Aug. 2, 1960 W. H. LINDSAY, JR 2,947,252

SHAPED CHARGE UNIT FOR WELL PERFORATORS

Filed Dec. 16, 1952

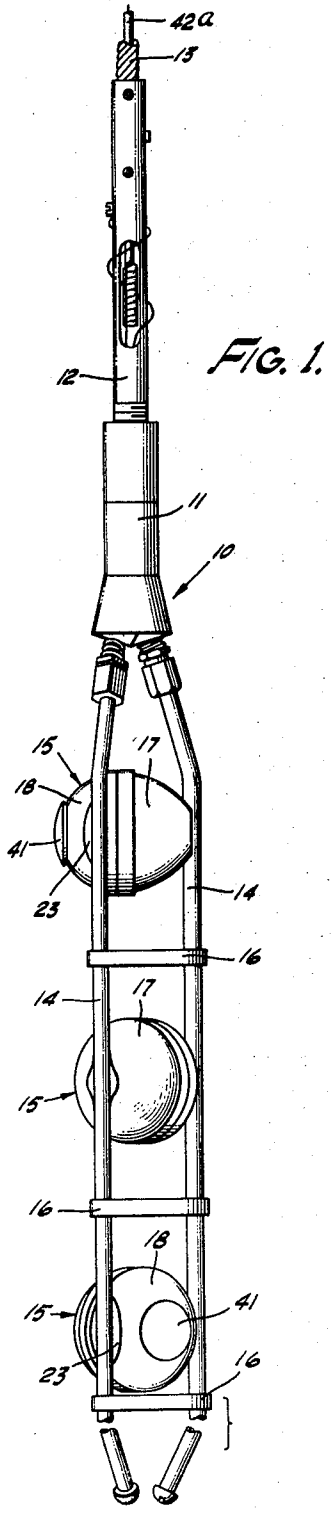


FIG. 1.

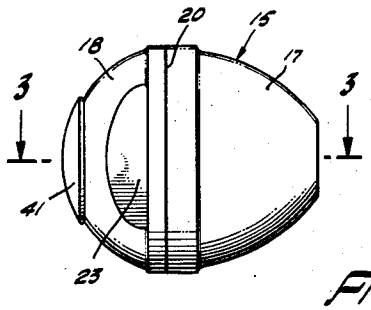


FIG. 2.

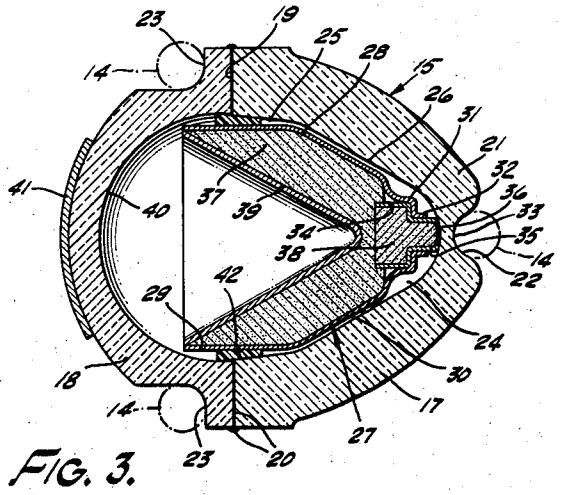


FIG. 3.

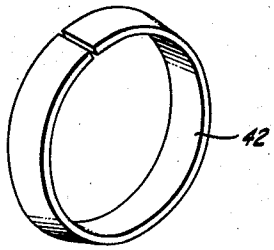


FIG. 4.

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SHAPED CHARGE UNIT FOR WELL PERFORATORS

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2 Claims. (Cl. 102—20)

This invention relates to perforators for well bores and casings therein for the purpose of making openings in the formations adjacent the well bore or for perforating the casing in order that production fluid from the formations may enter the well.

