

Oct. 28, 1941.

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2,260,306

PUMP

Filed April 16, 1938

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Fig. 1.

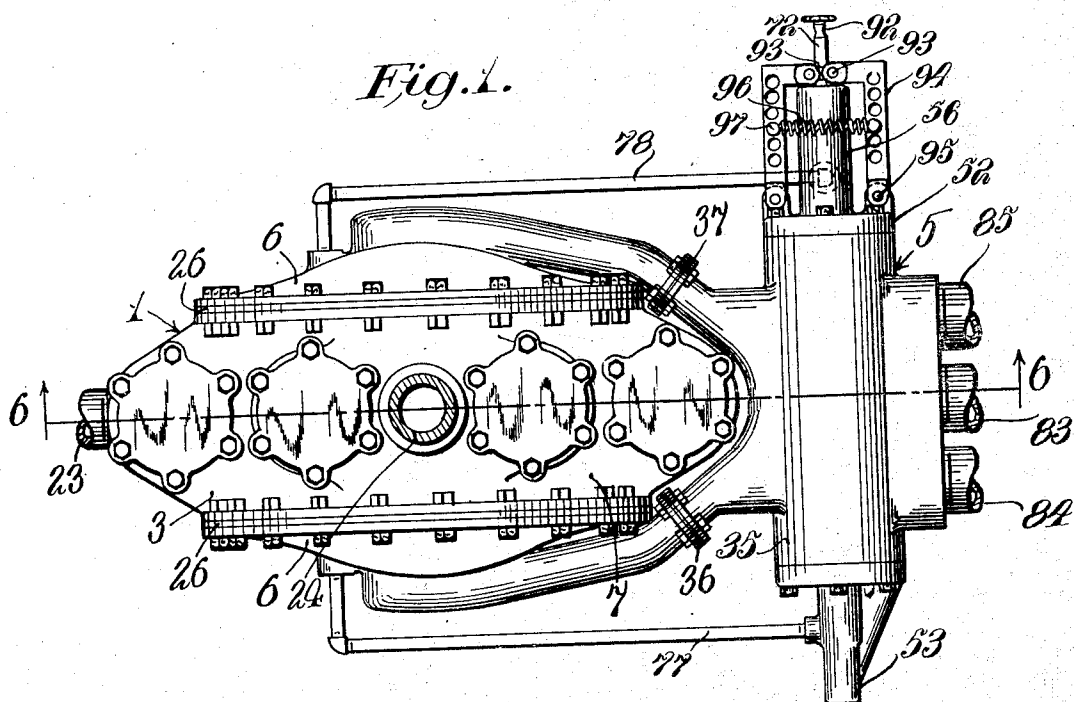
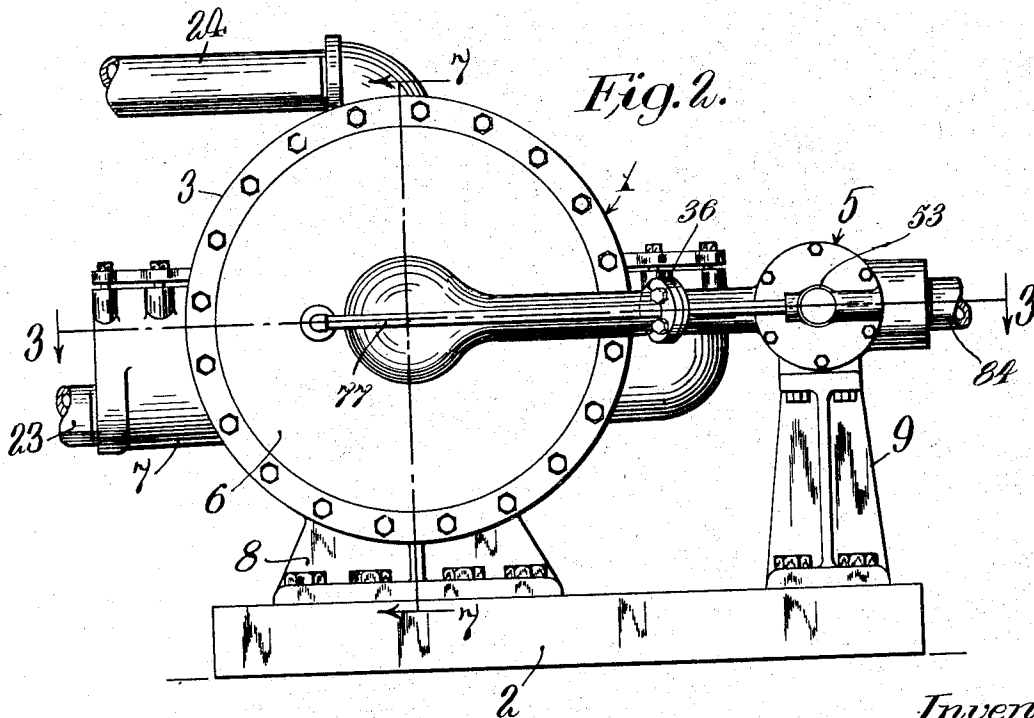


Fig. 2.



