# United States Patent [19]

**Kenagy**

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[45] **Dec. 10, 1974**


[54] **INSUFFLATOR GAS FLOW DEVICE**


[76] Inventor: **Paul E. Kenagy,** 2245 Richey Dr., La Canada, Calif. 91011



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**Related U.S. Application Data**

[63] Continuation of Ser. No. 208,688, Dec. 16, 1971, , which is a continuation-in-part of Ser. No. 60,524, Aug. 3, 1970, abandoned.

[52] **U.S. Cl.**..... **128/145.8,** 128/142.3, 128/209

[51] **Int. Cl.**..... **A62b 7/02**

[58] **Field of Search**..... 128/145.8, 145.5, 145.6, 128/145.7, 145 R, 142.3, 207, 211, 274; 137/63 R; 251/206, 207, 208



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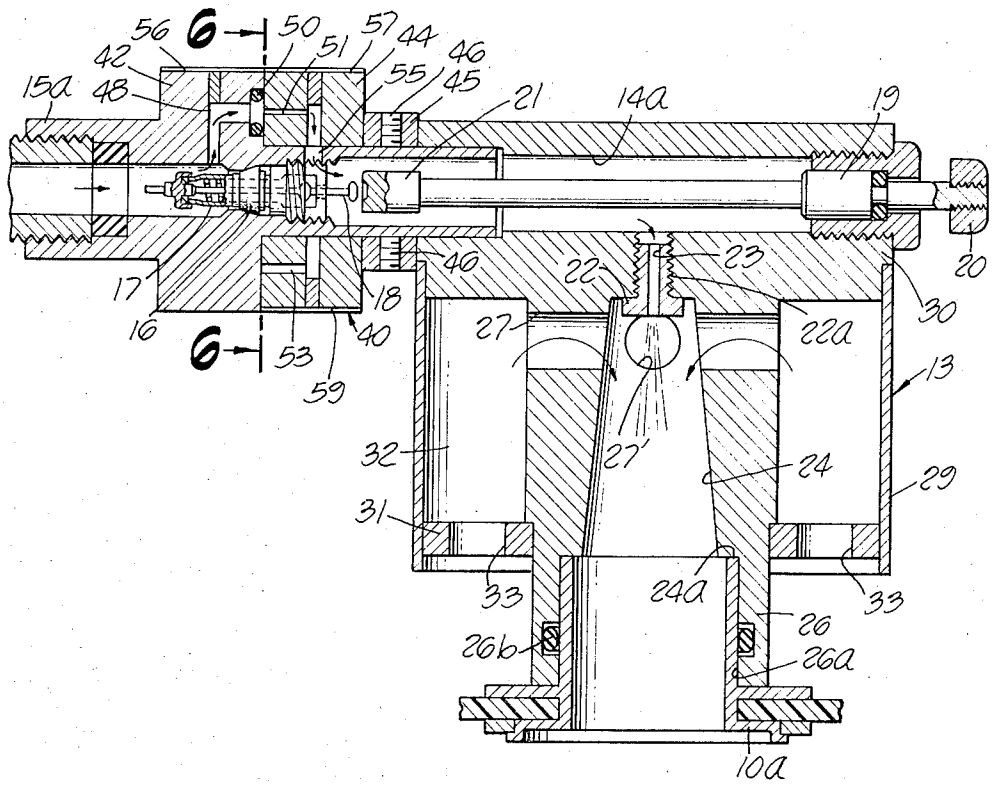
*Primary Examiner*—Richard A. Gaudet
*Assistant Examiner*—Henry J. Recla
*Attorney, Agent, or Firm*—Paul A. Weilein



[57] **ABSTRACT**

An inlet port admits pressurized oxygen and a breathing port is used by the patient. A venturi nozzle directs the pressurized oxygen into a venturi throat which leads to the breathing port and the venturi throat has a plurality of lateral vent ports to the atmosphere. For one mode of operation to treat an unconscious patient, a normally closed valve is operable to release the pressurized oxygen periodically to the venturi nozzle and for treating a conscious patient, a metering means bypasses the closed valve to release the compressed oxygen to the venturi nozzle at a continuous reduced rate.


