April 30, 1963 G. W. SCHOSSOW 3,087,493

ENDOTRACHEAL TUBE

Filed April 27, 1960

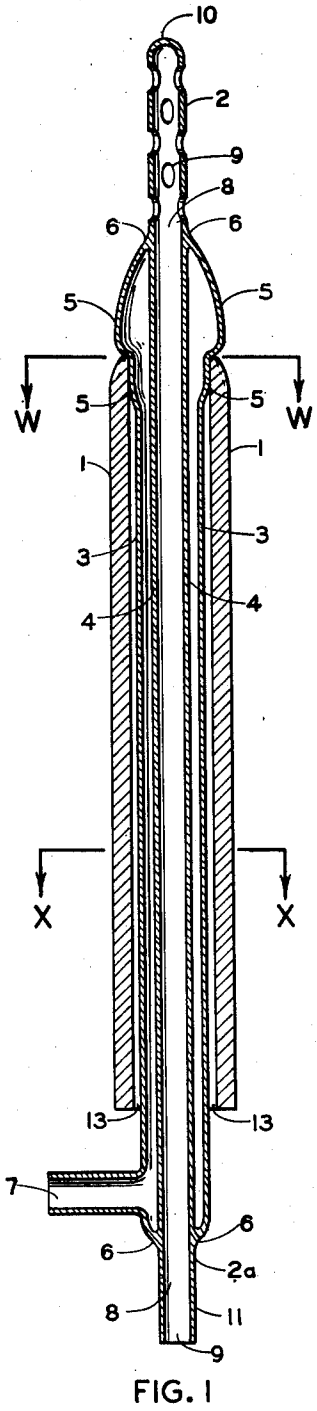

FIG. 1

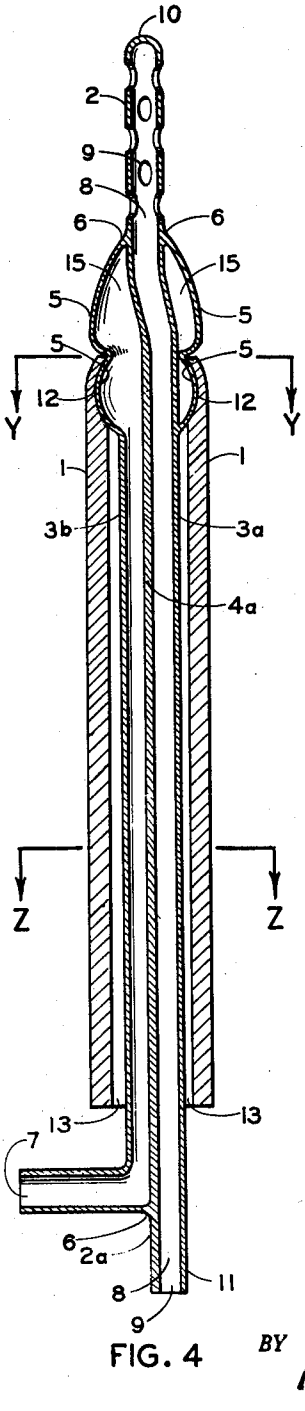

FIG. 4

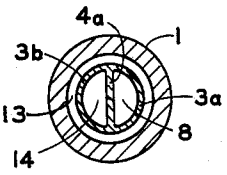

FIG. 6

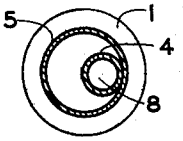

FIG. 5

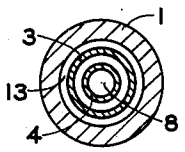

FIG. 3

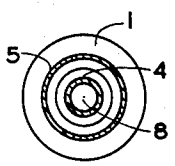

FIG. 2

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ENDOTRACHEAL TUBE

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This invention relates to methods and means for intubating the trachea and like openings, ducts and cavities of human and animal bodies.

One of the problems encountered in the management of certain surgical operations is the maintenance of a free airway or breathing passage. This is particularly true when general anesthetics are employed, but the problem is also present in certain types of surgery of the mouth, throat and nose, where purulent or mucus drainage, hemorrhage and other surgical incidents can make the problem very difficult. It is a particularly serious problem where vomiting occurs while the patient is under general anesthesia or has been under or is approaching such and is not in full possession of the reflexes which prevent the inhalation of liquids and solids into the trachea.

