June 18, 1946. J. E. MUNN 2,402,433

TREATMENT OF OIL WELLS

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Fig. 1.

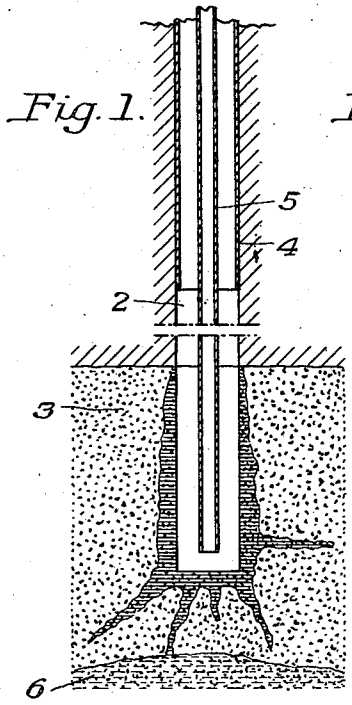


Fig. 2.

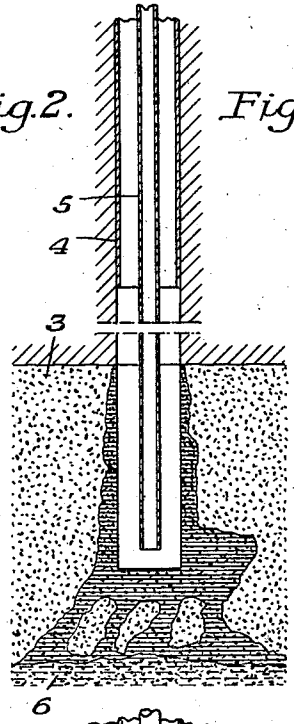


Fig. 5.

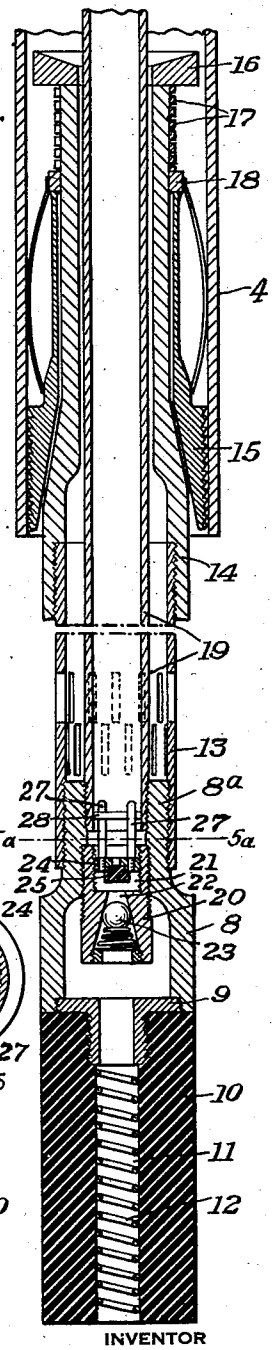


Fig. 3.

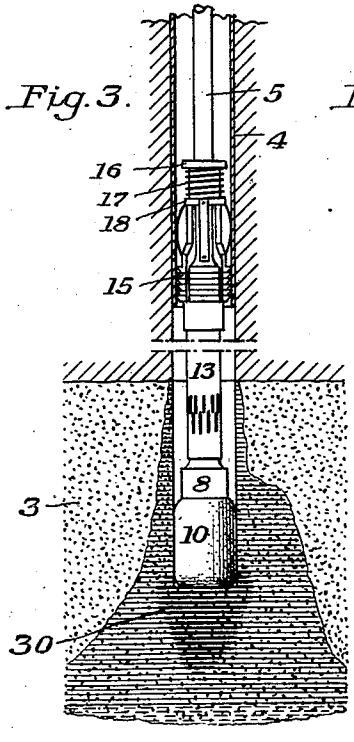


Fig. 4.

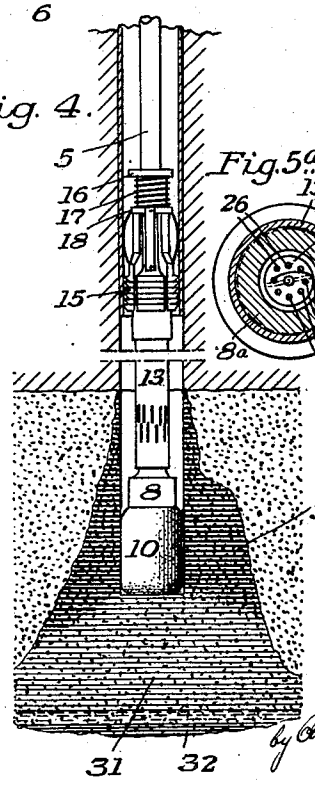


Fig. 5a.

