United States Patent

Melville et al.

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[54] HUMIDIFICATION

[72] Inventors: Alfred W. Melville, 255 Shirley Rd.; Frank W. Shacklock, 16 Watson Place, both of Papatoetoe, Auckland; David H. O'Hare, 47 Litten Road, Howick, Auckland, all of New Zealand

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[51] Int. Cl. B01f 3/04

[58] Field of Search ....128/192, 193, 212, 1 B; 219/274, 301, 307; 261/139, 142, 130, 154, 153, DIG. 34, DIG. 65

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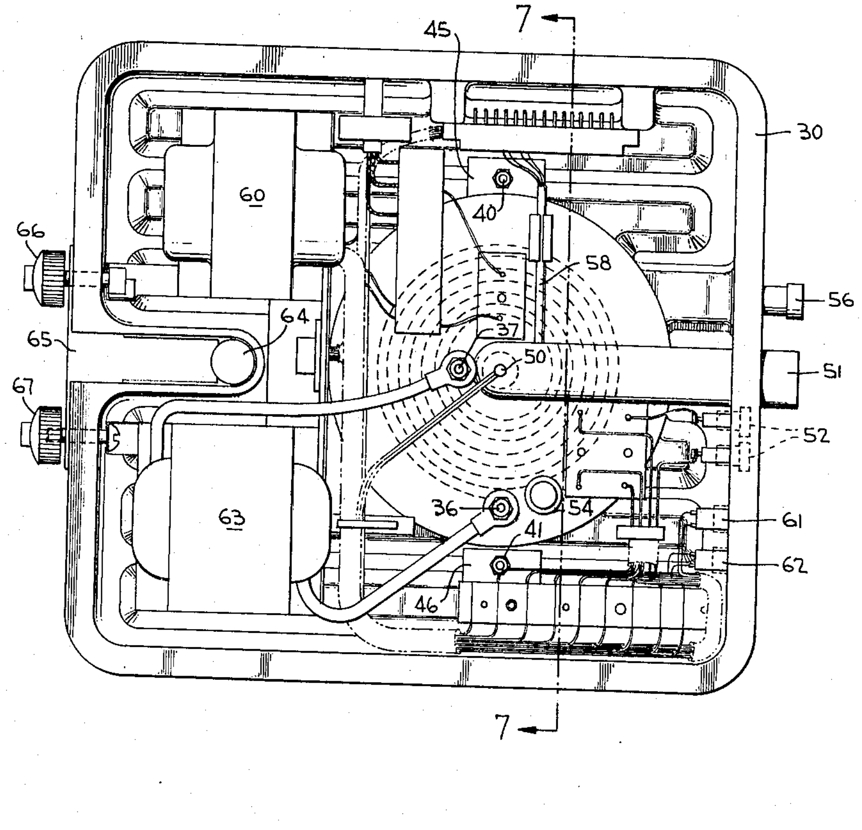
Primary Examiner—Tim R. Miles
Attorney—Holman & Stern

[57] **ABSTRACT**

Humidification and heating apparatus preferably including a spirally wound resistance-heated plate with its axis vertical and one side in thermal contact with a sheet of water absorbent material. Both plate and material are partially immersed in water in a tank the lid of which is sealingly engaged with the spiral plate. When used for artificial respiration air from a respirator is admitted and discharged from the tank at points such that it must travel along the spiral passage formed by the plate, water surface and lid thus picking up heat and water vapor to emerge preferably substantially saturated at a temperature which does not exceed the maximum desired input temperature at the patient. To prevent condensation en route to the end user, sufficient further heat is imparted to balance that lost in passage. Preferably the interconnecting apparatus between the humidifier and patient is heated at least in portions along its length and preferably by electrically heated elements embedded in the wall of the usual flexible tube leading from the humidifier to the patient.

