Nov. 25, 1969 F. MASSA 3,480,258

ULTRASONIC CLEANER

Filed Aug. 30, 1967 2 Sheets-Sheet 1

FIG - 1

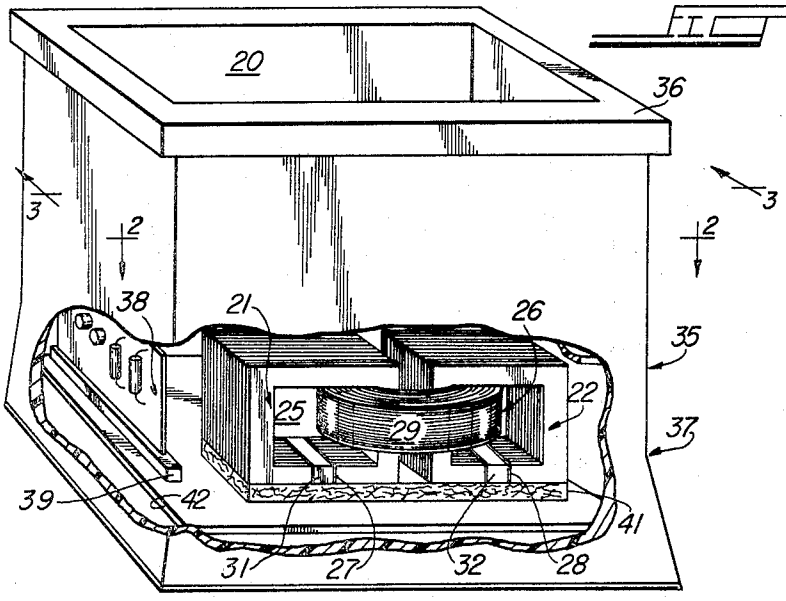
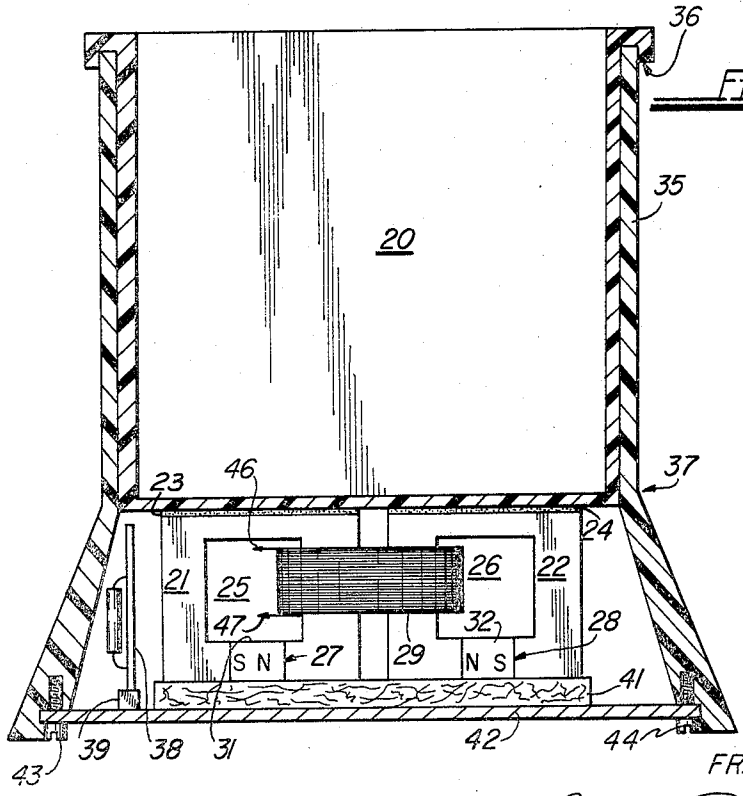


FIG - 3



INVENTOR.
FRANK MASSA

BY Louis Bernat

Atty.

