March 20, 1951 R. A. WALSH 2,545,506

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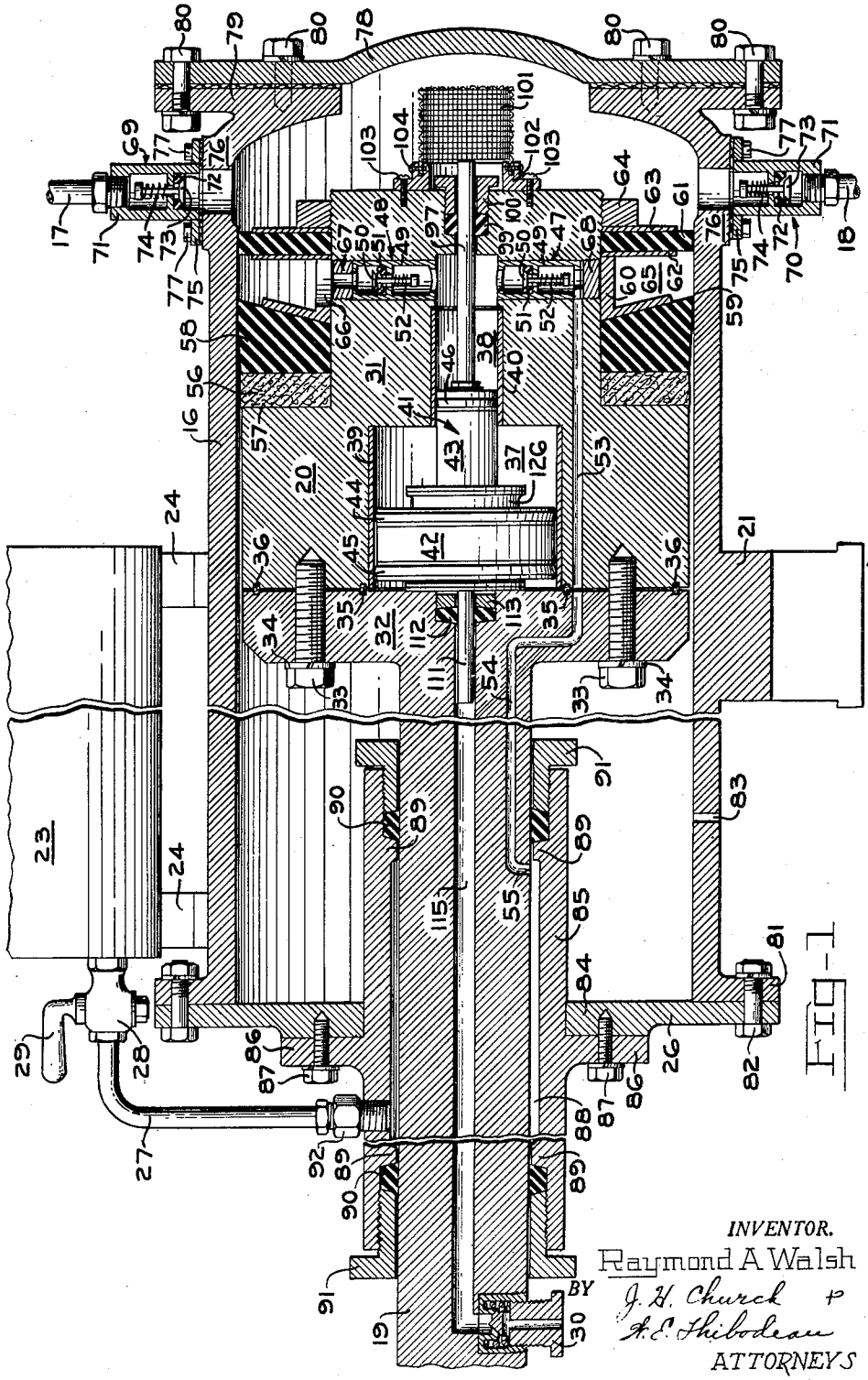


FIG-1

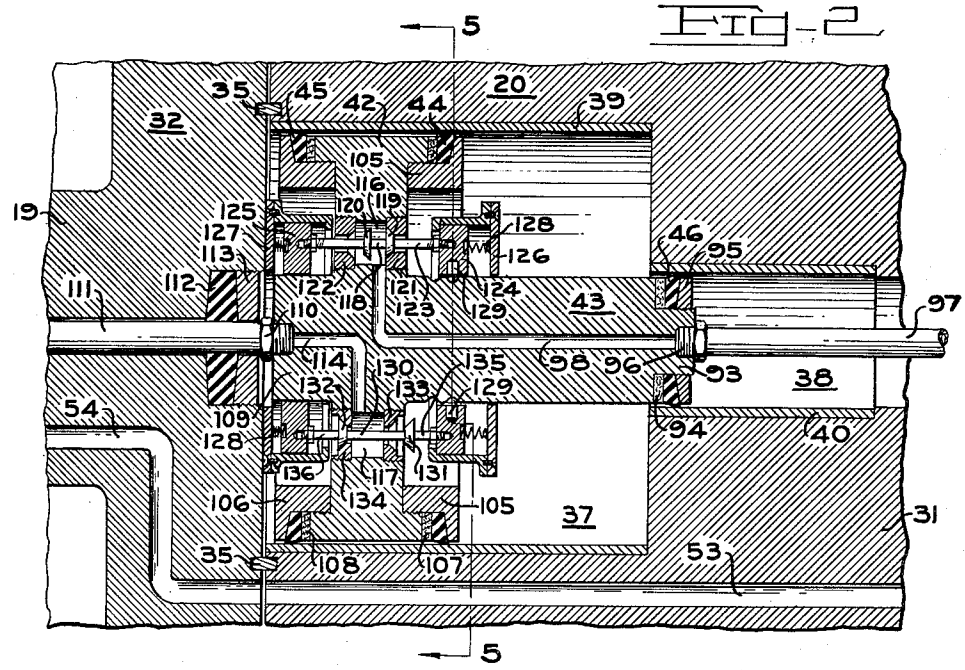
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Filed Oct. 17, 1945 4 Sheets-Sheet 2

FIG-2



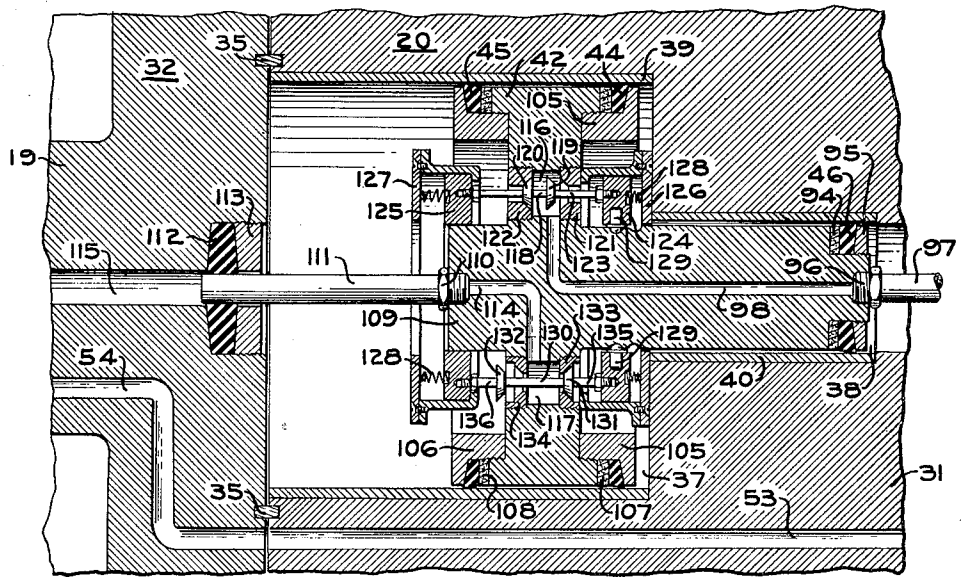


FIG-3

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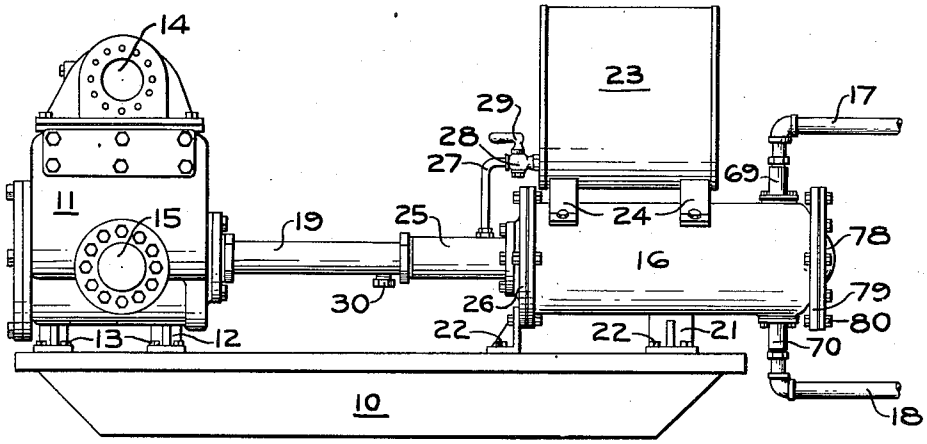