Suffocation of infants and children due to presence of mucus and other foreign matter in the trachea is not uncommon.

The solution which has been applied wherever it has been possible, in situations where food, blood or other solids or liquids enter the mouth cavity while the patient is unable to dispose of it normally and harmlessly, is to introduce into and maintain in the trachea a tube having an outside diameter usually approximating the diameter of the lumen of the trachea, which tube extends outwardly beyond the patient's mouth. This ordinarily requires considerable altering of the position of the patient's head. Usually the distal end of such a tube is shaped obliquely with respect to its length, forming a sort of lip projecting distally of the endotracheal tube, the purpose of such taper being to facilitate the introduction of the tube into the laryngeal orifice. But in spite of and to some extent because of the taper, which creates a more or less sharp leading edge, the distal end of the endotracheal tube, being of fairly rigid substance, is apt to damage the delicate membranous lining of the passage, and when forced past the vocal cords is capable of injuring them. Occasionally as a result of such trauma, patients lose their voices, either wholly or partially, sometimes permanently. This procedure ordinarily requires the use of a laryngoscope which exposes the laryngeal orifice and the vocal cords to direct vision and also guides the endotracheal tube along a trough into the airway. Of course, in the present procedure and using such equipment as has been heretofore available it has been necessary to move or disturb the anesthetist, his equipment, and the position of the patient. The laryngoscope may also be damaging to the patient's front teeth, lips, and tongue and occasionally the patient's neck will not hyperextend sufficiently to use the instrument properly, if at all.

Many patients have died because of difficulty and/or impossibility of inserting the endotracheal tube into the trachea before lethal inhalation of solids or liquids had occurred. This is a particular danger in the case of emergency traumatic surgery, where the physician has had no opportunity to establish a preoperative diet or medication of the patient in order to prevent or control nausea and resulting vomiting.

In many cases, speed of intubation is essential. One of the severe limitations of prior endotracheal tubes is that, because of their relatively large diameter and relative rigidity, it is usually necessary for the operator to have visual access to the laryngeal orifice and vocal

cords, and relative immobility of that part, and of the patient's whole body, in order to introduce the tube. It is next to impossible to intubate the trachea of a patient who is retching or undergoing the involuntary muscular activity associated with vomiting, using prior available endotracheal tubes.

Obviously, the use of known endotracheal tubes is ordinarily limited to physicians and especially-trained nurses, even where vomiting or hemorrhage is not involved and there is no acute or emergent situation.

It is an object of the present invention to provide methods and inexpensive means whereby the trachea may be intubated easily, without the use of a laryngoscope or other special instrumentation, quickly and without visual access to the laryngeal orifice or vocal cords, and without special positioning of the patient's head and neck.

It is another object of the invention to provide methods and means whereby such intubation may be carried out even when there is solid or liquid matter in the mouth of the patient.

It is another object of the invention to provide methods and means whereby intubation of a patient's trachea may be carried out with a minimum possibility of trauma to the patient's trachea, larynx, vocal cords, and buccal parts, i.e., teeth, lips and tongue.

It is a further object of the invention to provide methods and means whereby such a device as is employed to intubate the human trachea may be connected with ducts and/or tubes outside the patient for the purpose of drawing off from the patient's respiratory parts undesirable gases, liquids and/or solids and/or introducing beneficial gases or liquids into the trachea.

Another object of the invention is to provide means whereby intubation of a trachea may be carried out concurrently with the aspiration of the trachea.

It is a still further object of the invention to provide means for intubating the trachea of a patient in such manner that a seal may be created between a cuff portion of the tube and the trachea and the tube may be uniquely locked in the trachea until released by the operator.

Other and further objects of the invention will be apparent from a reading of this specification.

