April 27, 1954 O. F. RITZMANN 2,676,662

METHOD OF INCREASING THE PRODUCTIVITY OF WELLS

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Fig. 1.

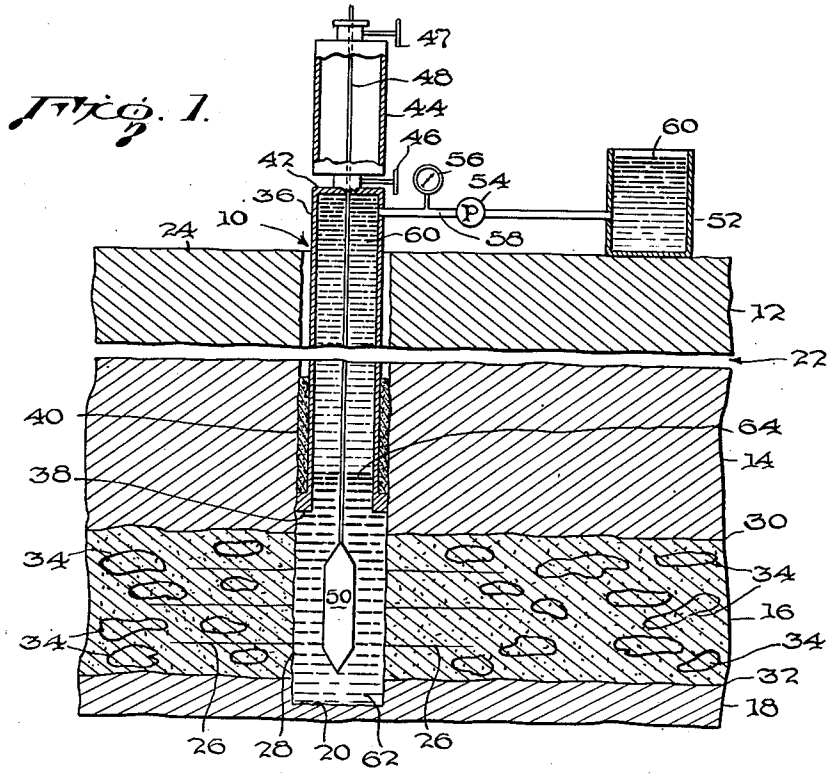
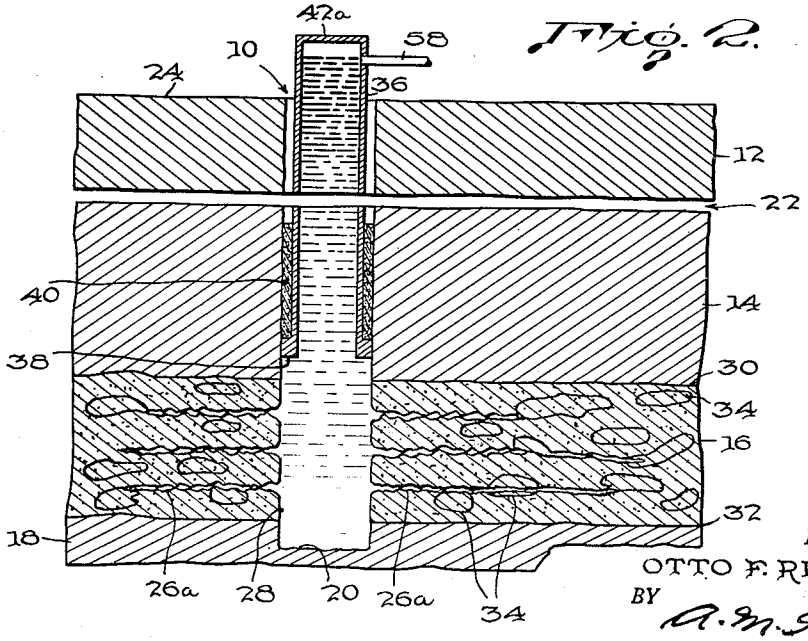


Fig. 2.



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METHOD OF INCREASING THE PRODUCTIVITY OF WELLS

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3 Claims. (Cl. 166—21)

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This invention relates to wells and means for increasing the productivity thereof.

An object of the invention is to provide a novel and improved process whereby, upon the application of the steps of the process to a well, the productivity thereof may be substantially increased.

Another object of the invention is to provide a novel and improved process for increasing the productivity of oil wells by applying internal static pressure to the well in the oil bearing level, and, while maintaining such internal static pressure at a magnitude sufficient to raise the overburden, producing at the oil-bearing level a vastly increased instantaneous dynamic pressure to irregularize the opposed interfaces of the cracks in the oil bearing formation enlarged upon raising the overburden, so as to block intermating of such surfaces upon release of said pressures, whereupon oil therein may be withdrawn from the well.