FIG-4

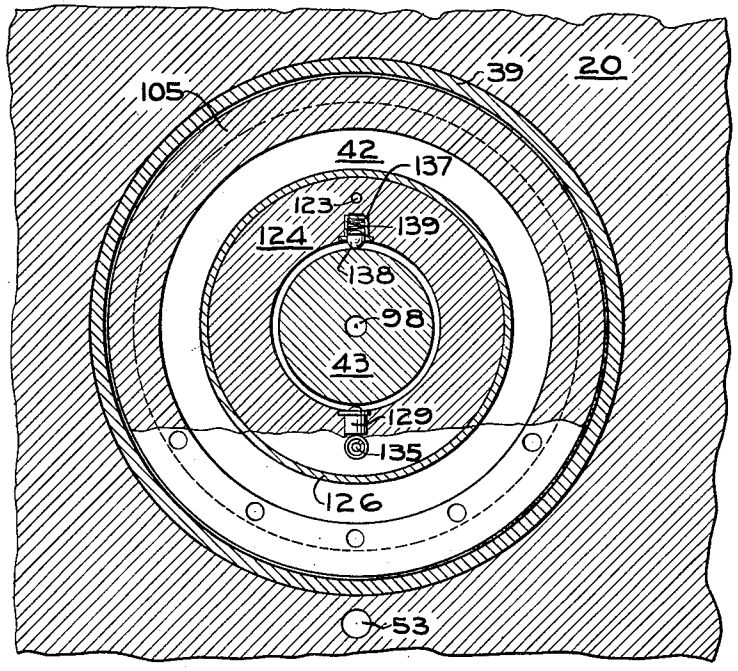


FIG-5

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March 20, 1951 R. A. WALSH 2,545,506

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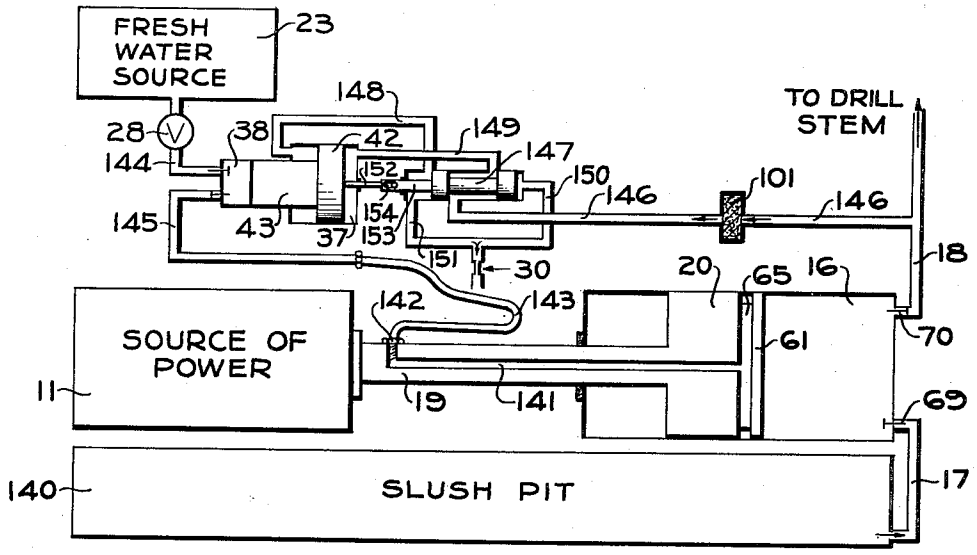


Fig-6

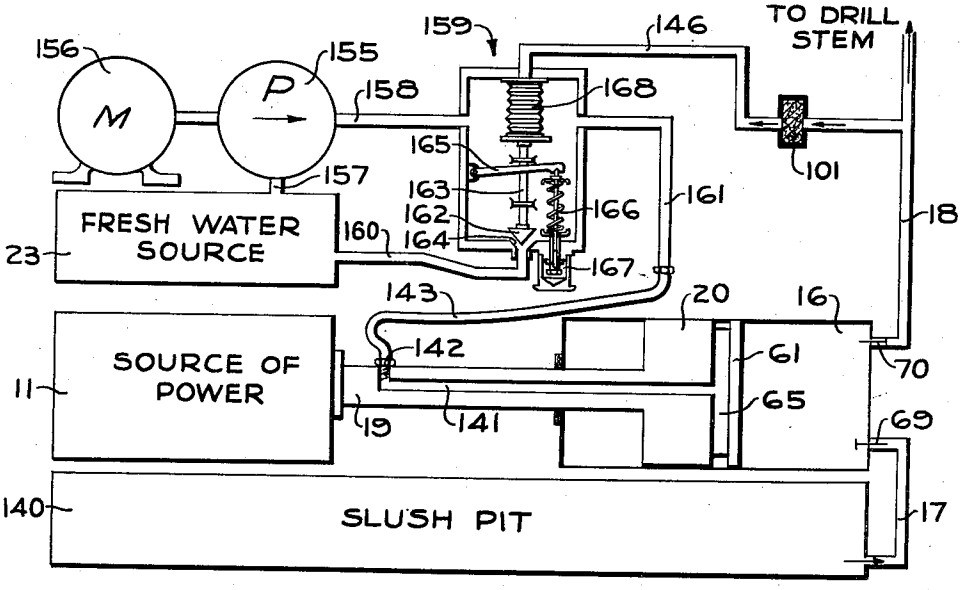
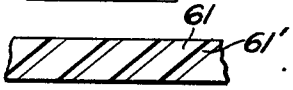


Fig-8 Fig-7



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Patented Mar. 20, 1951 2,545,506

UNITED STATES PATENT OFFICE

2,545,506

PUMP

Raymond A. Walsh, Davenport, Iowa

Application October 17, 1945, Serial No. 622,918

22 Claims. (Cl. 103—48)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

1

The invention described herein may be manufactured and used by or for the Government for governmental purposes, without the payment to me of any royalty thereon.

The present invention relates generally to the art of fluid pumping.

More particularly the invention relates to a novel type of hydraulic pumping apparatus especially adapted for the moving or the creation of pressure within a liquid which contains abrasive material of such nature as to be ordinarily harmful to those portions of the pumping apparatus with which it comes in contact.

Specifically the invention is disclosed herein in its application to a pump of the type generally termed a "slush pump" or a "mud pump" which is adapted to be employed in the rotary drilling of oil wells. In the drilling of oil wells through the various strata of earth overlying relatively high pressure oil fields such as are apt to be encountered, for example, in the Gulf Coast regions of the United States of America, it is customary to employ apparatus known as a rotary drill rig. This apparatus comprises in addition to the usual derrick and power equipment adjacent the surface of the well a rock bit or other suitable cutting tool mounted on the lower end of a length of hollow tubing known as the drill rod or drill stem which is adapted to be rotated by power equipment at the surface of the well. As the cutting tool cuts its way into the surface of the earth it is usual to encounter relatively high pressure areas from time to time, the pressure of which generally increases as the well increases in depth; for example, it is common in some fields to anticipate a well pressure in an amount approximating one-half pound per square inch for every foot of depth of the well. In rotary drilling apparatus this well pressure is balanced by the weight of a column of chemically weighted liquid which is continuously forced from the surface by a slush pump down through the drill stem to a point adjacent the cutting tool in the bottom of the well and thence upwardly externally of the drill stem but within an outer length of tubing generally referred to as the casing. This drilling fluid in addition to controlling the pressure at the bottom of the well serves also to wash the cuttings, sand, and grit produced by the cutting tool up through the well casing to a slush pit on the surface adjacent the top of the well where they may settle out of the drilling fluid.

The present invention as aforesaid concerns itself in its specific aspects with a slush pump adapted to be employed in the handling of abrasive-containing drilling fluid in well drilling systems of the type just described. In these systems one of the most serious problems in the past has been the wearing action of the abrasive fluid upon the working parts of the apparatus, particularly the pump piston packings. The invention accordingly concerns itself specifically with the protection of the piston packings of such an oil well slush pump although in its broader aspects it contemplates an improved method of packing other types of pumps as well as improved apparatus for moving other types of abrasive-containing fluids.

2

The invention contemplates broadly a slush pump having a conventional piston packing therein and further including an auxiliary pumping device responsive to the pressure of fluid within the drill stem of the main pump cylinder for delivering a nonabrasive fluid to a point adjacent the packing in such a manner that the main piston packing is always working in a bath of nonabrasive fluid and hence is not subject to the usual wear and tear caused by the abrasive fluid within the cylinder. In its preferred form the invention contemplates auxiliary pumping mechanism of the so-called differential piston type which is constructed in such manner that the delivery pressure of the differential piston pump is always higher in a certain predetermined ratio than the pressure of the abrasive fluid within the drill stem or main pump cylinder.

It is accordingly an important object of the present invention to provide a slush pump for forcing drilling fluid through the drill stem of a rotary well drilling apparatus wherein novel means are provided for protecting the pump packing from the wearing action of the abrasive-containing fluid within the pump cylinder.

Another object of the invention is to provide novel means in the form of a differential piston type pump mounted within a slush pump piston and responsive to the delivery pressure of the slush pump for circulating nonabrasive fluid at a higher pressure around the slush pump piston packing.

