

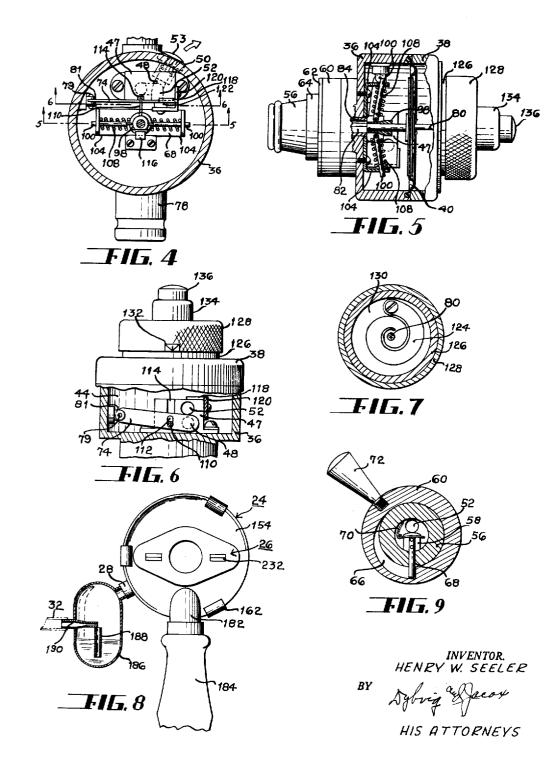
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DEVICE FOR TREATMENT OF PULMONARY DISEASES Filed Feb. 13, 1956

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## 1

3,083,707 DEVICE FOR TREATMENT OF PULMONARY DISEASES Henry W. Sceler, 3142 Atherton Road, Dayton 9, Ghio Filed Feb. 13, 1956, Ser. No. 565,015 11 Claims. (Cl. 128–29)

This invention relates to a device for treatment of pulmonary diseases and more particularly to a breathing apparatus for supplying a vaporized medicament to the lungs 10 treatment device. The reference numeral 20 indicates a of a patient, although not necessarily so limited.

The breathing apparatus to which this invention pertains is essentially a pressure control apparatus which periodically interrupts a flow of gas under pressure to the lungs of a patient. As the patient attempts to inhale, the control 15 mechanism operates automatically to allow the gas to flow into the patient's lungs as an aid to inhalation. When the gas pressure in the lungs reaches a preselected maximum value, the control mechanism operates automatically to cut off the supply of gas permitting the gas pressure in 20 the lungs to drop to atmospheric pressure, the patient exhaling naturally.

One object of this invention is to provide a breathing apparatus operable from a low pressure source of breathing gas. The source may be, for example, an electrically or 25 manually operated air compressor. A gas pressure of 35 mm. mercury is sufficient to operate the breathing apparatus, hence, the need for costly cylinders of highly compressed oxygen or the like is eliminated.

Another object of this invention is to provide, in combi- 30 nation with the breathing apparatus, a medicament nebulizer assembly, the operation of which is governed by the breathing apparatus. As a means for conserving medicament, the nebulizer assembly in this combination is operative only during the inhalation cycle of the breathing ap- 35 paratus so that medicament is never released to the atmosphere until it has passed into the lungs of a patient undergoing treatment.

Still another object of this invention is to provide a novel valve assembly in combination with the breathing 40 apparatus which permits exhalation of gas directly into the ambient atmosphere, by-passing the breathing apparatus. Contamination of the breathing apparatus parts with exhaled medicament is thus prevented. As a further consequence, the breathing apparatus is able to provide 45fresh gas for inhalation immediately upon initiation of the inhalation cycle, with no recycling of exhaled air.

Other objects and advantages reside in the construction of parts, the combination thereof and the mode of operation, as will become more apparent from the fol- 50 trating the wall of the housing member 36. A clapper lowing description.

In the drawings, FIGURE 1 is a perspective view of the pulmonary treatment device including the medicament nebulizer assembly.

stantially along the line 2-2 of FIGURE 1.

FIGURE 3 is an enlarged sectional view taken substantially along the line 3-3 of FIGURE 1.

FIGURE 4 is a sectional view taken substantially along 60the line 4-4 of FIGURE 2.

FIGURE 5 is an elevational view oriented 90°, of the portion of the pulmonary treatment device shown in FIGURE 4, with parts in section taken substantially along the line 5-5 of FIGURE 4.

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FIGURE 6 is an elevational view of the portion of the pulmonary treatment device shown in FIGURE 4, with parts in section taken substantially along the line 6-6 of FIGURE 4.

FIGURE 7 is a sectional view taken substantially along 70 the line 7-7 of FIGURE 2.

FIGURE 8 is an end elevational view of the portion

of the pulmonary treatment device shown in FIGURE 3 with parts in section taken substantially along the line -8 of FIGURE 1.

