

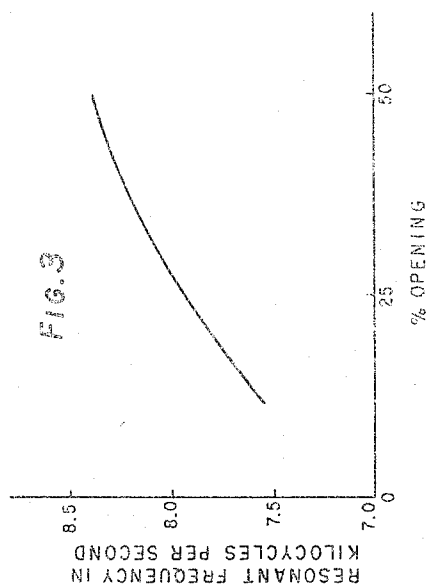
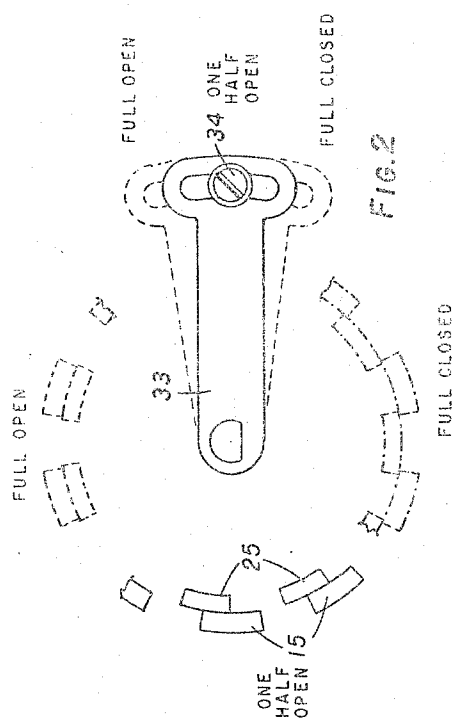
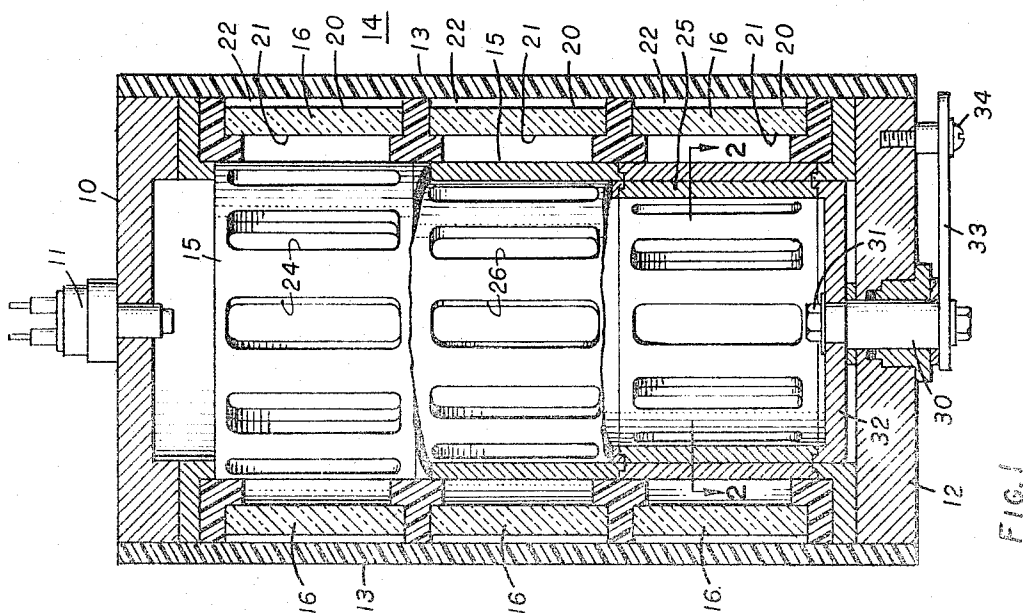
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CERAMIC TRANSDUCER ASSEMBLY

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CERAMIC TRANSDUCER ASSEMBLY

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This invention relates to electromechanical transducers and more particularly to polycrystalline ceramic transducers of the cylindrical or tubular form operating as radial vibrators.