A further object of the invention is the provision of suitable means such as a wiper element secured to a slush pump piston ahead of the usual packing in such manner as to define an annular chamber into which a nonabrasive fluid may be forced at a higher pressure than that within the main pump cylinder so that a continuous leakage of nonabrasive fluid may take place from the annular chamber past the wiper to

protect the packing from direct contact with the abrasive fluid within the pump cylinder.

A still further object of the invention resides in a novel method of packing expansible chamber type pumps.

Yet another object of the invention resides in the provision of a differential piston pump having a valve actuating mechanism comprising a lost-motion device and a snap-action device for positively moving and resiliently retaining the valves in either open or closed position.

Another object of the invention is the provision of an auxiliary pumping source in fluid communication with an apertured pump piston of the type described and including a by-pass valve which may be adjustably and resiliently biased in one direction and which may be biased towards closed position by a device responsive to the delivery pressure of the main pump in such manner that the delivery pressure of the secondary pump is always somewhat higher in a predetermined ratio than the delivery pressure of the main pump.

Other and further objects of the invention are: to provide a suitably apertured pump piston wherein an auxiliary pumping mechanism may be completely housed; to provide guiding means such as a plurality of axially inclined peripheral grooves on the wiper element for restricted egress of the nonabrasive fluid to wash the cylinder walls ahead of the piston; to provide in a pump piston a differential piston pump having the motor piston thereof in fluid communication with the working face of the main piston and including a filtering device for protecting said opening; to provide a device for the admission of a secondary fluid to the interior of a pump piston through a conduit formed in the piston rod thereof; and to provide a pump of the type described having a source of secondary fluid integrally formed therewith.

The manner of attainment of the above and other objects of the invention as well as a more complete understanding thereof will become more clearly apparent by reference to the following detailed description taken in conjunction with the accompanying drawings illustrating a preferred embodiment of the invention, wherein:

Fig. 1 is a longitudinal view in partial cross section of a slush pump embodying the invention, portions of the same being broken away and providing a foreshortened view;

Figs. 2 and 3 are cross sectional views to an enlarged scale of the differential piston pump forming a part of the invention and illustrating the motor piston and valve actuating mechanism in reversed positions, respectively;

Fig. 4 is a general view in front elevation of a complete slush pump assembly according to the invention including the prime mover and auxiliary fluid source;

Fig. 5 is a transverse cross sectional view taken along the line 5—5 of Fig. 2;

Fig. 6 is a schematic view of a preferred form of hydraulic operating circuit of the pump illustrated in Fig. 1;

Fig. 7 is a schematic view similar to Fig. 6 but illustrating a modified type of hydraulic operating circuit, and

Figure 8 is a fragmentary edge elevation of a portion of the wiper element.

Turning now to the drawings specifically and in detail, Fig. 4 illustrates an over-all assembly view of a horizontal piston, expansible chamber type slush pump of the general type commonly

employed in oil field operations and adapted to be used either singly or in various compounding arrangements for forcing drilling fluid down through the drill stem of a rotary drilling apparatus. The pump assembly is ordinarily mounted upon skids such as that designated generally by the reference numeral 10 in Fig. 4. A prime mover 11 suitably secured to the skid 10 as by means of supporting legs 12 and bolts 13 is adapted to be operated in the present case by steam supplied from a source (not shown) to an inlet connection 14 and includes a steam exhaust connection 15. The pump end of the assembly consists of the pump cylinder 16 having an inlet connection 17 and an outlet 18 and includes a piston designated by numeral 20 in Fig. 1 connected by means of a suitable piston rod 19 to the prime mover 11. Suitable supporting means 21 are provided on the pump cylinder 16 and are adapted to be secured to the skids 10 in any suitable manner as by means of the bolts 22.

As illustrated in Fig. 4, the pump end of the assembly also includes a reservoir 23 mounted on the pump cylinder 16 as by means of supporting members 24 and further includes a sleeve structure 25 mounted in an end wall 26 of the cylinder 16 and having a conduit 27 connected between said sleeve and the reservoir 23. A conventional stop valve 28 is provided in said conduit and is adapted to be operated by means of a handle 29. The piston rod 19 is also provided with an integral exhaust orifice comprising an adjustable choke valve 30. The operation and function of the choke valve 30, the sleeve 25, conduit 27, and reservoir 23 will be hereinafter more fully set forth. Aside from these elements the construction of the pump assembly thus far described is conventional including as it does the usual steam end and liquid end, the internal portions of which operate in conjunction with each other in a manner well understood in the art.

Turning now particularly to Fig. 1, the pump piston 20 is seen to comprise a main body portion of substantially full cylinder width together with an extension of said main body portion of a reduced diameter generally designated by reference numeral 31. The piston rod 19 includes an internal cap portion 32 adapted to be secured to the main body portion 20 of the piston as by means of a plurality of bolts 33 held in place by lock washers 34. Suitable inner and outer gasket packings 35 and 36, respectively, are provided between the opposed faces of the cap portion 32 and the piston main body portion 20 to provide a fluid-tight seal therebetween.

Both the main body portion 20 and the reduced diameter portion 31 of the piston are provided with coaxial cylindrical apertures, a larger diameter aperture 37 being provided in the body portion 20 and a smaller diameter aperture 38 being provided in the body extension 31. Suitable cylinder liners 39 and 40 of a wear resistant material are provided in the cylinders 37 and 38 in a conventional manner. A differential piston pump designated generally by the reference numeral 41 is mounted within the cylinders 37 and 38 and includes a large diameter portion 42 and a smaller diameter portion 43. Suitable packing means 44 and 45 are provided for the large diameter piston 42 and a similar packing 46 is provided for the smaller diameter piston 43. It will be understood that the pistons 42 and 43 slidably fit in the cylinders 37 and 38, respectively, engaging the walls of the latter in a fluid-

tight manner and are mounted for joint reciprocation therein. The larger piston 42 constitutes a motor piston or prime mover for imparting motion to the smaller piston 43 which in turn operates as a pump. The details of operation of this portion of the mechanism will be more fully explained below particularly in connection with the description of the operation of the device.

The reduced diameter piston body portion 31 is provided with suitable apertures near its forward end which are connected to the small diameter cylinder 38 and which are adapted to receive a pair of valve assemblies 47 and 48. Each of these valve assemblies includes a cage portion 49 having a valve 50 mounted therein and adapted to seat against a seat portion 51. Suitable springs 52 are provided for urging the valves 50 into closed position. It will be noted that the valve assemblies 47 and 48 are so mounted with respect to the cylinder 38 that the valve 47 opens inwardly towards the cylinder 38, whereas the valve 48 opens outwardly away from the cylinder 38 thus constituting inlet and exhaust valves, respectively, for the cylinder 38. The inlet valve 47 is connected to a source of nonabrasive fluid by means of a conduit 53 in the piston body which in turn is connected to a conduit 54 in the piston rod having an inlet orifice 55. The method and apparatus for supplying nonabrasive fluid to the inlet valve 47 will be hereinafter more fully set forth.

Surrounding the reduced piston body portion 31 are a series of packing devices having the general shape of rings and including a backing ring of felt or other suitable material designated by the reference numeral 56 which is adapted to abut the shoulder 57 formed at the juncture of the cut away portion 31 and the main body portion 20. Seated against the backing piece 56 is a main packing member 58 which may be made of rubber or other suitable packing material and which, as disclosed herein, is provided with an outwardly tapering sealing lip 59 adapted to firmly engage the inner wall of the cylinder 16 in sealing contact therewith. Holding the main packing member 58 in position is a spacer element 60 having a generally angular shape. A wiper element 61 of general ring shape, provided with axially inclined peripheral grooves 61' and having a pair of backing plates 62 and 63 on opposite sides thereof, is adapted to be next slid over the reduced portion 31 into abutting engagement with the inner portion of the angular member 60. All of the ring portions thus far described are securely held in place by means of a locking ring 64 which is secured in threaded engagement with the reduced body portion 31.

The construction of the main packing element 58, the angular spacer 60, and the wiper element 61 is such as to provide an annular chamber 65 surrounding the reduced body portion 31. A suitably cut away portion 66 is provided in the spacer 60 adjacent the exhaust valve 48 which in turn is held in place by an apertured locking member 67 to provide for free discharge of fluid from the cylinder 38 through the valve 48 and into the annular chamber 65. On the other hand the inlet valve 47 is adapted to be secured in place by means of a locking member 68 threadedly engaged with the body portion 31 which is solid and in fluid-tight engagement with said body portion, fluid being supplied to the inlet valve 47 through the conduit 53. It will be noted from Fig. 1 that the main pump cylinder inlet and outlet connections 17 and 18 are provided with inlet and outlet valves 69 and 70, respectively. Each of these valves is similar to the smaller inlet and outlet valves 47 and 48, respectively, previously described, and includes a housing 71, a valve seat 72, a valve 73, and a spring 74, urging the valve onto its seat. The valve housings 71 in this case are provided with suitable gaskets and flanges 75 adapted to be secured to the apertured bosses 76 on the cylinder 16 as by means of bolts 77. It will likewise be noted that the right-hand end of the cylinder 16 is suitably closed by a gasket and an end wall 78 secured to a flange or ring portion 79 formed on the end of the cylinder 16 by means of a plurality of bolts 80.

