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3,031,644

ACOUSTIC DETECTOR

Filed Feb. 1, 1946

2 Sheets-Sheet 1

FIG. 4.

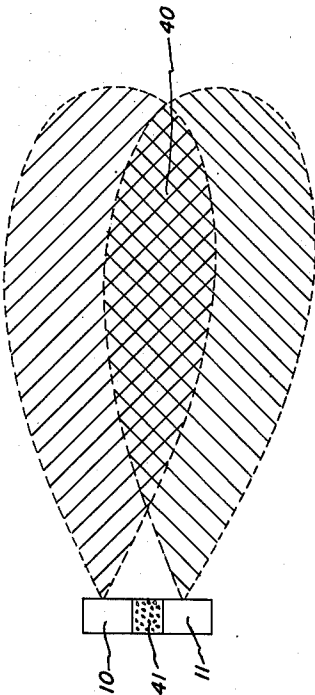


FIG. 1.

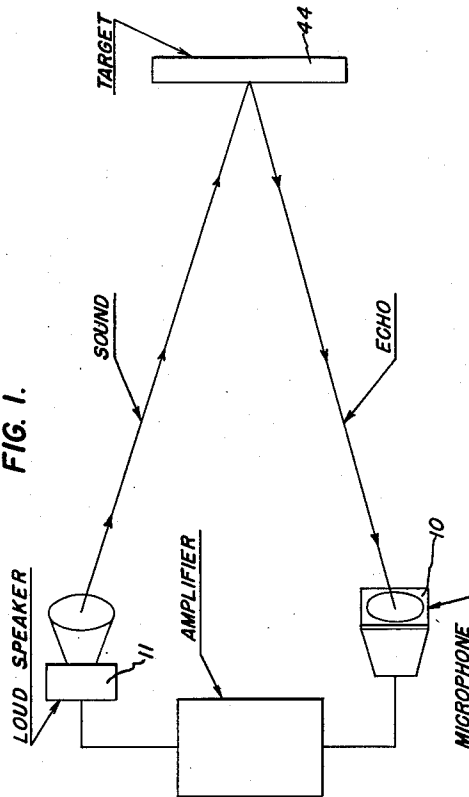
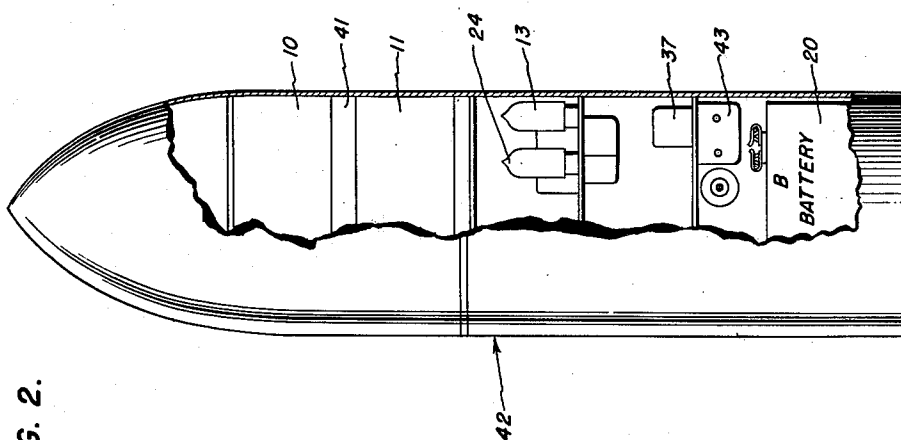


FIG. 2.



