Nov. 7, 1961 C. G. LEONHARDT ET AL 3,007,478

ULTRASONIC CLEANER

Filed April 15, 1958 5 Sheets-Sheet 1

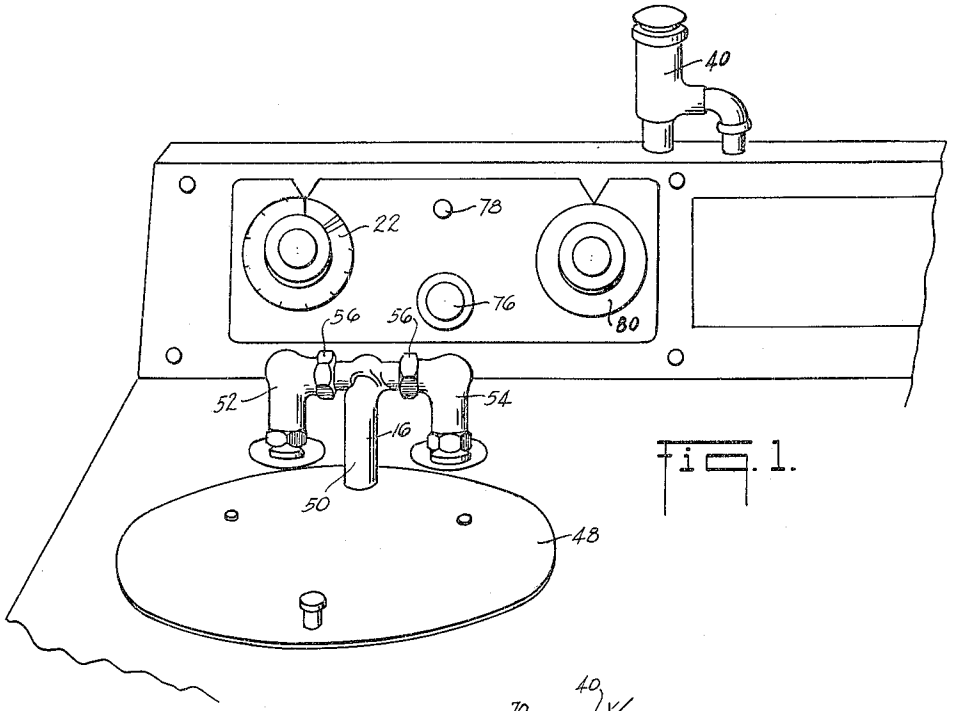


Fig. 1.

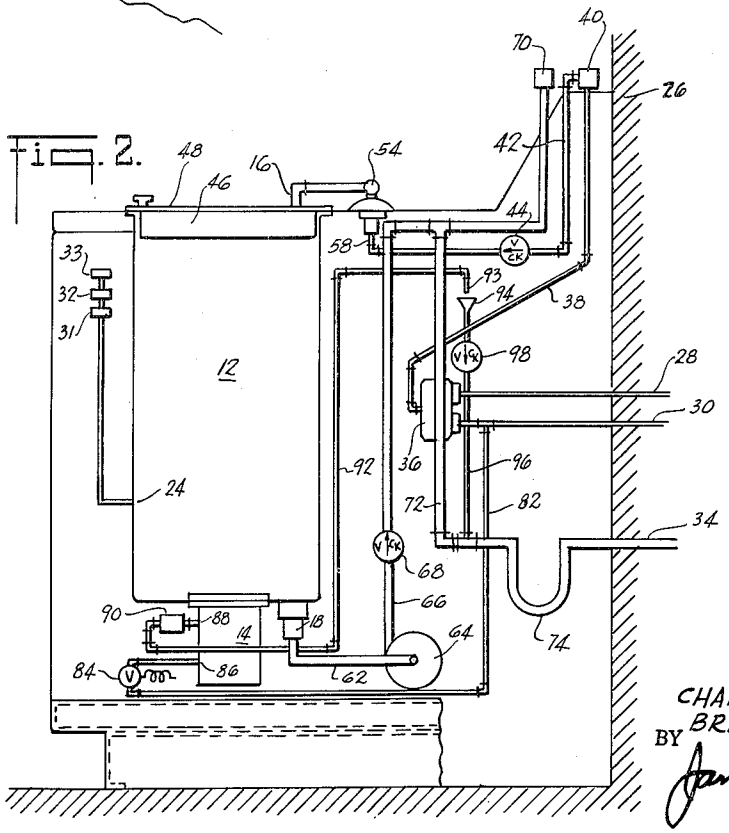


Fig. 2.

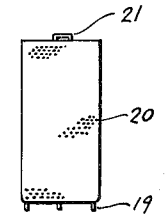


Fig. 2A.

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ULTRASONIC CLEANER

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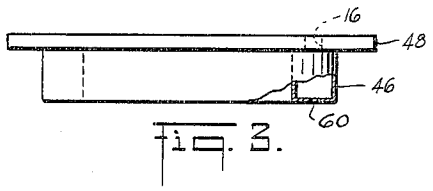


Fig. 3.

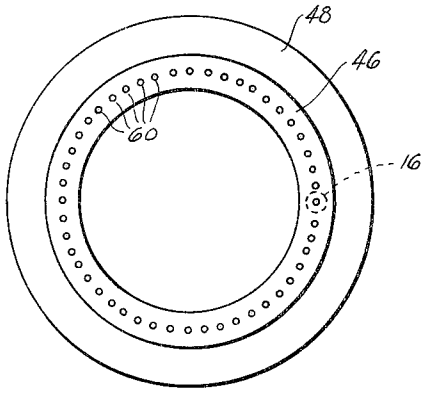


Fig. 4.

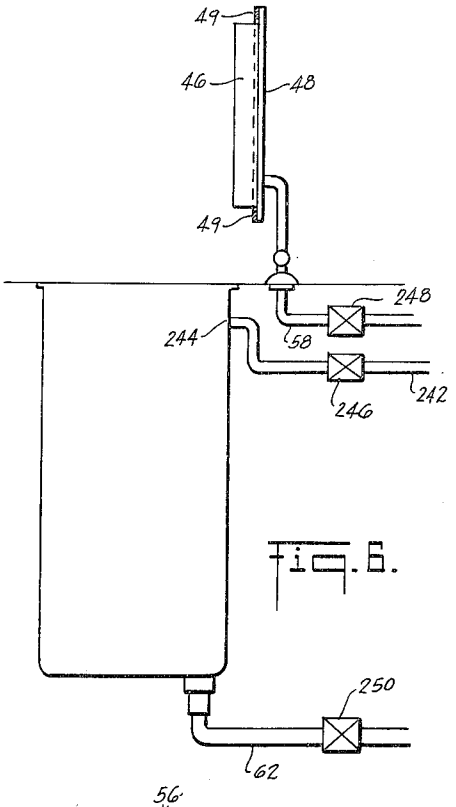


Fig. 6.

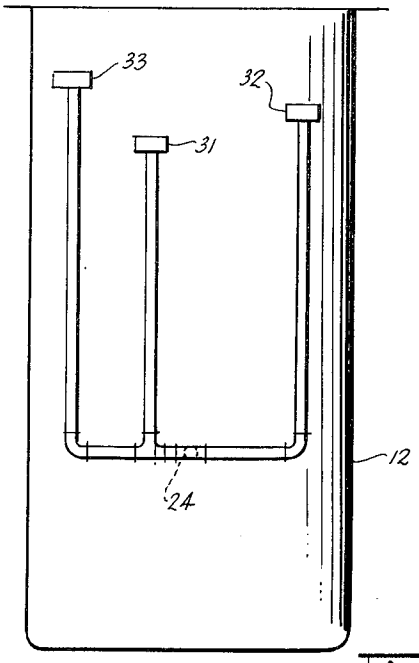


Fig. 5.

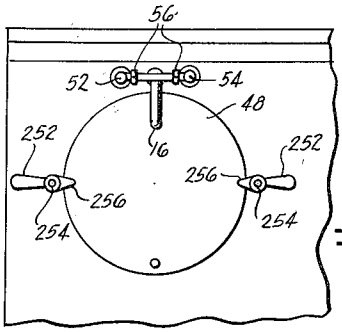


Fig. 7.

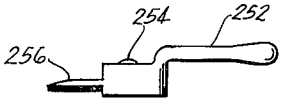


Fig. 8.

