Title
Respiratory gas humidifier system for a patient

International Patent Classification(s)
A61M 016/16
A61M 039/24
A61M 016/20

Application No: 2003227324
Date of Filing: 2003.07.29

Priority Data
Number 10234811.1-44
Date 2002.07.31
Country DE

Publication Date: 2004.02.19
Publication Journal Date: 2004.02.19

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ABSTRACT

A respiratory gas humidifier system for a patient featuring a combination of the following characteristics:

a) A replaceable, pressure-resistant, sealed water reservoir (1) is provided for the water supply to the respiratory gas humidifier system,

b) located below the water reservoir (1) is an intermediate storage vessel (4), sealed off from the environment, which contains water, where

c) the water reservoir (1) and the intermediate storage vessel (4) are each fitted with valve (16, 14) which interact with each other in such a way that

d) a flow connection between the water reservoir (1) and the intermediate storage vessel (4) can only take place when the water reservoir (1) is inserted into a connector (2) on the intermediate storage vessel (4),

e) the intermediate storage vessel (4) is linked by means of a water conduit (5), which is located below the water level, to a heated evaporation chamber (7) which feeds into the respiratory gas line to the patient in the space above the water evaporating at boiling temperature,

f) located between the heated evaporation chamber (4) and the intermediate storage vessel (12) is a gas pressure equalization line (12). (Figure 1)
The following statement is a full description of this invention, including the best method of performing it known to us:
RESPIRATORY GAS HUMIDIFIER SYSTEM FOR A PATIENT

The invention concerns a respiratory gas humidifier system for a patient with the characteristics of claim 1.

Respiratory gas humidifier systems are used especially in the machine-assisted respiration of patients, with respirator systems featuring a ventilator generating a constant respiratory pressure increasingly being used for the respiration of patients in a home setting, particularly for the treatment of sleep apnea. To prevent drying out of the respiratory passages, there is a need for respiratory gas humidifier systems featuring a simple design and easy operation.

A disadvantage of the respiratory gas humidifier systems known to date, such as the one described in DE 296 17 077 U1, is that, for the purpose of pressure equalization, the water supplied by the sterile water containers is directly exposed to the environment, and this can lead to the spreading of germs over time. The use of these known humidifier system for respirator systems with a constant respiratory pressure also means that there is no possibility of respiratory pressure building up in the respiratory gas line to the patient, due to the pressure equalization taking place in the water distribution section.

The object of the invention is the provision of a respiratory gas humidifier system that is of simple design and is easy to operate and which provides germ-free operation even when used in conjunction with a respirator generating a constant overpressure.

The object is met by the combination of the characteristics described in claim 1. The sub claims describe preferred embodiments of the object of the invention.

A significant advantage of the invention consists in the fact that the respiratory gas humidifier system including the water reservoir and the intermediate storage container are sealed off from the environment, so that there is virtually no possibility of germs spreading. A further advantage for the patient results from the fact that the water level in the heated evaporation chamber remains constant, so that once the heater is switched on, the volume of water vapour generated remains constant over time.

The replaceable, pressure-resistant and sealed water reservoir and intermediate storage container of the respiratory gas humidifier system are
preferably fitted with one check valve each, located in the connection between them which is formed by a connector piece, so that during the replacement of the water reservoir they act in such a way that a flow connection between the water reservoir and the intermediate storage container only exists when the water reservoir is seated in the connector to the intermediate storage vessel, otherwise the valves are shut off.

In the following, an example of an embodiment of the invention is explained with reference to the drawings.

Shown are in:

1. Figure 1 a respiratory gas humidifier system,
2. Figure 2 the connection between water reservoir and intermediate storage vessel and
3. Figure 3 the placement of a humidity sensor in the respiratory gas line for use with a respiratory gas humidifier system.

Sterilized water is provided by means of a replaceable, pressure-resistant, sealed water reservoir 1 according to Figure 1.

The water reservoir 1 is preferably made of a robust, transparent plastic, such as PET, PC or PEP, in order to enable safe handling and visual control of the water level. Typical use of a respirator in a home setting requires a volume of approx. 300 to 500 millilitres of water for an operating period of approx. eight to ten hours. The water reservoir 1 is linked to the intermediate storage vessel 4 via the connector 2. Figure 2 shows the details of the connector 2: As the water reservoir 1 is inserted into the connector 2 from above, both the first valve 16 with the first reset spring 17 of the water reservoir 1 as well as the second valve 14 with the second reset spring 13 of the intermediate storage vessel 4 are activated and opened by means of the plunger 15. The water can now flow from the water reservoir 1 into the intermediate storage vessel 4 of the humidifier system until the water level has risen to the point where the canal 3 of the connector 2 is sealed off, preventing air from flowing into the water reservoir 1.

When the water reservoir 1 is removed, both it and the intermediate storage vessel 4 are sealed off again, so that water is prevented from flowing out of the water reservoir 1 and the respiratory gas humidifier system stops providing humid air once the remaining water has evaporated, yet the pressure in the
respiratory gas line of a connected respirator is maintained. The water is fed to the evaporation chamber 7 by means of a water conduit 5 with a diameter of approx. 1 to 2.5 millimetres. In that chamber, the heater 6 supplies the required thermal energy for heating the water to boiling point in order to cause it to evaporate. The water vapour rises inside the evaporation chamber 7 and is deflected by the deflector 8 in such a way that water droplets or bubbles cannot be carried into the respiratory gas line along with the inhalation gas. The water vapour is fed along the path 9 to the outlet nozzle 10, where it is mixed with the inhalation gas coming from inlet nozzle 11 before being fed to the patient. The gas pressure equalization line 12 serves to equalize the pressure between the outlet nozzle 10 and the intermediate storage vessel 4, which serves as a water level regulator. The pressure at this point is equal to that inside the respiratory gas line. In the event that water continues to flow from the water reservoir 1, the resultant intake of air is supplied by means of this gas pressure equalization line.