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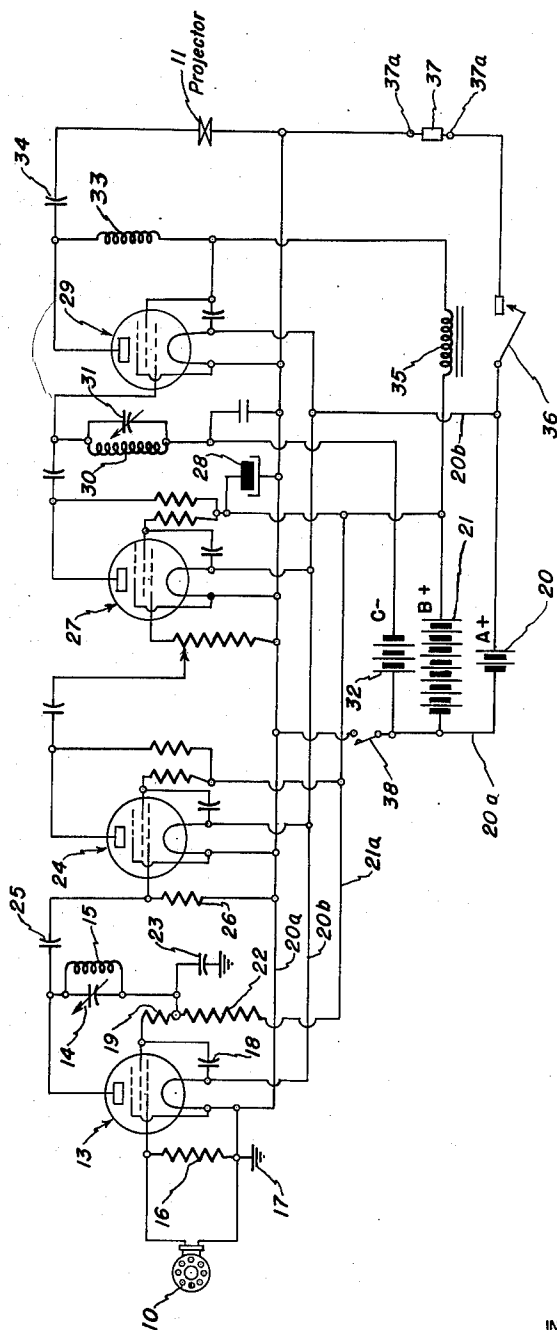
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2 Sheets-Sheet 2

FIG. 3.



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3,031,644

ACOUSTIC DETECTOR

Charles A. Hissfrich, Los Angeles, and Donald G. Reed, San Diego, Calif., assignors to the United States of America as represented by the Secretary of the Navy
Filed Feb. 1, 1946, Ser. No. 644,983
1 Claim. (Cl. 340-3)

This invention relates to acoustic detection and more particularly to a novel method and apparatus for detecting objects in an acoustic medium by the use of the phenomena of acoustic coupling.

One of the objects of our invention resides in the provision of an apparatus for detecting a target in an acoustic medium, which is so arranged to be acoustically coupled with the target when placed in proximity with it.

Another object of our invention is to provide a method for detecting a target, which utilizes the phenomena of acoustic coupling to indicate the presence of the target.

A further object of our invention is to provide an apparatus so arranged that when placed in proximity with a target, the phenomena of acoustic feedback produces oscillation within the system so as to indicate the presence of the target.

A further object of our invention is to provide an acoustic-electronic device which amplifies and projects noise and is so arranged that, in conjunction with a target, an acoustic feedback path is created; such feedback producing oscillation of the system to indicate the presence of the target.

Still another object of our invention is to provide a device which amplifies noise and is arranged to break into oscillation when a proximate target produces external acoustic coupling between the microphone and loud speaker of the device.

An additional object of our invention is to provide an acoustic detector which remains stable in the presence of ordinary random noise, but is excited by acoustic feedback when such noise is reflected from a target.

Still another object of our invention is to provide an acoustic fuze designed to detonate a bomb when it comes within a predetermined distance of the target.

Another object of our invention is to provide a bomb fuze designed to detonate a bomb when a proximate target completes an external coupling path for producing oscillation of the system.

Still another object of our invention is to provide a method for detonating a bomb acoustically when in proximity with a target.

A further object of our invention is to provide an acoustic fuze for detonating a bomb when it reaches the horizontal level of the target, by means of a transducer producing a sharp horizontal sound pattern.

These and other objects of the invention may be better understood by reference to the accompanying drawings, in which FIG. 1 is a schematic diagram illustrating the principal elements of the invention and the method of practicing it;

FIG. 2 is a view, partially in section, of an acoustic fuze made in accordance with the invention;

FIG. 3 is a schematic wiring diagram of the fuze illustrated in FIG. 2, and

FIG. 4 is a schematic diagram of the sound field produced by the fuze of FIG. 2.

In the past, many persons have observed the phenomena known as acoustic feedback, but its observation and study have generally been with the purpose of eliminating rather than utilizing it. However, its observation, so far as we know, has generally been limited to feedback caused by a direct coupling through the acoustic medium. The effect has been observed most often in conjunction with improperly placed microphones and loud speakers in

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which the sound emitted from the speakers was fed directly to the microphones. This set up coupling between the two, and the whole system broke into oscillation and the phenomena of "singing" was very noticeable.

