

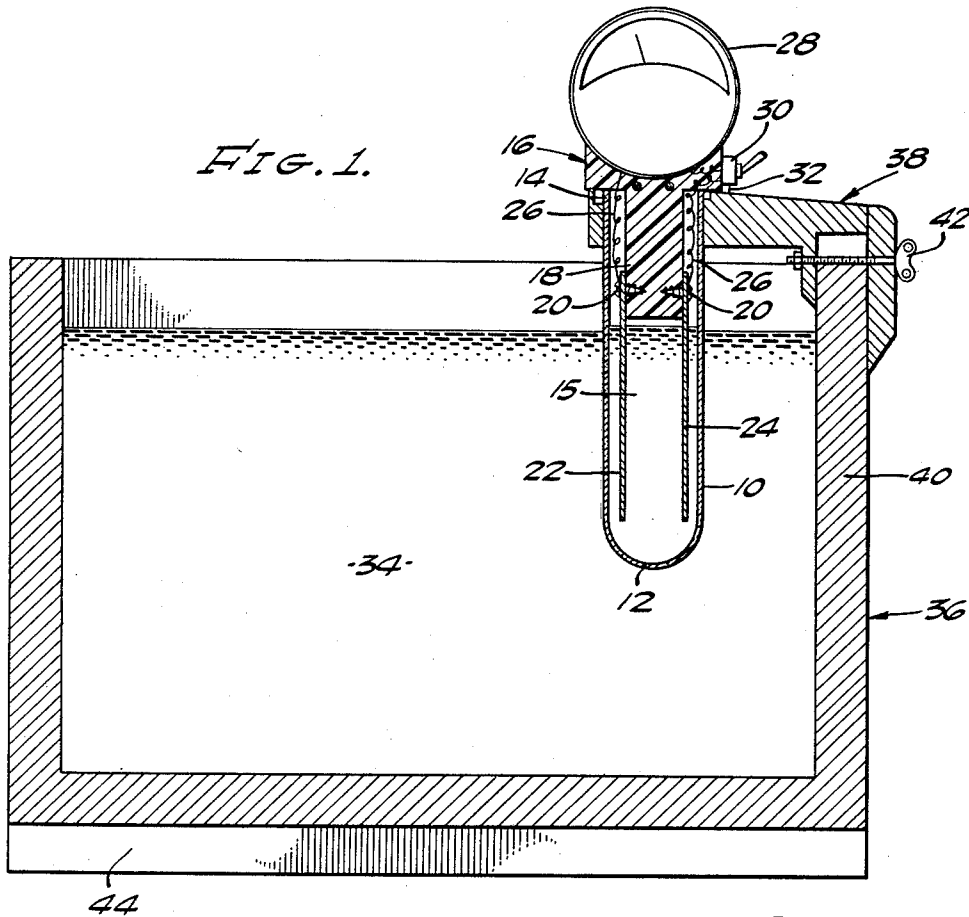
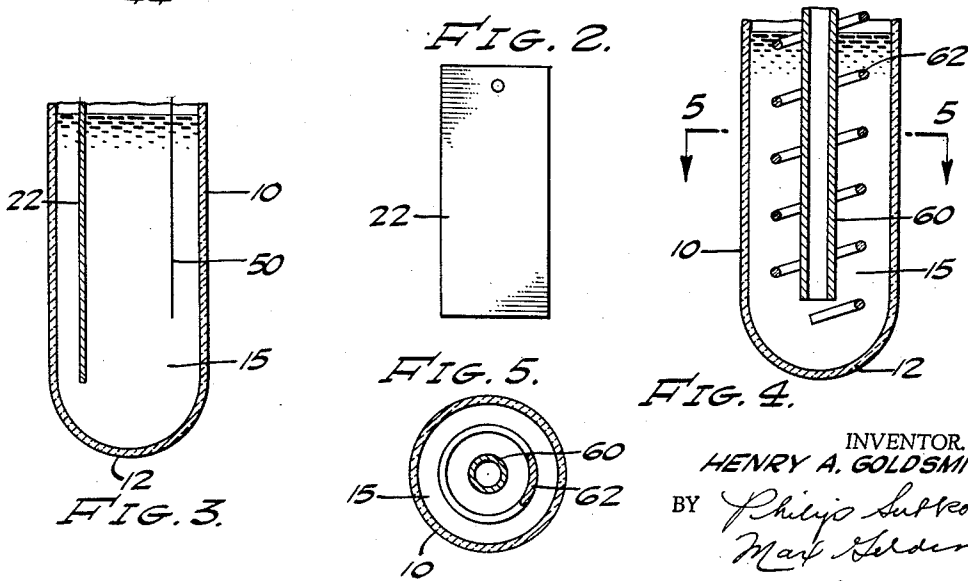
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PROCESS AND DEVICE FOR DETECTING THE
INTENSITY OF ULTRASONIC ENERGY

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PROCESS AND DEVICE FOR DETECTING THE INTENSITY OF ULTRASONIC ENERGY

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This invention relates to the use of ultrasonic energy in cleaning and other wet processing baths, and is particularly concerned with a method and device for quantitatively evaluating the efficiency of the ultrasonic radiation in an ultrasonic processing bath.

The application of ultrasonic energy to cleaning or processing baths to augment or enhance the action thereof is well known. Thus, it has been found in the case of ultrasonic cleaning that it can reduce labor costs and raise quality standards. Ultrasonic cleaning is particularly useful and economically feasible when it eliminates or reduces manual operations such as brushing, wiping or handling of parts. Also, when the shape or complexity of a part makes cleaning or inspection difficult, or when cleanliness standards are high, ultrasonic cleaning is a valuable technique. Various industries such as the metal, plastics, jewelry, surgical instrument, and optical glass industries are employing ultrasonic techniques. Ultrasonic cleaning installations employing conveyor lines for movement of work now handle large volumes of work with a relatively minor amount of manual labor. Similar results are obtained by the application of ultrasonic energy to other wet processes, such as deburring, descaling, emulsifying, or plating, and cleaning processes may serve as a typical example for all of these.

It is considered authoritatively that the improved removal of surface "soil" from parts submerged in an ultrasonic cleaning tank is due to cavitation occurring in the liquid. Cavitation is produced by sonic energy or sound waves transmitted to the liquid by the ultrasonic transducer. These sound waves consist of rapid changes of pressure which cause the rapid formation and collapse of minute cavities in the liquid. Such cavitation in effect tears minute holes or cavities in the liquid, then closes them. In ultrasonic cleaning, the cavitation is produced by sonic vibrations usually at frequencies above the audible range of the average human, e.g. above approximately 18 kilocycles per second (kc./sec.). Lower frequencies of the order of about 10 kc./sec. have sometimes been employed, but industrial ultrasonic cleaning equipment has been designed to operate at frequencies from about 18 kc./sec. up to as high as 1 megacycle/sec. (1000 kc./sec.).

Cavitation in liquids due to ultrasonic energy, assists in the removal of surface soil or other undesirable contamination by a mechanical eroding action, or by increasing the solvent action of the liquid, or by facilitating chemical attack by the solution, or a combination of these actions. This results in a removal and transfer of the soil or contamination from the surface of the submerged part to the liquid in the cleaning tank. The efficiency of such cleaning or soil removal in many instances depends on the intensity of the ultrasonic radiation.

Transducers employed as the source of the ultrasonic energy can be of various types. Thus, for example, a magnetostrictive transducer can be utilized, or a piezoelectric transducer based on quartz or barium titanate crystals can be employed for this purpose.

