

June 13, 1939.

W. BRANOWER

2,162,242

RESUSCITATION APPARATUS

Filed April 25, 1936

2 Sheets-Sheet 1

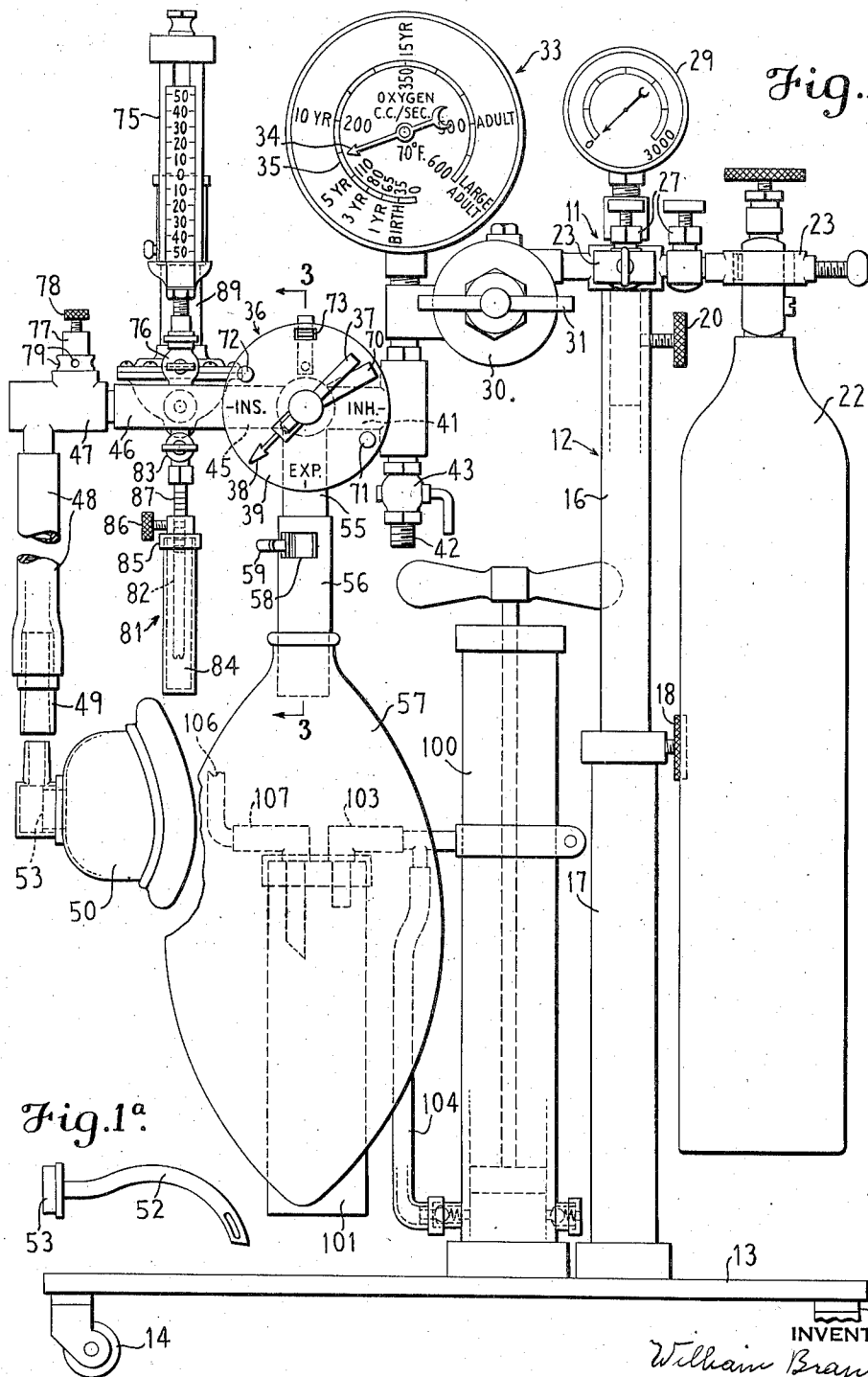


Fig. 1^a

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2 Sheets-Sheet 2.

Fig. 2.

