Jan. 6, 1953 J. D. NIXON 2,624,410

APPARATUS FOR SECONDARY RECOVERY IN OIL WELLS

Filed July 25, 1947 2 SHEETS--SHEET 1

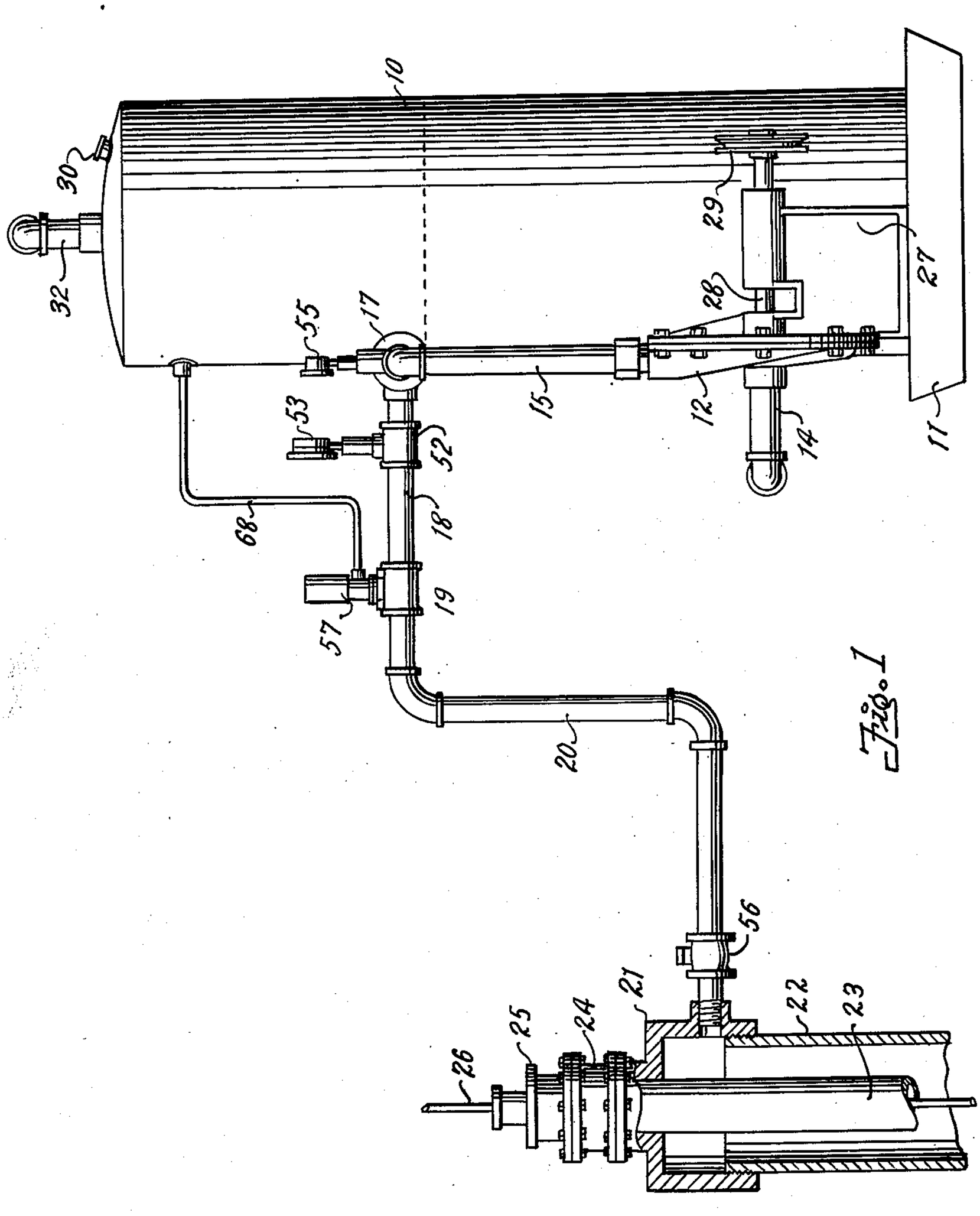

Fig. 1

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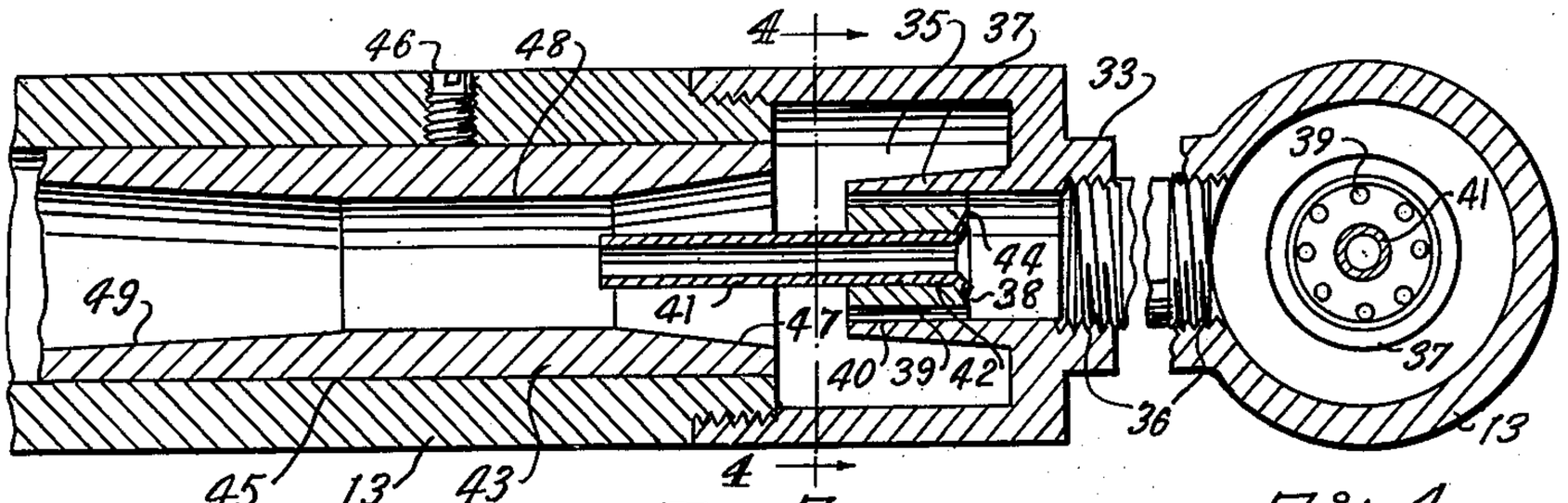