Referring now to the left-hand portion of Fig. 1, which it will be noted is considerably foreshortened by virtue of the broken away portions so that the relative positions of all the parts are not in true perspective, the left-hand end wall 26 of the cylinder 16 is secured to a flange 81 formed on the end of the cylinder 16 by means of a plurality of bolts 82. An aperture or vent 83 is provided in the cylinder 16 at its left-hand end for permitting free inlet and discharge of air into the space within the cylinder at the left-hand end of the piston as the latter is reciprocated during pumping operations and also to provide for discharge of any leakage fluid which would otherwise be trapped in this space. The end wall 26 is also formed with an inner apertured flange portion 84. An elongated cylindrical sleeve 85 is provided approximately midway between its ends with a radially outwardly extending flange portion 86 adapted to be secured to the flange 84 by means of a plurality of bolts 87. The sleeve 85 is preferably constructed with an outside diameter approximately equal to the internal diameter of the aperture formed in the end wall 26 so that although there is nothing critical in this relationship a snug fit of the parts is provided. The sleeve 85 is provided with an internal diameter appreciably larger than the external diameter of the piston rod which passes coaxially therethrough as a result of which an annular chamber 88 is provided between the piston rod and the inner walls of the sleeve. The sleeve 85 is also provided with annular internal flanges 89 adacent each of its ends and includes suitable packing elements 90 adapted to be compressed between the annular flanges 89 and a threaded gland member 91. The sleeve member 85 is provided adjacent its top portion with an apertured stud 92 constituting a fluid coupling between the conduit 27 and the annular chamber 88. The length of the sleeve 85 is so chosen and proportioned with regard to the reciprocatory length of travel of the piston 20 and rod 19 that the orifice 55 connected to the conduit 54 within the rod will always be in open communication with the annular chamber 88 during and within the limits of the reciprocation of the pump piston 20. The sleeve 85 thus constitutes a device for the admission of fluid from the reservoir 23 through the valve 28, conduit 27, annular chamber 88, orifice 55, conduit 54, and conduit 53 to the inlet valve 47 for the differential piston pump cylinder 38.

Referring now again to Fig. 1 and more particularly to Figs. 2 and 3, which disclose the differential pump mechanism in detail, the latter will be seen to consist of the larger diameter motor piston 42 reciprocably mounted in the cylinder 37 and the smaller diameter pump pis-

ton 43 reciprocably mounted in the smaller diameter cylinder 38. The smaller diameter piston 43 is provided with a main packing piece 46 similar to but much smaller than the main packing member 58 of the main pump piston 20. The packing 46 is adapted to be secured over a projecting boss 93 formed as an extension on the end of the smaller piston 43 and to be held in place against a backing member 94 by means of a locking ring 95 threadedly secured over the end of the boss 93. The boss 93 is also internally threaded to receive a threaded stud 96 formed on the end of a tube 97 which projects from the boss 93 and which is in fluid engagement with a conduit 98 formed in the interior of the piston 43. Referring to Fig. 1 the tube 97 is shown as extending through a packing member 99 and gland 100 into the inside of a screen or strainer device 101 mounted on the end of the reduced piston portion 31 of the main pump piston as by means of a securing ring 102, and bolts 103 and 104. The construction is such that the tube 97 reciprocates through the packing 99–100 in fluid-tight relationship therewith as the differential piston pump is operated, the open end of the tube 97 at all times being within the confines of the strainer screen 101 and thus being subject at all times to the working pressure within the main pump cylinder.

Referring back to Fig. 2, the large diameter portion 42 of the differential piston pump is preferably formed integrally with the smaller diameter portion 43 and is provided with similar packings 44 and 45 held in place by locking rings 105 and 106 against resilient backing members 107 and 108, respectively. Two sets of packings are provided on the larger diameter piston 42 for the reason that the latter is double-acting and is required to be sealed against fluid pressure admitted alternately against its opposite faces. The larger piston 42 is also provided with a boss 109 which is internally threaded to receive a coupling stud 110 formed on the end of a tube 111 which projects from the boss 109. A packing similar to the packing 99–100 and consisting of a packing element 112 and securing ring 113 is mounted in an aperture formed in the face of the piston rod cap portion 32 and is adapted to seal around the tube 111 in fluid-tight relationship therewith. The tube 111 is connected at its inner end to a conduit 114 formed in the boss 109 and extending into the inner portion of the larger diameter piston 42, and as shown in Figs. 1 and 3, the tube 111 is open at its outer end and reciprocates within a conduit 115 formed axially of the piston rod 19 and terminating at its outer end at the adjustable choke valve 30.

The piston 42 is provided centrally thereof with a pair of apertures 116 and 117 in communication with the conduits 98 and 114, respectively. Mounted within the aperture 116 is a valve 118 having two oppositely seating heads 119 and 120 adapted to alternately seat against the valve seat inserts 121 or 122 which are threadedly secured into opposite sides of the aperture 116. The valve 118 is also provided with an elongated valve stem 123 extending at opposite sides of the aperture 116 which is adjustably secured to a pair of contacting rings 124 and 125, respectively. The contacting rings 124 and 125 are mounted for limited reciprocation with respect to a pair of actuating cages 126 and 127, respectively, each of which is provided with one or more compression springs 128 adapted to urge the contacting rings 124 and 125 inwardly towards the aperture 116 or conversely to urge the actuating cages outwardly. The contacting ring 124 is provided with one or more spring-pressed detents 129 (two of which are shown in the drawings) adapted to seat in one of two annular grooves formed on the outer periphery of the piston 43. The valve portions 119 and 120 are adapted to alternately seat outwardly and thus constitute inlet valves for the admission of pressure fluid from the conduit 98 and aperture 116 to one side or the other of the piston 42 while simultaneously preventing the admission of pressure fluid to the opposite face of the piston 42. The aperture 117 contains a valve 130 mounted therein having two sealing faces 131 and 132 adapted to alternately seat against valve seat inserts 133 or 134. The valve 130 is likewise provided with elongated stem portions 135 and 136 extending from its opposite ends and adapted to be adjustably secured in the contacting rings 124 and 125, respectively. It will be noted that the valve 130 seats inwardly towards the working faces of the piston 42 and thus constitutes an exhaust valve for the discharge of working fluid alternately from one side or the other of the piston 42 whichever is not at the moment connected to receive pressure fluid. The discharge of spent fluid takes place through the appropriate valve seat insert 133 or 134, the aperture 117, the conduit 114, the tube 111, the conduit 115 in the main piston rod and finally the adjustable choke valve 30. The structure which has been just described constitutes a set of inlet and exhaust valves for the piston 42 and in addition comprises a lost-motion mechanism together with a snap-acting device for positively moving and resiliently holding the valves in one of two positions depending upon the position of the piston 42.

The snap-acting device for resiliently maintaining the differential piston pumping valves in one of two positions for admitting fluid to one side or the other of the piston 42 is illustrated to an enlarged scale in Fig. 5. As shown in this figure, the spring-pressed detent 129 is seen to consist of a cage member 137 having a ball 138 partially projecting from its open end and a spring 139 pressed between the inside of the cage and the ball.

As previously mentioned, Fig. 6 is a schematic or diagrammatic view of the hydraulic operating circuit forming a part of the present invention. Actually the representation of Fig. 6 is substantially identical, from the hydraulic standpoint, to that previously described and illustrated in Figs. 1 through 5, although in this case the structural details of the working parts of the mechanism have been substantially altered, the device being shown as broken down into its various separate components which are physically separated in space. The device as previously described and illustrated in Figs. 1 through 5 is of course a preferred embodiment of the invention, both hydraulically and mechanically, although it is contemplated that mechanism such as that illustrated in Fig. 6 could be arranged for satisfactory operation if desired.

Referring now specifically to Fig. 6 certain reference numerals have been applied to some of the parts to indicate similar structure to that previously set forth. The reference numeral 11 indicates a suitable source of power which may be any type of prime mover but is preferably an expansible chamber steam engine of the type illustrated generally in Fig. 4. This power source

is connected through a connecting rod 19 to the piston 20 which operates in the cylinder designated by reference numeral 16. Inlet and outlet valves 69 and 70 are provided in the end of the cylinder 16 for controlling the admission and exhaust, respectively, of the working fluid thereto. The inlet valve 69 is connected by means of a conduit 17 to a primary source of abrasive fluid herein indicated schematically as a slush pit and designated by the reference numeral 140. The outlet or exhaust valve 70 is connected to a conduit 18 which as heretofore indicated is adapted to be attached through conventional hydraulic fittings to the drill stem of a rotary well drilling apparatus. The piston rod 19 and piston 20 is provided with a conduit 141 having an external connection on the periphery of the rod 19 designated by reference numeral 142 and opening internally of the piston 20 to the annular chamber 65 formed between the working face of the piston 20 and a wiper element 61 previously described. A flexible conduit 143 is connected to the inlet fitting 142 for supplying nonabrasive fluid thereto as the rod and piston reciprocate within the cylinder under the mechanical actuation of the power source 11.