Nov. 25, 1969 F. MASSA 3,480,258

ULTRASONIC CLEANER

Filed Aug. 30, 1967 2 Sheets-Sheet 2

FIG. 2

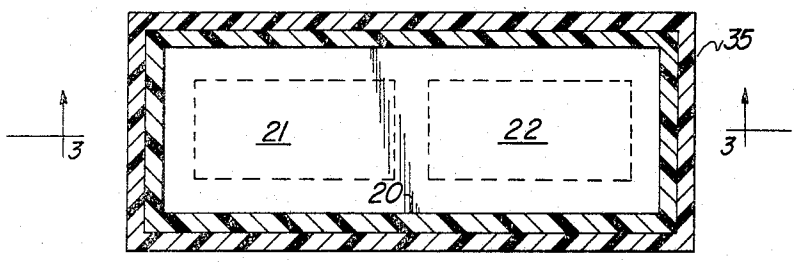


FIG. 5

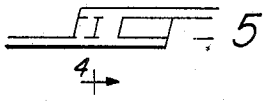
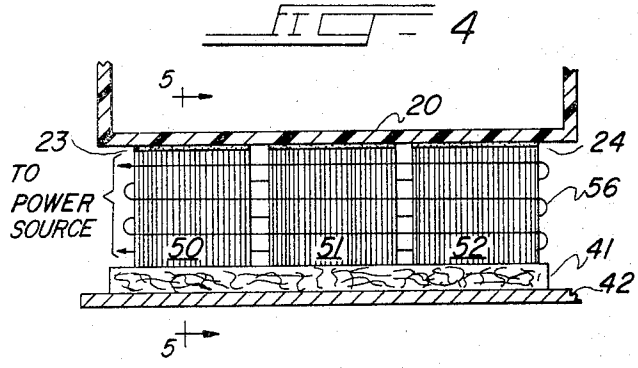


FIG. 4



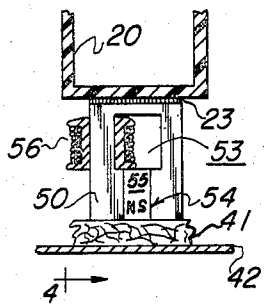


FIG. 6

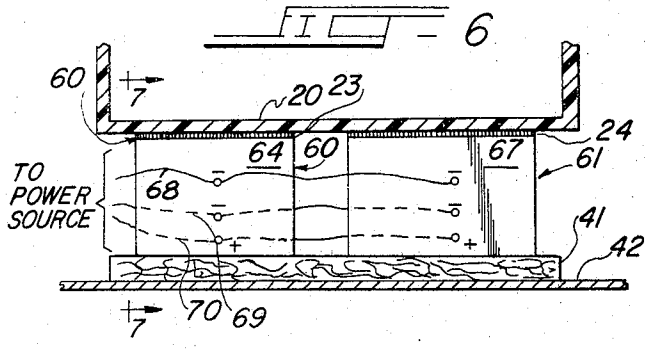


FIG. 7

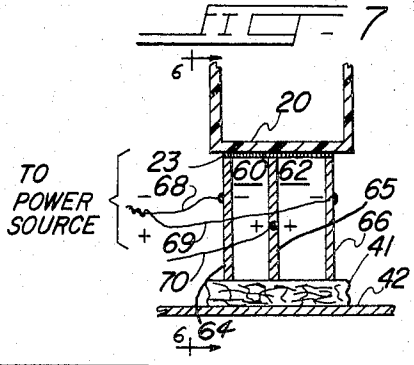
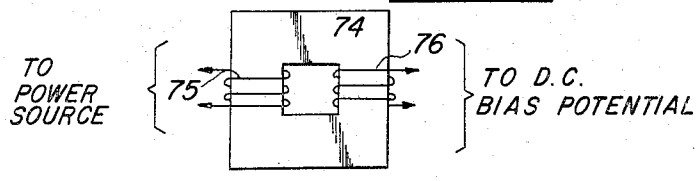


FIG. 8



INVENTOR
FRANK MASSA
BY Louis Bernat
Atty

United States Patent Office 3,480,258 Patented Nov. 25, 1969

3,480,258

ULTRASONIC CLEANER

Frank Massa, Cohasset, Mass., assignor to Massa Division, Dynamics Corporation of America, Hingham, Mass.

