Sept. 24, 1963 C. BAKS 3,104,611

PERFORATING APPARATUS

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Fig. 1

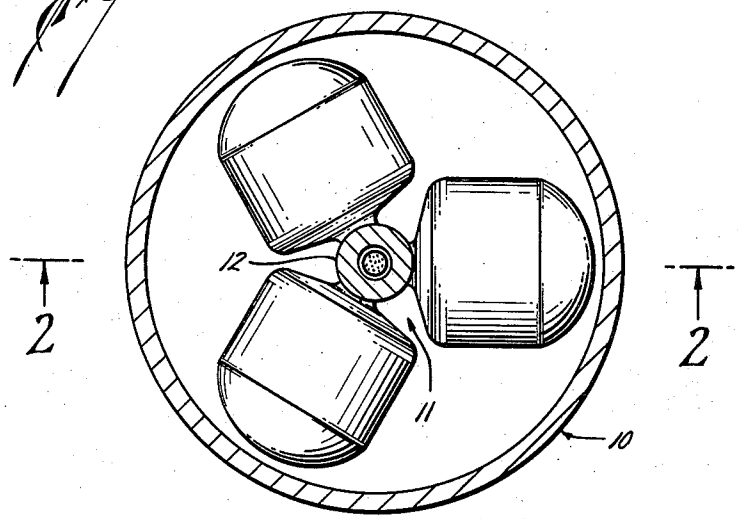
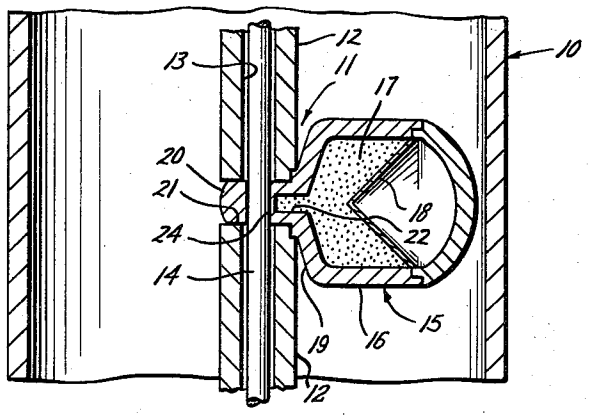


Fig. 2



Claude Baks
INVENTOR.

BY Donald H. Fidler

ATTORNEY

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Fig. 3

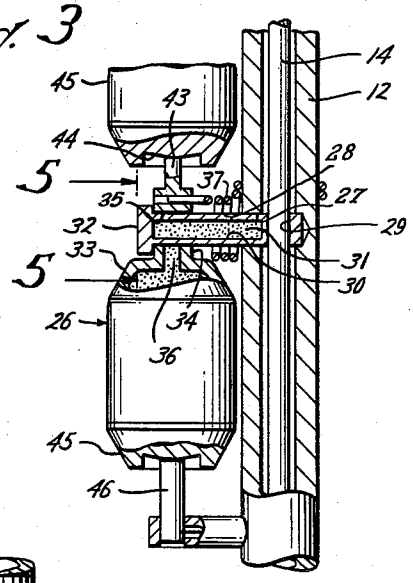


Fig. 5

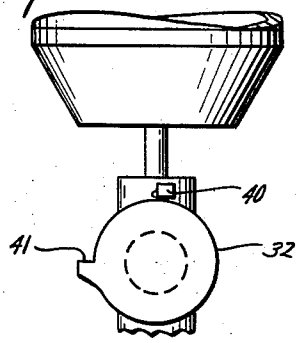


Fig. 4

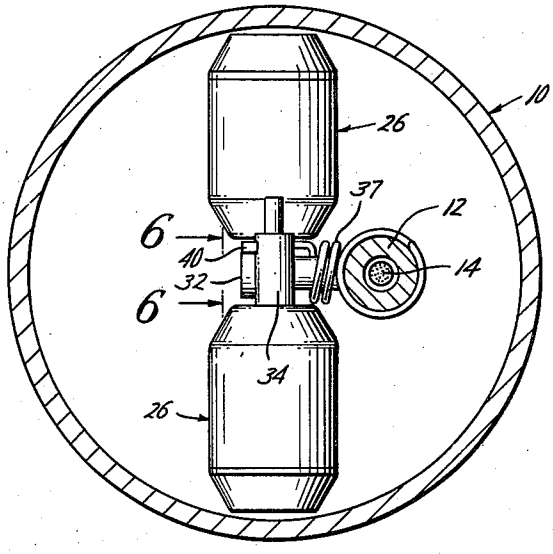
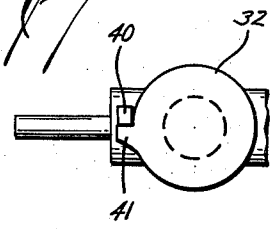


Fig. 6



Claude Baks
INVENTOR.

BY Donald H. Feller
ATTORNEY

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3,104,611
PERFORATING APPARATUS

Claude Baks, Paris, France, assignor to Societe de Prospection Electrique Procedes Schlumberger, Paris, France, a corporation of France

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4 Claims. (Cl. 102—20)

This invention relates to well perforating apparatus and, more particularly, to expendable types of perforating apparatus for use in well bores.

