No. 899,921.

W. M. STEPHENSON.

WELL PUMPING APPARATUS.

APPLICATION FILED NOV. 20, 1907.

Patented Sept. 29, 1908.

5 SHEETS—SHEET 1.

Fig. 1.

Fig. 5.

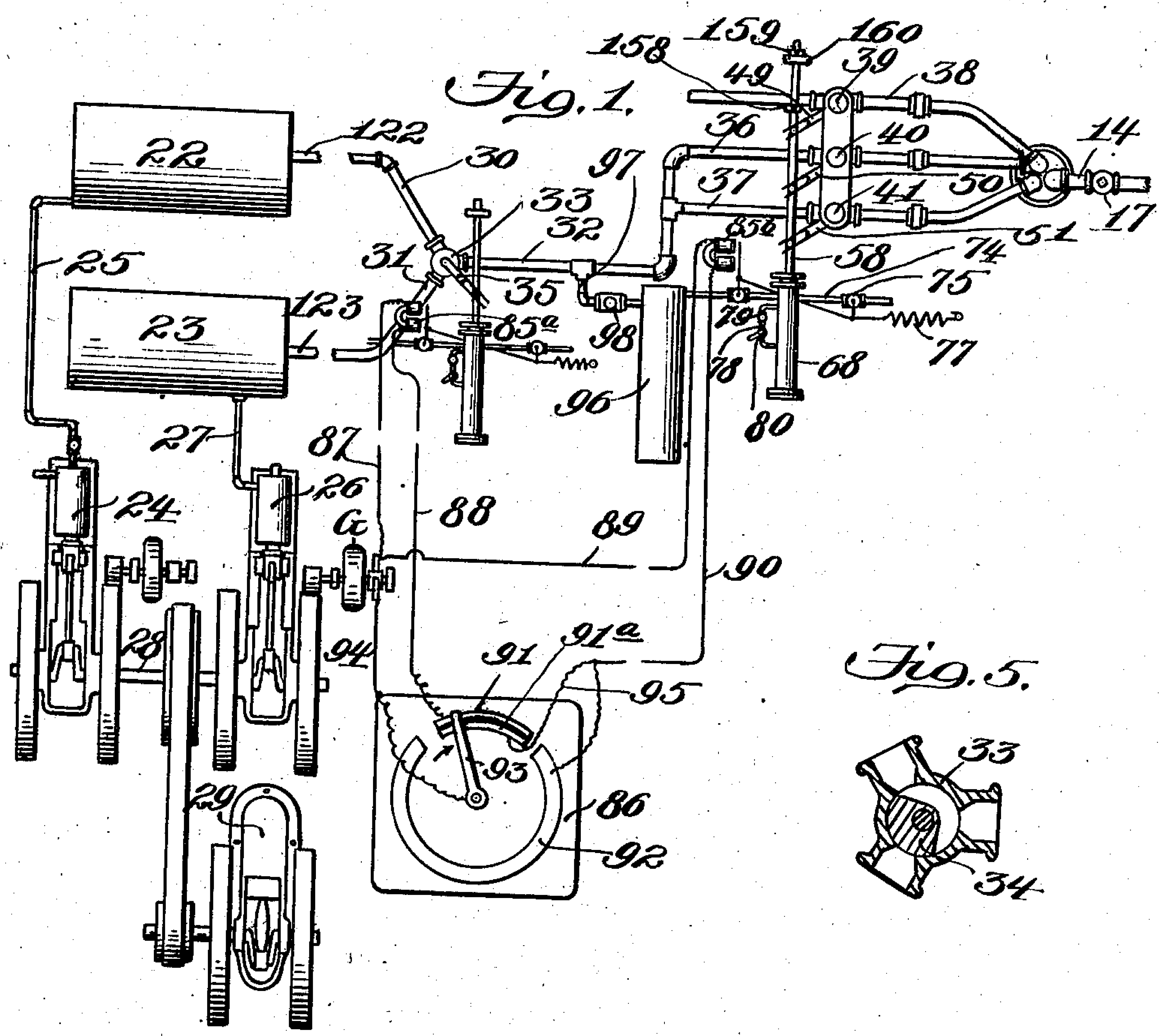
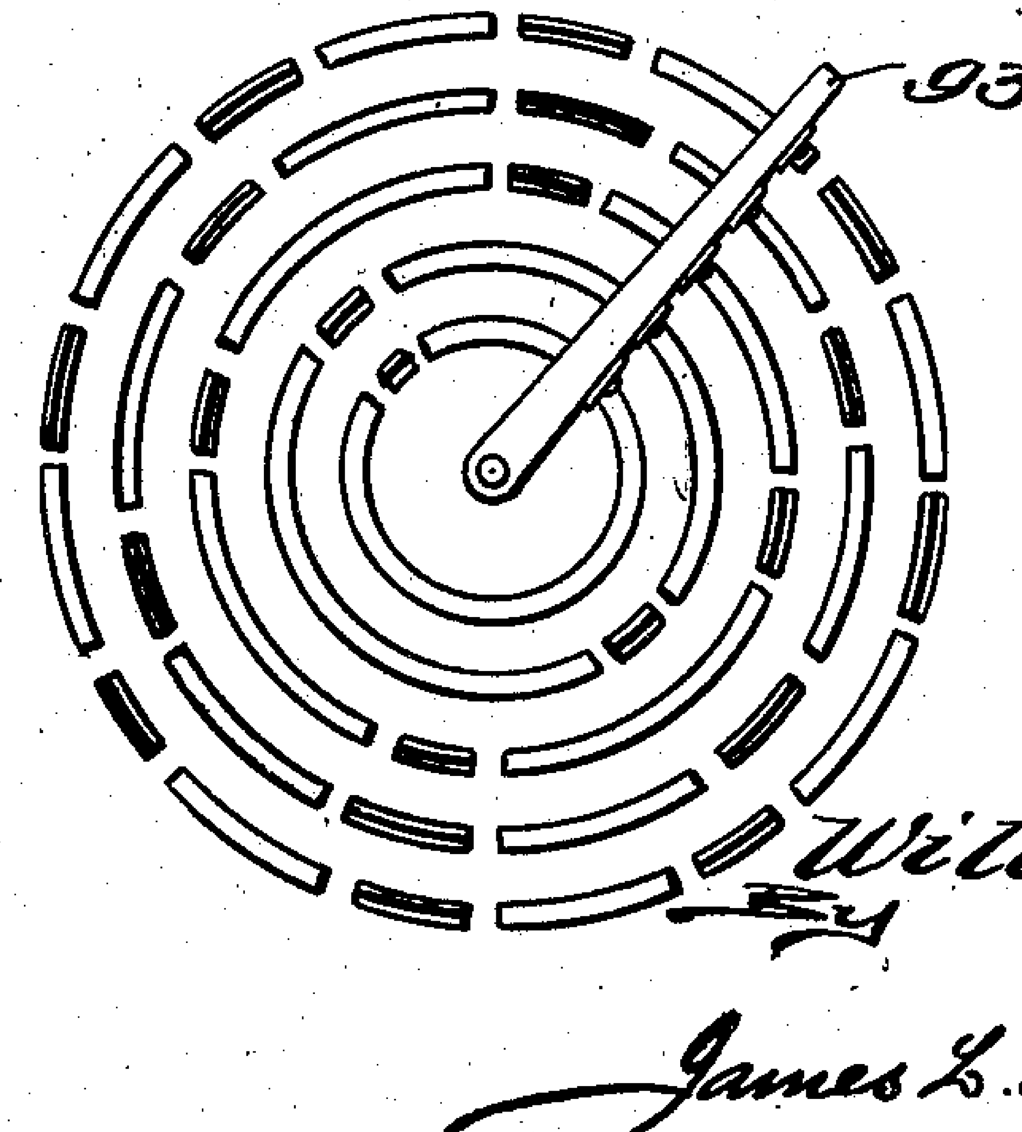


Fig. 6.



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5 SHEETS—SHEET 2.

Fig. 2.