Various qualitative or quantitative methods have been employed to estimate or measure the magnitude of the ultrasonic energy, or the degree of effectiveness of an ultrasonic bath. Thus, the force of cavitation has been estimated in a qualitative manner by its ability to per-

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rate immersed aluminum foils of a given thickness in a given period. The number and type of perforations and dents, as well as their distribution, permit the evaluation of the efficiency, or lack of it, of an ultrasonic bath. Aside from being qualitative, this test is not sufficiently sensitive and cannot be used in corrosive baths.

A quantitative method of measuring the force of cavitation in an ultrasonic bath involves the determination of weight losses resulting from the corrosion of immersed specimens of suitable metals, such as brass or lead, in a given period of time. This allows overall evaluation of certain bath conditions, but is much too slow to follow the state of cavitation in the bath at any given time. The method is also considered to be insufficiently accurate.

The sound pressure of ultrasonic baths may be evaluated in terms of the voltage it produces in an immersed transducer or hydrophone, but such a device is limited by its large size, high price, and relative lack of sensitivity.

Other methods which have been employed to measure the cleaning effectiveness of ultrasonic baths involve determinations of soil removal, either by inspection or by quantitative measurements of reflectance or weight loss. In these methods, the effect of the chemical makeup of the bath tends to obscure the contributions of the force of the cavitation because a combination of both these factors produces the measured effect. Other empirical evaluation tests are frequently employed.

However, heretofore, no simple quantitative method or device has been known for rapidly or almost instantaneously measuring the ultrasonic activity or amount of cavitation in an ultrasonic processing system under a variety of conditions.

It is an object of this invention to provide a method for substantially quantitatively determining the effectiveness of an ultrasonic processing bath.

Another object is the provision of procedure for measuring the intensity of the ultrasonic energy and of the cavitation induced in a bath by the ultrasonic waves in an ultrasonic processing, e.g. cleaning operation.

Still another object is to provide a technique useful in the laboratory and in the field to determine if a given processing, e.g. cleaning, solution is operating under optimum conditions for utilizing ultrasonic energy.

Yet another object is to afford a process to determine whether the ultrasonic energy produced in a given processing or cleaning solution under certain conditions is sufficiently intense or is of a nature such that it may enhance the efficiency of the solution over and above its efficiency in the absence of such ultrasonic energy.

Yet another object is to provide a simple process for measuring essentially quantitatively the ultrasonic radiation produced in an ultrasonic processing bath, particularly an ultrasonic cleaning bath, and applicable for determining a variety of parameters, including for example, determination of the optimum conditions of temperature and cleaner concentration, and effect of contamination of the cleaning solution by soil and other deposits removed from processed parts.

It is yet a further object to provide a simple device for carrying out the invention procedure, which is reliable, inexpensive, and can be readily handled and used in the field.

Other objects and advantages of the invention will be apparent from the following description.

The invention is based on the discovery that when a cell comprising a pair of spaced dissimilar electrodes is immersed in an electrolyte solution and the electrodes have been short circuited externally of the solution, when such solution is subjected to ultrasonic radiation, an electrode reaction occurs which results in a change in current flow in the cell, and such change in current flow can be used to measure the intensity of the ultrasonic activity or

the resulting cavitation. Thus, such electrode reaction may be a depolarization which results in an increased current flow in the cell which is generally proportional to the intensity of the ultrasonic radiation.

I have found, for example, that if a bimetallic voltaic cell which undergoes high polarization and which has sufficient potential to give a substantial current, is exposed to ultrasonic radiation, the resulting increase in current flow in the cell as compared to the relatively low current generated in the cell in the absence of ultrasonic radiation, can be employed to measure the intensity of such radiation under various bath conditions. Such increase in current flow in a given bath has been found to be a function of transducer power, bath deaeration, and bath resonance. Other factors such as bath temperature and electrode composition also tend to affect the increased current flow, and may be compensated for by reference to current flow in the absence of ultrasonic radiation. When the ultrasonic radiation is discontinued, current flow returns in a relatively short time to its relatively low equilibrium or starting value.

The intensity of ultrasonic radiation, termed herein the "activity" or "ultrasonic activity" of the bath, is defined herein as the maximum increase in cell current at a given ultrasonic radiation ($I_x - I_0$), where I_x is the maximum current of the cell on exposure to a given ultrasonic radiation and I_0 is the equilibrium cell current in the absence of such radiation, divided by the equilibrium current I_0 .

Briefly, the cell preferably employed comprises an envelope or sheath composed of any sound transmitting material such as glass or metals, e.g., a glass tube or a thin stainless steel envelope, containing an electrolyte in which are submerged a pair of spaced electrodes preferably formed of two different metals sufficiently spaced apart in the electromotive series of elements to give a substantial current, such electrodes being short circuited through a current measuring device such as a milliammeter.

I have found that a bimetallic cell containing copper and magnesium electrodes gives satisfactory response, stability and all-round performance, according to the invention. Such a cell shows a substantial increase in amperage when subjected to ultrasonic radiation, probably as result of depolarization caused by cavitation. For example, a cell composed of a copper and a magnesium plate in tap water was found to produce an initial current of 0.8 milliamp which increased to 2.7 milliamps with a maximum input of power to the transducer at optimum bath resonance. This effect was found to respond to increases and decreases of such power to the transducer, tuning to maximum resonance, and other variables of the ultrasonic activity. Other suitable electrode systems can however be employed, e.g. a combination of copper and zinc electrodes.

The electrodes should be immersed in the electrolyte to a depth sufficient to produce a substantial current increase when the ultrasonic radiation is applied. The factor which controls the effective length of the electrodes which should be used is the minimum frequency of ultrasonic radiation having practical utility. In preferred practice the length of the electrodes immersed in the electrolyte is not less than one half the wave length of minimum frequency output of the transducer, and most desirably not less than one full wave length of such frequency output. However, in order to obtain reproducible results rapidly, and to stabilize the current produced by the cell, the electrode length should be sufficient to intercept at least two node points of the standing ultrasonic wave. Hence, the length of the electrodes immersed in the electrolyte preferably should be at least equal to a single wave length, e.g. between one and 3 wave lengths, of the frequency of ultrasonic radiation, for best operation. It has been found that it is generally not desirable to use a frequency less than about 18 kilocycles per second because below that frequency, the sound waves become audible and the resulting operation becomes noisy. Based on the frequency

value of 18 kc./sec., the preferred minimum length of electrode should be about $2\frac{1}{2}$ inches. Using ultrasonic radiation of about 18 to 20 kc./sec., the length of electrodes immersed in the electrolyte may be about $2\frac{1}{2}$ to 3 inches. If desired, one electrode may be immersed in the electrolyte to a greater depth than the other. In preferred operation the frequency of ultrasonic radiation is between about 18 and 24 kc./sec. However, higher frequencies can be employed, and where these higher frequencies are employed, the depth of the electrodes immersed in the electrolyte required to obtain a full wave length of immersion can be less than the above noted length of $2\frac{1}{2}$ inches.

While it is possible to immerse the electrodes for a length equal to one half the wave length or less of the ultrasonic radiation frequency employed, since this shorter electrode will intercept only one of the nodes of the standing wave, under these conditions it is necessary to adjust the position of the electrode in the electrolyte after the ultrasonic radiation is turned on in order to obtain a "hot spot," that is, a location where the electrode intercepts a node of the standing ultrasonic wave, before maximum current readings can be obtained, thus increasing the time required to take readings, and reducing reproducibility of results.

