United States Patent

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[73] Assignee **the United States of America as represented by the Secretary of the Navy**

[54] **MICROPHONE AND HEADSET FOR UNDERWATER SWIMMER**
5 Claims, 8 Drawing Figs.

[52] **U.S. Cl.** **179/187,** 179/110, 340/10
[51] **Int. Cl.** **H04r 17/00**
[50] **Field of Search** 179/110.1, 187; 340/10, 8; 181/.5; 310/8.5, 8.6, 9.1

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ABSTRACT: An improved headset and microphone construction for use in aqueous environments of high ambient pressure and a method of manufacture thereof.

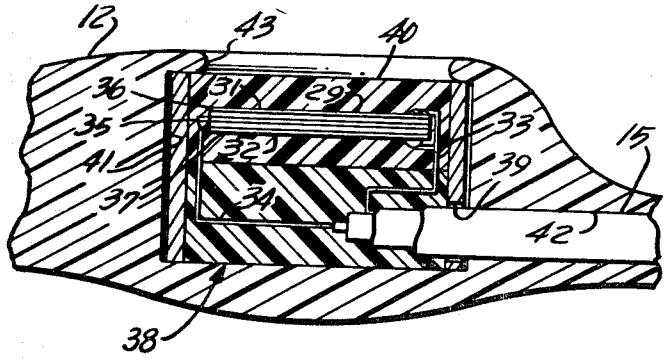


Fig. 1

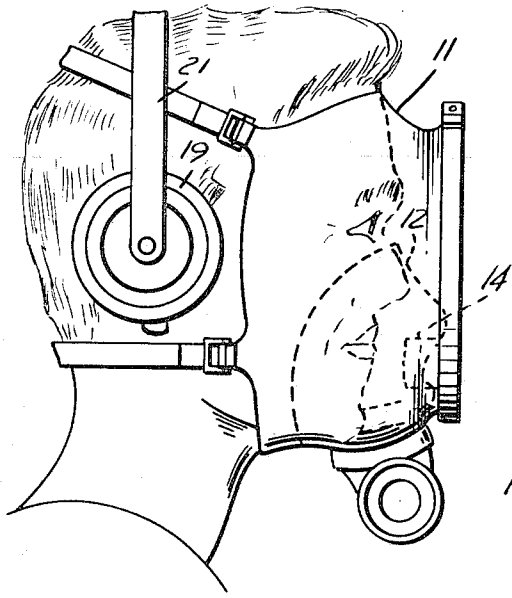


Fig. 2

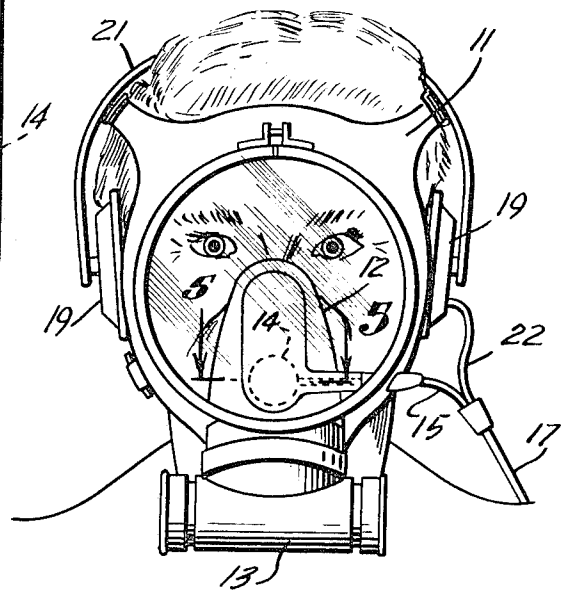
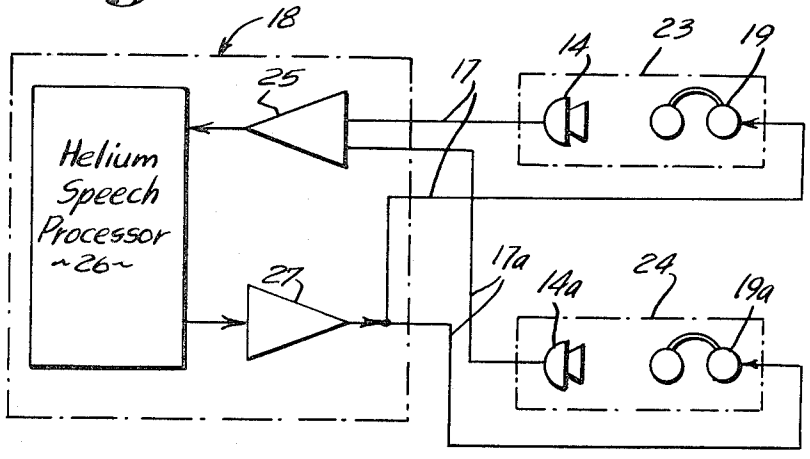


