Oct. 7, 1930. | J. W. TAYLOR | 1,777,536

PUMPING APPARATUS

Original Filed Sept. 3, 1925 | 4 Sheets-Sheet 1

Fig. 1.

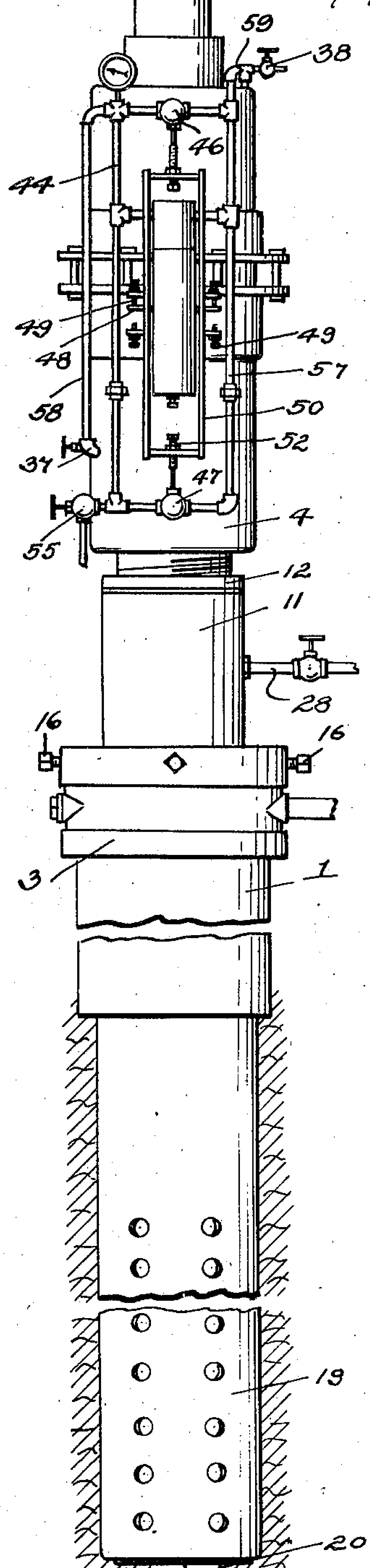
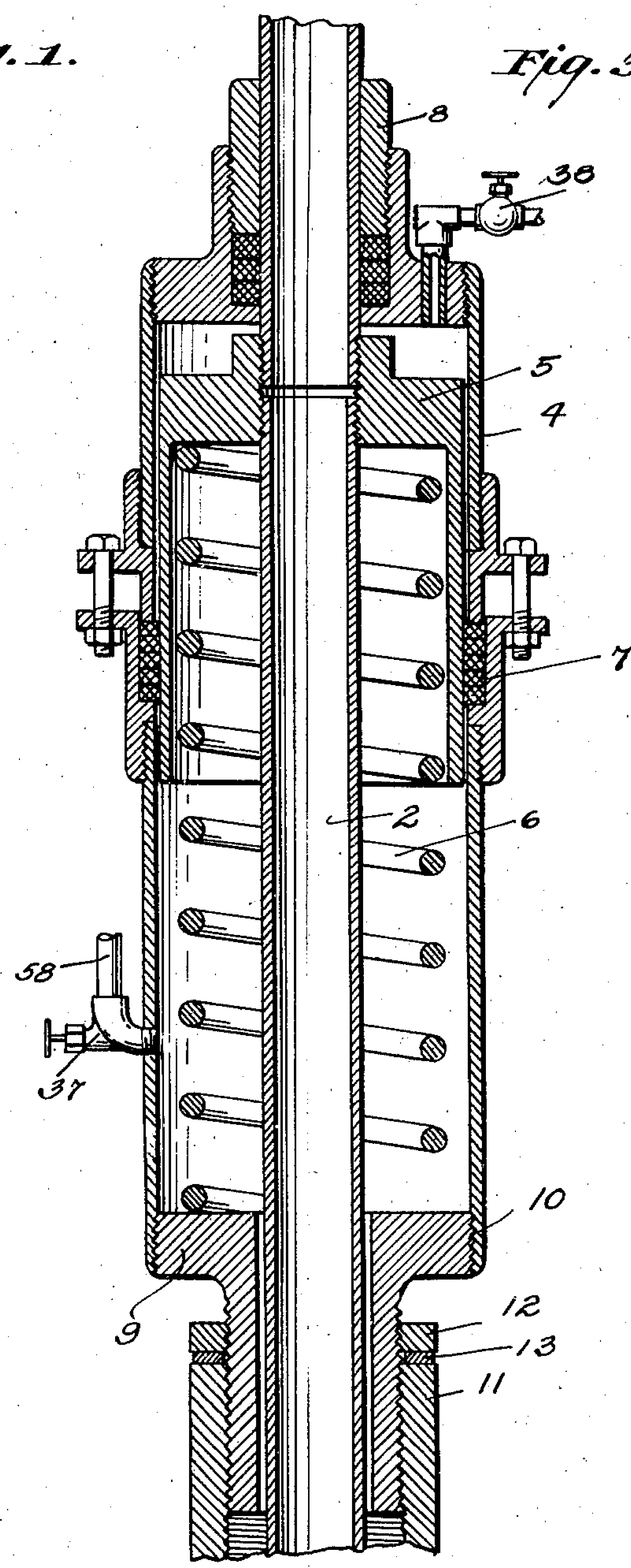


Fig. 3.



