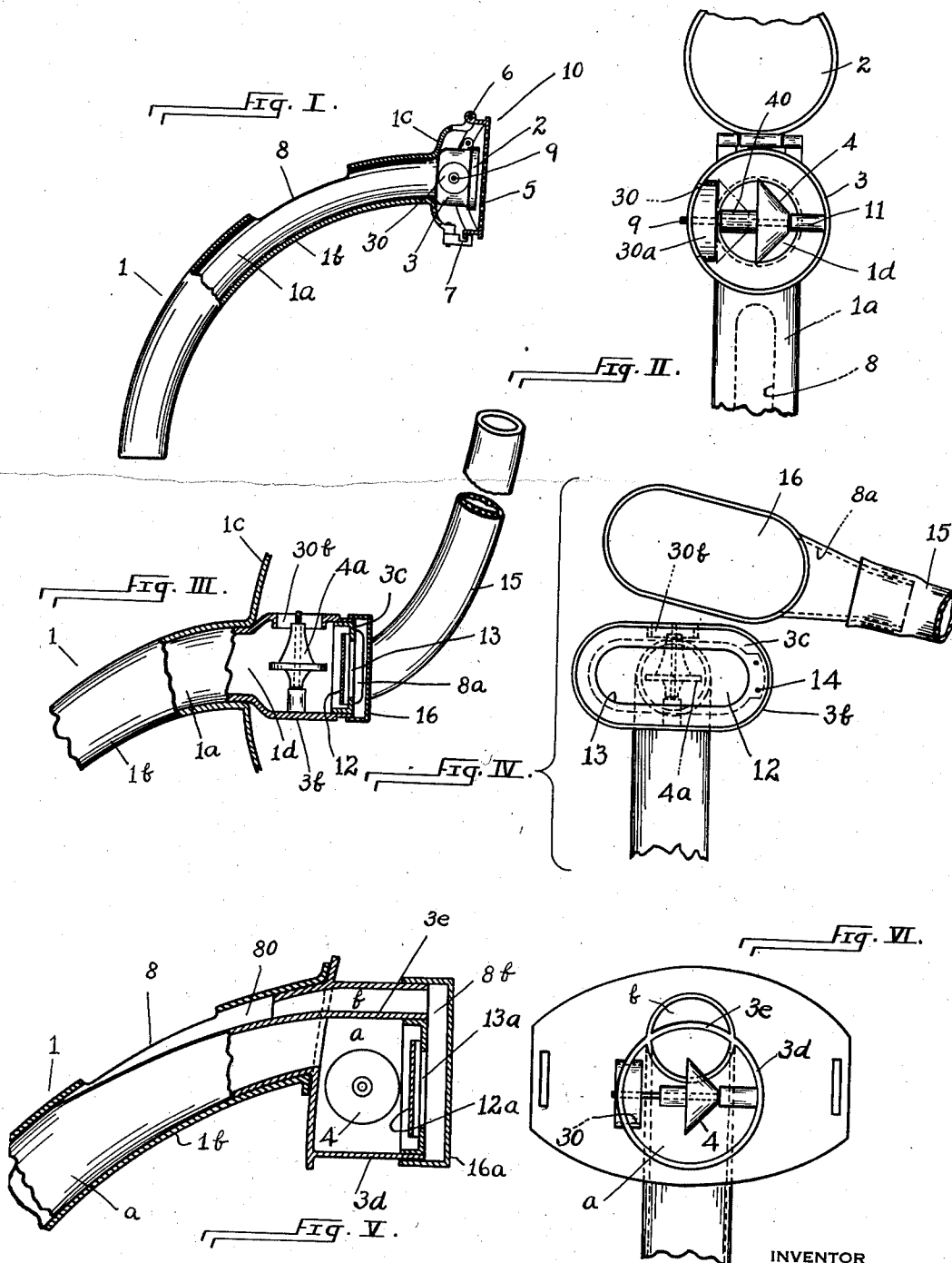


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TRACHEAL INSTRUMENT
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TRACHEAL INSTRUMENT

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My invention relates to tracheal instruments or appliances; devices, that is to say, which are adapted to assist in respiration, or speech, or both respiration and speech.

Persons suffering from goiter or other morbid throat or nasal conditions frequently reach a state of abnormality in which natural respiration is no longer possible. Surgery affords the remedy. The surgeon makes an incision in the wall of the patient's throat, below the lower jaw, and establishes communication with the wind-pipe or trachea. Thus, an abnormal but effective respiration is made possible.

Ordinarily, in cases of this kind an instrument known as a tracheal tube is introduced through the incision into the trachea, to facilitate the passage of air during breathing. In some cases the patient is able to exhale through the throat and nasal passages, and in such cases it is customary to provide at the outer end of the tube a valve which, standing in open position during inhalation, moves into closed position during exhalation. When the tube is thus closed to outward flow, the air exhaled from the lungs passes upward, between the wall of the trachea and the tube, into the throat and nasal passages. Thus it is that, during respiration, inhaled air enters through the instrument, and exhaled air exits through the natural throat and nasal passages, permitting the patient to speak at will. This assumes, of course, that the patient's larynx has not been removed and remains effective for the production of sound.

It has been found that a tube so arranged in the trachea substantially increases the resistance to air flow during exhalation, with the consequence and effect that respiration becomes laborious. Indeed, some patients have complained that this increased resistance to exhalation produces muscular exhaustion and conditions of painful irritation in the chest. An object of my invention is to obviate this objectionable circumstance.

More particularly, the invention consists in a tracheal tube provided with an aerodynamically operated valve which, normally standing in open position, closes when the user speaks. Under normal conditions of respiration, when the flow of air is at relatively low velocity, the valve remains open, and the user inhales and exhales through the tube. The physical effort required for such artificial respiration is no greater, and, indeed, may be less, than that expended by a perfectly normal person. When the user begins to speak and the exhaled air flows at relatively

high velocity, the valve closes; then and only then is the flow through the tube interrupted and the exhaled air diverted to the throat and nasal passages of the user. As in the course of respiration the user inhales, the valve immediately reopens, and remains in open position until air is again exhaled at speaking intensity. By virtue of such improvement in tracheal instruments, the above-mentioned objection is eliminated.

The invention embraces other refinements and elaborations.

In certain cases the larynx of the afflicted person is removed, or is so far affected, that natural speech is impossible. Artificial larynges have been provided, and through the use of such devices speaking has been made possible. So far as I am aware, most, if not all, of the artificial larynx structures hitherto known have consisted in a sound-producing device that is externally connected to the tracheal tube, by means of a length of rubber tubing, or other flexible conduit. A tubular bit is provided on such sound-producing device, and the user, desiring to speak, inserts the bit in his mouth and exhales through the instrument. This flow of air, at speaking intensity, actuates the sound-producing device, and the sound thus generated becomes effective in vowel chamber of the mouth and enables the user to speak. While artificial larynges of this sort have proved of great value to persons who otherwise would be mute, I have found need for improvement. Specifically, the instruments are too large and heavy; they are unsightly, and cumbersome to manipulate.

In accordance with the invention, I provide an artificial larynx which is light in weight and of compact construction, and which is arranged in particularly effective organization within or at the outer end of the tracheal tube.

In the accompanying drawing I illustrate several embodiments of the invention. The instrument shown in Figs. I and II is primarily designed to assist breathing, and in exemplary way the tube portion of the instrument is shown as a double tube, a tube within a tube, adapted to be inserted in the trachea; the outer end of the external tube is flared outward to shield the incision in the neck of the user, while the outer end of the inner tube is enlarged and equipped with a cover, to provide a housing for the valve alluded to in the introduction to the specification. Fig. I is a view of the instrument partly in side elevation and partly in section, and Fig. II is a fragmentary view, showing in elevation, and to

larger scale, the enlarged mouth of the inner tube, with the cover thrown open.

Fig. III is a fragmentary view, partly in side elevation and partly in section, of a modified and elaborated form of the instrument, including structure by virtue of which the tracheal tube is serviceable as an artificial larynx; and Fig. IV is a view in end elevation of the enlarged end of the inner tube, with its cover removed and shown in plan from within.

Fig. V is a view, comparable with Fig. III, illustrating certain modification in the structure and organization of the tracheal tube and artificial larynx; and Fig. VI is a fragmentary view of such assembly, as seen from the right of Fig. V, with the cover removed from the end of the inner tube. Figs. III to VI are, as in the case of Fig. II, shown on larger scale than that on which the instruments are actually built for service.

