Oct. 10, 1967

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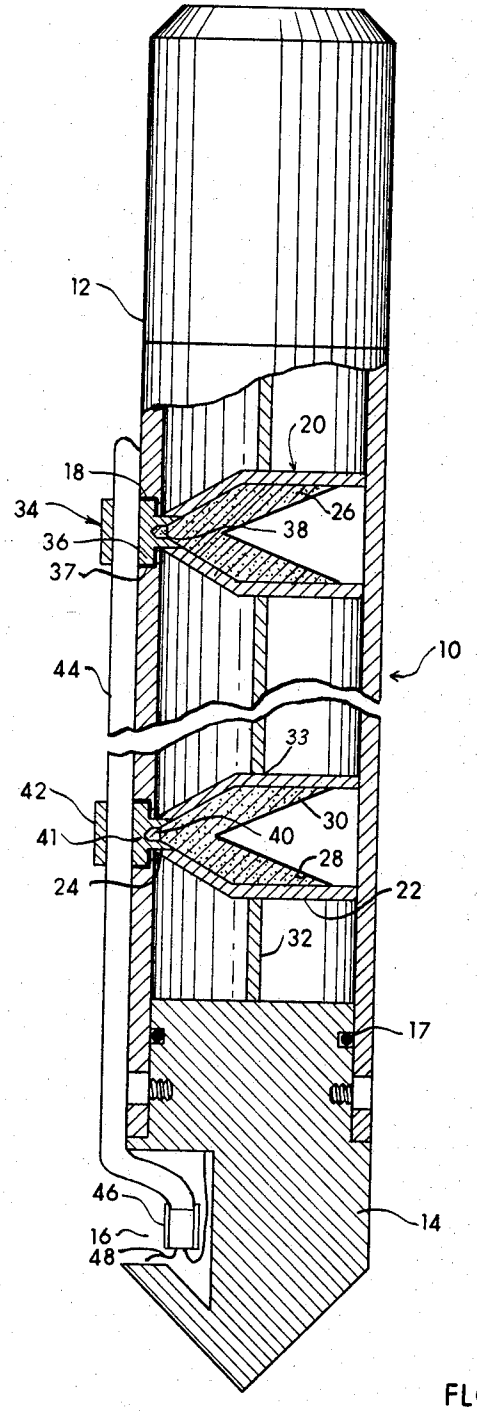
3,346,056

HOLLOW CARRIER GUN

Filed May 24, 1965



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United States Patent Office 3,346,056 Patented Oct. 10, 1967

3,346,056

HOLLOW CARRIER GUN

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Filed May 24, 1965, Ser. No. 458,222
3 Claims. (Cl. 175—4.6)

ABSTRACT OF THE DISCLOSURE

The length of a shaped charge extends substantially the entire diameter of the space inside a hollow carrier body, and a booster cap extends into an aperture in the wall of the carrier from the outside and has a portion extending externally therefrom to receive the Primacord which extends along the outer surface of the hollow carrier body.

This invention relates to lined shaped charge perforating guns and more particularly, to a hollow carrier type gun for use in small diameter tubing.

Lined shaped charges are used extensively by the petroleum industry for perforating operations. Generally speaking, there are two common types of carriers or guns used to properly position the shaped charges in the well borehole. These are the hollow carrier type gun and the capsule type gun. In the hollow carrier type gun, all of the charges are positioned within a generally cylindrical enclosed tubing. The explosive forces are retained within the tube and all residual parts resulting from the detonation of the lined shaped charges also remain in the gun. Therefore, no junk is left in the well. In the capsule type gun the lined shaped charge has its own pressure resistant housing. In some of the capsule type guns, the carrier for the charges is also expendable, however, in other types of capsule guns the carrier is retrievable and the only junk remaining in the hole is that left by the individual shaped charges. Accordingly, for many operations the hollow carrier type gun is preferred. However, since in hollow carrier type guns the charges are contained within a pressure resistant housing the length of the shaped charge is usually less than a corresponding diameter capsule type charge. In addition, the diameter of tubing has been decreasing and the problem of size of the gun used in the well is becoming more acute. For example, today in through-tubing or small diameter tubingless completions, the common sized tubing used has an outside diameter of 2⅞" and a nominal inside diameter of 2½". Moreover, in the through-tubing completion practice, there may be one or more landing nipples having a seating surface for packers which have a reduced inside diameter. For instance, 2¼" in 2⅞" tubing, $1\frac{25}{32}$" in 2⅜" tubing, etc. Retrievable perforator guns that go down through the tubing also have to be brought back out of the well without damaging the seating surface of the nipple. As mentioned, the explosive forces resulting from the detonation of the shaped charges is contained by the body of the hollow carrier gun and the guns swell. The swelling of the gun body is in localized spots opposite the flank of the charge. Knobby guns, which result from the localized swelling, decrease annular clearance and increase the hazards in running. In addition, there is often a burr resulting from the jet piercing through the gun body. This burr also increases the diameter of the gun. In the example above given where the inside diameter of a landing nipple is 2¼" and has a sealing surface which it is desirable not to mar, the producing companies have a rule that no hollow carrier gun exceeding 2" may be used and it is further specified that the gun may not exceed $2\frac{1}{10}$" after

firing. Therefore, the size of the gun body is of prime importance.