INVENTOR

John E. Munn

by Christy, Parmelee & Strickland
his attorneys

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Fig. 6.

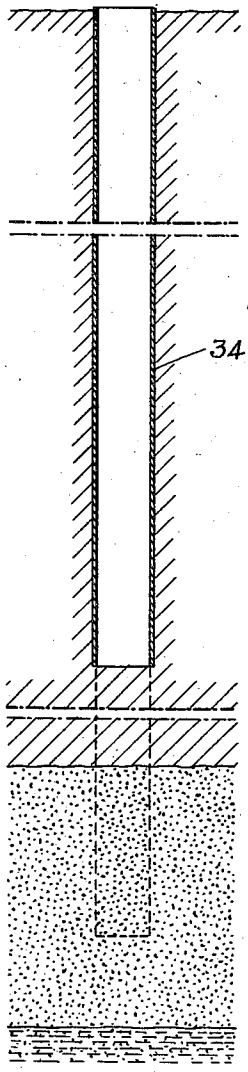


Fig. 7.

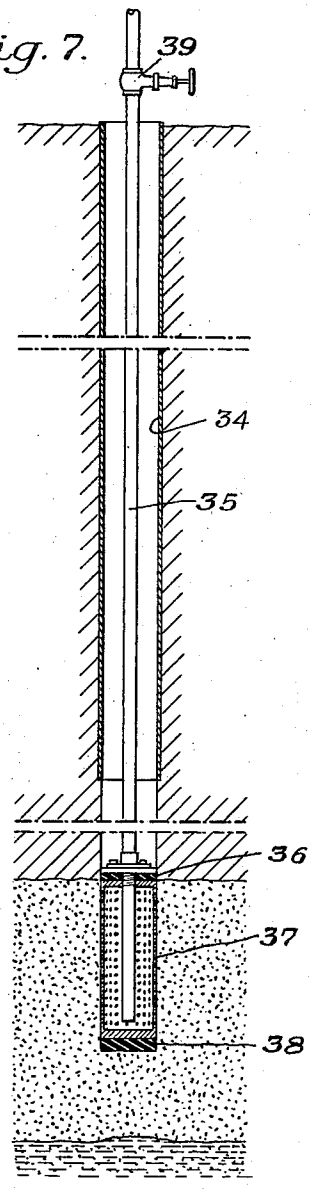
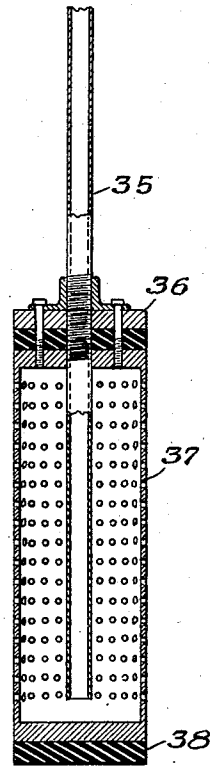


Fig. 8.



INVENTOR

John E. Munn

by Christy, Parmelee and Strickland

his attorneys

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2,402,433

TREATMENT OF OIL WELLS

John E. Munn, Bellevue, Pa., assignor to Chemical Service Company, Pittsburgh, Pa., a partnership comprising Theodore Schleid, Anita H. Munn, and John E. Munn

Application May 19, 1941, Serial No. 394,101

4 Claims. (Cl. 166—21)

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This invention pertains to the production of petroleum from wells, and relates particularly to the reduction or elimination of water from petroleum producing wells.

In many cases new wells which are driven into oil-bearing sands or stratum produce a relatively large volume of water from the beginning of the operation of the well. In other cases wells which have been in production for a period of time gradually begin to produce water and as the operation of the well continues the water flows in an increasing amount until it may, in some cases, entirely supplant the production of oil. The present invention is applicable to the drilling of new wells where it is anticipated that water may be encountered and it is also applicable to the correction of existing wells which are now producing a considerable volume of water.

In the oil fields where water is encountered the oil-producing sand or stratum is often immediately above a stratum containing water. The well is drilled into the sand far enough to produce oil but it is not drilled through the oil-bearing sand into the water.

