

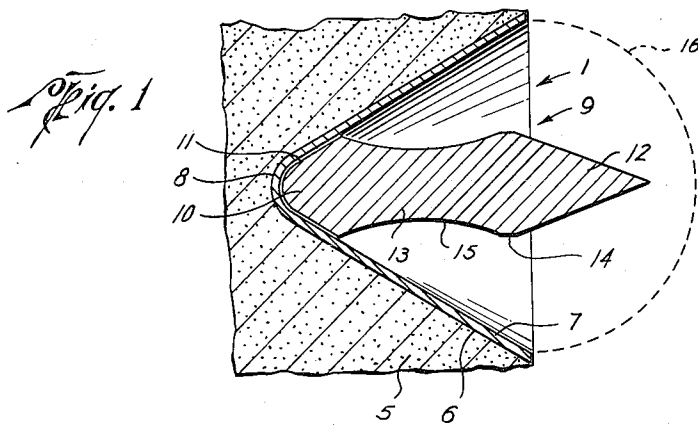
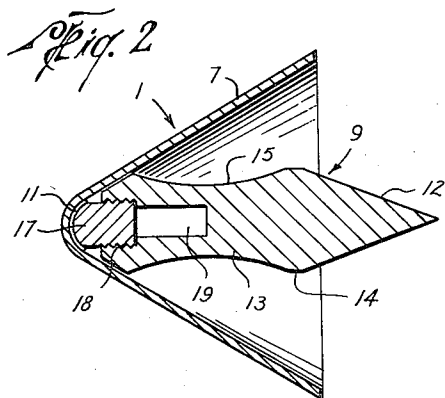
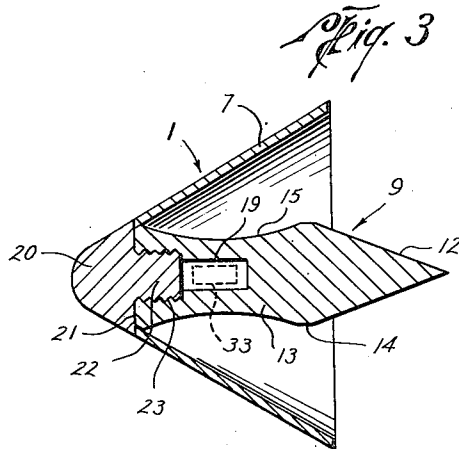
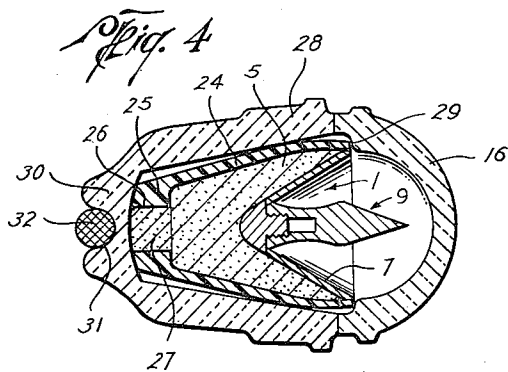
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PERFORATING DEVICES

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2,796,833

PERFORATING DEVICES

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5 Claims. (Cl. 102—20)

This invention relates to perforating devices and particularly to explosives actuated perforating devices for use in perforating in wells such as oil, gas or water wells.

In the art of perforating, particularly in wells, two principal methods are presently in wide use. In one, solid projectiles such as steel bullets, are propulsively driven by explosive propellants against the wall of a well bore to pierce the wall and penetrate into the surrounding earth formations. In the other, a high velocity jet of gases, generated in the well-known manner by detonating a hollowed or so-called "shaped" high explosive charge, is employed to produce the desired piercing and penetrative action, without the use of a solid projectile. The hollow or cavity of the high explosive charge is usually provided with a thin liner of metal or other non-explosive material to more effectively concentrate the explosion gases and increase the penetrative efficiency of the resulting gaseous jet.

The present invention is based upon the discovery that solid bullet and jet action may be effectively combined in a single perforating unit or device which will have greater piercing power and produce deeper penetration than either of the present conventional types.

