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DOUBLE BELLOWS CONTROLLED RESPIRATION UNIT

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Fig. 1.

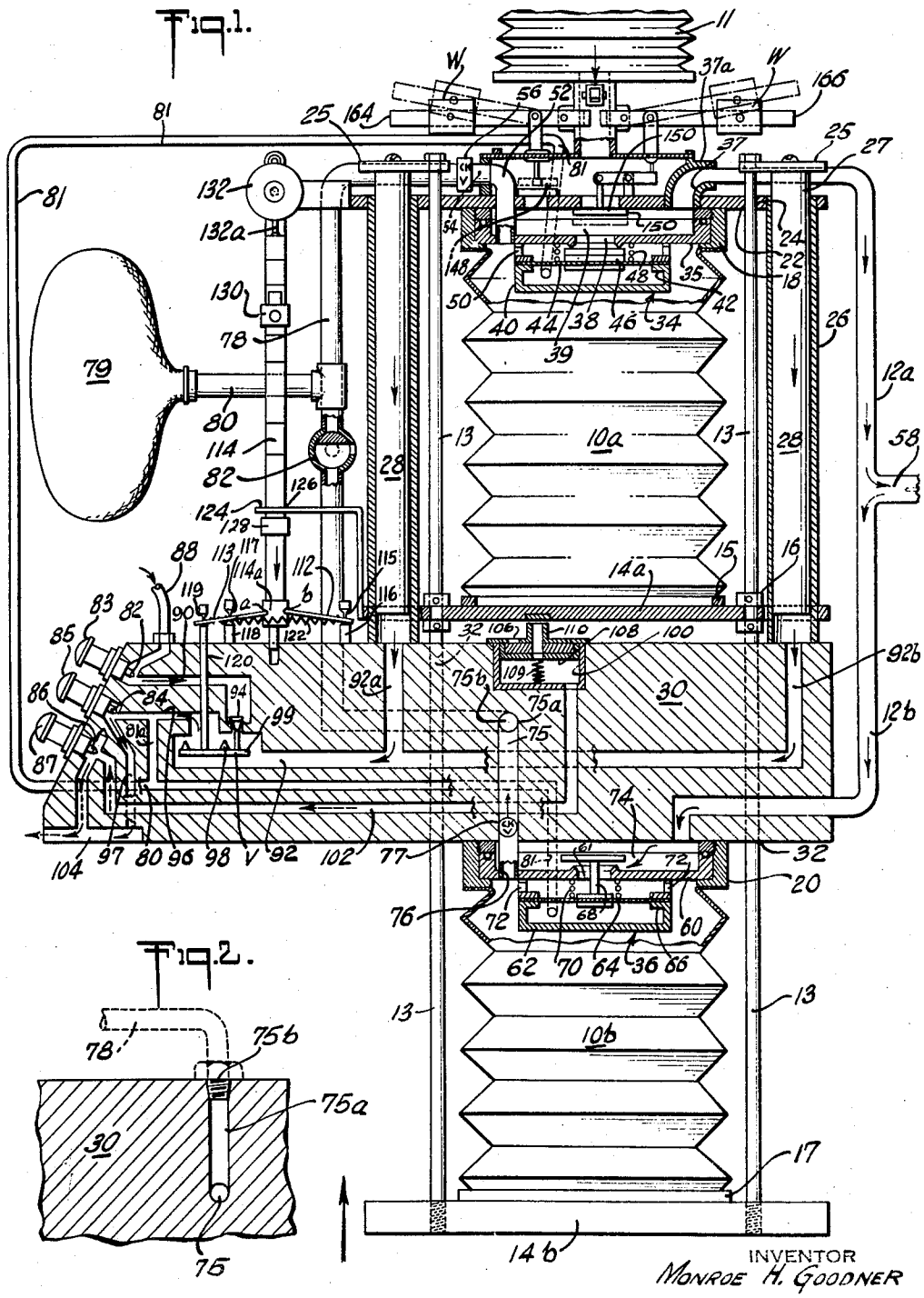


Fig. 2.

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DOUBLE BELLOWS CONTROLLED RESPIRATION UNIT

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5 Claims. (Cl. 128—29)

This invention relates to a controlled breathing device and is a modification of the device disclosed in my co-pending application Serial No. 633,163, filed January 8, 1957.

