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R. W. GILLESPIE
SUBMARINE SIGNALING DEVICE
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2,477,246

FIG. 1.

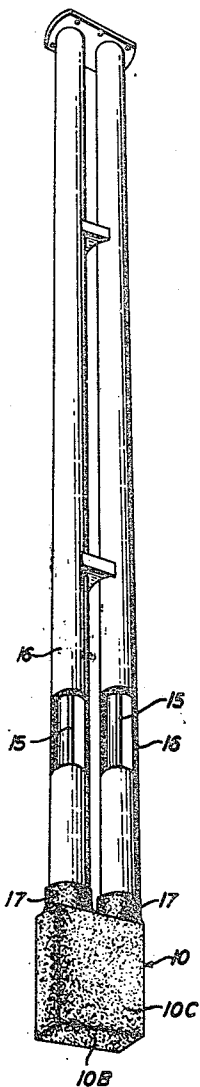


FIG. 2.

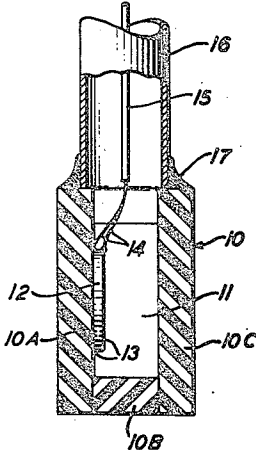


FIG. 3.

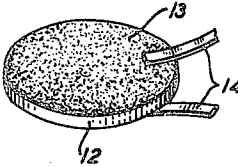


FIG. 4.

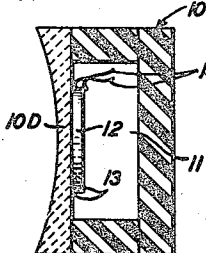


FIG. 5.

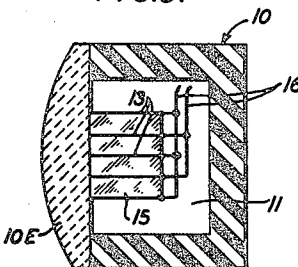
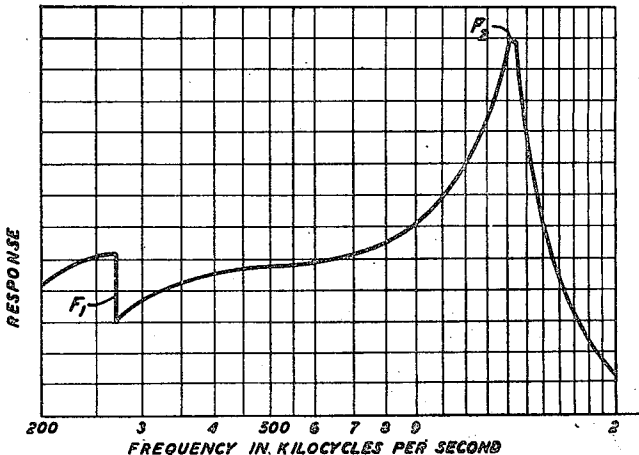


FIG. 6



INVENTOR
R. W. GILLESPIE
BY
Halter C. Kiesel
ATTORNEY

UNITED STATES PATENT OFFICE

2,477,246

SUBMARINE SIGNALING DEVICE

Rollin W. Gillespie, Chatham, N. J., assignor to
Bell Telephone Laboratories, Incorporated, New
York, N. Y., a corporation of New York

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8 Claims. (Cl. 177—386)

1

This invention relates to submarine signaling devices and more particularly to supersonic submarine signal transceivers of the piezoelectric type.

Supersonic submarine signal transceivers of the piezoelectric type of one present known construction comprise in general, a piezoelectric crystal mounted within a protective housing, the space between the active face of the crystal and the opposed housing wall being filled with a suitable liquid for providing a continuous transmission path of approximately the same impedance as that of sea water, between the crystal face and the sea in which the transceiver is immersed. Such construction, and particularly one intended to provide a unidirectional response pattern, entails a number of design complications.

For example, the mounting of the crystal introduces some restraint upon crystal vibration and, further, introduces one or more mechanical resonances so that the vibrational characteristics, such as the frequency response, of the mounted crystal may differ considerably from that of the free crystal. Also, for example, the use of a liquid filling requires considerable care and entails considerable cost in the fabrication of the transceiver. Further, in cases where unidirectional response was desired, baffles or compressional wave absorbers have been employed, and these involve design complications as well as expense.

One general object of this invention is to improve the construction and performance of submarine signaling devices.

More specifically, objects of this invention are to simplify the construction of supersonic submarine signaling devices, particularly of such devices having a unidirectional propagation or reception characteristic, and to enable realization of substantially ideal performance of supersonic piezoelectric transceivers, particularly to obtain a frequency response characteristic essentially identical with that of a freely vibratile crystal.

