

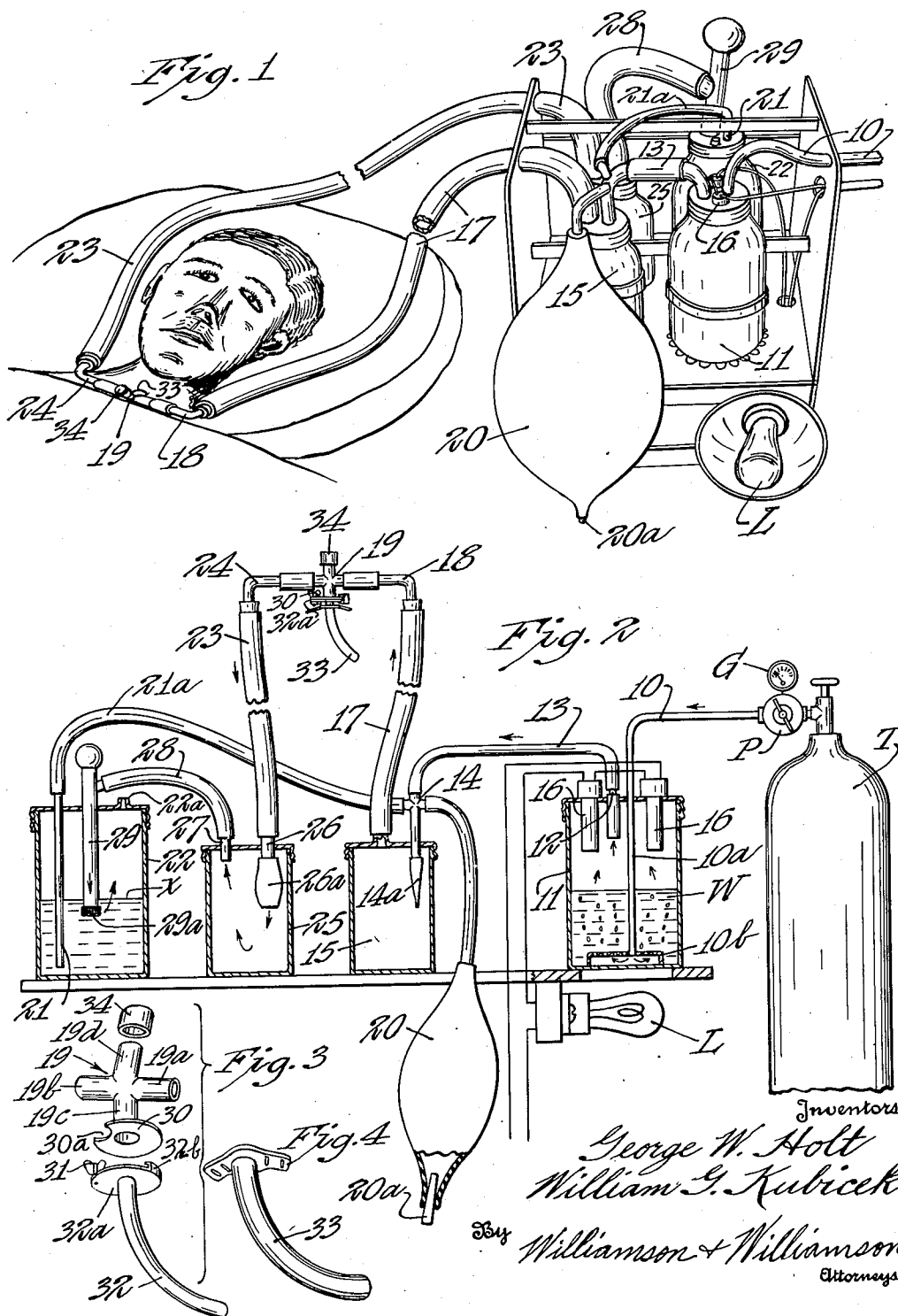
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TRACHEOTOMY INHALER APPARATUS

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TRACHEOTOMY INHALER APPARATUS

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This invention relates to the application of oxygen therapy for patients with tracheotomy.

