Jan. 14, 1958 C. J. CECIL ET AL 2,819,673

METHOD OF AND APPARATUS FOR OPENING OIL-AND GAS-BEARING STRATA

Filed Jan. 2, 1953

Fig. 1

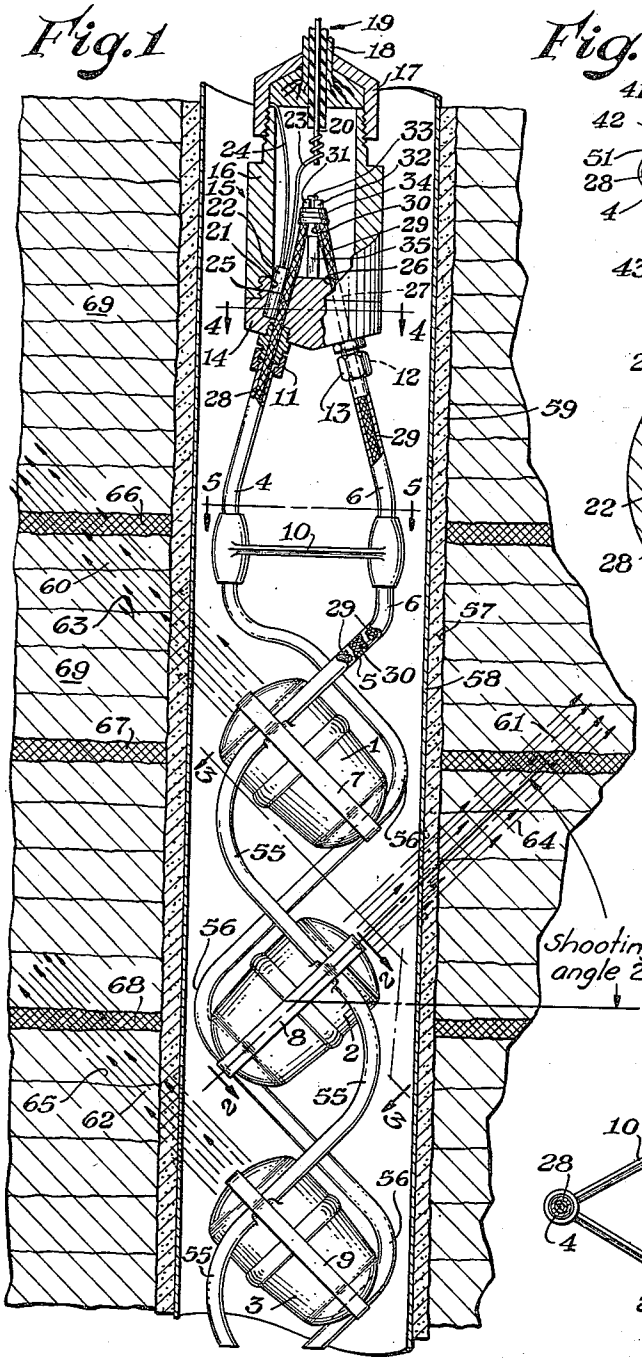
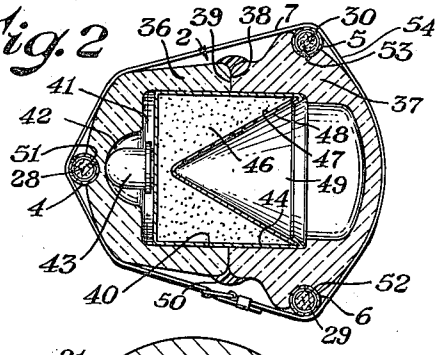


