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D. M. SALING

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EXPLOSIVE SOUND SOURCE FOR UNDERWATER ECHO RANGING TECHNIQUES

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2 Sheets-Sheet 2

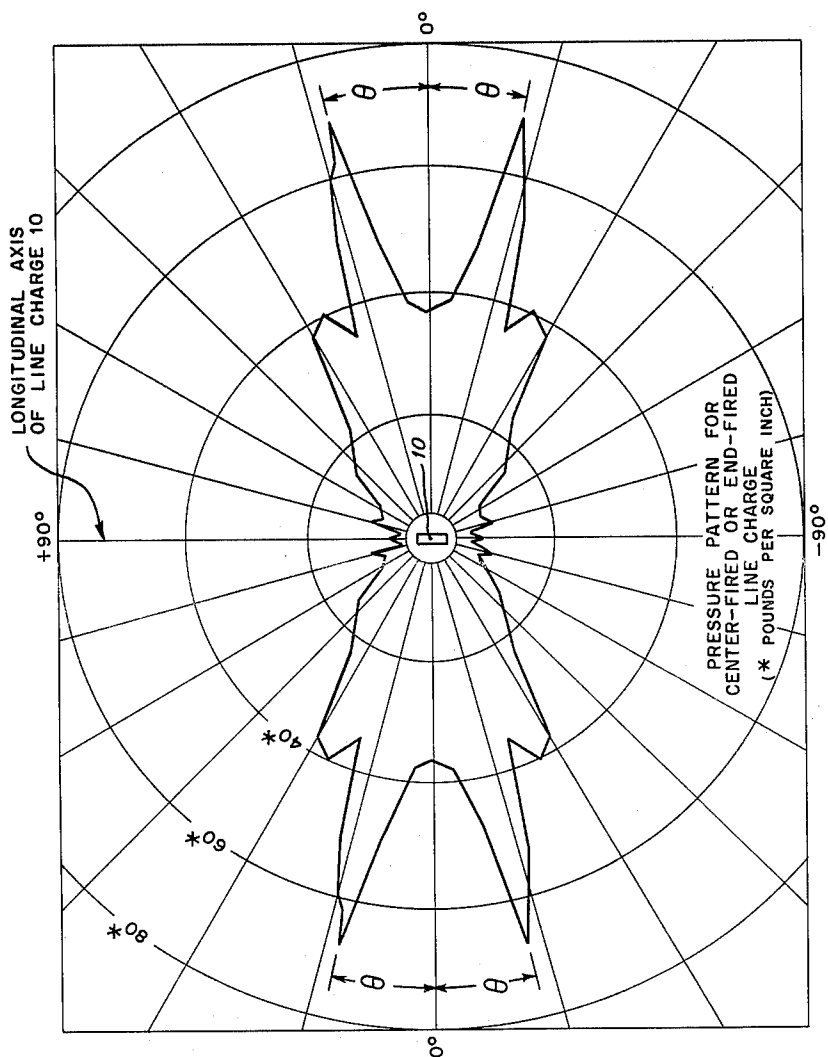


Fig. 3

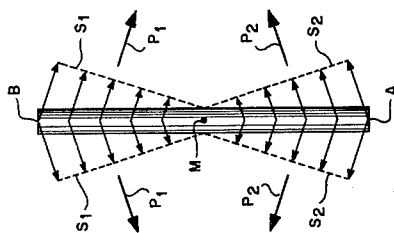


Fig. 6

INVENTOR.
DONALD M. SALING

BY

Henry Hansen
ATTORNEY

1

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EXPLOSIVE SOUND SOURCE FOR UNDER-WATER ECHO RANGING TECHNIQUES

Donald Murray Saling, Poughkeepsie, N.Y., assignor, by mesne assignments, to the United States of America as represented by the Secretary of the Navy
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The present invention relates to explosive sound sources and more particularly to an explosive sound source having directional propagating characteristics especially useful in underwater echo ranging techniques.

It is well known that sound resulting from a point source such as the detonation of a single block or ball of explosive material spreads in a homogenous medium in all directions from the source in the form of a spherical wave. Such source is omnidirectional and the intensity of the spherical wave diminishes inversely as the square of the distance from the source. The acoustic energy is also absorbed by the medium to further diminish the intensity. Experience has also shown that the intelligence obtained when using omnidirectional charges as sound sources in underwater echo ranging techniques is not altogether satisfactory due to false ranging echoes returned from bottom and surface reflections of the water.

Accordingly, it is an object of the present invention to provide a novel explosive sound source in which the sound waves developed thereby predominantly spread in predetermined planes and in which the sound waves spreading outside of said predetermined planes are of relatively low acoustic energy.

Another object of the invention is to provide an improved explosive sound source especially suitable for underwater echo ranging techniques in which the sound waves spread in a predominantly horizontal plane, in which there are inconsequential bottom and surface reflections of the water, and in which sound intensification is enhanced for selected probing elevations.