In the case of the drilling of a new well, the operation of the drilling tool up and down in the bottom of the well or the head pressure of water or drilling mud in the well drives water which may be in the well downwardly through the formations below the drilling tool, opening up the channels or capillaries through the underlying strata down to the water. Consequently when the oil-bearing sand has been penetrated to the desired depth, numerous channels or capillaries already extend from the bottom of the well down into the water-producing formation and the well will immediately produce water. Moreover, in the case of a producing well there is a region of reduced pressure immediately below the bottom of the well where the oil is being pumped or withdrawn from the oil-bearing strata. This reduction in pressure due to the withdrawing of the oil from the producing sand creates an aspirating effect and gradually causes the water level immediately under the well to rise and at the same time capillaries are gradually opened up from the zone immediately under the bottom of the well downwardly toward the water. These capillaries increase in size and eventually the entire zone in the oil-producing stream immediately below the bottom of the well becomes full of capillaries through which the water can flow directly from the water-bearing formation to the bottom of the well and eventually a point may be

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reached where nothing but water is pumped by the well.

According to the present invention it is contemplated that a fluid be introduced into the well which will displace the water in the capillaries or channels and which is heavier than the water so as to force the water downwardly out of the capillaries or channels away from the bottom of the well. After its introduction, the heavier fluid is trapped in the formation at the bottom of the well, preferably by a specially constructed packer, where it remains as a barrier to the further flow of water into the well.

My invention may be more fully understood by reference to the accompanying drawings in which—

Figure 1 is a schematic view representing the lower portion of a well at the time that it first begins to produce water in appreciable quantities;

Figure 2 is a similar view showing the growth of the channels through which water enters the well;

Figure 3 is a similar view showing the introduction of a correction packer into the well and illustrating the discharge of the first solution into the formation at the bottom of the well;

Figure 4 is a view similar to Figure 3 after the introduction of the second solution, two different solutions being used in succession in the correction of existing wells;

Figure 5 is a transverse vertical section through a correction packer used for the introduction of fluids into the well and for the subsequent operation of the well;

Figure 5*a* is a horizontal section in substantially the plane of line 5*a*—5*a* of Figure 5;

Figure 6 is a schematic view generally similar to Figure 1 showing the stage at which drilling is temporarily halted to take steps to prevent the opening of capillaries through the producing sand into the water-bearing stratum;

Figure 7 is a view similar to Figure 6 showing the completed well with the production packer therein; and

Figure 8 is a vertical section through one form of production packer which is used in new wells.

Referring first to Figure 1, 2 designates the well which extends down into the oil-bearing sand or stratum 3. 4 is the well casing which usually terminates at some point above the oil-producing sand and 5 designates the tubing through which oil is withdrawn or pumped from the bottom of the well. Under the oil-bearing sand 3 is a water-bearing formation or stratum 6.

When the well is producing oil flows laterally through the oil-bearing sand into the bottom of the well and is withdrawn or pumped out of the well tubing 5. The oil flowing in from the sides and up the tubing creates a suction or aspirating effect at the bottom of the well, creating a zone of relatively lower pressure in the vicinity of the bottom of the well which causes the normal water level in the stratum 6 to rise. At the same time channels or capillaries through which the oil previously entered the bottom of the well tend to open up from the bottom of the well in a zone of downwardly increasing area, eventually communicating with the underlying water. In Figure 1 the general character of these channels or capillaries at the time when the well first begins to produce water in appreciable quantities is diagrammatically illustrated. As shown in Figure 2, because the flow of water has become established an increasing number of passages from the bottom of the well to the water level are created and eventually there is a zone generally in the form of a cone from the bottom of the well down to the water-bearing stratum through which water is drawn into the well, in many cases to the complete exclusion of the oil.

In correcting a well where such a condition exists, a specially constructed packer is first entered into the bottom of the well and set. One form of packer suitable for this purpose is illustrated in Figure 5. The particular packer is the subject-matter of a copending application filed by me, Serial No. 394,102, filed May 19, 1941, (Patent Number 2,367,733, dated January 23, 1945 in which the packer is more fully described and claimed, and it will be described hereinafter only insofar as is necessary for an understanding of the present invention. The packer as shown in Figure 5 has a main lower body portion 8 having a nipple-like element 9 secured to the lower end thereof. Secured to the nipple element 9 is a compressible oil resistant resilient packing body 10. The body 10 is preferably formed of a specially prepared rubber or plastic, which has the resilient and elastic properties of rubber but which is not affected by oil or chemical compounds used in the treatment of the well. Rubber coated with a synthetic rubber such, for example, as that known under the trade-mark "Thiokol" may be employed for this purpose. The packing 10 has a central passage 11 therein and there is a coil spring 12 in this central passage to prevent the hole 11 from closing when pressure is put on the packing and it is expanded at the bottom of the well.