FIGURE 9 is a sectional view taken substantially along 5 the line 9-9 of FIGURE 2.

FIGURE 10 is an enlarged sectional view taken substantially along the line 10-10 of FIGURE 1.

Referring to the drawings in detail, FIGURE 1 shows the general arrangement of the elements of the pulmonary pressure regulator apparatus adapted to receiver gas from a source of gas under pressure (not shown). Connected to the pressure regulator apparatus 20 by means of a flexible conduit or hose 22 is a housing 24 for an exhalation valve assembly which functions to separate fresh gas for inhalation from exhaled gas. The valve housing 24 is provided with a breathing tube 26 for insertion in a patient's mouth. When desired, the breathing tube may be replaced with a face mask (not shown).

Attached to the valve housing 24 by means of a conduit 28 is a medicament nebulizer 30 for introducing medicament into the gas stream for inhalation by the patient. Gas under pressure is provided for operation of the nebulizer 30 through a hose or conduit 32 connecting to the pressure control apparatus 20.

#### Pressure Control Apparatus

The pressure control apparatus 20 is housed in a substantially cylindrical housing formed by two mating substantially cup-shaped housing members 36 and 38, as shown in FIGURE 2. Disposed radially within the housing and separating the cup-shaped members 36 and 38 is a resilient diaphragm 40 provided with an annular rib The annular rib 42 is seated in an annular groove 42. provided therefor in the end wall of the housing member 36 to provide a sealing gasket between the housing members 36 and 38. The housing members 36 and 38 are held in compressive engagement with the diaphragm by screws (not shown) or other suitable means.

The diaphragm 40 divides the housing into two substantially cylindrical chambers 44 and 46. The chamber 46 communicates with the ambient atmosphere through a port 49 provided in the wall of the housing member 38.

Mounted in the chamber 44 is an apertured block 47 functioning, as will be described subsequently, as a valve seat. An outlet port 48, seen best in FIGURE 4, traversing the block 47 connects to the ambient atmosphere through a conduit 50 seated in the block 47 and penevalve 53 closes the conduit 50, permitting a passage of gas only out of the chamber 44, not into the chamber 44. This construction is best seen in FIGURE 4.

An inlet port 52 extends angularly through the block 47 FIGURE 2 is an enlarged sectional view taken sub- 55 to communicate with a channel 54 through which a gas under pressure may be supplied to the chamber 44. The housing member 36 is provided with a spigot 56 providing the channel 54 for connection to a source of gas under pressure.

A gate valve 58 operated by a ring-lever 60 is provided for restricting the gas flow into the inlet port 52. The ring-lever 60 girdles the spigot 56 and is rotatably seated thereon. A washer 62 held in compressive abutment with the ring-lever 60 by an elastomeric band 64, also seated on the spigot 56, provides a substantially air-tight seal to prevent leakage of gas around the ring-lever.

As best seen in FIGURE 9, the ring-lever 60 is provided with an annular cam surface 66 which engages a pin 68 traversing the wall of the spigot 56 and carrying the gate valve 58. The pin 68 is held in compressive engagement with the cam surface 66 by means of a spring 70 engaging the internal wall of the spigot. A handle 72 secured to the

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ring-lever 60 provides for manual rotation of the ringlever to adjust the position of the gate valve 58 so as to adjust the flow of gas into the inlet port 52.

A spigot 78 integral with the housing member 36 provides for connection of the conduit 22 to the pressure con-The conduit member 22 communicates trol apparatus. eventually with the lungs of a patient, forming a closed volume with the chamber 44.

A slide valve plate 74, best seen in FIGURE 6, is provided in the chamber 44 for closing selectively either the 10 outlet port 48 communicating to the ambient atmosphere or the inlet port 52 communicating to the source of gas under pressure. The valve plate 74 is pivotally mounted upon a pin 79 secured to the housing member 36 with a U-shaped bracket 81. Depending upon the location of 15the valve plate 74, the pressure in the chamber 44 may either equal that of the ambient atmosphere, or be greater than that of the ambient atmosphere. A pressure gauge 76 is threadedly connected to the housing member 36 for measuring the pressure in the chamber 44.

Traversing axially the chambers 44 and 46 is a rod 80 having an enlarged substantially square end portion 82 seated in a cylindrical bearing member 84, in the base portion of the housing member 36. The opposite end of the rod 80 projects through the base portion of the hous-25ing member 38, the member 38 being provided with a bearing member 86 in the wall thereof for accommodating the rod 80.

The portion of the rod 80 traversing the chamber 44 has a diameter greater than the corresponding portion 30 traversing the chamber 46, thereby providing for a shoulder 88 for engagement with the diaphragm 40. The diaphragm 40 is secured to the rod 80 with a pair of washers 90, one seated upon the shoulder 88 on one side of the diaphragm and the other secured by a pin 92 traversing the rod 80 on the other side of the diaphragm 40.