It may also employ electrodes of various shapes. Thus, both electrodes may have the same shape, e.g. they may both be formed of thin rectangular sheets, or they may be of different shapes. Thus, I have found particularly advantageous the use of an unbalanced cell, wherein the anode has a substantially greater surface area than the cathode, thus providing high cathodic current density. For example, an unbalanced cell wherein the cathode is a copper wire and the anode is a rectangular magnesium plate has been found to give faster and more complete polarization after the ultrasonic energy is turned off, as will be made more apparent hereinafter. This is, after obtaining the aforementioned current value I_x of the cell subjected to ultrasonic radiation, the cell is removed from the bath or the ultrasonic energy is turned off to obtain the I_0 current reading, which is the equilibrium cell current reading in the absence of ultrasonic energy. Employing the latter type unbalanced cell with a small cathode and a large anode, the equilibrium I_0 reading can be obtained much more quickly, e.g. in about half the time, and reaches a lower value because of the more complete polarization produced under these conditions, as compared to a similar cell in which both the cathode and anode are of substantially the same size.

Also, I may employ an unbalanced cell wherein, for example, the large electrode, e.g. the magnesium anode, is in the form of a slotted or perforated cylinder and the other electrode, e.g. the copper cathode, is a wire positioned within the cylinder coaxially with or parallel to the axis of, the cylinder, or I may employ a cell in which the magnesium electrode is a centrally disposed tube and the copper electrode is an outwardly concentrically disposed spiral, or wherein the magnesium anode is in the form of a panel and the copper cathode is in the form of a tube.

In my cell I can employ as electrolyte any solution which will produce rapid polarization of the cell but still permit some flow of current. The electrolyte used should be one which does not completely inhibit the current flow, and its action should not be so rapid as to cause deterioration of the cell in a short period. While tap water alone can be employed as electrolyte, I preferably employ an electrolyte which produces a suitable level of conductivity, and preferably a dilute solution of a substantially neutral material such as sodium sulfate, or sodium lauryl sulfate (the latter marketed as Duponal ME), or sodium lignin sulfonate. A concentration of such material in the solution, ranging from about 0.125 to about 2% by weight, has been found particularly successful from the standpoint of initial current response, sensitivity, and stability of the cell over a relatively long period of continued operation.

The cell activity will vary to some degree depending on the specific amount of electrolyte material, e.g. sodium lauryl sulfate, employed. Examples of other electrolytes which can be employed include, for example, magnesium sulfate, alkylated diphenyl oxide, sodium sulfonate, and the alkali metal salts of ethylene diamine tetracetic acid, but the cells containing such electrolyte materials have inferior response as compared to use of sodium lauryl sulfate.

The addition of a small amount of hydroquinone to the electrolyte solution, e.g. about 0.10 to about 1% hydroquinone by weight of solution, has been found desirable to obtain reproducible cell current and to render the cell more stable and responsive. The hydroquinone is believed to function as an oxygen scavenger, and facilitates polarization following interruption of the ultrasonic radiation, and thus affords a more rapid return of the cell current to its equilibrium I_0 reading, and such equilibrium value is maintained more constant over a period of use. Thus, for example an electrolyte containing about 0.5% sodium lauryl sulfate and about 0.25% hydroquinone has proved highly useful. Instead of hydroquinone, I may employ other oxygen absorbing or readily oxidizable materials, e.g. hydroxy aromatic compounds such as pyrogallol or resorcinol, and in amounts in substantially the same range as in the case of hydroquinone.

I have also found that the addition of an alkali metal bicarbonate such as sodium bicarbonate to the electrolyte also improves the action of the cell. It is believed that the sodium bicarbonate has a buffering action, and in the copper and magnesium cell of the invention, reacts with the magnesium hydroxide formed at the magnesium electrode to produce magnesium carbonate and sodium carbonate, thus tending to maintain the pH of the electrolyte relatively constant, and improve the stability of the cell. Other buffering agents such as a borate also may be employed in such cell, but alkali metal bicarbonate is preferred because it leaves the electrodes. The pH of the copper-magnesium cell should be maintained below pH 11, and preferably between neutral and moderately alkaline, e.g. about 7 to about 9. I can employ about 0.10% to about 1% of buffering agent such as alkali metal bicarbonate, by weight of solution. The buffering agent, e.g. bicarbonate, can be used in combination with the oxygen absorber, e.g. hydroquinone or resorcinol. Thus, a mixture of hydroquinone and sodium bicarbonate can be utilized in an amount of about 0.10% to about 1% of said mixture by weight of the solution. However, the alkali metal bicarbonate can be employed in the absence of the oxygen absorbing material.

The use of corrosion inhibitors such as sodium chromate in the electrolyte should be avoided, since they rapidly suppress cell activity. The use of strong acids such as HCl, which produce little polarization, should also be avoided since they are too corrosive, reducing the life of the cell, and such cell is not very responsive. Alkaline electrolytes inhibit the cell and drastically reduce its current.

Cell currents may range from 0 to about 20 milliamps, and usually, particularly in the preferred magnesium-copper bimetallic system containing sodium lauryl sulfate and a small amount of hydroquinone, such current may vary from about 2 to about 12 milliamps when operating at a temperature between room temperature and 180° F.

The use of two or more of my cells in series, producing higher voltages, was found to result in a slightly faster cell response, whereas such cells connected in parallel or in opposition provided no apparent advantages. With the cells connected in series, the system usually requires only a short period (aside from the time necessary for temperature adjustments) to come to its maximum current, on exposure of the cells to ultrasonic radiation, and requires about 2 to 3 minutes, after the ultrasonic radiation is turned off, to return to its equilibrium, or so-called "zero" current, I_0 .

The life of the cell, in terms of a stable current output, can be extended by replacing the electrolyte with fresh electrolyte from time to time, and employing hydroquinone, preferably in combination with sodium bicarbonate, as above described, and by keeping the cell circuit open when the cell is not in use.

In preferred practice, the cell employed in the invention is separate and apart from the ultrasonic bath itself, that is, it contains its own enclosure and its own electrolyte, and the cell is immersed in the ultrasonic bath whose ultrasonic energy is to be measured, according to the invention. However, my system of bimetallic electrodes without an enclosing envelope, can be submerged in the ultrasonic bath itself, in which case the bath forms the electrolyte for the cell. However, under these circumstances, the behavior of the cell is subject to many uncontrollable variables such as bath contamination, concentration changes, unsuitable electrolytes and stray currents. When the cell employed in the invention contains its own enclosure or envelope, and its own electrolyte, it has the advantage of reproducibility under a variety of conditions. Thus, the same cell may be employed in measuring ultrasonic radiation in different tanks or in different baths.

The invention device will be more clearly understood by reference to the description below, taken in connection with the accompanying drawing, wherein:

FIG. 1 illustrates one embodiment of the bimetallic cell mounted on an ultrasonic tank;

FIG. 2 is a view of a typical electrode as used in the cell of FIG. 1;

FIG. 3 illustrates another embodiment of the bimetallic cell of the invention, showing a modified electrode system;

FIG. 4 illustrates another modification of my electrode system;

FIG. 5 is a section taken on line 5—5 of FIG. 4; and
FIG. 6 illustrates still another modified form of cell according to the invention.