A further object of the invention is to provide an explosive sound source which obtains a more persistent and concentrated sound wave with no increase in the amount of explosive charge.

Still another object of the invention is to provide an improved explosive underwater sound source which is relatively inexpensive to manufacture, utilizes conventional commercially available components, and is especially suited for underwater echo ranging techniques.

Various other objects and advantages will appear from the following description of several embodiments of the invention, and the most novel features will be particularly pointed out hereinafter in connection with the appended claims.

In the drawings:

FIG. 1 represents a longitudinal view of an explosive line charge superimposed by the theoretical sound wave front developed when the charge is fired progressively from one end to the other;

FIG. 2 represents a longitudinal view of an explosive line charge superimposed by the theoretical sound wave front developed when the charge is fired progressively from the middle to both ends;

FIG. 3 represents a cross-sectional plot of the sound wave pressure pattern produced by the line charge of FIG. 2 and FIG. 6 as taken in a plane coinciding with the longitudinal axis of the line charge;

FIG. 4 is a schematic representation of one embodiment of the invention in which the line charge is fired from the middle thereof;

FIG. 5 is a schematic representation of another embodiment of the invention in which the line charge is simultaneously fired at both ends thereof; and

2

FIG. 6 represents a longitudinal view of an explosive line charge superimposed by the theoretical sound wave front developed when the charge is fired progressively from both ends simultaneously to the middle.

Referring to FIG. 1, a line charge 10 of length L is shown emitting a series of sound waves in the form of spherical pressure patterns $p_1, p_2, \dots, p_n$. The line charge 10 was initially fired at one end, identified in the drawing as A, with detonation progressing at a velocity V toward the other end B. The diameter of the pressure pattern p_1 at end A relative to the diameter of the pressure pattern p_n at the other end B is determined by the velocity V and the velocity of propagation C of the medium. At the instant when detonation has progressed from the end A to the end B, an infinite number of spherical pressure patterns have been emitted along the length of the line charge 10 with the radius r of each pattern being incrementally smaller. Thus, a pressure wave front S of right circular cone configuration is generated which has its symmetrical axis coincident with the longitudinal axis of the line charge 10. The angle θ subtended by the line charge longitudinal axis and the wave front S is a function of the velocity of detonation progression V and the propagation velocity C of the surrounding medium. That is,

$$V = \frac{L}{t} \text{ and } C = \frac{r_1}{t}$$

where

V=velocity of detonation progression of line charge,

L=length of line charge,

t=time for complete detonation,

r_1 =radius of spherical pressure pattern at the line charge end A.

Combining these parameters,

$$r_1 = \frac{LC}{V}$$

The angle θ subtended by the line charge longitudinal axis and the pressure wave front S is therefore

$$\sin \theta = \frac{LC}{V}$$

or

$$\theta = \sin^{-1} \frac{C}{V}$$

For example, a detonation progression velocity V of 20,000 feet per second for a line charge such as Primacord, and a propagation velocity of 5,000 feet per second for a medium such as sea water, the angle θ is approximately fourteen degrees. The direction that the wave front S is predominantly moving is illustrated by the vectors P emanating from the line charge 10 normal to the wave front S.

Referring now to FIG. 2, the line charge 10 is shown superimposed by two opposed right circular cone pressure wave fronts S_1 and S_2 which are produced by initially firing the line charge 10 midway between its ends, as identified in the drawing by the letter M. Progression of firing from the middle M to the end A generates the pressure wave front S_1 , and progression of firing from the middle M to the end B generates the pressure wave front S_2 ; both fronts having a propagation velocity C and in respective directions P_1 and P_2 at angles θ above and below the plane normal to the longitudinal axis of the line charge 10.

Referring now to FIG. 6, the line charge 10 is shown superimposed by two opposed right circular cone pressure wave fronts S_1 and S_2 which are produced by initially firing the line charge simultaneously at both ends A and

3

B with detonation progression toward the middle M. Progression of firing from end A to the middle M generates the pressure wave front S_2 , and progression of firing from end B to the middle M generates the pressure wave front S_1 ; both fronts having a propagation velocity C and in respective directions P_1 and P_2 at angles θ above and below the plane normal to the longitudinal axis of the line charge 10.

FIG. 3 is a cross-sectional plot of the sound wave pressure pattern produced by the line charge 10, fired either from the middle M or simultaneously from the ends A and B. It will be observed that the maximum intensity of the pressure pattern occurs at inclined planes corresponding to the angle θ above and below the plane normal to the line charge longitudinal axis.

