

[54] **PRESSURE RELEASE HEMISPHERICAL
PIEZOELECTRIC TYPE TRANSDUCER**

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310/8.7, 9.1, 9.4, 9.5, 9.6**

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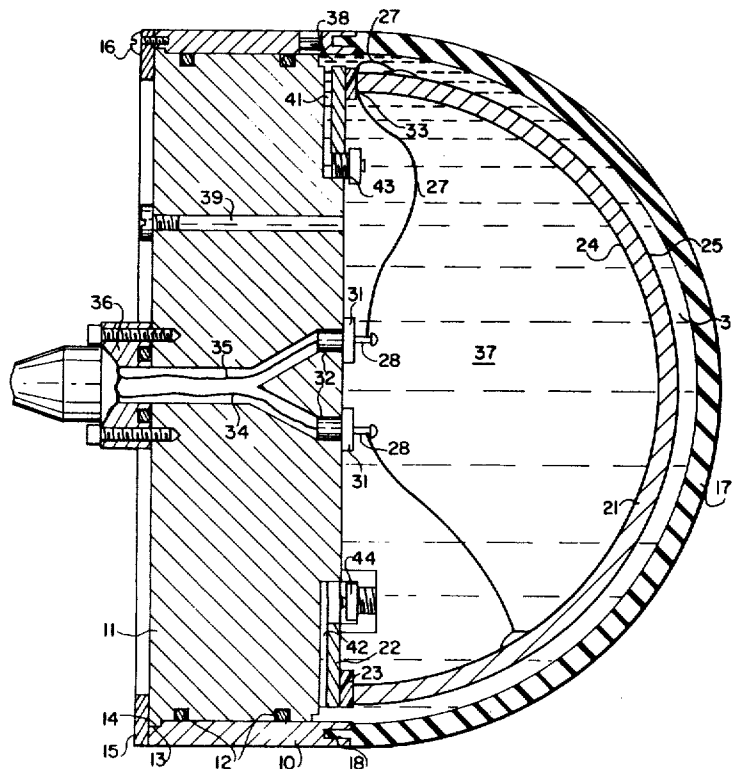
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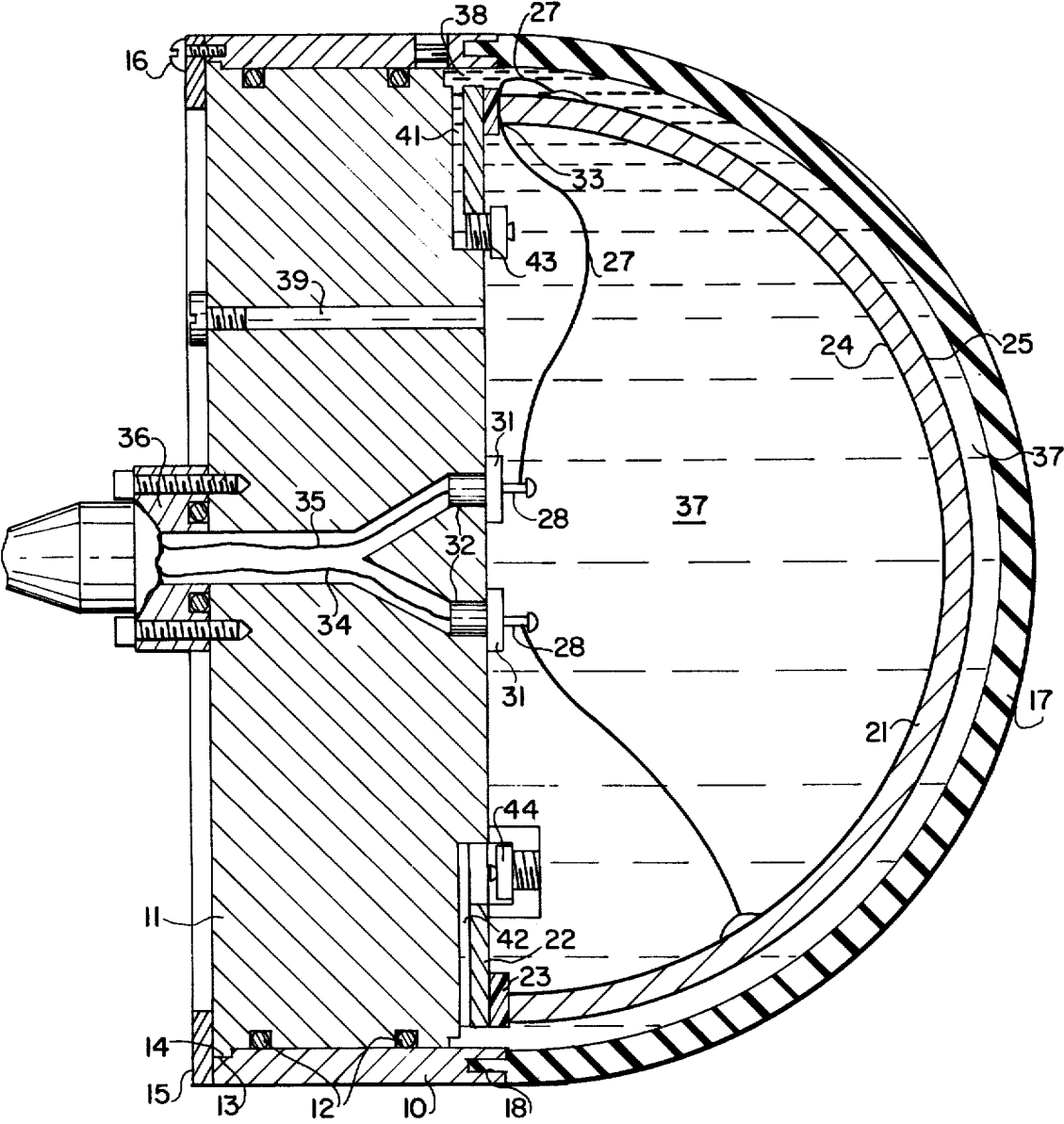
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ABSTRACT

