

Feb. 20, 1968

J. N. ANTONEVICH
ULTRASONIC TRANSDUCERS

3,370,186

Filed Feb. 5, 1965

Fig. 1.

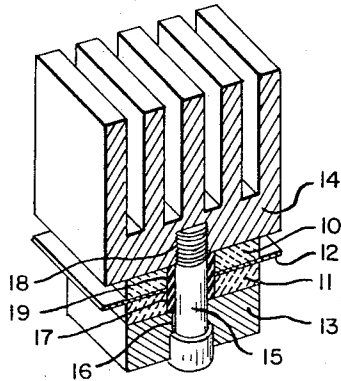


Fig. 2.

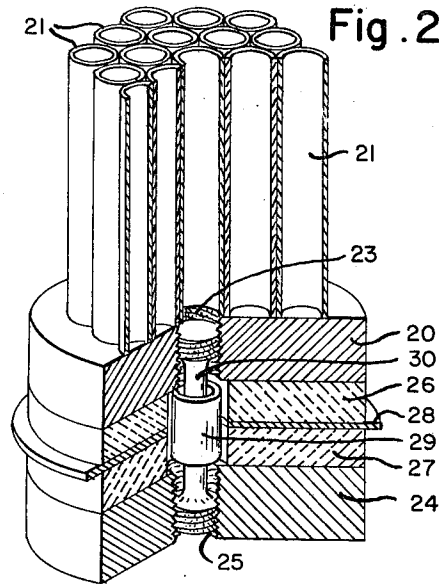


Fig. 3.

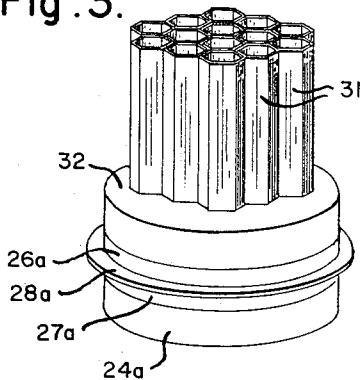


Fig. 5.

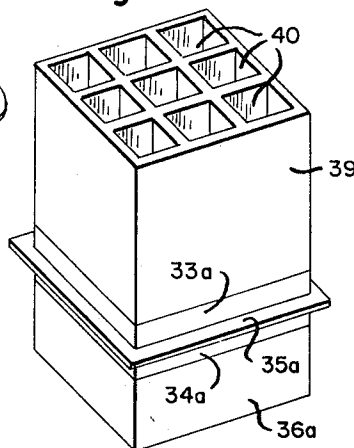


Fig. 4.

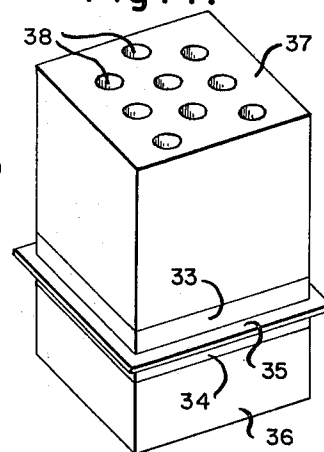


Fig. 6.

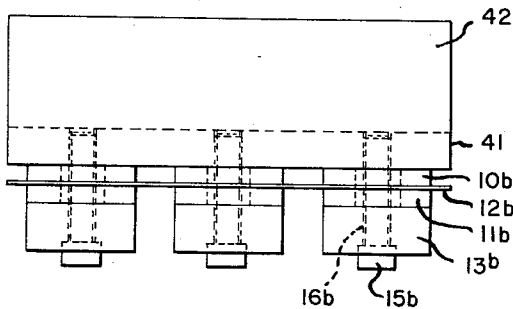
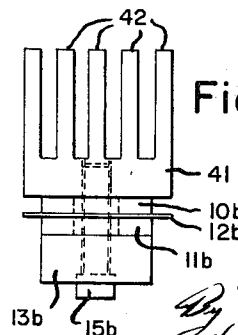


Fig. 7.



