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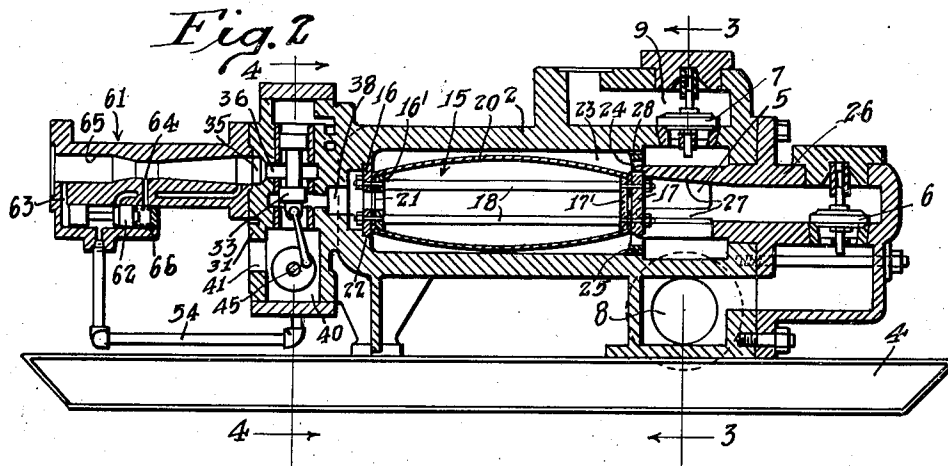
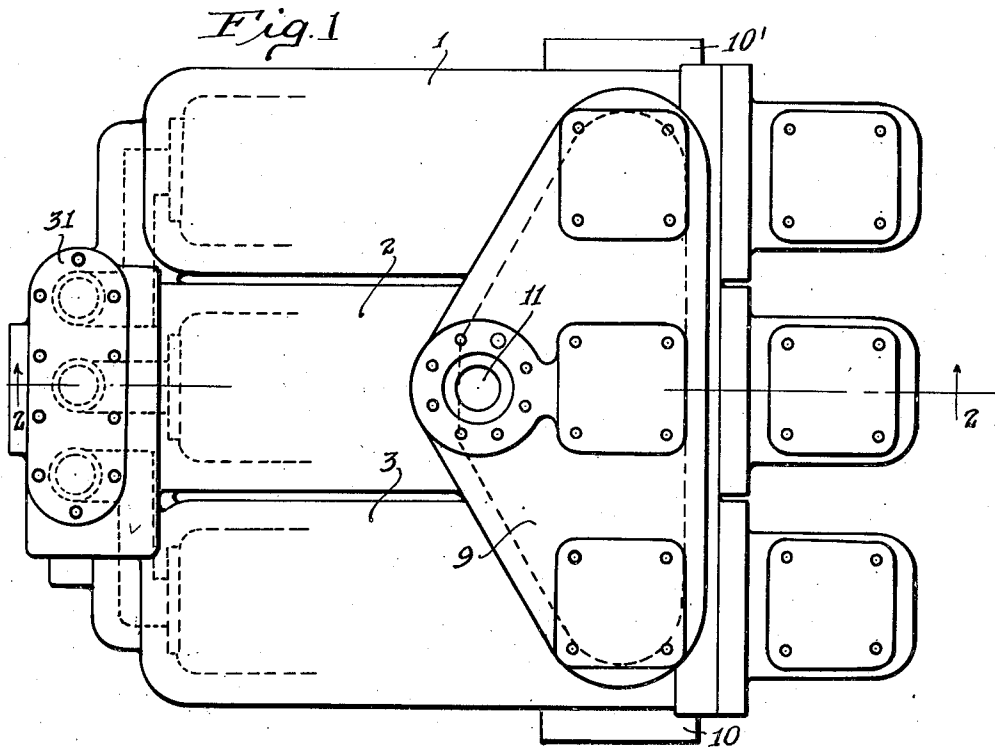
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2,186,972

