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TRANSDUCER

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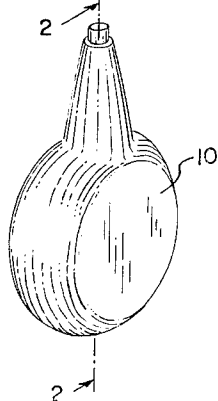


Fig. 1

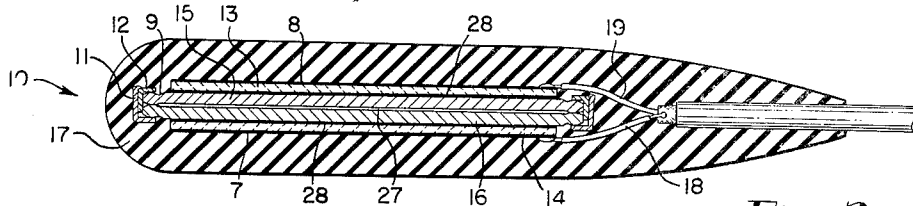


Fig. 2

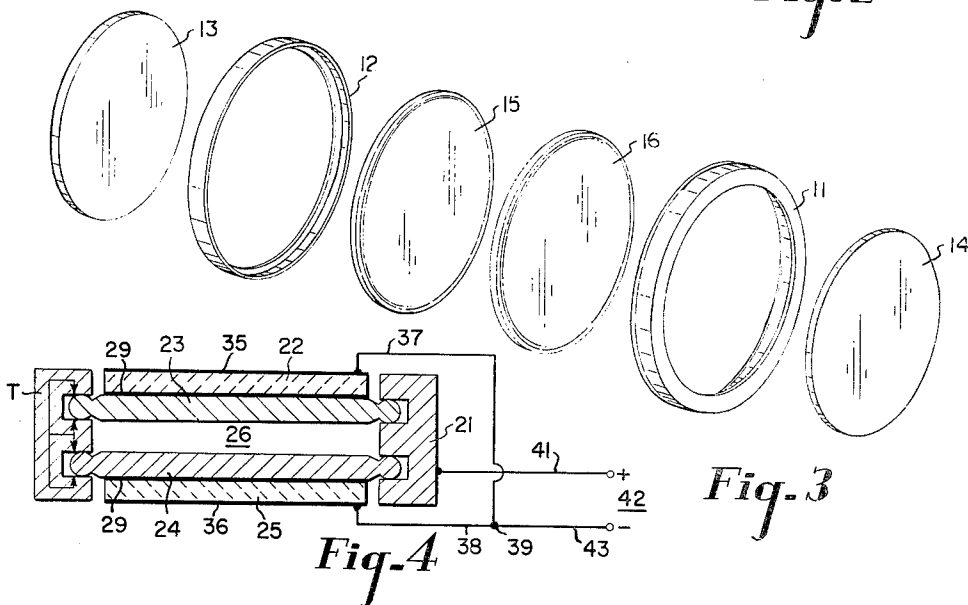


Fig. 3

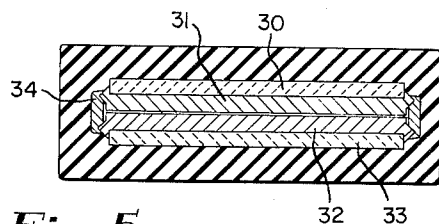


Fig. 5

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This invention relates generally to transducers for converting electrical energy into compressional wave energy and vice versa. It is more particularly directed to a high efficiency, low frequency transducer having linear characteristics throughout its operating range.

It is noted that in the prior art, transducers associated with the lower frequencies of operation, for instance 1000 cycles per second, become unwieldy from the standpoint of physical size and mass due to the inherent characteristics requiring that the transducer be, for instance, of a physical size equal to one-half of the wave length of the frequency to which it is to be resonant. In the case of operation at 1000 cycles per second, a ceramic barium titanate half-wave resonant transducer would have to be about eight feet long. By utilizing the principles of my invention for constructing a transducer, a 1000 cycle per second resonant transducer may be made in the order of two inches in diameter, or smaller. It is further noted that the prior art utilized massive mounting structures for low frequency transducers to isolate the back of a transducer element to prevent the concellation effects occurring at the lower frequencies.