The narrow water conduit 5, which runs below the water level in the intermediate storage vessel 4 and in the evaporation chamber 7 and which has a diameter of approx. 1 to 2.5 millimetres and links the boiling water in the evaporation chamber 7 and the cold water supply from the water reservoir 1, acts as a thermal insulation in so far as convection can not take place and the water in the intermediate storage vessel 4 does not heat up, which in turn means that the water in the water reservoir 1 and the air contained therein do not heat up and expand either, which would result in too much water being fed to the evaporation chamber 7. While the simplest mode of operation of the humidifier system according to Figure 1 is the continuous heating of the evaporation chamber 7 with a water evaporation rate that remains constant over time, a different mode of operation, depending on the humidity of the respiratory gas as measured at the inlet into the respiratory gas line to the patient, is explained using Figure 3: The inhalation section 100 to the patient connects to the line 21, which in turn is located at the outlet of the respiratory gas humidifier system. At this point, the respiratory gas from the respirator device is already mixed with the evaporated humid air. Located between the line 21 and the inhalation section 100 is a gap, which is surrounded by a mixing chamber 19. Located in the upper section of this
mixing chamber 19 is a capacitance-type humidity sensor 20 in particular, which is arranged in such a way that it is heated by means of the enclosure of the respiratory gas humidifier system or by means of the radiated heat from the associated electrical components, so that it attains a higher temperature than the humid respiratory gas and is therefore protected against condensation. Via a narrow conduit 22, a constant bypass flow supplies ventilation for the chamber 19, so that the humidity sensor 20 constantly measures the current degree of humidity of the respiratory gas. The measurement signal of the humidity sensor 20 is fed to an electronic circuit 18, where the measurement signal is compared to preset nominal values and used to regulate the thermal output 23 of the heater 6 (Figure 1). Located at the inlet to the respiratory gas humidifier system is a check valve 24, which is opened by means of the respiratory gas flow from the respirator device. When the respiratory gas flow is switched off, the check valve 24 closes automatically and prevents water vapour from the respiratory gas humidifier system from entering the respirator device where it might otherwise condense. Additionally a water trap 25 is provided which prevents any existing condensate from entering the respirator device. A further water trap 26 is provided at the back of the enclosure, ensuring that no condensate is able enter into the respiratory gas line and collect in the conduits 22 and 27 or drain off.
THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. Respiratory gas humidifier system for a patient with the following characteristics:
   a) a replaceable, pressure-resistant, sealed water reservoir (1) is provided for
      the water supply to the respiratory gas humidifier system,
   b) located below the water reservoir (1) is an intermediate storage vessel (4),
      sealed off from the environment, which contains water, where
   c) the water reservoir (1) and the intermediate storage vessel (4) are each
      fitted with valve (16, 14) which interact with each other in such a way that
   d) a flow connection between the water reservoir (1) and the intermediate
      storage vessel (4) can only take place when the water reservoir (1) is inserted
      into a connector (2) on the intermediate storage vessel (4),
   e) the intermediate storage vessel (4) is linked by means of a water conduit
      (5), which is located below the water level, to a heated evaporation chamber (7)
      which feeds into the respiratory gas line to the patient in the space above the
      water evaporating at boiling temperature,
   f) located between the heated evaporation chamber (7) and the intermediate
      storage vessel (4) is a gas pressure equalization line (12).

2. Respiratory gas humidifier system according to claim 1, characterised in
   that the first and the second valve (16, 14) each consist of a check valve fitted
   with an associated first and second reset spring (17, 13) so that the valves (16,
   14) are opened by means of the activation of a plunger (15) on one of the valves
   (16, 14).

3. Respiratory gas humidifier system according to claim 1 or 2, characterised
   in that the evaporation chamber (7) contains a deflector (8) which acts as an
   obstacle in front of the outlet to the respiratory gas line to the patient and which is
   designed in such a way as to allow the vapour to flow past.

4. Respiratory gas humidifier system according to at least one of the claims 1
   to 3, characterised in that it is connected to the respiratory gas line of a respirator
   system generating a constant respiratory pressure.
5. Respiratory gas humidifier system according to at least one of the claims 1 to 4, characterised in that in a mixing chamber (19) of the respiratory gas humidifier system a capacitance-type humidity sensor (20) is arranged in such a way that following the comparison of the signals measuring the respiratory gas humidity with the pre-set nominal values by means of an electronic circuit (18), the thermal output (23) of the heater (6) is adjusted.

6. Respiratory gas humidifier system according to at least one of the claims 1 to 5, characterised in that the water conduit (5) has a diameter ranging between 1 and 2.5 millimetres.

7. Respiratory gas humidifier system according to at least one of the claims 1 to 6, characterised in that the water reservoir (1) is made of polyethylene or polypropylene, with particular preference for polyethyleneterephthalate (PET), a polycarbonate (PC) or an ethylene/propylene-copolymer (PEP).

DATED this 28th day of July 2003
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Fig. 2