In FIG. 1 of the accompanying drawing there is shown for purposes of illustration one embodiment of a cell according to the invention. The cell comprises a glass envelope 10 closed at its lower end 12 and open at its upper end 14, e.g. a glass test tube having a diameter of about 1½ inches, and containing an electrolyte solution 15 such as an aqueous solution containing about 0.5% sodium lauryl sulfate and about 0.125% hydroquinone. Removably mounted on the open upper end of the tube 10 is an insulator support 16 which has a depending portion 18 suspended in the upper end of the tube above the surface of the electrolyte therein. Mounted by means of screws 20 along opposite sides of the depending portion 18 of the insulator support, are a pair of electrodes 22 and 24, both in the form of rectangular plates as seen in FIG. 2, which are submerged in the cell electrolyte 15. One of these electrodes, say 22, can be formed of a metal such as magnesium, and the other electrode 24 may be copper. In the instant embodiment, about 2 inches of each of the electrodes 22 and 24 are immersed in the electrolyte, equivalent to more than one wave length of the ultrasonic radiation at the frequency of operation. The electrodes are composed of different materials or metals such as magnesium and copper. Electrical leads 26 connect each of the electrodes to a milliammeter indicated at 28 which is mounted on the top of the insulator support 16. A switch 30 is provided in the circuit.

In use the cell shown in FIG. 1 is immersed in the liquid charge 34 contained in the ultrasonic tank 36 by mounting the tube 10 and insulator support 16 of the cell on a bracket 38 which may be attached to the wall 40 of the ultrasonic tank, by means of a clamp 42. The switch 30 of the cell is grounded by electrically connecting it at 32 to the bracket 38.

A commercially available transducer, indicated at 44, is cemented to the bottom of tank 36, or alternatively,

may be mounted on a side wall of the tank, or immersed in the bath itself. It will be noted that preferably the tube 10 of the cell is immersed in the ultrasonic bath 34 at a level such that the meniscus of the electrolyte 15 in the cell is at about the same level as the surface of the liquid charge 34 in the ultrasonic tank. The cell may be positioned in a similar manner in the ultrasonic tank when the transducer is mounted on the side walls of the tank or in the bath itself.

In FIG. 3 is shown another embodiment of my device in the form of an unbalanced cell. The cell shown in this figure is the same as that shown in FIG. 1 except that one of the electrodes 50, the cathode, is in the form of a wire. Hence the cell of FIG. 3 can comprise a magnesium plate 22 as anode and a copper wire 50, e.g. a 1/8 inch copper wire, as cathode, and such wire is immersed in the electrolyte a depth less than the depth of immersion of the anode 22.

In FIGS. 4 and 5 is shown another unbalanced type of cell according to the invention, wherein the electrode system comprises a centrally positioned anode in the form of a tube 60, which may be magnesium, and a cathode in the form of an outwardly concentrically disposed spiral 62, which may be copper.

In FIG. 6 is shown another modified form of cell comprising an electrode, e.g. a copper cathode, in the form of a tube 70, and an electrode, e.g. a magnesium anode, in the form of a plate or panel 72 immersed in the electrolyte 15 contained in the envelope 10, the outer surface of the anode plate 72 being larger than the outer surface area of the cathode tube 70. The cathode tube 70 is supported from a cap 74 placed in the upper open end of the envelope 10, and the anode panel 72 is suitably connected to a conductive support 76 which in turn is supported by the cap 74. The upper end of the tube 70 has attached thereto a flexible tube 78, which in turn is connected to a reservoir of electrolyte solution (not shown).

A leveler tube 80, formed of plastic, glass or a metal inert to the electrolyte of the cell, is also positioned within the cell envelope 10 and supported by the cap 74, so that the lower end of tube 80 is at a location corresponding to a predetermined level at which the electrolyte 15 in envelope 10 is desired to be maintained. The upper end of tube 80 has attached thereto a flexible drain tube 82, the opposite end of which is connected to a capillary flow regulator 84. An electrical lead 86 is soldered or otherwise connected to the upper end of electrode 70, and to a switch 88, the other pole of the switch being connected via lead 90 to one terminal of the milliammeter 23. The upper end of conductor 76 is electrically connected via lead 92 to the other terminal of milliammeter 23.

In operation of the cell of FIG. 6 the electrolyte 15 is fed from a reservoir (not shown) by gravity via tube 78 and the interior of the electrode tube 70 to the interior of envelope 10, and drainage of electrolyte from the body of electrolyte solution in envelope 10 takes place simultaneously via tubes 80 and 82, the rate of drainage flow being regulated by the capillary tip 84. The surface of the electrolyte in the cell should be maintained at a substantially constant level for best results. In this manner, the electrolyte in the cell is continuously replaced with fresh electrolyte and the strength of the electrolyte in the cell is maintained substantially constant, resulting in a cell which remains relatively stable over a longer period than the cells of FIGS. 1 to 5. That is, the equilibrium current I_0 for the cell of FIG. 6 is reproducible for a given set of temperature conditions over an extended period. The cell of FIG. 6 is accordingly a preferred embodiment of the invention.

In normal operation of the ultrasonic tank, the bath therein is first deaerated. This may be accomplished by subjecting the bath to ultrasonic radiation for a period of time by turning on the power to the transducer 44. Deaeration of an ultrasonic bath tends to increase the ultrasonic activity of the bath. Complete deaeration of an

aqueous bath may require, say, from about 1 1/2 to about 2 hours, depending on the temperature, and may result in doubling the ultrasonic activity of the bath. In using the ultrasonic bath the ultrasonic activity thereof may be varied by varying the power to the transducer and by tuning to a condition of resonance. The bath may be heated or cooled to obtain the temperature level desired for its operation.

To now measure the ultrasonic activity of the tank for a given set of conditions, the power to the ultrasonic transducer is turned on partially, e.g. half way, and the bath is tuned to the ultrasonic frequency most effective for producing a well defined standing wave in the ultrasonic tank. Tuning of the ultrasonic bath can be accomplished roughly by a visual observation of ripples breaking through the surface of the bath, or by other means such as by use of the aluminum foil test above mentioned, wherein the sharpness or degree of scatter of the dents produced in the foil indicates the sharpness of tuning. However, much more precise tuning can be obtained by mounting the cell of the invention on the ultrasonic tank as shown in FIG. 1 of the drawing, and adjusting the frequency of the ultrasonic radiation until a maximum current reading on the milliammeter 23 of the cell is obtained. Tuning of the ultrasonic bath results in standing waves which produce maximum turbulence at the nodes as result of cavitation. Optimum frequencies will vary with variations in the depth of liquid in the ultrasonic tank and/or the nature of immersed objects in the tank. Such tuning to maximum ultrasonic activity will be indicated by a maximum current reading (I_x) on the milliammeter 23, when the power to the transducer is turned on full. Hence optimum channels of ultrasonic frequency can be selected by tuning for the greatest cell current output.

To measure the equilibrium current in the absence of ultrasonic radiation, the current to the transducer is then turned off, or the cell is removed from the bath. Employing the cell of FIG. 1, cell current may be simultaneously broken by opening the circuit through actuation of the switch 30, e.g. for a period of about 30 seconds, and the cell circuit is then closed again for about 2.5 minutes to establish its equilibrium current value in the absence of ultrasonic energy. The resulting current reading at the milliammeter 23 corresponds to I_0 . The ultrasonic activity of the cell can then be computed by the expression:

$$\frac{I_x - I_0}{I_0} \times 100 \quad (1)$$

It has been found that this ratio is substantially directly proportional to the intensity of the ultrasonic radiation to which the cell is subjected.

If desired, the above operation for obtaining the equilibrium current value can be carried out leaving the switch in the cell circuit closed for the entire period following interruption of the ultrasonic energy, and until current equilibrium in the cell is obtained.