Perforators for the beforementioned purposes are now extensively employed in the oil industry, and are generally of either of two types; bullet type gun perforators which have been used for many years, or shaped-charge type perforators which are of more recent development. Up to the present time the gun bodies or housings for containing and supporting the required plurality of shaped-charges generally comprise an elongated fluid-tight cylinder or shell of steel having a plurality of laterally directed ports behind which the perforator units are positioned and suitably secured within the shell. Such perforator gun assemblies are subject to numerous inherent disadvantages and have many undesirable aspects, such as excessive bulk, weight, cost of manufacture and time of assembly, as well as relatively short usable lives. A particular disadvantage of the foregoing type of shaped-charge perforator is the difficulty of providing and maintaining the requisite fluid seal for the ports in the shaped-charge container body through which the charges fire, and also the problem of providing satisfactory positioning of the igniting or firing system within the body. Another disadvantage resides in the added limitations imposed upon the maximum size of the shaped-charge which can be employed and limitations upon the critical stand-off distance which can be maintained under such conditions where the shaped-charge must be housed within a heavy steel container body.

The foregoing objections and disadvantages have been largely overcome by the open, bodyless type of shaped-charge perforator apparatus disclosed in the copending application of Louis F. Jilly, Serial No. 313,895, filed October 9, 1952, which perforator apparatus is adapted to utilize shaped-charge units incorporating the important features of the present invention. In said copending application of Louis F. Jilly, the gun structure comprises, in brief, an open framework consisting of a plurality of vertically extending tubes spaced apart in a triangular arrangement which hold and secure by the clamping action therebetween a plurality of the shaped-charge units comprising the present invention.

It is therefore an object of this invention to provide a shaped-charge perforator unit of novel and improved design.

Another object of the invention is to provide a shaped-charge unit for well perforators having improved means for sealing the shaped-charge explosive from well fluids or drilling fluids.

A further object of the invention is to provide a shaped-charge unit of frangible material, such as porcelain or other ceramic whereby objectionable debris will not be left in the well borehole after the perforating operations.

An additional object of the invention is to provide improvements in a shaped-charge unit for well perforators

comprising a container and cover element so formed and adapted to be sealed together after assembly as to permit the use of larger shaped-charges with maximum effective stand-off distances in a borehole of given size.

Another object of the invention is to provide a shaped-charge unit as in the previous object, while at the same time providing an enclosure for the shaped-charge capable of withstanding the high fluid pressures encountered in deep fluid filled well boreholes.

Another object of the invention is to provide a shaped-charge unit for perforators, employing novel means for restraining the forces therefrom from impingement upon adjacent charges, which tend to affect detrimentally the formation of the perforating jet of the explosive in the other adjacent shaped-charges.

Other objects, advantages and features of novelty will be evident in the following specification, considered together with the accompanying drawing forming a part thereof, in which:

Figure 1 is an elevational view of the general assembly of a perforator incorporating shaped-charge units embodying the present invention; and

Figure 2 is a side elevation view of one of the shaped-charge units shown in Figure 1.

Figure 3 is an enlarged cross-sectional view taken along the line 3—3 of Figure 2.

Figure 4 is a perspective view of the lock ring element.

Referring to the drawing more in detail, the numeral **10** indicates generally a shaped-charge perforator assembly comprising an elongated head member **11** secured to an adapter **12** suspended from a conductor cable **13** on which the perforator is adapted to be lowered into a well casing or borehole. A plurality of tube members **14** are secured to and extend downwardly from the head member **11** in spaced relation about the central or longitudinal axis of the head member **11** and form a substantially open frame within which are positioned a plurality of shaped-charge units **15**. A plurality of bands or clamps **16** are attached to or encircle the tube members **14**, by which construction and arrangement the members **14** are urged inwardly toward the beforementioned central axis and into frictional supporting engagement with side portions of the shaped-charge units. One or more of the tube members **14** contain an elongated fuse such as Primacord, and an igniting charge for the fuses is contained in head member **11** and arranged to be suitably fired by an electrical blasting cap connected to a conductor **42***a* carried by cable **13**. This perforator assembly is shown and described more completely in the hereinbefore mentioned copending application of Louis F. Jilly, Serial No. 313,895.