Fig. 3



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Fig. 4

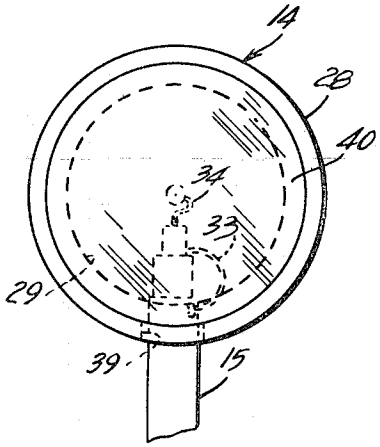


Fig. 5

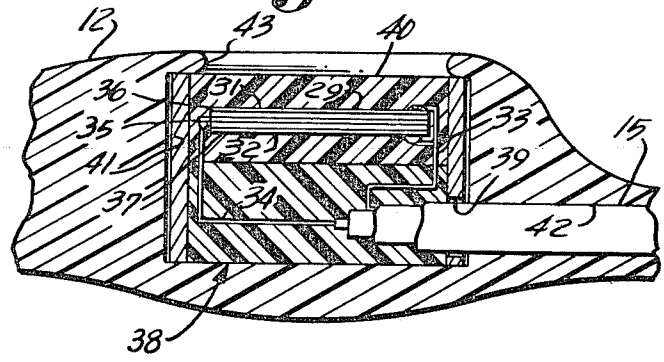


Fig. 6

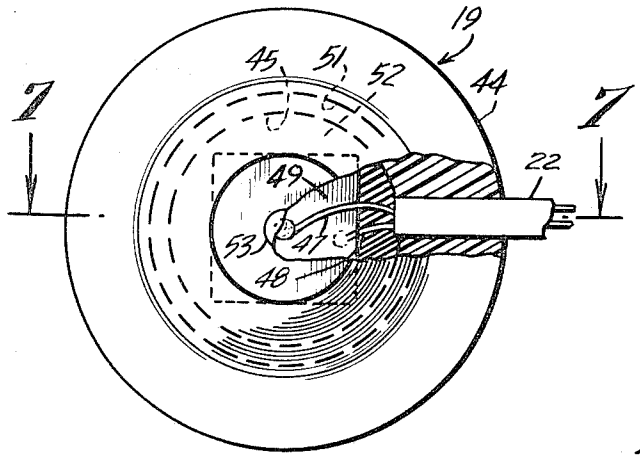


Fig. 8

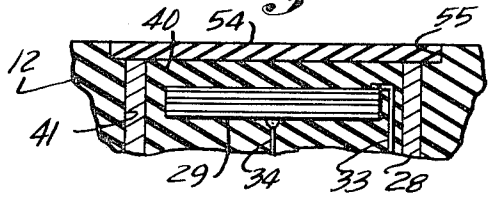
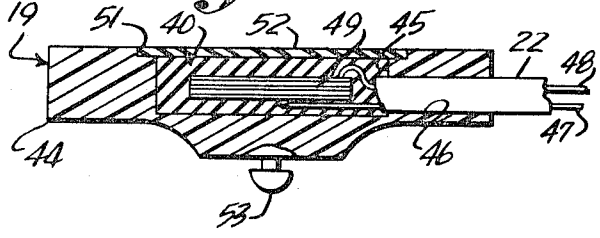


Fig. 7



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MICROPHONE AND HEADSET FOR UNDERWATER SWIMMER

This invention relates to voice communications between personnel beneath the surface of a body of water and in particular to an improved construction of the terminal elements, i.e., the headset and microphone, used in this communication system.

Modern oceanographic technology has given rise to many endeavors in which teams of personnel are required to work beneath the surface of the water in close cooperation. These demands have resulted in the electronic components of the communication systems being improved many fold from the beginning systems of a short while ago. Despite the remarkable advances in the electronic portions of the systems, the development of improved terminal elements has been less rapid.