Fig. 2



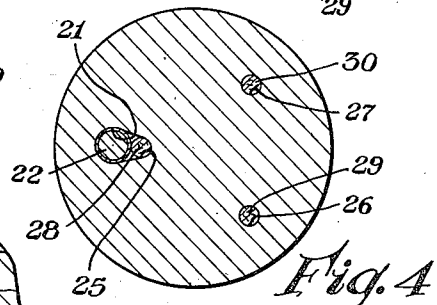


Fig. 4

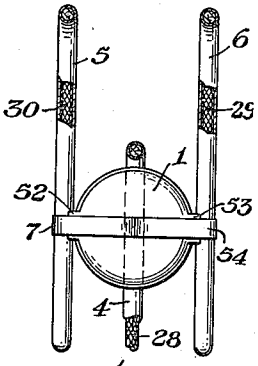


Fig. 3

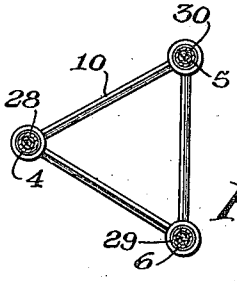


Fig. 5

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United States Patent Office 2,819,673 Patented Jan. 14, 1958

2,819,673

METHOD OF AND APPARATUS FOR OPENING OIL- AND GAS-BEARING STRATA

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Application January 2, 1953, Serial No. 329,304

2 Claims. (Cl. 102—20)

The invention relates to an improved method of and apparatus for opening oil- and gas-bearing strata penetrated by a well bore.

An object of the invention is to provide an improved method of and apparatus for facilitating the drainage of oil from strata penetrated by a well hole.

Another object of the invention is to provide a method of facilitating the flow of oil to a well hole particularly from thin oil-bearing formations penetrated by the well hole.

Another object is to provide a method of increasing the fluid permeability of an earth formation in the vertical direction adjacent to a well bore penetrating the formation.

Other objects and advantages of the invention will appear from the following description taken in conjunction with the accompanying drawing which illustrates a preferred embodiment of the apparatus and mode of carrying out the method of the invention.

We have found that the foregoing objects are attained by directing into the formation penetrated by the well bore the jet of high velocity gas produced on detonating a suitably shaped charge of detonable high explosive within the well bore, the charge being oriented in accordance with the invention so that its firing axis makes an angle of 20 to 70 degrees with a horizontal plane passing through the well bore. The usual form of shaped charge is employed, such as one in the form of a cylinder having a conical recess at one end, the conical recess having its axis in line with the long axis of the cylinder. The recess may be lined with a sheet metal cone from the open end of which the jet of high velocity gas issues on detonating the charge, the jet traveling in the direction of the axis of the cone. The high velocity jet of gas which issues from the shaped charge on being detonated possesses great piercing or perforating force and is, therefore, able to penetrate deeply into the earth formation surrounding a well hole at an angle to the horizontal even after passing through a casing wall if present in the well hole. The charge is desirably encased in a suitable container so as to protect the charge from the adverse action of well fluids and provide the necessary free or unobstructed space adjacent to the open end of the cone to permit the formation of the gas jet. It is preferable to employ a frangible material, such as glass, for the container and to support it in the well hole with a frangible support, both the container and support being expendable so that these parts will be shattered into small pieces which may be left in the well hole after the firing of the charges or removed from the well with the produced fluid when the well is put into production.

As a result of firing the oriented shaped charges of detonable explosive as described, passageways leading to the well hole are formed in the earth in the direction of the explosive jet whether or not the well hole is lined with the usual casing. The passageways may be made to slope either upwardly or downwardly away from the well hole according to whether the firing axis of the

charge is oriented upwardly or downwardly. It is preferable to slope the passageways upwardly from the well hole. It is manifest that the passageways so formed tap a plurality of earth layers by breaking down between them horizontal barriers to the flow of fluids, such as impervious shale streaks. The flow of earth fluids from one level to another adjacent to the well hole is thus facilitated and greater fluid production from the earth formation into the well hole results.

The invention may be further explained and illustrated by reference to the accompanying drawing.

In the accompanying drawing, Fig. 1 is a more or less diagrammatical side elevation of the apparatus, with some parts cut away to show structure, positioned in a well bore, a portion of which is shown in section, as in practicing the method.