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PUMPING APPARATUS

Original Filed Sept. 3, 1925 4 Sheets-Sheet 2

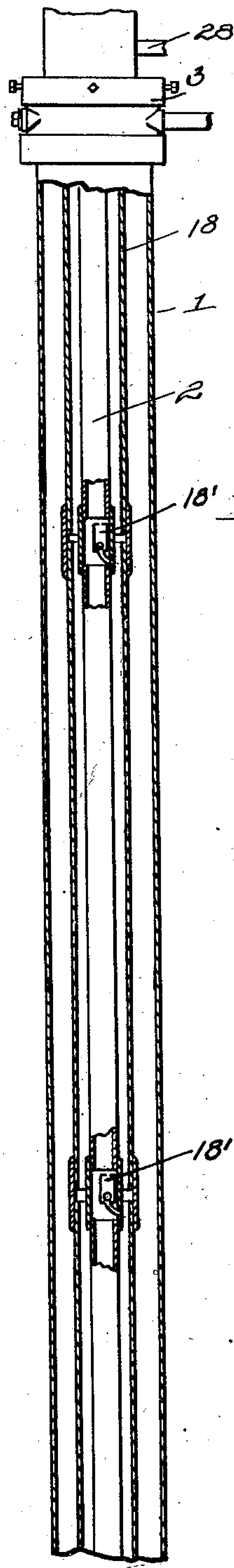

Fig. 2a.

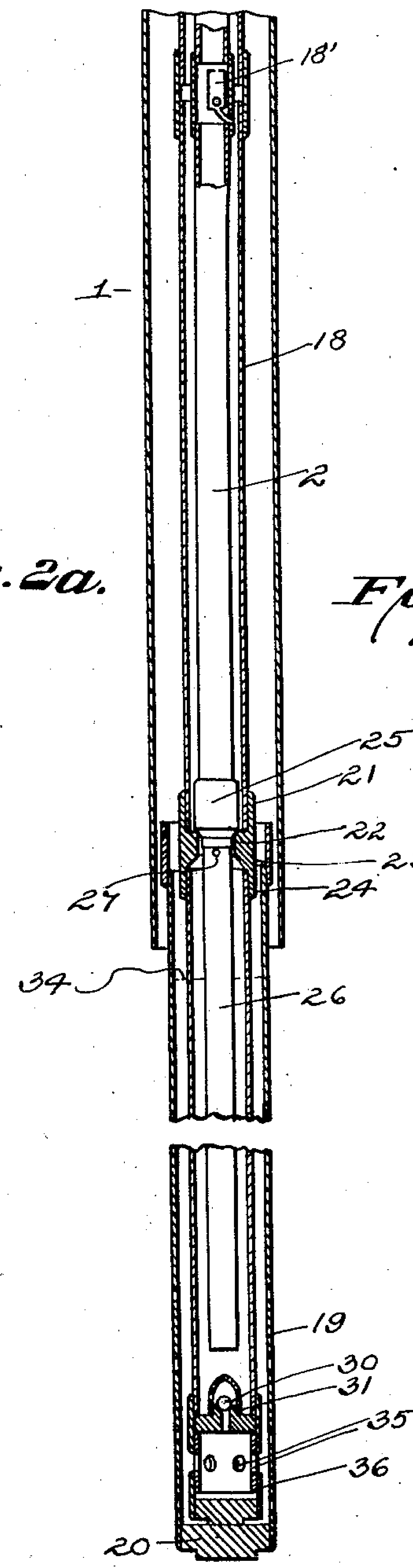

Fig. 2b.

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PUMPING APPARATUS

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Fig. 4.

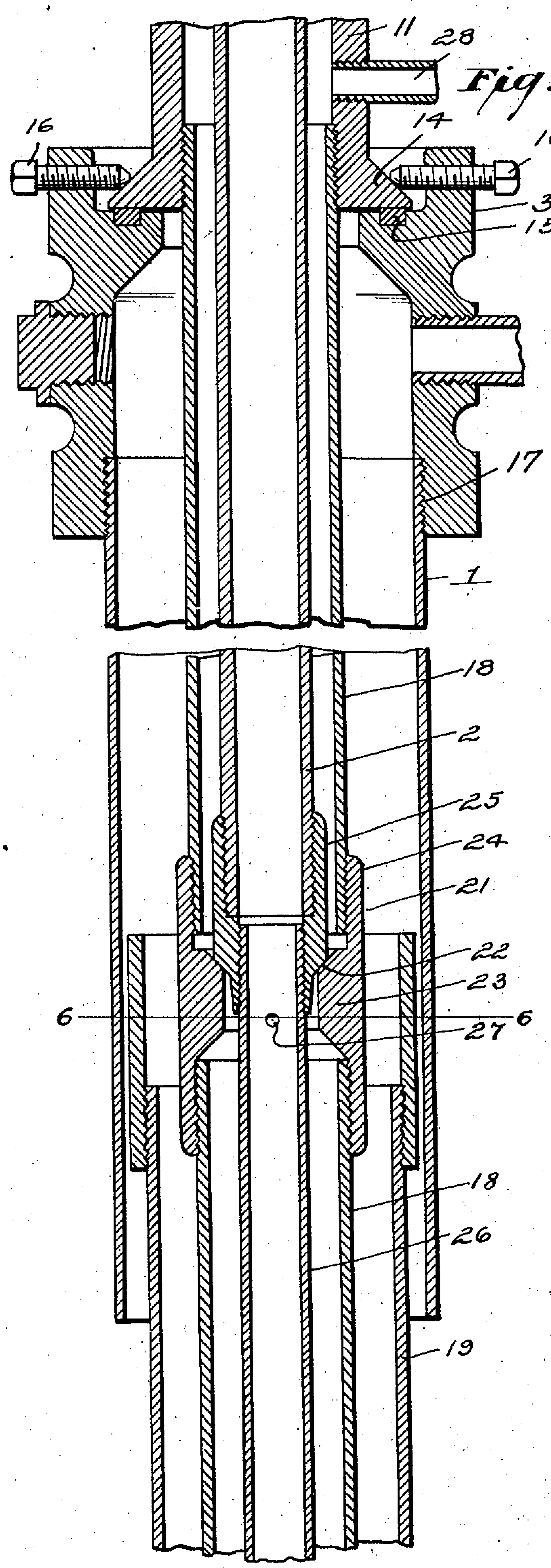


Fig. 5.