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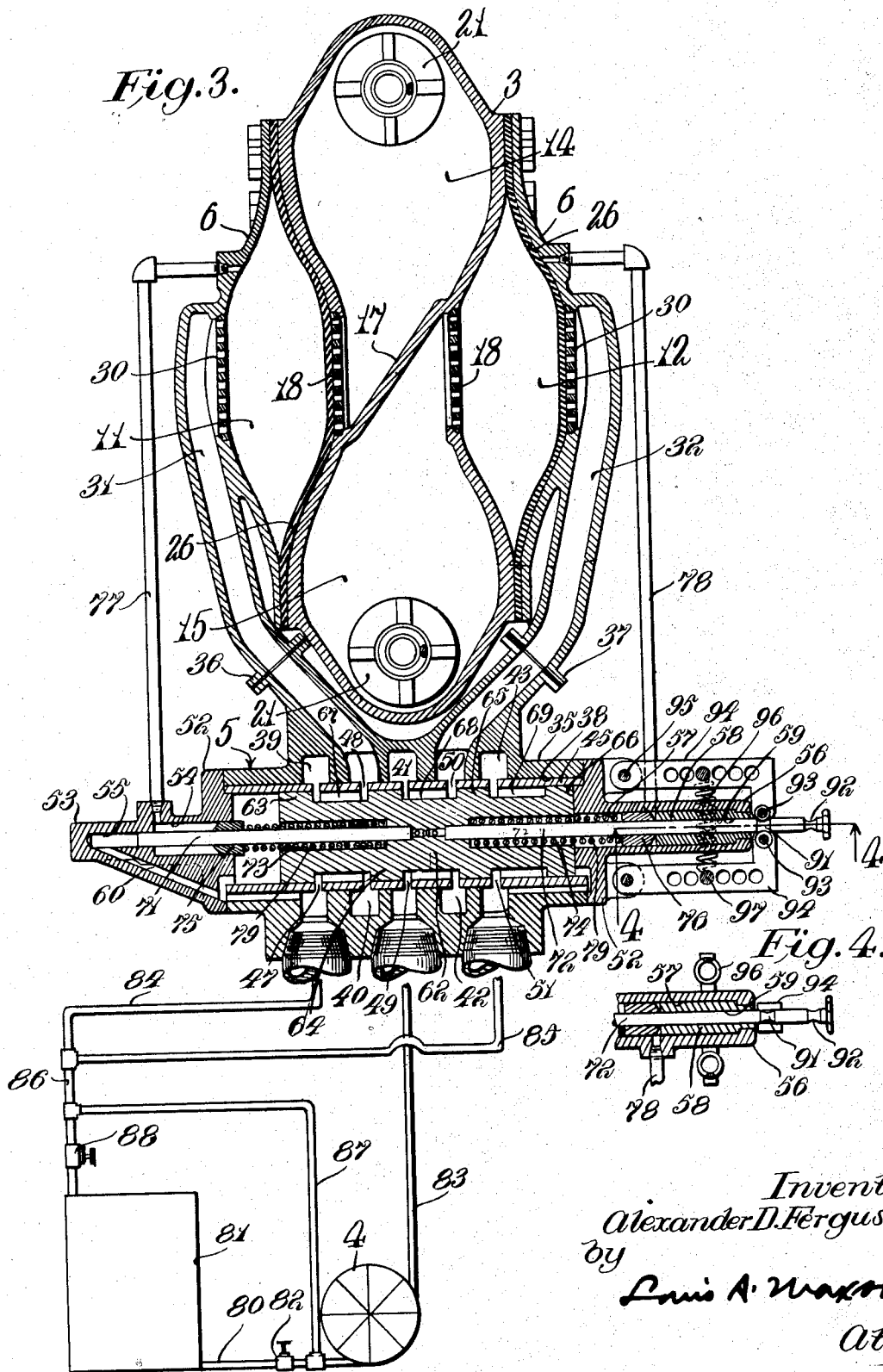
A. D. FERGUSON

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Filed April 16, 1938

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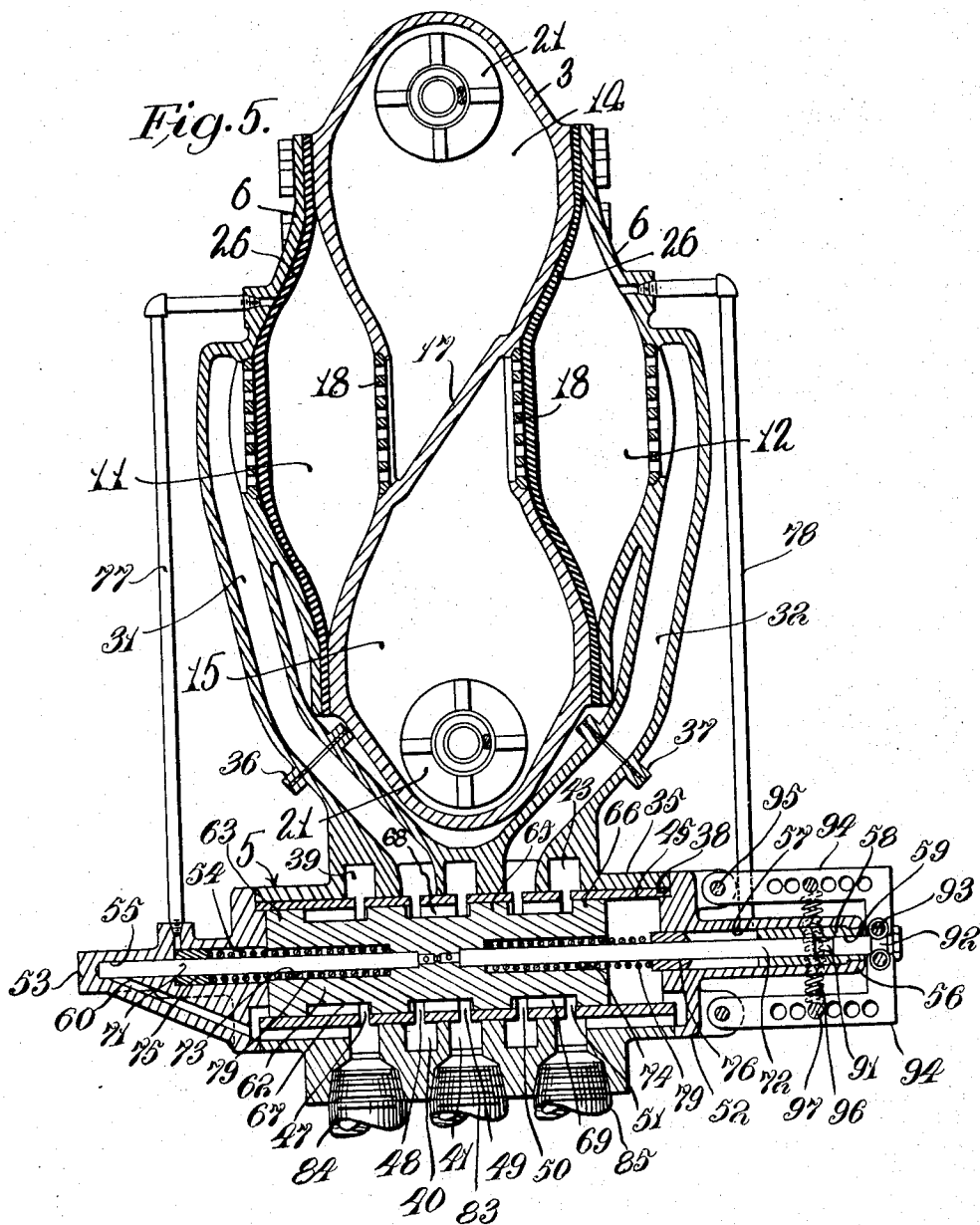
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2,260,306