A transducer including a hemispherical piezoelectric element backed by a mass of material and enclosed by a rubber boot. Oneway pressure valves are included in the structure to permit passage of oil into and from the area between the piezoelectric element and the mass to the area between the piezoelectric element and the rubber boot in order to maintain substantially constant pressure within the piezoelectric element.

4 Claims, 1 Drawing Figure





PRESSURE RELEASE HEMISPHERICAL PIEZOELECTRIC TYPE TRANSDUCER

BACKGROUND OF THE INVENTION

This invention relates to piezoelectric type transducers and more particularly to a hemispherical piezoelectric transducer which is provided with a pressure control that is operable at high pressures up to 16,000 psig and over a frequency range of from about 0 Hz to about 4000 Hz at a temperature from about 3°C to about 45°C.

Heretofore transducers have had limited use under great pressures because of unequal pressures on the inside and outside of the transducer. Some transducers have tried to correct this problem by use of small spacings or oil passage slots which permit limited free flow of oil from one area to another. The slots affect the required high acoustic impedance, therefore, low frequency performance is affected. Some patents on acoustical imaging tubes in combination with transducers have used pressure control devices. These known devices only allow for expansion and compression of the fluid and have no flow from one side of the active element to the other. Such systems are not operable at great pressures.

SUMMARY OF THE INVENTION

This invention is directed to a piezoelectric transducer which is capable of operation at high pressures, more particularly, operation in a tank facility for underwater acoustical calibration measurements in the low infrasonic and audio frequency range. The transducer includes pressure valves for equalization of the fluids on each side of the piezoelectric element. The device is operable over a frequency range of from just above zero frequency to about 4000 Hz at hydrostatic pressures up to 16,000 psig, and at temperatures of from about 3°C to about 45°C. The pressure valves are set for 12 psi, therefore, the pressure on the low pressure side of the piezoelectric element must build up to a pressure of 12 psi before any transfer of fluid from the high pressure side to the low pressure side.

BRIEF DESCRIPTION OF THE DRAWING

The drawing is a cross-sectional view illustrating the relative parts.

DESCRIPTION OF THE DEVICE

Now referring to the drawing, there is shown a cross-sectional view which illustrates the relative parts. As shown, a stainless steel housing or casing 10 includes therein a stainless steel cylindrical backing mass 11 which is coaxially centered therein, separated therefrom and provided with O-rings 12 surrounding its outer surface to prevent leakage between the two facing surfaces or a water tight seal between the two surfaces. The casing is cut out at 13 along its inner surface at its back end to receive a rib 14 on the back end of the backing mass. The rib prevents forward movement of the backing mass once it is in place. A retainer ring 15 is secured to the back surface of the casing by suitable bolts 16 which retains the backing mass in place. A hemispherical butyl rubber acoustic window 17 is vulcanized and bonded to a groove 18 in the front face of the casing to enclose the parts and to retain a fluid such as castor oil.

An active transducer element 21 such as lead-zirconate-titanate piezoelectric ceramic hemisphere is enclosed by the butyl window and is secured to the front face of the backing mass 12. A ring layer 22 of fiberglass is bonded to the face of the backing mass near its outer edge and an insulating ring 23 of good heat conductive material such as beryllium oxide is secured to the active element by use of an epoxy adhesive. The insulating ring with the active element is bonded to the fiberglass ring where they are held in place. The fiberglass ring eliminates the possibility of adhesive bond failure because of differences in the thermal coefficients of expansion of the backing mass 11 and the insulating ring 23.