In accordance with one feature of this invention, in a supersonic submarine signal transceiver including a housing and a piezoelectric crystal therein, the housing is constructed of a material highly transparent to supersonic compressional waves and the crystal is affixed directly to and in intimate face-to-face relation with an inner wall surface of the housing.

In accordance with another feature of this invention the portion of the housing to the wall of which the crystal is affixed is formed of a resilient non-resonant material, whereby the crystal

2

is free to vibrate bodily analogous to a piston substantially without restraint.

In accordance with a further feature of this invention, the housing is constructed and arranged to define an air chamber or pocket extending over the peripheral wall of the crystal and the face thereof opposite that affixed to one wall of the housing, whereby transmission of energy from all portions of the crystal other than the one wall noted, to the sea, or vice versa, is substantially prevented.

In accordance with still another feature of this invention, the portion of the housing to the inner wall of which the crystal is affixed is constructed to define a supersonic compressional wave lens.

The invention and the above-noted and other features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawing in which:

Fig. 1 is a perspective view of a submarine signal translating device illustrative of one embodiment of this invention;

Fig. 2 is a sectional view of a portion of the device illustrated in Fig. 1 showing particularly the construction of the transceiver unit included therein;

Fig. 3 is a perspective view of the piezoelectric crystal assembly included in the transceiver unit;

Figs. 4 and 5 are sectional views of transceiver units illustrative of other embodiments of this invention; and

Fig. 6 is a response characteristic of a typical transceiver unit.

Referring now to the drawing, the signal translating device illustrated in Figs. 1, 2 and 3 comprises a housing 10 constructed of a material having substantially the same impedance as sea water for the transmission of compressional wave energy. A particularly suitable material is a commercially available rubber generally known as ρ C rubber. The housing may be of rectangular configuration and formed by three portions or slabs 10A, 10B and 10C joined by a suitable waterproof cement, the intermediate portion or slab 10B having a circular aperture therein, whereby an air chamber 11 is provided within the housing.

Affixed to the inner face of the portion 10A, as by a suitable cement such as a rubber-like cement known commercially as "Vulcalock," and in intimate face-to-face relation therewith, is a piezoelectric crystal assembly constructed to vibrate normal to the faces of the portion 10A. This assembly, as shown clearly in Fig. 3, comprises a piezoelectric disc 12, for example of X-cut

3

quartz, vibratile in the thickness mode, the faces of which have a conductive coating or electrode 13, for example of silver, thereon. Leading-in conductors 14, such as thin platinum strips, are connected to the coatings 13 and also to the respective inner conductors 15 of coaxial lines, the outer conductors 16 of these lines being affixed to the housing 10 by a waterproof cement as indicated at 17.

The device illustrated is particularly suitable for the wide band propagation and reception of supersonic submarine signals and advantageously the crystal assembly is made of a diameter large in comparison to the wavelength in sea water of the lowest frequency in the intended operating band. Also, and particularly advantageously, the crystal is constructed so that its thickness resonance is above the band to be translated and its radial resonance is near the lower end of or below this band. Because of the high ratio of crystal diameter to wavelength, and other factors noted hereinafter, the response pattern of the device, for both reception and propagation of signals, is highly directional; because of the construction resulting in the relation of the resonances to the operating band, and of other factors pointed out hereinafter, a substantially uniform response throughout the operating frequency range is obtained. In a typical device intended for use particularly at frequencies between about 300 and 800 kilocycles, an X-cut quartz disc 3 centimeters in diameter and 2 millimeters thick has been found satisfactory.

As has been pointed out heretofore, the housing material has substantially the same impedance as sea water for the transmission of compressional wave energy. Hence, one face of the crystal, that is the face thereof toward the portion 10A, is coupled directly and efficiently to the sea, when the device is submerged. However, the paths between the sea and the other or rear face and the peripheral wall of the crystal include the air within the chamber 11. The air chamber impedance for the transmission of supersonic compressional wave energy is very low. Hence, a large impedance mismatch obtains between this chamber and the surrounding housing and sea and high reflection of compressional waves occurs so that for practical purposes, the rear face and peripheral wall of the crystal are insulated from the sea for supersonic compressional wave energy. Thus, the device exhibits a unidirectional response pattern.

Inasmuch as the crystal is mounted directly upon the rubber portion 10A and the latter is essentially non-resonant, the frequency response characteristic of the transceiver is determined by the parameters of the crystal assembly alone. Thus, the design of a transceiver to have any desired frequency response characteristic is greatly simplified, for the mounting of the crystal introduces no extraneous resonances of which account need to be taken.

Moreover, because of the manner in which the crystal is mounted, it will be appreciated that substantially no restraint is offered to vibration of the crystal assembly so that essentially piston-like vibration of the latter obtains.

Essentially, in the construction described, from the standpoint of operation the transceiver simulates a crystal mounted upon a stationary body of air so that substantially ideal crystal performance is realized.