The utility of the polycrystalline ceramic transducers for operation in the sonic and supersonic frequency range now is clearly established. One particularly desirable form for such transducers is a hollow cylinder or ring made up of barium titanate or lead zirconate titanate material carrying metalized electrodes dimensioned and polarized so that upon the application of an alternating signal to the electrodes the transducer cyclically expands and contracts radially, producing compressional waves in the medium in which it is submerged. It has been the common practice to control the radiation pattern to stack a number of cylindrical transducer elements in an axially aligned array. Such assemblies are commonly referred to as line transducers. One long-standing problem of ceramic transducers exists because the polycrystalline ceramic material exhibits the common properties of ceramics of brittleness, tendency to distort in the casting and the firing process, etc. The problem is that the ceramic elements are not readily subject to frequency adjustment after firing without costly dimension adjustment.

This invention is directed toward the elimination of a major problem existing in ceramic transducers. That is, despite the facility of manufacturing small transducer elements and the compensating of facts of variations in the resonant frequency of individual units which is achieved by the use of an array, there is often a danger that the resonant frequency of the assembly varies beyond design limits for the particular application. Heretofore it has been impractical to adjust the frequency of the stacked transducer assembly after manufacture.

Therefore the general object of this invention is to provide a tunable ceramic transducer which is adjusted in resonant frequency by a simple, mechanical, external adjustment. Another object of the present invention is to provide a ceramic transducer design wherein the resonant frequency may be controlled through the control of the physical characteristics of a back loading member. One further object of the invention is to provide such an adjustable frequency transducer without any mechanical adjustment of the transducer stack itself or of any of the mechanical portions of the assembly contacting the critical ceramic elements.

These and other objects of this invention are attained in accordance with this invention, one embodiment of which comprises a cylindrical housing including acoustically-transparent, cylindrical walls and end-sealing structures in which an array of axially aligned ceramic transducer elements are enclosed. Extending through the central openings in each of the transducer elements and spaced therefrom are a pair of concentric rigid tubular members, each having openings therethrough and movable with respect to each other to vary the size of registering openings communicating between the inner faces of the cylindrical transducers and the axis of the entire assembly. The housing is filled with a compressional wave-transmitting medium such as oil. Extending out of the assembly is a mechanical adjusting member for varying the position of the concentric tubular members.

One feature of this invention relates to the presence of a variable impedance back structure within a tubular

radial transducer providing variable back loading to the transducer assembly.

Another feature of this invention is the arrangement of a pair of such back-loading members relatively movable to adjust the degree of back-loading on the transducer element.

Another feature of the invention is the arrangement of a pair of concentric perforated tubular members, one of which is movable with respect to the other to constitute a composite back-loading member of variable area.

Another feature of the invention is the arrangement for externally controlling the orientation of the back-loading assembly to vary the frequency of the transducer.

These and other features of this invention may be more clearly understood from the following detailed description and by reference to the drawing in which:

FIG. 1 is a longitudinal view partly in section of a stacked transducer assembly employing this invention;

FIG. 2 is a composite sectional view along lines 2-2 of FIG. 1 through the back-loading assembly portion of the transducer of FIG. 1; and

FIG. 3 is a graphical representation of the relationship between the resonant frequency of a transducer and the orientation of the back loading member of FIG. 1.

Now referring to FIG. 1, the transducer incorporating this invention includes as the external housing members a top end plate 10 including an electrical connector 11, a bottom end plate 12 and a rubber boot or acoustically transparent window 13, extending between the two end plates together defining a cylindrical assembly 14. Within the assembly 14 is located as a main support member a perforated tubular member 15 extending between the end plates 10 and 12. Encircling the tubular member 15 spaced therefrom and likewise spaced within the acoustic window 13 is an array, in this case three tubular ceramic transducers 16 in a longitudinal array. The individual transducer elements have a mean diameter of approximately twice their height and have bonded metallic electrode layers 20 and 21 on their outer and inner surfaces whereby they constitute radial vibrators when an alternating signal is applied simultaneously across all ceramic elements 16.

As indicated above, the interior of the housing is filled with material such as castor oil having an acoustic impedance matching that of the normal surrounding medium for a transducer, e.g. salt water. The castor oil fills the space 22 between the outer surfaces of the transducer elements 16 and the inner surface of the enclosing window 13. The oil also fills the region between the individual transducer elements 16 and the tubular member 15 and fills the interior of the member 15 having a degree of freedom of flow through a number of elongated openings 24. This tubular member 15 constitutes the backbone of the mechanical assembly and provides a degree of acoustical back-loading of the transducer elements 16 by its interference with the free movement of the filling medium in response to operation of the transducer. The supporting tube 15 may be imperforate in which case the back loading effect of that tube increases the resonant frequency as compared with the same assembly without a tube; e.g. simply held together by tension bolts between the end plates.

The frequency of the assembly may be continuously varied over a limited range employing this invention in which the supporting tube is perforated by openings 24 as shown in the drawing, and it contains a second tube 25 similarly perforated by openings 26 and positioned concentric therewith and preferably in close sliding contact with the inner surface of member 15.

