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Jacobs

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[54] **HIGH PRESSURE RESUSCITATING AND VENTILATING SYSTEM INCORPORATING HUMIDIFYING MEANS FOR THE BREATHING MIXTURE**

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[63] Continuation-in-part of Ser. No. 59,206, July 29, 1970, Pat. No. 3,682,166.

[52] **U.S. Cl.** **128/145.8,** 128/194, 261/121

[51] **Int. Cl.** **A61m 16/00**

[58] **Field of Search** 128/351, 145.8, 145.6, 128/145.5, 145, 188, 194, 193; 261/121, 120

[56] **References Cited**

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[57] **ABSTRACT**

A resuscitating and ventilating system is provided wherein a relatively high pressure breathing gas mixture is utilized. The flow of the breathing mixture is cyclically controlled by inflating and deflating valve means, which valve means is actuated by an air motor driven by the high pressure gas. A high pressure piping system connects the source of high pressure gas to the valve means and to the gas supply pipe of the motor. A gas-bubbling-through-water type humidifier is incorporated in the system. The gas inlet of the humidifier tank is connected to the high pressure piping system upstream of its connection to the gas supply pipe of the motor, and the outlet pipe of the humidifier tank is connected to the high pressure piping downstream of its connection to the gas supply pipe of the motor. Thus, the humidifying system bypasses the motor. Further, a water supply is connected to the humidifying tank and the connections are so controlled by valves whereby the water in the tank may be replenished without shutting off the flow of the breathing mixture to the patient.

