June 24, 1941. S. M. ZANDMER 2,246,611

METHOD OF TREATING OIL AND GAS WELLS

Filed Oct. 12, 1936 2 Sheets-Sheet 1

Fig. 1

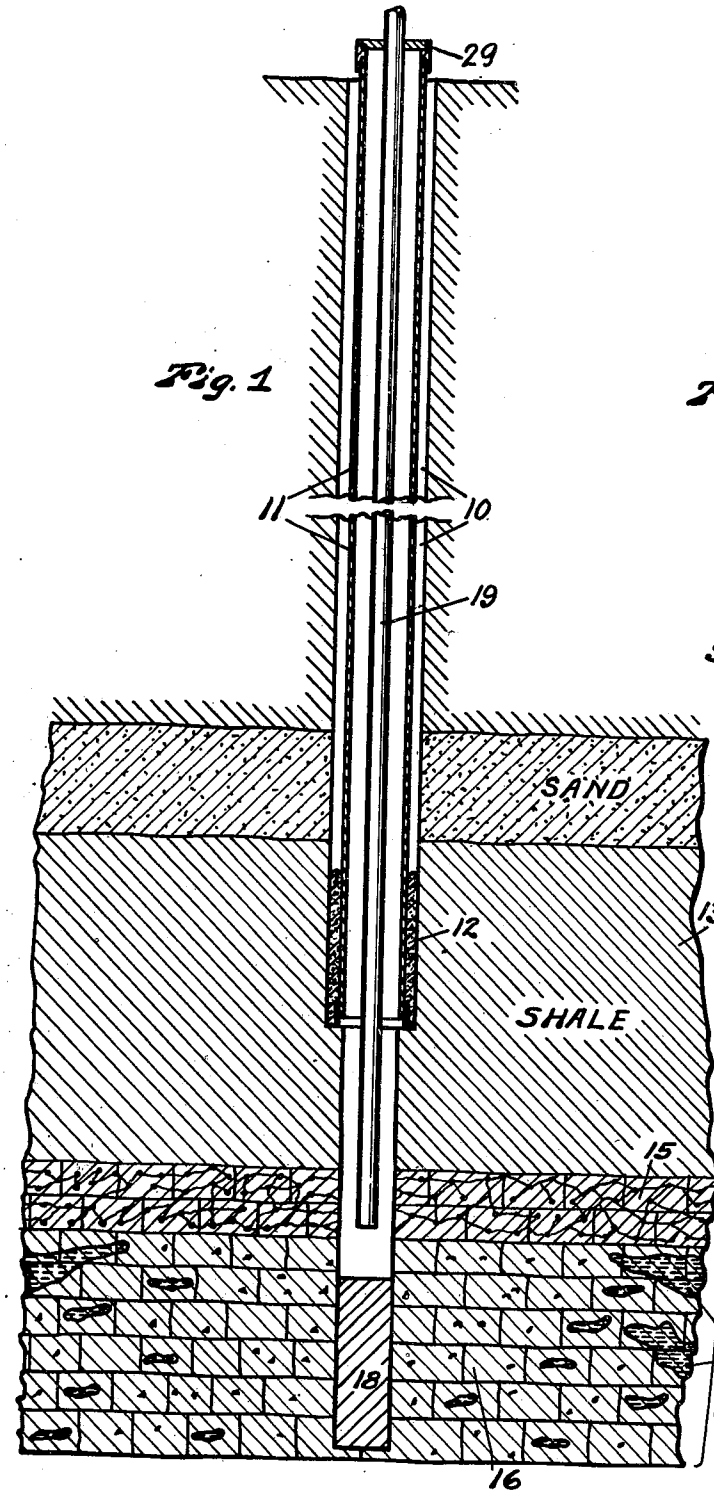
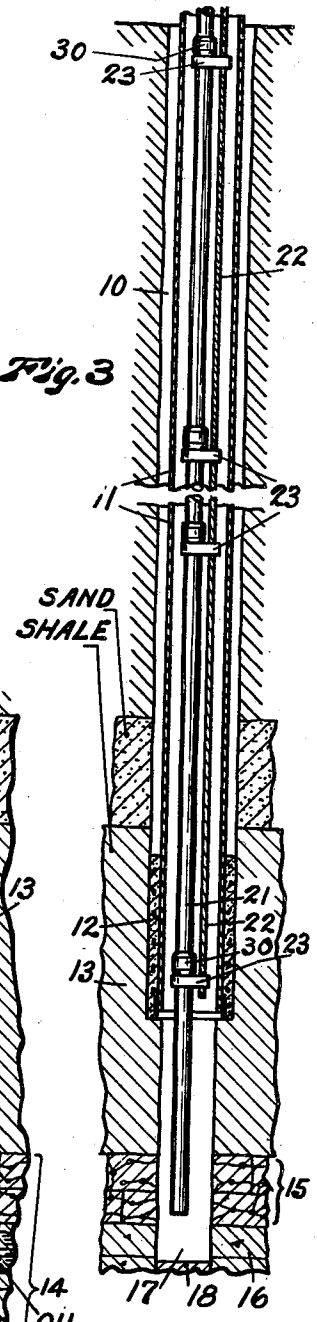