The differential piston mechanism constituting an auxiliary pumping device for maintaining a supply of nonabrasive fluid adjacent the working face of the main pump piston 20 is illustrated in Fig. 6 as comprising the larger diameter cylinder 37 having the piston 42 reciprocably mounted therein and a smaller diameter cylinder 38 having the piston 43 similarly mounted therein. Inlet and outlet valves are provided at the left-hand end of the smaller cylinder 38 for the admission and discharge of nonabrasive fluid to the cylinder 38. The nonabrasive fluid is indicated herein as fresh water supplied from a suitable source such as the reservoir 23 through a conventional stop valve 28 and the conduit 144 to the inlet valve of the auxiliary pump cylinder 38. The outlet valve of the cylinder 38 is connected through a conduit 145 to the flexible conduit member 143. It will thus be clear that as the piston 43 is reciprocated in the cylinder 38 fresh water from the source 23 will be drawn through the valve 28, conduit 144, and the inlet valve into the cylinder 38 and be discharged through the exhaust valve, the conduit 145, the conduit 143, the fitting 142 and the conduit 141 formed in the main connecting rod 19 to the annular space 65 adjacent the working face of the main pump piston 20.

Reciprocation of the piston 43 within the cylinder 38 is effected by means of the larger diameter piston 42 operating within the cylinder 37, the parts 37 and 42 constituting in effect a double-acting expansible chamber motor for driving the piston 43. Pressure fluid for operating the motor piston 42 is obtained from a conduit 146 leading from the exhaust conduit 18 of the main pump cylinder 16. A filter 101 is provided in the conduit 146 to prevent abrasive particles of appreciable size from reaching the valving and reciprocating parts of the differential piston motor. Admission of pressure fluid to opposite sides of the piston 42 is controlled by means of a balanced piston or barrel type valve designated generally by reference numeral 147. Pressure fluid supplied through the conduit 146 to the valve 147 intermediate its sealing portions is adapted to be supplied alternately to one of two conduits, 148 or 149, which are connected to opposite ends of the cylinder 37. That end of the cylinder 37 which is not connected through its conduit 148 or 149 to the pressure conduit 146 is adapted to be connected through the valve 147 to one of two exhaust conduits 150 or 151. The exhaust conduits 150 and 151 are interconnected adjacent their ends and are provided with a fluid discharge line through an adjustable choke valve 30. Actuation of the valve 147 is effected by means of a rod 152 connected to the piston 42 and a rod 153 connected to the valve 147, the rods 152 and 153 being interconnected by a lost-motion device such as a slot and pin connection designated by the reference numeral 154.

As illustrated in Fig. 6 the piston 42 has just moved to its extreme right-hand position, the rod 152 with its associated pin having contacted the right-hand end of the slot 154 and having moved the valve 147 to its extreme right-hand position by means of the rod 153. Pressure fluid from the conduit 146 is thus being admitted through the central valve body to the conduit 149 and thence to the right-hand portion of the cylinder 37 and is starting to move the piston 42 and consequently the piston 43 to the left. During movement of the piston 43 to the left fresh water which had previously been drawn into the cylinder 38 through the conduit 144 will be forced out through the conduits 145, 143, and 141 to the annular space 65 adjacent the working face of the main pump piston 20. As soon as the piston 42 moves to its extreme left-hand position the slot and pin connection 154 will be operative through the rods 152 and 153 to shift the valve 147 to the left, thus closing off the port leading to conduit 149 and opening the port leading to conduit 148 for admission of pressure fluid thereto through the central portion of the valve from the conduit 146. As soon as the limit of movement of piston 42 to the left has been reached the valve 147 will also have been moved sufficiently far to the left to uncover the valve port leading to conduit 149 so that it will be open through the extreme right-hand end of the valve body to the conduit 151 and thence to discharge through the adjustable choke valve 30. The function of the adjustable choke valve 30 will now be apparent. Since the piston 43 moving in the cylinder 38 is illustrated as single-acting there will be relatively little resistance to movement in the right-hand direction thereof during the intake stroke or while clear fluid is being drawn from the conduit 144 into the cylinder 38. In view of the relatively high pressure being admitted through the conduits 146 and 148 to the left-hand end of the cylinder 37 at that time there would be a tendency for the piston 42 to snap back very quickly to the right unless suitable means were provided for throttling the discharge of fluid within the cylinder 37 on the right-hand side of the piston 42 as it is discharged. The adjustable choke valve 30 is intended to accomplish this function and to prevent a too rapid actuation of the differential piston pump on its intake stroke.

In the operation of the schematic circuit illustrated in Fig. 6, it will be noted that the pressure face of the piston 42 which is subject to the pressure fluid supplied through conduits 146 and 148 is of an appreciably larger diameter than the working face of the piston 43. Since the total force operating on the pressure face of the piston 42 is equal to the pressure in pounds per square inch multiplied by the relatively large area of the piston face in square inches, and since in accordance with recognized and well-known hydraulic

principles this total force must be substantially equal to the total force produced by the piston 43 within the cylinder 38, and since further the area of the working face of the piston 43 is appreciably less than that of the piston 42 in square inches, it follows by a simple equation that the unit pressure in pounds per square inch within the cylinder 38 will be proportionately greater than the unit pressure in pounds per square inch within the cylinder 37. This proportion, subject of course to the usual and calculable differences occasioned by both mechanical and hydraulic friction, will remain substantially constant regardless of the pressure applied to the piston 42 and will be determined solely by the ratio or proportion of the cross sectional areas of the piston 42 and the piston 43. It thus follows that since the working face of the piston 42 is subject to the pressure in the conduit 146, or in effect the delivery pressure within the main pump cylinder 16, that the pressure within the cylinder 38 during the pumping stroke of the piston 43 will always be higher than the pressure within the conduit 146 or the cylinder 16 in this same predetermined ratio. The result of this hydraulic arrangement is that the pressure fluid delivered through the conduits 145, 143, and 141 to the annular space 65 will always be somewhat greater than the pressure within the cylinder 16 so that a slight amount of the nonabrasive fluid supplied by the differential piston pump will be permitted to escape past the wiper 61 in such manner as to wash the cylinder wall in advance of the main piston 20 to prevent contact of the main piston and its packing members with the abrasive fluid within the cylinder 16. It is contemplated that the pressure differential existing between the cylinder 16 and the annular space 65 will be so adjusted by means of the design proportions of the differential pump pistons 42 and 43 that the leakage of clear fluid past the wiper 61 will in no case be excessive or in such amount as to dilute to any substantial extent the primary working fluid supplied to the cylinder 16.

Referring now specifically to Fig. 7 there is illustrated diagrammatically a modified type of hydraulic operating circuit designed to effect a similar action to that just described in connection with the circuit illustrated in Fig. 6. In this case, however, the differential pump mechanism has been omitted and in its place an auxiliary pump, which may be of any well-known type, has been substituted together with a by-pass or relief valve designed to control the delivery pressure of this auxiliary pump. The only requirement of the modified system is that the auxiliary pump be inherently capable of delivering the nonabrasive fluid at a pressure in excess of any operating pressure liable to be encountered or built up by the main pump. It will thus be possible through proper actuation of the by-pass valve to control the output pressure of the auxiliary pump in such manner that at all times it will be proportionately higher than the delivery pressure of the main pump.

In Fig. 7, the prime mover is again designated by the reference numeral 11 and is similar to that of Fig. 6. The slush pit is also designated by reference numeral 140 and the detaiis of the main pump are in all respects similar to those described in connection with Fig. 6 and include a piston rod 19, main piston 20, cylinder 16, inlet and exhaust conduits 17 and 18 connected to inlet and exhaust valves 69 and 70, respectively, an annular space 65 formed between the working face of the piston 20 and a wiper 61, and a conduit 141 in the piston rod and piston connected by means of a fitting 142 to a flexible conduit 143. The auxiliary pump is designated by the reference numeral 155 and is suitably connected in any known manner preferably to a separate motor or other prime mover designated by reference numeral 156. The auxiliary pump 155 receives fluid through an inlet conduit 157 from a suitable source 23 and has its discharge side connected through a discharge conduit 158 to a by-pass valve generally designated by reference numeral 159. The by-pass or relief valve 159 is provided with an external pressure-tight housing which contains the working parts of the valve and includes a return line 160 leading back to the source 23 and a discharge conduit 161 connected to the flexible conduit 143 leading to the annular space 65 in the main pump piston. A valve 162 is mounted on a valve stem 163 which is slidably mounted in suitable brackets within the valve body. The valve 162 is adapted to seat against a valve seat 164 for variably restricting the flow of fluid through the by-pass conduit 160 in order to control the effective flow through the discharge conduit 161. A rocker arm 165 is pivotally mounted within the valve housing and is connected to the valve stem 163 for longitudinal movement therewith. A spring 166 mounted between the opposite end of the rocker arm 165 and an adjusting mechanism 167 is adapted to initially bias the valve 162 with respect to the valve seat 164. The upper end of the valve stem 163 is directly connected to the free end of a Sylphon bellows 168 which has its other end suitably anchored within the valve housing. The inside of the bellows 168 is connected by means of a conduit 146 to the discharge line 18 of the main pump. A suitable strainer or filter mechanism 101 is likewise provided in the conduit 146 as in the circuit illustrated in Fig. 6.

