(No Model.)

# T. L. CROWLEY.

## TUBING, PACKING, AND OPERATING OIL WELLS.

No. 280,139. Patented June 26, 1883.

Fig. 1. Fig. 2.

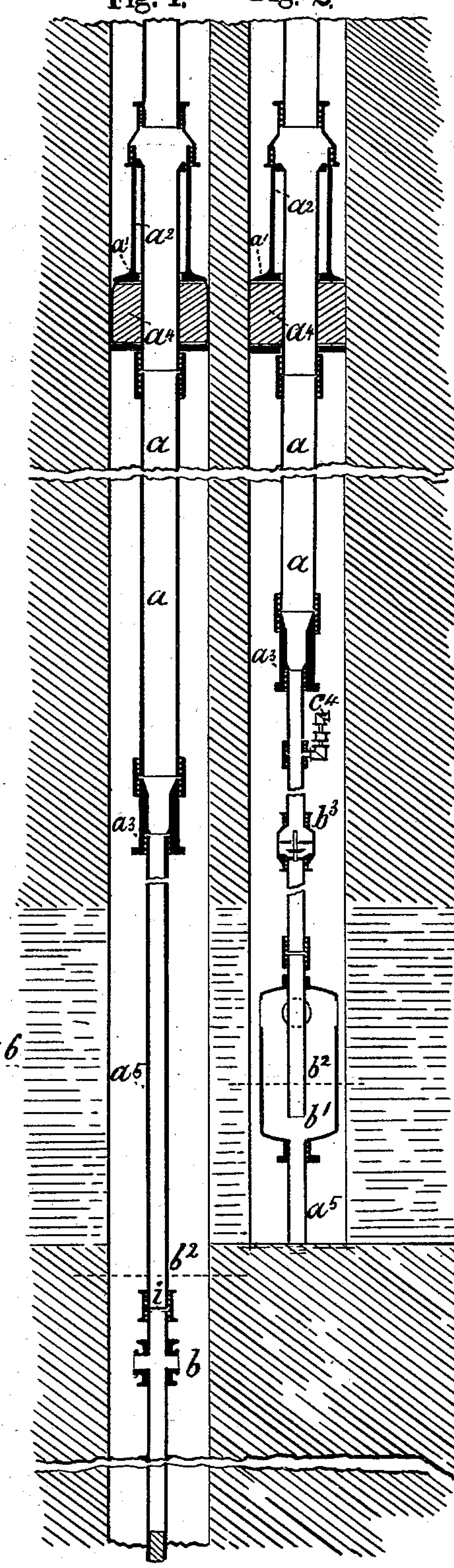
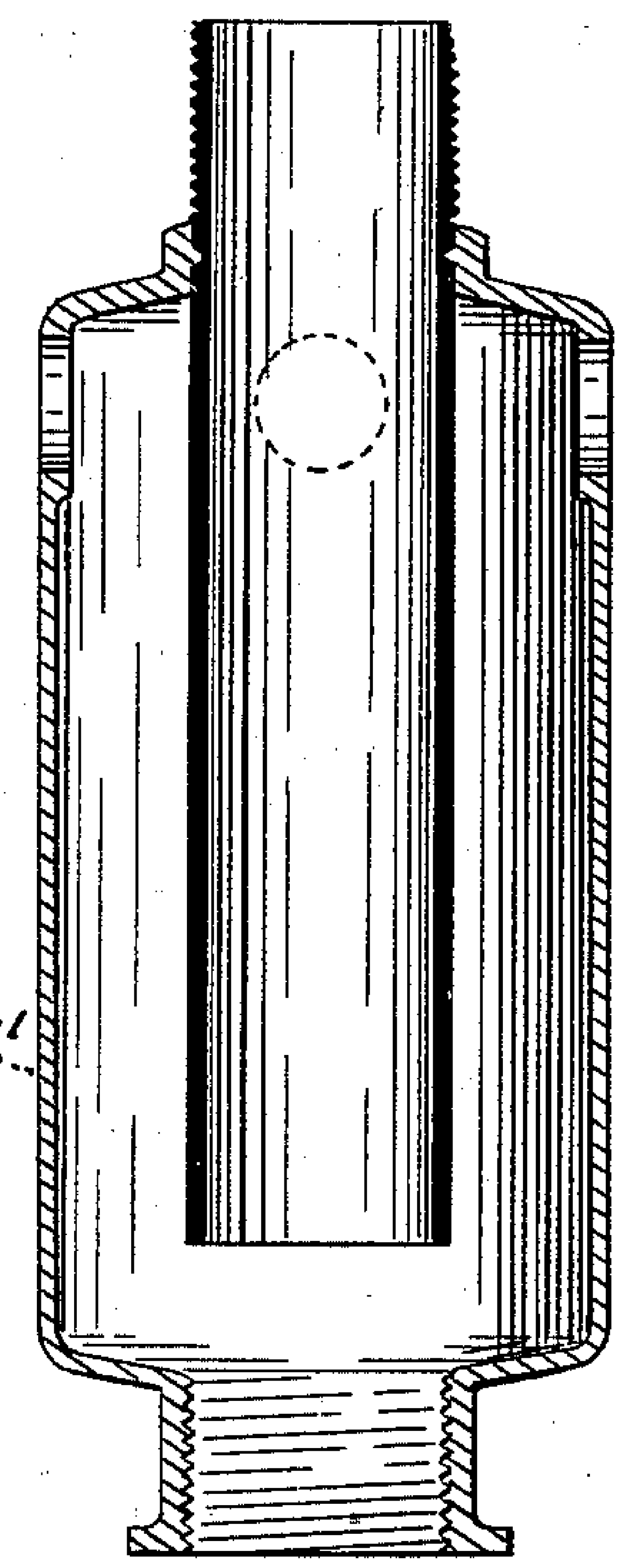



