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EXTENDED FREQUENCY RANGE PRESSURE BALANCED HYDROPHONE

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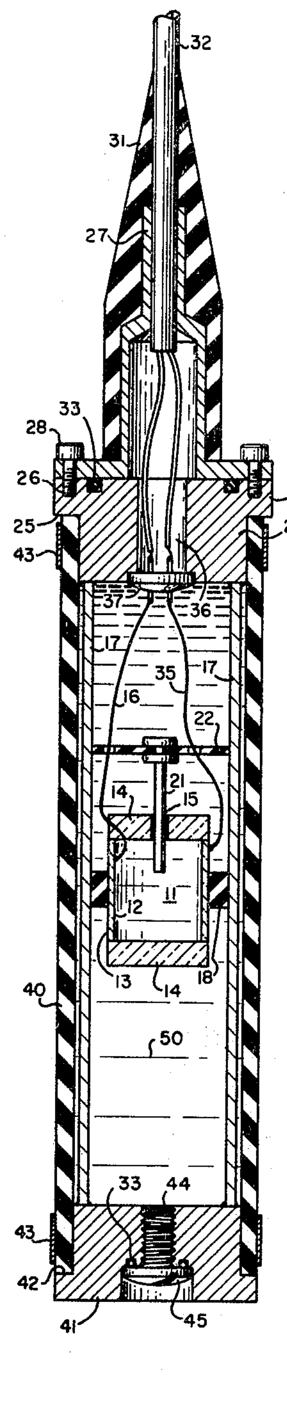

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EXTENDED FREQUENCY RANGE PRESSURE BALANCED HYDROPHONE

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ABSTRACT OF THE DISCLOSURE

A hydrophone including an oil-filled ceramic cylinder in which a steel plunger is provided to compensate for rapid changes in pressure. The ceramic cylinder is surrounded with oil which is admitted into the cylinder by the spacing between the steel rod and an aperture in an end cover on the cylinder. The steel rod transmits hydrostatic pressure to the inside of the cylinder to compensate for the pressure on the outside of the cylinder and provide high acoustic impedance to block acoustic pressure from the outside of the ceramic element.

The present invention is directed to an improved electroacoustic device and more particularly directed to an audio range hydrophone for operation at very high hydrostatic pressure.

Heretofore hydrophones or transducers have been adapted to withstand the crushing force of extreme ambient hydrostatic pressure by employing a liquid filling within the transducer core with a reservoir for the same type of liquid connected thereto by a restrictive orifice between the transducer core and the reservoir. The reservoir is confined within the structure by a collapsible pressure compensating type material such that the pressure of the surrounding medium is transmitted to the liquid within the core and will be equal thereto. The restrictive orifice between the reservoir and the transducer core enables ambient-pressure equalization without dynamic-pressure equalization so that acoustic sensitivity may be assured while maintaining static equilibrium, in all cases except for a very low frequency. A similar such hydrophone has been described in an article entitled Pressure-Balanced High-Pressure Hydrophone by Edward T. O'Neill, published in the Journal of the Acoustical Society of America, vol. 34, No. 10, pages 1661–1662, October 1962. Another such system is described in U.S. Patent No. 3,018,466. Such prior art devices have high pressure operability. However, the flat frequency response is not sufficiently broad and rapid pressure fluctuations cannot be tolerated.

The incident invention is directed to a hydrophone which comprises an oil-filled ceramic cylinder surrounded by oil in which a steel plunger supported by a rubber washer is admitted into the oil-filled ceramic cylinder through a small hole in one of the ends thereof. The purpose of the steel plunger is to compensate for rapid changes in pressure and at the same time to provide sufficiently high acoustic impedance to block the acoustic pressure from the inside of the ceramic cylinder. The ceramic cylinder is supported by a rubber washer attached to the framework and the whole assembly is encased in a butyl rubber boot which contains the oil that surrounds the ceramic cylinder.

It is therefore an object of the present invention to provide an improved transducer in which depth-compensation is automatically effected.

Another object is to provide a transducer capable of delivering useful output, without destruction of the instrument, at ambient pressures ranging from the surface of a body of water to any desired operating depth.

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Still another object is to provide a transducer which is capable of controlling the resonant frequency and low-frequency cutoff.

Yet another object is to provide a small, rugged relatively simple transducer capable of operation without degradation to an area in the deepest parts of the ocean.

While another object is to provide a transducer which is capable of rapid compensation and high acoustic impedance operable to achieve smooth response and mechanical integrity.