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ULTRASONIC CLEANER

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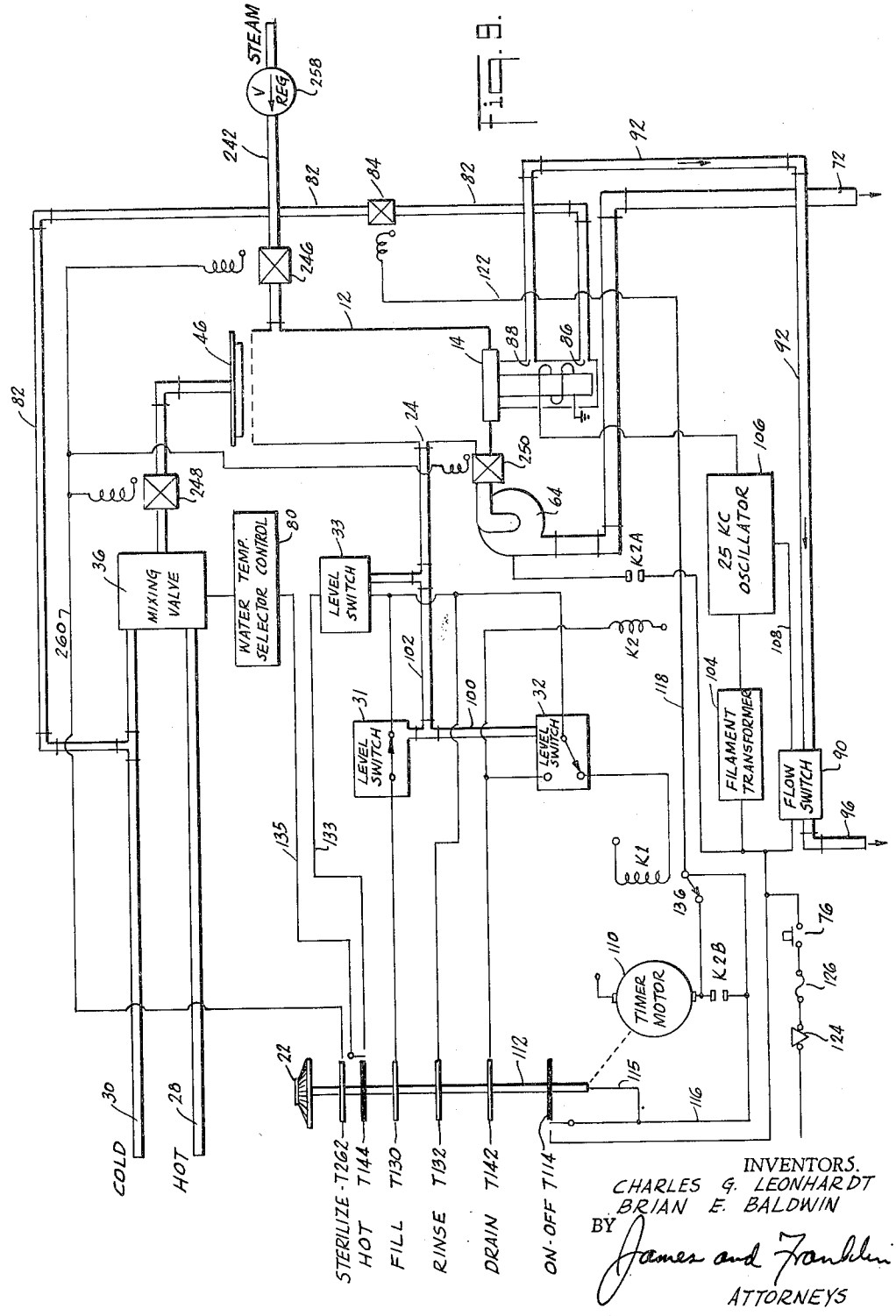


Fig. 9.

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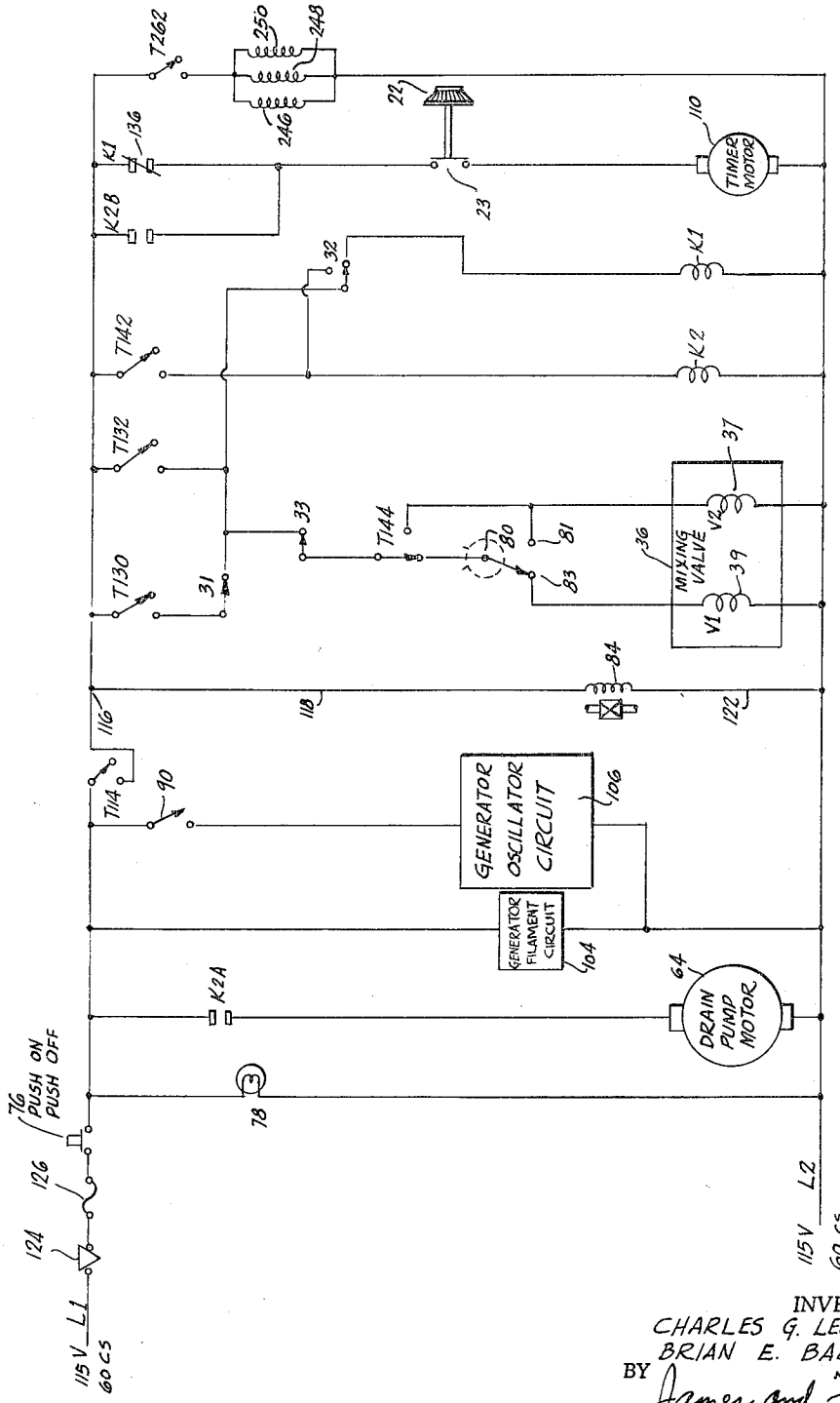


Fig. 10.

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ULTRASONIC CLEANER

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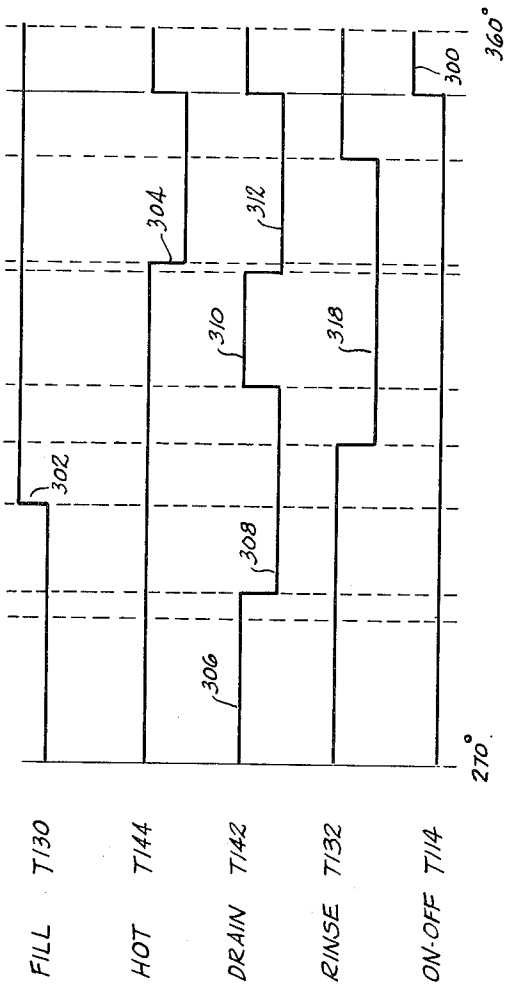


Fig. 11.