Our invention provides an apparatus and a method for supplying oxygen-enriched mixtures with humidification and optional use of positive pressure and includes an inspiratory system and an expiratory system with safeguards to effectively protect the patient's respiration and to facilitate an inspection during operation and determination of criteria.

Our apparatus and method is particularly adapted for treatment of poliomyelitis or other patients with involvement of the vital bulbar nuclei where demonstrable or impending laryngeal paralysis evolved.

It is an object of our invention to provide an inhalator apparatus and method of the class described which will supply and humidify oxygen-helium or oxygen air mixtures administered via tracheotomy, under optional positive pressure, so constructed that both expiratory and inspiratory positive pressures may be independently controlled, as emergency demands.

A further object is the provision of an apparatus and method of the class described wherein both inspiratory and expiratory systems are incorporated, both connected with the trachea through a common tracheotomy tube-inhalator attachment.

A further object is the provision of apparatus of the class described wherein moisture, secretion and other obstruction-producing elements are removed from both inspiratory and expiratory systems with inspection facilities at all times to determine respiratory excursions and conditions as well as possible obstructions or embarrassment to respiration.

Another object is the provision of a method and apparatus for supplying tracheotomy inspiration of oxygen-laden mixtures and also tracheotomy expiration which guarantees patency of the upper airway of the patient and which is effective in combating pulmonary edema.

These and other objects and advantages of our invention will be more apparent from the following description made in connection with the accompanying drawings wherein like reference characters refer to similar parts throughout the several views and in which:

Fig. 1 is a perspective view of an embodiment of our apparatus properly assembled and connected with a tracheotomy tube applied to a patient, the source of heat for the humidifier being swung to an inoperative position;

Fig. 2 is a somewhat diagrammatic view with

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portions shown in vertical section of our apparatus, connected for use;

Fig. 3 is an exploded view of a preferred form of tracheotomy tube-inhalator attachment constituting a part of our apparatus; and

Fig. 4 is a perspective view of a conventional type of tracheotomy tube.

Referring to the drawings, a conventional gas tank T is illustrated, having its discharge provided with a pressure control valve P and pressure gauge G, the output from said pressure control valve communicating with a small conduit 10 having a depending portion 10a which extends through a humidifier receptacle 11. Suitable means are associated with the discharge end of gas conduit 10 for distributing and finely diffusing the gas discharged. A satisfactory medium, as shown, comprises a horizontal, inverted shell 10b, multi-perforated in the body or upper side thereof in the manner of a percolator and disposed at the lower portion of the humidifier receptacle and submerged in the water W contained. With this structure, a multiplicity of minute bubbles are produced during the discharge of gas which are diffused through the water and individually pick up moisture in their upward travel. The water level is maintained at a medial point in receptacle 11 and a discharge nipple 12 for the moistened gas is provided in the removable top of the humidifier casing connected as shown, by a rubber or other flexible tube 13 with a fitting 14 communicating with the top of a container 15 which constitutes a condensation trap. Means for heating the water in humidifier receptacle 11 is provided, such as an electric lamp L, provided with a suitable inverted reflector and as shown, the heating unit is swingably mounted so that it may be swung from the position shown in Fig. 1, directly under the bottom of receptacle 11. It is desirable to maintain the temperature of the water in the humidifier receptacle below 36 degrees C. to prevent the subsequent over-accumulation and condensation of moisture in the system. To this end, thermostatic means are provided for controlling the operation of the heating unit and as illustrated, comprise two thermostatically controlled switch devices 16 mounted within the upper portion of receptacle 11 and electrically connected with lamp L so that if either thermostat fails, the other may function to maintain proper temperature.