A further object of the invention is to provide means for enhancing the productivity of an oil well comprising means for applying static pressure to the well in the region of the oil-bearing formation to enlarge incipient fractures and cracks in the oil-bearing formation, and means for producing in said well in the immediate level bearing said oil, an instantaneous shock wave adapted to penetrate said crevices, fractures and cracks and to produce fragmentation of projecting surfaces thereof to block intermating upon release of said pressures and shock wave, whereby passageways are formed to conduct oil from said formation into said well for withdrawal therefrom.

Still another object of the invention is to provide an improved and novel process for enhancing the productivity of an oil well by employment of the very simple and readily available means of hydrostatic pressure on the well and detonation of an explosive charge in the well at the level of the oil-bearing formation.

Other objects and advantages of the invention will become apparent from the following description of a preferred embodiment thereof as illustrated in the accompanying drawings, and in which,

Figure 1 is a sectional fragmentary elevation showing a section of ground into which a well has been driven to an oil-bearing formation, with pressurizing means applied to the well according to my invention, but not yet sufficient to lift the overburden, and with an explosive charge disposed in the well but not yet detonated.

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Figure 2 is a sectional fragmentary elevation similar to Figure 1, but showing the situation after my improved and novel process has been applied to the well, and the explosive charge has been detonated.

The yield of oil from wells bored into oil-bearing formations is frequently reduced gradually to a rate at which it is uneconomical to continue operation of the well unless the production thereof can be increased in some manner. It often happens that there is sufficient oil in the oil-bearing strata but that various conditions prevent this oil from flowing into the oil well itself so that it can ultimately reach the earth's surface for use.

The failure of the oil in the stratum to reach the oil well may be due to a number of causes, among which are, clogging up of the outlets of cracks and fissures in the stratum which thus block oil flow therethrough, and also the fact that many oil-bearing strata are themselves of a compact and fine-pored structure, such as fine-grained sandstone, which is of such poor permeability that the oil actually flowing under such resistance toward the oil well is very small in quantity. Under these conditions, when there is sufficient evidence from geological studies and geophysical exploratory devices to clearly indicate the presence of oil in commercial quantities in the stratum under study, it is important, in view of the existing financial investment in the well itself, that something be done to bring about increased productivity of the well.

This problem has long been under study, and many solutions have been proposed. For example, it has been submitted that such wells might be treated with acid which might, if all went well, dissolve the stratum surfaces opening upon the well, so as to permit oil to gush into the well. However, as is well known to those skilled in the art, such acid treatment of wells has its disadvantages and may well result in something less than satisfaction on the part of those owning the well when viewed in the light of the results obtained. Such negative results are also often obtained when resort is had to "shooting" the well according to the prior art methods, which may shatter the oil well surface at the oil-bearing level with indeterminable results, and which further may have disastrous consequences, causing leakage of oil through adjacent strata with consequent loss thereof entirely.

The present invention proposes an entirely new approach to the problem, wherein first the

inherent fissures and cracks in the oil-bearing stratum are enlarged by what may be termed mechanical or hydraulic means, sufficiently to permit flow of oil therethrough into the oil well. Thereafter, and while such fissures and cracks are held open, additional, instantaneous and high explosive forces are employed right in the same level as the oil bearing stratum under treatment, not only to further enhance the fluid-conducting capacity of such cracks and crevices, but also to excoriate and abrade their interior surfaces which have been forced apart by the hydraulic static pressures applied thereto, so as to make them incapable of mating contact when such pressures are ultimately released. As a result, upon release of such pressures, both static and dynamic, these opened cracks, crevices and fissures in the oil-bearing formation remain open for conducting oil from the formation into the well itself, from which it may be recovered by well-known means.

In order to understand clearly the nature of the invention, and the best means for carrying it out, reference may now be had to the drawings, in which like numerals denote similar parts and formations throughout the several views.

Figures 1 and 2 both show a sectional elevational view in fragment, of earth into which has been driven a bore 10 forming an oil well. The well passes through a number of strata disposed vertically above each other, such as those shown at 12, 14, 16 and 18. As illustrated, the lower end of the well 10 terminates after extending only partly through the lower stratum 18, to the level 20.

Thus, the stratum 12 may be earth or soil, and the layer 14 may be of some other material, such as an impervious cap rock in the nature of shale and the like. Directly below the top stratum 12 the drawing shows a broken area 22 which is merely to indicate that other intermediate strata may be disposed between the layers 12 and 14, and, as is well known in the art, the vertical distance between the earth's surface 24 and the lower level of the stratum 14 may actually be on the order of several thousand feet, such intermediate and well-known strata being omitted from the drawings only for purposes of clarity of illustration, since they are well known in the art, and form no important part of the invention as such.