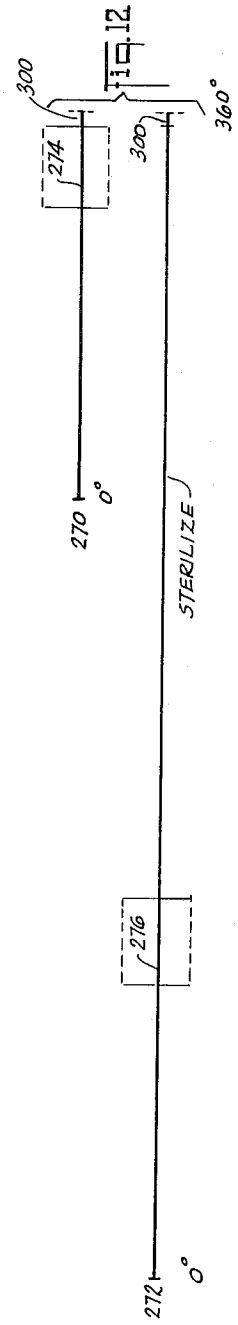


Fig. 12.

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United States Patent Office 3,007,478 Patented Nov. 7, 1961

3,007,478

ULTRASONIC CLEANER

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Filed Apr. 15, 1958, Ser. No. 728,667
17 Claims. (Cl. 134—57)

This invention relates to cleaners, and more particularly to a fully automatic ultrasonic cleaner.

The primary object of the present invention is to generally improve ultrasonic cleaners. A more particular object is to provide an ultrasonic cleaner which is completely automatic, for which purpose it employs a clock timer and level switches to establish a desired program of washing and rinsing. A more specific object is to provide such a cleaner for hospital and surgical use, for the cleaning of medical and surgical instruments. Still another object is to provide such a cleaner which acts additionally as a sterilizer for the medical instruments.

To accomplish the foregoing general objects, and other more specific objects which will hereinafter appear, our invention resides in the ultrasonic cleaner elements, and their relation to one another, as are hereinafter more particularly described in the following specification. The specification is accompanied by drawings in which;

FIG. 1 is a perspective view of one part of an ultrasonic cleaner embodying features of my invention;

FIG. 2 is a schematic transverse section through the cleaner;

FIG. 2*a* schematically represents a basket which may be loaded with instruments and inserted in the tank;

FIG. 3 is an elevation of a combined cover and spray head;

FIG. 4 is a bottom view of the same;

FIG. 5 shows the relation of a group of level switches to the tank;

FIG. 6 is a fragmentary view corresponding to a part of FIG. 2, but showing a modification which provides sterilizing as well as cleaning;

FIG. 7 is a plan view of a part of the modified cleaner, showing clamps applied to the cover;

FIG. 8 is a side elevation of one of the clamps, drawn to enlarged scale;

FIG. 9 is a highly schematic diagram explanatory of the flow circuit, for both water and electricity;

FIG. 10 is a wiring diagram showing the electrical circuitry;

FIG. 11 is a fragmentary diagram explanatory of a part of the timing of the cams in the clock timer; and

FIG. 12 shows the complete timing to much smaller scale, and compares the timing with and without sterilization.

Referring to the drawings, and more particularly to FIG. 2, the ultrasonic cleaner comprises a tank **12**, having a transducer **14** at the bottom of the tank. This is driven at a suitable ultrasonic frequency, for example, twenty-five kilocycles per second, by an ultrasonic generator not shown here. The transducer and generator may be conventional, and require no detailed description.

There is a water inlet at the top of the tank, shown at **16** in FIGS. 1 and 2, and a drain **18** at the bottom of the tank. For convenience, the articles to be cleaned, in this case medical and surgical instruments, may be loaded in a basket shown at **20** in FIG. 2*a*, and the said basket is lowered into the tank. The basket preferably has feet **19**, and handles **21**. It is drawn to reduced scale in FIG. 2*a*, and in practice may fit the tank. At the end of the cleaning operation, the basket is removed with the instruments.

Referring to FIG. 1, a clock timer is provided, the dial of which is indicated at **22**. This may be conventional, in that it includes an electrically driven synchrous clock motor which turns the timer shaft at desired speed. It has an "off" position, and may be started by manually turning the dial slightly, which puts it into its "on" position. As is customary, the shaft of the timer has a series of cams cooperating with a series of switches for controlling circuitry, and the particular timing program here employed is described later.

The circuitry further includes one or more water level switches connected to the tank, and in FIG. 2, there are three level switches **31**, **32** and **33**. These may all be connected to a common point on the tank, indicated at **24**, and the connection point is preferably well down, say six inches from the bottom. The arrangement of level switches is better shown in FIG. 5, which shows how switches **31**, **32** and **33** are connected by pipes to a common connection point **24** on the tank **12**. It may be mentioned that the desired operation could be controlled with a single level switch, the others being a refinement, as is explained later. The level switch is also called a "pressure switch," because it responds to the pressure of the water on its reaching a predetermined level.

The tank **12** is concealed within a generally flat sided housing structure somewhat resembling an automatic clothes washer or dishwasher or like appliance, and in the present case, the tank is located at the left end of the housing, while the ultrasonic generator occupies the right end of the housing. The housing may be backed against a wall, as indicated at **26** in FIG. 2, and has permanent plumbing connections, in this case, a hot water line **28**, a cold water line **30**, and a drain **34**. Hot and cold water are mixed in a mixer valve assembly **36** to produce water of desired temperature under thermostat control, which then flows through pipe **38** to a vacuum breaker **40**, and thence through pipe **42** to a check valve **44** to the inlet **16**. The drawing is not to scale, the distance between the tank and the wall being exaggerated in order to show the plumbing diagrammatically.

In accordance with one feature of the present invention, the inlet is in the form of a spray head, which is particularly valuable during the rinsing operation. The spray head is formed of a spray ring **46** which is hinged for removal from the top of the tank, as when inserting or removing the basket **20**. Most conveniently, the spray ring **46** is secured directly beneath and forms a part of a cover **48** for the tank, and the use of a flexible hose for the water supply is avoided by feeding the water supply through the hinge. More specifically, referring to FIG. 1, the cover **48** is carried by a bent pipe **50** supported between elbow couplings **52**, **54** with packing nuts at **56**. The water supply is connected to either the elbow **52** or **54**, as shown at **58** in FIG. 2. The construction of the spray head is also shown in FIGS. 3 and 4, the spray ring **46** being secured beneath cover **48**, and having a ring of spray holes **60**. The water connection to ring **46** is indicated at **16**. The hinge action and the open position of the cover and spray head, out of the way of the top of the tank, are shown in FIG. 6.

Reverting to FIG. 2, the drain connection **18** could be a gravity drain, but there are important advantages in using a drain pump, and in the present case, drain **18** leads through pipe **62** to a pump **64**, which may be of the centrifugal type, and the discharge of which flows upward through pipe **66**, and a check valve **68** to a valve check acting as a vacuum breaker **70**, and thence downward through pipe **72**, to a trap **74** and drain pipe **34**. The vacuum breaker **70** prevents syphoning of liquid out of the pump by admitting air at the point **70**, and thus helps keep the pump primed for its next operation. The check valve **68** prevents backflow. The diaphragm valve

or vacuum breaker **40**, and the check valve **44**, are requirements of the sanitary code in many communities, in order to prevent any possibility of backed up sewage entering the fresh water supply.

One advantage of the drain pump **64** is that the pump itself may be used under electrical control to time the draining of the tank. The pump may be an open pump, with free flow therethrough, but there is no drainage except when the pump operates because of the piping to the high point **70**, which is at a level higher than the liquid level in the tank. Another advantage of the pump **64** is that the drain piping may be smaller. In the present case, the tank is an eight-gallon tank, about ten inches in diameter and twenty inches high, yet it may be rapidly drained while using one inch piping at **62**, **66**, **72**, and **74**, and although leading into a conventional two-inch waste line **34**, which latter is the size of pipe that would be required without the pump.