The device disclosed in said co-pending application comprises a single main bellows communicating through valve means directly with a patient or indirectly, as through anesthesia equipment, and alternately collapsed and expanded to supply gas or gases under controlled pressure into a patient's lungs and to exhaust gas from a patient's lungs under controlled negative pressure. A storage chamber is provided in the form of a smaller bellows communicating with the main bellows through two separate, weighted valves through which gas may be removed from the main bellows to the storage bellows if the pressure in the main bellows exceeds a predetermined maximum, and through which gas may be returned to the main bellows from the storage bellows if the pressure in the main bellows falls below a predetermined minimum. Since the said storage bellows and weighted valves form no part of this invention, they are not described herein and are shown in the drawing only to illustrate that the device of the said co-pending application may be incorporated as a unit in the apparatus disclosed herein.

The device which is the subject of this application can be used wherever the device of said co-pending application is used, and, in addition, is particularly applicable in the case of patients, such as some convalescent patients, for example those convalescing from polio, where the device must be kept in use to control breathing for periods of several hours. In such cases it is especially desirable to avoid the possibility of contamination of the gases supplied to the patient due to passing through container, storage, or conduit means through which pass the gases withdrawn from the patient's lungs.

It is accordingly an object of this invention to provide a controlled breathing device for controlling the volume of gas supplied to and removed from a patient's lungs per unit of time characterized by separation of the path of gas supplied to the patient from the path of gas exhausted from the patient.

Another object of this invention is to provide a device of the above mentioned kind in which a controlled breathing unit such as is disclosed in my said co-pending application may be included as part of the device.

The invention will best be understood if the following description is read in connection with the drawings in which

Figure 1 is a schematic view of a device embodying my invention. The numeral **10***a* indicates a first collapsible gas container illustrated herein or a bellows, interconnected as by rods **13** with a second main collapsible gas container, illustrated herein as bellows **10***b*, thus providing for simultaneous collapsing and expanding movements of said members when either **10***a* or **10***b* is collapsed or expanded, and

Figure 2 is a detail view in vertical section showing

the connection and relation between conduits **75**, **75***a* and **78**.

Gas is supplied to a patient through the first main bellows **10***a* and conduit **12***a*, and is exhausted from the patient through conduit **12***b* and second main bellows **10***b*. Bellows **10***a* has the gas intake port **54** to which a source of gas supply may be coupled and in which the one-way check valve **56** is provided, and bellows **10***b* has the exhaust port **76** in which the one-way check valve **77** is provided. The upper end of bellows **10***b* is connected to the lower surface of valve chest **30** as by the ring bracket **20**. The lower end of bellows **10***b* is connected, as by ring **17**, to the base plate **14***b* which is connected to the lower ends of rods **13**.

Bellows **10***a* is attached at the bottom, as by ring **15**, to the base plate **14***a* which is fixed to the rods **13** by the coupling means **16**. Bellows **10***a* is attached at the top, as by bracket **18**, to the cross support member **22**, supported between the hollow columns **26** which rise from the top of the valve chest **30** on opposite sides of bellows **10***a* and have telescopically disposed within them the pistons **28** which are connected at their closed upper ends to the upper ends of the rods **13**, respectively, by the brackets **25**. It will be understood that the valve chest **30** is provided with bores **32** and the cross member **22** is provided with the bores **24** to permit the rods **13** to reciprocate freely through them; that rods **13** rise and fall with the pistons **27**, and that as the rods **13** move up and down the bellows **10***a* and **10***b* are simultaneously collapsed and expanded.

In the upper portion of the upper bellows **10***a*, a valve chamber **34** is provided and in the upper end of bellows **10***b* a similar valve chamber **36** is provided. As shown, these valve chambers are circular. Chamber **34** is defined by a top plate **35** depending from cross support **22** and as shown it fits within and is supported by the annular bracket member **18**. In the top plate **35** is the port **38** and depending from plate **35** and surrounding port **38** is the cup-shaped member **40** which defines the bottom and side walls of chamber **34**. Stretched horizontally across chamber **34** and supported at its periphery by the attachment means **42** is a flexible diaphragm **44** which carries the valve member **46** which is urged by the spring **48** in a direction away from the port **38** to leave the said port open. In the side wall of chamber **34**, above the diaphragm **44**, the apertures **50** are provided to pass into the upper portion of chamber **34** gas which is received into bellows **10***a* through the conduit **52**, the inlet end **54** of which may be coupled directly to a source of gas supply such, for example, as a tank of oxygen under pressure and has in it a one-way check valve **56** of known kind.

Leading from the space **39** above port **38**, between the top plate **35** of chamber **34** and the cross support member **22**, is the nipple or coupling **37***a* to which is connected the conduit **12***a* leading to the patient or the patient's face mask (not shown) through the branch conduit **58** which, in the drawing, is shown broken away. When the position of diaphragm **44** causes valve **46** to be open gas flows from bellows **10***a* through apertures **50** into the upper part of chamber **34** and through port **38** and space **39** to conduit **12***a*.