In response to pressure changes in the closed volume including the chamber 44, the rod 80 is urged to move axially by the diaphragm 40. An axial displacement of the diaphragm 40 is promoted by providing an annular arched portion 94 therein adjacent the cylindrical wall of the housing 20, the arched portion 94 straightening as the diaphragm moves axially. To obtain maximum effective pressure area for the diaphragm 40, a thin 45 metallic or plastic disc 96 is placed on each side of the diaphragm, each disc 96 being sandwiched between one washer 90 and the diaphragm 40.

The axial motion of the rod 80 and diaphragm 40 is utilized to govern the motion of the valve plate 74 through 50 a novel toggle mechanism shown in FIGURES 4 and 5. Slidably engaging the rod 80 within the chamber 44 is a sleeve 98, the sleeve being seated upon the enlarged square end portion of the rod 80, as shown in FIGURE 5. Pivotally secured to the sleeve 98 are two oppositely -55 directed, radially extending shafts 100 which slant upwardly toward the diaphragm 40 from the sleeve 98. The free outer ends of the shafts 100 are journalled for reciprocating movement into L-shaped bracket members 104, there being one such bracket member for each shaft 60 100. Each bracket member 104 is secured to the housing member 36 by any suitable means.

A helical spring 108 extends around each shaft 100 compressively abutting the sleeve 98 at one end of the shaft 100 and the L-shaped bracket member 104 at the 65 other end of the shaft 100. Due to the angular disposition of the shafts 100, the springs 108 cooperate to urge the sleeve 98 and, as a consequence, the rod 80, towards the base of the chamber 44.

An actuator arm 110 projects radially from the sleeve 70 98 through a slot 112 in the valve plate 74 to seat in an axially extending channel 114 provided therefor in the block 47. The slot 112 in the valve plate 74 is elongated axially, to permit lost axial motion of the actuator arm 110 within the valve plate 74.

The pressure control apparatus is depicted in the drawings at an instant when the pressure within both chambers 44 and 46 is that of the ambient atmosphere. If gas under pressure is delivered to the chamber 44 through the inlet port 52, the gas pressure within the chamber 44 The increasing gas pressure displaces the diawill rise. phragm 40 axially, so as to enlarge the chamber 44 and, as a consequence, the rod 80 is drawn axially away from the base of the chamber 44. The rod 80 carries with it the sleeve 98 of the toggle mechanism. As the sleeve 98 is carried axially in the chamber 44 away from the base thereof, the shafts 100 are pivoted into parallel alignment, while simultaneously the actuator arm 110 traverses the slot 112 of the valve plate 74. At the instant the toggle mechanism reaches the neutral or dead center position wherein the shafts 100 are parallel, the actuator arm engages the valve plate 74. The motion of the actuator arm 110 as the toggle mechanism approaches dead center is thus lost motion relative to the valve 20 plate 74.

With continued rise in pressure, the springs 108 of the toggle mechanism drive the sleeve 98 axially by a snap action along the rod 80 toward the diaphragm 40, where the sleeve 98 engages a stop 116 which limits the axial motion thereof. The stop 116 is secured to the base of the housing member 36 at such an elevation in the chamber 44 that when the sleeve 98 engages the stop 116, the valve plate 74, driven by the actuator arm 110 will cover the inlet port 52 in the block 47, thus shutting off the incoming gas.

Proper positioning of the valve plate 74 over the inlet port 52 is insured by placing a stop 118 secured to the block 47 by a bracket 120 for engaging the valve plate 74 as it covers the inlet port 52. The valve plate 74 is 35 firmly seated against the block 47 by a leaf spring 122, or the like, supported by the bracket 120.

As the valve plate is pivoted from a position covering the outlet port 48, as shown in the drawings, to the new position covering the inlet port 52, gas flows out of the closed volume including the chamber 44, through the outlet port 48, reducing the gas pressure within the chamber 44 to atmospheric pressure, and, as will be described subsequently, permitting a patient undergoing treatment to exhale. The falling pressure in the chamber 44 returns the diaphragm 40 to its equilibrium position, but does not reset the toggle mechanism. The sleeve 98 remains in abutment with the washer 90 of the diaphragm assembly.

In order to reset the toggle mechanism, the patient must inhale briefly, closing the clapper valve 53 to close the conduit 50 and lowering the pressure in the chamber 44 below atmospheric pressure. This causes the diaphragm 40 to move axially, driving the toggle mechanism toward the base of the chamber 44. As the toggle mechanism approaches the dead center position, the actuator arm 110 crosses the slot 112 in lost motion in the valve plate 74 and, as the toggle mechanism passes the dead center position, the springs 108 snap the sleeve 98 to the base of the chamber 44, moving the valve plate 74 to the position covering the outlet 48 in the block 47. Gas flows in the inlet port 52 and a new inhalation cycle is thereby initiated.