The method and apparatus of the present invention utilize this acoustic feedback in connection with an additional external element, herein called a target. If the microphone of the system is directed toward a target (reflecting surface), the sound waves reaching the target will be reflected from the target at an angle equal to the angle of incidence. If the microphone of the system is placed to receive the reflected sound, and the waves reach it in proper phase and amplitude, oscillation of the system is established. This external acoustic coupling can be easily regulated and its presence may be used to perform a variety of functions.

Before proceeding with the description, one additional phenomenon should be noted. In any medium, whether it be water, air or some other substance, it is observed that random noise is present. In water, this is called "water noise." This random noise varies in both amplitude and frequency over wide ranges. Because this noise is everywhere present, it can be used as a source of energy for our invention, if properly controlled, even though its source has never been definitely determined.

Basically then, our invention comprises a microphone (intended herein to include hydrophone), a loud speaker (intended herein to include an underwater projector), and an amplifier. The transducers are made to be sharply directive for best results, as this will prevent direct feedback, facilitate analyzing the information obtained, and allow acoustic feedback throughout the system in the presence of a target. Both the transducers and the amplifier are tuned to be responsive to some particular range of frequencies.

The output of the system has parallel circuits; one energizing the loud speaker and the other connected to a relay for operating an indicator or other device. The system, including the relay, is made subject to sensitive control whereby ordinary currents flowing in the output system will not trip the relay, but the relay is operated when and if considerably larger currents are caused to flow in the output for an appreciable time. These latter currents, in our invention, are caused to flow when the target causes external coupling and the whole system breaks into oscillation.

The new system, when made subject to this sensitive control, can be utilized for a variety of functions. Although it operates either in air or water, its principal use is in water where it may be made to detect ships, rocks, bottom, shore, wrecks, mines, submarines, etc. Likewise it may be made to detect walls, foreign bodies, the ground from an airplane, or abnormal discontinuities in any medium. By abnormal discontinuities, we refer to boundaries of a medium or non-homogeneous layers such as might be created by a sharp temperature gradient in a medium, but not to normal discontinuities such as random variation of temperature or sound. As used herein, the word "target" will be defined to include all these various objects and abnormal discontinuities.

In operation, the device is mounted in the medium so that the microphone receives a certain chosen range of sound frequencies produced by the above mentioned random noise. This received sound is fed to the amplifier where it is amplified and emitted by the loudspeaker. In the absence of a target, and either because of the directivity of the transducers or their position, the projected signals are insufficient to cause external coupling between the microphone and loudspeaker; and, as a result, no oscillation occurs and only very small currents flow in the output of the system. When, however, a target is introduced into the acoustic medium within the sensitive

range of the device, the emitted sound is reflected from the target back to the microphone and again amplified and emitted by the speaker toward the target, etc. This acoustic feedback cycle, if repeated again and again, produces oscillation of the system causing the current in the output to be built up to a value limited only by the power handling capabilities of the circuit itself. This greatly increased current is sufficient to trip the relay in the output circuit and operates an indicator or other device.

The present invention is adapted for a large number of uses and may take various forms. For example, it may take the form of an acoustic fuze for depth bombs or other underwater projectiles. A fuze of this type, embodying the present invention, will be described for illustrative purposes.

The fuze, of course, comprises the basic elements, namely, the microphone, the amplifier, and the loudspeaker. The amplifier gain control is set at a point below that which would cause direct feedback through the water adjacent the device. When, however, a reflecting target, such as a submarine, comes into proper range and relation with the fuze, the reflected energy returned to the microphone is greatly increased, which causes it to drive the amplifier power stage, which originally excited the projector. Immediately, sound is projected against the target and reflected back to the microphone and this feedback chain amplifies the signal chain until full output is obtained from the power stage. The power tube, biased by a fixed negative voltage, normally draws very little plate current but, when excited to this full output, draws sufficient current to close a relay which, in turn, causes detonation of the cap on the bomb.

Before describing the fuze in detail, it should be noted that space is of importance to this application of the invention. The device must be so constructed as to occupy the very small space available in the bomb, and we have found that the fuze described herein satisfies this requirement and occupies a cylindrical space not over twenty inches long and four inches in diameter.