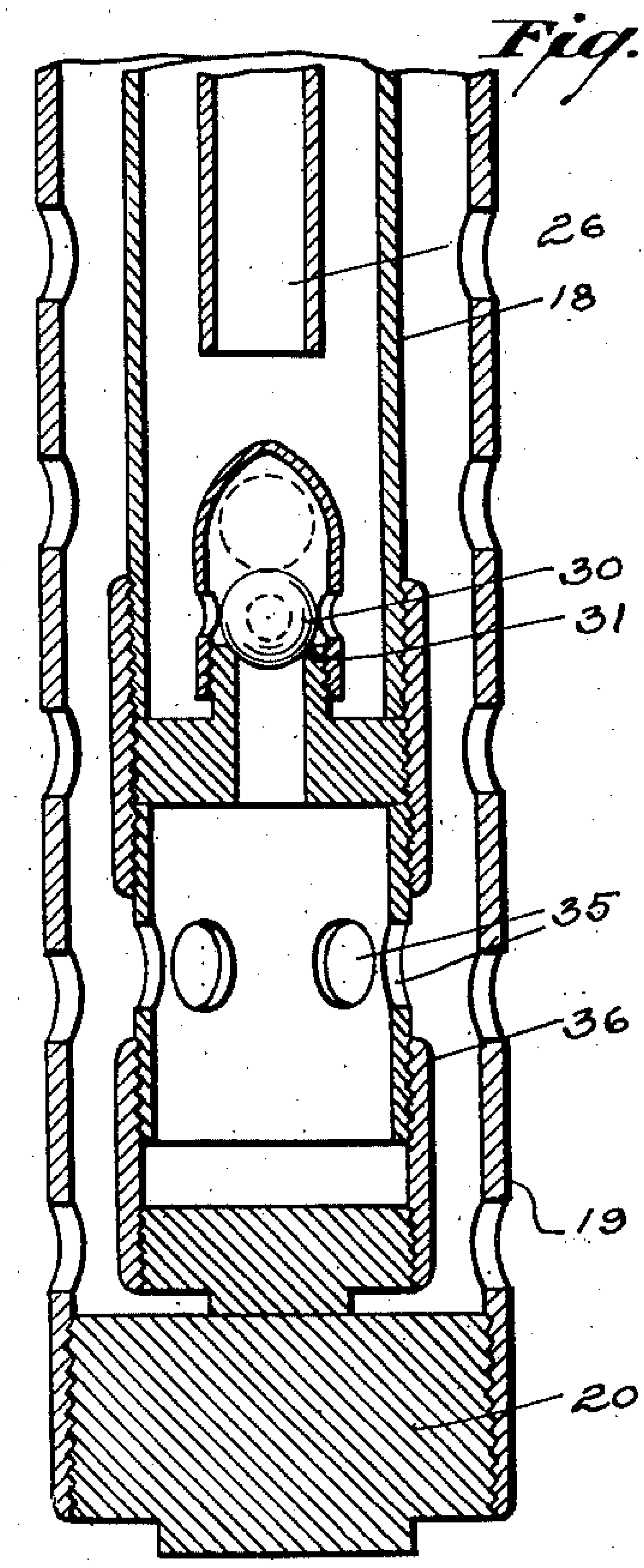
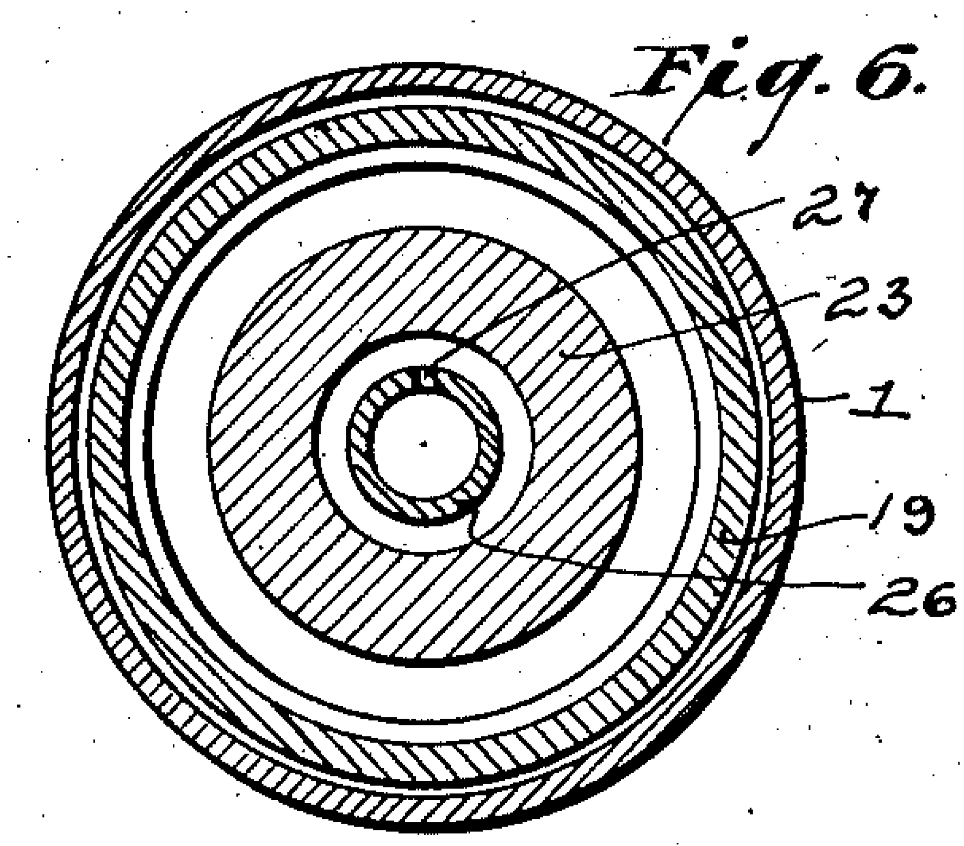


Fig. 6.