It is therefore an object of my invention to provide a compact, linear, high efficiency transducer for use in low frequency application.

It is a further object of my invention to provide a means and method of mounting an active element of a transducer so as to isolate the active element from the mounting means and to provide a high compliance of the active transducer element to compressional waves and electrical oscillation.

It is a still further object of my invention to provide a low frequency transducer element that may be inexpensively manufactured for use in applications requiring expendable materials.

Other objects and advantages of this invention will become apparent to those skilled in the art on reference to the accompanying specification, claims, and drawing in which:

FIGURE 1 is a perspective drawing of a transducer unit;

FIGURE 2 is a cross sectional view of the transducer shown in FIGURE 1 and shown partially in FIGURE 3;

FIGURE 3 is an exploded perspective drawing of the elements of FIGURE 2;

FIGURE 4 is a cross sectional sketch illustrating the principles of my invention; and

FIGURE 5, a cross sectional view, is a modification of the embodiment shown in FIGURE 2, wherein the method of support has been modified.

FIGURE 1 is illustrative of the form of a transducer constructed according to the principles of my invention and is suitable for immersion in a fluid media, for example, air, water to serve as a hydrophone for detecting compressional waves, or as a loud speaker for emitting compressional waves in response to electrical oscillatory signals.

Like elements in FIGURES 2 and 3 are provided with like reference characters.

FIGURE 2 shows the preferred embodiment of my invention in cross section indicated as 2-2 on FIGURE 1. A pair of carrier plates or members, which may be

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fashioned out of suitable conductive material, 15 and 16 are shown securely held or clamped together by the interaction of the cup like rim members 11 and 12. Rim member 11, it will be noted, has been rolled over rim member 12 to form a secure locking arrangement so as to form a contiguous cagelike member to securely clamp carrier plates 15 and 16 with a substantially uniform pressure, but not so securely that carrier plates 15, 16 cannot slide with respect to rim members 11, 12. It will be noted that the rounded cross sectional areas apparent at the opposite extremities, actually the peripheries, of carrier plates 15 and 16 provide a suitable separation 27 between the central portions of the carrier plates 15 and 16 when clamped in position by the mounting means 11, 12. This separation is of suitable dimension to allow the plates 15 and 16 to move inwardly for a predetermined distance before actual contact is made. The separation is enhanced by making the peripheral portions of carrier plates 15, 16 offset from the central portions as shown in FIGURE 2. The peripheral portions of carrier plates 15, 16 are separated from their central portions by a neck region 9 which has a thickness less than either the peripheral or central portions of carrier plates 15, 16. A neck region is also apparent in carrier plates 23, 24 of the embodiment shown in FIGURE 4. The purpose of this spacing or separation will be discussed below. Adherently mounted to the major surfaces of carrier plates 15 and 16 are active transducer elements of piezoelectric material having dimensions substantially smaller than the wave length of any incident compressional wave energy, shown by reference characters 13 and 14. These, of course, may be mounted on either surface of the carrier plates 15 and 16 and may be held securely in place by a conductive or nonconductive adhesive material 28, for example solder or epoxy resin. Suitable connections may be made to the active transducer elements 13 and 14 by applying leads, shown as leads 18 and 19, to the active transducer elements. The exact method of attaching the leads 18, 19 to the elements 13, 14 might be one of many methods known in the art, e.g., the method shown in a reissue patent to Jaffe Re. 24,191., issued July 31, 1956, wherein a thin layer of silver is applied to the active transducer element and the lead is soldered to the silver layer. This method is indicated by the layer 7, 8 on elements 13, 14 in FIGURE 2, and by layers 35, 36 on active piezoelectric elements 22, 25 respectively in FIGURE 4. It has been observed that active transducer elements 13 and 14 may be constructed of any suitable material having the desirable characteristic of providing a response in the flexural mode in that the piezoelectric properties are the same for all directions parallel to the major surfaces thereof. Suitable materials might be barium titanate, PZT (lead zirconate, lead titanate) or even quartz. It has also been observed that the active transducer element might consist of an electrostrictive material, such as barium titanate, that may be made active by the application of a suitable polarizing potential and that the polarization may be temporary or permanent. The transducer unit 10 is completed by the application of a covering of suitable material 17 to electrically isolate the device from the influence of media in which it might be immersed. In the normal application of this device in a water medium the covering material 17 would necessarily have to be waterproof to provide electrical isolation of the device from the water medium. It has been observed that the casing, or encapsulating material 17, should be of the density and have the characteristics suitable and necessary for the transmission of compressional wave energy therethrough.