When employing an unbalanced cell, e.g. the cell of FIG. 3, FIG. 4, or FIG. 5, the operation can be the same as that described above, but a lower I_0 reading will be obtained than that obtained using the cell of FIG. 1.

Further, using the cell of FIG. 3, for example, and employing substantially the same procedure as that described above, the cell of FIG. 3 reaches the I_0 or equilibrium current considerably more quickly than that of FIG. 1, and a reading may be obtained with the cell of FIG. 3 in about 1 to 1.5 minutes.

For another set of bath conditions, say at a higher bath temperature or following a cleaning cycle during which the bath in the tank has become contaminated, the ultrasonic activity of the bath can again be measured with the cell, by repeating the above procedure, that is, obtaining I_x and I_0 under this new set of conditions and computing the ultrasonic activity from the mathematical expression (1) above. This will indicate whether such activity has decreased or increased as result of changes in the bath

conditions, such as change of temperature (which is known to produce a change in ultrasonic activity) or contamination of the bath as result of the cleaning process, and hence affords an accurate measurement of the ultrasonic effectiveness of the bath.

Also, if desired, the increase in ultrasonic activity of the bath resulting from deaeration can be measured readily by use of my cell. Here the ultrasonic activity can be measured at the commencement of the deaeration period when the ultrasonic energy is first applied, using the procedure described above and the expression (1) above. After obtaining the values of I_x and I_0 at the initial stage of deaeration, such procedure can be repeated from time to time until deaeration has been completed, thus permitting calculation of the ultrasonic activity at various stages of deaeration. The increase in ultrasonic activity due to deaeration is thus readily determined.

As previously noted, ultrasonic activity varies with bath temperature. In water the optimum temperature of the ultrasonic bath for obtaining maximum activity is about 105 to 110° F., with activity nearly as good over the broader range of 95 to 125° F. The ultrasonic activity at any particular temperature can be determined in the above described manner with my cell. When the cell is placed in the tank, it should be allowed first to attain the same temperature as the bath in the tank before current measurements are made. When equilibrium temperature is reached in the cell, the above described procedure for measuring ultrasonic activity employing my cell is carried out.

The technique of the invention can be employed to evaluate the effect of the presence of contaminants or soil in the ultrasonic bath, on ultrasonic activity, and is also of value in obtaining data on the relative effectiveness of various cleaning solutions employed with ultrasonic radiation, and on the effect of varying the cleaner concentration. Thus, for example, the presence of soil in an ultrasonic bath generally tends to lower its ultrasonic activity as indicated by a lower ratio of $(I_x - I_0)/I_0$. The ultrasonic effectiveness of various cleaners, as measured by the invention technique, may be compared to such activity in water alone. Generally, a high activity indicates that the use of ultrasonic radiation with such a cleaner solution effectively enhances the cleaning action thereof. Where the ultrasonic activity is low in a particular cleaner solution, e.g. as in methylene chloride, even though the cleaner itself may be an effective one per se, such low ultrasonic activity signifies that ultrasonic radiation does not substantially enhance the cleaning action thereof. Hence the invention technique for rapidly measuring in a quantitative manner, the ultrasonic activity of the bath as a function of the increase in current which it produces in the cell, permits the development of effective cleaning formulations which may combine detergency with favorable ultrasonic cleaning action.

The following are examples of practice of my invention:

EXAMPLE 1

An ultrasonic tank 7 inches in length, 8½ inches in width, and 6 inches deep, and containing water to a depth of about 4½ inches, was deaerated for a period of one hour at room temperature by exposure to ultrasonic energy from a magnetostrictive transducer of a proprietary type cemented to the bottom of the tank. The particular transducer employed was a laboratory transducer rated at 15 watts/sq. inch and operating at 20 ± 1 kc./sec.

The ultrasonic energy was then turned off and a bimetallic cell of the type shown in FIG. 1 was then mounted on the ultrasonic tank as shown in FIG. 1. The cell had a glass tube envelope about 1½ inches in diameter and contained 50 cc. of an electrolyte consisting of water containing 0.5% sodium lauryl sulfate and 0.25% hydroquinone. One of the electrodes (the anode) of this cell was magnesium while the other was copper. Both were of rectangular shape, 1¼ inch in width, with about 2½

inches of the length of both electrodes immersed in the electrolyte.

When the temperature of the cell electrolyte attained equilibrium with the temperature of the water in the ultrasonic tank, which was 98° F., the switch in the cell circuit was closed and the power to the transducer was again turned on full. The frequency of the ultrasonic radiation was adjusted to produce the highest current reading on the cell milliammeter, thus tuning the cell to resonant frequency.

The current registering on the milliammeter gradually rose and in about 1-2 minutes the current attained a steady maximum reading of 6.4 milliamps. This is the I_x value corresponding to the ultrasonic activity or intensity of the ultrasonic bath.

The power to the ultrasonic transducer was then turned off, and the milliammeter reading of the cell commenced to drop. In about 3 minutes, the milliammeter reading was 2.8 milliamps and at the end of 5 minutes was 2.7 milliamps. This value was the cell current equilibrium value, a condition at which the electrodes have again become polarized in the absence of ultrasonic energy. This is the I_0 reading. From these values of I_x and I_0 the ultrasonic activity of the cell can be calculated as follows:

$$\frac{I_x - I_0}{I_0} \times 100 = \frac{6.4 - 2.7}{2.7} \times 100 = 137$$

EXAMPLE 2

The same procedure was carried out as in Example 1, except that a cell of the type shown in FIG. 3 was employed, having a magnesium anode in the form of a rectangular strip 1½ inch in width and having 2¾ inches of the length thereof immersed in the electrolyte, and employing as cathode a ¼ inch copper wire having a length of 1¾ inches immersed in the electrolyte. The same cell electrolyte as in Example 1 was employed, but the volume of electrolyte in the cell was 65 cc.

The I_x reading obtained was 6.4 milliamps. One minute after the ultrasonic energy was turned off, the current in the cell had fallen to 2.1 milliamps; after 3 minutes it had fallen to 1.9 milliamps; and after 5 minutes to 1.8 milliamps. Using the 2.1 value as the I_0 value, the ultrasonic activity obtained with the cell of FIG. 2 was

$$\frac{6.4 - 2.1}{2.1} \times 100 = 204$$

The 2.1 milliamps value was selected as the I_0 or equilibrium value because absolute equilibrium current values are not required in order to obtain equally reproducible comparative test results. That is, it is feasible to use the first value for "equilibrium" current which begins to asymptotically approach the true equilibrium value, even though it is higher than the true value. This is the preferred procedure because of the desirability of the desirability of reducing the time requirements for any single determination of ultrasonic activity. Thus it is preferable to select a particular time when each of the "equilibrium" current values will be read, say one minute in the present case. Thus, the term "equilibrium value" as employed herein does not necessarily denote the true equilibrium value, but includes values which substantially approach the true equilibrium value. Hence "equilibrium current" as employed herein is a time dependent factor.

Thus, in Example 1 above, although the 2.7 milliamps value obtained in 5 minutes may be considered the true equilibrium value, the 2.8 milliamps value attained in 3 minutes can be employed because it substantially approaches the equilibrium value with a time saving of 2 minutes. If the 2.8 value is employed, then subsequent comparative readings taken with the same cell should be taken at a time of 3 minutes after the ultrasonic radiation is turned off instead of 5 minutes thereafter.