FIG. 4 represents one embodiment of the invention as employed in underwater echo ranging techniques and in which an elongated line charge 10 is center-fired. The line charge 10 is secured at one of its ends to a cable 12 depending from a buoy 11. The length of the cable 12 is selected for any desired probing depth in the water. The other end of the line charge 10 is connected to another cable 13 from which an expendable weight 14 hangs for maintaining the line charge 10 in a substantially vertical attitude irrespective of water currents. A primer 16 is fastened to the line charge 10 midway between its ends with suitable ignition means 15 contained in the buoy 11 and operatively connected to the primer 16 by a conduit 17. The particular mode of operation of the ignition means 15 does not form an essential part of the present invention and may be any conventional device such as a radio or timer controlled switch or a sea activated power supply. Upon being fired, the line charge 10 generates pressure wave fronts such as S_1 and S_2 illustrated in FIG. 2 and a pressure pattern similar to the one shown in FIG. 3. This pattern can be mathematically translated into decibels for further acoustical analyses.

FIG. 5 illustrates another embodiment of the invention as employed in the underwater echo ranging techniques and in which an elongated line charge 10 is simultaneously fired from both ends by primers 18 and 19. A conduit 21 operatively connects the primers 18 and 19 in parallel for simultaneous firing from the ignition means 15. The buoy 11, cables 12 and 13, weight 14 and the means 15 are functionally identical to those described in connection with the embodiment of FIG. 4.

It should now be apparent that the directional sound source generated in accordance with the present invention obtains greater probing range with no increase in explosives. Even though the quantity of explosive which is detonating at any one instant is considerably smaller than that of the point source equivalent to the total weight of explosive, there is an actual increase in pressure intensity. Actual test results on the above-described embodiments of the present invention have shown that instead of a reduction in pressure there is an actual increase in certain directions as shown in FIG. 3. An examination of the lateral components of the wave fronts so generated shows that there is a very definite addition of pressure. Also, along the axis of the line charge, the persistence of pressure wave is longer than that of the point source due to an effective increase in detonation time.

Another benefit obtained from the use of the line charge of the present invention as a sound source derives from the inherent angles of the planes, both above and below the normal plane, in which the pressure waves are projected. This feature affords more concentrated probing at levels above and below the depth at which the line charge 10 is suspended without experiencing bottom or surface reflections.

It will be understood, of course, that various changes in the details, materials, steps and arrangement of parts, which have been herein disclosed and illustrated in order to explain the nature of the invention, may be made by

4

those skilled in the art within the principle and scope of the invention as expressed in the appended claims.

What is claimed is:

1. An explosive sound source for underwater echo ranging techniques, comprising:
 - a buoy;
 - an ignition means contained in said buoy;
 - an elongated explosive charge;
 - a cable depending from said buoy and connected to one end of said charge;
 - a weight connected to the other end of said charge for maintaining said charge in a substantially vertical attitude when said buoy is resting at the surface of water;
 - a primer operatively connected to said charge at a point along the length thereof for initiating progressive detonation; and
 - conduit means communicating between said ignition means and said primer for firing the latter;
2. An explosive sound source for underwater echo ranging techniques, comprising:
 - whereby progressive detonation of said charge emits pressure waves spreading in a predominantly horizontal direction.
3. An explosive sound source for underwater echo ranging techniques, comprising:
 - a buoy;
 - an ignition means contained in said buoy;
 - an elongated explosive charge;
 - a cable depending from said buoy and connected to one end of said charge;
 - a weight connected to the other end of said charge for maintaining said charge in a substantially vertical attitude when said buoy is resting at the surface of water;
 - a primer operatively connected to said charge midway between the ends thereof for initiating detonation; and
 - conduit means communicating between said ignition means and said primer for firing the latter;
4. An explosive sound source for underwater echo ranging techniques, comprising:
 - whereby progressive detonation of said charge emits pressure waves spreading in a predominantly horizontal direction.
5. An explosive sound source for underwater echo ranging techniques, comprising:
 - a buoy;
 - an ignition means contained in said buoy;
 - an elongated explosive charge;
 - a cable depending from said buoy and connected to one end of said charge;
 - a weight connected to the other end of said charge for maintaining said charge in a substantially vertical attitude when said buoy is resting at the surface of water;
 - a pair of primers operatively connected to said charge at respective ends thereof for initiating detonation; and
 - conduit means communicating between said ignition means and said primers for simultaneously firing the latter;
6. An explosive sound source for underwater echo ranging techniques, comprising:
 - whereby progressive detonation of said charge emits pressure waves spreading in a predominantly horizontal direction.

References Cited by the Examiner

UNITED STATES PATENTS

2,271,185	1/42	Dunajeff	102—10
2,586,706	2/52	Parr	102—22 X
2,609,885	9/52	Silverman	102—23 X
2,615,524	10/52	Poulter	181—5
2,622,691	12/52	Ording	181—5
2,775,940	1/57	Klotz	102—23
3,076,408	2/63	Poulter et al.	102—23

SAMUEL FEINBERG, *Primary Examiner*.

75 BENJAMIN A. BORCHELT, *Examiner*.