It is highly desirable in well completions to reduce the amount of debris of the perforating apparatus that is left in the well bore. Many factors, of course, enter into the design and selection of perforating apparatus and the amount of debris a given perforating apparatus will produce, but, in general, the types of perforating apparatus may be conveniently divided into a so-called carrier type of apparatus and a so-called capsule type apparatus. The advantages and disadvantages of the two types of apparatus need not be described herein, it being sufficient to specify that the present invention relates particularly to perforating apparatus of the capsule type.

Generally, in capsule type perofrating apparatus, a number of shaped charges in capsule containers are linked to one another by a linking mechanism on the capsules to form a chain or linked assembly of charges. A suitable blasting cord initiating means is interconnected between the various capsules to detonate the shaped charges therein. The debris that is produced in this capsule type perforator comes mainly from two sources, namely the capsule container itself and the linkage necessary to interconnect the capsules. In the present invention, an assembly of capsule type shaped charges is presented in which the debris left in the borehole is resultant solely from the capsule container while a support for linking the capsule containers is retrievable. In this manner, the debris left in the borehole can be considerably reduced.

Certain other types of capsule shaped charge perforating apparatus are of the so-called swing-jet type wherein elongated capsules are arranged to be axially aligned for passage through a small diameter tubing and, after entering into the casing below the end of the tubing, arranged to swing about pivot axes so that the elongated capsules are disposed normal to the axis of the well bore. Here, too, a debris problem has existed.

Accordingly, it is an object of the present invention to provide new and improved apparatus for reducing the amount of debris resultant from perforating apparatus of the above described types.

Apparatus in accordance with the present invention includes a tubular, retrievable support member which is adapted to receive, a blasting cord detonating means through its bore, and shaped charges adapted to be coupled to the support member. In one embodiment, the shaped charges are supoprted in fixed relation. In another embodiment of the present invention, the shaped charges are arranged to swing between an axially aligned position relative to the support member and a position normal to the support member.

In the drawings:

FIG. 1 is a top view of a gun assembly of one embodiment of the present invention, the assembly being shown in a cased well bore;

FIG. 2 is a view in cross-section taken along line 2—2 of FIG. 1;

FIG. 3 is a front elevation of a gun assembly of another embodiment of the present invention, portions of the assembly being illustrated in cross-section and the assembly being in one position of operation;

FIG. 4 is a top view of the gun assembly shown in

FIG. 3, the assembly being shown in a cased well bore in its other position of operation;

FIG. 5 is a view taken along line 5—5 of FIG. 3; and

FIG. 6 is a view taken along line 6—6 of FIG. 3.

Referring now to FIGS. 1 and 2, a section of a cased well bore 10 is illustrated which traverses earth formations. Apparatus 11 according to the present invention includes a tubular, elongated support member 12 with its bore 13 sized to receive a blasting cord initiating means 14. The support member 12 may be constructed, for example, of infrangible metal such as steel so as to be retrievable.

A capsule shaped charge device 15 includes a generally cylindrical and hollow container 16 constructed of a relatively frangible material such as aluminum, the capsule container receiving an explosive 17 fitted with a conventional liner 18 in the customary manner. At the rearward end 19 of the capsule device is a cylindrical stud member 20 is relatively small diameter which is sized to be received in a transverse bore 21 in the support member 12. The stud member 20 has a hollow portion 22 in which a booster explosive for the main explosive 17 is received, and adjacent to the hollow portion 22 is a bore 24 arranged normal to the axis of the capsule device to receive the blasting cord initiating means 14. The size of the bore 21 in the support member 12 and the diameter of the stud member 20 are sized to give fairly tight fit so that the capsule can be firmly positioned in the support member. The blasting cord initiating means 14 threaded through the bore 24 in the capsule device thereby prevents displacement of the capsule device relative to the support member 12.

It will, of course, be appreciated that the capsule devices 15 may be arranged in longitudinal alignment lengthwise of the support member 12 or may be rotatively positioned relative to one another lengthwise of the support member as shown in FIG. 1. The support member 12 is, of course, arranged to be suspended in a well bore by means of cable (not shown) and a winch (not shown) in a conventional manner. Also, it should be noted, in particular, that the ignition of the blasting cord 14 can be accomplished from either end of the assembly. Ignition of the blasting cord 14 from the upper end of the assembly, of course, eliminates the need for electrical wiring lengthwise of the assembly.

Referring now to FIGS. 3 and 4, a swing-jet type capsule 26 embodying the present invention is illustrated. In this embodiment, the tubular support member 12 has blind bores 27 arranged transverse to its longitudinal axis, the axes of the bores 27 lying in a common, longitudinally extending plane. One end of a cylindrical member 28 having a transverse bore 29 to receive a blasing cord is received in each of the bores 27. Adjacent to the transverse bore 29 in the cylindrical member 28 is a hollow portion 30 which receives an explosive 31 and the remaining end of the cylindrical member 28 is provided with a flange 32.