Each shaped-charge unit **15** comprises a hollow container which includes a cup-shaped body portion **17** and a hemispherical cover portion **18**, the combination when joined together as best shown in Figures 2 and 3, being ellipsoidal in general shape and contour, and thus shaped to effectively withstand external fluid pressures. The body portion **17** and cover portion **18** are preferably made of porcelain or other ceramic material, having high strength in compression but being relatively brittle or fragile. The shaped-charge unit container **17, 18** may also be made of a suitable plastic material. Parts **17** and **18** have annular contacting faces **19**, and after assembly of the unit with the explosive shaped-charge therein these parts are sealed together by a suitable sealing material **20**, such as for example No. 801 Sealer made by Minnesota Mining & Manufacturing Co. Container body portion **17** has a generally tapered or converging exterior rear end portion **21** formed at the rear extremity thereof with a transverse groove **22** of a shape and size suitable for receiving one of the rod or tube members **14**, and cap member **18** is formed with a pair of similar recesses **23** for receiving the remaining pair of rod or tube mem-

bers 14 which tube members are clamped by bands or clamps 16, as hereinbefore mentioned, for frictionally engaging and supporting the shaped-charge units 15 in the perforator frame. Container body portion 17 has a cavity 24 which has a slight taper at the forward interior portion 25 thereof, and a somewhat more sharply tapered intermediate interior portion 26 between portion 25 and its inner end which is located on the opposite side of the body wall from end 21 and transverse groove 22. The exterior of the shaped-charge itself is indicated at 27 and comprises a cup-like exterior shell 28, preferably made of steel, which has a cylindrical forward end portion 29, a tapered intermediate portion 30, and a flanged rear end seat portion 31 of reduced diameter. The rear end portion 31 of the shell 28 has an open-ended neck 32. A metallic cup 34 is seated on the inner surface of flange seat 31 and has a stem portion 35 which extends through the neck 32 of shell 28, the end closure of the stem of the cup which is indicated at 36 being die-formed or pressed to a relatively small thickness of the order of .005", the wall thickness of the cup 34 and shell 28 being of the order of .015". The principal shaped-charge or explosive charge is indicated at 37, and preferably comprises cyclotrimethylenetrinitramine, commonly known as "Cyclonite," desensitized with a small quantity of beeswax and graphite. Cup 34 contains a booster explosive charge 38, preferably of pure Cyclonite. The explosive charge 37 is formed with a forwardly facing conical cavity, by a conical shaped liner 39 preferably of copper, aluminum or other equivalent soft metal. Cover 18 has a semispherical cavity 40 therein, into which the outer end of the shaped-charge extends slightly. The shaped-charge is secured in cavity 24 of container part 17 by a split, slightly tapered locking ring 42, preferably of neoprene or other rubber-like material. A cover plate 41 made of steel or the like abrasion resistant material, may be suitably secured on the outer surface of cover 18.

In the operation of the invention, the shaped-charge units 15 are assembled as shown in Figure 3, and a plurality of such shaped-charge units are secured within the framework comprising the tube members 14, as shown in Figure 1, one or more of the tube members 14 being positioned in the end grooves 22 of one or more of the shaped-charge units, and the remaining tube members being positioned in grooves 23. The perforator is then in condition for operation and to be lowered into a well bore, either open-hole or cased, fluid-filled or empty, and thereafter brought to the desired level and fired by the application of a source of electric current applied to conductor 42*a*, the return circuit being by way of cable sheath 13 or through the ground. The thus applied electric current fires the blasting cap in head member 11, thus detonating the charge in the head member, which in turn detonates the fuses in the tube members 14, and these fuses detonate the booster charges 38 in the respective shaped-charge units 15, the detonating force of the fuse being conducted through the end portion 33 of reduced thickness of the container body part 17 and through the relatively thin wall 36 of the stem 35 of the booster charge cup 34 thereby finally detonating the main shaped-charge 37. Upon thus firing of the main shaped-charge 37 the entire shaped-charge unit is disintegrated into sufficiently fine particles as to leave no noticeable or objectionable debris in the borehole. A penetrating gaseous jet is produced forward of the cone 39 which penetrates the cover 18, cover plate 41 and the surrounding well bore hole casing or formation.