Fig. 3



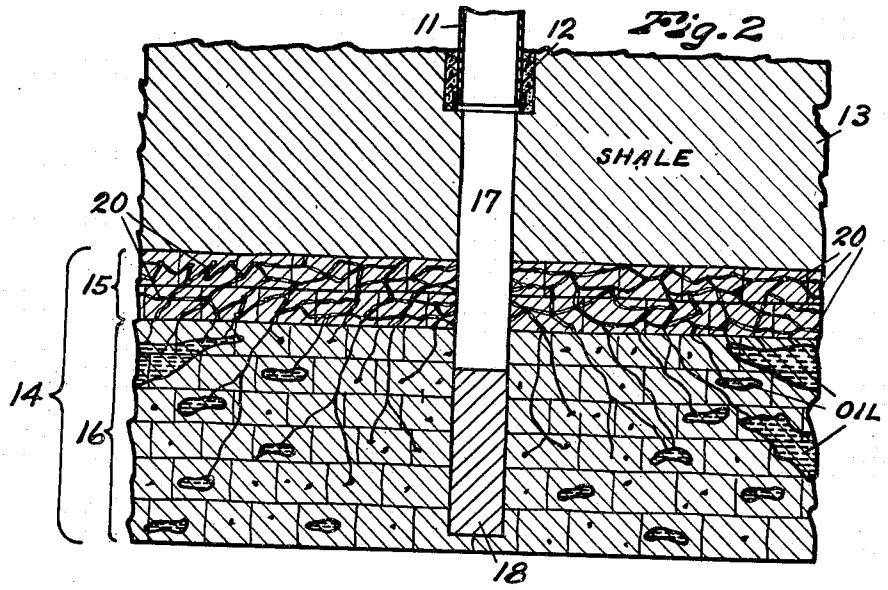
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Filed Oct. 12, 1936 2 Sheets-Sheet 2

Fig. 2



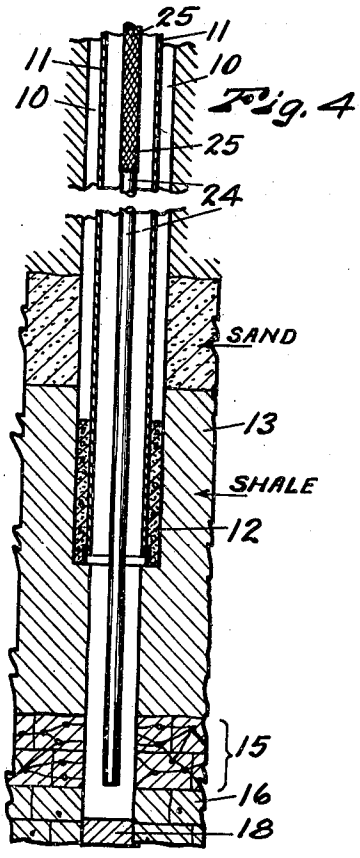


Fig. 4

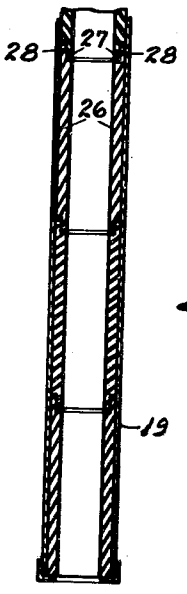


Fig. 5

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METHOD OF TREATING OIL AND GAS WELLS

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Application October 12, 1936, Serial No. 105,282

2 Claims. (Cl. 102—5)

My invention relates to the art of treating oil and gas wells. More particularly, my invention relates to a method of opening up passageways in the desired zone.

