April 5, 1966 W. T. BELL 3,244,101

PERFORATING APPARATUS

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Fig. 1

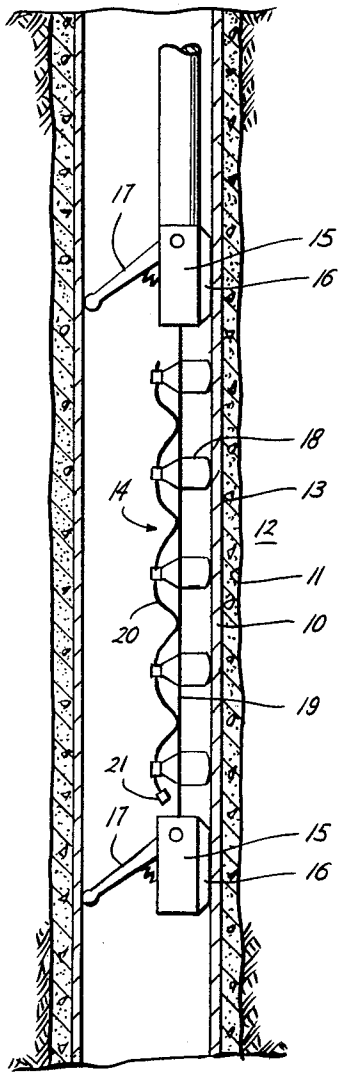
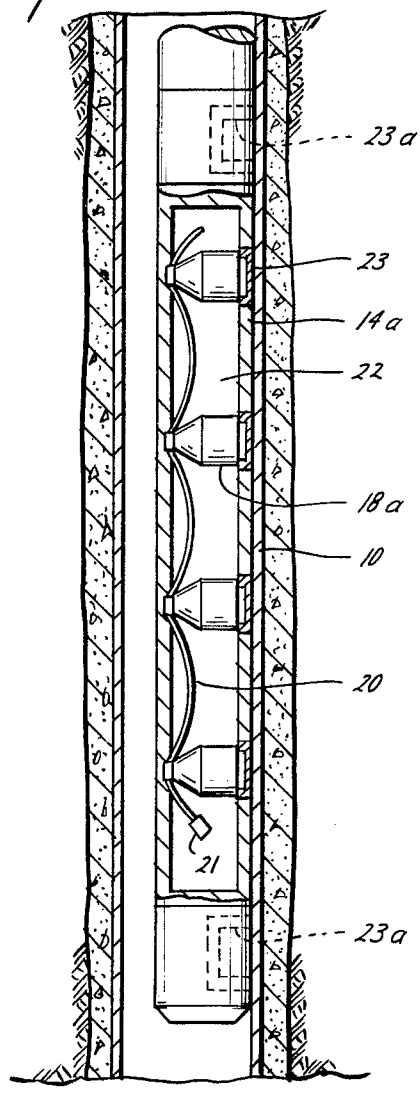


