Feb. 12, 1952 E. V. WATTS ET AL 2,585,522

METHOD OF INCREASING THE PRODUCTIVITY OF OIL WELLS

Filed March 8, 1947

FIG. 1.

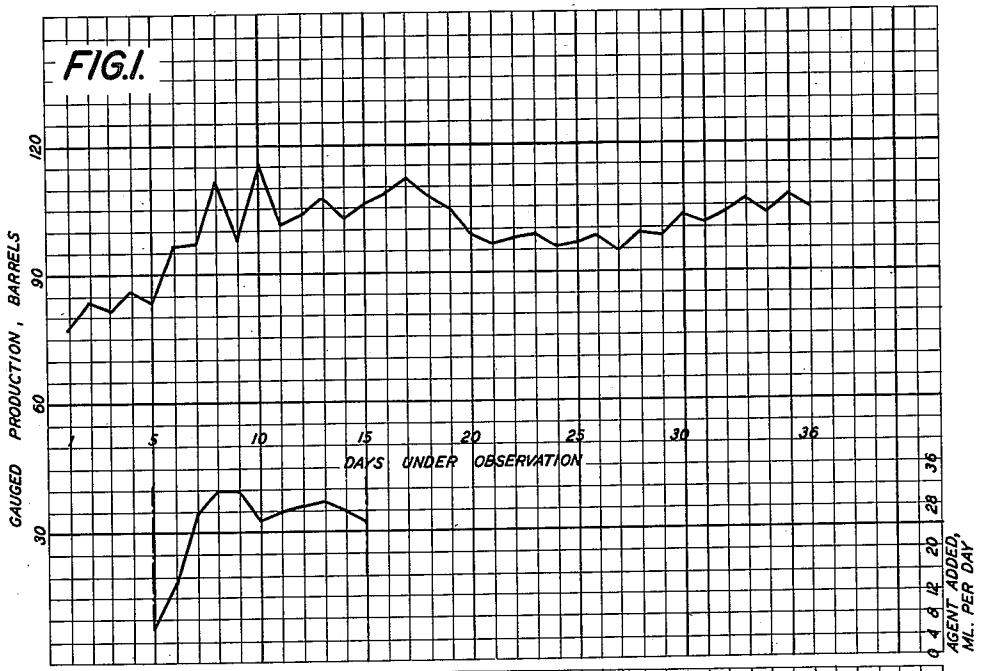
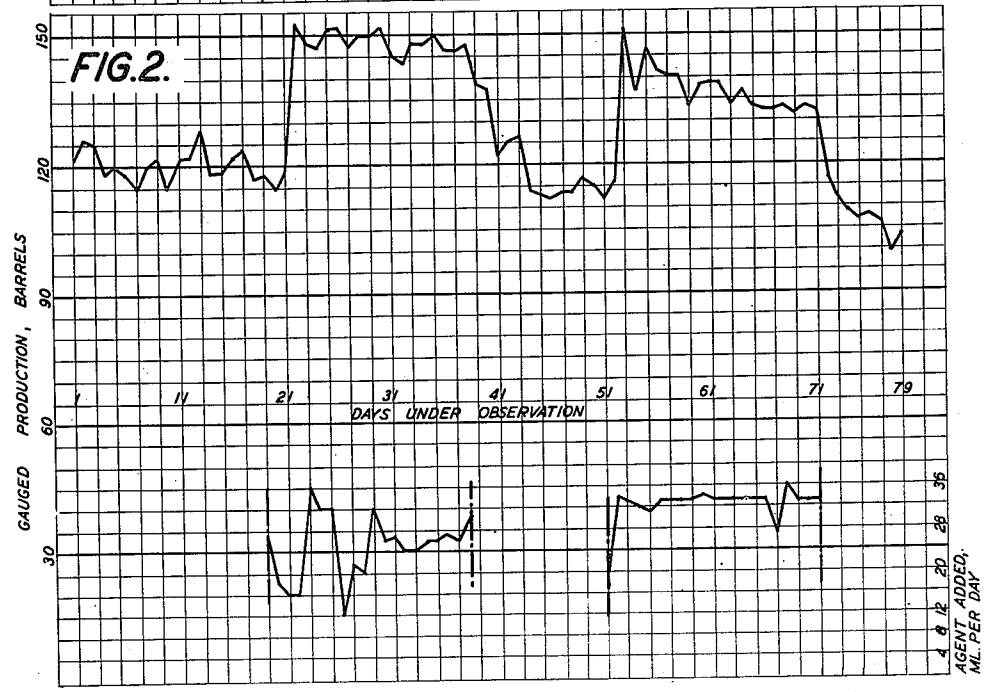



FIG. 2.




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Patented Feb. 12, 1952 2,585,522

# UNITED STATES PATENT OFFICE

2,585,522

## METHOD OF INCREASING THE PRODUCTIVITY OF OIL WELLS

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Application March 8, 1947, Serial No. 733,282

2 Claims. (Cl. 103—1)

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This invention relates to the pumping of oil wells, and particularly to steps by which the yield of heavy and viscous oils may be materially increased.

