Oct. 19, 1943. D. HANES 2,332,144

PUMP OUT EQUALIZING VALVE

Filed Sept. 21, 1940

Fig. 1.

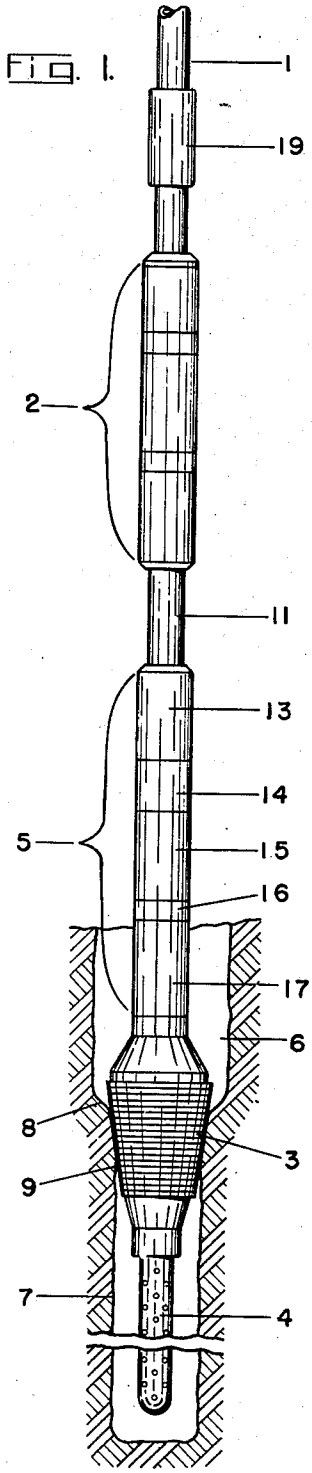



Fig. 2.

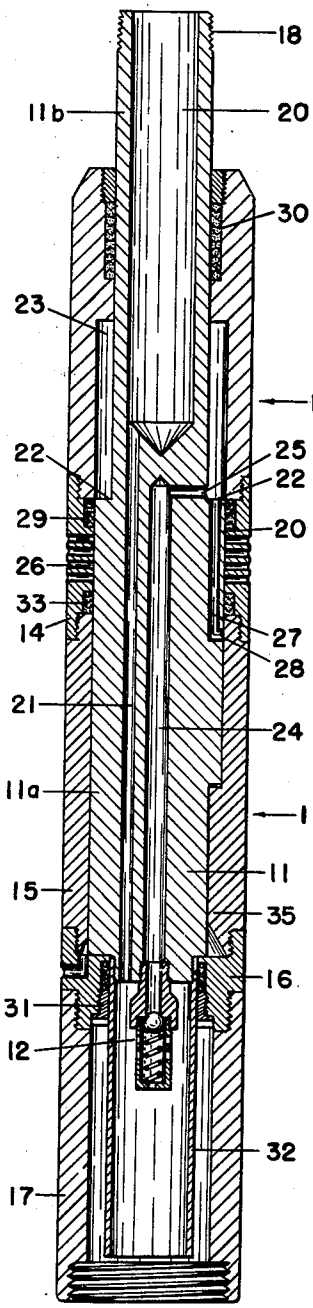
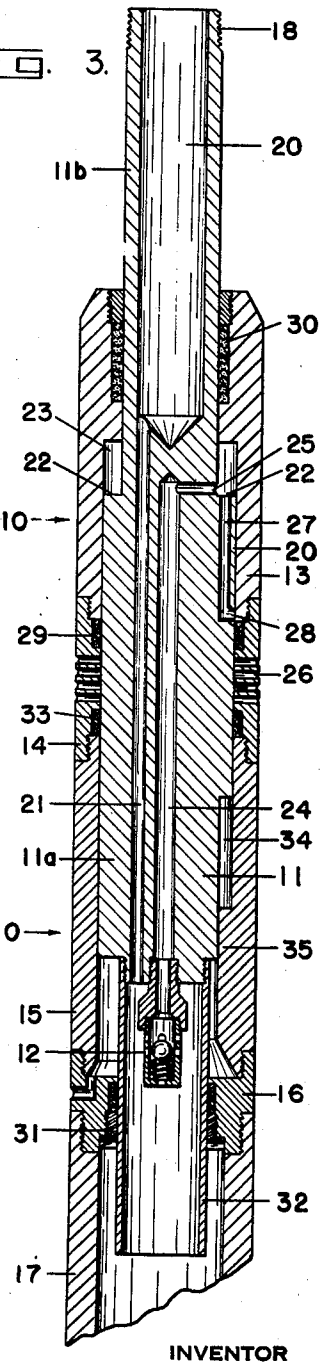



Fig. 3.