Filed Aug. 30, 1967, Ser. No. 664,561
Int. Cl. B01f 11/02
U.S. Cl. 259—72 9 Claims

ABSTRACT OF THE DISCLOSURE

The invention relates to ultrasonic cleaners of the home appliance type, and especially to denture cleaning devices. More particularly, a molded, one-piece, open top tank is set on its narrow side. An ultrasonic vibrator is attached to hang down below this narrow side and to drive sonic energy through that side and into a fluid in the tank. Since the driving transducer operates through the narrow side, it may be made much less powerful and at a lower cost without sacrificing any cleaning power.

This invention relates to ultrasonic cleaning devices, and more specifically to low cost household cleaners having a particular utility for cleaning small objects. While the following description will refer to these devices primarily as denture cleaners, the invention should not necessarily be construed as limited thereto. Quite the contrary, the invention has utility wherever it is necessary to clean relatively small articles of an appropriate type.

In the past, ultrasonic cleaning devices have usually been designed for industrial applications. Generally, these devices have tended to be larger and more complex than household appliances. However, the adaptation of lower cost ultrasonic devices to household uses is currently attracting widespread attention. By way of example, certain recent activities have been centered upon devices which may be used for cleaning dentures.

One form of an ultrasonic device adaptable to denture cleaning includes an open tank at least partially filled with a fluid or coupling medium. A transducer is coupled to a wall of the tank to vibrate that wall and drive sonic waves having intense pressure through the coupling medium. Thus, pressure waves in the coupling medium wash across and clean any objects placed in the tank. The effectiveness of this type of cleaning action depends upon cavitation in the coupling medium and this cavitation is, in turn, a function of the sonic power generated per square inch by the transducer radiating surface.

Accordingly, an object of the invention is to provide new and improved ultrasonic cleaning equipment and particularly—but exclusively—to equipment for cleaning small objects.

A further object is to reduce the cost of such equipment. In this connection, an object is to maintain in the coupling medium a fixed ultrasonic power density while reducing the total area of the activated transducer surface.

Another object of the invention is to provide a highly efficient ultrasonic cleaner particularly adapted to clean dentures .

Yet another object is to provide denture cleaners which are efficiently packaged to occupy a minimum shelf space. In this connection, an object is to provide a packaging design which lends itself to low cost manufacture with little special tooling requirements.

In keeping with an aspect of this invention, these and other objects are accomplished by an ultrasonic cleaner in which a one-piece molded tank or container has at least one ultrasonic transducer or vibrator bonded to its lower surface. The upper or open end of the tank

terminates at a cap-like lip or ridge which enables it to fit over, nest into, and seal against one end of a rigid tubular shell. The vibrator in the preferred embodiment is a magnetostrictive transducer coupled to drive through a narrow wall of the cleaner tank.

The nature of this preferred embodiment, and modifications thereto, may become more apparent from a study of the attached drawings in which:

FIG. 1 is a perspective view of an ultrasonic cleaner tank, partly broken away to disclose the nature of an ultrasonic, vibrating transducer unit enclosed therein;

FIG. 2 is a cross-sectional view, taken along line 2—2 of FIG. 1, showing the tank, supporting structure, and indicating the transducer location;

FIG. 3 is a second cross-sectional view taken along line 3—3 of FIG. 1 and at a right angle with respect to the cross section of FIG. 2;

FIGS. 4 and 5 are cross-sectional views—taken at right angles—of a second embodiment of the invention having three transducers;

FIGS. 6 and 7 are cross-sectional views—also taken at right angles—showing a third embodiment having piezoelectric transducers; and

FIG. 8 is a front elevation view of a transducer having a coil for providing a D.C. bias potential.

The various drawings show an open top tank **20** which may be made of any suitable material. For example, it could be one-piece of molded rubber. To accommodate human dentures of conventional size, the tank **20** should be about three and one-half inches in diameter, if round, or about three inches on a side, if square. The tank should be about one and a quarter inches wide.

According to conventional techniques, a transducer would be coupled to drive ultrasonic waves into the large side of the tank—in this particular case of a denture cleaner, the large side has an area of about nine square inches. However, cavitation in the cleaning fluid or coupling medium depends upon power density at the transducer face. Thus, a relatively large amount of power is required to activate nine square inches.