PUMPING APPARATUS

Filed July 18, 1938

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Fig. 3

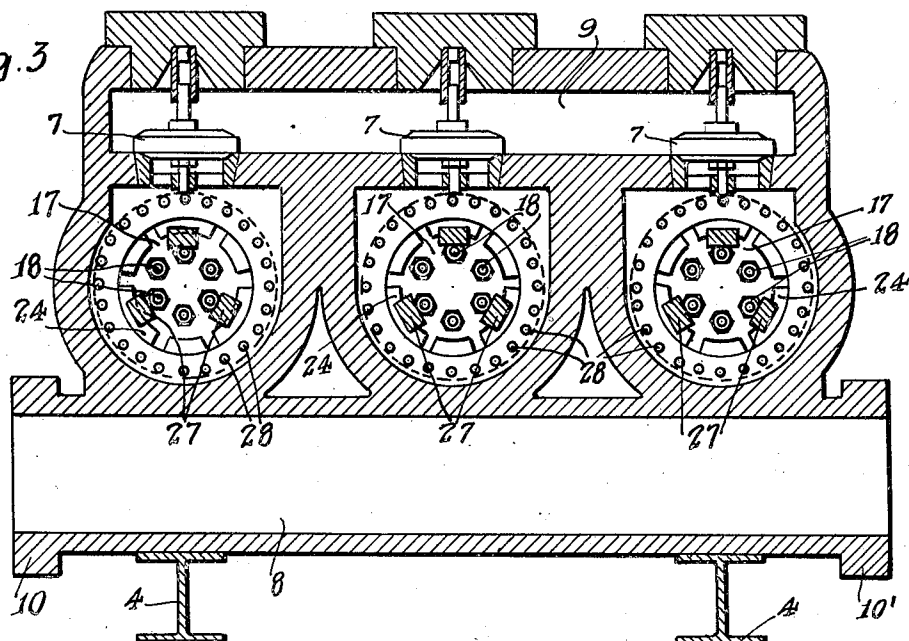
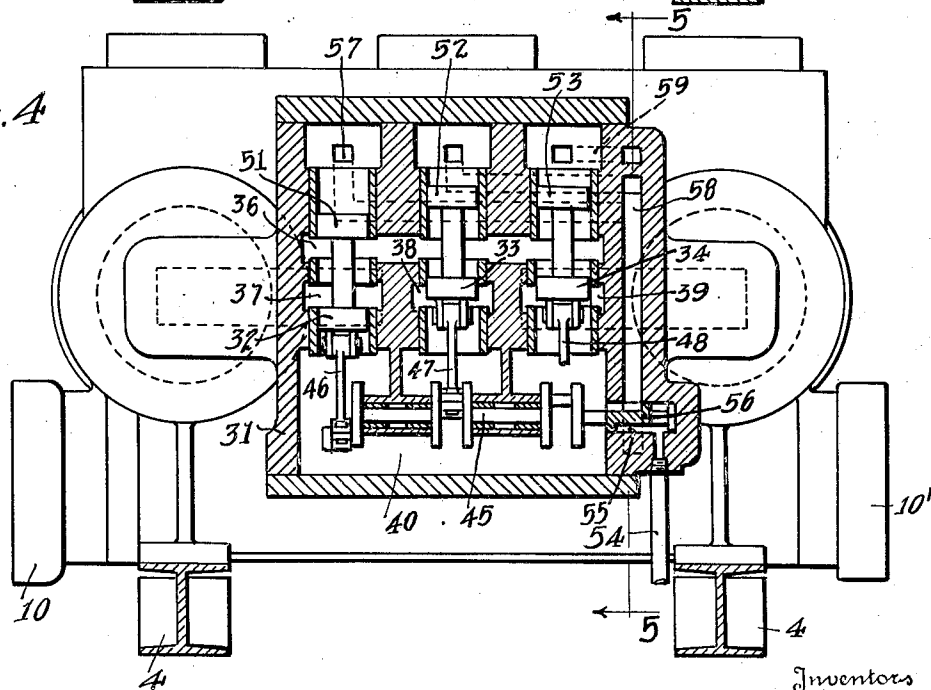


Fig. 4



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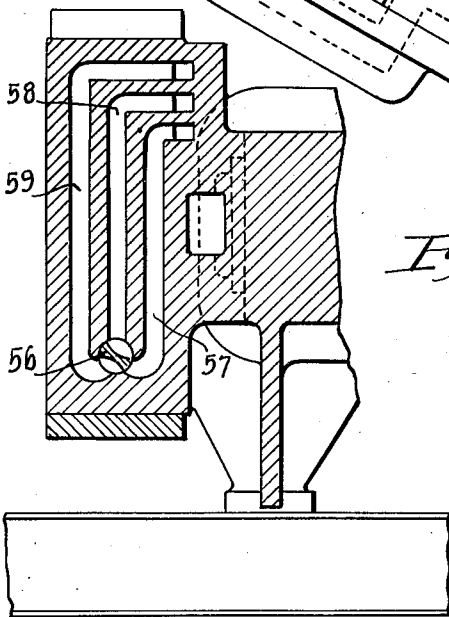
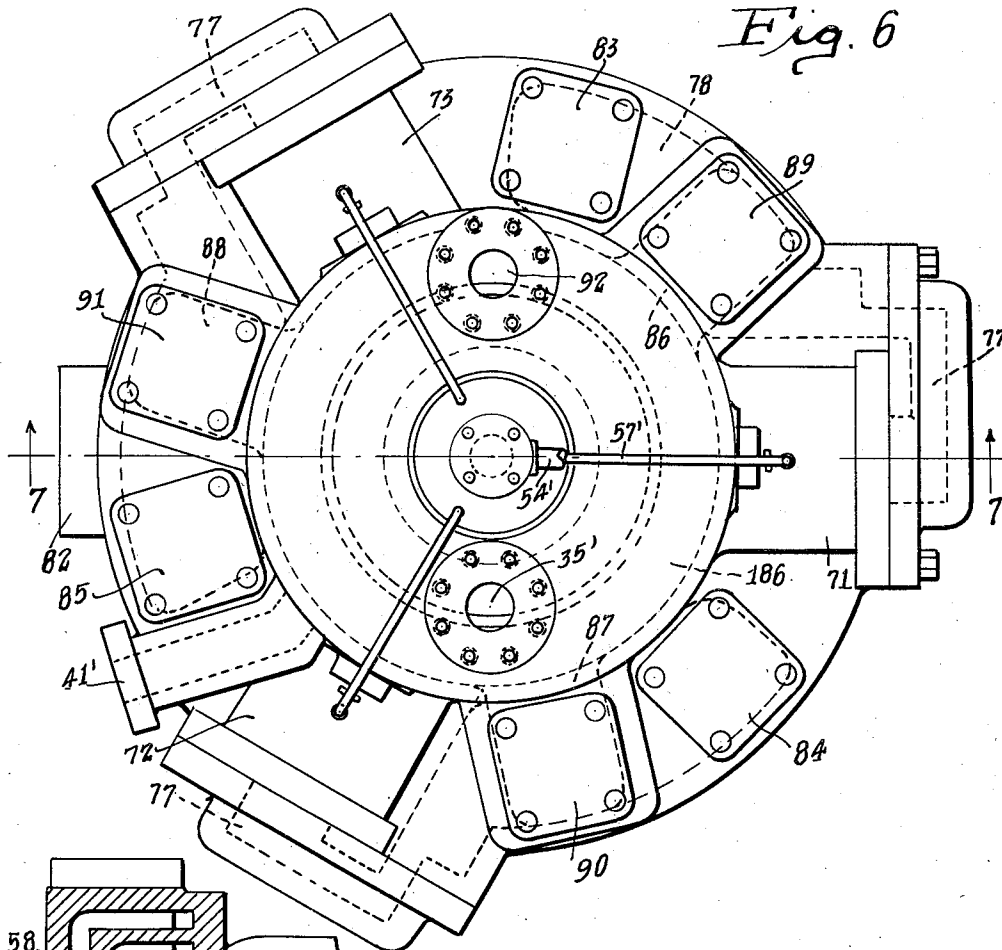