PUMP

Filed April 16, 1938

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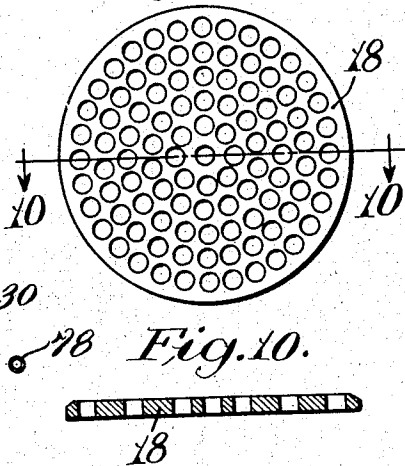
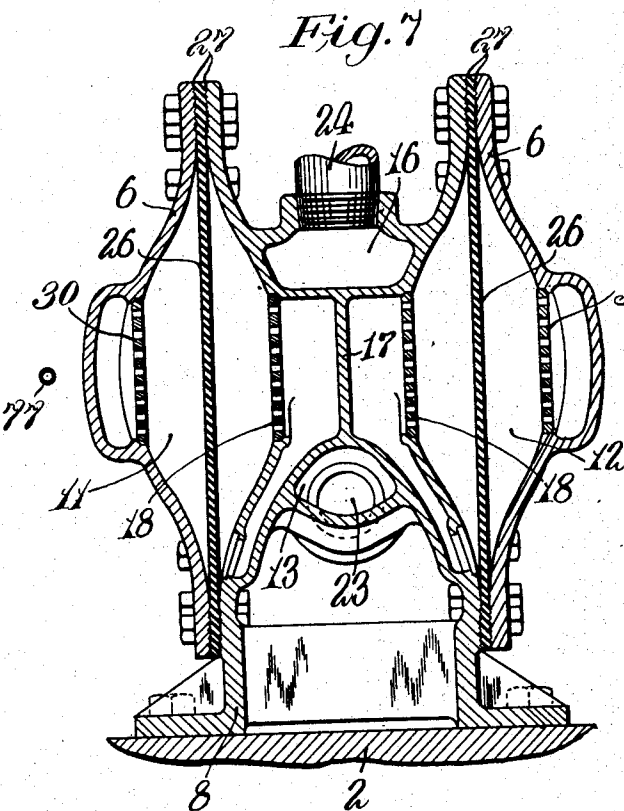
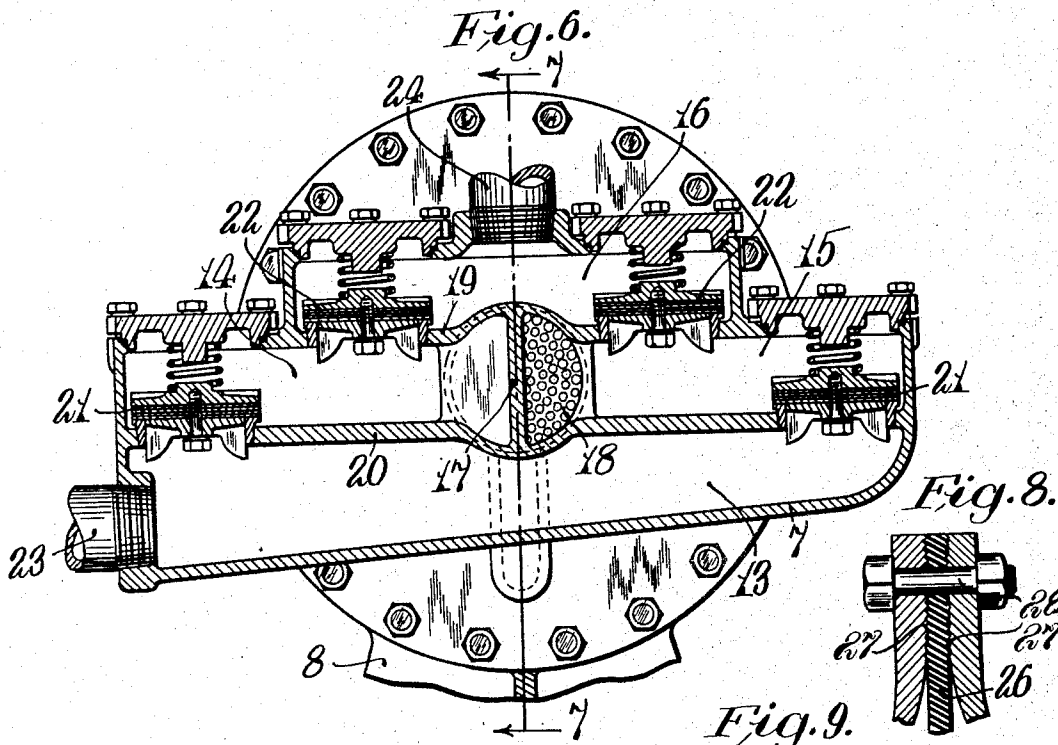
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Filed April 16, 1938

