

⑫

EUROPEAN PATENT APPLICATION

⑳ Application number: **90304656.3**

⑤① Int. Cl.⁵: **G10K 11/00, A47L 15/02**

㉔ Date of filing: **30.04.90**

③① Priority: **01.05.89 US 345889**
11.04.90 US 508085

④③ Date of publication of application:
07.11.90 Bulletin 90/45

⑧④ Designated Contracting States:
CH DE FR GB LI NL

⑦① Applicant: **Pedziwiatr, Edward Anthony**
50 Glenview Terrace
Cresskill, New Jersey 07626(US)

⑦② Inventor: **Pedziwiatr, Edward Anthony**
50 Glenview Terrace
Cresskill, New Jersey 07626(US)

⑦④ Representative: **Jones, Michael Raymond et al**
HASELTINE LAKE & CO. Hazlitt House 28
Southampton Buildings Chancery Lane
London WC2A 1AT(GB)

⑤④ **Ultrasonic induction apparatus and method.**

⑤⑦ Apparatus and method for inducing ultrasonic vibrations for use in an ultrasonic process, illustrated in the form of an ultrasonic cleaning process wherein ultrasonic vibrations are induced in a cleaning fluid in contact with an object to be cleaned for cleaning the object ultrasonically, utilize a sealed chamber within which ultrasonic fluid is confined separate from the cleaning fluid and isolated from the atmosphere, ultrasonic transducers associated with the sealed chamber for inducing ultrasonic vibrations in the ultrasonic fluid, and a coupling arrangement by which the vibrating ultrasonic fluid in the chamber is coupled with the cleaning fluid to induce ultrasonic vibrations in the cleaning fluid to accomplish the desired ultrasonic cleaning.

EP 0 396 363 A2

ULTRASONIC INDUCTION APPARATUS AND METHOD

This is a continuation-in-part of application serial number 345,889, filed May 1, 1989.

The present invention relates to ultrasonic apparatus and processes, and especially to ultrasonic treatment apparatus and processes such as ultrasonic cleaning apparatus and methods, and pertains, more specifically, to apparatus and method in which ultrasonic vibrations are induced for use in an ultrasonic process, such as induction in a cleaning fluid for ultrasonic cleaning of an object immersed in, or at least in contact with, the cleaning fluid.

Conventional ultrasonic cleaning usually is accomplished by immersing an object to be cleaned in a bath of cleaning fluid maintained in a reservoir in a cleaning tank and subjecting the bath to ultrasonic vibrations so as to induce within the cleaning fluid ultrasonic vibrations sufficient to establish what has become known as cavitation within the fluid. Such cavitation creates minute voids within the fluid, which voids tend to implode, thereby effecting a scrubbing action which accomplishes cleaning of the surfaces of the object immersed in the bath. The ultrasonic vibrations are induced by ultrasonic transducers, generally affixed to the tank, usually along the bottom wall of the tank, outside the bath, and driven by an ultrasonic generator so as to establish a resonance surface which vibrates and transmits ultrasonic vibrations to the fluid in the tank. In some instances, ultrasonic transducers are affixed to a resonance surface provided by a separate power bank which is immersed in the bath for inducing the requisite ultrasonic vibrations.

The transducers usually are affixed by bonding with a bonding material. The most commonly used ultrasonic transducers are ceramic transducers generally bonded to a resonance surface of the tank, or of a power bank, by epoxy bonding materials. Epoxy bonding materials, and like bonding materials commonly employed in connection with the affixation of ultrasonic transducers, generally are very hard and brittle, rendering these materials subject to cracking and the resultant failure to maintain the affixation necessary to attain the desired connection between the transducers and the tank wall, or the power bank, for the appropriate transfer of ultrasonic vibration to the cleaning fluid. Failure of the bond which holds a transducer in place not only defeats the effectiveness of the transducer, but can lead to burn-out of the transducer and breakdown of the ultrasonic generator which drives the transducer. Common causes of failure of the bond which secures the ultrasonic transducers in place within ultrasonic cleaning machines are as follows: An object is dropped into the

cleaning tank and strikes the tank bottom, or an immersed power bank, with sufficient force to break the bond and dislodge a transducer; The ultrasonic cleaning machine inadvertently is operated without cleaning fluid present in the tank so that the transducers and the ultrasonic generator are activated without a load, causing destruction of the bond and eventual breakdown of the transducers and the ultrasonic generator; The cleaning fluid is heated to a temperature which softens or even melts the bonding material, causing failure of the bond.

The present invention avoids the above-outlined causes of failure in that ultrasonic transducers are affixed to a sealed chamber containing an ultrasonic fluid, and the sealed chamber, in turn, is coupled for use in the ultrasonic process, such as being coupled to the cleaning fluid in an ultrasonic cleaning process so that rather than being bonded directly to a wall of the cleaning tank, or to a similar resonance surface of an immersible power bank, the transducers are coupled to the cleaning fluid through the ultrasonic fluid in the chamber. The chamber is sealed to confine the ultrasonic fluid and isolate the ultrasonic fluid from the atmosphere, and preferably is subjected to a vacuum to evacuate gases from the sealed chamber. In this manner, the transducers, and the bond between the transducers and the sealed chamber, are isolated from the reservoir of the cleaning tank in such a way that objects dropped against a wall of the tank will not affect the bond; the transducers always operate to effect ultrasonic vibrations in the ultrasonic fluid in the sealed chamber and cannot be operated inadvertently with no load; and the use of a heated cleaning fluid in the cleaning tank can be accommodated without deleterious effects on the bond since the heated cleaning fluid is separated from the bond by the ultrasonic fluid which can be cooled independently to maintain the bonding material below any critical softening or melting temperature. In addition, the use of a separate sealed chamber for the transfer of ultrasonic vibrations enables the extension of ultrasonic treatment processes, and especially ultrasonic cleaning, into areas heretofore not amenable to ultrasonic techniques.