In the operation of the hydraulic circuit illustrated in Fig. 7 it will be noted that the bellows 168 is responsive to pressure within the conduits 146 and 18 or, in other words, to the delivery pressure from the main pump cylinder 16. As the pressure within conduit 146 increases it tends to expand the bellows 168 in such manner as to force the valve stem 163 and valve 162 downwardly against the valve seat 164 to restrict the flow of fluid through the by-pass conduit 160. more fluid will thus be available for delivery through the conduits 161, 143, and 141 to the annular space 65 adjacent the working face of the main pump piston. As pressure within the valve housing 159 increases, it tends to collapse the bellows 168, or in other words to move the valve stem 163 upwardly to lift the valve 162 from its seat 164. This tendency to move the valve upwardly is of course resisted by the pressure within the bellows 168 received through the conduit 146 and hence by suitably adjusting the spring 166 by means of the adjusting mechanism 167 it is possible to provide a biased pressure balance which will tend to maintain within the conduit 161 a delivery pressure which is at all times somewhat in excess of the pressure within the conduit 146. As previously indicated, this effect is obtained by controlling the permissible amount of fluid to be by-passed through the by-pass conduit 160 and hence to retain the excess pressure within the condit 161 it is only necessary for the pump 155 be inherently capable at all times of delivering fluid at such a pressure. This object is not particularly difficult of attainment since the volume of fluid to be delivered by the

auxiliary pump 155 will at all times be relatively small in comparison with the volume of fluid to be delivered by the main pump 16—20. Obviously, various other types of suitable pressure-responsive by-pass valves or pressure-responsive pumping devices may be provided, the specific details illustrated in Fig. 7 being purely diagrammatic for purposes of explanation and such other devices being per se well-known in the hydraulic art.

The operation of the device constituting a preferred embodiment of the invention as illustrated in Figs. 1, 2, and 3 is substantially identical in its functional aspects to the operation of the schematic circuit illustrated in Fig. 6. Referring to Fig. 1 it will be noted that the entire differential piston mechanism is mounted within the main pump piston itself. The filter 101 is likewise mounted on the face of the main pump piston where its motion with respect to the abrasive fluid serves to prevent clogging or obturation of the screens and the admission and discharge of pressure fluid for operation of the piston 42 is effected through the packed tubes 97 and 111 which reciprocate with the differential piston structure. The adjustable choke valve 30 as illustrated in Fig. 1 is so located on the piston rod 19 as to be at all times freely open exteriorly of the pump and may of course be provided with any suitable means for leading away the exhaust fluid discharged therefrom. In operation the flow of exhaust fluid through the adjustable choke valve 30 serves as a visible indicator whereby to check the continued operation of the differential piston mechanism.

In the operation of the device of Fig. 1, the abrasive-containing drilling fluid is supplied through the conduit 17 and inlet valve 69 to the cylinder 16 and discharged through the exhaust valve 70 and conduit 18 to the drill stem of the drilling apparatus as the main piston 20 reciprocates within the cylinder 16. In order to prevent contact of the main piston packing 58 with the abrasive fluid being pumped, a nonabrasive fluid such as clear water from the reservoir 23 is supplied through the conduit 27, sleeve 85, conduits 54, 53, and the inlet valve 47 to the auxiliary piston pump chamber 38 whence it is discharged through the exhaust valve 48 to the annular space 65. Since as previously explained the discharge pressure of the differential piston pump, or in other words the pressure created within the chamber 38, is always in excess of the pressure within the main cylinder 16 by reason of the design proportions of the differential piston pump working face areas, the annular space 65 will be maintained full of fresh water which is permitted to leak past the wiper mechanism 61. Preferably the wiper 61 is provided with a series of tangential grooves or apertures which are axially inclined and which serve to direct the leakage or discharge of clear fluid from the annular space 65 so that it produces a scouring or washing action against the cylinder walls in advance of the piston. The amount of this leakage is at all times accurately controlled by the design of the differential piston pump to the end that relatively little dilution of the drilling fluid within the main pump cylinder will take place.

The operation of the differential piston pump per se is most clearly illustrated in Figs. 2 and 3 of the drawings wherein pump is shown in two opposite positions. As illustrated in Fig. 2, the differential piston 42—43 has just completed a movement to the left and the valve mechanism has been actuated in such manner as to admit pressure fluid to the left-hand face of the piston 42 to initiate movement thereof in a right-hand direction. As shown in this figure, the valves 118 and 130 are in their extreme right-hand position wherein the valve 119 is seated against the valve seat 121 and the valve 132 is seated against the valve seat 134. Pressure fluid supplied from the working face of the main pump piston through the tube 97 and the conduit 98 is thus admitted past the valve 120 and the valve seat 122 into the cylinder 37 on the left-hand side of the piston 42 to force the same to the right within the cylinder 37. Since the valves 132 and 119 are closed, no pressure fluid can be admitted to the right-hand face of the piston 42 nor can any of the pressure fluid on the left-hand face of the piston 42 escape through the exhaust conduit 114 and tube 111. The fluid trapped within the cylinder 37 on the right-hand face of the piston 42 is, however, free to escape past the valve 131, valve seat 133, and aperture 117 into the conduit 114 and tube 111. This exhaust fluid is eventually discharged as shown in Fig. 1 through the conduit 115 and the adjustable choke 30.

As the differential piston moves to the right, the valves 118 and 130 are retained in the position which they occupy in Fig. 2 by the engagement of the spring-pressed detent 129 with its associated right-hand groove. As the piston 42 approaches the limit of its right-hand travel during which time a pumping stroke of the piston 43 has taken place within the cylinder 38, the valve actuating cage 126 abuts against the right-hand wall of the cylinder 37 and is gradually compressed against contacting ring 124 against the action of the compression springs 128. As the motion of the piston 42 towards the right is continued the actuating member 126 eventually comes up solid against the contacting ring 124 or at least sufficiently to disengage the detent 129 from the right-hand groove at which time the springs 128 operate to snap the contact ring 124 to the left so that the detent 129 will then be seated in its associated left-hand groove. At this time the valve parts will be in the positions indicated in Fig. 3 wherein it will be noted that the contacting ring 124 through its connection with the valve stem extensions 123 and 135 has moved the valves 118 and 130 into their extreme left-hand positions so that the valve 120 is now seated against the valve seat 122, the valve 119 is lifted from its seat 121, the valve 131 is seated against its valve seat 133, and the valve 132 is lifted from its associated seat 134. This positioning of the parts now provides for the admission of pressure fluid through the conduit 98 and the aperture 116 past the valve 119 and seat 121 into the right-hand portion of the cylinder 37 to initiate movement of the piston 42 in a left-hand direction. The position of the exhaust valve 130 is likewise such that the pressure fluid now being admitted to the right-hand side of the piston 42 cannot escape through the closed valve 131—133 whereas the spent fluid on the left-hand side of the piston 42 is now free to escape through the exhaust valve 132—134 into the conduit 114 and tube 111. The differential piston is thus conditioned for a return movement to the left during which time the piston 43 performs an intake stroke drawing clear fluid into the pumping chamber 38.

As previously mentioned violent action or a snapping back of the differential piston in the

left-hand direction due to the lack of resistance during the intake stroke of the piston 43 is prevented by the adjustable choke valve 30 which throttles the fluid being discharged from the left-hand side of the cylinder 37. When the differential piston reaches the left-hand limit of its movement the actuating cage 127 contacts the left-hand end of the cylinder 37 and through its associated contact ring 125, springs 128, and valve stem extensions 136 acts to unseat the spring-pressed detent 129 from its associated left-hand groove and to positively move the same rapidly into seating engagement with its right-hand groove whereupon the valves 118 and 130 will again be positioned as illustrated in Fig. 2 for initiating movement of the piston 42 in a right-hand direction. The operation of the differential piston 42—43 is thus seen to be cyclic in nature wherein the piston 42 operates as a motor under the action of pressure fluid delivered through the conduit 97—98 from the working face of the main pump piston 20 to reciprocate the piston 43 as a pump within its cylinder 38. It will also be apparent from a consideration of Figs. 2 and 3 that the relative cross sectional areas of the pistons 42 and 43 are substantially different as a result of which the unit pressure in pounds per square inch within the cylinder 38 will always be maintained at a predetermined higher proportionate pressure than the unit pressure in pounds per square inch of the working fluid operating against the piston 42 within the cylinder 37. The relative cross sectional areas of these piston faces as explained above are so chosen that the design will provide for a predetermined slight amount of leakage of nonabrasive fluid past the wiper 61 where it is ultimately mixed with the abrasive or primary working fluid within the main pump cylinder.

Throughout the specification refeernce has been made to oil wells and rotary drilling apparatus as well as to fluid pumps. It will be obvious to one skilled in the art that the principles of the invention may be equally adapted to double-acting pumps as well as to single-acting pumps of the type disclosed. Likewise the invention will find many other uses and is not limited in its applicability to oil wells or to rotary drilling apparatus but may be used with other types of drilling apparatus or in the drilling of other types of wells. Similarly, although the nonabrasive fluid has been referred to as clear water, it will be apparent that various other types of primary and secondary fluids may be substituted for the specific examples disclosed.

It will be further apparent that by the practice of the invention as set forth herein it is possible to protect the packings and cylinder walls of abrasive fluid pumps for indefinite periods of time and that in the event replacement of parts becomes necessary, such parts as the wiper device or the relatively small sized differential piston portions which are in contact with the abrasive fluid will be much less expensive to replace.

