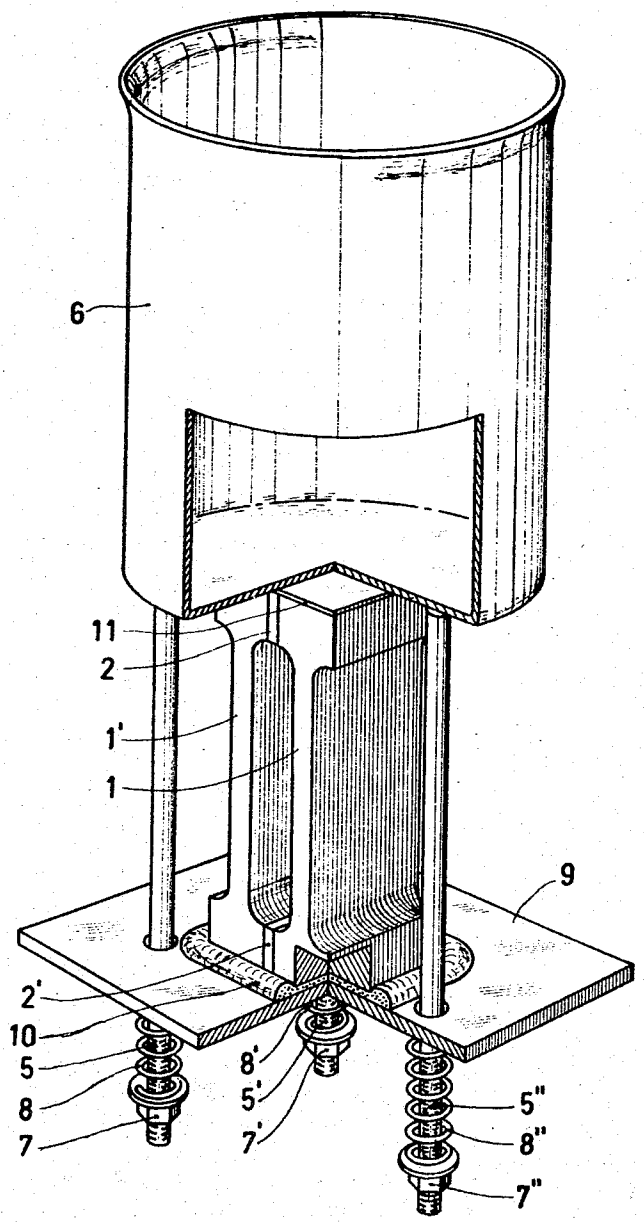
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DEVICE FOR PRODUCING AND USING ULTRASONIC VIBRATIONS

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# DEVICE FOR PRODUCING AND USING ULTRASONIC VIBRATIONS

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## ABSTRACT OF THE DISCLOSURE

An ultrasonic cleaning device includes a container holding a liquid to be ultrasonically treated, an electromechanical transducer vibrated at an ultrasonic frequency, and means for transmitting the vibrations from the transducer to one wall of the container comprising a thin layer of bouncing putty interposed between and in compressive contact with one end of the transducer and said one wall of the container.

The invention relates to a device for producing and using ultrasonic energy comprising one or more transducers which are connected to a receiver, for example, a container or the like, in which the mechanical energy is dissipated. An essential part of ultrasonic cleaning apparatus is the so-called transducer which has for its function to transform the electrical power supplied into mechanical vibrations. The element which effects this transformation may consist of a ceramic material, for example, ferroxcube, on which wire turns are provided. One or more of these elements is connected to a tray or vessel consisting of erosion-resistant and chemically-resistant material, usually stainless steel. In this construction the connection layer is subject to large alternating forces of high frequencies (20–40 kc./s.). In order to dissipate the smallest possible power in the connection layer because of the mechanical losses occurring thereat, the connection layer must be thin. Thermo-hardenable glues on the basis of ethoxylin resins have proven to be particularly suitable for this purpose. However, it was found in practice that glued joints obtained with this synthetic material or, if desired, other thremo-hardenable synthetic materials having corresponding physical properties, are sensitive to high relative humidities in as far as the adherence is concerned. However, such a condition frequently occurs in a cleaning apparatus in which water often is used as the cleaning liquid. Under the influence of this, the glued seams may work loose. In addition, it is hardly avoidable when using glued joints that great stresses occur in the glued joints which may result in fracture even under a small load, while also the mode of vibration of the transducer is adversely influenced by it.