I do not require this amount of power because I drive the ultrasonic waves into a relatively small side of the tank. Thus, the transducer face is reduced to an area of about three by one and a quarter inches which is less than half the surface area of the transducer used in the conventional design. Since cavitation is proportional to power density, the power requirements of my transducer is reduced to less than one-half of the power requirement of the conventional design. This less than half-sized transducer does not in any manner reduce the power density in the coupling medium, and only about 40% of the transducer structure is required.

In addition to a savings of power and transducer structure, my arrangement also saves shelf space (as in a medicine cabinet, for example) since the tank rests on its narrow side.

While any of many suitable transducer elements may be used, a preferred embodiment of my invention uses at least one transducer providing an optimum power density—as described in my U.S. Patent No. 2,702,260, for example. In greater detail, two ultrasonic vibration generating transducers **21, 22** are here shown as bonded to the bottom of the tank **20**, as by means of an epoxy cement **23, 24**, for example, as best seen in FIG. 3. Each of these transducer arrangements includes a number of nickel laminations arranged in stacks and provided with coil receiving windows **25, 26** and adjoining slots **27, 28**. After the laminations have been assembled into two adjacent stacks, a coil **29** of insulated wire is wound by passing it through the slots **27, 28** and around one leg on each of the core structures **21, 22**. Then, after the coil **29** is in

place, a permanent magnet **31**, **32** is installed in each of the slots **27**, **28** with like magnetic polarities facing the center line between the transducers, as shown in FIG. 3. These permanent magnets provide a magnetic bias in the laminations, with known results.

For enclosing and supporting the tank and transducer assembly in an upright position, a generally rectangular housing tube **35** of any suitable rigid material is provided with an open top and bottom. The cross-sectional shapes of the tank **20** and housing **35** coincide so that the tank **20** may be snugly fit into the housing **35**. To facilitate attachment, the upper edge of the tank **20** is provided with a ridge or lip-like portion **36** which overhangs and nestingly receives the upper edge of the housing **35**. Thus, the tank **20** and housing **35** may be assembled into a unitary structure by slipping the tank **20**, transducer end first, into the housing **35** and then snapping the lip **36** over the upper edge of the housing. The relative shapes and sizes are such that the lip **36** provides an efficient seal at the upper end of the housing **35** to prevent an entry of moisture or other foreign elements.

To increase mechanical stability and provide greater storage room, the lower part of the housing **35** is flared, as shown at **37**, by way of example. Any suitable electronic components may be mounted on a printed circuit board **38** and then fitted into this flared base **37**. This electronic equipment provides power, in the form necessary, to drive the transducers **21**, **22**. However, since the electronics are entirely conventional and are not considered to be part of the invention, no further comments need be directed to them. The printed circuit board **38** may either be plugged into a conventional printed circuit board connector **39** or soldered in place, as required, by cost considerations.

To provide a mechanical shock resistant support for the transducers **21**, **22**, a sheet of sponge rubber **41** is placed beneath them. Then, a lower panel **42** is secured in place, as by means of screws **43**, **44**, to close the bottom of the housing **35**. The sponge rubber **41** may have cement added at its upper and lower surfaces in order to help secure the assembly together; however, this is an optional method of construction. Preferably, the panel **42** and housing **35** have complementary shapes so that the panel effectively seals the housing. An alternative embodiment would make the housing **35** and panel **42** a single unitary molded structure. Either way suitable provisions are made for connecting the two ends **46**, **47** of the wire forming the transducer coil **29** to an external source of power or to rechargeable batteries.

The foregoing description covers a preferred embodiment of the invention. It should be understood, however, that other alternative embodiments fall within the true spirit and scope of the invention. By way of example, three of these alternative embodiments are shown in FIGS. 4–8. It is thought that there is no need to describe the components in these five figures which have the same reference numerals since they are the same as similar components in FIGS. 1–3.