It is well known that most crude petroleums, when in position in the sand, contain material amounts of dissolved hydrocarbon gas. When the pressure on the oil is reduced or released by passage through the sand and the perforations into the casing, this gas passes out of solution in the form of extremely minute bubbles. If the oil is of low viscosity, these bubbles rise rapidly through the oil column in the casing and do not interfere with pumping operations. But in cases in which the oil is viscous and has a high surface tension the minute bubbles rise very slowly by reason of the high viscosity and are prevented from aggregating into larger bubbles by the high surface tension, the result being the formation of a fine grained and very stable froth.

In the conventional reciprocating oil well pump, located far below the earth's surface, a standing valve at the lower end of the pump barrel admits fluid during the upstroke of the plunger, at whatever pressure may exist in the casing. During the ensuing down stroke a travelling valve in the plunger opens to permit the fluid trapped in the pump barrel to pass to the upper side of the plunger, by which it is lifted through the tubing on the next upstroke.

So long as the fluid entering below the plunger is wholly or substantially liquid, and therefore substantially incompressible, such pumps will lift and discharge a volume of oil approximating their displacement. But where the fluid entering the barrel is a highly compressible mixture of oil and gas, the travelling valve does not open until the gas has been compressed sufficiently to over-balance the pressure of the column of oil in the tubing and resting on the valve.

In such cases the effective stroke of the pump is that portion of the total stroke measured from the point at which the travelling valve opens to the point at which stroke direction reverses, and in many instances is only a small fraction of the whole. In extreme cases the quantity of gas contained in the froth remaining in the clearance space at the end of the down stroke may be sufficient to fill the barrel during the up stroke at a pressure no greater than that existing below the standing valve. In these cases the standing valve does not open during the up stroke of the plunger, no fluid enters the barrel and the pump becomes gas-locked and nonfunctional.

Many partial remedies for these conditions are

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available, for example: the control of plunger speeds; an increase in stroke length, by which end clearance is reduced; increase in the pressure maintained on the casing, and the use of gas anchors in which the froth is separated mechanically from the oil and is in part broken down. All of these expedients are useful under suitable conditions, but none has proven adequate to permit a gassy, heavy oil well to produce the maximum quantity of oil of which it is inherently capable.

We have discovered that the above difficulties may be corrected and the production of frothy oil wells largely increased by the introduction into the well of extremely minute amounts of the class of substances used as defoamants in lubricating oils. Numerous metallo-organic substances are available for that purpose, but we prefer to use the dihydrocarbon silicates and silicones described in United States Patents 2,258,218 to Rochow and 2,385,384 to McGregor. The use of these substances in preventing lubricating oils from foaming is common practice and has been highly successful.

We have also discovered that destabilization of the froth and the consequent more rapid separation of the gas act not merely to increase the lifting capacity of any given pump, but that they increase the actual productivity of the well by permitting a lower liquid level to be carried in the casing and thus reducing the back pressure of the oil column against the producing formation.

The conditions existing in an oil well are quite different from those existing in enclosures in which lubricating oils are used. In the latter the foam is produced by strong agitation of the oil body and the function of the defoamant is rather to prevent the formation of foam than to break it after it has formed. The froth encountered in an oil well is generated in the sands adjacent the well bore, by release of pressure and consequent evolution of part of the dissolved gas, and the function of the defoamant is to break foam already formed.

The remarkable effectiveness of these agents in resolving crude oil froth is illustrated by the results of the following experiment. Measured samples of froth were taken direct from the lead line of a well producing a very frothy crude of 14.6° A. P. I. gravity. Into these samples were stirred the minute quantities of dimethyl silicone shown in the following table, in solution in diesel oil. The froth samples were stirred vigorously for one minute to disperse the defoamant through the

froth and were then allowed to stand and the volume of the froth measured at the intervals shown in the table. After sixty minutes observation the samples were allowed to stand until no gas remained in the oil, the volume of oil being then measured. The difference between the total volume of the sample at each observation time and the net oil volume was assumed to be the volume of free gas present in the form of froth, and this quantity divided by the difference between the original volume and the net oil volume represents the percentage of the original gas remaining in the form of froth.

*Table*

| Time | Parts per Million Added Defoamant | | | | | | |
|---|---|---|---|---|---|---|---|
| | None | 0.094 | 0.19 | 0.24 | 1.00 | 1.90 | 3.80 |
| | Per Cents Original Gas Remaining as Froth | | | | | | |
| 4 | 95.8 | 92.6 | 83.0 | 64.0 | 61.0 | 38.7 | 22.2 |
| 8 | 93.6 | 87.2 | 81.9 | 34.7 | 31.6 | 20.4 | 16.7 |
| 12 | 91.5 | 70.2 | 39.4 | 24.2 | 22.0 | 14.0 | 8.9 |
| 16 | 82.0 | 44.7 | 21.3 | 19.0 | 16.0 | 10.8 | 2.2 |
| 20 | 78.7 | 36.2 | 18.0 | 15.7 | 14.9 | 9.5 | ..... |
| 24 | 74.5 | 21.3 | 12.0 | 10.3 | 9.5 | ..... | ..... |
| 30 | 74.5 | 17.0 | 5.6 | 4.0 | ..... | ..... | ..... |

