

March 16, 1965

J. L. LAUGHLIN ETAL

3,174,129

UNDERWATER SOUND TRANSMITTER

Filed Dec. 12, 1960

2 Sheets-Sheet 1

Fig 1

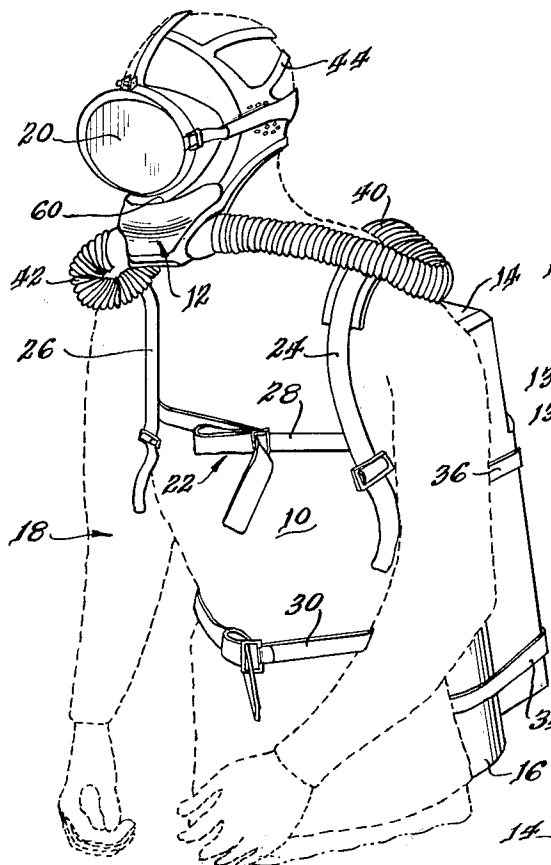


Fig 2

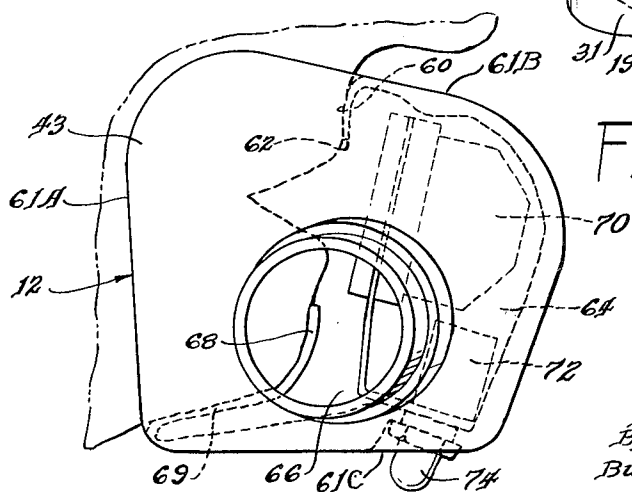
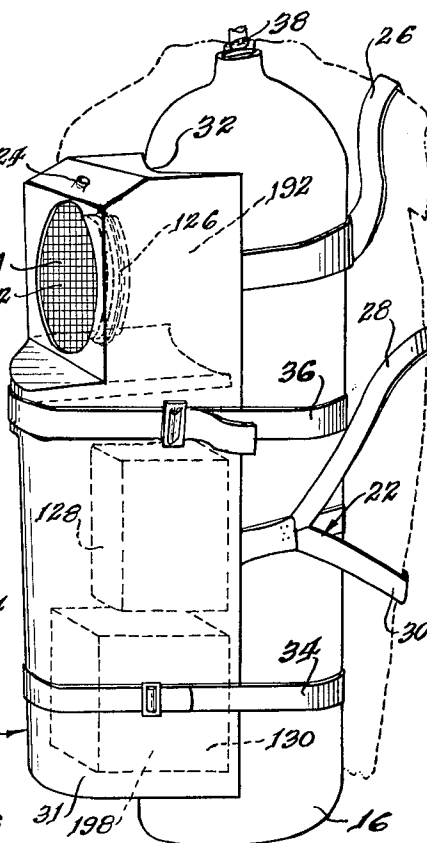