1 Claim, 2 Drawing Figures

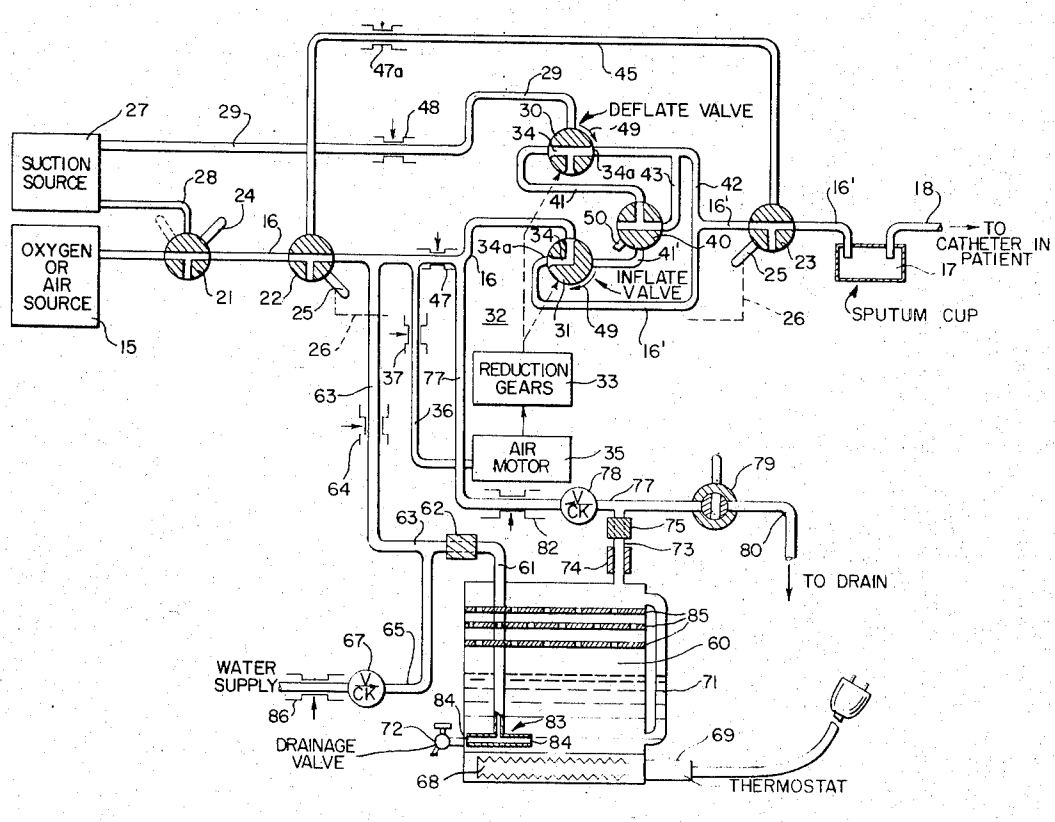

FIG. 1

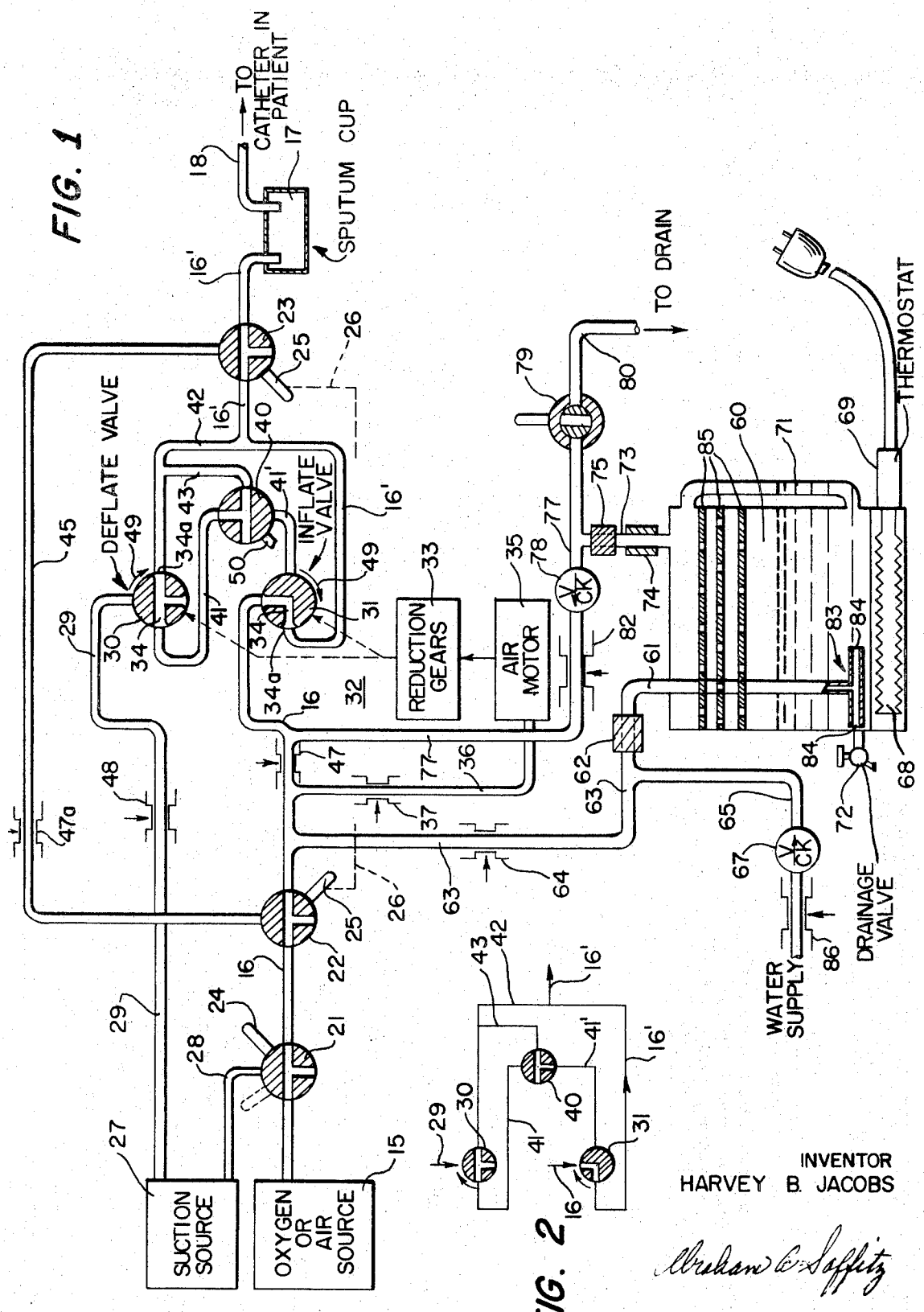

FIG. 2

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HIGH PRESSURE RESUSCITATING AND VENTILATING SYSTEM INCORPORATING HUMIDIFYING MEANS FOR THE BREATHING MIXTURE

This application is a continuation-In-part of my U.S. Pat. application, Ser. No. 59,206, filed July 29, 1970 now U.S. Pat. No. 3,682,166 granted Aug. 8, 1972.

This invention relates to relatively high pressure resuscitating or ventilating apparatus which embodies a humidifying means for the breathing air or gas mixture.

While it is old in the art to embody humidifying means in very low pressure resuscitating or ventilating apparatus, no suitable humidifying means has been provided for effeciently and properly humidifying the breathing mixture in ventilating systems using high pressure.

An object of this invention is to provide humidifying means suitable for incorporating in a high pressure resuscitating or ventilating apparatus, particularly the apparatus disclosed in my parent application, Ser. No. 59,206.

