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PROTECTIVE SHAPED CHARGE

Filed April 26, 1962

FIG. 1

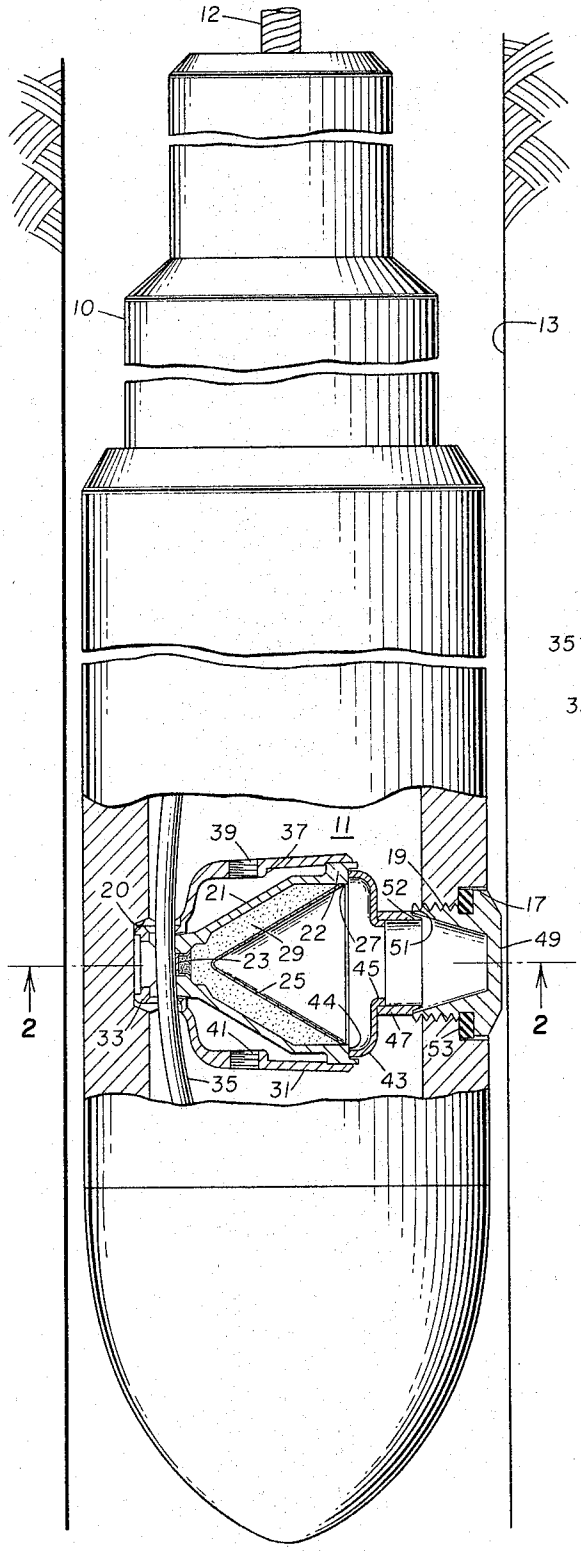


FIG. 2

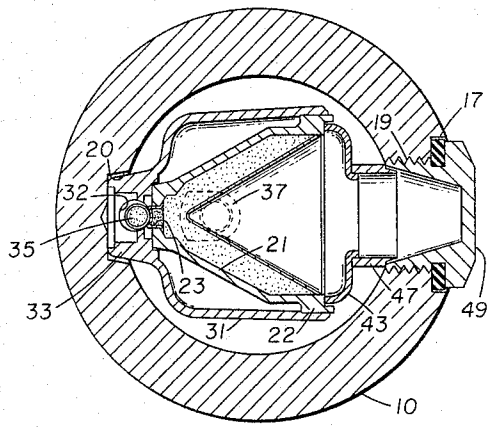
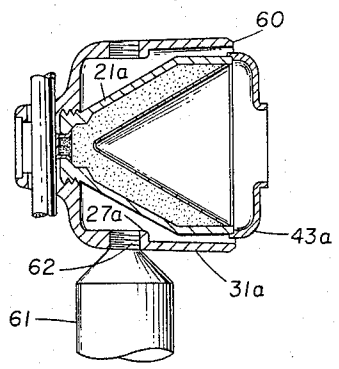


FIG. 3



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PROTECTIVE SHAPED CHARGE

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This invention relates to shaped charges of the type employed in oil well perforating and more particularly to a charge for use in retrievable perforating guns.