**13 Claims, 8 Drawing Figures**



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SHEET 1 OF 2

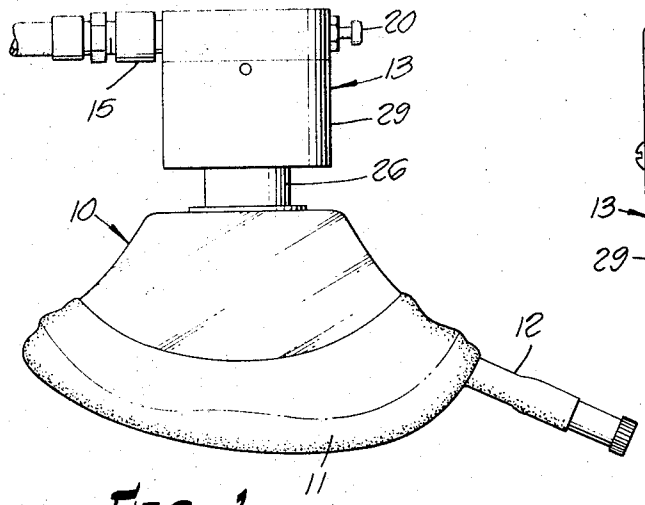



FIG. 1.

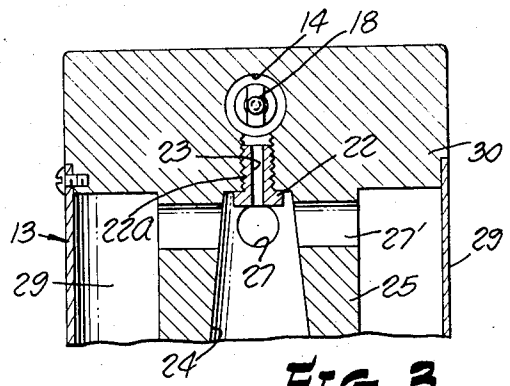



FIG. 3.

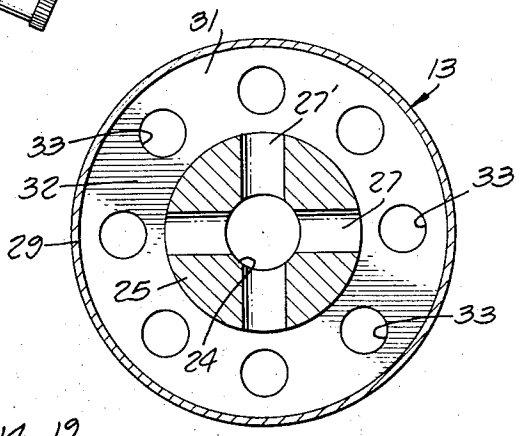
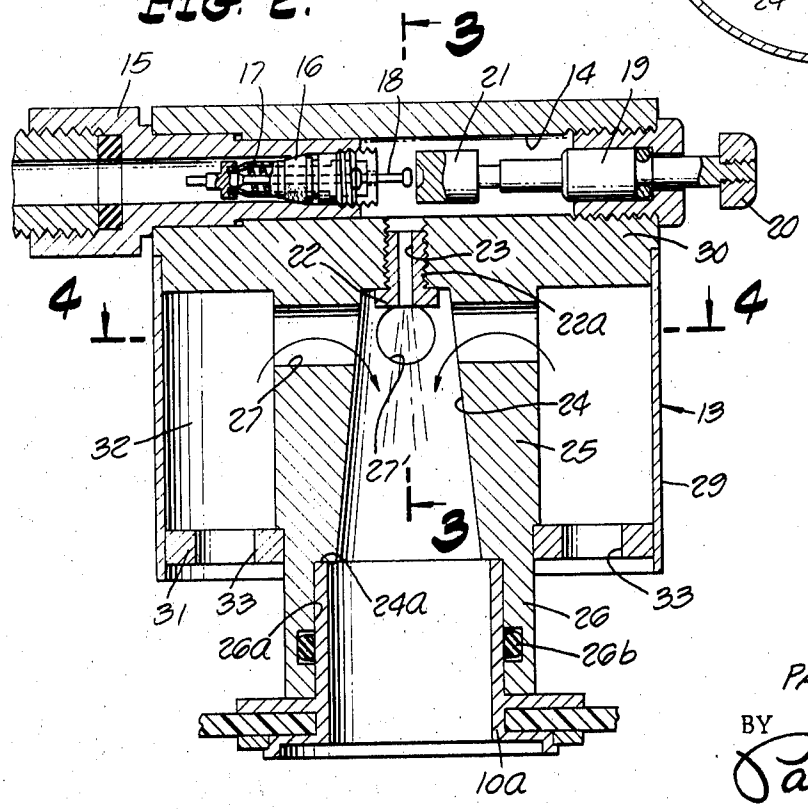



