Dec. 3, 1963 G. A. NODDIN 3,112,699

SONIC PULSE GENERATOR

Filed April 14, 1961

FIG. 1

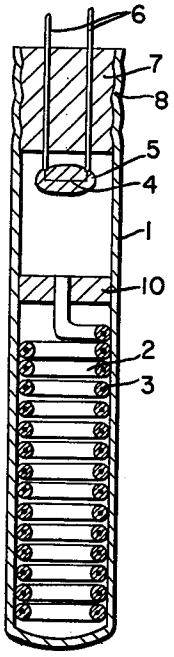


FIG. 4

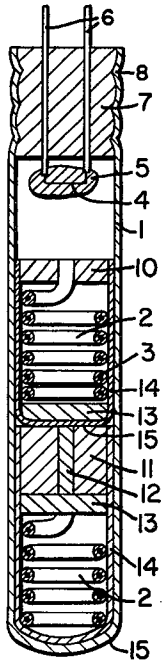


FIG. 2

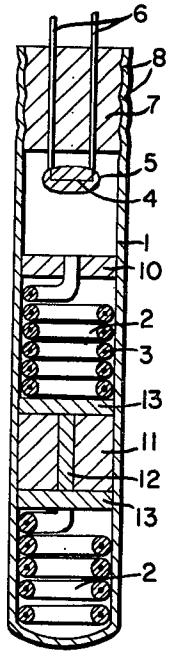
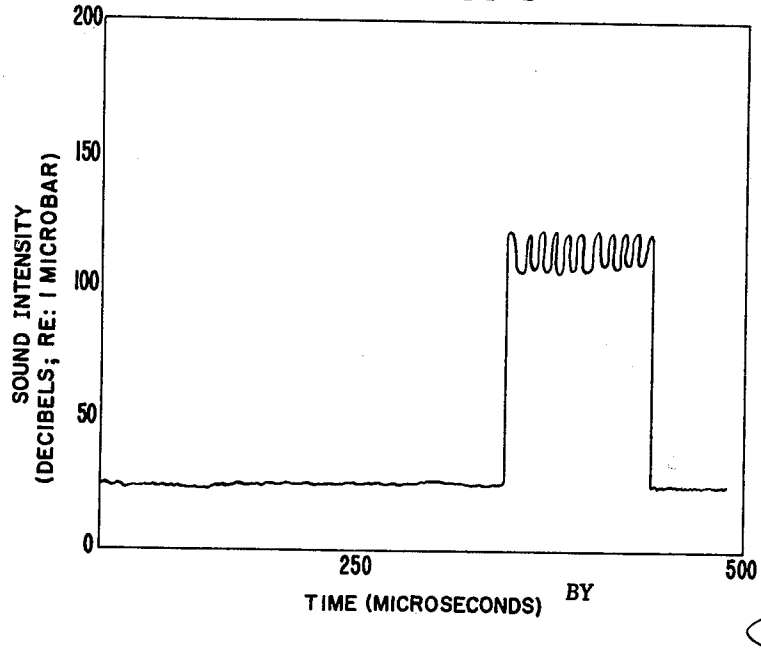


FIG. 3



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SONIC PULSE GENERATOR

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The present invention relates to a device for generating a sonic pulse, which device is particularly adapted for use under water.

A need exists for a sonic pulse producing device adapted for use in calibrating the pulse-receivers of echo-ranging systems and for rapidly and accurately measuring the velocity of sound in water at various depths and temperatures.

