June 19, 1956 T. GAINES 2,750,884

BLASTING OF UNDERGROUND FORMATIONS

Filed Oct. 16, 1951

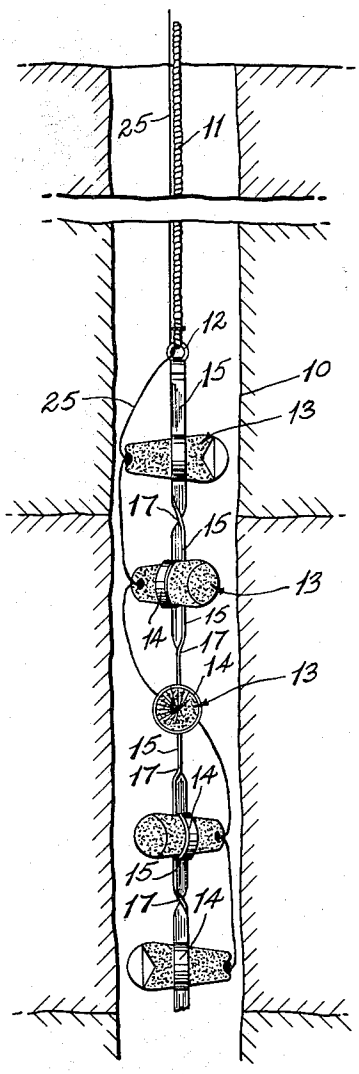


Fig. 1.

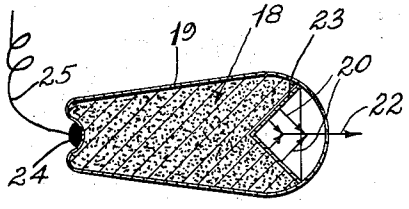


Fig. 2.

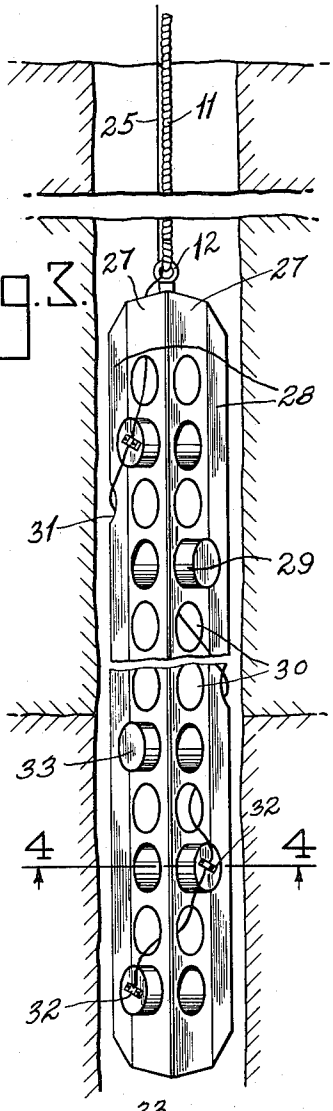


Fig. 3.

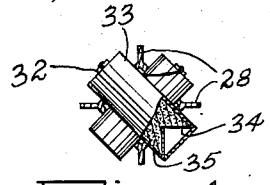


Fig. 4.

INVENTOR.
TOM GAINES
BY
ATTORNEYS

United States Patent Office 2,750,884
Patented June 19, 1956

2,750,884

BLASTING OF UNDERGROUND FORMATIONS

Tom Gaines, Denver, Colo., assignor to The Texas Company, New York, N. Y., a corporation of Delaware

Application October 16, 1951, Serial No. 251,563

7 Claims. (Cl. 102—20)

The present invention relates to opening up flow between a borehole and the surrounding formation, as in the production of fluids, such as oil or gas from underground formations, and, more specifically, to the shooting, blasting or perforation of the structure about a producing well bore for opening up extensive avenues of oil flow to the well bore.

The present invention has particular application to the so-called jet perforation or formation blasting technique, wherein the blasting of the structure is effected by means of a so-called shaped charge utilizing the Munroe effect, in accordance with which the high explosive forces of detonation are focused to concentrate their blast directionally into the surrounding structure. It is therefore contemplated for use primarily in open hole shooting although it is applicable in cased hole shooting, particularly where a portion of the energy is employed to shatter the formation outside the casing.

In accordance with the present invention, the blasting of the structure or formation about the well bore is effected by one or a plurality of radially directed shaped charges suspended in the well bore by an expandable carrier or "gun" composed of material which, per se, is explosive and which is capable of detonation by the explosion of the shaped charges. Each of the shaped charges is provided with an individual detonator and also with a booster, if desired, and simultaneous firing of the charges thus initiates the detonation of the carrier which is thereby completely consumed.