The upper part of the body 8 has a neck portion 8a of reduced diameter and screwed on to the outside of this neck portion is a tube 13. The tube 13 is of a length sufficient to extend from the body 8 up to a point adjacent the bottom of the casing 4. In practice this tubing may be as much as fifty feet or more in length. The tube 13 is perforated, at least throughout that portion of its length which traverses the oil bearing stratum, and which is immediately above the lower terminal portion of the tube, the perforations preferably being in the form of narrow slots. This perforated portion of the tubing provides a screen through which oil may flow after the well is again put into operation. At the top of the tubing 13 is a conical body 14 about which are a series of radially movable slips 15 of a type commonly found in oil well packers, the members 15 having serrations on their outer faces to catch against the interior of the casing and hold the packer against upward movement. At the top of the body 14 is a collar 16 and a compression spring 17 interposed between the collar 16 and a ring 18 serves to exert longitudinal pressure against the ring 18 for forcing the slips 15 down over the conical surface of the body 14 for expanding the slips into contact with the casing.

Passing down through the body 14 and through the tubing 13 is a well tube 19. This tube is shown in Figure 5 as being screwed into the upper end of the neck 8a of the body 8.

Contained within the body 8 is a plug 20 having an upper chamber 21 therein and having a central passage 22 therethrough with an upwardly closing ball check valve 23 in this passage. The chamber 21 at the top of the plug 20 has an internal thread which is a left-hand thread and screwed into the chamber is a disk 24 having a compressible plug 25 at the center thereof. As shown in Figure 5a, this disk has a series of openings 26 therein around the center and it is provided with two diagonally opposite upstanding pins 27. In the lower end of the tubing 19 is a crosspin 28 which extends between the two pins 27 forming, in effect, a spline or wrench for turning the disk 24. The arrangement is such that when the well tubing 19 is rotated in a counterclockwise direction so as to screw it upwardly out of the neck 8a of the body 8, the disk 24 will be turned, but because of the thread on the interior of the chamber 21 being a left-hand thread the disk will screw down as the tubing screws up to force the sealing plug 25 down against the top of the hole 22 and tightly plug this hole.

In the treating of the well the packer which has been described is attached to the lower end of the well tubing and it is lowered into the bottom of the well. Pressure on the well tubing causes the body 10 of packing material to be expanded against the sides of the well. When the compressed packing tends to re-expand by slightly lifting the well tube, it tends to lift the body 8 and the tubing 13 and the body 14. The conical surface of the body immediately expands the slips or grips 15 against the interior of the casing, thus setting the packer so that the packing 10 remains permanently under compression. At this time the disk 24 is in the position shown in Figure 5 and fluid may be introduced into the well tubing. This fluid will flow down the well tube through the holes 26 in the disc 24, through the hole 22, forcing the valve 23 downwardly. The liquid may continue down through the packing 10 and be discharged into the bottom of the well.

In the practice of the present invention I preferably first introduce into the bottom of the well through this specially constructed packer a liquid whose function is to enter the capillaries extending downwardly from the bottom of the wall and decrease the surface tension of the water in the area immediately below the bottom of the well. In Figure 3 the shaded area designated generally at 30 indicates the diffusion of this first liquid through the zone at the bottom of the well. Numerous substances may be used for this purpose. Ordinary alcohol, for example, will mix with the water and decrease its surface tension. Various industrial soaps may be used, or a wetting agent, such as that sold under the trade name of "Aerosol" may be employed. By the introduction of a wetting agent into the bottom of a well to reduce surface tension of the water,

the water will tend to drain more freely from the capillaries. As the wetting agent is introduced it will tend to flow downwardly and spread out laterally, eventually permeating the conical zone extended from the bottom of the well down to the normal water-level. The amount of wetting agent to be introduced has to be determined from known factors in the particular field in which the well is located, the amount depending very largely, however, upon the depth of the oil-bearing sand and the calculated distance from the bottom of the well to the normal water level. The fluid is introduced under pressure greater than the normal pressure in the well.