Fig. 3

Fig. 4

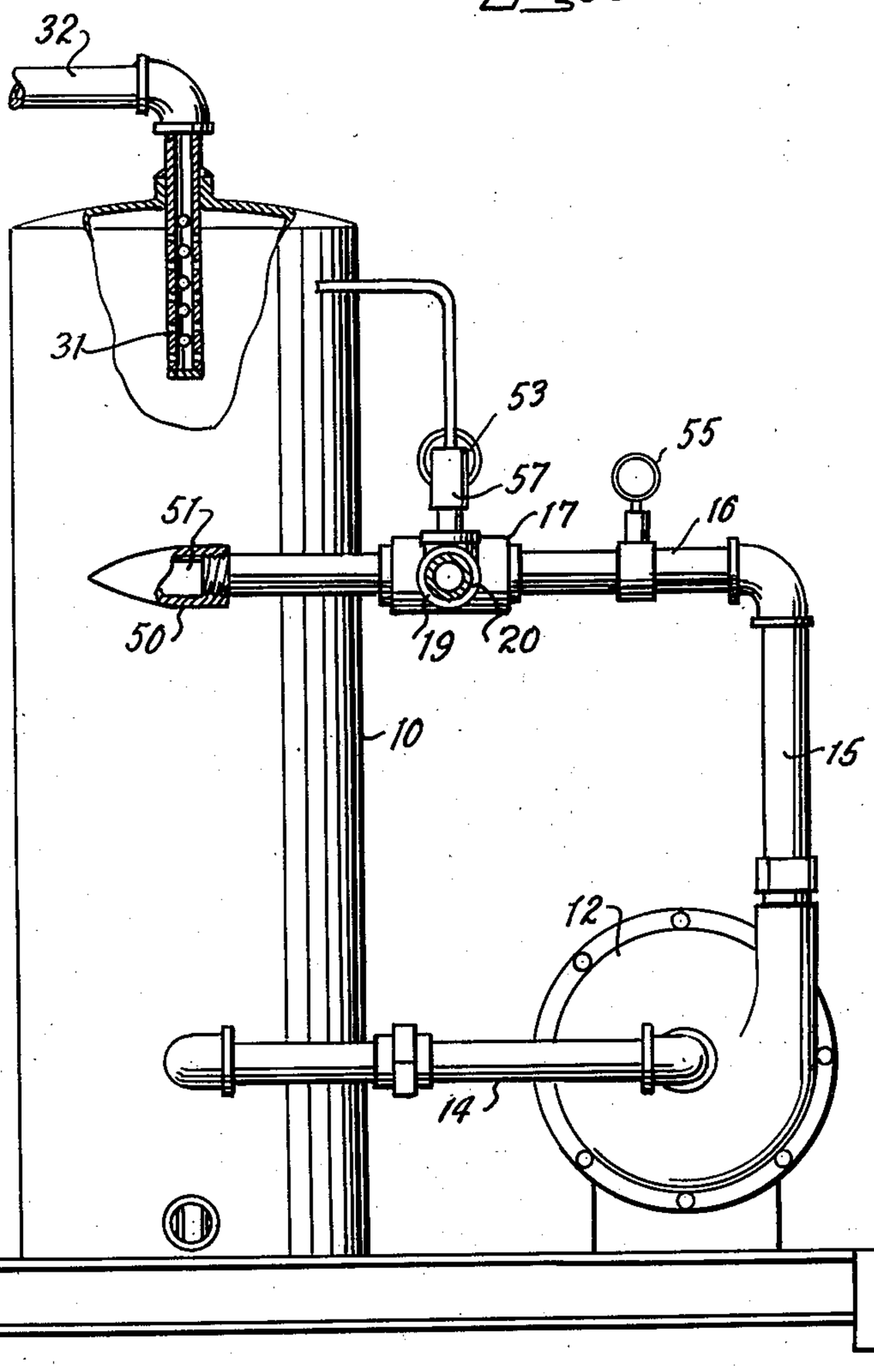

Fig. 2

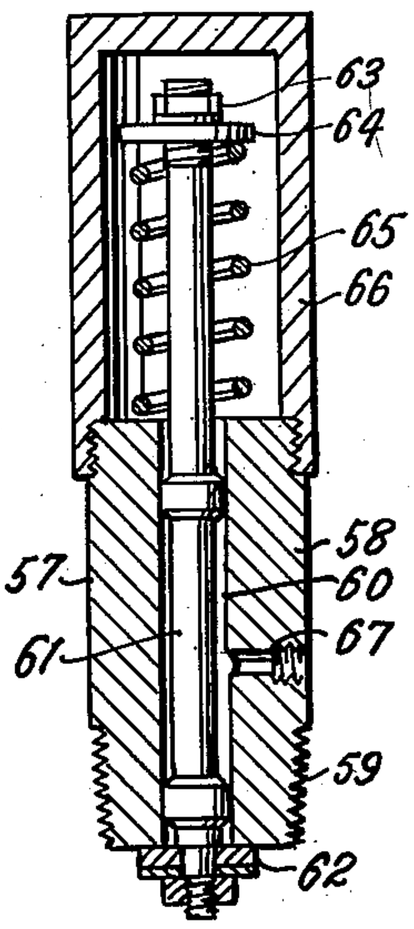

Fig. 5

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UNITED STATES PATENT OFFICE

2,624,410

APPARATUS FOR SECONDARY RECOVERY IN OIL WELLS

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7 Claims. (Cl. 166—2)

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This invention relates to new and useful improvements in apparatuses for secondary recovery in oil wells.

There are a certain class of oil wells known as "stripper" or "low production" wells. These wells are pumping wells and are usually relatively shallow and commonly less than a thousand feet deep, although many of these wells are deeper. Such wells under ordinary pumping conditions produce various quantities frequently under ten barrels a day and often, less than five barrels per day. Because of their low production, they must be economically operated and the maintenance costs must be low, otherwise they would not be profitable. These wells are usually pumped with a jack and motive power is available at many wells.

When the production of a well declines to 2 to 4 barrels of oil per day, it is not generally considered profitable to pump them. There are a number of oil fields and oil wells which have been abandoned because they could not be produced on a paying basis, although it is known that large quantities of residual oil remain in these formations.

It has been found that by pulling a vacuum on the producing formation, the oil production, per day, is increased. So far as I know the vacuum methods heretofore employed include a central plant equipped with expensive vacuum pumps and connected to a plurality of wells. Vacuum pumps create a vacuum by piston displacement, which produces a pulsating or vibratory suction on the formation and thus, the vacuum is not steady or stable. Such systems often cause caving of the formation, clogging or other troubles. These plants are expensive to purchase and install, operate and maintain and when the plant is shut down, production from all of the wells is stopped. Because of the distance from the wells, the plant being centrally located, the suction lines are long, are subject to leaks and the time required to build up a vacuum in a well frequently runs 24 hours. This leads to relatively high costs.

