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SHAPED CHARGE CONSTRUCTION

Filed Feb. 10, 1964

Fig. 1

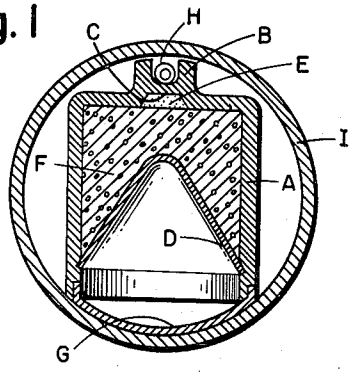


Fig. 2

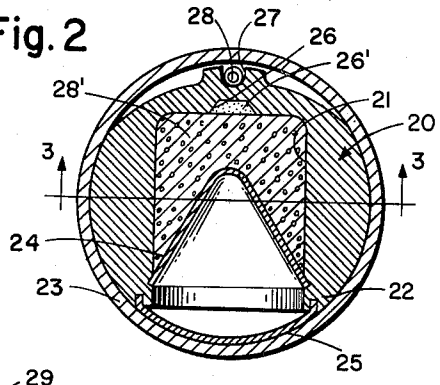


Fig. 3

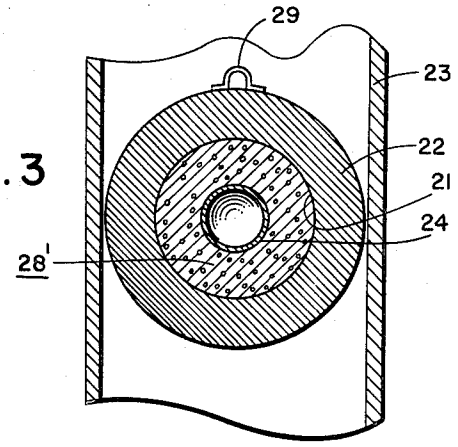


Fig. 4

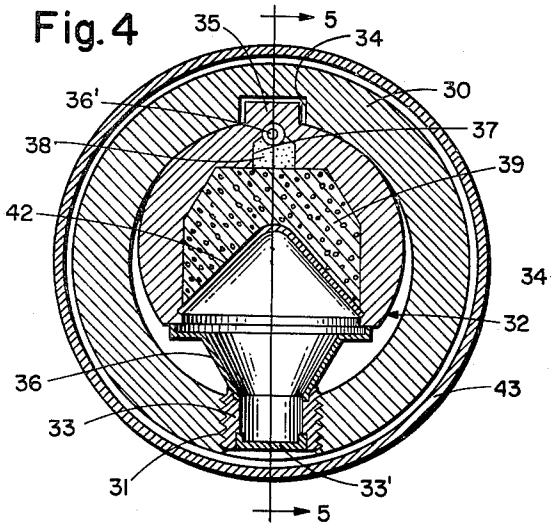
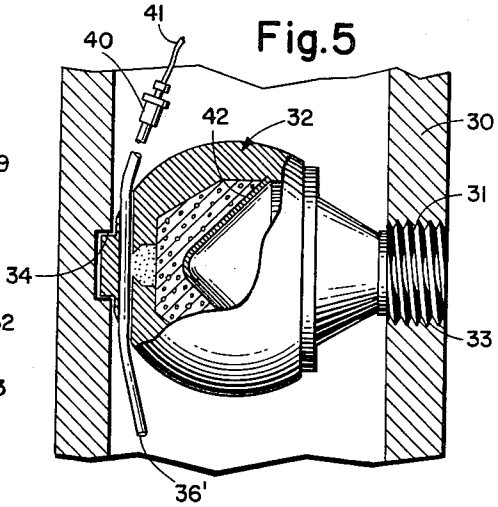


Fig. 5



INVENTOR
LOUIS ZERNOW
IRVING LIEBERMAN
JOHN L. SQUIER

BY Edward O. Ansell

ATTORNEY

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SHAPED CHARGE CONSTRUCTION

Louis Zernow, Glendora, John L. Squier, Riverside, and Irving Lieberman, Covina, Calif., assignors to Aerojet-General Corporation, Azusa, Calif., a corporation of Ohio

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This invention generally relates to improved explosive charges to be used for industrial purposes, and more particularly to improvements in confined explosive charges known as "shaped charges."

