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Rishell

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[54] **ACOUSTIC IMAGE CONVERSION TUBE**

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[52] **U.S. Cl.** .... **340/5 MP,** 315/11, 340/10

[51] **Int. Cl.** **H04b 11/00,** H01j 31/495

[58] **Field of Search** .... 340/5, 8 PC, 8 MM, 10; 178/5.6, 5.8, 6 SP, 7.8, 7.5 E, 6.8, 7.82; 73/67.5, 67.6, 67.7; 313/312, 324, 66, 67, 172, 183, 185–187, 220, 233, 238, 239, 240, 244, 246, 311, 312, 323, 324; 315/55, 108, 110, 12, 10, 11; 181/0.51

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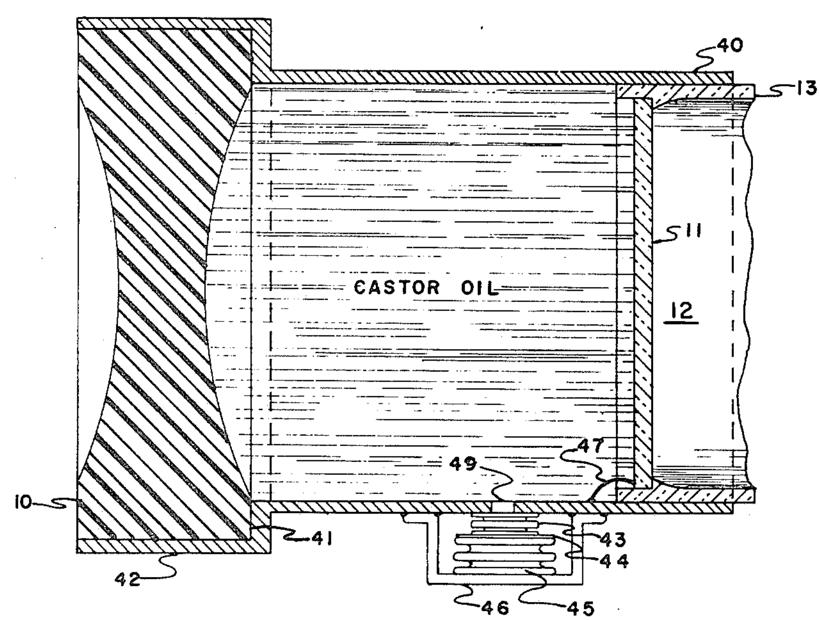
EXEMPLARY CLAIM

1. An underwater acoustic device comprising in combination a substantially rigid front wall member of sound transparent material, a rear wall member of piezoelectric material spaced back of said front wall member in generally parallel relation thereto and substantially coextensive therewith, said rear wall member comprising the front face of a cathode ray tube means joining said wall members together at their edges to form a fluid tight enclosure, a liquid filling said enclosure, a liquid filled reservoir in fluid communication with said enclosure means movable for varying the volume of said reservoir, and means responsive to changes in the ambient pressure for moving said volume varying means to change the volume of said reservoir as a direct function of changes in the ambient pressure.

2 Claims, 3 Drawing Figures



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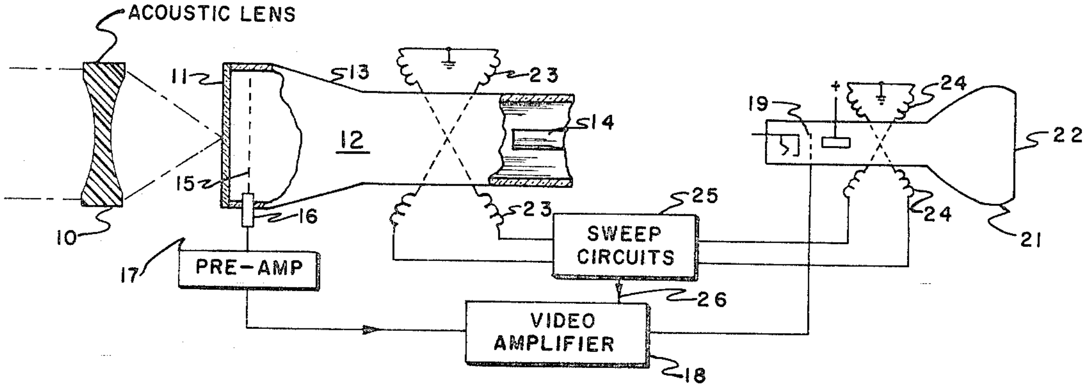