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PUMPING APPARATUS

Original Filed Sept. 3, 1925 4 Sheets-Sheet 4

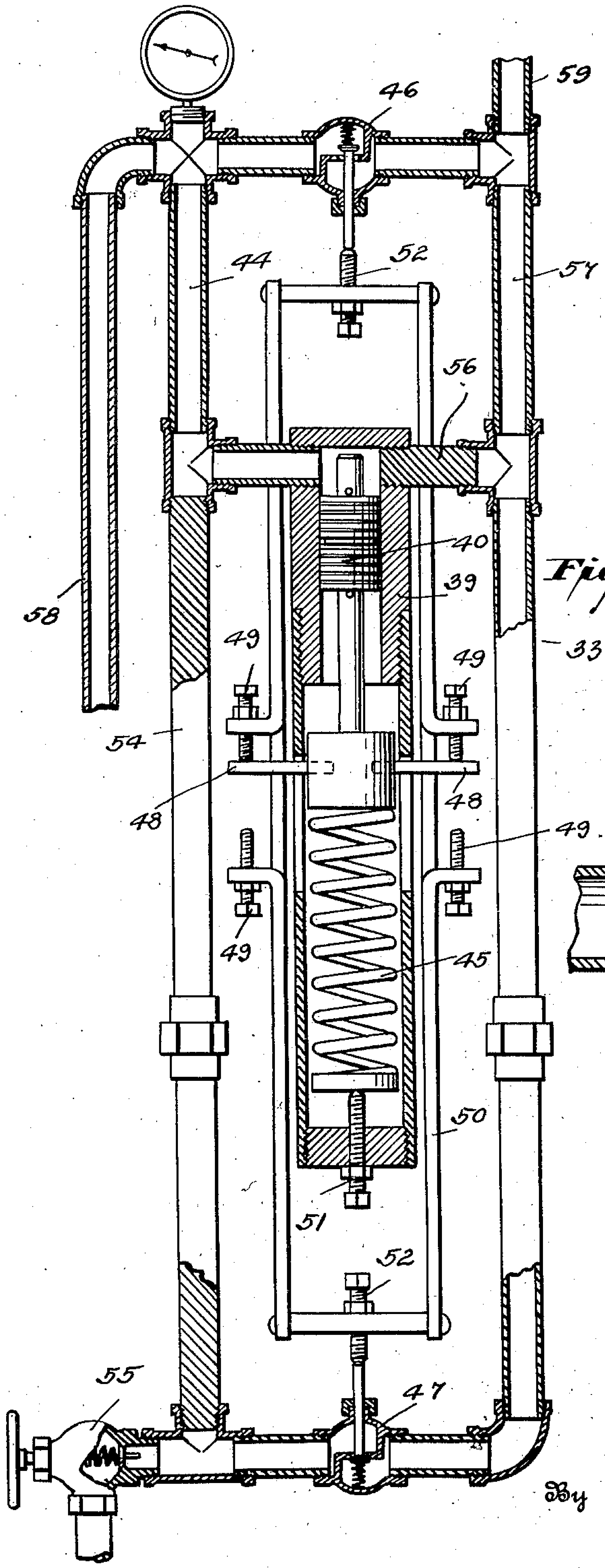

Fig. 7.

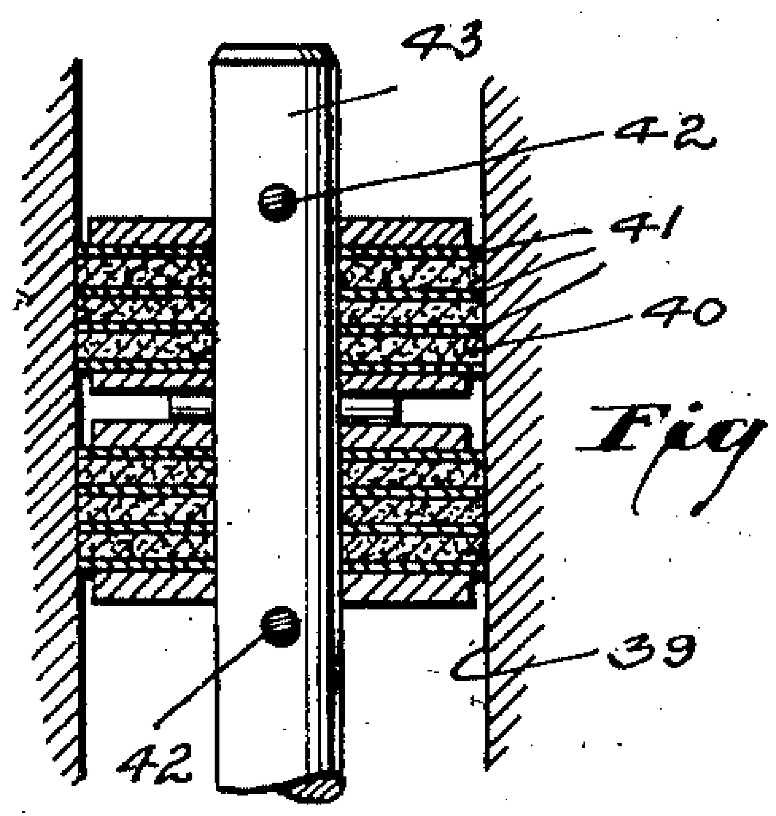

Fig. 8.