Shaped charges generally include a charge of high explosive contained in a case between a hollow conical metal liner and the wall of the case, the liner being arranged with its rim secured around the open end of the case. On detonation of the explosive, practically all of the energy of the explosion is utilized in collapsing the liner into a jet of metal. The jet of metal is driven axially out of the case at extremely high velocity enabling it to penetrate steel or to be driven deeply into the strata surrounding a well. The described characteristic has caused shaped charges to be widely used in the oil well industry for rejuvenating a dry oil well by perforating the oil well tubing and surrounding strata to increase the yield of oil in the area of the well. Shaped charges of known construction, although utilizing the greatest part of the energy derived from the detonation of the explosive, do permit some of the energy of the explosion to be wasted in the deformation of the shaped charge case thereby.

It is, accordingly, an object of this invention to provide a shaped charge of improved construction, wherein the effective energy from the detonation of the explosive material in the shaped charge which is utilized by the shaped charge is increased to a degree not heretofore achieved by shaped charges of known construction.

It is another object of the invention to provide an improved shaped charge case which will lengthen the useful life of shaped charge devices.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in conjunction with the accompanying drawings wherein:

FIGURE 1 is a horizontal section through a conventional shaped charge suspended in a well tubing;

FIGURE 2 is a horizontal section through a shaped charge constructed in accordance with the present invention;

FIGURE 3 is a vertical section taken along line 3—3 in FIGURE 2;

FIGURE 4 is a horizontal section through a perforator gun having a modified arrangement of the novel shaped charge of the invention mounted therein; and

FIGURE 5 is a vertical section taken along line 5—5 in FIGURE 4 with the outer tube omitted.

Referring now to FIGURE 1, a conventional configuration of a shaped charge is shown which includes a cylindrical casing A having a channel or groove B extending along the outer rear surface thereof, a central recess C in the inner rear surface of the casing A adjacent the channel B, and a liner D in the form of a hollow cone of metal positioned with its apex disposed toward the rear of the casing A and its open end secured to the casing A around the front end thereof. Recess C is loaded before the liner D is positioned in the casing A with a charge of sensitive "booster" explosive E, while a charge of high explosive F is disposed in the space within the casing A located between the rear wall thereof and the liner D. The front end of the casing is closed by a cap G.

A length of Primacord H extends through the channel B, the Primacord H including an explosive contained in a waterproof tube and providing in effect a detonation wave which travels at a high rate of speed through the length of the cord. Any suitable means such as a squib, not shown, may be provided to initiate detonation of the Primacord H. The shaped charge shown in FIGURE 1 is illustrated in position for perforating an oil well tube I, the shaped charge being suspended at a desired depth by any suitable means, not shown. When the shaped charge is to be fired, the Primacord H is detonated which creates a detonation wave that travels past the booster explosive charge E, detonating the latter which in turn detonates the charge of high explosive F.

The hollow conical liner D is shaped to guide or direct the greater part of the energy derived from the detonation of the high explosive F in an axial direction with respect to the liner D so as to effect melting of the liner D into a fine jet of metal which travels at such speed through the front end of casing A as to traverse cap G and the wall of well tube I, and thereafter proceeds into the earth strata surrounding the tube I.

While the greater part of the energy of the detonated explosive F is directed forwardly, a significant amount of energy is expended in tending to effect deformation of the casing A, and it is a particular function of the present invention to provide an improved shaped charge having a casing which resists such deformation. The energy thus conserved is added to that acting axially and effects penetration of the strata to a greater depth. When greater depth penetration is not of major importance, the improved shaped charge embodying the present invention will permit a smaller detonating charge to be used to effect a penetration equal in magnitude to that effected by a larger shaped charge of conventional construction.

The improved performance of a shaped charge constructed in accordance with the present invention may result from various structural forms of the case, one of which is shown in FIGURES 2 and 3. In these figures, a shaped charge case 20 is shown formed as a metallic casting which substantially fills the transverse cross-sectional area of the pipe or tube 23 to be pierced or perforated. The case 20 is provided with a cylindrical transverse cavity 21 and has a thickened metallic body wall 22 which resists deformation from the energy generated by the detonation of the high explosive to be contained within the case 20. The thickened body wall 22 has a generally spherical outer surface which provides a maximum of additional metal thickness of the case 20 for use in the oil well tube 23 having a circular cross-section, as shown. The increased thickness of the body wall 22 retards the outward movement of the case 20 upon detonation of the explosive charge contained therein, and serves to concentrate more of the energy which has been released by the detonation of the explosive charge upon the collapsible cone. This concentration of the explosive energy on the collapsible cone serves to impart higher energies to the jet formed from the collapsing of the cone. These higher energies provide increased jet velocities which result in deeper and larger diameter penetrations into the surrounding material. Tests have indicated an increase in excess of 25% in the depth of penetration effected by the use of the improved shaped charge.