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3,370,186

ULTRASONIC TRANSDUCERS

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4 Claims. (Cl. 310-8.2)

ABSTRACT OF THE DISCLOSURE

An electromechanical transducer system made up of an electrostrictive means sandwiched between a perforate and an imperforate mass and being mechanically resonant in the length of direction of the system and equalling at least one half wave length unit.

This invention relates to ultrasonic transducers and particularly to a novel form of transducer for transforming electrical energy into ultrasonic energy. The use of transducers for transforming electrical energy into ultrasonic energy is not in itself new. Many varied forms of electromechanical transducers have been proposed in the past in an effort to device some means of effectively transferring the mechanical vibrational energy from the transducer to an adjacent system such as, for example, a cleaning bath.

Typical of the devices which have been proposed in the prior art are those illustrated in Heising Patent No. 2,044,000, Rich Patent No. 3,101,419, Probus Patent No. 2,895,061, Church Patent No. 2,998,535, Rich Patent No. 2,947,889 and Branson Patent No. 3,066,232. In all of the prior art transducers, the designs are such that impedance match or velocity transformation is accomplished by the use to two different homogenous transducer media on opposite sides of the nodal displacement plane or active element(s) of a composite transducer. The transducer media are different in the cross section and in density. In such transducers, the mass on opposite sides of the nodal plane or active element(s) is controlled by using metals of differing density. For example, in Rich Patent No. 2,947,889, a high density material such as steel is used on one side of the nodal plane and a low density material such as aluminum is used on the other side of the nodal plane. The reason for using different masses is to reduce the Q of the transducer and achieve better acoustical impedance match between transducers and loads where load impedances differ greatly from transducer material impedance. An ideal transducer design would have an output impedance equal to the input impedance of the load for maximum energy transfer and a low Q for a broad frequency band of resonant operation.

A review of the patents which have been mentioned above will show that in all cases the inventors go to a light metal, such as aluminum, in order to obtain the reduction in Q and improved impedance matching for the maximum output of energy into usual low impedance loads such as cleaning baths. This technique has very serious disadvantages. Perhaps the greatest of these disadvantages is that the transducer cannot be bonded to the usual form of relatively low impedance load by a metallurgical bond but must be attached by means of an adhesive. Since the containers for ultrasonic cleaning baths are usually made of steel, it is evident that it would be desirable to have a steel transducer element which could be welded or otherwise metallurgically bonded directly to the body of the bath. This cannot be done feasibly in the prior art forms of transducers using different metals on opposite sides of the displacement nodal plane. Another very significant problem with these prior art transducers was the fact that they required many expen-

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sive materials in the transducer. Finally, in prior art transducers, the problem of overheating was a continual source of difficulty, particularly where adhesive bonds are required.

I have invented a transducer for transforming electrical energy into ultrasonic energy which eliminates the foregoing problems which characterized transducers made of dissimilar metals and yet provides the low Q and the high energy radiation which previously could only be obtained by using metals of different density in a composite transducer.

In a preferred practice of my invention, I provide an electromechanical transducer means sandwiched between two pieces of metallic material of like density, one in the imperforate state and the other in a highly perforate state, means holding and prestressing the electromechanical means between said metal members, said transducer means and said metal members being designed so as to vibrate as a vibrator of desired multiple of half wave lengths in the direction of a line through said pieces. Preferably the metal members are of a metal which may be metallurgically bonded to the load to which the transducer is to be applied. The perforate metal member may take the form of a labyrinth structure or any of a variety of cross-sectional forms and degree of perforation to provide predictable acoustical impedance. For example, the member may be built up of tubular members metallurgically bonded to a base or the member may take the form of a honeycomb structure set into a proper base. Alternatively, the member may simply be a metallic piece into which a multiplicity of holes have been drilled. It is of course feasible to use materials of different density although I do not prefer to do this.