Particularly is it a primary object of my invention to open up passageways for an appreciable distance away from the bore hole or well to the end of substantially increasing the production of the oil or gas from the well.

Also, it is a primary object of my invention to provide a method for increasing the production of oil or gas wells comprising pouring the explosive into the well bore and causing it to go from the bore into the surrounding formation or country rock, and detonating the explosive while in intimate contact with said country rock.

My invention will be set forth as applied to an oil well. However, it must be remembered that oil wells produce oil and gas in greatly varying ratios, and also that oil is derived from various formations, although generally oil is found in an upwardly arched geologic structure which forms the trap for said oil. For purposes of greater definiteness in illustrating and setting forth my invention, I will describe the same as applied to a type of oil bearing limestone structure actually encountered. My invention is applicable to wells of variable gas-oil ratios.

Oil and gas accumulations, in a field in which limestone is a reservoir-rock, naturally are more prolific in areas in the limestone structure which contains the larger porosity (reservoir space for oil or gas). The history of limestone fields shows that these porous areas are spotted, i. e., isolated by areas of less porosity, or even by impervious areas, so that the condition of porosity in the particular place in which the bottom of a well bore reaches this productive limestone heretofore has determined to a large extent the quantity of oil and gas available to entry into the well bore. By the use of my invention I am now able to make these areas of porosity, which were previously isolated by more or less impervious areas, available for entrance to the well bore by opening up passageways to such isolated areas. Also by the use of my invention, I am able to open up interconnecting passageways in and to the less pervious producing area, so that more or less finely disseminated quantities of oil over extended areas, which would heretofore be unrecoverably held in the limestone formation, are now available for connection and entry into the well bore. Heretofore, the absence of sufficient fissures, avenues, openings, passageways and channels in the country rock immediately surrounding the well bore resulted in much of the oil in the producing formation not reaching the well bore. When such was encountered, very often chemical solutions were injected into the well to react with the producing formation to open up fissures and channels to permit the oil in the surrounding producing area to enter the well bore or well cavity.

The most common chemical method is that of acidizing. By this method, acid, such as hydrochloric acid where the formation is limestone, is pumped down tubing to the bottom of the well. Here the acid, generally held under pressure, eats its way through the various channels present into the surrounding limestone formation. New passageways are formed or the presently existing cracks or fissures are enlarged by the dissolving action of the acid until substantial channels are formed in the producing formation, which channels serve as outlets for the oil or gas.

The difficulty, residing in the use of chemical solutions to react with the formation surrounding the well, is that the chemicals will go mainly into the more porous gas zone, or at least to the zone from which the gas is escaping. Such chemicals, in taking the lines of least resistance, tend to enlarge the already existing porosity of the gas producing zone and do not substantially cause openings through the more impervious limestone portion wherein the oil is located especially if large quantities of gas are present.

There may not be sufficient porosity in the limestone surrounding the bore to permit the oil to flow into the well bore. However, the gas is invariably able to enter the bore even though the oil is held back by the relatively impervious character of the formation. It is the primary object of this invention to provide a method for increasing the porosity of the area surrounding the well bore so that such oil in porous areas remote from the bore, as well as the oil in the less pervious area, will be tapped and drained to the well bore even though the oil be at substantial distances therefrom and/or even though the oil is in the so-called impervious limestone.

Attempts have been made to use explosives to open up the formation surrounding the well, but in such attempts, the use of explosives has been confined to the well bore itself and not supplied to the country rock. The procedure in these attempts is to lower into the well an explosive in cylinders or canisters and detonate such explosive in the well bore while so contained in such cylinders or canisters. The extent of the detonation is limited because of the limited quan-

tity of explosive, which quantity is limited by the volume of the well bore opposite the productive zone to be treated. Likewise, the effect of the explosives is confined to the formation adjacent the well bore and often fails to render the well more productive.