One object of the invention is to provide an improved system, whereby the production of oil from wells of the class described, which have declined in production, may be profitably increased, or which, may be utilized to rehabilitate depleted or abandoned wells or with wells redrilled in depleted or abandoned oil fields.

Another object of the invention is to provide an improved system of secondary recovery, whereby an individual well may be profitably

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produced in a simple, efficient and economical manner with an individual unit which may be purchased, installed, operated and maintained at a low cost.

A further object of the invention is to provide an improved system wherein the vacuum is created and maintained in the well by circulating a liquid stream, preferably water, under a relatively high velocity through means for setting up a suction at a point in the stream and utilizing the suction to pull the vacuum in the well, whereby gas or air in the well is sucked into the liquid stream, and then, reducing the velocity of the stream and separating the gas or air therefrom. The method is made more economical by recirculating the liquid stream.

A still further object of the invention is to provide an improved means of pulling a vacuum in an oil well, whereby a steady and stabilized suction is exerted on the formation which prevents caving, clogging and other troubles and assures more efficient production.

Another object of the invention is to provide an improved system of the character described wherein the vacuum pulled on an individual well may be controlled and regulated.

Still another object of the invention is to provide an improved unit, which may be one of a number of units for performing the method, and which includes a tank or receptacle for containing a body of liquid and having a circulating conductor connected thereto, with a pump and an injector connected therein, whereby the liquid is circulated under a relatively high velocity, the well fluid is sucked into the injector and a vacuum pulled in the well, and the well fluid is then separated from the liquid in the receptacle.

A still further object of the invention is to provide an improved unit of the character described including means for controlling and regulating the vacuum pulled on the well connected with the suction pipe from the well and a by-pass from said means to the receptacle, whereby the vacuum pulled on a particular well may be limited in accordance with the oil recovery and pumping conditions therein.

Still another object of the invention is to provide an improved injector having a passage therethrough opening into a suction and atomizing chamber intermediate its ends with a Venturi section beyond the chamber and atomizing ducts extending from the entrance end of the passage with a nozzle extending into the Venturi section, whereby the velocity of a liquid forced through the passage is accelerated and a suction is

created in the chamber and through the inlet thereto and the liquid is atomized in the chamber, which acts to more effectively pick up the injected fluid.

A construction designed to carry out the invention will be hereinafter described together with other features of the invention.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawings, wherein an example of the invention is shown, and wherein:

Fig. 1 is a schematic view showing a well installation made in accordance with the invention,

Fig. 2 is a side elevation of a unit constructed in accordance with the invention, partly in section to show the gas nozzle,

Fig. 3 is an enlarged, partial longitudinal sectional view of the injector,

Fig. 4 is a transverse, sectional view of the injector taken on the line 4—4 of Fig. 3, and

Fig. 5 is an enlarged, vertical sectional view of the vacuum valve.

In the drawings, the numeral 10 designates the tank of the vacuum unit mounted on a base skid 11. This unit includes a centrifugal pump 12, which is also mounted on the base skid. In general the intake of the pump is connected with the lower portion of the tank by a pipe 14; while the discharge of the pump is connected with the medial portion of said tank by an upright pipe 15 and a horizontal pipe 16. An injector 17 is connected in the medial portion of the pipe 16. A water level is maintained in the tank at or below the pipe 16.

A lateral suction pipe 18 is connected in one side of the injector 17 and has a tee 19 screwed onto its end. When the pump is in operation, water is drawn from the tank by way of the pipe 14 and discharged by the pump through the pipes 15 and 16 into the tank and thus a constant water circulation through the pipes is maintained. The water is discharged under a predetermined pressure and relatively high velocity and in passing through the injector head, creates a suction through the pipe 18.

The tee 19 is connected with a pipe line 20 leading to the casing head 21 on the upper end of the casing 22 of a pumping oil well. The well tubing 23, which is less in diameter than the casing so as to leave an annular space therebetween, is supported in a hanger 24 mounted on the casing head. The tubing carries the usual stuffing box 25, through which the polish rod 26 reciprocates. The well elements are shown in conventional form. The suction created through the pipe 18 is also established in the pipe 20, casing head 21 and the annular space of the casing 22. By this arrangement a vacuum is set up at the bottom of the well.