The present invention thus has the advantage of overcoming impairment of the well bore which has resulted from the poorly fragmented debris of expandable guns or carriers heretofore employed. The effect of such debris upon the well is particularly exemplified in the case of expendable gun carriers composed of sheet material. For example, the products of disintegration of a typical sheet aluminum carrier following detonation of the shaped charges includes shedded strips of aluminum of varying width and length which are not only highely resistant to clean out operations such as fishing and bailing, but which seriously interfere with the recovery of the dislodged shale, sand and other formation material fragmented by the explosion.

In effecting the complete consumption of the gun carrier, therefore, the present invention is particularly advantageous from the standpoint of eliminating objectionable debris or residue from the well bore which would tend to impair subsequent development and operation. Accordingly, for example, the formation may be fractured, penetrated and opened up to any desired extent without clogging by undesired, extraneous material.

The shaped charges, as well known, are directional, per se, requiring only that they be suspended or faced in the desired orientation with regard to the formation. Therefore, the structure of the gun or carrier may be relatively simple, comprising merely a frame or web of sheet material to which the several charges are attached or in which they are suspended in the desired orientation.

It is accordingly contemplated forming the gun or carrier of any suitable plastic, solid explosive material which is detonated by the explosion of the charge held thereby, and which can be formed into a plastic sheet, web, film, or other integral structural member. Nitrocellulose film or web, for example, provides a particularly effective carrier structure, and possesses adequate strength in relatively thin sections to support the charges. Therefore, the explosive effect resulting from the detonation of the carrier is relatively small relative to that of the directional charges and does not interfere therewith. Moreover, since the detonation of the carrier follows detonation of the main charges, there is no impairment of the directional explosive effect.

The figures of the present drawing illustrate more or less diagrammatically various structures of the gun and carrier herein contemplated. In the drawing, Fig. 1 illustrates one embodiment of a perforating gun in accordance with this invention; Fig. 2 represents in cross section a shaped charge suitable for use in the practice of this invention; Fig. 3 represents another embodiment of a perforating gun in accordance with this invention and Fig. 4 represents in partial cross section a view taken along line 4—4 of the embodiment illustrated in Fig. 3.

In the Figure 1, the gun, suspended within the well bore **10** by means of a wire line or cable **11** and a ring or shackle **12**, is formed of strips of sheet nitrocellulose in which the shaped charges **13** are mounted. Thus, as shown in the figure, each of the charges is circumferentially gripped by an annularly arranged strip **14** of expendable supporting material forming a ring in which the charge fits snugly. The rings **14** are vertically spaced and suspended by vertically extending strips **15** which merge therewith. Thus, the carrier comprises a series of vertical supporting and spacing strips integrally joined to vertically spaced receiving collars for the explosive charges, arranged with their axes directed radially of the well bore.

Provision is advantageously made for displacing the directional axis of each charge angularly with respect to the adjacent charges in order to penetrate all sides of the well bore and effect a maximum of the radial fracturing. To this end each of the vertical spacing strips is set with a permanent twist as at **17**, which displaces the plane of the strip or web through an angle of 45° about its vertical axis. In this way each of the charges **13** supported by rings is offset about 45° about a vertical axis from the adjacent charges, above and below. Obviously, the radial orientation of the charges may be varied as desired in accordance with any predetermined pattern.

While the structure of the individual shaped charges, per se, forms no part of the present invention, one specific form thereof is indicated more or less diagrammatically in Figure 2 to facilitate complete understanding of the embodiment. As shown therein, the high explosive material **18** is arranged within a frangible casing **19** formed preferably of glass, plastic or the like. At its directional extremity the explosive material is formed with a deep conical recess, the sides of which make an acute angle with the axis of the charge, in a known manner, to focus the explosive forces **20** in the direction indicated by arrow **22**. Usually the conical recess receives a conical insert **23** of sheet aluminum or plastic. Frequently the space between the conical extremity of the charge and the rounded end of the casing **19** is occupied by a plug of soft metal such as copper.

Numeral **24** designates the detonator for the charge as indicated in Figure 1. The several detonators are connected by a detonator cable **25** which is actuated from the surface by means not shown to simultaneously detonate the charges.

The detonation of the charges therefore directs the

explosive products of each charge radially to fracture the surrounding formation in the predetermined pattern. Also, the same procedure may be followed in penetrating a surrounding well casing. As is known, focusing of the blast along the axis of each charge from the conical extremity thereof multiplies the explosive effect many times in the desired direction.