Fig. 3.




Fig, 4,

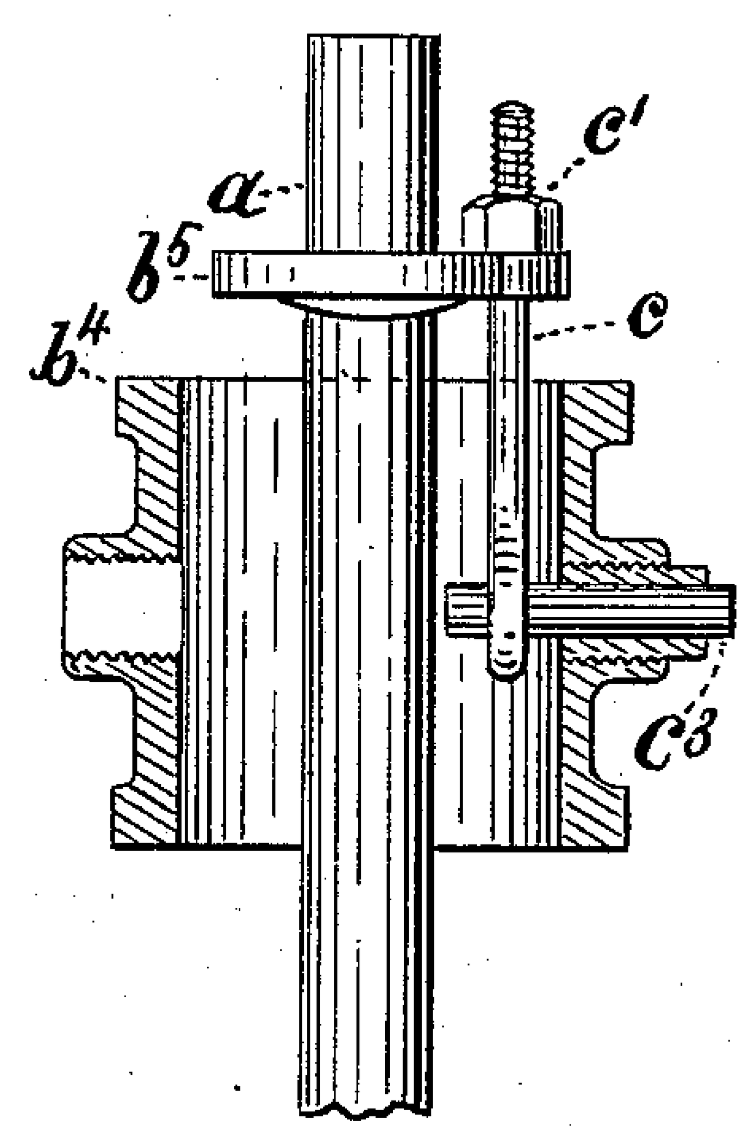
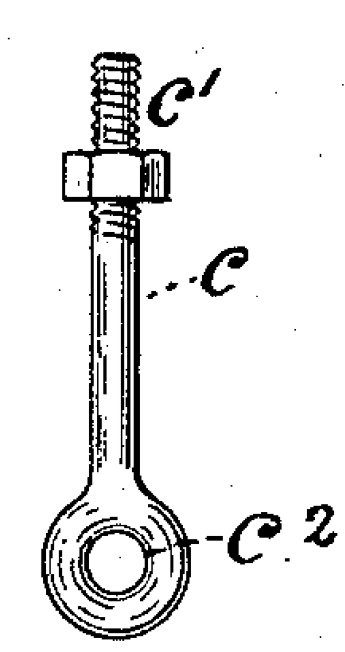