In the course of drilling the well 10, it is assumed that the stratum 16 has been found or determined, by well-known methods, to be oil bearing. Incipient cracks or fissures 26 radiate outwardly from the inner surface 28 of the well bore 10, between the top level 30 of the oil-bearing stratum 16 and its lower level 32. Although, for purposes of clarity only, six such incipient cracks or fissures 26 are shown in Figure 1, it will be understood that such cracks and fissures 26 may be large in number, and running in all possible directions and at all angles, and extending in the oil-bearing stratum for considerable distances from the oil well bore 10 itself.

Further, it will be observed that for purposes of illustration only, these incipient fissures and cracks 26 in Figure 1 are not shown as irregular, but it will be understood that actually they may be quite irregular, undulating, and undoubtedly will intersect with adjacent incipient cracks and fissures at many points and, indeed, these incipient cracks may merely be lines of weakness in the oil-bearing rock whose tensile strength is usually not very great. Inside the oil-bearing formation 16, there will also be localized regions 34 of high oil concentration, which are normally out of direct communication with the oil well 10, and between which it is desired to open communication so that the oil in such regions 34 may flow freely into the well.

As shown diagrammatically in Figure 1, a tubular pipe or casing 36 extends downward into the well 10, from the earth's surface 24, through all the intervening strata 12, 14 and those indicated by the broken area 22, the lower end portion 38 of the casing having an outwardly flanged casing seat in or just above the oil-bearing stratum 16, and tightly sealed by means of cement or any suitable well-known sealing substance 40 forming a gasket against leakage around the outer surface of the well casing. The cement 40 is shown rising only a short distance in the annular space outside the casing but may rise many hundreds of feet or even fill the annular space all the way to the surface 24. A well head 42 is secured to the top of the well casing, closing the same, and a so-called lubricator or air lock head in the form of a hollow cylindrical closed housing 44 is secured to the well head 42 through an interconnecting gate diagrammatically shown at 46 which is lined with resilient material (not shown) forming a gland packing to accommodate slidably without leakage a suspension cable 48, but which may be opened to permit larger tools to be introduced into the well. A similar gate is shown diagrammatically at 47. While for purposes of illustrating my invention I have shown the equipment at the top of the well connecting directly with the casing, it is to be understood that this equipment may alternatively be connected to high pressure tubing (not shown) in the well, such tubing being anchored and sealed to the casing in its lower reaches by means of a packer and expanding slip jaws in well-known manner.

The upper end of the cable 48 is secured to hoisting apparatus of any well-known type, for lowering into the well an explosive device 50. The device 50 may be lowered into the well through the lubricator 44 or alternatively the lubricator may be dispensed with and the device 50 lowered into the well prior to pressurization. The device 50 may be in the form of a housing containing an explosive charge, and means for detonating the charge, and it will be understood that the detonator may be electrically actuated if desired, by means of current supplied from a source within the housing 50 and actuated by automatic timing means, or by current supplied by wires included in the suspension cable 48.

According to a preferred form of my process, I fill the well with fluid such as water, and increase the pressure of the fluid in the well by pumping from a fluid source 52 by means of a pump indicated at 54 and of any well-known type. Pumping is continued until the pressure in the well has been raised to a previously-calculated pressure sufficient to lift the overburden at the producing formation 16. By the term overburden is meant the overlying rocks between the formation 16 and the surface of the earth 24. A pressure-indicating instrument is shown at 56 in the fluid inlet pipe 58.

The pressurizing fluid 60 may be an aqueous fluid, but I have found it to be advantageous to fill the lower portion of the well, contiguous to the oil-producing formation, with a slug of oil 62, which may thus extend from the floor of the well 20, approximately to the level shown at 64,

the oil 62 being sufficiently dense to remain at the position indicated. Sufficient hydrostatic pressure to lift the overburden may be obtained with relative ease because to the pressure applied at the surface there is automatically added the hydrostatic head of the column of well fluid which may be weighted to have a high density as is well known in the art. The first stage pressurization by means of the pump 54, the amount of which is easily computed from the density of the overlying rocks and the fluid in the well may, according to one calculation for a typical well of average depth, have a pressure of between about 1000 to 2000 pounds per square inch at the oil-producing level. A pressure slightly above that needed to just lift the overburden appears desirable, and it will be found that by thus hydraulically lifting the overburden at the oil-producing stratum, the incipient cracks, fissures and crevices 26 will be opened at many places in this stratum, so that passageways are formed through which the oil in the blocked pockets 34 may flow into the well bore.

