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WAVE MOTION ACTUATED HYDRAULIC PUMP

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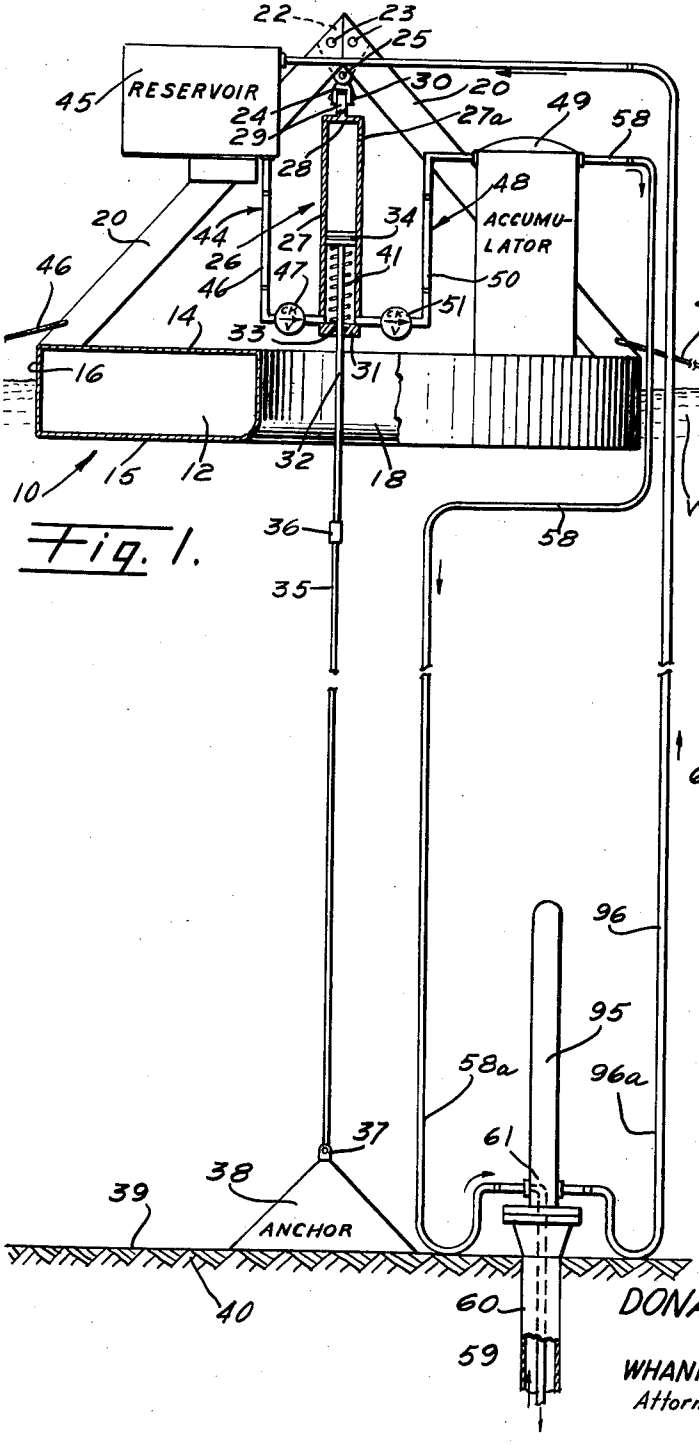

Fig. 1.

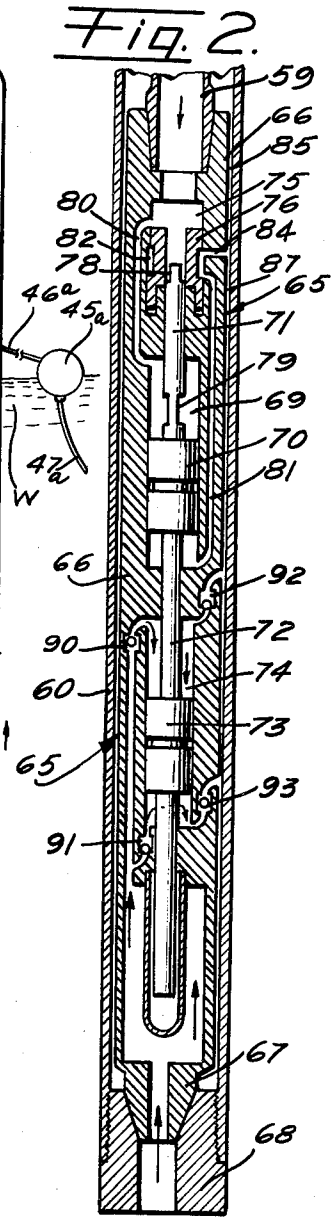

Fig. 2.

DONALD U. SHAFFER,
INVENTOR.
WHANN & McMANIGAL
Attorneys for Applicant
by

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WAVE MOTION ACTUATED HYDRAULIC PUMP

Donald U. Shaffer, 315 S. Flower, Brea, Calif.

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This invention relates generally to pumping mechanisms and relates more particularly to wave actuated pumping apparatus.

While the invention has particular utility in connection with pumping oil from oil wells and the like, and is shown and described in such connection, it is to be understood that its utility is not confined thereto.

A recent development in the petroleum industry is the exploration for oil in formations underlying bodies of water such as the ocean and the drilling of oil wells into such formations for the removal of oil from subterranean oil pockets or formations.

It is, therefore, an object of the present invention to provide efficient apparatus for pumping oil from such wells.

It is another object of the invention to provide apparatus of this character utilizing waves in the water as a source of energy or power to effect the pumping operation.

It is still another object of the invention to provide apparatus of this character that will accommodate itself to variations in the height of the tides of a body of water such as the ocean.

It is a further object of the invention to provide apparatus of this character that is simple in construction.

It is a still further object of the invention to provide apparatus of this character that is effective and efficient in operation.

It is another object of the invention to provide apparatus of this character that is relatively inexpensive to manufacture.

It is still another object of the invention to provide apparatus of this character embodying hydraulic pumping means.

The characteristics and advantages of the invention are further sufficiently referred to in connection with the following detailed description of the accompanying drawings which represent one embodiment. After considering this example, skilled persons will understand that variations may be made without departing from the principles disclosed and I contemplate the employment of any structures, arrangements, or modes of operation that are properly within the scope of the appended claims.

Referring to the drawings:

FIG. 1 is a diagrammatic side view of apparatus embodying the present invention; and

FIG. 2 is a longitudinal section of a hydraulic pump of the hydraulic system of the present apparatus.

Referring more particularly to the drawings, there is shown a float, indicated generally at 10 in a body of water W, said float comprising an annular or ring-like water tight air compartment 12 having upper and lower walls 14 and 15, an annular peripheral wall 16 and a central cylindrical wall defining an axial opening 18 through said float. While the float is shown herein as being annular in form, it is to be understood, of course, that it may have other shapes and the walls of the float may be of metal or any other suitable material. It is also to be understood that the float may be a hull that is not necessarily air tight, the top wall being merely a protection against water washing over the float filling the interior thereof.

A suitable super structure is provided, said super structure being shown as comprising a pair of support beams 20 having their lower ends secured by any suitable means,

not shown, to the top wall 14 of the float adjacent the edge thereof and at diametrically opposite points. The beams 20 are inclined upwardly and inwardly and are joined at the apex 21. The upper ends of said beams at said apex are secured together by any suitable well-known means such as bolts, not shown, and at one side of said apex, there is a plate 22 which is secured to said support beams by bolts 23 or the like and which has a depending ear to which a universal joint or swivel 24 is attached by means of a bolt 25 or the like.