In FIG. 1, attention is directed to push button **76**. This is a preliminary "start" button which is pressed before beginning operation of the machine, and which serves to supply heater current to the cathodes of the main vacuum tubes of the oscillator. It is customary and desirable to warm the vacuum tube cathodes before applying the high plate voltage, and the latter is not applied until after the machine is actually started. This actual start of the machine is obtained by turning the dial **22** away from its "off" position, as previously mentioned. The part **78** is a pilot lamp which lights whenever the button **76** has been pressed to heat the cathodes. This "start" button **76** is of the type called "push on-push off," meaning that when pushed, the circuit stays on, and when pushed again, the circuit remains off. The only indication that the heater circuit is on is the pilot lamp **78**. The dial **80** is a temperature selector dial. In the present case, this provides two temperatures. One temperature is that of the hot water supply available in the building, which may be from one hundred forty degrees to one hundred eighty degrees Fahrenheit. This may be used for the cleaning of ordinary articles. The other temperature is a substantially lower temperature, say one hundred five degrees Fahrenheit, and this is used in hospitals for the cleaning of surgical instruments, because the higher temperature tends to "set" blood, pus, etc.

Referring now to FIG. 2, the cold water line **30** is tapped by a pipe **82** which supplies cooling water to the water jacket of transducer **14**. The flow of cooling water is controlled by a solenoid operated valve **84**, and leads into the water jacket at **86**. The cooling water is discharged at **88**, and the existence of an actual flow of cooling water is detected by a flow detecting device indicated at **90**, the purpose of which is explained later. The cooling water then flows upward through pipe **92**, and possible back pressure in the transducer jacket is avoided by an open spout **93** and funnel **94**. The discharged cooling water flows gravitationally through pipe **96** to the trap **74**. A check valve **98** is provided in line **96** to counteract any pressure developed by the drain pump **64**, and is anyway desirable in the event of backing up of the waste line **34**.

Referring now to FIG. 9, the cold water line is indicated in the upper left corner at **30**, the hot water line at **28**, their mixing valve at **36**, the waste line in the lower right corner at **72**, and the transducer cooling water waste line at **92**, **96**. The tank **12**, with its transducer **14**, shower inlet **46**, and drain pump **64** are also shown schematically. The three level switches are indicated at **31**, **32** and **33**, and are connected to the tank at the point **24** by pipes **100** and **102**. The cooling water for the transducer is supplied through pipe **82** (top of diagram) and solenoid valve **84** to the jacket at **86**, and leaves at **88** through pipe **92** and flow switch or flow detector **90**. The "start" button for heating the vacuum tubes is shown at **76** (lower left part of the diagram), and supplies current to a filament transformer **104**, and also to the flow detector switch **90**. However, the oscillator, indicated at **106**, does not start until energized by closing of flow detector switch **90**, as indicated here by the connection **108**. This is a safety interlock which insures that power will not be supplied to the transducer **14** unless it first is supplied with cooling water, and the continued operation of the oscillator **106** is dependent at all times on the continued flow of cooling water, as detected by the flow switch **90**.

The timer or clock motor is shown at **110**. It drives a cam shaft **112** carrying a series of cams which operate switches. The dial of the timer is shown at **22**, and by turning this slightly away from its "off" position, a cam **T114** closes a switch to supply current through line **116** to the timer motor **110** if relay **K2** is energized, or if relay **K1** is de-energized. It also supplies current to timer switches **T130**, **T132**, and **T142**, as shown at **115**.

In addition there is a supply of current through line **118** and **122** to the solenoid valve **84** which controls the flow of cooling water through pipe **82** to the transducer jacket. This in turn starts the oscillator **106** because the flow of cooling water closes the flow switch **90** and supplies current to oscillator **106**.

Before describing the operation in detail, it may be well to refer to the wiring diagram shown in FIG. 10. This is an "across the line" diagram, with the switching performed in the upper line "L1," and with a ground return shown by the lower line "L 2." The element **124** is simply an interlock controlled by the front panel of the cleaner, in order to de-energize all of the circuitry if the front panel is removed. This is done because of the high voltages used in the oscillator. A fuse is shown at **126**, and a "start" button at **76**, which remains closed, it being a push start push stop button. When the button is pressed, the pilot lamp **78** is lighted, and current is supplied to the filament heating circuit of the oscillator, indicated at **104**.

To further start the cleaner, the clock dial is turned away from "off" position thereby causing a cam to close timer switch **T114** leading through line **118** to the solenoid of solenoid valve **84**, which causes a flow of cooling water to the transducer. That flow closes the flow detector switch **90**, thereby starting the ultrasonic generator **106** by putting high voltage on the plates of the previously warmed tubes. Additional timer switches are shown in generally upright position, and are prefixed by the letter "T." The three level switches are shown in generally horizontal position at **31**, **32**, and **33**. The temperature selecting dial and its switch are shown at **80**. The timer motor is shown at **110**, and the drain pump motor at **64**.

The mixer valve is indicated at **36**, and it may be explained at this point that it comprises two solenoid valves and a thermostat. It is so constructed as to receive three pipe connections, two coming in with hot and cold water, and one leaving with mixed water. It also receives only two electrical connections, here symbolized as leading to two solenoids **37** and **39**, but the internal construction is not simply two separate solenoid valves operating hot and cold lines. When the "hot" water solenoid is connected, there is an on and off control of hot water alone. When the "warm" water solenoid is connected, there is an on and off control of warm water, the warmth of which depends on a thermostat action which admits and mixes cold water with the hot water in appropriate amounts. When the temperature selector switch **80** is moved to "hot," the circuit is closed to contact **81**, for on and off control of hot water, and when selector **80** is moved to "warm," the circuit is closed to contact **83**, for on and off control of warm water. In this case, the flow is further controlled by a thermostat, not shown. When there is to be no flow of water, both circuits are de-energized, and this may be done by opening of level switch **31** or **33**. However, with the level switches closed, the flow of water is controlled by the

timer, as indicated for example by the timer switches T130 and T132.

There is a relay K1 which has one pair of contacts, which are normally closed, as shown at 136. There is another relay K2 which has normally open contacts K2A controlling the drain pump motor 64, and K2B shunting the contacts 136.

Operation

At the beginning, the timer is in "off" position, and pressure on push button 76 (FIGS. 9 and 10) turns on the pilot light 78, and heats the tube filament circuit indicated at 104.

Before or after pressing the "start" button 76, the basketful of instruments is placed in the tank, a quantity of detergent is added, say three ounces, and the cover is closed. At any time during this preliminary period, before or after loading the tank, the temperature dial 80 is properly set. If the cleaner is being used continuously for surgical instruments, this dial will simply remain in the warm (one hundred and five degree Fahrenheit) position.

The timer dial is then turned from "off" into the "wash" cycle. Without the sterilization referred to later, the cleaning operation takes less than fifteen minutes, and a fifteen-minute clock may be used, that is, one which turns one full revolution in fifteen minutes. Most of this is available for the "wash" cycle, but less than all of the available "wash" cycle may be used by simply turning the dial further into the "wash" cycle. In the particular case here illustrated the maximum washing time is 10.4 minutes, but this may be cut down to anything less, if desired, by simply turning the dial as far as desired along the "wash" cycle.

In any case, movement of the timer from "off" position starts the flow of cooling water to the transducer through the action of cam T114 and conductors 116, 118, and 122, energizing cooling water solenoid valve 84. The resulting flow of cooling water closes detector switch 90, and starts the ultrasonic generator 106, whereupon the transducer is energized. Meanwhile, water of appropriate temperature is sprayed into the tank by opening of one or both solenoid valves of the mixing valve, and for this purpose, clock switch T130 is closed. thereby supplying energy to the mixer valve, it being kept in mind that the level switches 31 and 33 are closed at this time, and remain closed until the tank is full. Also clock switch T144 is closed. In FIG. 9 the circuit is through level switches 31 and 33 and conductors 133 and 135.

Relay K1 has normally closed contacts 136. However, at this time, the level switch 32 is closed to its lower contact, thereby energizing the solenoid of relay K1, and thus opening the contacts 136, and because contacts 136 are open, the timer motor 110 does not run. In general, the timer motor is de-energized during filling of the tank, and is energized during washing, and during parts of the rinsing cycles. The relay K2 is energized whenever the drain pump motor operates, because it controls the drain pump motor through its contacts K2A, and therefore the contacts K2B also close whenever the drain pump motor operates. These shunt the contacts K1 even when the latter are open. Relay K1 opens during filling, and the timer motor stops unless the tank is also draining, in which case the timer motor runs because of closing of contacts K2B.