15 Claims, 7 Drawing Figures



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SHEET 1 OF 3

FIG. 1

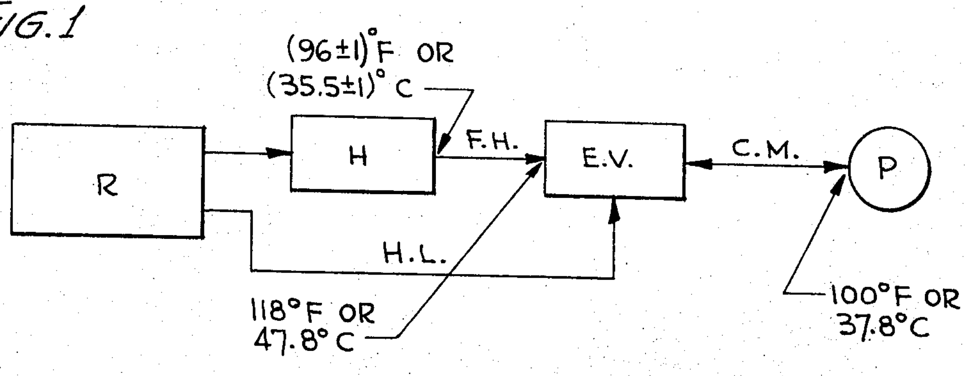


FIG. 2

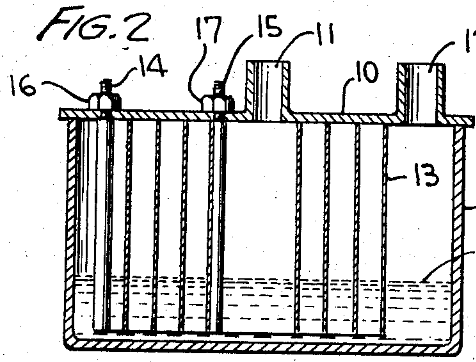


FIG. 3

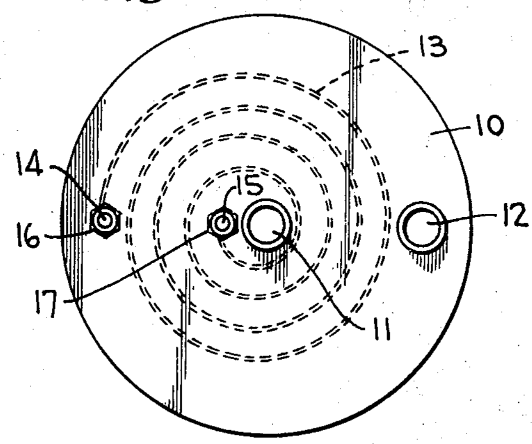


FIG. 4

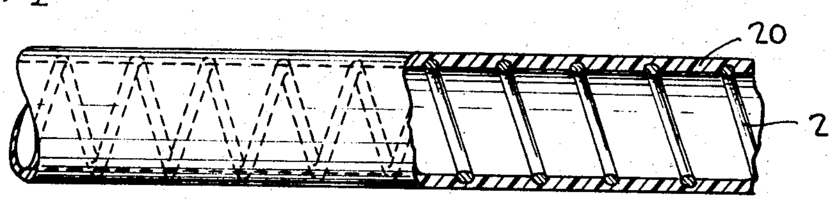
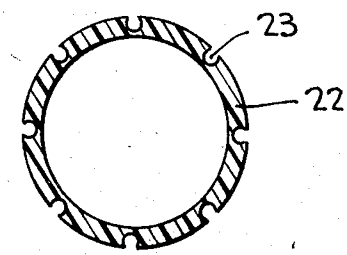


