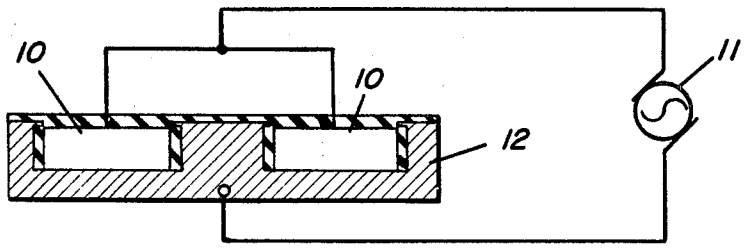
Aug. 6, 1968 J. W. ANDERSON ET AL 3,396,286

TRANSDUCER ASSEMBLY FOR PRODUCING ULTRASONIC VIBRATIONS

Filed Jan. 21, 1965

FIG 1



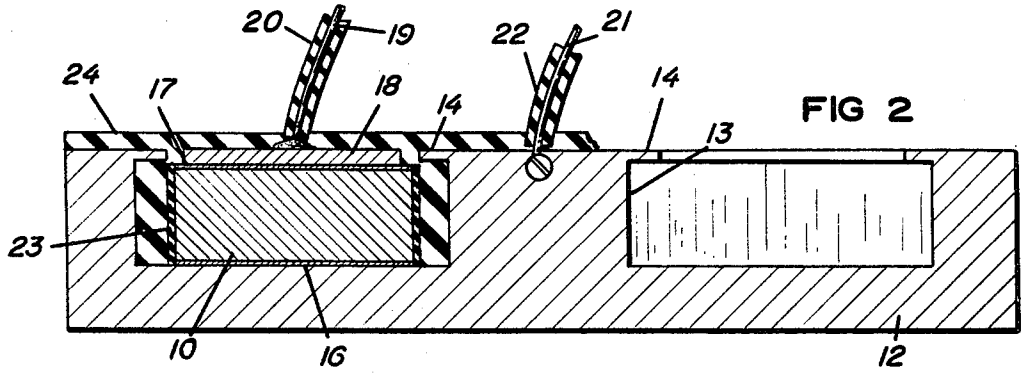


FIG 2

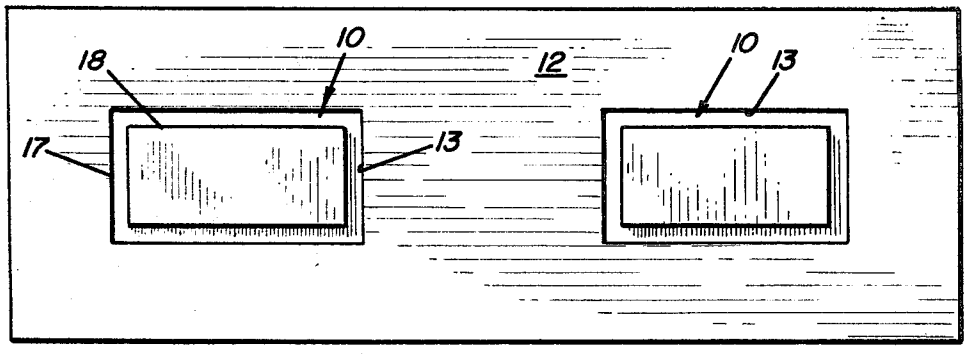


FIG 3

James W. Anderson
Steve Heny
Bobby L. Joyner
INVENTORS

BY Wenderoth, Lind & Ponack

ATTORNEYS

United States Patent Office 3,396,286 Patented Aug. 6, 1968

3,396,286

TRANSDUCER ASSEMBLY FOR PRODUCING ULTRASONIC VIBRATIONS

James W. Anderson, State College, Steve Heny, Hublersburg, and Bobby L. Joyner, State College, Pa., assignors of one-half to Linden Laboratories Inc., State College, Pa., and one-half to Edward G. Cook, Yardley, Pa.

Filed Jan. 21, 1965, Ser. No. 426,985
4 Claims. (Cl. 310—9.1)

ABSTRACT OF THE DISCLOSURE

A transducer assembly for producing ultrasonic vibrations, comprising a metal housing having at least one well therein, a polycrystalline piezoelectric element in said well having one face against the bottom of the well and in electrically conductive relationship with said housing, a first electric conductor electrically coupled to said housing, a second electrical conductor electrically coupled to a face of said element opposite said one face, a coating of insulation material on said element, and a high shear strength potting compound around said element in said well and filling said well and covering said well where it opens out of said housing.

This invention relates to a transducer assembly containing a piezoelectric element for producing ultrasonic vibrations.