Shaped charges are widely used in oil well completion operations where casing cemented in a bore hole is to be perforated at selected points along a formation to be tested or produced. Various types of devices are employed for positioning the charges at selected levels within the casing and for orienting the charges at such levels. In a retrievable gun, shaped charges are located at spaced points along the length thereof. They are aligned with apertures radially directed through the wall of the gun. The gun is ordinarily of heavy wall tubing, a typical example being such that a 3⅛ inch tubing is provided with a ½ inch wall thickness. Shaped charges are mounted with the axis of each charge aligned with an aperture in the gun wall. A high velocity stream of solid particles and gases is projected out through the aperture upon fragmentation of a liner in the shaped charge. Repeated use of such guns results in the mechanical working of the walls in and around the site at which each charge is located. The walls become deformed, eroded and eventually rupture upon relatively few repeated impacts from conventional shaped charges.

It is an object of the present invention to provide a shaped charge which minimizes working and erosion of the perforating gun.

More particularly, it is an object of the invention to provide a confined buffer zone between the shaped charge and the walls of the perforating gun.

In accordance with one aspect of the invention, there is provided structure for supporting an explosive charge as a liner and an inner case for confining a quantity of an explosive. An outer case encompasses and supports the inner case but in spaced relation at a zone remote from the rim of the inner case to provide a buffer zone between the cases. The outer case is adapted to receive a detonator at a point remote from the rim of the inner case for detonation of the explosive between the walls of the liner and inner case.

In a more specific aspect there is provided a gun body having a central bore with a lateral port. A conical liner and an inner case are sealed at the base of the liner to confine a quantity of an explosive therebetween. A cup shaped outer case encompasses the inner case and is secured thereto at the bottom of the outer case and at the lip thereof to support the charge with a space in the region intermediate the bottom and rim.

Means are provided for supporting the outer case in the central bore with the rim of the liner facing the lateral port and for detonating said explosive charge at the point of the liner remote from the rim.

For a more complete understanding of the present invention and for further objects and advantages thereof, reference may now be had to the following description taken in ocnjunction with the accompanying drawings in which:

FIGURE 1 is a view, partially in section, of a perforating gun;

FIGURE 2 is a sectional view taken along the line 2—2 of FIGURE 1; and

FIGURE 3 is a modification of the invention.

Referring now to FIGURE 1, there is illustrated a

perforating gun **10** showing a mid-portion thereof broken away and sectionalized to illustrate a shaped charge **11** mounted therein. It is to be understood that the gun **10** is an elongated casing in which a plurality of shaped charges, such as the charge **11**, are mounted. The charges are mounted with their axes perpendicular to the axis of the gun **10** and in alignment with a radially directed aperture in the wall of the gun. The upper end of the gun is secured to a conductor-carrying cable **12** for raising and lowering the same in a wellborne **13** and for energizing a detonator for charge **11**.

As illustrated, the gun is provided with a radially directed port or aperture **17** which is re-entrant and threaded in the zone **19** thereof. The wall of the gun **10** diametrically opposite the aperture **17** has a shallow, circular recess **20** therein.

In the embodiment shown in FIGURES 1 and 2, the shaped charge **11** is formed with an inner case **21** having a cylindrical mouth **22**. The inner case is truncated at the apex and is formed to receive primer charge **23** retained in a thin-walled cup. The primer charge extends through the peak of the truncated case **21**. A liner cone **25** is positioned coaxially within the case **21**. The liner **25** is sealed to the case **21** at the mouth **27** of the liner **25**. The mouth **27** of the cone is pressed or secured into the cylindrical mouth section **22** of the case **21**.

A quantity of explosive material **29** fills the conical space as a relatively thin shell between the case **21** and the liner **25**. The explosive **29** fills the entire space between the liner **25** and case **21**, except for the primer charge **23**.

The inner case **21** is mounted in an outer case **31** in coaxial relation and with the apex of the case **21** at the bottom of the outer case **31**. The inner case liner **21** is mounted with a press-fit in the outer case **31**, engaging the same at the mouth of the case **31**.

The outer case **31** has a relatively short, cylindrical stem **33** which is received in the recess **20**. The stem **33** is pierced with a cylindrical opening which is tangent to the primer charge **23**. A detonator **35** of primacord or the like is threaded through the opening in the stem **33** to provide for detonation of the primer charge **23** and the explosive charge **29**.