The benefits resulting from the use of defoamants in frothy oil wells is even more strikingly illustrated by the following field experiments, described below with reference to the production curves of the well shown in the two figures of the attached drawing. The experiments were carried out in the same well, at different times, under the following conditions:

| | |
|---|---|
| Depth of well ____ feet | 2530 |
| Pump set at ____ do ____ | 2446 |
| Gas anchor, 2½", length ____ do ____ | 21 |
| Pump, diameter ____ do ____ | 2½ |
| Pump strokes per minute, both experiments | 15 |
| Length of stroke, first experiment ____ inches | 24 |
| Displacement, barrels per day, first experiment ____ inches | 125 |
| Length of stroke, second experiment ____ do ____ | 44 |
| Displacement, barrels per day, second experiment ____ inches | 300 |
| Gravity of oil ____ °A. P. I. | 14.6 |

In the first experiment, illustrated by the curves of Fig. 1, a quantity of dimethyl silicone ranging from 7 to 32 millilitres per twenty-four hours was introduced into the well in the form of a solution in diesel oil at a concentration of 0.22%. The effect of the first addition was observable the following day in a sharp rise in the production curve and this increased productivity persisted for three days after the addition of the agent was discontinued. During the entire period of observation, thirty-six days, the trend of productivity was upward and it is noted that the trend lines, with and without the agent, are roughly parallel, and about 15 barrels apart. Constant pumping conditions were maintained throughout this experiment and the reason for the sharp peaks on the eighth and tenth days is not known.

In the second experiment, illustrated by the curves of Fig. 2, the same agent was introduced into the same well at a period, some months later, during which the trend of productivity was downward. The addition was made in two periods of twenty and twenty-one days respectively with a thirteen day interval between them. The dosage during the first period averaged twenty-five millilitres per day, during the second period thirty millilitres or approximately one fluid ounce. The production of the well responded sharply when the feed of the agent began and fell off somewhat more slowly when it was discontinued. As before, the trend lines with and without the agent are roughly parallel, but are separated by a greater distance, equal to about thirty barrels per day.



The quantities of these agents required to produce a material increase in production is extremely minute, of the order of one-half part per million to five parts per million and more commonly about 1 part to two parts per million. This is in sharp contrast to the behavior of the same and similar bodies in lubricating oils, in which the common usage is from fifty to five hundred parts per million. Consumptions of this larger order would, of course, be entirely out of the question economically in the production of crude petroleum, but the quantities actually required ordinarily cost less than one cent per barrel when figured on the total production of the well or from two to three cents per barrel when figured only on the increased production gained by their use.

In order to obtain increased production with the use of these minute dosages of the defoamant it is essential to dilute the actual agent very strongly, as for example with from two hundred to five hundred times its volumes of a suitable solvent such as kerosene or diesel oil. When so diluted the agent may be fed into the well casing, outside the tubing, either in slugs at intervals or in a very fine stream by the use of any proportioning device.

The well in which this destabilizing agent was used is provided with a moderately effective gas anchor, which was operative during the entire term of both experiments. It is believed (though not demonstrated with certainty) that the remarkable increase in production resulting from the addition of these minute quantities of the agent was due in large part to the effect of the agent in increasing the effectiveness of the anchor rather than to the resolution of froth in the well casing.

A gas anchor has two functions, the relative values of which vary with the quantitative relation between gas and oil in the well fluid. First, the anchor provides a long and more or less vertical passage through which the fluid moves downwardly at such low velocity that at least the larger gas bubbles may move upwardly through it at a greater velocity and thus escape being drawn into the pump suction. This is a separating function purely, and is most effective when the gas bubbles are relatively large and are free to move through a relatively large proportion of liquid oil.

The anchor also provides extended metallic surfaces over which the well fluid moves and which tend to rupture the oil skins surrounding the gas bubbles and to aggregate them to bubbles of greater dimensions which rise and separate from the oil with greater rapidity. This resolving function becomes of major importance when a true froth is entering the anchor, that is to say, when the gas bubbles are separated only by thin oil skins. In such cases, which are common in the production of gassy, viscous oils, even a slight decrease in the stability of the froth leads to extreme magnification of the resolving effect of the anchor and of its effectiveness in feeding only liquid oil to the standing valve of the pump.

We claim as our invention:

1. In the operation of an oil well having a pump and tubing through which oil is pumped, the step of introducing a minute quantity of a dihydrocarbon silicone into the space within the well surrounding the tubing, whereby the productivity of said well is increased, the quantity of said silicone so introduced being from one-half part per million to five parts per million figured on the net volume of oil produced by said well.

2. In the operation of an oil well having a pump and tubing through which oil is pumped, the step of introducing a minute quantity of dimethyl silicone into the space within the well surrounding the tubing, whereby the productivity of said well is increased, the quantity of said silicone so introduced being from one-half part per million to five parts per million figured on the net volume of oil produced by said well.



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