output. During the early stages of drilling a well, where the "going" is easy, usually with a large hole in soft formation, the steam driven pump gave a large volume of output, and this permitted rapid drilling. As the hole became deeper and the formations became harder, the steam pump automatically adjusted itself to the changing conditions and requirements, and the higher the resistance encountered, the higher the output pressure of the pump became, until the limit was reached.

Now in the pump of the instant invention there is present the same flexibility of automatic adjustment to the changing conditions between the starting of a well until its final depth is reached without manual adjustment or replacement of parts.

In the pumping system shown in the drawings, referring particularly to Fig. 1, there is shown an installation of three main mud pumps generally designated **6**, **8**, and **10** having interconnected controls so that the pumps discharge in sequence, and thus produce a continuous and uniform output of work fluid, although it will be understood that a greater or lesser number of these pumps may be connected up in this manner, and thus give a non-pulsating or steady uniform flow, with substantially no variance of volume or pressure as would be the case where a single pump would be used. While the pumps **6**, **8** and **10** are shown as having mechanically interconnected controls, it will also be understood that the controls may be interconnected electrically or by other suitable means, and that the disclosure shown is merely by way of illustration.

In the construction shown, a mud tank **12** is connected by a conduit **14** to a low pressure centrifugal type pump **16** which is preferably of the rubber lined type generally used as sand pumps and the like in which the impeller and interior surfaces have synthetic rubber bonded to the surfaces so as not to be readily cut out by abrasion. The discharge of the pump **16** is into a header conduit **18** which is provided with three branches **20**, **22**, and **24** leading to intake check valves generally designated **26**, **28**, and **30**, respectively.

The check valves are connected to the main pumps **6**, **8**, and **10** by conduits **32**, **34**, and **36**, respectively, which conduits also communicate with outlet check valves **38**, **40**, and **42**, respectively. The outlet valves are in turn connected to return branches **44**, **46**, and **48**, respectively, all of which communicate with a discharge header **50** which carries the output or discharge of the pumps to the drill stem of the drilling rig through the usual hose, swivel and driving or "Kelly" joint.

The interior constructions of the main pumps **6**, **8**, and **10** are all substantially identical, and therefore a detailed description of one will suffice for all.

Referring to Figs. 2, 3, and 4, the main pump **6** is shown in detail, as well as the intake check valve **26** and outlet check valve **38**.

The main mud pump comprises a pair of semi-spherical members **52** and **54** of substantially identical shape and volumetric capacity having outwardly projecting flanges **56** and **58**, respectively, integrally formed thereon which may be secured together in face-to-face relationship by a plurality of bolts **60**. It will be understood, however, that in actual practice these members **52** and **54** do not necessarily need to be of semi-spherical shape, but may be considerably elongated so as to give greater or lesser capacity or volume to the pump, such shape being a matter of designer's choice. The adjacent faces of the members **52** and **54** and their respective flanges are provided with registering annular grooves which receive, embrace, and tightly clamp the marginal edge of a flexible diaphragm **62** which may be of rubber, synthetic rubber, or other composition which gives a flexible diaphragm having long wearing qualities and able to withstand a large number of bendings or flexings without rupture, although it will be understood that the diaphragm **62** is not subjected to stretching or like distortion for the reason that its surface area, as shown particularly in Fig. 4, is equal to the interior surface area of the members **52** or **54**, and thus merely forms a movable wall which separates the pump **6** into two compartments, the lower one, designated **64**, being for the work fluid or mud which is to be pumped, and the upper one, designated **66**, being for an actuating fluid such as oil.

The center of the diaphragm **62** is connected to a vertically disposed rod **68** by a disk **70** rigidly fixed to the rod which bears against the top side of the diaphragm, and an inverted saucer-shaped washer **72** which embraces and bears against the under side of the diaphragm. The diaphragm is gripped between the disks **70** and **72** by the tightening of a nut **74** threaded on the rod **68**, and which may be suitably adjusted to secure a tight liquid seal between opposite sides of the diaphragm.

