166-307 CROSS REFERENCE SEARCH ROOM

Oct. 6, 1964 J. KARPOVICH ETAL 3,151,679
METHOD OF FRACTURING AN EARTH FORMATION
WITH A FRANGIBLE IMPLODABLE DEVICE
Filed Jan. 20, 1960 3 Sheets-Sheet 1

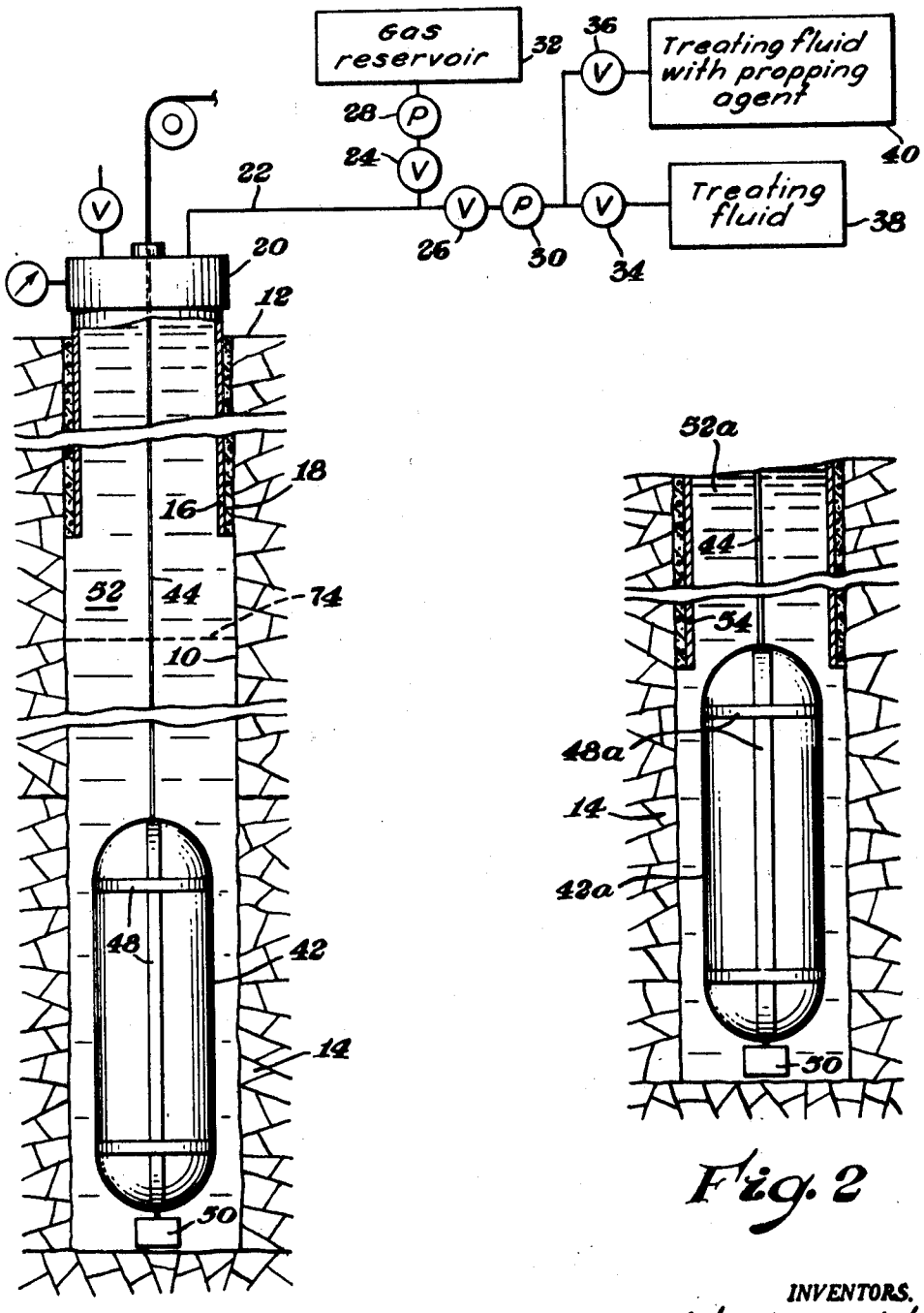


Fig. 1

Fig. 2

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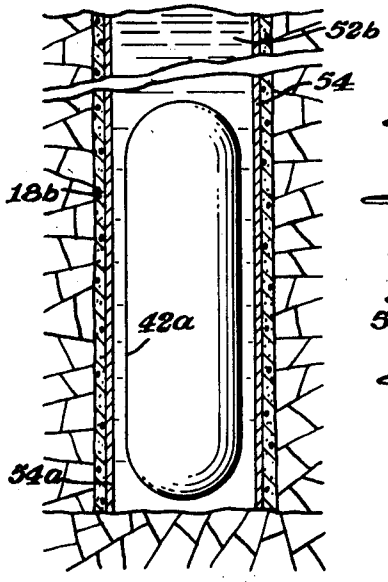