Fig. 5

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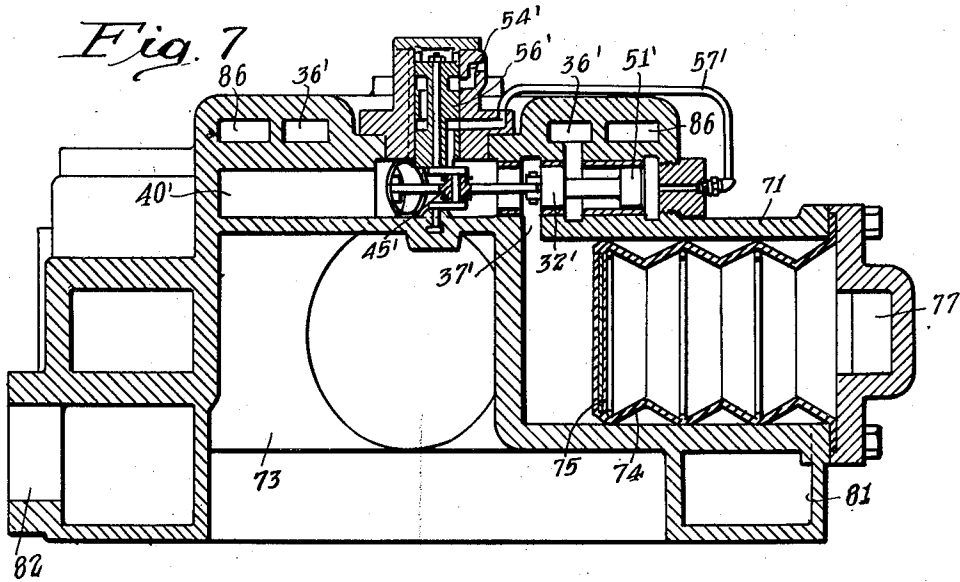
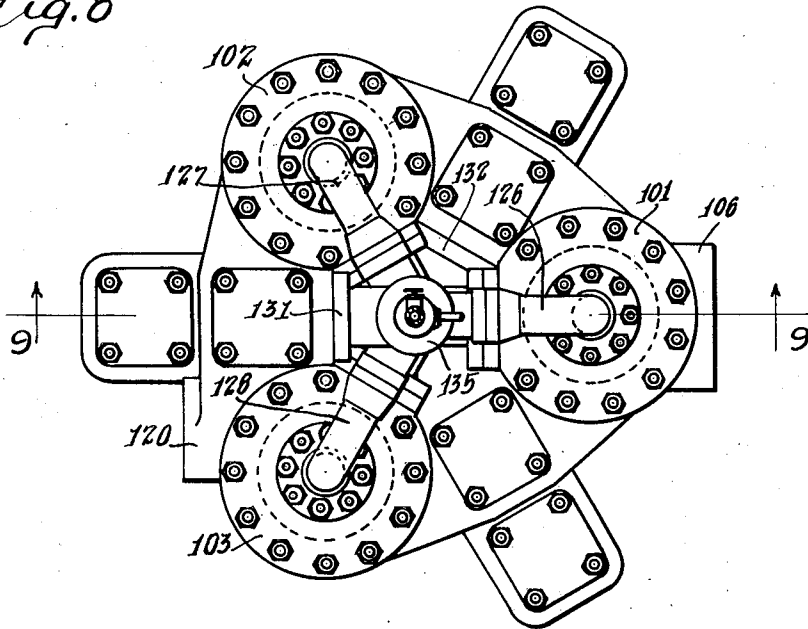