The rod **68** extends downwardly and is slidable through a spider **76** located in the top end of the conduit **32**. The rod **68** also extends upwardly and is slidable through a spider **78** located in a vertically disposed tubular fitting **80** mounted on the top of the member **54** and in communication therewith. The top end of the rod **68** is provided with a collar **82** which engages the inner end of a control valve operating lever **84** when in its lowermost position, and likewise engages the inner protruding end of a control valve operating lever **86** when moved to its uppermost position. The levers **84** and **86** are mounted to be moved in vertical planes, and are shown as being mounted on ball fulcrums which are sealed on their seats so as to make liquid tight joints between the inner and outer ends of the valve operating levers.

As shown most clearly in Fig. 3 of the drawings, the inner end of the lever **86** is pivoted at **88** so that upward movement of the rod **68** and collar **82** will rock the inner pivoted end **90** upwardly as shown in broken lines in Fig. 3 without actuating the lever **86**, but after the collar **82** passes thereby, it will then engage the underside of the collar and rock the lever **86** upwardly upon downward movement of the rod **68**.

Means are provided for normally urging the rod **68** downwardly, and comprise a helical compression spring **92** which surrounds the upper end of the rod 68, and has its lower end bearing against the disk 70, and its upper end bearing against the spider 78.

The tubular or hollow fitting 80 is in communication with a power fluid line 94 which is connected through a pilot operated valve 96 to a high pressure automatically variable discharge pump 98 to which fluid is supplied from a reservoir 100. The pump 98 is shown more in detail in Fig. 5, and the particular type illustrated is a well-known high pressure pump having automatically variable output or discharge, but it will be understood that any high speed, high pressure automatically variable discharge pump may be used as a unit of my improved pumping system. The pump 98 is provided with a plurality of relatively small pumping cylinders so that a plurality of discharge strokes is required in order to fill the compartment 66 and move the diaphragm to the position shown in Fig. 4. In this manner a high speed, high pressure pump has its output converted to operate a low speed, high torque mud pump.

As shown in Fig. 1 of the drawings, the levers 84 and 86 are pivoted to rocker arms and links generally designated 102 which operate pilot valves 104, 106, and 108, respectively, for the pumping units 6, 8, and 10. Fluid is supplied to and exhausted from the pumping unit 8 by a pilot operated control valve 110, and fluid from the pump 98 is likewise supplied to and exhausted from the pumping unit 10 by a pilot operated control valve 112. The arrangement of the pilot control valves 104, 106 and 108 is such that when one of the pumping units 6, 8, or 10 reaches the position shown in Fig. 4 of the drawings, its pilot valve will be operated to move the control valve 96, 110 or 112 of that pump so as to vent the working fluid and at the same time connect the next succeeding pumping unit with the high pressure pump 98 so as to move its diaphragm 62 to the discharge position. As soon as the high pressure or upper side of the diaphragm is vented back to the reservoir 100, the low pressure mud pump 16 will fill that pumping unit with mud from the tank 12 and have it in readiness for being discharged as soon as the appropriate valve action takes place.

It will be noted particularly in Figs. 2 and 4 of the drawings that the disk 72 has its marginal edge shaped to fit a sloping valve seat so that when the pumping unit is fully discharged as shown in Fig. 4, the disk 72 will close and seal the outlet from the lower compartment 64, and thus prevent rupture, strain or damage to the diaphragm 62 under any unusual operating condition. It will also be noted that the rod 68 not only controls the valving of the high pressure operating fluid to the upper compartment 66 of the pump, but also serves to guide and govern the folding and flexing of the diaphragm 62 so that tight folds are never formed therein which might injure the material from which the diaphragm is made.

The helical compression spring serves to govern the folding or flexing of the diaphragm when the upper compartment containing the operating fluid is vented to its reservoir line. When the venting of the upper compartment takes place, the lower pressure mud charging pump fills the lower compartment against the action of the compression spring, and during this filling action the spring controls and governs and resists the upward movement of the diaphragm.

Although but one specific embodiment of this invention has been herein shown and described, it will be understood that numerous details of the construction shown may be altered or omitted without departing from the principle of this invention as defined by the following claims.