So, although the advantages of a pressure joint are clear, no construction for such a pressure joint between a transducer and a receiver is known which is usable for practical purposes. This is quite conceivable. For example, even the thinnest layer of gas between a transducer and a receiver, for example, a container as is used in ultrasonic cleaning apparatus, reflects all the energy. It was found in practice that the surfaces of engagement of transducer and receiver cannot be made so smooth that a layer of gas which reflects the energy is absent. When a liquid is provided between the surfaces, a transmission of the energy is obtained, it is true, but the layer of liquid is destroyed within a short period of time, particularly in the case of greater energies, by cavitation and spattering. When using hard solid substances it is not possible to entirely fill all the space between two surfaces unless very great pressures are employed. This could naturally be the case with soft kneadable waxy substances, but these substances damp very strongly in the ultrasonic range as a result of which high mechanical losses occur in such a joint.



It is an object of the invention to solve this problem and to provide additional improvements which will be described in greater detail below.

The invention features the use of a pressure or clamping joint between the transducer and the receiver, wherein a layer of a "bouncing putty" is placed between the contacting faces of the transducer and the receiver in which the ultrasonic energy usually is dissipated.

A bouncing putty is a substance which reacts highly elastically to rapid actions of applied forces and plastically to slow actions of applied forces.

It has been found that a pressure or clamping joint according to the invention very readily transmits the energy with very little damping. In general the damping is even smaller than in glued joints. This appears, for example, from the fact that even at lower power levels, cavitation occurs in a liquid in a container which serves as a receiver in the device according to the invention. For obtaining a good acoustic contact, usually pressures between 100 and 300 g./cm.$^2$ are sufficient. Often the mere weight of the article in which the ultrasonic energy is dissipated is already sufficient. Since the layer thickness need be only 50–100 microns it is in general not necessary to take precautions to prevent the flowing away of the bouncing putty. Under the influence of capillary forces, a layer of sufficient thickness between the transducer and the article in which the ultrasonic energy is dissipated is maintained for a very long time. Should the article become too thin or disappear partly, it is very simple to provide a new layer of bouncing putty.

A bouncing putty can be obtained, for example, by heating a mixture of polymeric dimethyl siloxane and boron oxide (0.5–15% by weight of the siloxane) for some time at a temperature of 200° C. or higher. Bouncing putties prepared according to this method are obtainable in trade.

Alternatively, substances having bouncing putty properties can be obtained, for example, by preparing the zinc salt of a liquid copolymer of butadiene and acrylic or methacrylic acid.

In order that the invention may readily be carried into effect, one of the possible embodiments will now be described, by way of example, with reference to the accompanying drawing the sole figure of which showns an elevation, partly in cross-section, of a device according to the invention.

The transducer which transforms the electrical energy into mechanical energy consists, in the embodiment shown in the figure, of two members **1** and **1'** of the shape shown and consisting of a soft magnetic ceramic material, for example, ferroxcube, the ends of which are glued together with the interposition of the hard magnetic plates **2** and **2'**, consisting of, for example, ferroxdur. Under the influence of a high-frequency electric current (for example 20–40 kc./s.) which is conveyed through coils (not shown) which surround the thin portions of the members **1** and **1'**, the bodies **1** and **1'** start performing magnetostrictive oscillations of the same frequency. The device shown further comprises a vibration vessel **6** which may contain a cleaning liquid and to which a number of bars **5**, **5'** and **5''** are rigidly secured, the bars being screw-threaded at their ends. The transducer element **1**, **1'** is forced against the pressure vessel **6** by means of nuts **7**, **7'** and **7''**, the pressure springs **8**, **8'** and **8''** and the pressure plate **9**. Between the pressure plate **9** and the element **1**, **1'** is arranged a plate **10** consisting of synthetic foam, or foamed rubber with closed cells, by means of which