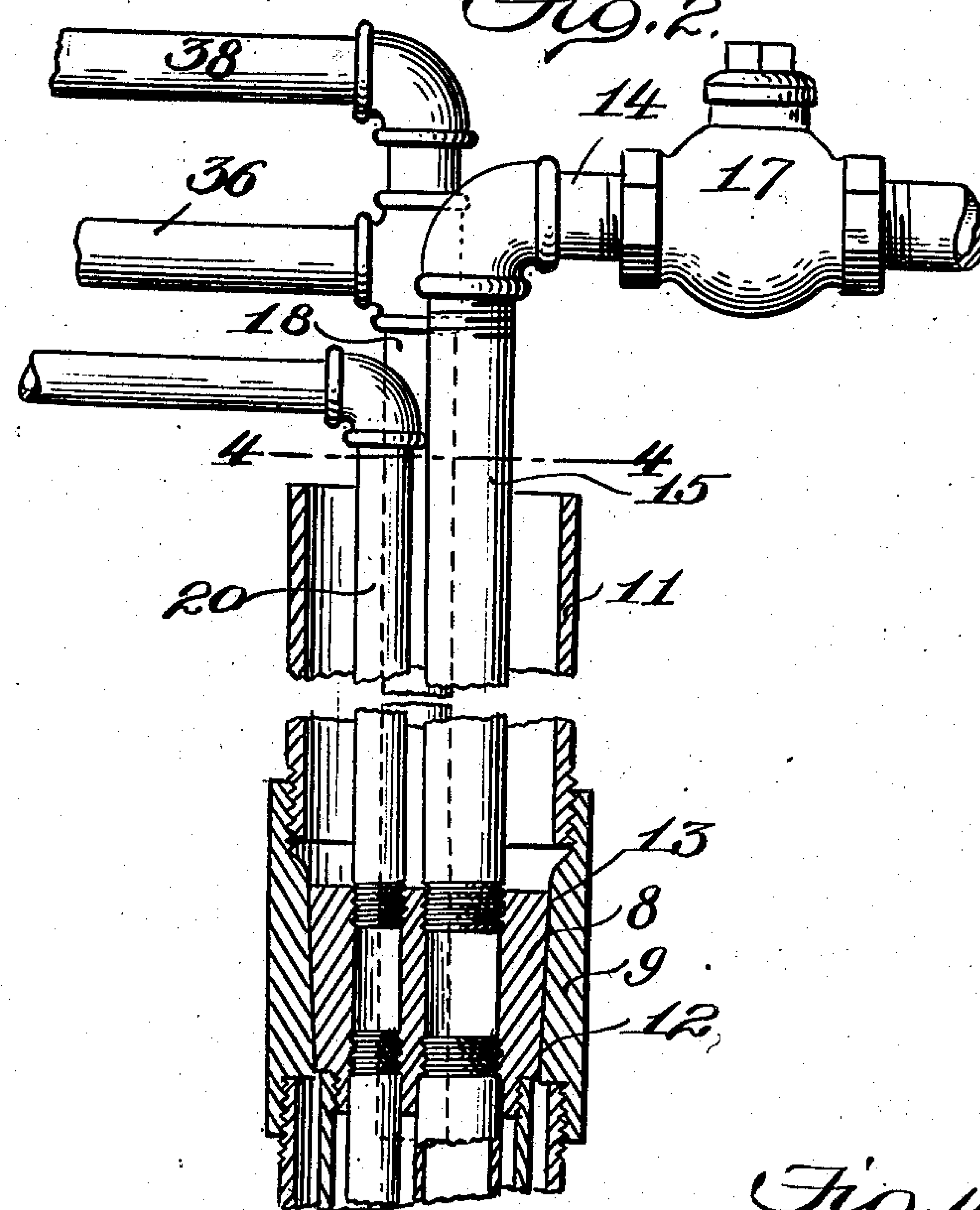
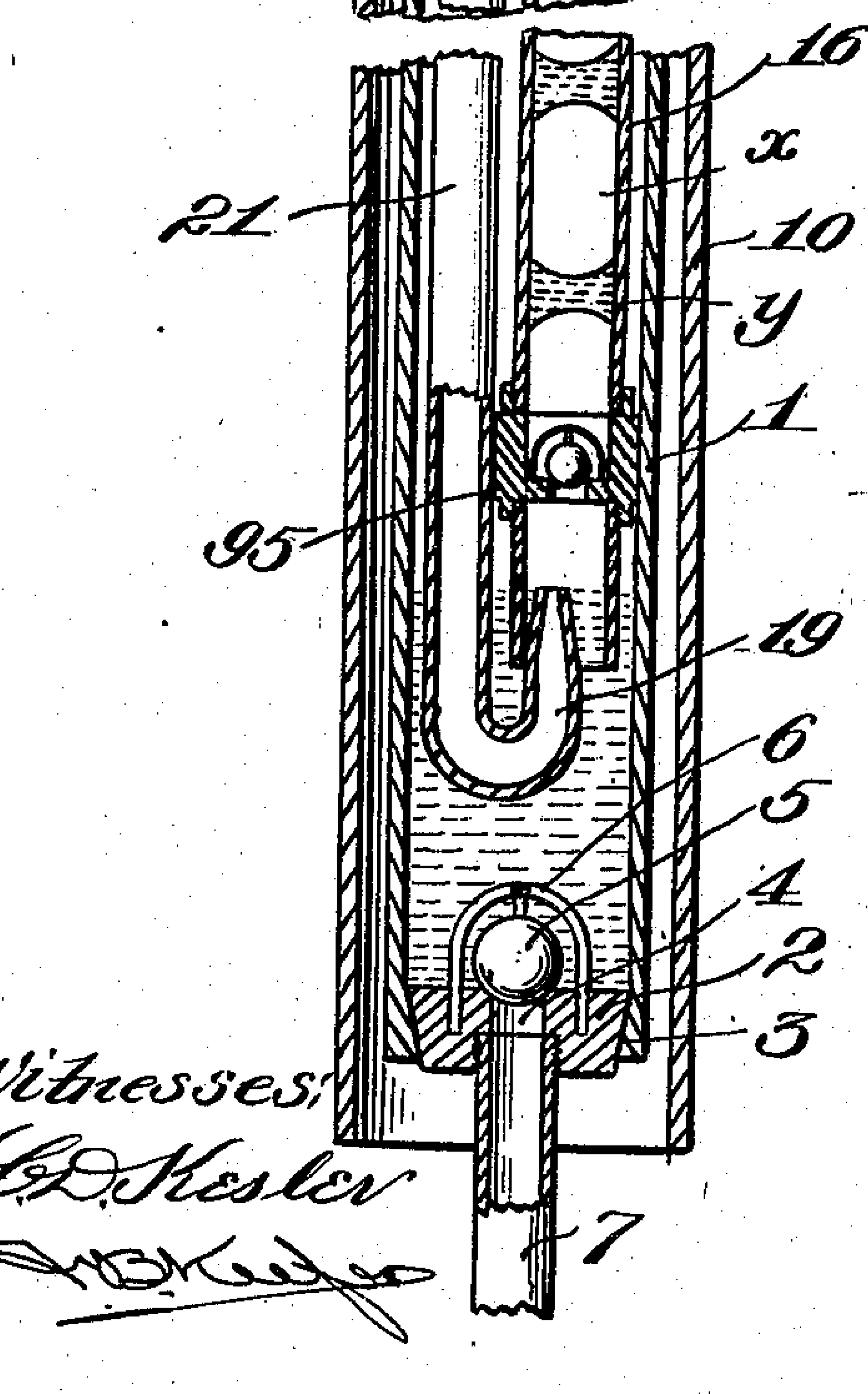



Fig. 3.

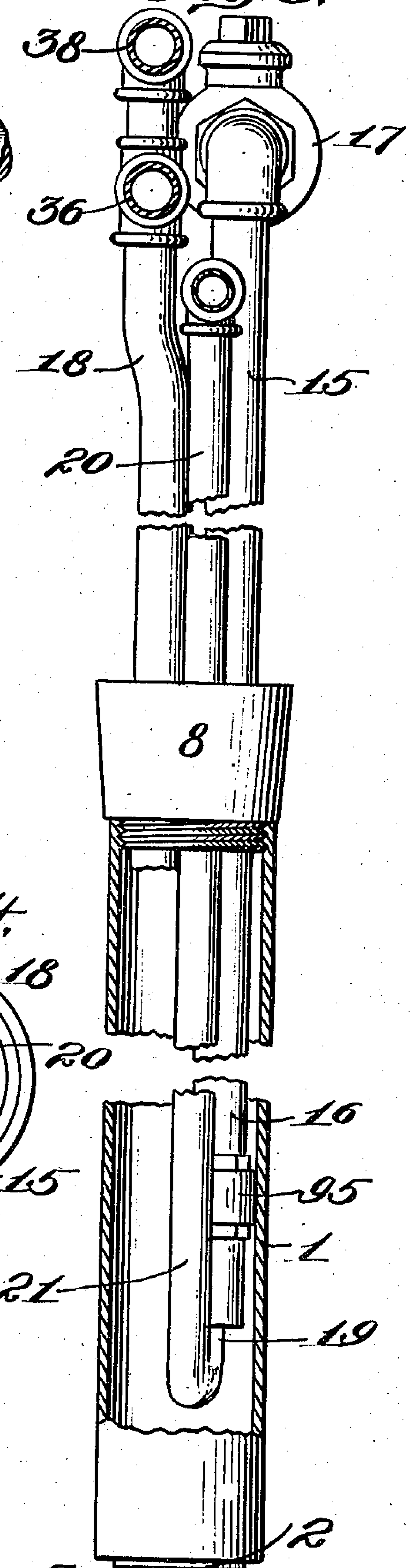
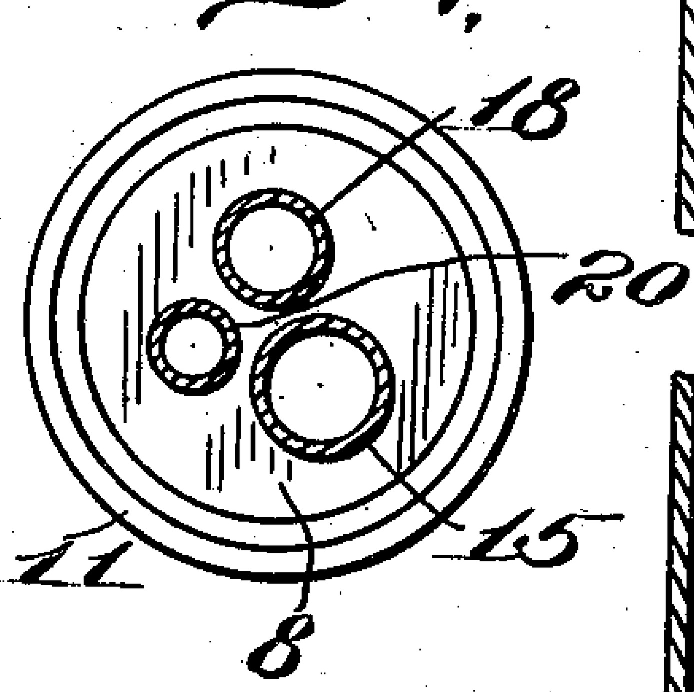


Fig. 4.



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5 SHEETS—SHEET 3.

Fig. 7.