Fig. 5.




Fig, 6,

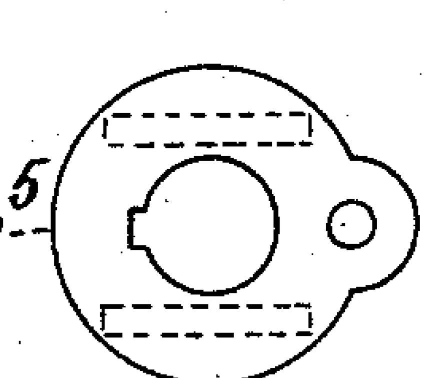
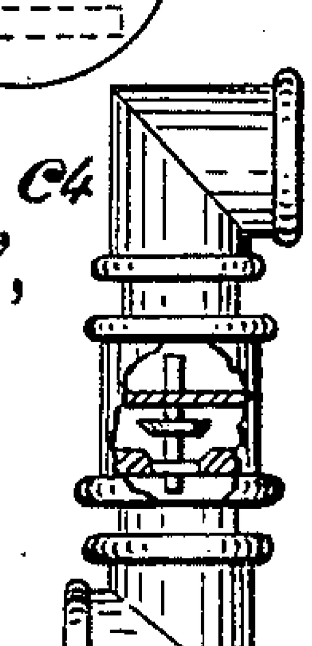



Fig. 7,

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# UNITED STATES PATENT OFFICE.

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## TUBING, PACKING, AND OPERATING OIL-WELLS.

SPECIFICATION forming part of Letters Patent No. 280,139, dated June 26, 1883.

Application filed March 10, 1883. (No model.)

*To all whom it may concern:*

Be it known that I, THOMAS L. CROWLEY, a citizen of the United States, residing in Rew, in the county of McKean and State of Pennsylvania, have invented certain new and useful Improvements in Tubing, Packing, and Operating Oil-Wells, of which the following is a specification.

The object of my invention is to provide the means for increasing the production of oil-wells by an economical application of the expansive force of the gas contained in said wells, all of which will be fully and clearly hereinafter shown by reference to the accompanying drawings, in which—

Figure 1 is vertical central section through an oil-well and my improved apparatus, showing the invention as adapted to a well which produces no water below the packer, and which is drilled below the oil-rock. Fig. 2 represents a similar view, showing the apparatus as adapted to oil-wells which produce water below the packer, and also to wells which are not drilled below the oil-rock. Fig. 3 is an enlarged vertical central section through the gas-trap. Fig. 4 is an enlarged vertical longitudinal section through the head of the casing, and a side elevation of the device for increasing the pressure on and more effectually expanding the packer when required. Fig. 5 is a detached side elevation of the connecting-link and nut forming a part of the device for expanding the packer. Fig. 6 is a face view of the supporting ring or flange which forms a part of the said packer tightening or expanding mechanism; and Fig. 7 is an enlarged side view of the small check-valve, partly in section.