Fig. 2 is an enlarged cross section on the line 2—2 of Fig. 1.

Fig. 3 is a cross section on the line 3—3 of Fig. 1.

Fig. 4 is an enlarged cross section on the line 4—4 of Fig. 1.

Fig. 5 is a cross section on the line 5—5 of Fig. 1.

In the several figures, like numerals designate like parts.

Referring to the drawing in detail, there is shown a plurality of shaped detonable explosive charge containers, e. g. 1, 2, 3, respectively, supported by an expendable carrier frame comprising three tubular members 4, 5, and 6, respectively, formed of thin wall aluminum tubing for example, onto which the containers are strapped by the straps 7, 8, and 9, respectively. A triangular guide member 10 spaces apart the tubular members near their upper ends which are secured by pipe fittings, 11, 12, and 13, to the lower removable end 14 of the detonator housing indicated generally by numeral 15. This comprises a cylindrical body portion 16 to which the lower end 14 is screw threadedly secured as shown. The upper end of the detonator housing is closed by the removable cable socket 17 in which is anchored the outside metallic sheath 18 of the cable 19 which encloses a central insulated conductor 20.

A pocket 21 is provided in the lower end 14 to accommodate an electrical detonating or blasting cap 22, one lead 23 of which is connected to the conductor 20 and the other 24 is grounded to the body 16. The lower end 14 of the detonator housing is provided with three passageways 25, 26, and 27 communicating with the bore of pipe fittings 11, 12, and 13 and the tubular members 4, 5, and 6, respectively, passageway 25 being adjacent to and communicating with the pocket 21. As shown, each of the bores of the tubular members are threaded with a detonable explosive cord, e. g. primacord, 28, 29, and 30, the upper ends 31, 32, and 33, respectively, being brought through the pipe fittings 11, 12, and 13, and passageways 25, 26, and 27, respectively, into the detonator housing and bound together with a tape 34. The inside of the lower end 14 of the detonator housing is provided with a baffle 35 in the form of a rectangular plate interposed between the portion of the primacord 28 which is adjacent to the blasting cap, and the portions of the other two primacords between the lower end 14 and the tape 34.

The shaped charge containers 1, 2, and 3 consist of two cup shaped members 36 and 37 (e. g. Fig. 2) having flat rims 38 and 39, respectively, butting together in a plane perpendicular to the longitudinal axes of the cups. One of the cups, e. g. 36, may be referred to as the receptacle for the shaped charge the other 37 as the cover. The inside 40 of the receptacle is cylindrical and in the bottom 41 there is a recess 42 which accommodates a booster charge 43. The inside 44 of the cover is also cylindrical and in alignment with the inside of the receptacle. The cover is provided with a shoulder 45.

As shown, each of the containers is loaded with a shaped charge, e. g. 46, Fig. 2, with its conical recess 47 lined with a metal cone 48, e. g. copper, the open end 49 of which faces the cover 37 and is held in place by the shoulder 45. The abutting rims 38 and 39 are sealed around their peripheries by a coating of sealing compound 50 to exclude well fluids from the container. The receptacle is provided with a groove 51 diametrically across the end on the outside in which may be lodged the tubular member 4 while the cover is provided with grooved bosses 52 and 53 on opposite sides in which may be similarly lodged, as shown, tubular members 5 and 6, respectively, the three tubular members being held in place by the strap 54 which also holds the cover on the receptacle.

In operation, as many loaded containers as desired may be strung together on the carrier frame of tubular supporting members 4, 5, and 6 which may be made of appropriate length. About two charges per foot of carrier frame is a suitable loading. For purposes of illustration, a string of three charges is shown in Fig. 1. To give the loaded containers the proper orientation so that the firing axis of each of the enclosed shaped explosive charges will make the desired acute angle (20 to 70 degrees) with a horizontal plane passing through the vertical axis of the well hole, or vertical axis of the carrier frame, the tubular member 4, 5, and 6 are given a series of bends alternating in opposite directions before strapping the containers to them. For example, for orienting the containers at 45° to the horizontal tubular members 5 and 6, which are parallel to each other below the guide 10, are given the same bends, e. g. 90° bends 55, and tubular member 4 is given a similar series of 90° bends 56. After suitably bending the tubes 4, 5, and 6, the loaded containers are strapped in place as by straps 7, 8, and 9.

