Jan. 13, 1959 B. BROOKE 2,868,198

UNIDIRECTIONAL VALVE FOR ANESTHESIA EQUIPMENT

Filed March 9, 1956

2 Sheets-Sheet 1

Fig. 1

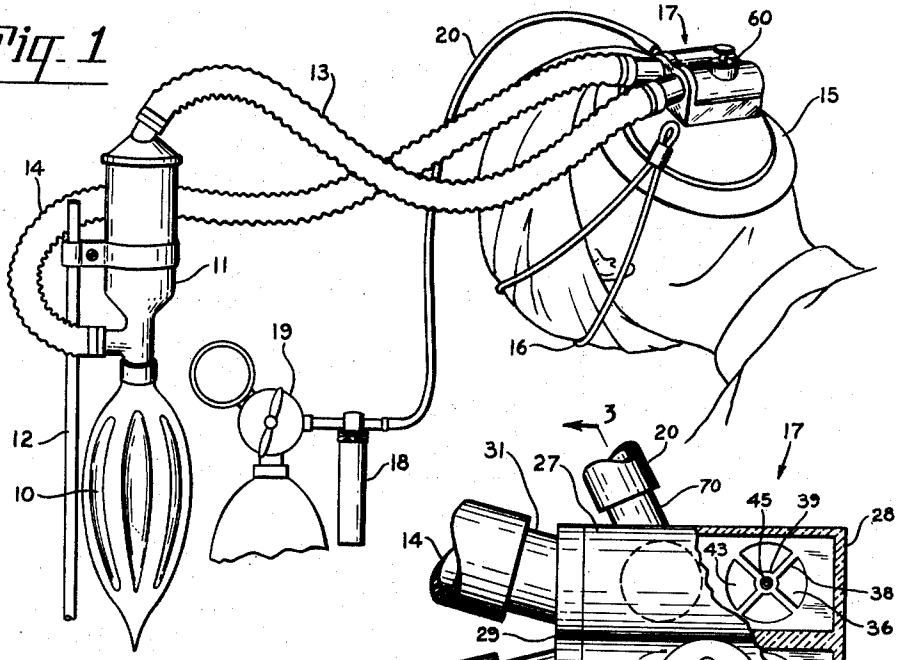


Fig. 2

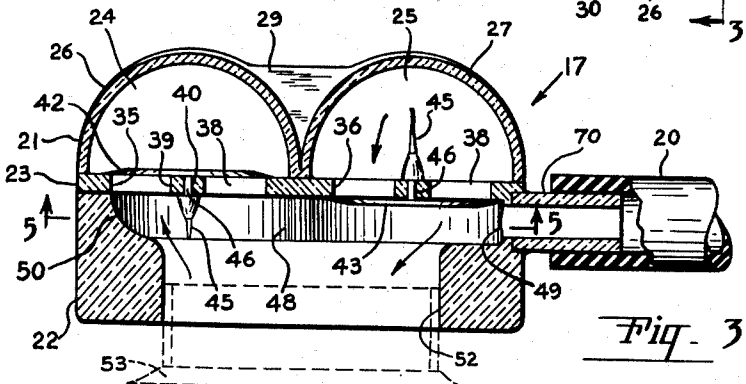


Fig. 3

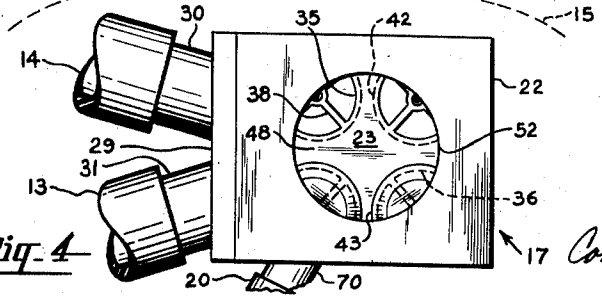


Fig. 4

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2 Sheets-Sheet 2

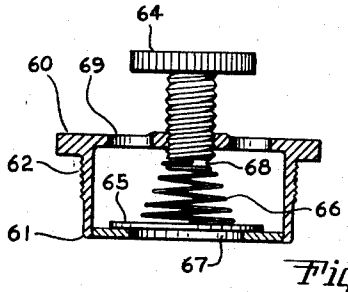


Fig. 7

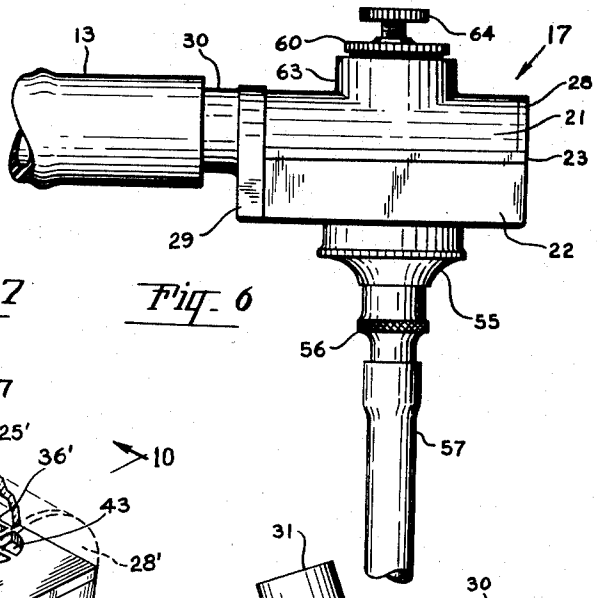


Fig. 6

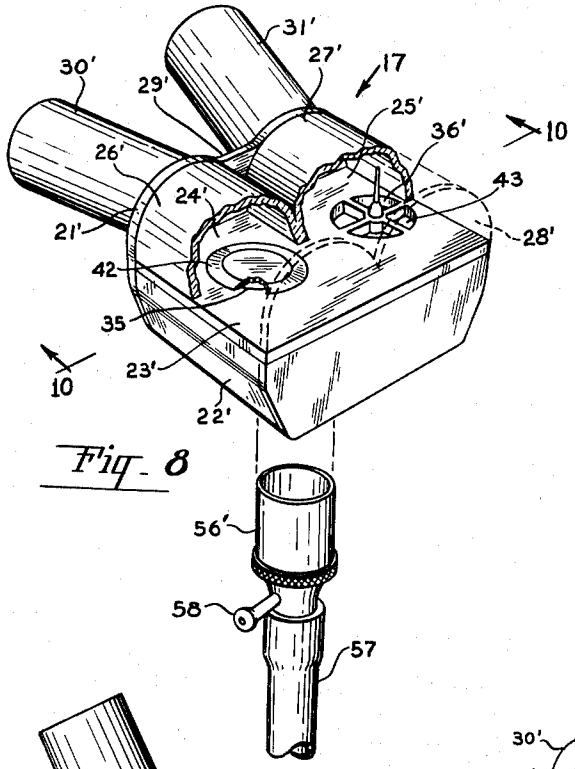


Fig. 8

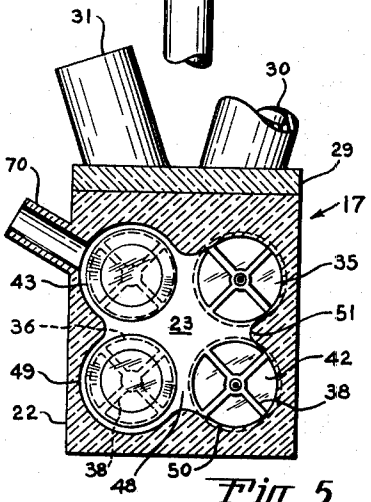


Fig. 5

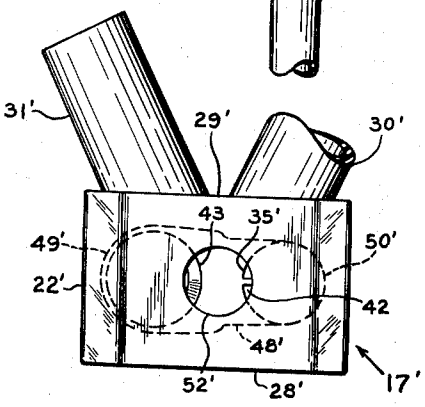


Fig. 9

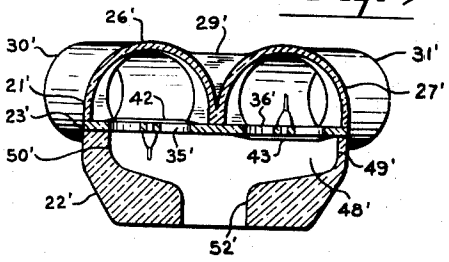


Fig. 10

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UNIDIRECTIONAL VALVE FOR ANESTHESIA EQUIPMENT

Burnham Brooke, Portland, Oreg.

Application March 9, 1956, Serial No. 570,576

9 Claims. (Cl. 128—188)

This invention relates to a unidirectional anesthesia valve for use with a conventional face mask or endotracheal tube.

Although the present invention may be used with various apparatus, it is illustrated herein as equipment more efficiently to administer an inhalation anesthetic to a patient. Equipment for administering inhalation anesthetics by the commonly known method of circle breathing comprises principally a face mask, a canister to remove exhaled carbon dioxide, a breathing bag, anesthetic containing means, and suitable tubing and valve structure, and the desired function is to supply said anesthetics to patients in suitable amount and in a manner to produce smooth breathing with a minimum of resistance