FIG. 1

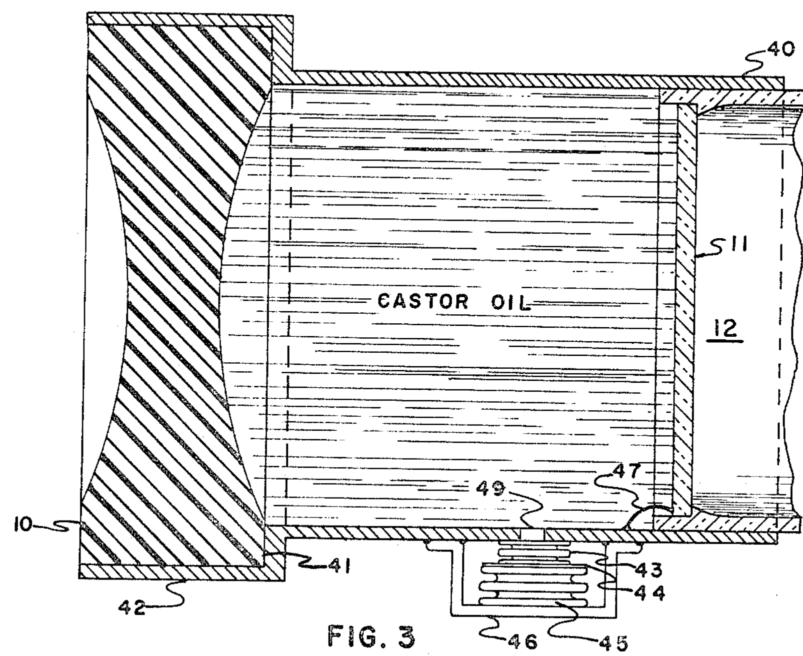

FIG. 3

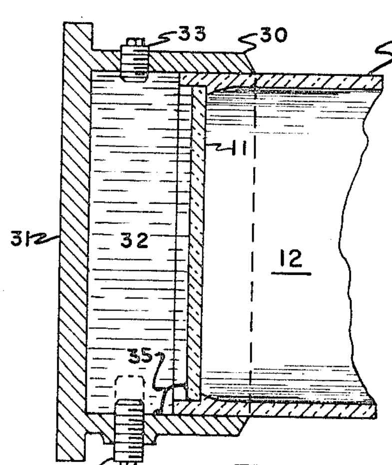

FIG. 2

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ACOUSTIC IMAGE CONVERSION TUBE

The present invention relates to tubes of the cathode ray type for converting an acoustic image into a video signal and more particularly to such tubes constructed to be robust enough to withstand pressures of several atmospheres without sacrificing desired operating characteristics or performance.

A slab of piezoelectric material such as quartz or polarized barium titanate having lateral dimensions large compared to the wavelength of the acoustic energy present in an acoustic image applied to an electroded side of the slab through a coupling medium will produce localized electrical effects such that an electrical image will appear on the opposite bare side as an alternating potential pattern having the frequency of the acoustic excitation. If this piezoelectric slab, which will hereinafter be referred to as the conversion plate, is utilized as the front face of a cathode ray tube with its bare face inward; electron beam scanning of this bare face will detect the point-by-point variations in electric charge distribution thereon corresponding to the acoustic energy distribution on its outer face and generate a time varying signal, i.e., a video signal, which by a system common to television practice can be reproduced as a visual image on the screen of a cathode ray oscilloscope to display point-by-point the intensity of the acoustic energy coming from corresponding points in the object field imaged on the front face of the conversion plate. Such a system can not compete with television in any medium transparent to light but in certain mediums opaque or substantially opaque to light such as turbid water such a system is useful and at the present time is the only one known which will present to remote viewers a "picture" of an object submerged in turbid water.

The optimum thickness for the conversion plate is a half wavelength of the acoustic energy utilized to form the acoustic image and for both quartz and barium titanate this corresponds to a thickness of approximately 0.1 inches at a frequency of 1.0 megacycle per second (mcps). If a half wave conversion plate alone constitutes the end of the image tube, the maximum diameter for a rim supported plate which will withstand a pressure of one atmosphere (for a frequency of 1.0 mcps) is about 6.0 inches for quartz and about 4.4 inches for barium titanate. Waters to a depth of 180 feet are usually assumed to be mineable and if the acoustic image tube is to be employed for mine hunting at such depths it would be subjected to pressures exceeding six atmospheres and obviously the diameter of an image tube employing only an unreinforced conversion plate is severely limited. The apparent size advantage afforded by quartz is mainly illusory because of its unavailability in sizes much greater than 3 inches except as museum pieces. Strength can be gained by dimensioning the conversion plate an odd multiple of one-half wavelength thick but in the present state of the art this introduces shortcomings which are unacceptable. It has been proposed to solve this strength problem by bonding the conversion plate to a metal front plate which forms an integral part of the vacuum tube envelope. This "sandwich" type construction is difficult to bond on the molecular-scale necessary and the metal plate constitutes a necessary evil in the acoustic path.