In the present invention, a round outer tube has an outside diameter approximating or smaller than the diameter of the inside of the trachea of the patient, and may or may not be tapered to smaller outside diameter toward its distal end. Inside and concentric with the outer tube and extending beyond it at both ends is an inner tube which may or may not be but is preferably more flexible over most of its length than is the outer tube. The inner tube may or may not be fixedly attached to the outer tube. The inner tube may comprise two layers or in effect one tube inside the other, over most of its length, the inner layer of which extends at both its ends beyond the outer layer, which is separated from and not laminated with the inner layer except that the outer layer terminates distally of a soft, balloon-like cuff part of it which is considerably more elastic and consequently more readily expandable or stretchable upon inflation than is the remainder of the outer and inner layers. At its terminations on either end the outer layer is continuous with the inner layer and sealed therewith. The space between the two layers of the inner tube is intended to communicate with a fluid or gaseous pressure means. The distal end of the inner tube is of sufficient length to extend through the outer tube which lies next inside the trachea and a desired length into the trachea, and its lumen is in open communication with that of the trachea. The lumen of the inner tube is, at its proximal end, open to communicate with the atmosphere or be

connected with devices or ducts by or through which it may be desired to selectively apply suction or else inject fluids or desirable gases into the trachea. When in use the invention comprehends means for inflating the space between the layers of the inner tube, and a valve means interposed between the inflating means and the interlayer space, so that the cuff may be optionally inflated and deflated.

In place of concentric layers forming a double walled inner tube, the inner tube may actually take the form of two tubes lying alongside one another, the one affording communication between the inflatable, soft, elastic balloon-like cuff portion of the inner tube and the means of inflating the space underlying that portion so as to provide for expansion of the diameter of the balloon-like cuff part, and the other tube furnishing an airway through which the trachea may communicate with the atmosphere, or, selectively, with a fluid environment selected by the operator. Of course, the side-by-side arrangement of the two tubes may actually take the form of what amounts to a single tube which is divided over at least a part of its length by a longitudinal septum sealing one side from the other, and then deviating into two distinct tubes at their termini in order to facilitate their functioning.

The diameter of the outside tube which lies next inside the trachea may over all or some of its entire length be relatively smaller and therefore less disposed to traumatize the membranes past which it passes and which it touches than is possible in the absence of the inflatable sealing, cushioning, dilating balloon-like cuff part of the inner tube, which is a part of the invention, and where the wall of the tube is depended upon to furnish a seal with the trachea.

In the accompanying drawing there is shown a preferred form of the invention in which:

FIG. 1 is a central longitudinal cross section of the preferred form of my compound endotracheal tube.

FIG. 2 is a cross sectional view taken transversely of the length of the compound tube along the line W—W shown in FIG. 1.

FIG. 3 is a cross sectional view taken transversely of the length of the compound tube along the line X—X shown in FIG. 1.

FIG. 4 is a central longitudinal cross section of an alternative form of the compound tube, showing as an optional feature, an annular groove in the interior wall of the outer tube in the area which is juxtaposed with the expandable, balloon-like part of the outer layer of the inner tube, when the invention is in functioning position.

FIG. 5 is a cross sectional view taken transversely of the length of the tube along the line Y—Y shown in FIG. 4.

FIG. 6 is a cross section taken transversely of the length of the compound tube as shown at Z—Z of FIG. 4.

Referring now to the drawing wherein like numerals represent like parts, **1** is an outer tube having an outside diameter preferably but not necessarily significantly smaller than the diameter of the lumen of the trachea of the patient. **2** is the single-walled, distal portion of an inner tube which is of smaller diameter and longer than the outer tube and is inside the outer tube. *2a* is the single-walled proximal portion of the inner tube, **3** is the outer layer or wall of the inner tube which has two layers or plies which are not laminated but rather are not connected with one another over most of their length but sealed together at the ends of the outer layer, at points approximately as indicated in the drawing, except for the duct **7** leaving a space between the two layers of the inner tube which is capable of being inflated and expanded. **4** is the inner layer or wall of the inner tube. **5** is a thin, soft, readily expandable, balloon-like part of the outer layer of the inner tube. **6** is the point where **3** and **4** are continuous so as to define the ends of the space or chamber separating **3** and **4**. **7** is a duct communicating with the chamber between **3** and **4**. **8** is the lumen of

the inner tube and **9** are ports or openings into **8**. **10** indicates the distal portion of the inner tube and **11**, its proximal portion. **12** is an annular groove which may optionally be included in the distal interior wall of the outer tube for the purpose of allowing **5** when inflated to expand therein, locking the inner and outer tubes in fixed longitudinal position relative to each other, so that neither will slide lengthwise of the other. **13** is the proximal lumen of the outer tube. **14** is the lumen of the duct communicating between **15**, the space underlying **5**, and the means of inflation of **15**, in the alternative form shown in FIG. 4; *3a* and *3b* are walls defining, respectively, ducts **8** and **14** in the form of the invention shown in FIG. 4. *4a* is a septum defining the separation of **14** and **8** in the FIG. 4.