Generally stated, perforating devices in accordance with the present invention employ a generally conventional high explosive cavity charge having a concave metal liner seated in the charge cavity and corresponding in shape thereto, the liner having a metal bullet positioned on its longitudinal axis with the butt end of the bullet secured in a suitable manner to the apex of the liner. By this arrangement, it is found that advantage may be taken both of the normal penetrative properties of the cavity charge jet and of the propulsive action of the jet on the solid bullet to obtain superior penetrative effectiveness. The bullet may be specially shaped, as by providing it with a circumferential shoulder intermediate its ends, to additionally improve the penetrative action of the device.

More specific objects and advantages of this invention will become more readily apparent from the following detailed description when read in conjunction with the accompanying drawings which illustrate several useful embodiments in accordance with this invention.

In the drawings:

Fig. 1 is a longitudinal sectional view of the hollowed end of high explosive cavity charge having mounted in the cavity thereof a metal liner and bullet structure in accordance with one embodiment of this invention;

Fig. 2 is a longitudinal sectional view of another embodiment of metal liner and bullet unit to be employed with a hollow charge;

Fig. 3 is a view similar to Fig. 2 of still another embodiment of liner and bullet unit; and

Fig. 4 is a longitudinal sectional view of one form of a complete perforating device employing a liner and bullet unit of the form illustrated in Fig. 3.

Referring first to Fig. 1, there is shown the end of a

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body of a high explosive charge 5 having a cavity 6 of generally cuneiform or conical shape in which is seated a liner and bullet unit, designated generally by the numeral 1, in accordance with one embodiment of this invention. Charge 5 may be one of the many high brisance types of detonatable chemical explosives commonly used in shaped charges, as for example, trinitrotoluene ("TNT"), pentaerythritol tetranitrate ("PETN"), "Pentolite," "Cyclonite," etc. Unit 1 includes a thin walled hollow liner 7, having a shape complementary to that of cavity 6, which is seated in the cavity with its entire exterior surface in close contact with the adjacent explosive material. The apex portion 8 of the liner may be smoothly rounded, as shown the apex portion of cavity 6 being of like shape.

An elongated, generally cylindrical bullet member, designated generally by the numeral 9, is disposed in the interior of liner 7 along its longitudinal axis. Bullet member 9 has a rearward or butt end portion 10 shaped to fit snugly in the interior of the apex portion of the liner and is secured thereto by any suitable securing means 11, as by welding, brazing, soldering, or the like, in order that the bullet member may be released from the liner upon detonation of the charge. Bullet member 9 is formed or constructed to provide it with a forwardly tapering generally conical nose portion 12, and with a shank portion 13 of somewhat reduced diameter connecting the nose portion to the butt portion. The reduction in diameter of shank portion 13 relative to the maximum diameter of the nose portion provides a radially projecting shoulder 14 circumferentially about the body of the bullet member intermediate its ends. The reduction in diameter to form shank portion 13 may be effected in any suitable and conventional manner, as by machining, casting, forging, or otherwise, to form the shank portion on a radius to thereby provide an arcuate annular recess 15 in the outer periphery of the shank portion, which recess merges smoothly at its forward end into shoulder 14 and at its rearward end into butt portion 10. The length of bullet member 9 will ordinarily be made greater than the axial length of liner 7 so that nose portion 12 will project forwardly somewhat from the outer open end of the liner. The open end of the cavity and of the liner may, if desired, be enclosed by a convex hollow cap or cover, indicated by the broken line 16, to provide a stand-off for the charge and to seal the stand-off space in a generally conventional manner, bullet member 9 being thus also thereby enclosed within the cover and extending into the stand-off space.

Liner 7 is preferably constructed of a suitable metal commonly used for shaped charge liners, such as copper, brass, aluminum, steel and the like, which will largely vaporize or disintegrate upon detonation of the surrounding explosive charge. Bullet member 9 is preferably constructed of hard steel of the character commonly employed in the bullet perforating art, it being important only that it be harder or more dense than the metal of which liner 7 is constructed. The means 11 which is employed to secure the butt end of the bullet member to the liner should be of a different and softer or less dense material than the bullet member, and may be of the same or of a different material than that composing the liner 7.