Fig 4

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Fig - 3

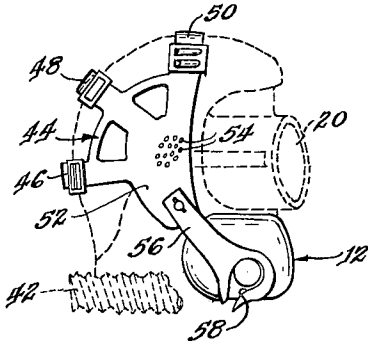


Fig - 5

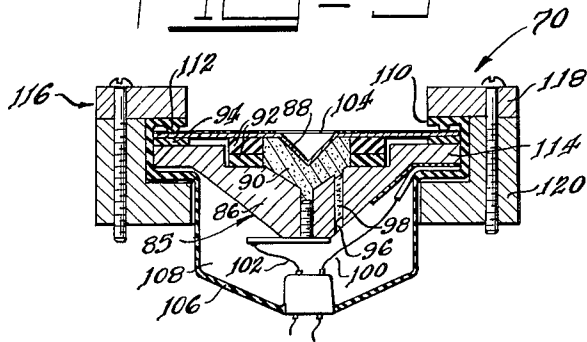


Fig - 6

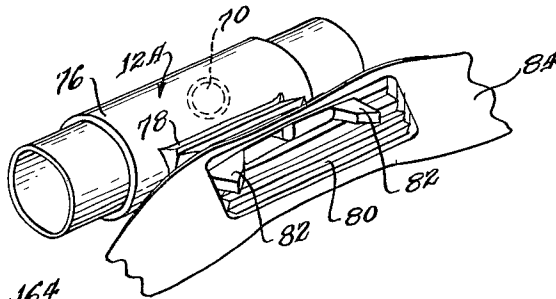


Fig - 8

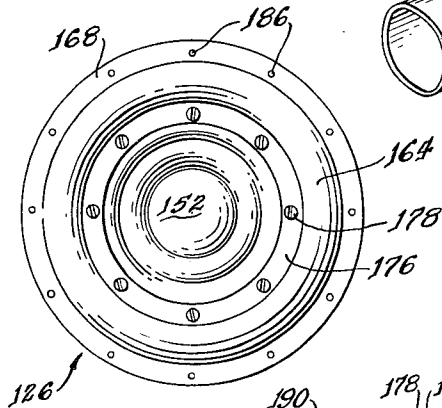
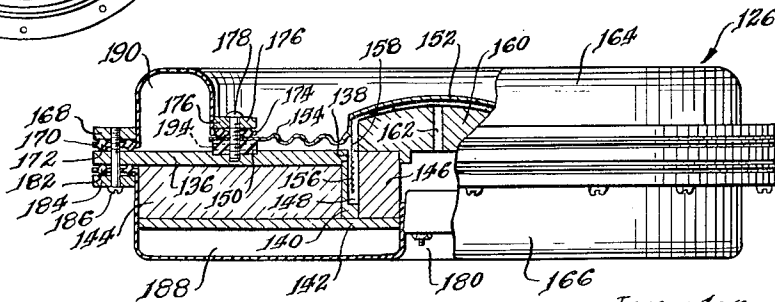


Fig - 7



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3,174,129

UNDERWATER SOUND TRANSMITTER

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17 Claims. (Cl. 340-5)

The present invention relates generally to devices for communicating beneath the surface of a body of water, and more particularly to a communications device for use by an underwater diver.

In recent years, diving has become a sport as well as an occupation for some parties, and divers descending in groups have difficulty communicating with each other. Communications between divers is most desirable from the point of view of safety, and also makes diving more enjoyable as a sport.

The fact that sound waves are propagated through water has, of course, been known for many years. This has not been a convenient mechanism for underwater communications because of the fact that the mouth of the diver is always covered with the diver's breathing apparatus. Patent No. 2,844,212 to Hogan discloses a device which attempts to overcome this problem by providing the diver's breathing apparatus with a sound transmitting diaphragm which is in contact with the surrounding water. The range of communications with such a device as disclosed by the Hogan Patent is necessarily short, particularly in view of the fact that the breathing equipment for the diver utilizes a mask which extends into the mouth of the diver and interferes with the normal motions of the jaw and mouth which occur during speech.