It is thus seen that employing the cell of FIG. 3, "cur-

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rent equilibrium" was reached substantially in 1 minute at 2.1 milliamps, after the ultrasonic energy was turned off, and using the cell of FIG. 1, the "equilibrium" I_0 value was attained substantially in about 3 minutes and at a higher I_0 reading of 2.8. Hence it is apparent that the cell of FIG. 3 reaches equilibrium much more rapidly than the cell of FIG. 1, and the equilibrium current value using the cell of FIG. 3 being lower than that with the cell of FIG. 1, results in higher ultrasonic activity values than those for the cell of FIG. 1 for substantially the same bath conditions, providing a greater spread for the comparative evaluation of the ultrasonic activity as between various bath conditions. It will be understood of course that such comparisons of ultrasonic activity must always be based on the use of the same cell, in order to obtain the desired invention results.

EXAMPLE 3

The procedure of Example 1 for measuring ultrasonic activity, was carried out, using a cell substantially as described in Example 1. The method was repeated at varying temperatures, in two different tanks, one tank being a large tank of 12 liters capacity having an ultrasonic transducer capable of delivering 9 watts/sq. inch and the other a small tank of 5 liters capacity having an ultrasonic transducer of 15 watts/sq. inch rating. In this case, however, when the transducer was turned off, the switch of the cell was opened to ground for 30 seconds, and then closed for 2½ minutes, at which time the I_0 reading was obtained. Both transducers were operated on inputs of 0.45 amp.

Table I

LARGE TANK

Temp., °F.	80	82	88	96	104	108	112	122	133	143	148
I_x	7.4	7.9	8.2	10.5	11.0	10.5	8.8	11.5	11	13	12.5
I_0	3.2	3.4	3.5	4.0	4.2	4.0	3.3	4.4	4.6	5.6	5.8
Activity	124	132	134	162	162	162	164	162	139	132	115

Table II

SMALL TANK

Temp., °F.	76	80	92	106	118	136	142	156	160	168	178
I_x	6.0	6.8	7.6	8.4	8.6	12	12	13	12	12	12
I_0	2.8	3.0	3.2	3.6	3.8	5.4	5.6	6.2	6.4	6.7	7.4
Activity	115	126	138	133	126	122	114	110	88	80	62

From Tables I and II it is seen that the greatest ultrasonic activity in both tanks took place at between about 90 and 120° F., and that ultrasonic activity was greater in the large tank, reaching a maximum of 164, than in the small tank, where a maximum activity of 138 was attained.

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EXAMPLE 4

The procedure of Example 1 is repeated except employing as electrolyte in the cell water containing 1% sodium sulfate and 0.35% hydroquinone.

Results similar to those of Example 1 are obtainable.

EXAMPLE 5

The procedure of Example 1 is repeated employing as a further additive in the electrolyte about 0.20% sodium bicarbonate. Results closely approaching those of Example 1 are obtainable.

EXAMPLE 6

A cell of the type illustrated in FIG. 6 was provided, having a glass envelope 19, a copper cathode tube 79 of ½" outside diameter, and a magnesium anode plate 72. The electrolyte in envelope 19 was distilled water containing 0.125% sodium lauryl sulfate and 0.125% sodium bicarbonate, by weight of solution. The drainage of electrolyte from envelope 19 was regulated by the capillary tip 24 to produce a flow rate of 180 ml./hr. while the volume of electrolyte in envelope 19 was maintained at about 65 ml. Using this cell, a series of tests was carried out while subjecting the bath 34 and the cell positioned therein to ultrasonic radiation, over successive periods of heating and cooling of bath 34 and electrolyte 15, to obtain data on the ultrasonic activity of the bath 34 at various time intervals during these periods, such ultrasonic activities being obtained in a manner similar to the procedure of Example 1.

The results obtained are given on Table III below.

Table III

Elapsed time, mins.	30	85	97	105	120
Bath Temp., ° F.	100	122	90	95	132
I_{max}/I_0	8.4/3.4	9.4/4.3	9.2/3.8	8.8/3.7	9.4/4.6
Activity	147	118	142	138	102

Elapsed time, mins.	140	170	200	208
Bath temp., ° F.	97	114	120	105
I_{max}/I_0	8.8/3.7	10.2/4.3	9.3/4.3	9.8/4.1
Activity	138	143	125	140

EXAMPLE 7

The current measuring procedure of Example 1 was substantially carried out employing the cell described in Example 1 to obtain ultrasonic activities at varying temperatures in a tank of 12 liters capacity, in one bath containing water alone, in a second bath containing 0.3% Santomerse E, a sodium alkyl aryl sulfonate, and in a third bath containing 0.3% Marasperse N, a sodium lignyl sulfonate. The results are shown in Table IV below.

Table IV

ULTRASONIC CLEANING; EVALUATION OF BATH ACTIVITY BY VOLTAGE CELLS
EFFECT OF ANIONIC SURFACTANTS ON BATH ACTIVITY

Water only			0.3% Santomerse E			0.3% Marasperse N		
Temp., ° F.	I_{max}/I_0	Activity	Temp., ° F.	I_{max}/I_0	Activity	Temp., ° F.	I_{max}/I_0	Activity
80	7.4/3.2	124	78	6.0/2.9	105	78	8.0/3.4	135
82	7.9/3.4	132	80	5.8/2.5	108	82	8.8/3.6	151
88	8.2/3.5	134	100	6.6/3.2	108	88	10/3.8	163
96	10.5/4.0	162	100	9.2/4.0	130	102	12/3.2	186
104	11.0/4.2	162	110	10.5/4.5	132	114	10.5/3.8	175
108	10.5/4.0	162	118	8.0/3.8	110	116	12/4.4	172
112	8.8/3.3	164	126	11.0/5.0	120	124	10/3.8	161
122	11.5/4.4	162	130	7.0/4.3	63	128	12/4.7	155
133	11/4.6	139	141	9.5/5.6	70	135	16/6.2	138
143	13/5.6	132	145	6.4/4.8	33	143	15.5/6.4	142
148	12.5/5.8	115				152	13.0/6.0	117
156	11.5/6.3	83				162	12.7/6.0	72
164	10/6.4	57						

From Table IV, it is seen that Marasperse N, at 0.3% concentration, improved the ultrasonic activity of the bath over water alone. On the other hand, Santomerse E, at 0.3% concentration, lowered bath activity. This shows that Marasperse N will increase the ultrasonic effectiveness of the bath, whereas Santomerse E will probably not aid the ultrasonic effectiveness of the bath, although it may otherwise aid the cleaning action of the bath.

EXAMPLE 8

The current measuring procedure of Example 1 was substantially carried out using the cell of Example 1, for a series of tests in which additions of a solid soil, namely Celite Snowfloss, a type of diatomaceous earth, were made successively to the bath. The ultrasonic tank was a 12 liter tank, and temperature was maintained at 125° F. The results are given in Table V below:

Table V

Elapsed time, minutes	Additions made (total)	$I_{\max}/I_0$	Activity
0-----		11.0/5.1	115
15-----		9.2/5.1	80
16-18-----	1 g. Snowfloss/12.1	9.2/5.1	80
20-22-----	2 g. Snowfloss/12.1	8.4/5.1	65
24-26-----	3 g. Snowfloss/12.1	8.4/5.1	65
26-28-----	4 g. Snowfloss/12.1	8.2/5.1	61
30-32-----	6 g. Snowfloss/12.1	7.4/5.1	45
40-42-----	12 g. Snowfloss/12.1	6.8/5.1	33
85-100-----	Add 12 g. Marasperse N-----	9/5.1	76

From Table V, it is seen that as little as 2 grams of Snowfloss per 12 liters lowered the ultrasonic activity of the bath. When 12 grams of Snowfloss per 12 liters of bath (0.1%) was added, the bath activity was cut by about 60%. It is seen that the addition of 12 grams Marasperse N (0.1%) substantially restored the ultrasonic activity of the bath.