In the foregoing general description, I have attempted to point out certain objects, advantages and purposes of this invention. Other objects, advantages and purposes of the invention will be apparent from a consideration of the following description and the accompanying drawings in which:

FIGURE 1 shows an isometric view partly in section of one form of a transducer according to my invention;

FIGURE 2 shows an isometric view partly in section of a second embodiment of my invention;

FIGURE 3 shows an isometric view of a third embodiment of my invention;

FIGURE 4 shows an isometric view of a fourth embodiment of my invention;

FIGURE 5 shows an isometric view of a fifth embodiment of my invention;

FIGURE 6 shows a side elevation of a sixth embodiment of my invention using a multiplicity of transducer elements in a modified form of FIGURE 1; and

FIGURE 7 is an end view of the embodiment of FIGURE 6.

Referring to the drawings, I have illustrated in FIGURE 1 an active element 10, which may be of quartz, barium titanate or any other electrostrictive material. The plate 11 is a second active element or an electrically insulating member. An electrically conducting plate 12 is placed between elements 10 and 11 and the composite is then sandwiched between a steel mass 13 and a perforate mass 14. The sandwich assembly is held together and prestressed by a bolt 15 which passes through a hole 16 in the steel mass 13, element 11, a hole 17 in the electrode 12, element 10 and is threaded into an opening 18 in the perforate mass 14. An electrically insulating tube 19 is inserted between bolt 15 and the electrically excited elements. Mass 14 and 13 is electrically grounded and an alternating voltage of desired frequency is applied between the mass and electrode 12 to electrically stress element 10 and/or 11 causing the composite assembly to

vibrate at the frequency of electrical excitation or at a mechanical resonant frequency.

In FIGURE 2, I show another form of transducer according to my invention. The perforate mass in this form consists of a steel plate 20 having metallurgically attached an array of tubes 21 which has a tapped hole 23 axially thereof. The imperforate mass 24 is cylindrical having a tapped hole 25 located along its axis. Sandwiched between mass plates 20 and 24 is the electrostrictive element 26, and the element 27 which is an electrical insulator or an electrostrictive element, electrode 28 and insulating tube 29. A stud 30 is threaded into tapped holes 23 and 25. The assembly is held together and prestressed by turning cylindrical mass 24 on stud 30. The unit is electrically excited as described for FIGURE 1.

In FIGURE 3, I have illustrated a transducer whose form is identical to either FIGURE 1 or FIGURE 2 with the exception that the perforate mass consists of elongated hexagonal members 31 which are metallurgically attached by welding or brazing to a plate 32 to form the perforate structure in the typical form of a honeycomb. The remaining parts which correspond to like parts in FIGURE 2 carry numbers identical to the same parts in FIGURE 2 with the suffix *a* added.

In FIGURE 4, I have illustrated a transducer whose make-up is similar to either FIGURE 1 or FIGURE 2. In this embodiment electrostrictive elements 33 and 34 with electrode 35 therebetween are sandwiched between an imperforate plate 36 and a perforate plate 37 formed by drilling a plurality of holes 38 to obtain desired acoustic impedance by area and mass reduction.

In FIGURE 5, I have illustrated a transducer which is substantially identical with FIGURE 4, except that the perforate plate 39 is cast with openings 40 therein. The remaining elements which are identical with like elements of FIGURE 4 bear like numbers with the suffix *a*.

In FIGURES 6 and 7 I have illustrated a transducer having a plurality of the basic transducer forms depicted in FIGURE 1 unitized in a single transducer. In this form a common perforate mass consisting of a continuous member 41 having upstanding ribs 12 is provided and acts to sandwich a plurality of electrostrictive elements between itself and imperforate masses. The electrostrictive elements and imperforate masses are identical to those used in FIGURE 1 and bear like numbers with the suffix *b* added. This provides a unique construction for producing large quantities of ultrasonic energy and means of impedance matching the transducer to a load having large areas but low impedance such as a cleaning tank in which case the upstanding ribs would be joined, preferably by a metallurgical bond such as welding or brazing, to the cleaning tank.