Referring to Fig. I of the drawing, the tracheal instrument or appliance consists in a tubular body 1 terminating at one end in a head portion 10. In service the tubular body is inserted in the trachea of the user, with the head portion 10 positioned over and closing the incision in the user's neck. The tubular body 1 is curved in its extent, as shown, and includes an inner tube 1a snugly fitted within, but removable from, an outer tube 1b. The instrument is constructed of nickel, or stainless steel, or silver, or a more noble metal, that is resistant to corrosion and chemically neutral to the moisture and glandular secretions present in the human throat.

The outer end 3 of the inner tube 1a is enlarged in diameter and provided with a hinged cover 2, forming a housing for a valve 4 which controls a port 30 in the housing and adapts the instrument to alternate conditions of service, as presently will appear. The outer tube 1b terminates in a flange or basal portion 1c that serves in double capacity: (1) it provides a shield that overlies and protects the incision in the throat of the user; (2) it provides means upon which the housing 3 may seat, to retain the inner tube in proper position within the outer tube.

In Letters Patent of the United States No. 2,039,142, granted to me April 28, 1936, I illustrate and describe how a neck-encompassing band or necklace, connected to the flange or basal portion 1c of the outer tube, may be used to secure the instrument in position of service, and additionally I disclose in such patent how the otherwise exposed ends of the two tubes may be screened within a cover, preferably an ornamental cover that blends artistically with the necklace or band. While my present improvements are not immediately concerned with the invention claimed in the patent, I show in Fig. I a cover 5 which is arranged to screen the parts which, when the instrument is in place in a human throat, otherwise present an unpleasant appearance. The cover 5 may be plain, or it may be of ornamental filigree design. In this case I show the cover to be hinged, as at 6, to the upper edge of the basal portion 1c, and secured to the lower edge of such basal portion, by means of a disengageable catch 7.

The wall of the housing 3 carries a cylindrical flange 30a which, encompassing the port 30, extends an interval into the housing, as shown in Fig. II. The valve 4 is mounted for movement to and from position of closure on the inner peripheral edge of such flange. Advantageously, the valve consists in a frusto-conical body to which the reference numeral 4 is immediately

applied in Fig. II, and such body carries an integral sleeve portion 40. The mounting for the valve consists in a stem 9 borne rigidly by a supporting block 11 on the wall of the housing. The stem 9 extends on the axis of, and normal to the plane of, the orifice or port 30, and the valve 4, 40 is slidable on the stem 9 between the full-line position (Fig. II), in which the port 30 is open, and the broken-line position, in which the port is closed. It is to be further noted that the valve is arranged with its axis extending athwart the line of air flow from the tracheal tube; that is, the axis of the valve extends transversely to the outlet 1d that opens from the tube 1a into the valve-housing 3. The conical side surface of the valve is exposed to the stream of air that, during exhalation, flows outward through the tube, and manifestly, under the influence of this exhaled stream of air, the valve tends to move from open to closed position. (The friction between the valve and the stem is utilized to oppose such tendency.) The weight of the valve and the proportions of the parts are so determined that the valve (in open position) is unresponsive to the flow of air at normal breathing intensity; alternately, when air is exhaled at the higher intensity incident to speaking, the valve is immediately shifted into closed position. The outer end of the tracheal tube is thus closed to the exhalation of air at speaking intensity, and the stream of air entering the open inner end of the tube 1 is diverted through an auxiliary port or secondary opening 8 in the double side walls of such tube into the upper tracheal and oral passages of the user. The user is able to speak. As in the course of respiration the user inhales, the valve is immediately restored to open position, and air flows from the outer atmosphere, through the port 30 and tube 1, into the trachea and lungs of the user. The valve continues in open position during normal conditions of respiration; that is, the valve remains open until the user again expels air at speaking intensity. Thus, advantages of the nature indicated are realized.