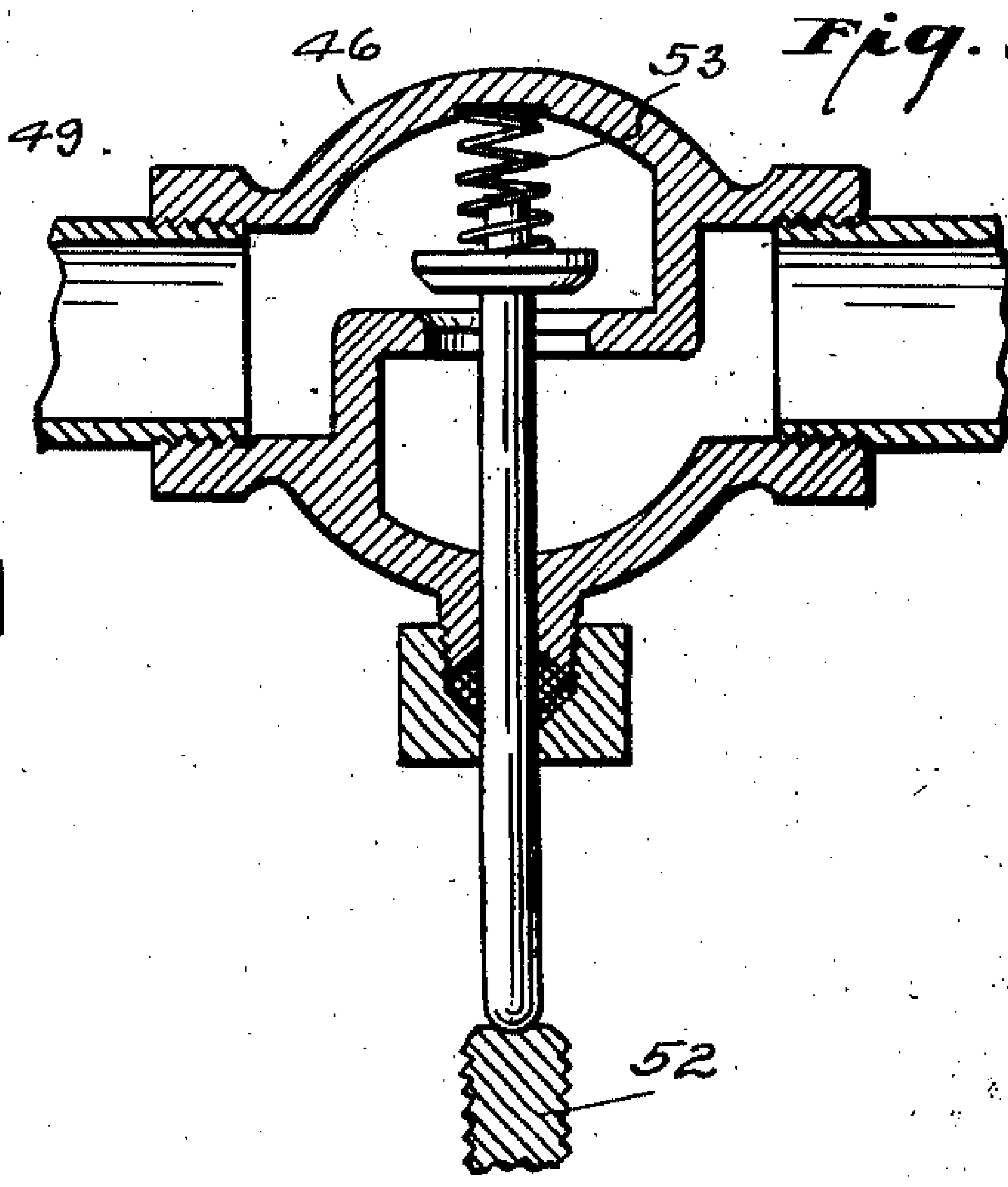

Fig. 9.

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Patented Oct. 7, 1930 1,777,536

UNITED STATES PATENT OFFICE

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PUMPING APPARATUS

Application filed September 3, 1925, Serial No. 54,382. Renewed December 24, 1928.

This invention relates to improvements in pumping apparatus and is especially directed to the art of lifting oil from subterranean wells by the employment of a gaseous motive fluid acting under pressure to lift the oil from the well.

The general object of the invention resides in the provision of apparatus for the purpose set forth, capable of operating automatically to control the lifting of the liquid from the well in accordance with the natural rise of the liquid in the bottom of the well; in admitting the gaseous expelling fluid into elevating cooperation with the liquid in the well in such a manner that sudden and premature expansion of the expelling fluid is prevented, the weight of the column of liquid to be lifted serving to arrest premature expansion of the expelling fluid so as to avoid the "cutting" or emulsifying of the liquid by subjecting the liquid to excessive gaseous pressures, and various other features of construction and operation hereinafter set forth in detail.

Heretofore it has been found impracticable to operate certain oil wells with gaseous pressure. The class of wells referred to is that wherein a small liquid output is obtainable, for if the amount of oil finding its way to the well from the producing sands is small, it is evident that the oil will remain at a low level in the well, thus making it difficult or impossible to secure what is termed flowing submergence, that is, sufficient oil or liquid above the point where the lifting gas pressure is being admitted to the tubing to prevent the flowing of the gas through the oil. Not only is the energy used in compressing the gas lost when attempts are made to operate this class of wells, but the violent agitation of the oil by the rapidly and primarily expanding gas cuts and emulsifies the oil to a degree where it has but little commercial value.

