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APPARATUS FOR GENERATING SONIC VIBRATIONS IN LIQUIDS

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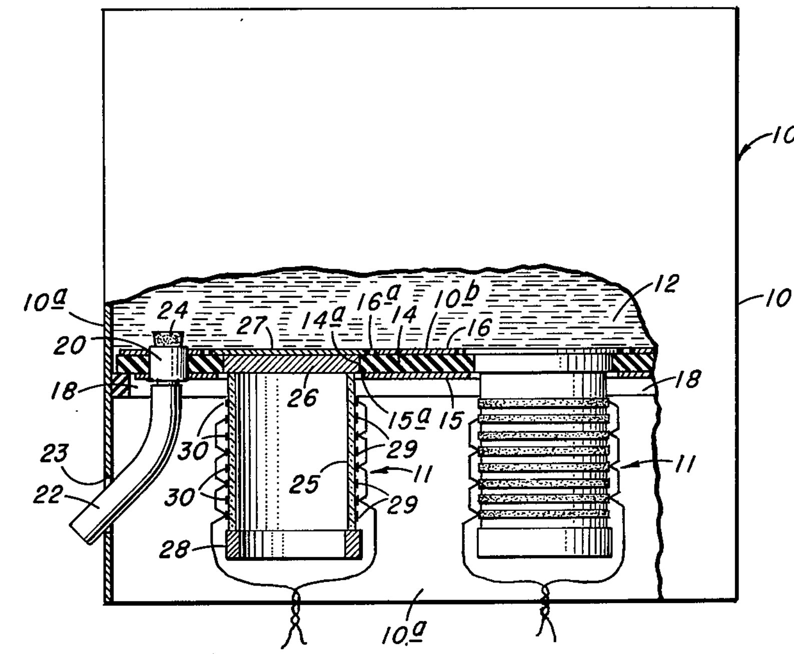


FIG. 1

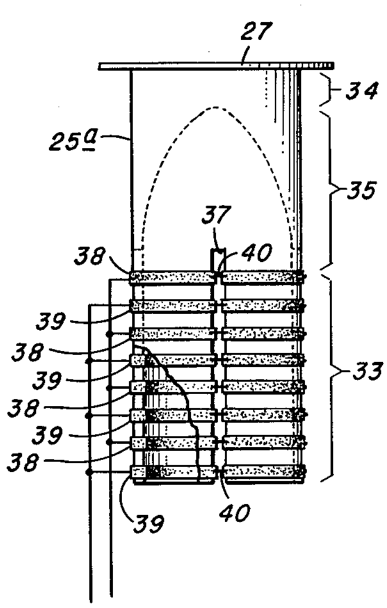


FIG. 2

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# APPARATUS FOR GENERATING SONIC VIBRATIONS IN LIQUIDS

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5 Claims. (Cl. 310—8.7)

This invention relates broadly to transducers for generating sonic (including ultrasonic) vibrations in liquids and to the mounting of such transducers. The invention has particular utility in, although it is not limited to, apparatus for generating sonic waves in a liquid contained in a tank for treating articles submerged in the liquid.

An object of the invention is to provide an efficient, simple and inexpensive transducer for generating sonic waves in liquids.

Another object is to provide a simple, inexpensive and effective wall and transducer assembly for vibrating liquid on one side of the wall.

Other more specific objects and features of the invention will appear from the following detailed description of certain embodiments of the invention disclosed in the drawing.

In the drawing:

FIG. 1 is an elevation view, with portions shown in section, of a sonic cleaning tank incorporating the invention.

FIG. 2 is an elevation view, with portions shown in section, of an alternative transducer unit that may be used in FIG. 1.

Referring to FIG. 1, there is shown a sonic cleaning apparatus consisting of a tank **10** having a plurality of identical transducers **11** for creating sonic vibrations in a liquid **12** contained in the tank to increase its cleaning action on objects immersed in the liquid.

The tank **10** may be of any desired shape, but is here shown as rectangular, having side walls **10***a* and a bottom wall **10***b* which is located intermediate the upper and lower ends of the side walls.