to the breathing efforts of the patient. In any given respiratory effort a certain portion of air lodges in the dead space of the respiratory tract and is consequently ineffective as a means of modifying the gas content of alveolar air. In patients who have relatively large tidal volumes, such as strong, grown persons, the administration of anesthetics does not raise critical problems because the tidal volume exceeds the combined volume of the mechanical and physiologic dead spaces, whereby even though there is re-breathing of a certain volume of exhaled gases, sufficient fresh gases, including the anesthetic, will be inhaled.

The mechanical dead space is the dead space in the apparatus, such as in the mask, and the "physiologic dead space" is the dead space in the human comprising the combined volume of the nasobucco pharynx, trachea and bronchi. In patients having a small tidal volume, such as children or aged and weak persons, or in patients where the tidal volume is reduced by drugs, major problems arise in administering an anesthetic because the tidal volumes in these types of patients frequently do not exceed the mechanical and physiologic dead spaces. In such case there is an oscillation of excess exhaled gases in the mechanical and physiologic dead spaces whereby untreated exhaled gases are re-breathed to produce the undesirable physiological disturbances caused by excess carbon-dioxide retention. Heretofore, circle breathing has been impractical in children below seven years of age because the volume of dead space in the apparatus has been excessive.

The physiologic dead space, or dead space of the respiratory tract in an adult man, is approximately 150 cc., and is correspondingly smaller in children and infants. The tidal volume of a man at rest is approximately 500 cc., and correspondingly smaller as the chest size decreases. There is a wide variation in tidal volume not only from subject to subject but also from moment to moment in the same subject. Under such variable conditions, minimizing the re-breathing of exhaled gases also involves conflicting problems in minimizing the backlash of gases and resistance to flow, particularly through the valves.

The principal object of the present invention is to provide an improved valve unit to minimize as much as possible the re-breathing of untreated exhaled gases in anesthesia equipment to and reduce resistance to respiratory effort.

Another object is to provide an improved valve unit which makes the circle breathing method of administering anesthetics practical for use on children.

More specific objects of the invention are to provide a valve unit having a compact arrangement of passageways and chambers for reducing to a minimum the mechanical dead space therein; to provide a valve unit for use with a face mask or endotracheal tube, which employs valves located closely adjacent the face mask or endotracheal tube to reduce to a minimum the dead space between the valves and the patient; and to provide a novel valve unit and arrangement which is quickly responsive to gas flow for efficiently controlling the flow of anesthetic and exhaled gases.