However this flow will not take place while this very high static pressure is being maintained, and, if the pressure is released, the overburden will settle once again, and the opposed surfaces of the cracks and fissures will mate with each other so they will again close, blocking flow of oil therethrough. Accordingly, while the overburden is in such raised position, with the incipient cracks and fissures opened I apply a vastly increased instantaneous shock wave to these cracks and fissures by detonating the explosive device 50, with the result that the interior juxtaposed surfaces of the cracks and fissures are broken up to such an extent that they will no longer mate when all pressure is released, and further, broken off chunks of rock will lodge at various points in such cracks so as to hold them open.

When the pressure is again released, these cracks and fissures, now enlarged in size and cross section, and held open by their irregular and non-mating surfaces, and by broken off particles of rock lodged therebetween, will form open passageways for oil in the formation to flow to the well bore 10. In a deep well hole, the explosion of the device 50 may merely produce a momentary shock at the surface, and if the shot is effective there will be a drop in well-head pressure due to fluid passing out into the formation through the enlarged cracks produced. The well is afterward put on production in any conventional and well-known manner.

Figure 2 shows more clearly the situation immediately after the explosive charge 50 has been detonated. It will be seen that the cracks and crevices 26a have been quite substantially enlarged by the application of the static pressure by means of the pump 54 which lifted the overburden, and that as a result of the vastly increased instantaneous explosive detonation and shock wave from actuation of the device 50, the opposed surfaces of each of the cracks and crevices 26a have been made quite irregular and no longer mate with each other, so that they prop the cracks open. Further, it will be understood that broken-off chunks of rock will be broken off from these crevice surfaces and become lodged therebetween, so as to assist in propping them open. The pumping equipment and lubricator 44 of Figure 1 are not repeated in Figure 2, being omitted therefrom.

While the main explosive charge in the housing 50 may be nitroglycerine, it will be understood that other well-known explosives may also be employed, these being preferably placed inside the housing which may be designed to withstand the pressure applied by the pump 54, prior to detonation. By use of such a housing forming a bomb, the bomb fragments will also be forced into the opened crevices in the formation, and will assist in holding them open. The cable 48 may be dispensed with, if desired, and the bomb 50 arranged for dropping down the well while it is under pressure, for detonation upon hitting bottom, or after a time interval has elapsed.

Although I have described my invention in specific terms, it will be understood that various changes may be made in the selection of the parts and means for carrying the same out, and in their arrangement, within the spirit and scope of the invention as defined by the appended claims.

I claim:

1. A process for increasing the productivity of an oil well which penetrates an oil-bearing rock formation under cover of an overburden and in which communication between oil-bearing regions of said formation and said oil well is at least partially blocked, which comprises filling said oil well at said oil-bearing formation with a liquid, placing in said liquid opposite said formation an explosive charge, applying to said liquid sufficient hydraulic pressure to raise the overburden, thereby opening cracks and fissures in said formation between the well and oil-bearing regions of said formation, and detonating said explosive charge while maintaining said hydraulic pressure, whereby the interiors of said cracks and fissures are subjected to a high-intensity shock wave sufficient to irregularize opposed surfaces of said cracks and fissures to block mating thereof and to break off therefrom rock fragments to lodge therebetween, and thereupon releasing said hydraulic pressure, whereupon said opened cracks and fissures in said formation remain propped open to form passageways communicating between said oil-bearing regions and said oil well, and whereupon said oil in said regions is free to enter said oil well.

2. A process for increasing the productivity of an oil well which penetrates an oil-bearing rock formation under cover of an overburden and in which communication between oil-bearing regions of said formation and said oil well is at least partially blocked, which comprises filling said oil well at said oil-bearing formation with a liquid compatible with oil, placing in said liquid opposite said formation an explosive charge, applying to said liquid sufficient hydraulic pressure to raise the overburden, thereby opening cracks and fissures in said formation between the well and oil-bearing regions of said formation, and, while maintaining said hydraulic pressure, detonating said explosive charge to produce a high-order detonation and shock wave at the level of said oil-bearing formation, said disturbance acting violently upon the interiors of said opened-up cracks and fissures to irregularize the opposed surfaces to block intermating thereof and to break off therefrom rock fragments to lodge therebetween, and thereupon releasing said hydraulic pressure, whereupon said opened cracks and fissures in said formation remain propped open to afford communication between said oil-bearing regions of said formation and the interior of said oil well.

3. A process for increasing the productivity of

an oil-bearing rock formation penetrated by a well and covered with an overburden, which comprises filling said well at said oil-bearing formation with a liquid, placing in said liquid opposite said formation an explosive charge, applying to said liquid at the level of said formation a hydraulic pressure sufficient to substantially overbalance the overburden pressure, and detonating said explosive charge while maintaining said hydraulic pressure.

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