I claim:

1. A hydraulic pumping system, comprising: a pump housing; a movable wall within said housing dividing the interior thereof into two compartments; the first of said compartments being provided for a work fluid to be pumped, and the second for an actuating fluid to actuate said movable wall to effect pumping of said work fluid from said first compartment; means providing an inlet and outlet for each of said compartments; means for introducing work fluid under pressure into said first compartment to move said movable wall from an initial position at one end of its travel to the opposite end of its travel; means in said second compartment yieldably opposing movement of said movable wall by said work fluid; means for delivering actuating fluid under pressure to said second compartment to return said movable wall to its initial position and thereby forcibly discharge the work fluid from said first compartment; and means actuated in response to movement of said movable wall for cycling the introduction and discharge of said actuating fluid.

2. A hydraulic pumping system, comprising: a pump housing; a movable wall within said housing dividing the interior thereof into two compartments, the first of said compartments being provided for a work fluid to be pumped, and the second for an actuating fluid to actuate said movable wall to effect pumping of said work fluid from said first compartment; means providing an inlet and outlet for each of said compartments; a centrifugal pump for introducing work fluid under pressure into said first compartment to move said movable wall from an initial position at one end of its travel to the opposite end of its travel; means in said second compartment yieldably opposing movement of said movable wall by said work fluid; a relatively high speed, high pressure automatically variable output pump for delivering actuating fluid under pressure to said second compartment and requiring a multiple number of discharges to return said movable wall to its initial position and thereby forcibly discharge the work fluid from said first compartment; and means actuated in response to movement of said movable wall for cycling the introduction and discharge of said actuating fluid.

3. A hydraulic pumping system, comprising: a pump housing; a flexible wall within said housing dividing the interior thereof into two compartments, the first of said compartments being provided for a work fluid to be pumped, and the second for an actuating fluid to actuate said movable wall to effect pumping of said work fluid from said first compartment; means providing an inlet and outlet for each of said compartments; means for introducing work fluid under pressure into said first compartment to move said flexible wall from an initial position at one end of its travel to the opposite end of its travel; means in said pump housing governing the folding and flexing of said flexible wall; means for delivering actuating fluid under pressure to said second compartment to return said flexible wall to its initial position and thereby forcibly discharging work fluid from said first compartment;

and control means actuated in response to movement of said flexible wall for cycling the introduction and discharge of said actuating fluid.

4. A hydraulic pumping system as defined in claim 3, including means yieldably opposing movement of the flexible wall by the work fluid.

5. A hydraulic pumping system, comprising: a pump housing; a movable wall within said housing dividing the interior thereof into two compartments, the first of said compartments being provided for a work fluid to be pumped, and the second for an actuating fluid to actuate said movable wall to effect pumping of said work fluid; means providing an inlet and outlet for each of said compartments; means for introducing work fluid into said first compartment to move said movable wall from an initial position at one end of its travel toward the opposite end of its travel; means for delivering actuating fluid under pressure to said second compartment to return said movable wall to its initial position and thereby forcibly discharge the work fluid from said first compartment; a valve element carried by said movable wall arranged to obstruct the outlet from said first compartment and form a closure therefor when said movable wall is returned to its said initial position; and control means actuated in response to movement of said movable wall governing the introduction and discharge of actuating fluid to and from said second chamber.

6. A hydraulic pumping system, comprising: a pump housing; a flexible diaphragm within said housing dividing the interior thereof into two compartments; the first of said compartments being provided for a work fluid to be pumped, and the second for actuating fluid for actuating said diaphragm to effect the discharge of said work fluid from said first compartment; means providing a common inlet and outlet passage for said second compartment; pump means for introducing work fluid under pressure into said first compartment to move said flexible diaphragm from an initial position at one end of its travel to a position at the opposite end of its travel; means in said second compartment yieldably opposing movement of said flexible diaphragm from its said initial position; means for introducing actuating fluid under pressure into said second chamber to return said flexible diaphragm to its initial position and thereby discharge the work fluid from said first compartment; means actuated in response to the movement of said flexible diaphragm for controlling the introduction and exhaust of actuating fluid to and from said second compartment, said last mentioned means including a rod secured to said diaphragm; means guiding said rod for reciprocating movement, and means actuated by said rod as it approaches the end of its travel in opposite directions for governing said admission and exhaust of actuating fluid.

7. A hydraulic pumping system as defined in claim 6, wherein said means for guiding the rod for reciprocating movement comprises an element mounted in at least one of said passages.