The walls of the outer case **31** are provided with two diametrically opposed interior shoulders, such as the shoulder **37**. The shoulders are provided to add to the wall thickness of the cup along a line parallel to the aperture in the stem **33**. The upper shoulder portion has a threaded opening **39** therethrough. A second threaded opening **41** is provided in the bottom, which is aligned with the opening **39**.

A string of charges, such as the charge **11**, having a primacord detonator such as the cord **35** threaded therethrough, are loaded into the gun **10** one at a time. The gun is then sealed at the upper end so that the interior thereof is maintained free of bore hole fluids until the charges are fired.

The openings **39** and **41** are provided to facilitate loading of the shaped charge **11** in the gun **10**. A loading rod, hereafter more fully described, having a threaded end is secured to the charge **11** by threadedly engaging one of the openings **39** and **41**. Each charge is inserted from one end of the gun by means of such rod while the gun is in horizontal position. Each charge is provided with a cap or alignment washer **43** which rests on the cylindrical shoulder **44** at the lip of the cylindrical section **22** of inner case **21**. Each charge is then moved along the length of the gun until its stem **33** is in registration with a recess such as recess **20**. When in this position, the cone or liner **25** may be seen through the aperture **17**.

The washer **43** has a short cylindrical section **45** which is aligned with the axis of the charge **11**. With the charge

11 in position, a short cylinder or alignment sleeve 47 is dropped through the aperture 17 to encircle the cylinder 45. The alignment sleeve 47 thus mates with the alignment washer 43. A plug 49 is then threaded into the aperture 19 engaging the outer end of the alignment sleeve 47. It will be noted that the alignment sleeve is provided with a shoulder 51 and a tapered section 52. The plug 49 is hollow with a tapered inner surface so that it mates with the tapered section 52 and the end thereof rests on the shoulder 51. As the plug 49 is threaded into the aperture 17, it applies a force to the inner case 21 and thence to the outer case 31 to maintain the charge in fixed position within the gun barrel. A gasket 53 on plug 49 prevents ingress of fluids and provides for desired application of force to the cup 31. With the shaped charge 11 thus positioned, the gun may be lowered into a well bore whereupon detonator 35 when energized will fire the explosive charges therein.

It has been found that gun 10, even though of relatively thick-walled construction and of materials which ordinarily withstand deformation, after use 2, 3, or more times with conventional shaped charges, will be worked in the region around the charge to an intolerable degree. Deformation of the gun barrel is such that it must be replaced after extremely short life. Applicants have found that protection is afforded to the walls of the gun barrel by providing the outer case 31 in an encompassing relation with respect to the inner case 21 to extend the life of the gun. A space is maintained between the inner case 21 and the walls of the outer case 31. The outer case 31 serves to impede the fragments of the inner case 21 as they are propelled outward upon detonation of the charge 29. While both the inner case 21 and the outer case 31 are disintegrated in the course of the firing operation, the use of the present invention minimizes working of the barrel walls. The outer jacket 31 modifies the pattern of the shock wave as well as the trajectory of solids and gases. Air pressures build up in the inner case space modifying the pressure wave patterns to diffuse the explosive energy over a fairly large area.

It should be noted that not only does the outer jacket 31 modify the travel of high velocity particles from the jacket 21, but it also accommodates a loading tool such that a relatively simple rod structure connected thereto as shown in FIGURE 3 may be employed. The shoulders 37 have been illustrated as formed on the inner surface of the wall of the outer case 31. It will be understood that they may be formed exteriorly of the case 31. The choice of site depends somewhat upon the preferences in fabrication. However, the entire structure is shown to be symmetrical with respect to the axes of the ports 17 and the recess 21.

As best seen in FIGURE 2, the primacord detonator 35 passes through the aperture 32 in the stem 33 and ordinarily is maintained by tension in intimate contact with the curved surface of the primer charge 23. It will be noted from FIGURE 2 that the truncated end of the inner case 21 rests in a cylindrical recess in the mouth of the outer jacket 31. The shoulder 37 is of relatively limited extent, thus adding a minimum of materials to the wall of the cup 31, at the same time providing adequate purchase for threaded engagement by a loading rod. In practice, the inner case 21 and outer case 31 are cast or are extruded from zinc but may be formed of other materials. The liner 25, preferably of copper, may be of brass, iron, bronze, powdered metal or glass. Liner 25 is secured within the jacket 21 by a press-fit between the mouth of the liner 25 and the inner surface of the cylindrical section 22. The alignment sleeve 47 may be formed of plastic or of other materials such as light metals. The port seal 49 similarly may be of light metal such as aluminum or the like.