a complete reflection of the ultrasonic energy is effected. Between the transducer element **1**, **1'** and the vibration vessel **6**, a thin layer **11** of bouncing putty is provided, for example, a product manufactured as described in United States Patent No. 2,431,878 or in an article by W. Cooper in the December 24, 1955 issue of "Chemistry and Industry," pages 1741–1742. One commercial source of bouncing putty based on a silicon resin and boriumoxide is the product sold under the trade name Silicon Bouncing Putty MS 4046 by Midlands Silicones Ltd. By means of the nuts **7**, **7'** and **7''** and the pressure springs **8**, **8'** and **8''** the connection layer **11** is under pressure.

In some cases, however, it has been found that the weight of the vibration vessel is already sufficient for building up the required pressure in the connection layer **11**. In that case, the part of the construction constituted by parts **5**, **5'** and **5''**, **8**, **8'** and **8''** and **7**, **7'** and **7''** may be omitted.

From the following experiment it was shown that the use of bouncing putty has the advantage of a smaller damping as compared with glued joints.

Compared was a construction in which the transducer was connected to a container by means of bouncing putty as described above the pressure in the joint being 187.5 g./cm.$^2$—with a construction in which the joint consisted of a glued layer of epoxy resin (Araldit XV with hardener XV marketed by C.I.B.A.). In both cases the container, the transducers, the liquid (water) and the quantity thereof in the container were quite equal.

It was found that in order to achieve the same cavitation intensity in the liquid, a load of between 25 and 30 watts was required in the first case when the bouncing putty was used, and a load of 50 watts was required in the second case, both operating at 23 kc./s.

What is claimed is:

**1**. Ultrasonic vibratory apparatus comprising an electro-mechanical transducer arranged to vibrate an end surface thereof at an ultrasonic frequency, a container for a substance to be treated by ultrasonic vibratory energy adjacent said end surface, and vibration transmitting means comprising a thin layer of a bouncing putty material interposed between and in contact with said end surface of the transducer and one wall of said container, said container and transducer being urged together to form a compressive pressure joint therebetween at said layer.

**2**. Apparatus as described in claim **1** wherein said layer of bouncing putty is approximately 50 to 100 microns thick.

**3**. Apparatus as described in claim **1** wherein said bouncing putty is composed of a mixture of polymeric dimethyl siloxane and boron oxide.



**4**. Ultrasonic vibratory apparatus comprising a liquid container composed of rigid wave-transmitting material, an ultrasonic transducer having one end surface adjacent a wall of said container, and vibration transmitting means interconnecting said transducer and container comprising a thin layer of non-adhesive bouncing putty in contact with said transducer one end surface and said container wall, and means for mounting said transducer and container so as to urge said transducer and container towards one another to exert a compressive force along said layer.

**5**. Ultrasonic vibratory apparatus comprising a liquid container having a bottom wall and side walls of rigid wave-transmitting material, an ultrasonic transducer having first and second end surfaces and positioned under said container with said first end surface facing said bottom wall, means for transmitting vibrations from said transducer to said container comprising a thin layer of non-adhesive bouncing putty interposed between and in contact with said first end surface and said container bottom wall, and means for urging said conntainer and transducer together so as to exert a compressive force along said layer.

**6**. Apparatus as described in claim **5** wherein said means for urging comprises, a rigid plate having a plurality of holes therein and positioned adjacent to and facing said transducer second end surface, a layer of elastic material having low vibration-damping properties interposed between and in contact with said second end surface of the transducer and said rigid plate, a plurality of rods attached to said container and extending through the holes in said plate, and force applying means coupled to said rods and bearing against said rigid plate.

**7**. Ultrasonic vibratory apparatus comprising a liquid container composed of rigid wave-transmitting material, an ultrasonic transducer having one end surface adjacent to the bottom wall of said container, and vibration transmitting means interconnecting said transducer and container comprising a thin layer of non-adhesive elastomeric material exhibiting plastic cold flow properties interposed between and in contact with said transducer one end surface and said container wall, said container and transducer being forced together to form a compressive pressure joint at the surfaces contacting said layer.

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