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SONIC TRANSDUCER

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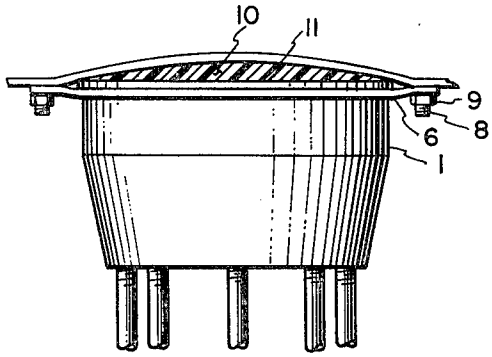


FIG. 1

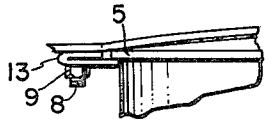


FIG. 2

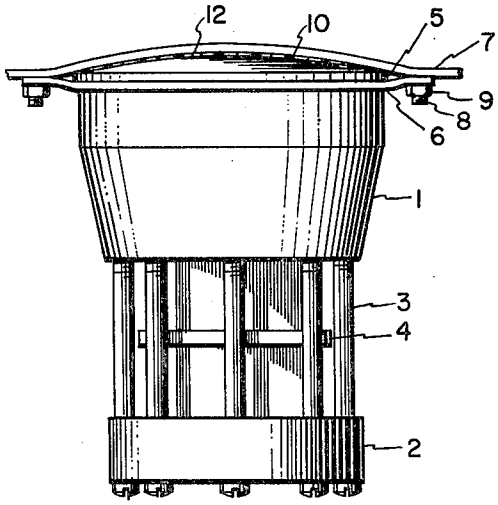


FIG. 3

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SONIC TRANSDUCER

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This invention relates to improved sonic transducers and their connection to extended container walls.

The sonic, and particularly ultrasonic, cleaning of materials, has developed into an effective industrial tool, which is widely used for many purposes. The present invention is not limited to a device for use with a sonic cleaning tank. It is useful wherever transducers are coupled to liquids through walls. As the problems and their solution by means of the present invention are well illustrated by sonic cleaning tanks, this particular modification will be used as illustrative in the general description of the invention.

When sonic, and particularly ultrasonic, vibrations are to be transmitted from transducers through walls, usually metal walls, into a liquid in a cleaning tank, a number of problems arise. At the outset, it should be realized that these operations involve the transmission of quite respectable amounts of power in the form of sonic vibrations through the wall of the cleaning tank into the liquid bath therein. This requires a highly efficient sonic coupling from the transducer to the wall. The fact that the walls are thin and flexible, frequently being made of stainless steel of moderate gauge, intensifies the problem. An ordinary driving transducer for sonic cleaning usually includes one or more, commonly two, piezoelectric ceramic wafers, ordinarily clamped tightly between metallic resonating blocks. It is common for one of these blocks to be of a relatively lighter material, such as aluminum, so that it can be flared and present a larger surface to contact with the walls of the tank. The piezoelectric transducers are by far most commonly used in sonic cleaning operations, though of course other types of converters, such as magnetostrictive transducers may also be used, but in such a case likewise the surface of the transducer contacting the wall of a cleaning tank is normally increased. The present invention, which deals with the sonic coupling of the transducer to the container wall and so to its liquid content, is not concerned with the particular mechanism by which sonic vibrations are generated. Therefore, in the following more specific description of the invention, a typical piezoelectric transducer will be used as illustrative though the invention is in no sense limited to this particular design.

It is common to fasten mechanically the flared surface of the transducer to the container wall, usually with a bedding layer of plastic, which may, for example, be an epoxy resin. As with the method of generating the sonic vibrations, the present invention is not directed to the use of any particular bedding plastic and therefore epoxy resin will be described simply as a typical and very effective bedding layer.

It is common practice in sonic cleaning tanks to weld threaded studs into the stainless steel tank wall at the points where the sonic transducers are to be attached. A thin layer of epoxy resin is then applied and the flared transmitting surface of the transducer is then clamped tightly, for example by lugs which protrude from the transducer and through which the welded studs pass. The clamping is by conventional means, using nuts and generally the clamping is effected with quite a high torque on the nuts. The epoxy resin may then harden and the transducer is considered mounted.

In practice, there has been considerable disappointment in the efficiency of the transducers mounted, either

in the beginning or after some period of use. The sonic coupling becomes less efficient and a great deal of the power is wasted in poor vibration transmission. Extended investigation of tank walls and transducers showed that when the clamping lugs are turned up tight, the relatively flexible wall of the tank, for example a stainless steel wall, is flexed. It is being pulled down hard against the edges of the transducer and tends to bow up in the middle. This subjects the epoxy resin bonding layer to uneven stresses and may cause it to break away or make imperfect sonic contact with the bowed tank wall.

Another factor which accentuates the imperfection of the sonic coupling lies in the fact that the rigid transducer resonating block is clamped to the container wall at only a few points, normally four. Between the points of attachment to the transducer block, there are unsupported areas which throw a strain on the transducer block itself. It is true that this block is a fairly rigid piece of metal, for example a thick flared aluminum block, but when the clamping nuts are turned down to extreme tightness, even the aluminum is capable of distortion, and this is very greatly increased if the degree of clamping is not absolutely uniform. It is true that initially, with modern torque wrenches, a uniform clamping can be obtained by the exercise of reasonable care. However, in use, both the container wall and the transducer block are subjected to continuous violent sonic vibrations, even though the travel of each vibration is quite short. In time, therefore, warping or deformation of the transducer block has resulted. This has accentuated the imperfect setting in the epoxy resin layer. Even though the resin has great strength and the deformations may be small, in time the deformation often results in markedly reduced sonic coupling. This in turn reduces the effectiveness of the cleaning tank.