The method heretofore employed for packing and tubing oil-wells is generally to put the packer down as close as possible to the oil-rock without getting into the fractured rock. The T or cross of the tubing or other inlet-opening is put on immediately below the packer, and another T or cross-opening is sometimes put on at or about the lower part of the oil-rock. A disk is generally put in above the packer, which disk is finally broken, and the well, if a small producer, sometimes does not flow until the expiration of twelve or thirty-six hours, or until the tubing gradually fills with foaming, boiling oil. This method is defective in several respects: First, there is little or no reservoir for the storage of gas between the flows or gushes, so that the gas is constantly bubbling up through the oil in the tubing and going to waste; second, there is always a high column of oil within the tubing, the pressure of which continually rests upon the oil-rock and against the oil and gas issuing or discharged therefrom, thereby presenting a great obstruction to such discharge, and sometimes stopping it entirely until the well is agitated.

The upper or large string of tubing, $a$, is connected together in the usual way.

$a'$ represents the packer, made in the ordinary manner, excepting its position is reversed for the purpose of making a tight joint. It is provided with a common telescope-joint, $a^2$, and operates in the usual way by expanding the rubber $a^4$, so as to tighten the joint between the walls of the well and the tubing.

At the bottom of the larger tubing, $a$, is a reducer, $a^3$, to which the smaller tubing, $a^5$, is connected. The reducer $a^3$ is arranged at a considerable distance above the bottom of the oil-rock $a^6$—say from one to two hundred feet. $b$ is the ordinary cross or inlet, which, being arranged below the oil-rock, constitutes a gas-trap, and solely, by reason of its position below the oil-rock, answers the same purposes as gas-trap $b'$.

In Fig. 2 the gas-trap $b'$ is adapted to be used only in wells which are not drilled below the oil-rock, because they are adapted to receive the oil and conduct it into the tubing at a point covered with oil below the issuing-point of the gas.

In Fig. 1 the sides of the well below the oil-rock produce the same effect as the outer sides of the trap $b'$, as it will be readily seen that as the level of the oil rises to the dotted lines $b^2$, or thereabout, in Figs. 1 and 2, the flow of gas into the tubing will be shut off by the oil. A well that produces water below the packer should be provided with a vertical check-valve, $b^3$. It should be in the string of smaller tubing, and located, say, from sixty to eighty feet below the bottom of the larger tubing; but the location of this check depends to some extent upon the proportion of gas in comparison to the amount of oil and water to be thrown out, and also upon the depth of the well; but it should be located far enough below the top of the smaller tubing to allow all the drip and spray from the large tubing to run back into the small tubing, where it is supported on the said check-valve. From this arrangement, as the well operates by intermittent flows, it will be seen that the water remaining in the tubing, being the heaviest, will sink toward the bottom and be caught and held by the check-valve, and, the next time the well flows, the rapidly-moving upward current of oil mixes with and carries up the water with it, the motion of the oil being so rapid that the water is carried up faster than it can settle down through it, so that it is thrown out with the oil.

In my process some flowing wells can be flooded with great advantage, sometimes the production being doubled. In this case I employ a very small vertical check-valve, $c^4$. (Shown in Fig. 2, and also in the enlarged view, Fig. 7.) It should be about three-eighths of an inch in diameter of opening, and should be located above the other check-valve, $b^3$, at or near the top and outside of the smaller tubing, and should open upward and outward, as shown, so that the liquid or gas, &c., can pass out of the tubing into the well, but not back into the tubing. This check $c^4$ is required only in wells where the large check $b^3$ is used. When a well is thus flooded, the oil or other liquid run into the tubing will pass out through the small check-valve $c^4$ into the well, and also, when the well is blown out by an air or gas blast, it will pass into the well through this check, as it cannot pass down through the large check $b^3$. In starting the well after being flooded, it will be necessary to drop the ordinary standing valve into the socket or the reducer $a^3$, and then fit the well with the usual pumping apparatus; but the working-valve in this case should be made to fit and work in the tubing. It would be well to use a smooth piece of tubing for the lower joint in which the working-valve operates. After the well is thoroughly pumped out and flows, the valves and rods are all removed or drawn out.

The casing used is the well-known casing made in the ordinary way, and requires no description here.