Fig. 8



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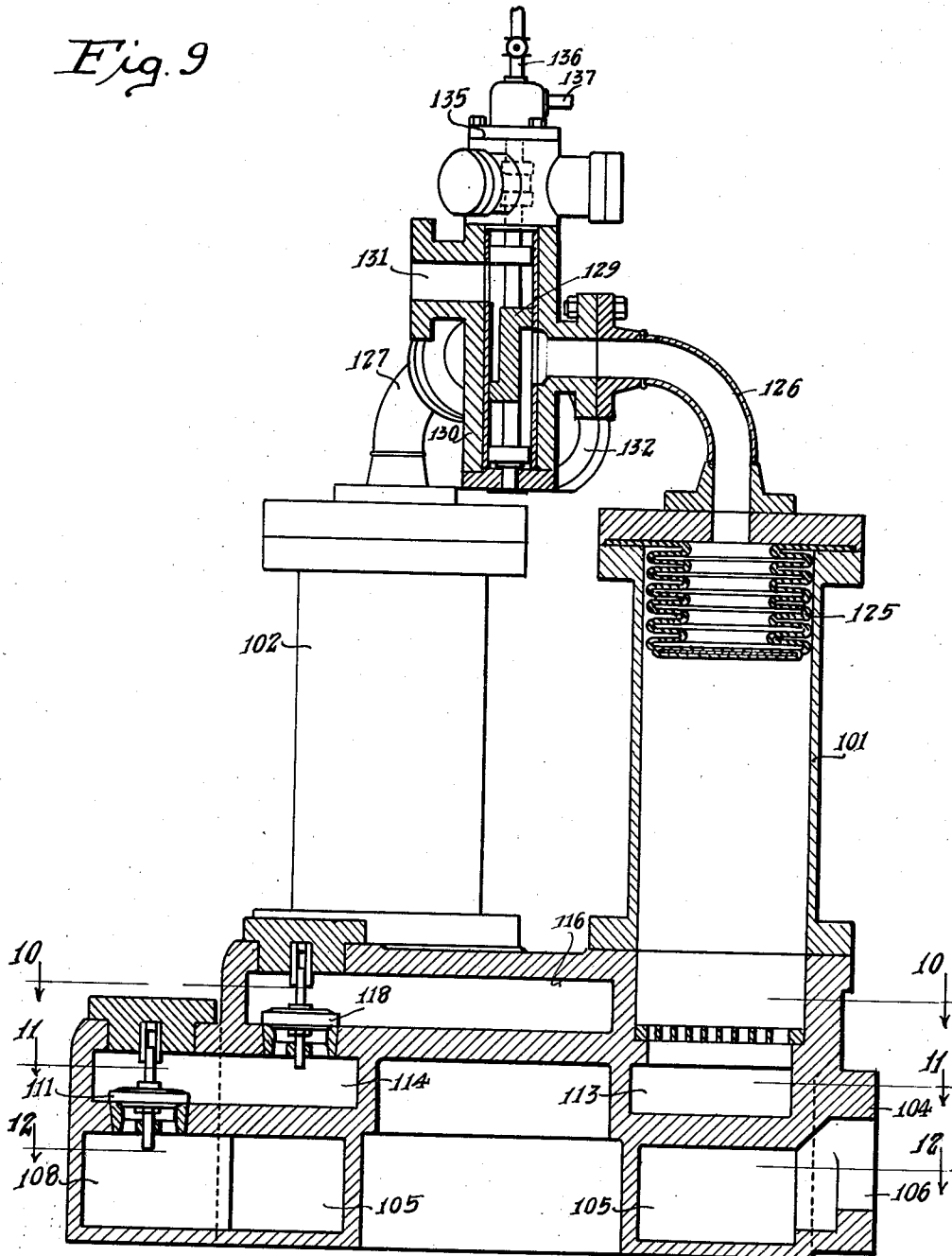
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Fig. 9



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Fig. 10

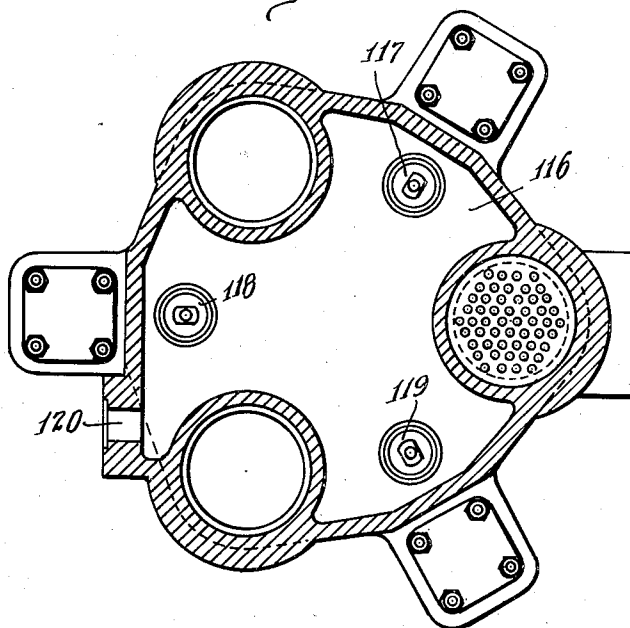
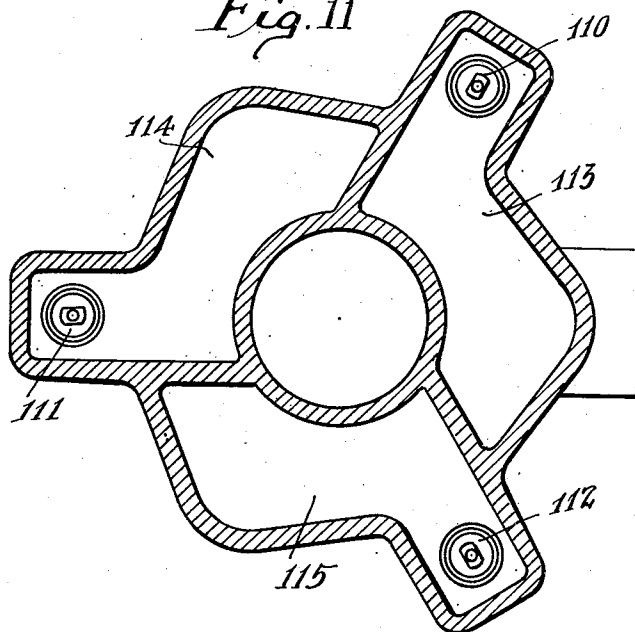