The purpose of the present invention is to effectively use the available space in a hollow carrier gun body thereby to permit the design and manufacture of shaped charges with superior performance characteristics.

It has been customary in hollow carrier guns to have the Primacord which is customarily used as the detonating means for shaped charges, to extend inside the gun barrel at the axial rear end of the booster in the charge. Accordingly, the Primacord takes up an inproportionately large part of the available space inside the hollow carrier gun. Efforts have been made to place the Primacord at the side of the booster of the charge, however, trials of charges in which the Primacord has been placed on the side rather than at the axial rear end have been inefficient and inconsistent.

The demand for elimination of gun debris in boreholes has led to increased use of retrievable gun bodies of thin walled steel tubing. In such guns the wall of the guns must withstand the explosive force of the shaped charge and the Primacord. The inside diameter of the gun body limits the length of the shaped charge and consequently, the depth of the penetration of the charge. The gun body must be retrieved through established restrictions. In current designs, expansion of the gun body is such that definite clearances between the outside diameter of the gun body and the minimum inside diameter are provided.

It is an object of the present invention to more effectively use the space inside a hollow carrier gun by removing the detonating means from within the body of the hollow carrier gun.

It is another object for small diameter hollow carrier guns to increase the effective size of the charge by fully utilizing the space available.

In accordance with the present invention, the Primacord used for detonating the charges is removed from inside the housing and placed tangent to the outer periphery. The shaped charges used in the improved hollow carrier type gun have a booster portion extending into the wall of the hollow carrier type gun so that the detonating forces of the Primacord will properly excitate the shaped charge. By moving the shaped charge over against the wall of the hollow carrier type gun and actually having a portion of it in the wall of the hollow carrier type gun, the depth of the shaped charge is increased; therefore, the angle of the cavity may be decreased, increasing the jet resulting from the detonation of the charge, accordingly increasing the depth of penetration obtainable with the shaped charge.

As previously mentioned, the diameter of a hollow carrier has to be substantially smaller than the smallest diameter it encounters in entering the well because of swelling resulting from the detonation of the charge within the gun. However, in the present invention the Primacord is outside the gun body and disappears upon detonation, therefore, the space occupied by the Primacord may be used for swelling.

Accordingly, it is a further object to use expendable detonating means located outside the hollow carrier gun body so that the diameter of the gun on coming out of the well does not exceed predetermined maximums.

Other objects and objects relating to details of manufacture and use will be more fully apparent from the detailed description about to follow, taken in conjunction with the single figure in the drawing showing a cross section of improved hollow carrier type gun of the present invention.

Referring now to the drawing, it can be seen that the hollow carrier gun of the present invention is comprised of a length of hollow open-ended tubing which forms a

gun body **10**, the length of the tubing will depend upon the number of charges which it is desired that the gun will carry. Since the present gun is designed as an expendable gun and the shaped charge will shoot through the body, the tubing forming the gun body may be thin walled tubing of mild or heat treated steel. However, as previously explained, the debris from the charge will remain inside the gun enabling the gun and debris resulting from the detonation of the charges to be retrieved from the well. A closure closes each end of the tubing making the inside of the gun body **10** pressure resistant. The upper closure **12** has means enabling the hollow carrier gun to be attached to a cable so that it may be properly positioned in the borehole, as is well known in the art. The bottom closure **14** is provided with a space **16**, the purpose of which will be described subsequently. Means are provided to seal around each closure. They may take the form of an O-ring **17** illustrated or other suitable sealing means. Means are also provided to secure the closure to the tubing.

A plurality of counterbore apertures **18** are positioned along the length of the tubing **10**. These may be in either spiral arrangement or may be vertically aligned.

A plurality of shaped charges **20** are positioned inside the tubing. Each shaped charge **20** is formed of a case **22** which is so designed that it will fit inside the tubing **10**. The case **22** is generally cup-shaped and provided with an axial aperture **24** at its lower end. A block of explosive **26** normally used in forming a shaped charge such as RDX or cyclonite, is positioned inside the casing **22**. The block of explosive **26** has a cavity **28** in its front face. A suitable liner **30** covers the face of the cavity as is well known in the art. The shaped charge **20** is formed in accordance with conventional methods, except for the fact that the casing **22** is not provided with a booster as is customary. As can be seen, the length of the case **22** without the booster is equal to the diameter of the inside of the body. Therefore, the charge utilizes all available space. By so doing, the included angle of the cavity **28** may be decreased to permit the formation of the longest jet and subsequently, the deepest penetration available for a shaped charge of such caliber.

The shaped charges **20** are positioned in a carrier strip **32** which has a number of apertures **33**, which positions the charges opposite the apertures **18** in the body **10**.