It is one of the objects of the present invention to provide a device for extending the range of communications between two divers or between a diver and a surface craft.

It is a further object of the present invention to provide an improved mask which is provided with a microphone and which is suitable for use by a diver.

Also, it is an object of the present invention to provide an improved loud speaker for use underwater which is inexpensive in construction and capable of use at substantial depths.

These and further objects of the present invention will be more readily apparent upon a further consideration of this disclosure, particularly when viewed in the light of the drawings, in which:

FIGURE 1 is a front elevational view of a diver equipped with sound transmitting equipment constructed according to the teachings of the present invention;

FIGURE 2 is a fragmentary rear elevational view of the diver of FIGURE 1 showing the sound transmitting equipment mounted on the diver's back;

FIGURE 3 is a fragmentary side elevational view of the diver of FIGURES 1 and 2 illustrating the mask and harness of the sound transmitting equipment;

FIGURE 4 is an elevational view of the mask showing the microphone and push to talk switch in broken lines;

FIGURE 5 is a sectional view along the central axis of the microphone illustrated in FIGURE 4;

FIGURE 6 is an isometric view of a modified mask construction suitable for use in the equipment of the present invention;

FIGURE 7 is a view of the loud speaker illustrated in the equipment of FIGURE 2 shown partly in section and partly in elevation; and

FIGURE 8 is a front elevational view of the loud speaker illustrated in FIGURE 7.

The human ear is, of course, sensitive to sound waves whether exposed to the atmosphere or submerged in a body of water. The present invention utilizes this property of the human ear to effect communications between

divers or between a surface craft and a diver. As indicated in FIGURES 1, 3 and 4, a diver, designated 10, is provided with a special face mask 12 which covers the mouth of the diver, and a unit 14 which is secured to the diver's air tank 16. As is conventional for divers, the diver 10 is provided with a water tight suit generally designated 18, and goggles 20. The air tank 16 is also mounted to the diver by a harness 22. The harness 22, as illustrated in FIGURE 1, has two straps 24 and 26 which are secured to the air tank 16 and extend over the shoulders of the diver. The straps 24 and 26 are secured to a strap 28 which extends around the chest of the diver and beneath his arms, and a further strap 30 is secured to the air tank below the strap 22 and extends about the waist of the diver.

The unit 14 has a housing 31 with a concave surface 32 which abuts the exterior cylindrical surface of the air tank 16, and the unit 14 is secured to the air tank 16 by a pair of straps 34 and 36 which extend about the unit 14 and air tank 16. The air tank 16 is provided with a valve 38 at one end, and the valve is connected to the mask 12 by a pair of air hoses 40 and 42 in the conventional manner.

As illustrated in FIGURES 3 and 4, the mask 12 has a body 43 of air impermeable material which covers the chin and mouth of the diver, but does not enter into the mouth of the diver to interfere with speech. The mask 12 is secured to the head of the diver by a head harness 44 which has three branches 46, 48 and 50, which extend over the top, back and central portions of the diver's head. The three branches 46, 48 and 50 are interconnected by portions 52 which extend over the diver's ears and are provided with perforations 54. A strap 56 is removably secured to the portions 52 of the harness 44 and is secured to the mask 12 by means of openings 58 which extend about the air hoses 40 and 42.

The body 43 of the mask 12 is made of a solid molded material and has a central indentation 60 at one side 61A thereof, and an opening 62 extends into a cavity 64 within the mask 12 from the indentation 60. The indentation 60 forms a curved recess in the side 61B of the body which is adjacent thereto, but no such recess is formed in the other adjacent side 61C. The cavity 64 is connected to the air hoses 40 and 42 by openings 66 at the ends of the mask 12. The mask 12 is provided with rolled compliant flanges 68 at the perimeter of the opening 62 to form a fluid tight seal to the face of the diver, and the jaw of the diver abuts the surface of the lip 69 formed by the side 61C.

A microphone 70 is disposed within the cavity 64 of the mask 12 immediately confronting the opening 62, and hence confronting the mouth of the diver. A push to talk switch 72 is also mounted in the cavity 64 and electrically connected to the microphone 70. The switch 72 has an actuating button 74 which protrudes from the mask 12, but the actuating button is enclosed in a plastic film to prevent water from entering into the mask.