Fig. 11



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Fig. 13

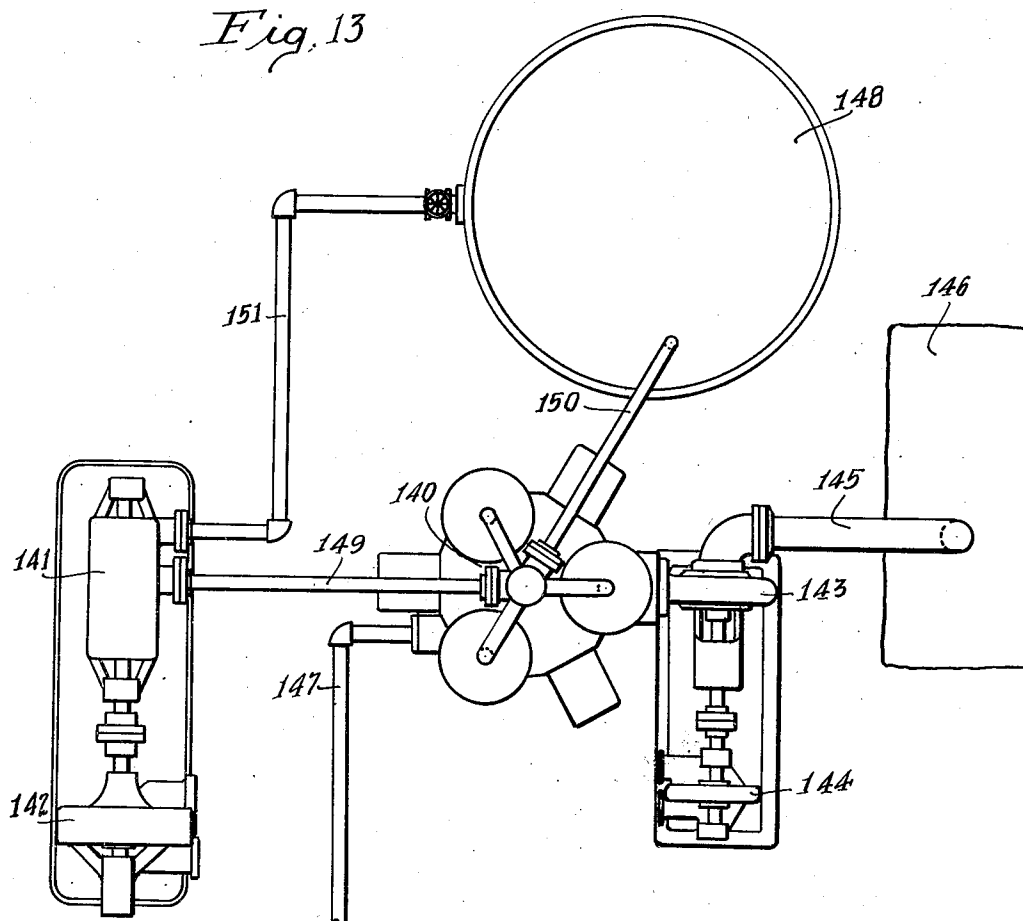
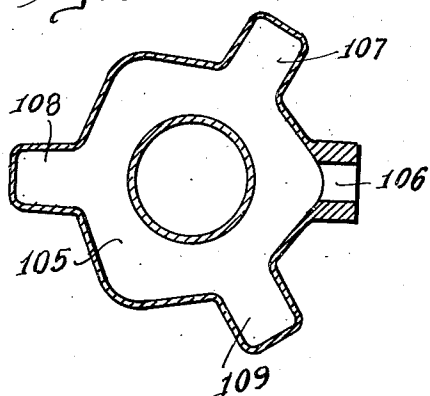


Fig. 12



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UNITED STATES PATENT OFFICE

2,186,972

PUMPING APPARATUS

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Application July 18, 1933, Serial No. 219,804

9 Claims. (Cl. 103—152)

This invention relates generally to hydraulic pumping apparatus and particularly to a multicylinder diaphragm pump adapted to be actuated by motive liquid supplied thereto under steady flow and steady pressure conditions.

A principal object of this invention is to provide a diaphragm pump particularly adapted to be actuated by a motive liquid (such as water) supplied by a centrifugal pump, to handle drilling mud used during the drilling of deep oil wells. As set forth in the copending application of Aladar Hollander, Ser. No. 197,139, filed Mar. 21, 1938, for Pumping apparatus, the pressure-volume characteristics of a centrifugal pump are admirably suited to the pumping requirements in this service. Because of the abrasive nature of the drilling mud, however, it is not practical to handle it directly by a high-speed centrifugal pump. The hydraulic pump of the present invention is adapted to be interposed between the drilling mud, and the clear water handled by the centrifugal pump, as in the aforementioned application.