A plurality of booster caps **34**, one for each shaped charge **20**, are positioned in each of the apertures **18**. The booster cap is formed of a round stepped end **36** which is matingly engaged and sealed by appropriate sealing means **37** with the counterbore apertures **18**. The end of the booster cap extends into the axial aperture **24** in the case **22** of the shaped charge **20**. The stepped round end **36** of each booster cap **34** is provided with a hole **38** in which is positioned a charge of explosive **40** forming the booster for the main body of the explosives of the shaped charge. The hole **38** is limited in depth so that a fluid resistant bulkhead **41** is formed. The booster **40** is actually in contact with the end of the explosive **26** of the shaped charge **20**. The booster cap **34** has an annular extension **42** extending from the round stepped end **36**.

A length of Primacord **44** extends from the space **16** in the bottom closure **14** through each of the annular extensions **42** of the booster caps **34**. An electrically fireable pressure resistant blasting cap **46** is located in the space **16** of the end closure **14** and a pair of wires **48** extend from it to the cable and thence to the surface to the firing control, as is well known in the art.

Accordingly, firing of the blasting cap **46** will ignite the Primacord **44** which will in turn detonate the booster **40** through the bulkhead **41**. The detonation of booster **40** detonates the block of explosive forming the shaped charge **20**. The explosive force developed by the shaped charge will disintegrate the liner **30** and form a particle laden jet which will penetrate the wall of the tubing and then further penetrate the steel casing of the well bore, the cement sheath and cause a hole to be formed in the formation. The detonation of the Primacord **44** will break the annular extension **42** of the booster cap **34** into small pieces.

Since the shaped charges are contained within the hollow carrier gun, any residue left from the detonation of the shaped charges **20** will be retained in the hollow carrier gun. Although the hollow carrier gun of the present invention may be formed of thin walled tubing and will swell as a result of the detonation of the shaped charges, nevertheless, in view of the fact that the space occupied by the Primacord **44** on entry of the shaped charge gun into the well has now been eliminated. The overall diameter of the hollow carrier of the gun body will not be such as to hang up as it is being retrieved from the well, and the only residue which will be left in the well will be the finely disintegrated portions of the annular extension of the booster cap which will be so minor as not to be of any significance.

I claim:

1. A hollow carrier gun for lined shaped charges for use in perforating small diameter tubing, said gun comprising:

a gun body formed of a length of hollow, open-ended tubing having counterbore apertures spaced apart along its length, a closure sealingly engaged with each end of the tubing; a shaped charge carrier strip inside said body, said carrier strip having apertures aligned with said apertures in said body, a plurality of shaped charges in said apertures of said carrier strip, each shaped charge formed of a generally cup-shaped case designed to fit inside of the gun body and having an axial aperture aligned with the opposing aperture in said gun body; a block of high explosive in said case having a lined cavity in its front face; a plurality of booster caps, one for each shaped charge, each booster cap formed of a round, stepped end sealingly engaged with the counterbore aperture in the body and engaging the axial aperture in the case of the shaped charge; a booster in the end of said booster cap contacting the block of explosive of the shaped charge, an annular extension extending from the round stepped end; a Primacord passing through the annular extension of each booster cap, and ignition means attached to the end of the Primacord.

2. A hollow carrier gun for lined shaped charges for use in perforating small diameter tubing, said gun comprising:

a gun body formed of a length of hollow, open-ended tubing, a plurality of counterbore apertures along the length of the body, a closure sealingly engaged with each end of the tubing; a plurality of shaped charges inside said body, each shaped charge formed of a generally cup-shaped case designed to fit inside the body and aligned with said aperture, the case having an axial aperture at its small end; a block of high explosive in said case having a cavity in its front face; a plurality of booster caps, one for each shaped charge, each booster cap formed of a round, stepped end sealingly engaged with the counterbore aperture in the body and engaging the axial aperture in the case of the shaped charge; a booster in the end of said booster cap contacting the block of explosive of the shaped charge, an annular extension extending from the round stepped end; a Primacord passing through the annular extension of each booster cap, ignition means attached to the end of the Primacord.

3. A hollow carrier gun for lined shaped charges for use in perforating small diameter tubing, said gun comprising:

a hollow gun body, a plurality of apertures along the length of the body; a plurality of shaped charges inside said body, each shaped charge formed of a generally cup-shaped case designed to fit inside the

body, having an axial aperture at its small end; the axial aperture of the case aligned with an opposing aperture in the gun body; a block of high explosive in said case having a lined cavity in its front face; a plurality of booster caps, one for each shaped charge, each booster cap engaged with the aperture in the gun body and the axial aperture in the case of the shaped charge; a booster in the end of said booster cap contacting the block of explosive of the shaped charge, an annular extension extending from the booster cap external of said body; a Primacord passing along the outside of said body and through each annular extension, ignition means attached to the end of the Primacord.

References Cited

UNITED STATES PATENTS

2,764,938	10/1956	Harcus	175—4.6
2,785,631	3/1957	Blanchard	175—4.6
2,925,775	2/1960	McKee	175—4.6 X
2,980,017	4/1961	Castel	175—4.6
2,986,089	5/1961	Meddick	175—4.6
3,128,702	4/1964	Christopher	175—4.6

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