

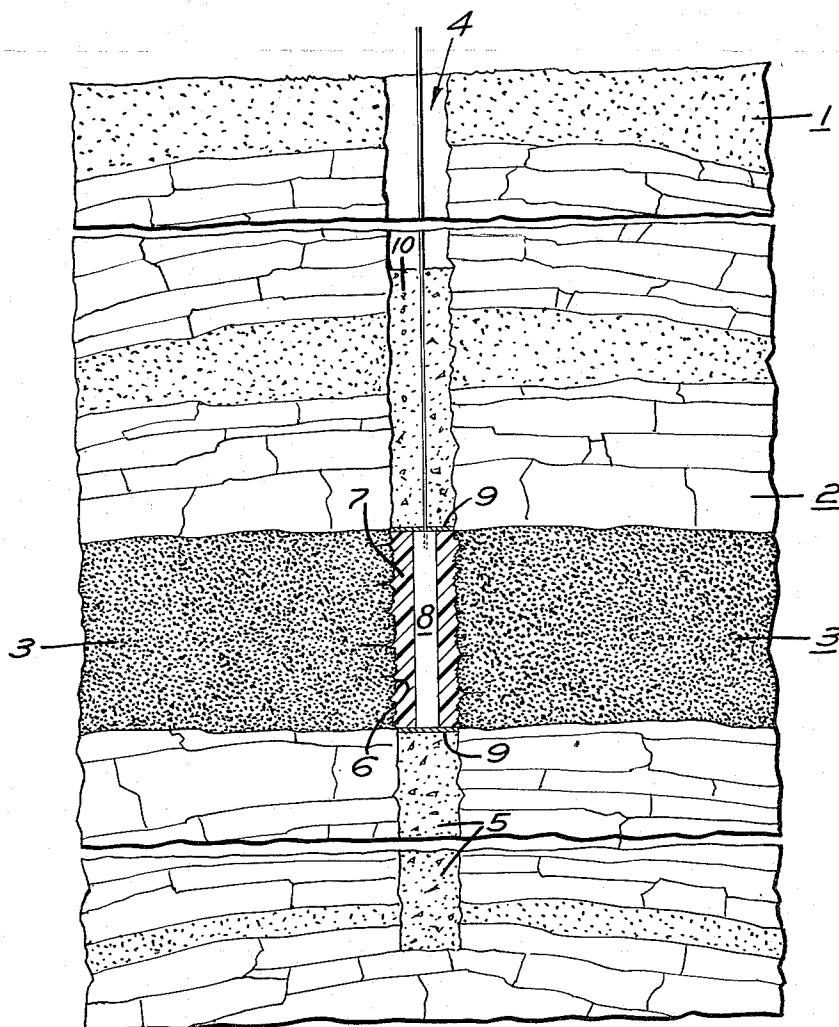
Nov. 3, 1959

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2,911,046

METHOD OF INCREASING PRODUCTION OF OIL, GAS AND OTHER WELLS

Filed July 5, 1956



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2,911,046

METHOD OF INCREASING PRODUCTION OF OIL, GAS AND OTHER WELLS

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Application July 5, 1956, Serial No. 596,095

10 Claims. (Cl. 166—36)

This invention relates generally to the treatment of fluid producing wells, and more specifically to a new and useful method for increasing the fluid production thereof.

It is customary, when the production of a well has begun to drop off, to attempt to increase the same by any one or a combination of three different methods, as follows: creating artificial pressure on the producing region as by introducing fluid such as water, gas or air under pressure into another well in the same area; shooting the well by lowering an explosive charge into the well to the level of the producing region and then exploding it to open up new passages for the flow of fluid; and fracturing the producing formation adjacent the well bore by hydraulic pressure.

However, the use of artificial pressure, while often successful for a time, has certain limitations in that, for example, after the fluid reservoirs supplying the most direct natural channels, into the well have been exhausted the water, gas or air is apt to flow therethrough into the well to a point where further production is unprofitable. Shooting the well by simply setting off a charge of explosive is of limited effectiveness and if the well is shot dry may tend to fuse the material of the producing formation and prevent flow into the well. Also, in the case of wells previously shot it is apt to cause the wall of the well to collapse, necessitating a lengthy and expensive cleanout procedure. The use of hydraulic fracturing is more complicated, requiring high pressure pipe and other expensive, complicated equipment, with the concomitant danger associated with contained hydraulic pressure, and in addition it often is of limited effectiveness.