$b^4$ represents the casing-head. (See Fig. 4.)

To the tubing $a$ is firmly secured a ring or supporting-piece, $b^5$, by a key, or in any other well-known way. Through this ring is passed a link, $c$, provided with a screw and nut, $c'$. In the opposite end of the link or eyebolt $c$ is an eye, $c^2$.

$c^3$ is a pin rigidly fastened in any suitable way to the casing-head, which pin or piece of pipe passes into the eye $c^2$ of the link. It will now be seen that by screwing up on the nut $c'$ the tendency is to lift the casing (which in some cases weighs a ton or more) and to force the tubing down, thereby affording the means for compressing and expanding the packer at will. This construction is necessarily connected with my invention, as it requires that the packer should form a perfectly-tight joint between the pipe or tubing and the wall of the well, as I use a much larger portion of the tubing below the packer than has heretofore been done. Any other suitable packer than the one I have described can be used; but it should be one that would produce a perfectly-tight joint for deep as well as shallow wells, especially when used for pumping through.

The altitude of the packer is one of the most particular points in my process of packing, tubing, and operating an oil-well, and the proper altitude depends upon a good many conditions—the depth of the well, the amount of gas in proportion to the amount of oil the well produces, the size of the tubing, &c. A well having an unusually large flow of gas in proportion to its oil production should be packed much higher, and consequently have a larger gas-chamber, than a well having a smaller flow of gas in comparison with its oil production. For instance, a well having double the amount of gas compared with the average amount of oil should be packed about twice as high as the average well packed by my method of packing. The size of the gas-chamber should be about sufficient to hold all the gas production of the well below the packer while a sufficient head of oil is being produced and stored in the tubing to confine this gas by its liquid-pressure until the expansive force of this gas has elevated the head of oil from the bottom of the well to the top while flowing. Other things being equal, when there is an average amount of gas in proportion to the amount of oil, and the wells are of an average depth—for instance, fourteen to sixteen hundred feet—and two-inch tubing is used for the top and one and one-half inch for the bottom, I limit the length of the gas-chamber to about or nearly one-third the depth of the well. Tubing of half the capacity above mentioned will of course require about one-half the capacity of gas-chamber; but other things being equal in regard to the conditions mentioned, a well two thousand feet deep should not generally be packed near twice as high as a well one thousand feet deep, as the pressure in the oil-rock will not permit of it. Still there are some wells which have gas enough to be packed at the casing-head, and there are some wells having a very small flow of gas, in which the gas-chamber should be from one-fourth to one-fifth the length of the well. If the packer is too high, the pressure of the gas will not increase as fast as the pressure of oil, and consequently the well cannot flow until the packer is lowered to its proper position. If the packer is too low, the gas-chamber will not hold enough gas to give sufficient expansive force to cause the well to flow or carry the head of oil up to the top of the well, and the gas-chamber will fill so quickly that enough of oil cannot accumulate in time to confine it while ascending the tubing, so that the gas will pass through the head of oil and throw out but little or no oil.

Wells operated by my method should be shut in and blown out in the usual way when required. Some few wells of this construction, for various reasons, are inclined to continue to throw out gas too long after being shut in and blown out, which sometimes stops the well from flowing. In this case, in about ten or twenty minutes after the well has quit flowing and spraying, the gas should be shut in and left so from five to ten minutes, and then allowed to escape. Another advantage in my process is when a well fills up with sand and other sediment to the inlet, and partly clogs the same, a high pressure of air (or gas where air is injurious to the oil-rock) may be forced down the tubing into the gas-chamber by any suitable air-pump. The oil will thus be forced onto the outside of the tubing by said air or gas pressure, and when the pressure in the gas-chamber has reached the required high tension the tubing should be opened at the top of the well and the contents allowed to escape suddenly. This should be done when there is a head of oil in the well, or some should be run in. When the tubing is thus opened at the top, the oil is forced violently into and up the tubing, and carries up with it the sand and other sediment out of the well, thereby leaving it in proper condition to flow again. When a well stops flowing for any reason, it may be started in the above manner, instead of agitating, as usual. Naphtha, gasoline, or other similar liquid may be run into the tubing and forced back into the oil-rock, by the above-mentioned air or gas pressure, by increasing the pressure to a sufficiently high point and allowing it to remain long enough to force the liquid into the pores of the rock, and then let it escape suddenly, as above mentioned. In this way the pores in the rock are sometimes cleared out, and the production of the well is considerably increased. I have found in my experience that the difference in the capacity of the tubing used should be from about one-half to four-tenths—that is, the large tubing $a$ should be about two inches (more or less) in diameter, and the tubing $a^5$ about one and one-half inch in diameter, more or less; but of course these proportions may be varied somewhat, as experience under varying conditions may dictate; or one or more additional sizes of tubing may be added, if desired, without changing the nature of my invention. Great care should be exercised in getting all the joints in the tubing below the packer perfectly tight.