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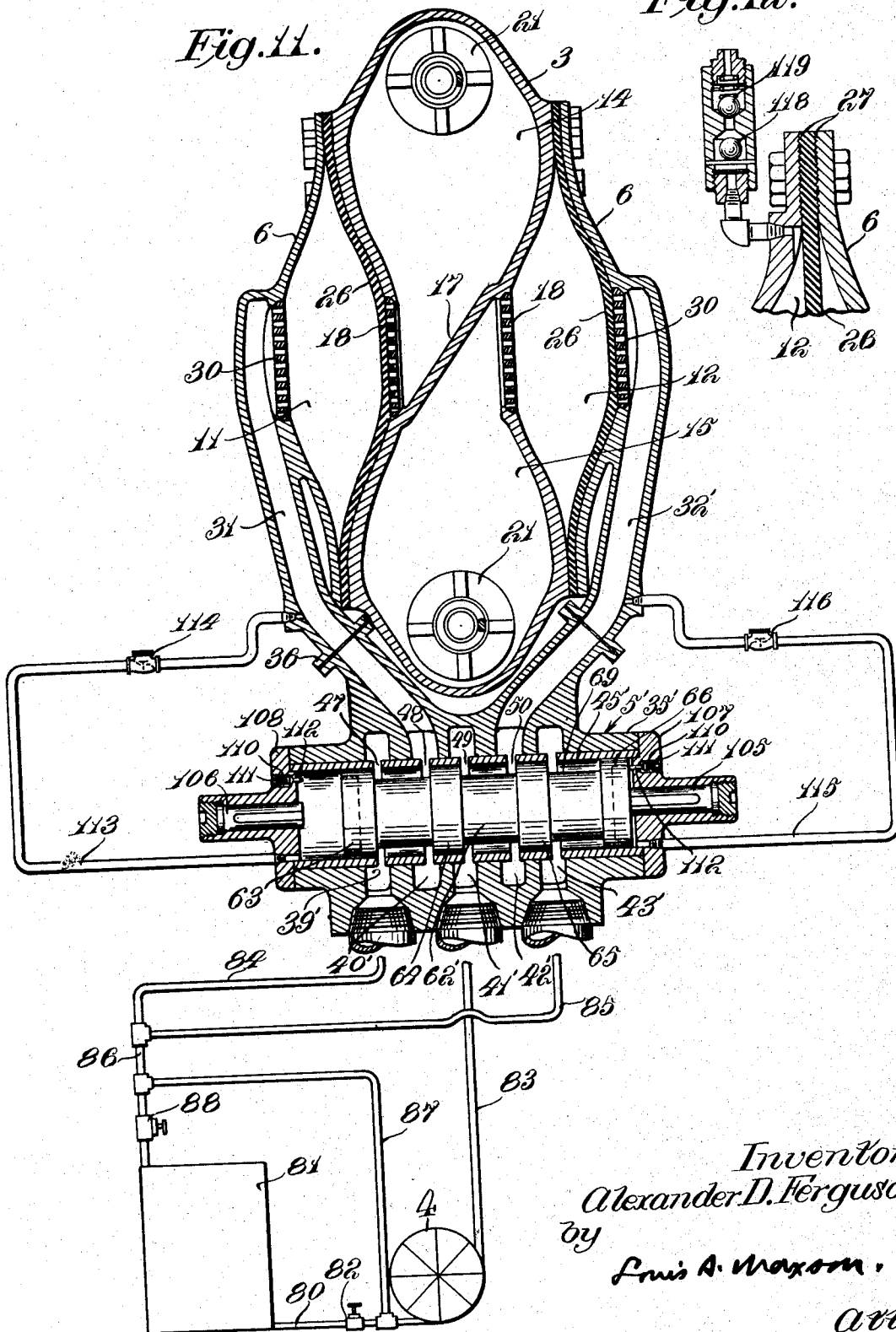
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2,260,306

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UNITED STATES PATENT OFFICE

2,260,306

PUMP

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Application April 16, 1938, Serial No. 202,374

10 Claims. (Cl. 103—152)

This invention relates to pumps, and more particularly to improvements in pumps of the multi-chamber, diaphragm type which are especially useful in pumping liquids.

In oil well drilling, particularly where rotary drills, such as diamond core drills, are employed, it is desirable to use mud fluid as a circulating fluid, so that the fluid, as the rod line rapidly rotates, is thrown by centrifugal action into the walls of the drill hole to plaster the sides thereof, thereby to reduce the possibility of caving. Mud fluid is usually pumped into the drill hole under pressure by a conventional liquid pump of the piston type. It is relatively thick and often contains acid which exerts a corrosive action on the pump parts. Moreover, the conventional pumps are comparatively heavy, and it is desirable to cut down to a minimum the weight of the apparatus, so that transport thereof may be made less difficult.