An alternate face mask designated 12A is shown in FIGURE 6, and the mask 12A may be used in place of the mask 12 described above. The mask 12A has a tubular portion 76 which is connected to the air hoses 40 and 42, and the tubular portion 76 also houses the microphone 70. A hollow rectangular member 78 extends from the tube 76 confronting the microphone 70, and the member 78 terminates in a bellows 80. The bellows 80 abuts the face of the diver and forms a fluid tight seal therewith. A mouthpiece 82 is disposed within the bellows and attached to the rectangular member 78 confronting the diver, and in normal use, the diver places the mouthpiece 82 in his mouth to maintain the assembly of mouthpiece and tubular member in position. A face strap 84 is also provided and sealed to the perimeter of the opening of the bellows 80. The face strap 84 extends about the head of the diver.

When the diver desires to talk into the microphone, it is necessary with this construction to remove the mouthpiece 82 from his mouth by extending the bellows. When thus extended, the face strap 84 prevents seepage of water into the mouth and the diver is able to talk into the microphone without interference from the mouthpiece 82. The mask 12 illustrated in FIGURE 4 is of course in position for communication at all times, while the mask illustrated in FIGURE 6 must be manipulated to remove the mouthpiece 82 from the diver's mouth.

The microphone 70 for use in either of the mouthpieces 12 or 12A is illustrated in section in FIGURE 5. This microphone employs an electromechanical transducer 85 with a diaphragm 88. The transducer 85 has a conical housing 86 which has a conical surface spaced from a conical diaphragm 88. The region between the diaphragm 88 and the housing 86 is filled with carbon granules 90. The diaphragm 88 is spaced from the housing 86 by two electrically insulating washers 92 stacked on each other, and a compliant electrically insulating ring 94 at the periphery of the housing 86. A channel 96 extends through the housing 86 and is filled with a plug 98 of air permeable material, such as fiberglass. The diaphragm 88 is constructed of electrically conducting material and a lead 100 is electrically connected to the diaphragm. The housing 86 is also constructed of electrically conducting material, and a lead 102 is connected to the housing. A protective film 104 extends across the diaphragm, and may be constructed of Mylar.

The entire microphone 70 with the exception of the portion covered by the protective film 104, is enclosed in a compliant bladder 106. The bladder is constructed of soft compliant air impermeable plastic or rubber and is sealed about the periphery of the conical housing 86. The bladder is substantially larger than the volume of the housing 86 to provide an air chamber 108 between the housing 86 and the bladder 106. The bladder has an opening 110 which confronts the film 104, and an O ring 112 is formed integral with the bladder 106 adjacent to its opening 110 and abutting the Mylar film 104. The housing 86 is provided with a circular flange 114 at its periphery, and a clamp 116 disposed about the flange 114 forces the O ring portion 112 of the bladder 106 into engagement with the Mylar film to form an airtight seal. The clamp 116 is formed by a circular plate 118 which is bolted to a circular member 120 with an L shaped cross-section, the flange 114 of the housing 86 being clamped between the L shaped member 120 and the plate 118.

As the diver descends beneath the surface of a body of water, the diver is subjected to increased pressure. The microphone 70 is designed to equalize the pressure between the surface of the housing 86 confronting the carbon granules of the microphone and the diaphragm 88 of the microphone. This is accomplished without impairing the fluid tight seal surrounding the microphone by means of the bladder 106 and the channel 96. Increased pressure resulting from the depth at which the diver is operating causes the bladder 106 to move toward the housing 86, thus reducing the size of the air chamber 108 to equalize the pressure of the air within the chamber 108 and on the exterior of the bladder 106. The plug 98 is air permeable, and thus the pressure of the air chamber 108 is exerted upon the carbon granules and permitted to permeate through the carbon granules to the diaphragm 88. As a result of this equipment, the microphone 70 can be used at depths beneath the surface of a body of water which would otherwise injure the microphone.