Accordingly, the present invention provides apparatus and method having several objects and advantages, some of which may be summarized as follows: Resists failure of the source of ultrasonic vibrations in ultrasonic process apparatus and methods due to conditions likely to be encountered during use; enables greater flexibility and range of use of ultrasonic processes, and especially ultra-

sonic treatment and cleaning; opens new fields of use for ultrasonic process apparatus and methods; increases the reliability of ultrasonic process apparatus, and especially ultrasonic treatment and cleaning apparatus, without a concomitant increase in complexity; enables simplified operating procedures in the use of ultrasonic process apparatus and methods; and provides more rugged ultrasonic treatment and cleaning apparatus, capable of more widespread use, over a longer service life.

The above objects and advantages, as well as further objects and advantages, are attained by the present invention which may be described briefly as apparatus and method for inducing ultrasonic vibrations for use in an ultrasonic process, such as inducing ultrasonic vibrations in a cleaning fluid in contact with an object to be cleaned for cleaning the object in an ultrasonic cleaning process, the apparatus and method comprising: means for and the step of effecting ultrasonic vibrations in a confined ultrasonic fluid medium isolated from the atmosphere; and means for and the step of coupling the confined vibrating ultrasonic fluid medium for use in the ultrasonic process, such as coupling the confined ultrasonic fluid medium with the cleaning fluid in the ultrasonic cleaning process so as to induce ultrasonic vibrations in the cleaning fluid.

The invention will be understood more fully, while still further objects and advantages will become apparent, in the following detailed description of preferred embodiments thereof illustrated in the accompanying drawing, in which:

FIG. 1 is a laterally cross-sectioned, partially diagrammatic perspective view of an apparatus constructed in accordance with the invention;

FIG. 2 is a partially diagrammatic, lateral cross-sectional view of another apparatus constructed in accordance with the invention;

FIG. 3 is a partially diagrammatic, lateral cross-sectional view of still another apparatus constructed in accordance with the invention;

FIG. 4 is a partially diagrammatic, lateral cross-sectional view of yet another apparatus constructed in accordance with the invention;

FIG. 5 is a partially diagrammatic, lateral cross-sectional view of another apparatus constructed in accordance with the invention;

FIG. 6 is a laterally cross-sectioned, partially diagrammatic perspective view of another apparatus constructed in accordance with the invention; and

FIG. 7 is a partially diagrammatic, lateral cross-sectional view of still another apparatus constructed in accordance with the invention.

Referring now to the drawing, and especially to FIG. 1 thereof, an ultrasonic process is carried out in an ultrasonic treatment apparatus shown in the form of ultrasonic cleaning apparatus 10 construct-

ed in accordance with the invention and seen cleaning an object 12 ultrasonically. Object 12 is immersed in a bath of cleaning fluid 14 held within a reservoir 16 provided by a cleaning tank 20 of the apparatus 10. Cleaning tank 20 includes upwardly extending side walls 22 around the perimeter of the cleaning tank 20, forming the sides of the reservoir 16, and a bottom wall 24 forming the bottom of the reservoir 16.

A further wall 26 is located beneath the bottom wall 24 and includes an inside surface 28 spaced downwardly from the bottom wall 24 to establish a chamber 30 contiguous with the reservoir 16 and separated from the reservoir 16 by the common partition provided by bottom wall 24. Chamber 30 is filled with an ultrasonic fluid 32. Ultrasonic fluid 32, generally a liquid, is chosen from those fluids known in the art of ultrasonic cleaning for the ability to transmit ultrasonic vibrations most effectively. Among the more common ultrasonic fluids are mixtures of water and detergents, and chlorinated and fluorinated liquids, any of which is a suitable choice for ultrasonic fluid 32.

Ultrasonic generating means are coupled with the chamber 30 for generating ultrasonic vibrations within the ultrasonic fluid 32 in the chamber 30, the ultrasonic generating means being in the form of ultrasonic transducers 34 affixed to the outside surface 36 of the further wall 26, as by an adhesive 38, and an ultrasonic generator 40 connected to the ultrasonic transducers 34 by conductors 42. Upon activation of the ultrasonic generator 40, the ultrasonic transducers 34 will induce ultrasonic vibrations in the ultrasonic fluid 32 within the chamber 30. Since the chamber 30 is filled with ultrasonic fluid 32, the ultrasonic fluid 32 is contiguous with the common partition provided by bottom wall 24 of the cleaning tank 20, and the common partition, in combination with the ultrasonic fluid medium provided by ultrasonic fluid 32, serves as coupling means for coupling the vibrating ultrasonic fluid 32 with the cleaning fluid 14 in the reservoir 16 within the cleaning tank 20 so that ultrasonic vibrations are induced in the cleaning fluid 14 and the object 12 is cleaned ultrasonically.