The other parts of the shaped charge, such as the conical metallic liner 24, end cap 25, recess 26 filled with the booster explosive charge 26', and the channel or groove 27 for Primacord 28 are similar to the corresponding parts in FIGURE 1 and no further description thereof is believed to be necessary. The high explosive positioned between the liner 24 and the case 20 is indicated at

28'. The shaped charge may be suspended in a desired area by a line connected to an eye 29 welded to the case as indicated in FIGURE 3.

In FIGURES 4 and 5, a modified form of the improved shaped charge in accordance with the present invention is shown, the modified shaped charge being intended for use in a perforator gun. A perforator gun may be used to form a number of perforations in a localized area. It would be desirable to use a perforator gun repeatedly, but heretofore, such guns have had a relatively short life. In the latter respect, the tubular body of a perforator gun has been characteristically susceptible to deformation caused by the distortion of the cases of the shaped charges used therewith when the explosive material contained in the shaped charges was detonated, while the ports in the wall of the perforator gun through which the jets of metal from the detonated shaped charges issued were subjected to excessive wear because of inaccurate firing of the metal jets through the ports which often occurred. These defects are remedied by the construction now described.

The perforator gun comprises a thick cylindrical tube or wall 30 having a plurality of radial ports 31 (only one such port 31 being shown in FIGURES 4 and 5) through which the liquid metal jets from the shaped charge units 32 are to be fired. A threaded bushing 33 is mounted in the port 31, the outer end of the bushing 33 being closed by a cap 33'. The bushing 33 serves to protect the surface of the cylindrical tube 30 bounding the port 31 and to accurately position the forward end of the spaced charge unit 32 corresponding thereto, it being understood that a plurality of spaced charge units 32 corresponding in number to the plurality of ports 31 in the cylindrical tube 30 are disposed along the length thereof. A recess 34 is provided in the inner surface of the gun tube 30 and is aligned with the port 31. Recess 34 receives a stub 35 integral with the shaped charge unit 32 and extending radially outwardly from the rear portion thereof so as to accurately locate the rear portion of the shaped charge unit 32 within the cylindrical tube 30 of the perforator gun.

The shaped charge unit 32 has an end cap 36 provided with a frusto-conical outer portion converging toward the port 31, the end cap 36 serving as a spacer element between the remainder of the shaped charge unit 32 and the port 31 and having an outwardly convergent passage therethrough providing communication between the interior of the shaped charge unit 32 and the port 31. The bushing 33 is screwed into port 31 so as to engage the forward end of the spacer element or end cap 36 and hold the stub 35 in recess 34. The case of the shaped charge unit 32 is provided with a longitudinally extending passageway therethrough for receiving a length of Primacord 36', the passageway and the Primacord 36' extending therethrough being located slightly forward of the stub 35. The Primacord 36' is in communication with a recess 37 which is provided in the rear portion of the case for the shaped charge unit 32, the recess 37 opening inwardly and containing a booster explosive charge 38. The booster explosive charge 38 adjoins a charge of high explosive 39 which is received within the central transverse cavity formed in the case of the shaped charge unit 32.

It will be noted that while the configuration of the transverse cavity in the case of the shaped charge unit 32 has been altered in the embodiment shown in FIGURES 4 and 5 from that illustrated in FIGURES 2 and 3, the volume of the transverse cavity in the shaped charge unit 32 is maintained at a magnitude comparable to the volume of the transverse cavity 21 in the shaped charge unit of FIGURES 2 and 3 by providing a rearward frusto-conical cavity portion therefor, the thickness of the wall of the case of the shaped charge unit 32 being maintained throughout the extent thereof. A liner 42 comprising a hollow cone of metal with its apex disposed toward the rear of the case of the shaped charge unit 32 is secured to the case to retain the high explosive charge 39 in place.

Maximum advantage is taken of the available space within the gun tube 30 through the use of the generally spherical case shown, although it will be understood that the case of the shaped charge unit 32 may take other forms, which may be similarly thickened in other geometric shapes. The added wall thickness of the case of the shaped charge unit 32 serves to minimize damage to the gun tube 30 due to greater retention of the energy of shock by the greater mass of metal in the case, and confinement of the blast effects arising from the detonation of the shaped charge unit 32, which results in a slower rate of expansion and fragments of lower velocity. The additional advantages previously stated with regard to the embodiment of FIGURES 2 and 3 of providing greater concentration of energy from the detonation of the explosive material in the shaped charge unit 32 and thus imparting greater energy to the liner 42 and the jet of molten metal formed therefrom are also realized in the embodiment of FIGURES 4 and 5.

A squib is diagrammatically shown at 40 for initiating detonation of the length of Primacord 36', the squib 40 being fired by electric energy directed thereto via electrical conductors or wires 41 which are connected to a suitable source of electrical power controlled by a switch, not shown, located at a remote station.