Other objects and advantages of the invention will hereinafter become more fully apparent from the following description of the annexed drawing, which illustrates a preferred embodiment and wherein the drawing illustrates a cross-sectional view of a preferred embodiment of the invention.

Rerferring now to the drawing, there is shown by illustration a transducer made in accordance to the present invention. The cylindrical ceramic element **11** is provided with conductive inner and outer surfaces **12** and **13**, and is provided with glass discs or any other suitable material **14** at each end of the cylinder, secured thereto by any well known means. The upper disc **14** is provided with an axial aperture **15** therein, the purpose of which will be explained hereinafter, and a second aperture therein through which a conductive wire **16** is passed and connected to the inner conductive surface **12** of the ceramic cylinder. The cylindrical ceramic transducer element **11** is secured centrally of a steel rod assembly and mounted therein between the steel rods **17** by a rubber mount **18** or any other suitable material. A steel rod **21** is mounted axially of the ceramic cylinder and the steel rod support assembly members **17** such that the lower end of the steel rod **21** passes through the axial aperture **15** in the upper disc **14** and extends into the area confined by the ceramic cylinder. The steel rod **21** is held in place at a desired position by a rubber washer **22** mounted within the confines of the steel rods **17** for axial movement relative to the upper disc **14** through which the steel rod **21** extends.

The upper ends of the steel rods **17** are secured to a metallic cylindrical element which is formed of two portions **23** and **24**, each of different diameter such that the upper portion **24** has the greater diameter to form a flange or lip **25**. The lip **25** is provided with threaded holes **26** therein to which an electrical cable securing element **27** is secured by screws **28**. The cable securing element **27** is covered by a molded sleeve **31** which extends upwardly about the electrical cable **32** to prevent leakage of water between the cable and the cable securing means. Any suitable cable connecting means may be used so long as there is no water leakage between the electrical cable and the transducer element. A suitable O-ring **33** is used between the cable securing element and the upper end element **24** to which the steel rods are secured to prevent water leakage therebetween. The electrical wires **16** and **35** from the electrical cable pass through an axial aperture **36** in the upper end element and through an insulator element **37** to the ceramic cylindrical electroacoustical element and are connected respectively to the inner and outer electrical conductive coatings on the electroacoustical element. The insulator element is secured to the bottom of the upper element and is provided with a hermetic seal to prevent any water leakage into the area in which the ceramic cylinder is secured. A butyl rubber boot **40** is slid over the steel support rods extending upwardly about the lower portion **23** of the upper end element and extending downwardly beyond the end of the steel support rod of the lower end. A bottom end element **41** with a portion thereof that fits inside of the butyl rubber boot is extended into the boot until the lower end of the boot rests against a lip **42** on the bottom of the bottom element. A hose clamp **43** is positioned around the upper end and the lower end of the butyl rubber boot and tightened down to afford a leakproof joint between the upper and lower elements and the butyl rubber boot. The bottom element is provided with an axial aperture **44** therein, which is screw-threaded to recive a threaded plug **45** wherein the plug may be removed to fill the chamber confined by the butyl rubber boot with castor oil **50**. Five of the steel rods may be welded to the upper member **23** and the lower member **41** and then the ceramic member **11** and the rubber washer and steel rod placed in position and then the sixth steel rod welded into place at the top and bottom. The butyl rubber boot **40** may be slipped over the bottom end element **41** and then secured into place by hose clamps **43**. Any other suitable manner of assembly may be used so long as the ceramic clylinder and associated steel rod are secured in place within the rods.

The rubber mounts positioned about the center of the ceramic cylinder and the rubber washer to which the steel rod **21** is connected may be provided with apertures therethrough which permit the castor oil to surround the ceramic cylinder and therefore fill the entire chamber area confined by the butyl rubber boot. Also, the castor oil will flow upward around the washers in the area of the rods **17**. Since the entire chamber confined by the butyl rubber boot and the inside of the ceramic cylinder includes castor oil which is admitted through the axial opening in the top glass disc thereof through which the steel rod is passed into the ceramic cylinder, the device will withstand high pressures since the pressure surrounding the butyl rubber boot and the device must compress the liquid within the confines of the butyl rubber boot. Since the inside of the ceramic cylinder includes castor oil as well as the outside thereof, the pressure on the inside of the ceramic cylinder will be equal to the pressure on the outside thereof; therefore, the effect on the ceramic cylinder will be the same regardless of the pressure on the outside of the rubber boot. The ceramic cylinder may be filled with castor oil when positioned in place within the confines of the rods **17**.