A primary object of the present invention is to provide a liquid pump, especially designed to be used in pumping mud fluid in oil well drilling, in which the objectionable features of a conventional liquid pump are, to a substantial extent, eliminated. Another object is to provide an improved pump of the multi-chamber, diaphragm type having novel means for actuating the pump diaphragms, together with improved controlling valve means for regulating the pumping action. A further object is to provide an improved mud fluid pump especially designed to use in oil well drilling, for circulating the mud fluid in the drill hole. A still further object is to provide a pump of the above character which is relatively simple and rugged in design and extremely compact and light in weight, well adapted to meet the demands of service in oil well drilling work. Yet another object is to provide an improved pump especially designed to use generally in pumping liquids, and which is especially applicable to the pumping of liquids such as acids, which exert a corrosive action on metals. Still a further object is to provide an improved diaphragm-type, pressure-fluid-operated pump having improved distribution means for the operating fluid. Yet another object is to provide an improved vacuum-actuated valve mechanism. Still another object is to provide an improved trigger-type valve actuating system. Other objects and advantages of the invention will, moreover, hereinafter more fully appear.

In the accompanying drawings there are shown for purposes of illustration two forms which the invention may assume in practice.

In these drawings,—

Fig. 1 is a plan view of one illustrative embodiment of the invention.

Fig. 2 is a side elevational view of the pump shown in Fig. 1.

Fig. 3 is a horizontal sectional view taken substantially on line 3—3 of Fig. 2, and with its showing partially diagrammatic.

Fig. 4 is a fragmentary vertical sectional view taken substantially on line 4—4 of Fig. 3.

Fig. 5 is a view similar to Fig. 3, but with parts omitted and with a number of the parts shown differently positioned.

Fig. 6 is a view in longitudinal section taken substantially on line 6—6 of Fig. 1.

Fig. 7 is a vertical sectional view taken substantially on line 7—7 of Figs. 2 and 6.

Fig. 8 is a detail sectional view, on a larger scale, showing a portion of the securing means for the pump diaphragm.

Fig. 9 is a detail view showing a strainer screen plate.

Fig. 10 is a detail sectional view taken on line 10—10 of Fig. 9.

Fig. 11 is a horizontal sectional view somewhat similar to Fig. 3, showing another form of the invention.

Fig. 12 is a detail sectional view.

In the illustrative embodiment of the invention shown in Figs. 1 to 10 inclusive, the numeral 1 generally designates a pump of the multi-chamber, diaphragm type, generally comprising a base 2, a pump chamber casing 3, a motor driven pump 4 and a control valve mechanism generally designated 5. The pump chamber casing is herein shown as comprising a pair of opposite end plates 6, 6 and a central body portion 7. A pedestal 8, herein integral with the body 7, supports the pump casing 3 on the base, while a frame 9 supports the valve mechanism on the base. The pump casing body 7 and the heads 6, 6 cooperate in providing laterally-spaced, circular, vertical coaxial diaphragm chambers 11 and 12, and the body 7 provides a bottom liquid-supply chamber 13, intermediate pump chambers 14 and 15 and a top discharge chamber 16. As shown in Fig. 3, the chambers 14 and 15 are divided by a diagonal vertical septum 17 and communicate through perforated, disc-like strainer plates 18, 18 (see also Figs. 9 and 10) with the diaphragm chambers 11 and 12; and as shown in Fig. 6, the pump chambers 14 and 15 are spaced from the discharge chamber 16 by a generally horizontal wall 19 and from the supply chamber by horizontal wall 20. Inlet valves 21, 21, of any suitable type,

control the flow of liquid from the supply chamber 13 to the pump chambers 14 and 15, while discharge valves 22, 22, which may also be of any suitable type, control the discharge of liquid from the pump chambers 14 and 15 to the discharge chamber 16. The supply chamber is provided with a supply pipe 23, and the discharge chamber 16 is provided with a discharge pipe 24.

As illustrated, clamped between outer annular surfaces on the pump casing body and the detachable head members 6, 6 are flexible diaphragms 26, 26, herein preferably composed of a rubberized material, having their sides exposed to the liquid to be pumped impregnated or coated with a suitable acid-resisting substance. As shown most clearly in Fig. 8, the coating diaphragm-clamping surfaces on the pump casing body and heads, between which the diaphragms are clamped, are serrated or roughened at 27, so that when the heads are clamped in position on the pump casing body, as by clamping bolts 28, the annular portions of the diaphragms adjacent their outer peripheries are securely held. It may be noted that the remaining portions of the diaphragms 26 are movable within the diaphragm chambers 11 and 12 and form movable boundaries for the portions of such chambers which are in communication with the pump chambers 14 and 15 respectively, while the portions of the diaphragm chambers which lie to the outsides of the diaphragms respectively constitute motor spaces later to be described in more detail. The particular portions of the diaphragm chambers 11, 12 which operate as motor spaces, are connected through suitable gratings 30, with passages 31 and 32 respectively, which each constitute alternatively working fluid supply and exhaust passages, and lead to and are controlled by the valve mechanism 5.