The shock of this explosion, however, detonates the explosive carrier, as above indicated, resulting in its complete explosive decomposition. Therefore, there remains in the well nothing but the minute fragments of casing **19** and the like together with the removable wire line and supporting ring.

As above intimated, the present device is primarily effective for opening up underground strata of restricted permeability for selective and increased production of petroleum or other fluids. As the formation is split, fissured and shattered, avenues of ready flow are opened up into a greatly increased surface area of compacted producing material, thus greatly improving flow to the well bore.

Another embodiment of the invention shown in Figure 3 indicates the wide variety of structure contemplated. The carrier thus shown comprises four elongated sheets of nitrocellulose fused along their side margins as indicated to form a box-like frame having vertical side webs or films **27** joined at their vertically extending margins to form radially projecting fins **28**. The fins **28** confer rigidity and thus permit use of rather thin section films. Aligned apertures **30** in opposite side webs accommodate shaped charges **29** inserted as indicated, and detonation cable **25** passes spirally about the carrier connecting to the detonator **32** at the rear of each charge. Recesses **31** in fins **28** accommodate the cable **25**. Any convenient means not shown may be provided for locking each of the charges within the carrier in the position indicated or the charge may be frictionally held in place by providing for snug fitting engagement within the cylindrical apertures provided.

As more particularly indicated in Figure 4, the directional charge assembly may vary somewhat in detail, the unit used herein comprising a cylindrical housing **33** of plastic or frangible metal closed at both extremities and provided with conical insert **34** which retains the effective extremity of the high explosive charge **35** in the required shape.

While reference has been made specifically to nitrocellulose as a material capable of forming a web or sheet of satisfactory structural properties, many other moldable solid explosives possess such properties and may be readily detonated by the shock wave of the high explosive shaped charge. Such, for example, are trinitrotoluene and many other explosives.

It is to be understood that the conventional details of explosive compounding form no part of the present invention, per se, and therefore are considered superfluous. Moreover, since detonation of the explosive carrier depends upon the character of the explosive shock produced by the directional charges, it is obviously dependent upon such things as the type of directional explosive selected, the size and number of charges and many other factors within the discretion of the operator. In any event, it follows that the sensitivity of the explosive carrier material is determined by these factors and compounding carried out accordingly.

Obviously many modifications and variations of the invention as hereinbefore set forth may be made without departing from the spirit and scope thereof, but only such limitations should be imposed as are indicated in the appended claims.

I claim:

1. An apparatus useful for shooting a well comprising an elongated support member provided with a plurality of spaced apart openings formed in said member, said openings being adapted to receive a charge of high explosive and said member being formed solely of explosive material explodable by said charge of high explosive.

2. An apparatus according to claim 1, wherein said explosive material is nitrocellulose.

3. An apparatus useful for shooting a well comprising an elongated support member provided with a plurality of spaced apart openings formed in said member, said openings being adapted to receive a charge of high explosive and being positioned along the longitudinal axis of said member, said member being formed solely of explosive material explodable by said charge of high explosive.

4. An apparatus useful for shooting a well comprising an elongated strip member made solely of explosive material and provided with a plurality of spaced apart openings formed in said member, said openings being adapted to receive a charge of high explosive therein, said member intermediate each pair of openings being permanently set so as to displace the openings of said pair an angle of 45° with respect to each other about the longitudinal axis of said member and said member being explodable by said charge of high explosive.

5. An apparatus useful for shooting a well comprising an elongated support member made solely of explosive material and formed by joining together four elongated strips of said explosive material along their longitudinal edges to form a frame having a rectangular cross section, each of said strips in said frame being provided with a plurality of spaced apart openings, each of said openings in said strips being located at the same position relative to each other with respect to said frame and adapted to receive a charge of high explosive therein, said member being explodable by said charge of high explosive.

6. An apparatus according to claim 5 wherein said frame is provided with fins made of said material and joined to the outside longitudinal edges of said frame and extending outwardly from the center of said frame.

7. An apparatus according to claim 6 wherein said explosive material is nitrocellulose.

References Cited in the file of this patent

UNITED STATES PATENTS

2,026,061	Prikel	Dec. 31, 1935
2,138,603	Johnson	Nov. 29, 1938
2,362,829	Kinley	Nov. 14, 1944
2,414,349	Alexander	Jan. 14, 1947
2,543,814	Thompson et al.	Mar. 6, 1951
2,599,245	Finn	June 3, 1952
2,619,186	Carlisle	Nov. 25, 1952