In order to assure that the chamber 30 is filled with ultrasonic fluid 32 and that the medium provided by the ultrasonic fluid 32 is coupled appropriately with the cleaning fluid 14, a filler pipe 44 and a vent pipe 46 both communicate with the chamber 30 and extend upwardly to an elevation above the bottom wall 24 of the cleaning tank 20. Each of the pipes 44 and 46 has sealing means in the form of a cap 48. When the caps 48 are removed, chamber 30 is filled with ultrasonic fluid 32 and the ultrasonic fluid 32 is allowed to rise in the pipes 44 and 46 to a level which assures that the chamber 30 is filled and that ultrasonic fluid 32

is contiguous with the common partition provided by the bottom wall 24 of cleaning tank 20. In this manner, it is assured that the ultrasonic vibrations produced by the transducers 34 are propagated through the further wall 26, the ultrasonic fluid 32 and the bottom wall 24 of tank 20 to the cleaning fluid 14 in the reservoir 16. The chamber 30 is sealed to confine the ultrasonic fluid 32 within the chamber 30 and to assure that the desired ultrasonic vibrations are generated in the ultrasonic fluid 32 in chamber 30. It has been observed that if the ultrasonic fluid is exposed to the atmosphere, cavitation will decrease with the passage of time, so that the effectiveness of the generation of ultrasonic vibrations in the ultrasonic fluid will be diminished drastically. In order to avoid such diminishing effectiveness, ultrasonic fluid 32 is isolated from the atmosphere by sealing the chamber 30. By confining the ultrasonic fluid 32 to the sealed chamber 30, the effectiveness of the transducers 34 in generating ultrasonic vibrations in the ultrasonic fluid 32 is maintained and efficiency remains high.

The construction of apparatus 10 places the ultrasonic transducers 34 remote from the bottom wall 24 of the cleaning tank 20 and couples the ultrasonic transducers 34 to the cleaning fluid 14 in the reservoir 16 through the ultrasonic fluid 32 in chamber 30. Thus, the impact of any object 12 dropped into cleaning tank 20 and against the bottom wall 24 of the cleaning tank 20 will tend to be isolated from the ultrasonic transducers 34 in that the shock of the impact will be dispersed and dissipated by the ultrasonic fluid 32 in the chamber 30, and the bond provided by the adhesive 38 will remain undisturbed, even upon impact of a relatively heavy object on the bottom wall 24. Further, should apparatus 10 inadvertently be operated with little or no cleaning fluid 14 in the reservoir 16 of cleaning tank 20, the chamber 30 of ultrasonic fluid 32 will place a load on the ultrasonic transducers 34 and the ultrasonic generator 40 sufficient to enable such operation without burn-out or breakdown of either the ultrasonic transducers 34 or the ultrasonic generator 40.

Turning now to FIG. 2, another apparatus 110 illustrates one way in which the present invention facilitates the use of hot, or even very hot, cleaning fluids without deleterious effects upon the adhesive which bonds the ultrasonic transducers to the apparatus. Thus, apparatus 110 includes a bath of cleaning fluid 114 held within a reservoir 116 provided by a cleaning tank 120 of the apparatus 110. Cleaning tank 120 includes upwardly extending side walls 122 around the perimeter of the cleaning tank 120, forming the sides of the reservoir 116, and a bottom wall 124 forming the bottom of the reservoir 116. A further wall 126 is located beneath

the bottom wall 124 and is spaced downwardly from the bottom wall 124 to establish a chamber 130 contiguous with the reservoir 116 and separated from the reservoir 116 by the common partition provided by bottom wall 124. Chamber 130 is filled with an ultrasonic fluid 132.

Ultrasonic generating means are coupled with the chamber 130 for generating ultrasonic vibrations within the ultrasonic fluid 132 in the chamber 130, the ultrasonic generating means being in the form of ultrasonic transducers 134 affixed to the outside surface 136 of the further wall 126, as by an adhesive 138, and an ultrasonic generator 140 connected to the ultrasonic transducers 134 by conductors 142. Upon activation of the ultrasonic generator 140, the ultrasonic transducers 134 will induce ultrasonic vibrations in the ultrasonic fluid 132 within the chamber 130. Since the chamber 130 is filled with ultrasonic fluid 132, the ultrasonic fluid 132 is contiguous with the common partition provided by bottom wall 124 of the cleaning tank 120, and the common partition, in combination with the ultrasonic fluid medium provided by ultrasonic fluid 132, serves as coupling means for coupling the vibrating ultrasonic fluid 132 with the cleaning fluid 114 in the reservoir 116 within the cleaning tank 120 so that ultrasonic vibrations are induced in the cleaning fluid 114, all as described in connection with the embodiment of FIG. 1, above. As before, chamber 130 is sealed and the ultrasonic fluid 132 is confined and isolated from the atmosphere.

The sealed chamber 130 of ultrasonic fluid 132 serves as a buffer between the hot cleaning fluid 114 and the adhesive 138 which bonds the ultrasonic transducers 134 to the outer surface 136 of the further wall 126 of chamber 130, thereby enabling the use of higher temperatures in the cleaning fluid 114 without compromising the integrity of the bond provided by the adhesive 138. For further protection of the adhesive bond between the ultrasonic transducers 134 and the outer surface 136, the ultrasonic fluid 132 is circulated through a heat exchanger 150 to cool the ultrasonic fluid 132 and maintain the temperature at the adhesive 138 within acceptable limits. Thus, a pump 152 circulates the ultrasonic fluid 132 through a conduit 154 which communicates with the chamber 130 and the heat exchanger 150.

The embodiment of FIG. 3 is similar to that of FIG. 2, and like component parts are referred to by the same reference characters; however, in the embodiment of FIG. 3, rather than circulating the ultrasonic fluid 132 itself through heat exchanger 150, the conduit 154 is connected to a cooling coil 156 which passes through the sealed chamber 130, and the ultrasonic fluid 132 in the chamber 130, and a heat exchange medium 158 is circulated by

the pump 152 through a closed circuit provided by the cooling coil 156 and the conduit 154 to the heat exchanger 150, thereby effectively maintaining the temperature at the adhesive 138 within acceptable limits. The chamber is sealed at 148 and the ultrasonic fluid 132 is confined and isolated from the atmosphere.