In prior art headsets and microphones for use under the water, the sound transducers are encased in a gas or air filled enclosure at atmospheric pressure and sealed against the influx of water under the pressure corresponding to that encountered at the expected depth of operation. This construction, while satisfactorily avoiding water-caused shorting, limits effective operation as a sound transducer by virtue of acoustic properties of the different transmitting mediums. The original water seal is also troublesome to maintain under the pressure and temperature changes encountered in subsurface operations. Too, prior art constructions were often quite fragile for the arduous conditions encountered while working below the surface of the water.

It is accordingly an object of this invention to overcome the aforementioned limitations of the prior art, and to provide effective terminal elements of an improved construction for use in an underwater environment and a method for the manufacture thereof.

A further object of this invention is the provision of an improved headset for use in underwater applications, and a method of manufacture thereof.

A further object of this invention is the provision of an improved microphone construction which is compatible with existing diving masks and other diving equipment and a method of making said microphone.

Other objects and many of the attendant advantages will be readily appreciated as the subject invention becomes better understood by reference to the following detailed description, when considered in conjunction with the accompanying drawings wherein:

FIGS. 1 and 2 illustrate the devices of the invention as worn by a diver;

FIG. 3 shows a block diagram of a communication system using the terminal devices as taught by the invention;

FIGS. 4 and 5 illustrate a microphone construction according to the invention which is compatible with diving masks and underwater breathing apparatus designed for conventional microphone constructions;

FIGS. 6 and 7 show constructional details of the headset made in conformity to the teachings of the invention; and

FIG. 8 depicts an alternate construction of a microphone mounting which is analogous to the constructional techniques employed in manufacture of the headset.

As shown in FIGS. 1 and 2, a face mask 11, worn by an underwater swimmer, has a facially conforming breathing mouthpiece 12 carried therewithin in such a position that it closely fits over the mouth and nose of the swimmer. Mouthpiece 12 communicates with swimmer worn gas bottles, not shown, via coupling means 13, external to mask 11. A microphone 14 is held by suitable mounting within breathing mouthpiece 12 and in close proximity to the mouth of the swimmer. An electrical conductor 15, which is preferably coaxial cable designed for this purpose, joins microphone 14 to connector 16 and thence, via cable 17, to appropriate circuitry 18 (FIG. 3), to be described, presently, in greater detail.

The swimmer receives audio signals via two receivers 19 which, as shown in FIGS. 1 and 2, are joined by a headband 21 and electrically united with connector 16 by a conductor 22.

Headband 21, together with suitable unillustrated pockets or other structure forming a part of mask 11 or a diving suit of the swimmer, locates receivers 19 in cooperative location relative to the ears of the swimmer for transmittal of sound thereto. Cable 17, which is joined to conductors 15 and 22 by connector 16, is sufficiently long to permit the swimmer to have the desired degree of mobility to accomplish the particular underwater task which he undertakes and has conductors for carrying the signals from microphone 14 and to receivers 19. Cable 17 may be brightly colored, if desired, to minimize the chances of accidental severing by the swimmer in performance of his underwater tasks.

The basic circuit for interconnection of two swimmers to permit voice communication therebetween is diagrammatically illustrated in FIG. 3. Blocks 23 and 24 represent a first and second swimmer, respectively, and include microphones 14 and 14*a* and receivers 19 and 19*a*, respectively. Cables 17 and 17*a*, as explained above, connect each swimmer to circuitry 18. For purposes of clarity, provision for only two swimmers is shown but it is understood that more may be, and generally are, accommodated by circuitry 18. It should also be understood that circuitry 18 may be physically located either beneath, or above, the surface of the water, as, for example, in an underwater environment station or aboard a surface vessel.

Circuitry 18 comprises a mixer-preamplifier 25 which combines the electrical signals fed by cables 17 and 17*a*, increases the electrical magnitude thereof, and feeds the thus increased signals to a helium speech processor 26. The electrical output of the helium speech processor 26 is amplified by an amplifier 27 and is fed, via cables 17 and 17*a*, to receivers 19 and 19*a*.

The use of helium gas to replace nitrogen, the principal gas in normal surface air, is accepted to avoid undesirable effects of nitrogen on the body when breathed in high pressure environments. Because of the different density of the helium-oxygen mixture from that of surface air, the speech of the breather is highly distorted. The purpose of the helium speech processor is to electrically synthesize a normal speech signal from the signal generated by microphone 14 when activated by the voice of a helium-oxygen breathing swimmer. A variety of such circuits are known and, since no individual one is required for use with the microphone and receiver construction of the instant invention, a detailed description thereof is not considered necessary.