The piezoelectric hemisphere is provided with fired-silver electrodes 24, 25 that cover its inner and outer surfaces, respectively. The electrodes are margined back at the major diameter to provide further insulation at the edge of the piezoelectric element. Insulated electrical wires 26 and 27 are connected respectively at one end to the inner and outer electrode surfaces on the active element 21 with their other ends connected to electrical posts 28 of a high pressure-high voltage hermetic seal 31 that are fitted into passages 32 within the backing mass. The wire 27 that connects with the outer electrode surface passes through a small channel 33 milled across the surface of the beryllium oxide insulator. Once the wire has been passed through the channel and connected in place, the channel is closed and hermetically sealed with epoxy adhesive during assembly of the transducer. Other wires 34 and 35 connect with the opposite side of the hermetic seal and pass through the backing mass to a high pressure cable gland 36 secured to the backing mass and thence to suitable electrical circuitry thus completing the electrical connections to the electrodes on the active element.

The area between the cover and the outer surface of the active element and the area between the inner surface of the active element and the backing mass are filled with a suitable degassed fluid such as castor oil 37, having the proper impedance for transmitting the acoustical energy to the active element. Oil fill passages 38 and 39 are provided for filling the areas. Suitable threaded plugs are used to cap the filler passages. In order to provide oil flow or oil communication between the areas on opposite sides of the active element, L-shaped passages 41 and 42 are provided in the backing mass. The end of the passage communicating with the area on the inner side of the active element are sufficiently large to receive therein a 12 psi pop valve 43, 44. The intake valve 43 in passage 41 opens toward the area between the backing mass and the inner surface of the active element whereas the relief valve 44 in passage 42 opens away from the above mentioned area. Thus, the pop valves acting in opposite directions compensate for differences in hydrostatic pressure on opposite sides of the active element. The intake valve 43 compensates when the external hydrostatic pressure is increasing thereby increasing the pressure under the active element. The relief valve 44 compensates when the external pressure is decreasing or less than that confined by the active element. Since the valves are 12 psi pop valves, when the relative pressure is less than 12 psi both valves will be fully closed and no oil will flow and therefore no acoustical path is provided in the passage between the inside and outside of the active hemispherical element. When the relative pressure is

greater than 12 psi, the oil will flow toward the area of least pressure. Thus, the fluid filled volume within the active element is completely pressure compensated to within 12 psi of any hydrostatic pressure permitting accurate operation at great pressures.

It is known that transducer elements having slits therein, through which oil flows, are limited in low frequency performance because the required high acoustic impedance cannot be maintained. Since there is a 12 psi pressure compensation between the inner and outer areas, no oil will flow until the relative pressure changes by 12 psi. Therefore, destructive interference associated with slit pressure compensation are avoided.

Total pressure compensation permits the use of thin-walled piezoelectric hemispheres that have higher response and low driving impedance. The higher response and lower impedance overcome the electrical driving problems of prior art transducers. Total compensation allows the transducer to be used at pressures greater than that found at maximum ocean depth. The upper frequency limit of operation is determined by the lowest frequency mode of the fluid volume within the active element. Active elements may be made approximately 15 cm in diameter with a wall thickness of only 0.6 cm.

It is seen that transducers made in accordance with the teaching of this invention are of simple construction, low mass, and accessible for easy maintenance. Also the device is relatively low weight because of the simple construction. Therefore the device is easy to handle.

Obviously many modifications and variations of the present invention are possible in 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. A piezoelectric transducer; which comprises,
 - a solid cylindrical backing mass,
 - a hemispherical piezoelectric ceramic active element secured at the major diameter thereof to one end face of said backing mass,
 - a ring of insulating material insulating said active element from said backing mass, and
 - a layer of fiberglass bonded between said backing mass and said insulating ring.
2. A piezoelectric transducer as claimed in claim 1; which includes,
 - a casing surrounding said backing mass,
 - means to prevent leakage of water between said casing and said backing mass, and
 - a hemispherical acoustic window surrounding said active element, spaced therefrom and secured to said casing.
3. A piezoelectric transducer as claimed in claim 2; which includes,
 - an acoustical energy transmitting fluid in the area confined by said active element and between said window and said active element,
 - means for admitting said fluid into said areas, and
 - intake and relief valves for compensating for differences in hydrostatic pressure of the fluid confined by said active element and between said active element and said window.
4. A piezoelectric transducer as claimed in claim 3; wherein said intake and relief valves operate at a differential pressure of 12 psi.

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