A hydraulic pressure supply pump, indicated generally at 26, is provided to supply pressure fluid. The hydraulic pressure supply pump 26 includes a cylinder 27 which is closed at the upper end by a wall 28, the latter having a member 29 operably connected to the universal joint or swivel 24 by a pin or bolt 30 or by any other suitable means. Cylinder 27 is provided at the lower end with a wall 31 which has an opening therethrough for slidable reception of a piston rod 32, there being a seal 33 in a groove provided therefor in said wall 31 for sealing engagement with said rod 32. The piston rod 32 is provided with a piston 34 operably disposed within the cylinder 27. The lower end of rod 32 is connected to the upper end of a connecting member 35 which may be either a rod or a cable, said connecting member having its lower end pivotally connected to an ear 37 of an anchor 38 which rests on the surface 39 of an undersea or underwater formation 40 or the like.

Means is provided for counteracting or counterbalancing the weight of the piston 34, rod 32, member 35 and collar 36, said means comprising a spring 41 in the lower end of the cylinder 27 which reacts between the lower wall 31 of the cylinder and said piston 34. This spring is of sufficient strength to cause the piston 34 to move upwardly in the cylinder 27 when the float is moving downwardly. It is to be understood, of course, that any other suitable counterbalancing means may be used such as a weight which could be attached to the piston or piston rod and pull same upwardly through a suitable pulley arrangement, or an air spring could be provided to perform the counterbalancing function.

The float 10 may also be anchored against drifting by other suitable means such as buoys 45*a* suitably arranged about the float and connected thereto by cables 46*a* which are secured to the support beams 20 or other suitable part of the float. The buoys are also connected to anchors of any well-known type by means of cables 47*a*. The arrangement of the buoys and anchors may be of any desired type which will hold the float in substantially the selected spot while permitting vertical movements thereof due to wave and tidal action.

The upper end of the cylinder 27 is provided with a vent opening 27*a* to relieve any undesired pressure above the piston 34, while the lower end of the cylinder 27 is connected by a conduit or connector, indicated generally at 44, with a reservoir 45, there being a flexible section 46 in the conduit 44 to accommodate swaying motion of the float. Conduit 44 also has a check valve 47 therein so that fluid from the reservoir will be drawn into the lower end of the cylinder with upward movement of the piston and will be prevented by said check valve from return movement to the reservoir upon downward movement of said piston. The lower end of the cylinder also is provided with a connection or conduit, indicated generally at 48, with an accumulator 49, said connection 48 also having a flexible part 50 and a check valve therein, indicated by the reference numeral 51, which permits delivery of fluid from the lower end of the cylinder to the accumulator upon downward movement of the piston 27 but prevents return flow of fluid from the accumulator to the cylinder upon upward movement of said piston.

The accumulator 49 may be of any well-known type for providing an accumulation of pressure fluid and said accumulator is provided with a conduit 58, including a flexible slack portion 58*a*, leading downwardly and connected to a conduit or pipe 59 within the well casing 60, said pipe 59 terminating at its upper end in the wellhead 61. Pipe 59 leads downwardly to a hydraulic, well pump, indicated generally at 65. This pump may be of any well-known type and is disposed in the lower end of the well casing 60. This pump is shown as comprising a body 66 having a bottom plug 67 seated on a seating shoe 68 at the lower end of the casing 60. The pipe 59 is connected to the upper end of the pump body and supplies pressure fluid to an engine cylinder 69 in said body 66. Within the cylinder 69 is operably disposed an engine piston 70 mounted on a rod 71, said piston 70 being connected by a middle rod 72 with a pump piston 73 operably mounted in a pump cylinder 74. Above the engine cylinder 69 there is a cylindrical chamber 75 in which is mounted an engine valve 76 which controls the flow of hydraulic pressure fluid to the respective ends of the cylinder 69 for actuating the engine piston 70. The rod 71 is provided with valve operating ports 78 adjacent the upper end of said rod 71 and valve operating ports 79 adjacent the upper end of the piston 70.