In accordance with the present invention, a device for generating an easily distinguishable sonic pulse of long duration comprises a tubular metal shell having one closed end, a length of explosive cord consisting essentially of a core containing a high-velocity detonating explosive encased in a tubular sheath of ductile material, disposed within said shell, said length being in the form of a tightly-coiled helix having a diameter essentially equal to the inner diameter of the shell, the quantity of explosive and the combined strength of the shell and the sheath being such that the detonation of said explosive cannot rupture the shell wall, and an ignition means sealing the open end of said shell. In a preferred embodiment, the shell will contain a plurality of helically-coiled lengths of explosive cord and a length of deflagrating composition interposed between the successive helically-coiled lengths of explosive cord. In a particularly preferred embodiment, at least a portion of said deflagrating composition will be contained in the axial bore of a heavy-walled tube of a ductile material, the outer diameter of the tube being essentially equal to the inner diameter of the shell.

In order to describe the present invention in greater detail, reference is made to the accompanying drawings in which:

FIGURES 1, 2 and 4 are sectional elevations of the sonic pulse-generating assembly of the present invention,

FIGURE 3 is a graphic representation of the pressure-time characteristics of the sonic pulse obtained upon detonation of the explosive charge in the device of the instant invention.

The sonic pulse generating device shown in FIGURE 1 includes as components thereof a shell 1, a helically-coiled length of cord 2 composed of a core of a high velocity detonating explosive 3 encased within a sheath of a ductile metal. The cord is so positioned that the outer periphery of each helix of the cord is in snug engagement with the wall of the shell 1. A high resistance bridge wire 4 surrounded by a coherent mass or bead of ignition composition 5 is attached to, and held in position by, lead wires 6 which are held by, and passed through a sealing plug 7 of resilient material which is sealed in and closes the open extremity of the shell 1. Circumferential crimps 8 in the shell maintain the plug 7 in proper position. The helically coiled cord is kept in place by a second resilient plug 10.

FIGURE 2 describes the device of FIGURE 1 with a heavy-walled tube, i.e., a ferrule, 11 seated within the shell 1 in tight peripheral engagement with the shell wall. The tube is readily described as having an axial bore loaded with a deflagrating explosive 12. A layer of an unconfined deflagrating mixture 13 is interposed between the ends of the heavy walled tube and ends of the helically-coiled length of explosive cord adjacent the heavy walled tube and in propagating relationship thereto. In FIGURE 3, the intensity of the sonic pulse produced by a representative device of the invention as expressed in

decibels is plotted as the ordinate whereas the time in microseconds is plotted as the abscissa. After initiation of the device (at 0 time), the sound intensity remains at an almost constant level as represented by the essentially holizontal line during the initiation and a subsequent initiation lag. Upon actuation of the high velocity detonation explosive there is a sharp increase in the sound intensity as shown by a substantially vertical line. The sonic pulse occurring as the detonation impulse is propagated through the coiled length of cord is represented by a series of sharp peaks of maximum intensity and troughs of slightly lower intensity, the number of sharp peaks corresponding in number to the number of revolutions of the cord in the helix. When the detonation ceases, the sound intensity decreases rapidly to the original level. If a multiplicity of coiled lengths of cord separated by deflagrating compositions were present in the shell, the sound level would be maintained at substantially the original level for the length of time required for the burning of the deflagrating composition and would increase sharply again upon actuation of the high velocity detonating explosive in the subsequent coiled length of cord and decrease to the original level during the burning of each train of deflagrating composition.

In FIGURE 4, the elements are as in FIGURE 2 with the exception that a series of preassembled pulse units are provided, each pulse unit comprising a tubular shell 14 integrally closed at one end by a thin closure element 15 and containing a length of deflagrating composition 13 and a helically coiled length of cord 2. The preassembled units which are in snug peripheral engagement with the walls of the shell 1 enable the devices to be loaded conveniently and are not detrimental to the functioning of the device.

In operation, when the device is submerged in water, electric current applied to the lead wires of the ignition assembly passes through the high resistance bridgewire producing heat sufficient to effect combustion of the ignition composition in contact with the bridgewire. This combustion actuates the detonation of the high-velocity explosive charge contained in the axial bore of the explosive cord with the formation of a detonation front. A pressure front is developed out of this detonation front which is propagated as a sonic pulse through the fluid (water) surrounding the unit and is detected by a pressure-time detecting device, e.g., a piezoelectric gage connected to an oscilloscope.

