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Cavallo

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[54] **RESPIRATORY APPARATUS**

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[51] **Int. Cl.** **A61m 16/00**
[58] **Field of Search** ..... 128/145.6, 145.5, 145.7, 128/145.8, 142, 142.2, 142.4, 188, 191, 195, 201, 202, 192, 193, 194, DIG. 17, 196, 197, 209, 210, 212, 147; 251/65

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[57] **ABSTRACT**

Respiratory apparatus comprising a multistage air displacing turbine driven by an electric motor and whose output is fed to a mouthpiece by way of an electromagnetically operated valve that is open and shut at a predetermined rate or as determined by the respiration rate of a patient using the apparatus. A source of oxygen may be provided for adding oxygen to the air supplied by the turbine. The apparatus incorporates a safety device for connecting the mouthpiece to the atmosphere in the event of pressure drop at the turbine output.

6 Claims, 3 Drawing Figures

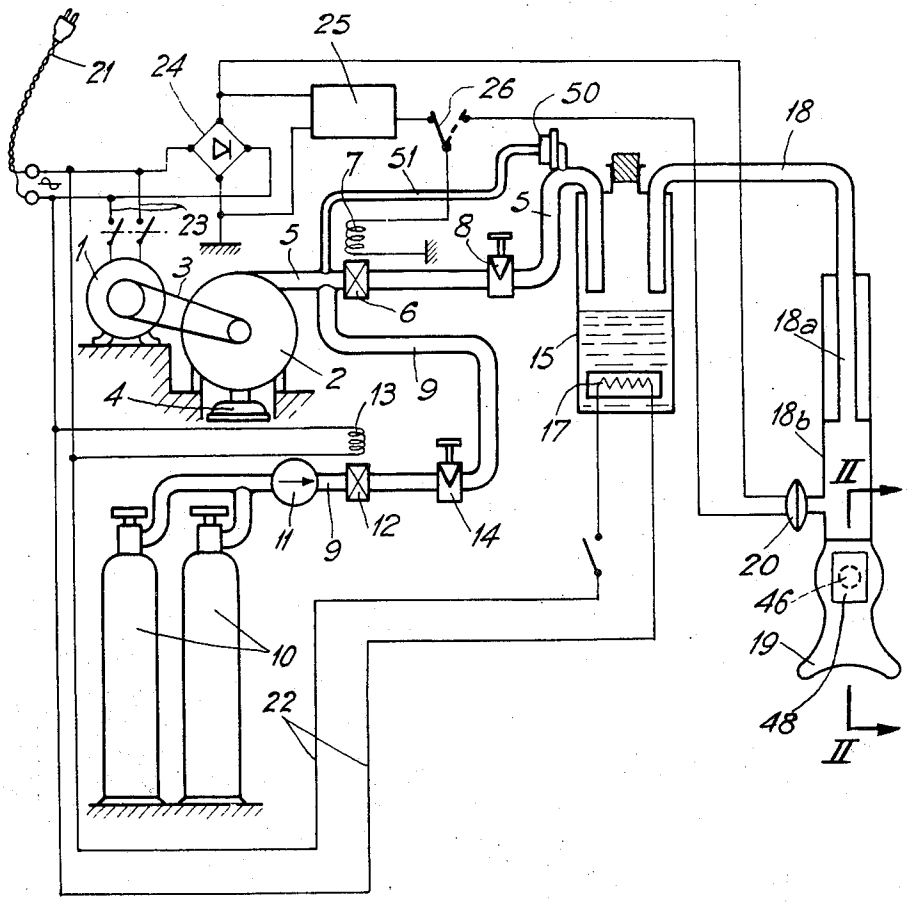
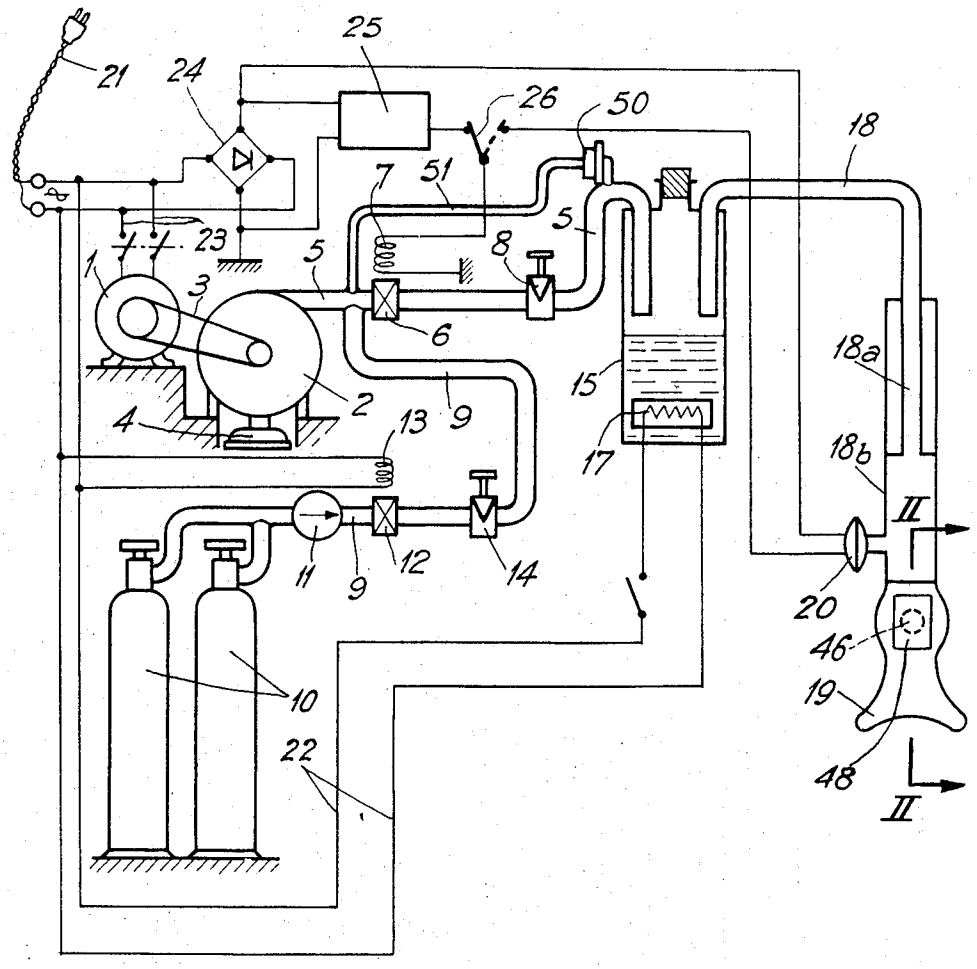