When the squib 40 is fired, the Primacord 36' is ignited and burns explosively and progressively throughout its length detonating booster explosive charge 38 which in turn detonates the main charge of high explosive 39 causing liner 42 to be projected as a fine stream of molten metal at extremely high velocity outwardly through the bushing 33, so as to pierce the end cap 33' and the well tubing 43.

In the case of a conventional perforating gun repeatedly fired with the usual form of shaped charges mounted therein, deformation of the shaped charge units causes slight but cumulative damage to the perforating gun at each firing thereof, and the accuracy of the path of the molten metal jets through the ports in the wall of the perforating gun is soon impaired to cause the gun wall around the ports to be worn away resulting in unsatisfactory performance. On the contrary, the positive suppression of deformation or distortion of the cases of shaped charge units constructed in accordance with the present invention insures long and satisfactory functioning of the perforator gun. The advantageous form of the shaped charge cases herein described may be readily and inexpensively produced by conventional casting procedures.

Preferred embodiments of the invention have been described and shown by way of illustration but should not be construed as necessarily limitative of the scope of the invention, since various modifications may be made by those skilled in the art without departing from the scope of the invention as defined by the appended claims.

We claim:

1. A shaped charge construction comprising
   (a) a shaped charge case having a forwardly opening transverse cavity provided therein,
   (b) explosive material received in said cavity,
   (c) a metallic liner secured to said case and closing off said cavity,
   (d) means operably associated with said case to initiate detonation of said explosive material for forcing said metallic liner forwardly at high velocity in the form of a jet of molten metal, and
   (e) said case being substantially spheroid in shape and having solid walls bounding said cavity, said solid walls having a cross-sectional thickness greatest at the point on said case intermediate the forward and rear ends thereof and progressively diminishing in thickness toward each of the forward and rear ends thereof, whereby said solid walls are of sufficient thickness to substantially prevent deformation of said case from the energy released by the detonation of said explosive material.

2. A shaped charge construction for insertion into a tubular member to form a perforation, said shaped charge construction comprising

(a) a shaped charge case having a transverse cavity therein which is open at the forward end of the case,

(b) explosive material received in said cavity,

(c) a metallic liner secured to said case and closing off said cavity to enclose said explosive material therein,

(d) means operably associated with said case for initiating detonation of said explosive material for forcing said metallic liner forwardly at high velocity in the form of a jet of molten metal, and

(e) said case having solid walls bounding said cavity, said solid walls having a transverse thickness substantially greater than the transverse thickness of said metallic liner and being provided with a transverse cross-sectional thickness along the cavity of sufficient dimensions so as to enable said case to define a perimeter in contiguous relation throughout at least a substantial portion of its entire extent with the internal surface of the tubular member into which the shaped charge construction is adapted to be inserted, whereby deformation of the case upon detonation of said explosive material is substantially prevented and greater energy from the detonation of the explosive material is concentrated on said metallic liner to enhance the perforating effect of the jet of molten metal formed therefrom.

3. In combination,

(a) an elongated cylindrical tubular member,

(b) a shaped charge case positioned in said tubular member and having a transverse cavity therein which is open at the forward end of the case,

(c) explosive material received in said cavity,

(d) a metallic liner secured to said case and closing off said cavity to enclose said explosive material therein,

(e) means operably associated with said case for initiating detonation of said explosive material for forcing said metallic liner forwardly at high velocity in the form of a jet of molten metal,

(f) said case being substantially spheroid in shape and having solid walls bounding said cavity, said solid walls having a transverse thickness substantially greater than the transverse thickness of said metallic liner and being provided with a transverse cross-sectional thickness greatest at the point on said case intermediate the forward and rear ends thereof and progressively diminishing in thickness toward each of the forward and rear ends thereof, and

(g) said case defining a circular perimeter in contiguous relation throughout at least a substantial portion of its entire extent with the internal surface of said tubular member, whereby deformation of the case upon detonation of said explosive material is substantially prevented and greater energy from the detonation of the explosive material is concentrated on said metallic liner to enhance the perforating effect of the jet of molten metal formed therefrom.