The sonic pulse produced by the device of the present invention is characterized by a series of sharp peaks corresponding in number to the number of coils in the helix. The nature of this sonic pulse is attributed to the fact that as the detonation front is formed corresponding to the shape of the helix, the pressure front develops radially from each point on the helically-shaped detonation front. Consequently, the sonic pressure pulses created at points varying in distance from the pressure-pulse detecting means reach the pressure-pulse detector at varying times and with varying intensities depending upon the distance from the point on the helix from which the pressure-pulse eminates to the detector, producing a waxing and waning in intensity of the sonic pulses falling on the detector. When the helically coiled lengths of explosive cord are separated by a tube containing a slow-buring composition, sonic pulses which occur at times corresponding to the burning rate of the composition are produced.

The special confinement of the explosive charge is critical to this invention. The outer diameter of the helix should be such that it will fit snugly against the inner wall of the shell provided, leaving a negligible open space. If the helix does not fit snugly, the acoustical properties of the unit may be detrimentally effected, i.e., reverbera-

tions may occur due to possible rupture of the walls during detonation of the explosive. Naturally, the diameter and length of the helix are adjusted in relation to the explosive loading required.

Any detonating explosive which will propagate a detonation in lengths less than ¼-inch can be used. Such explosives include lead azide, pentaerythritol tetranitrate, picryl sulfone, tetryl, nitromannite, and the like. Lead azide is preferred because of its ease of initiation.

The sheathing is of a material which is non-reactive with the detonating explosive. Ductile metals such as lead, aluminum, tin, silver, copper, or their ductile alloys may be used and are preferred. Various polymeric materials or plastics having the requisite strength may also be used.

The helix containing the detonating explosive is positioned axially in the thin-walled metal shell in igniting proximity to the ignition assembly. Preferably, the material used for the shell is of thin gage commercial bronze, or another copper alloy, copper, or aluminum, although other metals or polymeric material having the requisite structural strength may be used as well. The shell wall must be of a thickness such that the detonation of the explosive charge will not rupture it. Obviously, the thickness of the shell wall will depend upon the explosive loading, with the greater explosive loadings requiring the thicker shell. We have found that with explosive loadings of 0.5 to 28 grains per foot, the shell wall will have a thickness of 0.005–0.03 inch. At thicknesses less than 0.005 inch or greater than 0.03 inch loading and crimping will be more difficult, the thinner shell being too fragile and the thicker shell too resistant to crimping. Naturally, the length of the shell depends upon the size and number of the charges, and the number and length of deflagrating elements to be incorporated into the unit.

A variety of ignition assemblies can be sealed into the shell, for example by means of a resilient plug of conventional design used in electric blasting caps, through which the customary lead wires are introduced. Suitable ignition assemblies include a bridgewire and bead arrangement, a bridgewire inserted into a mass of a loose ignition composition, an exploding bridgewire unit and an arc-firing system in which the bridgewire is eliminated. The ignition assembly may be actuated by lead wires extending to a source of electric current at the surface of the water, or by a detonator actuated by a pull wire or a stab primer, or the lead wires may be attached to a water-actuated wet battery or a pressure-sensitive initiator which will fire the charge at a predetermined depth. An electric current of approximately 0.5 ampere is generally sufficient to initiate a bridge-wire unit. For several units in a series, the current supply should be at least 1.5 amperes.

To provide sequential firing action of each detonating explosive charge, a delay train of the desired interval is provided between each of the successive charges. Such trains, which are conventional in delay initiators, comprise a length of a deflagrating composition, e.g., boron and red lead, silicon and red lead, or barium peroxide and selenium among others. In the preferred embodiment, the delay composition is confined within a heavy-walled tube such as of lead or aluminum. When the delay composition is thus confined, it is preferred to provide a thin layer of the same or an equivalent deflagrating composition at each end of the heavy-walled tube to facilitate the ignition of the small core of detonating explosive in the next cylinder. The provision of such layers eliminates the need for great precision in aligning the respective small diameter core of deflagrating composition and detonating composition. When the delay train consists of a length of uncased deflagrating composition, no problem of aligning cores exists.