In this regard, let it be noted that quite often a nonproductive or non-commercial well has been drilled in a productive limestone oilfield, said well being adjacent to or offsetting a large producing oil well. In many of these cases, it has been impossible by detonating an explosive in the non-commercial well bore to "break" or "connect" up this dry bore with the productive areas feeding the large producing adjacent well, as shown by the resultant failure of the explosive action to make a commercial producer of the non-commercial well. By use of my invention, the explosive will be sent from the non-commercial well bore into the country rock before detonating said explosive, and hence be closer to said productive areas feeding the large producing well and consequently have that much better chance to tap this area by being exploded closer to said oil productive area.

The common practice in drilling oil wells is to provide the well bore with casing (usually from 4" to 12" in diameter) to a point above the producing formation and then cementing the casing at its lower end, i. e., seal off communication between the bore and the space surrounding the casing above the lower end or "shoe" of the casing. Thereafter the drilling of the well is continued through the producing formation until the desired level is reached.

If the well is not productive or sufficiently productive, one method which was heretofore used in attempting to increase the production of a well was accomplished by the use of explosives. Explosives were lowered into the well bore and such explosives were exploded while in the well bore. This method is called "shooting" the well and in recent years has been substantially replaced by the acidizing process. The effect of the explosive was sometimes successful, but very often the action was local and no contact was made between the well bore and the more removed porous areas in the country rock. In these cases the well production was not materially increased.

In recent years the most common and accepted commercial practice used if the well is not sufficiently productive is that known as acidizing,—this because fissures or passageways can be opened up at more distant points from the well bore by such practice, as an acid under pressure affects more distant areas than did an explosive detonated in the well bore. The explosive which was detonated in the well bore failed to "crack-up" or reach into the formation which is distant from the well bore. In applying the acidizing treatment to a well, ordinarily a tubing is let down inside the casing and reaches substantially the bottom of the well bore. This tubing is made from sections of pipe, such as two or three inch steel pipe and the various sections secured together by screw type couplings. The well is then filled with oil and then the acid is pumped under pressure down this tubing to the bottom of the well and the pressure held to permit the acid to eat its way through the surrounding limestone formation and enlarge the existing cracks, openings and fissures for the purpose of increasing the porosity of the formation, and to reach into oil reservoir areas. Oftentimes this acidizing of a well fails to bring practical results because the acid tends to follow the more porous gas zone adjacent to the oil zone, and does not increase the oil productivity of the well.

In my invention I provide a method for placing and detonating an explosive in the surrounding formation, as distinguished from placing and detonating the explosive in the well bore itself, which results in greatly increasing the openings in the surrounding formation, despite the fact that such formation may be of the more solid and more impervious limestone. In other words, whether the acid has produced openings in the oil zone, or in the gas zone next to the oil zone, my invention provides for delivering explosive to and detonating the same in the said openings in the formation surrounding the well bore, thereby opening a fissuring system and hence a far greater drainage area is created and made available to the well.

In carrying out the above method, which is the subject matter of my invention, I find that special provision must be made for lowering the explosive into the well bottom. The tubing which has been heretofore used for acidizing the well may not be used to introduce certain explosive into the well bottom and from the well bottom into the formation surrounding the well. If it were attempted to introduce certain explosives into the well by means of the heretofore used steel tubing, there, of course, would be a thin film of the explosive adhering to the inside of the pipe and in the interstices formed by the abutting ends of the separate pipe sections as well as the threaded connections between the pipe sections. When the tubing so made up of such sections would be attempted to be removed from the well bore, it would be necessary to unscrew the various sections which form the tubing. In this attempt to unscrew such sections, the friction and heat created thereby would detonate explosives or at least would create too dangerous a situation. Obviously, such a practice would be unworkable, with danger to life of the operators to the extreme. Parenthetically let it be remembered that the nitroglycerin containers, even after they have been most carefully emptied, contain sufficient particles left so that a bullet striking near the seam at the base of the can will explode the can.