There are known in the art transducer assemblies for producing ultrasonic vibrations. These assemblies have one or more piezoelectric members mounted on a base and across which an alternating electric voltage is impressed for vibrating the piezoelectric members together with the base at an ultrasonic frequency. It has heretofore been the practice to mount the piezoelectric members directly on the outside surface of the metal base by bonding them to the base by an adhesive. Such transducer assemblies are now available on the market, and have been found to be particularly useful as means for producing ultrasonic vibrations in a tank of liquid for cleaning articles immersed in the liquid.

These transducer assemblies have serious limitations, however, when they are placed in ordinary everyday commercial use. Because the piezoelectric elements are of ceramic materials, they are not robust, and if the assembly is dropped while being handled during installation or repair, or is accidentally struck by a foreign object, there is a ready tendency for it to break, thereby rendering the assembly substantially useless. Also, if a cleaning apparatus having such an assembly therein is accidentally run without liquid in it, the heat produced by the ultrasonic vibrations of the elements quickly destroys them. More important, however, even if the assembly can, by careful handling and caution when engaging in activities in the vicinity of the assembly, be protected against physical blows from outside the assembly, it cannot easily be kept insulated from temperature changes in the atmosphere in which it is located, and by its very nature it is subject to ultrasonic vibrations during its normal use. The effect of temperature changes and repeated periods of ultrasonic vibrations is to weaken seriously the ceramic elements and greatly shorten their life, The tendency of these elements is to crack and then rupture, thereby ending their usefulness in producing ultrasonic vibrations.

Numerous efforts have been made to overcome these limitations, by taking more care in making the ceramic elements, by more precisely dimensioning them, and by bonding them more strongly to the metal base. While some improvement has been made, the assemblies are still inherently subject to self destruction, and as a result

they have not come into very wide use, particularly in connection with the home appliance field.

It is an object of the present invention to provide a transducer assembly which overcomes the limitations of the prior art assemblies, and which is robust in its construction, yet which is fully as effective in producing ultrasonic vibrations as the prior art assemblies.

It is a further object of the present invention to provide a transducer assembly which is as easy, if not easier, to produce than the prior art assemblies, and which can be produced for little or no more than prior art assemblies.

The transducer assembly of the present invention has the ceramic piezoelectric element or elements positioned in wells in a metallic base or housing and held in place by a metal cover plate and a high shear strength potting compound surrounding the element and covering the cover plate. It has been found that with this construction, the assemblies can be subjected to treatment many times as rough as they will encounter in any normal service, and yet will continue to operate with practically undiminished output.

The invention will now be described in connection with the accompanying drawings, in which:

FIG. 1 is a schematic representation of the transducer assembly according to the present invention in a conventional circuit for subjecting it to alternating frequency voltages;

FIG. 2 is a cross-sectional elevation view of one embodiment of the transducer assembly according to the present invention; and

FIG. 3 is a top plan view of the transducer assembly of FIG. 2 with the covering of potting compound removed.

As seen in FIG. 1, the transducer assembly has two polycrystalline piezoelectric elements **10** therein which are connected in parallel with a source of alternating voltage **11**, the circuit being completed through the metal housing **12**. Activation of the source of voltage **11** excites the piezoelectric elements **10**, causing them to vibrate at an ultrasonic frequency and thus causing the metallic housing **12** to vibrate at the same frequency. The actual frequency at which vibrations will take place depends primarily on frequency of the alternating voltage and to some extent on the specific type of ceramic elements, the type of metal of which the housing is made, and the dimensions of the assembly. For example, when an alternating voltage alternating at 40 kc. is used, the assembly will vibrate at a frequency close to a frequency of 40 kc.

It should be noted that although two piezoelectric elements are shown as being coupled in parallel, it is not necessary that there be two such elements. A single element can be used, and likewise three or more elements coupled in parallel can be used. Changing the number of elements acts primarily to increase the power output of the assembly.

Referring to FIGS. 2 and 3, in which the specific structure of the assembly is shown in greater detail, the housing **12** has one or more wells **13** therein, which wells in the preferred embodiment of the assembly have an inwardly projecting lip **14** extending around the upper edge of the well. Positioned within well **13** is a ceramic polycrystalline piezoelectric element **10**. The wells **13** and elements **10** are shown as being rectangular, but any other convenient shape can be used. Each element **10** has an electrode **16** on the bottom thereof and an electrode **17** on the top thereof, these electrodes acting as contacts for passing the alternating voltage through the ceramic element **10**. The thickness of these electrodes has been exaggerated in the drawing for illustrative purposes. The electrode **16** on the bottom of the element **10** is in electrical contact with the metal of the housing **12**. In the preferred form of the assembly, the dimensions of the ceramic

element **10** are such that it will just fit through the opening defined by the inner edge of the lip **14**.