EXAMPLE 9

The current measuring procedure of Example 1 was substantially carried out employing the cell described in Example 1, for a series of tests with water and with various proprietary cleaner solutions, the ultrasonic activity for each cleaner being measured at various temperatures. Each of these tests were carried out in a 1.5 gallon ultrasonic tank.

The results are shown in Table VI.

Table VI
CALIBRATION WITH WATER ONLY

Temp., ° F-----	86	86	88	90	95	96	103	105	110	112	114
I_x -----	6.0	7.0	6.8	7.4	8.0	8.6	8.2	8.7	9.2	8.8	9.4
I_0 -----	3.0	3.0	3.2	3.2	3.5	3.8	3.6	3.7	4.2	3.9	4.1
Activity-----	100	132	112	130	128	127	128	135	118	126	129

PROPRIETARY CLEANER A—6% (8 OZ./GAL.) IN TAP WATER

Temp., ° F-----	93	94	100	108	125	135	150	168
I_x -----	6.6	8.0	9.8	8.4	10.5	11.5	12	11
I_0 -----	3.1	3.1	4.0	3.3	4.3	4.5	5.4	6.1
Activity-----	113	158	145	155	145	155	122	81

PROPRIETARY CLEANER B—20% BY VOL. IN TAP WATER

Temp., ° F-----	82	90	102	110	124
I_x -----	7.0	8.6	8.8	9.0	9.2
I_0 -----	2.8	3.2	3.2	3.4	4.0
Activity-----	150	168	175	165	130

PROPRIETARY CLEANER C—10% IN TAP WATER

Temp., ° F-----	86	102	106	112	120	134
I_x -----	7.7	9.4	8.4	10.2	10.2	7.8
I_0 -----	3.2	3.7	3.3	4.2	4.2	4.5
Activity-----	140	154	155	143	143	173

PROPRIETARY CLEANER D—5% BY VOL. IN TAP WATER

Temp., ° F-----	90	96	100	105	120	132	142
I_x -----	9.0	9.8	9.8	10.4	10.4	9.6	-----
I_0 -----	3.4	3.7	3.8	3.9	4.0	4.1	4.7
Activity-----	165	165	158	167	160	132	100

Table VI shows that the solutions of each of the cleaners tested had improved ultrasonic activity as compared to water alone, over substantially the entire temperature range at which tests were made, indicating increased effectiveness of these cleaner solutions by application of ultrasonic energy.

While it has been indicated that the invention described herein is believed based primarily on a polarization-depolarization electrode reaction, the invention is not to be taken as limited by such reaction, and the current changes produced in my cell, when it is subjected to ultrasonic radiation, may be brought about by other reactions or phenomena taking place at the electrodes, such as removal of a film or of ion barriers from the electrodes, or a combination of these various reactions.

It is accordingly seen from the foregoing, that the invention provides a procedure and device for quantitatively measuring the ultrasonic activity of an ultrasonic cleaning or processing bath, with particular application to the following parameters or phenomena: checking transducer design efficiency and output thereof; tuning the bath to maximum ultrasonic activity; selecting suitable ultrasonic frequencies; checking the degree of deaeration of an ultrasonic bath; determining optimum temperature conditions for greatest effectiveness of an ultrasonic bath; determining effect of contamination of cleaner solutions on ultrasonic activity; evaluating cleaners to determine effectiveness thereof with or without application of ultrasonic energy.

While I have described particular embodiments of my invention for the purpose of illustration, it should be understood that various modifications and adaptations thereof may be made within the spirit of the invention as set forth in the appended claims.

I claim:

1. The process for measuring the intensity of ultrasonic activity and of the resulting cavitation produced in a bath subjected to ultrasonic radiation, which comprises placing in said bath a cell comprising a sound transmitting envelope containing therein an electrolyte comprising a dilute aqueous solution of a substantially neutral material selected from the group consisting of sulfates and sulfonates, and which produces polarization of said cell, a pair of spaced electrodes composed of two different metals sufficiently spaced apart in the electromotive series of elements to give a substantial current when electrically connected in an external circuit, one of said electrodes being magnesium, said electrodes being immersed in said electrolyte to a depth not less than one half wave length of the ultrasonic radiation, and a current indicator in short circuit with said electrodes, with relatively low current generated in said cell and passing through said circuit, and exposing said bath and electrolyte to ultrasonic radiation, to cause a depolarizing electrode reaction to occur in said cell and to produce a consequent substantial increase in current in said circuit, for a period sufficient to obtain a maximum current value as shown by said current indicator.

2. The process for measuring the intensity of ultrasonic activity and of the resulting cavitation produced in

a bath subjected to ultrasonic radiation, which comprises placing in said bath a cell comprising a pair of spaced electrodes composed of two different metals sufficiently spaced apart in the electromotive series of elements to give a substantial current when electrically connected in an external circuit, one of said electrodes being magnesium, said electrodes being immersed in an electrolyte comprising a dilute aqueous solution of a substantially neutral material selected from the group consisting of sulfates and sulfonates, and which produces polarization of said cell, and a current indicator in short circuit with said electrodes, with relatively low current generated in said cell and passing through said circuit, and exposing said bath and electrolyte to ultrasonic radiation, to cause a depolarizing electrode reaction to occur in said cell and to produce a consequent substantial increase in current in said circuit, for a period sufficient to obtain a maximum current value as shown by said current indicator, discontinuing said ultrasonic radiation and permitting the current in said cell to attain a reduced equilibrium value, the ratio of the difference between said maximum and equilibrium cell current values, to said equilibrium current value being proportional to the ultrasonic activity of said bath.

3. The process for measuring the intensity of ultrasonic activity and of the resulting cavitation produced in a bath subjected to ultrasonic radiation, which comprises deaerating said bath, placing in said bath a cell comprising a pair of spaced electrodes one composed of copper, the other magnesium, said electrodes being immersed in an electrolyte comprising a dilute aqueous solution of a substantially neutral material selected from the group consisting of sulfates and sulfonates, and which produces polarization of said cell, and a current indicator in short circuit with said electrodes, with relatively low current generated in said cell and passing through said circuit, and exposing said bath and electrolyte to ultrasonic radiation, to cause a depolarizing electrode reaction to occur in said cell and to produce a consequent substantial increase in current in said circuit, for a period sufficient to obtain a maximum current value as shown by said current indicator, discontinuing said ultrasonic radiation and permitting the current in said cell to attain a reduced equilibrium value, the ratio of the difference between said maximum and equilibrium cell current values, to said equilibrium current value being proportion to the ultrasonic activity of said bath.

4. The process for measuring the intensity of ultrasonic activity and of the resulting cavitation produced in a bath subjected to ultrasonic radiation, which comprises immersing in said bath a bimetallic cell comprising an envelope composed of a sound transmitting material and containing therein an electrolyte comprising a dilute aqueous solution of a substantially neutral material selected from the group consisting of sulfates and sulfonates, and which produces polarization of said cell, a pair of spaced electrodes immersed in said electrolyte, said electrodes formed of two dissimilar metals sufficiently spaced apart in the electromotive series of elements to give a substantial but relatively low current when said electrodes are electrically connected in an external circuit, one of said electrodes being magnesium, and a current indicator in short circuit with said electrodes, said electrolyte producing polarization of the cell but permitting some current flow in said circuit, and exposing said bath and electrolyte to ultrasonic radiation to cause depolarization to occur in said bimetallic cell and to produce a consequent increase in current in said circuit for a period sufficient to obtain a maximum current value as shown by said current indicator, discontinuing said ultrasonic radiation and permitting the current in said cell to attain a reduced equilibrium value, the ratio of the difference between said maximum and equilibrium cell current values, to said equilibrium current value being proportional to the ultrasonic activity of said bath.