Accordingly, a primary object of my invention is to provide a relatively safe and inexpensive, and highly effective method of fracturing the producing formation adjacent the well bore to increase the flow of fluid into the well and thereby increase the production thereof.

Another object of my invention is to provide a method of fracturing a well to increase the production thereof, which tends to produce a vertical fracture and thereby utilize the weight of the earth above the fracture to hold it open and eliminate the necessity of introducing prop-
agating agents into the well for this purpose.

The method of increasing the production of a well in accord with my invention is characterized by filling the well bore in the region of the producing formation with a material which will solidify in the well and provide a hard lining for the well bore at that region, the explosive being embedded within the lining to comprise therewith a solid plug in the well bore at the producing formation, and then disintegrating this lining by explosive means to fracture the surrounding producing formation, whereby the lining provides only momentary support for the well bore, tending to reduce caving in and adverse blast effects while utilizing to the fullest the shock forces provided by the explosive to fracture the producing formation.

The foregoing and other objects, advantages and characterizing features of the method of increasing the pro-

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duction of a well in accord with this invention will become clearly apparent from the ensuing detailed description taken together with the accompanying drawing forming a part of this specification and illustrating the application of the method of my invention, wherein the single figure represents a sectional view through a well being treated to increase the production thereof in accord with the method of this invention just prior to exploding the same.

My invention is primarily directed to increasing the production of new wells, where high bottom hole pressures and large fluid volumes are not involved, or old wells producing fluids such as for example crude oil, natural gas, fresh or salt water, or any mineral bearing liquid or gas, and the term fluid as used herein is meant to include any liquid or gas being produced by a well which is adapted to be treated to obtain additional production in accord with my invention. However, I contemplate that at least certain aspects of the method of my invention might be useful in other fields, such as for example seismic exploration for more efficient wave propagation.

By way of illustrating my invention, the drawing shows a well 4 which penetrates through different formations such as those indicated at 1 and 2 and a fluid producing formation indicated at 3. In practicing the method of this invention, the well 4 is filled in to approximately the bottom level of the producing formation 3 with any suitable fill material 5 such as for example cement, a quick setting, cement-like compound such as Cal-Seal, sold by Halliburton Oil Well Cementing Co., or the like. Then the well 4 is filled, in the region of the producing formation 3 with a material adapted to coat the wall surface 6 and set in the well and form a hard, solid lining 7. The material of lining 7 should be a substance which will set up in the presence of hydrocarbons and fresh and brine water, and also one which does not produce any emulsification of the fluid in the producing region 3, and preferably comprises a high polymer, thermo-setting resin or like plastic material and a hardener therefor causing the same to set in situ. I have found epoxy resins such as bis phenol epichlorohydrin with a hardener such as a combination primary and tertiary amine to be quite suitable for the purpose.

An explosive charge indicated at 8 and comprising any desired medium such as for example nitroglycerine or the like is embedded in the lining 7 before it sets, and this is accomplished either by inserting the explosive into the plastic to displace the latter, or by inserting the explosive into the well bore and pouring the plastic thereover.

The explosive charge 8 preferably is selected to exert a strong compressive force, rather than a pure shattering effect, and is of such strength that it will substantially completely disintegrate the resinous lining 7. Then the lining 7 is permitted to harden and set, which might take several days depending on the nature and amount of hardener in the mixture which can be varied.

Thus, the lining 7 and explosive 8 together comprise a solid plug completely filling the well bore at the producing formation 3, thereby restoring that portion of the well to an equilibrium state simulating the undrilled condition thereof. In other words, that portion of the well is restored as far as possible to a condition resembling its natural condition before the well bore was initially drilled. The well bore then is filled in over the plug comprising lining 7 and charge 8, using water, oil, additional resinous or other suitable material 10.

Then, after the lining 7 has set, it is disintegrated by exploding charge 8, which fractures the surrounding producing formation 3.