Chamber **36** in bellows **10**b is similar to chamber **34** and is defined by the top plate **60** having therein the port **61** surrounded by the cup-shaped member **62** defining the side wall and bottom of the chamber. Extending horizontally across the chamber is the flexible diaphragm **64** supported at its periphery by the attachment means **66**. Mounted on diaphragm **64** is the T-shaped valve member **68** which is urged by the coil spring **70** downwardly to close the port **61**.

Conduit 12*b* communicates between the patient or the patient's face mask and the space 74 between the bottom of the valve chest 30 and plate 60. In the side wall of chamber 36, the apertures 72 are provided to pass exhalation gases from the space 74 into bellows 10*b* when the position of diaphragm 64 causes valve 68 to be in open position. In the open circuit operation of the device exhalation gas thus accumulated in bellows 10*b* during expansion of bellows 10*b* is discharged from the apparatus to atmosphere through the exhaust port 76, the one-way valve 77 therein, and conduits 75 and 75*a*, leading to discharge port 75*b*.

However, if a closed system is desired, port 75*b* may be coupled to the inlet 54 of intake conduit 52, as by means of the interconnecting conduit member 78, and the gases from exhaust port 76 may be recirculated, preferably through filter means of known kind, and any excess gases may be stored in the expansible, preferably rubber, bag 79, which communicates with conduit 78 through branch conduit 80, and fed back into said system whenever pressure therein falls below predetermined amount. In conduit 78 is the two-way valve 82 which, in one position permits flow of gas in conduit 78 to inlet port 54 and to the bag 79, and in another position discharges the gas to atmosphere.

Compressed air is supplied to, and exhausted from, each of the valve chambers 34 and 36 through the conduit 81 as will be explained. During the expanding movement of bellows 10*a* and 10*b* this pressure is supplied to the valve chambers and serves to counter-balance the springs 48 and 70, respectively, and therefore to hold valve member 46 closed and valve member 68 open during the expansion of said bellows thus preventing supply of gas to the patient's lungs and causing gas to be withdrawn from the patient's lungs. Upon the upward, collapsing movement of the bellows 10*a* and 10*b* the pressure is released from under the valve diaphragms through conduit 81, permitting them to move downward, and spring 48 then serves to hold valve 68 open and spring 70 serves to hold valve 68 closed, thus causing gas to be supplied to the patient from bellows 10*a* and causing gas previously exhausted from the patient to be discharged from bellows 10*b*.

Except for the addition of compressed air conduit 81/81*a*, the structure of valve chest 30 and the means provided for collapsing and expanding the bellows 10*a* and 10*b* and for regulating the duration of each of these movements, and for providing a "dwell," or flattening of the inhalation or exhalation curve near its end (flattening of the exhalation curve being illustrated herein) may be the same as those illustrated and fully described in my co-pending application Serial No. 633,163. These means include the three needle valves 82, 84 and 86 which are controlled respectively by knobs 83, 85 and 87 each of which is surrounded by a calibrated ring. These valves control the flow of compressed air within passages schematically illustrated in Figure 1. The compressed air or equivalent means used in the said passages is employed for collapsing containers 10*a* and 10*b* simultaneously and is entirely separate from the gas or gases contained within the container means and exchanged between said means and the patient directly, or indirectly as through anesthesia equipment.

Valve 82 controls the admission of compressed air from supply conduit 88 to passage 90 from which it flows to passage 92 when valve member 94 of valve assembly *v* is unseated. Passage 92 communicates with both hollow columns 26 through branches 92*a* and 92*b*, and gas supplied and exhausted through passage 92 serves to raise and lower the cylindrical pistons 28 which move up and down within said columns and in turn raise and lower the base plates or platform members 14*a* and 14*b* thereby collapsing or expanding the bellows 10*a* and 10*b*.

Valve 84 controls the exhausting of air from columns 26 and passage 92 and 92*a* and 92*b* through passage 96, when the ring 98 on the head portion 99 of valve assembly *v* is unseated and valve member 94 is seated, which is the position shown in Figure 1. Conduit 81 through branch 81*a* communicates with passage 96 between valve assembly *v* and valve member 84, and consequently supplies compressed air to chambers 34 and 36, under the diaphragms 44 and 64, respectively, during the time valve ring 98 is unseated and the compressed air is flowing out of columns 26 and the bellows 10*a* and 10*b* are consequently expanding, causing valve 46 to close and valve 68 to open. The pressure under the diaphragms 44 and 64 is released when valve ring 98 is closed during which time conduit 81 is able to exhaust gas through passages 81*a*, 96 and 97, thus causing valve 46 to open and valve 68 to close. At this time compressed air supplied through passage 90, past valve head 94 and through passage 92, is raising the pistons 28, thus collapsing the bellows 10*a* and 10*b* and gas is being supplied to the patient while exhalation gases are being separately exhausted from bellows 10*b*.