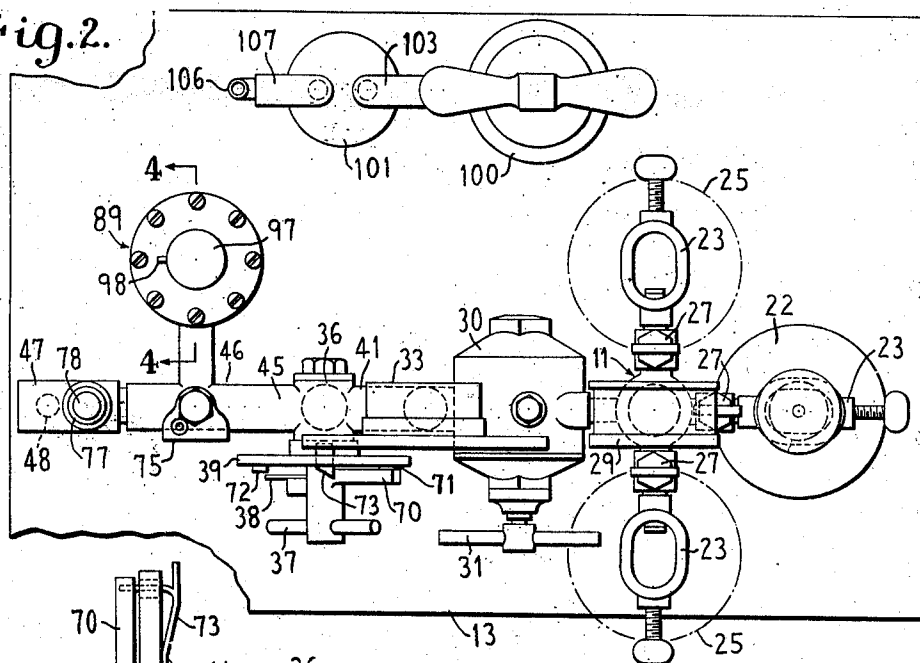


Fig. 3.

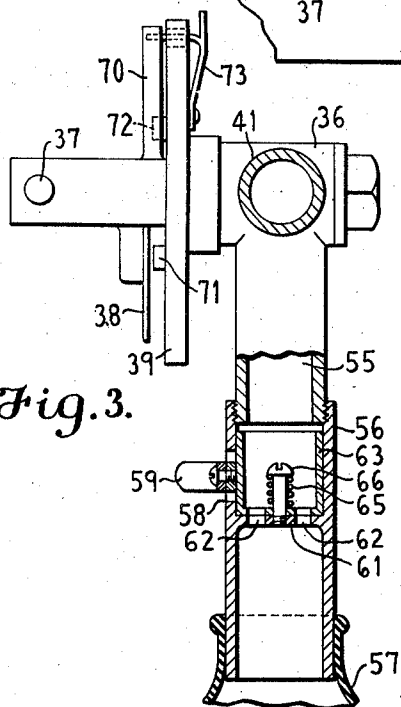


Fig. 4.

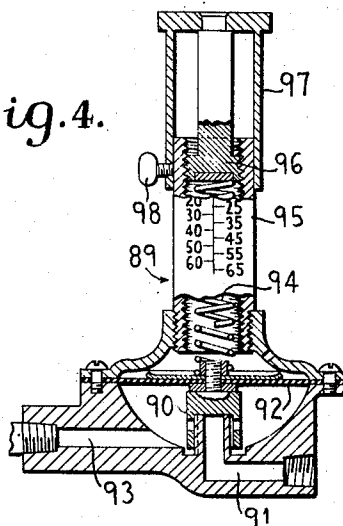


Fig. 5.

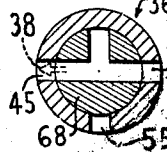


Fig. 6.

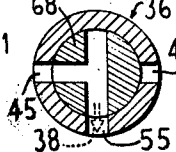


Fig. 7.

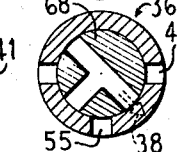
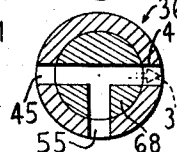


Fig. 8.