The operation of my invention is as follows: First, it should be borne in mind that the pressure per square inch at the bottom of any vertical column of liquid is due entirely to the height or depth, without regard to the diameter of the pipe or vessel that contains it; second, that the inflow of gas from the oil-rock is more free and copious against an increasing high pressure than the inflow of oil, comparatively. In other words, the inflow of oil compared with the inflow of gas is more free and copious just after a high pressure is removed than at any other time. In starting a well the ordinary disk, $i$, in the coupling (see Fig. 1) is broken in the usual way, and the well makes a flow. The expansive force of the large chamber of compressed gas blows all the oil out of the tubing down to the inlet $b$. The flow is closely followed by a spray of oil passing up the tubing directly from the oil-rock, blown out of the tubing by the lateral part of the gas from the gas-chamber, assisted by the fresh inflow of gas from the oil-rock as the high pressure is removed. After the last expansive force of the gas in the gas-chamber has liberated itself through the tubing, then the spray of oil in the tubing, together with the drip on the sides of the tubing, gradually settles back to the bottom of the well, and, as it settles into the lower part of the smaller tubing $a^5$, it is joined by the fresh oil produced from the oil-rock, thereby filling the gas-trap, whether it be the trap $b'$ or the pocket-trap $b$, and seeks a level inside and outside of the tubing as far as the increasing pressure of gas outside of the tubing will permit. Here it will be understood that the spray and drip will fill the smaller tubing much farther or higher than the same amount of oil will fill the larger tubing, and thereby more fully confine the increasing gas-pressure in the gas-chamber by the elongation of the liquid column and its consequently increasing pressure as it passes from the larger tubing into the smaller. The pressure at its base is increased in direct proportion to its increased length. Now the flow of oil and gas goes on issuing freely from the oil-rock. The gas is prevented from entering the tubing by the gas-trap arrangement. As the trap is filled or partly filled with oil, the gas cannot descend through the oil and get into the tubing unless the downward current of the oil in the trap is more rapid than the upward movement of the bubbles of gas through the oil by their buoyancy, which is not the case excepting when the well is making a flow. So the gas ascends and accumulates and compresses in the gas-chamber, exerting its pressure downward upon the surface of the oil at its lower extremity, gradually pressing the oil downward on the outside of the tubing, causing it to rise therein, fed by the oil production of the rock, and slowly elevated in the tubing by the increasing pressure of gas in the gas-chamber. The increasing pressure at the base of the oil column in the smaller tubing at the gas-trap nearly keeps pace with the increasing pressure in the gas-chamber, so as to confine the gas until the top of the column of oil has reached about the top of the smaller tubing; and, as stated before, the gas issues from the rock comparatively faster against an increasing high pressure than the oil. So if the gas-chamber is about the right size, or the packer has been properly located, the gas-pressure will have gained sufficiently on the oil production and oil-pressure to have all the oil on the outside of the tubing forced into the tubing down to the inlet by the time the smaller tubing is filled with oil. Should the gas-chamber be quite large, the gas-pressure will continue to raise the oil into the large tubing by its downward pressure on the oil on the outside of the tubing. The oil will now increase in height as much slower while filling the large tubing as the difference in capacity between the small and large tubing, $a$ and $a^5$. The gas-pressure in the gas-chamber will therefore soon overcome or overbalance the oil-pressure. As soon as the oil is all forced into the tubing down to the inlet, the well is ready to flow. The gas then begins to pour into the tubing from the gas-chamber, and every quart or gallon of gas that enters the tubing displaces an equal amount of oil from the small tubing into the large tubing, and reduces the height or length of the oil column accordingly. For example, if the small tubing has just half the storage capacity per foot as the large tubing, every two feet of oil that passes out of the small tubing into the large tubing will fill it only one foot, thus giving the gas-pressure a rapidly-increasing power over the oil column until the oil is all forced out of the small tubing into the large. Then there would only be half as much liquid-pressure per square inch for the gas-pressure to lift. At this stage of the process the expansive force of gas in the gas-chamber is sending the head of oil up the tubing rapidly. If the gas begins to pour into the tubing at the inlet before the column of oil reaches to the top of the small tubing, the effect will be similar, only differing in degree. This operation is repeated at every flow, excepting the breaking of the disk, which is only done when the well is first started.