Fig. 3

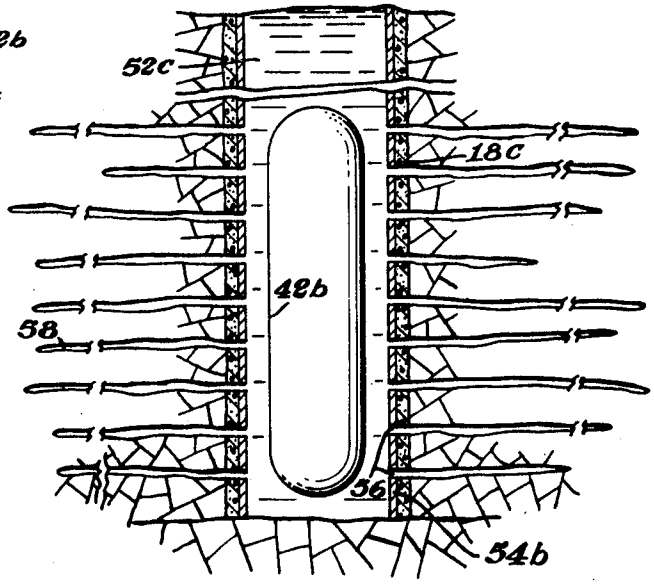


Fig. 4

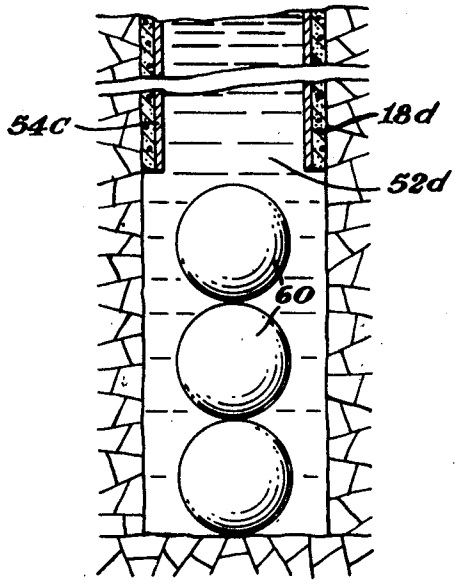


Fig. 5

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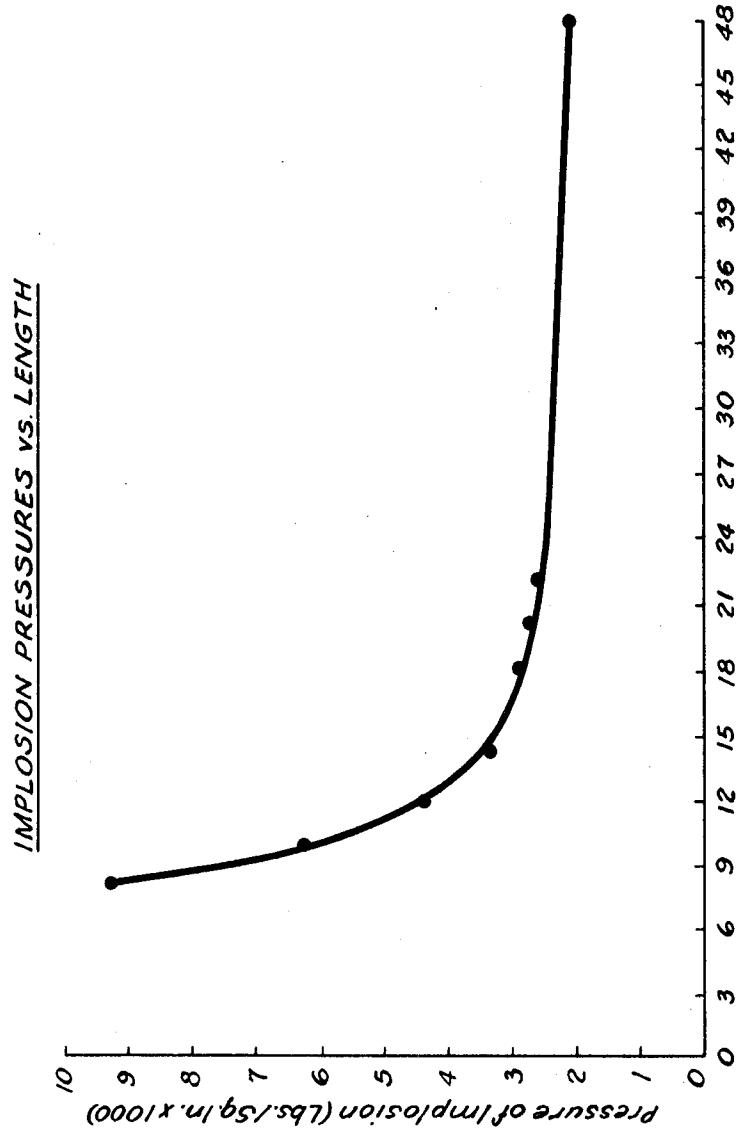


Fig. 6

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METHOD OF FRACTURING AN EARTH FORMATION WITH A FRANGIBLE IMPLODABLE DEVICE

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7 Claims. (Cl. 166—42)

This invention relates to a method of treating bore holes in earth formations and particularly to a method of treating bore holes and the adjacent earth formations wherein a cavity or liquid-free space in the bore hole is collapsed while a fluid column in the bore hole is under pressure.

Known well treating methods for fracturing earth formations have attained a high degree of acceptance in the industry. However, the producing formations of some wells have not been fractured because the casing and/or tubing of the well have not been able to withstand the severe pressures required to cause such fractures or breakdown of adjacent earth formations.

In other wells it has sometimes been very difficult to assemble at the well head equipment which has the capacity to pump at the rate required to attain the high pressures needed to cause fracturing of the sub-surface formation penetrated by the well.

In another aspect of well servicing, well casing has been perforated in the past by means of bullet projectiles and by means of so-called shaped explosive charges. Such explosive means are inherently dangerous to use, but non-explosive perforating means heretofore proposed have been somewhat slow, inconvenient, or expensive to use.

Accordingly, a principal object of this invention is to provide an improved method of servicing an earth well wherein a so-called cavity in the bore hole is collapsed.

Another object of this invention is to provide an improved method of fracturing an earth formation which is penetrated by a bore hole.

An additional object of this invention is to provide an improved and/or safer method of perforating the casing in an earth well at a predetermined position along the casing.