It is desirable that the inhalation cycle be initiated with a minimum of effort on the part of the patient. Accordingly, the springs 108 in the toggle mechanism are made just strong enough that they properly position the valve plate 74. The reduced pressure in the chamber 44 necessary to actuate the toggle mechanism is then minimized, so as to be readily created by a patient. The control apparatus herein disclosed is a demand responsive mechanism, in that the inhalation cycle is started only after the patient demands air.

A flat spring 124, shown in FIGURES 2 and 7, is employed for controlling the maximum inhalation pressure developed in the chamber 44. A threaded annular 75 flange 126, concentric with the rod 80, is provided on the end of the housing member 38. Threadedly connected to the flange 126 is a cap member 128, carrying a disc 130, to which is secured the flat spring 124. The cap member 128 is adjusted by rotation, so that the flat spring 124 engages the rod 80 at substantially the instant the 5 toggle mechanism is driven to the neutral point during the inhalation cycle. Clearly, in order to terminate the inhalation cycle, the diaphragm 40 must first overcome the restraining or biasing force of the flat spring 124 before driving the toggle mechanism away from the 10 neutral position. The maximum pressure obtained in the chamber 44 is determined by the resistance offered by the spring 124.

By rotating the cap member 128 so as to move the spring 124 closer to the diaphragm 40, the restraining 15 force exerted by the spring 124 can be increased, since it becomes necessary to displace the spring 124 a greater distance to terminate the inhalation cycle. The cap member 128 thus represents a pressure adjustment. A pointer 132, integral with the cap member 128, cooperates with 20 suitable indicia (not shown) on the housing member 38 to provide a means of presetting the spring 124 for a particular maximum pressure value.

For occasions when the patient undergoing treatment has apnea and is therefore unable to initiate the inhalation 25 cycle, a manual actuator is provided for starting the inhalation cycle. Seated within a hollow cylindrical projection 134 in the cap 128 is a button 136 loaded with a helical spring 138, compressively engaging the disc 130 at one end thereof and the button 136 at the other end 30 thereof. This structure is shown in FIGURE 2.

Projecting into the cap member 123 is a shaft 140 of diameter smaller than the rod 80 slidably seated in the button 136. As the button 136 is depressed, the shaft 140 is thrust through a small aperture 142 placed therefor 35 in the center of the flat spring 124, to engage the rod 80, so as to drive the rod 80 and the diaphragm 40 axially toward the base of the chamber 44. This resets the toggle mechanism, positioning the valve plate 74 over the outlet port 48 and opening the gas inlet port 52 so as to initiate 40 an inhalation cycle.

In the event the button 136 is not released, an override spring 144 is provided, allowing the pressure control apparatus to operate as a resuscitator. The override spring 144 is strong in comparison to the toggle mechanism, but weak as compared to the flat spring 124. After initiation of the inhalation cycle, the override spring 144 yields to the axial movement of the diaphragm 40 and the rod 80, allowing the toggle mechanism to operate the valve 74. After the termination of one inhalation cycle, 50 a new inhalation cycle is initiated as soon as the gas pressure in the chamber 44 drops sufficiently that the spring 144 can reset the toggle mechanism. Since the spring 144 is weak in comparison to the flat spring 124, the maximum positive pressure developed during resuscitation 55is not significantly greater than would occur during normal demand responsive operation.

#### The Exhalation Valve Assembly

The pressure regulator supplies an intermittent gas pressure of variable amplitude to the conduit 22 which communicates with the valve housing 24. As best seen in FIGURE 3, the valve housing is formed with two mating substantially conical members 152 and 154, separated by a flexible diaphragm 156. The diaphragm 156 is provided with an annular rib 158 at the perimeter thereof which seats in a complementary annular groove in the wall of the conical member 154. The diaphragm serves as a sealing gasket between the two members 152 and 154 which are held in compressive engagement therewith by releasable clasps 162.

The conical housing member 152 is provided with a spigot 164 for connection to the conduit 22 communicating with the pressure regulator apparatus and the conical housing member 154 is provided with a spigot 166 for 75

connection to the breathing tube 26 leading to the patient's lungs. The diaphragm 156 therebetween provides for a check-valve between the housing members 152 and 154 resisting a flow of gas from the breathing tube to the conduit 22; but offering only small resistance to a flow of gas from the conduit 22 to the breathing tube.

The diaphragm 156 is provided with an annular flange 168, the diameter of the flange 168 being approximately half the diameter of the rib 158. The flange 168 projects into the conical housing member 154 to seat a circular check-valve 170. The check-valve 170 has a stem 172 projecting normally from the center thereof through an aperture in the center of the diaphragm 156. An annular channel 174 in the stem 172 engages the central portion of the diaphragm as a means of securing the valve 170 to the diaphragm. A pair of apertures 176 are placed in the diaphragm 156 intermediate the annular flange 168 and the stem 172 to provide for a passage of gas through the diaphragm.