The bottom wall **10***b* is laminated, consisting of a first central lamination **14** of an elastomer, such as rubber, a second lamination **15** on the lower surface, and a third lamination **16** on the upper surface. The laminations **15** and **16** are of stiffer material than the first lamination **14** and may be of metal or other strong, stiff material. All three laminations are firmly cemented or bonded together. When the lateral dimensions of the bottom wall are small, both of the stiff laminations **15** and **16** may not be necessary to provide the desired stiffness, and one of them may be eliminated.

The bottom wall **10***b* is supported from the side walls **10***a* by a peripheral flange **18** on the inner surfaces of the side walls. This shoulder **18** is preferably of an elastomer material which may be bonded to the side walls. It is also desirable to have the second lamination **15** of the bottom wall stop short of the outer edge of the first, elastomer lamination **14** so that the latter rests directly on the shoulder **18** and is bonded thereto to provide a fluid-tight construction. A drain orifice **20** may be provided in the bottom wall connected at its lower end to a drain hose **22** which may extend through an aperture **23** provided therefor in one of the side walls **10***a*. Normally the orifice fitting **20** may be closed by a stopper **24**.

As shown in FIG. 1, each transducer **11** comprises a longitudinally vibratile element having a hollow cylindrical section **25** of electromechanically-responsive material, a substantially rigid head section **26** on one end thereof, a face plate **27** on the outer face of the head section **26**, and a hollow cylindrical mass section **28** on the lower end of the section **25**. The sections **25**, **26**, **27**



and **28** are all firmly bonded together to vibrate as an integral unit.

The section **25** may be of any one of many types of electromechanically-responsive material, but is here shown as a ceramic element containing some piezoelectric material, such as barium titanate, which responds to electrostatic forces to change its dimensions. In this instance, the section **25** is energized by applying potential between band electrodes **29** and **30** provided on the outer surface of the element **25**. The bands **29** alternate with the bands **30** so that electrostatic fields are produced having a longitudinal component within the section **25**, thereby energizing it in longitudinal direction, which is the direction of vibration. It is to be understood that other known methods of electroding may be employed, such as a single electrode covering the inner surface, and another single electrode covering the outer surface.

The head section **26** may be constructed of various materials, such as aluminum. It is purposely relatively thick so as to have rigidity and vibrate as a unit without flexing.

The face plate **27** is relatively thin and is preferably of some hard, corrosion-resistant material, such as stainless steel, to withstand the eroding effects of cavitation.

The mass section **28** on the lower end of section **25** is not essential in all instances, but improves the efficiency of the transducer.

As shown in FIG. 1, the head section **26** is of the same thickness as the first lamination **14** of the bottom wall and fits within an aperture **14***a* in the lamination, the face plate **27** being of larger diameter than the head section **26** and extending over the margins of the aperture **14***a* to support the transducer with respect to the lamination **14**. The aperture **14***a* is preferably dimensioned to provide a press fit with respect to the head section **26**. The head section **26** and the face plate **27** are preferably bonded to the lamination **14** with a suitable cement to prevent leakage.

The upper, or third, lamination **16** of the bottom wall **10***b* has apertures **16***a* therein aligned with the apertures **14***a*, but of larger diameter so that the outer edges of the face plates **27** do not contact the lamination **16**. The second lamination **15** has apertures **15***a* therein aligned with the apertures **14***a* and of larger diameter than the latter, so that the head section **26** does not contact the second lamination. Although the head section **26** is shown in FIG. 1 as having the same thickness as the first lamination **14**, this is not necessary, and the head may be of greater thickness than the lamination and extend down through and beyond the aperture **14***a*.

The construction of the bottom wall **10***b* described provides, with the face plate **27** and head sections **26** of the transducers, a rigid, water-tight wall assembly while eliminating any contact between the rigid portions **26** and **27** of the transducers and the rigid portions **15** and **16** of the bottom wall. This provides more efficient operation than would be obtained if the bottom wall **10***b* were a simple, rigid wall. The support of the bottom wall **10***b* from the side walls **10***a* by the elastomer shoulder **18** also prevents direct transfer of vibration from the transducer elements to the side walls **10***a*, and further increases the efficiency.

If the liquid **12** is hot, the active material of the transducer may be raised to a temperature above which it is inoperative. Thus, ceramic materials containing barium titanate as the active element become inoperative above a temperature of 120° C. Other piezoelectric ceramic materials are known that are operative over a higher temperature range, but in general they are more expensive than the materials that are limited to a lower operating range.