With reference to FIGS. 4 and 5, the constructional details of one form of the invention may be seen. FIG. 5, it will be observed, is a sectional view taken along line 5–5 of FIG. 2. In this form of the invention, a metal sleeve 28 houses a microphone element, indicated generally at 29.

Microphone element 29 is piezoelectric element which flexes or bands in response to compressional waves from the speech organs of the swimmer. A particularly satisfactory construction of this element joins two face-shear cut piezoelectric plates 36 and 37, which may be of .024" inch thick lead zirconate, on either side of a flexible metallic electrode 35. The axis of plates 36 and 37 are arranged in such a fashion that the dimensions of electrostatic expansion extend in different directions. This construction causes the unit to twist rather than bend relative to a single axis and results in a unit that is many times more sensitive and more linear with a change of temperature than a single element. Deposited surface electrodes 31 and 32 on the outer faces of the assembly permit parallel or series connection of the two piezoelectric plates into a two terminal devices. For purposes of explanation, microphone element 29 has surface electrodes 31 and 32 connected to outer conductor 33 and center conductor 34 of coaxial conductor 15 in a series connection with the centrally disposed flexible electrode 35 electrically uniting the faces of piezoelectric plates 36 and 37 which are remote from surface electrodes 31 and 32. Should a parallel connection be desired, surface electrodes 31 and 32 may be joined, a first external connection made thereto, and a second external connection made to the flexible center electrode 35, as shown in FIG. 5.

The microphone element 29, joined to conductor 15, is placed within sleeve 28 with cable protruding through aperture 39. Sleeve 28 is then filled with a potting material 38 to a point covering aperture 39 and cable 15, but not covering microphone element 29, and allowed to harden. This forms a secure mechanical bond between cable 15 and sleeve 28. Potting material 38 may be any suitable electrically-insulating, water-impervious material. That marketed under the trade name "Scotchcast", by the Minnesota Mining and Manufacturing Company, has proven acceptable. The remaining portion of sleeve 28 is then filled with a liquid silicone rubber material 40. The resulting rubber encapsulation is lightweight, waterproof, acoustically transparent, and thermally insulating.

Sleeve 28 is so dimensioned that the completed microphone 14 is dimensionally equivalent to the prior art constructions thereby enabling microphone 14 to fit existing diving equipment without modification thereof. Such an arrangement is shown in FIG. 5. Mouthpiece 12 has a microphone receiving pocket 41 which contains microphone 14. A passageway 42 communicating with pocket 41 and fits cable 15 with sufficient tightness to render the cable-mouthpiece joint watertight. Pocket 41 also has lips 43 which are located about the mouth thereof and extend partially thereacross to constitute microphone retaining means.

The silicone rubber material 40 is sufficiently pliable to permit microphone element 29 to flex slightly in response to the sound waves generated by the voice of the swimmer. Because of the aforementioned increased sensitivity afforded by the construction of microphone element 29, the slight flexure permitted by the rubber material 40 is sufficient to obtain a signal of useable magnitude.

A similar construction technique to that employed with respect to microphone 14 is used in the construction of an improved receiver assembly, as shown in FIGS. 6 and 7. Receiver body 44, which may be shaped to conform with the head of a user, is made of molded rubber material and has a molded pocket 45 therein. A passageway 46, best shown in the sectional FIG. 7, communicates with pocket 45 and the exterior or receiver body 44 and carries conductor 22 therethrough. The insulation of conductor 22 may be vulcanized, during the molding process, to receiver body 44 to effect an improved seal therebetween. Conductor 22 carries two wires 47 and 48 which are electrically joined to piezoelectric element 49, lying within pocket 45. A silicone rubber material 40 fills pocket 45 to the level of a surrounding recess 51 and encapsulating piezoelectric element 49. An adhesive-backed, synthetic rubber preform 52, not unlike that used to close ruptures in pneumatic tubes, is placed across the pocket 45 in recess 51, thereby inhibiting the accidental puncture of rubber material 40 to the determent of piezoelectric element 49. A fastening means 53, shown as an integrally molded button, on the rear of receiver body 44 fastens receiver 19 to headband 20. Fastening means 53 may be of any suitable type in accordance with the desires of the skilled artisan making the device and that shown should be regarded only as illustrative.