The humidified oxygen-laden gaseous mixture enters closed container 15 through a one-way

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"duck-bill" type, flat valve 14a and accumulation of moisture condensation is effected in the lower portion of container 15. The gaseous mixture from the upper portion of container 15 passes through the top of the container and enters the inspiration tube 17 which is constructed of highly flexible material and is detachably connected by a transparent elbow 13 with one of the lateral nipples of a tracheotomy tube-inhalator attachment or coupling, indicated as an entirety by the numeral 19.

The inspiratory system described is provided with a breathing reservoir bag 20 constructed of highly flexible material and connected at a suitable point such as with the delivery fitting 14 through a lateral nipple thereof. The breathing bag 20, as shown, is provided with a removable closure and clean-out plug 20a detachably applied to the lower end thereof. The inspiratory system is also provided with an adjustable, positive pressure manometer constituting, as shown, a manometer tube 21, adjustably mounted in the top of a liquid container 22 which is partially filled with water or other liquid to a predetermined level X, said tube being submerged in the water contained to a predetermined distance depending upon the particular requisite of the system. Manometer 21 is connected as shown, by a tube 21a, with a lateral nipple of the delivery fitting 14 and through said fitting with the breathing bag 20.

Our expiratory system, forming a part of our apparatus, comprises a highly flexible expiratory tube 23 connected by a transparent elbow 24 with a second lateral nipple of the tracheotomy tube attachment or coupling 19. Expiration tube 23 communicates with the upper portion of an enclosed water trap receptacle 25. To this end, a small metal nipple 25 is provided in the closed top of receptacle 25, having secured to the lower and discharge end thereof, a one-way, flexible flap or "duck-bill" valve 26a.

A nipple 27 passing through the closed top of water trap receptacle 25 is connected by a short conduit 28 with a positive pressure manometer 29 mounted in the top of manometer receptacle 22. Manometer 29 is in the form of a depending tube submerged, in most instances, a relatively short distance below the water level X of the manometer container and is preferably screened at its lower discharge end 29a. The manometer receptacle, at its upper end is open to the atmosphere through an air outlet 22a.

The tracheotomy tube-inhalator attachment or coupling in the form shown, comprises a four-way fitting 19 having the lateral nipples 19a and 19b respectively, for connection with the inspiration tube 17 and the expiration tube 23 and having the depending, short conduit 19c for connection with the tracheotomy tube, said conduit terminating in a coupling disc 30 provided with a lock-accommodating notch 30a. The fitting 19 is also provided with an upper short conduit or passage 19d open at its upper end and adapted to be occluded by a surrounding rubber cap member 34.

Cooperatively associated with the fitting 19 is a curved, inner tracheotomy tube 32 adapted to longitudinally telescope within the main tracheotomy tube 33 and rigidly carrying at its upper end, a coupling disc 32a having an overlying arcuate flange 32b adapted to engage and retain a marginal portion of the coupling disc 30. An angular lock 31 is pivoted on the marginal portion of disc 30a in position to be accommodated by the notch 30a when swung to

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neutral position. It may be turned in either direction with the discs 30 and 32a abutted concentrically to lock said discs together.

Operation

In setting up this apparatus for use on the tracheotomy patient, water is put into the humidifier flask to a level of 4 to 5 centimeters above the perforated rubber tubing. Our apparatus is arranged in relation to the patient so that both moisture traps 15 and 25 are dependent to afferent and efferent tubing for proper drainage of condensation water. The light bulb under the humidifier flask 11 is turned on and the temperature of the vapor regulated to 35 degrees C. by adjustment of the distance between the bulb and the flask. Patency of the inspiratory system may be checked by manually occluding the end of the inspiratory system at the point where it is to be fitted to the tracheotomy inhalator attachment. Starting the flow of gas through the humidifier 11 will then inflate the breathing bag 20. Release of the end of the inspiratory tube allows part of this volume of gas to pass through the one-way flap valve 14a. The expiratory system may then be checked for patency by approximating the open ends of the inspiratory and expiratory tubes 17 and 23 (circumventing for the moment, tracheotomy tube 19). Flow of gas should then occur through the entire unit as indicated by continuous bubbling of gas from the positive pressure manometer 21 under water. All fittings in the inhalator should be checked for leaks. All inhalator parts should be sterilized carefully before use.