Fig. 2



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Fig. 3

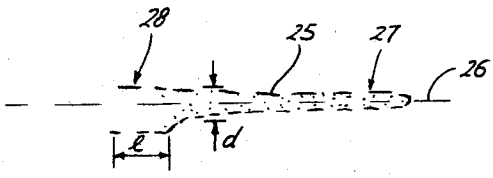


Fig. 4

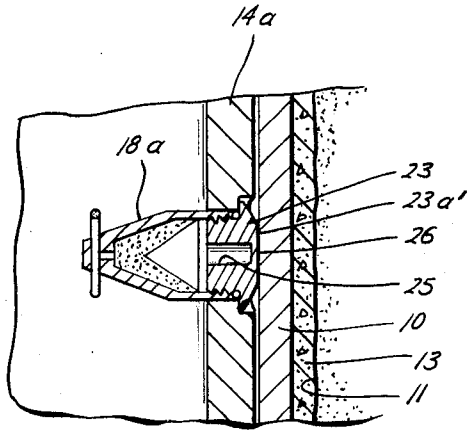


Fig. 5

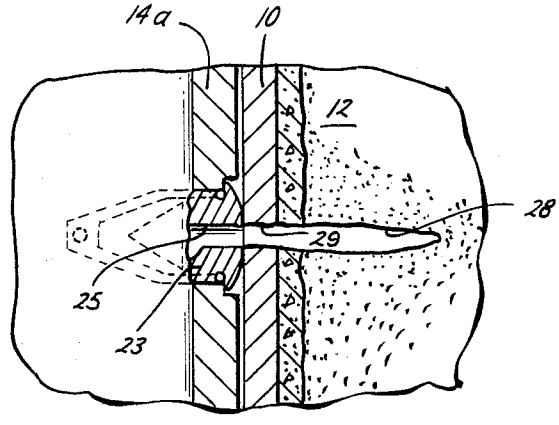
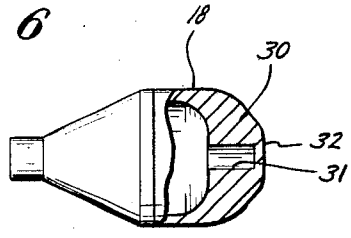


Fig. 6



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3,244,101

PERFORATING APPARATUS

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2 Claims. (Cl. 102—20)

This invention relates to perforating apparatus and, more particularly, pertains to new and improved perforating apparatus employing shaped explosive charges.

Shaped charges are widely and effectively used as perforating devices in well bore completions. Usually a shaped charge intended for such a purpose includes a block of explosive material which has a conical recess in its front face. This recess receives a liner having a suitable thickness and composition so that upon detonation of the explosive material, the explosive shock wave traveling toward the liner eventually collapses the liner and a high velocity perforating jet is formed along the axis of the recess. Because of the high velocity and energy content of the perforating jet it is capable of penetrating the wall of the casing which lines the well bore, the cement sheath surrounding the casing and the earth formations therebeyond. It has been of concern recently that the entry hole to the perforation does not always have a suitable shape or configuration to profitably utilize a "ball sealer" used in subsequent fracturing operations.

It is, therefore, an object of the present invention to provide new and improved apparatus for use in perforating in a well bore whereby a uniform entry hole is provided in the casing.

This and other objects of the invention are obtained by shaped charge apparatus with means for absorbing or eliminating objectionable portions of a perforating jet which form irregularly shaped entry holes.

The novel features of the present invention are set forth with particularity in the appended claims. The present invention both as to its organization and manner of operation, together with further objects and advantages thereof, may best be understood by reference to the following description when taken in conjunction with the accompanying drawings in which:

FIG. 1 is a longitudinal view of an expendable shaped explosive charge perforating apparatus constructed in accordance with the invention and shown disposed in a well bore;

FIG. 2 is a longitudinal view of a carrier shaped explosive charge perforating apparatus constructed in accordance with the invention and shown disposed in a well bore;

FIG. 3 is a view of a perforating jet;

FIGS. 4 and 5 are views before and after the operation of apparatus of the present invention; and

FIG. 6 is a side view of a variation of the invention.

In FIG. 1 of the drawings, there is illustrated a casing **10** in a well bore **11** which traverses earth formations **12**. A column of cement **13** is disposed between the casing and well bore. Shaped charge apparatus **14** can be suspended in the casing in any usual manner and includes a number of fluid-tight shaped charge capsules **18** which are attached to a rigid retrievable carrier **19** such as rods or a strip. Blasting cord **20** for detonation of the charges is connected to an electric blasting cap **21** which can be electrically ignited in the usual manner from the surface by wires and a power source (not shown).