The frequency response characteristic of a typical transceiver of the construction illustrated

4

in Figs. 1 to 3 and described hereinabove is shown in Fig. 6. The radial and thickness resonance frequencies are indicated at F_1 and F_2 respectively. As is apparent from Fig. 6, a uniform response over a wide range of frequencies is attained. For example, in an illustrative device utilized as a receiver, the response in the range between 300 and 800 kilocycles varied by less than 4 decibels. Further, as is apparent from Fig. 6, the response characteristic of the transceiver is free of irregularities such as are due to minor resonances and antiresonances occasioned by the housing and mounting for the crystal in prior devices.

In the embodiment of the invention illustrated in Fig. 4, the crystal assembly is mounted directly upon and in intimate face-to-face relation with the plane inner surface of the front portion of the housing as in the embodiment illustrated in Figs. 1 to 3. However, this portion 10D functions as a concentrating lens, the outer face thereof being concave as shown, and is formed of a material having low absorption and reflection losses and a high index of refraction for supersonic compressional waves. A number of plastics, such as polystyrene, highly transparent to supersonic compressional wave energy are suitable lens materials.

In the embodiment of the invention illustrated in Fig. 5, the portion 10E of the housing is constructed to serve as a diverging lens to broaden the directional pattern of the transceiver. The piezoelectric crystal 15 is composed of a plurality of similar slabs, for example of ammonium dihydrogen phosphate, connected electrically in parallel by leading-in conductors 16 and mechanically oriented so that the several slabs vibrate in phase in the longitudinal mode and normal to the inner face of the front portion 10E. In a particularly advantageous construction especially suitable for single frequency operation, the crystal height, i. e., the dimension thereof in the direction of major vibration, is made equal to one-half wavelength of the operating frequency of the transceiver.

In the constructions illustrated in Figs. 4 and 5, the crystals are affixed to the front portion of the housing by a suitable low loss adhesive such as "Vulcalock" and the front portion is similarly affixed to the body of the housing as by self-vulcanizing neoprene cement.

Although in the constructions shown and described, a single crystal assembly is employed, a plurality of such assemblies secured to the front portion of the housing 10 and mounted side by side in alignment or to constitute a mosaic of transducer elements may be utilized. Furthermore, it will be understood that the several specific embodiments shown and described are but illustrative and that various modifications may be made therein without departing from the scope and spirit of this invention as defined in the appended claims.

What is claimed is:

1. A supersonic submarine signaling device comprising a housing having substantially the same impedance as sea water for the transmission of supersonic compressional waves, and a piezoelectric crystal having one face in intimate face-to-face relation with an inner wall of said housing, said housing having therein an air chamber overlying the opposite face of said crystal.

2. A supersonic submarine signaling device comprising a housing of a resilient rubber having

5

substantially the same impedance as sea water for the transmission of supersonic compressional wave energy, and a piezoelectric crystal having one face jointed to an inner wall of said housing and in intimate face-to-face relation therewith, said housing having therein an air chamber overlying the opposite face of said crystal.

3. A supersonic submarine signaling device comprising a body of resilient rubber having substantially the same impedance as sea water for the transmission of supersonic compressional wave energy, said body having an air chamber therein, and a piezoelectric crystal within said chamber and having one face thereof joined in face-to-face relation with a bounding wall portion for said chamber.

4. A supersonic submarine signaling device comprising a body of resilient rubber having substantially the same impedance as sea water for the transmission of supersonic compressional wave energy, said body having an air chamber therein, and a piezoelectric crystal disc vibratile in the thickness mode mounted upon a bounding wall portion of said chamber and having one face in intimate face-to-face relation with said wall portion.

5. A supersonic submarine signaling device comprising a hollow housing of a material having substantially the same impedance as sea water for the transmission of supersonic compressional wave energy, one wall of said housing being of a material having a high index of refraction and constructed to define a supersonic lens, and a piezoelectric crystal having one face joined to the inner face of said one wall.

6. A supersonic submarine signaling device comprising a hollow housing having one wall of a material having a high index of refraction and constructed to define a supersonic lens, the remaining walls of said housing being of a material having substantially the same impedance as sea water for the transmission of supersonic compressional wave energy, and a piezoelectric crystal joined to the inner face of said one wall in face-to-face relation therewith.

6

7. A supersonic submarine signaling device comprising a housing defined by a dished portion of resilient rubber having substantially the same impedance as sea water for the transmission of compressional wave energy and a supersonic lens defining wall portion joined to said dished portion, and a piezoelectric crystal disc vibratile in the thickness mode and joined to the inner surface of said wall portion in intimate face-to-face relation therewith.

8. A supersonic submarine signaling device comprising a housing including a wall portion having substantially the same impedance as sea water for the transmission of supersonic compressional wave energy, and a piezoelectric crystal having one face affixed in intimate face-to-face relation with the inner face of said wall portion, the opposite face of said crystal being free, said crystal being supported solely by said portion, and said wall portion being of a material having a high index of refraction and being shaped to define a supersonic lens.

ROLLIN W. GILLESPIE.

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