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2,162,242

RESUSCITATION APPARATUS

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Application April 25, 1936, Serial No. 76,369

5 Claims. (Cl. 128—29)

This invention relates to resuscitation apparatus.

The treatment required for resuscitation depends upon the degree of asphyxia of the patient, and the degree of asphyxia is proportionate to the extent of the trauma inflicted by the asphyxial agent upon the brain and the vital respiratory and cardiac centers.

In cases where the nervous system has been but slightly traumatized and reflex respirations have not been abolished, no artificial respiration is required, and the patients can usually be revived by the application of heat and stimulants, and the inhalation of oxygen or a low mixture of carbon-dioxide and oxygen.

In other cases where there is a temporary suspension of animation and more or less paralysis of the respiratory and cardiac centers, the vitality of the nervous system is not completely abolished and the patient can be revived with ordinary methods of artificial respiration or apparatus for that purpose.

In very severe cases of asphyxia it is often impossible to revive the patient by the ordinary methods and apparatus employed for artificial respiration. In these extreme cases of asphyxia, with respirations at a standstill and the vital centers of the medulla almost completely paralyzed, insufflation of small volumes of oxygen under low pressure does not suffice to inaugurate that chain of stimuli which motivates the respiratory mechanism.

Under normal conditions, there is a respiratory exchange in the average adult of approximately five hundred cubic centimeters of air during each quiet respiration. This volume is known as the tidal volume. For large adults the average tidal volume is six hundred cubic centimeters, and for children very much less, the amount depending upon the age of the child.

The postural methods of artificial respiration, of which the Schaefer prone pressure technique is the most popular, can not effect a respiratory exchange of much more than one-half the tidal volume of the average adult, and this may be ineffective to inaugurate the chain of stimuli necessary to revive the victim. Apparatus capable of supplying larger volumes has been devised, but as far as I am aware my invention is the first combination of apparatus with which the tidal volume, or definite, prescribed multiples of the tidal volume, can be administered with perfect control, by the operator, of the rhythm, volume and intrapulmonary pressure.

It may be said that one object of the inven-

tion is to provide improved apparatus for artificial respiration with measured and controlled volumes and lung pressures.

Another object is to provide a simple and convenient apparatus for revival by artificial respiration, or by inhalation of oxygen, or oxygen mixtures, or other therapeutic gases from a bag by natural respirations.

In accordance with one feature of the invention, gas from a storage cylinder or other high-pressure source is reduced in pressure by a flow control device which supplies a definite volume of gas per unit of time. The flow control device is adjustable to change the rate of delivery, and this rate is indicated on a gauge which has a scale with notations along its length designating the age or size of the patient for which various points on the scale represent the correct tidal volume per second. The flow control device can, therefore, be adjusted until the gauge indicator registers with the notation corresponding to the age or size of the patient to be treated, and the apparatus is then operated to administer the tidal volume or a prescribed multiple of the tidal volume for that patient by making the period of inspiration one, two or three seconds.

Another object of the invention is to provide an improved portable resuscitation apparatus, which is simple, compact, and convenient to use for giving various treatments which may be required by victims of asphyxia.

Other objects, features and advantages of the invention will appear or be pointed out as the specification proceeds.

In the accompanying drawings, forming part hereof:

Fig. 1 is a side elevation of the preferred embodiment of my improved apparatus for artificial respiration;

Fig. 1^a is a side elevation of a catheter, which may be attached to the apparatus of Fig. 1 in place of the face mask;

Fig. 2 is a top plan view of the apparatus of Fig. 1 with the bag, tube, and face mask removed;

Fig. 3 is an enlarged side elevation of the respiratory valve, and a sectional view of the valve at the bag entrance, the section being taken on the line 3—3 of Fig. 1 but with the valves in different positions;

Fig. 4 is an enlarged sectional view on the line 4—4 of Fig. 2; and

Figs. 5-8 are diagrammatic sectional views of the respiratory valve in different positions.

A manifold 11 is supported by a standard 12

connected to and extending upward from a base 13. Casters 14 on the base add to the portability of the apparatus. The standard 12 is adjustable in height and comprises a hollow column 16 which telescopes into a lower column 17 but can be held in any set position by a set-screw 18. The manifold 11 has a stem that fits into the upper end of the hollow column 16 and is secured in place by a set-screw 20.