On top of the electrode **17** is a contact plate **18**, such as a brass plate, and secured to the plate **18** by brazing, soldering or the like is an electrical conductor **19** covered by insulation **20**. Secured to the metal housing **12** is also a ground wire **21** covered by insulation **22**.

Around the peripheral surface of each ceramic element **10** is a coating **23** of insulating material for electrically insulating the ceramic element to insure that the voltage is impressed directly across the element. Surrounding each insulated ceramic element **10** and filling the remainder of the space in the well **13** and forming a layer over the top of the contact plate **18** and over the well **13** is a potting compound **24** of a high shear strength material. In the preferred embodiment, the layer covers the entire top of the housing **12** and covers the ends of the insulation **20** and **22** on the wires **19** and **21**, thereby sealing the entire unit. The lip **14** insures that the block of material **24** will be held in the well.

The specific materials of which the assembly is made are not critical. The housing **12** is preferably metal, and can be of aluminum, brass or stainless steel, for example. The polycrystalline piezoelectric ceramic elements **10** can be lead-zirconate-titanate ceramic, as disclosed in U.S. Patent 2,708,244, or can be barium titanate ceramic as disclosed in U.S. Patent 2,486,560, for example. Various insulating materials can be used for the insulating coating **23**, the material sold by E. I. DuPont de Nemours and Co., under the trademark Teflon, a plastic consisting of tetrafluoroethylene polymer, being preferred. For the electrodes, thin coatings of silver are preferred. It has been found that a particularly satisfactory potting compound is a high shear strength epoxy resin compound known as Shell Epon 28, an epoxy resin sold by Shell Oil Co.

The assembly as described above has been found to be especially rugged in service. As a test of its ability to withstand impacts, it has been thrown against a brick wall, and thereafter its operating characteristics have been found to be substantially unimpaired. It has been used in a cleaning apparatus in which it is mounted on the outside of a tank, and the apparatus has been run without any cleaning liquid in the tank without damaging the assembly. The assembly has also been operated for long periods of time and under conditions of changing ambient temperature without showing signs of failure.

While the transducer assembly of the present invention has been described in a form in which it is particularly adapted to be mounted on the outside of a tank of a cleaning apparatus, it will be appreciated that it can also be used as a transducer element to be placed directly into the liquid in a cleaning apparatus, and can also be used where a high power output air and underwater sonic sound projector is needed. In fact, any application that requires high power driving transducer can utilize this transducer assembly.

It is thought that the invention and its advantages will be understood from the foregoing description and it is apparent that various changes may be made in the form, construction and arrangement of the parts without departing from the spirit and scope of the invention or sacrificing its material advantages, the form hereinbefore described and illustrated in the drawings being merely a preferred embodiment thereof.

What is claimed is:

1. A transducer assembly for producing ultrasonic vibrations, comprising a housing having at least one well therein, a lip extending into the opening of said well from the housing around the periphery of the well, a single piece polycrystalline piezoelectric element in said well, said element having a first electrode on one face thereof in electrical contact with the bottom of the well and having an opposite face with a second electrode thereon, a contact plate over the second electrode and in electrical contact therewith, a first electrical conductor in electrical contact with said contact plate, a high shear strength vibration transmitting potting compound around said element in said well and filling said well and covering said contact plate, and a further conductor electrically coupled to said first electrode.

2. A transducer assembly as claimed in claim **1** in which said high shear strength potting compound is an epoxy resin.

3. A transducer assembly as claimed in claim **1** in which said housing is metal, and in which said further conductor is electrically connected to said housing, and said assembly further comprising a coating of insulation around the surface of said element on which there are no electrodes.

4. A transducer assembly for producing ultrasonic vibrations, comprising a housing having a plurality of wells therein, a single piece polycrystalline piezoelectric element in each well, a plurality of first electrical conductors each coupled to one of said elements and in turn connected in parallel, a plurality of second electrical conductors each electrically coupled to one of said elements to a face opposite the face to which the said one electrical conductor is coupled to the respective element, and a high shear strength vibration transmitting potting compound around each element in each well and filling each well and covering the well where it opens out of the housing.

References Cited

UNITED STATES PATENTS

2,914,686	11/1959	Clements	310—9.1
2,972,068	2/1961	Howry	310—9.1
3,209,176	8/1965	Paley	310—9.1
2,565,159	8/1951	Williams	340—10
2,748,369	5/1956	Smyth	340—10
2,891,176	6/1959	Branson	310—8.1

J. D. MILLER, *Primary Examiner.*