A further object is to provide a humidifier which will cooperate with the high pressure gas of the ventilating system to atomize and vaporize water to a desired degree and at a suitable rate, and thereby provide a properly humidified breathing mixture in accordance with the particular requirements of the patient.

Another object is to provide a gas-bubbling-through water type humidifier means which is connected to the high pressure gas of the ventilating system and which is also connected to a suitable supply of water and provided with a valve system whereby the water in the humidifying tank may be replenished without shutting off the flow of the breathing mixture to the patient and without removing the humidifying means from the system.

Further objects and advantages of this invention will be apparent from the following descriptions and accompanying drawings of which:

FIG. 1 is schematic view of the resuscitating or ventilating apparatus disclosed in my co-pending application, Ser. No. 59,206, filed July 29, 1970 and incorporating breathing gas humidifying means and control valve means therefor; and,

FIG. 2 illustrates the alternate position of the cycle control valve means.

The resuscitating or ventilating system incorporating the humidifying means will be sufficiently described herebelow to fully disclose the functioning and control of the humidifying means and its cooperation with the ventilating system whereby there is provided a regulated and properly humidified breathing mixture. For further disclosure of the details of construction and application of the high pressure ventilating system, reference may be had to the parent application, Ser. No. 59,206, filed July 29, 1970.

The system comprises a source of gas under pressure **15.** This source may be compressed air, pure oxygen or air fortified with a higher percentage of oxygen than normal atmospheric air. The source **15** is connected by conduit means **16** and **16'** to a sputum trap **17.** From sputum trap **17,** a conduit means **18** extends to the catheter attached to the trachea of the patient.

Conduit means **16–16'** has a series of three-way valves **21, 22** and **23** inserted therein. Valve **21** has a handle means **24** to move it to a selected position.

While valves **22** and **23** are shown diagrammatically as two separate plug means, their passages may be incorporated in a single plug valve device at axially spaced planes. To illustrate the unitary operation of valves **22** and **23,** a handle **25** is provided for each valve, the handle being connected for joint movement by a connecting link means **26.** Valves **22** and **23** rotate in opposite 90° directions.

Suction or vacuum source **27** has conduits **28** and **29** extending therefrom with conduit **29** connected to deflate valve means **30,** and conduit **28** connected to valve **21.**

A two-way valve means **31** is located between conduits **16** and **16'** and functions as an inflate valve. For illustrative purposes, valves **30** and **31** are shown as separate valves; however, they work in unison by connecting means **32** which connects them to reduction gear drive **33.**

It is preferable that the outlet ports **34***a* of the several passages **34** in valves **30** and **31** be of a tapered configuration. Outlet portion **34***a* is elongated in the direction of valve movement and may be of elliptical or diamond configuration whereby the flow from the valve to the conduits connected thereto is gradually initiated and gradually cut off. The duration of time of fluid flow may be regulated by the length of the longer axis of the port configuration.

Reduction gear device is driven by fluid motor **35,** connected by conduit **36** to conduit **16** and thus to source **15.** The speed of motor **35** is regulated by an adjustable throttle valve means **37** inserted in line **36,** which valve is diagrammatically illustrated as an adjustable choke valve.

A three-way valve **40** is connected by conduit **41** to valve **30** and by conduit **41'** to valve **31.** The function of valve **40** is to control the ratio of inflation pulses or phases to deflation phases during a revolution of valves **30–31.** It may be termed an inflation and delfation phase control valve. A conduit **42** connects valve **30** to conduit **16'.** A branch conduit **43** connects conduit **42** to valve **40.** A conduit **45** connects valves **22** and **23.**

To control the rate of flow of the oxygenated gas in accordance with the age and size of the patient, throttle or choke valve **47** is inserted in line **16** upstream of valve **31** and a similar valve **47***a* is inserted in conduit **45.** Valve **47** controls the rate of flow when the system operates automatically. Valve **47***a* controls the rate of flow during manual control of ventilation. The rate of flow of deflation gas from the patient may be controlled by throttle valve **48** inserted in suction line **29.**

The FIG. **1** illustrates the positions of the several valves in the system for automatic operation of the ventilating system. Air under suitable pressure flows from source **15** through conduits **16** and **16'** and through the connecting passages in valves **21, 22, 31** and **23** to sputum cup and from there by conduit means **18** to the catheter. Thus, air with the proper selected percentage of oxygen flows to the patient at a rate controlled by throttle valve **47.**

At this phase of the cycle, valve **30** cuts off the several connecting conduits and valve **40** from suction conduit **29.**