The manifold 11 has three branches for connecting with gas storage cylinders. One cylinder 22 is shown connected to the manifold 11 by a supporting clamp 23 at the end of one branch of the manifold. Similar clamps at the ends of the other manifold branches are shown in Fig. 2 and the positions which the other cylinders would occupy are indicated by broken-line circles 25.

Of the three cylinders which can be connected to the manifold, one may contain oxygen, another a low-percentage mixture of carbon dioxide and oxygen, and the third a higher-percentage mixture of carbon dioxide and oxygen or other therapeutic gases. When necessary to connect the manifold with "commercial size" cylinders or other sizes which do not fit into the clamps 23, "pigtail" tubing is used and by such means the manifold can be connected with any size of cylinder.

Each branch of the manifold has a shut-off valve 27, which can be closed to permit the removal and replacement of a cylinder without stopping or otherwise interfering with the operation of the apparatus for resuscitation.

A pressure gauge 29 at the center of the manifold 11 indicates the gas pressure in the manifold. When one cylinder is in communication with the manifold, the gauge 29 shows the pressure and indicates the available supply of gas in that cylinder.

The manifold 11 supplies gas to a regulator and flow control device 30 which reduces the pressure and delivers definite volumes of gas per unit of time. The flow control device 30 preferably includes a two-stage regulator like that disclosed in the Deming Patent No. 1,948,027, dated February 20, 1934, and an orifice on the downstream side of the regulator. This orifice is of a restricted cross-section so that for the higher rates of flow that the control device 30 is intended to deliver, the intrapulmonary pressure is substantially lower than the "critical pressure" at which flow through the orifice would be affected by back pressure. In the description of this invention "volume of gas" means volume reduced to a standard of temperature and pressure. This standard is preferably 70° F. and normal atmospheric pressure. A flow control device using an orifice to supply a constant weight of gas will therefore supply a constant "volume". The flow control device has a handle 31 by which it can be adjusted to change the rate of delivery.

The volume of gas delivered per second by the flow control device 30 is indicated by a gauge 33. This gauge has an indicator 34 which travels around a scale 35. There are notations along the scale designating the tidal volume of gas for patients according to age or size. For example, the average tidal volume of a 5 year old child is 110 cubic centimeters, and the 110 cubic centimeter point on the scale 35 has the notation "5 yrs." so that when using the apparatus to resuscitate a child of that age the operator can turn the handle 31 until the indicator 34 rises to the "5 yrs." notation. The apparatus will then deliver the tidal volume for the child in one second.

The length of time that gas flows from the flow control device 30 to the patient is regulated by a respiratory valve 36 having a handle 37 with a pointer 38 which travels over a dial 39 on the front of the valve. Markings on the dial show the positions of the respiratory valve for inspiration, expiration, and inhalation, the markings for these valve positions being designated by the abbreviations "Ins.", "Exp.", and "Inh.", respectively.

The respiratory valve 36 has a port and conduit 41, through which it receives gas from the flow control device 30. In case of failure of the compressed gas supply, air can be fed into the conduit 41 from a bellows, air compressor, or other source connected with an air inlet 42. This inlet is closed by a stopcock 43 during the ordinary operation of the apparatus.

The respiratory valve 36 has a port and conduit 45, from which gas is supplied to the patient through a T fitting 46, elbow 47, conduit or delivery tube 48, adapter 49, and face mask 50.

Instead of the face mask 50, an intratracheal tube or a pharyngeal airway 52, shown in Fig. 1a, can be connected to the adapter 49 by means of an end coupling 53. The tube 48 is preferably short, to eliminate dead space, and is flexible, non-collapsible and of large lumen, to permit to and fro breathing without resistance.

Through a port and conduit 55 the respiratory valve 36 communicates with the upper end of a valve casing 56, the lower end of which opens into a bag 57. There is a port 58 in the side of this valve casing 56, and a valve element operated by a handle 59 opens and closes this port and at the same time closes and opens passages leading to the bag 57.