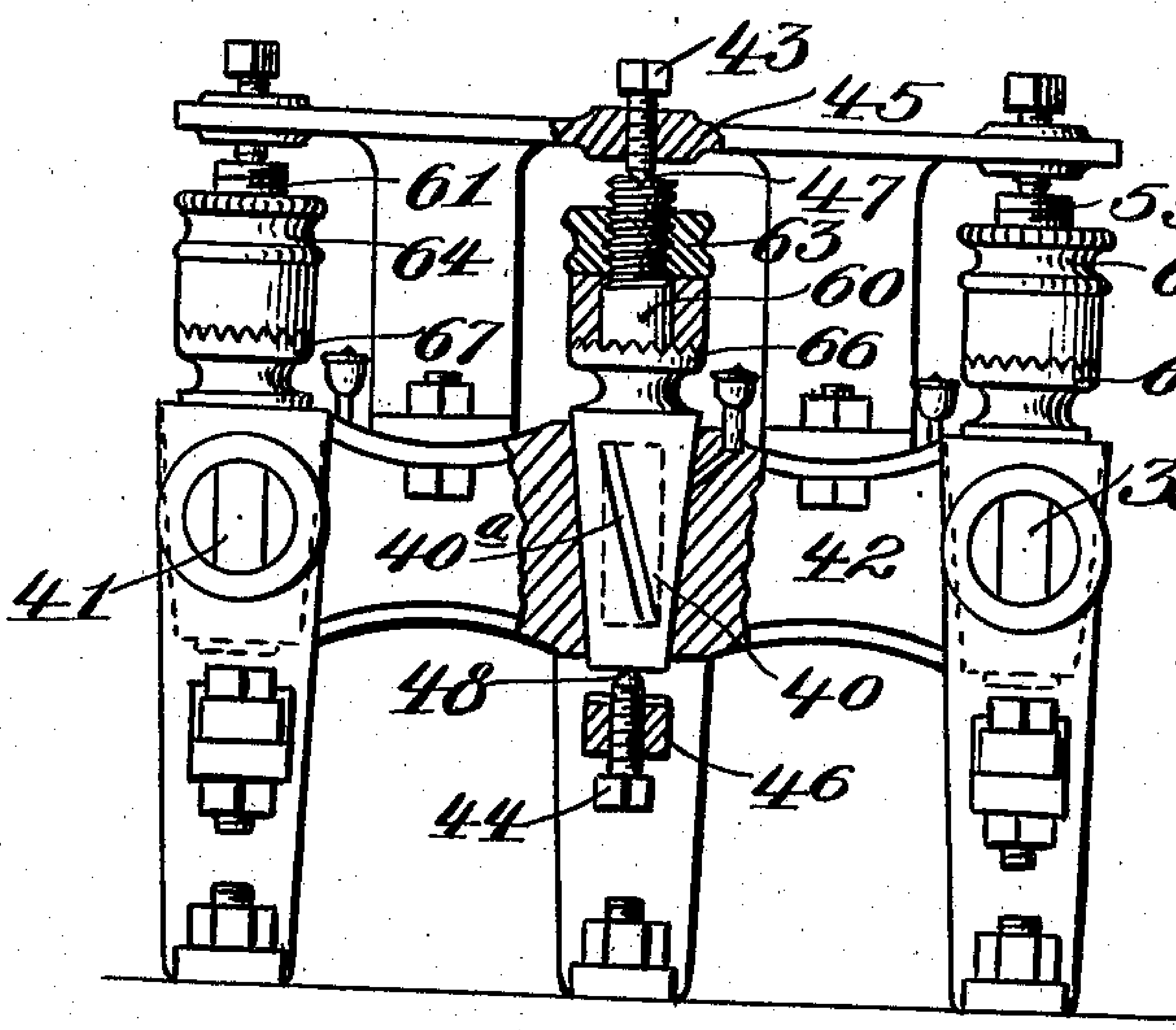


Fig. 9.

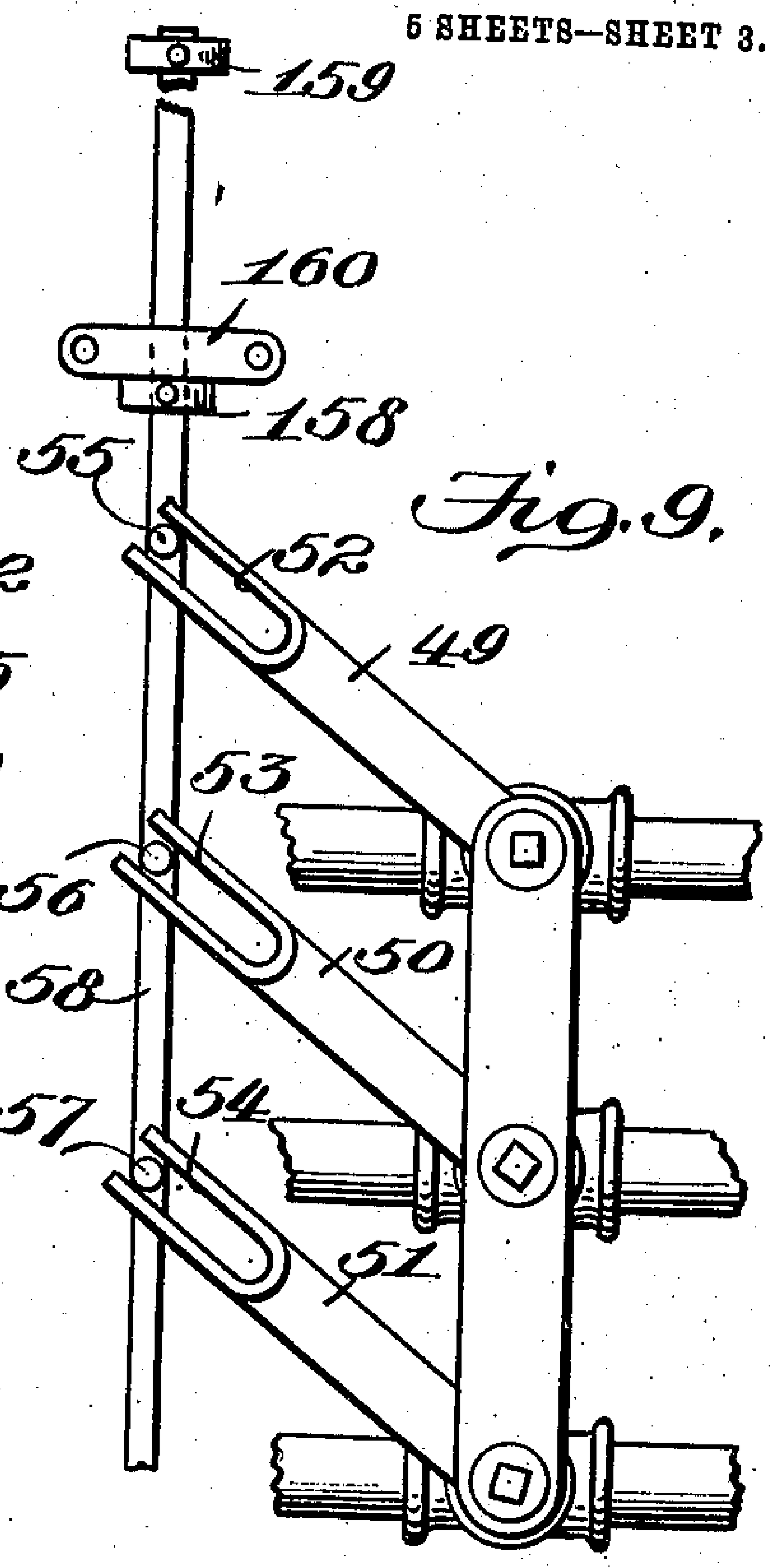


Fig. 8.

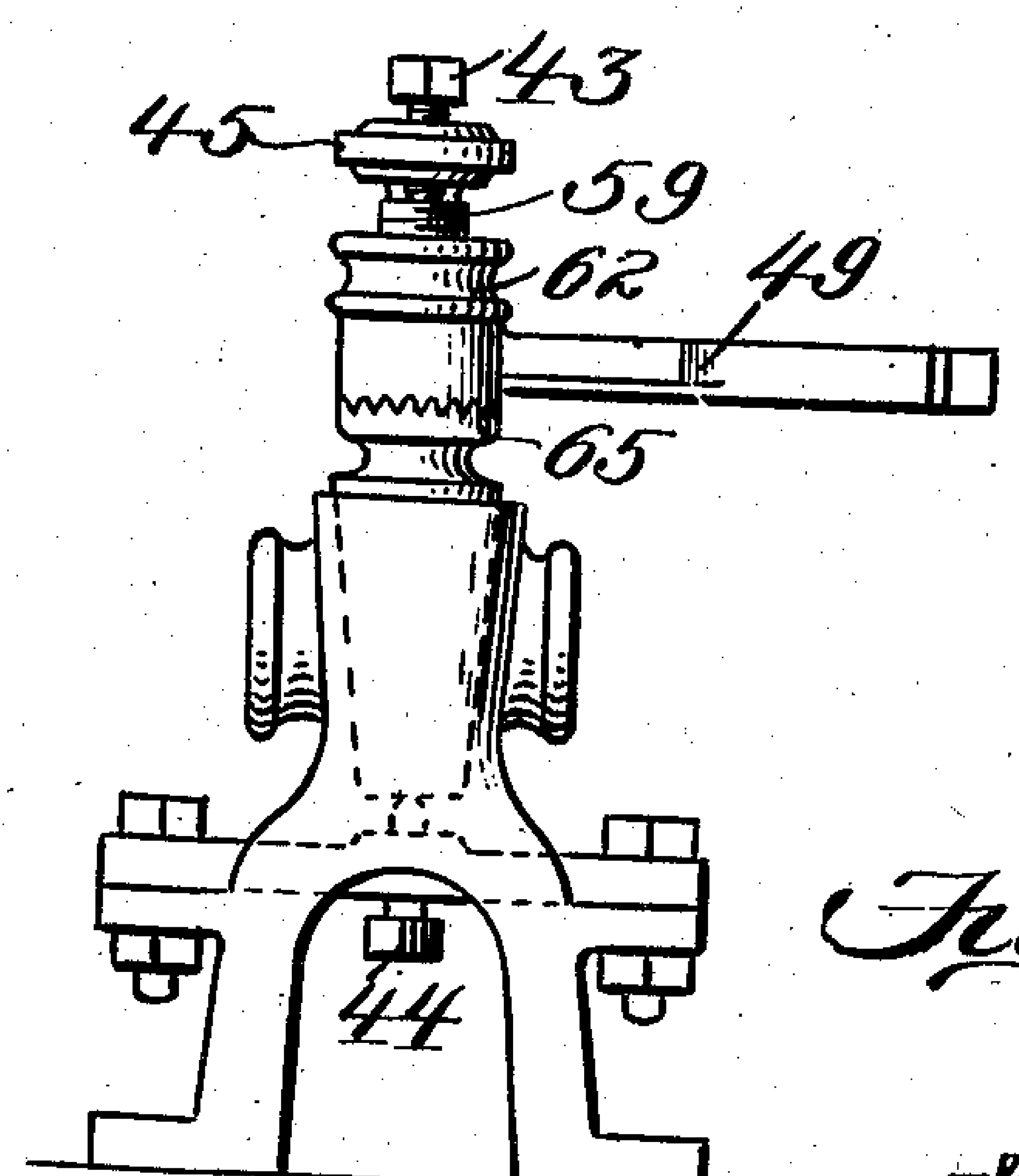


Fig. 10.