8. A hydraulic pumping system, comprising: a plurality of pumping instrumentalities operable in succession in predetermined sequence, each including a movable wall providing two compartments, the first of said compartments being provided for a work fluid to be pumped, and the second for an actuating fluid for actuating said movable wall to effect pumping of said work fluid from its associated first compartment, each of said compartments having inlet and outlet means; means to successively introduce work fluid into each first compartment to move said movable wall from an initial position at one end of its travel to the opposite end of its travel; means for successively discharging actuating fluid into each second compartment to return the movable wall to its said initial position and thereby forcibly discharge the work fluid from the first compartments; separate conduit means for said actuating fluid and said work fluid; and control means including elements actuated in sequence in response to the movement of each movable wall as it approaches one end of its stroke for controlling the actuating fluid so that it is introduced into one second compartment and substantially simultaneously exhausted from another second compartment.

9. A hydraulic pumping system, comprising: a plurality of pumps operable in succession in predetermined sequence, each pump including a housing, a movable wall in said housing dividing the interior thereof into two compartments, the first of said compartments being provided for a work fluid to be pumped, and the second for an actuating fluid for actuating said movable wall to effect pumping of said work fluid from its associated first compartment; means providing an inlet and outlet for each of said compartments; means to successively introduce work fluid into the first compartment of the respective pumps to move said movable wall from an initial position at one end of its travel to the opposite end of its travel; means for successively delivering actuating fluid under pressure to the second compartment of the respective pumps to return the movable wall associated therewith to its said initial position and thereby forcibly discharge the work fluid from said second compartments; separate conduit means for said actuating fluid and said work fluid; and control means including elements actuated in sequence in response to the movement of each movable wall as it approaches one end of its stroke, for controlling the actuating fluid so that it is introduced into the second compartment of one pump and substantially simultaneously exhausted from the second compartment of another pump.

10. A hydraulic pumping system, comprising: a plurality of pumps operable in succession in predetermined sequence, each pump including a housing, a movable wall in said housing dividing the interior thereof into two compartments, the first of said compartments being provided for a work fluid to be pumped and the second for an actuating fluid to actuate said movable wall to effect pumping of said work fluid from its associated first compartment; means providing an inlet and outlet for each of said compartments; means for delivering a work fluid to the first compartment of each of said pumps; means for delivering actuating fluid to the second compartment of each of said pumps including conduit means having a pilot valve for controlling the supply and exhaust of actuating fluid to each pump; a control valve connected with each of said pilot valves; means actuated in sequence in response to the movement of the movable wall of each pump for sequentially actuating the control valves as the movable walls approach the opposite ends of their stroke; and means interconnecting the control valve of each pump with the corresponding pilot valve of each pump to thereby sequentially control the admission and

exhaust of actuating fluid to and from the second compartment of each pump.

11. A hydraulic pumping system, comprising: a plurality of pumps operable in succession in predetermined sequence, each pump including a housing, a movable wall in said housing dividing the interior thereof into two compartments, the first of said compartments being provided for a work fluid to be pumped and the second for an actuating fluid to actuate said movable wall to effect pumping of said work fluid from its associated first compartment; means providing an inlet and outlet for each of said compartments; a mud tank; a low pressure centrifugal pump having an inlet connected with said mud tank; a header conduit connected to the discharge of said centrifugal pump; a supply branch conduit extending from said header conduit adapted to be placed in communication with the first compartment of each of said pumps; a return branch conduit adapted to be placed in communication with the first compartment of each of said pumps; a discharge header connected with each of said return branch conduits; an inlet valve disposed between each supply branch conduit and one of said first compartments; an outlet check valve disposed between each return branch conduit and one of said first compartments; a reservoir for actuating fluid; a high speed, high pressure automatically variable positive output pump having its inlet connected with said reservoir and requiring a multiple number of discharges to fill each second compartment; conduit means connected with the discharge of said high speed pump including pilot valves for controlling the supply and exhaust of actuating fluid to the second compartment of each of said pump housings; a control valve connected with each of said pilot valves; means actuated in sequence in response to the movement of the movable wall of each pump for sequentially actuating the control valves as the movable walls approach the opposite ends of their stroke; and means interconnecting the control valve of each pump with the corresponding pilot valve of each pump to thereby sequentially control the admission and exhaust of actuating fluid to and from the second compartment of each pump.

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