Fig. 3 shows the construction inside of the valve casing 56. A partition 61 extends across the inside of the valve casing 56. There are openings 62 in this partition for the passage of gas. A valve element 63 having the form of a cylindrical cup has openings through its bottom wall adapted to register with the openings 62 when the valve element is in one position. The angular spacing of the openings in the bottom of valve element 63 and in the partition 61 is so related to the size of the openings that rotation of the valve element causes all of the openings to be blocked, as when the shaker top of an ordinary powder can is closed.

There is a port in the side of the valve element 63 which registers with the port 58 when the valve element is in one position. The side port in the valve element 63 is in such relation with the bottom openings, however, that the valve element closes the port 58 when the openings in the bottom of the valve element are in register with the openings 63 through the partition. Movement of the handle 59 far enough to completely open the port 58 shifts the valve element 63 into position to fully close the openings 62.

The handle 59 can be moved, therefore, into one position to put the conduit 55 into communication with the open air through the port 58 while the passages to the bag 57 are completely closed, or the handle 59 can be moved into another position in which the conduit 55 is in communication with the bag 57 and the port 58 fully closed. Intermediate positions of the handle 59 leave the port 58 and openings 62 both open in varying degrees.

The valve element 63 is held in light frictional contact with the partition 61 by a spring 65 which

is compressed against the valve element 63 by a screw 66.

The respiratory valve 36 contains a valve element 68 having right-angle passages which can be moved into register with the valve ports to connect any combination of the conduits 41, 45 and 55. Fig. 5 shows the valve element 68 in the "Inspiration" position. Gas from the flow control device, or other source, flows to the conduit 41 and straight through the valve 36 to the conduit 45. With the valve element 68 in this position gas is supplied from the storage cylinder to the patient at a rate determined by the adjustment of the flow control device 30. The rate of flow is indicated by the gauge 33. If this gauge shows the flow control device adjustment to be for 110 cubic centimeters per second, and the operator wants to deliver the tidal volume to a 5 year old child, he will keep the valve element 68 in the position shown in Fig. 5 for one second. If the child is to be given twice or three times his tidal volume, the operator leaves the valve element 68 in the inspiration position for two or three seconds, respectively.

At the end of one, two or three seconds, the valve element 68 is turned to the "expiration" position shown in Fig. 6. With the valve element in this position the conduit 41 is closed and the conduits 45 and 55 are in communication. The patient exhales through the valve 36 and into the valve casing 56, from which the expired gas escapes into the open air through the port 58. This port is kept open when the apparatus is being used for artificial respiration. The bag 57 is used only when the patient is breathing naturally but it is desirable to administer some therapeutic gas from the bag.

It should be noted that the apparatus employs no suction to deflate the lungs. Any suction to facilitate expiration is unnecessary, even dangerous, and is intentionally dispensed with. The natural high elasticity and resiliency of the lungs effect an immediate recoil to the collapsed state when the pressure or inflating force is removed at the end of the inspiratory phase. Suction closes and obliterates the thin-walled bronchioles before it succeeds in emptying the alveoli of their noxious or poisonous gases, and thereby defeats the very purpose for which artificial respiration is intended.

If the valve element 68 is stopped in a "Neutral" position, in which its passages do not register with any of the valve ports, as is the case in Fig. 7, then the respiratory valve cuts off the supply of gas to the patient and at the same time prevents escape of the insufflated gases from the lungs. The valve element 68 is ordinarily moved back and forth between the inspiration and expiration positions of Figs. 5 and 6 without stopping in the neutral position shown in Fig. 7. The special circumstances in which the neutral position of the valve element is used will be explained in connection with the description of the determination of intrapulmonary pressure.

Fig. 8 shows the valve element 68 in its "Inhalation" position. This position is used only when the patient is breathing naturally but it is desirable to administer some therapeutic gas. The handle 59 can be shifted to various positions to cause the patient to breathe into and out of the bag, or only partly from the bag if the port 58 is partially open.

An arm 70 (Fig. 1) extending from the stem of the handle 37 strikes against limit abutments 71 and 72 when the pointer 38 reaches the in-

spiration and inhalation notations. A leaf spring 73 is fastened to the back of the dial 39 and has a portion extending through an opening in the dial in position to stop the arm 70 when the valve 36 reaches its expiration position. When the apparatus is being used for artificial respiration, the handle 37 is turned back and forth between the limits imposed by the abutment 71 and the limit stop provided by the forwardly extending portion of the leaf spring 73.