The leads 100 and 102 are collected in a cable which is provided with a water tight jacket, and the cable extends from the mask 12 to an input connector 124 on one end of the unit 14. The unit 14 contains a loudspeaker, designated 126, an amplifier 128 and self-con-

tained batteries 130. The microphone 70 is connected to the input of the amplifier 128, and the output of the amplifier is connected to the loudspeaker 126. The batteries power the amplifier and provide a substantial volume of audio output to drive the loudspeaker and set up sound waves in a body of water capable of being propagated over a distance of several hundreds of feet.

The loudspeaker 126 confronts an opening 131 in the unit 14, and a water permeable screen 132 confronts the opening 131. The screen 132 permits the passage of sound waves into the water, and also permits the sound waves to enter the unit 14.

FIGURES 7 and 8 illustrate the loud speaker 126. The speaker employs a circular ferromagnetic plate 136 which is provided with a central circular opening 138. A centering ring 140 of non-magnetic material abuts the plate 136 at the opening 138 thereof and extends to a second plate 142 which is disposed parallel to the plate 136 and is also constructed of ferromagnetic material. A ring magnet 144 is disposed between the plates 136 and 142, the magnet being polarized oppositely at the faces of the plates 136 and 142. A sleeve 146 of ferromagnetic material abuts the plate 142 and extends into the opening 138 of the plate 136 and forms an angular gap therewith, the gap being designated 148 and carrying a magnetic flux between the plate 136 and the sleeve 146.

A ring 150 is mounted on the plate 136 about the opening 138 thereof, and the ring 150 supports a diaphragm 152. The diaphragm 152 is provided with a plurality of corrugations 154 adjacent to the ring 150 in order to provide the diaphragm with compliance. A voice coil 156 is positioned in the magnetic gap 148 and mounted on the diaphragm 152 by a sleeve 158 of electrically insulating material. A plug 160 is disposed in the region between the diaphragm and the sleeve 146 and within the electrically insulating cylinder 158. The plug 160 is provided with a central channel 162 which extends from the diaphragm through the plug 160. The plug 160 is for the purpose of reducing the volume of air on the rear side of the diaphragm, and the channel 162 is for the purpose of permitting air to pass from the diaphragm through to the interior of the loudspeaker 126.

The loudspeaker is provided with both a front bladder 164 and a rear bladder 166. The front bladder is clamped between a ring 168 which extends about the periphery of the plate 136, and the plate 136, the bladder 164 having a flange portion 170 which extends between the ring 168 and the plate 136. The flange portion 170 of the bladder 164 is provided with integrally disposed O-ring portions 172. The bladder 164 is also provided with a similar flange 174 of smaller diameter than the flange 170 which abuts the portion of the diaphragm 152 confronting the ring 150, and a second mounting ring 176 is disposed in abutment with the flange portion 174 and clamps the flange portion 174 against the diaphragm. A plurality of spaced screws 178 which extend through the rings 150 and 176 serve to perform this clamping function.

The rear bladder 166 is provided with a pair of electrical terminals 180 molded and sealed at the center thereof. The terminals 180 extend through the bladder, and these terminals are connected to the voice coil 156. This central portion of the rear bladder 166 extends into the ferromagnetic sleeve 146, and serves to mechanically anchor the central portion of the rear bladder 166 to the other elements of the loudspeaker assembly. The rear bladder 166 also is provided with a peripheral flange portion 182 which is clamped against the plate 136 by means of a ring 184 and a plurality of screws 186 which extend through the ring 184, the flange portion 182 of the rear bladder 166, the plate 136, the flange portion 170 of the bladder 164, and are anchored in the ring 168. The rear bladder 166 extends from the plate 142 of the loudspeaker to form a rear air chamber 188, and the front bladder 164 also extends from the front plate 136

to form a second air chamber 190. While the rear bladder 166 has a relatively flat wall spaced from the plate 142, the front bladder 164 has a curved wall surrounding the diaphragm.

The loudspeaker 126 is mounted in a separate compartment of the unit 14, designated 192, and the screen 132 permits water to fill this compartment 192 when the unit 14 is submerged. Water also is free to seep into the compartment 92 between the concave surface 32 of the housing 31 and the water tank 16, since no seal is provided at this location. As a result, the pressure of the water is exerted against both the front bladder 164 and the back bladder 166 as well as against the diaphragm 152. The ring 150 which mounts the front bladder 164 to the front plate 136, is provided with a plurality of spaced air passages designated 194 which permits the air from the bladder to equalize the air pressure between the diaphragm 152 and the plate 136. In like manner, air can travel from the air chamber 188 into this region due to the loose fit of the rear bladder 166 and the rear plate 142, and other links about the magnet 144. In this manner, the pressure exerted upon the diaphragm 152 by the weight of the water when the unit 14 is submerged is equalized on the rear surface of the diaphragm.