I am aware that it has been proposed to line wells with various substances, and then perforate the lining as by

conventional gun perforators or explosive charges to provide channels through the lining to admit fluid into the well, with the lining otherwise remaining in place as a support for the well wall. This obviously does not provide the desired vertical fractures.

However, I propose first of all to restore the wall surface of the well bore, in the fluid producing region, to a condition of substantial homogeneity, in order to equalize the pressure thereon, and simultaneously to restore that portion of the well bore to an equilibrium condition by providing a temporary supporting lining resembling a thick walled cylinder having an explosive charge contained therein. Then, I disintegrate this lining by explosive means producing an extremely strong, intensified shock wave which ruptures the lining. The lining appears to react according to the concept of a thick walled cylinder and initially rupture predominantly in a vertical plane, and it is my belief, based on experiments using this method, that this tends to produce more nearly vertical fractures in the formation surrounding the lining.

Thus, in the natural course of drilling a well the differential hardness of successive rock strata produces varying diameters in the well bore, generally as a function of the varying rigidity of these layers. Shale layers in particular show a tendency to spall away and thereby increase the diameter of the well hole. This differential spalling off effect is magnified in wells which previously have been shot with explosives or other fracture methods.

With my method, when the coatings agent is introduced into the hole it is in the fluid state and will flow along the lines of least resistance and thereby fill all voids, fractures and fissures within the potential producing horizon. In this way the weakest sections, being those which have had the greatest spalling or erosion, receive the greatest quantity of coating agent, and the harder, stronger sections receive a thinner coating. By introducing enough coating agent to provide a lining within the well bore it will be appreciated that the agent which penetrates the voids, interstices and the like will restore the well wall to a more homogeneous condition, which I believe is more favorable for producing vertical fractures.

The filling agent, in addition to producing a condition of greater homogeneity, is believed possibly to have some tendency to selectively plug the well bore surface at the producing formation by flowing into the more porous and permeable layers which usually give up their oil, or whatever fluid is being sought, first and which thereafter act as preferred channels for a flooding agent introduced to create artificial pressure. This would tend to prevent flooding of the well through these channels, thereby increasing the efficiency of the flooding agent on the remainder of the producing horizon, because the deeper penetration thereof by the coating agent is less apt to be disturbed by the explosive force. The low porosity, low permeability strata is apt to be hardly penetrated at all, and it is these latter horizons which usually retain the reserve oil saturations being sought.

Similarly, it is believed that a measure of natural selective shooting is provided, because the stronger, less permeable and porous areas, which are most apt to hold back their oil, have the thinnest coating and therefore are exposed to the shock force first.

In accord with my invention, the lining is disintegrated and therefore provides only temporary, substantially instantaneous support to the well bore wall, the only resinous material remaining being that which has penetrated the interstices of highly porous flooded out sections. At the same time my method provides deeper penetration into the producing horizon and therefore opens it up better, and the tendency to align the fractures vertically takes advantage of the weight of the strata thereabove to hold the fractures open and avoids the necessity of introducing propping agents for this purpose.

Further to this end I find that the material comprising the lining 7 apparently should be stronger than the sur-

rounding producing formation 3, and in addition the charge 8, or its container, preferably is intimately bonded to the lining 7 with no void therebetween. The greater strength of the lining, relative to the surrounding producing formation, appears to give a better fracturing action, and the direct contact between the explosive and the solid lining greatly intensifies the explosive force and provides a shock wave of the desired amplitude.

The shock wave developed by the explosive charge 8 is contained, confined and reflected by fill 5 and 10, and I believe that it can be further intensified by placing reflective layers 9, of steel, lead, limestone or other material having good wave reflecting characteristics, at the opposite ends of lining 7.

It is impossible, at this time, to be certain of the theory underlying my method, but I believe that the initial shock wave travels through the lining 7 at great velocity and is reflected back at the outer wall of the lining adjacent the producing formation 3 placing the lining and the adjacent producing formation under tension. I believe that the development of tensile stresses produces or at least has a tendency to produce vertical fracturing. In this regard it is noted that the fluid filling agent tends to maintain fluid at its contact with the wall of the well bore and provide a film of moisture on the surface thereof which I believe tends to lower its tensile strength.