Referring now to FIG. 4, another embodiment of the invention is illustrated in connection with apparatus 210 in which an object 212 is to be cleaned ultrasonically. A cleaning fluid 214 is held within a reservoir 216 in a cleaning tank 220 having side walls 222 and a bottom wall 224. An ultrasonic cleaning unit 226 is immersed within the reservoir 216 of cleaning fluid 214 and includes a sealed chamber 230 filled with an ultrasonic fluid 232. Ultrasonic transducers 234 are affixed to the outer surface 236 of an inner chamber wall 238 and are connected to an ultrasonic generator 240 by means of conductors 242.

Ultrasonic cleaning unit 226 includes a housing 244 which is divided by the inner chamber wall 238 into the chamber 230 and a compartment 246 contiguous with and outside the chamber 230, within which compartment 246 the ultrasonic transducers 234 are placed. Compartment 246 is sealed against the cleaning fluid 214, and to that end includes a seal 248 so that together, the compartment 246 and the seal 248 serve as enclosure means enclosing the transducers 234 against contact with the cleaning fluid 214. The ultrasonic fluid 232 in the chamber 230 is confined and sealed within the chamber 230 and is coupled with the cleaning fluid 214 through the portion of the chamber wall at 250 so that ultrasonic vibrations induced by operation of the ultrasonic transducers 234 in the ultrasonic fluid 232 will be transmitted to the cleaning fluid 214 for accomplishing ultrasonic cleaning of object 212. As in the earlier-described embodiments, the ultrasonic transducers 234 are located remote from the reservoir 216 so that the transducers 234 are protected against the impact of dropped objects to be cleaned and against operating without a load sufficient to preclude burn-out or breakdown. Ultrasonic cleaning unit 226 merely is immersed within the bath of cleaning fluid 214 in reservoir 216 and rests upon the bottom wall 224 of tank 220 along a basal portion 252 of the housing 244, remote from coupling portion 250 of the chamber wall, and thus renders ultrasonic cleaning available in a much wider range of applications than available heretofore by virtue of the ability to immerse the unit in a wide variety of cleaning tanks.

Turning now to FIG. 5, the present invention makes available ultrasonic cleaning in semi-dry applications, such as in the cleaning of objects in the form of floors, either carpeted or not, and like

surfaces. An ultrasonic cleaning unit 310 includes a chamber 312 filled with an ultrasonic fluid 314. Ultrasonic fluid 314 is confined and sealed within chamber 312 and is isolated from the atmosphere. A plurality of ultrasonic transducers 316 are affixed to an upper wall 318 of the sealed chamber 312 and are connected to an ultrasonic generator 320 through conductors 322. The chamber 312 includes a lower wall 324 which is to be placed against a surface to be cleaned, as illustrated by a floor surface 326. A film of cleaning liquid 328 is maintained between the lower wall 324 of the chamber 312 and the surface 326, and ultrasonic vibrations induced in the ultrasonic fluid 314 in chamber 312 by the operation of ultrasonic transducers 316 are transmitted to the cleaning liquid 328 for effecting cleaning of the surface 326 by virtue of the coupling of the lower wall 324 with the cleaning liquid 328.

Ultrasonic cleaning unit 310 is translated along the surface 326 to accomplish cleaning. Lower wall 324 of the chamber 312 preferably is provided with a channeled configuration, as illustrated at 330, for enhancing the ability of the lower surface 332 of the lower wall 324 to maintain an effective film of cleaning liquid 328 while utilizing a minimum volume of cleaning liquid. Thus, channels 334 extend along the lower surface 332 and assist in retaining a film of cleaning liquid 328 between the lower surface 332 and the surface 326 to be cleaned. In addition, the channeled configuration assists in scrubbing yielding surfaces, such as carpeted surfaces, in that the ribs 336 between the channels 334 can penetrate into the yielding surface somewhat to enhance cleaning.

Referring now to FIG. 6, the ability to generate ultrasonic vibrations within the ultrasonic fluid 32 in the chamber 30 of ultrasonic cleaning apparatus 10 is enhanced by evacuating gases from the chamber 30. To this end, a source of vacuum, such as a vacuum pump 50, communicates with the chamber 30 through a valve 52. Upon filling the chamber 30 with ultrasonic fluid 32, valve 52 is opened and gases within the chamber 30 are evacuated. Valve 52 then is closed to seal the chamber 30 and confine the ultrasonic fluid 32 within the chamber 30, isolated from the atmosphere. Such removal of gases increases the ability to generate ultrasonic vibrations within the ultrasonic fluid 32 in the sealed chamber 30 and enhances the mechanism by which ultrasonic cleaning is attained; namely, cavitation is promoted by the removal of gases from the ultrasonic fluid 32. It is noted that as a result of the evacuation of gases, there is a slight downward bowing of the bottom wall 24 of the cleaning tank 20, and the bottom wall 24 is tensioned somewhat. The bowing and tensioning of the bottom wall 24 enhances the coupling of the ultrasonic fluid 32

with the cleaning fluid 14 in the cleaning tank 20 for more effective induction of ultrasonic vibrations in the cleaning fluid 14.