Referring now in detail to the valve mechanism, and more particularly to Figs. 3, 4 and 5, it will be noted that this valve mechanism includes a transversely extending valve chest member 35, herein connected through couplings 36 and 37 with the heads 6, 6 respectively associated with the chambers 11 and 12. The valve chest member 35 is bored longitudinally as at 38, and surrounding and communicating with said bore 38 there are five annular chambers 39, 40, 41, 42 and 43. The chambers 40 and 42 respectively communicate with the passages 31 and 32. The central annular chamber 41 is a supply chamber, and the chambers 39 and 43, which are the outside, i. e. relatively most remote, chambers, constitute exhaust chambers. The bore 38 is provided with a liner 45 suitably ported to provide communication between its interior and the several annular chambers 39 to 43 through annular portings respectively designated 47, 48, 49, 50 and 51.

The ends of the valve chest member 35 are provided with closure members 52, 52. Each of these is provided with a projecting portion of reduced size, the left-hand head in Fig. 3 having its projecting portion 53 provided with coaxial bores 54 and 55, and the right-hand head member 52 in Fig. 3 having its reduced portion 56 provided with a bore 57 corresponding to the bore 54 and having a bushing 58 bored at 59 to correspond to the bore 55, inserted therein. The bore 55 is connected by a passage 60 with the exhaust space 39. Within the liner 45 is reciprocable a piston-type valve 62 having four annular heads, so to speak, 63, 64, 65 and 66 spaced by grooves, 67 between heads 63 and 64, 68

between the heads 64 and 65 and 69 between the heads 65 and 66. The width of the grooves is such that each groove is capable of connecting an adjacent pair of the portings 47, 48, 49, 50 and 51. Rods 71 and 72 are fixedly mounted, coaxially with the valve 62, in the latter, and project from the opposite ends of the valve, being surrounded by annular spring-receiving recesses 73 and 74 opening through the ends of the valve element. Annular pistons 75 and 76 surround the rods 71 and 72 respectively, and fit and slide in the bores 54 and 57. Connections 77 and 78 connect the motor spaces within the chambers 11 and 12, when the diaphragms 26 are in such position as to provide motor spaces within these chambers, with the outer ends of the bores 54 and 57.

Suitable springs 79, having sufficient strength to throw the valve 62, are arranged in each of the bores 73, 74, and are compressible by the pistons 75, 76. More will be said as to the strength of these springs later.

A suitable force pump 4 is connectible by a line 80 with a suitable liquid tank 81 under the control of a valve 82, and discharges through a line 83 to the annular space 41 in the valve chest member 35. The annular exhaust spaces 39 and 43 are connected by lines 84 and 85 respectively with a return line 86, which may be connected through a by-pass 87 with the pump intake or through a valve-controlled connection 88 with the liquid tank 81. The rod 72, which is reciprocable, as above explained, with the piston valve 62, projects through the outer end of the bushing 58, and is provided with a pair of annular grooves 91 and 92. With these grooves, rollers 93 carried by pivoted arms 94 mounted for swinging movement by pivot pins 95 upon the head 52, are adapted to coast. Springs 96 connect adjustably locatable pins 97 carried in the arms 94 and cause rollers 93 to exert additional holding force upon the rod 72, depending upon the location of the pins 97.

It should be understood that the pump 4 is of such a character that it is capable of continued operation against very high pressures. A staged centrifugal pump would be one type which could be used. The liquid system, including the motor spaces in the diaphragm chambers, the connections 31 and 32, the connections 77 and 78, the distributing valve and valve chest spaces, the piping 83, 84, 85, 86 and 87 and the pump 4, will be provided with a quantity of liquid such that at the instant when the distributing valve is about to be thrown all the spaces to which it is connected to deliver fluid will be filled with liquid, and there will be sufficient fluid in the spaces connected to the intake of the pump 4 so that, while a suction sufficient to effect main pump intake will be provided, the pump 4 will still have liquid at its intake.

With the further understanding that the pressure necessary to move the valve 62, when the latter is held stationary by the rod 72 and trigger mechanism, exceeds that which is exerted by the plungers 75 or 76 and springs 79 except when the diaphragms have completed their normal pumping movements, the operation of the mechanism will be readily understood. The mud fluid or other liquid to be pumped is taken into the intake chamber 13, through the pipe 23, and is adapted to be discharged from the discharge chamber through the discharge line 24. With the position of the parts shown in Fig. 3, the portion of the chamber 12 to the left of the dia-

phragm 26 and the pump chamber 15 are filled with liquid to be displaced. The chamber 11 has the space to its left side filled with motive liquid, but is connected with the intake side of the hydraulic pump 4. The chamber 14 is filled with mud fluid awaiting entrance to the portion of the chamber 11 which will be to the right of the diaphragm 26 as that diaphragm moves to the left in Fig. 3.