Usually more or less gas is present in the oil at the bottom of the well and the operation of the traveling valve in the working barrel (not shown) causes churning or agitation of the oil which results in foaming due to the presence of the gas. The pumping operation also causes the gas to build up in pockets, to expand and foam gas heads. The result is that pumping wells produce more or less gas with the oil and therefore, the volume of liquid or oil, per stroke, is reduced because of the presence of such gas.

By pulling a vacuum on a well and also upon the producing formation, as herein set forth, the free and released gas in the vicinity of the formation and the working barrel, is drawn up the annular space in the casing and discharged into the tank 10. This method greatly reduces the ratio of gas to oil in the tubing. Usually the pumping stroke is about 27 inches, but because of the vacuum method, not only may the stroke be shortened, but the oil-to-gas ratio of the eduction stream is greatly increased. As an illustration, where a well produced approximately 2.7 barrels of oil per day, the same well produced approximately 8.1 barrels of oil when pumped with the method herein described, without lowering the market value of the oil per barrel.

The pump 12 is mounted on a standard 27 which supports the impeller shaft 28. A belt pulley 29 is mounted on this shaft. Since a pumping engine or motor is frequently installed at the well, the pump 12 may be easily driven by the same. The tank 10 has a water filling cap 30 in its top. Gas drawn into the injector 17 will be discharged with the water by the pipe 16, into the tank. A gas outlet nozzle 31 is mounted in the top of the tank and connected with an exterior gas discharge pipe 32. The nozzle is of the perforated or screen type and prevents water globules being carried out with the gas.

The injector 17 is of considerable importance and while its structure may be varied, I have found the form illustrated in Figs. 3 and 4 to be most satisfactory. The injector includes a substantially horizontal cylindrical casing 13 having integral, internally screw-threaded collars 33 at its ends, which are axially alined. At its entrance end the injector has an annular atomizing chamber 35 which is provided at one side with a lateral screw-threaded opening 36, into which the pipe 18 is screwed.

The collar 33 is co-axially alined with a nipple 37 integral with the head and extending partially across the chamber 35. An atomizing head 38 is formed in the discharge end of the nipple and drilled to form annularly spaced cylindrical ducts 39 coincident with the cylindrical wall of the bore 40 of said nipple. A tubular nozzle 41 is snugly fitted in a reduced bore 42 in the head 38 and extends across the chamber 35 into a Venturi sleeve 43. The inner end of the nozzle is upset into a flared mouth 44 in the inner end of the head 38, the inner ends of the ducts 39 opening into said mouth.

The Venturi sleeve 43 is removable and has a snug fit in an elongate bore 45 in the casing 13, being fastened in place by a set screw 46. The sleeve is of particular construction having a converging mouth 47, through which the nozzle extends. A cylindrical bore or mixing chamber 48 extends into the sleeve from the inner reduced end of the mouth 47. From the discharge end of the bore, the sleeve is gradually flared outwardly to its discharge end, as indicated at 49.

The water discharged into the nipple 37, under pressure, and velocity is directed by the mouth 44 into the ducts 39 and nozzle 41. The water stream is thus divided into a relatively large or central stream by way of the nozzle 41, which stream, owing to the reduced size of the nozzle is discharged into the chamber 43, under a relatively high velocity. This stream coacting with the Venturi mouth creates a draft or suction in the head chamber 35.

While a portion of the water stream in the nipple 37 is discharged through the nozzle 41, another portion is ejected through the ducts 39 into the chamber 35, relatively circumferentially of said nozzle. These duct streams are

more or less atomized by the suction of the nozzle stream and upon entering the Venturi mouth 47 function to build up the suction in the chamber 35, acting through the opening 36 and pipe 18 to pull gas from the well casing, as well as to pick up the gas or air. A thorough mixing of the fluids takes place in the bore or chamber 43 and owing to the flare 49 of the sleeve, the velocity of the stream is reduced as it travels to the pipe 16 and into the tank.

The pipe 16 is screwed into a transition 50 on the side of the medial portion of the tank having its bore 51 at a tangent to the inner circumferential surface of the tank. The water-gas stream is thus discharged tangentially into the tank and travels a short distance on the inner surface, spreading and losing velocity. Owing to the relatively large area of the tank, the water and gas readily separate so that the water moves downwardly to the body of water in said tank and the gas rises and escapes through the nozzle 31 and pipe 32.

A tee 52 may be connected in the pipe 16 in advance of the injector 17 and a pressure gage 53, mounted therein and a tee 54 may be connected in the pipe 18 and a vacuum gage 55 connected thereto. A check valve 56 is connected in the pipe 20, adjacent the casing head 21, arranged to close and hold the vacuum in the well casing when the unit is shut down.