Numerous other modifications and alterations of the structure which has been disclosed herein for purposes of illustration will be apparent to one skilled in the art and it is obvious that the same may be made without departing from the spirit and scope of the invention as defined in the following claims.

I claim:

1. A slush pump for forcing drilling fluid through the drill stem of a rotary well drilling apparatus, comprising a prime mover, a main pump cylinder, a main pump piston having a piston rod secured thereto, means operatively connecting said prime mover to said rod for reciprocating the latter, valve means in the pressure end of said cylinder for the admission and discharge of drilling fluid thereto, said piston comprising an apertured central body portion and a wiper portion defining a substantially closed annular space therebetween, said wiper portion having a plurality of axially inclined peripheral grooves providing restricted fluid egress from said annular space, a secondary differential piston type pump mounted within the apertures in said main piston central body portion including at least two pistons of different diameters, the larger diameter piston constituting a power source for actuating the smaller diameter piston, inlet and outlet valves associated with the aperture containing said smaller diameter piston for controlling the admission and discharge of washing fluid thereto, said larger diameter piston including valve means for controlling the admission and discharge of pressure fluid on opposite sides thereof, a reservoir mounted on said main pump cylinder adapted to contain washing fluid, conduit means interconnecting said rservoir and said inlet valve, and second conduit means adapted to provide for the inlet and discharge of pressure fluid to said larger diameter differential piston valve means, the pressure inlet of said second conduit means being in fluid communication with the pressure side of said main pump piston whereby the washing fluid within said annular space is maintained at a predetermined substantially constantly proportionate higher pressure than that of the drilling fluid within said main pump cylinder.

2. A slush pump for forcing drilling fluid through the drill stem of a rotary well drilling apparatus, comprising a prime mover, a main pump cylinder, a main pump piston having a piston rod secured thereto, means operatively connecting said prime mover to said rod for reciprocating the latter, valve means in the pressure end of said cylinder for the admission and discharge of drilling fluid thereto, said piston comprising an apertured body portion, first means forming an annular space therein and second means providing restricted fluid egress from said annular space, a secondary differential piston type pump mounted within the apertures in said main piston body portion including at least two pistons of different diameters, the larger diameter piston constituting a power source for actuating the smaller diameter piston, inlet and outlet valves associated with the aperture containing said smaller diameter piston for controlling the admission and discharge of washing fluid thereto, said larger diameter piston including valve means for controlling the admission and discharge of pressure fluid on opposite sides thereof, a reservoir mounted on said main pump cylinder adapted to contain washing fluid, conduit means interconnecting said reservoir and said inlet valve, and second conduit means adapted to provide for the inlet and discharge of pressure fluid to said larger diameter differential piston valve means, the pressure inlet of said second conduit means being in fluid communication with the pressure side of said main pump piston whereby the washing fluid within said annular space is maintained at a predetermined substantially constantly proportionate

higher pressure than that of the drilling fluid within said main pump cylinder.

3. A slush pump for forcing drilling fluid through the drill stem of a rotary well drilling apparatus, comprising a main pump cylinder, a main pump piston having a piston rod secured thereto, valve means in the pressure end of said cylinder for the admission and discharge of drilling fluid thereto, said piston comprising an apertured central body portion and a wiper portion defining a substantially closed annular space therebetween, said wiper portion having a plurality of axially inclined peripheral grooves providing restricted fluid egress from said annular space, a secondary differential piston type pump mounted within the apertures in said main piston central body portion including at least two pistons of differet diameters, the larger diameter piston constituting a power source for actuating the smaller diameter piston, inlet and outlet valves associated with the aperture containing said smaller diameter piston for controlling the admission and discharge of washing fluid thereto, said larger diameter piston including valve means for controlling the admission and discharge of pressure fluid on opposite sides thereof, a reservoir mounted on said main pump cylinder adapted to contain washing fluid, conduit means interconnecting said reservoir and said inlet valve, and second conduit means adapted to provide for the inlet and discharge of pressure fluid to said larger diameter differential piston valve means, the pressure inlet of said second conduit means being in fluid communication with the pressure side of said main pump piston whereby the washing fluid within said annular space is maintained at a predetermined substantially constantly proportionate higher pressure than that of the drilling fluid within said main pump cylinder.

4. A pump comprising a prime mover, a main pump cylinder, a main pump piston having a piston rod secured thereto, means operatively connecting said prime mover to said rod for reciprocating the latter, valve means in the pressure end of said cylinder for the admission and discharge of drilling fluid thereto, said piston comprising an apertured central body portion and a wiper portion defining a substantially closed annular space therebetween, said wiper portion having a plurality of axially inclined peripheral grooves providing restricted fluid egress from said annular space, a secondary differential piston type pump mounted within the apertures in said main piston central body portion including at least two pistons of different diameters, the larger diameter piston constituting a power source for actuating the smaller diameter piston, inlet and outlet valves associated with the aperture containing said smaller diameter piston for controlling the admission and discharge of washing fluid thereto, said larger diameter piston including valve means for controlling the admission and discharge of pressure fluid on opposite sides thereof, a reservoir mounted on said main pump cylinder adapted to contain washing fluid, conduit means interconnecting said reservoir and said inlet valve, and second conduit means adapted to provide for the inlet and discharge of pressure fluid to said larger diameter differential piston valve means, the pressure inlet of said second conduit means being in fluid communication with the pressure side of said main pump piston whereby the washing fluid within said annular space is maintained at a predetermined substantially constantly proportionate higher pressure than that of the fluid within said main pump cylinder.

5. A pump of the expansible chamber type comprising a main cylinder, inlet and outlet valves for controlling admission and exhaust of primary working fluid to said main cylinder, and a main piston, said main piston comprising a main body portion having a plurality of apertures of different diameters therein and a rod portion having a conduit therein, a secondary differential piston type pump mounted in the apertures in said main body portion and including at least two pistons of different diameters, the larger diameter piston constituting a power source for actuating the smaller diameter piston, a first tube projecing from said smaller diameter piston in fluid-tight relationship therewith and with its associatd aperture and constituting a fluid connection between the larger diameter piston and the pressure face of said main piston, a strainer mounted on the pressure face of said main piston and enclosing the open end of said first tube, a second tube projecting from said larger diameter piston into the conduit in said rod portion in fluid-tight relationship therewith and with its associated aperture and constituting a fluid connection between the larger diameter piston and said conduit, inlet and outlet valves associated with the aperture containing said smaller diameter piston, a source of washing fluid, means connecting said source to said last mentioned inlet valve, and means operatively associated with said last mentioned outlet valve for providing restricted egress of washing fluid to the pressure face of said main piston, the entire assembly being constructed and arranged whereby in operation the washing fluid will be constantly delivered to the pressure face of said main piston at a proportionately higher pressure than that of said primary working fluid.

6. A pump of the expansible chamber type comprising a main cylinder, inlet and outlet valves for controlling admission and exhaust of primary working fluid to said main cylinder, and a main piston, said main piston comprising a main body portion having a plurality of apertures of different diameters therein and a rod portion having a conduit therein, a secondary differential piston type pump mounted in the apertures in said main body portion and including at least two pistons of different diameters, the larger diameter piston constituting a power source for actuating the smaller diameter piston, a first tube projecting from said smaller diameter piston in fluid-tight relationship therewith and with its associated aperture and constituting a fluid connection between the larger diameter piston and the pressure face of said main piston, a second tube projecting from said larger diameter piston into the conduit in said rod portion in fluid-tight relationship therewith and with its associated aperture and constituting a fluid connection between the larger diameter piston and said conduit, inlet and outlet valves associated with the aperture containing said smaller diameter piston, a source of washing fluid, means connecting said source to said last mentioned inlet valve, and means operatively associated with said last mentioned outlet valve for providing restricted egress of washing fluid to the pressure face of said main piston, the entire assembly being constructed and arranged whereby in operation the washing fluid will be constantly delivered to the pressure face of said main piston at a

proportionately higher pressure than that of said primary working fluid.

7. A pump of the expansible chamber type comprising a main cylinder, inlet and outlet valves for controlling admission and exhaust of primary working fluid to said main cylinder, and a main piston, said main piston comprising a main body portion having a plurality of apertures of different diameters therein and a rod portion having a conduit therein, a secondary differential piston type pump mounted in the apertures in said main body portion and including at least two pistons of different diameters, the larger diameter piston constituting a power source for actuating the smaller diameter piston, means constituting a fluid connection between the larger diameter piston and the pressure face of said main piston, means constituting a fluid connection between the larger diameter piston and said conduit, inlet and outlet valves associated with the aperture containing said smaller diameter piston, a source of washing fluid, means connecting said source to said last mentioned inlet valve, and means operatively associated with said last mentioned outlet valve for providing restricted egress of washing fluid to the pressure face of said main piston, the entire assembly being constructed and arranged whereby in operation the washing fluid will be constantly delivered to the pressure face of said main piston at a proportionately higher pressure than that of said primary working fluid.