Fig. 1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18b
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II

Fig. 2

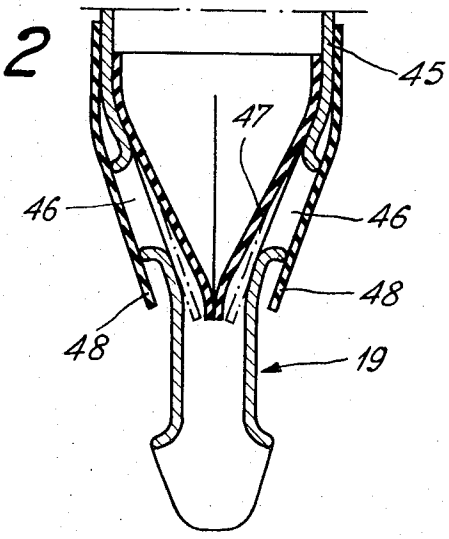
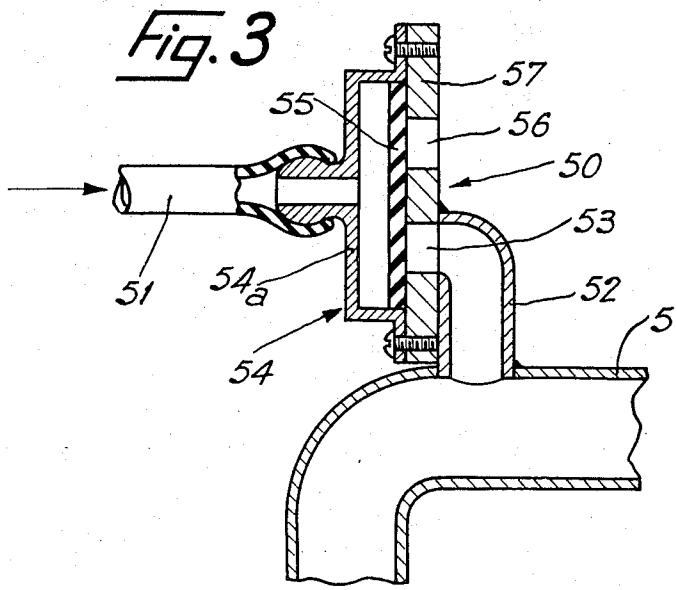