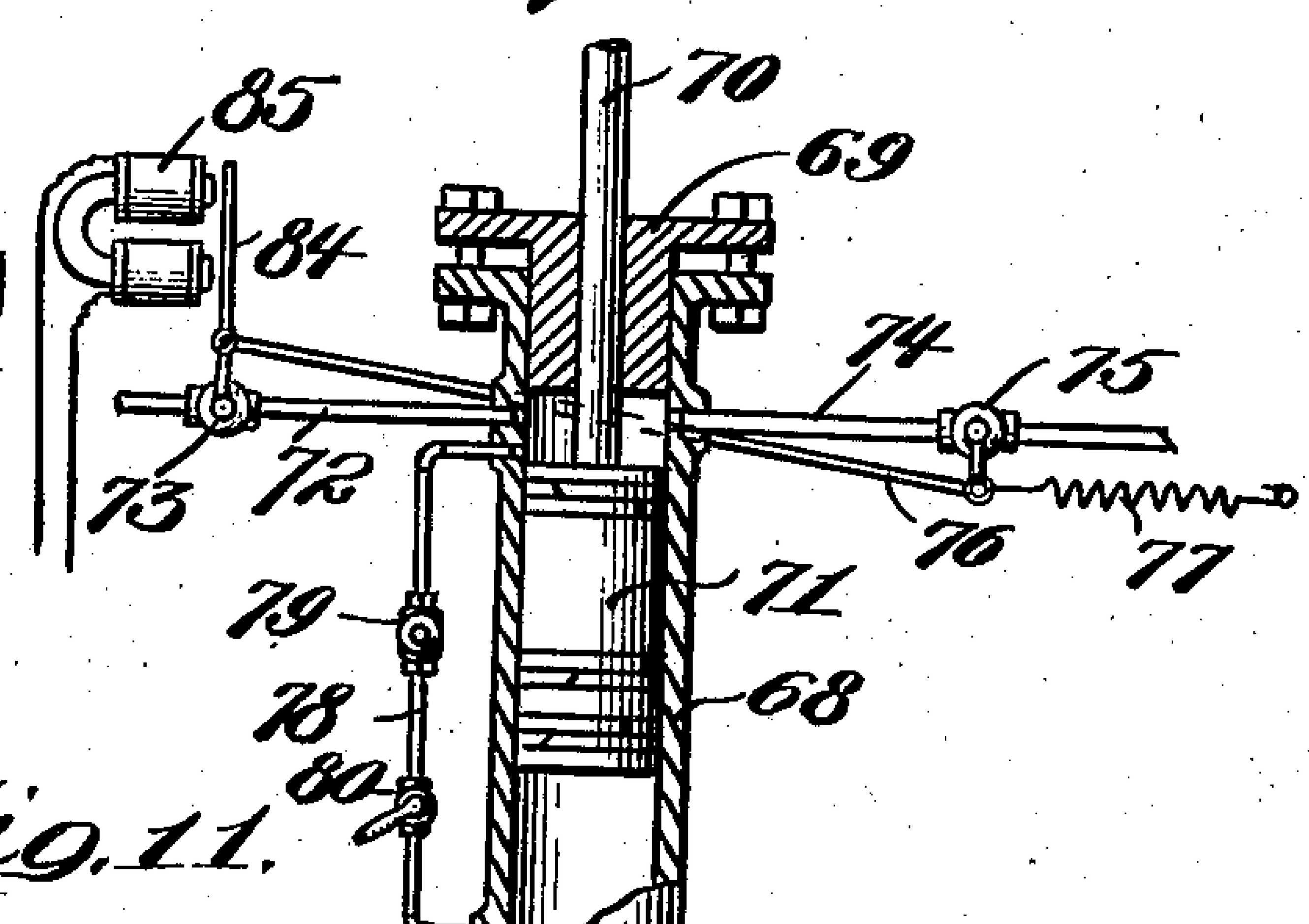
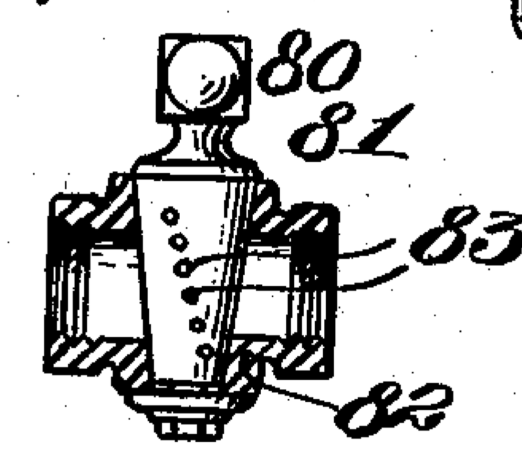


Fig. 11.



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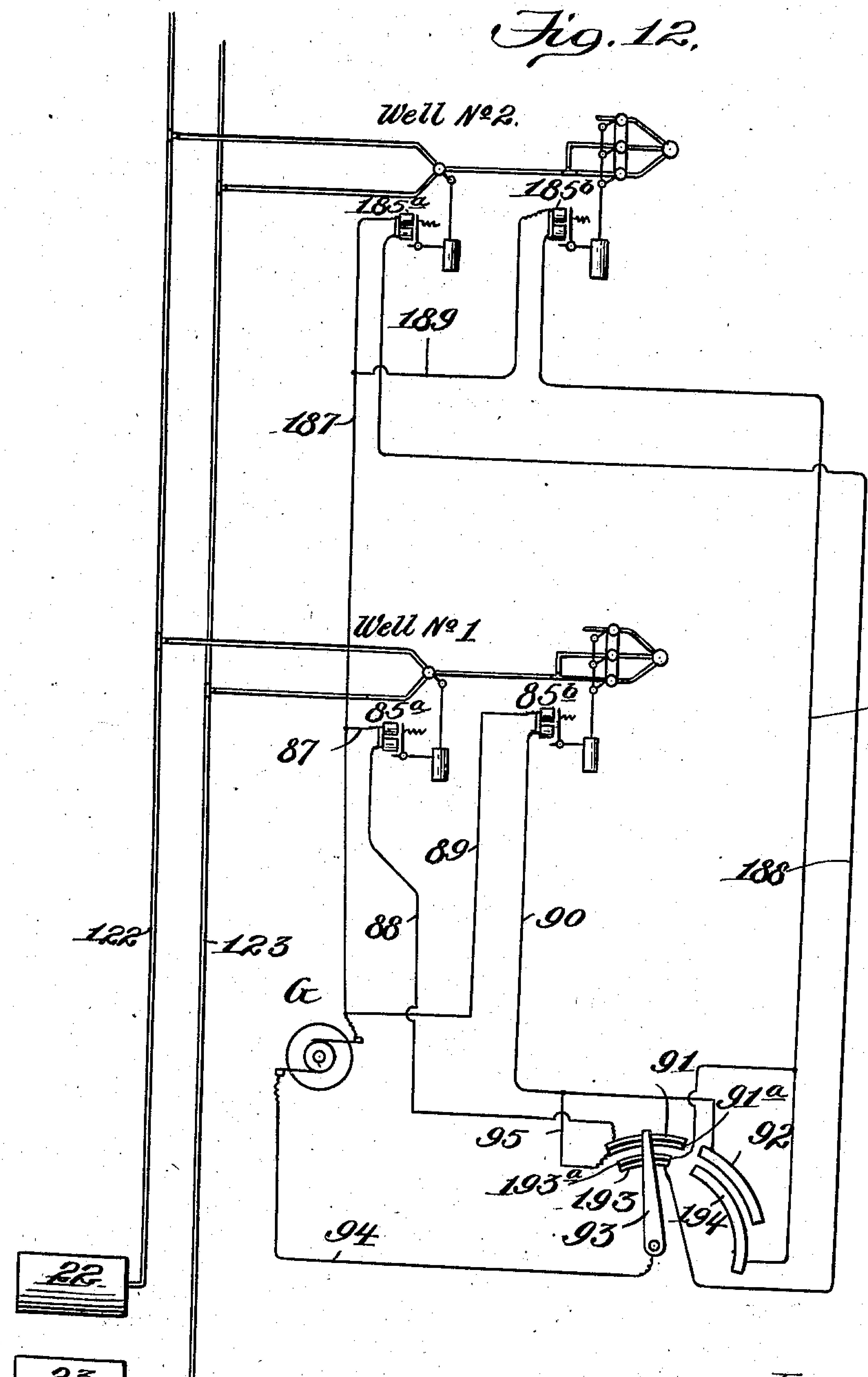
5 SHEETS—SHEET 4.

Fig. 12.