The inhalator may now be used for oxygen therapy in the patient with tracheotomy (Fig. 1). After locking the tracheotomy tube 19 in place on the inner cannula 32 of the tracheotomy, the three remaining outlets are left open until the flow of the desired oxygen mixture has filled the breathing bag. The inspiratory tube is then connected to one of the lateral outlets 19a of the tracheotomy tube attachment, the expiratory tube to the other (19b). Finally, the superior outlet 19d is occluded. The above sequence prevents embarrassing of inspiration until an adequate flow of gas is available through the inhalator. The total flow rate of the oxygen mixture should be adjusted so that the breathing bag is fully inflated during expiration and not less than $\frac{3}{4}$ inflated during inspiration. A rate of 6 liters per minute for adults and 3 to 4 liters per minute for children is usually satisfactory. If, at any time, the breathing bag is being deflated excessively during inspiration, the rubber stopper 34 in the superior outlet of the tracheotomy tube attachment should be removed at once while the flow rate of gas through the inhalator is being adjusted. During these adjustments, embarrassment of inspiration may be prevented by occluding temporarily the superior outlet of the tracheotomy tube attachment with the finger which is quickly removed if the breathing bag continues to show excessive deflation during inspiration. This rubber stopper 34 should be removed at any time it becomes necessary to discontinue the flow of gas through the inhalator as in the changing of gas cylinders or in the event of any difficulty in operation of the inhalator. The temperature of the vapor in the humidifier should never be allowed to exceed 35 degrees C. since this causes excessive condensation in the inspiratory system. The necessity of arranging the condensation traps dependent to the tubing in the inhalator and

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leading to the patient, cannot be overemphasized. The entire system should be checked for condensed water every four hours if heat is applied to the humidifier and every twelve hours if the humidifier is operated at room temperature.

Our apparatus makes efficient provision for inspection during operation to determine adequacy of respiratory excursions as well as other criteria and to detect obstructions to respiration. The breathing bag 20 is observed to undergo volume changes with each tidal exchange, being partially deflated during inspiration and fully inflated during expiration if the flow rate of gas is properly adjusted, since during the latter phase of respiration the one-way flap valve is closed. This excursion of the breathing bag should not proceed to a point of less than $\frac{3}{4}$ full inflation. If this excursion of the breathing bag is not occurring, there is either an obstruction in the inhalator, the tracheotomy tube, the flow rate of gas through the inhalator is excessive, or the patient is breathing through his upper airway.

Intermittency of the bubbling of the patient's expired air through the positive pressure manometer 29 under water on the expiratory system affords another criteria that the inhalator is operating properly. While this estimation is in no way quantitative, the amount of gas emitted by way of the manometer and the duration of this bubbling is useful, particularly in patients with apnea, a serious symptom in poliomyelitis.

For application of the above criteria, it is frequently necessary to occlude the upper airway above the tracheotomy by holding the nose and mouth closed. This prevents whatever upward leak is occurring around the outside of the tracheotomy tube, thus avoiding dilution of the gas administered through the inhalator with air via the upper airway. If this leak has been appreciable and the excursions of the breathing bag have not been apparent, the above procedure should cause such excursions to appear in the breathing bag. Similarly, occluding the upper airway (by mask or manually) should cause bubbling in the positive pressure manometer during expiration.