Valve means **31** and **30** are continuously rotated in the direction of the arrows **49** at the proper desired speed by air motor **35.** Assuming the setting of the valves in FIG. **1** to be 0°, at 90° of rotation, valve **31** blocks flow from conduit **16** to conduit **16',** and valve

30 connects suction source 27 and conduit 29 to conduit 41 and through valve 40 to conduits 43, 42 and 16' and thereby the catheter is connected to the suction source whereby deflation or exhalation of the patient is aided. At 180° of rotation, valve 31 still blocks air flow to 16', and valve 30 connects conduit 42 to conduit 29 and therethrough to suction source 27. At 270° of rotation, valve 31 still blocks flow to conduit 16' and valve 30 still connects conduit 42 to conduit 29. At 360° of rotation valves 30 and 31 again assume the positions of FIG. 1 and air is again delivered to the patient to aid in the inhalation phase of breathing.

Thus, a single cycle or rotation of valve 30 and 31 results in one inflation and three deflation phases. Under certain conditions, it may be desirable to have the same extent of inflation and deflation. Inflation and deflation phases control valve 40 is provided for such operation. If valve 40 is moved by its handle 50 to the position illustrated in FIG. 2, the following connections occur during a single cycle or rotation of valve means 30 and 31. At 0°, valve 31 connects conduits 16 and 16' and suction conduit 29 is cut off from all connection by valve 30. At 90° of rotation in the direction of arrows 49, valve 31 disconnects conduits 16 and 16' and connects conduits 16 and 41'; and through the passages in valve 40 conduits 41', 43, 42 and 16' are interconnected, for a second inflation phase, while deflation (suction) is blocked. At 180° or rotation, conduit 16 is cut off from the other conduits by valve 31. Suction conduit 29 is connected by valve 30 to conduits 42, 16', and 18 to the catheter for the deflation phase. At 270° of rotation, valve 31 still cuts off flow from conduit 16 and valve 30 connects conduits 29, 42 and 16' for a second deflation phase. At 360° of rotation, the valves assume the positions illustrated in FIG. 2, that is, the 0° position, in which an inflation phase is initiated.

Thus, with valve 40 in the position of FIG. 2, there are two inflation and two deflation phases during a cycle or a revolution of the valve means 30 and 31.

Under certain conditions, the patient cannot be subject to the automatic inflation and deflation and the operator must manipulate the inflation and deflation phases in accordance with the abnormal conditions of the patient. Valves 22 and 23 are shifted by means of their handles from their positions of FIG. 1 to their opposite positions. Valve 30, 31 and 40 are by-passed, and at the same time flow to motor 35 is shut off by valve 22. Thus, valves 22 and 23 interconnect conduit 16 to 16' at sputum cup 17 by means of conduit 45 which bypasses the valve means 30, 31 and 40, and their interconnected conduits.

Valve 21 is then manipulated by the operator from one position to another by handle 24. The position shown in solid lines is the inflate position wherein oxygenated pressure gas regulated by throttle valve 47a flows from source 15 to conduits 16, 45, 16', 18 to the catheter. When deflation is desired, valve 21 is moved anticlockwise 90° to the dotted line positions of handle 24. In this deflate position, suction source 27 is connected by the valve means to conduits 16, 45, 16', 18 and the catheter. The duration of the inflation and deflation phases will be regulated by the operator in accordance with the requirements of the patient which is under his visual observation.

The humidifying means comprises a tank 60, preferably made of stainless steel or other mateiral which may be subject to sterilization and can withstand high internal pressure. The tank has a high pressure gas input pipe 61 which is secured by a conventional, quick acting, detachable coupling means 62 to high pressure pipe 63. Pipe 63 is connected to pipe 16 upstream of throttle valve 47. A throttle valve 64 is inserted in pipe 63 for controlling the rate of flow of humidifying gas and also for shutting off the flow through the pipe. A pipe connected to a suitable water supply is joined to pipe 63 upstream of coupling means 62. A check valve 67 opening toward tank 60 is inserted in pipe 65. For controlling the temperature and the degree of vapor saturation of the humidified breathing mixture, an electric heater means 68 is provided and is controlled by adjustable thermostat 69 whereby any desired temperature may be selected.

Tank 60 may be provided with a transparent sight tube 71 whereby the water level may be visually observed. A drainage valve 72 for emptying the tank whenever desired is inserted at the bottom of tank 60.

A tank outlet pipe 73 is secured to the top of tank 60. Pipe 73 may have a heat exchange means therein in the form of a heavy metal tube 74 to condense any excess water vapor which will drain back to the tank. Pipe 73 may have a finned portion in lieu of tube 74 to act as a heat exchanger to permit the outside air to cool and condense any excess water vapor generated in the tank.