The present invention provides apparatus for overcoming this and other difficulties and makes it both practical and economical to operate any and all wells, the arrangement being such that if the well will produce sufficient liquid to maintain flowing submergence, then the apparatus may be set to operate continuously. Should, however, the sands become depleted of their oil, then the mere manipulation of a valve arrangement will adapt the apparatus to the intermittent or "heading" system of flowing the well, and this latter system may be continued until the well ceases producing.

With these and other objects in view, as will appear as the description proceeds, the invention consists in the novel features of construction, combinations of elements and arrangements of parts hereinafter to be fully described and pointed out in the appended claims.

In the accompanying drawing:

Figure 1 is a side elevation of the pumping apparatus comprising the invention,

Figure 2[a] is a vertical sectional view taken through a fragment of the apparatus,

Figure 2[b] is a vertical sectional view forming a continuation of Fig. 2[a],

Figure 3 is a vertical sectional view on an enlarged scale taken through the tubing controlling means,

Figure 4 is a similar view showing the tubing valve mechanism,

Figure 5 is an enlarged vertical sectional view taken through the lower part of the apparatus,

Figure 6 is a horizontal sectional view on the line 6—6 of Figure 4,

Figure 7 is a vertical sectional view of the governing valve mechanism for controlling the position of the well tubing,

Figure 8 is a detail sectional view of the piston used in said controlling valve mechanism, and

Figure 9 is a sectional view of one of the valve units of said mechanism.

Referring more particularly to the accompanying drawings, the numeral 1 represents a well casing which, as usual, is formed from aligned pipe sections of standard diameter and length, and arranged to extend from the ground surface of the well to or adjacent the oil producing strata. Within this casing there is disposed the usual flow line or tubing 2 which, also, is formed from pipe sections of suitable length and possesses a diameter materially less than the casing 1. The tubing is suspended, as will be hereinafter set forth, from the casing head 3 of the well and is adapted to possess a limited axial movement with respect to the casing. The upper end of the tubing is slidably positioned within a cylinder 4 carried by the casing head 3 and is threaded into secure engagement with a piston 5, the said piston being normally elevated within the cylinder by means of a strong coil spring 6, which acts to resiliently sustain the weight of the tubing so that the latter may be moved with facility in an axial direction. The exterior of the piston is smoothly matched and engages with a packing 7 provided in the walls of the cylinder 4. The tubing projects through and above the piston 5 and the upper portion thereof protrudes through a packing gland 8 provided in the upper end of said cylinder and leads to a suitable point of discharge. The bottom of the cylinder is provided with a head 9, which is threaded as at 10 to the upper end of a sleeve 11 carried by the casing head 3. The numeral 12 designates a nut which is threaded upon the head 9 and is adapted to frictionally engage with a packing washer 13, so as to prevent the escape of gas or air through the threaded union existing between the head 9 and the sleeve 11 when gas pressure is applied to the well.

The lower end of the sleeve 11 is annularly enlarged as at 14, and rests upon a packing ring 15 seated in an anular groove provided in the upper end of the casing head 3. Radially disposed screws 16 are carried by said casing head and are threaded in the walls thereof so that the inner ends of said screws may impinge upon the beveled circumference of the enlargement 14, so as to securely draw and hold the sleeve 11 in secured frictional engagement with the casing head. The casing head proper is threaded as at 17 upon the upper end of the casing 1 and ordinarily seals the upper end of said casing to prevent gas and liquid escape therefrom. Threaded into the lower end of the sleeve 11 is the upper end of a suitable length of air piping 18 which is of greater diameter than the tubing 2 but of smaller diameter than the casing 1. The air piping 18 is, however, stationarily arranged within the well in contrast to the vertical longitudinal movement obtained by the mounting of the tubing. The piping 18 which may be termed an "air line" is used to carry the air, or other expelling gas, to the bottom of the well, the annular space between the tubing 2 and the piping 18 being utilized for this purpose, and in this manner the air line is maintained independent of the casing. Nozzles 18′ are placed at intervals in the tubing and operate successively to carry off the liquid located therein.

The bottom of the casing may be provided with the usual perforated screen 19 in which is positioned the bottom plug 20 that rests ordinarily on the bottom of the well. This plug may also support the bottom of the piping 18, so as to relieve the threads 17.

Arranged within the tubing at any suitable position above the liquid level within the well is a valve structure 21. This structure comprises an annular conical seat 22 formed in connection with an inner annular enlargement 23 provided upon a coupling 24 that is threadedly maintained between lengths of the piping 18. The tubing 2 has threadedly secured therewith a valve member 25, which engages normally with the seat 22. The upper end of this valve member is interiorly threaded for association with the lower end of the upper length of the tubing 2, while the lower end of said valve member 25 is also interiorly threaded for connection with the upper end of the lower length 26 of the tubing. In this instance the upper length of the tubing is of greater diameter than the lower length. It will be observed that the lower end of the length 26 of said tubing terminates an appreciable distance above the plug 20 in the bottom of the well. A small orifice 27 is provided in the upper end of the tubing length 26, contiguous to the valve member 25, for the purpose of allowing the escape of any air or gas leakage between the valve member 25 and the seat 22, since if this relief were not provided, a small leak in the valve structure would be apt to build up a pressure in the air line below the valve structure that would prevent the oil entering that part of the line below the valve 21.

