Sept. 18, 1962 L. D. MEDDICK 3,054,938

MEANS AND MODE FOR DEPOSITING MATERIAL BY JET PERFORATION

Original Filed June 5, 1956 2 Sheets-Sheet 1

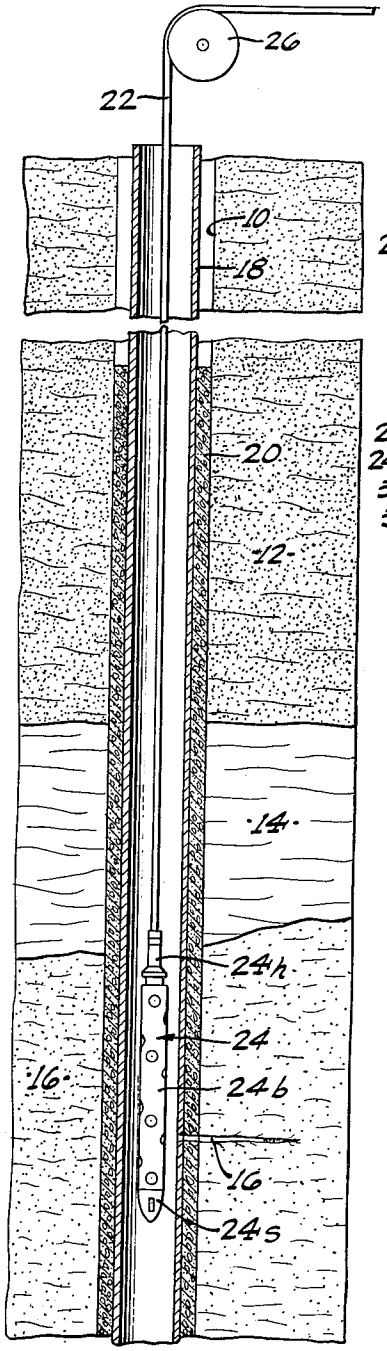


FIG. 1.

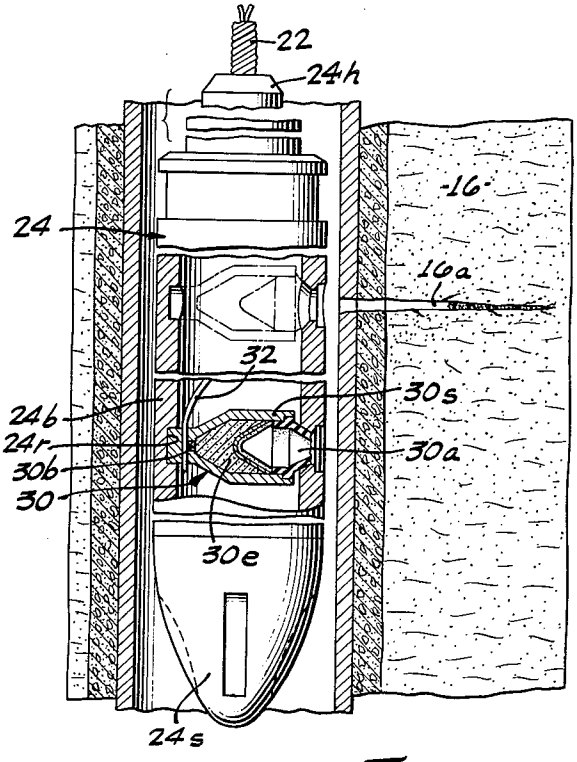


FIG. 2.

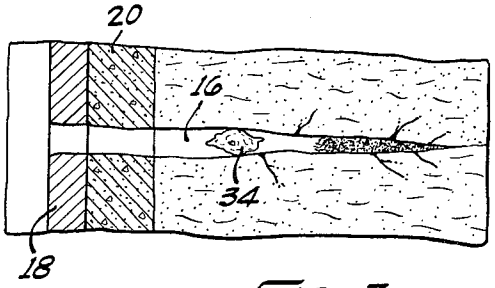


FIG. 3.

LORRAIN D. MEDDICK
INVENTOR.

BY Fritz D. Peterson
AGENT

Sept. 18, 1962 L. D. MEDDICK 3,054,938

MEANS AND MODE FOR DEPOSITING MATERIAL BY JET PERFORATION

Original Filed June 5, 1956 2 Sheets-Sheet 2

FIG. 8.