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## PUMP-OUT EQUALIZING VALVE

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Application September 21, 1940, Serial No. 357,793

1 Claim. (Cl. 166—1)

This invention relates to the testing of oil wells and more particularly to the releasing of tools which have become stuck in a well hole.

A formation tester is a device designed to be lowered on a string of drill pipe or tubing to the bottom of an oil well for the purpose of obtaining a fluid sample from an earth formation which is suspected of containing oil in commercial quantities. One form of tester is shown in the U. S. patent to Simmons, No. 1,930,987, granted October 17, 1933.

In operating a formation tester, it frequently happens that after the tester valve has been opened and the fluid sample has passed up into the drill string or tubing, the resultant downward force on the packer is so great that the packer cannot be lifted away from the rat hole without grave risk of breaking or at least damaging the supporting string. Heretofore, when such a condition has been encountered, it often has been necessary to open the tester valve and pump fluid down through the string in order to apply an upwardly acting force to the bottom of the packer of sufficient magnitude to overcome the excessive downwardly acting force exerted by the column of mud. Such an expedient, though effective to release the tool, results in loss of the sample.

It has previously been proposed, as in the patent to Ziegler, No. 2,201,281, for example, to provide a valved by-pass for the packer by means of which the fluid pressure above and below the same could be equalized after closing the tester valve. While such an expedient is of value, it is not always sufficient to bring about a release of the packer.

The primary object of the present invention is to provide means which will not only permit fluid to by-pass the packer and equalize the pressure, but which will also actually cause the fluid pressure beneath the packer to be greater than that above it, without loss of the sample.

It is a further object to provide means for exerting fluid pressure beneath a packer at the same time that tension is taken in the drill pipe or tubing tending to lift the packer.

It is still another object of the invention to provide means for multiplying the lifting force transmitted to a packer by hydraulic means whereby a mechanical advantage is obtained and the packer is more easily dislodged in the event it has become stuck in the well.

Other objects and advantages reside in certain novel features of the arrangement and construction of the apparatus as will be apparent from the following description, taken in connection with the accompanying drawing, in which:

Figure 1 is an elevational view of a conventional rat hole type formation tester modified by the addition of apparatus constructed in accordance with the present invention;

Figure 2 is a longitudinal sectional view of apparatus incorporated in the arrangement of Fig. 1 and constructed in accordance with the invention and showing the parts in one operative position;

Figure 3 is a longitudinal view of the apparatus of Figure 2, showing the parts in another operative position.

Referring to the drawing in detail, the formation tester illustrated in Figure 1 comprises a string of pipe 1 which extends upwardly to the derrick floor, a valve structure 2 like that of the Simmons patent referred to above, operative by the pipe, a conical or rat hole packer 3 and a perforated intake pipe 4. In addition, the structure of Figure 1 includes, as a novel component, a plunger type pump 5 interposed between the valve 2 and the packer 3 and illustrated in detail in Figures 2 and 3. In other words, the device 5 shown in side elevation in Figure 1 and in detailed cross-section in Figures 2 and 3 is incorporated in a test string like that of the Simmons patent mentioned above, between the tester valve and the packer. Reference numeral 6 identifies the main borehole which extends all the way to the ground level and reference numeral 7 identifies a rat hole.

The operation of a formation tester is well known to those skilled in the art and will not be described here.

As previously indicated, the problem with which this invention deals is that of enabling the operator to overcome the forces tending to prevent dislodgment of the packer after a sample of fluid has been taken from the formation, and to do so without loss of the sample. To that end, the pump 5 is employed for building up a pressure in the rat hole sufficient to overcome the hydrostatic head of mud on the packer and break the grip of the formation on the packer. The solution of the problem, according to the present invention, resides in so designing the pump 5 that mud or other well fluid is drawn into the pump and forced into the rat hole beneath the packer in response to an upward movement of the string of pipe.