FIG. 5



INVENTORS,
ALFRED W. MELVILLE
FRANK W. SHACKLOCK
DAVID H. O'HARE

BY

ATTORNEYS

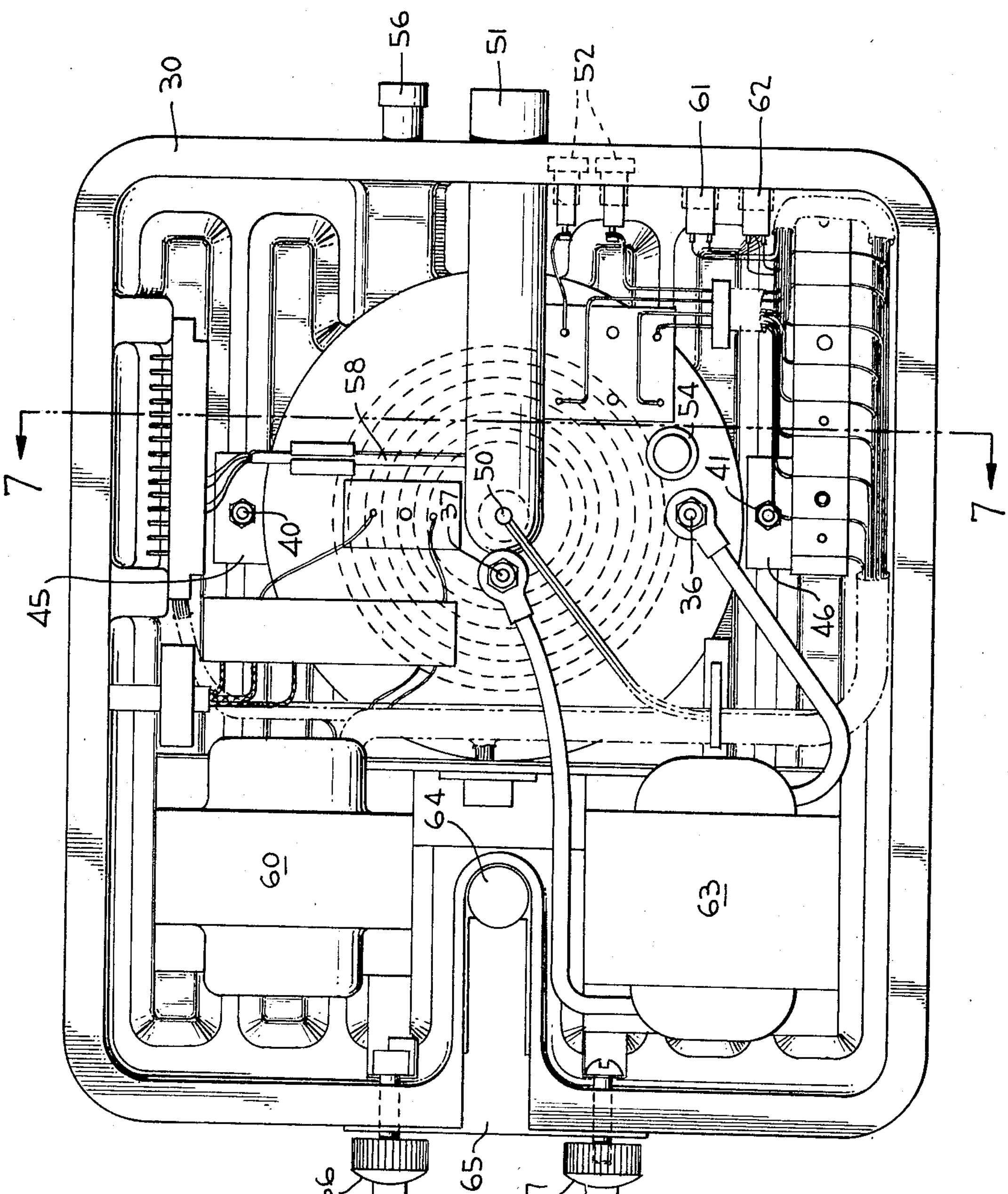


FIG. 6

INVENTORS,
ALFRED W. MELVILLE
FRANK W. SHACKLOCK
DAVID H. O'HARE

BY

ATTORNEYS

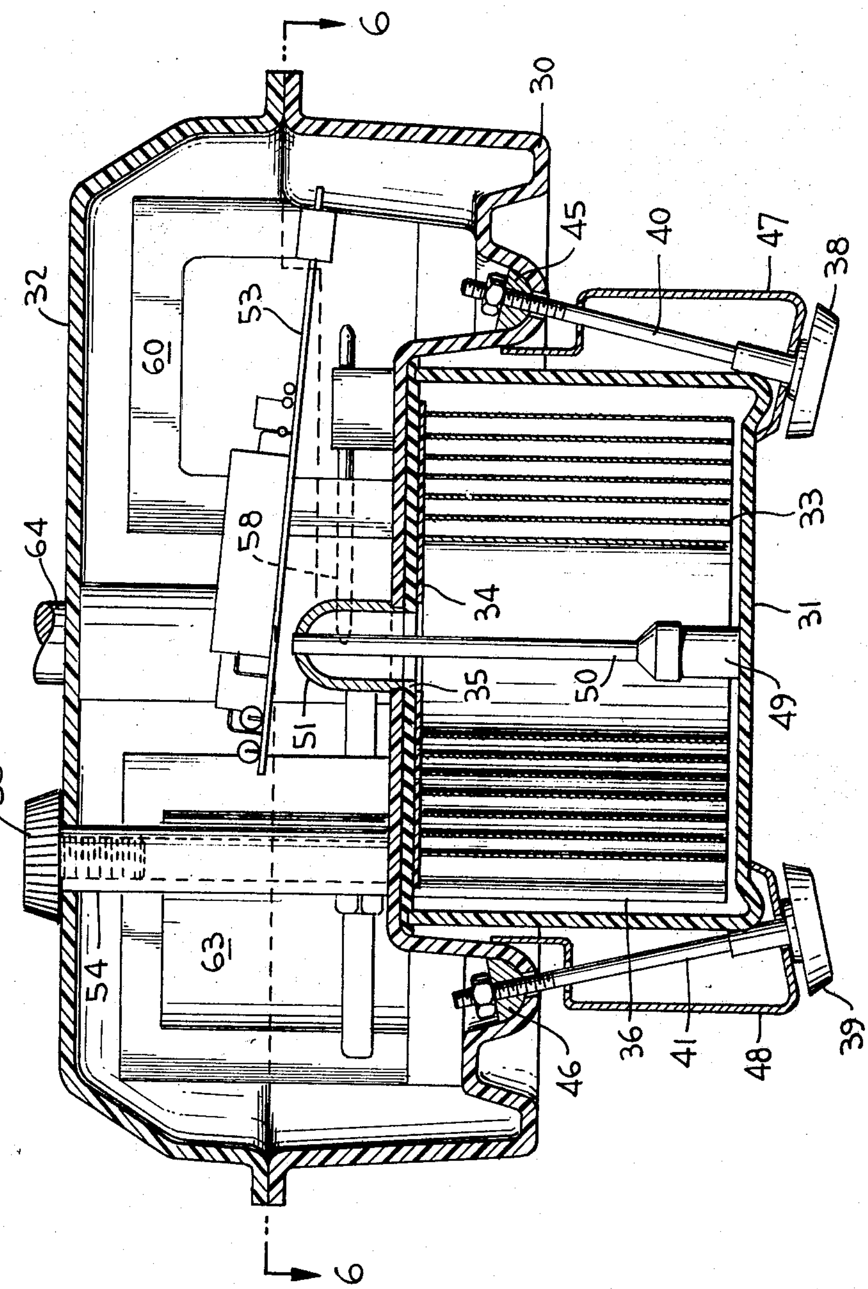


FIG. 7

INVENTORS,
ALFRED W. MELVILLE
FRANK W. SHACKLOCK
DAVID H. O'HARE

BY

ATTORNEYS

HUMIDIFICATION

This invention relates to apparatus for humidifying and heating air particularly but not solely air which is to be breathed by a patient undergoing artificial respiration.