As stated above, the housing 31 is constructed of water impermeable material, and the compartment 192 for the loudspeaker 126 is permitted to fill with water. The amplifier compartment 196 of the housing is air tight, but the battery compartment 192 is free to fill with water. The air in the amplifier compartment of the housing provides buoyancy for the unit 14, and the weight of the water displaced by the air within the housing of the unit 14 is selected to approximately equal the weight of the unit 14, mask 12, and interconnecting cables. In this manner, the effective weight of the communicating equipment has essentially no effect upon the diver's operations.

From the foregoing disclosure, those skilled in the art will readily devise many modifications and other applications for the present invention. It is therefore intended that the scope of the present invention be not limited by the foregoing disclosure, but rather only by the appended claims.

The invention claimed is:

1. An underwater communications device comprising, in combination: a mask having an opening therein, means attached to the mask adapted to mount the opening of the mask about the mouth of a diver, and a microphone responsive to sounds in the audio frequency range mounted within the mask confronting the opening; an electrical audio frequency amplifier having an input and an output, means attached to the amplifier adapted to mount the amplifier on said diver, and means for electrically connecting the input of the amplifier to the microphone; and a loudspeaker responsive to electrical currents in the audio frequency range, means for electrically connecting the loudspeaker to the output of the amplifier, and means attached to the loudspeaker adapted to mount the speaker on said diver for communication into a body of water.

2. An underwater communications device for divers comprising the elements of claim 1 wherein the mask comprises a body of water impermeable material having a cavity therein, said body having an indentation extending therein from one side adapted to accommodate the jaw and mouth of a diver, said indentation forming a pair of generally parallel wall portions adapted to abut against the cheeks of the diver and an interconnecting lip portion disposed adjacent to a surface of the body and extending between the wall portions, said lip portion being adapted to engage the lower portion of the jaw of the diver, said body having an opening from the indentation into the cavity located between the wall portions and adapted to confront the mouth of the diver.

3. An underwater communications device for divers comprising the elements of claim 2 wherein the means

for mounting the mask comprises a harness adapted to fit about the head of the diver having a portion extending over the ears of the diver provided with openings.

4. An underwater communications device for divers comprising the elements of claim 2 wherein the means for mounting the mask comprises a harness adapted to fit about the head of the diver having two portions extending therefrom toward opposite sides of the jaw of the diver, a pair of straps, each strap being attached at one end to the body on the opposite side of the indentation from the other strap, and a releasable fastening means mounted between each strap and one of said portions having engageable parts, one part being on the other end of each strap and the other part being on one of the portions of the harness.

5. An underwater communications device for divers comprising the elements of claim 4 in combination with a switch mounted within the cavity and having an actuating member extending through the body, said switch being electrically connected between the microphone and the amplifier.

6. An underwater communications device comprising the elements of claim 1 wherein the mask comprises a tubular member having openings at opposite ends adapted to be sealed to air hoses, and an orifice between the ends thereof, a mouthpiece adapted to fit within the mouth of the diver, having a passage therethrough, the mouthpiece being sealed to the tubular member about the orifice thereof with the passage in communication with the orifice, the microphone being mounted within the tubular member, and an extendable water impermeable bellows mounted about the mouthpiece and extending away from the tubular member, whereby a diver can retract the mouthpiece into the bellows to remove the mouthpiece from his mouth without permitting water to enter into the tubular member.

7. An underwater communications device comprising the elements of claim 1 wherein the microphone comprises a diaphragm, an electro-acoustical transducer mechanically coupled to the diaphragm, and a water impermeable flexible envelope disposed about the transducer and diaphragm, said envelope forming a chamber in communication with one side of the diaphragm, the other side of the envelope being adapted to communicate with the water, said transducer having an air impermeable electrically conducting housing having a recess therein, the diaphragm being electrically insulated from the housing and extending across the recess, a mass of carbon granules packed within the recess, said housing having a channel extending therethrough from the recess, and an air permeable plug disposed within the channel, said plug being sufficiently dense to prevent the granules from passing through the channel.