Valve 86 controls the exhausting of air from an air chamber 100 in valve chest 30 through passage 102. The outer end portions of passages 96 and 102 are shown merging in a common discharge passage 104.

Air chamber 100 is not supplied with compressed air but is connected to atmosphere through passage 102. Piston 108 is urged in a direction away from the outlet to passage 102 by coil spring 109, and has the plunger 110 extending through the top of the chamber in which the small port 106 is provided. When the descending base plate or platform 14*a* strikes plunger 110 its downward movement is resisted and slowed in proportion to the rate at which the adjustment of valve 86 allows air to escape from chamber 100 through passage 102. Valve 86 may be adjusted to slow the downward movement of piston 108 so that during the final portion of the expansion of bellows 10*a* and 10*b* the negative pressure exerted on the patient's lungs from container 10/bellows 10*b*, as for example through anesthesia equipment and a face mask, is substantially level thus providing in effect a pause between the exhalation and inhalation phases of a breathing cycle.

As is explained in my co-pending application, this levelling off of the pressure curve approaching zero provides a pause in the breathing cycle enabling the operator to make the cycle of the device correspond with the breathing cycle of the patient. The duration of the interval during which the pressure curve is thus substantially flattened is determined by the position of base plate 14*a* when it strikes plunger 110 and in the illustrated embodiment of the invention this depends upon the distance to which plunger 110 extends above valve chest 30.

It will be understood that by placing chamber 100 on top of base plate 14*a*, in position to cause plunger 110 to be depressed by contact with the cross member 22 during the upward movement of base plate 14*a*, a pause or interval during which the pressure remains substantially constant can be obtained substantially between the inhalation and exhalation phases.

The position of valve assembly *v* is controlled by toggle mechanism comprising the toggle arms 112 and 113, the knife edge inner ends of which are received in the V-shaped indentations *a* and *b* provided in the opposite faces of the enlarged lower end 114*a* of the control rod 114 extending upwardly from the top of valve chest 30. Rod 114 is supported by said toggle arms and is movable up and down to actuate the toggle mechanism, being guided by the downwardly extending guide pin 115 which extends into a guiding vertical bore provided in the valve chest 30. Toggle arm 112 is supported at its outer end on the reduced portion 115 of a post 116 projecting up from valve chest 30. Toggle arm 113 is pivotally supported intermediate its ends on the reduced portion 117 of a post 118 projecting up from valve chest 30, and the outer end of arm 113 is connected to the reduced portion 119 of valve stem 120 of the valve assembly *v*. The outer ends of the toggle arms are joined together by coil spring means 122.

Projecting from the moving base plate **14***a* is a lip **124**, shown schematically in Figure 1 as an angle extension member, having a slot **126** through which the control rod **114** extends. On rod **114** below the outer end of extension **124** is a lower fixed stop **128**, and above the outer end of extension **124** is an upper adjustable stop **130**, rod **114** being preferably calibrated to facilitate setting of the position of adjustable stop **130** as may be desired to determine the volume of bellows **10***a* and **10***b*, i.e., the extent to which they can be expanded which of course determines the volume of gas **10***b* can receive from the patient's lungs, and the volume of gas **10***a* can transfer to the patient's lungs when it is collapsed.

When expansion of bellows **10***a* moves its lower end to the end of its downward stroke lip **124** contacts fixed stop **128** and moves control rod **114** downwardly enough to actuate said toggle arms downwardly, thus raising valve stem **120** and ending the negative or exhalation phase of the breathing cycle and starting the succeeding positive phase. When the collapsing of container **10***a* causes the lip **124** to strike the upper adjustable stop member **130** control arm **114** is elevated just enough to trip the toggle mechanism and lower valve stem **120** causing valve **94** to close and unseating ring **98**, thus ending the positive phase of the breathing cycle and starting the negative phase.

Control rod **114** may be raised or lowered and locked in either of said positions to stop automatic operation of the device, by means of a control dial **132** on the upper end of control rod **114**. Since the means for raising and lowering the control rod forms no part of this invention and is fully described in my said co-pending application, it is not described here except to say that the dial **132** may be turned from a middle running position in one direction for locking it in raised position and in the other direction for locking it in lowered position. When the dial **132** is in raised position, the valve assembly *v* is lowered and valve **98** in passage **92** is open so that when the dial is turned to the middle position automatic operation will be resumed at the start of the downward movement of the containers **10***a* and **10***b* which corresponds with the exhalation phase of the breathing cycle.