FIG. 4.

FIG. 2.




INVENTOR
PAUL E. KENAGY

BY
Paul A. Weilcin
ATTORNEY

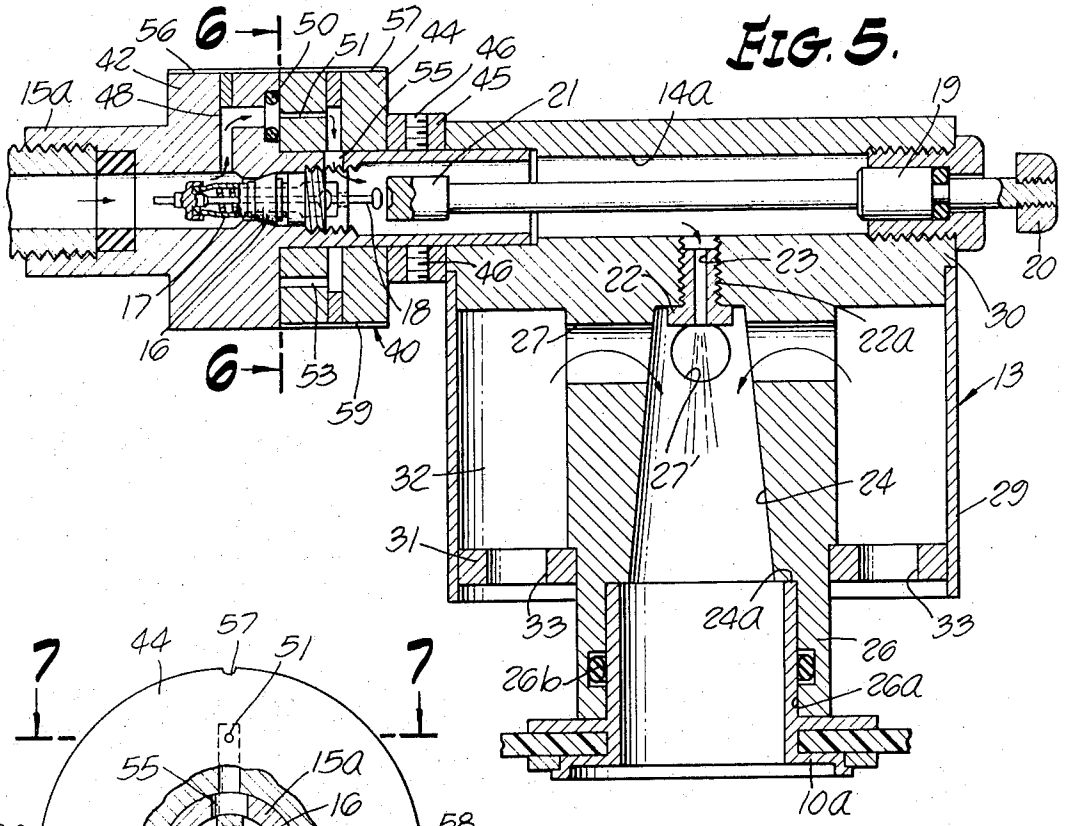



FIG. 5.

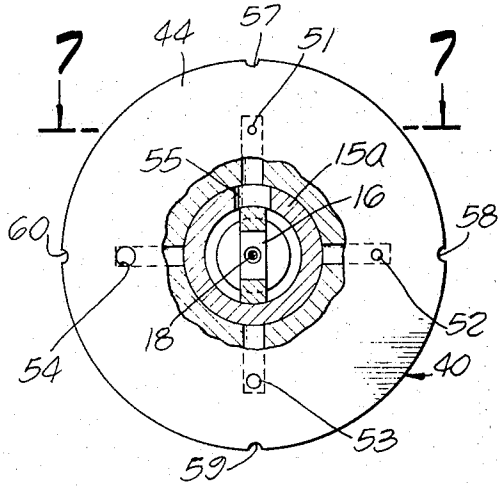



FIG. 6.