It will be understood that with the exception of the high pressure pump shown in detail in Fig-

ures 2 and 3, all the component parts of Figure 1, including the valve 2, packer 3 and intake pipe 4 are old in the art, and, therefore, require no detailed illustration or explanation.

The high pressure pump structure, per se, includes a cylinder member identified as a whole by reference numeral 10; a plunger member identified as a whole by reference numeral 11 and a check valve identified as a whole by reference numeral 12. The cylinder member 10 is an articulated structure comprising parts 13, 14, 15, 16 and 17—the latter constituting merely a spacer or sub between the pump and upper end of the packer.

Plunger member 11 comprises an elongated cylindrical portion 11*a* of a diameter to fit slidably, as a piston, in the bore of the cylinder members 13, 14 and 15, and a tubular, cylindrical stem portion 11*b* which is integral with portion 11*a* and extends upwardly therefrom through the upper end of cylinder member 13—being packed off by the gland 30 in the upper end of cylinder member 13. Stem 11*b* functions as a piston rod as well as a supporting medium for all parts below and is threaded at 18 for engagement with the lower end of the valve structure 2 (see Fig. 1). The lower end of the plunger is threaded to engage a tubular sleeve member 32 which reciprocates with the plunger and functions, in conjunction with a gland 31, to prevent inflow of mud to the rat hole when the sample is being taken and also to enable pressure to be built up below the packer in excess of the pressure above the packer.

Cylinder member 14 is threaded at both ends and constitutes a sub for interconnecting members 13 and 15. The upper and lower end portions of member 14 are counterbored to receive packing rings 29 and 33, respectively, and the mid-portion of member 14 is provided with a large number of lateral openings 26 which serve as intake ports through which mud is taken into the pump.

The plunger and cylinder members, jointly, define an annular space 23 which is the pressure chamber of the pump into which mud is received through intake ports 26 upon the downstroke of the plunger and from which mud is discharged downwardly through a vertical passageway 24 upon the upstroke of the plunger. The discharge passageway 24 terminates at the lower end of the plunger in a ball check valve 12 which serves to permit the well fluid to flow downwardly but not upwardly.

At this point it should be clear that as the tubing string is lifted, mud from chamber 23 is forced into the string below valve 22 and thus added to the body of fluid which is acting upwardly on the packer and string and tending to dislodge the packer. And it will be evident that if the volume of fluid thus discharged from chamber 23 is greater than the corresponding negative displacement of the rising plunger, pressure will be added to the fluid in the rat hole during each rise of the plunger. Otherwise the rat hole pressure will drop, momentarily, to some extent during the rise of the plunger, but fluid will be added to that already in the rat hole and in the space within the string below valve 2 (which valve is closed).

Drilled downwardly from shoulder 22 of the plunger member and disposed along the peripheral edge of said plunger member are a plurality of holes 27. As many of these should be provided as may be needed to take care of the inflow, but only one is shown in Figures 2 and 3. The holes 27 extend down far enough so that when the plunger member 11 is in its downmost position as depicted in Figure 2 the lateral openings 28 which are drilled from the outside of the plunger member into the holes 27 will be situated below packing ring 33. This prevents inflow of mud to chamber 23 through the intake ports 26 via holes 27 and 28 when the plunger member is down and the fluid sample is being admitted to the tubing through valve 2. Otherwise the fluid sample would be contaminated with mud entering through the intake ports 26.

Upon lifting plunger member 11 a short distance above its lowermost position, the openings 28 will come into registration with intake port holes 26 and mud will thereupon be admitted to chamber 23. The pressure being very high the chamber will fill rapidly and will be completely filled by the time the openings 28 have moved above the intake port area. Packing ring 29 serves to isolate openings 28 from the intake ports 26 when said openings 28 are above said packing ring; and when such isolation has become effective during each upward stroke, the fluid in chamber 23 will be subjected to pressure which will cause it to be forced downwardly through discharge passageway 24 and check valve 12.