With the parts of the engine mechanism positioned as shown in FIG. 2, pressure fluid from the pipe 59 enters the cylinder 75 and passes to the upper end of the cylinder 69 by way of a passage 80. Fluid below the piston 70 is exhausted by way of a passage 81, an annular groove 82 in the engine valve and outwardly through an exhaust passage 84 into the annular space 85 between the body of the pump and the interior of the casing 60. When the piston 70 reaches its downward limit of movement, pressure fluid is applied from the upper end of the cylinder 75 through the valve operating ports 78 and through the passage 87 to act on the underside of the engine valve and move same upwardly to reverse the connections with the cylinder 69 and reverse the movement of the engine piston 70 and the pump piston 73.

Pump cylinder 74 is provided with upper and lower intake valves 90 and 91 and upper and lower exhaust valves 92 and 93. The oil or other fluid pumped by the piston 73 is discharged into the annular space 85 between the body 66 and the interior of the casing 60. The hydraulic fluid discharged from the engine and the fluid discharged by the pump is conducted upwardly in the casing 60 and into the tubular member 95 of the wellhead from which member said fluid is carried by means of a conduit 96, including a flexible slack portion 96*a*, to the reservoir 52 or to any other storage reservoir or the like.

Waves in the body of water W cause the float to rise and fall and this movement of the float causes the piston 34 of the pump 26 to move upwardly and downwardly within the cylinder 27 thereby pumping hydraulic fluid from the reservoir 45 into the accumulator. During this pumping action the spring 41 moves the piston 34 upwardly with downward movement of the float, the upper end of the cylinder being vented at 27*a*. Fluid is drawn into the cylinder 27 below the piston as the latter moves upwardly and said fluid is forced out of the cylinder as the float rises.

Pressure fluid in said reservoir is conducted downwardly through the pipe 58, into the pipe 59 and thence to the engine of the hydraulic pump at the bottom of the well. Exhaust fluid from said pump is, of course, carried upwardly and back to the reservoir as above described. The flexible slack portions 58*a* and 96*a* permit raising and lowering of the float as a result of both wave and tidal action.

When the float is anchored in the ocean, there is a substantial variation in the depth of the water due to the tide. It is, therefore, necessary to provide means for the pump 26 to compensate for such tidal variations. In the present invention, such compensation is effected by

having the cylinder 27 of the pump 26 of sufficient length so that as the tide varies, the operating position of the piston 34 in the cylinder 27 will vary accordingly. The stroke of the piston 34, as effected by wave movement, is of limited range and may be considered as the pumping stroke. When the tide is low, the piston 34 will be located toward the upper part of the cylinder 27 where the pumping stroke will occur. However, as the tide rises, the position of the piston 34 will generally move downwardly although the range of the pumping stroke may not vary materially. However, it is to be understood that the range of the pumping stroke may also vary according to the height of the waves.

It is to be understood that while a bottom-hole pump has been shown and described as being the pump operated by pressure fluid developed by the action of the float, other types of hydraulic pumps may be used and driven by such pressure fluid. For example, there is another type of hydraulic pump which actuates a piston which is attached to rods which pump the oil through a conventional rod-actuated bottom-hole pump. It is also to be understood that the invention can be used to provide hydraulic pressure fluid for several pumps. Also, the wave motion actuated hydraulic pump of the present invention may be used at sea in connection with wells which are situated on land or on an artificial island or the like which may be a fill or a structure above the water, the float with its mechanism for supplying pressure fluid being anchored nearby.

It is thought that the invention and many of its attendant advantages will be understood from the foregoing description and it is thought that it will be apparent that various changes may be made in the form, construction and arrangement of the parts of the invention without departing from the spirit and scope thereof or sacrificing all of its material advantages, the embodiment hereinbefore described being merely for the purposes of illustration.