Outlet pipe 73 is connected by a conventional quickly detachable coupling means 75 to pipe 77 connected to pipe 16 between throttle valve 47 and valve 31, preferably close to valve 31. A check valve 78 opening towards line 16 is inserted in pipe 77. Pipe 77 terminates in a shut-off valve 79 whereby pipe 77 may be closed to drain outlet 80 or be opened thereto. An optional throttle valve 82 may be inserted in pipe 77 to control the flow of humidified gas and may be used in conjunction with throttle valve 64 in line 63.

A gas disperser 83 may be connected to the open end of tube 61 whereby the gas is dispersed into numerous paths to increase the bubbling effect. Disperser 83 may be in the form of a hollow cylindrical body having numerous parts in its cylindrical wall, or may assume any other well known structure for breaking up a flow of fluid into numerous paths, as for example, a porous body, perforations in the walls of inlet tube 61 or any other similar structure.

In order to insure that the bubbling gas picks up atomized or vaporized water particles, a baffle means comprising spaced perforated plates 85 are placed above the water level. Unduely large droplets or particles of water would impact against the plates and would not be carried along by the gas stream to outlet pipe 73.

The application of the humidifying system is initiated when application of the ventilating system is initiated, assuming throttle valve 64 is set to permit the desired flow of gas to tank 60, and the tank is partly filled with water, as illustrated in FIG. 1. Check valve 67 is closed under the pressure of the gas flowing in pipe 63. The gas flows through the open ends of inlet pipe 61 and through the gas dispersion unit 83 close to the bottom of tank 60 and bubbles through the properly heated water. The fine bubbling causes atomization and vaporization of the water, and the outgoing gas at outlet pipe 73 is saturated with water moisture. Massive bubbling and very large water particles are blocked and returned to the water by baffle means 83. Excess moisture is condensed by passing through cooling means 74. The hu-

midified gas then passes through pipe **77** and joins the gas flowing the inflating valve **31.**

The amount of moisture may be controlled by regulating the flow of gas in pipe **63** by throttle valve **64.**

To replenish the water in tank **60,** valve **64** is closed to stop the flow of gas in pipe **63** and valve **79** is actuated to connect pipe **77** to the drain **80.** Shut off valve **86** in pipe **65** is opened and under such pressure conditions, water flows through pipe **65** and check valve **67** into pipes **63** and **61** and the tank **60.** The water level may be observed through sight tube **71,** and when it reaches the desired height valve **79** is turned to disconnect pipes **73** and **77** from the drain **80.** This action stops the flow of water and valve **83** in pipe **65** is closed to secure this inflow. By opening and regulating valve **64** the flow through pipe **63** is again resumed and humidified gas flows to valve **31.**

If sterilization of tank **60** is desired it may be quickly disconnected from pipes **63** and **77** by means of quick acting coupling means **62** and **75.** Thermostat **69** may be detachably plugged into the heater means.

Check valves **67** may be eliminated and check valve **77** may be replaced by a normally shut off valve similar to valve **86.** Thus in replenishing tank **60** valves **86** and **79** would be opened to permit water to flow into the tank and shut off valve replacing valve **77** would be closed.

While the invention has been described and illustrated in detail, it is to be clearly understood that this is intended by way of illustration and example only and is not to be taken by way of limitation.

I claim:

1. A ventilating apparatus comprising a source of high pressure breathing gas, inflating and deflating valve means, first pipe means connecting said source of breathing gas to said inflating valves means, output pipe means connected to said valve means for delivering breathable gas from the inflate valve means to the patient and for returning the exhalation from the patient to the deflate valve means, air motor means operatively connected to said inflate and deflate valve means to cyclically actuate the same, a pressure gas supply line connecting said first pipe means to said air motor, high pressure humidifying means between said breathing source and said inflating and deflating valve means comprising a tank having water therein, an inlet gas pipe fed with high pressure breathing gas opening below the water level to permit a heat exchanger, a condenser which removes liquid water from said highly humidified vapor in said outlet and thereby prevent flooding, a heater to maintain a high temperature in the liquid so as to assure a supply of highly humidified air at high pressure in the tank outlet pipe without trapped water therein, gas flowing through the inlet pipe to bubble through the water and thereby become highly humidified, a tank outlet pipe to permit the humidified gas to flow out of the tank, a second pipe means connecting said inlet pipe to said first pipe means upstream of said pressure gas supply line, and a third pipe means connecting said tank outlet pipe to said first pipe means downstream of said pressure gas supply line, whereby the air motor is bypassed by the humidified air flow, which prevents the loss of water at the interior from the humidified gas going to the patient.

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