In a similar manner, the ability to generate ultrasonic vibrations within the ultrasonic fluid 232 in chamber 230 of ultrasonic cleaning unit 226 is enhanced by evacuating gases from the chamber 230. Thus, as seen in FIG. 7, a source of vacuum, such as a vacuum pump 260, communicates with the chamber 230 through a valve 262. Upon filling the chamber 230 with ultrasonic fluid 232, valve 262 is opened and gases within the chamber 230 are evacuated. Valve 262 then is closed to seal the chamber 230 and confine the ultrasonic fluid 232 within the chamber 230, isolated from the atmosphere. Such removal of gases increases the ability to generate ultrasonic vibrations within the ultrasonic fluid 232 within the sealed chamber 230 and enhances the mechanism by which ultrasonic cleaning is attained; namely, cavitation is promoted by the removal of gases from the ultrasonic fluid 232. It is noted that the evacuation of gases from chamber 230 is sufficient to cause a slight bowing inwardly of the chamber wall at 264. The bowing and tensioning of the chamber wall at 264 enhances the transmission of ultrasonic vibrations from the ultrasonic fluid 232 to the article to be cleaned.

It will be seen that the present invention enables apparatus and methods which resist failure of the source of ultrasonic vibrations in ultrasonic process apparatus and methods due to conditions likely to be encountered during use; enable greater flexibility and range of use of ultrasonic processes, and especially ultrasonic cleaning; opens new fields of use for ultrasonic process apparatus and methods; increases the reliability of ultrasonic process apparatus, and especially ultrasonic treatment and cleaning apparatus, without a concomitant increase in complexity; enables simplified operating procedures in the use of ultrasonic process apparatus and methods; and provides more rugged ultrasonic process apparatus, and especially ultrasonic treatment and cleaning apparatus, capable of more widespread use, over a longer service life.

It is to be understood that the above detailed description of preferred embodiments of the invention is provided by way of example only. Various details of design, construction and procedure may be modified without departing from the true spirit and scope of the invention as set forth in the appended claims.

Claims

1. Apparatus for inducing ultrasonic vibrations for use in an ultrasonic process, the apparatus

comprising:

means for effecting ultrasonic vibrations in a confined ultrasonic fluid medium isolated from the atmosphere; and

5 means for coupling the confined vibrating ultrasonic fluid medium externally of the confined ultrasonic fluid medium for use in the ultrasonic process.

2. Apparatus for inducing ultrasonic vibrations for use in an ultrasonic process, the apparatus comprising:

10 a chamber;

an ultrasonic fluid within the chamber;

15 sealing means for sealing the chamber such that the ultrasonic fluid is confined within the chamber and isolated from the atmosphere;

ultrasonic generating means coupled with the sealed chamber for generating ultrasonic vibrations within the ultrasonic fluid in the sealed chamber; and

20 coupling means for coupling the vibrating ultrasonic fluid externally of the sealed chamber for use in the ultrasonic process.

3. Apparatus for inducing ultrasonic vibrations for treating an object ultrasonically, the apparatus comprising:

25 a chamber;

an ultrasonic fluid within the chamber;

30 sealing means for sealing the chamber such that the ultrasonic fluid is confined within the chamber and isolated from the atmosphere;

ultrasonic generating means coupled with the sealed chamber for generating ultrasonic vibrations within the ultrasonic fluid in the sealed chamber; and

35 coupling means for coupling the vibrating ultrasonic fluid with the object to be treated externally of the sealed chamber.

4. Ultrasonic process apparatus for treating an object immersed in a treating fluid, the apparatus comprising:

40 a treatment tank having a reservoir for holding the treating fluid and receiving the object for immersion in the treating fluid in the treatment tank;

45 a sealed chamber contiguous with the reservoir in the treatment tank and isolated from the reservoir for containing an ultrasonic fluid contiguous with the treatment tank and isolated from the treatment fluid in the reservoir and confined within the sealed chamber so as to be isolated from the atmosphere; and

50 ultrasonic generating means coupled with the sealed chamber for generating ultrasonic vibrations in the ultrasonic fluid within the sealed chamber and propagating the ultrasonic vibrations through the ultrasonic fluid such that ultrasonic vibrations will be induced in the treating fluid in the reservoir to treat the object immersed within the treating fluid in the treatment tank.

5. Apparatus for inducing ultrasonic vibrations in a cleaning fluid in contact with an object to be cleaned for cleaning the object ultrasonically, the apparatus comprising:

means for effecting ultrasonic vibrations in a confined ultrasonic fluid medium isolated from the atmosphere; and
means for coupling the confined vibrating ultrasonic fluid medium with the cleaning fluid to induce ultrasonic vibrations in the cleaning fluid.

6. Apparatus for inducing vibrations for cleaning an object ultrasonically, the apparatus comprising:

a chamber;

an ultrasonic fluid within the chamber;

sealing means for sealing the chamber such that the ultrasonic fluid is confined within the chamber and isolated from the atmosphere;

ultrasonic generating means coupled with the sealed chamber for generating ultrasonic vibrations within the ultrasonic fluid in the sealed chamber; and

coupling means for coupling the vibrating ultrasonic fluid with the object to be cleaned externally of the sealed chamber.

7. Apparatus for inducing ultrasonic vibrations in a cleaning fluid in contact with an object to be cleaned for cleaning the object ultrasonically, the apparatus comprising:

a chamber;

an ultrasonic fluid within the chamber;

sealing means for sealing the chamber such that the ultrasonic fluid is confined within the chamber and isolated from the atmosphere;

ultrasonic generating means coupled with the sealed chamber for generating ultrasonic vibrations within the ultrasonic fluid in the sealed chamber; and

coupling means for coupling the vibrating ultrasonic fluid with the cleaning fluid so as to induce ultrasonic vibrations in the cleaning fluid.