An ancillary object of this invention is to provide an improved method of increasing the permeability to fluid of the earth formation penetrated by a well bore.

Yet another object of this invention is to provide an improved method of cementing earth wells.

A still further object of this invention is to provide an improved method of acidizing earth wells.

In accordance with the method of this invention a substantially empty space or void in a compressed fluid column comprising liquid in a bore hole is maintained at a desired position along the bore hole. The boundary of the empty space or void is suddenly ruptured or removed by means of hydraulic pressure or a liquid transmitted shock wave, permitting liquid of the pressurized column to move rapidly into the empty space. The high velocity with which the column moves into the space in the bore hole produces very high localized pressures, in effect producing a liquid hammer of high intensity.

The invention, as well as additional objects and advantages thereof, will be best understood when the following detailed description is read in connection with the accompanying drawings, in which:

FIG. 1 is a diagrammatic view of an earth well in which a sealed frangible implodable "capsule" or vessel, e.g., glass, is disposed in open hole adjacent to an earth formation to be treated in accordance with the invention;

FIG. 2 is a fragmentary diagrammatical view showing a frangible implodable capsule disposed in open hole below the casing of the bore hole;

FIG. 3 is a fragmentary diagrammatical view showing an implodable capsule disposed along the casing of an earth well adjacent to a producing formation;

FIG. 4 is a fragmentary diagrammatic view showing an implodable capsule disposed beside perforations in a well casing;

FIG. 5 is a fragmentary diagrammatic view showing a plurality of spherical implodable vessels disposed in open hole below the casing of an earth well, and

FIG. 6 is a graph showing imploding pressures for frangible vessels of fixed diameter and wall thickness and of various lengths.