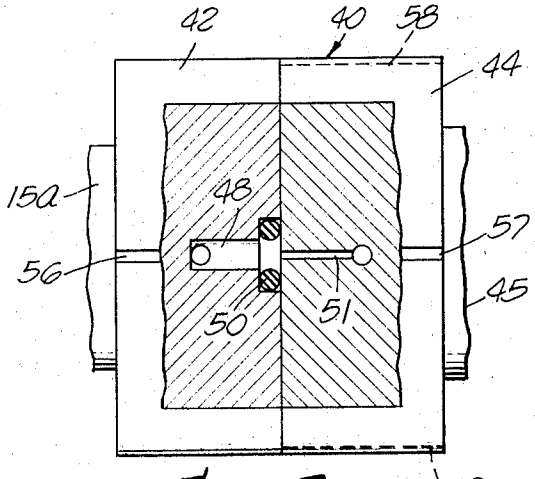



FIG. 7.

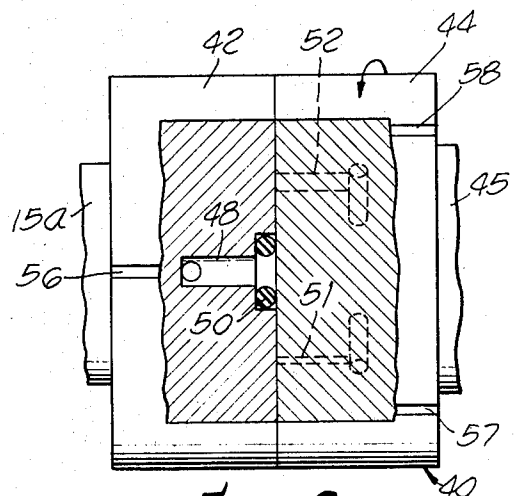



FIG. 8.

INVENTOR
PAUL E. KENAGY

BY
Paul A. Weilein
ATTORNEY

# INSUFFLATOR GAS FLOW DEVICE

## CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation of application Ser. No. 208,688, filed Dec. 16, 1971, and which is a continuation-in-part of application Ser. No. 60,524 entitled INSUFFLATOR GAS FLOW DEVICE invented by Paul E. Kenagy and filed Aug. 3, 1970 both now abandoned.

## BACKGROUND OF THE INVENTION

The invention relates generally to the field of artificial respiration, and is more particularly concerned with artificial respiration in those situations where external cardiac massage is administered in emergency cases involving asphyxia and heart failure. Resuscitation is normally required for patients who have been stricken by heart attack, electrical shock, carbon monoxide poisoning, and drowning. Various other causes contribute to asphyxia. In some patients and particularly in older patients, respiratory failure may often be accompanied by a complete lack of pulse, thus indicating a need for cardiac massage. External cardiac massage is a recommended practice and techniques for such massage have improved considerably in recent years.

Usual cardiac massage procedures consist in the application of rapid, firm manual compressions on the sternum at a rate of between 50 and 80 per minute. Normally, compression strokes are applied by the hands of a practitioner who presses one hand upon the other against the sternum. During massage, it is desirable to insufflate the patient's lungs with a large quantity of oxygen or air-oxygen mixture. The recommended technique is to insufflate between every fifth and sixth compression. Resuscitations with positive and negative pressure applications is not indicated in these cases so that a certain relationship can be maintained between the insufflation of the lungs and the imposed heart pulse resulting from the sternum compression.

There is preferably an upper limitation on the pressure of gas delivered to the lungs in order to protect the lungs and not overburden the heart by a too high lung pressure. A low mean lung pressure is desired in order to enhance cardiac output.