8. Ultrasonic cleaning apparatus for cleaning an object immersed in a cleaning fluid, the apparatus comprising:

a cleaning tank having a reservoir for holding the cleaning fluid and receiving the object for immersion in the cleaning fluid in the cleaning tank;

a sealed chamber contiguous with the reservoir in the cleaning tank and isolated from the reservoir for containing an ultrasonic fluid contiguous with the cleaning tank and isolated from the cleaning fluid in the reservoir and confined within the sealed chamber so as to be isolated from the atmosphere; and

ultrasonic generating means coupled with the sealed chamber for generating ultrasonic vibrations in the ultrasonic fluid within the sealed chamber and propagating the ultrasonic vibrations through the ultrasonic fluid such that ultrasonic vibrations will

be induced in the cleaning fluid in the reservoir to clean the object immersed within the cleaning fluid in the cleaning tank.

9. Apparatus according to any one of claims 2 to 4 and 6 to 8, wherein the apparatus includes a compartment contiguous with and outside the sealed chamber, the ultrasonic generating means including at least one ultrasonic transducer within the compartment and affixed to the sealed chamber.

10. Apparatus according to claim 9, which also includes enclosure means for enclosing the ultrasonic transducer within the compartment against contact with the cleaning fluid so that the sealed chamber may be immersed within the cleaning fluid without contact between the cleaning fluid and the ultrasonic transducer.

11. Apparatus according to any one of claims 2 to 4 and 6 to 8, which also includes heat exchange means coupled with the sealed chamber for removing heat from the ultrasonic fluid.

12. Apparatus according to claim 11, wherein the heat exchange means includes means for circulating the ultrasonic fluid outside the chamber to cool the ultrasonic fluid outside the sealed chamber.

13. A method of inducing ultrasonic vibrations for use in an ultrasonic process, the method comprising:

effecting ultrasonic vibrations in a confined ultrasonic fluid medium isolated from the atmosphere; and

coupling the confined vibrating ultrasonic fluid medium externally of the confined ultrasonic fluid medium for use in the ultrasonic process.

14. A method of inducing ultrasonic vibrations in a cleaning fluid in contact with an object to be cleaned for cleaning the object ultrasonically, the method comprising:

effecting ultrasonic vibrations in a confined ultrasonic fluid medium isolated from the atmosphere; and

coupling the confined vibrating ultrasonic fluid medium with the cleaning fluid to induce ultrasonic vibrations in the cleaning fluid.

15. A method according to claim 13 or 14, wherein the ultrasonic fluid medium is confined within a chamber and there is also included the step of evacuating gases from the chamber within which the ultrasonic fluid medium is confined and then sealing the chamber.

16. A method of inducing ultrasonic vibrations in a treating fluid in contact with an object to be treated for treating the object ultrasonically, the method comprising:

effecting ultrasonic vibrations in a treating fluid medium confined within a sealed chamber so as to be isolated from the atmosphere; and juxtaposing the sealed chamber with the treating

fluid to couple the vibrating ultrasonic fluid medium with the treating fluid for the induction of ultrasonic vibrations in the treating fluid.

17. A method according to claim 16, wherein the juxtaposition of the sealed chamber with the treating fluid includes immersing the sealed chamber within the treating fluid. 5

18. A method of inducing ultrasonic vibrations in a cleaning fluid in contact with an object to be cleaned for cleaning the object ultrasonically, the method comprising; 10

effecting ultrasonic vibrations in an ultrasonic fluid medium confined within a sealed chamber so as to be isolated from the atmosphere; and juxtaposing the sealed chamber with the cleaning fluid to couple the vibrating ultrasonic fluid medium with the cleaning fluid for the induction of ultrasonic vibrations in the cleaning fluid. 15

19. A method according to claim 18, wherein the juxtaposition of the sealed chamber with the cleaning fluid includes immersing the sealed chamber within the cleaning fluid. 20

20. A method according to any one of claims 16 to 19, which includes evacuating gases from the chamber and then sealing the chamber. 25