After the first fluid has been introduced, a second fluid is introduced in the same manner. This second fluid is a liquid which is heavier than water. The fluid is preferably one which is a solvent for oil and which, while normally not readily miscible with water will, by reason of the wetting agent which has been introduced into the water, mix to some extent therewith. The fluid which is preferably used is carbon tetrachloride, which substance is a solvent for petroleum but which is normally substantially insoluble in water. When the carbon tetrachloride is injected into the bottom of the well, it follows down the capillaries toward the water-bearing stratum. Because of its being heavier than the water, it forces much of the water down these capillaries out of the oil-bearing sand. Some of the water with the wetting agent in it will be forced upwardly into the sand around the bottom of the well. The action of the second fluid is diagrammatically illustrated in Figure 4 where the area **31** designates that zone through which the second fluid has permeated. The darker area **30** above it represents some of the water with the first solution that has been forced upwardly, and the darker area **32** at the bottom of the figure designates the zone down into which the rest of the water with the first fluid has been forced. The amount of carbon tetrachloride to be used has to be determined from the known facts about the well, including the depth of the oil-bearing sand and the distance between the bottom of the well and the normal water level.

After the second fluid has been introduced, the well is then ready to be put back into operation. The first step in putting the well back into operation is to turn the well tubing **19** in a counterclockwise direction to disconnect the tubing from the neck portion **8a** of the body **8** at the bottom of the packer. The turning of the tube in this direction screws the disk **24** downwardly, forcing the plug **25** against the top of the hole **22**. The check valve **23** forms one positive seal against any of the fluid which has been forced through the packer down into the well from flowing back through the bottom of the well and back through the packer into the well tubing. The plug **25** forms a second positive seal so that if, for any reason, the check valve should be clogged or not closed tightly, the packer would nevertheless be tightly sealed against any reverse flow of fluid through it. Two sealing valves are thus provided, each forming a check against the other to assure against the back flow of fluid through the packer. When the well tubing **19** has been unscrewed from the neck **8a** of the body **8** it is elevated a short distance above the body **8**. After the tubing has been thus disconnected and raised, the pumping of the well may be started. The packer at the bottom of the well prevents any flow of liquid in a vertical direction directly up into the well. All of the liquid that can enter the well must flow into the well laterally in the zone above the packing **10**. It enters the tubing **13** through the slots therein and is then drawn or forced up into the well tubing.

In the first short period of the operation of the well the water in the zone **30** will be withdrawn from the well, and after this water has been withdrawn the oil will flow laterally through the sand. One reason for the original entry of the water into the well is that the oil in flowing into the well and then up to the well tubing creates an aspirating effect or low pressure area immediately below the bottom of the well tending to raise the water level, and eventually draw the water up through the oil-bearing sand into the bottom of the well. The provision of a packing **10** positively destroys this aspirating action. With this invention there is created a condition where, in the conical area immediately under the bottom of the well the capillaries are filled with the carbon tetrachloride tending to prevent any up-flow of water and the bottom of the well is plugged by the packing **10** so as to prevent any suction in a vertical direction from the bottom of the well downwardly. Thus the water is either eliminated entirely or to such an extent that it does not seriously impair the production of oil. The well, after being so treated, should not thereafter produce water in any substantial quantities for an indefinite period of time.

This treatment of the well is relatively inexpensive in that the chemicals used for the treatment are relatively cheap and aside from the chemicals the only additional equipment required is the packer.

An important function of the packer is its construction which permits the forcing of the liquid downwardly through the bottom of the well into the sand below the bottom and which positively seals the bottom of the well against any flowing fluid upwardly through the packer.

In the drilling of new wells in formations where water is anticipated, the drilling is proceeded with as usual until the drilling tool approaches relatively close to the oil-bearing sand. When the drilling has approached within a predetermined distance of say, fifty feet of the oil-bearing sand, the drilling operation is stopped and as much of the water as possible is bailed out of the bottom of the well. After the well has been bailed as dry as possible, a considerable quantity of liquid which is heavier than water, preferably carbon tetrachloride, is poured into the well, after which the drilling is continued. Thus instead of water being forced downwardly through the formations under the impact of the drilling tool, carbon tetrachloride is forced downwardly through these formations. When the oil-bearing sand is eventually reached and penetrated by the drilling tool, the capillaries are filled with carbon tetrachloride which is heavier than water and which tends to prevent the rise of water upwardly through the capillaries. Carbon tetrachloride also dissolves paraffin deposits in the oil-bearing statum, thus enabling oil to flow more freely into the well.