A further object is to provide a multicylinder diaphragm pump wherein the diaphragms are successively displaced in overlapping timed relation, by motive liquid under the control of a distributing valve. In a preferred form of the invention the distributing valve is actuated hydraulically by the motive liquid, suitable control means being provided to synchronize the rate of valve actuation with the rate of displacement of the diaphragms.

A still further object is to provide a hydraulic pumping system including a diaphragm pump, wherein the latter is actuated by motive liquid under pressure supplied by a centrifugal pump, and wherein the contractions, or suction strokes, of the diaphragm are effected by applying a positive head to the suction side of the pump.

Other objects will be apparent from the following description of several practical embodiments of the invention, taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is a top plan view of one form of the invention;

Fig. 2 is a central vertical longitudinal section on line 2—2 of Fig. 1;

Fig. 3 is a transverse section on line 3—3 of Fig. 2;

Fig. 4 is a transverse section on line 4—4 of Fig. 2;

Fig. 5 is a fragmentary sectional view taken on line 5—5 of Fig. 4;

Fig. 6 is a top plan view of a modification of the pump shown in Figs. 1 to 5;

Fig. 7 is a vertical section taken on line 7—7 of Fig. 6;

Fig. 8 is a top plan view of another modification;

Fig. 9 is a vertical section taken on line 9—9 of Fig. 8;

Figs. 10, 11, and 12 are horizontal sectional views taken on lines 10—10, 11—11, and 12—12, respectively, of Fig. 9; and

Fig. 13 is a schematic illustration of a layout of a complete pumping system according to this invention.

Referring to the form of the invention illustrated in Figs. 1 to 5, the hydraulic pump is shown as of the triplex, horizontal type having three horizontally disposed cylinders 1, 2, and 3 mounted on a base 4. At the right-hand end of each cylinder, as viewed in Fig. 2, a pump liquid suction and discharge chamber 5 is provided, each chamber having an inlet valve 6 and a discharge valve 7. The valves associated with each chamber open and close in response to expansion and contraction of diaphragms in the respective cylinders, to establish communication between the respective chambers 5 and a common suction header 8 extending transversely beneath the chambers (Fig. 3), and between the chambers and a common discharge header 9 above the chambers. Either end 10 or 10' of the suction header is adapted to be connected to a suitable source of liquid to be pumped, and a discharge outlet 11 provides connection between the discharge header and a discharge conduit.

Disposed in each of the cylinders is a diaphragm assembly generally designated 15 (Fig. 2). In this instance the diaphragms are of the radially expansible bellows type, having fixed ends. The assembly comprises two pairs of end plates 16, 16' and 17, 17' secured respectively to opposite ends of a plurality of spacer bars 18. An elongated sleeve 20 of rubber or other elastic material has its ends clamped between the end plates 16, 16' and 17, 17', the plates 17, 17' being imperforate while plates 16, 16' are annular, defining a central opening 21 for the admission of motive liquid to the interior of the diaphragms.

Each diaphragm assembly is supported centrally within its respective cylinder with its open end adjacent the motive liquid end of the pump. The end plate 16 fits within a recess in the end of the cylinder, a packing ring 22 being provided to form a fluid-tight joint between the cylinder and the end plate, thus isolating the interior of

the diaphragms from the cylinder space 23 outside the diaphragms. The periphery of the end plate 17 is cut away at intervals, forming passages 24 (Fig. 3) establishing communication between the suction and discharge chamber 5 and the cylinder space 23. The bore of the cylinder is reduced at the pump liquid end by an annular shoulder 25, forming a bore in which the end plate 17 snugly fits. The valve housing 26 secured to the outer end of each cylinder has a plurality of fingers 27, herein three in number, projecting inwardly in end abutting relation to the end plate 17, whereby the diaphragm assembly is securely supported against endwise movement when the valve housing is bolted to the end of the cylinder. A plurality of small holes 28 are drilled through the annular shoulder 25, to prevent the cylinder becoming air-bound.

From the foregoing it will be apparent that if motive liquid is intermittently admitted to the interior of the diaphragms and exhausted therefrom through the opening 21, the diaphragms will alternately expand and contract, and, if pump liquid is supplied to the suction header 8 at positive pressure, the pump liquid will enter the cylinder space 23 through passages 24 during contraction of the diaphragms, and will be forced therefrom during expansion.

Referring now to the means for alternately supplying and exhausting motive liquid from the diaphragms, a valve housing 31 is provided at the motive liquid end of the pump, and, as shown in Fig. 4, is divided laterally into a plurality of vertically extending bores in which valves 32, 33, 34 are reciprocally mounted. A motive liquid inlet 35 communicates with each of the valve bores through a common passage 36. Passages 37, 38, 39 extend from the valve bores to the cylinders 1, 2, and 3, respectively, communicating with the interiors of the diaphragms. At the lower ends of the valve bores is a common discharge chamber 40 having an outlet 41 through which spent motive liquid is returned to the source of supply.

The valves 32, 33, 34 are continuously reciprocated in their bores in predetermined sequence, between an upper position in which the cylinder port 37, 38, or 39 is cut off from the supply passage 36 and is open to the discharge chamber 40, and a lower position in which the cylinder port is open to the supply passage 36 and closed to the discharge chamber. The predetermined phase relationship between the valves is maintained by connecting them to a common crank shaft 45 by connecting rods 46, 47, 48.