It is frequently desired to respirate a patient who is in a condition of shock. It is important in such a case that the air delivered into the patient's body should be at a temperature of blood heat (98.4° F. or 36.9° C.) or within a reasonable tolerance and nearly or completely saturated with water vapor in order to maintain body heat and water content. If the air is not substantially saturated, then water is lost from the patient because every time he exhales, the expired air is, as usual, laden with moisture. The heat required to vaporize this moisture is of course extracted from the patient. Furthermore, as the air impinges on the trachea and other parts of the breathing passages the viscosity of the mucous is increased if the air is not near saturation and, apart from irritations, complete blockage of an air passage can occur, especially in babies.

The apparatus which is currently used to respirate a patient comprises a respirator which produces a series of pulses of air at the required (and known) pressure and volume, a humidifier coupled to the output of the respirator for saturating the air with water vapor, a flexible conduit or hose from the humidifier to a respiratory valve, and a further flexible conduit universally known as the "Catheter Mount" terminating in a tube (the tracheal tube) which is inserted in the mouth or nose of the patient, or into an opening in the throat if the patient has had a tracheotomy. This tube extends to the top of the patient's chest cavity.

The expiratory valve includes a small circular disc valve between the Catheter Mount and the exhaust outlet. This valve is held on its seat by means of a very light spring and also by means of air pressure supplied via an air hose from the respirator. Thus, when the respirator delivers a pulse of air to inflate the patient's lungs, the exhaust valve is also held firmly on its seat, but this holding pulse is removed subsequently so that when the lungs deflate under normal muscular contraction the only force holding the exhaust valve shut is the light spring pressure which is easily overcome to allow the air to exhaust. The back pressure of air in the connection between the expiratory valve and the humidifier prevents any reverse flow of air in that region.

The humidifiers currently used either humidify air by spraying and subsequent evaporation of tiny droplets of water produced from very small jets as the air flows through the apparatus, or they use a large heated bath of water over which the air is passed from the respirator to pick up moisture.

In the first type of apparatus the very small jets necessary tend to block and if filters are provided then the filters need to be cleaned very frequently if the performance of the apparatus is to be maintained. Both of these are serious disadvantages. Also, the water droplets produced do not always vaporize completely by the time they reach the patient. Water passing into the patient's lungs in liquid state has no beneficial effect, in fact tends to drown the patient. Therefore, the water must be removed periodically so that the patient cannot be left unattended for very long periods. Considerable condensation also occurs during the passage of water vapor and the droplets between the humidifier and the patient, as a connection tube approximately four feet long is necessary to enable the humidifier and respirator to be conveniently positioned. In some cases the accumulation of water in the connection tube can be so severe as to seriously impede the flow of air therethrough if the tube is not frequently cleared. The expiratory valve is a condensation trap, as it is at a temperature lower than blood heat and surface tension effects from condensed water operating on the circular disc valve tend to hold it to its seat and thus restrict the patient when he is trying to exhale.

With the above-mentioned disadvantages it is, of course, impossible to tell how much water the patient is actually getting during a given time and, of course, knowledge of this quantity is important as it is very desirable to balance the patient's water intake with the water lost during expiration, which can be calculated quite easily.

The second known type of apparatus using a large heated area of water at about 97° F. or 36.1° C. does not suffer from clogged jets or filters, but accurate and quickly responsive temperature control is a problem because of the large mass of water which is slow to heat or cool. The evaporating surface is limited and the degree of humidification is dependent on airflow. Apart from this disadvantage the remaining disadvantages of the spray-type humidifiers are also present. Droplets of water are frequently observable as mists over the water both surface and these are prone to precipitate elsewhere on the apparatus or in the patient.

It is therefore an object of the present invention to provide apparatus for humidifying and heating air which will at least partially overcome the above mentioned disadvantages and/or which will provide the public with a useful choice.

In one aspect the present invention consists in apparatus for humidifying and heating air to be breathed by a patient undergoing artificial respiration, comprising humidification and heating means to heat air to a suitable temperature which does not exceed, under steady operating conditions, the maximum desired temperature at which the air is to be admitted into the patient's body, and to substantially saturate the air with water vapor at that output temperature; and further heating means to further heat the substantially saturated air from said output temperature, the air heated by said further heating means being carried in use through auxiliary apparatus into the patient's body, the construction and arrangement being such that in use the increase in temperature of the air to be breathed which is imparted by said further heating means at the output thereof is selected to be equal to or to exceed the temperature drop which occurs in the air so heated in its passage between said output of said further heating means and the patient's body and in any event said temperature increase is adjusted to ensure that the air is delivered to the patient at no more than said maximum desired temperature.