Practitioners in the art of cardiopulmonary resuscitation therefore are faced with a compound problem. A relatively large volume of air-oxygen must be introduced into the lungs in a short time interval, but overdistension of the lungs must also be avoided. The present invention overcomes this twofold problem as well as other problems inherent in the known prior art, by providing a unique combination of elements which are susceptible of relatively inexpensive fabrication and which can be manually operated in a simple and facile manner.

## SUMMARY OF THE INVENTION

The device has an inlet port to receive a pressurized therapeutic gaseous fluid, for example, compressed oxygen, and has a breathing port for use by the patient. A venturi nozzle is mounted in a venturi throat that leads to the breathing port and a normally closed valve is operable to release the pressurized oxygen periodically to the venturi nozzle.



The venturi throat has at least one lateral vent port to the atmosphere to serve three purposes when the device is used to treat an unconscious patient, namely: to induce atmospheric air into the venturi throat to mix with the oxygen when the valve is opened periodically to fill the lungs of the unconscious patient; to vent the oxygen from the venturi nozzle to the atmosphere when filling the patient's lungs creates a back pressure in the venturi throat while the valve is open; and then to permit the patient to exhale to the atmosphere through the venturi throat when the valve is closed.

In a second mode of operation to treat a conscious patient, the valve is kept closed and a metering bypass around the closed valve releases oxygen to the venturi nozzle at a constant rate that is sufficiently reduced to permit the patient to exhale periodically through the venturi throat to the one or more vent ports of the venturi throat.

The various objects and advantages of the invention will be apparent from the following detailed description and the drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an elevational view of the insufflator gas control device attached between a gas supply line and a conventional resuscitator mask;

FIG. **2** is an elevational sectional view of the device as viewed in FIG. **1**;

FIG. **3** is a fragmentary vertical sectional view, taken along the line **3—3** of FIG. **2**;

FIG. **4** is a transverse sectional view, taken along the line **4—4** of FIG. **2**;

FIG. **5** is a view similar to FIG. **2** showing how an adjustable bypass may be provided around the control valve to meter the oxygen at a reduced rate;

FIG. **6** is an enlarged transverse section taken as indicated by the line **6—6** of FIG. **5**;

FIG. **7** is a fragmentary section taken as indicated by the line **7—7** of FIG. **6** with a rotary component of the metering bypass in a position to release the pressurized oxygen at a given reduced rate; and

FIG. **8** is a section similar to FIG. **7** with the rotary component of the bypass turned to a position to cut off flow through the bypass.

## DESCRIPTION OF THE SELECTED EMBODIMENTS OF THE INVENTION

In FIG. **1** there is illustrated a conventional resuscitator mask **10** having a hollow resilient cushion perimeter **11** adapted to sealingly conform to the area around the patient's nose and mouth. The perimeter **11** is inflatable and deflatable through a valve connection **12** to achieve proper resilience.

The mask is connected to an insufflator device **13** for the intermittent introduction of oxygen to a patient's lungs during treatment. As best shown in FIG. **2**, the device **13** has a transversely extending passage **14**, one end of which has an inlet port connected through an appropriate connector **15** to a pressurized source (not shown) of a gas, such as oxygen.

In the presently preferred cardiopulmonary resuscitation technique, a sternum compression stroke rate of 50–80 compressions a minute is preferred. It is also desirable to introduce between 128–145 liters of an air-oxygen mixture per minute into the lungs of the patient during the sternum compression. It has been found best to introduce the oxygen-air mixture between the fifth

and sixth compressions. In order to achieve the average 135 liters per minute rate, more than one liter per second must be introduced into the lungs.

The connector **15**, has therefore a conventional type of quick-acting air valve **16** axially mounted at its inner end, A valve spring **17** is adapted to maintain the valve in a normally closed position. The valve has an actuating stem **18** which is operatively associated with a manually depressible plunger **19** having an exteriorly positioned push button **20** by means of which a head portion **21** of the plunger is movable into engagement with the stem **18** to open the control valve.