Another object is to provide an improved valve unit which may be embodied in equipment for children and infants, as well as for adults.

Another object is to provide a valve unit of the type described which is adapted for a quick exchange from a face mask to endotracheal tube during the procedure of intubation.

Another object is to provide a valve unit of the type described which is transparent to permit observation of the functioning of the valves, which is readily washable, and which is relatively simple and inexpensive to manufacture.

The objects stated above are carried out by a one-way valve unit adapted to be used in conjunction with the necessary anesthesia equipment comprising a face mask, inhalation and exhalation tubes, a canister, a breathing bag, anesthetic containing means, and oxygen supply means. The inhalation and exhalation tubes communicate with separate valve passageways which communicate with a common breathing chamber through inlet and outlet mushroom valves mounted in a wall between the separate valve passageways and the breathing chamber. One of the walls defining the breathing chamber has an opening leading into said chamber which frictionally receives either a fitting on the face mask or a fitting on an endotracheal tube. As will be pointed out in greater detail hereinafter, the valve unit assumes a structure which minimizes as much as possible the re-breathing of untreated exhaled gases, whereby a small volume inhalation will bring the anesthetic into the patient's lungs.

The invention will be better understood and additional objects and advantages will become apparent from the following description taken in connection with the accompanying drawings which illustrate a preferred form of the invention. It is to be understood, however, that the invention may take other forms, and that all such modifications and variations within the scope of the appended claims, which will occur to persons skilled in the art, are included in the invention.

In the drawings:

Figure 1 is a perspective view of the present invention and other equipment for administering an anesthetic;

Figure 2 is a top plan view of the present valve unit with a portion of the valve housing broken away;

Figure 3 is an enlarged cross sectional view taken approximately on the line 3—3 of Figure 2;

Figure 4 is a bottom plan view of the valve unit;

Figure 5 is a cross sectional view taken on the line 5—5 of Figure 3;

Figure 6 is a side elevational view of the valve unit, and showing bottom connections for an endotracheal tube;

Figure 7 is a sectional view of an outlet valve used in conjunction with the present valve unit;

Figure 8 is a perspective view of a slightly modified form of the present valve unit for small children;

Figure 9 is a bottom plan view of the embodiment of Figure 8; and

Figure 10 is a cross sectional view taken on the line 10—10 of Figure 8.

Referring to the drawings, Figure 1 shows equipment for administering anesthetic to a patient. The equipment shown comprises a breathing circuit composed of a breathing bag **10**, a soda-lime canister **11** supported on a standard **12** for absorbing carbon dioxide, an exhalation tube **13**, an inhalation tube **14**, a face mask **15** having suitable strap means **16** for securing it on the patient's head, and a valve unit **17** which forms the present invention. This equipment also has ether-oxygen apparatus comprising principally an ether bottle **18** and an oxygen tank **19** connected to the valve unit **17** by a tube **20**. The exhalation tube **13** is connected between the valve unit **17** and one end of the canister **11**, and the other tube **14** is connected between the valve unit and the breathing bag **10**, the discharge end of the canister being connected in circuit with the tube **14** so that treated exhaled gases being discharged from the canister **11** are rebreathed by the patient. The purpose of the valve unit **17** is to produce circulatory flow in the direction of the arrows and to minimize the rebreathing of untreated exhaled gases.

The valve unit **17** comprises a composite housing having an upper housing portion **21**, a lower housing portion **22**, and in intermediate wall or port plate **23**. The upper portion **21** of the housing comprises a pair of parallel longitudinal passageways **24** and **25** defined at the upper portion thereof by semi-cylindrical wall portions **26** and **27**, respectively, closed at one end by a wall **28**. At the opposite end of the valve unit is a wall **29**, and integrally mounted in this wall are connecting tube portions **30** and **31** which communicate with the passageways **24** and **25**, respectively, and which are adapted to receive by a frictional fit the exhalation tube **13** and the inhalation tube **14**.