5. The process for measuring the intensity of ultrasonic activity and of the resulting cavitation produced in a bath subjected to ultrasonic energy, which comprises immersing in said bath a bimetallic cell comprising an envelope composed of a sound transmitting material and containing therein a pair of spaced electrodes, one formed of magnesium and the other of copper, said electrodes being immersed in an electrolyte in said cell, said electrolyte comprising a dilute aqueous solution of a substantially neutral material selected from the group consisting of sulfates and sulfonates, and which produces polarization of the cell but permitting current flow when said electrodes are electrically connected in an external circuit, and a current indicator in short circuit with said electrodes, and exposing said bath and electrolyte to ultrasonic radiation to cause depolarization to occur in said bimetallic cell and to produce a consequent increase in current in said circuit for a period sufficient to obtain a maximum current value as shown by said current indicator, discontinuing said ultrasonic radiation and permitting the current in said cell to attain a reduced equilibrium value, the ratio of the difference between said maximum and equilibrium cell current values, to said equilibrium current value being proportional to the ultrasonic activity of said bath.

6. The process for measuring the intensity of ultrasonic activity and of the resulting cavitation produced in a bath subjected to ultrasonic radiation, which comprises exposing said bath to ultrasonic radiation to deaerate said bath, immersing in said bath a bimetallic cell comprising a glass envelope containing therein a pair of spaced electrodes, one formed of magnesium and the other of copper, said electrodes being immersed in an electrolyte in said envelope, said electrolyte comprising a dilute aqueous solution containing sodium lauryl sulfate and hydroquinone, and a milliammeter in short circuit with said electrodes, subjecting said bath to an ultrasonic frequency corresponding to a maximum current value on said milliammeter, producing depolarization in said bimetallic cell, interrupting said ultrasonic radiation for a period sufficient to permit the current reading on said milliammeter to reduce to a substantially minimum equilibrium value in the absence of ultrasonic radiation, and determining the ultrasonic activity of said bath from the expression

$$\frac{I_x - I_0}{I_0} \times 100$$

where I_x is said maximum current value and I_0 is said equilibrium current value.

7. An electrolytic cell for measuring the intensity of ultrasonic activity and of the resulting cavitation produced in a bath subjected to ultrasonic radiation, which comprises a sound transmitting envelope containing therein a pair of spaced electrodes one formed of magnesium, the other copper, an electrolyte comprising a dilute aqueous solution containing from about 0.25% to about 2% by weight of sodium lauryl sulfate and about 0.10% to about 1% by weight of sodium bicarbonate, said electrodes being immersed in said electrolyte, and a current indicator connected in short circuit with said electrodes.

8. An electrolytic cell for measuring the intensity of ultrasonic activity and of the resulting cavitation produced in a bath subjected to ultrasonic radiation, which comprises a sound transmitting envelope containing therein an electrolyte solution comprising a dilute aqueous solution of a substantially neutral material selected from the group consisting of sulfates and sulfonates, and which produces polarization of said cell, a pair of spaced electrodes formed of two dissimilar metals, said electrodes immersed in said solution to a depth not less than about 2½ inches, and a current indicator connected in short circuit with said electrodes, said metals forming said electrodes being sufficiently spaced apart in the electromotive series of elements to give a current in said circuit, one of said electrodes being magnesium.

9. In combination with a tank, adapted to contain a

bath, and an ultrasonic transducer mounted in operative association with said tank for subjecting said bath to ultrasonic radiation, an electrolytic cell for measuring the intensity of ultrasonic activity and of the resulting cavitation produced in said bath when it is subjected to ultrasonic radiation, said cell being immersed in said bath, said cell comprising an envelope composed of a sound transmitting material and containing therein an electrolyte solution comprising a dilute aqueous solution of a substantially neutral material selected from the group consisting of sulfates and sulfonates, and which produces polarization of said cell, a pair of spaced electrodes composed of two dissimilar metals sufficiently spaced apart in the electromotive series of elements to give a substantial current when electrically connected in an external circuit, one of said electrodes being magnesium, said electrodes immersed in said solution to a depth not less than one half wave length of the minimum frequency output of said transducer, and a current indicator connected in short circuit with said electrodes.

10. In the combination of claim 9, means for continuously feeding fresh electrolyte solution to said cell and for simultaneously removing a substantially equal amount of electrolyte solution from said cell.

11. In the combination of claim 9, said anode having a substantially greater surface area than said cathode.

12. An electrolytic cell as defined in claim 8, wherein the cathode is in the form of a copper tube and the anode is in the form of a magnesium plate, and including means for feeding electrolyte through said copper tube into said envelope, a second tube positioned in said envelope, the lower end of said last mentioned tube being at the level of the surface of the electrolyte in said envelope, and a flow regulator connected to said second tube to control the rate of discharge flow of electrolyte out of envelope and through said last mentioned tube.

13. In combination with a tank, adapted to contain a bath, and an ultrasonic transducer mounted in operative association with said tank for subjecting said bath to ultrasonic radiation, an electrolyte cell for measuring the intensity of ultrasonic activity and of the resulting cavitation produced in said bath when it is subjected to ultrasonic radiation, said cell being immersed in said bath, said cell comprising an envelope composed of a sound transmitting material and containing therein a pair of spaced electrodes, one formed of magnesium and the other of copper, and an electrolyte comprising a dilute aqueous solution containing from about 0.25% to about 2% by weight of sodium lauryl sulfate, and about 0.10% to about 1% by weight of sodium bicarbonate, said electrodes immersed in said electrolyte to a depth at least equal to one wave length of the minimum frequency output of said trans-

ducer, and a current indicator connected in short circuit with said electrodes.

14. The process for measuring the intensity of ultrasonic activity and of the resulting cavitation produced in a bath subjected to ultrasonic radiation, which comprises deaerating said bath, placing in said bath a cell comprising a pair of spaced electrodes one composed of copper, the other magnesium, said electrodes being immersed in an electrolyte, and a current indicator in short circuit with said electrodes, with relatively low current generated in said cell and passing through said circuit, and exposing said bath and electrolyte to ultrasonic radiation, to cause an electrode reaction to occur in said cell and to produce a consequent increase in current in said circuit, for a period sufficient to obtain a maximum current value as shown by said current indicator.

15. The process for measuring the intensity of ultrasonic activity and of the resulting cavitation produced in a bath subjected to ultrasonic energy, which comprises immersing in said bath a bimetallic cell comprising a glass envelope containing therein a pair of spaced electrodes, one formed of magnesium and the other of copper, said electrodes being immersed in an electrolyte in said envelope, said electrolyte comprising a dilute aqueous solution containing sodium lauryl sulfate, and a current indicator in short circuit with said electrodes, and exposing said bath and electrolyte to ultrasonic radiation to cause depolarization to occur in said bimetallic cell and to produce a consequent increase in current in said circuit for a period sufficient to obtain a maximum current value as shown by said current indicator.

16. A cell as defined in claim 8, wherein the cathode is in the form of a copper wire and the anode is in the form of a magnesium plate.

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