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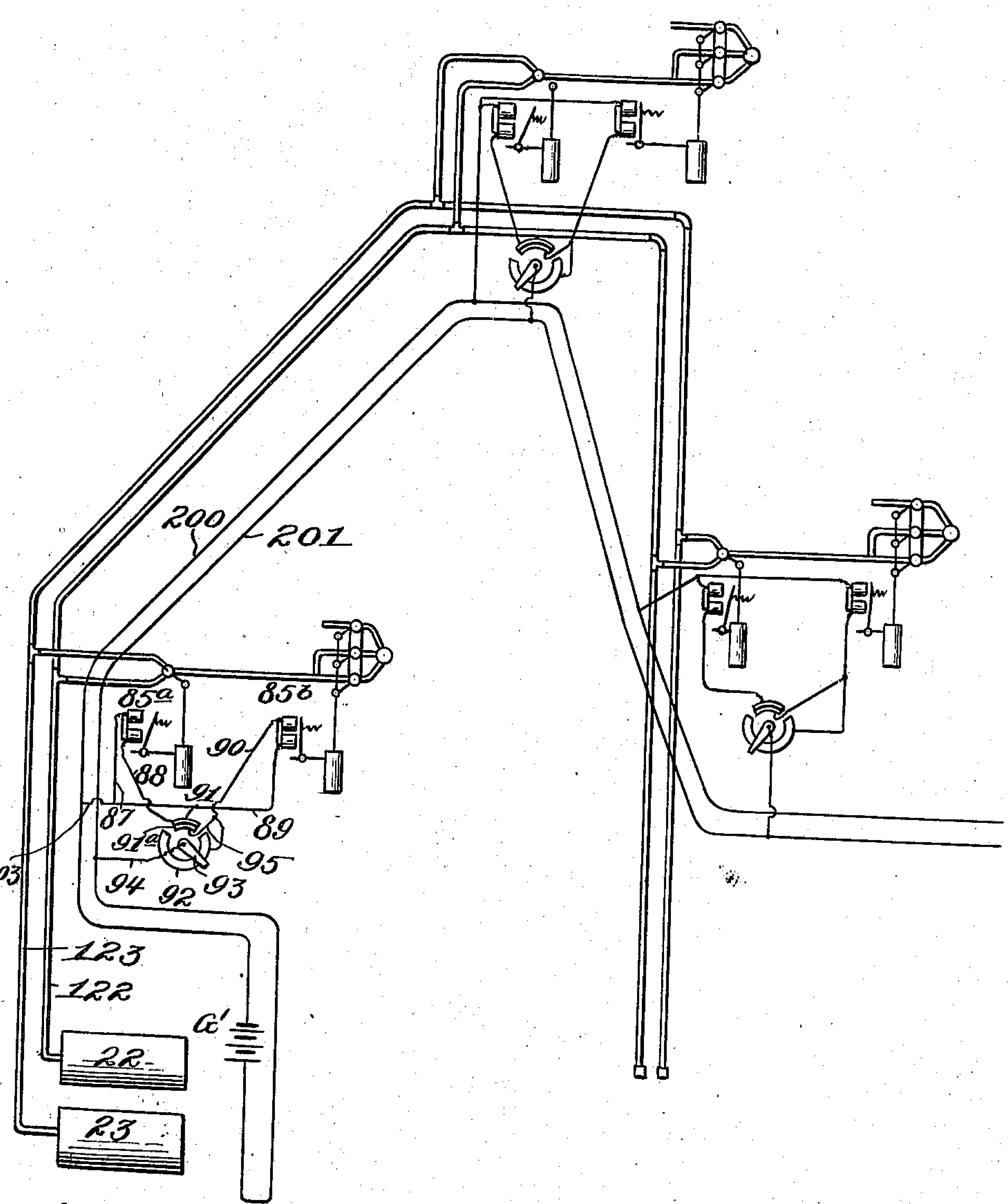
5 SHEETS—SHEET 5.

Fig. 13.



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UNITED STATES PATENT OFFICE

WILLIAM M. STEPHENSON, OF BATSON, TEXAS.

WELL-PUMPING APPARATUS.

No. 899,921. Specification of Letters Patent. Patented Sept. 29, 1908.

Application filed November 20, 1907. Serial No. 403,029.

To all whom it may concern:

Be it known that I, WILLIAM M. STEPHENSON, a citizen of the United States, residing at Batson, in the county of Hardin and State of Texas, have invented new and useful Improvements in Well-Pumping Apparatus, of which the following is a specification.

My present invention relates to improvements in apparatus for pumping oil or water from deep wells wherein the liquid must be lifted or elevated a considerable distance, and it has for its purpose primarily to provide an apparatus of this character that is capable of lifting the oil at a minimum cost and in such a manner as will promote the flow of oil into the well and thereby increase the capacity thereof.

Another object of the invention is to provide a pumping apparatus that is capable of being readily regulated according to the capacity or flow of the well and is also adapted to be used in pumping a plurality of wells simultaneously, although the pumping apparatus for each well is capable of being independently regulated according to the capacity of its respective well.

A further object of the invention is to provide a well pumping apparatus that is operated pneumatically, the oil being drawn into a receptacle in the bottom of the well by a vacuum, and thence discharged from the receptacle and elevated to the surface by compressed air which is presented to the discharging column of oil in the form of pistons, the pressure within the oil receptacle being controlled automatically and in a manner that will enable the duration of the periods during which the receptacle is receiving or discharging oil, to be varied as desired.

To these and other ends, the invention consists in certain improvements, and combinations and arrangements of parts, all as will be hereinafter more fully described, the novel features being pointed out particularly in the claims at the end of the specification.

In the accompanying drawings—Figure 1 is a diagrammatic view of a well pumping apparatus constructed in accordance with the present invention; Figs. 2 and 3 are sectional views of the oil receptacle and the surrounding well casing; Fig. 4 represents a transverse section on the line 4—4, Fig. 2; Fig. 5 is a detail sectional view of the three-way valve which controls the connections of the pressure and intermediate tanks to the main air pipe; Fig. 6 is a detail view of a commutator adapted for use in connection with the apparatus whereby a plurality of wells may be pumped simultaneously and at differently timed intervals varying according to the output of the well; Figs. 7 and 8 are detail views of a valve system which controls the flow of air to and from the oil receptacle; Fig. 9 is a detail view of the valve system showing the actuating rod therefor; Fig. 10 is a detail sectional view of a pneumatic motor for actuating the valve and the devices for controlling the motor; Fig. 11 is a detail sectional view of the throttling valve which controls the flow of the fluid through the by-pass leading to opposite sides of the piston shown in Fig. 10; Fig. 12 is a diagrammatic view of a pumping system connected for the simultaneous pumping of a plurality of wells. Fig. 13 is a diagram of an oil field having a plurality of well pumping apparatus distributed therein, a separate current distributing commutator being provided for the apparatus at each well.

Similar parts are designated by the same reference characters in the several views.

There are certain features of the present invention that adapts it for use generally in pumping liquids of various kinds from one point to another, but in the present instance the apparatus is especially applicable to the pumping of oil or water from relatively deep wells, and in accordance with the present invention, a receptacle is located at or about the bottom of the well into which the oil or water is drawn from the cavity of the well by a vacuum, and is then discharged from the receptacle into a vertical column which leads to the surface, the receptacle being so placed and its inlet and discharge so controlled that the oil sand within the cavity of the well is more or less under a vacuum during the operation of the apparatus.

In the present instance the receptacle comprises generally a tube 1 having a valve controlled inlet at the bottom through which the liquid is introduced into the chamber, the bottom 2 of the receptacle in the present instance having a substantially conical periphery to engage a similarly shaped contracted portion 3 at the lower end of the tube, and this bottom is provided with an inlet opening 4 that is controlled by a suitable check valve that will permit liquid to flow into the chamber and will prevent liquid or fluid under pressure from discharging through this inlet, a ball check valve 5 being shown in the present instance which coöperates with the upper end of this inlet opening as a seat, a cage 6 serving to prevent displacement of the ball valve. The oil or other liquid is conducted to the inlet by a suction pipe 7 which is usually of a short length and has its lower end submerged in the oil or other liquid in the cavity of the well. The upper end of this oil receptacle is closed by a plug 8 which may be threaded or otherwise attached to the tube 1 of the receptacle. Any suitable means may be employed for supporting or positioning the receptacle at the bottom of the well, but it is generally preferable to interpose a sleeve 9 between the lowermost section of the well casing 10 and the adjacent section 11 as a coupling, the inner surface of this sleeve being tapered or of conical form to provide a seat 12 with which the correspondingly formed periphery 13 of the plug coöperates. These tapered surfaces coöperate not only to support the oil receptacle at a proper position at the bottom of the well, but they also form a substantially fluid tight joint between the well casing and the receptacle so that the vacuum produced within the cavity of the well, due to the suction in filling the oil receptacle, may be maintained and thereby serve to promote the flow of the oil from the sand.

In order to weight the oil receptacle sufficiently to retain it properly seated at the bottom of the well, and also further prevent leakage between the tapered plug 8 and its coöperating seat, oil, water or other suitable liquid may be poured into the well casing above the plug.

The oil discharge pipe 14 extends from the ground level downwardly through the well casing and opens at its lower end within the oil receptacle, the discharge pipe shown in the present instance embodying upper and lower sections 15 and 16 which are tapped into the plug which closes the top of the chamber so as to form a fluid tight joint, and this oil discharge pipe may lead to any desired point of delivery, a check valve 17 being preferably employed at the top of the well and a supplemental check valve 95 may also be arranged at or in proximity to the lower end of the oil discharge pipe for the purpose of preventing back flow of the oil while the oil receptacle is under a vacuum. In some cases, however, for instance when a well is producing large quantities of sand and small quantities of oil, the sand would settle on the check valve at the bottom of the discharge pipe, and in such cases, such check valve would be omitted or dispensed with, or such check valve could be arranged at the bottom of the discharge pipe below the ejector nozzle, and the valve 41 could be so adjusted as to constantly maintain a sufficient flow of air from the nozzle to keep the liquid in the discharge pipe constantly agitated and thus prevent settling of sand in the check valve. A pressure controlling pipe 18 also extends downwardly from the surface through the valve casing and the plug closing top of the receptacle and discharges within the latter.

The oil or liquid within the receptacle is discharged therefrom by an ejector comprising in the present instance a nozzle 19 which extends a suitable distance into the lower open end of the oil discharge pipe, and it is connected to a suitable source of fluid pressure supply by means of the upper and lower pipe sections 20 and 21 which, in the present instance, are threaded into the plug closing the top of the oil receptacle. The oil receptacle may, of course, be removed from the well at any time by merely disengaging the coöperating tapered or conical surfaces on the plug thereof and the sleeve interposed in the well casing, as shown in Fig. 3, and the driving of the well is accomplished before the receptacle is introduced into the casing, the tapered seat formed on the coupling or sleeve of the casing extending only a short distance into the bore of the casing so that it does not constitute an obstruction that would hamper the drilling operation.