In accordance with the present invention the image tube is constructed with a pressure relief barrier between the water medium and the conversion plate which effectively protects the conversion plate and eliminates the need for a strength member bonded to the plate.

Also in accordance with the invention a rigid covering cap is mounted over the conversion plate and the enclosed volume is filled with a liquid at a reduced pressure not less than the vapor pressure of the liquid and such reduced pressure is maintained substantially constant regardless of variations in the external pressure on the covering cap.

An object of the invention is to provide an acoustic image conversion tube with a window structure which will withstand the pressure differential between the substantial vacuum of the tube and the hydrostatic pressure at substantial depths under water.

Another object of the invention is to provide a pressure relief barrier between the conversion plate of an acoustic image tube and the surrounding medium.

A further object of the invention is the provision of a method of manufacturing a pressure relief barrier for an acoustic image tube.

The features of this invention which are believed to be novel are set forth with particularity in the appended claims. The invention itself, both as to its structure and operation together with further objects and advantages thereof may be best understood by reference to the following description taken in connection with the accompanying drawing in which:

FIG. 1 is a diagrammatic representation of an acoustic-to-visual system in which the invention is utilized;

FIG. 2 is a fragmentary view in section of a pressure relief barrier mounted over the conversion plate of an acoustic image tube and enclosing a liquid whose volume can be varied; and

FIG. 3 is a similar view showing another form of pressure relief barrier incorporating a lens and provided with automatic pressure control.

Referring now to the drawing, FIG. 1 represents an apparatus for classifying and identifying objects under water by forming from high frequency acoustic energy reflected by such object an acoustic image on a conversion plate of piezoelectric material, scanning the resulting electrical image on the opposite side of the conversion plate to develop a corresponding video signal and synthesizing a visual image from this video signal. This apparatus as shown includes an acoustic lens **10** of suitable material, such as methyl methacrylate plastic, positioned to image an object field on the conversion plate **11** of suitable material, such as quartz or barium titanate, forming the front end of a cathode ray tube **12** comprised of a generally cylindrical envelope **13** having an electron gun **14** and a screen mesh electrode **15** positioned to collect secondary electrons resulting from the scanning of the rear surface of the conversion plate **11.** The collector electrode **15** is connected through an external terminal **16** to a preamplifier **17** which preferably is included in the underwater assembly with the tube **12.** The output of the preamplifier **17** is fed through a video amplifier **18** to the intensity grid **19** of a cathode ray tube **21** having on its face a fluorescent screen **22.** Each of the tubes **12** and **21** is provided with horizontal and vertical deflecting coils **23** and **24,** respectively, which are connected to be energized in synchronism by suitable sweep circuits **25** in accordance with common practice in the television art. Also in accordance with common practice, the vertical return trace in the cathode ray tube 21 may be blanked through the video amplifier 18 under the control of a signal carried over a lead 26 from the vertical sweep generator in the sweep circuits 25.