8. An underwater communications device comprising the elements of claim 1 wherein the loudspeaker comprises a diaphragm having one side adapted to communicate directly with the water, an electromechanical transducer mechanically coupled to the diaphragm, and a compliant water impermeable bladder sealed about the diaphragm and extending around the transducer, the bladder forming an air chamber in communication with the opposite side of the diaphragm.

9. An underwater communications device comprising the elements of claim 1 wherein the loudspeaker comprises an electromechanical transducer having a circular plate, a circular water impermeable diaphragm mounted at its periphery on said plate, a spacer disposed between the diaphragm and plate having at least one channel extending therethrough, a circular bladder, having an inner periphery sealed to the periphery of the diaphragm and an outer periphery sealed to the periphery of the plate to form an air chamber in communication with the diaphragm through the channel of the spacer.

10. An underwater communications device comprising the elements of claim 9 in combination with a second

circular bladder sealed at its outer periphery to the plate forming a second air chamber in communication with the diaphragm.

11. An underwater communications device comprising the elements of claim 1 wherein the amplifier is mounted in a housing having a concave side, and means are attached to the housing for securing the housing to the surface of a cylindrical air container.

12. An underwater communications device comprising the elements of claim 11 wherein the housing is provided with a compartment extending therein from the concave side and an opening therein communicating with the compartment, the speaker being mounted confronting the opening and including a diaphragm having one side adapted to communicate directly with the water, an electromechanical transducer mechanically coupled to the diaphragm, and a compliant water impermeable bladder sealed about the periphery of the diaphragm and extending around the transducer, the bladder forming an air chamber in communication with the opposite side of the diaphragm.

13. An underwater communication device comprising the elements of claim 11 wherein the housing is provided with a compartment extending therein from the concave side and an opening therein communicating with the compartment, the speaker being mounted confronting the opening and including an electromechanical transducer having a circular plate, a circular water impermeable diaphragm mounted at its periphery on said plate and having one side confronting the opening in the housing, a spacer disposed between the diaphragm and plate having at least one channel extending therethrough, a first circular bladder constructed of compliant water impermeable material having an inner periphery sealed to the periphery of the diaphragm and an outer periphery sealed to the periphery of the plate to form an air chamber, a passage disposed between the first bladder and the other side of the diaphragm through the channel of the spacer, a second circular bladder sealed at its outer periphery to the plate and extending about the side of the transducer opposite the diaphragm, said second bladder forming a second air chamber in communication with the same side of the diaphragm as the first air chamber.

14. An underwater communication device comprising the elements of claim 11 wherein the housing, amplifier, loudspeaker, and mask displace a volume of water having a weight at least equal to their weight.

15. A loudspeaker comprising an electromechanical transducer having a circular plate, a circular water impermeable diaphragm mounted at its periphery on said plate, a spacer disposed between the diaphragm and plate having at least one channel extending therethrough, a

circular bladder having an inner periphery sealed to the periphery of the diaphragm and an outer periphery sealed to the periphery of the plate to form an air chamber in communication with the diaphragm through the channel of the spacer.

16. A loudspeaker comprising the elements of claim 15 in combination with a second circular bladder sealed at its outer periphery to the plate and extending about the side of the transducer opposite the diaphragm, said second bladder forming a second air chamber, means defining a passage extending between said second bladder and the same side of the diaphragm as the first air chamber.

17. A microphone comprising a diaphragm, an electroacoustical transducer mechanically coupled to the diaphragm, a water impermeable flexible envelope disposed about the transducer and diaphragm, said envelope forming a chamber in communication with one side of the diaphragm, the other side of the envelope being adapted to communicate with the water, said transducer having an air impermeable electrically conducting housing having a recess therein, the diaphragm being electrically insulated from the housing and extending across the recess, a mass of carbon granules packed within the recess, said housing having a channel extending therethrough from the recess, and an air permeable plug disposed within the channel, said plug being sufficiently dense to prevent the granules from passing through the channel.

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