When there is a pressure differential across the diaphragm such that the pressure in the conical housing member 154 is greater than the pressure in the housing member 152, the valve 170 scats firmly upon the flange 168 and no air can pass through the diaphragm. When the pressure differential is reversed, the valve 170 is displaced from the flange 168 to permit gas to flow through the diaphragm.

Intermediate the annular flange 168 and the annular rib 158, the diaphragm 156 is provided with an annular arched portion 177 which permits an axial displacement of the diaphragm in response to a pressure differential across the diaphragm. The conical housing member 154 is provided with an annular wall or flange 178 engaging the diaphragm 156 intermediate the annular arched portion 177 and the annular flange 163 of the diaphragm. The annular flange 178 of the housing member 154 cooperates with the arched portion 177 of the diaphragm to provide an annular channel 180 in the conical housing member 154. The annular channel 180 communicates with an exhalation port 192 integral with the conical housing member 154.

When a pressure differential develops across the diaphragm 156 such that the pressure within the housing member 152 is greater than or equal to the pressure in the housing member 154 and greater than the pressure in the annular channel 180, the diaphragm is driven axially toward the annular flange 178 of the housing member 154 to close off the channel 180 therein, and hence to close off the exhalation port 182. When the pressure differential is reversed so that the pressure in the housing member 154 or the channel 180 is greater than that in the housing member 152, the diaphragm 156 is displaced axially away from the annular flange 173 to open the annular channel 180. This permits gas to be exhaled into the exhalation port 182. The port 182 connects to a low resistance exhalation check-valve 184, which prevents inhalation through the port 182.

The valve assembly in the valve housing 24, permits a passage of gas to a patient's lungs isolating the exhalation port during the inhalation cycle. During the exhalation cycle, exhaled gases are vented directly to the ambient atmosphere through the exhalation port. In this manner, the valve assembly functions to separate exhalation and inhalation gases.

### The Medicament Nebulizer Assembly

The medicament nebulizer 30 connects to the conical valve housing member 154 through a conduit 23. As shown in FIGURE 8, the medicament nebulizer comprises a vertically oriented substantially cylindrical housing 186, in which is mounted a vertically extending hollow tube 188. The hollow tube 188 cooperates with a gas inlet jet 190, to provide a conventional atomizer for vaporizing a medicament placed in the housing. The gas jet 190 is supplied with gas under pressure through the hose 32

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connecting to a spigot 192 threadedly connected to the housing member 36 of the pressure control apparatus. Through an aperture 194 in the housing member 36, the hose 32 connects directly to the incoming gas regulated by the gate value 58.

As a means of conserving medicament, a pressure sensitive hose clamp assembly, as shown in FIGURE 10, is utilized to regulate the gas flow to the nebulizer 30 in response to pressure variations produced by the pressure control apparatus.

The hose clamp assembly includes a shallow cylindrical housing 196 having a base portion 198 and enclosed by a top portion 200. A flexible diaphragm 202 extending radially in the housing 196 divides the housing into two chambers 204 and 206. The diaphragm 202 is provided 15 with an annular flange 208 along the perimeter thereof which is secured to the wall of the housing 196 by a suitable means. An aperture 210 traverses the wall of the housing 196 to the chamber 206, so as to maintain the chamber 206 at atmospheric pressure.

The diaphragm 202 is adapted to move axially in the housing 196 by providing an annular arch 212 therein. A thin metal or plastic disc 214 engages the central portion of the diaphragm 202 within the chamber 206, to prevent bowing or stretching of the diaphragm.

The legs 216 of a U-shaped bridge member 218 encircling the hose 32 slidably penetrate the top 200 of the housing 196. The legs 216 are secured in any suitable manner to the disc 214. A helical spring 220 encircles the legs 216 within the chamber 206, compressively en- 30 gaging the disc 214 at one end thereof and the top 200 of the housing 196 at the other end thereof.

A bolt 222 threadedly engages the arcuate portion of the U-shaped bridge member 218. The bolt 222 is provided with a tapered tip 224 which pinches the hose 32. 35 When the pressure in both chambers 204 and 206 is that of the ambient atmosphere, the spring 222 is sufficiently strong to cause the tapered tip 224 to fully close the flexible hose 32.

Through a conduit or hose 226, the chamber 204 of 40 the hose clamp assembly communicates with the conduit 22. When the pressure in the conduit 22 is substantially that of the atmosphere, the hose 32 is closed and no medicament is vaporized. As the pressure in the conduit 22 rises during the inhalation cycle of the pressure control 45 apparatus, the diaphragm 202 in the hose clamp assembly is displaced axially against the spring 220 actuating the bridge member 218 to open the hose 32. The opening in the hose 32 may be adjusted by rotating the bolt 222. This permits vaporization of medicament, which travels into 50 the breathing tube 26 through the valve housing member 154. At the termination of the inhalation cycle, the pressure in the conduit 22 returns to atmospheric pressure and, as a consequence, the flexible hose 32 is pinched closed and vaporization of the medicament ceases.