In case the afflicted person's larynx and the upper portion of his trachea are removed, or are so far affected that no sound can be naturally produced, I provide in my instrument an artificial larynx. The artificial larynx is a sound-producing device; ordinarily, and as shown in this case, it consists in a reed 12 adapted to be vibrated by the stream of air exhaled through the tube 1 at speaking intensity. More specifically, the reed 12 consists in an elongate, thin leaf of resilient metal secured at one end, by means of rivets 14, to the wall portion 3c of the housing 3b at the outer end of the tube 1. (Note Figs. III and IV.) The wall portion 3c includes an open window 13, and the reed 12 extends adjacent to and in approximate parallelism with such window. The form of the housing 3b is modified, as a comparison with the structure of Fig. I and II will reveal, and the valve 4a is, conveniently, arranged to move vertically rather than horizontally. Indeed, the valve 4a is modified in specific details of shape, but it is operable to control the port 30b in the same general manner that the valve 4 controls the port 30. Whereas, in the structure first described, the stream of air diverted by the closing of the valve 4, passes through an opening 8 in the tube 1 into the upper trachea of the user, in the structure of Figs. III and IV, the stream of air at speaking intensity is diverted through the sound-producing device (12, 13) into a flexible tube 15. More particular-

ly, a cover 16 is secured over the reed assembly, and such cover includes a port or passage 8a that communicates with the tube 15. (Note Fig. IV.)

During normal conditions of respiration, the valve 4a stands in open position, and air enters and leaves the instrument by way of the port 30b. When the user desires to speak, he places the distal end of the tube 15 in his mouth and exhales air at speaking intensity. Immediately, the valve 4a is shifted into closed position; the exhaled stream of air is diverted and flows through the window 13, outlet 8a, and tube 15 into the vowel chamber of the user's mouth. Such flow of air through the window 13 causes the reed 12 to vibrate and produce sound, which is transmitted through the tube to the user's mouth. In known way the user may speak.

While the valve 4a, the sound-producing device 12, the cover 16 and the tube 15 are shown as parts assembled with the walls of chamber 3b integral on the outer end of the inner tube 1a, it is to be understood that these elements may be assembled in a unit that may be mounted on the outer end of the tube and removed at will, whereby the user may carry the unit hidden from view, say in his coat pocket, until such times as he desires to talk.

In Figs. V and VI, I show a structure in which the flexible tube 15 is eliminated, and the sound produced by the artificial larynx is carried into the mouth of the user through the upper portion of the user's trachea. This structure is particularly serviceable in those cases in which, with the larynx removed or ineffective, the trachea still affords communication with the mouth. The principal modification in the structure consists in the provision of a double passage within the tracheal tube 1, although it will be noted that certain other changes in detail are illustrated and perfectly intelligible in the drawing.

As shown in Fig. V, the inner tube 1a is tapered towards its outer end, in such manner that a secondary passage 8b is provided within the tube assembly. The housing 3d is integral with the inner tube 1a, and is horizontally partitioned, as indicated at 3e, providing two chambers a and b that severally communicate with the two passages within double tube 1. A valve 4 is arranged in the chamber a to control the inlet and outlet port 30, and a reed 12a is arranged before a port or window 13a which, together with the space 8b within cover 16a, establishes communication between the two chambers a and b. During normal respiration, the valve 4 stands in open position and air flows alternately in and out through the bore of the inner tube 1a and the port 30. When, from time to time, air at speaking intensity is exhaled through the tube, the valve 4 moves into port-closing position, and the stream of air is diverted through the sound-producing device 12a, 13a, the passage 8b, the secondary chamber b, the secondary passage 80, and the auxiliary or secondary outlet 8, into the upper trachea of the user. Such flow of air energizes the reed 12a, and the sound thereby produced is conducted through said course of flow into the vowel chamber of the user's mouth. Thus, the user may speak. The artificial larynx is entirely enclosed within the confines of the relatively small housing 3d, and is adapted to be hidden from view within or below the collar of the user's shirt or dress. Whether or not a cover, such as the cover 5 of Fig. I, be used is a matter of choice. Indeed, no such covers are shown for the structures of Fig. III to VI.

I claim as my invention:

1. An instrument of the class described comprising a tube adapted to be inserted in the trachea of the user and provided at its outer end with a chamber, a port establishing communication between said tube and the outer atmosphere, an aerodynamically operated valve movable between alternate port-controlling positions, and a wind-operated, sound-producing device arranged in said chamber and adapted to be energized when said valve is in one of its alternate positions.

2. In a tracheal tube including a port and a valve at its outer end; the refinement herein described in which said valve consists in an aerodynamically operated valve including a body mounted on and movable longitudinally of an axis extending angularly to the plane of opening of said port in response to the flow of air through the tube at speaking intensity.