The spring 73 has an end portion extending beyond the edge of the dial 39 so that the spring can be pushed back out of the way of the arm 70 when the valve 36 is to be moved into its inhalation position. The arm 70 strikes the abutment 72 when the pointer 38 reaches the inhalation notation on the dial.

A manometer 75 communicates with the interior of the fitting 46 through a stopcock 76, which is always open when the apparatus is in use. This manometer indicates the intrapulmonary pressure at all times, and the column of the manometer moves up and down with the inspirations and expirations of the patient. If the exact pressure at some particular time in the cycle is desired, the respiratory valve 36 can be turned into its neutral position to stop the oscillating movement of the manometer column.

An expiratory valve 77 in the elbow 47 is a spring-loaded relief valve, and the tension on the spring can be relaxed by means of an adjusting screw 78 to permit the escape, through ports 79, of some of the air exhaled by the patient. This valve 77 is heavily loaded and does not function when the apparatus is used for artificial respiration, but with the patient breathing naturally, and the valve 36 in inhalation position, the expiratory valve 77 is adjusted to determine the extent of "rebreathing" by permitting various amounts of exhaled air to escape into the atmosphere.

When the apparatus is employed for artificial respiration it is essential that precaution be taken against excessive intrapulmonary pressure. A safety valve 81 comprises a tube 82 which communicates with the interior of the fitting 46 through a stopcock 83. The stopcock 83 is intended to be open at all times and its only purpose is to prevent a leak in the apparatus in case the safety valve 81 becomes broken. The stopcock 83 is tight so that it is difficult to turn. This prevents accidental closing, which would make the safety valve 81 ineffective.

The tube 82 extends into a vessel 84 which is partially filled with liquid, preferably mercury. The vessel 84 is connected to a cover 85, which is perforated to permit gas to escape from the vessel. The tube 82 extends through an opening in the cover 85, and the cover can be moved up and down along the tube to determine the depth of immersion of the tube 82 in the mercury. A set-screw 86 threads through the hub of the cover 85 and clamps against the tube 82. There is a scale 87 on the upper portion of the tube 82, and this scale has notations which indicate the pressure at which gas will escape from the tube 82 and through the mercury in the vessel 84 when the top surface of the hub of the cover 85 is even with the various markings on the scale 87.

A second safety valve 89 is connected with the branch of the T fitting 46. The internal construction of the safety valve 89 is shown in Fig. 4. A valve element 90 closes the end of an inlet conduit 91. The valve element 90 is in a chamber which is closed at the top by a diaphragm 75

92, and this chamber has an exhaust conduit 93 communicating with the open air. The diaphragm 92 and valve element 90 are urged downward by a spring 94 enclosed in a cylindrical housing 95. A plug 96 fits threads on the inside wall of the housing 95, and can be screwed up or down in the housing to change the tension of the spring 94 which determines the pressure at which the safety valve operates.

The plug 96 is connected to a sleeve 97 which fits over the outside of the housing 95. As the sleeve 97 is rotated to screw the plug 96 further down in the housing 95, the sleeve moves downward with the plug and the bottom edge of the sleeve moves over a scale on the outside of the housing 95. Notations on the scale indicate the pressure at which the safety valve 89 will open when the bottom edge of the sleeve is even with the respective markings of the scale. The safety valve can be held in any set position by a set-screw 98, which threads through the sleeve 97 and clamps against the housing 95.

Referring again to Fig. 1, a vacuum pump 100 attached to the base 13 is operated to withdraw air from a receptacle 101 which communicates with the suction side of the pump through a fitting 103 and hose 104. The fitting 103 clamps on the pump cylinder and serves as the support for the receptacle. A tube 106 communicates with the interior of the receptacle through a fitting 107.

When the pump 100 is operated to produce a partial vacuum in the receptacle 101, the tube 106 can be inserted into the oral and respiratory passages of the patient to clear these passages by sucking blood or other obstructing fluid or semi-fluid material into the receptacle. Such a clearing of the patient's air passages may be necessary before artificial respiration is begun and may be required at intervals during the resuscitation process if the passages tend to fill up.