It will be understood that cavity 6 and its correspondingly shaped liner 7 may have suitable re-entrant hollow shapes other than the cuneiform or conical shape illustrated. For example, the shape may be pyramidal, hemispheric, parabolic or other equivalent hollow shape, as commonly used in the cavity charge perforating art.

When a perforating device, constructed as above described, is detonated, convergence of the explosion gases toward the axis of the hollow and consequent jet for-

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mation occurs as in the usual shaped charge, with liner 7 and the means 11 being vaporized and disintegrated, the disintegration progressing from apex portion 8 toward the open larger end of the liner, thereby releasing the bullet, which will be propelled at extremely high velocity by the force of the jet, along the axis of the cavity toward the well wall or other object to be pierced. The jet apparently converges symmetrically about the bullet member and the circumferential shoulder 14 provides a projection or abutment against which the jet acts to intensify its propulsive action on the bullet member. Securing means 11 acts to momentarily restrain release of the bullet member while the jet formation and propulsive force thereof builds up in the body of the charge.

It will be understood that the mechanism of the action above described is largely theoretical and that the invention, therefore, is not to be restricted to any theory of the action, which is simply advanced for the purpose of supplementing the disclosure herein set forth. It is found, however, that employment of a perforating device as above described results in substantially deeper perforation than may be obtained by use of the lined hollow charge alone or by a bullet alone as fired from a conventional bullet-type gun.

Fig. 2 illustrates a modification of the liner and bullet unit of the perforating device illustrated in Fig. 1 and described above. In the modification shown in Fig. 2, a short cylindrical boss 17 is secured to the interior of apex portion 8 of liner 7 in any suitable manner, as by welding, brazing or soldering. Boss 17 is preferably constructed of a metallic material which is softer than the material comprising bullet member 9. The latter is secured to boss 17 in any suitable manner. As illustrated, boss 17 may be externally threaded at 18 and butt portion 10 of the bullet member may be provided with an internally threaded axial recess 19 for threadedly connecting the bullet member to boss 17. Or bullet member 9 may be pressed on boss 17.

When the liner and bullet unit illustrated in Fig. 2 is seated in a hollowed explosive and the latter is detonated the perforating action will be substantially the same as that previously described.

Fig. 3 illustrates another embodiment of the liner and bullet unit 1 in accordance with this invention. In this embodiment the apex portion of liner 7 is cut off and is replaced by a rounded, cone-shaped cap 20 provided with a flat face 21 at its larger end, the outer edge of which forms an annular shoulder adapted to seat against the rim of the truncated end of liner 7, to which it is firmly secured in any suitable manner, as by welding, brazing, soldering, or equivalent means. The exterior surface of cap 20 is shaped and dimensioned to form a flush continuation of the outer surface of liner 7. Extending forwardly from the center of face 21 of the cap, and preferably integrally formed therewith, is a boss 22 which is externally threaded at 23 to be received in the internally threaded recess 19 of bullet member 9. Butt portion 10 of the latter is cut square, as shown, to seat against face 21 when the bullet member is screwed down fully on boss 22. In other respects bullet member 9 is substantially identical with that shown in Fig. 2. Cap 20 is preferably constructed of metal or metallic materials softer or less dense than bullet member 9 and may be softer than the material of which liner 7 is constructed. Examples of suitable material for cap 20 are aluminum, magnesium, lead, brass or equivalents thereof.

The embodiment illustrated in Fig. 3 operates in a manner similar to the previously described embodiments when employed with a hollowed high explosive charge, such as charge 5.

Fig. 4 illustrates one exemplary embodiment of a completely assembled well perforating device embodying the specific form of liner and bullet unit 1 illustrated