The port plate **23** forms the bottom wall of passageways **24** and **25** and has a pair of outlet ports **35** disposed in communication with the passageway **24** and a pair of inlet ports **36** disposed in communication with the passageway **25**. Each of the ports **35** and **36** is bridged by a spider portion **38** forming a portion of the wall **23**. Each spider **38** has a central hub portion **39** provided with an aperture **40**.

Associated with the outlet ports **35** are valves **42**, and associated with the inlet ports **36** are valves **43**. Each valve comprises a thin, flat disc of flexible rubber having an integral stem **45** and a reduced neck portion **46**. Neck portion **46** is locked in the aperture **40** whereby the central portion of the valve is anchored, but, due to the flexibility of the valve, portions thereof spaced from the center are readily flexed away from its seat by a relatively slight pressure differential on opposite sides of the mushroom disc.

Disposed below the wall **23** in the lower portion **22** of the valve housing is a chamber **48** which communicates with all the ports **35** and **36**. Referring to Figure 5, the shape of the chamber **48** is shown in plan and comprises a pair of semi-circular wall portions **49** on the inlet port side and a pair of semi-circular wall portions **50** on the outlet port side. Wall portions **49** assume a shape slightly larger than the valves **43** to permit free operation thereof, and wall portions **50** assume a shape which follows substantially the contour of a portion of outlet ports **35**. The chamber **48** has projecting portions **51** which fill in portions of the spaces between adjacent valves.

Referring to Figure 3, which shows the chamber **48** in cross section, defining wall **49** is substantially straight and vertical and the wall **50** is curved. The shape of the chamber **48**, as described, is such as to assume as small a volume as possible to minimize dead space in which untreated exhaled gases may oscillate and yet is large enough to permit the free operation of the valves and to permit

sufficient flow of gases therethrough without appreciable impedance. Chamber **48** constitutes the mechanical dead space in the valve unit which must be added to the mechanical dead space in the face mask or endotracheal tube. In the valve unit shown in Figures 2 and 3 the dead air space has been reduced to 10 cc. In conventional practice a Y-chimney piece or other fitting having considerable volume is added to the dead space of the mask.

Communicating with the chamber **48** is a bottom opening **52** adapted to receive, by a frictional fit, a connector **53** on the face mask **15**, the upper portion of the wall defining the opening **52** being rounded to provide in conjunction with chamber **48** a streamlined flow of gases. As an alternative, and as seen in Figure 6, the opening **52** may frictionally receive an adaptor connector **55** which in turn frictionally receives a connector **56** on an endotracheal tube **57**, whereby, as is the usual custom in certain cases the patient is first put to sleep by use of the mask and then subsequently, the tube **57** is substituted for the mask. Such interchangeability of the patient-engaging piece is thus readily and conveniently accomplished by disengagement of the valve **17** with the connector for the desired piece without disconnecting any of the tubes **13**, **14** or **20**. Although not shown on the drawings, the standard endotracheal tube **57** may be equipped with an inflatable cuff adjacent its bottom end for sealing off the subject's trachea when the tube **57** is inserted.

An outlet valve **60** is provided in the wall **26** of passageway **24**, and this valve comprises a housing **61** having external threads **62** engageable in a threaded boss **63** which forms an integral part of the wall **26**. A turning stem **64** is threadedly mounted in the housing **61** and urges a valve **65** by means of a spring **66** into sealing engagement with a port **67** on the bottom of the housing. The turning stem **64**, valve **65** and spring **66** are preferably connected together so that, by unscrewing the stem **64**, sufficient tension is taken off the valve so that it will be disengaged from its seat by exhaled gases, the stem **64** having a groove **68** adjacent its bottom end which is engageable by the top coil of the spring **66** for connecting the stem and spring together. The top wall of the housing **61** has a plurality of openings **69** for discharging exhaled gases from the housing.

The purpose of the valve **60** is to discharge exhaled gases to atmosphere when desired, in which case the stem **64** is unscrewed so that the valve **65** will be unseated by the flow of exhaled gases and permit the exhaled gases to flow through the openings **67** and **69** to atmosphere. During inhalation, the valve is pulled firmly into engagement on its seat. When the closed system is used, the valve **60** is closed by tightening stem **64** so that exhaled gases will pass through the canister.