When it is desired to produce a series of the sonic pulses by using a plurality of lengths of the helically-coiled explosive-containing cord separated by deflagrating compositions, the components may be preassembled for convenience in loading in thin-bottomed shells, e.g., of aluminum, which may be later inserted into the outer shell. The deflagrating compositions should function in the bottom of each of the preassembled shells to insure reliable propagation of the series.

Since the shell of the unit is not ruptured and is only slightly expanded when the assembly is fired under water, there are no annoying bubbles produced and the sound is free of secondary reverberations which might introduce error into the measurements and calibrations made by using the device of the instant invention. The assembly functions well in water at any depth and at temperatures ranging from the freezing point to the boiling point of the water. The units may also be used in other fluids, e.g. oil, which are nonreactive with the metal comprising the outer shell thereof.

When the units as herein described are fired in air, the sonic pulse produced is of lower intensity and the expansion of the outer shell is slightly greater for an identical shell fired in a liquid. A unit satisfactory for use in accordance with this invention may rupture when fired in air because of the lesser confinement offered by air, thus the strength required is that which will resist rupture when the assembly is submerged in water, regardless of the depth of the water.

The device of the present invention is particularly well-suited for applications in which an easily distinguishable sonic pulse is desired since the high pressure pulse produced by the detonation of the high velocity detonating explosive in the helically-coiled cord is of long duration and may be distinguished easily even at long distances over other subsurface noises or over a single spike sonic pulse.

In order to illustrate the present invention, reference now is made to the following example.

Example 1

A unit is assembled as shown in FIGURE 1. Before assembling this unit the $3\frac{15}{16}$ inches long commercial bronze shell, 0.310 inch O.D., 0.260 I.D., is annealed for 1 hour at 500° C. and then cooled. A one-foot length of detonating cord consisting of a tubular lead sheath, O.D. 0.097 inch, containing as a continuous core of 7 grains of lead azide is coiled into a helix $2\frac{15}{16}$ inches long having an outer diameter of approximately 0.257 inch; one end of this coiled tube is turned away from the coiled length of cord and inserted into a rubber plug. Subsequently, this coiled cord attached to the rubber plug is lowered into the shell until the unattached end of the coiled cord is near the bottom of the shell, a one inch open space being allowed between the top of the rubber plug and the top of the shell. The shell is closed by a conventional rubber plug assembly in which a 0.0019 inch diameter 80/20 nickel-chromium bridgewire surrounded by a bead comprising a 75/20/5 mixture of the lead salt of dinitro ortho cresol, potassium chlorate and selenium in a matrix of polyvinyl acetate is soldered to the lead wires separated to provide a ⅛-inch span and projecting ⅛-inch from the base of the rubber plug. The lead wires contained in the rubber plug are of 20-gage copper insulated by nylon. After the unit is loaded and the plug inserted, three peripheral crimps are made in the shell wall to seal in the plug.

The lead wires of the thus assembled unit were connected to a source of voltage and the unit was dropped in a body of cold water (at about 20° C.) to a depth of six feet, and three feet from a piezoelectric gage attached to a standard oscilloscope by a coaxial cable 150 feet long. Upon application of the electric current, the pressure-time curve detected on the oscilloscope indicated that the maximum sound level obtained was 122 decibels with reference to one microbar and the pulse was maintained for 110 microseconds. The unit was retrieved after firing and it was observed that the shell was not ruptured

at any point but was uniformly expanded to an outer diameter of 0.362 inch.