It is desirable in some installations to limit the amount of vacuum or suction pulled on the well and for this purpose a by-pass valve 57 is employed. This valve includes a cylindrical body or block 58 having screw-threads 59 at its bottom so that it may be screwed into the tee 19. The block has a vertical bore 60 therethrough for receiving a valve stem 61 of less diameter than said bore. The lower end of the stem is reduced and has a valve 62 secured thereon so as to seat against the bottom of the block which is exposed in the tee. The upper end of the stem is screw-threaded and receives nuts 63, bearing on top of a follower washer 64. A coil spring 65 is confined between the washer and the top of the block. A cap 66 enclosing the stem and spring is screwed onto the block.

A lateral port 67 leads from the bore 60 through one side of the block and this port is connected with the upper portion of the tank by a small by-pass pipe 68. When ever the suction in the pipe 18 and tee 19 reaches a predetermined value, it will overcome the expansive force of the spring 65, whereby gas will be drawn from the tank into the tee 19. By this means the vacuum on the well will be controlled. By adjusting the nuts 63 and varying the compression of the spring, the point at which the valve opens may be set.

These units have been installed on a number of wells and it has been found that satisfactory results are obtained by pulling from 12 to 20 inches of vacuum, according to the well conditions. Gas has been handled at as low as 2000 cubit feet, per day and as high as 20,000 cubit feet per day. By the use of a centrifugal pump, a constant and steady stream of water is forced through the injector and this results in a stabilized vacuum. Pump pressure varying from 25 to 40 lbs. per sq. in. have been used. The R. P. M. of the pump may vary from 800 R. P. M. to 3600 R. P. M., depending upon the amount of vacuum desired and the volume of gas an individual well is producing.

The figures and values given are merely examples and not limitations of the invention. It

has been found that, as an average, a unit will dissipate about 2 gallons of water a week and the capacity of the tank is such that checking and adding water every 10 days or twice a month, in hot weather and once or twice a month in colder weather, is amply sufficient.

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

1. A secondary well recovery unit including a tank having a body of liquid therein, a liquid circulating conductor having its ends connected to and communicating with the lower and medial portions of the tank above and below the liquid level in said tank, a pump connected in said conductor, and an injector connected in the upper portion of the conductor between the pump and the tank and having an inlet well connection.

2. A secondary well recovery unit as set forth in claim 1, wherein the tank has separating elements for separating gas from the liquid.

3. A secondary well recovery unit including, a tank having a body of liquid therein, a liquid circulating conductor having its ends connected to and communicating with the lower and medial portions of the tank above and below the liquid level in said tank, a pump connected in said conductor, an injector connected in the upper portion of the conductor between the pump and the tank and having a suction inlet, a pipe connected with the injector inlet, a vacuum control valve connected with the pipe, and a by-pass conductor extending from the valve to the tank above the liquid level therein.

4. A secondary well recovery unit including, an upright cylindrical tank having a body of liquid therein, a gas outlet at the top of the tank spaced above the liquid level in said tank, an inlet fixture on the side of the tank having a discharge conductor communicating with the tank above the liquid level therein, a circulating conductor having one end connected to the fixture and its other end connected to the lower portion of the tank for receiving liquid therefrom, a pump connected in the conductor, and an injector connected in the conductor between the pump and the fixture and having a lateral fluid inlet.

5. A secondary well recovery unit as set forth in claim 4, with a fluid inlet pipe connected to the inlet of the injector, a vacuum control valve connected to said pipe, and a by-pass line from the valve to the tank above the liquid level therein.

6. A system of secondary recovery in oil wells which includes, a pumping well which is cased and closed at its upper end by a casing head and having an oil production tubing packed off therein and extending down into the well, said casing head and casing being air tight to permit the pulling of a vacuum in said casing and through said head, a tank containing a body of liquid up to a level below its upper end, a tubular liquid circulating conductor connected to and communicating with the tank at upper and lower levels one of which is above and another of which is the liquid level and having a liquid circulator connected therein, an injector connected in the conductor for creating a liquid circulation from the lower portion of said tank to the upper portion thereof above the liquid level therein and a suction through said injector, and a tubular conductor for connecting the injector with the well casing outside the production tubing

for creating a vacuum in the well acting upon the producing formation thereof.

7. A system as set forth in claim 6, wherein a space is provided in the tank above the liquid level for separating gas from the liquid.

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