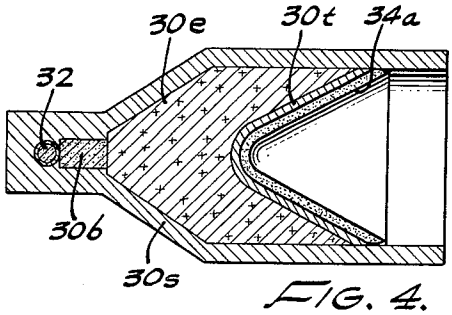
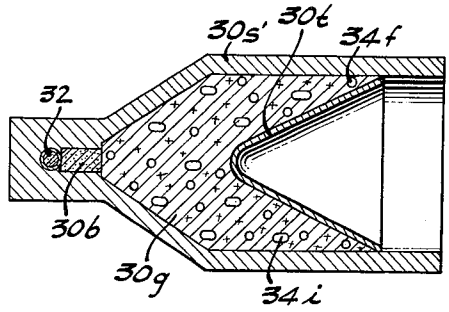


FIG. 4.



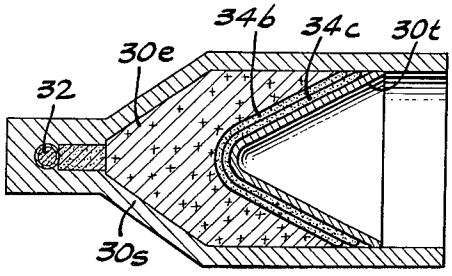


FIG. 5.

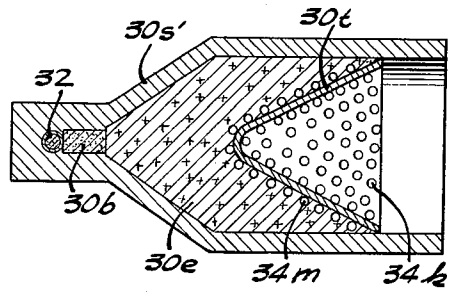


FIG. 9.

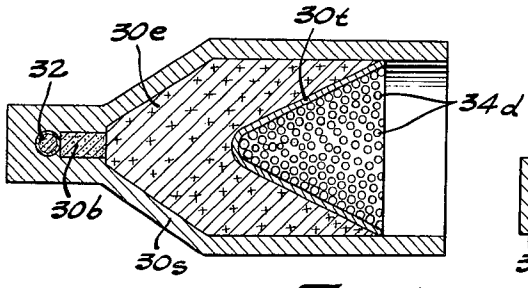


FIG. 6.

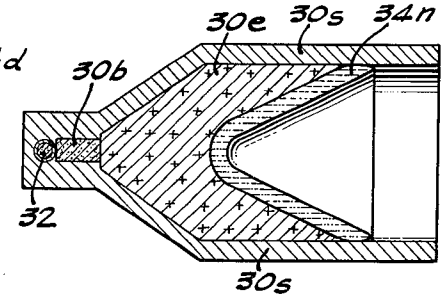


FIG. 10.

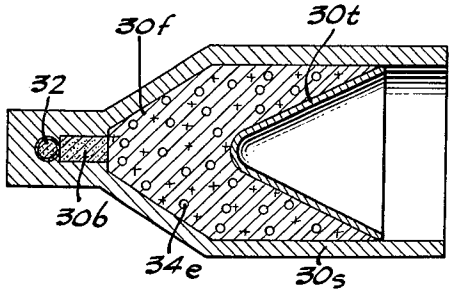


FIG. 7.

LORRAIN D. MEDDICK
INVENTOR.

BY

AGENT

United States Patent Office

3,054,938

Patented Sept. 18, 1962

3,054,938

MEANS AND MODE FOR DEPOSITING MATERIAL BY JET PERFORATION

Lorrain D. Meddick, Houston, Tex., assignor to Dresser Industries, Inc., Dallas, Tex., a corporation of Delaware

Continuation of application Ser. No. 589,421, June 5, 1956. This application Nov. 9, 1959, Ser. No. 854,217

3 Claims. (Cl. 102—20)

The present invention relates generally to well casing perforating, and particularly to a novel means and mode for introducing into an earth formation encircling a cased earth well, through the casing encircling cement, a corrosion-inducing or acidizing substance concurrently with perforation of the casing and formation of a hole or opening into the encircling earth formation. More specifically, the invention relates to a mode and means for concurrently perforating in situ a cemented well casing and depositing in the encircling earth formation a corrosion-inducing substance or component thereof, through detonation of a suitably fabricated or compounded specially shaped charge of high explosive.