The preferred embodiment of the invention has been described, but changes and modifications can be made and some features may be used without others without departing from the invention as defined in the claims.

I claim:

1. Resuscitation apparatus for delivering measured and controlled volumes of therapeutic gases to a patient, including in combination a device for connection with a gas storage cylinder or other source of gas under pressure, a gas flow control device which receives the gas at high pressure and delivers it at a reduced pressure and at a rate of flow limited to a given volume of gas per unit of time, said control device including means for changing its rate of delivery, a gauge having notations of the tidal volume for the lungs of patients according to age or size, said gauge including means for indicating the delivery rate of the control device with reference to the notations on the dial, a conduit through which gas from the control device is delivered to a patient, and a valve between the control device and said conduit, said valve being effective in one position to establish communication between the control device and conduit so that gas flows to the patient, and effective in another position to shut off the gas supply to the patient and open the conduit to the atmosphere to permit the patient to exhale.

2. Apparatus for artificial respiration including in combination means for connection with a source of gas under pressure, a gas flow control

device for receiving the gas under pressure and delivering it at a reduced pressure and predetermined uniform rate, means for supplying the gas to a patient including a conduit, a respiratory valve between the conduit and the delivery side of the flow control device and effective in one position to put the conduit in communication with the delivery side of the flow control device and effective in another position to open the conduit to an exhaust port, a gauge on said conduit for indicating the intrapulmonary pressure at all times, and another gauge between the flow control device and respiratory valve for indicating the volume of gas supplied to the patient in a unit of time.

3. Resuscitation apparatus comprising a gas flow control device which limits to a predetermined value the rate of flow and pressure of gas supplied from a high-pressure source, means for administering gas to a patient including a conduit, an inflatable bag, a respiratory valve having three ports through which the valve communicates with the flow control device, conduit, and bag, respectively, said respiratory valve including a valve element which can be moved into four positions including an inspiration position in which it connects the flow control device with said conduit and closes the port communicating with the bag, a neutral position in which it closes all ports, an expiration position in which it connects the conduit and the port leading to the bag and closes the flow control device port, and an inhalation position in which it connects all ports, and another valve between the respiratory valve and the bag operative to put the bag communicating port of the respiratory valve in communication with either the bag or the outside air.

4. Resuscitation apparatus comprising a gas flow control device which limits to a predetermined value the rate of flow and pressure of gas supplied from a high-pressure source, means for administering gas to a patient including a conduit, an inflatable bag, a respiratory valve operative to establish communication between the flow control device, conduit, and bag in any combination or to shut off all communication between the flow control device, conduit, and bag, another valve between the respiratory valve and the bag operative to connect the respiratory valve with either the bag or the outside air, an expiratory valve on the conduit adjustable to permit the escape of some gas from the conduit and thereby regulate the extent of rebreathing when the respiratory valve is in position to cause the patient to breathe into the bag, a gauge for indicating the rate of flow of gas from the flow control device, and another gauge, communicating directly with said conduit, for indicating the intrapulmonary pressure regardless of the position of the respiratory valve.

5. Resuscitation apparatus including in combination a manifold for connection with a plurality of gas storage cylinders, a pressure gauge on the manifold, a flow control device connected with the manifold, and constructed and arranged to limit the rate of flow of gas to a definite volume per unit of time, a gauge associated with the flow control device and adapted to indicate the rate of flow from said control device, means for administering gas to a patient including a conduit, an inflatable bag, a respiratory valve operative to establish communication between the flow control device, conduit, and bag in any combination or to shut off all communication between the flow control device, conduit, and bag,

5 another valve between the respiratory valve and the bag operative to connect the respiratory valve with either the bag or the outside air, an air-inlet valve through which air can be supplied to the respiratory valve through its connection to the flow control device in the event of exhaustion of the gas in the storage cylinders on the manifold, a gauge communicating directly

with the conduit and indicating the intrapulmonary pressure regardless of the position of the respiratory valve, and relief valve means connected with the conduit for limiting the intrapulmonary pressure to a predetermined maximum. 5

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