Fig. 3



RESPIRATORY APPARATUS

This invention relates to respiratory apparatus and has particular reference to such apparatus that is readily mobile and can be used at a patient's home.

It is known that some patients suffering from pulmonary deficiency require the assistance of a respiratory apparatus several times in the course of a day and sometimes for relatively long periods. Known forms of respiratory apparatus are somewhat cumbersome and not readily transportable from one location to another and are not suitable for use at a patient's home.

Accordingly it is an object of the present invention to provide an improved respiratory apparatus which is readily transportable, easy to use and operable from a home power supply.

According to the present invention, a respiratory apparatus comprises a multistage air turbine pump, an electric motor for driving the pump, a mouthpiece, a pipe interconnecting the pump output and the mouthpiece, including an adjustable throttling valve and upstream of the latter a flow control valve and means for periodically opening and shutting the flow control valve.

Use of a multistage turbine pump for supplying air to the patient provides the following advantages. The flow of air with a low output pressure is important and, with a turbine and open or closed control valve said pressure is substantially constant. Moreover as explained below when oxygen is added to air, the turbine acts as a gas holder when the said control valve is closed.

In the case of certain deep respiratory deficiencies, it is desirable to add oxygen to the air output of the turbine, the oxygen being supplied from cylinders via a further pipe connected to the first mentioned pipe upstream of said control valve, said further pipe including a further adjustable throttling device.

Owing to the first adjustable throttling device, the output of the pump is maintained at a constant pressure slightly in excess of atmospheric pressure even when the control valve is open, oxygen being supplied through a throttling device at a pressure above said output pressure into said first pipe. When the flow control valve is open, oxygen passes directly into the air stream through the valve but, when the latter is shut, oxygen accumulates in the turbine and is drawn out when the valve next opens.

The means for opening and shutting the valve may include a multivibrator of variable frequency output. The frequency may be preset or it may be determined by the demand of a patient using the apparatus.

The apparatus may include a humidifier. Air leaving the turbine is normally at a temperature above ambient, so preferably the apparatus also includes means for reducing the temperature to an acceptable value. Such means may comprise a heat exchanger in the form of telescopically engaged lengths of pipe forming part of the pipe conveying gas to the mouthpiece.

Advantageously, the apparatus also includes a safety valve which operates to connect the mouthpiece to atmosphere in the event of a predetermined reduction in pressure at the output of the pump.

An embodiment of the invention will now be described in greater detail with reference to the accompanying drawing in which:

FIG. 1 shows the embodiment in diagrammatic form only;

FIG. 2 is a section on the line II-II of FIG. 1; and,

FIG. 3 is a section of one of the components of the embodiment of FIG. 1.

The embodiment shown in FIG. 1 comprises a transportable frame (not shown) in which is mounted an A.C. motor **1** driving a multistage air turbine via a driving belt **3.** The turbine **2** draws in air via a filter **4** and the output of the turbine consisting of warmed, compressed air is delivered to pipe **5.** Flow of compressed air along pipe **5** is controlled by an electromagnetically-operated valve **6** having an energizing winding **7** and also by a throttling device **8** adjustable to permit a predetermined flow of air along the pipe **5** or, if necessary, to stop the flow altogether.