Now, the operation of the pump 4 with the parts arranged as in Fig. 3 will force liquid under considerable pressure through the line 83, the annular chamber 41 and the porting 49, the valve groove 68, the porting 50, the annular chamber 42 and conduit 32, and the holes in the grating 30, to act upon the right-hand side of the diaphragm 26 arranged in chamber 12; causing the diaphragm to displace from chamber 12 the mud fluid therein and thereby effect a discharge of mud fluid from the pump chamber 15 through the discharge valve mechanism 22 to the discharge chamber 16, and thence through the discharge line 24. Simultaneously, the motive liquid within the chamber 11 to the left of the left hand diaphragm 26 will be withdrawn through the connection 31, the annular groove 40, the porting 48, the groove 67 in the valve, the porting 47, the space 39, the discharge line 84 and the return line 86; and the left hand diaphragm 26 will be caused to move to effect the entry of a diaphragm chamber full of liquid from the intake chamber 14 to the chamber 11. When the diaphragm 26 associated with chamber 12 has been moved to the position shown in Fig. 5, continued operation of the pump will increase the pump discharge pressure within the chamber 12, and since, with the diaphragm member of chamber 12 moved from the position shown in Fig. 3, the pressure acting upon its right side is enabled, through the connection 78, to act upon the piston 76, that piston will be subjected to the increased pressure. When this pressure has increased sufficiently to compress the spring within the spring chamber 57, as will occur when the piston 76 moves to the left in Fig. 3, to a position corresponding to that of the piston 75, a pressure sufficient to move the rod 72 longitudinally despite the action of the rollers 93, will be developed; and the valve 62 will then move sharply to the left until the position shown in Fig. 5 is reached. It will be noted that the rollers 93 will then cooperate with the groove 92 and hold the valve in the position of Fig. 5 until conditions for a reverse flow are brought about by the development of a high pressure to act upon the outer end of the piston 75. It will be observed that the springs acting to move the piston valve 62 in opposite directions are of such length, and that the travel of the pistons 75 and 76 is also of such length, that even at the completion of valve throwing there is a preponderance of pressure in the throwing direction until after the piston 75 or 76 which has effected the throwing starts to move outwardly in its respective cylinder. It should be noted with respect to Fig. 3 that this is an instantaneous position, so to speak, and that the piston 75 is shown in the position it occupied to effect the throwing of the distributing valve 62, instead of in the position in the left-hand end of the cylinder 54 which it will occupy almost immediately after the position of the distributing valve shown in Fig. 3 is established. It will be noted that the points of communication of the passages 77 and 78 will be so related relative to the diaphragm chambers that any small rises in pressure during

starting of diaphragm movement will not be transmitted to the pistons 75 and 76. Obviously the faces of the plates or heads 6, 6 could be grooved to enable action on a larger diaphragm area of the pumping liquid, immediately upon supply thereof, if desired.

The valve mechanism described is positive in action; does not have any tendency to stop in an intermediate position; and is firmly held in its different working positions while in them. By appropriate selection of materials, the pump chamber gratings, the valve mechanisms and the diaphragms can be made to be very durable and largely immune to injury by the mud fluid or acid. A light and powerful pumping unit is provided by the structure described.

Fig. 11 shows a different embodiment of the invention. The details of the pump casing body, the pump casing heads and most of the structure of the distributing valve chamber are the same as the structure disclosed in Figs. 1 to 10 inclusive, but instead of effecting high pressure valve throwing, this embodiment of the invention is designed to produce the differential pressures which effect transfers of the distributing valve from one working position to the other as a result of the subjection of one end thereof or the other to sub-atmospheric pressure; and the holding of the valve in its opposite positions is effected by magnetic, rather than trigger-type, detent mechanism.

Bearing in mind that corresponding unchanged parts will be numbered the same as in Figs. 1 to 10, it may be observed that the valve mechanism 5' of Fig. 11 comprises a valve chest member 35' having a liner 45' provided with portings for connecting its interior at its longitudinal center with an annular fluid supply chamber 41', and its ends with annular fluid discharge chambers 39' and 43'; and intermediate the central chamber 41' and each of the chambers 39' and 43' is another annular space, these numbered respectively 40' and 42' and connected through conduits 31' and 32' with the chambers 11 and 12. The valve 62' is herein desirably made of light material, as, for example, of aluminum, and is provided at its opposite ends with plates of iron or other suitable material which may coact with stationary permanent magnets 105 and 106 fixedly arranged in the heads 107 and 108 of the valve chest body 35'. The heads 107 and 108 are preferably made of nonmagnetic material and the magnets 105 and 106 may advantageously be made of such material as "Alnico." Each of the heads 107 and 108 is provided with a chamber 110 containing a spring-pressed check valve 111 having a stem 112 projecting into the bore of the liner 45' sufficiently far so that when the valve 62' is in either of its extreme opposite positions, its end shall strike the stem of one of the valves 112 and open the latter. The left-hand end of the chamber in which the valve 62' is reciprocable, is connected through a passage 113, having a check valve 114 therein opening towards the passage 31', with that passage; and the right-hand end of the distributing valve chamber is connected through a passage 115 and a check valve 116 opening towards the passage 32', with the latter. The force pump 4 has its discharge 83 connected with the chamber 41'. Lines 84 and 85 connect the spaces 39' and 43' with a return line 86 which connects through a by-pass 87 with the intake side of the pump 4. A liquid reservoir is provided at 81, and its communica-

tions with the return line 86 and with the suction side of the pump 4 are respectively controlled by valves 88 and 82, all as in Fig. 3. Obviously, by suitable control of the valves 82 and 88 the requisite quantity of motive liquid may be insured in the hydraulic system. Desirably, the liner 45' and possibly also the entire valve chest member 35' may be made of non-magnetic material, so that the action of the distributing valve 62' may be made more positive.

Fig. 11 shows the relation of the parts at the instant when valve 62' has been snapped to its extreme right-hand position. Valve 62', as it completes this movement, shoves the right-hand valve 111 from its seat and permits air to flow at atmospheric pressure into the right-hand end of the valve chest, thus relieving the vacuum. The magnet 105 now holds the valve 62' in the right-hand position. The pump 4 now pumps liquid through the passage 32' to act upon the right-hand side of the right-hand diaphragm 26; and the liquid to the left of the left-hand diaphragm 26 is pumped out. As soon as the diaphragm 26 in the chamber 11 reaches its left-hand extreme position, a substantial vacuum will be produced in the passage 31' and this will result in a reduction in pressure, within the space to the left of the valve 62' in the chamber in which the latter moves, so great that the differential in pressure on the opposite ends of the valve will overcome the holding force of the magnet 105, and valve 62' will be snapped over to its left-hand position. It will there open valve 111 in the head 108, breaking the vacuum; and be held in its new position by the magnet 106. It will be noted that the pumping fluid cannot be discharged from either the passage 31' or the passage 32' into either of the opposite ends of the chamber in which the valve 62' moves. The quantity of liquid in the pump operating system will be chosen so that it will be less than sufficient completely to fill the entire system, the actual amount being determined similarly to the method used in connection with the system of Figs. 1 to 10. As air in small quantity will be taken into the system upon each reversal of the valve, suitable means for its discharge must be provided. Such means must preclude liquid discharge, so a combination of a float valve 118 and a check valve 119 such as is shown in Fig. 12 may be advantageously used. A location at the top of each diaphragm chamber will be advisable, and any suitable valve means may be employed. The continuous operation of the pump will be apparent from the description so far given.