When the static head has been carried off the well through the tubing 2, the apparatus is regulated for uniform operation by limiting the amount of air or expelling gas which enters the air line at 28. Any suitable means may be associated with the entrance 28 so as to admit gas pressure into the air line at a uniform steady pressure, such apparatus having been illustrated in my co-pending application, Serial Number 15,755 filed March 16, 1925. Assuming that the well's production be 24 barrels per day and that the air line or reservoir between the valve structure 21 and the check valve 30, in the bottom of the air line, will hold one-half barrel of oil, it will be seen that the number of "heads" required to keep the oil out of this receptacle or reservoir will be forty-eight heads per day, or one head each one-half hour. Assuming, also, that the well is to head when the pressure in the air line has reached one hundred pounds, it will be seen that by feeding air, or other expelling gas, into the air line at 28 a gas pressure may be built up therein slowly and uniformly to one hundred pounds, and this may be regulated so that every thirty minutes the valve structure may be opened so as to apply gas pressure to the liquid in the reservoir, that is, in the air line below the valve structure, so as to force the liquid from said reservoir in a downward direction and causing corresponding elevation thereof in the tubing or flow line. When downward pressure is applied to the liquid in the reservoir, the check valve 30 automatically closes against its seat 31 and prevents the forcing of the liquid back into the space between the casing and the air line.

When the pressure has reached, for example, one hundred pounds in the air line, an automatic governor 33 will act to release the pressure from the upper side of the piston 5. Since the pressure will then be lower in the upper end of the cylinder 4 than in the lower end, the tubing will be raised by the piston moving upwardly, in response to the influence of the unbalanced fluid pressures and the spring 6, which results in opening the valve structure 21, allowing the inflow of gas into the reservoir in the bottom of the air line and the consequent expulsion of the liquid through the tubing. When the valve structure is opened, the air or gas which has been held at this point, will rush into the section of the air line below the valve structure and force the oil that has accumulated therein downwardly in the air line and upwardly in the tubing 19. While this action is taking place the check valve 30 in the bottom of the air line remains closed and prevents the air from escaping into the casing 1 while the oil is being forced from the well.

Since the air is being fed into the air line much slower than it is escaping from the line through the tubing, it will be seen that there is a rapid lowering of pressure in the air line. This brings about, as will be hereinafter explained, a reverse operation in the governor 33, and the tubing is lowered, closing the valve structure 21 and allowing pressure to again build up in the air line so as to repeat the cycle of operation.

The governor may be set to open the valve structure at any pressure desired by the operator and also set to close the valve structure when the pressure in the air line has dropped to any point desired. In other words if it is set to start a head at one hundred pounds pressure it may be set to close when the pressure has dropped to seventy-five pounds or less, depending entirely on the depth of the well and the frequency with which the well is heading.

While the well is heading, the oil from the sands will be free to enter the well through the screen 19 and mount in the casing as shown by the dotted line 34. As soon, however, as the valve structure 21 closes, and the pressure is removed from the reservoir in the air line below said valve structure, by the air escaping to the atmosphere through the tubing 2, the oil in the casing will lift the check valve 30 from its seat and again begin filling the reservoir in the air line.

As previously stated the weight of the tubing 2 is carried by the spring 6, and also, the closure of the valve 21 is secured by the tubing pressing the member 25 against the seat 22. It is not desirable, however, to place any more pressure against the seat 22 than is necessary to insure complete closure, and provision is made for this by the adjustment provided between the head 9 and the sleeve 11, which serves to provide an adjustable limiting means to control the vertical descent of the tubing. When the apparatus is initially installed in the well, the tubing will be of proper length to permit the valve member 25 to be spaced a short distance above the seat 22, with the spring 6 supporting the entire weight of the tubing. To secure proper closure and relation between the valve member 25 and the seat 21, the cylinder 4 is then rotated bodily about the axes of the threads 10, and the tubing thus lowered until the desired normal relation between the seat 22 and the valve member 25 is obtained and normally a complete closure of the valve structure is secured. The nut 12 is then clamped down upon the packing 13, the nut serving to lock the cylinder and the tubing in its adjusted position and the packing serving to prevent the escape of air or other gas through any looseness which may exist in the threads 10.

In the use of this apparatus, it is intended that the space between the air line and the well casing shall be utilized to trap the gas arising normally from the oil, since the oil will find its way into the reservoir through the perforations 35 provided in the coupling 36 at the lower end of the air line, but as these perforations or openings will be submerged at all times by the oil, the gas will not enter the reservoir but will be separated from the oil and trapped in the upper part of the casing. Thus it will be seen the casing is used both as a separator and gas trap, and it is contemplated that the gas will be drawn from the casing by the compressor and used in lieu of air in operating the well.

If the oil is entering the well fast enough to maintain submergence or steady flowing then, as will be hereinafter explained, by closing the valve 37 of the governor 33 and opening the valve 38 which is connected to the atmosphere, the air pressure will be relieved on the upper side of the cylinder and the valve structure 21 will remain open, since the tubing will be raised and remain raised, for the pressure is then permanently greater on the lower side than on the upper side of the piston 5, and a steady supply of air or gas will find its way into the bottom of the tubing to flow the well continuously.

Referring more particularly to the details of the automatic governor 33, which is employed to regulate the opening and closing of the valve structure 21, the same, as shown in Figures 7 to 9, consists of a cylinder 39, in which is positioned for sliding movement a plunger or piston 40. This piston consists, as shown in Figure 8, of steel washers 41 pinned as at 42 to a shaft 43, and between which washers is interposed a plurality of alternately arranged copper and leather washers which frictionally engage the walls of the cylinder 39 to prevent fluid passing around the piston. A gaseous lifting fluid, obtained from a compressor, tank or other source of supply (not shown) is introduced into the cylinder by way of the pipe line 44 and acts constantly upon the upper end of the piston.

The pressure thus exercised on the upper end of the piston 40 causes a spring 45 to be compressed, and this movement is transmitted to the spaced valves 46 and 47 by the studs 48 which strike the adjustable screws 49 rigidly fixed in the yoke shaped frame 50. A screw 51 is provided in the bottom of the cylinder 39 to place the required tension on the spring 45, and the screws 52, adjustably carried by the ends of the frame 50, permit of a fine adjustment of the device relative to the operating stems of the valves 46 and 47.