This application is a continuation of the copending application of Lorrain D. Meddick, Serial No. 589,421 filed June 5, 1956, now abandoned, for Means and Mode for Depositing Materials by Jet Perforation.

It is known in the prior art to perforate in situ cemented well casings my means including suitably shaped and positioned charges of highly explosive material. Such operations are conventionally termed shaped-charge perforating and involve the detonation of a suitably positioned explosive charge having a suitably formed depression or concavity therein, and which, when detonated, produces a high-velocity stream or jet of material capable of piercing steel well casing, cement and earth formation. It has been discovered that the earth formation thus breached by a high-velocity jet may be penetrated to a considerable distance beyond that region within which connate fluids may, and actually do, readily flow from the formation into the hole produced by the jet. The remainder of the penetrated extent of earth formation while actually of the general shape of a tapered hole, is sometimes found to be filled with semi-compacted formation material or debris which greatly impedes drainage of connate fluid into the produced hole. Since the primary purpose of perforating the casing and forming a hole extending into the encircling earth formation is to permit ready access of connate fluids into the well casing, it is desirable that the hole formed by the jet be free and open throughout its entire extent. The present invention aims to provide a mode and means whereby this plugging effect in the most distant reaches of the produced hole is greatly reduced and the compacted material there deposited is rendered loose, whereby flow of connate fluid into the well casing is greatly facilitated.

The principal aim of the invention is accomplished by incorporating in the material composing the jet which pierces the well casing and encircling formation, one or more substances which when deposited in the produced hole will produce an acidizing or other corrosive effect, either alone or in combination with connate or introduced fluids. The corrosion-inducing or acidizing material or substance has the effect of softening, dissolving or loosening the cementing material by which the discrete particles of material compacted together in the outer reaches of the produced hole are held together. The freeing or loosening effect thus produced in the outer end of the opening breached into the earth formation is operationally the equivalent of producing an opening of much greater effective depth. The corrosion-inducing or acidizing material to be deposited is carried into the opening substantially concurrently or simultaneously with the production of the opening by the high velocity jet or by the after jet. The substance to be thus deposited may comprise one or more liquid components and/or one or more solid or granular components, which, when deposited in the opening or hole, either alone or in combination with fluids there present, or with each other, produce the desired loosening of the grain structure of the plug in the end of the hole. The substances to be thus introduced into the hole substantially concurrently with its formation are, according to the invention, so disposed with relation to the substances producing and comprised in the jet as to be incorporated in the latter in one or the other of several related ways. These modes and the requisite structures for carrying them out will hereinafter be more fully explained.

As constructed heretofore, shaped charge casing-perforating devices have generally included a metallic shell or cone-like "liner" of copper or other similar metal or alloy nested in the depression or concavity of the explosive charge, the purpose of which shell or liner is to aid the high-velocity jet to pierce or penetrate any nearby object in its path. It has been determined experimentally that in many instances a portion of this metallic shell is lodged within the opening produced in the well casing and formation, thus forming an obstruction impeding the flow of fluids into the well. The relative positioning and general shape of such a "carrot" or obstruction may vary but is often such as to form a tightly fitting plug. It is a subsidiary aim of the present invention to provide means whereby such obstruction or carrot is not produced, or if produced is soon corroded and thus removed from the opening in the casing or at least loosened to the extent of minimizing its impedance to fluid flow.

In view of the preceding stated considerations it is a primary object of the present invention to provide apparatus for producing a perforation in an earth well casing and concurrently therewith producing and acidizing a fluid-draining hole in the adjacent earth formation. It is another object of the invention to provide means whereby a greater effective depth of penetration into an earth formation may be effected with shaped charge explosive means.

Another object of the invention is to provide a mode for producing an earth-penetrating opening of greater effective depth outwardy through a cemented well casing.

Another object of the invention is the provision of means for enhancing the results secured by earth well casing perforating by shaped charge explosive means.

The preceding and other objects and advantages of the invention which will hereinafter be made more fully apparent are accomplished by the mode of the invention as practiced with apparatus according to the concepts thereof, a preferred form of which apparatus and modifications thereof is depicted in the several views of the accompanying drawings.