In a further aspect the present invention consists in a method of preventing condensation of water from humidified air in its passage from a humidifier to a place of ultimate use via suitable conduits, in which the air is humidified at the desired temperature in said humidifier to the desired level and is then further heated so that during passage to said place of ultimate use the air temperature never drops below the dew point and arrives at said place of ultimate use at the desired temperature and with the initial water content.

One preferred form of the present invention will now be described with reference to the accompanying drawings in which;

FIG. 1 shows a block diagram of the components in a normal respiratory system including the present invention in which the usual temperatures at various points in the system are labeled,

FIG. 2 is a diagrammatic cross section through a simplified humidifier and heater,

FIG. 3 is a plan view of the simplified humidifier and heater from above, showing in dotted outline the spirally wound plate.

FIG. 4 shows a side elevation and partial cross section of a flexible tube having a heating element embedded in the inside surface thereof.

FIG. 5 shows a cross section of an alternative form of flexible tube in which the heating elements (not shown) lie within grooves extruded into the outer surface of the tube;

FIG. 6 shows a plan view of the actual humidification and heating apparatus from above; and

FIG. 7 shows a cross section on the lines VII—VII of FIG. 6.

FIG. 1 shows a general arrangement of respiratory apparatus in which a respirator R delivers pulses of air to a humidifier and heater H which humidifies and heats the air, which is then delivered via a flexible hose FH to an expiratory valve EV. When the patient is inhaling, the air from the expiratory valve passes through the catheter mount CM to the patient P. When the patient exhales air passes in the reverse direction through the catheter mount CM through the expiratory valve CV to exhaust into the atmosphere. The hold line HL from the respirator to the expiratory valve ensures that the exhaust valve is closed when the patient is inhaling.

As indicated in FIG. 1, the preferred temperature ranges of the air at various points in the apparatus are as follows:

The air leaving the humidifier should preferably be 35.5 (±1) C. and should preferably be saturated or at least 85 percent saturated. The air arriving at the expiratory valve should preferably be 47.8° C., assuming that there will be a 10° drop in temperature before the air enters the patient. With an expiratory valve as marketed by the Bird Corporation of U.S.A. combined with a typical catheter mount, which is of standard construction comprising a length of about 6 inches of flexible rubber tube, the temperature drop will be approximately 10° C. Naturally, if other expiratory valves or catheter mounts are used the temperature drops may be greater or smaller, in which case the temperature at the inlet to the expiratory valve will need to be suitably adjusted. It will be understood that the preferred temperature of the air entering the patient's body will be 37.8° C. at which temperature the water content of the air will be about 11 percent below saturation, if it was initially saturated at 35.5° C.

The three main principles on which the present invention is based reside in the recognition that if the saturation point temperature of the air leaving the humidifier is maintained at or below the temperature at which the air is admitted to the patient and the temperature between the humidifier and the patient is not allowed to drop below the saturation point temperature, there can be no condensation of water vapor between the humidifier and patient. In practice, this can be achieved either by ensuring that the air leaving the humidifier contains a relatively low proportion of water vapor, in which case the saturation point temperature will be lower than the temperature of the air leaving the humidifier, or preferably, since one of the objects of the invention is to ensure that the patient's water balance is maintained, to ensure that the air leaving the humidifier has a saturation point temperature at approximately blood heat and to ensure that this temperature is exceeded at all other points in the apparatus leading to the patient. Also, the design of the humidifier having excess humidification surface so that substantial saturation is always achieved at all usual air flows assists in eliminating a further variable.

The third basic principle is to ensure that the expiratory valve is at a temperature above blood heat. The reason for this is that the air which the patient exhales is saturated with water vapor at blood heat. If the expiratory valve is maintained above this temperature then no condensation can occur on the exhaust valve and the patient's breathing is therefore not restricted.

Preferably, the catheter mount is also maintained at a temperature above blood heat.

Considering now the design of the humidifier and heater, some of the criteria governing the design are that the humidifier must be capable of saturating the air at an average flow of 10 liters or a maximum flow of 30 liters per minute. The humidifier and heater should also heat the air passing through it to approximately blood temperature. In fact, as mentioned above, a temperature of 35.5 (±1.0)° C. is chosen.

FIGS. 2 and 3 show a preferred form of humidifier comprising two body portions **9** and **10** which are normally in sealing engagement with each other but are also demountable when necessary for cleaning and other purposes. The body portions **9** and **10** form a container for water to be evaporated in the apparatus.