Referring to FIG. 1, there is shown a well bore **10** which extends from the surface **12** of the earth into an earth formation **14** which is to be treated. Surface pipe **16** is set in the bore hole **12** and is cemented (as at **18**) in place. A casing or control head of **20** of suitable type capable of being opened to pass through enclosed vessels having a diameter only slightly smaller than the diameter of the casing.

Coupled to the header **20** through the line **22** and valves **24**, **26** are pumps **28**, **30**. The pump **28** is coupled to a gas reservoir **32**. The pump **30** is coupled, through valves **34**, **36** to a reservoir **38** of treating fluid, and a reservoir **40** of treating fluid comprising liquid and a propping agent, respectively.

An implodable vessel **42**, made of frangible material such as glass or cast iron for example, is lowered into the bore hole on a cable **44** that passes over a sheave **46** and is secured to a draw works (not shown) and positioned adjacent to the part of the earth formation which is to be treated. The vessel **42** is an elongated frangible tube having its ends closed and sealed generally in hemispherical form, and is usually as large in diameter as may be conveniently lowered into the well bore without damaging the walls of the vessel. The length of the vessel is a matter of choice and may be from a few inches to several feet, but in any case, the vessel occupies a space sufficient to nearly equal, but always less than, the volume by which the liquid column in the well will be compressed in carrying out the treatment. The wall thickness and configuration of the vessel are chosen so that implosion of the vessel occurs when a desired external liquid transmitted pressure is applied thereto. A strap-like frame **48** surrounds the vessel **42** and has a weight **50** at the lower end of the frame. The weight **50** is at least sufficient to overcome the buoyancy of the vessel **42** and its frame.

In operation, as illustrated in FIG. 1, the sealed implodable vessel or so-called capsule **42** in its strap-like frame **48** with weight **50** attached is lowered on the cable **44** down the bore hole **10** to a position beside that part of the earth formation which is to be treated. The bore hole may be either empty or more or less filled with liquid **52** as the vessel **42** is lowered into position.

The length and wall thickness, type of glass, ceramic or other frangible material of which the vessel is made, diameter of the vessel with respect to the diameter of the bore hole (casing diameter if well is cased) at the point where the vessel is disposed at the time of implosion of the vessel, the volume of the vessel compared with the volume, pressure and length of the fluid column in the bore hole are among the factors which must be considered when choosing vessels which, when imploded, will result in the occurrence of pressure sufficient to fracture or assist in fracturing the formation.

The manner of choosing an implodable vessel for a specific treatment situation will be discussed in more detail later.

In the treatment situation described below it is desired to fracture the earth formation beside the implodable

vessel and an implodable vessel of suitable capabilities is assumed to have been lowered down the well bore.

After the implodable vessel is in position in the well bore, the bore hole **10** is preferably completely filled with liquid (if not already so filled) which preferably contains a fluid loss preventative agent (e.g., U.S. Patent 2,779,735) and the fluid column placed under hydraulic pressure by means of the pump **30**, for example, which is coupled through the valve **34** to the reservoir of treating agent liquid **38**. Gas may desirably be added, in some well treatments, to the fluid column in the bore hole by means of the pump **24** or other suitable means. The pressure on the fluid column is increased, thereby compressing it, until the vessel **42** implodes as a result of being subjected to said pressure, at which time the fluid column expands and moves in to fill the fluid-free space formerly bounded by the capsule walls.

Tests have shown that when cylinderical frangible "capsules" having hemispherically shaped ends are under a high degree of compression as exists in the well bore during a well treatment in accordance with this invention, the capsules shatter into small particles when imploded by hydraulic pressure. The walls of the liquid free space are thus quickly and effectively removed upon the implosion of the "capsule" permitting the expanding fluid column to move suddenly into the now available space with little or no deflection by any part of the imploded vessel.