It will be noted that this apparatus functions very similarly to that of Figs. 1 to 10, with this exception—that valve throwing is effected by fluid at atmospheric pressure acting upon one end of the valve, following the production of a vacuum at the other end of the valve, acting to overcome a magnetic valve holding force.

In both embodiments of the invention, it will be appreciated that there is provided a comparatively simple construction of relatively light weight, capable of the production of the requisite pumping pressures, not likely to be injured by the presence of substances in the liquid pumped which would be harmful to ordinary steel, reciprocating-type pumps, and of general application, as well as especially adapted to the particular field for which the present illustrative embodiments are primarily intended.

While there are in this application speci-

cally described two forms which the invention may assume in practice, it will be understood that these forms are shown for purposes of illustration and that the invention may be modified and embodied in various other forms without departing from its spirit or the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent is:

1. In combination, in a diaphragm pump, a chamber having a movable diaphragm dividing its interior into pump and motor spaces, means for supplying and exhausting motive fluid relative to said motor space including a pressure fluid actuated valve, and a controlling passage for said valve connected with said motor space at a point covered by said diaphragm when said valve assumes the position for admission to said motor space.

2. In combination, in a diaphragm pump, a chamber having a movable diaphragm dividing its interior into pump and motor spaces, means for supplying and exhausting motive fluid relative to said motor space including a pressure fluid actuated valve having associated therewith means for holding the same against throwing except when the valve is subjected to a greater pressure than is normally present in said motor space during displacement of fluid from said pump space, and a throwing passage for said valve connected with said motor space at a point covered by said diaphragm when said valve assumes the position for admission to said motor space.

3. In combination, in a diaphragm pump, a chamber having a diaphragm movable therein to vary inversely the volumes at opposite sides thereof, inlet and exhaust valves for a fluid to be pumped connected with said chamber at one side of said diaphragm, means for delivering to and withdrawing from the other side of said diaphragm a fluid under pressure, and means for switching the pressure fluid connections, said last mentioned means having oppositely facing surfaces one subjected to atmospheric pressure to effect actuation of said means when the other surface is subjected to subatmospheric pressure produced at one side of said diaphragm after the latter reaches one of its extreme positions.

4. In combination, in a pressure-fluid-operated pump having a fluid actuated pump element, pump operating fluid supply means including a reversely movable valve for controlling the supply of pump operating fluid relative to said pump element, magnetic means for holding said valve in opposite extreme positions, and means for subjecting the opposite ends of said valve alternately to vacuum and to atmospheric pressure to effect throwing of said valve.

5. In combination, in a pressure-fluid-operated pump having a fluid actuated pump element, pump operating fluid supply means including a reversely movable valve for controlling the supply of pump operating fluid relative to said pump element, magnetic means for holding said valve in extreme opposite positions, means for subjecting one end of said valve to a pressure not exceeding atmospheric, means for subjecting the opposite end of said valve to a lower pressure to produce a differential throwing pressure thereon, and means actuated by said valve for admitting pressure to restore the lower pressure to atmospheric.

6. In combination, in a pressure-fluid-operated pump having a fluid actuated pump element, pump operating fluid supply means including a

reversely movable valve for controlling the supply of pump operating fluid relative to said pump element, magnetic means for holding said valve in extreme opposite positions, means for subjecting one end of said valve to a pressure not exceeding atmospheric, means for subjecting the opposite end of said valve to a lower pressure to produce a differential throwing pressure thereon, and means for admitting pressure to restore the lower pressure to atmospheric.

7. In combination, in a pressure-fluid-operated pump having a fluid actuated pump element, pump operating fluid supply means including a reversely movable valve for controlling the supply of pump operating fluid relative to said pump element, permanent magnetic means for holding said valve in opposite extreme positions, and means for effecting opposite throwing movements of said valve.

8. In combination, in a pressure-fluid-operated pump having a fluid actuated pump element, pump operating fluid supply means including a valve for controlling the supply of pump operating fluid, springs exerting opposite pressures on said valve in directions longitudinally of the latter, pistons movable to vary the compression of said springs, and means for subjecting said pis-

tons alternately to pressures transmitted past said valve.

9. In combination, in a multi-working-chamber pump, a distributing valve for supplying pressures to effect discharge from one chamber and intake into the other and vice versa in alternation, springs alternatively active to throw said valve, and means for loading said springs to a valve-throwing pressure including pistons coaxial with said valve.

10. In a pump, in combination, diaphragm chambers having diaphragms therein dividing their interiors into pump and motor spaces, means for subjecting the motor space side of one diaphragm to pressure and the motor space side of the other to suction, means for reversing the pressure conditions upon said diaphragms including a reciprocably movable valve, means for connecting one end of said valve to atmosphere when in one of its extreme positions, and means subjected to the pressures in said motor spaces and operative at a predetermined subatmospheric pressure therein for connecting the other end of said valve to the motor space in which the subatmospheric pressure exists and producing a differential throwing pressure thereon.

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