In the drawings:

FIGURE 1 is a diagrammatic view, partly in longitudinal section, of a portion of an earth well borehole which has been cased and cemented, the well borehole extending through a plurality of earth formations; and showing means according to the invention suspended in the borehole;

FIGURE 2 is a longitudinal view in vertical section through a portion of cased earth borehole in which is situated apparatus according to the present invention, and illustrating one shaped charge device positioned for operation and showing the effect produced by previous detonation of a similar device;

FIGURE 3 is a fragmentary view in sectional elevation to an enlarged scale of a portion of cased earth well borehole with the casing perforated and formation breached by a shaped charge explosive device; and

FIGURES 4 through 10 are longitudinal views in section through respective shaped charge devices having structural arrangements according to the present invention.

Referring now to the drawings and to FIGURE 1 in particular, there is shown an earth borehole **10** penetrating earth formations **12**, **14** and **16**, the borehole having been cased with a conventional well casing **18** cemented in place along a portion of its length or extent by cement **20** suitably introduced into the annular space between the exterior of the casing **18** and the borehole wall. The casing or borehole, as is conventional, may be substantially filled with fluid, or either or both may be unoccupied except for gases. Shown suspended at a desired location in the cased borehole by means of an electric conductor suspending cable **22**, is a well casing perforating apparatus **24** hereinafter more fully described. The suspending cable **22** may extend over a guide sheave **26** and be wound upon or unwound from conventional hoist drum means (not shown). Perforating apparatus **24** comprises a cable head **24***h* in which the electric cable conductor **22** is terminated, and the head may comprise or be terminated at its lower end by means for detonating a length of primacord by electric current conducted thereto through cable **22**. The perforating apparatus comprises a tubular body section **24***b* connected in known manner to cable head **24***h*, and terminated at its lower end by a conventional bull plug **24***s*. This much of the apparatus, with the exception of shaped charge devices supported in body section **24**, may be conventional and is well known in the art, and will not hereinafter be more fully described.

Referring now to FIGURE 2, in which is depicted partially in sections, portions of perforating apparatus **24** and fragmentary portions of a well casing and cement and adjacent earth formation, one unexploded shape charge device **30** is shown in position for detonation. A hole **16***a* is shown, formed in the adjacent earth formation by detonation of a similar shaped charge device previously located as indicated in dotted outline. The unexploded shaped charge device shown generally at **30** comprises an outer rigid body or shell **30***s* fitting in an internal recess **24***r* formed in body **24***b*, and a charge aligner **30***a* fitting in a port opposed to recess **24***r* and adapted to maintain the shell **30***s* in proper position in body **24***b*. The shaped charge device also comprises a charge of explosive **30***e* suitably secured in shell **30***s*, and additional and unconventional means hereinafter more fully described. Suitably threaded in a transverse bore through the reduced-diameter base of shell **30***s* is a length of detonable fuse **32** such as primacord, which extends to and is adapted to be detonated by conventional fuse-detonating means in or immediately below cable head **24***h*, all as is well known in this art. Positioned in close proximity to the detonable fuse **32** in the base of shell **30***s* is a booster charge **30***b* of high explosive adapted to be detonated by action of fuse **32** and adapted in turn to detonate the explosive **30***e* comprised in the specially shaped unit contained in the body of shell **30***s*.

According to the concept of the present invention, the interior elements housed within shell **30***s* may be constructed and arranged in a variety of different forms several of which are shown in longitudinal cross-section in FIGURES 4 through 9, while shell **30***s* and aligner **30***a* may be as shown or of conventional form. The structure within shell **30***s* is so constructed and arranged as to provide, when detonated, a jet comprising one or more substances which, either alone or in combination with connate fluid and/or each other, will aid in deeper effective penetration of the formation by weighting the jet and/or by inducing corrosion in the produced opening formed by the jet. Preferably the device is so constructed and arranged that when detonated there is carried into the produced opening with the jet one or more acidizing or corrosion-inducing elements or substances the penetration and corrosive effect being preferably aided by introducing into the jet a heavy substance of proper characteristics, such as, for example, mercury.