At the moment the compressed fluid column expands it rushes into and fills the space formerly occupied by the vessel **42** thereby creating a shock wave and concomitantly a very high pressure is thereby created and transmitted by the liquid to adjacent objects, e.g. the well bore, as with a liquid hammer because of the sudden arresting of movement of the considerable mass and high velocity of the expanding column.

The high pressures described above have produced so-called fractures in the earth formation adjacent to the position of the vessel **42** even though the pressure on the fluid column in the well bore just before the time of implosion of the vessel **42** is considerably less than the hydraulic pressure conventionally required to produce such fractures. Further, the localized high pressure which results from the implosion and causes the fracturing of the adjacent earth formation does not damage the casing lying above the vessel **42** even though the localized pressure adjacent to the location of the implosion may exceed the pressure which may be withstood by the casing.

While FIG. 1 illustrates the invention as practiced in open hole when anly surface pipe has been set in the well, the treating situation illustrated in FIG. 2 is more common.

As shown in FIG. 2, the well is cased and the casing cemented in place near the part of the earth formation to be treated. The vessel **42***a* is suspended in its retaining "frame" **48***a* on a cable **44** below the casing and is to be imploded while in that position. The procedure followed in imploding the vessel is the same as described in connection with FIG. 1.

In one specific example of a well treatment in accordance with this invention, the well is completed in a gas producing formation at a total depth of 1022 feet. The well contains 5½ inch 14 pound J–55 steel casing to a depth of 985 ft. The casing is set with 20 sacks of cement. Before the well treatment the well made only a small (not over 20,000 cu. ft./day) show of gas. Attempts had previously been made to hydraulically fracture the gas containing formation by pressurizing the well with liquid in conventional manner but the formation would not fracture at a hydraulic pressure of 4,000 pounds per square inch, which is close to the bursting pressure (nominally 4270 lbs./sq. in.) for the well casing. A 4 inch diameter by 24 inch long borosilicate glass vessel was lowered into the well to a depth of 995–997 ft. The bore hole was dry when the vessel (cylindrical with hemispherical ends) was lowered, but fluid could have been in the bore hole, if desired. In fact, having the vessel at least covered by liquid before liquid is pumped down the casing towards the vessel prevents undue bouncing of the vessel against the casing wall.

The well was then filled with water (with formation gas entering the casing) and the pump **30** continued in operation (pumping barrel/minute) until the gauge pressure at the surface was 1500 pounds per square inch, whereupon the vessel imploded because of the hydraulic pressure exerted upon it. This means that the vessel had a pressure of 1930 p.s.i. on it due to the pump pressure and hydrostatic head of the fluid column in the well. On implosion of the vessel the pressure at the well head immediately dropped back to 1,100 p.s.i. and then increased momentarily to 2300 p.s.i.

Following the implosion, the pump maintained a pumping rate of about one barrel per minute and the pressure dropped to 700 p.s.i. and remained steady at that pumping rate. When the pumping rate was increased to about two barrels per minute, the gauge pressure at the well head rose to 1,100 p.s.i. The pumping rate was then increased to five barrels per minute which was the highest rate at which the pump would operate and the maximum gauged injection pressure at that injection rate was 1,600 p.s.i.

It was thus concluded that a fracture had been caused by forces set in action by the imploding vessel. Two days after the treatment the well was gauged at 57,000 cu ft./day, which was about average for the field. Seven days after the treatment the well was flowing gas at the rate of 140,000 cu. ft/day. A few days later the flow rate exceeded 200,000 cu. ft/day, making the well among the best producers in the field (these better wells were first shot with nitroglycerin).

Referring now to FIG. 3, there is shown an implodable vessel **42***a* positioned in a cased well. For the sake of simplicity no positioning means such as weight, frame, or cable is shown. When a vessel of suitable capabilities is used, well casing **54***a* may be burst adjacent to the vessel by placing the fluid column in the casing under sufficient pressure to implode the vessel. While the perforation or perforations produced by this method are not round, they are, none the less, useful, and the danger of premature explosion which is inherent in conventional perforating practices is eliminated.