In the application of the endotracheal tube the operator positions the outer tube **1** along the length of the inner tube in such position that **5**, the thin, soft, balloon-like cuff part of the inner tube lies directly juxtaposed with and partially protruding distally from the distal end of the outer tube, as shown in FIG. 1. **7** is connected with air pressure means such as described elsewhere herein, and sufficient air is forced through duct **7** into the space between **3** and **4**, the walls of the inner tube, or in the form shown in FIG. 4, the space **15** so that the cuff **5** is expanded adequately so as to take on an outside diameter at least as great as and preferably greater than the outside diameter of the distal end of outer tube **1**. This will ordinarily lock the inner and outer tubes against lengthwise sliding with relation to each other and will cushion or shield the butt or sharp leading edge of **1** as it moves into the airway so as not to traumatize the larynx, vocal cords, or trachea. **9** may be optionally attached to suction means or means for introducing beneficial fluids or gases into the respiratory tract of the patient. Once it is in place in the trachea **5** may if desired be further expanded by further inflating the space between **3** and **4** in FIG. 1 or the space **15** in FIG. 4 in order to form a tight seal between **5** and the trachea to lock the endotracheal tube in its applied position. It is desirable to expand **5** sufficiently to lock the inner tube into position with relation to the outer tube before inserting the distal end **2** of the inner tube into the laryngeal orifice.

With or without reference to visual sense, the operator locates the epiglottis and laryngeal orifice. He then inserts the small, soft, flexible extreme distal end **10** of the inner tube into the laryngeal orifice through the vocal cords, and into the trachea, with **1**, the less flexible larger outer tube naturally following the same course, the butt distal end of **1** being covered or cushioned by **5**. The inflation means connected with **7** may take the form of a small hand squeeze bulb which is equipped with an unidirectional valve which will permit air to pass from the atmosphere into but not out of the bulb and means (for example, a screw-controlled or needle valve) for readily relieving the pressure developed in the interlayer space between **3** and **4** or the space **15**. Many such means are old in the art and may be found, for example, on arm-cuffs of blood pressure manometers commonly used by physicians. Some such means is desirable, inasmuch as relatively little inflation of the space is required and such means as a hand squeeze bulb equipped as described allows the operator to regulate the amount of inflation very closely and to readily unlock the whole from its functioning position in the trachea by rapid deflation of **5**.

Especially where endotracheal intubation is carried out when foreign matter (vomit, blood, mucus, etc.) is in the mouth or throat, it will be ordinarily desired to carry out the suction process of aspirating the trachea by suction means connected with **9** concurrently with placement of the endotracheal tube in its desirable position within the trachea, thereby avoiding the forcing of such matter down the trachea ahead of the endotracheal tube, as is apt to occur with presently available equipment.

It is usually desired that the inner tube be inflated and inserted with the outer tube into the trachea and then deflated and rapidly removed without removal of the outer tube, which is then left in position as long as precribed for anesthetic purposes.

It may be desired to connect 9 (if the inner tube remains inside of 1) or (if the inner tube is removed) 13 to breathing means, such as a pulmotor, in order to simulate natural breathing, or else to directly connect it with supplies of gases ordinarily used by anesthesiologists such as anesthetics, carbon dioxide, oxygen, etc.

It will be understood that, as used herein, distal refers to the portion of the endotracheal tube toward or intended to lie within the trachea, while proximal is used to describe the portion opposite thereof, lying away from the trachea or away from the inserted end of the device. In other words, "proximal" and "distal" are with respect to the operator or technician.