Referring now to FIGURE 4, the principal components of one type of shaped charge device according to the present invention, with the charge aligner removed, is shown in section. Shell **30***s* houses or includes the booster charge **30***b* adjacent which a detonable fuse **32** (such as primacord) extends through a transverse bore in the base of the shell, as shown or as in conventional shaped charge construction. Also included in shell **30***s* is a charge **30***e* of high explosive having, at its face opposed to the booster charge **30***b*, a depression or concavity formed therein which is preferably of generally conical form, as indicated. Nested in the shell **30***s* and preferably but not necessarily in contact with the explosive charge **30***e*, is a conical liner **30***t* of suitable metal such as copper, as is conventional practice. In certain forms of shaped charge devices according to the present invention, this metallic liner **30***t* may be dispensed with or a substitute of a type hereinafter more fully explained may be employed. As is well known in the shaped charge devices arts, detonation of the charge **30***e* at its base by booster charge **30***b* results in creation of a high velocity detonation wave in the shaped explosive charge **30***e* which proceeds generally forward through the charge and which, upon reaching the apex of liner **30***t*, causes a forwardly progressing disintegration of the liner with possible partial vaporizing of the liner material resulting in the formation of a forwardly-directed, high velocity jet of gases and particulated and vaporized liner material. As is well known, such jet is capable of piercing a considerable thickness of steel or other resistant material.

In accordance with the concepts of the present invention there is included within the body member or shell **30***s* for transportation by and with the high-velocity jet produced by the explosive, one or more materials which, when transported into the opening produced by the jet, will produce a corroding effect such as, for example, an acidizing effect, in the opening. In the embodiment of apparatus depicted in section in FIGURE 4, there is incorporated in shell **30***s* in close proximity to cone-like liner **30***t*, a cone-like hollow sealed capsule **34***a* in the interior of which is contained one or more ingredients designed to produce the corroding effect when injected into the produced opening. The material contained in capsule **34***a* may be an acid, or may be a material in granular or like form which, upon contact with fluid in the produced opening, will combine therewith to produce an acid or corrosive substance. Capsule **34***a* is made of material suitable to the purpose, and may be, for example, of glass, synthetic rubber, or the like, where the contained material is a free acid. Preferably the material of which capsule **34***a* is constructed is one which will be vaporized or substantially completely particulated by the explosion, and will be such as not to add materially to a cementing action of displaced particles of the formation pierced. It is evident that the material

contained in capsule 34*a* will in large measure be picked up and incorporated in finely divided form into the produced jet and thereby injected into and through the openings produced in the casing and encircling cement, and carried into and deposited in the far reaches of the opening breached into the formation. The thus deposited material dissolves or otherwise weakens or destroys the cementing substances holding the grains of the formation material together. An important subsidiary effect of the material thus deposited in the breached hole or opening is that of corroding or dissolving any so-called "carrot" particles or other fragments of the shaped charge device which may be lodged in the opening in the casing or formation and thus obstruct the free flow of fluids from the formation into the well.

Referring now to FIGURE 5, a modified form of structure is depicted in which the conical metal liner 30*t* is positioned with two capsules 34*b* and 34*c* between it and the explosive charge. Capsules 34*b* and 34*c*, which may be constructed in a manner similar to that above explained with respect to capsule 34*a*, are each adapted to contain separated components which, when mixed together in the high velocity jet and transported into the breached opening are adapted to combine and produce the desired corrosive effect. While any desired combination of materials may be thus deposited in the breached opening, there may be cited as typical examples sodium hydroxide, potassium hydroxide, sulphur, sulphuric acid and hydrochloric acid.

Another means and mode of introducing into the jet stream material to be deposited in the breached opening is illustrated in FIGURE 6 wherein shell or liner 30*t* has suitably cemented to it a plurality of discrete capsules or bodies 34*d* consisting of or comprising materials to be deposited by the jet. It will be evident that the particles or capsules 34*d* may, under some circumstances, be cemented or otherwise secured to the opposite surface of liner 30*t*, thus being positioned between the liner and explosive charge 30*e*. Capsules or bodies 34*d* may be capsules of mercury, acid, or other corrosion-inducing material, or may be suitable coated pellets of corrosive-agent constituents such as sodium hydroxide or potassium hydroxide, which wil combine with, for example, water in the opening, to provide a corrosive effect.

FIGURE 7 illustrates an additional form of means for introducing the material to be deposited in the breached opening, the structure there comprising a conventional liner 30*t* and a specially-compounded shaped charge 30*f* of high explosive in which is incorporated or embedded dispersed discrete particles or capsules 34*e*, each of which may consist of or comprise one or more of the substances to be injected into the produced opening by the jet. Alternatively, two or more types or sets of particles or capsules may be employed, each type or set comprising a material different from that of the other set; and such modification of the structure shown in FIGURE 7 is illustrated in FIGURE 8, wherein there is incorporated in the high explosive shaped charge a plurality of capsules or pellets 34*f* comprising one material and a plurality of larger capsules or pellets 34*i* comprising a different material.