It might be possible, once the lining 7 has hardened, to drill a hole therein and fit the charge 8 in the hole in a manner such that a tight bond is achieved between the line 7 and the charge 8. However, it is felt that it would be nearly impossible to do this and still maintain the bonding required between the material and the explosive, and therefore it is preferred to either insert the explosive charge 8 into the lining 7 when it is in a plastic condition and displace the same, or to pour the plastic lining material over the explosive.

In this regard, a particular feature of practical importance lies in the simplicity of the invention. No complicated machinery or expensive equipment is required because the plastic forming the lining 7 can be introduced into the well bore in an ordinary dump bailer or sand pump. Also, none of the dangers associated with hydraulic fracturing exist in my method except those found in any well shooting operation. In addition, the cost of fracturing a well in this manner is far below that using conventional hydraulic fracturing equipment.

It might be possible to increase the shock force by properly selecting a filler agent for the lining material, such as barium titanate, quartz, salt, limestone or other material of various densities, to comprise one acting as a shock wave propagator and this might find use in seismic exploration as would the use of clear resin. In addition, while I believe that a resinous material is to be preferred for the liner, and particularly a high polymer resin which appears to assist greatly in the development of the desired shock waves, it is possible that other lining materials might find utility in this method such as for example sulfur which could initially be melted as by a heater or thermit bomb and then permitted to harden around the explosive. Also, while I believe that a hard lining is to be preferred, I contemplate that a viscous, plastic lining might, at least under certain circumstances, accomplish to some degree the purposes of my invention.

It will be appreciated that variations in the above described presently preferred method of this invention might occur to those skilled in the art without departing from the spirit of the invention or the scope of the appended claims.

Having fully disclosed and completely described my invention, together with the manner of carrying out the same, what I claim as new is:

1. The method of improving the production of a well having a bore extending into a fluid producing formation which comprises, filling the well bore in the region of the producing formation with a viscous plastic material

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adapted to solidify within the well bore and form a plug-like supporting lining for the wall thereof, embedding an explosive charge within said material in intimately bonded relation thereto, and exploding said charge after said material has solidified to disintegrate said lining and fracture the surrounding producing formation.

2. The method of claim 1, wherein the explosive charge is inserted into the filling material after it has been applied to the well bore and while it is in a plastic condition.

3. The method of claim 1, wherein the explosive charge is positioned in the well bore before it is filled with the plastic material.

4. The method of increasing the production of a well having a bore extending into a fluid producing formation comprising, filling the well bore in the region of the producing formation with a material adapted to harden in the well bore and provide a solid lining therefor at the producing formation, positioning an explosive charge in the region of the producing formation in a manner such that it is incased in said lining, said lining and said explosive means together completely plugging the well bore in the region of the producing formation, and substantially completely disintegrating said lining by exploding said charge.

5. The method set forth in claim 4, wherein said lining has a compressive strength substantially greater than that of the surrounding producing formation.

6. The method set forth in claim 4, wherein said lining has a tensile strength substantially greater than that of the surrounding producing formation.

7. The method set forth in claim 4, wherein shock

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wave reflecting means are provided adjacent the upper and lower ends of said lining.

8. The method set forth in claim 4, wherein the material of said lining comprises a high polymer thermosetting resin and a filler therefor.

9. The method set forth in claim 8, wherein said filler comprises a shock wave propagating material.

10. The method of increasing the production of a well having a bore extending into a fluid producing formation which comprises filling the well bore at the producing formation with a material adapted to form a supporting lining for the wall thereof, embedding an explosive charge within said material in intimately bonded relation thereto, said lining and said charge completely plugging the well bore at the producing formation, and substantially completely disintegrating said lining to fracture the producing formation by exploding said charge.

References Cited in the file of this patent

UNITED STATES PATENTS

2,236,836	Prutton	Apr. 1, 1941
2,246,611	Zandmer	June 24, 1941
2,316,596	Kennedy	Apr. 13, 1943
2,436,036	Defenbaugh	Feb. 17, 1948
2,599,245	Flinn	June 3, 1952
2,619,186	Carlisle	Nov. 25, 1952
2,703,528	Lee et al.	Mar. 8, 1955
2,704,514	Barlow et al.	Mar. 22, 1955
2,725,942	McCullough	Dec. 6, 1955
2,745,346	Aitchison et al.	May 15, 1956