In the preferred form a substantial void is formed between the outer wall of the jacket 21 and the inner wall

of the cup 31 while maintaining a configuration with all parts having symmetry with respect to the axis of the cup 31 to facilitate fabrication and permit ease of mounting of the system.

However, it is to be understood that non-symmetrical shapes may be employed where construction dictates departure from symmetry or where the nature of the hole to be formed requires a non-symmetrical arrangement.

Further, various modes of construction other than that shown in FIGURES 1 and 2 may be employed. For example, in FIGURE 3 a modification of the invention is shown in which the inner case 21*a* is supported in outer case 31*a* at its apex rather than at its mouth. In this embodiment the truncated apex of inner case 21*a* is threaded to mate with a threaded recess in the apex of outer case 31*a*. Alternatively, tapered members may be employed to join the inner case and outer case with a press-fit at either or both the closed ends and/or the mouths thereof. The outer case 31*a* encompasses the inner case 21*a* but does not touch or engage the same at the mouth thereof, an annulus 60 being present between the mouth of the outer case 31*a* and the inner case 21*a*. The washer 43*a* has a recessed end as to encompass the mouth of the inner case 21*a* thereby to facilitate proper positioning of the same.

A loading rod 61 is shown secured to the outer case, a threaded stud 62 being screwed into the opening in shoulder 27*a*. Prior art devices required a loading claw or pincher by which the charge was grasped and located at the desired point in the gun. In accordance with the present invention, the rod 61 is received by the outer case. When the charge is secured at a desired position as by engagement with alignment sleeve 47 and plug 49, the rod 61 may be disengaged and removed for use in loading a second like charge. Thus in the present invention, there is provided a new charge and loading system. The charge provides for control of application of explosive forces to the gun and for receiving a loading rod.

Having described the invention in connection with specific embodiments thereof, it will be understood that further modifications may now suggest themselves to those skilled in the art and it is intended to cover such modifications as fall within the scope of the appended claims.

What is claimed is:

1. A well perforating apparatus which comprises:
   (a) a pressure-resistant hollow body having a central bore with a lateral port extending from said bore;
   (b) a shaped charge structure having an inner case with an open mouth and a liner confining a quantity of an explosive therebetween;
   (c) an outer case encompassing and supporting said inner case at its mouth and apex but maintained in substantial spaced relation from said inner case in the region remote from said mouth of said inner case;
   (d) sealing means in said port and coupled to said charge structure for supporting said structure in said central bore with said mouth aligned with and facing said lateral port; and
   (e) means for detonating said explosive charge at a point remote from said mouth.

2. A well perforating apparatus which comprises:
   (a) a hollow body having a central bore with a lateral port extending through the wall of said body and a recess in the inner wall of said body axially aligned with said port;
   (b) a shaped charge having a liner and an inner case confining a quantity of an explosive and sealed at a juncture between the mouth of said liner and the mouth of said inner case;
   (c) an outer case coaxial with said inner case encompassing said inner case and secured thereto at the base of said outer case with an air space between said inner case and said outer case in the region remote from the mouths thereof;

(d) means including a closure member for said port extending through said port for mechanically engaging said inner case to force a portion of said outer case into said recess with the mouth of said cone aligned with and facing said port; and

(e) means for detonating said explosive charge at a point remote from said mouth.

3. A well casing perforating device for use in deep wells containing a column of liquid which comprises:

(a) a hollow, watertight pressure-resistant container adapted to be lowered into the well and having at least one opening formed in the side wall thereof,

(b) watertight and pressure-resistant closure means for said opening,

(c) a shaped explosive charge supported in said container by said closure means and having a forward hollowed out portion facing said opening and lined with a metallic liner, and

(d) a cylindrical cup axially aligned with said opening and having a mouth facing said opening and encompassing said shaped explosive charge for shielding the inner walls of said casing when said charge is detonated.

4. A well casing perforating device for use in deep wells containing a column of liquid which comprises:

(a) a hollow, watertight pressure-resistant container adapted to be lowered into the well and having at least one opening formed in the side wall thereof,

(b) a shaped explosive charge having a conical jacket

and a forward hollowed out portion facing said opening and lined with a metallic liner,

(c) an outer cup axially aligned with said opening and having a mouth facing said opening and encompassing said shaped explosive charge with substantial spacing therefrom except at the apex and base of said conical jacket for shielding the inner walls of said casing when said charge is detonated,

(d) watertight and pressure-resistant closure means for said opening, and

(e) means forced by said closure means into engagement with said jacket for securing said charge and said cup within said container.

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