A venturi nozzle in the form of a bushing **22** is provided which is threadedly engaged in a threaded passage **22***a* which connects centrally of the passage **14.** Bushing **22** has a restricted flow passage **23** therethrough. The bushing may be easily replaced to meet changed conditions. The passage **23** discharges a jet stream into the inlet end of a venturi throat **24** that is formed by a wall **25** which terminates in a collar portion **26** which provides attachment means for connecting the insufflator device with the resuscitator mask. The venturi throat **24** is frusto-conical in configuration and tapers inwardly from a shoulder **24***a* formed by the intersection of the venturi throat **24** and a cylindrical throat **26***a* of larger diameter into which a mask connector **10** fits and is circumferentially sealed by an O-ring **26***b*. The mask connector **10** forms a breathing port for use by the patient.

The venturi throat is disclosed as conical. However, cylindrical and stepped venturi throats are not thereby excluded as workable configurations. The conical configuration is preferred because it lends itself to efficient mass production. As can be seen in FIG. **4**, radial fluid vent passages **27, 27′** are provided in the wall **25** of the venturi throat to permit an induced flow of ambient air into the venturi throat **24** as a result of the venturi action by the nozzle **22** when valve **16** is open, and the vent passages further provide for outflow therethrough when exhausting the lungs on exhalation. To prevent any clogging or other interference with the flow through the passages **27, 27′**, a surrounding sleeve **29** is connected at one end to a housing portion **30** and a ring **31** is added to define a protective annular cavity **32** about the wall **25.** The ring **31** is provided with a plurality of fluid flow ports **33** whose total flow area is preferably greater than the total flow area of the passages **27, 27′**.

It is desirable that the device be constructed for ease of manipulation and control. Therefore, the sleeve **29** is located and dimensioned so that it will afford a hand grip for the device **13** which places the manual button **20** in a convenient position for manipulation by the same hand that is used for holding the device.

The illustrated embodiment is capable of serving the functional demands of the resuscitation technique. In those situations wherein operating line pressure of the oxygen supply introduced through connector **15** is in the range of 45 psi to 55 psi, the passage **23** preferably has a diameter of substantially 0.055 inch and the jet stream emerges into a venturi throat which is about fifteen-sixteenths inch long and has a major diameter of approximately one-half inch.

The maximum desired mask pressure during insufflation is about 35 to 48 centimeters of water (35–48 cm $H_2O$) to guard against too high a lung pressure. This is equivalent to 0.50 to 0.70 psi. As noted before, a low mean lung pressure is also desirable to enhance cardiac output.

Where the supply gas is supplied at approximately 50 psi passages **27, 27′** each have a diameter of approximately seven-thirtyseconds inch when four passages are used. The ports **33** of collar **31** are of approximately the same diameter, but since there are eight such ports, their effective flow area is twice that of the passages **27, 27′**.

## OPERATION

The device **13** is coupled through connector **15** to a source of oxygen which is supplied at approximately 50 psi. Mask **10** is placed over the nose and mouth of a patient and held in position by one hand of a first operator. A second operator begins the sternum compression at the aforesaid rate of 50–80 compressions per minute. After each five compressions, the first operator manually opens valve **16** by momentarily depressing button **20,** to direct a jet stream of oxygen into the venturi throat **24.** The jet stream creates a venturi effect which creates a pressure differential across the passages **27, 27′** to induce a flow of ambient air through the passages **27, 27′** into the venturi throat where the air mixes with the oxygen and this mixture is forced through the mask into the patient's lungs. When the rapid insufflation of the oxygen-air mixture completely fills the patient's lungs, back pressure builds up in the mask and in the venturi throat.

The increased back pressure reduces the pressure differential across the jet nozzle **22** with consequent reduction in the velocity of the jet stream and consequent termination of the venturi effect. At the same time the increased back pressure in the venturi throat reverses the pressure differential across the radial vent passages **27, 27′** and as long as the valve **16** remains open after the patient's lungs are full, all of the oxygen supplied by the jet stream is released to the atmosphere through the vent passages **27, 27′**. It is apparent, therefore, that the duration of the open periods of the valve **16** is not at all critical and that the patient is automatically protected against overinflation of the lungs.

When the valve **16** is again closed after the patient's lungs are filled, the patient's lungs freely contract and exhaust into the venturi throat **24** and out into the atmosphere through the radial vent ports **27, 27′**.

Coordination between the first and second operators seeks to achieve normal heart and lung pace relationship. Once a pulse rate is established and breathing becomes partially voluntary, the insufflation stage may be terminated and resuscitation with other equipment instituted.