Reciprocation of the valves is effected hydraulically, by the alternate application of motive liquid to the upper sides of pistons 51, 52, 53 secured respectively to stems on the valves 32, 33, 34. Motive liquid is supplied to the pistons from the main source through a branch conduit 54, the supply being regulated in a manner to be hereinafter described. The conduit 54 leads to a valve chamber 55 in which is rotatably mounted a rotary distributor valve 56 secured to the crank shaft 45. As shown most clearly in Fig. 5, a plurality of passages 57, 58, 59 extend from the valve chamber 55 to the cylinders of the valve pistons 51, 52, 53, the rotary valve 56 admitting motive liquid to the passages and exhausting liquid therefrom in sequence.

In order to regulate the volume of motive liquid flowing to the valve motor, and consequently the rate of actuation of the valves, in accordance with the rate of flow of motive liquid to the diaphragms in the main cylinders, a flow respon-

sive regulator 61 (Fig. 2) is interposed between the main supply conduit and the branch conduit 54. The regulator is of the Venturi type, in which the position of a throttle valve 62 controlling the flow to the branch pipe 54 is controlled by the difference in pressures at points 63 and 64 in a Venturi tube 65. It is well known that this pressure difference is a direct function of the velocity of the main stream of motive liquid, increasing with increased flow. The higher pressure at 63 is partially overcome by a spring 66, which yields when the pressure difference exceeds a predetermined amount, allowing the throttle valve 62 to admit more motive liquid to the valve motor.

It is essential for maximum efficiency and smoothness of operation that the rate of actuation of the main valves be synchronized with the rate of flow of motive liquid to the diaphragms; if the valve actuation is too rapid the diaphragms will not be permitted to expand fully before the motive liquid is cut off, and if the valve actuation is too slow there will occur a delay between full expansion of the diaphragms and reversal of the respective valve. If the motive liquid is supplied by a centrifugal pump, and the pumping pressure varies materially, the volume will vary proportionately and a regulator such as that described is necessary.

In Figs. 6 and 7 we have shown a modification of the pump previously described. The modifications, however, are merely structural, this form also embodying the essential features of that just described.

The pump is shown in this form as a three-cylinder or triplex radio pump, having cylinders 71, 72, 73 extending radially in equiangularly spaced relation. In each cylinder is mounted an axially expandible Syphon bellows 74 having a rigid end plate 75 in its movable end. In this instance the open end of the bellows is clamped between the outer end of the cylinder and a cap 76, the latter having a passage 77 therein communicating with a suction and discharge chamber 78 (Fig. 6) for pump liquid.

An annular suction header 81 extends from an inlet 82 circumferentially about the base of the pump, communicating with the respective chambers 78 through conventional suction valves beneath the valve covers 83, 84, 85. An annular discharge passage 86 is formed in the upper portion of the pump casing, communicating through branch passages 86, 87, 88 with the chambers 78 through conventional discharge valves disposed beneath the valve covers 89, 90, 91, and having a discharge outlet 92.

The motive liquid distribution system is similar to that in the form previously described, and comprises radially extending valve bores disposed above the respective cylinders, one of the valves being shown in Fig. 1. The valve 32', corresponding to valve 32, of Fig. 4, is reciprocable in its bore between a right-hand position, as shown, wherein the interior of cylinder 11 is in communication with a common discharge chamber 40' through passage 37', and a left-hand position wherein the cylinder is open to an annular motive liquid inlet passage 36' extending about the upper portion of the pump casing concentric with the pump liquid discharge passage 86. A motive liquid inlet 35' communicates with the passage 36'.

A rotary valve 56' similar to valve 56 of Figs. 4 and 5 is rotatable about a central vertical axis, and controls the intermittent application of mo-

tive liquid to valve pistons secured to the main valves, piston 51' being actuated by motive liquid admitted through conduit 57' from the valve 56', and the other valves being similarly actuated. As in Fig. 4, the main valves are interconnected by a common crank shaft, being connected in this case to a common connecting rod bearing 45'. Motive liquid for actuating the valves is admitted through an inlet 54', through a regulator similar to the regulator 61 of Fig. 2, or an equivalent device.

Inasmuch as the operation of this form of the invention is identical with that of Figs. 1 to 5, further explanation thereof is deemed unnecessary.

In Figs. 8 to 12 a still further modification is disclosed, differing from the two previously described forms mainly in structural details. In this form a plurality of cylinders 101, 102, 103 are disposed vertically, being mounted on a base 104 in which are formed pump liquid suction and discharge valves and passages. An annular suction header 105 extends from an inlet 106 to chambers 107, 108, 109, beneath suction valves 110, 111, 112. As shown in Fig. 11, the suction valves control communication between the suction header 105 and suction and discharge chambers 113, 114, 115 individual to the cylinders 101, 102, 103, respectively. Disposed in planes above the chambers 113, 114, 115 is a common discharge header 116 (Fig. 10) communicating with the respective chambers through discharge valves 117, 118, 119. A discharge outlet 120 leads to the usual discharge conduit.

The plungers 125 in this form of the invention are radially expansible Sylphon bellows as in Figs. 6 and 7, being secured in this case, however, to the motive liquid ends of the cylinders. Motive liquid is alternately admitted to the interiors of the bellows and exhausted therefrom through conduits 126, 127, and 128 leading from a rotary distributing valve 129 rotatably mounted in a valve housing 130. A motive liquid inlet 131 and an outlet 132 are connected to opposite sides of the valve. The valve is rotated by a small hydraulic motor 135 of the radial piston type, motive liquid being supplied thereto through an inlet 136 and discharged through an outlet 137.