The lack of violence of the device is apparent. No noise aside from a characteristic "ping" is produced by the unit. Visual inspection of the units indicates that no rupture of the shell occurred indicating the absence of shattering effect. These features are important from the standpoint of preventing injury to the system in which it is to be used and in insuring nonhazardous operation.

It will be obvious to those skilled in the art that many modifications in the design and use of the sonic-pulse generating device of the present invention are possible without departing from the scope of the invention. We intend, therefore, to be limited only by the following claims.

What is claimed is:

1. A device for generating a sonic pulse which comprises a tubular shell closed at one end, a plurality of helically-coiled lengths of explosive cord consisting essentially of a core of a high-velocity detonating explosive encased in a sheath of a ductile material, said explosive being at a distribution of 0.5–28 grains per foot of length, said helically-coiled cords being positioned axially in said tubular shell, said coiled cord being in peripheral engagement with said tubular shell, a length of a deflagrating composition interposed between successive helically wound lengths of cord in propagating relationship with said helically-wound lengths of explosive cord, and an ignition assembly sealed within the open end of said tubular shell in igniting relationship to said explosive charge.

2. A device for generating a sonic pulse which comprises a tubular shell closed at one end, a plurality of helically-coiled lengths of explosive cord consisting essentially of a core of a high-velocity detonating explosive encased in a sheath of a ductile material, said explosive being at a distribution of 0.5–28 grains per foot of length and said helically-coiled lengths of cord being positioned axially in said tubular shell in snug peripheral engagement with the wall of said shell, at least one deflagrating composition interposed in propagating relationship between successive helically-coiled lengths of explosive cord, at least a portion of said deflagrating composition being enclosed within a ferrule of a ductile material, said ferrule having an outer diameter substantially equal to the inner diameter of said tubular shell; and an ignition assembly sealed within the open end of said tubular shell in igniting relationship to said explosive charge.

3. A device for generating a sonic pulse beneath the surface of a body of water which comprises a first tubular shell having one integrally closed extremity, a plurality of pulse units contained within said first shell, each of said units consisting essentially of a short-length second tubular shell integrally closed at one extremity by a thin closure member and each of said second shells containing in sequence from said closure member, a length of deflagrating composition and a helically coiled length of explosive cord consisting essentially of a core of from 0.5 to 28 grains per foot of detonating explosive encased in a sheath of ductile material, the coils of said expolsive cord being in snug peripheral engagement with the walls of said second tubular shell, said pulse units being positioned in said first shell with each of their closure members nearest the closed extremity of said first shell, and initiating means closing the open extremity of said first shell, with the proviso that the lodaing of said detonating explosive is insufficient to rupture said first shell, when said device is actuated under water.

4. A device for generating a modulating sonic pulse beneath the surface of a body of water which comprises a tubular shell closed at one end, at least one helically-coiled length of detonating cord positioned longitudinally within said shell in snug peripheral engagement with the wall of said shell, said cord consisting essentially of a core of from 0.5 to 28 grains per foot of length of high-velocity detonating explosives encased in a sheath of ductile material, the loading of said cord being insufficient to rupture the walls of said shell, and an ignition assembly sealed within the open end of said tubular shell in igniting relationship to said detonating cord, said cord being adapted upon initiation, to produce a modulating sonic pulse characterized by a series of sharp peaks of high intensity, corresponding to the number of reveolutions of cord in the helix.

References Cited in the file of this patent

UNITED STATES PATENTS

2,558,924	Blake	July 3, 1951
2,586,706	Parr	Feb. 19, 1952
2,679,205	Piety	May 25, 1954
2,771,033	Lewis et al.	Nov. 20, 1956
2,974,596	Allen	Mar. 14, 1961
2,982,210	Andrew et al.	May 2, 1961
2,992,611	Felch	July 18, 1961
3,014,425	Turnbull et al.	Dec. 26, 1961
3,021,786	Miller et al.	Feb. 20, 1962