4. In combination,

(a) a tubular member having at least one port through the wall thereof,

(b) a shaped charge case having a transverse cavity therein which is open at the forward end of the case,

(c) explosive material received in said cavity,

(d) a metallic liner secured to said case and closing off said cavity to enclose said explosive material therein,

(e) said metallic liner being positioned to direct the energy of explosion from the detonation of said explosive material through the open end of said transverse cavity,

(f) said shaped charge case being positioned in said tubular member with the open end of said transverse cavity being in registration with said port in said tubular member,

(g) means operably associated with said case for initiating detonation of said explosive material for forcing said metallic liner forwardly at high velocity in the form of a jet of molten metal, and

(h) said case having solid walls bounding said cavity, said solid walls having a transverse thickness substantially greater than the transverse thickness of said metallic liner and being provided with a transverse cross-sectional thickness along the cavity of sufficient dimensions so as to define a perimeter for said case in contiguous relation throughout at least a substantial portion of its entire extent with the internal surface of said tubular member, whereby said tubular member acts to reinforce the walls of said case so as to substantially prevent deformation of said case upon detonation of said explosive material, thereby concentrating the energy from the detonation of said explosive material on said metallic liner to enhance the perforating effect of the jet of molten metal formed therefrom.

5. In combination,

(a) an elongated tubular perforator gun having at least one port through the wall thereof and an inwardly opening recess in the wall in oppositely disposed relation to the port,

(b) a shaped charge case having a transverse cavity therein which is open at the forward end of the case,

(c) explosive material received in said cavity,

(d) a metallic liner secured to said case and closing off said cavity to enclose said explosive material therein,

(e) said metallic liner being positioned to direct the energy of explosion from the detonation of said explosive material through the open end of said transverse cavity,

(f) said shaped charge case having a rearwardly extending stub and being positioned in said tubular gun with said stub being received in the recess and with the open end of said transverse cavity being in registration with the port in said tubular gun,

(g) means operably associated with said case for initiating detonation of said explosive material for forcing said metallic liner forwardly at high velocity in the form of a jet of molten metal,

(h) said case having solid walls bounding said cavity, said solid walls having a transverse thickness substantially greater than the transverse thickness of said metallic liner and being provided with a transverse cross-sectional thickness along the cavity of sufficient dimensions so as to define a perimeter for said case in contiguous relation throughout at least a substantial portion of its entire extent with the internal surface of said tubular gun to substantially prevent deformation of said case upon detonation of said explosive material, thereby concentrating the energy from the detonation of said explosive material on said metallic liner to enhance the perforating effect of the jet of molten metal formed therefrom,

(i) bushing means received by the port to protect the surface of said tubular gun bounding the port, and

(j) a frusto-conical end cap interposed between said case and said tubular gun with the smaller end of said end cap registering with said bushing means and the larger end of said end cap registering with the open end of said transverse cavity so that the jet of molten metal is directed through said bushing means, whereby said tubular gun may be repeatedly used without damage to the port.

6. In combination,

(a) an elongated tubular perforator gun having at least one port through the wall thereof and an inwardly opening recess in the wall in oppositely disposed relation to the port,

(b) a shaped charge case having a transverse cavity therein which is open at the forward end of the case,

(c) explosive material received in said cavity,

(d) a metallic liner secured to said case and closing off said cavity to enclose said explosive material therein,

(e) said metallic liner being positioned to direct the energy of explosion from the detonation of said explosive material through the open end of said transverse cavity,

(f) said shaped charge case having a rearwardly extending stub and being positioned in said tubular gun with said stub being received in the recess and with the open end of said transverse cavity being in registration with the port in said tubular gun,

(g) means operably associated with said case for initiating detonation of said explosive material for forcing said metallic liner forwardly at high velocity in the form of a jet of molten metal,

(h) said case being substantially spheroid in shape and having solid walls bounding said cavity,

(i) said cavity tapering inwardly at the rear portion thereof to maintain a substantially equal transverse thickness of said solid walls from the forward end of said case to the rear end thereof,

(j) said solid walls having a transverse thickness substantially greater than the transverse thickness of said metallic liner and being provided with a transverse cross-sectional thickness along the cavity of sufficient dimensions so as to define a perimeter for said case in contiguous relation throughout at least a substantial portion of its entire extent with the internal surface of said tubular gun to substantially prevent deformation of said case upon detonation of said explosive material, thereby concentrating the energy

from the detonation of said explosive material on said metallic liner to enhance the perforating effect of the jet of molten metal formed therefrom,

(k) bushing means received by the port to provide a protective liner for the surface of said tubular gun bounding the port, and

(l) a frusto-conical end cap interposed between said case and said tubular gun to space the forward end of said case from said tubular gun with the larger base portion of said end cap conforming to the open end of said transverse cavity and the smaller top portion of said end cap conforming to said bushing means so that the jet of molten metal is directed through said bushing means, whereby said tubular gun may be repeatedly used without damage to the port.

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BENJAMIN A. BORCHELT, *Primary Examiner.*

V. R. PENDEGRASS, *Assistant Examiner.*