Thus turning the time dial to any position in the approximately ten minute long "wash" cycle causes ultrasonic energy to be presented to the tank through energizing of the cooling solenoid, and causes water to spray into the tank, since the "fill" contact T130 closes and level switch 31 is closed in its relaxed condition. The temperature switch 80 selects either the warm or the hot input, causing warm or hot water to flow. Level switch 32 is closed to its lower contact, thus energizing relay K1, and so opening contacts 136 and thereby opening the line to the timer motor 110.

It will be noted that the transducer is operating during filling of the tank. This is a significant feature of the invention, because it has been found that this provides rapid degassing of the water. The ultrasonic cleaning action is weakened by gas content in the water. If the tank were first filled before starting vibration, it would take some fifteen or twenty minutes to degas the water. (Without vibration it would take many hours.) However, by providing transducer vibration during the filling of the tank, the water is degassed in a matter of only two minutes, one of which is anyway occupied by filling of the tank, so that for all practical purposes, the water is degassed in one additional minute. The tank is filled to a height established by level switch 31, which in the present case is four inches from the top of the tank.

Timer motor 110 will not run until level switch 31 has been tripped open, and relay K1 is thereby de-energized. When the tank has been filled to the said first level, the mixer valve and the relay are de-energized, shutting off input water at mixer 36 and beginning operation of timer motor 110. Motor operation will not be interrupted, and the water level remains constant, throughout "wash" interval.

At the end of the "wash" cycle, the timer "fill" contact T130 opens and the timer "drain" contact T142 closes. This energizes the relay K2 and so the drain pump motor 64, and therefore the tank empties.

The complete rinse action of the present cleaner may be divided into two main parts. The first may be referred to as a "fluctuating-level rinse," which is provided by a continuous inlet or spray rinse accompanied by an intermittent drain, with the drain at a faster rate than the spray inlet. Thus, there is a continuous spray action, but the level in the tank changes from partly empty to full, and this may be done repeatedly for a number of fluctuations determined by the timer clock, as explained later. In the present case there are three fluctuations.

It has been found that the use of a large distributed spray is highly preferable to mere filling through an inlet at the side or top of the bank, because the spray helps remove any clinging residue of skin on the instruments during draining. These tend to cling, but by using a spray filling or rinsing action during actual bulk drainage of liquid from the tank, the clinging of skin to the instruments has been reduced by some ninety percent. Moreover, a side water connection to the tank, for example like that shown for steam at 244 in FIG. 6, creates a vortex which reduces the efficiency of ultrasonic cleaning. It would also fail to have the downward and widely distributed spray for the removal of clinging particles, as does the spray head, which sprays downwardly over the entire basket.

Because the pump drainage is much faster than the spray inlet, the tank is largely, say half or more emptied, in about thirty seconds, whereupon the pump stops, and the continued spray fills the tank again. The filling during this fluctuating spray is to a point three inches from the top of the tank, as determined by the level switch 32. The level switches 31 and 32 are set an inch apart in height not only for desired liquid level, but also to make certain that there is no interference in their operation. It would not do to have level switch 32 trip, when only level switch 31 is supposed to, because then there would be drainage of water and detergent during the washing cycle. It is found that a one inch difference is adequate, and that is what is here used.

The level switch 33 is located about two inches from the top of the tank and is not normally used. It acts as a safety device which stops the spray inlet to prevent overflow in the event of failure of drainage, or failure of either level switch 31 or 32. Thus, in FIG. 10, it will be seen that opening of level switch 33 will de-energize the mixer valve circuit, and so prevent further filling.

Level switch 32, unlike the others, is used in a differ-

ential way, that is, it has two contacts as shown in FIG. 10, the upper of which is closed when the pressure exerted thereon indicates a water level three inches from the top of the tank, and the lower of which is connected to the relay coil K1. The upper contact leads to the coil of relay K2, and during the fluctuating rinse period, the motor 64 is started each time the tank is full. It is stopped when the level switch opens at its upper contact, and this is a differential or delayed action which does not take place until the water level has dropped a substantial amount, which in the present case is some eight inches.

After about thirty seconds, the timer "rinse" contact T132 closes. Drain continues while water sprays into the tank. The timer continues to run though relay K1 trips, since relay K2 is holding the timer motor line in, at the contacts K2B.

After fifteen seconds of this operation, timer "drain" contact T142 opens. Relay K2 opens and therefore the drain motor stops. Water then begins to fill the tank. The timer motor 110 stops because of opening of relay K2.

Level switch 31 has no effect on the operation during the "rinse" interval. When the level switch 32 trips, the relay K1 is de-energized, causing closing of contacts 136 which causes the timer motor 110 to run. Level switch 32 also energizes relay K2 and causes the drain pump 64 to come on, while water continues to spray into the tank. The draining action is considerably faster than the filling, and the water level will drop through the differential distance of the level switch 32. At the lower level, approximately eight inches below the actuating height, the level switch 32 returns to its relaxed position. Drain pump 64 and timer motor 110 stop until the water level rises to produce the same cycling over again.

It will thus be seen that the medical and surgical instruments are here subjected to what is here termed a fluctuating-level rinse, the rinsing action being continuous, but the level of water in the tank being cyclically varied between a height of, say nine inches, and a height of say seventeen inches. One important advantage of the fluctuating-level rinse is that it avoids what might be termed "dead spots," that is, spots where the ultrasonic activity is weak. By moving the liquid level up and down, different loads are put on the transducer, and the regions of maximum and minimum ultrasonic activity and consequent cavitation are moved around or changed, so that at one time or another, there is strong activity in every part of the tank.

It is important to understand that the transducer is kept operating throughout the washing and rinsing cycles, and indeed its operation is continuous. Thus, there is cavitation, and cleaning of any residual bits of skin from the instruments by the body of warm water in the tank, apart from the falling spray action. When the tank is partly emptied, the lower region is subjected to ultrasonic cleaning, and the upper region to spray action. Thus, considerable overall cleaning time is saved by continuously spraying during the filling and draining of the tank, and by continuing the ultra-sonic vibration during the filling and draing of the tank.

The timer motor runs whenever the drain motor runs. Thus, during the fluctuating-level rinse, the timer motor runs during "drain," even though draining and stoppage of drain is controlled by the level switch 32. The time of drain is known, it being, say one and one-half second per inch, and thus the clock cam may be set to terminate the fluctuating-level rinse after a desired number of fluctuations, say three in the present case.

After three cycles of raising and lowering of the level, the timer drain contacts 142 close, causing the tank to empty while water still sprays in, and keeping the timer motor 110 running. Also at this time the timer switch 144 moves to the hot contact, so that the ensuing final rinse is with hot water. After thirty seconds, the timer "rinse" contact 132 opens.

Timer "drain" contact 142 remains closed for fifteen seconds to insure completely evacuating the liquid in the tank, the latter being only about half full.

Following this final drain period, the timer "on-off" contact T114 opens, interrupting the power to all of the timer controlled circuits, and shutting off the generator circuit through the cooling water solenoid valve 84. The generator vacuum tube filaments remain heated until the main switch button 76 is pushed, this being a "push on push off" switch. The pilot lamp shows the need for this final shut down, assuming there are no further batches of instruments waiting to be cleaned.

Timer and circuitry

FIG. 11 shows a part of the timer cam operation, drawn to enlarged scale. Without sterilization, the timer duration may be say fifteen minutes, which is represented at 270 in FIG. 12, while the portion shown in the dotted rectangle 274 corresponds generally to what is shown in enlarged scale in FIG. 11. In general, when the cam is shown down, its switch is closed, and when the cam is shown up, its switch is open. Thus, the timer switch T114 is closed throughout the cycle, as soon as the dial is turned away from the "off" position, and the "off" position is indicated at 300 at the end of the cycle. All cams are raised at this point, so that all switches are open, and it corresponds to the rest or off position of the timer dial.

The timer cam T130 is closed for most of the cycle, but opens and remains open at the point 302. The timer switch T144 provides hot water for the final rinse, and this switch is therefore open most of the time. It closes at the point 304, which marks the beginning of the second or hot water rinse.

The timer drain switch T142 is open at 306, closed at 308, open at 310, and closed at 312. However, as will be seen by referring to FIG. 10, this does not constitute the only supply of power for relay K2 and the drain pump, and the relay also may be energized through level switch 32 during the period that timer switch T130 and level switch 31 are closed, and also during the period that timer switch T132 is closed. This takes effect during the fluctuating-level rinse.

Timer switch 132 is for the both rinses. It differs from timer switch 144, which controls the water temperature, whereas timer switch 132 controls the flow operation of the mixing valve. The power supply is indicated to be on at 318, which corresponds to both the fluctuating-level rinse, and the hot rinse.

Referring now to FIG. 9, the timer cams are schematically indicated at the left of the diagram, and the numbers correspond to the numbers previously used in FIGS. 10 and 11. In FIG. 9, an additional cam 262 is shown, which has to do with sterilization, as is explained later.

The timer has been simplified, and omits the switches at most of the cams. For this reason cams T144 and T114 are shown as though made of insulation. It will be seen that the conductor from cam 130 leads to the level switch 31, as it does in FIG. 10; that the cam 132 leads to level switches 32 and 33, and indirectly to the level switch 31, as it does in FIG. 10; and that the cam 142 leads to the level switch 32 and to the coil of relay K2, as it does in FIG. 10. The cam 114 closes a circuit from the push button start switch 76 and runs as though to the other timer switches at 115, and to valve 84 at 116, 118, and 122. The cam 144 closes a switch leading from level switch 33 to water temperature control 80, also as in FIG. 10.

Sterilization

The final rinse is with hot water, regardless of the setting of the temperature selector, and this is so because of the action of the clock timer switch T144 located in FIG. 10 above temperature selector 80. If the cleaner

is not arranged for sterilization, the instruments then simply dry in the machine, which for all practical purposes is shut down. The hot final rinse assists rapid dry.

However, by some modification, the machine may be used to provide sterilization. Referring to FIG. 6, a steam line **242** is connected to the tank at **244**, and the supply of steam is controlled by a solenoid operated valve **246**. An additional solenoid operated valve **248** is inserted in the water line **58** leading to the spray head **46**. A third solenoid operated valve **250** is inserted in the drain line **62**. The cover **48** is preferably proviedd with a peripheral gasket **49**.

Referring now to FIG. 7, the cleaner is provided with a suitable cover locking means, here illustrated by a pair of clamps **252** pivoted at **254**. The nature of these clamps will be clear from inspection of FIG. 8, in which it will be seen that the working end **256** of the clamp preferably slopes on bottom to provide a camming or wedge action.

Referring now to FIG. 9, the steam line is shown at **242**. A pressure regulating or reducing valve **258** may be provided if the steam supply is at too high a pressure. The three added solenoid valves are indicated at **246**, **248** and **250**. The steam valve **246** is normally closed while the valves **248** and **250** are normally open. In such case, all of the solenoids may be connected together to a common line **260** which leads to an additional cam switch T262 on the timer clock. It will be evident that if switch **262** is energized at the end of the washing and rinsing cycles, steam will be admitted to the tank **12** to sterilize the instruments. The steam will be held under pressure by the closing of the valves **246** and **250**, and the clamping of the cover. Sterilization is ordinarily carried out at a temperature of about two hundred fifty degrees Fahrenheit, by using steam pressure of about thirty pounds per square inch. This is carried out for a period of say one half hour, although some may prefer less and others more time.

In FIG. 10, the added timer switch **262** is shown at the right, and controls all three solenoid valves **246**, **248** and **250**.

Referring now to FIG. 12 of the drawing, this com pares the cleaning cycle without sterilization, shown a **270**, and the cleaning cycle with sterilization, shown at **272**. The cycle shown at **270** is about fifteen minutes long, with about ten minutes devoted to washing. The dotted rectangle **274** corresponds substantially to what is shown to much larger scale in FIG. 11.

In the cycle shown at **272**, the same ten minute wash period is provided, followed by the same rinsing cycle shown in dotted lines at **276**, which again corresponds to what is shown in detail in FIG. 11. This is followed by a sterilizing period which, as here illustrated, is about one half hour long. The clock timer used in this case is a three-quarter hour clock, thus providing the desired additional one half hour time for sterilization. At the end of this time, the clock switch T262 in FIG. 9 opens; the steam valve **246** is closed, and the sealing valves **248** and **250** are opened, thus restoring the machine to its "off" condition.

A one hour clock may be used, and the sterilizing time may be pushed ahead for less time, or a separate adjustment of sterilizing time may be provided. Some doctors believe a much shorter sterilizing time is adequate.

Miscellaneous

In FIG. 10, the dial **22** is shown connected to contacts **23**. It may be explained that the clock timer is so constructed that if the dial is pulled toward the operator, the clock motor is de-energized, and this provides an easy way for manual control. Thus, any desired timing of any part of the program may be provided under manual control by simply pulling the dial out, and turning it manually as desired. This feature is available in conventional clock motors, which are already commercially available on the market. In the present case, the clock timer is made by Bayside Timers of Bayside, Long Island, New York. It comprises steel cams working on microswitches. A similarly usable timer is made by Hayes Manufacturing Company of Wisconsin.

The level switches here used are Type No. 18355 made by Bendix Corporation of Cincinnati, Ohio. They may also be Type No. 1466318 made by Westinghouse Electric Company at Mansfield, Ohio. The flow switch **90** which interlocks the cooling water of the transducer with the operation of the ultrasonic generator, is that known commercially as "Shur Flow" made by Hayes Manufacturing Company of Erie, Pennsylvania, but other flow switches are commercially available.

It will be understood that while we have shown three level switches, only one would be essential, in which case a single tank level would be used for both washing and for the fluctuating rinse, instead of the two slightly different levels here employed. The use of a second level switch simplifies the circuitry. The third level switch is merely for safety.

It will be understood that the transducer may be conventional, and may be of the magnetostrictive type, or the piezoelectric type using barium titanate ceramic. The ultrasonic generator also may be conventional, and requires no detailed description.

Suitable transducers and generators may be obtained from Acoustica Associates, Inc. of Mineola, Long Island, New York.

High temperature water would be used throughout the cleaning operation, instead of only for the final rinse when cleaning articles other than bloody medical instruments. Even with medical instruments, the last rinse may be and is a hot rinse, because the blood and skin etc. have already been washed away.

It is believed that the construction and operation of our improved ultrasonic cleaner, as well as the advantages thereof, will be apparent from the foregoing detailed description. It will also be apparent that while we have shown and described our invention in preferred forms, many changes may be made without departing from the scope of the invention, as sought to be defined in the following claims.

We claim:

1. An ultrasonic cleaner comprising a top-loading tank, a transducer affixed to said tank, a generator for supplying power to drive said transducer, a water inlet in said tank, a drain for said tank, a water level switch set to fill the tank deeply for complete immersion of the articles to be cleaned, a clock timer driving a series of cams controlling electrical circuitry to provide a program of washing and rinsing, and means connecting said circuitry to said generator and water level switch, and providing a first cam and circuit portion arranged in circuit with said generator and adapted to energize said generator substantially throughout said program, a second cam and circuit portion arranged in circuit with said flow switch to determine the maximum depth to which said tank can be filled, and further means automatically to drain said tank while continuing to introduce water into said tank through said inlet, whereby said circuitry and clock timer provide a program of washing and rinsing accompanied by ultrasonic cleaning and degassing of water in said tank produced by continuous vibration of said transducer throughout said program.

2. An ultrasonic cleaner comprising a tank, a transducer affixed to said tank, a generator for supplying power to drive said transducer, a water inlet in said tank in the form of a spray head covering substantially the full area of the tank, a drain for said tank, a water level switch for said tank set to fill the tank deeply for complete immersion of the articles to be cleaned, a clock timer driving a series of cams controlling electrical circuitry to provide a program of washing and rinsing, and means connecting

said circuitry to said generator and water level switch, and providing a first cam and circuit portion arranged in circuit with said generator and adapted to energize said generator substantially throughout said program, a second cam and circuit portion arranged in circuit with said flow switch to determine the maximum depth to which said tank can be filled, and further means automatically to drain said tank while continuing to introduce water into said tank through said inlet, whereby said circuitry and level switch and clock timer provide a program of washing and spraying.

3. An ultrasonic cleaner comprising a tank which opens at the top for top loading, a transducer affixed to said tank, a generator for supplying power to drive said transducer, a water inlet in said tank, a drain for said tank, a water level switch set to fill the tank deeply for complete immersion of the articles to be cleaned, a clock timer driving a series of cams controlling electrical circuitry to provide a program of washing and rinsing, and means connecting said circuitry to said generator and water level switch, and providing a first cam and circuit portion arranged in circuit with said generator and adapted to energize said generator substantially throughout said program, a second cam and circuit portion arranged in circuit with said flow switch to determine the maximum depth to which said tank can be filled, and further means automatically to drain said tank while continuing to introduce water into said tank through said inlet, whereby said circuitry and clock timer provide a program of washing and rinsing accompanied by ultrasonic cleaning and degassing of water in said tank produced by continuous vibration of said transducer throughout said program, the water inlet being a spray head mounted for movement into or out of the tank to facilitate top loading, and the pipe leading to said spray head being designed to accommodate such movement.

4. An ultrasonic cleaner comprising a tank, a hinged cover for said tank, a transducer affixed to said tank, a generator for supplying power to drive said transducer, a water inlet at the top of the tank, a drain for said tank, a water level switch for said tank, a clock timer driving a series of cams controlling electrical circuitry to provide a program of washing and rinsing, means connecting said circuitry to said generator and water level switch, and providing a first cam and circuit portion arranged in circuit with said generator and adapted to energize said generator substantially throughout said program, a second cam and circuit portion arranged in circuit with said flow switch to determine the maximum depth to which said tank can be filled, and further means automatically to drain said tank while continuing to introduce water into said tank through said inlet, whereby said circuitry and level switch and clock timer provide a program of washing and rinsing, the water inlet at the top of the tank being a spray head mounted for movement into or out of the top of the tank, said spray head being carried by the cover of the tank, the pipe leading to said spray head acting as the hinge for such movement of the cover and spray head.

5. An ultrasonic cleaner for medical and surgical instruments, said cleaner comprising a tank, a transducer affixed to said tank, a generator for supplying power to drive said transducer, a water inlet at the top of the tank, a drain for said tank, a water level switch set to fill the tank deeply for complete immersion of the articles to be cleaned, a clock timer driving a series of cams controlling electrical circuitry to provide a program of washing and rinsing, means connecting said circuitry to said generator and water level switch, and providing a first cam and circuit portion arranged in circuit with said generator and adapted to energize said generator substantially throughout said program, a second cam and circuit portion arranged in circuit with said flow switch to determine the maximum depth to which said tank can be filled, and further means automatically to drain said tank while continuing to introduce water into said tank through said inlet, whereby said circuitry and clock timer provide a program of washing and rinsing, a mixer valve assembly ahead of said inlet and having cold and hot water inlet connections, said assembly comprising solenoid valves and a thermostat to maintain a desired warm water temperature so low as not to set blood, and a manually controllable selector to make either the thermostat operative, or the hot water supply alone operative, whereby the cleaner may be operated with either the aforesaid low temperature warm water or much higher temperature hot water as desired.

6. An ultrasonic cleaner comprising a tank, a transducer affixed to said tank, a generator for supplying power to drive said transducer, a water inlet in said tank, a drain for said tank, a water level switch set to fill the tank deeply for complete immersion of the articles to be cleaned, a clock timer driving a series of cams controlling electrical circuitry to provide a program of washing and rinsing, and means connecting said circuitry to said generator and water level switch, and providing a first cam and circuit portion arranged in circuit with said generator and adapted to energize said generator substantially throughout said program, a second cam and circuit portion arranged in circuit with said flow switch to determine the maximum depth to which said tank can be filled, and further means automatically to drain said tank while continuing to introduce water into said tank through said inlet, whereby said circuitry and clock timer provide a program of washing and rinsing accompanied by ultrasonic cleaning and degassing of water in said tank produced by continuous vibration of said transducer throughout said program, said clock timer and associated circuitry being so arranged that the transducer is vibrated during filling of the tank to provide degassing of water in said tank during said filling.

7. An ultrasonic cleaner comprising a tank, a transducer affixed to said tank, a generator for supplying power to drive said transducer, a water inlet in said tank, a drain for said tank, a water level switch for said tank set to fill the tank deeply for complete immersion of the articles to be cleaned, a clock timer driving a series of cams controlling electrical circuitry to provide a program of washing and rinsing, and means connecting said circuitry to said generator and water level switch, and providing a first cam and circuit portion arranged in circuit with said generator and adapted to energize said generator substantially throughout said program, a second cam and circuit portion arranged in circuit with said flow switch to determine the maximum depth to which said tank can be filled, and further means automatically to drain said tank while continuing to introduce water into said tank through said inlet, whereby said circuitry and level switch and clock timer provide a program of washing and rinsing accompanied by ultrasonic cleaning and degassing of water in said tank produced by continuous vibration of said transducer throughout said program, said clock timer, level switch and associated circuitry being so arranged that the transducer is vibrated continuously throughout the cleaning operation, including filling, washing, and rinsing to provide degassing of water in said tank commencing with said filling and continuing during said operaton.

8. An ultrasonic cleaner comprising a tank, a transducer affixed to said tank, a generator for supplying power to drive said transducer, a water inlet in said tank, a drain for said tank, a water level switch set to fill the tank deeply for complete immersion of the articles to be cleaned, a motor driven drain pump for rapid drain, a second water level switch for said tank set at a lower level than said first-named water level switch, a clock timer driving a series of cams controlling electrical circuitry to provide a program of washing and rinsing, said clock timer and level switches and associated circuitry being connected to provide a first cam-controlled circuit branch

including said generator and adapted to energize said generator substantially throughout said program, a second cam-controlled circuit branch including said first-named water level switch to determine the maximum depth to which said tank can be filled, and a third circuit branch including both of said level switches and the motor of said drain pump to control operation of said drain pump, and through the cams under control of said clock timer providing a program including a washing period of desired duration followed by a fluctuating-level rinse, said fluctuating-level rinse being provided by a continuous inflow accompanied by an intermittent operation of said pump to provide drain at a faster rate than the inflow said transducer being vibrated continuously throughout the filling of said tank to provide degassing of water in said tank during said filling, and throughout said program and said fluctuating level rinse.

9. An ultrasonic cleaner comprising a tank, a transducer affixed to said tank, a generator for supplying power to drive said transducer, a water inlet in said tank, a drain for said tank, a water level switch set to fill the tank deeply for complete immersion of the articles to be cleaned, a motor driven drain pump for rapid drain, a second water level switch for said tank set at a lower level than first-named water level switch, a clock timer driving a series of cams controlling electrical circuitry to provide a program of washing and rinsing, said clock timer and level switch and associated circuitry being connected to provide a first cam-controlled circuit branch including said generator and adapted to energize said generator substantially throughout said program, a second cam-controlled circuit branch including said first-named water level switch to determine the maximum depth to which said tank can be filled, and a third circuit branch including both of said level switches and the motor of said drain pump to control operation of said drain pump, and through the cams under control of said clock timer providing a program including a washing period of desired duration followed by a fluctuating-level rinse, said fluctuating-level rinse being provided by a continuous inflow accompanied by an intermittent operation of said pump to provide drain at a faster rate than the inflow, said circuitry being so arranged that the transducer is vibrated throughout the washing and fluctuating-level rinse to provide continuous degassing of water in said tank and ultrasonic cleaning of articles which may be in said water.

10. An ultrasonic cleaner comprising a tank, a transducer affixed to said tank, a generator for supplying power to drive said transducer, a spray head in said tank, a drain for said tank, a motor driven drain pump for rapid drain, a water level switch for said tank set to fill the tank deeply for complete immersion of the articles to be cleaned, a clock timer driving a series of cams controlling electrical circuitry to provide a program of washing and rinsing, said clock timer and level switch and associated circuitry being connected to provide a first cam-controlled circuit branch including said generator and adapted to energize said generator substantially throughout said program, a second cam-controlled circuit branch including said water level switch to determine the maximum depth to which said tank can be filled, and a third circuit branch including said water level switch and th emotor of said drain pump to control operation of said drain pump, and through the cams under control of said clock timer providing a program including a washing period of desired duration followed by a fluctuating-level rinse, said fluctuating-level rinse being provided by a continuous spray through said spray head accompanied by an intermittent operation of said pump to provide drain at a faster rate than the inflow through said spray head, said circuitry being so arranged that the transducer is vibrated throughout the washing and fluctuating-level rinse to provide continuous degassing of water in said tank and ultrasonic cleaning of articles which may be in said water.

11. An ultrasonic cleaner for medical and surgical instruments, said cleaner comprising a tank, a transducer affixed to said tank, a generator for supplying power to drive said transducer, a water inlet in said tank, a drain for said tank, a water level switch set to fill the tank deeply for complete immersion of the articles to be cleaned, a motor driven drain pump for rapid drain, a clock timer driving a series of cams controlling electrical circuitry to provide a program of washing and rinsing, a mixer valve assembly ahead of said inlet, and having cold and hot water inlet connections, said assembly comprising solenoid valves and a thermostat to maintain a desired warm water temperature so low as not to set blood, a manually controllable selector to make either the thermostat operative or the hot water supply alone operative, whereby the cleaner may be operated with either the aforesaid low temperature warm water or much higher temperature hot water as desired, said clock timer and associated circuitry being connected to provide a first cam-controlled circuit branch including said generator and adapted to energize said generator substantially throughout said program, a second cam-controlled circuit branch including said water level switch and said solenoid valves with said selector intervening to determine the maximum depth to which said tank can be filled and the temperature of the water therein, and a third circuit branch including said water level switch and the motor of said drain pump to control operation of said drain pump, and through the cams under control of said clock timer providing a program including a washing period of desired duration followed by a fluctuating-level rinse, said fluctuating-level rinse being provided by a continuous inflow accompanied by an intermittent drain at a faster rate than the inflow.

12. An ultrasonic cleaner for medical and surgical instruments, said cleaner comprising a tank, a transducer affixed to said tank, a generator for supplying power to drive said transducer, a water inlet in said tank, a drain for said tank, a motor driven drain pump for rapid drain, a water level switch for said tank set to fill the tank deeply for complete immersion of the articles to be cleaned, a clock timer driving a series of cams controlling electrical circuitry to provide a program of washing and rinsing, a mixer valve assembly ahead of said inlet and having cold and hot water inlet connections, said assembly comprising solenoid valves and a thermostat to maintain a desired warm water temperature so low as not to set blood, a manually controllable selector to make either the thermostat operative or the hot water supply alone operative, whereby the cleaner may be operated with either the aforesaid low temperature warm water or much higher temperature hot water as desired, said clock timer and level switch and associated circuitry being connected to provide a first cam-controlled circuit branch including said generator and adapted to energize said generator substantially throughout said program, a second cam-controlled circuit branch including said water level switch and said solenoid valves with said selector intervening to determine the maximum depth to which said tank can be filled and the temperature of the water therein, and a third circuit branch including said water level switch and the motor of said drain pump to control operation of said drain pump, and through the cams under control of said clock timer providing a program including a washing period of desired duration followed by a fluctuating-level rinse, said fluctuating-level rinse being provided by a continuous inflow accompanied by an intermittent drain at a faster rate than the inflow, said circuitry being so arranged that the transducer is vibrated throughout the washing and fluctuating-level rinse cycle.

13. An ultrasonic cleaner for medical and surgical instruments, said cleaner comprising a tank, a transducer affixed to said tank, a generator for supplying power to

drive said transducer, a water inlet in said tank, a drain for said tank, a motor driven drain pump for rapid drain, a water level switch for said tank set to fill the tank deeply for complete immersion of the articles to be cleaned, a clock timer driving a series of cams controlling electrical circuitry to provide a program of washing and rinsing, a mixer valve assembly ahead of said inlet and having cold and hot water inlet connections, said assembly comprising solenoid valves and a thermostat to maintain a desired warm water temperature so low as not to set blood, a manually controllable selector to make either the thermostat operative or the hot water supply alone operative, whereby the cleaner may be operated with either the aforesaid low temperatuer warm water or much higher temperature hot water as desired, said clock timer and level switch and associated circuitry being connected to provide a first cam-controlled circuit branch including said generator and adapted to energize said generator substantially throughout said program, a second cam-controlled circuit branch including said watel level switch and said solenoid valves with said selector intervening to determine the maximum depth to which said tank can be filled and the temperature of the water therein, and a third circuit branch including said water level switch and the motor of said drain pump to control operation of said drain pump, and through the cams under control of said clock timer providing a program including a washing period of desired duration followed by a fluctuating-level rinse with warm water, said fluctuating-level rinse being provided by a continuous inflow of mixed water accompanied by an intermittent drain at a faster rate than the inflow, said fluctuating-level rinse being followed by a final rinse with only the hot water supply made operative, regardless of the position of the aforesaid selector.

14. An ultrasonic cleaner for medical and surgical instruments, said cleaner comprising a tank, a transducer affixed to said tank, a generator for supplying power to drive said transducer, a water inlet in said tank, a drain for said tank, a motor driven drain pump for rapid drain, a water level switch for said tank set to fill the tank deeply for complete immersion of the articles to be cleaned, a clock timer driving a series of cams controlling electrical circuitry to provide a program of washing and rinsing, a mixer valve assembly ahead of said inlet and having cold and hot water inlet connections, said assembly comprising solenoid valves and a thermostat to maintain a desired warm water temperature so low as not to set blood, a manually controllable selector to make either the thermostat operative or the hot water supply alone operative, whereby the cleaner may be operated with either the aforesaid low temperature warm water or much higher temperature hot water as desired, said clock timer and level switch and associated circuitry being connected to provide a first cam-controlled circuit branch including said generator and adapted to energize said generator substantially throughout said program, a second cam-controlled circuit branch including said water level switch and said solenoid valves with said selector intervening to determine the maximum depth to which said tank can be filled and the temperature of the water therein, and a third circuit branch including said water level switch and the motor of said drain pump to control operation of said drain pump, and through the cams under control of said clock timer providing a program including a washing period of desired duration followed by a fluctuating-level rinse with warm water, said fluctuating-level rinse being provided by a continuous inflow of mixed water accompanied by an intermittent drain at a faster rate than the inflow, said fluctuating-level rinse being followed by a final rinse with only the hot water supply made operative, regardless of the position of the aforesaid selector, said circuitry being so arranged that the transducer is vibrated throughout the washing and fluctuating-level rinse cycle.

15. An ultrasonic cleaner comprising a top-loading tank, a transducer affixed to said tank, a generator for supplying power to drive said transducer, a cover for said tank, a water inlet in said tank, a drain for said tank, a valve to seal said drain, a valve to seal said inlet, a lock for the cover of the tank, a steam line connected to said tank, a valve controlling said steam supply, a clock timer driving a series of cams controlling electrical circuitry for controlling said valves and generator to provide a program of washing and rinsing, followed by a sterilizing period, and means connecting said generator and valves in respective circuit branches under control of said cams to provide a first circuit branch including said generator and adapted to energize said generator substantially throughout said program, a second circuit branch including said valve to seal said drain to provide a draining portion of said program, and a third circuit branch including all of said valves to provide a sterilizing period whereby said circuitry and clock timer provide a program of washing and rinsing accompanied by ultrasonic cleaning and degassing of water in said tank produced by continuous vibration of said transducer throughout said program, and a sterilizing period following said program of washing and rinsing, during which sterilizing period the inlet and drain valves are closed and the steam valve is opened.

16. An ultrasonic cleaner comprising a top-loading tank, a transducer affixed to said tank, a generator for supplying power to drive said transducer, an openable cover for said tank, a spray head at the top of the tank within the cover and secured to said cover, a drain for said tank, a valve to seal said drain, a valve to seal said inlet, a lock for the cover of the tank, a steam line connected to said tank, a valve controlling said steam supply, a clock timer driving a series of cams controlling electrical circuitry for controlling said valves and generator to provide a program of washing and rinsing, followed by a sterilizing period, and means connecting said generator and valves in respective circuit branches under control of said cams to provide a first circuit branch including said generator and adapted to energize said generator substantially throughout said program, a second circuit branch including said valve to seal said drain to provide a draining portion of said program, and a third circuit branch including all of said valves to provide a sterilizing period whereby said circuitry and clock timer provide a program of washing and spraying and rinsing accompanied by ultrasonic cleaning and degassing of water in said tank produced by continuous vibration of said transducer throughout said program, and a sterilizing period following said program of washing and rinsing, during which sterilizing period the inlet and drain valve are closed and the steam valve is opened.

17. An ultrasonic cleaner comprising a tank, a transducer affixed to said tank, a generator for supplying power to drive said transducer, a water inlet in said tank, a drain for said tank, a water level switch set to fill the tank deeply for complete immersion of the articles to be cleaned, a motor driven drain pump for rapid drain at a rate greater than the maximum fill rate through said inlet, a low-level water level switch for said tank, a clock timer driving a series of cams controlling electrical circuitry to provide a program of washing and rinsing, said clock timer and level switches and associated circuitry being connected to provide a first cam-controlled circuit branch including said generator and adapted to energize said generator substantially throughout said program, a second cam-controlled circuit branch including said first-named water level switch to determine the maximum depth to which said tank can be filled, and a third circuit branch including both of said level switches and control for said drain, and through said cams under control of said clock timer providing a program including a washing period of desired duration followed by a fluctuating-level rinse during which said drain pump is intermittently

operated, said timer and circuitry being so arranged that the transducer is vibrated throughout the washing period and the fluctuating-level rinse to provide continuous degassing of water in said tank and ultrasonic cleaining of articles which may be in said water.

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