When the dial is in lowered position, the valve assembly *v* is raised and valve **98** is closed, and valve **94** in passage **92** is open so that when the dial is turned to middle or running position automatic operation will be resumed at the start of the upward movement of the containers **10***a* and **10***b* which corresponds with the inhalation phase of the breathing cycle. The dial **132** is shown provided with the finger piece **132***a*.

The structure shown herein above cross member **22** between intake conduit **52** and the nipple **56** forms no part of this invention and is illustrated herein merely to indicate that the complete device as disclosed in my co-pending application may be bodily incorporated in a device of the kind disclosed herein.

There has thus been provided a device in which the objects stated above have been achieved in a practical way.

What I claim is:

1. Apparatus for controlling breathing comprising two expansible and collapsible gas containers and means interconnecting the containers for operation in unison, an inlet port in one of said containers for connection to a source of gas supply, conduit means for providing communication between said container and a patient, conduit means for providing communication between the patient and the other container, exhaust port means for exhausting gas from said other container, means for alternately expanding and collapsing said containers simultaneously, valve means, for closing the conduit between said one container and the patient while said containers are expanding and gas is consequently being drawn into said one container from said source and gas is being drawn into the other container from the patient's lungs and for opening the conduit between said one container and the patient while said containers are collapsing and gas is consequently being supplied to the patient from said one container and gas is being exhausted from said second container through said exhaust port means, a valve chest disposed between said two containers, rod means extending through said valve chest and interconnecting said containers, and means for reciprocating the rods for alternately collapsing and expanding said gas containers.

2. Apparatus for controlling breathing comprising two expansible and collapsible gas containers and means interconnecting the containers for operation in unison, an inlet port in one of said containers for connection to a source of gas supply, conduit means for providing communication between said container and a patient, conduit means for providing communication between the patient and the other container, exhaust port means for exhausting gas from said other container, means for alternately expanding and collapsing said containers simultaneously, valve means, for closing the conduit between said one container and the patient while said containers are expanding and gas is consequently being drawn into said one container from said source and gas is being drawn into the other container from the patient's lungs and for opening the conduit between said one container and the patient while said containers are collapsing and gas is consequently being supplied to the patient from said one container and gas is being exhausted from said second container through said exhaust port means, other valve means for controlling flow of gas from the patient into said other container, pressure responsive means tending to hold the first-mentioned valve means closed and the second mentioned valve means open, and means for alternately exerting pressure and relieving pressure to control the operation of said valve means.

3. Apparatus for controlling breathing comprising two expansible and collapsible gas containers and means interconnecting the containers for operation in unison, an inlet port in one of said containers for connection to a source of gas supply, conduit means for providing communication between said container and a patient, conduit means for providing communication between the patient and the other container, exhaust port means for exhausting gas from said other container, means for alternately expanding and collapsing said containers simultaneously, valve means, for closing the conduit between said one container and the patient while said containers are expanding and gas is consequently being drawn into said one container from said source and gas is being drawn into the other container from the patient's lungs and for opening the conduit between said one container and the patient while said containers are collapsing and gas is consequently being supplied to the patient from said one container and gas is being exhausted from said second container through said exhaust port means, and means for connecting said inlet and outlet ports to provide a closed circuit.

4. The apparatus claimed in claim 3 including a 2-way valve means in the connecting means for controlling the proportion of exhaled gas recirculated to said inlet and the proportion discharged to atmosphere.

5. Apparatus for controlling breathing comprising two expansible and collapsible gas containers and means interconnecting the containers for operation in unison, an inlet port in one of said containers for connection to a source of gas supply, conduit means for providing communication between said container and a patient, conduit means for providing communication between the patient and the other container, exhaust port means for exhausting gas from said other container, means for alternately expanding and collapsing said containers simultaneously, valve means, for closing the conduit between

said one container and the patient while said containers are expanding and gas is consequently being drawn into said one container from said source and gas is being drawn into the other container from the patient's lungs and for opening the conduit between said one container and the patient while said containers are collapsing and gas is consequently being supplied to the patient from said one container and gas is being exhausted from said second container through said exhaust port means, means for connecting said inlet and outlet ports to provide a closed circuit, a gas storage member, means communicating between said storage member and said connecting means, and valve means to permit gas to flow to and from said storage member.

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