The above mentioned general objects of my invention, together with others inherent in the same, are attained by the process and apparatus therefor illustrated in the following drawings, the same illustrating a preferred exemplary form of application of my invention, throughout which drawings like reference numerals indicate like parts:

Figure 1 is a somewhat diagrammatic view in vertical section showing a well and a geological structure, with parts somewhat exaggerated for purpose of illustration, to which this invention may be applied;

Fig. 2 is a view similar to Figure 1, with the upper portion broken away, showing the geological structure after this invention has been applied thereto;

Fig. 3 is a somewhat diagrammatic view in vertical section, with parts broken away, of a well, showing a means for supporting therein a long flexible hose which would not be self supporting due to its great length;

Fig. 4 is a fragmentary vertical sectional view of the lower portion of a well showing therein a portion of a relatively long flexible hose which is reinforced, except for a section of its lower end portion to render said hose self-supporting where

relatively long lengths of said hose are used; and

Fig. 5 is a fragmentary sectional view showing a form of a lining, such as made from a phenol condensation product or Bakelite, to be lowered within the well casing.

In the drawings the drill hole 10 is provided with the usual casing 11. After the well has been bored the desired depth, such as when the productive horizon has been reached, the casing is cemented as indicated at 12. The distance, below the surface at which the casings are cemented, of course varies with each well. The drilling continues through the productive horizon or zone, which zone will vary in thickness with each individual well. Drilling may be continued through this zone until the well begins to produce gas and oil, or until it has been determined that sufficient productive formation has been drilled through to be included in a production test.

In illustrating my invention, I have indicated in the drawings the cap rock formation as at 13, and an oil producing limestone formation or country rock as at 14. In the limestone formation I have illustrated the upper pockets or relatively porous or gas producing area 15 and the lower relatively impervious oil producing area 16 in the country rock surrounding the well bore 17.

In my invention the well may be chemically treated by any of the usual means, such as providing acid through the tubing 19, to mention only the most usual method, to enlarge or open up fissures and passageways and the well then "cleaned" of the acid and reaction products thereof. Thereafter, if the well is not properly producing, an explosive in accordance with my invention is introduced into the well bore 17. Before introducing the explosive into the well bore, in most cases it is desirable to fill the bottom of the well bore 17 with a plug member 18 back to the porous or gas area 15 thereabove, so that the explosive is not resting on the well bottom, which may be near an underlying water horizon. The plug member 18 may be a material such as a tar product, which will be readily later removable and will keep the explosive off the well bottom and thereby prevent breaking the well bottom down into the water table or level underlying the oil level. If the explosive to be used is nitro-glycerine, then the well is filled with a liquid, such as water, in which nitro-glycerine is relatively insoluble and which has a specific gravity sufficiently less than the specific gravity of the nitro-glycerine so that the explosive will gently settle through it. Thereupon, a fluid explosive, as nitro-glycerine, is introduced into the well bore 17. The specific gravity of the nitro-glycerine is such that by fluid pressure the explosive may be gently floated down through the water to the well bore 17 and thence into the fissures and cracks in the surrounding country rock 14. Thereupon, the explosive is detonated and due to the fact that the explosive is distributed substantially in the various fissures and openings, the explosion or detonation of the explosive will open up the producing zones 14, 15 and 16 and provide sufficient avenues so that oil and gas products in the said producing zones, even at remote distances from well bore 17, will have access through these avenues to the well bore 17 and allow resultant oil and/or gas drainage to the said bore.

As one example of the type of well in which my invention has application, the following is given: A well was drilled to approximately 4,900 feet where shale was encountered. At this point the well was cemented in the usual manner as at 12. The drilling was continued to approximately 5,017 feet, at which point Madison limestone formation was reached. In drilling into this limestone formation, a flow of gas was encountered. Upon continued drilling the gas flow steadily increased until at the depth of 5,055 feet a flow of approximately two million cubic feet of gas per day resulted.

A bailer run into the well at this point bailed the first oil encountered in the well, but the oil would not flow from the well for the reason that the gas was above the oil and the gas merely entered the well and escaped without lifting the oil, which was present in such limited quantities that it did not rise to the gas level. The drilling continued until a depth of approximately 5,073 feet, and more oil continued to show, but still not enough to raise to the gas zone and be carried from the well by said gas. At this point the well was acidized in the usual manner in the attempt to make the well commercially productive.

In acidizing, the entire well is filled with oil and then acid pumped down the tubing to the well bottom and held under pressure to make it flow into the surrounding country rock. The last step in acidizing is to pump oil down the tubing to drive the remaining column of acid in the tubing into the formation so that when the acidizing job is complete the hole remains full of oil, both in the casing and in the tubing. This was done in the above mentioned well, in which case 4,000 quarts of acid were forced out of the well bottom into the country rock.