From the foregoing description, it will be apparent that the shaped-charge perforator and shaped-charge unit of this invention possess numerous features of superiority and improvement over known structures. The shaped-charge units 15 are of light weight and of readily frangible material; the units are fluid-tight; the shaped-charges 27 can be readily assembled as sub-units from the preformed shell booster cup and liner and positioned in the cavity 24 of the container part 17 and secured with the lock ring 42 with facility and a minimum of danger in the handling of the explosive material. Also this perforator has a greater effective "stand-off" for a given sized explosive charge than is possible in the conventional tubular bodied shaped-charge type of perforators heretofore employed.

It will be understood that the foregoing description is illustrative rather than restrictive of the invention, and that changes or modifications may be made without departing from the spirit and scope of the invention as defined in the subjoined claims.

What is claimed is:

1. A shaped charge unit adapted for use while submerged in a borehole comprising: a container including forward and rearward cup-shaped container portions made of porcelain or a similar material having high strength in compression and being relatively brittle or fragile, the rims of said container portions abutting one another and being sealed together to provide a fluid-tight enclosure, said rearward container portion having a thin section centrally located in the rearward wall thereof through which detonating forces originating outside of the container are readily conducted; a shaped charge explosive sub-unit disposed in said container including a cup-like shell having a rearward portion conforming substantially to the inner wall of said rearward container portion, and a booster cup projecting rearwardly from said shell and terminating in a transverse end portion in contact with the thin section of said rearward container portion, said shell having a forward portion extending forwardly of the rim of said rearward container portion; and a locking ring of rubber-like material wedged between said shell and the forward portion of the inner wall of said rearward container portion effective to center said sub-unit in said container with said end portion of said booster cup firmly seated in contact with said thin section, said sub-unit being spaced from the inner walls of said container portions at all points other than at the transverse end portion of said booster cup.

2. A shaped charge unit adapted for use while submerged in a borehole comprising: a container having a generally ellipsoidal exterior surface and being made of porcelain or a similar material having high strength in compression and being relatively brittle or fragile, said container having a rearward, cup-shaped, body portion and a forward hemispherical cover portion, said portions having annular faces in contact in a plane transverse to the axis of the container and being sealed together to provide a fluid-tight enclosure, said body portion having a transverse groove on the exterior at the rear extremity thereof and having walls defining a forwardly facing cavity tapering generally rearwardly from the annular face of the body portion and terminating forwardly of the bottom of said groove, the bottom of said cavity and the bottom of said groove defining therebetween an axial section of said body portion having a reduced thickness through which detonating forces originating in the groove are readily conducted, said cover portion having walls defining a rearwardly facing generally hemispherical cavity extending forwardly from the annular face of said cover portion, the walls of said cavities being symmetrical about the axis of the container and merging with one another to define a generally ellipsoidal hollow in said container; a shaped charge explosive sub-unit disposed in the hollow of said container including a cup-like shell having a rearward portion conforming substantially to the wall of the cavity of said body portion, and a booster cup projecting axially rearwardly from said shell and terminating in a thin walled transverse end portion in contact with said axial section of reduced thickness, said shell having a forward portion extending into the hemispherical cavity of said cover portion; and a locking ring of rubber-like material having a tapering cross-section

wedged between said shell and the forward portion of the wall of the cavity of said body portion effective to center said sub-unit in the hollow of said container with said end portion of the booster cup firmly seated in contact with said body portion of reduced thickness, said sub-unit being spaced from the walls of the hollow of said container at all points other than at the transverse end portion of said booster cup.

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