The synthetic rubber material 40 used in both the microphone 14 and receiver 19 constructions is of the type that is liquid at room temperatures and hardens upon exposure to air. This material has the desirable property of being self leveling and of vulcanizing or bonding to other rubberlike synthetics at moderate or room temperatures. This material, when solidified, has the properties of securing the encapsulated elements against mechanical shock and rapid thermal variations while offering no undue impedance to normal, operational vibrations. One such material is known and marketed under the trade name RTV, manufactured by The General Electric Company.

The improved construction used in manufacturing the receiver 19 is applicable to microphone construction, as illustrated at FIG. 8, if the requirement of compatibility with existing diving apparatus is not controlling. As shown, the pocket 41 in mouthpiece 12 is provided with an annular recess 55. Sleeve 28, which may be omitted in this construction if desired, extends to the inner edge of recess 53 and is filled to that point with a silicone rubber material 40 to encapsulate microphone element 29. An adhesive-backed, synthetic rubber preform 54 fits flush in recess 55 to close pocket 41 and, thereby, protect microphone element 29.

The aforedescribed constructions result in lightweight, compact terminal devices for use in aqueous, subsurface voice communications systems. The units are pressure resistant without incorporating gas-liquid seals, and exhibit excellent response linearity in a variety of water term temperatures. Further, they have shown excellent response characteristics to depths of 600 feet. In general, the devices of the invention have exhibited an unprecedented combination of desirable attributes which belies their mechanical simplicity and economy of manufacture.

Obviously, other embodiments and modifications of the subject invention will readily come to the mind of one skilled in the art having the benefit of the teachings presented in the foregoing description and the drawings. It is, therefore, to be understood that this invention is not to be limited thereto and that said modifications and embodiments are intended to be included within the scope of the appended claims.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

We claim:

1. An audio transducer for use in aqueous, subsurface environments comprising:

a molded, flexible, body-fitting means;

a pocket molded into the interior of said flexible, body-fitting means and communicating with one surface thereof;

a passageway through said flexible body-fitting means connecting the exterior thereof to said pocket;

a metallic sleeve member in said pocket substantially coextensively with the outer edge thereof, having an aperture aligned with said passageway;

electroacoustic transducer means disposed within said pocket, and within the confines of said metallic sleeve member so as to be spaced therefrom, said electroacoustic transducer including:

a first platelike, piezoelectric crystal having two major faces and a piezoelectric axis;

a thin, flexible, metallic electrode, with a first face thereof being secured to one of the major faces of said first piezoelectric crystal, said electrode having an area greater than said platelike piezoelectric crystal so as to extend therebeyond;

a second platelike, piezoelectric crystal having two major faces, one of which is secured to a second face of said thin, flexible, metallic electrode opposite to said first face thereof in alignment with said first platelike piezoelectric crystal, and having a piezoelectric axis differently oriented than the piezoelectric axis of said first platelike piezoelectric crystal;

two surface electrodes on the major faces of the first and second platelike, piezoelectric crystals not joined to the aforesaid thin, flexible, metallic electrode and coextensive therewith;

an insulated electrical conductor means passing through said passageway, dimensioned to effect a watertight seal therewith, and passing through said aperture in said metallic sleeve member and enclosing therein a first and a second electricity conducting means;

said first electricity conducting means being effectively attached to said two surface electrodes to provide electrical circuit connection therewith;

said second electricity conducting means being effectively attached to said thin, flexible, metallic electrode to provide electrical circuit connection therewith;

a layer of silicone rubber material filling at least a portion of said pocket and encapsulating said piezoelectric element,

so as to position it within the confines of said pocket and sleeve member; and

retaining means at the said one surface of said molded, flexible, body-fitting means cooperating therewith to extend across the pocket communicating therewith and thereby retain said encapsulated electroacoustic transducer means therewithin.

2. An audio transducer according to claim 1 in which said insulated electrical conductor is bonded to the walls of said passageway.

3. An audio transducer according to claim 1 in which said molded, flexible, body-fitting means is shaped to closely fit about the ear region of the average human head.

4. An audio transducer according to claim 1 in which said molded, flexible, body-fitting means is shaped to closely fit about the nose and mouth region of the average human head.

5. An audio transducer according to claim 1 in which said retaining means comprises a preformed sheet of synthetic rubber material fitting within a recess in said one surface of said molded, flexible, body-fitting means and adhesively secured thereto, extending across said pocket, and adhesively secured to the said layer of silicone rubber material.