30

35

40

45

50

55

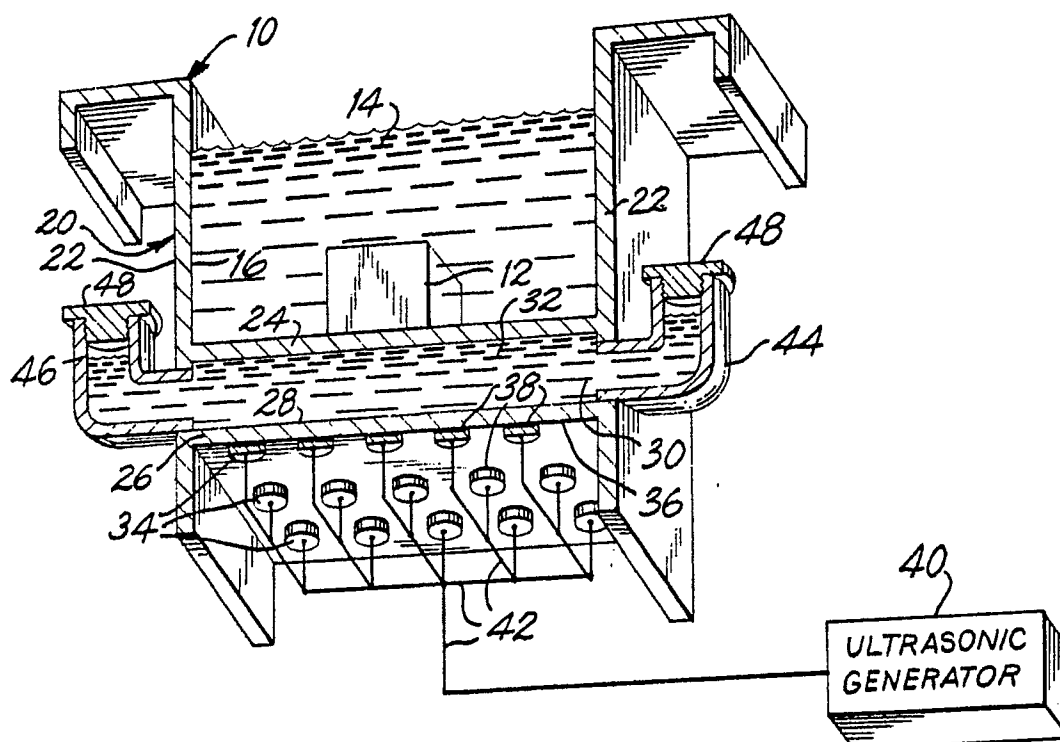


FIG. 1

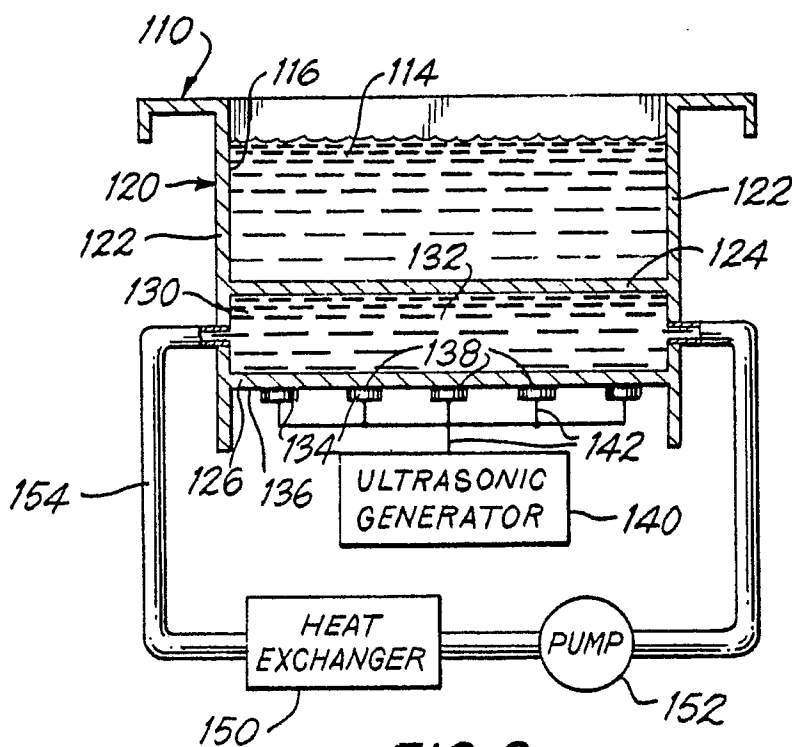
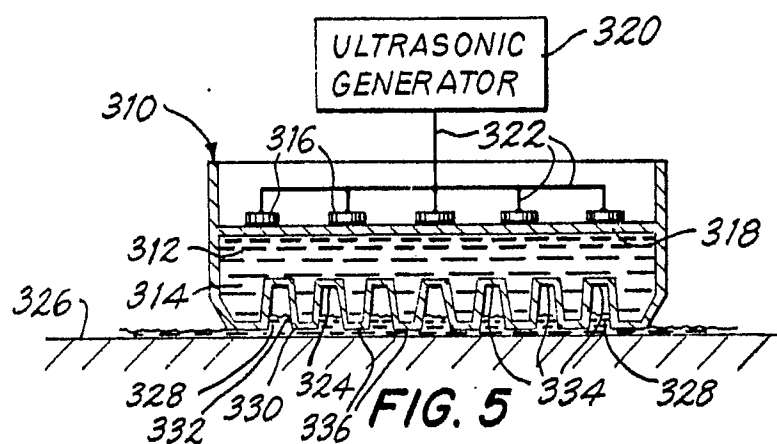
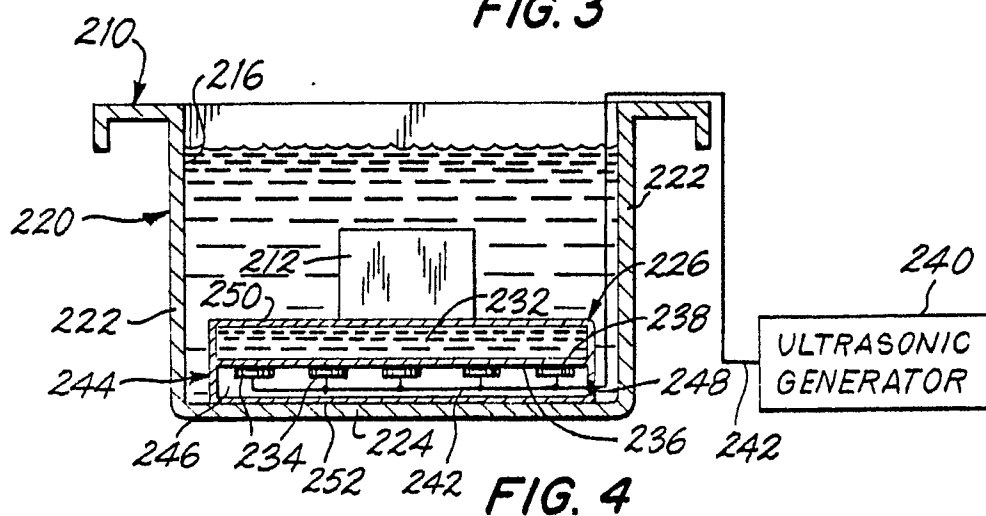
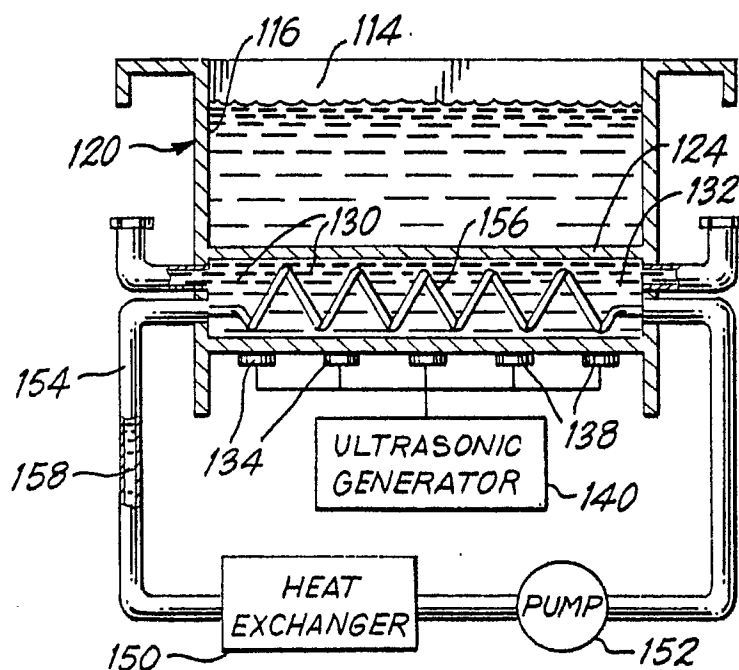