A typical capsule 26 is generally cylindrical and hollow to contain a shaped charge explosive as above described. At the rearward end 33 of the capsule, a cylindrical stud member 34 of relatively small diameter has a bore 35 arranged transverse to the axis of the capsule which is sized to be sidably received by the cylindrical member 28 adjacent to the flange 32. The stud member 34 has a hollow portion 36 in which a booster explosive for the main explosive is received, the hollow portion terminating short of the bore 35. A coiled spring 37 secured to the support member 12 and wound about the cylindrical member 28 has an end received in a bore in the stud member 34. It will be noted that the spring 37 is attached to the support member 12 and is therefore re-

trievable with the support member. The spring member 37 serves to exert a torque on the capsule about the cylindrical member 28. The stud member 34 also has a small projection 40 (FIG. 5) extending out over the flange 32 of the cylindrical member 28 which cooperates with a projection 41 (FIG. 6) on the flange 32 of the cylindrical member 28 to limit movement of the capsule when it swings to a position normal to the axis of the support member 12 under the influence of the spring. Extending axially from the stud member 34 of each capsule is a small-diameter cylindrical latching member 43 which is arranged to be received in a recess 44 in the forward end 45 of an adjacent capsule to latch the capsules in an axially aligned position lengthwise of the support member.

A blasting cap 46 may be located in the forward end 45 of the lowermost charge so that when it is detonated, the lowermost charge is free to swing about the cylindrical member 28 and accordingly each charge is successively freed of restraint so as to pivot outwardly under the influence of a spring 37 until the charges in the assembly are disposed normal to the axis of the supporting members. The arrangement of the springs is such that the charges will alternately swing in opposed directions.

Thereafter, the charges may be detonated by ignition of the blasting cord 14, and the explosive 31 in the cylindrical members 28 serves to fragment both the cylindrical members 28 and the stud member 34.

It should be appreciated from the foregoing that all metals used are frangible except for the tubular support 21 and spring 37 (FIG. 3).

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 as defined in the appended claims.

I claim:

1. A perforating apparatus comprised of a rigid elongated tubular member constructed of infrangible material, said tubular member having a plurality of bores therein arranged transverse to the length of said tubular member and distributed along the length of the tubular member, cylindrical supporting members containing explosive materials respectively having first end portions sized for reception in said bores in said tubular member and second end portions extending outwardly from said tubular member, said first end portions of said supporting members respectively having an opening therein arranged to align with the interior of said tubular member and blasting cord received by said tubular member, and said openings thereby to secure said supporting members to said tubular member, shaped charge devices including frangible containers respectively having an opening therein for pivotal mounting on said second end portion of a supporting member, and springs respectively coupled between said tubular member and said charge devices to rotate the same about the respective supporting members.

2. A perforating apparatus comprised of a rigid elongated tubular member constructed of infrangible material, said tubular member having a plurality of bores therein arranged transverse to the length of said tubular member and distributed along the length of the member, hollow cylindrical supporting members respectively sized for reception in said bores in said tubular member, explosive material disposed in said hollow supporting members, said supporting members respectively having an opening therein adjacent to a hollow portion which opening is arranged to align with the interior of said tubular member, and blasting cord received by said tubular member and said openings thereby to secure said supporting members to said tubular member, shaped charge devices including frangible containers respectively having an opening therein for pivotal mounting on a supporting member, and springs respectively coupled between said tubular member and said charge devices to rotate the same about said supporting members.

3. A perforating apparatus comprised of a rigid elongated tubular member constructed of infrangible material, said tubular member having a plurality of bores therein arranged transverse to the length of said tubular member and distributed along the length of the member so that the axes of the bores are aligned in a common plane, cylindrical supporting members containing explosive materials and respectively having first end portions sized for reception in said bores in said tubular member and second end portions extending outwardly from said tubular member, said first end portions of said supporting members respectively having an opening therein arranged to align with the interior of said tubular member, and blasting cord received by said tubular member and said openings thereby to secure said supporting members to said tubular member, shaped charge devices including frangible containers respectively having an opening therein disposed normal to a lengthwise axis of a container for pivotal mounting on said second end portions of a supporting member, and springs coupled between said tubular member and said charge devices to rotate the same about said supporting members, said charge devices respectively having forward recessed end portions and rearward extensions arranged to interlock for retaining the lengthwise axes of the containers in alignment in one position of said charge devices relative to said tubular member.

4. A perforating apparatus comprised of a rigid elongated tubular member constructed of infrangible material, said tubular member having a plurality of bores therein arranged transverse to the length of said tubular member and distributed along the length of the member and aligned in a longitudinally extending plane, cylindrical supporting members containing explosive materials and respectively sized having first end portions for reception in said bores in said tubular member and second end portions extending outwardly from said tubular member, said first end portion of said supporting members respectively having an opening therein arranged to align with the interior of said tubular member, and blasting cord received by said tubular member and said openings thereby to secure said supporting members to said tubular member, shaped charge devices including frangible containers respectively having an opening therein for pivotal mounting on said second portions of a supporting member, and spring respectively coupled between said tubular member and said charge devices to rotate the same about said supporting members, said springs being arranged so as to rotate shaped charge devices alternately in opposed directions.

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