After permitting the acid to remain in the surrounding strata for a few days, the oil in the tubing was removed to a depth of approximately 1,800 feet, at which time the gas pressure forced the remaining column of oil out, and the well "cleaned itself," and removed the acid and reaction products thereof.

The result of this acidizing job was that some acid had eaten into the producing area, which resulted in an increase of oil, (although not in commercial quantities) so that the gas now actually produced a continual spray of oil in flowing from the well. However, in so acidizing, the acid flowed from the bore, for the most part, to the more porous gas producing area 15, taking the lines of least resistance and did not eat its way into the more solid and more impervious limestone country rock formation 14 and to the oil producing area 16, this being obvious from the fact that the gas production was considerably increased and the oil production only slightly increased.

The well was deepened through impervious limestone (as shown by the limestone samples recovered from this deepening operation) to 5,118 feet, i. e., about forty-five feet and a further slight showing of oil was encountered. The well was acidized again, but it was found that in supplying 6,000 quarts of acid to the well that no pumping pressure whatsoever was required, whereas in the first acidizing process while using less acid, the original pumping pressure had been as high as 1,000 pounds. This clearly indicated that the acid in the second acidizing operation mainly reentered the original gas yielding zone 15 (said zone lying immediately over the oil zone 16) in which it had previously eaten channels. This further acidizing did not substantially increase the oil production of the well, as it was not opening further channels, but merely flowing through the original channels which had been

created by the first acidizing, i. e., the liquid was following lines of least resistance.

In other words, at this point in the drilling and production of the well, the usual and commercially accepted method failed to open sufficient channels into the oil zone 16 or to increase the porosity to such an extent as to provide sufficient channels through the oil bearing zone 16, to the end of increasing the production to commercial quantities.

In connection with introducing the 6,000 quarts of acid in the above described second acid application, a quantity of oil amounting to 40 barrels (in excess of 6,000 quarts) was also introduced into the well and followed the acid out of the well bore 17. Also more oil could have been introduced into the well without requiring appreciable pumping pressure. All these facts establish clearly that there was an extended area immediately adjacent to and above the oil zone 16 in that particular case. Such an extended area will permit the introduction of a like large quantity of explosive therein.

In general, my invention provides and employs an explosive in the country rock 14 surrounding the bore 17 to open up channels in the oil bearing strata at places of substantial distances from the well bore. In such a well as just described, the nitro-glycerine may be deposited in the well bore 17, which has been filled with water and the nitro-glycerine will gradually and gently settle by gravity to the bottom of the well. From the bottom of the well, the explosive will move by fluid pressure into the fissures and openings in the formation which may be those naturally there or those opened by a chemical process, such as acidizing. Upon detonation of such explosive, the porosity of the well is substantially increased and openings are made through the solid and more impervious limestone formations.

In my invention I employ a fluid explosive in a mobile form, as nitro-glycerine, and by gravity and pressure force the explosive into the country rock 14 or formation surrounding the well bore and I detonate such explosive while it is in the country rock. This may be accomplished by detonating an explosive in the well bore 17, thereby causing a force to be transmitted to the explosive in the surrounding rock and detonating such explosive. This method results in opening up of fissures and openings 20, leading to the bore so that the production of a well may be increased far beyond that of anything accomplished by present methods. Of course, the tubing would be removed before detonation.

Ordinary well mechanics, which provides the necessary care in handling explosives so as to protect the casing and the equipment, as well as prevailing well mechanics in general, are not detailed here. Proper care in putting the explosive by fluid pressure into the formation will include holding the explosive in the bottom portion of the well bore 17 and not allowing it to rise into the casing. This protection is secured by having the space between the tubing 19 and casing 11 filled with water and closed at the well top by valves or gates, or the removable screw plug 29, shown in the drawings, so that no explosive supplied to the bottom of the well can rise appreciably up the well bore 17, so as to rise to the level of the base of the casing.

By pumping water down the tubing at the end of the process of introducing the explosive to the formation, said explosive will be completely displaced from the tubing by pumping water down the tubing, measuring instruments being provided to indicate the proper fluid volumes to accomplish this. By means of these accurate measurements and devices now in common practice in well boring to displace fluids in the well bore, all of the explosive will be in the country rock, except the small quantity which will be retained in the bottom portion of the bore, preferably in a sealed canister, so as to have in the bore only sufficient explosive to detonate the charge in the country rock, but not enough to injure the casing.