I claim:

1. Apparatus for pumping fluid from a well having therein a hydraulic well pump including a hydraulic engine provided with an inlet and an outlet comprising: an annular float having a central opening therethrough; a super structure for said float comprising a pair of support beams secured at their lower ends to said float and extending upwardly and inwardly to an apex disposed over said central opening in the float and in upwardly spaced relation thereto; a hydraulic fluid supply pump having a relatively long cylinder, said cylinder having an upper end wall and a lower end wall with an axial opening therein; a universal joint connected to said upper end wall of the cylinder and to the super structure at the apex thereof; a piston operably disposed in said cylinder; a piston rod extending through the opening in the lower wall; sealing means for said lower wall for sealing engagement with said piston rod; an anchor disposed on the underwater formation below the float; means connecting said anchor with the lower end of said piston rod; spring means counterbalancing the weight of said piston, piston rod and said connecting means; a fluid reservoir on said float, said reservoir having a connection with the lower end of said cylinder; a check valve in said connection permitting fluid flow into the cylinder but preventing reverse flow; a pressure accumulator on said float; a connection between the lower end of said cylinder and said accumulator; a check valve in the last mentioned connection permitting fluid to be discharged from said cylinder into said accumulator but preventing reverse flow; conduit means, including a slack portion, providing a fluid connection between said accumulator and the inlet of said engine of the hydraulic well pump in the well; conduit means, including a slack portion, providing a fluid connection for carrying fluid from the well to the reservoir; and anchoring means for said float to retain same substantially over the anchor and having sufficient slack to

permit upward and downward movements of said float both as the result of wave action and of tidal movement.

2. Apparatus for pumping fluid from a well having therein a hydraulic well pump including a hydraulic engine provided with an inlet and an outlet, comprising: an annular float having a central opening therethrough; a super structure for said float comprising a pair of support beams secured at their lower ends to said float and extending upwardly and inwardly to an apex disposed over said central opening in the float and in upwardly spaced relation thereto; a hydraulic fluid supply pump having a relatively long cylinder, said cylinder having a lower end wall with an axial opening therein and an upper end wall having a swivel connection wtih the super structure at the apex thereof; a piston operably mounted in said cylinder; a piston rod having the piston secured to the upper end, said piston rod extending through the opening in the lower wall, sealing means for said lower wall for sealing engagement with said piston rod; an anchor disposed on the underwater formation below the float; means connecting said anchor with the lower end of said rod; means counterbalancing the weight of the piston, piston rod and connecting means; a fluid reservoir on said float, said reservoir having a connection with the lower end of said cylinder; a check valve in said connection permitting fluid flow into the cylinder but preventing reverse flow; a pressure accumulator on said float; a connection between the lower end of said cylinder and said accumulator; a check valve in the last mentioned connection permitting fluid to be discharged from said cylinder into said accumulator but preventing reverse flow; conduit means, including a slack portion, providing a fluid connection between said accumulator and the inlet of said engine of the hydraulic well pump in the well to provide pressure fluid from the accumulator to said well pump engine for operating the latter; and conduit means, including a slack portion, providing a fluid connection for carrying fluid from the well to the reservoir.

3. In apparatus for pumping fluid from a well, the combination with a hydraulic well pump including an engine provided with an inlet and an outlet of a float having an opening therethrough from top to bottom; a super structure for said float having a part disposed over said opening in the float and in upwardly spaced relation thereto; a relatively long cylinder closed at the ends, there being a lower end wall having an axial opening therein; a piston operably disposed in said cylinder; a piston rod having its upper end secured to said piston, the upper end of said cylinder having a swivel connection with the part of the super structure over said float opening, said piston rod extending through the opening in the lower wall; sealing means for said pitson rod; an anchor disposed on the underwater formation below the float; means connecting said anchor with said rod; counterbalancing means acting upwardly on said piston; a fluid reservoir on said float, said reservoir having a connection with the lower end of said cylinder; a check valve in said connection permitting fluid flow into the cylinder but preventing reverse flow; a pressure accumulator on said float; a connection between the lower end of said cylinder and said accumulator; a check valve in the last mentioned connection permitting fluid to be discharged from said cylinder into said accumulator but preventing reverse flow; conduit means, including a slack portion, providing a fluid connection between said accumulator and the inlet of the engine of the hydraulic well pump to provide pressure fluid from the accumulator to said engine for operating the latter; conduit means, including a slack portion, providing a fluid connection for carrying fluid from the engine outlet to the reservoir; and anchoring means for said float to retain same in operable position relative to the anchor and having sufficient slack to permit upward and downward movements of said float both as the result of wave action and of tidal movement.