The present invention solves both of these problems and the solution is a permanent one insofar as any device which is subjected to continuous violent sonic vibrations can be said to be permanent. The two problems require two different mechanical solutions. The first and most serious problem caused by bowing of the container wall when the transducer is clamped on or after extended use is solved by making the surface of the transducer block convex. The center of the flared transducer block then first contacts the container wall through the bedding layer and the bowing of the container wall as the transducer is clamped down conforms the wall to the contour of the convex surface. Thus, after clamping, there is as nearly perfect parallelism of the bowed container wall and the transducer block as is possible. Departures from parallelism are infinitesimal in comparison to the very serious effects when a flat transducer surface is clamped onto a container wall. It should be understood that the actual bowing is comparatively small but it is this small difference which causes the difficulty. The present invention is not limited to any exact quantitative shape because this will be determined by the nature of the container wall, by the size of the transducers and other factors. A typical transducer may have its surface domed with a radius of curvature of approximately a hundred inches. This is a good average degree of curvature, but for each tank wall material and thickness there will be an optimum and so the curvature should be chosen to approximate as closely as possible to perfection for the particular materials used and particular gauges of tank wall. The hundred inch radius has been taken from a tank having a moderate gauge stainless steel wall with transducers having surfaces of several inches in diameter.

The second problem of uneven transducer attachment is solved by providing the transducer with a shoulder or flange at its lower end and attaching it to the stud bolts, either by a continuous plate or by clips. In each case,

the attachment is somewhat flexible and any nonuniform clamping does not show up as a deformation of the transducer metal block itself.

The invention will be described in greater detail in conjunction with the drawings, in which:

FIG. 1 is an elevation of a mounting block of a transducer having a flat surface;

FIG. 2 is a detail of a clip mounting; and

FIG. 3 is an elevation of a transducer having a continuous plate and domed surface.

The problems encountered are illustrated by FIG. 1, the transducer block **1** having a flat surface **11** and being clamped to a container wall by welding studs threaded at **8**, using nuts **9**. The clamping is shown effected by a surrounding plate **6**. It will be seen that the epoxy bedding layer **10** is squeezed out at the edges and thick in the middle. In use, an imperfect sonic coupling results and there is therefore a marked loss in efficiency.

FIG. 3 illustrates a transducer with a domed resonant block. The bolts **3** are shown extended to a steel clamping block **2**. An electrode disc **4** is shown in its usable position, in the piezoelectric ceramic wafers which are between disc **4** and blocks **1** and **2**. It will be noted that the surface **12** is not flat as in FIG. 1 but is domed and therefore when the nuts **9** are clamped tight, the container wall **7** is bowed so that it is substantially parallel to the dome face of the transducer resonating block **1** and adjusts itself approximately parallel thereto so that the epoxy layer **10** is substantially uniform in thickness and is not subjected to unbalanced stresses.

It will be seen that the mounting plate **6** bears on a flange **5** on the transducer block and completely surrounds it, being provided with four holes through which the stud bolts pass. The plate bends so that any irregular clamping stresses are uniformly distributed around the flange **5** and there is no tendency toward warping or deformation of the block **1** by reason of uneven clamping force. The doming of the block **1** and the bending of the plate **6** are both shown somewhat exaggerated. In practice, as has been pointed out above, the doming will have a large radius of curvature and this is difficult to show clearly in a drawing.

Distribution of clamping stresses to the block **1** may also be effected by means of clips **13**, which are shown in FIG. 2. The shape of the clips is such that they have a longer lower portion which extends under the shoulder and a shorter upper portion which does not quite touch the shoulder, leaving a slight gap. While the clips are very easy to make, distribution of clamping pressure is not

quite as uniform as with the surrounding plate, as shown in FIGS. 1 and 3, and for this reason, the latter construction is preferred. Other mountings, which are sufficiently flexible to take up nonuniform clamping stresses, may of course be used, the clips and preferred mounting plate being illustrative examples.

We claim:

1. A sonic transducer adapted to be mounted on a container wall comprising in combination,

(*a*) a domed coupling surface of the transducer adapted to be mounted on a container wall, and

(*b*) means for clamping the said transducer surface to the container wall at separated points around the periphery of the surface, whereby, when clamped to the wall, the wall is bowed, the doming of the transducer surface corresponding approximately to the bowing so that when the transducer is mounted on the container wall the domed transducer coupling surface and the bowed container wall are substantially parallel.

2. A transducer according to claim 1 in which a thin bedding layer is present between the transducer surface and the bowed container wall to effect uniform sonic coupling.

3. A transducer according to claim 2 in which the portion of the transducer having the domed coupling surface is provided with a shoulder around its periphery and the clamping means to the container wall includes deformable means engaging said shoulder.

4. A transducer according to claim 3 in which the clamping means is multielement and includes a plate having a central hole of smaller diameter than the shoulder but larger diameter than the remaining portion of the transducer element having the dome coupling surface, said plate being provided with openings cooperatable with the other elements of the clamping means and the plate being sufficiently deformable and flexible to distribute clamping pressure uniformly over the shoulder when the transducer is clamped to the container wall.

5. A transducer according to claim 3 in which the clamping means includes flexible clips with ends bearing on the shoulder.

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