The illustrated embodiment comprises a device suited to operation under oxygen pressures of about 50 psi. With present conventional pressure regulators such a pressure is usually easily maintained. However, in those instances where such a pressure is not available or cannot be readily provided, the passages **27, 27′** and the venturi bore **24** may have different dimensions to achieve the same desired beneficial results.

It is to be noted that the described device does not have any relief valves or check valve or any type of rubber flap. In fact, the only moving part is the one valve mechanism and when the valve is either open or closed for a period of time the device functions without any moving parts whatsoever. The advantage, of course, is

that the device is capable of a long trouble-free service life.

The structure of the second embodiment of the invention shown in FIGS. **5–8** is largely similar to the construction of the first embodiment as indicated by the use of corresponding reference numerals to indicate corresponding parts. Actually the only difference is the addition of an adjustable metering device, generally designated **40,** which provides a bypass around the valve **16** which may be placed into service whenever desired. The metering device **40** includes a circular enlargement **42** of the connector **15***a* and an adjacent collar **44** which is rotatably mounted on the connector. The collar **44** backs against the enlargement **42** and is confined by a ring **45** which in turn is secured to the connector **15***a* by set screws **46.**

The enlargement **42** has a single fixed angular passage **48** which terminates at the adjacent face of the rotatable collar **44,** the angular passage being enlarged to accommodate a sealing ring **50.** The angular passage **48** is dimensioned for the maximum bypass flow that is desired and the rotatable collar **44** is provided with a plurality of ports in the form of angular passages of graduated sizes to register with the fixed angular passage **48** selectively to provide selected rates of bypass flow. For this purpose the rotatable collar **44** has four equally circumferentially spaced angular passages **51–54** respectively. When any one of the four angular passages **51–54** registers with the stationary angular passage **48,** it also registers with a radial bore **55** in the body of the connector **15***a*. Thus, rotary adjustment of the collar **44** affords a choice among four different rates of bypass flow around the valve **16.**

Any suitable index means may be provided for guidance in the rotary positioning of the collar **44.** In this particular embodiment of the invention the index means comprises a fixed longitudinal external groove **56** which serves as a reference on the enlargement **42** and four similar grooves **57–60** corresponding to the four angular passages **51–54** of the rotatable collar **44** which may be registered with the fixed groove selectively. Suitable indicia may be added to identify the four grooves **57–60** with respect to the four corresponding angular passages **51–54** respectively.

If the second embodiment of the invention is intended to function in the previously described manner of the first embodiment of the invention, the rotatable collar **44** is turned to a position where none of the grooves **57–60** registers with the fixed groove **56.** The collar is then at a position at which the sealing ring **50** is pressed against a blank portion of the adjacent face of the rotatable collar to prevent bypass flow. When the bypass is in service the valve **16** is kept closed.

The bypass is used for a patient that is capable of voluntary inhalation and in that event the mask may be omitted. The radial vent ports **27, 27′** provide additional needed air from the atmosphere or alternately exhausts the excess oxygen-air mixture to the atmosphere when it is supplied at a greater rate than required to match the rate of inhalation by the patient. On the other hand, when the patient exhales, the radial vent passages **27, 27′** accommodate the exhalation as well as the unneeded oxygen that flows into the venturi throat. The patient is permitted to relax and breathe in a normal manner and it is not necessary to maintain a seal between the mask and the patient's face.

It is apparent that other variations within the scope of the invention will occur to those skilled in the particular art. It is therefore desired that the invention be measured by the appended claims rather than by the illustrative embodiments disclosed herein.

I claim:

**1.** In a device to provide a therapeutic gaseous mixture for inhalation by a patient, wherein the device has an inlet port to receive a pressurized therapeutic gaseous fluid and has a breathing port for use by the patient, the combination of:

a venturi throat having its downstream end in communication with the breathing port;

a nozzle at the upstream end of the venturi throat to direct a jet stream of the pressurized therapeutic gaseous fluid into the venturi throat;

at least one vent port to the atmosphere in the wall of the venturi throat near the jet stream from the nozzle to serve three purposes, namely: to induce atmospheric air into the venturi throat to mix with the gaseous therapeutic fluid when the device functions to fill the lungs of the patient; to vent the therapeutic fluid from the venturi throat to the atmosphere when the filling of the patient's lungs creates a back pressure in the venturi; and to permit the patient to exhale into the atmosphere; and

metering means in direct communication with said nozzle to release the pressurized therapeutic fluid to the nozzle at a constant reduced rate.