The valve unit **17** has an oxygen connection **70** mounted in a side wall thereof. The connection **70** establishes communication between the chamber **48** and the oxygen tube **20**, the connection **70** being disposed closely adjacent the inlet valves **43** so that when oxygen is used it will be introduced directly into the flow of gases from valves **43** at a point remote from outlet valves **42**. Oxygen entering while inlet valves **43** are closed, during exhalation, crowds the exhaled gases to the left side of chamber **48** in Figure 3, adjacent outlet valves **42**, to effect a scavenging operation in each breathing cycle.

Figures 8, 9 and 10 illustrate a valve unit **17'** having a slightly modified structure from that shown in the other views. This valve is of smaller size and is intended primarily for small children. Similar to the main embodiment, the valve unit **17'** comprises a composite housing having an upper portion **21'**, a lower portion **22'**, and an intermediate wall or port plate **23'**. The upper portion **21'** of the housing has a pair of parallel, longitudinal passageways **24'** and **25'** defined at the upper portion thereof by semi-cylindrical wall portions **26'** and **27'**, respectively, closed at one end by a wall **28'**. The other end of the unit has a wall **29'** in which is mounted a

pair of tube connections 30' and 31' communicating, respectively, with the passageways 24' and 25'.

This structure differs from the main embodiment in that only a single port 35' and 36' is provided in port plate 23', the flow of gases through these ports being controlled by valves 42 and 43, respectively. Lower portion 22' has a chamber 48' which, as seen in dotted lines in Figure 9, has a semi-circular portion 49' slightly larger than valve 43 and a semi-circular portion 50' which follows substantially the periphery of a portion of the port 35'. Wall 49' is substantially straight and vertical and the wall 50' is curved. This embodiment of the invention has a small bottom opening 52' arranged like the opening 52 in Figure 3 to overlap portions of the ports 35' and 36', the upper portion of the wall which defines the opening 52' being rounded to provide, in conjunction with chamber 48', a stream-lined flow of gases. Opening 52 is adapted to receive a connector 56' for the endotracheal tube 57. Connector 56' has a fitting 58 for the oxygen tube 20. In this embodiment the mechanical dead space in valve portion 22' has been reduced to 5 cc., whereas the mechanical dead space in a conventional Y-chimney piece, which is variable according to the particular apparatus employed, may be 25 ccs.

The valve units of the present invention, therefore, provide, in combination with other equipment, an improved system for administering anesthetic to a patient. The valve unit is disposed closely adjacent the patient's respiratory system to obviate any unnecessary dead air spaces in the mask, fittings or tubes between the patient and the valve. As best seen in Figure 4, almost half of each port 35 and 36 is overlapped by opening 52 and is substantially in a direct line with the flow of gases through the opening 52 of the mask or endotracheal tube, whereby no appreciable turbulence or resistance to flow is created in the valve, and, importantly, the valves 42 and 43 operate substantially instantaneously and effortlessly with the flow of gases by inhalation and exhalation.

The structure of the valves 42 and 43 reduces the impedance to the passage of gases to a minimum. Each of these valves is formed from a flexible rubber whereby very little energy has to be expended in overcoming the inertia in opening and closing them. This quick response of the valves to the movement of gases prevents any appreciable reverse flow or backlash of gases which would otherwise occur just as the valves are closing. The total cross-sectional area of the inlet ports 36 is greater than the cross-sectional area of the subject's trachea so that no resistance to breathing will result.

An important feature of the present valve unit is the lack of dead air space therein whereby there is a minimum re-breathing of carbon dioxide by the patient. The depth of chamber 48 is sufficient to provide for the free flow of gases through the valves but yet is sufficiently reduced in size to prevent any appreciable dead air space, as was pointed out hereinbefore. Therefore, anesthetic is efficiently administered to a patient with as little untreated exhaled gases as possible to produce minimal re-breathing of the patient's carbon dioxide. In persons having a small tidal volume, the efficient operation of the present valve structure produces improved administration of the anesthetic.