3. In a tracheal tube including a port and a valve at one end; the refinement herein described in which said valve consists in an aerodynamically operated valve including a conical member arranged with its axis athwart the line of air flow from the mouth of said tube and movable under the influence of air pressure to and from port-closing position.

4. In an instrument of the class described including a tube adapted to be inserted in the trachea of the user, a port providing an inlet and an outlet for air, a valve controlling such port, and an auxiliary port providing an outlet for air when the valve is in position of closure on the port first mentioned; the refinement herein described in which said valve is mounted for movement under inhalation from position of closure on said port to open position and adapted to continue in open position under normal conditions of respiration, said valve provided with a surface exposed to the stream of air exhaled through the tube and so arranged that the force of the stream tends to shift the valve from open to closed position, the parts being so proportioned that the stream flow of less intensity (incident to normal exhalation) is insufficient and the stream flow of greater intensity (incident to speaking exhalation) is sufficient to shift the valve into closed position and to divert the flow of exhaled air through said auxiliary port.

5. The structure of the next-preceding claim, together with a sound-producing element arranged in the line of flow to said auxiliary port.

6. An instrument of the class described including a chamber, a passage for establishing communication between said chamber and the trachea of the user, a port communicating with the outer atmosphere and providing an inlet and an outlet for said chamber, an aerodynamically operated valve adapted to close such port during speaking exhalation through said passage, and an auxiliary port for delivering exhaled air to the larynx of the user when the port first mentioned is closed by said valve.

7. An instrument of the class described including a chamber, a passage for establishing communication between said chamber and the trachea of the user, a port communicating with the outer atmosphere and providing an inlet and an outlet for said chamber, an aerodynamically operated valve adapted to close such port during speaking exhalation through said passage, an auxiliary port providing for the delivery of a speaking stream of air when the port first mentioned is closed by said valve, and a wind-oper-

ated sound-producing device arranged in the assembly in the line of flow between said passage and said auxiliary port.

8. In an instrument of the class described including a tube adapted to be inserted in the trachea of the user, a chamber provided at the outer end of said tube, a port establishing communication between such chamber and the outer atmosphere, and a valve controlling said port; the refinement herein described in which said tube is provided with two tracheal openings and includes two passages severally establishing communication between said openings and said chamber, said valve being mounted for movement under inhalation from position of closure on said port and adapted to continue in open position when, under normal conditions of respiration, the inhaled and exhaled streams of air flow through one of said passages, said valve being exposed to the stream of air exhaled through said last passage and so arranged and proportioned that a stream flow of speaking intensity shifts said valve into closed position, whereby said speaking flow of air is diverted to the second passage in said tube and redelivered to the trachea of the user.
9. In an instrument of the class described including a tube adapted to be inserted in the trachea of the user, a chamber provided at the outer end of said tube, a port establishing communication between such chamber and the outer atmosphere, and a valve controlling said port; the refinement herein described in which said tube is provided with two tracheal openings and includes two passages severally establishing communication between said openings and said chamber, said valve being mounted for movement under inhalation from position of closure on said port and adapted to continue in open

position when, under normal conditions of respiration, the inhaled and exhaled streams of air flow through one of said passages, said valve being exposed to the stream of air exhaled through said last passage and so arranged and proportioned that a stream flow of speaking intensity shifts said valve into closed position, whereby said speaking flow of air is diverted to the second passage in said tube and redelivered to the trachea of the user, and a sound-producing device arranged in the line of flow of such diverted stream of air.

10. A tracheal tube including two outlet openings, and an aerodynamically operated valve arranged in cooperative relation with respect to one of said openings, said valve standing in one position with the flow of air in the tube at normal respiration intensity and movable into alternate position when the flow of air rises to speaking intensity.

11. In a tracheal tube including an air passage and a valve mounted for movement between alternate passage-controlling positions; the refinement herein described in which said valve comprises an aerodynamically operated valve including a body resting in one of said positions when air flows through said tube at normal respiration intensity, said valve body having a surface extending angularly to the line of air flow, the flowing air (impringing on such surface) tending to shift said valve from such position of rest to its alternate position, the area of such surface being so proportioned that when the flow of air rises to speaking intensity the aerodynamic force acting on said area becomes effective to shift the valve into its said alternate position.

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