FIG. 2 shows a transducer construction that may be used in the apparatus of FIG. 1, and may be operated at higher liquid temperatures.

In FIG. 2, the separate head section **26** of FIG. 1 is eliminated, and the integral ceramic element **25*a*** has a lower active section **33**, a head section **34**, and a motion-transforming section **35**. The face plate **27** is bonded directly to the end of the head section **34**.

The active section **33** is divided by four slots **37** into four segments of a cylinder, and each segment is provided with alternate sets of electrodes **38** and **39**, respectively, which are connected as in FIG. 1. Each electrode **38** or **39** is connected to the corresponding electrode on the next adjacent segment by connectors **40**. Each electrode may extend completely around its segment on both the inside and outside surfaces thereof, although this is not essential. The separation of the section **33** into separate segments improves the vibrational characteristics by decreasing the susceptibility to undesired lateral vibrations.

The motion-transforming section **35** is cylindrical on the outside, but of increasing wall thickness from its lower end to the upper end, where it merges with the head section **34**.

The chief advantage of the structure shown in FIG. 2 over that shown in FIG. 1 is that the electrically inactive section **35** constitutes a thermal barrier between the head section **34** and the active section **33**. This enables the use of liquids of temperature above the temperature at which the ceramic material loses its electromechanical properties, because a substantial temperature gradient will exist in the motion-transforming section **35**.

In general, transducers supported only at the working end, as shown in FIGS. 1 and 2, should be a half wavelength or a multiple of a half wavelength in longitudinal dimension. Usually, in the case of the transducer type shown in FIG. 1, the over-all length is desirably made one-half wavelength. The type of transducer shown in FIG. 2 may be one-half wavelength in over-all length, and preferably the electrically active portion **33** should contsitute one-half or more of the total length.

As a typical example, the transducer of the type shown in FIG. 1 may have the following dimensions for an operating frequency of 20,000 cycles per second:

| | Inches |
|---|---|
| Diameter of element **25** | 1.6 |
| Diameter of element **26** | 2.0 |
| Diameter of element **27** | 2.5 |
| Thickness of element **25** | .25 |
| Thickness of element **26** | .25 |
| Thickness of element **27** | .040 |
| Internal diameter of element **28** | 1.1 |
| Length of element **28** | .5 |
| Radial thickness of element **28** | .25 |

The dimensions of a transducer of the type shown in FIG. 2 for operation at 20,000 cycles per second may be as follows:

| | Inches |
|---|---|
| Outside diameter of sections **35, 34** and **33** | 1.6 |
| Thickness of section **33** | .25 |
| Length of section **34** | .25 |
| Length of section **35** | 1.0 |
| Length of section **33** | 2.0 |



Although for the purpose of explaining the invention a particular embodiment thereof has been shown and described, obvious modifications will occur to a person skilled in the art, and I do not desire to be limited to the exact details shown and described.

I claim:

1. Apparatus for generating sonic vibrations in liquids comprising:
   a vibratile element including a substantially rigid head having an outer face for imparting vibrations to a liquid in contact therewith, and means for vibrating said head in direction normal to said outer face;
   a face plate on said outer face of said head substantially thinner than the head and having edge portions projecting beyond the peripheral edge of the head and means securing the face plate to said outer face of the head for vibration therewith;
   means constituting a liquid barrier between said vibrating means and the front face of said face plate including a wall having an aperture in which said head is positioned with said face plate and said vibrating means on opposite sides of said wall, respectively, said projecting edge portions of said face plate overlapping and engaging the marginal portion of said wall defining said aperture;
   said wall comprising a first lamination of elastomeric material of substantial thickness juxtaposed to said head and a second lamination of stiffer material on one face of said first lamination.
2. Apparatus according to claim 1 including additional walls defining with said mentioned wall a liquid-retaining tank, only said first lamination of said wall being joined to said additional walls.
3. Apparatus according to claim 1 in which that portion of said aperture in said first lamination is a press fit with said head and that portion of said aperture in said second lamination is larger than said head.
4. Apparatus according to claim 3 in which said wall includes a third lamination of stiffer material than said elastomer material on the other face of said first lamination.
5. Apparatus according to claim 3 in which said second lamination is on that face of said first lamination overlapped by said face plate and the aperture in said second lamination is larger than said face plate whereby said edge portions of said face plate contact said first lamination and do not contact said second lamination.

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