The circuit diagram shown herein is illustrative only, as it could be designed in several ways to produce the desired result. We have found, however, that the one illustrated gives excellent results.

Electronically, it consists of a high gain, battery-operated amplifier containing two parallel tuned resonant circuits. As shown in FIG. 3, it comprises two identical transducers; the microphone 10 and the projector 11. The microphone is connected to the grid of a pentode generally designated 13. The plate circuit of this tube is tuned by a variable condenser 14 and an inductance 15 so as to pass only high frequencies, of the order of 70 kilocycles per second, to the grid of the next tube. A large resistance 16, of the order of one megohm, is introduced in the grid circuit to provide a D.C. path to ground 17. The screen grid of the tube is also by-passed to ground 17 by means of condenser 18 and its voltage is maintained at its proper value by means of resistance 19. The cathode is connected to an A-battery 20 through wires 20a and 20b, and the screen grid is connected to B-battery 21 through resistance 22, by-passed to ground 17 through condenser 23, and wire 21a.

The plate circuit of tube 13 is connected to the grid circuit of an identical pentode, generally designated 24, through a coupling condenser 25, resistance 26 providing the grid return. The plate circuit of tube 24, except that it has no tuned unit, is the same as that of tube 23 and is connected to the grid of a third identical pentode, generally designated 27, which serves as the driver for the power stage. A condenser 28 provides a large capacity by-pass to ground for the B+ system. The plate of tube 27 is coupled to the grid circuit of tube 29, which contains a tuned section composed of inductance 30 and a variable condenser 31. This tuned circuit serves two purposes: (1) it acts as one of the two tuned circuits of the

amplifier, and (2) it offers a low ohmic resistance path for supplying fixed negative voltage to the grid of the power stage. This latter function could not have been performed by a tuned circuit placed in the plate circuit of the driver stage, and explains why it is so positioned. Tube 29 is a tetrode serving as the power stage of the amplifier and by means of C-battery 32, has a fixed bias applied to its grid. Thus, the operation is of class B type and very small amounts of current flow in the plate circuit. The plate circuit contains an R.F. choke 33 to prevent radio frequencies from being dissipated to ground 17, and is coupled to projector 11 by means of condenser 34.

The plate circuit of tube 29 is connected to the positive terminal of battery 21 through a sensitive relay coil 35. This relay coil operates relay contacts 36 connected so as to supply current to the blasting cap 37 from battery 20.

A switch 38 is also placed in the cap circuit in series with the A-battery 29. This is pressure or depth operated and prevents the bomb from being detonated until it is closed. Its purpose, of course, is for safety so that the bomb will not be detonated after leaving the ship or plane before it has traveled a distance greater than its effective range. Its construction can be of any design, many of which are known in the art.

The transducers 10 and 11 which produce the best results in connection with our fuze are of the crystal type and are so arranged as to produce a flat doughnut-shaped field in the horizontal plane, with little vertical divergence, as illustrated in FIG. 4. Because they are mounted one above the other, there is produced a small overlapping sensitive field 40 in which both are effective. Only when the bomb has fallen to the vertical level of the target so that the latter appears in this field 40 is the device set into operation. It should also be noted that the transducers must be acoustically insulated from one another by a layer of cork 41 or other material, to prevent acoustic feed-back through the frame of the fuze itself. The transducers, of course, are chosen with a certain resonant frequency (70 kilocycles per second has proven very effective), to which the amplifier circuit is tuned. Thus, the whole electronic-acoustic circuit is tuned to one selected frequency.

Since space limitations are of very great importance insofar as physical structure is concerned, transformer coupling of the transducers to their related vacuum tubes is undesirable. This accounts for the circuit as outlined, wherein we have utilized capacity coupling, and necessitates matching the various impedances, which is done by connecting the multiple units of the crystals together to produce such matching impedance, directly to the tube plate or grid. As an example, we have found that excellent results are obtained by connecting the microphone crystals in series and the projector crystals in series-parallel.

In operation, the device is first mounted in the bomb or depth charge 42 which it is designed to detonate. The cap terminals 37a are connected to the cap 37 which in practice is generally positioned to explode a booster charge 43 for detonating the main charge of the bomb. Safety switch 38, of course, remains open to prevent accidental firing before the bomb is placed in the water or has reached the proper depth.