While the vessels **42***a* may be evacuated if desired, sealing the vessels at somewhere near atmospheric pressure eliminates the hazard of flying particles (glass) which would be hazardous if one or more of the vessels in evacuated condition were accidentally dropped or otherwise imploded above ground. The gas atmosphere in the vessel may be that of a vaporized liquid, e.g. water, or a so-called non-condensible gas, e.g. air, N_2 or other gas which is soluble or insoluble in the liquid in which the vessel is imploded. A vessel which is evacuated or contains a gas which is soluble in the liquid of the well column would tend to decrease any cushioning of the liquid which rushes in at the moment of implosion. In instances where it is desired to resonate the fluid column or to more efficiently direct the forces of the liquid hammer following implosion, non-soluble gas may be introduced into the vessel at a minor fraction of the fluid column pressure required to implode the vessel.

FIG. 4 shows an implodable vessel **42***b*, illustrated without any positioning means for the sake of simplicity, disposed beside a number of perforations **56** in a well casing as, for example, in making an acidizing treatment in accordance with this invention. The capsule **42***b* is imploded by hydraulic pressure or liquid transmitted shock wave to provide localized pressure high enough to break down the formation prior to pumping acid solution, for example, into the formation.

FIG. 5 illustrates a plurality of implodable hollow vessels **60** disposed in open hole below well casing **54***c*.

Although the vessels are spherical in form, they could, of course, have other configurations. The vessels could be lowered and maintained in position by means such as illustrated in FIG. 1, but such means are not shown for the sake of simplicity of the drawing. The vessels **60** are imploded by means of hydraulic pressure, for example, as discussed previously. In practice one vessel will usually implode before the others, but the force of that implosion, transmitted to the other vessels, immediately causes the implosion of the remaining vessels.

Incidentally, although the implodable vessels have been illustrated as being disposed at the bottom of wells, it is realized that in many instances the vessels may desirably be located elsewhere along the well bore.

While it might be suspected that vessels having large liquid free volumes would produce the best or most powerful reaction in a well being treated, such is not always the case. It is desirable that the increased volume of fluid present in the fluid column in the well bore due to the compressibility of the fluid column plus the volume of liquid in the fluid column due to expansion of the casing from the pressure of the liquid in it should be at least twice the amount necessary to fill the liquid free space to insure a powerful or more effective reaction when the vessel implodes under hydraulic action. This is an empirical limit based on a limited number of well tests, but is believed to be reasonable for field treatments.

From the above it will be realized that advantage is taken of the spring action due to the compressibility of the fluid column in the well bore and the expansion of the casing to substantially increase the velocity of the fluid column at its lower end as it rushes in to fill the liquid free space as the vessel implodes.

If formation fracturing is to occur in an efficient manner, the implodable vessel should be of such diameter as to permit only a relatively small amount of fluid between the vessel and the casing or wall of the well bore.

In order to produce a fracture in the formation, the pressure caused by the liquid hammer must exceed the pressure necessary to lift the overburden plus the force to overcome the tensile strength of the formation and the compressive strength of the formation to be treated. While no set pressures can be stated here in connection with the fracturing of particular wells, the fracturing pressures are usually capable of estimation based on the fracturing pressures in other wells in the field in which the well to be treated is located.

As a rule of thumb, a vessel for a fracturing treatment should be chosen whose volume is within the limits defined above and which will implode at a pressure at least half of that pressure which is required to fracture the formation. It is, of course, realized that liquid hammers produced in well bores in accordance with this invention may result in pressures many times in excess of the hydraulic pressure applied on the fluid column on pumping fluid into the well bore. Well treatments are not always conducted under ideal theoretical conditions, however, and in many treatments the pressures realized may be only a small fraction of the pressure which is theoretically possible. The implosion in accordance with this invention may be effected within and under pressure of any of the liquids conventionally used in well treating operations, taking due precautions to control fluid loss if necessary.

FIG. 7 is a graph which shows the imploding pressures for cylindrical vessels having a nominal outer diameter of four inches, a nominal wall thickness of $\frac{3}{16}$ inch and generally hemispherical ends. The capsule shaped vessels which were imploded in obtaining the data for the graph were made of a conventional formulation of borosilicate glass, suitably annealed after the vessel is made, and were all sealed in the same manner. Variations in manufacturing controls indicate that the implosion pressures may vary plus or minus ten percent from the implosion pressures indicated on the graph.