It will be seen from the foregoing structures that the device of this invention provides unique advantages in the control of velocity output of the transducer, in control of acoustic impedance of the transducer, and control of transducer Q with a minimum amount of high cost transducer materials.

The present invention eliminates the need for using dissimilar or differing density materials, thus reducing the materials costs. Where material costs are negligible wider ranges in the stated advantages could be realized by resorting to the combined influence of material density and volume reduction. The invention provides a transducer which can be welded or brazed or otherwise metallurgically bonded to the load which is to be treated. This could not be done with the prior art transducers using two dissimilar metals of different densities. This eliminates, when required, the undesirable adhesive-type bond between transducer and load and provides equipment having much greater reliability. In addition large area coverage, as is the case in cleaning systems, can be excited with minimal amounts of expensive electrostrictive elements to achieve uniform energy distribution over the area.

Finally, but not by any means of least significance,

is the fact that the transducers of the present invention permit efficient air cooling as, for example, the transducer of FIGURES 1 and 6 (or of FIGURES 1 and 2 when elements 21 and 31 are loosely packed) permit the flow of gas or liquid coolant through the labyrinth formed by the elements 14 and 38, as the case may be.

In the foregoing specification, I have set out certain preferred embodiments of my invention. It will be understood, however, that this invention may be otherwise applied within the scope of the following claims.

I claim:

1. An ultrasonic transducer comprising in combination, an electrostrictive means, an imperforate back plate of solid material on one side of said electrostrictive means, a front plate of like material with the back plate, said front plate having a base in contact with the electrostrictive means and a plurality of tubular members extending therefrom in side by side relation and lying on the opposite side of said electrostrictive means from the back plate, a conductive means attached to the electrostrictive means, a second conductor means attached to the solid material, means for applying an electrical current to said conductor means and means for applying compressive force to said plates and electrostrictive means to urge them together.

2. An ultrasonic transducer comprising in combination, an electrostrictive means, an imperforate back plate of solid material on one side of said electrostrictive means, a perforate front plate of like material, said front plate having a honeycomb-like structure, and lying on the opposite side of said electrostrictive means, a conductive means attached to the electrostrictive means, a second conductor means attached to the solid material, means for applying an electrical current to said conductor means and means for applying compressive force to said plates and electrostrictive means to urge them together.

3. An ultrasonic transducer comprising in combination a plurality of side by side electrostrictive means, an imperforate back plate of solid material on one side of said electrostrictive means, a common perforate front plate having a plurality of perforations located on the opposite side of said electrostrictive means, a conductive means attached to the electromechanical transducer, a second conductor means attached to the solid material, means for applying an electrical current to said conductor means and means for applying a compressive force to said plates and electrostrictive means to urge them together under pressure.

4. In combination a load to be acted upon by ultrasonic vibrations, a perforate mass metallurgically attached to said load at one side and electrostrictive means sandwiched between the opposite side of said perforate mass and an imperforate mass, said electrostrictive means and perforate and imperforate mass being mechanically resonant in a direction transverse to the load.

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J. D. MILLER, *Assistant Examiner.*

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,370,186

February 20, 1968

John N. Antonevich

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 24, for "device" read -- devise --;
line 35, for "to" read -- of --; column 2, line 68, for "and",
first occurrence, read -- or --; column 3, line 15, for
"descrcibed" read -- described --; line 41, for "12" read -- 42 --
line 68, for "undersirable" read -- undesirable --; column 4,
line 60, for "2,930,914" read -- 2,930,913 --.

Signed and sealed this 24th day of June 1969.

(SEAL)

Attest:

Edward M. Fletcher, Jr.

Attesting Officer

WILLIAM E. SCHUYLER, JR.

Commissioner of Patents