The plunger member having reached the upper limit of its stroke, the fluid content of chamber 23 will have been substantially exhausted into the space below check valve 12—which is in immediate communication with the rat hole—and if the increase of pressure thus induced does not suffice to dislodge the packer, the string is released and the plunger member allowed to settle down. The combined weight of the plunger, valve 2 and tubing string, minus the weight of the displaced well fluid, is therefore brought to bear upon the fluid in the rat hole and this weight, amounting to many thousands of pounds, being distributed over a relatively small cross-sectional area is capable of building up the rat hole pressure accordingly—provided the back-flow of fluid into the formation does not greatly off-set the increase of pressure in the rat hole which would otherwise occur. If the formation is quite porous and the formation pressure relatively low, the rat hole pressure will tend rapidly to diminish due to leakage into the formation; but by reciprocating the plunger with some little rapidity, fluid can be pumped into the rat hole at such a rapid rate as to build up the pressure before it can leak off through the formation.

Aperture 21 extending longitudinally through the plunger member is a part of the passageway through which fluid from the rat hole flows upwardly into the tubing string when the sample is being taken; and the bore 20 in stem 11*b* is a continuation of the same passageway. When the tester valve 2 is closed, no fluid flows through the passage 21, no matter how the plunger is manipulated.

To prevent the plunger from rotating relatively to the cylinder member when the string is rotated to operate valve 2, a slot 34 is cut in the plunger—which slot is engaged by a suitable spline 35.

In operating the device, the tubing string 1, with the several parts 2 to 5 inclusive attached to the lower end thereof, as shown in Figure 1, are lowered into the well. While suspended on the string and prior to striking bottom, the valve

2 is closed. Upon reaching bottom the intake pipe 4 enters the rat hole 7 and the conical packer 3 sets down on the shoulder of the rat hole as illustrated. The parts in the pump assembly will then be in the position shown in Figure 2. The weight of the plunger and string are thus brought to bear upon the packer, causing it to be forced into the rat hole, thus affecting a good seal between the main bore and the rat hole, which seal is effective to exclude additional mud from the rat hole and from the interior of the string. Valve 2 is then opened by manipulation of the string and the fluid in the rat hole will move up the string through valve 2—provided there is sufficient formation pressure to cause the fluid to rise. The fluid, if any, which rises above valve 2 is the sample which it is desired to recover and includes oil from the tested formation if there is oil present. When the sample has flowed up into the string, the string is manipulated to close valve 2 so as to entrap the sample in the string above said valve; and the string is then lifted to remove the tester from the hole and to recover the sample.

Usually the packer can be lifted out of the rat hole without applying a dangerous overload to the string even without the aid of pump 5; but often the packer is so tightly wedged in the rat hole and the fluid pressure above the packer so much greater than that in the rat hole, that the force necessary to dislodge the packer is greater than that which can safely be imposed upon the string. As the string is lifted the first time, the fluid pressure above and below the packer will be equalized by flow of liquid through ports 26, the passages 27, the chamber 23 and the passage 24. Assuming, however, that the packer is not immediately dislodged in response to an upward pull applied to the string, it will be apparent that, by additional spudding of the string, fluid will be forced down from chamber 23 through check valve 12 as the plunger rises. The superinduced pressure thus created may not in itself be enough to dislodge the packer, but whatever its magnitude may be, it is over and above that which would result from merely by-passing the mud from the main bore to the rat hole, and represents a corresponding reduction in the tension required to be taken in the string to dislodge the packer.

While only one embodiment of the invention has been shown and described herein, it is obvious that various changes may be made in the arrangement and construction of parts without departing from the spirit of the invention or the scope of the annexed claim.

I claim:

The combination with a formation tester comprising a packer and a tubular supporting string for said packer of a pump interposed between said packer and said string, said pump comprising a cylinder member and a plunger member, one of said members being connected to said packer and the other said member being connected to said string, said plunger member being reciprocable in said cylinder member and defining conjointly with said cylinder member a pressure chamber, a fluid discharge passageway extending from said pressure chamber through said packer to the underside of said packer, means defining a fluid intake passageway extending into said chamber for admitting fluid thereto, a check valve in said fluid discharge passageway operative to permit downward passage only of fluid, a second passageway through said plunger for admitting formation fluid to said string and a valve interposed between said pump and said string for controlling the admission of formation fluid to said string.

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