The air is exhausted from the receptacle during the filling thereof into a vacuum tank 22, and the pressure that is admitted to the receptacle for the purpose of discharging the oil therefrom is supplied from a tank 23. Any suitable means may be employed, of course, for maintaining the tank 22 at a vacuum pressure and the tank 23 at a suitable pressure above that of the atmosphere, a vacuum pump 24 being shown in the present instance which is connected to the tank 22 by means of a pipe 25, and an air compressor 26 is connected to the tank 23 by means of a pipe 27, the vacuum pump and the compressor being driven by the shaft 28 which is belted or otherwise connected to a gas engine or other form of motor 29. The tanks 22 and 23 are connected to a pair of line pipes 122 and 123 which extend over the oil field, and the oil elevating apparatus at the well is connected by means of the branches 30 and 31 to a well pipe 32 by means of a three-way valve 33, the latter embodying a casing into which the branches and the well pipe are tapped, a rotary plug 34 serving to alternately connect the vacuum and pressure tanks to the well pipe, the plug being actuated by a lever 35.

The tanks and the pumps associated therewith may be conveniently arranged within a central power station, and the line pipes serve to connect the air tanks with the oil elevating mechanism at the well, at which point the well pipe divides to form separate branches 36 and 37, the branch 36 communicating with the pressure controlling pipe 18 which communicates with the receptacle at the bottom of the well, and the branch 37 communicates with the ejector pipe section 20, as shown in Fig. 2. The third branch pipe 38 also communicates with the pressure controlling pipe 18 and this branch pipe opens to the atmosphere. The flow of the fluid through the several branch pipes 38, 36 and 37 is controlled by the respective valves 39, 40 and 41, the valve 39 serving to control communication between the branch pipe 38 and the atmosphere, the intermediate valve 40 controlling communication between the two tanks and the receptacle within the well, and the valve 41 controlling the admission of compressed air to the receptacle to discharge the oil or liquid therefrom. These valves may be constructed in any suitable way, but I prefer generally the construction shown in Figs. 7, 8 and 9, the valve casings of the several valves being formed of a single casting 42 or in such a manner as to insure maintenance of their proper relation, and this casting may be secured to any suitable support.

The valves shown are of the plug type, and in order to insure a proper operation thereof with a minimum friction, I prefer to provide means for adjusting the axial thrust on these valves that will enable them to be readily adjusted so as to avoid leakage, and at the same time there is no liability of their sticking. The devices employed in the present instance for accomplishing this purpose comprise pairs of set screws 43 and 44 which are threaded in the supports 45 and 46 that are rigid with the casting or frame and their inner ends are provided with conical points 47 and 48 which are arranged to coöperate with correspondingly formed recesses arranged axially in the opposite ends of each plug, the set screws being capable of adjustment to shift the respective plugs axially and thereby permit a proper seating thereof, and undue friction or binding is avoided. The several valves are operated by the levers 49, 50 and 51 having longitudinal slots 52, 53, and 54 at their outer ends which are adapted to coöperate with pins or projections 55, 56 and 57 on a common actuating rod 58, the latter being limited to the proper range of movement by a pair of stops 158 and 159 that are adapted to coöperate with the guide 160. These several actuating levers are preferably so connected to the respective valves that the latter may be set in proper relation relatively to one another so as to obtain a proper timing of the relative opening and closing thereof, and for this purpose the valve stems are provided with threaded ends 59, 60 and 61 on which the levers are fitted loosely, and the levers are operatively connected to the respective valves by means of the lock nuts 62, 63 and 64 which engage the respective levers and force them against the shoulders 65, 66 and 67 of the respective valves. In order to provide a positive connection between the levers and the respective valves, it is preferable to serrate the coöperating surfaces of the shoulders of the valves and the respective levers as shown in the present instance. The valve 39 is so set that it is in open position so as to establish communication with the atmosphere when the valves 40 and 41 are in closed position and vice versa, and the intermediate valve 40 is preferably provided with a diagonal port 40^a in order that it may be closely adjusted to vary the quantity of air passing through the pipe 18 relatively to pipe 20, for, by opening valve 40 to a greater or less degree, the proportion of oil discharged is varied from a solid column to any proportion of oil and air that may be desired.

Any suitable means may be employed for controlling the movements of the three-way valve 33, and the valve set controlling the branch pipes 37 and 38, but it is generally preferable to employ automatically controlled devices for this purpose that will enable the system to operate to fill and empty the receptacle at the bottom of the well at properly timed intervals and without requiring the aid of an attendant. Pneumatic motors are employed for this purpose in the present instance, each motor comprising an elongated cylinder 68 which is permanently closed at one end and provided with a stuffing box 69 at its opposite end through which a piston rod 70 operates, the piston rod being connected to the valve actuating rod 58 or to the lever 35 of the three-way valve as the case may be. The piston 71 operates in the upper portion of the cylinder, or that end thereof in proximity to the stuffing box. Air under pressure is admitted to the upper side of the piston by a pipe 72 controlled by a valve 73, and the air is exhausted from the upper side of the piston by means of a pipe 74 controlled by a valve 75, the valves 73 and 75 being connected for simultaneous movement by a link 76 and are so arranged that the valve 75 is closed while the valve 73 is admitting air to the cylinder and after the inlet valve 73 closes, the exhaust valve 75 opens. Normally the inlet valve is retained in closed position and the exhaust valve in open position by means of a spring or its equivalent 77. The air admitted to the upper side of the piston, of course, serves to produce a downward movement of the latter, and the return stroke is effected by the air confined under pressure between the rear or under side of the piston and the closed end of the cylinder, after the air above the piston has been exhausted through the valve 75.

A suitable pressure is maintained within the cylinder at the rear of the piston by means of a by-pass 78 which is tapped into the cylinder wall at points above and below the piston and is provided with a check valve 79 which permits the air to pass from the upper side of the piston to the lower side thereof, and prevents flow of air in the opposite direction. It is preferable to regulate the flow of air through the by-pass into the closed end of the cylinder by means of a throttling valve 80, that shown in the present instance comprising a plug 81 fitting the valve casing 82 and is provided with a series of minute ports or apertures 83 which are arranged diagonally thereof in order to permit close regulation to be had.

The pneumatic valve actuating motors may be controlled in various ways, but it is preferable to control them electrically. This is accomplished in the present instance by providing an armature 84 on one of the valve actuating arms and a coöperating magnet or solenoid 85, the magnet being so placed as to attract the armature when energized and operate the valves 73 and 75 in opposition to the spring 77, that is to say, the magnet when active will operate to open the inlet valve 73 and close the exhaust valve 75, and when deënergized the spring 77 serves to return both valves to normal position.

The current used to operate the magnets may be derived from any suitable source, a generator G being shown in the present instance for supplying the necessary current, and it is preferable to control the operation of the different magnets by means of a commutator 86. The magnet 85ª which controls the operation of the pneumatic motor which actuates the three-way valve 33, is connected to the generator or source of current supply according to Fig. 1, by a conductor 87 and to the commutator by a conductor 88, while the magnet 85ᵇ which controls the motor for actuating the valves for the branch pipes at the well, is connected to the generator by a conductor 89 and to the commutator by a conductor 90. The circuits for the magnets 85ª and 85ᵇ are so connected to the commutator that while the switch arm 93 thereof rests on the segment 91, both magnets will be energized, whereas, when the said switch arm rests on the segment 92, the magnet 85ᵇ only will be energized, and in order to insure this result, the segment 91 is virtually divided into two sections insulated from one another, the supplemental section 91ª thus provided being connected to a branch conductor 95 leading from the magnet 85ᵇ while the conductor 90 is directly connected to the segment 92 and the conductor 88 leading from the magnet 85ª is connected to the section 91 of the commutator, and hence, the switch arm 93 will close the generator circuit through both magnets when it rests on the shorter segment 91, and when it rests on the segment 92 it will close the circuit through the magnet 85ᵇ only. The commutator so distributes the current that the three-way valve 33 will be operated to connect the line pipe alternately with the vacuum and pressure tanks, while the magnet 85ᵇ will operate to control the supply and exhausting of air relatively to the oil receptacle. Any suitable commutator may, of course, be employed for this purpose, the relative length of the segments being determined according to the duration of the periods during which the oil receptacle is under a vacuum, and is at a pressure above that of the atmosphere respectively.

In practice, the well casing is introduced into the well opening in the usual way, except that the sleeve 9 is preferably coupled between the two lowermost sections of the casing in order that the tapered surfaces therein may provide a seat to support the oil receptacle. The latter is introduced into the casing and lowered to the bottom of the well, that is to say, until the tapered periphery of the plug 8 thereon engages the contracted or tapered surfaces of the sleeve 9 of the casing. The taper fit thus provided between these parts insures a substantially fluid tight joint between the oil receptacle and the well casing so that a vacuum of more or less degree may be maintained in the cavity of the well, the casing, of course, fitting the surrounding earth sufficiently tight to seal the same to the entrance of air into the well cavity from above. The suction pipe 7 extends, of course, into the oil sand and the necessary connections are made for conducting air to and from the receptacle and for discharging the oil through the pipe 14, as shown in Fig. 2. As previously stated, the vacuum and pressure tanks and their coöperating pumps, the motor for driving the pumps, and also the commutator are preferably located at a central station, the main pipes 122 and 123 extending from the station to the well or wells to be pumped. Assuming that the tank 22 is substantially at vacuum pressure, and the tank 23 contains compressed air at a suitable pressure, and that the contact arm 93 rests on the segment sections 91 and 91ª of the commutator, as shown in Fig. 1, it will be understood that the current traversing the conductor 87, magnet 85ª, conductor 88, segment 91, contact arm 93 and conductor 94, will energize the magnet 85ª, causing it to attract its armature 84 and as the latter operates, it will cause the inlet valve 73 of the pneumatic motor, as shown in Fig. 10, to open, and admit compressed air to the upper side of the piston 71, simultaneously closing exhaust valve 75 through the connecting link 76. The air thus admitted above the piston 71 will cause it to move toward the closed end of the cylinder, and in this case the operating arm 35 of the three-way valve 33 which is operatively connected to the piston of its respective motor, will actuate the three-way valve to establish communication between the compressed air pipe 123 and the well pipe

32, the current from the generator also traversing the conductor 89, magnet 85^b, conductor 90 and branch conductor 95 to the supplementary section 91^a of the commutator, thence to the contact arm 93 and conductor 94 back to the generator, causing the magnet 85^b to be energized, and its coöperating armature to be actuated to open the inlet valve 73 to admit compressed air to the upper side of the piston of the pneumatic motor, and simultaneously close the exhaust valve 75, and as the piston of the motor moves toward the closed end of its cylinder, the valve actuating rod 58 will be shifted from the position shown in Fig. 9 to that shown in Fig. 1, causing the valve 39 to close and thereby seal the branch pipe 39 from the atmosphere, and simultaneously the valves 40 and 41 are opened. The well pipe 32 communicates with both branches 36 and 37, the branch 36 controlled by the valve 40 discharging air into the pipe 18 at a point above the oil contained in the receptacle at the bottom of the well, the purpose of admitting compressed air through this pipe being to regulate the rate of flow of the oil from the receptacle. The compressed air from the branch pipe 37 passes through the valve 41 and the pipe sections 20 and 21 and finally discharges through an upturned nozzle 19 into the lower open end of the oil discharge pipe 16 which is submerged in the oil contained in the receptacle, as shown in Fig. 2. The air thus discharged has an action on the oil similar to the ordinary ejector or inspirator, causing the oil to be drawn into the oil discharge pipe, and the air from the nozzle forms air pistons *x* which are interposed alternately between the bodies of oil *y*, and the oil is thus discharged from the receptacle aided by the buoyancy of the air and regulated by the quantity of air admitted through the pipe 18. The quantity of air admitted to the pipe 18 may be readily controlled by adjusting the angular position of the diagonal port 40^a of the intermediate valve 40 relatively to the operating lever 50 connected thereto, the clutch connection between these parts permitting such an adjustment to be readily made.