Condensation and accumulation of fluids, including mucous may be observed in the transparent elbows 18 and 24 respectively, as well as in the transparent trap containers 15 and 25. If the excursion of the breathing bag and the intermittent bubbling of expired air through the water above the positive pressure manometer 29 does not occur when the nose and mouth are occluded, an obstruction in the trachea or the tracheotomy tube must be ruled out. Following suction of the tracheotomy, failure of the breathing bag excursions to occur and continuous bubbling through the manometer implies an obstruction in the trachea or bronchi. Nurses are instructed to suction only the tracheotomy tube. If aspiration does not relieve the obstruction, bronchoscopy should be considered. The bronchoscopist has the choice of removing the mucous accumulations which are usually the source of the obstruction, by passing the catheter into the trachea and bronchi or aspiration under direct observation by bronchoscopy. Thus, by the proper use of the inhalator, the physician may determine by the above criteria, the indication for suction of the tracheo-bronchial tree below the level of the tracheotomy.

Oximetry may be employed to determine the patient's requirement not only for oxygen therapy

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but more specifically, whether such oxygen should be administered under positive pressure. If such studies indicate that positive pressure is not necessary but that oxygen therapy alone maintains a satisfactory arterial oxygen saturation, the tracheotomy inhalator is used with the positive pressure manometer 29 submerged below the surface of the water only 1 or 2 cm. This adjustment is recommended to preserve the feature of convenient visualization of the patient's expired air through the manometer and applies a negligible positive pressure against expiration. For all practical purposes, the use of the inhalator in this way does not exert therapeutically effective positive pressure.

The depth of the positive pressure manometer 29 is adjustable in the water and forms a restriction to the flow of oxygen which builds up a back pressure in the expiratory system and determines and hence indicates the expiratory positive pressure applied. In the presence of impending or existent pulmonary edema, pressures from 4 to 12 c. of water have been used, depending upon the degree of oxygen deficiency.

The depth of manometer 21 in the liquid X determines the inspiratory positive pressure applied and operates as a pressure release which permits the escape of excess pressure through the liquid X of vessel 22 and thence through outlet 22a into the air in the event that pressure builds up in the system due to a stoppage or clogging.

It will of course, be understood that various changes may be made in the form, details arrangement and proportions of the parts without departing from the scope of our invention.

What we claim is:

1. Apparatus for applying oxygen therapy with optional use of positive pressure for respiration, having in combination an inspiratory conductor system and an expiratory conductor system, a connector fitting for application to the patient having branch passages for connection of terminals of both of said systems and thereby also interconnecting said two systems, said inspiratory system including a terminal connection for communication with a source of oxygen-laden gas under pressure and including also a discharge intermediate of the terminals of said inspirator system, said expiratory system having a discharge provided with an adjustable means for restricting the flow of fluid therethrough and having also mechanism interposed therein for collecting liquids and solids passing therethrough.

2. The structure set forth in claim 1 and an expansible and contractable breathing reservoir connected with said inspiratory system.

3. Apparatus for applying oxygen therapy with humidification for respiration, having in combination an inspiratory conductor system and an expiratory conductor system, a connector fitting for application to the patient, having branch passages for connection of terminals of both of said systems, said inspiratory system including a terminal connection for communication with a source of oxygen-laden gas under pressure, a humidifier for moistening gas passing through said inspiratory system, means for collecting condensation moisture prior to inspiration and means for adjusting pressure supplied in said inspiratory system and a check valve to preclude expiration therethrough, said expiratory system having a discharge provided with adjustable means for building back pressure therein and a check valve for precluding inspiration therethrough.

4. The structure set forth in claim 3 and an

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expansible and contractable breathing reservoir connected with said inspiratory system.

5. Apparatus for applying oxygen therapy with humidification and optional use of positive pressure to patients with tracheotomy having in combination, an inspiratory conductor system and an expiratory conductor system, a tracheotomy tube-attachment fitting having provision for connection with the tracheotomy tube in the patient and for detachable connection of terminals of both of said systems, said inspiratory system including a terminal connection for communication with a source of oxygen-laden gas under pressure, a humidifier for moistening gas passing through said system and a restricted discharge intermediate of the terminals of said inspiratory system, said expiratory system having an adjustable restriction therein and having also, a check valve for precluding inspiration therethrough.