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In constructing a transducer in accordance with the principles of my invention, the following materials and dimensions were used:

Ref. character:	Material and dimensions
13 -----	Barium titanate 1.5" diam. .003" thick.
14 -----	Barium titanate 1.5" diam. .003" thick.
15 -----	¼ hard brass 1.710 diam. .045" thick.
16 -----	¼ hard brass 1.710 diam. .045" thick.

FIGURE 3 is an exploded perspective view along an axis normal to the major surfaces of the elements comprising the device constructed according to the principles of my invention and clearly illustrates the inter-relationship of the component parts of the preferred embodiment shown in FIGURE 2.

FIGURE 4 is another embodiment of my invention that more clearly shows the principles of operation utilized in the holding means to provide the operation herein described. In FIGURE 4, which is also shown in cross section, a mounting means 21 is shown holding a pair of carrier plates 23 and 24 substantially parallel and separated by a space indicated by the reference numeral 26. Mounted on the major faces of the carrier plates 23 and 24 are the active piezoelectric elements 22 and 25. The active piezoelectric elements 22 and 25 are bonded to the carrier plates 23 and 24 respectively by means of any suitable electrically conductive adhesive means 29. Electrodes 35 and 36 make contact with elements 22 and 25 respectively on the external major surfaces of elements 22 and 25. A conductor 37 and a conductor 38 are connected to electrodes 35 and 36 respectively and are further connected together at junction 39. A conductor 41 is connected from mounting means 21 to one terminal of an alternating, or pulsating, potential source 42. Alternating potential source 42 further has another terminal which is connected by means of conductor 43 to the junction 39. Thus there are two parallel current paths connected to alternating potential source 42. Assume that the instantaneous output of potential source 42 is such that conductor 41 is positive with respect to conductor 43. A first current path can be traced from the instantaneously positive terminal of alternating potential source 42 through conductor 41, mounting means 21, carrier plate 23, adhesive means 29, element 22, electrode 35, conductor 37, and conductor 43 to the instantaneously negative terminal of alternating potential source 42. The second path can be traced from the instantaneously positive terminal of potential source 42 through conductor 41, mounting means 21, carrier plate 24, adhesive 29, element 25, electrode 36, conductor 38, and conductor 43 to the instantaneously negative terminal of potential source 42. Considering the structure formed by the carrier plate 23 and piezoelectric element 22, it will be seen that when the combination is bent, or flexed, an electric field appears between the two surfaces of the piezoelectric element and conversely when a potential difference is applied between the two surfaces, the structure can be made to bend in accordance therewith. This obtains a flexural mode of operation similar to that shown and described in the United States Patent 1,860,529 to F. C. Cady. The exact manner in which the flexing element comprised of plate 23 and piezoelectric element 22 is allowed to move is dependent upon the mounting means utilized and of course, it is desirable to have a maximum deformation of the flexing element for any given applied pressure and/or electric potential. This might also be termed a high compliance to external forces. The lines of force, T, illustrate the balanced force system obtained due to the stresses set up in the holding means 21 by the movement of both of the carrier plates 23 and 24. This provides a device which will not transmit vibrations of the carrier plates to the holder due to flexing, or vibrations, of the carrier plates, twisting of the carrier plates about the radius defined by the peripheral cross section of the plates, nor due to the radial movement of the periphery of the carrier plates

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caused by the flexing action. It should therefore be apparent that my novel construction and method of mounting provides a maximum of unrestrained movement of the carrier plates, and thereby the piezoelectric elements, in the flexural mode while providing substantially complete isolation of the active transducer elements from external influences, other than the desired signals, applied to the device.

FIGURE 5 illustrates a further embodiment of my invention in which a pair of carrier plates 31 and 32 are securely held in spaced parallel relationship through the use of the holding means 34 which is rolled to provide mechanical holding strength and rigidity. Again, piezoelectric elements, shown by reference numerals 30 and 33 are mounted upon the major surfaces of the carrier plates.