The rubber washer which secures the steel rod **21** relative to the cylindrical ceramic electroacoustical element may be positioned at any desired position linearly along the steel rods **17** such that the steel rod **21** extends into the ceramic cylinder a desired distance. The purpose of the steel rod is to compensate for rapid changes in pressure and at the same time to provide sufficiently high acoustic impedance to block the acoustic pressure from the inside of the ceramic. Rapid changes in pressure is compensated by axial movement of rod **21** relative to the disc **14** which changes the pressure of the fluid within the ceramic cylinder. Movement of rod **21** results from changes in pressure of the fluid within which the device is located thereby changing the pressure of the fluid within the device which creates a pressure differential on the upper and lower ends of rod **21**. The pressure differential on the ends of the rod permits axial motion of the rod thereby controlling the pressure within the ceramic cylinder. The pressure differential on the rod results from a difference in the area of the top of the rod and the area of the bottom of the rod. This difference permits movement of the rod relative to the ceramic cylinder. The steel rod or plunger introduces considerable mass and resistance into this system, thus moving the resonance to a frequency low enough to make the controlling impedance resistive at any reasonable temperature while keeping the response flat to ± 1.0 db. from 2.0 cycles per second. The rod increases the acoustic mass in the ratio of the increases in length and density. In general terms, the steel rod replaces the fluid in the neck of a Helmholtz resonator. This increases the mass of the moving fluid into the neck, and hence reduces the resonant frequency established by the compliance of the volume of oil inside the ceramic cylinder and the mass in the neck. The length and weight of the plunger, the diameter of the plunger and the volume inside the cylinder determine the low frequency cutoff.

As an example of an operable transducer for use in low frequency calibration and as a high pressure probe, the device may be made as follows:

The diameter and length of the ceramic cylinder are each three-quarters of an inch and the aperture in the end gap is approximately 0.040 in diameter. The steel rod or plunger that extends into the ceramic cylinder has a length of one inch and a diameter of approximately 0.040 inch. Each of the end caps on the ceramic cylinder has a thickness of approximately three-sixteenth of an inch. The chamber within which the ceramic cylinder is mounted has a length of approximately four-and-a-half inches and a diameter of approximately one inch and one-quarter.

Transducers made in accordance to the present invention are stable over a wide range of pressure. They are small in size, and have adequate sensitivity which may be operative without a preamplifier. The addition of the plunger or steel rod in the ceramic cylinder compensates for rapid changes in pressure and at the same time provides a sufficiently high acoustic impedance to block the acoustic pressure from the inside of the ceramic cylinder. Thus the plunger or steel rod controls the resonant frequency and low frequency cutoff of the transducer.

Transducers have been made using different shapes and utensils for end caps such as magnesium, beryllium, aluminum and ceramic. It has been determined that a conically shaped beryllium end cap gives the greatest frequency range and a tungsten plunger would lower the cutoff.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed and desired to be secured by Letters Patent of the United States is:

1. An electroacoustic transducer which comprises:
an elongated cylindrical transducer element electrically responsive to incident pressure,
an elongated cylindrical member forming a chamber about said electrically responsive element coaxial therewith,
a compressible fluid filling within said chamber, surrounding said electrically responsive element and within said electrically responsive element,
an end cap on each end of said electrically responsive element,
an aperture in one of said end caps coaxial with said electrically responsive elements,
a solid elongated plunger positioned relative to said electrically responsive element coaxial therewith,
said plunger extending through said aperture in said end cap in said electrically responsive element into the area confined by said electrically responsive element, and
an extensible support, supporting said plunger for axial movement within said aperture relative to said transducer element.

2. An electroacoustic transducer as claimed in claim **1**, wherein:
said elongated cylindrical transducer element is formed of ceramic.

3. An electroacoustic transducer as claimed in claim **2**, wherein:
said fluid within said chamber about and within said transducer element is castor oil.

4. An electroacoustic transducer as claimed in Claim **1**, wherein:
said solid plunger is made of metal.

5. An electroacoustic transducer as claimed in claim 4, wherein:

said elongated cylindrical member forming said chamber is made of extensible material.

6. An electroacoustic transducer as claimed in claim 4, wherein:

said member forming said chamber is supported inwardly by a framework of spaced apart rods.

References Cited

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