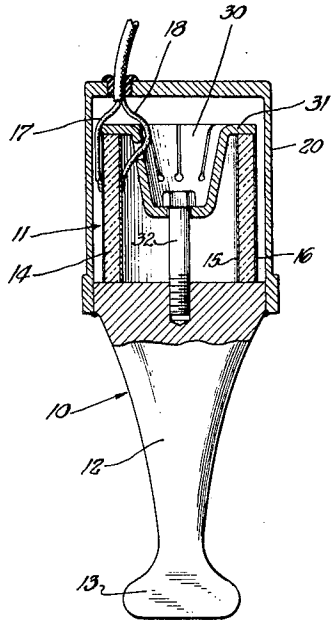
Oct. 5, 1965 A. G. BODINE, JR 3,210,580

ELECTRO-ACOUSTIC TRANSDUCER

Original Filed Feb. 4, 1957



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ELECTRO-ACOUSTIC TRANSDUCER

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Original application Feb. 4, 1957, Ser. No. 637,941, now Patent No. 3,022,814. Divided and this application July 11, 1961, Ser. No. 123,207
6 Claims. (Cl. 310—8.3)

This application is a continuation-in-part of my parent application Serial No. 517,880, filed June 24, 1955, entitled Torsional Vibration Sonic Drill, now Patent No. 2,921,372, and is a division of my co-pending application Serial No. 637,941, filed February 4, 1957, entitled Method and Apparatus for Sonic Bonding, and now Patent No. 3,022,814.

This invention relates generally to electro-acoustic transducers of the type employing a body which changes its dimensions in response to electric or magnetic fields. The best known example is probably the electrostriction transducer, using commonly a ceramic cylinder composed typically of barium titanate as the responsive element. This element, when subjected to a periodically varying electric field, vibrates in step with the field. Barium titanate is a ceramic, having a crystalline structure, and, unfortunately, is frangible to the extent that it is prone to rupture when driven at good amplitude. There are other known ceramic, crystalline materials that have the property of electrostriction, such as lead zirconate titanate, and this material is also frangible. A basic common characteristic of these electrostriction materials is frangibility.

Some recently discovered materials have been formed, by sintering, into frangible bodies which demonstrate the property of magnetostriction, and such bodies have been used in electro-acoustic transducers. These bodies also are frangible, and prone to rupture.

A general object of the invention is the provision, in an electro-acoustic transducer of the type incorporating a frangible body which vibrates responsively to an energizing voltage or current, of means guarding against rupture of said body when undergoing the stresses incident to large amplitude vibration.

This object is accomplished, in accordance with the present invention, by placing the frangible body under an initial compressive stress in the direction of vibration. So mounted, the frangible body does not undergo periodic negative stress, and the tendency for disruption of the body is effectively countered.

Reference is now directed to the drawing, the single figure of which shows, partly in logitudinal section and partly in elevation, a present preferred embodiment of the invention.

At **10** is designated generally a typical sonic tool designed for welding two thermosetting plastic sheets to one another. This tool was first disclosed in my co-pending application Serial No. 637,941, filed February 4, 1957, entitled Method and Apparatus for Sonic Bonding.

The tool **10** comprises essentially a vibratory driver **11**, and a longitudinally vibratory "horn" **12** formed at the extremity with a suitably shaped foot **13** for application to the work. The form of the horn and the shape of the foot have no bearing on the present invention, and may be substituted for by any desired driven device.

The vibrating driver **11** comprises a cylinder **14** composed, typically, of barium titanate, which substance is a ceramic, of crystalline structure, and frangible to the extent of proneness to shattering when driven at substantial amplitude. Prevention of such shattering is the primary accomplishment of the invention.

The cylinder **14** is provided on its inside and outside surfaces with electrodes in the form of silvered coatings such as indicated at **15** and **16**, respectively. Leads **17** and **18** are connected to these coated surfaces and led out through cylinder casing **20**, fitted to horn **12**, as clearly shown in the drawings.

The leads **17** and **18** are externally connected to a suitable source of electrical energy or power, such as an oscillator, not shown, of a frequency corresponding to the resonant frequency of the cylinder **14**.

As is well known, a barium titanate cylinder, energized on its opposite surfaces with a high frequency alternating current, alternately elongates and contracts, at the frequency of the driving current. The cylinder **14** of course has a natural resonant frequency, and accordingly is preferably dimensioned to operate at resonance at the designed operating frequency, and the driving oscillator will be understood to be adjusted to supply power at this frequency.

Cylinder **14** seats on the upper end of vibratory horn **12**, and is clamped thereto by spring saddle **30** and screw **31**. The saddle **30**, as here shown, comprises a slotted, cup-shaped part with a flange portion **31** bearing on the upper end of cylinder **14**, and is normally stressed by means of screw **32**, so as to be capable of resilient elongation and contraction to accommodate the alternate elongation and contraction of cylinder **21**.

The cylinder **14** is thus placed under longitudinal or endwise compression. At the same time, preferably, the mounting or compressing means includes a resilient element affording capability of alternate resilient elongation and contraction. The cylinder may be said to have a yielding longitudinally oriented compressional bias, and when it alternately contracts and elongates, the degree of its compression is thereby varied. Preferably, the degree of compression is made sufficient that, even with large vibration amplitude, the cylinder, in elongating, does not go into a tension state. Under these conditions, the usual proneness of the cylinder to rupture is eliminated.

From the foregoing disclosure, the invention will be fully understood, and it will further be understood that the invention can be embodied in numerous diverse forms without departing from the scope of the appended claims.

I claim:

1. In an electro-acoustic transducer, adapted to convert variable electrical input energy to vibratory output energy, a frangible body whose dimensions are variable with electrical input energy, means to apply said electrical input energy, and means clamping said body between its two extremities in compression in one of said variable dimensions.

2. In an electrostriction transducer, a frangible cylinder having electrostriction properties, electrodes on the inside and outside faces of said cylinder, and means clamping said cylinder at its ends and holding it normally under longitudinal compression.

3. In an electro-acoustic transducer, a frangible cylinder whose length dimension is variable with variations in input energy, and means clamping said cylinder at its ends and holding it normally under longitudinal compression.

4. In an electro-acoustic transducer, adapted to convert variable electrical input energy to vibratory output energy, a frangible body whose dimension in one direction is variable with electrical input energy, and mounting means for said body arranged and adjustable to exert a compressive stress on said body in the direction of said variable dimension.

5. In an electro-acoustic transducer, adapted to convert variable electrical input energy to vibratory output energy, a frangible body whose dimensions are variable

with electrical input energy, means to apply said electrical energy, and means clamping said body in compression between two extremities with said body in the direction of one of said variable dimensions, said means including a resilient element having a range of elastic deformation in the direction of said variable dimension.

6. In an electro-acoustic transducer, a frangible cylinder whose length dimension is variable with variations in input energy, and resilient means clamping said cylinder at its ends and holding it normally under yielding longitudinal compression.

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ORIS L. RADER, *Examiner.*

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,210,580 October 5, 1965

Albert G. Bodine, Jr.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 3, for "with" read -- of --.

Signed and sealed this 28th day of June 1966.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents