HIGH FREQUENCY ULTRASONIC FOG GENERATOR AND METHOD

Filed July 28, 1967 4 Sheets-Sheet 1

Fig.1.

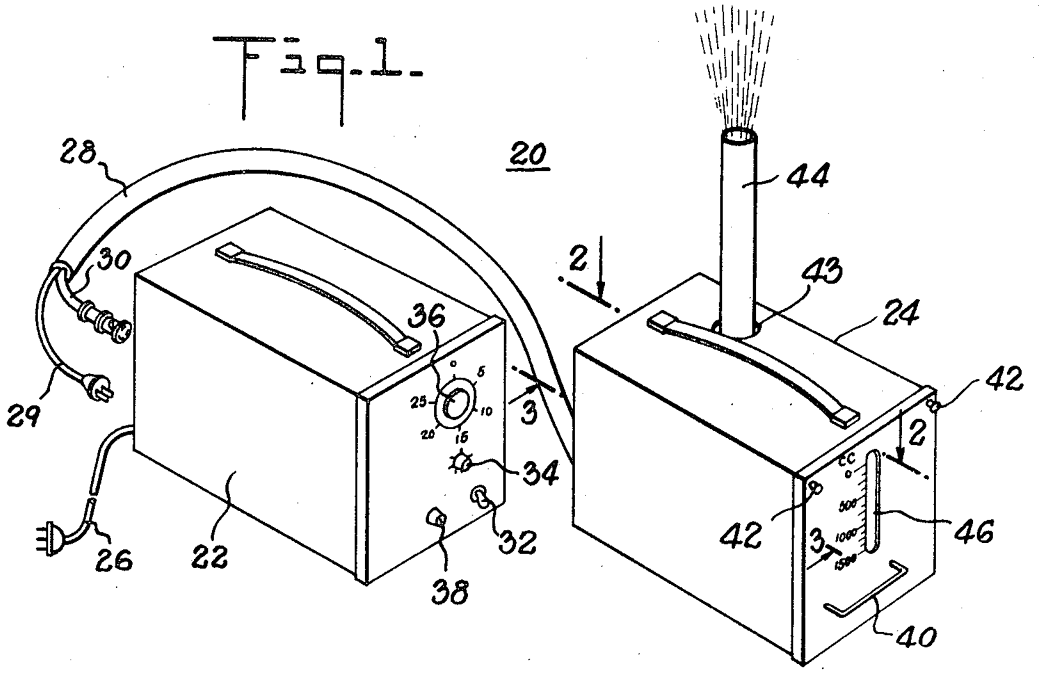
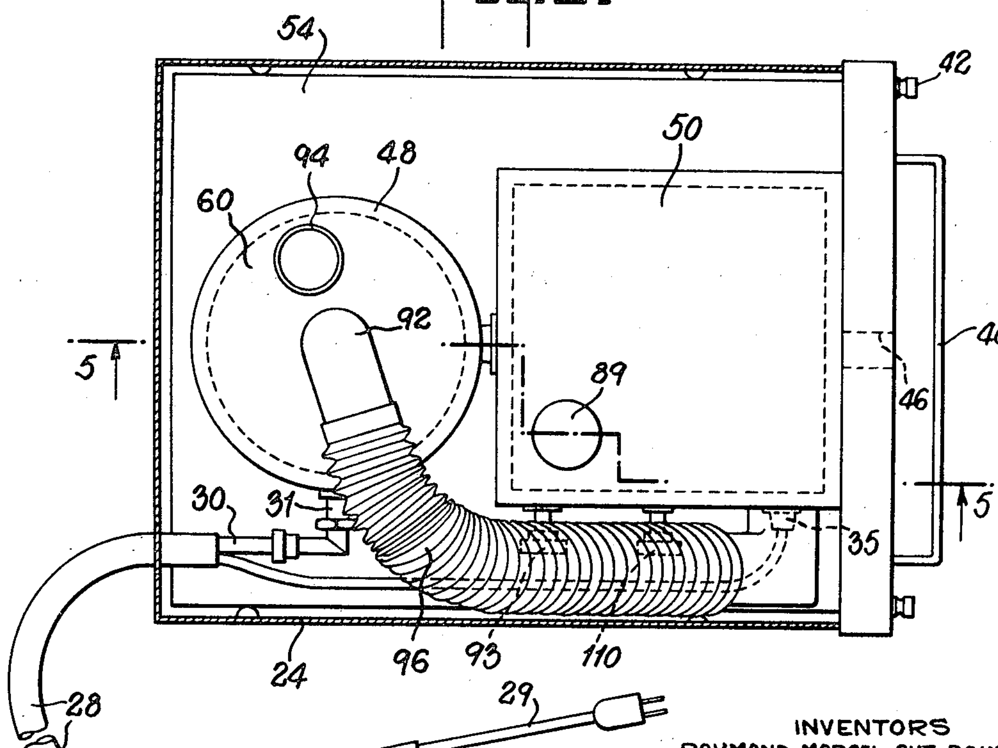


Fig.2.



INVENTORS
RAYMOND MARCEL GUT BOUCHER
CARLTON D. TOBIN
BY Samuelson & Jacob
ATTORNEYS

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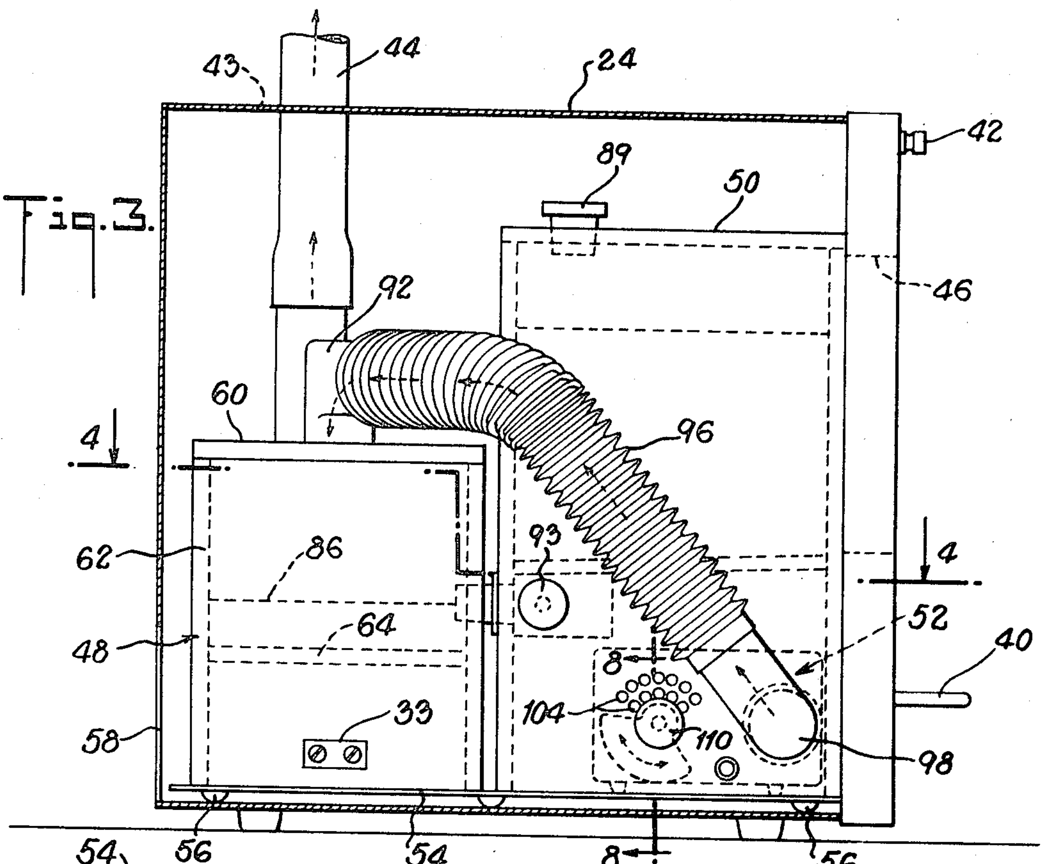
Fig.3.



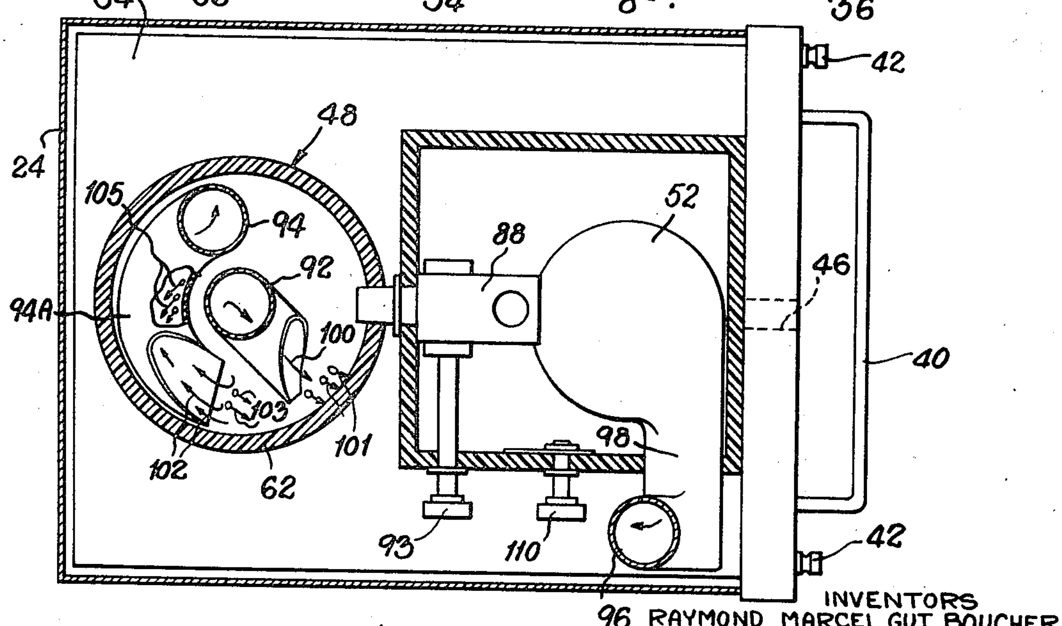


Fig.4.

INVENTORS
RAYMOND MARCEL GUT BOUCHER
CARLTON D. TOBIN
BY
Samuelson & Jacob
ATTORNEYS

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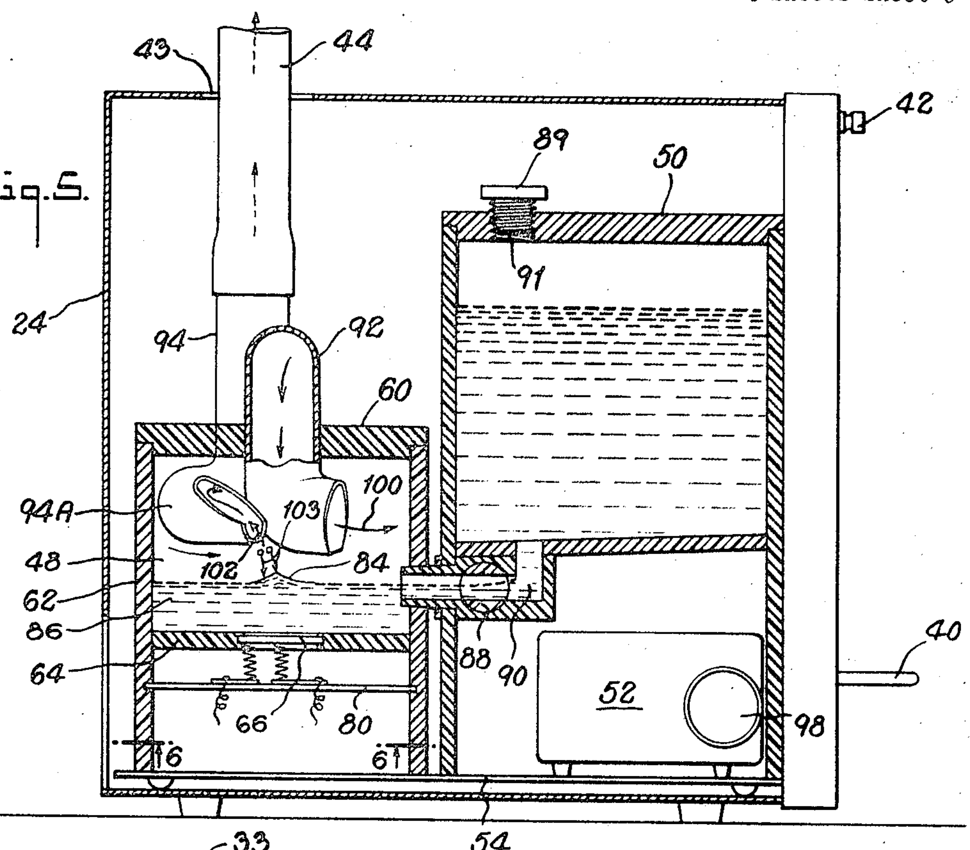

Fig.5.

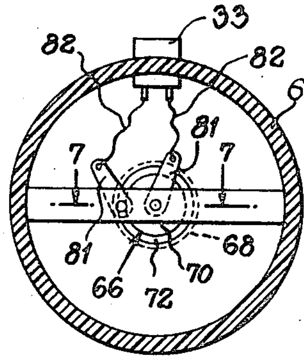

Fig.6.

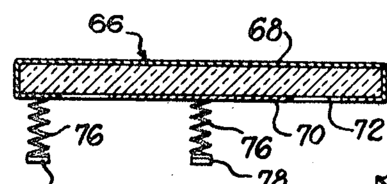

Fig.7.

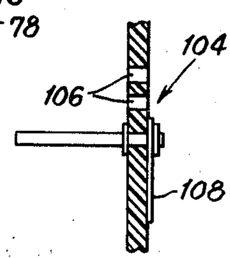

Fig.8.

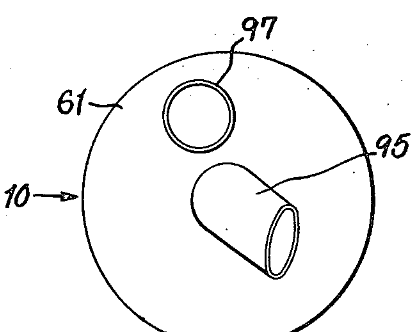

Fig.9.

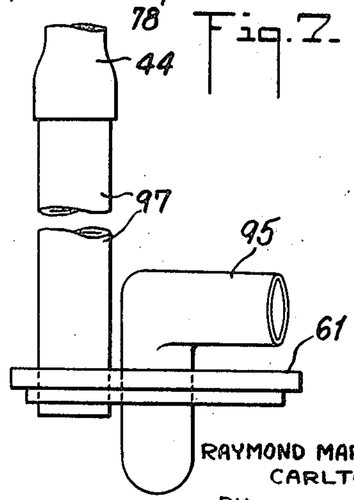

Fig.10.

INVENTORS
RAYMOND MARCEL GUT BOUCHER
CARLTON D TOBIN

BY Samuelson & Jacob
ATTORNEYS

HIGH FREQUENCY ULTRASONIC FOG GENERATOR AND METHOD

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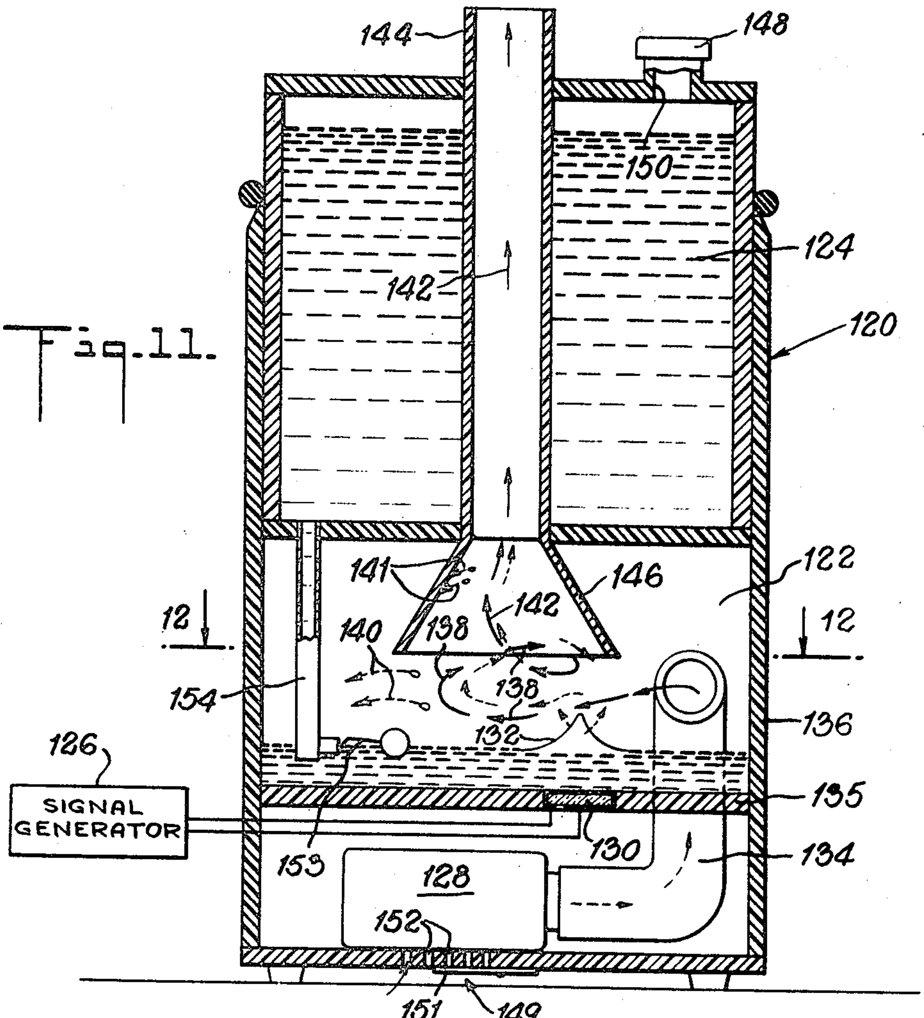

Fig. 11.

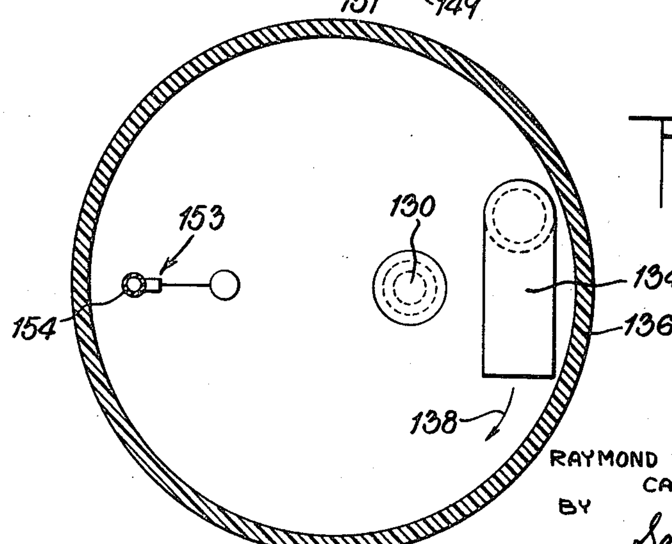

Fig. 12.

INVENTORS
RAYMOND MARCEL GUT BOUCHER
CARLTON D. TOBIN
BY
Samuelson & Jacob
ATTORNEYS

United States Patent Office

3,469,785
Patented Sept. 30, 1969

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3,469,785

HIGH FREQUENCY ULTRASONIC FOG GENERATOR AND METHOD

Raymond Marcel Gut Boucher, Metuchen, and Carlton D. Tobin, Rahway, N.J., assignors to Macrosonics Corporation, Carteret, N.J., a corporation of New Jersey

Filed July 28, 1967, Ser. No. 656,905
Int. Cl. B05b 17/06, 7/00, 3/14
U.S. Cl. 239—4 9 Claims

ABSTRACT OF THE DISCLOSURE

A high frequency ultrasonic fog generator having a liquid chamber containing the liquid to be formed into a fog, transducer means associated with the liquid chamber for agitating the liquid therein with ultrasonic energy to form a geyser, means for introducing gas into the liquid chamber such that swirlings and directional changes are imparted to the fog, a cover on the liquid chamber having at least one opening therein communicating from the exterior of the liquid chamber to the interior thereof, the opening being employed to emit a mist of the liquid from the liquid chamber, means as a part of the cover for causing the large droplets in the geyser to drop back into the liquid in the liquid chamber.

The invention relates to ultrasonic fog generators and, in particular, to such fog generators wherein the fog is generated in a chamber and is entrained from the chamber into the surrounding atmosphere.

Ultrasonic fog generators of the invention are most generally utilized for medical treatment purposes. For some treatments, the moisture in the air to be breathed should be made available to the patient in the smallest possible droplets. For other treatments, the droplets should be somewhat larger.

Up to now, it has been quite difficult to emit only the very small droplets, obtained from the liquid, into the surrounding atmosphere. In order to utilize only the very small droplets, it is necessary to remove the larger droplets from the geyser which is developed in the chamber. The geyser is made up of droplets of the liquid and is formed by irradiating the liquid with enough acoustic power by means of an ultrasonic transducer operating, preferably, in the frequency range of 600 kHz. to 1 mHz.

The transducer is positioned in the base of the liquid chamber and is, preferably, a flat disk which is vibrated in its thickness mode. Most commonly, these disk transducers are formed of barium titanate, barium cobalt titanate, barium strontium titanate, barium lead titanate, other metallic titanates, or in various combinations with or without other additives. The particular transducer materials used are dictated by the various operating parameters and are determined in a manner well-known in the transducer art. Nonetheless, other types of ultrasonic transducers, which are capable of being mounted in the base of the chamber and of producing ultrasonic vibrations of the proper frequency and of sufficient power, may also be used.

The disk transducer vibrates the liquid, which directly overlies it, and causes a geyser to form above the transducer. This geyser is made up of small droplets which are formed by the disintegration of the liquid subjected to intense, internal, acoustic turbulence by the ultrasonic field. The diameter of the bulk of the droplets in the geyser is in the range between 0.01 and 100 microns. The acoustical energy in the liquid radiates upward from the center of the transducer in the shape of a cone. For this reason, the flat transducer possesses one principal advantage over a focusing transducer. The energy from a

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focusing transducer is concentrated at the focus and if the level of the liquid in the chamber is not above the focus, there will not be enough transfer of acoustical energy to the liquid.

To form a usable geyser for use as a fog generator for dispensing medication for inhalation, it is best, according to the present invention, to utilize a nonfocusing transducer, such as a flat disk, which produces direct ultrasonic excitation of the overlying liquid over a relatively broad area. This broad area constitutes about 25% of the surface area of the transducer.

It is an important object of the invention to provide a method of producing fog by ultrasonic excitation of the liquid.

It is also an object of the invention to provide such a method wherein only the smaller droplets remain in the fog and the larger droplets are returned to the liquid source.

It is a further object of the invention to provide apparatus for producing fog by ultrasonic excitation of the liquid source.

It is a still further object of the invention to provide such apparatus wherein only the smaller droplets are emitted into the surrounding atmosphere.

It is a still further object of the invention to provide such apparatus wherein in the liquid in the chamber in which the geyser is being formed is maintained at a predetermined level.

It is another object of the invention to provide such apparatus wherein a gas is introduced into the chamber at a pressure above the ambient pressure.

It is still another object of the invention to provide such apparatus wherein the gas is introduced through the top of the chamber.

It is a still further object of the invention to provide such apparatus wherein the gas is introduced near the wall of the chamber and in a direction such that it swirls within the chamber to cause the larger droplets to fall back under centrifugal forces into the pool of liquid.

These and other objects, features, advantages and uses will be apparent during the course of the following desciption, when taken in conjunction with the accompanying drawings, wherein:

FIGURE 1 is a perspective view of an ultrasonic fog generator of the invention, showing the units enclosed in their cabinets, ready to be connected together and to the A–C mains;

FIGURE 2 is an enlarged, horizontal, sectional view, taken on the lines 2—2 of FIGURE 1, viewed in the direction of the arrows;

FIGURE 3 is an enlarged, vertical, sectional view, taken on the lines 3—3 of FIGURE 1, viewed in the direction of the arrows;

FIGURE 4 is a horizontal, sectional view, taken on the lines 4—4 of FIGURE 3, viewed in the direction of the arrows;

FIGURE 5 is a vertical, sectional view, taken on the lines 5—5 of FIGURE 2, viewed in the direction of the arrows;

FIGURE 6 is a horizontal, sectional view, taken on lines 6—6 of FIGURE 5, viewed in the direction of the arrows;

FIGURE 7 is an enlarged, vertical, sectional view, taken on lines 7—7 of FIGURE 6, viewed in the direction of the arrows;

FIGURE 8 is an enlarged, vertical, sectional view, taken on the lines 8—8 of FIGURE 3, viewed in the direction of the arrows;

FIGURE 9 is a horizontal, plan view of an alternative embodiment of the top which may be used with the liquid chamber of FIGURES 1 through 8;

FIGURE 10 is a vertical, elevational view of the top of FIGURE 9, viewed in the direction of arrow **10** of FIGURE 9;

FIGURE 11 is an alternative embodiment of ultrasonic fog generator of the invention; and

FIGURE 12 is a vertical, sectional view, taken on the lines **12**—**12** of FIGURE 11, viewed in the direction of the arrows.

In the drawings, wherein for the purpose of illustration, are shown preferred embodiments of the ultrasonic fog generator of the invention, the numeral **20** designates a fog generator of the invention, generally. Fog generator **20** (FIGURE 1) is seen to comprise cabinets **22** and **24**. Cabinet **22** contains the ultrasonic signal generator (details not shown) and cabinet **24** contains the liquid chamber, the liquid reservoir and the blower.

The ultrasonic signal generator is connected to the 115 volt A-C mains by means of cable **26** and to the blower and transducer by means of cable **28**. The ultrasonic signal generator is of a type well-known in the art and any circuit may be used which will produce a signal of sufficient power at the nominal frequency of the order of 800 kHz. It should be understood, however, that the teachings of the invention apply within the range of about 600 kHz. to about 1 mHz.

Line **29**, which is contained in cable **28**, supplies A-C power from the ultrasonic signal generator to the blower and line **30**, which is also contained in cable **28**, supplies the ultrasonic signal to the transducer. Switch **32** on the front panel of cabinet **22** is the master switch and it connects the A-C power to the contacts of timer **36**, turns on the filaments of the vacuum tubes of the signal generator and the pilot light **38** and turns on the cooling fan which is mounted inside cabinet **22** (details not shown).

Timer **36** turns on the blower in cabinet **24** and applies high voltage to the vacuum tubes of the signal generator. Trimmer control **34** is used to tune the signal generator to obtain maximum output (highest geyser) from the transducer. This adjustment is made with the assembly contained in cabinet **24** removed from the cabinet to permit viewing of the geyser when making the adjustment. After this has been done, the trimmer **34** is locked and the contents of cabinet **24** are slid back into the cabinet. Cabinet **24** is provided with handle **40** and knurled screws **42** to facilitate the removal of the assembly from the cabinet. In order to remove the assembly from the cabinet, it is necessary to lift pipe **44** from the assembly and out of the cabinet through opening **43**.

The fog is emitted into the surrounding atmosphere through pipe **44** and the amount of liquid in the reservoir is viewed through opening **46** which is provided with an indicator to show the amount of liquid which must be added to the reservoir to bring it back to full capacity.

FIGURES 2 through 5 show the placement of the equipment within cabinet **24**. It comprises liquid chamber **48**, liquid reservoir **50** and blower **52**. These components are mounted on plate **54** to which are attached plastic buttons **56** to facilitate sliding the assembly in and out of the cabinet. Connection from the ultrasonic signal generator to the transducer is made by means of plug **31** and receptacle **33** (FIGURES 2 and 3). A similar plug and receptacle are used at the signal generator. Cable **30** is brought into cabinet **24** through opening **58** in the rear thereof. A-C connection is made to the blower **52** by means of connector **35** as shown in FIGURE 2.

Liquid chamber **48** comprises top **60** which is preferably removable, wall **62**, and base or bottom **64**. Transducer **66**, which is preferably of the ceramic type previously described, is mounted in base **64** as shown in FIGURE 5. Transducer **66** is provided with two electrodes **68** and **70** applied to the opposite faces of the disk. Electrode **68** completely covers one face of the transducer, its edges and the peripheral portion of the second face. Electrode **70** is applied to the second face of transducer **66** such that there is an unelectroded ring portion **72** between electrode **70** and the portion of electrode **68** on the second face of the transducer.

Springs **76** are connected to the electrodes and to conductive pads **78** (FIGURE 7) which are mounted on strut **80** so as to be insulated from each other. Connection is made to connector **33** by means of lugs **81** and wires **82** as shown in FIGURE 6. When an ultrasonic excitation signal of the proper frequency is applied to transducer **66** through these connections, the transducer vibrates in thickness mode and forms a geyser **84** from the liquid **86** as shown in FIGURE 5.

The liquid **86** is kept at the proper level by means of valve **88** which is located between reservoir **50** and chamber **48**. Valve **88** is a two position valve; in one position, it closes channel **90** and thereby inhibits the flow of liquid from the reservoir **50** to the chamber **48** and in the other position, it opens channel **90** and thereby permits liquid to flow from reservoir **50** to chamber **48**. The position of valve **88** is controlled by means of knob **93**.

It should be noted that chamber **48** may be easily disconnected from channel **90**. This is possible because channel **90** is connected to chamber **48** by means of a force-fit taper as shown in FIGURES 3–5. This enables the user to disconnect the chamber and place it, for example, in an autoclave for sterilization.

Reservoir **50** is filled to the correct level, as shown on the indicator, through opening **91** with valve **88** closed. When the correct level is reached, cap **89** is threaded snugly over opening **91** providing an airtight seal to produce a partial vacuum above the liquid in the reservoir as its level diminishes. Now, fill chamber **48** to a level that covers the inlet from the reservoir **50** to the midpoint of channel **90**. Open valve **88** and henceforth, as the liquid in the chamber is consumed, it will be replenished from the reservoir.

Usually, one can also obtain the same result, by filling reservoir **50** and then opening valve **88**. In either case, operation will continue if the surface tension and viscosity of the liquid were broken initially. The surface tension may also be broken, under certain conditions, by using a wetting agent in the liquid. However, the wetting agent must be compatible with the solution and the treatment procedure.

Since, as a general rule, small moisture droplets are best for the treatment of most respiratory ailments, it is advisable to avoid, insofar as is possible, the emission of large droplets into the surrounding atmosphere. This is accomplished by causing the larger droplets to precipitate or fall back into the liquid source or to collect in the exit conduit prior to emission into the surrounding atmosphere. Top **60** of chamber **48** is removable and is provided with a pair of conduits of noncorrosive plastic such as polycarbonate or similar material. These conduits **92** and **94** are respectively utilized to supply gas, such as air, to the chamber at a pressure above ambient pressure, and to entrain the liquid mist (fog) into the surrounding atmosphere.

As can be seen from the figures, conduits **92** and **94** lead from the inside to the outside of the chamber through suitable openings in top **60**. While the gas utilized in the embodiment of the invention, illustrated and described, is air, it is also within the contemplation of the invention to use other gases for medical purposes. Moreover, one may use a pressure tank or other device for delivering the gas to the chamber in lieu of the blower shown and described.

Flexible hose **96** is connected between blower output **98** and conduit **92** so that the air is delivered to chamber **48** close to its wall **62** so that the air swirls around the chamber in a direction away from the opening of conduit **94** within the chamber. As the air swirls in the chamber in the direction indicated by arrows **100**, as shown in FIGURES 4 and 5, the liquid droplets forming the geyser **84** move first in the same direction as the airflow. But when they reach the aperture of helicoid section **94**A of tube **94** they are subjected to a sharp change in direction (nearly 340° upwards) which separates out the remaining large or medium size drops which have not been collected on the walls **62**. After entering into conduit **94**, which has a helicoidal shape **94**A, there is a further centrifugation of the few large drops which may have escaped the two preceding separating steps (i.e. collection on walls **62** and change of direction as shown by arrows **102**).

The theory underlying the production of fine fogs containing small droplets is:

(1) The introduction of the gas into the chamber such that its motion is tangential to the walls, which causes centrifugation of the geyser and a dropping back of many of the larger droplets into the liquid pool (as shown by arrows **101**).

(2) The remainder of the droplets in the fog must change direction by an angle of about 340° (as shown by arrows **102**), against, among other forces, the force of gravity when the mist enters helicoid portion **94**A of conduit **94**. This causes many of the remaining larger droplets to separate from the flow of the balance of the mist and drop back into the liquid pool (as shown by arrows **103**).

(3) Further centrifugation takes place in conduit **94** since the radius of the gas vortex has decreased due to its being confined in the conduit and the balance of the large droplets are deposited on the walls of helicoid portion **94**A of conduit **94** (as shown by arrows **105**). The droplets so collected drop back into the liquid pool because conduit **94** is tilted downward toward the opening of the conduit within the chamber.

The amount of airflow can be varied by adjusting damper **104** (FIGURES 3 and 8). Damper **104** is comprised of openings **106** and plate **108**. Plate **108** is rotated by means of knob **110** so that it closes all but one, some, or none of the openings **106** in damper **104**. When all but one of the openings are closed, air reaching the blower is considerably reduced and the air delivered by the blower is at a minimum. When all the openings are open, air is fed to the blower through the damper openings so that the air delivered by the blower is at a maximum.

Under certain conditions, a coarse mist (large droplets) is desired. In such cases, top **61** is substituted for top **60**. Gas enters the chamber through conduit **95** and the mist is emitted to the surrounding atmosphere through conduit **97**. Because very little of the conduit **97** projects into the chamber, the droplets separation by selective swirling stages within the chamber is minimal. Consequently, a large number of coarse droplets from the geyser is entrained through conduit **97** and emitted through pipe **44** which is attached to conduit **97** when it is in operation.

Operation for the production of mists of small droplets (using top **60**) proceeds as follows: the screws **42** are loosened, pipe **44** is removed and the assembly is slid out of cabinet **24**. Valve **88** is closed and cap **89** is removed from opening **91**. Medicated solution is poured into reservoir **50** to the proper level and cap **89** is replaced. Medicated solution is now poured into chamber **48** to at least the midpoint of channel **90** and then valve **88** is opened. Next, switch **32** is turned on and after 60 seconds delay, timer **36** is turned on for 2 or 3 minutes. As soon as the geyser forms, trimmer **34** is adjusted for maximum geyser height and locked in place. Now, the timer is moved to the off position and switch **32** is turned off. The assembly is moved back into cabinet **24** and pipe **44** is put in place. Screws **42** are tightened and the fog generator is ready for treatment of patients.

Switch **32** is turned on. After 60 seconds' delay, the timer is moved to the setting for the desired treatment time and treatment begins. The system is designed so that if the timer is set for the maximum time permitted, it will turn off before the liquid in the reservoir is completely exhausted. This will prevent damage to the transducer and the signal generator.

In FIGURES 11 and 12, there is illustrated a further embodiment of ultrasonic fog generator of the invention. Fog generator **120** is seen to comprise liquid chamber **122**, liquid reservoir **124**, signal generator **126** and blower **128**. Transducer **130** is similar to transducer **66** and is suitably connected to signal generator **126**. When transducer **130** is excited, a geyser **132** is formed as shown in FIGURE 12. The gas such as air is delivered to the chamber **122** by means of conduit **134** in the base **135** of the chamber so that it enters the chamber close to wall **136**. This causes the air to swirl in the chamber as shown by arrows **138**.

The tangential flow of air causes an air vortex which subjects the geyser **132** to low frequency mechanical oscillation. This oscillation weakens the geyser's resistance to disintegration and increases the mist output. The large droplets are refluxed into the liquid pool as shown by arrows **140**. The mist formed of the smaller droplets of geyser **132** move in the direction of arrows **142** out of conduit **144** which is flared within the chamber as shown at **146** for collecting large drops which then reflux into the liquid along the funnel walls.

The removal of the larger droplets from the mist formed by the geyser takes place in two steps:

(1) The gas is introduced into the chamber such that its motion is tangential to the walls, causing centrifugation of the geyser and a refluxing of many of the larger droplets back into the liquid pool as shown by arrows **140**.

(2) Further centrifugation as shown by arrows **141** takes place in conduit **144** due to the constriction of the gas vortex within the conduit. This final centrifugation takes place because in a true vortex the product of the tangential velocity and the radius remains constant. Since the radius has been reduced drastically, the tangential velocity becomes very large thereby forcing the larger droplets against the walls of the conduit along which they run and then drop back into the liquid pool.

The reservoir **124** is filled by removing cap **148** and pouring the medicated solution through opening **150**. The level in chamber **122** is maintained by means of float valve **153** which is connected to pipe **154** and operates in a manner well-known in the art. As the level lowers, the float drops, the valve opens and liquid flows through pipe **154** from reservoir **124** to chamber **122**. When the liquid in the chamber reaches the desired level, the float valve closes and the flow of liquid from the reservoir to the chamber stops.

Controls similar to those used in the embodiment of FIGURES 1 through 10 may also be used for the operation of fog generator **120**. Its operation is similar to that of the earlier described embodiment. Damper **149** is utilized to control the volume of air delivered to blower **128**. Plate **151** is slid so that it covers none, some, or most of openings **152**. If none are covered, the maximum amount of air is delivered by the blower. If most of them are covered, the minimum amount of air is delivered by the blower.

Operation of the apparatus of the invention and the carrying out of the method thereof are often improved if the gas is delivered to the liquid chamber at high velocity and thereby facilitates the initiation of the swirling motion within the liquid chamber.

While particular embodiments of the invention have been shown and described, it is apparent to those skilled in the art that modifications are possible without departing from the spirit and scope of the invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. An ultrasonic fog generator for entraining fogs produced from a liquid into the surrounding atmosphere comprising:

an enclosed chamber for containing the liquid from which the fog is to be produced having a base, a top and a wall;

at least one nonfocusing transducer mounted in the base of the chamber in direct contact with the liquid from which the fog is to be produced;

means for applying ultrasonic excitation to the transducer such that when such excitation is applied to the transducer, a geyser is formed from the liquid within the chamber;

means for introducing gas into the chamber at higher than ambient pressure and at high velocity such that the gas initiates a swirling motion within the chamber and upon contacting the geyser, causes the liquid particles therein to swirl in the same direction within the chamber to thereby cause centrifugation of the geyser so that the larger droplets of the geyser are refluxed into the liquid;

said means for introducing gas into the chamber comprising a blower and a pipe having two ends, one end of the pipe being connected to the output of the blower;

the other end of the pipe being open and projecting into the chamber such that gas is introduced into the chamber near the wall thereof;

the portion of the conduit projecting into the chamber being helicoidal in shape and positioned such that the mist entering the conduit is caused to change direction by about 340° to thereby cause the larger droplets to reflux into the liquid;

the top of the chamber having an opening therein;

a conduit projecting into the chamber through the opening in the top thereof through which the fog is dispensed into the surrounding atmosphere;

the conduit having a smaller radius than the chamber so that further centrifugation of the fog takes place therein to thereby cause the larger droplets to collect on the walls of the conduit and to be refluxed into the liquid.

2. The invention of claim **1** including:

a liquid reservoir for storing the liquid from which the fog is produced to be delivered to the chamber;

a valve connected between the liquid reservoir and the chamber such that the liquid in the chamber is maintained at a predetermined level.

3. The invention of claim **2** wherein the top of the chamber is removable.

4. The method of forming fog and entraining the said fog into the surrounding atmosphere which comprises:

placing liquid from which a fog is to be produced in a chamber;

exciting the liquid at an ultrasonic frequency over a broad area such that a geyser is formed within the chamber;

introducing gas at higher than ambient pressure into the chamber tangential to the walls thereof at high velocity such that the gas initiates a swirling motion within the chamber and upon contacting the geyser causes the liquid particles therein to swirl in the same direction within the chamber to thereby cause centrifugation such that the larger droplets thereof are refluxed into the liquid;

emitting the formed fog into the surrounding atmosphere through a conduit having a smaller radius than the chamber so that further centrifugation of the fog takes place to thereby cause the larger droplets to collect on the walls of the conduit and to be refluxed into the liquid.

5. The method of claim **4** wherein the ultrasonic frequency is of the order of 600 kHz. to 1 mHz.

6. The method of claim **4** including: causing the fog being emitted through the conduit to change direction by an angle of the order of 340° upon entering the conduit to thereby cause the large droplets to be refluxed into the liquid.

7. The method of claim **6** wherein the ultrasonic frequency is of the order of 600 kHz. to 1 mHz.

8. An ultrasonic fog generator for entraining fogs produced from a liquid into the surrounding atmosphere comprising:

a chamber for containing the liquid from which the fog is to be produced having a base, a top and a wall;

at least one nonfocusing transducer mounted in the base of the chamber in direct contact with the liquid from which the fog is to be produced;

means for applying ultrasonic excitation to the transducer such that when such excitation is applied to the transducer, a geyser is formed from the liquid within the chamber;

the top of the chamber having two openings therein;

means for introducing gas into the chamber at higher than ambient pressure and at high velocity through the first of the openings in the top thereof, said means for introducing gas into the chamber comprising a blower;

a pipe having two ends mounted in the first opening in the top of the chamber, one of the ends being inside the chamber, the other of the ends being outside the chamber;

a portion of the pipe being inside the chamber, which portion is shaped such that the gas introduced into the chamber is caused to swirl therein;

means connecting the end of the pipe outside the chamber to the blower;

means in the second opening in the top of the chamber through which the fog is entrained into the surrounding atmosphere.

9. An ultrasonic fog generator for entraining fogs produced from a liquid into the surrounding atmosphere comprising:

a chamber for containing the liquid from which the fog is to be produced having a base, a top and a wall;

at least one nonfocusing transducer mounted in the base of the chamber in direct contact with the liquid from which the fog is to be produced;

means for applying ultrasonic excitation to the transducer such that when such excitation is applied to the transducer, a geyser is formed from the liquid within the chamber;

the top of the chamber having two openings therein;

means for introducing gas into the chamber at higher than ambient pressure and at high velocity through the first of the openings in the top thereof; said means for introducing gas into the chamber comprising a blower; a pipe having two ends mounted in the first opening in the top of the chamber, one of the ends being inside the chamber, the other of the ends being outside the chamber; and means connecting the end of the pipe outside the chamber to the blower;

said gas being introduced into the chamber in a direction tangential to the walls thereof such that the gas initiates a swirling motion within the chamber and upon contacting the geyser, causes the liquid partiles therein to swirl in the same direction within the chamber to thereby cause centrifugation of the geyser so that the larger droplets of the geyser are refluxed into the liquid;

the means through which the fog is entrained into the surrounding atmosphere comprising a conduit having a helicoidal shape within the chamber and placed such that the direction of motion of the fog entering the conduit is changed by an angle of the order of 340° to thereby cause the larger droplets to reflux into the liquid;

the conduit having a smaller radius than the chamber so that further centrifugation of the fog takes place therein to thereby cause the larger droplets of the fog to collect on the walls of the conduit and to be refluxed into the liquid;

means in the second opening in the top of the chamber through which the fog is entrained into the surrounding atmosphere.

(References on following page)

References Cited

UNITED STATES PATENTS

2,466,020	4/1949	Goldberg	128—185

FOREIGN PATENTS

1,487,480	5/1967	France.
1,499,393	9/1967	France.

OTHER REFERENCES

Macrosonics Corporation, Bulletin 102, dated Feb. 24, 1964.

M. HENSON WOOD, Jr, Primary Examiner

BERNARD BELKIN, Assistant Examiner

U.S. Cl. X.R.

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