Preferably, and as shown in the drawings, the body portion **9** is in the form of a transparent tank and the body portion **10** is in the form of a lid therefor. There are first and second air passages **11** and **12** which in the drawings are shown passing through the lid portion **10**. Other arrangements are possible, however, in which the air passages pass through the body portion **9** or both body portions **9** and **10**. In use, one of the air passages **11** or **12** is attached by a hose to the respirator and the other is attached to the flexible hose leading to the expiratory valve. A heater to heat the air passing through, and also the water in, the apparatus comprises a spirally wound electrically and heat conductive plate **13** arranged with its axis substantially vertical in use. The ends of the plate are wound around and spot-welded to stainless steel terminal rods **14** and **15** which are threaded at the upper ends where they pass through suitable apertures in the lid portion **10**. In practice, a suitable plate with seven full turns has been constructed of "430"or "304 L" grade stainless steel plate 0.305 millimeters (0.012 inch) thick, the height of the spiral being 7.6 centimeters, the maximum radius being 5.4 centimeters and the length of the plate in the spiral being 157.5 centimeters, approximately. The total resistance of the plate is about 0.04 ohms and a low-level input voltage of about 1 volt is applied from a suitable transformer (not shown) incorporated in the apparatus. The spirally wound plate thus dissipates about 20 to 30 watts on the average. Control of the input to the transformer feeding the spirally wound plate, if considered necessary, may be effected by means of a suitable thermostat. In an alternative construction a sheathed resistance element may be wrapped around the spiral plate to effect heating, or a conventional element could be inserted directly in the water and the spiral plate left unheated. This latter construction has, however, obvious disadvantages.

A still further possibility is to use a spirally wound aluminum or other metal plate which, before winding, is punched to press out suitably spaced rows of spaced tabs under which a suitable length of plastic coated or otherwise insulated electric heater wire may be threaded prior to bending the tabs over to hold the wire in position and forming the plate into a spiral. Suitable wire would have a resistance in the order of about 3 ohms per meter and a length of about 3 to 5 meters would be sufficient. The advantage of this construction is that the necessity for a heavy current transformer is eliminated.

The spirally wound plate **13** is maintained substantially in sealing engagement for maximum efficiency with the lid portion **10**. In practice the plate **13** is bonded by an epoxy resin to an insulating plate at the top and is pulled up into contact with a rubber seal around the lid by means of nuts **16** and **17** on the terminal rods **14** and **15**. The lower end of the spirally wound plate **13** is submerged under water, the normal water level being shown at **18**, and thus air admitted through whichever of the air passages **11** and **12** is the inlet passage must pass along the spiral passage formed by the plate **13** before it can emerge from the air outlet. Naturally, the outlet of the air passages **11** and **12** into the body of the apparatus is above water level.

In order to ensure that there is a sufficiently large heated surface from which water can evaporate into the air within the body of the apparatus, a spirally wound coil of absorbent paper, such as blotting paper or filter paper, is inserted into the spiral coil in close contact with the plate **13** along the innermost surface thereof. The natural tendency of the paper to unwind enables it to be held to the spiral plate by means of simple securing means at the ends. In practice, the paper is relatively long lasting but nevertheless it is desirable to be able to demount the body portions **9** and **10** occasionally to renew the paper when necessary and also to clean out any sediment which might accumulate in the bottom of the apparatus.

Water may be added to the apparatus to replenish that lost by means of a suitably capped aperture preferably in the lid portion **10**. This aperture is not shown in the simplified drawings of FIGS. **2** and **3**. The filling aperture must of course be normally well sealed to ensure that there are no air leaks from the humidifier and heater when pressurized with air from the respirator.

Such a humidifier is able to supply air heated to about 35.5° C. the precise temperature being adjustable, and almost if not completely saturated at that temperature. Because of the comparatively small thermal mass of the heated plate **13** there is a relatively quick response to conform to any desired temperature change. Also, the apparatus reaches an operative condition in a matter of a few (10) minutes as of course the body of water in the apparatus does not have to be brought to the operating temperature before the apparatus will function usefully, due to the comparatively low-thermal conductivity of the heated plate 13.

The humidifier and heater construction thus described successfully ensures that in a comparatively small and simple apparatus air of the desired temperature and moisture content is obtained with no undue pressure drop and, it has been found, independent of the usual range of flow rates.

In order to achieve the remaining object of the invention, i.e., further heating of the air to prevent condensation, the air from the exit aperture could simply be heated at the exit point with a further heating means before conveyance to the flexible hose leading to the expiratory valve. However, there would be a considerable temperature drop across the flexible hose which is a relatively poor thermal insulator if constructed of polythene or similar plastic material. It has been found desirable to heat the flexible hose along its length rather than to heat the air to be supplied to the hose, and the manner in which this has been accomplished will now be described with reference to FIGS. 4 and 5.

The flexible hose is preferably a transparent thermoplastic tube 20 such as polythene and, as shown in FIG. 4, an internal heating element 21 may be arranged within it. Such an element 21 is in the form of a helix and, to improve the mechanical stability of the element, it is partially embedded in the inner wall of the hose. The heating element is preferably 22 gauge enameled constant-resistance wire and the pitch of the helix in which it is wound is preferably 0.63 centimeters. With this pitch condensation does not occur between turns of the helix. The helix is actually double wound so that electrical connections may be made at one end of the tube. In practice, the tube is connected with a taper fitting (not shown) which fits into a suitable taper socket provided on the air outlet of the humidifier, and the electrical connections are at that end and plug into suitable electrical sockets provided from the electrical system of the humidifier. The actual wattage of the element, which is run on about 12 volts for safety reasons, is approximately 16 watts and this achieves a temperature rise of about 12.3° C. when the length of the hose is bout 112 centimeters.