### Mode of Operation

The breathing tube 26 is provided with a resilient end plate 230 adapted for insertion in a patient's mouth between the lips and teeth. The patient retains the breath- 60 ing tube by biting on a pair of flanges 232 projecting from the end plate 230.

As the patient undergoing treatment first demands air, the clapper valve 53 closes the outlet port 48 and the gas actuates the toggle mechanism to shift the position of the valve plate 74 opening the gas inlet port 52 and closing the gas outlet port 48.

A gas under pressure flows to the chamber 44 through the inlet port 52 and thence through the conduit 22 to the 70 patient's lungs, forcefully filling the lungs. With increasing gas pressure in the conduit 22, the hose clamp assembly is operated to open the hose 32 leading to the nebulizer 30. Vaporized medicament is released to the gas stream, flowing therewith into the lungs of the patient.

When the gas pressure in the lungs, conduit 22, and chamber 44 reaches the maximum pressure as determined by the setting of the cap 128, which positions the flat spring 124, the toggle mechanism is actuated to shift the position of the valve plate 74, closing the gas inlet port 52 and opening the outlet port 48. The high gas pressure in the chamber 44 forces open the clapper valve 53 and gas flows out of the chamber 44 and the conduit 22 reducing the gas pressure therein to substantially atmospheric pressure.

The reduced gas pressure in the conduit 22 operates the hose clamp assembly to close off the hose 32, thus cutting off the supply of medicament to the lungs. Simultaneously, the high gas pressure in the lungs operates the diaphragm 156 in the valve housing 24 so as to open the exhalation port 182 and gas is permitted to flow out of the lungs in normal exhalation.

As soon as the patient again demands air by attempting to inhale, the cycle described above begins anew.

The time duration of the inhalation cycle is controlled by regulating the flow of gas into the chamber 44. The flow of gas is increased or decreased by adjusting the gate valve 58 with the handle 72 projecting from the pressure control apparatus. The maximum pressure developed in 25 the patient's lungs is regulated by adjusting the cap 128 positioning the flat spring 124, which biases the movement of the diaphragm 40. The amount of medicament delivered to the gas stream by the nebulizer may be regulated by adjusting the bolt 222 in the hose clamp assembly.

The patient may exhale at any time during the inhalation cycle by developing a lung pressure greater than the pressure in the conduit 22. This operates the valve assembly in the housing 24 to close off the conduit 22 and open the exhalation port 182. As the patient exhales, the chamber 44 will rapidly build up to maximum pressure actuating the toggle mechanism to open the outlet port 48. The pressure control apparatus will thus be in proper position to initiate a new inhalation cycle when the patient next attempts to inhale.

It is highly desirable in a device such as this that provision be made for sterilizing the components subject to contamination. It is apparent that, in the present device, only the breathing tube and exhalation valve assembly are subject to contamination from the patient's breath

since the pressure control apparatus is isolated from the patient's exhalation breath by the operation of the exhalation valve assembly.

The releasable clasps 162 of the valve housing 24 provide for quick disassembly of the valve housing so that the housing member 154, the diaphragm 156, the checkvalve 170, the breathing tube 26, and the exhalation valve 184 may all be separated to facilitate sterilization. The housing member 152 of the valve housing is not subject to contamination.

Although the preferred embodiment of the device has 55 been described, it will be understood that within the purview of this invention various changes may be made in the form, details, proportion and arrangement of parts, the combination thereof and mode of operation, which

generally stated consists in a device capable of carrying out the objects set forth, as disclosed and defined in the appended claims.

Having thus described my invention, I claim:

1. A device operable from a source of gas under pressure in the chamber 44 decreases. The diaphragm 40 65 pressure for use in the treatment of patients having pulmonary disorders, said device comprising, in combination, pressure responsive means connected to the source of gas under pressure for regulating the flow of gas therefrom, a conduit communicating with said pressure respon-

sive means and terminating in an adapter for fitting the mouth of a patient for conveying gas to the lungs of the patient, said pressure responsive means operating to permit a flow of gas from said source to said conduit in response to a gas pressure less than that of the ambient 75 atmosphere created by inhalation demand of the patient

and operating to stop the flow of gas from said source to said conduit while simultaneously connecting said conduit to the ambient atmosphere when the gas pressure in said conduit obtains a predetermined maximum value relative to that of the ambient atmosphere, and pressure sensitive valve means positioned between said adapter and said conduit for closing said conduit and simultaneously providing a passage from said adapter to the ambient atmosphere whenever the gas pressure in said adapter exceeds the gas pressure in said conduit.