8. A pump of the expansible chamber type comprising a main cylinder, inlet and outlet valves for controlling admission and exhaust of primary working fluid to said main cylinder, and a main piston, said main piston comprising a main body portion having a plurality of apertures at different diameters therein and a rod portion, a secondary differential piston type pump mounted in the apertures in said main body portion and including at least two pistons of different diameters, the larger diameter piston constituting a power source for actuating the smaller diameter piston, inlet and outlet valves associated with the aperture containing said smaller diameter piston, a source of washing fluid, means connecting said source to said last mentioned inlet valve, and means operatively associated with said last mentioned outlet valve for providing egress of washing fluid to the pressure face of said main piston, the entire assembly being constructed and arranged whereby in operation the washing fluid will be constantly delivered to the pressure face of said main piston at a proportionately higher pressure than that of said primary working fluid.

9. In a pump of the expansible chamber type, a main piston having a plurality of apertures of different diameters therein, a secondary differential piston type pump mounted in said apertures and including at least two pistons of different diameters, the larger diameter piston constituting a power source for actuating the smaller diameter piston, a source of washing fluid, valved means for admitting such fluid to the smaller diameter aperture, valved means for providing egress of washing fluid from said smaller diameter aperture to the pressure face of said main piston, and means for subjecting said larger diameter piston to such operating pressures that pressures developed by said smaller diameter piston will exceed pressures in the expansible pump chamber whereby in operation the washing fluid will be constantly delivered to the pressure face of said main piston at a proportionately higher pressure than that of said primary working fluid.

10. In combination with a pump of the expansible chamber type comprising a main pump cylinder and a main piston therein, a source of washing fluid, means for providing egress of washing fluid around the outer periphery of said main piston, and a secondary differential piston type pump including at least two pistons having different working face pressure areas, the larger piston constituting a power source for actuating the smaller piston, said secondary pump being interconnected between said source and said egress means and said larger piston being responsive to the working pressure within said main pump cylinder, the relative areas of said main piston, said larger piston and said smaller piston being such that pressures developed by said smaller piston will exceed pressures developed by said main piston whereby in operation the washing fluid will be constantly delivered to the pressure face of said main piston at a pressure which is substantially always higher in a predetermined uniform proportion than the pressure within said main pump cylinder.

11. In combination with a pump of the expansible chamber type comprising a main pump cylinder and a main piston therein, a source of washing fluid, means for providing egress of washing fluid around the circumferential periphery of said main piston, and means comprising a piston responsive to the delivery pressure of said main pump piston hydraulically interposed between said source and said egress means and constructed and arranged whereby in operation the washing fluid will be constantly delivered to said main piston at a pressure which is higher in a predetermined substantially uniform proportion than the delivery pressure of said main pump piston.

12. In a pump adapted to create pressure in an abrasive-containing fluid and comprising a main pump piston and cylinder, packing means providing a movable seal between said piston and cylinder, and means comprising a piston carried by said pump and responsive to the pressure of said abrasive-containing fluid for delivering a secondary, nonabrasive fluid adjacent said packing at a proportionately higher pressure than that of said abrasive-containing fluid whereby to substantially prevent contact of said packing with said abrasive-containing fluid.

13. In a pump adapted to create pressure in a primary fluid and comprising a main pump piston and cylinder, packing means providing a movable seal between said piston and cylinder, and means comprising a piston carried by said pump and responsive to the pressure of said primary fluid for delivering a secondary fluid adjacent said packing at a proportionately higher pressure than that of said primary fluid whereby to substantially prevent contact of said packing with said primary fluid.

14. Apparatus for moving an abrasive-containing fluid comprising, a pressure generating device including a portion in contact with said fluid, packing means for said portion, and means comprising a piston carried by said device and responsive to the pressure of said fluid for delivering a secondary nonabrasive fluid adjacent said packing at a proportionately higher pressure than that of said abrasive-containing fluid whereby to substantially prevent contact of said packing with said abrasive-containing fluid.

15. Apparatus for moving a primary fluid com-

prising, a pressure generating device including a portion in contact with said primary fluid, packing means for said portion, and means comprising a piston carried by said device and responsive to the pressure of said primary fluid for delivering a secondary fluid adjacent said packing at a proportionately higher pressure than that of said primary fluid whereby to substantially prevent contact of said packing with said primary fluid.

16. A slush pump for supplying drilling fluid to the drill stem of a rotary well drilling apparatus comprising a prime mover, a main pump cylinder, a main pump piston having a piston rod secured thereto, said piston including a packing and means forming an annular chamber adjacent to said packing and said rod including a conduit connected to said chamber at one end and having its other end open exteriorly of said cylinder, means operatively connecting said prime mover to said piston rod for reciprocating the latter, valve means in the pressure end of said cylinder for the admission and discharge of drilling fluid thereto, an auxiliary prime mover, an auxiliary pump adapted to be driven by said auxiliary prime mover and capable, relative to said main pump, of delivering a smaller volume of fluid at a higher pressure, a source of washing fluid connected to the inlet of said auxiliary pump, conduit means connecting the outlet of said auxiliary pump to the open end of said first mentioned conduit and including by-pass valve means therein having a return line to said source, resilient means for adjustably biasing said by-pass valve, and means responsive to the delivery pressure of said main pump for biasing said by-pass valve towards closed position whereby to maintain the pressure of washing fluid delivered to said chamber at a proportionately higher pressure than the delivery pressure of said main pump.

17. A slush pump for supplying drilling fluid to the drill stem of a rotary well drilling apparatus comprising, a main pump cylinder, a main pump piston having a piston rod secured thereto, said piston including a packing and means forming an annular chamber adjacent to said packing and said rod including a conduit connected to said chamber at one end and having its other end open, an auxiliary pump capable, relative to said main pump, of delivering a smaller volume of fluid at a higher pressure, a source of washing fluid connected to the inlet of said auxiliary pump, conduit means connecting the outlet of said auxiliary pump to the open end of said first mentioned conduit and including by-pass valve means therein having a return line to said source, resilient means for adjustably biasing said by-pass valve, and means responsive to the delivery pressure of said main pump for biasing said by-pass valve towards closed position whereby to maintain the pressure of washing fluid delivered to said chamber at a proportionately higher pressure than the delivery pressure of said main pump.

18. A pump of the expansible chamber type comprising a main cylinder, inlet and outlet valves for controlling admission and exhaust of primary working fluid to said main cylinder, and a main piston having a piston rod secured thereto, said piston including a packing and means forming an annular chamber adjacent to said packing and said rod including a conduit connected to said chamber at one end and having its other end open exteriorly of said cylinder, an auxiliary prime mover, an auxiliary pump adapted to be driven by said auxiliary prime mover and capable, relative to said main pump, of delivering a smaller volume of fluid at a higher pressure, a source of washing fluid connected to the inlet of said auxiliary pump, conduit means connecting the outlet of said auxiliary pump to the open end of said first mentioned conduit and including by-pass valve means therein having a return line to said source, resilient means for adjustably biasing said by-pass valve, and means responsive to the delivery pressure of said main pump for biasing said by-pass valve towards closed position whereby to maintain the pressure of washing fluid delivered to said chamber at a proportionately higher pressure than the delivery pressure of said main pump.

19. A pump of the expansible chamber type comprising a main piston including packing means and means forming an annular chamber adjacent to said packing means, conduit means connected to said chamber at one end and having its other end open, an auxiliary pump capable, relative to said main pump, of delivering a smaller volume of fluid at a higher pressure, a source of washing fluid connected to the inlet of said auxiliary pump, conduit means connecting the outlet of said auxiliary pump to the open end of said first mentioned conduit and including by-pass valve means therein having a return line to said source, resilient means for adjustably biasing said by-pass valve, and means responsive to the delivery pressure of said main pump for biasing said by-pass valve towards closed position whereby to maintain the pressure of washing fluid delivered to said chamber at a proportionately higher pressure than the delivery pressure of said main pump.

20. In a pump of the expansible chamber type, a piston, packing means for said piston, means forming an annular chamber adjacent to said packing means, first conduit means connected to said chamber at one end and having its other end open, auxiliary pressure generating means capable, relative to said pump, of delivering a smaller volume of fluid at a higher pressure, second conduit means connecting the outlet of said auxiliary pressure generating means to the open end of said first mentioned conduit and including by-pass valve means therein, first means for biasing said by-pass valve, and second means responsive to the delivery pressure of said pump for biasing said by-pass valve towards closed position whereby to maintain the pressure of fluid delivered to said chamber at a proportionately higher pressure than the delivery pressure of said pump.

21. In a pump of the expansible chamber type, a piston, packing means for said piston, means forming a chamber adjacent to said packing means, first conduit means adapted to be connected to said chamber at one end, auxiliary pressure generating means capable, relative to said pump, of delivering fluid to said chamber at a higher pressure, second conduit means adapted to connect the outlet of said auxiliary pressure generating means to the other end of said first mentioned conduit and including by-pass valve means therein, and means responsive to the delivery pressure of said pump for biasing said by-pass valve towards closed position whereby to maintain the pressure of fluid delivered to said chamber at a proportionately higher pressure than the delivery pressure of said pump.

22. In a pump of the expansible chambr type, a piston, packing means for said piston, means

forming a chamber adjacent to said packing means, auxiliary pressure generating means capable, relative to said pump, of delivering fluid to said chamber at a higher pressure, by-pass valve means operatively associated with said auxiliary pressure generating means, and means responsive to the delivery pressure of said pump for biasing said by-pass valve towards closed position whereby to maintain the pressure of fluid delivered to said chamber at a proportionately higher pressure than the delivery pressure of said pump.

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