6. The structure set forth in claim 5 and an expansible and contractable breathing reservoir connected with said inspiratory system.

7. In apparatus for applying oxygen therapy with humidification and optional use of positive pressure for respiration, an inspiratory conductor system comprising a terminal for connection with a fitting applied to the patient, a terminal for connection with a source of oxygen-laden gas under pressure, a humidifier for moistening gas passing through said system, a check valve to preclude expiration therethrough, a discharge to atmosphere connected immediately of said system and having an adjustable restriction for determining the pressure of said system and an expansible and contractable breathing reservoir connected with said system.

8. The structure set forth in claim 7 and said discharge including a positive pressure manometer.

9. The structure set forth in claim 7 and means for collecting condensation moisture prior to inspiration.

10. In apparatus for applying oxygen therapy to patients with tracheotomy, a tracheotomy tube-inhalator attachment comprising an inner tracheotomy tube adapted to telescope within a conventional tracheotomy tube and having a coupling element at the upper end thereof, a multipassage fitting having a depending canal adapted to register with the upper end of said inner tracheotomy tube and having a pair of lateral passages adapted for connection with an inspiratory conductor and an expiratory conductor respectively, and coupling means comprising a pair of abutable elements and an interlocking member for readily securing said fitting to the upper end of said inner tube with said depending canal in communication with said inner tube.

11. The structure set forth in claim 10 having also an upper open ended passage and removable means for occluding said passage.

12. A tracheotomy tube-inhaler attachment for facilitating oxygen therapy in patients with tracheotomy comprising an inner tracheotomy tube adapted to telescope within a conventional tracheotomy tube and having a coupling flange at the upper end thereof, a four-way fitting having a depending passage adapted to register with the upper end of said inner tracheotomy tube, having a pair of lateral passages adapted for connection with an inspiratory conductor and an expiratory conductor respectively and an upwardly

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extending open ended passage and means for occluding the same, said depending passage terminating in a coupling element for engagement with the coupling flange of said inner tracheotomy tube and means for detachably locking said coupling element and coupling flange together.

13. Apparatus for applying oxygen therapy with humidification and optional use of positive pressure to patients with tracheotomy having in combination, an inspiratory conductor system and an expiratory conductor system, a tracheotomy tube-attachment fitting having provision for connection with the tracheotomy tube in the patient and for detachable connection of terminals of both of said systems, said inspiratory system including a terminal connection for communication with a source of oxygen-laden gas under pressure, a humidifier for moistening gas passing through said system and a discharge conduit intermediate of the terminals of said inspiratory system, said expiratory system having mechanism interposed therein for removing solids and liquids passing therethrough and for also precluding inspiration therethrough and having a discharge conduit, a manometer tank common to both systems and positive manometer elements connected with the said discharge conduits of said inspiratory and expiratory systems and independently adjustable in the liquid level of said tank for building back pressures within said systems.

14. The structure of claim 1 further characterized in that the expiratory system mechanism for collecting liquids and solids comprises a receptacle for containing a liquid therein, and a tube, one end of said tube being adapted to be submerged to adjustable depth in a liquid in said vessel for collection of moisture and secretions.

15. In an apparatus for applying oxygen therapy with humidification and optional use of positive pressure for respiration, an expiratory conductor system comprising a terminal for connection with a fitting applied to the patient, a terminal for connection with the atmosphere, a flexible flap valve to preclude inspiration therethrough, and means for restricting the flow of fluids therethrough, and means for adjusting the pressure in said expiratory system.

16. The apparatus of claim 15 further characterized in that the expiratory system includes a receptacle for the collection of liquids and solids.

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