In FIGS. 4, 5 three core structures **50**, **51**, **52** of magnetostrictive laminations are shown as a general illustration that a plurality of such structures may be used. Each of these structures may be a stack of nickel laminations which are punched in a somewhat bifurcated shape (as shown in FIG. 5), to define a coil receiving window **53** and a slot **54**. A permanent magnet, polarized as shown in FIG. 5, is inserted in the associated slots of each core structure to polarize the laminations in the same relative magnetic directions. That is to say, the portions of each of the stacks **50**, **51**, **52** which are seen in FIG. 4, have the same magnetic polarity. A single coil **56** is wound through the window in each of the laminated stacks which form the core structure.

In FIGS. 6, 7, plates **60–62** of piezoelectric material are assembled to provide the ultrasonic driving transducer. Each of these plates may be made from any suitable

material, such as a 45° Z-cut ammonium dihydrogen phosphate crystal, polarized barium titanate, or lead zirconate. As best seen in FIG. 7, these piezoelectric crystals are arranged in pairs of parallel plates with a common polarity in the center. The surfaces of each of these plates have electrodes (such as **64**, **65**, **66**) attached thereto or deposited thereon. From an inspection of FIGS. 6, 7, and after a moment of reflection, it should be apparent that four piezoelectric plates are arranged in two rectangular, bi-laminar, structures with one polarity (here negative) on the two outside surfaces **64**, **66** and the opposite polarity (here positive) in the center of the structure.

To provide the necessary connections to electrical circuits, the wires **68**, **69** run across comparable electrodes of similar polarities. Thus, the wire **68** interconnects the electrodes **64**, **67** while the wire **69** interconnects the electrode **66** and another electrode (not seen) in the back of the structure **61**. Since all of these electrodes have the same negative polarity, the wires **68**, **69** are twisted or otherwise connected together. The wire **70** interconnects the positive electrodes in the centers of the structures **60**, **61**.

FIG. 8 shows yet another embodiment of the invention in which a single magnetic core structure **74** is provided with a driving coil **75** which is essentially similar to the coils **29**, **56**. The coil **76** is energized by a constant D.C. bias potential for providing a magnetic field which is equivalent to the field produced by the permanent magnets **31**, **32**, and **55**.

Still other embodiments of the invention could use materials which are different from those described herein. For example, other well known ferrites could be substituted for the described nickel laminates.

The operation of each of the transducers shown herein is well known. Therefore, nothing further need be said about them except to note that they vibrate at ultrasonic frequencies when they are energized from a proper voltage source.

The operation of the ultrasonic cleaner should now be clear. The tank **20** is filled with a suitable coupling fluid, and the dentures are dropped in edgewise. Then, the power is turned on for a minute or two while the transducers send ultrasonic pressure waves through the bottom of the tank **20**—which is a narrow side—and the coupling fluid to clean the dentures. After the power is turned off, the cleaned dentures are removed from the tank **20**.

The advantages should now be obvious to those skilled in the art. More particularly, since the tank is stood on a narrow side having area dimensions which are less than one-half the area of the large side of the tank, the entire transducer is made less than one-half the size of comparable transducers which would drive into the large side of the tank. Power is also reduced to less than half of the power required by those comparable transducers. Moreover, the shelf space, as in a medicine cabinet, for example, required to support the ultrasonic cleaner is reduced by more than half.

I claim:

1. An ultrasonic denture cleaner comprising a tall and narrow vertically oriented open top tank at least partially filled with a coupling medium, said tank having a narrow lower surface, said tank being a molded one-piece container terminated at its upper and open end in a cap-like lip, a rigid tubular housing having an upper end with a contour which is complementary to the contour of said cap-like lip, said tank and housing being assembled and sealed as a unit when said cap-like lip is snapped over the upper end of said housing, and at least one ultrasonic transducer driving means attached to and suspended beneath said lower surface for driving ultrasonic waves through said coupling medium.