Upstream of the valve **6,** pipe **5** is joined to a second pipe **9** through which oxygen from cylinders **10** is conveyed to pipe **5.** The pressure of oxygen from the cylinders **10** is regulated by a pressure reducer valve **11** while the flow of oxygen is controlled by throttling valve **14.** The system so far described operates under substantially constant pressure so that valves **8** and **14** are calibrated in flow rates, e.g., liters per minute. Located in pipe **9** between valves **11** and **14** is an electromagnetic valve **12** whose energizing coil **13** is directly connected across the electric power input terminals as shown and shuts automatically when the apparatus is disconnected from the supply source.

The frame mentioned above has provision for mounting the cylinders **10** but this is not essential. To lighten the frame and make it more readily transportable the cylinders may be carried separately and placed at the side of the frame. In that case, the pipe **9** includes a flexible portion with suitable connectors to facilitate connection to the cylinders.

The embodiment shown a humidifier **15 5** to which pipe **5** is attached as shown. Humidifier **15** contains water **16** and an immersion heater **17.** The output of the humidifier **17,** which might be air or an air/oxygen mixture, enters pipe **18,** one part of the length of which comprises telescopically engaged portions **18*a*, 18*b*** which may be of metal. That part forms a heat exchanger in which gas passing along the pipe **18** is cooled to an extent depending upon the length of the portion. The gas passing along the pipe **18** is sometimes hotter than is desirable and can be cooled as it passes through the parts **18*a*, 18*b*.**

Joined to pipe **18** is a mouthpiece **19** shown in more detail in FIG. **2** and which includes means for separating inhaled and exhaled gas flows. The mouthpiece includes a conduit **45,** normally connected to pipe **18,** is flattened and contoured to form the rigid mouthpiece **19** and is formed with apertures **46** in its side walls. The apertures are normally closed by means of flap valves **48.** Within the conduit **45** is a valve **47** shaped rather like a duck's bill with flexible jaws able to flex between the closed, solid line position and the open, dot-dash position shown in FIG. **2.** When a patient using the apparatus inhales, valve **47** opens into the dot-dash position shown and in so doing closes the apertures **46.** When the patient exhales, valve **47** closes but flap valves **48** open so permitting exhaled air to pass into the atmosphere.

Joined to the part **18*b*** of the telescopic portion of the pipe **18** is a pressure detector **20** which is responsive to the pressure within the pipe **18** and thus within the conduit **45.** When the patent inhales, valve **47** opens and

the detector **20** is exposed to the reduced pressure then existing in pipe **18.**

In the embodiment shown in the drawings, throttling valve **8** regulates the total gaseous flow to the patient while throttling valve **14** regulates the flow of oxygen. Pipe **9** discharges into a chamber of practically constant pressure–the air turbine **214** and so valve **14** can be calibrated directly in units indicating volume of oxygen supplied per unit time. Thus the volume of oxygen supplied to the patient can be accurately determined.

When valve **6** is open, oxygen passes directly into the stream of air emerging from the pump **2.** When the valve **6** is closed, oxygen still flows into pipe **5** but passes into the turbine and is pumped out when the valve **6** next opens.

The apparatus is energized via a flexible connector **21** which can be plugged into an electricity supply point. Immersion heater **17** is supplied via conductors **22** which include a control switch as shown, while motor **1** is supplied via conductors **23** which include a double pole control switch. Also energized from the supply is a rectifier **24** supplying a device **25** described in more detail in the Specification of concurrently filed co-pending Pat. application entiled "Improvements in or relating to control devices for respiratory apparatus" Ser. No. 304,487 . Diagrammatic switch **26** allows operation of the apparatus either at a frequency determined by the respiratory rhythm of the patient or at some predetermined frequency. Further details of the way in which this is achieved are found in the Specification just mentioned.