It will be seen that air supplied to cylinder 4 by pipe 28 is carried from the lower to the upper side of the cylinder 4 through the valve 37 by way of pipe 58, valve 46 and pipe 59. Pipe 58 also carries pressure through the line 44 into the cylinder 39. The arrangement of the valves 46 and 47 is such that one of the two valves will at all times be open by the positions of the frame 50, since when one opens the other is automatically closed by the action of the springs 53 therein which engage with the stems of the valves and normally tend to keep the latter closed, as shown in Figure 9. One of the supporting stanchions 54 for the cylinder 39, and which constitutes a continuation of the line 44, is closed to fluid passage and prevents the escape of the air or gas through the relief valve 55. Also, a support 56, opposite to the entry 44 of the pipe line into the cylinder 39 is closed to prevent the escape of air from the cylinder through the exhaust line 57.

Assuming it is desired that the well discharge a head of oil when the pressure in the air line 18 has reached substantially one hundred pounds, the tension on the spring 45 will be set by adjusting the screw beneath the same so as to offer one hundred pounds resistance to the plunger or piston 40. When the studs 48 come in contact with the screws 49 the frame 50 presses upon the stem of the valve 47, and this valve will be forced open and the valve 46 will close automatically for both the pressure in the line 44 and the action of the spring tend to close said valve. When the valve 46 closes, the pressure to the upper side of the cylinder 4 is shut off at this point and is released to the valve 47 by way of pipes 59 and 57. Upon the release of the pressure from the upper side of the piston 5, the latter will move upwardly and carry the tubing 2 with it. This action will lift the valve structure 21, unseating the same and allowing the air to enter the reservoir in the bottom of the air line 18 below the valve structure, so as to discharge the oil from the well in the manner previously described.

Since the air is being fed to the air line slower than it will escape through the tubing when the valve structure 21 is open, the pressure in the cylinder 39 will begin dropping as soon as the valve structure 21 is open, thus permitting the spring 45 to force the piston 40 upwardly, and this continues until the studs 48 engage the upper screws 49, which opens the valve 46 and allows the valve 47 to close. As this shifting of the valve takes place, the pressure on both sides of the piston 5 will again become equalized and the tubing will be lowered and the valve structure 21 again closed.

Since only a fraction of the weight of the tubing will be resting on the valve seat 22, it is evident that only a few pounds of pressure removed from the upper side of the cylinder 4, will be needed to assure the raising of the tubing to open the valve structure 21. This being true the relief or pop valve 55 is provided. If the well is being operated with one hundred pounds air pressure, and it is found that the release of ten pounds air pressure is sufficient to raise the tubing, then the relief valve will be set at ninety pounds. This prevents the waste of air or gas for it is evident that if the exhaust from the upper side of the cylinder 4 be left open, all of the air in this space would be exhausted upon every heading of the well, when a fractional part of the pressure released will bring about the desired result, and furthermore will prevent the unnecessary escape of air.

It will be seen from the foregoing that the frequency with which the well heads or flows will be determined entirely by the amount of air forced into the air line, since the faster the air is fed to the line the quicker the pressure is built up to the pressure at which the well is to head or flow. It will also be seen that the operation of this apparatus will be entirely automatic and will require no attention other than the air supply.

What is claimed is:

1. In oil well pumping apparatus, a casing, a flow line and an air line within said casing, said flow line being slidably mounted in said air line for axial movement, a valve member carried by said flow line and cooperative with a seat provided in connection with said air line for governing the passage of air from said air line into the flow line, a piston con-

nected with said flow line and operating in a chamber in communication with said air line so that the gas pressure within said air line will assist in supporting the weight of the flow line, whereby said valve member may be moved into and out of engagement with said seat in accordance with pressure fluctuations in the air line.

2. In oil well pumping apparatus, a casing, longitudinally extending, normally spaced air and flow lines arranged within said casing, said flow line being slidably mounted in said air line for axial movement, a cylinder provided upon the upper end of said casing and having one end thereof arranged in communication with said air line, said air line being extended through said cylinder, a spring in said cylinder and cooperative with said flow line to resiliently sustain the weight of the latter, and a valve mechanism operated by the rise and fall of said flow line to control fluid flow from said air line into said flow line.

3. In oil well pumping apparatus, a casing, flow and air lines extending into said casing, said flow line being slidably mounted in said air line for axial movement, means for introducing an expelling gas under pressure into said air line, a valve mechanism operated by the rise and fall of the flow line for controlling gas passage through said air line into expelling engagement with the liquid in the flow line, a stationary cylinder above said casing communicating interiorly with said air line, a piston connected with said flow line and arranged for sliding movement within said cylinder, and automatically operating valve means for admitting of the application of uneven gas pressures to the opposite sides of said piston so as to control the rise and fall of said flow line.

4. In well pumping apparatus, a casing, a vertically movable flow line within said casing, valve mechanism governed by the rise and fall of said flow line for admitting and expelling gas under pressure into the lower end of said flow line, means for controlling the rise and fall of said flow line consisting of a cylinder carried by the upper end of said casing, a piston in said cylinder connected with said flow line, means connecting one side of said cylinder with the source of gas supply, a pipe leading from one side of said cylinder to an air outlet, a valve in said pipe, a second pipe leading from the other side of said cylinder to said outlet, a second valve in said last named pipe, and means responsive to variations in gas pressure for opening and closing said last named valves so as to produce unbalanced pressures on the opposite sides of said piston.

In testimony whereof I affix my signature.

JAMES W. TAYLOR.