Referring to Figure 3, the housing parts 21, 22 and 23 are preferably formed from a transparent plastic. These three portions are integrally secured together by any suitable means, such as a transparent plastic cement, insuring a gas-tight device. Thus, the operation of the valves may be observed at all times and visibly tested before use to insure safety.

To install the valves 42 and 43, the stem thereof is first inserted in the aperture 40 of the hub 39 and the projecting end thereof is grasped by a suitable, commonly available instrument, such as tweezers or a hemostat, and sufficient tension is then applied to the stem to lock the neck portion 46 in the aperture 40. Valves 42 are

moved into place through the tube connection 30 and the necessary tension for locking its neck portion 46 in the aperture 40 is applied by the instrument inserted through opening 52. Valves 36 are moved into place through the opening 52 and the stem engaged by the instrument inserted through connection 31. The valves are thereby readily replaceable when they deteriorate.

Having now described my invention and in what manner the same may be used, what I claim as new and desire to protect by Letters Patent is:

1. A respiratory valve unit for use with a face mask or endotracheal tube comprising a wall member, parallel semi-cylindrical inlet and outlet passageways extending along one side of said wall member, said wall member forming one side of said passageways, tubular connectors on said passageways projecting parallel with said wall member, a breathing chamber on the opposite side of said wall member, an inlet port in said wall member between said inlet passageway and said chamber, an outlet port in said wall member between said outlet passageway and said chamber, an inlet valve in said chamber on said inlet port, an outlet valve in said outlet passageway on said outlet port, and means in said chamber for mounting said valve unit on a tubular connector on a face mask or endotracheal tube.

2. A valve unit as defined in claim 1 wherein said chamber includes a wall closely spaced from said wall member and said chamber wall is provided with a connector opening for said mask and tube overlapping portions of said inlet and outlet ports.

3. A valve unit as defined in claim 2, further including a gas inlet connected with said chamber at a point adjacent said inlet port.

4. A respiratory valve unit for use with a face mask or endotracheal tube comprising a port plate having inlet and outlet ports, a housing member on one side of said plate forming with said plate an inlet passageway extending along said plate and communicating with said inlet port and an outlet passageway extending along said plate and communicating with said outlet port, a housing member on the opposite side of said plate defining a chamber in communication with both of said ports, said last housing member having a connector opening for said mask and tube closely adjacent and overlapping both of said ports, and valves on said ports.

5. A valve unit as defined in claim 4 including a gas inlet connected with said chamber at a point adjacent said inlet port and remote from said outlet port.

6. A valve unit as defined in claim 4 including a spring loaded outlet valve on said first housing member providing an automatic exhalation outlet from said outlet passageway to atmosphere.

7. A respiratory valve unit for use with a face mask or endotracheal tube comprising a port wall having inlet ports adjacent one edge thereof and outlet ports adjacent an opposite edge thereof, valves on said ports, a housing on one side of said wall forming with said wall side by side inlet and outlet passageways extending along said wall and communicating with said ports, respectively, external tubular connections on said housing at the ends of said passageways, and a housing on the opposite side of said wall forming a chamber in communication with all of said ports and having connector means for said mask and tube comprising a circular opening overlapping all of said ports.

8. A valve unit as defined in claim 7 including a gas inlet in said second housing connected with said chamber through the inlet port side of said second housing.

9. A respiratory valve unit comprising a port plate having port openings therein, a divided housing portion on one side of said plate forming inlet and outlet passageways extending along said one side of said plate in communication with said port openings, inlet and outlet valves on said port openings, a breathing chamber on the opposite side of said plate communicating with said port

openings, said breathing chamber having a wall parallel with said port plate provided with a circular opening overlapping said port openings to receive a tubular face mask or endotracheal tube connector, and side walls on said breathing chamber contoured closely around said port openings to minimize the volume of said chamber.

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