The operation of this form is also similar to that of the two previously described forms, and therefore detailed description thereof is deemed unnecessary.

In Fig. 13 there is illustrated schematically a layout of a hydraulic pumping system employing a pump constructed in accordance with this invention for handling drilling mud during the drilling of a deep oil well by the rotary method. The pump 140 is shown for purpose of illustration as of the type disclosed in Figs. 8 to 12, although it could as well be either of the two previously described types. Motive liquid for operating the pump is supplied in a steady stream from a multistage centrifugal pump 141 driven at constant speed by a steam turbine 142. Drilling mud is supplied to the suction header of the pump at a pressure sufficient to contract the pump diaphragms in the allotted line, from a low pressure centrifugal pump 143 driven by a steam turbine 144. A mud suction line 145 extends from the mud pit 146 to the pump 143, and a mud discharge line 147 leads from the hydraulic pump 140 to the usual rotary swivel (not shown) suspended in the derrick. The motive liquid is cir-

culated in a closed circuit between the centrifugal pump 141, the hydraulic pump 140, and a storage tank 148 through conduits 149, 150, and 151.

From the foregoing description of three preferred embodiments of the invention, the mode of operation and the advantages thereof will be apparent. As distinguished from the usual diaphragm pump wherein pressure liquid is alternately forced against the diaphragm and withdrawn therefrom by reciprocation of pistons individual to each diaphragm, in the pump of this invention motive liquid is supplied in a steady stream from a source common to all of the diaphragms, and is distributed to the individual diaphragms in sequence by suitable valve mechanism. The discharge pressure of the pumped liquid is therefore at all times that of the common motive liquid, and there is no possibility of leakage from individual closed circuits, as often occurs in diaphragm pumps of the type heretofore employed. In the last-mentioned type the discharge pressure is necessarily pulsating, since in the individual motive liquid circuits the pressure alternates from suction to full pressure. However, in the pump described herein the pressure remains steady, regardless of the extent of overlapping of the pumping strokes.

We claim:

1. Hydraulic pumping apparatus comprising a plurality of cylinders, diaphragm means in each of said cylinders dividing the latter into motive liquid and pump liquid compartments, a common source of motive liquid under pressure, valve means for alternately admitting motive liquid from said source to the motive liquid compartments of said cylinders and exhausting spent motive liquid therefrom to cause displacement of said diaphragms alternately in opposite directions, said valve means controlling the flow of motive liquid to and from said cylinders in predetermined sequence, and pump liquid inlet and discharge valve means controlling the flow of pump liquid to and from the pump liquid compartments of said cylinders in response to movements of the diaphragm, and means for actuating said motive liquid valve means solely by motive liquid independently of movements of said diaphragms.

2. Hydraulic pumping apparatus as defined in claim 1, including a common pump liquid inlet and means for supplying pump liquid to said inlet under initial pressure sufficient to expand said pump liquid compartments and discharge spent motive liquid from said motive liquid compartments.

3. Hydraulic pumping apparatus comprising a plurality of cylinders, plunger means in each of said cylinders dividing the latter into motive liquid and pump liquid compartments, a common source of motive liquid under pressure, valve means for alternately admitting motive liquid from said source to said motive liquid compartments and for exhausting spent motive liquid therefrom to move said plungers in opposite directions and thus vary the relative sizes of said compartments, pump liquid inlet and discharge connections to said pump liquid compartments, and means for supplying pump liquid to said inlet connections under initial pressure sufficient to move said plungers in a direction to discharge spent motive liquid from said motive liquid compartments, and means for actuating said motive liquid valve means solely by motive liquid independently of movements of said plungers.

4. Hydraulic pumping apparatus comprising a plurality of cylinders, a movable partition in each cylinder dividing the latter into compartments, a common source of motive liquid at relatively high pressure, valve means for intermittently admitting said motive liquid in predetermined sequence to said cylinders on one side of said partitions to move the latter in one direction, a common source of pump liquid at relatively low pressure, and valve means for admitting pump liquid to said cylinders on the other side of said partitions to move said partitions in the opposite direction between intervals of admission of motive liquid, and means for actuating said motive liquid valve means solely by motive liquid independently of movements of said partitions.

5. Apparatus as defined in claim 4, in which each of said partitions comprises an expansible diaphragm having flexible side walls, a closed end wall, and an open end communicating the interior thereof with one of said sources of liquid.

6. Apparatus as defined in claim 4, in which each of said partitions comprises an expansible diaphragm having radially expansible side walls, and means for anchoring the ends of said side walls in relatively fixed relation.

7. Apparatus as defined in claim 4, in which each of said partitions comprises a Sylphon bellows, and means for anchoring the open end of said bellows in its respective cylinder, the free end thereof being rigid.

8. Hydraulic pumping apparatus comprising a plurality of cylinders, plungers in said cylinders, a common source of motive liquid under pressure, valve means for admitting motive liquid in predetermined sequence to said cylinders on one side of said plungers and for exhausting spent motive liquid therefrom, means actuated by said motive liquid for operating said valve means, a regulator associated with the motive liquid supply line to said valve operating means, said regulator being controlled by the flow of motive liquid to said cylinders, and pump liquid inlet and discharge connections to said cylinders, on the other side of said plungers.

9. Apparatus as defined in claim 8, in which said regulator is operable to automatically increase the flow of motive liquid to said valve operating means upon increase of flow of motive liquid to said cylinders.

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