Referring to Figure 6, this figure indicates the depth to which the well is drilled, after which the drilling operation is stopped and the carbon tetrachloride introduced into the well while the dotted lines projecting downwardly from the well indicate the depth to which the well is to be subsequently drilled. In this figure the casing is designated **34**. After the well has been drilled to its

full depth, a packer is set in the bottom of the well to close the bottom of the well against the flow of fluid upwardly through it and prevent the aspirating effect heretofore described from drawing the water from the normal water level into the sand in the bottom of the well. One form of packer which may be used for this purpose is shown in Figures 7 and 8, while my copending application above referred to discloses another form of packer for the same purpose. Referring to Figure 7, 35 designates the well tubing, and 36 designates generally the packer at the bottom of the tubing. This packer has a shell 37 which is perforated to permit the flow of oil laterally from the sand into the interior of the shell. The well tubing 35 extends down into the shell and terminates above the bottom of the packer. Carried at the bottom of the packer is a body 38 of a resilient compressible material as, for example, synthetic rubber, or natural rubber coated with "Thiokol." Under the weight of the superimposed column of tubing 35 the packing 38 is expanded radially and compressed against the bottom of the well to effectually seal the bottom of the well against any upflow of fluids. The oil which flows through the perforated shell 37 is, of course, drawn out through the tube 35. Where the well flows under its own pressure I prefer to use a valve 39 at the top of the well so as to partially restrict the flow of oil because by restricting the flow of oil a greater pressure is maintained in the zone around the bottom of the well tending to prevent the water from forcing upwardly.

Thus in the development of new wells, as in the correction of existing wells, my invention contemplates the penetration of the oil-bearing sand in the zone under the bottom of the well with a liquid which is heavier than water, followed by the mechanical sealing of the bottom of the well to prevent any direct upflow of fluid in a vertical direction.

The fluid which is heavier than water penetrates, as previously indicated, the water passages and capillaries in the oil producing stratum below the bottom of the well. It diffuses through the capillaries in a downwardly spreading cone with the bottom of the well at the apex of the cone and serves as a blanket over the underlying water, filling the capillaries and preventing the water from rising. Being heavier than the water, it will act positively to force the water back through the capillaries, spreading out in a conical pattern of downwardly increasing diameter. When the treated well is subsequently being pumped the greatest suction is at the bottom of the well. This is due not only to the action of the pump itself, but to the aspirating effect of the oil flowing laterally inwardly. The packer, being at the apex

of this cone, definitely prevents the heavy liquid from being drawn back into the bottom of the well. Also, since the liquid is heavier than water, any suction will be more effective to move the oil which is lighter than water, than to move the liquid which is heavier than water, which is a further factor tending to prevent the rapid removal of the heavy fluid.

While I have illustrated and described certain specific apparatus for the practice of my invention and certain specific materials for use in carrying out my invention, it will be understood that various changes and modifications may be made, both in the apparatus and materials, and within the contemplation of my invention and the scope of the following claims.

I claim:

1. The method of treating oil wells in which water is present which comprises forcing a liquid capable of reducing the surface tension of water into the oil-producing stratum below the bottom of the well, thereafter introducing a second liquid consisting essentially of carbon tetrachloride into the same portion of the stratum to displace the water which has been treated with the first liquid, and thereafter sealing the bottom of the well only below a given oil producing level against the upflow of liquid therethrough.

2. The method of correcting producing wells in which water is flowing which comprises forcing a wetting agent into the oil-producing stratum in the zone immediately below the bottom of the well, and then forcing carbon tetrachloride into the same zone, and trapping the carbon tetrachloride in said zone.

3. The method of correcting producing wells in which water is flowing which comprises forcing a wetting agent into the oil-producing stratum in the zone immediately below the bottom of the well, then forcing carbon tetrachloride into the same zone, and thereafter sealing the bottom of the well against the direct upflow of fluid therethrough whereby the carbon tetrachloride is trapped in the zone into which it is injected.

4. A method of treating oil wells in which water is present which comprises forcing a liquid capable of reducing the surface tension of water through a tubing extending to the bottom of the well into the oil producing stratum below the bottom of the well, said liquid being confined to penetration of the portion of the stratum at the bottom of the well only, thereafter in the same manner introducing into the oil producing stratum below the bottom of the well only a liquid consisting essentially of carbon tetrachloride, and then mechanically sealing the carbon tetrachloride so introduced in the oil producing stratum below the bottom of the well.

JOHN E. MUNN.