In the foregoing I have illustrated the application of my invention to one well, but it is to be understood that I am not to be limited to any such specific application. There will be different conditions in the wells, which will determine the best method of putting the explosive into the well bottom, and then from the well bottom into the country rock. In some instances it may be advisable to lower the explosive into the well bottom by lowering it in bailers with a valve on the bailers, so that the explosive will be released when the bailers reach the bottom of the well. Also in some wells it may be desirable to place the explosive in a container, such as a capsule. After the capsule is lowered into the well bore, the capsule may be dissolved by a suitable agent and the explosive will thereupon be released at the bottom of the well. In any of the above methods, the explosive is located at the bottom of the well and from there it is forced into the surrounding country rock and exploded in the country rock.

In Fig. 3 I show a preferred construction where a continuous rubber tube 21 without joints is supported by a wire cable 22. The rubber tube is connected to said cable by a clamp 30 connected with the rubber tube 21 and a connector means 23 connected with said clamp 30 and with the connector means 23. Thus there are no joints in which the explosive may lodge. A hose having joints between sections thereof, however, may be used as the hose is flexible and may be removed as a unit. The cable 22 thus supports the weight of the rubber tube 21. Otherwise the weight of the rubber tube involved in reaching the bottom of an oil well, such as of 5,000 feet or more depth, might be excessive, so far as the strength of the material is concerned and involve undue strain of the rubber and breakage.

In Fig. 4 a flexible tubing 24 is illustrated, which is reinforced by metal 25, such as wire. This character of tubing may be manufactured so as to be self-supporting, for use in great lengths for suspension in wells.

Either of these types of tubing 21 or 24 shown in Figs. 3 and 4 may be employed for introducing the explosive into the bottom of the well. The explosive may be introduced into the well down such a tube. This tubing may be provided on large drums and therefore will present no problem in removing.

In Fig. 5 a lining 26 is illustrated, which may be made from a phenol condensation product, or Bakelite. This lining would fit within the well casing, such as inside of the tubing 19, and would be made in sections, preferably corresponding in length to the lengths of the sections of the tubing 19. The union of the sections of the lining 26 may be provided by having telescopically interfitted end portions 27 and 28, i. e., the sections will have no threads and therefore there will be no friction involved in removing these sections from each other, and at the same time this lining will serve to exclude the explosive from coming

in contact with the threaded portions between the sections of steel tubing 19. By such means, a lined steel tubing may be used and successfully removed from the well.

Obviously, changes may be made in the forms, dimensions and arrangement of the parts of my invention, without departing from the principle thereof, the above setting forth only preferred forms of embodiment.

I claim:

1. The method of increasing gas and oil production from a well drilled in oil bearing limestone, comprising the step of introducing a chemical agent into the fissures in the surrounding country rock to increase the size of said fissures; the step of removing said chemical agent and the reaction products of said chemical agent with said country rock; the step of substantially filling the well bore with a liquid; the step of introducing into said liquid an explosive in a liquid state, said explosive in the liquid state being characterized by having a specific gravity greater than said liquid in the well bore, whereby the said explosive in the liquid state settles slowly down the well bore through the said liquid to the well bottom and thence laterally into the fissures in the surrounding country rock; and the step of detonating said explosive in the fissures in the surrounding country rock.

2. The method of increasing oil and gas production from a well drilled in oil bearing zones, comprising drilling the well bore into the gas bearing strata positioned above the oil bearing strata; introducing a chemical agent into the fissures in the gas bearing strata to increase the size of said fissures; the step of removing said chemical agent and the reaction products of said chemical agents with the country rock forming said gas bearing strata; the step of substantially filling the well bore with a liquid; the step of introducing an explosive in a liquid state into the liquid in the well bore, said explosive in the liquid state being characterized by having a specific gravity greater than said liquid in the well bore, whereby the explosive settles downwardly through the liquid to the bottom of the well bore and into the fissures in the gas strata; and the step of detonating said explosive in the fissures in the gas strata, whereby upon the detonation of said explosive openings are caused to extend from the oil bearing strata into the gas bearing strata.

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