2. An ultrasonic denture cleaner comprising a tall and narrow vertically oriented open top tank at least partially filled with a coupling medium, said tank having a nar-

row lower surface, said tank being a molded one-piece container terminated at its upper and open end in a cap-like lip, a rigid tubular housing having an upper end with a contour which is complementary to the contour of said cap-like lip, said tank and housing being assembled and sealed as a unit when said cap-like lip is snapped over the upper end of said housing, a plurality of ultrasonic transducer driving means cemented to and suspended beneath said lower surface, said transducer means driving ultrasonic waves through said coupling medium, a mechanical shock resistant material positioned beneath said transducer, and a lower panel sealing the bottom of said housing and supporting said shock resistant material.

3. An ultrasonic denture cleaner comprising a tall and narrow vertically oriented open top tank at least partially filled with a coupling medium, said tank having a narrow lower surface, a plurality of ultrasonic transducer driving means attached to and suspended beneath said lower surface, said transducer means driving ultrasonic waves through said coupling medium, said tank being a molded one-piece container terminated at its upper and open end in a cap-like lip, and a rigid tubular housing having an upper end with a contour which is complementary to the contour of said cap-like lip, said tank and housing being assembled and sealed as a unit when said cap-like lip is snapped over the upper end of said housing, the lower end of said housing having a generally flared shape for increasing mechanical stability and providing greater storage room, said plurality of transducers and electronic driving means being enclosed in said flared end of said housing.

4. An ultrasonc denture cleaner comprising a tall and narrow vertically oriented open top tank at least partially filled with a coupling medium, said tank having a narrow lower surface, at least one ultrasonic transducer driving means attached to and suspended beneath said lower surface for driving ultrasonic waves through said coupling medium, said transducer comprising at least two stacks of magnetostrictive laminations linked by a single coil of insulated wire, and means for providing a biasing magnetic field in each of said stacks of laminations.

5. An ultrasonic denture cleaner comprising a tall and narrow vertically oriented open top tank at least partially filled with a coupling medium, said tank having a narrow lower surface, and at least one ultrasonic transducer driving means attached to and suspended beneath said lower surface for driving ultrasonic waves through said coupling medium, said transducer comprising a plurality of plates of piezoelectric material arranged in pairs and oriented with a first common polarity on each plate at the center of said pair and a second common polarity on each plate at the outside of said pair.

6. In combination, a sonic cleaning system comprising a container with a cross-sectional dimension which is relatively narrow along one axis and relatively wide along another axis which is at a right angle to said one axis, said container being characterized in that its wider dimension is approximately twice the narrower dimension, said container having a closed bottom and an open top on opposite ones of said narrow dimensions, electroacoustic transducer means bonded to the outside bottom surface of said container for transmitting mechanical vibrations through the bottom wall of said container, and a housing structure having a generally tubular shape, one end of said tubular housing structure having the same general contour as the contour of said container for receiving said container and forming a closure for said tubular housing.

7. The invention set forth in claim 6, and a base panel which has the same general contour as the contour of the opposite end of said tubular housing, said panel sealing the bottom of said housing, and means for mounting electronic components on said panel, said components being enclosed within the base of said tubular housing when said panel is attached thereto.

8. The invention set forth in claim 6, and further characterized in that said container is constructed from a pliable material, further characterized in that said container has a cap-like surface projecting around its open end and overhanging said housing structure, and still further characterized in that said cap-like surface conforms to the contour of one open end of said housing structure.

9. In combination, a sonic cleaning system comprising a container with a cross-sectional dimension which is relatively narrow along one axis and relatively wide along another axis which is at a right angle to said one axis, said container being characterized in that its wider dimension is approximately twice the narrower dimension, said container having a closed bottom and an open top on opposite ones of said narrow dimension, electroacoustic transducer means bonded to the outside bottom surface of said container for transmitting mechanical vibrations through the bottom wall of said container, said electroacoustic transducer means comprising at least two magnetostrictive vibrators, and a single coil of wire commonly associated with at least two separate magnetostrictive vibrators, and a housing structure having a generally tubular shape, one end of said tubular housing structure having the same general contour as the contour of said container for receiving said container and forming a closure for said tubular housing.

References Cited

UNITED STATES PATENTS

3,113,761	12/1963	Platzman	259—72
3,329,408	7/1967	Branson	259—72
3,357,684	12/1967	Kunnen	259—72

ROBERT W. JENKINS, Primary Examiner