The embodiment shown in FIG. **1** also includes a safety valve **50** mounted on the pipe **5** adjacent the humidifier. This valve is controlled by the output pressure of the turbine **2** to which the valve is exposed via pipe **51.**

Pipe **5** is joined to the safety valve **50** via a branch pipe **52** which is connected via an aperture **53** to the interior of a casing **54** at least the base **54*a*** of which is of ferro-magnetic material. Movable within the casing **54** is a disc **55** of magnetic rubber, e.g., an elastomer containing aligned, magneticed particles. Bolted to the casing **54** is a plate **57** of non-magnetic material in which, in addition to the aperture **53,** there is a second aperture **56.**

In the absence of pressure in the pipe **51,** the disc **55,** which, in effect, constitutes a flap valve, is held against the base **54*a*** so that the branch **52** is in communication with the atmosphere via apertures **53** and **56.** However, when the pump **2** is in operation pressure in pipe **51** forces the disc **55** against the plate **57** so closing apertures **53** and **56.**

Thus, as long as pressure exists in pipe **5** upstream of valve **6,** air, air/oxygen mixture or oxygen can be supplied to the patient. Lack of pressure at the location described in effect, opens pipe **18** to atmosphere and enables the patient to breathe atmospheric air via apertures **53** and **56.**

In one particular embodiment of the invention, pump **2** is an axial flow pump with six stages and operates at a pressure of 100–120 cm W.G. The pump has an output of 250 liters/minute. Although an output of 25–30 liters/minute is normally sufficient, the output must almost instantaneously reach 75–100 liters/minute when valve **6** opens.

Air leaving the pump is normally at a temperature of from 60°–70°C and is saturated with water vapor by the humidifier **15** and at the same time its temperature is reduced to 30°–35°C.

For human use, the frequency of operation of the valve **6** is set to from 10–60 exhalations and inhalations per minute. However, for veterinary use a wider range may be necessary depending upon the animal being treated. In practice, a range of 1–100 is satisfactory for most purposes.

The embodiment may be used to treat patients demanding the use of a respirator and is especially suitable for treating at home patients with chronic respiratory deficiency.

I claim:

1. A respiration apparatus comprising:

a multistage air-displacement turbine pump having a discharge side;

an electric motor connected to said pump for driving same;

a first pipe connected to said discharge side of said pump;

a mouthpiece connected to said first pipe and receiving air from said pump through said first pipe;

an adjustable first throttle valve along said first pipe between said discharge side of said pump and said mouthpiece for controlling the airflow to said mouthpiece;

an electromagnetic flow-control valve along said first pipe between said discharge side and said throttle valve for selectively passing and blocking flow of air to said mouthpiece from said turbine pump;

means for periodically opening and shutting said flow-control valve;

a safety valve communicating with said first pipe for connecting said mouthpiece to the atmosphere upon pressure in said first pipe upstream of said flow-control valve falling below a predetermined level and indicating a failure at said pump;

another pipe connected to a source of oxygen under pressure and communicating with the first-mentioned pipe between said flow-control valve and said discharge side of said turbine pump; and

a further throttle valve in said other pipe between said source and said first pipe, said electromagnetic valve constituting the sole valve for flocking and unblocking flow of air and oxygen to a patient.

2. The apparatus defined in claim **1** wherein said other pipe is provided with an electromagnetic valve operatively connected with said motor and open upon operation thereof.

3. The apparatus defined in claim **1** wherein said first pipe has a plurality of telescopically engaged parts forming a heat exchanger between the air traversing said first pipe and the ambient atmosphere.

4. The apparatus defined in claim **1,** further comprising a humidifier in said first pipe between said flow-control valve and said mouthpiece.

5. The apparatus defined in claim **1** wherein said mouthpiece is provided with valve means defining separate inhaled and exhaled gas flow paths, said exhaled flow paths comprising apparatus sealable by said valve means.

6. The apparatus defined in claim **1** wherein said safety valve comprises a closure member of elastomeric magnetized material, a housing enclosing said closure member and including a base portion of ferro magnetic material, means forming a flow path normally closed by the closure member, and a conduit connecting said housing to said first pipe.

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