Referring now to FIG. 2, wherein parts in common with FIG. 1 are given like reference characters, the end of the tube 13 in which the conversion plate 11 is sealed has fused thereto the annular skirt 30 of a cap member having a transmission window 31 of metal or any material of suitable strength and sound transmitting properties. The electrode on the front surface of the conversion plate 11 is grounded through a lead 35. The cap comprised of the skirt 30 and the window 31 together with the conversion plate 11 defines an enclosed volume which is filled with a liquid 32 such as castor oil capable of transmitting acoustic energy from the window 31 to the conversion plate 11 without serious loss. The oil 32 may be introduced through a filler opening sealed by a threaded plug 33. In accordance with the invention, the volume to be oil filled can be varied to the end that the pressure on the sealed-in oil 32 can be reduced. In the embodiment of FIG. 2, this is accomplished by means of a threaded volume varying element 34 which is screwed to the "in" position, indicated by broken line, during the oil filling and sealing-in operation. Thereafter, the element 34 is backed off until the pressure on the oil 32 is some value which is not less than the vapor pressure of the particular liquid employed, i.e., a pressure above that at which bubble formation would take place. By thus reducing the pressure on the conversion plate 11, the need for a metal strength member bonded to the plate 11 is eliminated. The transmission window 31 of the cap will, of course, have a thickness which is a function of the wavelength of the acoustic energy employed as well as the index of refraction of the material utilized, as is well known to those skilled in this art. The window 31 is made as strong as necessary to withstand the hydrostatic pressure when the tube 12 is submerged during its intended use. However, the thickness of the window 31 selected for near optimum acoustic properties will, when submerged to depths corresponding to several atmospheres, bow a certain amount in the direction tending to reduce the volume occupied by the oil 32 and hence will increase its pressure but this does no harm within the range the pressure was initially reduced. Such pressure changes in greater range can be compensated by providing a pressure senser which could be coupled to drive the element 34 in or out to maintain constant the pressure on the transmission liquid 32 regardless of changes in external pressure on the transmission window 31. One very simple arrangement for pressure change compensation is shown in the embodiment now to be described in connection with FIG. 3.

FIG. 3 shows an embodiment of the invention in which the end of the cap member on the tube 12 comprises a lens 10 rather than a flat plate and the axial length of the cap member is such that the distance between the conversion plate 11 and the back face of the lens 10 equals the back focal length of the lens 10. More specifically, the conversion plate end of the tube 13 has sealed thereto an axially extending tubular member 40, the forward end of which is provided with an outwardly facing shoulder 41, and a tubular extension 42 of greater diameter than the portion 40, the shoulder 41 and the tube 42 comprising a seat in which the lens 10 is mounted. By mounting the lens 10 with a radially snug fit in the tube 42, radial expansion of the lens 10 is prevented and, inasmuch as the lens 10 will ordinarily be of substantially incompressible material, it will be evident that only a very small deformation or axial displacement of the concave inner face of the lens 10 can take place when its external surface is subjected to hydrostatic pressure. The volume enclosed by the conversion plate 11, the tube 40 and the rear face of the lens 10 is filled with a suitable liquid such as castor oil. Changes in this volume due to small displacements of the lens 10 are compensated by a hydrostatically operated variable volume device, here shown as comprising an oil filled bellows 43 in communication with the main body of castor oil through a passageway 49 in the tube 40. The bellows 43 has an axially movable end wall 44 which is connected to be moved by a gas filled or evacuated bellows 45 suitably mounted external to the tube 40 as on a U-shaped bracket 46. As here shown, the movable wall 44 is common to both the liquid filled bellows 43 and the gas filled bellows 45. It will be evident that by suitably proportioning the diameters of the bellows 43 and 45, with the bellows 45 being of course the larger, hydrostatic pressure exerted on the bellows 45 can be made to vary the volume of the castor oil sufficiently to compensate for any small movement of the lens 10 and still maintain the castor oil at the desired low pressure. The electroded front surface of the conversion plate 11 is shown grounded by a lead 47.

It will be understood that the embodiment shown in FIG. 3 may be provided with a threaded volume varying element such as the screw 34 in FIG. 2 for lowering the pressure of the castor oil after initial filling or, alternatively, prior to the time the castor oil volume is sealed, the bellows 45 is expanded, preferably mechanically, and then released after the oil volume is sealed to reduce the oil pressure as desired. By reason of the oil initially being under reduced pressure, there is considerable tolerance in the operating requirements of the volume varying device under the control of external pressure.

While for the purpose of disclosing the invention to enable those skilled in the art to practice the same preferred embodiments have been described in detail, it is to be understood that the invention is not limited to the precise structures shown and that many modifications thereof will be obvious and may be made without departing from the scope of the invention as set forth in the appended claims.

What is claimed is:

1. An underwater acoustic device comprising in combination a substantially rigid front wall member of sound transparent material, a rear wall member of piezoelectric material spaced back of said front wall member in generally parallel relation thereto and substantially coextensive therewith, said rear wall member comprising the front face of a cathode ray tube means joining said wall members together at their edges to form a fluid tight enclosure, a liquid filling said enclosure, a liquid filled reservoir in fluid communication with said enclosure means movable for varying the volume of said reservoir, and means responsive to changes in the ambient pressure for moving said volume varying means to change the volume of said reservoir as a direct function of changes in the ambient pressure.

2. An acoustic device according to claim 1 in which said front wall member comprises an acoustic objective lens and said rear wall member is in an image plane of said lens.

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