When the bomb or depth charge is thrown or dropped into the water, switch 38 is still open and remains in such position until after the bomb stops tumbling and assumes a substantially vertical fall. This is obviously desirable, for if the fuze were armed immediately it would quite likely "see" the surface or the attacking ship as it tumbled, and the returning echo might set up acoustic coupling to detonate the bomb prematurely. Switch 38 is designed to close only after vertical fall begins, which point can be easily determined for each type of bomb, depending upon its weight, shape, volume, etc. Its operation may constitute a closing of the switch

by a simple pressure diaphragm or, as is true in some cases, by mechanism for shifting the booster into a position surrounding the cap 37. In any case, these methods are widely used at present and do not constitute a part of our invention.

When switch 38 is closed, the fuze is armed and is in its operable condition. Since the water noise is present at all points in the water, microphone 10 now picks up and feeds to the circuit the noise in the 70 kc. range. The amplitude of this 70 kc. sound, though random, naturally varies from point to point as the bomb falls through the water. At those points where the amplitude of the 70 kc. components of noise are greatest, the plate drive of the driver tube 27 overcomes the grid bias of power tube 29, which causes the projector 11 to emit a signal. Because of the sharp directivity of both the projector and microphone, in the vertical direction, the power tube 29 can readily be biased so as not to be overcome by the small amount of input from such a signal. However, if a target 44, such as a submarine, appears in the sensitive field 40 due to the movement of the bomb and fuze, this interruption causes the signals emitted by the projector 11 to be reflected from the target back to the microphone 10, amplified and re-emitted by the projector, greatly amplified. This signal in turn is reflected off the target 44, picked up by the microphone 10, again amplified and emitted. This acoustic feedback cycle is repeated again and again, until the plate current in the driver tube 27 so overcomes the grid bias on the power stage 29 that a substantial amount of current flows in the plate circuit of tube 29. Since the relay coil 35 is included in this plate circuit, this increased current causes the relay 36 to close and current is supplied to the detonating cap 37 by the battery 20. When this occurs, the cap is set off and detonates the booster 43 and main explosive charges. It is also probable that in many cases the target itself will be producing noise by means of its screws, machinery, etc., which noise will possess certain components in the 70 kc. range. This will likewise tend to increase the output of the power stage in the presence of the target and so assist in detonating the bomb when it is properly related to the target. It will be apparent

that the explosion resulting from operation of cap 37 indicates external acoustic coupling between the microphone 10 and speaker 11.

In the above description we have set forth a specific application of our invention to illustrate one of many uses. The circuit illustrated has been found to be very satisfactory, but can obviously be redesigned by those skilled in the art to perform many other functions. It is therefore to be clearly understood that we are not to be limited by this showing and that our invention is based on the use of external acoustic coupling produced by a target in the acoustic medium.

We claim:

Apparatus for detecting an object in an acoustic medium comprising a microphone, an amplifier and a loud speaker, said microphone being located with respect to the loud speaker so that it will receive sounds originating in the medium and sounds reflected from the object but will not substantially receive sounds directly from the loud speaker, said amplifier being responsive to a certain band of frequencies, means connecting the microphone to the input of the amplifier, means connecting the output of the amplifier to the loud speaker whereby the originating sound is amplified and emitted by the loud speaker and if an object is in the vicinity the reflections of the loudspeaker sounds from the object will cause self-oscillation of the system and means operated by such oscillations indicative of the presence of an object.

References Cited in the file of this patent

UNITED STATES PATENTS

1,636,502	Fessenden	July 19, 1927
2,031,951	Hartley	Feb. 25, 1936
2,060,198	Hammond	Nov. 10, 1936
2,333,688	Shepard	Nov. 9, 1943
2,341,351	Barkley	Feb. 8, 1944
2,400,309	Kock	May 14, 1946
2,403,755	Rankin	July 9, 1946

FOREIGN PATENTS

117,603	Australia	Oct. 7, 1943
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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,031,644

April 24, 1962

Charles A. Hisserich et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

In the grant, line 1, and in the heading to the printed specification, line 3, for "Charles A. Hissfrich", each occurrence, read -- Charles A. Hisserich --.

Signed and sealed this 28th day of August 1962.

(SEAL)

Attest:

ESTON G. JOHNSON

Attesting Officer

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Commissioner of Patents