The contact arm 93 is operated by a clock motion or other motor and preferably one that is capable of being regulated so as to vary the period of time elapsing during each revolution thereof so that the duration of the periods during which oil receptacle is under a vacuum and at a pressure above that of the atmosphere, may be varied according to the rate of flow or capacity of the well, it being understood, of course, that wells differ widely in capacity. While the contact arm rests on the segment 91 of the commutator, the discharging of oil from the receptacle will continue. However, at the moment the contact arm passes off this segment, the circuits through both magnets 85^a and 85^b are broken, the spring 77 of each pneumatic motor causing the respective inlet valves to be closed to cut off the supply of air thereto, and the corresponding exhaust valves are opened to permit the compressed air above the piston to be discharged. The reduction in pressure above the piston enables the compressed air below or behind the piston to actuate the latter in a direction that will turn the three-way valve into a position that will establish communication between the vacuum tank and the line pipe, and the movement of the piston of the pneumatic motor controlled by the magnet 85^b to reverse the position of the valves 39, 40 and 41, the valve 39 opening at this moment so that any compressed air remaining in the oil receptacle and piping connected thereto may be exhausted to the atmosphere, while the valves 40 and 41 are closed. This condition remains while the contact arm is traversing the gap between the segment 91 and the segment 92, but at the moment the contact arm engages the segment 92, the circuit for the magnet 85^b will be completed through the conductors 89 and 90, commutator sector 92, contact arm 93 and conductor 94, and the attraction of the armature of this magnet as it is energized, will cause the inlet valve of its pneumatic motor to be opened and the exhaust valve thereof closed, and the compressed air thus admitted above the piston of this motor will cause the latter to operate, and cause the valves 39, 40 and 41 to be restored to the position indicated in Fig. 1, that is to say, the valve 39 communicating with the atmosphere is closed and the valves 40 and 41 are opened. A vacuum pressure is on the well piping at this time, the air contained in the oil receptacle being exhausted therefrom through the branch pipe 36 and the connecting pipe 18 which extends into the upper portion of the receptacle, the check valve 95 being preferably inserted in the lower portion of the discharge pipe to avoid the exhausting the air throughout the length of the discharge pipe and also to prevent back flow of the oil between operations. The vacuum thus established within the oil receptacle causes the oil from the oil sand to enter the suction pipe 7, the valve 5 lifting from its seat as the oil enters. The rate at which the oil enters the receptacle should be regulated generally according to the rate of flow of the well so as to insure a complete filling of the receptacle preparatory to each discharging operation, and this result may be accomplished by adjusting the valve 40 to the proper angular position relative to its operating lever 50. At the moment the contact arm 93 passes off the segment 92 of the commutator, the circuit for the magnet 85^b is broken, permitting the piston of its respective pneumatic motor to return to a position that will open the valve 39 and permit air from the atmosphere to enter the piping and thereby relieve the vacuum therein and within the oil receptacle, and the valves 40 and 41 are closed to cut off the vacuum tank from the piping at the well. However, as soon as the contact arm reaches the commutator segment 91, the circuits of both magnets 85^a and 85^b will be closed, as previously described, causing the three-way valve to turn to a position that will establish communication between the pressure tank 23 and the well piping, and the magnet 85^b will operate the valves of its respective pneumatic motor, causing the latter to close the valve 39 to the atmosphere and open the valves 40 and 41 so that pressure from the well piping may enter the well and discharge the oil from the oil receptacle in a manner previously described, the cycle of operations being performed automatically so that the aid of an attendant to control the operation of the apparatus is unnecessary.

In order to avoid the necessity of extending piping from the pressure tank 23 which is usually located at a power station, to the well or wells to be pumped, which are usually located at a distant point, it is preferable to provide a supplemental compressed air tank 96 which is located at the well and is connected to the inlet valve 73 of the pneumatic motor located at that point, and this supplemental tank receives pressure from the well pipe through a branch 97 having a check valve 98 therein, the compressed air flowing from the line pipe while pressure is on the system, and the check valve preventing back flow of the air when the system is under a vacuum.

As previously stated, a plurality of wells may be easily connected up to a central station so that they may be pumped from a single pair of vacuum and compressed air tanks, it only being necessary to extend a line pipe from the central station to each well, and I have shown such an arrangement in Fig. 12.

In operating a plurality of wells from a single system or apparatus, the vacuum line piping 122 and the pressure line piping 123 are extended over the field from one well to another, and the well pipes 32 of the respective wells are connected to the vacuum and pressure line pipes by the branch pipes 30 and 31, respectively, these branch pipes being connected to the well pipe at each well by the three-way valve 33. When the pumping system is thus laid out, the line pipe 122 is constantly under a vacuum pressure, being connected to the vacuum tank 22 and the line piping 123 constantly contains a supply of compressed air from the air pressure tank 23. It will be understood, of course, that a three-way valve 33 and a set of controlling valves 39, 40 and 41 according to this arrangement, may be located at each well, and they operate and are controlled substantially in the manner described in connection with the system represented in Fig. 1, in this case the pumping apparatus for exhausting and compressing air, respectively, in the tanks 22 and 23, and also the electrical controlling mechanism for the valves at the well are, according to Fig. 12, located at a central point or station, and suitable wiring is extended from the central station to the several wells. In the present instance, a single commutator is connected in the valve controlling circuits for the several wells, the commutator shown in this instance containing a separate row of segments for each well, each row containing sets of relatively shorter segments 91, 91^a and 193, 193^a, respectively, and alternately arranged sets of longer segments 92 and 194, respectively, that correspond substantially to the segments 91, 91^a and 92 of the commutator shown in Fig. 1, except that a plurality of sets thereof are provided, so that at each revolution of the switch arm or hand 93 all wells connected to the segments will be pumped a predetermined number of times.

According to Fig. 12, two rows of segments are shown, the outer row being connected by a wiring corresponding to that shown in Fig. 1 to the magneticd evices 85^a and 85^b of well No. 1, while the inner row of segments are connected to the magnetic devices of well No. 2, the same switch arm 93 serving to close the circuit through both rows of segments. In the present instance the magnet 185^a of well No. 2 is connected to one terminal of the generator by a conductor 187 and the magnet 185^b is connected to the same terminal of the generator by means of a conductor 189. The magnet 185^a is connected to the supplemental section 193 on the commutator by means of the conductor 188, while the magnet 185^b is connected by the conductor 190 to the section 193^a and the segment 194.

Of course, the commutator may be provided with any desired number of sets of segments in order that the desired frequency of operation of the wells may be attained, and in some instances it may be advantageous to employ a commutator such as that illustrated in Fig. 6, the commutator shown therein embodying five rows of segments, the number of sets of segments in the outer row being preferably of a maximum number, and the number of sets of segments in the remaining rows decreasing progressively toward the axis of the commutator so that in one revolution of the switch arm or hand those wells connected to the segments of the outer row will be pumped a proportionately greater number of times than those connected to the inner rows of segments, and such a commutator enables the wells to be pumped at frequencies corresponding to the rates of flow thereof.

In some cases it may be advantageous to locate an independent commutator at each well, and I have shown such an arrangement in Fig. 13, wherein the generator or other source of current G′ is located at a suitable point and conductors 200 and 201 extend over the oil field and are suitably connected to the commutators at the several wells, the wiring at each well being substantially the same as that shown in Fig. 1, the conductors 87 and 89 being connected by means of a conductor 203 to the main wire 200, and the conductor 94 is connected directly to the main line wire 201. Such a system is particularly advantageous in those cases wherein the wells are located several miles apart.

In practice, it is preferable to heat the compressed air preparatory to its entering the well, as such a heating will serve to expand the air considerably in volume and will result in a greater efficiency in the operation of the system. These air heaters may be located at any suitable point, preferably in proximity to each well.

A well pumping apparatus constructed in accordance with my present invention is capable of raising the oil a considerable height with an expenditure of a minimum quantity of air at comparatively a low pressure, as it is only necessary to fill the receptacle at the bottom of the well with the compressed air in order to lift the oil at each discharging operation, and the air pistons formed in the discharging oil column serve to assist in the lifting of the oil. Moreover, the capacity or rate of flow of many wells may be considerably increased by the use of a pumping apparatus of this character, for the reason that the oil sand at the bottom of the well casing is sealed from the surface by reason of the close fitting of the oil receptacle within the casing, and hence, the vacuum pressure within the oil receptacle during the charging or filling thereof will produce a partial vacuum within the well cavity that will be maintained by reason of the sealing of the cavity, and this has a tendency to increase the flow of the oil from the sand.

The automatic air control insures a correct operation of the system without requiring the constant presence of attendants, and the electrical controlling devices enable the apparatus to be set up and operated with the greatest facility whether there is a single or a plurality of wells to be pumped from the same tanks, the latter together with their charging pumps being conveniently located at a power station and the line pipes being extended to the different wells.