It will now be seen that the oil production is utilized to confine the gas and act as a valve of great weight, its weight increasing with the pressure of the gas, and thus prevent the wasting of the gas between the flows, and the thickening of the oil by the agitation of the constantly-escaping gas, and saving the gas until there is a sufficient pressure to eject the entire accumulated head of oil from the tubing in one continued blow or gush by its expansive force. In this way the gas is generally shut into the well in from five to ten minutes after the well quits flowing and spraying by the settling back of the spray and drip of the tubing, as before mentioned. If some wells should not start flowing when the disk is broken, the oil should be swabbed out or pumped out, as directed for pumping out a well after flooding.

It may be well to state here that the capacity of the lower section of the string of tubing may be reduced by using tubing of the same size through its entire length, and then partly filling the lower section with rods, tubing, or other equivalent material; but it would not answer the purpose so well; but such an arrangement would not change the nature of the invention.

I do not make any claim in this application to the peculiar construction of gas-trap shown in Fig. 3, but reserve the right to make a separate application therefor.

I claim—

1. The combination, in an oil-well, of a string of tubing, the lowermost sections of which are of less size or reduced capacity compared with the upper sections, a packer shutting the passage outside of the tubing, and a suitable inlet below the oil and gas rock, substantially as described.

2. The combination of a string of tubing, the lowermost sections of which are of less size than the upper sections, a packer at the proper altitude, substantially as specified, and a gas-trap at or near the lower end of the smaller tubing and in or near the oil-producing rock, substantially as described.

3. An oil-well having a string of tubing, the lowermost sections of which are of less size than the upper, and provided with an inlet at or below the oil-rock, and a packer for forming a joint between the walls of the well and the tubing, substantially as described.

4. The combination of two strings of tubing of different sizes coupled to each other, the smallest tubing being in the lower part of the well, and provided with a vertical check-valve, $b^3$, inside of the tubing, a small vertical check-valve, $c^4$, outside of the tubing, and a suitable inlet in or below the oil-rock, and a packer above the same, for the purposes set forth.

5. A string of tubing for oil-wells, consisting of two portions, the lower portion being reduced in diameter or capacity, and connected to the upper portion by a reducer, $a^3$, and provided with a suitable inlet, substantially as specified.

6. The combination of a string of tubing, the lower portion of which is reduced in size, a packer, a vertical check-valve, $b^3$, and an inlet, $b$, substantially as described.

7. A tube, $a$, for oil-wells, provided with a ring or holding device, $b^5$, rigidly secured to it, in combination with the eyebolt or link $c$ $c'$, and a pin, $c^3$, attached to the casing-head or other equivalent holding-down device for the purposes of expanding the packer, substantially as described.

8. The method herein described for tubing and packing oil-wells, consisting in reducing the bore of the tubing in the lower part of the well in substantially the proportions specified, and forming a gas-chamber between the wall and tubing by adjusting the altitude of the packer in proportion to the depth of the well, the capacity of the tubing, and the amount of flow of oil and gas, substantially as specified.

9. In an oil-well, the combination of a pocket below the oil-rock, the tubing having an induction-opening below the oil-rock and in the pocket, a packer between the tubing and the wall of the well, and an enlarged gas-chamber of the proportions specified, substantially as described.

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