I claim as my invention:

1. A means for catheterizing the human trachea or the like comprising an outer tube the outside diameter of which approximates the inside diameter of the passage to be intubated, an inner tube which is within the outer tube and which inner tube comprises walls defining two ducts, the one duct affording communication between a relatively soft, small-diameter terminal portion on the one end which is, in its operative location, in open communication with the cavity to be intubated and on its other end the atmosphere or a selected fluid environment, and the other duct affording communication between a relatively distal, soft, elastic and balloon-like cuff part on the one end which is juxtaposed with and readily expandable into engagement with the distal end of the outer tube upon inflation of the space underlying it and means for inflation of said space on the other end.

2. A means for catheterizing the human trachea or the like comprising in combination an outer tube the outside diameter of which approximates the inside diameter of the passage to be intubated, a relatively soft, more flexible inner tube which is within and concentric with the outer tube and which inner tube comprises concentric longer inner and short outer walls, the outer wall being in the portion of it juxtaposed and at least partially protruding from that at which the outer tube terminates distally, a cuff part which is soft, elastic and balloon-like and juxtaposed with and more readily expandable into engagement with the distal end of the outer tube upon inflation of the space between the said walls than is at least most of the remainder of the outer and inner walls, the two walls of the iner tube being joined and sealed together at both ends of the outer wall over its entire circumference, the space between the two walls of the inner tube being ducted for optional communication with means for inflating the said space, and the inside surface of the inner wall of the inner tube defining a lumen extending the length of the inner tube and open at both ends, the said iner tube extending distally beyond the outer tube and terminating in a relatively soft, flexible, small-diameter portion.

3. Means according to claim 2, in which the soft, elastic balloon-like cuff portion of the outer wall of the inner tube extends distally beyond the distal end of the outer tube a sufficient distance so that when inflated and expanded the said balloon-like portion provides a smooth, linear, outer contour over the length of that part of the entire means which is intended to be inserted in an orifice.

4. Means according to claim 2, in which the soft,

elastic, balloon-like cuff portion of the outer wall of the inner tube extends distally beyond the distal end of the outer tube sufficient distance so that when inflated and expanded the said balloon-like portion provides a soft cushion having an outside diameter greater than the outside diameter of the distal end of the outer tube.

5. Means according to claim 2, in which the distal end of the outer tube is at all points about its circumference transverse the length thereof, the wall of the said tube tapering in decreasing outside diameter toward the distal end thereof from a point proximal the distal end, to form in effect a truncate cone having a sharply defined annular distal edge.

6. Means according to claim 2 comprising an annular groove about the inside surface of the distal end of the outer tube in juxtaposition with the soft, elastic, balloon-like portion of the outer wall of the inner tube.

7. Means according to claim 2 wherein the soft, elastic balloon-like cuff portion of the outer wall of the inner tube protrudes distally beyond the outer tube so that when the space between the walls of the inner tube is sufficiently inflated, a seal between the said outer wall of the inner tube and the trachea may be formed.

8. A means for catheterizing the human trachea or the like comprising in combination an outer tube the outside diameter of which approximates the inside diameter of the passage to be intubated, two smaller tubes which are within the outer tube, said two smaller tubes defining two ducts, the one duct affording communication between a relatively soft, small-diameter portion on the one end, which said portion is in its operative location in open communication with the cavity to be intubated, and on its other end the atmosphere or a selected fluid environment, and the other duct affording communication between a relatively distal soft, elastic and balloon-like cuff part on the one end which is juxtaposed with and readily expandable into engagement with the distal end of the outer tube upon inflation of the space underlying it and means for inflation of said space on the other end.

9. A means for catheterizing the human trachea or the like comprising in combination an outer tube the outside diameter of which approximates the inside diameter of the passage to be intubated, an inner tube which is within the outer tube and which inner tube comprises walls defining two ducts which coextend longitudinally over at least a part of their length and are separated from each other by a septum, the one duct affording communication between a relatively soft, small-diameter portion on the one end, which is in its operative location in open communication with the cavity to be intubated and on its other end the atmosphere or a selected fluid environment, and the other duct affording communication between a relatively distal, soft, elastic and balloon-like cuff part on the one end, which cuff part is juxtaposed with and readily expandable into engagement with the distal end of the outer tube upon inflation of the space underlying it and means for inflation of the said space on the other end.

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