To construct such a hose, the wire helix is wound in close coil form over a mandrel of suitably large diameter and when completed is removed from the mandrel and stretched to the required length. The internal diameter of the heating element helix is chosen to be equal to that of the internal diameter of the polythene tube into which it is to be inserted. If the gauge of the wire is uniform, this method ensures that the pitch of the helix is also uniform. The stretched heating element is then placed within a metal tube of suitably large diameter which enables the heating element to have a sliding fit within it. At one end of the tube there is an air inlet which can be attached to a source of compressed air. At the other end, the tube is attached by means of a suitable adapter to the polythene tube into which the element is to be inserted. The other end of the polythene tube is blocked by a plug. Compressed air is then blown into the metal tube to inflate the polythene tube (which, if necessary, is slightly heated to render it plastic) and when the tube has been sufficiently expanded by two wire diameters the heating element slides form the metal tube through the adapter and into the polythene tube. With a little shaking it can be positioned where required and the polythene tube is then deflated so that it contracts onto the spirally wound heating element. It is then desirable to release stresses in the polythene tube by passing a current of about 2 amperes through the element. Alternatively, the tube can be heated by other means. Following this step a current of about 5 amperes is passed through the element for a short period so that the tube melts around the element and while this is done the tube is rolled gently on a flat surface to assist the element to embed into the walls. The final result is that the element is embedded so that it does not significantly obstruct the flow of the air through the flexible hose and so that the element's resistance to crushing is improved.

When a connection tube constructed in this manner is attached to the humidifier described above, the expiratory valve is heated to 2 to 3° C. above blood temperature which effectively prevents condensation on the valve seat.

Such a connection tube can also be used with known types of humidification apparatus and it can be adjusted so that the spiral is of closer pitch at the input end of the tube. Thus water droplets from conventional types of spraying humidifiers can be vaporized and the air heated during its passage through the tube to prevent condensation therein and to eliminate condensation on the expiratory valve.

FIG. 5 shows an alternative form of hose 22 in which the hose is extruded with several longitudinal grooves 23 equally spaced around its circumference. These grooves provide a key for insulated heater wire which is advantageously flexible wire able to withstand continual flexing. With this construction a slightly higher wattage is necessary to cope with increased losses from the outside surface of the tube. In a similar arrangement to FIG. 5 a hose could be provided with longitudinal holes instead of slots spaced circumferentially within the walls and through which heating wires could be threaded.

There is shown in FIG. 6, which is a plan view along the line VI—VI of FIG. 7, the interior layout of a prototype humidifier.

FIG. 7 is a section of the prototype on the lines VII—VII of FIG. 6.

From FIGS. 6 and 7 it will be seen that a lid portion 30 is vacuum-formed into a suitable shape preferably from ABS plastic. The lid portion 30, besides forming a lid for a vacuumed-formed perspex, acrylic or polycarbonate water container 31 of circular cross section, also forms a mounting base on which most of the necessary electrical components are mounted. These electrical components are covered by a cover portion 32, also of ABS plastic, which is screwed or clipped at its edges to the lid portion 30. A resistance heated spiral wound plate 33 is bonded to an annular disc of insulating material 34 and is clamped against an annular rubber seal 35 on the lid portion by means of nuts on the terminal studs 36 and 37. The water container 31 is clamped to the lid portion 30 by means of knurled thumbscrews 38 and 39 having long threaded shafts 40 and 41, the threaded portions of which are engageable in threaded holes in short semicylindrical anchor pieces 45 and 46 which ride in longitudinal grooves formed in the lid portion 30 for strengthening purposes. Suitable clips 47 and 48 are associated with the thumbscrews to exert an upward thrust on the base of the water container 31 at diametrically opposite points to maintain it in sealing engagement with the annular rubber gasket 35. Thus the water container 31 may be removed easily and simply by undoing the thumbscrews 38 and 39 to enable accumulated sediment to be cleaned from it when deposits become obvious.

Partially immersed in water during normal operation of the apparatus is a bimetallic thermal cutout 49 which opens circuits when the water temperature reaches 40° C. The thermal cutout is a plug-in type and plugs into an extended socket 50.

The air inlet 56 to the apparatus is only partially shown, but comprises a short tube solvent-adhered to the water container 31 above water level around a suitable aperture in the wall of the container. The air outlet comprises a right-angled branched pipe 51, one end communicating with a central aperture through the lid portion 30, leading into the central core formed by the spiral plate 33, leading into the central core formed the other end extending outwardly to enable the flexible heated hose to be connected thereto in use. Adjacent to the connection point of the flexible hose to the air outlet 51 are banana plugs 52 into which the heating element of the flexible hose may be plugged.

The exit air temperature is monitored by means of a thermistor 58 extending into the air outlet. The thermistor forms part of a bridge circuit, resistance variations of which are amplified by means of conventional circuitry mounted on a plugfin board **53** and used to control the current fed to the spirally wound plate **33**.

Water is admitted as required into the water container **31** via a vertical tube **54** fitted with a screw-in stopper **55**. Alternatively a water inlet may be provided at the appropriate level in the water container **31** to prevent overfilling.