2. A device operable from a source of gas under pressure for use in the treatment of patients having pulmonary diseases, said device comprising, in combination, a pressure regulator connected to the source of gas under pressure for regulating the flow of gas therefrom to establish 15 a breathing cycle, an adapter for delivering the gas to a patient, a conduit connecting said pressure regulator with said adapter, exhalation valve means responsive to a gas pressure differential between said conduit and said 20 adapter interposed therebetween, said exhalation valve means providing a first passage between said adapter and said conduit and a second passage between said adapter and the ambient atmosphere, said valve means having two positions, a first position opening said first passage while closing said second passage, and a second position closing 25 said first passage while opening said second passage, a nebulizer operating from the source of gas under pressure supplying a vaporized medicament to said conduit, and means responsive to the gas pressure in said conduit for regulating the flow of gas from said source to said nebulizer, the construction and arrangement being such that gas is permitted to flow from said source to said nebulizer to deliver vaporized medicament to said conduit only when the gas pressure in said conduit exceeds a 35 predetermined value above that of the ambient atmosphere.

3. A device operable from a source of gas under pressure for use in the treatment of patients having plumonary diseases, said device comprising, in combination, control means connected to the source of gas under pressure for regulating the flow of gas therefrom to establish a breathing cycle, conduit means communicating with said control means for conveying gas therefrom to the lungs of a patient, nebulizer means communicating between the source of gas under pressure and the conduit means for 45 supplying a vaporized medicament to the conduit means, means responsive to the gas pressure in said conduit means for regulating the nebulizer means such that gas is permitted to flow from said source to said nebulizer to deliver vaporized medicament to said conduit only when the gas pressure in said conduit exceeds a predetermined value above that of the ambient atmosphere, and valve means providing for exhalation by the patient to the ambient atmosphere and preventing exhalation by the patient into said conduit means.

4. A pressure control apparatus for regulating the flow of gas from a source of gas under pressure into a closed volume, said apparatus including a housing defining a gas receiving chamber communicating with and forming a part of said closed volume, pressure sensitive means communicating with said chamber, means providing a gas inlet to said chamber communicating with the source of gas under pressure, means providing a gas outlet from said chamber communicating with the ambient atmosphere, a valve member, disposed in said chamber for alternately covering the gas inlet and the gas outlet, valve operating means responsive to said pressure sensitive means for actuating said valve member so as to close the gas inlet when the gas pressure in said chamber obtains a predetermined maximum value and to close the gas outlet when the gas 70 pressure in said chamber obtains a predetermined minimum value, and yielding means for manually actuating said valve operating means so as to close the gas outlet when the gas pressure in said chamber is greater than the minimum valve, said yielding means yielding when the 75 gas pressure in said chamber exceeds a predetermined maximum value.

5. A pressure control apparatus for regulating the flow of gas from a source of gas under pressure into a closed volume, said apparatus including a housing defining a gas receiving chamber communicating with and forming a part of said closed volume, pressure sensitive means communicating with said chamber, means providing a gas inlet to said chamber communicating with the source of 10 gas under pressure, means providing a gas outlet from said chamber communicating with the ambient atmosphere, pressure operated valve means disposed in said gas outlet for closing the gas outlet when the gas pressure in said chamber is below that of the ambient atmosphere, a pivotally mounted valve member for closing alternately the gas inlet and gas outlet, and valve operating means responsive to said pressure sensitive means for pivoting said valve member between the gas inlet and the gas outlet so as to close the gas inlet, opening the gas outlet when the gas pressure in said chamber obtains a predetermined value above atmospheric pressure and to close the gas outlet opening the gas inlet when the gas pressure in said chamber obtains a predetermined value below atmospheric pressure.

6. A pressure control apparatus for regulating the flow of gas from a source of gas under pressure into a closed volume, said apparatus including a housing defining a gas receiving chamber communicating with and forming a part of said closed volume, a pressure sensitive diaphagm 30 disposed in one wall of said chamber, a rod carried by said diaphragm traversing said chamber, means providing a gas inlet to said chamber communicating with the gas under pressure, means providing a gas outlet from said chamber communicating with the ambient atmosphere, a pivotally mounted valve plate having a slot therein, said valve plate closing alternately the gas inlet and the gas outlet, reciprocably mounted means operated by said diaphragm for positioning said valve means, said reciprocably mounted means comprising a toggle mechanism including a sleeve slidably mounted on said rod for reciprocating motion thereon about the dead center position of said toggle assembly, resilient means biasing the toggle mechanism away from dead center so as to urge said sleeve to occupy one of two extreme positions on said rod, and an actuator arm carried by said sleeve projecting into the slot in said valve plate for pivoting the valve plate between positions covering the gas inlet and the gas outlet, the slot in said valve plate providing for lost motion of the actuator arm therein whereby the actuator arm 50 pivots the valve plate only as the sleeve carrying the actuator arm moves away from the dead center position of the toggle assembly.