FIG. 2



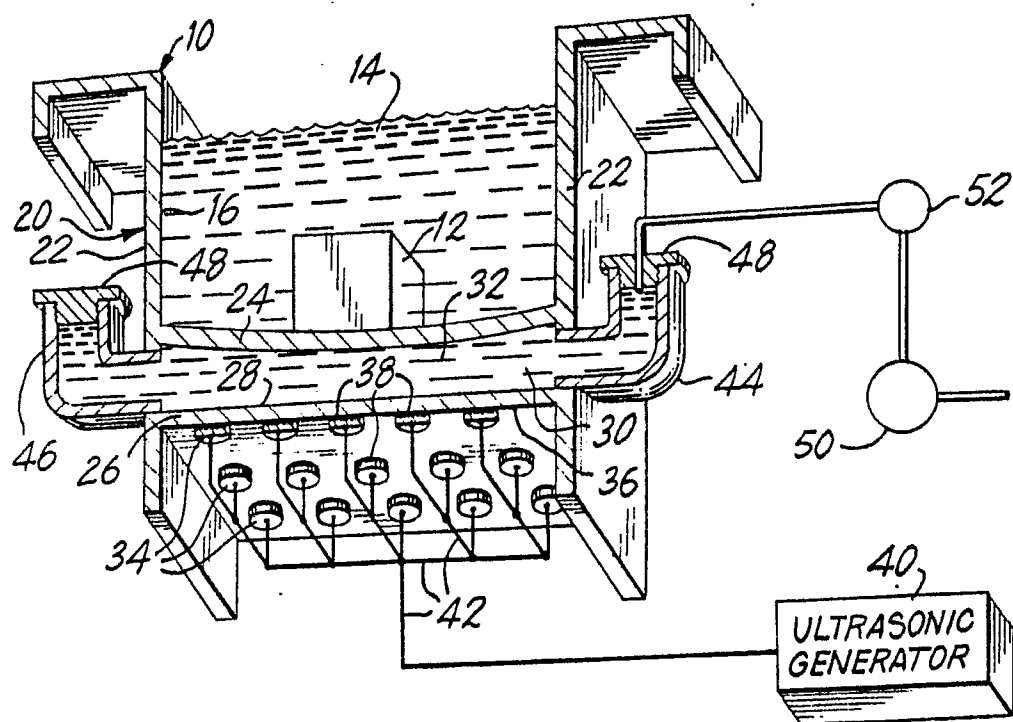


FIG. 6

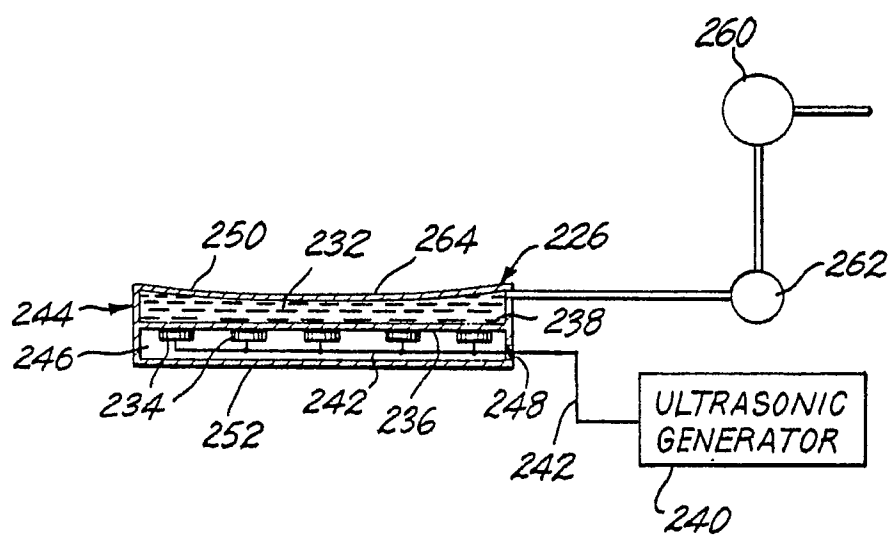


FIG. 7