Other electrical components in the apparatus are an isolating and step-down transformer **60** which provides the necessary output voltages to operate the thermostat, flexible hose heater and warning lights **61** and **62** which indicate when the apparatus is functioning normally or when there is a malfunction. In addition, the transformer **60** provides the input for a step-down transformer **63** which provides the large current necessary for resistance heating the spiral plate **33**. In use, the apparatus is usually mounted on a vertical tube **64** which is fastened onto a wheeled base in the conventional arrangement and also carries the respirator. The tube **64** is held into a suitable slot formed in the lid and cover portions **30** and **32** by means of a T-shaped holding bracket **65** which is detachably fastened to the lid portion **30** by means of thumbscrews **66** and **67**.

The foregoing brief description of a prototype apparatus is inserted herein as an aid to understanding the invention, as of course there are obviously numerous other ways of making satisfactory apparatus.

In operation the apparatus is very successful. Independent control of the wattage of the flexible hose is unnecessary since it takes at least a 5° F. (2.8° C.) air temperature rise at the inlet of the expiratory valve to increase the temperature at the point of entry to the patient by approximately 1° F. (0.55° C.). The effect of room temperature, which in most hospitals would b about 75° F. (22.8° C.), is minimal. When the humidifier is uncoupled to manipulate the patient the first air coming through on recoupling is at the safe temperature of about 93° F. (34° C.) because of the initial cooling effect of the expiratory valve which will have lost heat when the apparatus was uncoupled. When commencing to use the apparatus the heated flexible hose reaches its operating temperature very quickly and prevents any condensation as the water content of the air passing is more slowly brought up to its normal value.

Safety is ensured by arranging a thermal cutout to stop the water from being heated beyond a safe level.

What is claimed is:

1. Apparatus for humidifying and heating air to be breathed by a patient undergoing artificial respiration, comprising humidification and heating means to heat air to a suitable temperature which does not exceed, under steady operating conditions, the maximum desired temperature at which the air is desired to be admitted into the patient's body, and to substantially saturate the air with water vapor at that output temperature; and further heating means to further heat the substantially saturated air from said output temperature, the air heated by said further heating means being carried in use through auxiliary apparatus into the patient's body, the construction and arrangement being such that in use the increase in temperature of the air to be breathed which is imparted by said further heating means at the output thereof is selected to be equal to or to exceed the temperature drop which occurs in the air so heated in its passage between said output of said further heating means and the patient's body and in any event said temperature increase is adjusted to insure that the air is delivered to the patient at no more than said maximum desired temperature; said air humidifier and heater comprising a body portion forming a water container adapted to be pressurized and including sealable water inlet means to enable water to be introduced from time to time in use; a water heater to heat water placed in said water container in use; a heat conductive plate arranged as a spiral coil with suitably spaced turns and located within said water container; a water absorbent material disposed along the spiral passage formed by said heat conductive plate; firs and second air passages through said body portion communicating with the interior of said body portion, at least the entrance of the outlet air passage being above water level and one of said air passages communicating with the outside core, and the other with the inside core, of said spiral passage, said water absorbent material being partially immersed in water, said spirally coiled heat conductive plate arranged with its axis substantially vertical in use and also being partially immersed in said water to provide a lower seal to said spiral passage, the top of said spirally coiled heat conductive plate being substantially in sealing engagement with said body portion so that air passing in whichever of said first or second air passages is the inlet passage can only leave via the other air passage and after passing through said spiral passage during which it gains an increased heat and water vapor content.

2. Apparatus as claimed in claim **1** wherein the exit of said air inlet passage is above water level.

3. Apparatus as claimed in claim **1** wherein said humidifier and heater effects at least 85 percent saturation of the air passing through it at a volume flow of **30** liters per minute.

4. Apparatus as claimed in claim **1** which includes air temperature control means to monitor and control the temperature of the air leaving the humidifier and heater.

5. Apparatus as claimed in claim **4** in which the humidification and heating means include control means to ensure that the air supplied therefrom does not exceed a temperature of blood heat.

6. Apparatus as claimed in claim **1** wherein said body portion is in two parts one of which comprises a water tank and the other a lid therefor, both being normally in sealing engagement but being demountable when desired.

7. Apparatus as claimed in claim **6** wherein said sealable water inlet is comprised by providing said body portion in said two parts.

8. Apparatus as claimed in claim **6** wherein a sealable hole is provided through said water container to enable water to be added to said apparatus.

9. Apparatus as claimed in claim **1** wherein said water absorbent material is in contact with said heat conductive plate.

10. Apparatus as claimed in claim **9** wherein said water absorbent material is paper.

11. Apparatus as claimed in claim **10** wherein said water heater is comprised by said heat conductive plate.

12. Apparatus as claimed in claim **11** wherein said heat conductive plate is in thermal contact with an electrical heating element.

13. Apparatus as claimed in claim **12** wherein said heat conductive plate is a metal plate having pressed out tabs securing to it, in a suitable disposition, a suitable length of insulated electric heating element wire.

14. Apparatus as claimed in claim **12** wherein said heat conductive plate is itself electrically conducting and is heated by passage of current directly through it.

15. Apparatus as claimed in claim **14** wherein said heat conductive plate is made of stainless steel.

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