7. A pressure control apparatus for regulating the flow of gas from a source of gas under pressure into a closed 55 volume, said apparatus including a housing defining a gas receiving chamber communicating with said forming a part of said closed volume, pressure sensitive means communicating with said chamber, means providing a gas inlet to said chamber communicating with the source of 60 gas under pressure, means providing a gas outlet from said chamber communicating with the ambient atmosphere, a single valve element for closing alternately the gas inlet and the gas outlet, and valve operating means powered by said pressure sensitive means for shifting the position of the valve element alternately between the gas inlet and the gas outlet, said valve operating means including a lost motion mechanism whereby limited lost motion of the pressure sensitive means is permitted prior to actuation of said valve means.

8. The combination with a medicament nebulizer operated by a source of gas under pressure connected thereto by a flexible hose, said medicament nebulizer delivering gas to a gas stream of variable pressure, of means responsive to the gas pressure of said gas stream for regulating the operation of the nebulizer, said means includ3,083,707

ing a housing defining a gas receiving chamber, means connecting said chamber with the gas stream, pressure sensitive means communicating with said chamber, and hose pinching means operated by said pressure sensitive means for pinching said hose an amount determined by 5 the gas pressure in the gas stream.

9. A device operable from a source of gas under pressure for use in the treatment of patients having pulmonary diseases, said device comprising, in combination, control means connected to the source of gas under pressure 10 for regulating the flow of gas therefrom to establish a breathing cycle, conduit means communicating with said control means for conveying gas therefrom to the lungs of a patient, nebulizer means communicating between the source of gas under pressure and said conduit means 15 surface. for supplying a vaporized medicament to said conduit means, means responsive to the gas pressure in said conduit means for regulating the nebulizer means such that gas is permitted to flow from said source to said nebulizer to deliver vaporized medicament to said conduit only 20 when the gas pressure in said conduit exceeds a predetermined value above that of the ambient atmosphere, and valve means providing for exhalation by the patient to the ambient atmosphere, said valve means including a housing partitioned by a flexible diaphragm disposed in 25 said conduit, said diaphragm having an aperture located centrally therein, pressure sensitive valve means secured to said diaphragm for closing said aperture when the gas pressure in the patient's lungs exceeds that delivered by said pressure regulating means and for opening said aper- 30 ture when the pressure differential is reversed, means associated with said housing providing an exhalation passage from said conduit to the ambient atmosphere intermediate the patient's lungs and said diaphragm, and means cooperating with said diaphragm to close said exhalation 35 passage when the pressure delivered by said pressure regulating means exceeds that in the patient's lungs

10. A pressure control apparatus for regulating the flow of gas from a source of gas under pressure into a closed volume, said apparatus including a housing defin- 40 ing a gas receiving chamber communicating with and forming a part of said closed volume, pressure sensitive means communicating with said chamber and with the ambient atmosphere, means providing a gas inlet to said 45 chamber communicating with the source of gas under pressure, means providing a gas outlet from said chamber communicating with the ambient atmosphere, a valve member for alternately covering the gas inlet and the gas outlet, means responsive to said pressure sensitive means 50for operating said valve member so as to close the gas inlet when the gas pressure in said chamber obtains a predetermined maximum value relative to that of the ambient atmosphere and to close the gas outlet when the gas pressure in said chamber obtains a predetermined

minimum value, and means for regulating the time required for the gas pressure in said chamber to reach the predetermined maximum value, said means including a gate valve, an annular ring encircling said gas inlet, radially disposed pin means slidably penetrating said annular ring and supporting said gate valve in said annular ring for reciprocal movement across said inlet between opposite extreme positions, said gate valve fully closing said inlet in one extreme position and opening said inlet in the opposite position, annular cam means rotatably journalled on said annular ring and having an internal cam surface of varying radius engaging said pin means for adjustably moving said gate valve across said inlet, and resilient means biasing said pin means against said cam surface.

11. A device operable from a source of breathing gas under pressure for use in the treatment of patients having pulmonary diseases, said device comprising, in combination, control means connected to the source of gas under pressure for regulating the flow of gas therefrom to establish a breathing cycle, conduit means communicating with said control means for conveying gas therefrom to the lungs of a patient, said conduit means excluding atmospheric gases from the breathing gas, nebulizer means communicating directly between the source of gas under pressure and the conduit means for supplying the vaporized medicament to the breathing gas in said conduit means, and means responsive to the gas pressure in said conduit means for regulating the nebulizer means such that gas is permitted to flow from said source to said nebulizer to deliver vaporized medicament to said conduit only when the gas pressure in said conduit exceeds a predetermined value above that of the ambient atmosphere.

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