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in Fig. 3. Except for the liner and bullet unit, this embodiment is substantially identical in all other respects with one of the embodiments of a perforating device illustrated and described in my co-pending application Serial No. 163,146, filed May 20, 1950, now Patent No. 2,629,325, dated February 24, 1953. As illustrated therein and in Fig. 4, charge 5 is of generally frusto-conical shape and encased in a plastic capsule 24 of the same general shape as charge 5 and having a rearward end wall 25 provided with an axial opening 26 in which is seated a pellet or body 27 composed of a suitable and well-known booster explosive. The forward end of capsule 24 extends to a point substantially flush with the forward end of cavity 6 and liner 7 seated therein. Capsule 24, with its enclosed explosives and liner and bullet unit, is, in turn, completely enclosed inside a hermetically sealed fluid-tight casing 28, which may be composed of glass or ceramic material, or other material which is adapted to be completely shattered and disintegrated by the force of explosion of charge 5. The forward end portion of casing 28 constitutes the cover 16 of Fig. 1, being shaped and dimensioned to provide the necessary stand-off for the charge and to seal the stand-off space in front of the charge and liner cavities. Cover 16 of casing 28 is provided with an internal annular shoulder 29 against which the forward ends of capsule 24 and liner 7 are seated, the rearward face of end wall 25 containing pellet 27 being seated snugly against the inner face of the rear wall 30 of the casing. The outer face of rear wall 30 is provided with a notch or recess 31 registering with the longitudinal axis of the perforating device and has disposed therein in contact with the outer face of wall 30, a detonating element 32 which may be a portion of a cord-type detonating fuze such as the well-known "Prima-cord."

As described in the aforementioned application Serial No. 163,146, firing of fuze 32 transmits detonating shock through the material comprising rear wall 30 to booster pellet 27, which is thereby set-off and, in turn, detonates charge 5, resulting in the production of a gaseous penetrating jet and propulsion of bullet member 9, the jet and the bullet member being projected by the explosive forces from the perforating device along its longitudinal axis against the target.

The perforating devices in accordance with this invention may employ bullet member 9 as a carrier for transporting marking or identifying material which it may be desired to deposit in the perforation made by the device, particularly in earth formations surrounding a well bore. In such event, a small body or pellet 33 (Fig. 3), composed of a suitable marking or identifying material, such as a radioactive substance may be inserted in recess 19 when the device is assembled. When the charge is fired and the bullet member propelled into the target, the body 33 will be transported by the bullet member and deposited thereby within the target material, where it may later be located by means of a suitable locating device responsive to the particular marking or identifying substance composing body 33.

It will be understood that numerous alterations and modifications may be made in the details of illustrative embodiments within the scope of the appended claims without departing from the spirit of this invention.

What I claim and desire to secure by Letters Patent is:

1. A perforating device, comprising, a high-explosive charge having a re-entrant cavity therein forming a shaped charge, a metallic liner element seated in said cavity, and a metallic bullet member coaxially disposed within said liner element with its butt portion secured to said liner element, the body of said bullet member having an accurate annular recess about an intermediate portion thereof defining a radially projecting circumferential shoulder radially spaced from the surrounding wall of the liner element, and a conical nose portion extending forwardly from the forward end of said recess.

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2. The combination with a high explosive charge having a re-entrant cavity therein forming a shaped charge, a perforating unit insertible in said cavity, comprising, a metallic liner element conforming in shape to said cavity, a metallic bullet member coaxially disposed within said liner element with its butt portion secured to said liner element, said bullet member having an arcuate annular recess about an intermediate portion thereof defining a radially projecting circumferential shoulder spaced forwardly of the portion secured to said liner element and circumferentially spaced from the surrounding wall of said liner element, and metallic connecting means softer than said bullet member securing the butt portion of said bullet member to said liner element.

3. A perforating unit according to claim 2 wherein said metallic connecting means comprise a boss connected to the liner element, and a boss-receiving recess in the butt portion of said bullet member.

4. A perforating unit according to claim 2 wherein said metallic connecting means comprises an externally threaded boss connected to the liner element, and an internally threaded boss-receiving recess in the butt portion of said bullet member.

5. A liner and bullet unit for cavity perforating charges, comprising, a metallic liner of truncated generally conical form shape, a metallic cap member connected to the smaller end of said liner element and shaped to form the apex portion thereof, and a bullet member coaxially dis-

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posed within said liner element with its butt portion separably secured to said cap member, said bullet member having a radially projecting circumferential shoulder means intermediate its ends spaced forwardly of the portion secured to said cap member, said cap member being composed of a metal different than that composing said liner element and softer than that composing said bullet member.

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