In FIGURE 9 there is depicted another modified form of shaped charge structure according to the invention, in which shell 30*s*′ is of superficially changed dimensions and liner 30*t* has cemented or otherwise suitably secured thereto on its inner face a plurality of pellets or capsules 34*k*, and on the outside surface thereof a plurality of pellets or capsules 34*m*, pellets or capsules 34*k* and pellets or capsules 34*m* containing or comprising either the same or similar materials, or alternatively, different materials. One of the materials contained in one of the sets of pellets or particles may contain or comprise a very heay metal, such as mercury, which may aid in producing the desired corrosive effect in the produced formation-penetrating hole or opening, and may concurrently aid the high velocity jet in producing a deeper penetration into the formation by weighting the jet. In particular, mercury may substantially weight the jet and corrode or soften, as by amalgamation, a copper or other soft-metal carrot lodged in the casing perforation or formation opening. It will be understood that such heavy metal or other jet-weighting material may be incorporated in other forms of apparatus herein depicted, as, for example, in capsule 34*b* illustrated in FIGURE 5.

Additionally, and in accordance with the concept of the present invention, all possibility of the production of a carrot or other undesirable metallic fragment in the casing perforation or opening in the formation may be eliminated by forming the liner of a suitable non-metallic capsule filled with such heavy liquid metal as mercury. Such a liner or capsule is adapted to feed into the high velocity jet a stream or flow of mercury to weight the jet for effectively deep penetration of the encircling formation, without any possibility of production of a carrot at the casing perforation or in the encircling formation. A structure suitable for this mode of operation is depicted in FIGURE 10, in which a hollow, core-shaped capsule 34*n* of, for example, glass, containing mercury, is depicted in close proximity to the high explosive charge 30*e* whereby the liquid metal is picked up and entrained in the high velocity jet produced when charge 30*e* is detonated.

It will be seen from the foregoing that there is provided by the invention a mode and means for providing effectively deeper and better penetration of an earth formation encircling a cased well borehole, by suitably incorporating into the high velocity jet produced by the detonation of a shaped charge of explosive, one or more substances which aid the jet in effectively penetrating the formation to a deeper extent and/or depositing in the lower or outer reaches of the produced opening breached into the formation a corrosive material or a corrosion-inducing material which is adapted to effectively attack soft-metal fragments and the cementitious material securing the grains of the formation together. It is evident that in the light of the present disclosure modifications of the mode and apparatus herein disclosed as exemplary will occur to those skilled in the art, and accordingly it is not desired to be limited to the specific details of the illustrative mode and apparatus, but what is claimed is:

1. An explosive perforating device comprising:
a detonable explosive shaped charge having a conical, concave face;
a hollow, cone shaped capsule fitted against said conical face and including spaced apart conical wall means forming a chamber therebetween, said chamber being disposed over substantially the entire area of said conical, concave face;
a body of liquid within said chamber to provide a layer of liquid over substantially the entire area of said conical, concave face; and
means for detonating said shaped charge.

2. An explosive perforating device comprising:
a detonable shaped charge having a conical, concave face;
a conical metal body composed principally of copper;
a hollow, cone shaped capsule fitting against said conical face and between said shaped charge and said metal body, said capsule including spaced apart conical wall means forming a chamber therebetween with said chamber being disposed over substantially the entire area of said conical, concave face;
a body of liquid reactive with copper within said chamber to provide a layer of such liquid over substantially the entire area of said conical, concave face; and
means for detonating said shaped charge.

3. An explosive perforating device comprising:
a detonable shaped charge having a conical, concave face;
a conical metal body composed principally of copper fitting against said face;
a hollow, cone shaped capsule fitting within said conical body and including spaced apart conical wall means forming a chamber therebetween, said chamber being disposed over substantially the entire area of said conical body;
a body of liquid reactive with copper within said chamber to provide a layer of liquid over substantially the entire area of said conical, concave face; and
means for detonating said shaped charge.

References Cited in the file of this patent

UNITED STATES PATENTS

2,796,833	Sweetman	June 25, 1957
2,809,584	Moses	Oct. 15, 1957

FOREIGN PATENTS

131,701	Australia	Mar. 10, 1949
479,259	Canada	Dec. 11, 1951

OTHER REFERENCES

Published Abstract Jan. 13, 1953, Class 102–20 of Doll application 78,333, published in 666 O.G. 599–600, Jan. 13, 1953.