4. In apparatus for pumping fluid from a well, the combination with a hydraulic well pump including an engine provided with an inlet and an outlet of a float having an opening therethrough from top to bottom; a super structure for said float having a part disposed over said opening in the float; a relatively long cylinder closed at the ends, there being an upper end wall having a swivel connection with said super structure and a lower wall having an axial opening therein; a piston operably disposed in said cylinder; a piston rod, said piston being secured to the upper end thereof, said piston rod extending through the opening in the lower wall; sealing means for said lower wall for sealing engagement with said piston rod; an anchor disposed on the underwater formation below the float; means connecting said anchor with said rod; counterbalancing means which will raise the piston when the float is moving downwardly; a fluid reservoir on said float, said reservoir having an operable connection with the lower end of said cylinder; a check valve in said connection permitting fluid flow into the cylinder but preventing reverse flow; a pressure accumulator on said float; a connection between the lower end of said cylinder and said accumulator; a check valve in the last mentioned connection permitting fluid to be discharged from said cylinder into said accumulator but preventing reverse flow; conduit means, including a slack portion, providing a fluid connection between said accumulator and the inlet of the engine of the hydraulic well pump to provide pressure fluid from the accumulator to said well pump engine for operating the latter; and conduit means, including a slack portion, providing a fluid connection for carrying fluid from the engine outlet to the reservoir.

5. In pumping apparatus, the combination with a hydraulic engine having an inlet and an outlet of a float having an opening therethrough; a relatively long vertical cylinder in alignment with said float opening, said cylinder having a lower end wall with an axial opening therein and a wall closing the upper end; a piston operably disposed in said cylinder; a piston rod having the piston secured to the upper end, said piston rod extending through the opening in the lower wall; means operably connecting said cylinder to the float; sealing means for said lower wall for sealing engagement with said piston rod; an anchor disposed on the underwater formation below the float; means operably connecting said anchor with said piston rod; a fluid reservoir on said float, said reservoir having a connection with the lower end of said cylinder; a check valve in said connection permitting fluid flow into the cylinder but preventing reverse flow; a pressure accumulator on said float; a connection between the lower end of said cylinder and said accumulator; a check valve in the last mentioned connection permitting fluid to be discharged from said cylinder into said accumulator but preventing reverse flow; conduit means providing an operable fluid connection between said accumulator and the inlet of said engine to provide pressure fluid from the accumulator to said engine for operating the latter; conduit means providing an operable fluid connection for carrying fluid from the engine outlet to the reservoir; and means yieldingly urging said piston in a direction to draw fluid into said cylinder.

6. Apparatus for supplying pressure fluid for a fluid pressure operated device, comprising: a float having an opening therethrough; a reciprocating pump including a relatively long cylinder with a piston operably disposed in said cylinder; a piston rod operably connected to said rod and extending outwardly of said cylinder; means operably securing said cylinder to said float for movement therewith; means securing said rod against movement with said float; a fluid reservoir on said float operably connected with said cylinder; a pressure accumulator on said float operably connected with said cylinder, said accumulator having a pressure fluid outlet for the supply of pressure fluid to operate fluid pressure operable means; and means yieldingly urging said piston in a direction to draw fluid into said cylinder.

7. Fluid pumping apparatus, comprising: a fluid operated engine; a float for floating on the surface of a body of water so as to move upwardly and downwardly with corresponding movements of the surface of the water; a relatively long cylinder having an end wall with an axial opening therein and an end wall closing the other end with an attaching part thereon; a piston rod slidable in said end wall opening and having an attaching part; a piston operably disposed in said cylinder and secured to the inner end of said rod; an anchor weight disposed on the formation at the bottom of said body of water; means connecting one of said attaching parts with said anchor; means operably connecting the other of said attaching parts to said float; means operably connecting one end of the cylinder interior with a source of fluid; an accumulator; means operably connecting said one end of the interior of said cylinder with said accumulator; conduit means connecting said accumulator with said fluid operated engine to provide pressure fluid thereto for operating same; means for conducting fluid discharged by said engine to a disposal point; and means yieldingly urging said piston in a direction to draw fluid into said cylinder.