I claim as my invention—

1. In a well pumping apparatus, the combination with air supplying and exhausting means, of a substantially closed receptacle connected to the air supplying and exhausting means, a device for controlling communication between the latter and the receptacle and means for venting said receptacle to the atmosphere between the periods the air supplying and exhausting means are in communication with said receptacle.

2. In a pumping apparatus of the character described, the combination with pressure and vacuum tanks, a line pipe connected thereto, pneumatic discharging means for elevating the liquid from the well, and means for controlling communication between the respective tanks and the line pipe and for automatically venting said receptacle to the atmosphere between the periods the pressure and vacuum tanks are in communication with the receptacle.

3. In a pumping apparatus of the character described, the combination with a substantially closed receptacle having a valve inlet, of air supplying and exhausting means connected thereto, a valve for alternately connecting the air supplying and exhausting means to the receptacle for discharging and refilling the same, and means for venting said receptacle to the atmosphere between the periods the air supplying and exhausting means are in communication with said receptacle.

4. In a pumping apparatus of the character described, the combination with pressure and vacuum tanks, a receptacle, and controlling means for alternately connecting the vacuum and pressure tanks to the receptacle for filling and emptying the same, of a device for establishing communication between the receptacle and the atmosphere between the periods during which the receptacle is being filled and emptied.

5. In a well pumping apparatus, the combination with a substantially closed receptacle adapted to be arranged at the bottom of a well and provided with a valve controlled inlet, of pressure and vacuum tanks connected to the receptacle, a valve for alternately connecting the vacuum tank to the receptacle for filling the latter, and connecting the pressure tank thereto for discharging the contents thereof, and electro-pneumatically operated devices for effecting the operation of the valve to alternately connect the pressure and vacuum tanks to said receptacle, and a commutator for timing the operation of said devices.

6. In a well pumping apparatus, the combination with air supplying and exhausting means, and a line pipe connected thereto, of a receptacle having a valve controlled inlet, a three-way valve for alternately connecting the air exhausting means to the line pipe for filling the receptacle, and connecting the air supplying means to the receptacle for dis-

charging the contents thereof, and means for venting said receptacle to the atmosphere between the periods the air supplying and exhausting means are in communication with the receptacle.

7. In a well pumping apparatus, the combination with vacuum and pressure tanks, a line pipe, and a valve for controlling communication between the latter and the tanks, of a substantially closed receptacle adapted to be located in the bottom of a well and provided with a valve controlled inlet, the receptacle being connected to the line pipe, means for operating the said valve to alternately connect the vacuum and pressure tanks to the line pipe, and a valve controlled vent connected to the receptacle and operating to establish communication between the latter and the atmosphere between the periods during which the air is being admitted to or exhausted from the receptacle.

8. In a pumping apparatus of the character described, the combination with a receptacle adapted to receive the liquid to be pumped, a line pipe leading thereto, and air supplying and exhausting means adapted to be connected to the line pipe, of a valve for controlling the flow of air to and from the receptacle, electro-magnetic devices for controlling the operation of said valves, and a commutator in circuit with the electro-magnetic devices, for controlling the operation of the valve.

9. In a pumping apparatus of the class described, the combination with a receptacle adapted to receive and discharge the liquid to be pumped, and air supplying and exhausting means connected thereto, of a valve controlling communication between the air supplying and exhausting means and the receptacle, a fluid pressure motor for actuating the valve, electro-magnetic devices for controlling the operation of the said motor, and a commutator for controlling the action of the magnetic devices.

10. In a pumping apparatus of the character described, the combination with a receptacle adapted to receive and discharge liquid to be pumped, and air supplying and exhausting means connected to the receptacle, of a valve for controlling communication between the air supplying and exhausting means and the receptacle, a second valve for controlling the flow of air to and from the receptacle, means for venting the latter to the atmosphere while said second valve is closed fluid pressure motors for actuating the respective valves, electro-magnetic devices for controlling the respective motors, and a commutator for distributing the current to the respective electro-magnetic devices for timing the operations thereof.

11. In a pumping apparatus of the character described, the combination with a receptacle adapted to receive and discharge the liquid to be pumped, and air supplying and exhausting means connected thereto, of a three-way valve for controlling communication between the air supplying and exhausting means and the receptacle, a second valve for controlling the flow of air to and from the receptacle, means for venting the latter to the atmosphere while said second valve is closed electro-magnetically controlled motors for actuating the respective valves, and a commutator having the segments thereon connected to the respective motors for actuating the three-way valve to alternately connect the air supplying and exhausting means to the receptacle and for actuating the second mentioned valve to control the flow of air to and from the receptacle.

12. In a pumping apparatus of the character described, the combination with vacuum and pressure tanks, a line pipe connected thereto, and a receptacle adapted to receive and discharge the liquid to be pumped, of a valve for controlling communication between the vacuum and pressure tanks and the line pipe, a pair of branch pipes connected to the line pipe and leading to the receptacle, one of said branch pipes serving to vent said receptacle to the atmosphere valves connected to the branch pipes, and controlling means for actuating the valves for exhausting air from the receptacle to fill the latter with the liquid to be pumped and then subjecting the latter to a pressure to discharge the liquid therefrom and for venting the receptacle to the atmosphere between the periods the pressure and vacuum tanks are in communication with the receptacle.

13. In a pumping apparatus of the character described, the combination with a receptacle having a valve controlled inlet and a liquid discharge, an ejector extending into the receptacle for delivering air into the discharge, vacuum and pressure tanks connected to the receptacle, means for supplying air pressure to the receptacle independently of said ejector and means for controlling communication between the vacuum and pressure tanks and the receptacle through said air supplying and exhausting means independently of the ejector.

14. In a pumping apparatus of the character described, the combination with a receptacle having a valve controlled inlet and a discharge pipe leading therefrom, a pipe extending into the receptacle and having an upturned nozzle thereon for delivering air into the discharge pipe, and an air controlling pipe also entering the receptacle, of vacuum and pressure tanks connected to the receptacle, a three-way valve for controlling communication between the vacuum and pressure tanks and the receptacle, and regulating and cut off valves adjustable rela-

tively for controlling the passage of air through the nozzle and the air controlling pipe communicating with the receptacle.

15. In a pumping apparatus of the character described, the combination with a receptacle having a valve controlled inlet, and a discharge pipe leading therefrom, an ejector pipe extending into the receptacle and having a nozzle thereon directed into the discharge pipe, and an air controlling pipe also extending into the receptacle, of vacuum and pressure tanks, a line pipe connected to the latter, a valve for controlling communication between the tanks and the line pipe, a pair of branch pipes connected to the line pipe and to the ejector and air controlling pipes respectively, valves for controlling the flow of air through the branch pipes, a vent pipe communicating with the receptacle, and a valve in the vent pipe operable simultaneously with the valves of the branch pipes for establishing communication between the receptacle and the atmosphere when the valves and the branch pipes are closed.

16. In a pumping apparatus of the character described, the combination with a receptacle adapted to be located in the bottom of a well and having a valve controlled inlet and a discharge pipe, vacuum and pressure tanks and a line pipe connecting the latter to the receptacle, of a valve located at the well for controlling the flow of air to and from the receptacle through the line pipe, a pneumatic motor for actuating the said valve, a supplemental pressure tank for supplying fluid pressure to the motor, and a valve controlled pipe connecting the supplemental tank to the line pipe.

17. In a pumping apparatus of the character described, the combination with a receptacle having a valve controlled inlet and a discharge pipe leading therefrom, an ejector pipe extending into the receptacle and having a nozzle directed into the discharge pipe thereof, and an air controlling pipe also leading into the receptacle, of vacuum and pressure tanks for supplying and exhausting air relatively to the receptacle, a line pipe connected to the tanks, a pair of branch pipes connected to the line pipe and communicating respectively with the ejector and air controlling pipes of the receptacle, a vent pipe also connected to the air controlling pipe, and a set of valves connected to the branch pipes and vent pipe for closing the latter and opening a passage through the branch pipes and vice-versa.

18. In a well pumping apparatus, the combination with vacuum and pressure tanks, a plurality of receptacles for receiving and discharging the liquid from a plurality of wells, said receptacles being provided with means of communication with the vacuum and pressure tanks, valves for establishing communication alternately between the vacuum and pressure tanks and the several receptacles, and a controlling device common to and coöperating with said valves for independently timing the periods during which the respective receptacles are in communication with the vacuum and pressure tanks.

19. A pneumatic well pumping apparatus comprising an oil receptacle adapted to be closed to the atmosphere and located at the bottom of a well, coöperating axially tapered seats formed on the receptacle and casing respectively for supporting the receptacle and sealing the space between the latter and the casing, a valve controlled inlet for admitting oil to the receptacle, an oil discharge pipe extending through the top of said receptacle, a nozzle arranged within the receptacle for producing an aerated column of oil in the discharge pipe, and an air supply pipe opening within the receptacle and independent of the nozzle, said air supply pipe having a controlling valve for regulating the proportion of oil and air in the column ascending the discharge pipe.

20. A pneumatic well pumping apparatus comprising an oil receptacle adapted to be located at the bottom of a well and provided with means for sealing the passage through the casing to the entrance of air to the oil sand, a check valve in the bottom of said receptacle for admitting oil thereto and preventing its escape, an air controlling pipe entering the receptacle and adapted to be connected to exhausting means for creating a partial vacuum in the receptacle to draw the oil into the latter, an oil discharge leading from the receptacle, an ejector connected to receive a supply of compressed air independently of the controlling pipe for producing an aerated column of oil in the said discharge, means for alternately exhausting air from the receptacle through the said pipe to fill the receptacle with oil, and supplying compressed air to the receptacle through said pipe and ejector for discharging the oil from the receptacle in the form of an aerated column, and a check valve mounted adjacent to the bottom of said oil discharge for preventing back flow of fluid from the latter into the receptacle while air is being exhausted from the latter.

In testimony whereof I have hereunto set my hand in presence of two subscribing witnesses.

WILLIAM M. STEPHENSON.

Witnesses:
H. E. KARNES,
W. T. ROSE.