Vessels whose diameter is close to the diameter of the casing or bore hole are best for use in fracturing but vessels of smaller diameter are useful in fracturing treatments under many conditions.

In practice the weight **50** is often placed just above the vessel, rather than below it as illustrated in FIGS. 1 and 2. The vessel seems to lower into the well without difficulty with the weight above it and there is more assurance that the weight can be recovered after the treatment when the weight is in the upper position.

Another way of securing the vessel at the proper place in the well is to use the buoyancy of the vessel to hold it in position when secured by a light line to a weight resting at the bottom of the hole. The vessel is thus inserted by dropping it into a bore hole which is more or less filled with fluid and letting it settle to the bottom of the well.

To prevent inadvertent scratching of the glass or other frangible surface of the vessel on the way down the bore hole, at least the side surfaces of the vessel may be coated or covered with a thin buffer layer of material, such as polyvinyl chloride or rubber, for example, which will protect the side walls yet will not adversely affect the attainment of the desired effects of the implosion.

It should also be recognized, in a "fracturing" treatment with the above surface apparatus as in FIG. 1, for example, that following the implosion of the vessel **42** and the subsequent increased injection of liquid into the fractured earth formation, treating agent with propping agent such as particulated sand, for example, may then be pumped into the well bore and injected into the formation either before or after the cable **44** is removed from the well bore. Alternatively, the capsule may be imploded in the presence of fluid containing a propping agent such as a jelled fluid having sand in suspension, for example, as in Reissue 23,733.

A modification of the embodiment shown in FIG. 3 may be used to advantage in treating cased wells which cannot withstand the hydraulic pressures necessary for conventional fracturing operations or where fracture treatments or formation break down at more than one position along the well bore are to be given.

In the treatment situation where the casing can stand only low pressures, an implodable vessel, which implodes at an external hydraulic pressure the well can withstand, is disposed adjacent to (or within several feet of) and preferably above a second vessel which will implode at a higher external pressure. The pressure increase resulting from the imploding of the "low pressure" vessel will then implode the second or higher pressure vessel which in turn results in the fracturing or formation stimulation of the earth formation adjacent to it.

In the treatment situation where multiple fracture zones are wanted, a plurality of implodable vessels are spaced apart (attached in "cages" as shown in FIGS. 1 and 2, for example and secured to a cable in the well bore) along the well bore beside the sections of the formation to be fractured or broken down. Preferably the upper implodable device or vessel is one which will implode at a pressure lower than that which is required to implode the vessels disposed lower in the well bore. The vessels may be closely spaced as shown in FIG. 5 or spaced as far as fifty to one hundred feet apart, for example.

Such a disposition of vessels and the technique for imploding them finds use where two sections of earth formation are to be fractured, for example, because situations have been encountered where once one section of formation has been fractured (whether in a cased well or in open hole) it has been found difficult or impossible to pressurize the fluid column of the well sufficiently to implode a later positioned second implodable vessel.

In well treatments heretofore described the fluid column in the well bore at the time of implosion of a vessel **42** has been either a liquid or a liquid having a gas dispersed therein to increase the compressibility of the fluid column.

It should be realized, however, that most of the fluid column in the well may be liquid with the remainder or upper part of the column being compressed gas (as injected from the reservoir **32** by means of the pump **28** shown in FIG. 1). Alternatively, only a small part of the fluid column need be liquid provided there is at least sufficient liquid to more than fill the space occupied by the capsule to be collapsed, that is, at least enough liquid should be in the well to cover the vessel up to and including the time of implosion of the capsule or implodable vessel (based on the assumption that some liquid may be lost into the formation prior to the implosion), the remainder of the column being compressed gas, for example.

Best results are achieved when the amount (volume increase) of expansion of the casing and compression (volume decrease) of the pressurized fluid column at the time of the implosion of a capsule, together exceed the volume of the capsule.

Other means of placing the fluid column under compression include burning a gas producing squib either in the well casing or externally of the well but coupled thereto. Also, in some places gas is present in the field under high pressure in pipe lines. In such cases, the line, if under suitable pressure, may merely be coupled to the well under treatment. Also, in fields where water flooding is done, water from the pipe lines often is available where the water pressure is sufficient to implode vessels suitable for well treatment.