It should be apparent to one skilled in the art that the exact electrical connection made to the various active piezoelectric transducer elements will be dependent upon the means utilized to affix the elements to the major faces of the carrier plates (i.e. whether it is conductive or nonconductive) and that a series or parallel, or any combination thereof, connection may be used to provide greater or lesser output or to provide impedance matching where necessary.

The size and material of the carrier plates and piezoelectric elements is determined by the desired operational characteristics. The shape of the plates and elements, it has been observed, is not limited to the circular shape shown in the drawing. For example, an elliptical or even square shape might be used where the application requires it.

The spacing 27, 26 between the carrier plates, referred to above, is governed primarily by the characteristics and dimensions of the materials utilized for the carrier plates. The purpose of the spacing 27, 26 is to allow for flexural movement and to provide a transducer unit which may be unaffected by the shock effects of high energy compressional wave excitation in that the spacing 27, 26 is dimensioned so that the carrier plates will contact one another before the structural limitations of the carrier plates, or transducer elements, are exceeded. The high efficiency and sensitivity of the device is regained immediately upon passage of such high compressional energy. It has been observed that the spacing 27, 26 between the plates may also be filled with a suitable damping material.

It has been observed that the carrier plates may be of any material, metallic or non-metallic, which has suitable physical characteristics. It is even possible to provide a single plate of piezoelectric material to provide the operation obtained with the composite arrangement shown in the drawing. In this event, the single plate may be formed in a manner similar to the carrier plate referred to above. Where the piezoelectric material does not have suitable machining characteristics or mechanical strength, a plate having a central piezoelectric portion and an annular ring fastened to it, may be utilized. In the case of the single plate, the applied field must be at a right angle to the remanent polarization, and this can be achieved by polarizing from the center of the piezoelectric material, outward toward the edges and applying the electric field across the thickness of the plate.

While for purposes of illustration, several forms of this invention have been disclosed, other forms thereof may become apparent to those skilled in the art upon reference to this disclosure. Therefore, this invention is to be limited only by the scope of the appended claims.

I claim as my invention:

1. A hydrophone, comprising:

a pair of carrier plates;

mounting means;

a pair of piezoelectric elements;

and means for making electrical connection to said piezoelectric elements, said carrier plates having rounded edges adapted to coact with said mounting means to minimize any restriction on the freedom

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of motion of the central portions of said carrier plates in a direction normal to the surface of the central portion, said mounting means adapted to hold said carrier plates in back to back relationship, said piezoelectric elements respectively adherent to said carrier plates, respectively, and means for encapsulating said carrier plates, mounting means, piezoelectric elements and electrical connecting means to electrically isolate them from a surrounding medium.

2. In a hydrophone, electrically isolated from an external medium, and adapted to transfer energy:

a pair of carrier plates each having a periphery delineated from a central portion by a necked portion having a thickness less than that of the central portion;

clamping means applied contiguous to the periphery of said carrier plates to hold said plates in spaced substantially parallel relationship, providing a line contact between the periphery of said plates and said clamping means; and

a pair of piezoelectric elements, each element respectively adherent to a carrier plate respectively.

3. A hydrophone comprising:

a pair of carrier plates;
mounting means;

a pair of piezoelectric elements; and

means for making electrical connections to said piezoelectric elements, said carrier plates having rounded edges and flat surfaced central portions, the edges adapted to coact with said mounting means to minimize any restriction on the freedom of motion of the central portions of said carrier plates in a direction normal to the surface of the central portion, said mounting means adapted to hold said carrier plates in back to back relationship, said piezoelectric elements respectively adherent to said carrier plates, said carrier plates, mounting means, piezoelectric elements and electrical connecting means being electrically isolated from a surrounding medium by encapsulation with a suitable material.

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4. A hydrophone comprising:

a pair of carrier plates;

mounting means;

a pair of piezoelectric elements; and

means for making electrical connections to said piezoelectric elements, said carrier plates having flat surfaced central portions and rounded edges, the edges adapted to coact with said mounting means to minimize any restriction on the freedom of motion of the central portions of said carrier plates in a direction normal to the surface of the central portion, said mounting means adapted to hold said carrier plates in a back to back arrangement with the rounded edges of the said plates abutting each other along a line of contact, said piezoelectric elements respectively adherent to said carrier plates, said carrier plates, mounting means, piezoelectric elements and electrical connecting means being electrically isolated from a surrounding medium by encapsulation with a suitable material.

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