At suitable locations positioning devices **15** are attached to the carrier **19**. Positioning devices **15**, for example, can be housings with portions **16** brought into contact with the casing wall by means of properly located spring biased arm members **17**. The housing portions **16**

are aligned relative to the capsules so as to bring the forward faces of the shaped charge capsules **18** into or nearly into contact with the wall of the casing. To do this, of course, requires the suitable positioning of arms **17** relative to the carrier **19** and capsules **18**. Positioning devices are not necessary to the present invention but as used above prevent the formation of a burr on the entry hole of the perforation.

In FIG. 2, a retrievable, re-usable steel housing carrier **14***a* is illustrated wherein shaped charges **18***a* are disposed within the fluid-tight interior **22** of the housing. Port hole covers **23** through which a perforating jet may pass are located adjacent the forward end of each charge. Cover **23** has a portion **23***a'* with a curvature complementary to the curvature of a casing. Carrier **14***a* has permanent magnets **23***a* aligned relative to the port hole covers so as to bring the port hole covers **23** into proximate contact with the wall of the casing.

It will be appreciated that while positioning devices are illustrated as preferable, they are not absolutely necessary for the operation of the present invention.

Referring to FIG. 3, a fully developed perforating jet **25** extending along a perforating axis **26** is illustrated. Jet **25** includes forward and rearward portions **27** and **28**.

It is always expected that the perforating jet has a uniform configuration about the jet axis; however, experience has shown that shaped charges, when detonated in a well bore, can have some small defect which distorts the trailing end of the jet. As shown in FIG. 3, such a defect often takes the form of an eccentric enlargement which, for example, produces a key shaped entry hole in the casing. A key shaped entry hole is particularly objectionable where "sealing balls" are used in fracturing operations. Ordinarily, the forward end **25** of a jet has a relatively small diameter *d* when first generated and the defect in the trailing portion of the jet has a determinable length *l*. The length *l* is easily determined by observation of tests.

Referring now to FIG. 4, a section of apparatus as shown in FIG. 2 is further detailed. In particular, the carrier housing **14***a* carries the usual shaped charge **18***a*. In the present invention the port hole covers **23** are constructed of solid metal and have a blind bore **25** terminating at a forward thin-walled section **26**. Bore **25** has a diameter just greater than the diameter *d* of the perforating jet and a length just longer than the determinable length *l* of a distortion in the trailing end of a jet. Hence, after the charge **18***a* is detonated as shown in FIG. 5, a penetration **28** is formed with a uniformly shaped entry hole **29** since the metal of the cover **23** will use up the distorted trailing portion **28** of a jet.

As shown in FIG. 6, the above-described principle can be applied to capsule charges **18** as used in FIG. 1 where the forward end **30** of the capsule is provided with a blind bore **31** in manner as heretofore described. End **30** also has an outer surface **32** with a curvature complementary to the curvature of a casing.

While particular embodiments of the present invention have been shown and described, it is apparent that changes and modifications may be made without departing from this invention in its broader aspects and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

What is claimed is:

1. Shaped charge apparatus for use in a well bore comprising: a shaped charge means adapted when operated to produce a perforating jet, and capsule means enclosing said charge means and having a forward portion with a curvature substantially the same as the curvature of a casing, said capsule means having a metal bar-

rier disposed adjacent to said charge means with a blind bore terminating at a thin-walled section, said bore having a diameter just greater than the diameter of the effective penetrating portion of a perforating jet and having a length greater than the effective length of eccentric distortion in the non-effective penetrating portion of a perforating jet, and means for placing said forward curved portion into contact with a casing.

2. Shaped charge apparatus for use in a well bore comprising: a hollow carrier having a port hole, a shaped charge means disposed adjacent said port hole and adapted, when operated, to produce a perforating jet, and closure means disposed in said port hole adjacent to said charge means, said closure means having a forward portion with a curvature substantially the same as the curvature of a casing and a blind bore terminating at a thin-walled section, said bore having a diameter just greater than the diameter of the effective penetrating portion

of a performating jet and having a length greater than the effective length of eccentric distortion in the non-effective penetrating portion of a perforating jet, and means for placing said forward curved portion into contact with a casing.

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