It is also practical to implode the implodable vessel using only the hydrostatic pressure obtained by a liquid column in the well bore, assuming the pressure on the capsule or vessel is high enough as, for example, in a deep well.

Liquids which are useful in the practice of the invention include the petroleum oils either crude or refined and any available water including sea water and brines, aqueous solutions of acid, e.g. 15 percent hydrochloric acid, cement slurries as used in squeeze cementing, emulsions, and drilling muds either oil or water based. It is advantageous to use as the liquid a solution of a soluble gas under pressure where the pressure retaining the gas in solution is at least close to the pressure to be applied against the space to be imploded.

An example of this is a solution of methane in petroleum oil, the vapor pressure of the methane over the solution being in the order of the implosion pressure to be used. Another example is a solution of carbon dioxide in water with similar gas pressure requirements. Such solutions have the advantage of being able quite suddenly to sustain the hydraulic pressure in the well hole following the implosion when dissolved gas exerts its partial pressure on being evolved from the solution.

It is also possible to carry out the method using mixtures of a substantially insoluble gas and a liquid as by the use of foams or a two-phase system as distinguished from the single phase gas solution systems above exemplified.

As an example of the two-phase gas containing system, there may be cited a foamed liquid column, e.g. water having air bubbles dispersed therein. In this system the foam is put under sufficient pressure to more or less collapse the foam. Subsequently, when the capsule collapses, the gas (e.g., air) bubbles expand following the implosion and tend to sustain the hydraulic pressure in the well hole.

With any of the types of liquid systems above mentioned, viz., plain liquids, solutions of a gas in a liquid, two-phase systems, such as the emulsions, foams, and slurries, the method can be carried out either with the well completely or partially filled as already indicated, the remaining space being occupied by a gas, e.g. air, natural gas, etc., an subjected to pressurizing when the implosion is to be effected.

Partially filling the well and thereby leaving a gas space above the liquid column has the advantage of conserving liquid and providing a more sustained driving force on the column following the implosion. Reference to FIG. 1 illustrates this practice in which the liquid column may occupy the lower portion of the well and extend to a level **74**, for example, well above the vessel **42**. The space in the well above the level **74** is filled with gas which may be pumped into the well through the line **22** by means of pump **28**, valve **24** being open and valve **26** being closed.

While the invention has been described in connection with the lower end of the fluid column being the moving end, such description is done only by way of example. It is recognized that the implodable vessel or vessels may in fact be disposed within a compressed fluid column in such a position that, on collapse of the vessel or vessels, parts of the fluid column above and below the vessel will move in to fill the cavity produced by collapsing the vessels.

Likewise, well treatments made in accordance with this invention may be made with a capsule disposed in a compressed fluid column disposed between two packers set along the well bore (one of which is usually a packer between tubing and casing) or between a packer and either the bottom or the upper part of the well bore.

What is claimed is:

1. A method of fracturing an earth formation which is penetrated by a bore hole which communicates with said formation; comprising lowering into said bore hole at least to the approximate depth of the formation to be fractured at least one completely frangible implodable device which implodes when pressure of a predetermined range is applied thereto while said bore hole is filled with liquid to at least slightly above said formation to be fractured, subjecting said liquid to pressure sufficient to implode and shatter said device, and then pumping liquid into said formation.

2. A method in accordance with claim 1, wherein said implodable device is a hollow ceramic vessel.

3. A method in accordance with claim 1, wherein a substantial part of said liquid comprises an aqueous acid solution, the device being disposed in said aqueous acid solution.

4. A method in accordance with claim 1, wherein said device is evacuated.

5. A method in accordance with claim 1, wherein the internal pressure of said device is a minor fraction of the pressure of said liquid at the time of implosion of said device.

6. A method in accordance with claim 1, wherein the average transverse cross-sectional area of said device exceeds half the cross-sectional area of that part of the bore hole which is adjacent to said device.

7. A method in accordance with claim 1, wherein the minimum pressure of said predetermined pressure range is at least half of that pressure required to fracture said earth formation.

References Cited in the file of this patent

UNITED STATES PATENTS

2,361,558	Mason	Oct. 31, 1944
2,621,351	Piety	Dec. 16, 1952
2,712,355	Hoff	July 5, 1955
2,768,694	Moll et al.	Oct. 30, 1956
2,871,943	Bodine	Feb. 3, 1959