**2.** A combination as set forth in claim **1** in which the metering means is adjustable for different rates of flow.

**3.** A combination as set forth in claim **2** in which said metering means includes a fixed passage and a valve member having a plurality of ports therethrough of different sizes,

said valve member being movable to place said ports selectively in register with the fixed passage to permit different rates of flow through the metering means.

**4.** A combination as set forth in claim **3** in which said valve member is a rotary member.

**5.** In a device to provide a therapeutic gaseous mixture for inhalation by a patient, wherein the device has an inlet port to receive a pressurized therapeutic gaseous fluid and has a breathing port for use by the patient, the combination of:

a venturi throat having its downstream end in communication with the breathing port;

a nozzle at the upstream end of the venturi throat to direct a jet stream of the pressurized therapeutic gaseous fluid into the venturi throat;

at least one vent port to the atmosphere in the wall of the venturi throat near the jet stream from the nozzle to serve three purposes, namely: to induce atmospheric air into the venturi throat to mix with gaseous therapeutic fluid when the device functions to fill the lungs of the patient; to vent the therapeutic fluid from the venturi throat to the atmosphere when the filling of the patient's lungs creates a back pressure in the venturi; and to permit the patient to exhale into the atmosphere;

a control valve between said inlet port and said nozzle operable to control flow of the therapeutic fluid to the nozzle; and

a metering means in direct communication with said nozzle providing a bypass around the control valve

to provide a flow of pressurized therapeutic fluid to said nozzle at a reduced rate when the control valve is closed.

**6.** A combination as set forth in claim **5** in which said control valve is a normally closed manually operable valve.

**7.** A combination as set forth in claim **6** in which said control valve is a push button valve.

**8.** A combination as set forth in claim **5** which includes means to cut off flow through the bypass.

**9.** A combination as set forth in claim **5** in which said bypass is adjustable for various rates of flow therethrough.

**10.** A combination as set forth in claim **5** in which said bypass has a fixed portion;

which includes a valve member having at least one port therethrough to serve as a portion of the bypass, said valve member being movable to a position to register said port with the fixed portion of the bypass,

said valve member being movable to position said port out of register with the fixed portion of the bypass to cut off flow through the bypass.

**11.** A combination as set forth in claim **10** in which said valve member has a plurality of passages therethrough of different flow capacities for registration selectively with said fixed portion of the bypass.

**12.** A combination as set forth in claim **11** which includes index means to indicate the various positions of the valve member at which the various ports therethrough register respectively with said fixed portion of the bypass.

**13.** In a device to provide a mixture of air and a therapeutic gas for inhalation by a patient, wherein the device has an inlet port to receive a pressurized therapeutic gas and has a breathing port for use by the patient, the combination of:

a venturi throat having its upstream end in communication with said inlet port, said venturi throat being near said breathing port and having its downstream end in communication with the breathing port;

a nozzle at the upstream end of the venturi throat to direct a jet stream of the pressurized therapeutic gas from said inlet port into the venturi throat;

at least one vent port to the atmosphere in the wall of the venturi throat near the jet stream from the nozzle to serve three purposes, namely: to induce atmospheric air into the venturi throat to mix with the therapeutic gas when the device functions to fill the lungs of the patient; to vent the therapeutic gas from the venturi throat to the atmosphere when the filling of the patient's lungs creates a back pressure in the venturi throat; and to permit the patient to exhale into the atmosphere through the venturi throat without entrapping in the device an excessive amount of exhalation that must be subsequently inhaled by the patient;

a first manually operable valve means between the inlet port and the nozzle;

a bypass from the inlet port around the first valve means to said nozzle; and

a second manually operable valve means controlling the bypass,

whereby with the second valve means closed, the first valve means may be opened intermittently for use of the device on an unconscious patient and with the first valve means closed the second valve means may be kept open for use of the device on a conscious patient.

* * * * *