8. Fluid pumping apparatus, comprising: a fluid operated engine; a float for floating on the surface of a body of water so as to move upwardly and downwardly with corresponding movements of the surface of the water; a relatively long cylinder having end walls, said cylinder having attaching means; a piston operably disposed in said cylinder and having attaching means; an anchor weight disposed on the formation at the bottom of said body of water; means operably connecting one of said attaching means with said anchor; means operably connecting the other of said attaching means to said float; means operably connecting one end of the cylinder interior with a source of fluid; conduit means including a slack portion connecting said cylinder with said fluid operated engine to provide pressure fluid thereto for operating same; and means yieldingly urging said piston in a direction to draw fluid into said cylinder.

9. In apparatus for supplying pressure fluid: a float for floating on the surface of a body of water so as to move upwardly and downwardly with corresponding movements of the surface of the water; a relatively long cylinder having attaching means, said cylinder having an inlet and an outlet; a piston operably disposed in said cylinder and having attaching means; an anchor weight disposed on the formation at the bottom of said body of water; means operably connecting one of said attaching means with said anchor; means operably connecting the other of said attaching means to said float; and means yieldingly urging said piston in a direction to draw fluid into said cylinder, the length of said cylinder being sufficient to accommodate to variations in the tide and permit the piston to operate in different portions of said cylinder in accordance with the height of the tide.

10. In apparatus for supplying pressure fluid for a fluid pressure operated device: a float for tidewater wherein there is also wave motion; a two part reciprocating pump, one part of said pump being a relatively long cylinder having an inlet and an outlet and the other part comprising a piston operably disposed in said cylinder; means connecting one part of said pump with said float for movement therewith; means securing the other part of said pump against movement with said float so that the cylinder and piston have relative longitudinal reciprocating movement, the vertical movement of the float with wave motion causing relative reciprocating action between the piston and cylinder through a limited range comprising the normal pumping stroke, said cylinder being sufficiently long so that said pumping stroke of the piston and cylinder will occur in various longitudinal portions of said cylinder as the float rises and falls with the tide; and means yieldingly urging said piston in a direction to draw fluid into said cylinder.

11. In apparatus for supplying pressure fluid for a fluid pressure operated device: a float for tidewater wherein there is also wave motion; a two part reciprocating pump, one part of said pump being a cylinder having an inlet and an outlet, and the other part comprising a piston operably disposed in said cylinder; means connecting one part of said pump with said float for movement therewith; means securing the other part of said pump against movement with said float so that the cylinder and piston have relative longitudinal reciprocating movement, the vertical movement of the float with wave motion effecting normal reciprocating pumping movement of the piston and cylinder, said pump being longitudinally dimensioned to compensate for the rise and fall of the float with corresponding movements of the tide; and means yieldingly urging said piston in a direction to draw fluid into said cylinder.

12. In apparatus for supplying pressure fluid for a fluid pressure operated device: a two part reciprocating pump, one part of said pump being a relatively long cylinder and the other part comprising a piston operably disposed in said cylinder; means connecting one part of said pump with means to effect limited longitudinal movement thereof; means securing the other part of said pump against longitudinal movement so that the cylinder and piston have limited relative longitudinal movement; said relatively long cylinder enabling said movement to occur in various longitudinal portions of said cylinder; and means yieldingly urging said piston in a direction to draw fluid into said cylinder.

13. In apparatus for supplying pressure fluid for a pressure operated device: a two part reciprocating pump, one part of said pump being a relatively long cylinder and the other part comprising a piston operably disposed in said cylinder; means for causing limited relative movement between said pump parts to provide a pumping stroke; said relatively long cylinder enabling said stroke to occur in various longitudinal portions of said cylinder with variations of the relative position of one of said pump parts relative to said stroke; and means yieldingly urging said piston in a direction to draw fluid into said cylinder.

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