An axial shaft 30, secured as by a bolt 31 to an end plate 32 on the inner tube 25 of the two concentric tubes 15 and 25, extends out of the lower end plate 12 through

appropriate sealing rings and is secured to an arm 33 mounted for limited rotational movement to adjust orientation of the inner tubular member 25 with respect to the outer member 15. Therefore by adjustment of the arm 33 from the exterior of the assembly, the degree of registration of the elongated openings in the two concentric tubular members 15 and 25 may be adjusted continuously over a limited arc and locked in place by a screw 34. In a preferred embodiment the openings approximate in area one-half of the area exposed to transducer elements 16.

FIG. 2 is a composite sectional view of three separate sets of conditions: full open, one-half open and full closed registration of the openings in the members 15 and 25. Shown in FIG. 2 are the operating arm 33 for the frequency adjustment and the segments of the tubes 15 and 25 shown in solid lines in a position corresponding to the one-half open position, in dashed lines in the position corresponding to full open, and in alternate dash-dot lines in the position corresponding to full closed. It can be seen from FIG. 2 that the two tubes are in closed, virtually sliding relationship so that they act as a single unit in their loading to the rear face of the transducer. It may be seen that the continually adjustable orientation of the two tubes results in a continuously varying opening through the back-loading member to the interior of the entire assembly. This results in a continuously varying back load on the transducer and a continuous adjustment of the resonant frequency of the assembly.

As shown in FIG. 3 the resonant frequency of the assembly vs. adjustment of the loading tubes 15 and 25 is reasonably linearly displaced over the range which amounts to approximately 10% of the resonant frequency. In comparing FIGS. 2 and 3, the "FULL OPEN" position of FIG. 2 corresponds to the 50% opening position on the graph (FIG. 3) since the structure shown could never provide a 100% opening. In most applications this degree of adjustability is in great excess to that necessary to tune the transducer assembly to a required frequency. It also allows the manufacture of a number of identical assemblies and, subsequent to manufacture and installation, to adjust each to a selected different frequency. It is thereby possible to provide an array of such transducers, each of which is identifiable from another on a frequency basis.

Although for the purpose of explaining the invention a particular embodiment thereof has been shown and described, other modifications within the spirit and scope of this invention will occur to person skilled in the art. The scope of this invention is only limited by the appended claims.

We claim:

1. A transducer assembly for operation in a liquid medium comprising a plurality of radially vibratile cylindrical radiating elements of polycrystalline material arranged in an axially aligned array,

means for acoustically isolating the interior of said array from its exterior,

an acoustic transmitting liquid placed within said array and adjacent the internal surfaces of said radiating elements, and

an acoustic loading member of generally cylindrical configuration placed within the central cavity of said array for modifying the operating frequency characteristics of said transducer assembly.

2. A transducer assembly for operation in a liquid medium comprising a radially vibratile tubular radiating element of polycrystalline ceramic material,

means for acoustically isolating the interior from the exterior of said radiating element,

an acoustic transmitting liquid placed within and adjacent to the internal surface of said tubular radiating element, and

an acoustic loading member of generally tubular configuration placed within the central cavity of said tubular radiating element for modifying the operating frequency characteristics of said transducer assembly.

3. A variable-frequency transducer assembly comprising a tubular radiating element operating as a radial vibrator,

means acoustically isolating the internal cavity from the exterior radiating surface of said tubular radiating element,

the internal cavity of said radiating element being filled with an acoustic energy transmitting medium,

a member movable within said cavity to vary the acoustic loading of the inner surface of said tubular element, and

means for moving said member to vary the operating frequency characteristics of said transducer assembly.

4. A variable-frequency transducer assembly comprising a tubular transducer element vibrator,

means mounting said radiating element for operation as a radial vibrator including means for acoustically isolating the internal and external cylindrical surfaces,

a fluid acoustical energy-transmitting medium within the internal cavity defined by said tubular radiating element and said mounting means,

a tubular rigid member positioned within the internal cavity including perforations therethrough, and

means cooperating with said rigid member to variably restrict the passage of said fluid medium through the perforations in said tubular rigid member between the inner surface of said transducer and the interior of said tubular member.

5. The combination in accordance with claim 4 wherein said cooperating means comprises a second perforated tubular member, said second tubular member movable with respect to said first mentioned tubular member to change the degree of registration of perforations in said tubular members to vary the internal loading on said transducer element and thereby vary the frequency characteristics of the transducer assembly.

6. The combination in accordance with claim 5 wherein said perforated tubular members are positioned in coaxial nested relationship and one of said members is rotatable with respect to the other.

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