The so-assembled apparatus is lowered into the bore of the well to be treated so that the charges are opposite the formations to be pierced. In Fig. 1, the apparatus is shown lowered into a well hole 57 which is cased with a casing 58 and cemented in place with cement 59. After positioning the apparatus in the well the blasting cap 22 is detonated. This detonates the primacord 28. The detonation of primacord 28 detonates the charge in each of the containers 1, 2, and 3 and also the primacords 29 and 30, the upper ends of which are taped together with the upper end of 28. The detonation of cords 29 and 30 in tubes 5 and 6 is delayed slightly compared with that of cord 28 in tube 4 because the shock wave from the blasting cap 22 is compelled by baffle 35 to travel a longer path from the blasting cap to the primacords 29 and 30 in tubes 5 and 6, respectively, than that from the blasting cap to the primacord 28 in tube 4 before reaching the shaped charge containers. The purpose of this delay is to detonate each shaped charge by primacord 28, acting through the booster charges 43, before the detonation wave in primacords 29 and 30 reaches the shaped charge containers. The detonation of the primacords shatters the tubular members 4, 5, and 6 and guide member 10 and the detonation of the shaped charges shatters the containers 1, 2, and 3 so that no junk is left in the well hole to cause obstructions.

The directional explosive effect or jet indicated at 60, 61, and 62 of the detonated shaped charges in containers 1, 2, and 3, oriented as shown in Fig. 1, forms passageways into the earth formation indicated at 63, 64, and 65, respectively, at an angle of approximately 45° to the horizontal plane passing through the vertical axis of the well bore 57. The passageways so-formed intersect and open up impervious streaks, e. g. 66, 67, and 68 in the adjacent earth formation 69 so that fluid therein may more readily reach the well hole.

The detonator housing 15 preferably is made rugged enough to withstand the detonation of the blasting cap and the portions of the primacords which extend through the pipe fittings 11, 12, and 13, respectively, into the sub. The lower end 14 generally remains intact after the detonations, although the pipe fittings 11, 12, and 13 may be blasted away and require replacement before reuse of the apparatus.

In the claims as elsewhere herein, the term shaped detonable explosive charge means any high explosive in the form of a recessed chunk, molded block, cylinder, or the like, which on detonation or firing delivers explosive energy along an axis which has a direction through and away from the recess as a piercing jet, the jet-like action being sometimes referred to as the Monroe effect.

We claim:

1. A well wall piercing apparatus for wells drilled into the earth comprising a plurality of individual frangible enclosures each adapted to enclose a shaped detonable explosive charge having a single firing axis; a frangible elongated carrier for the enclosures comprising three tubular members adapted to be lowered endwise into the well bore, said frangible enclosures being mounted on the tubular members in a row extending along the longitudinal axis of the carrier, said tubular members being oriented so that the firing axis of the charge in each frangible enclosure makes an angle of 20 to 70 degrees with the longitudinal axis of the carrier; a housing adapted to enclose a detonator; means to secure the upper ends of the tubular members to the housing, said housing having passageways therein communicating with the bore of the tubular members; a detonable explosive fuse means extending through the bore of each tubular member into the said housing, the fuses being bound together at their upper ends in the housing; a blasting cap in the housing adjacent to one of the explosive fuse means; and strap means for securing to the bottom of each container the tubular member containing the explosive fuse means whose upper end is adjacent to the said blasting cap; said strap means also securing to the frangible enclosures on opposite sides thereof the other two tubular members.

2. The apparatus according to claim 1 including a baffle in the housing between the explosive fuse means which is adjacent to the blasting cap and the other explosive fuse means in the housing.

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