May 23, 1933. R. R. RIESZ ET AL 1,910,966

ARTIFICIAL LARYNX

Filed July 23, 1929

FIG. 1

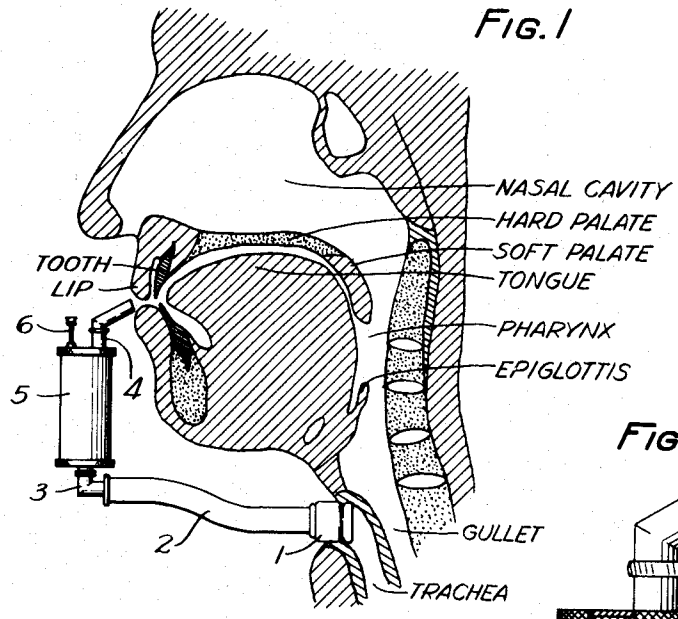


FIG. 2-A

FIG. 2

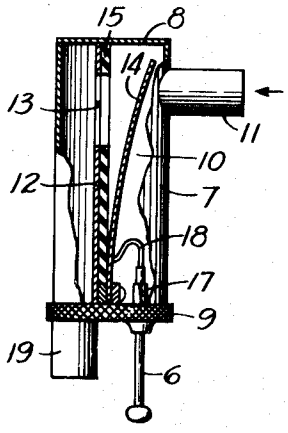


FIG. 3

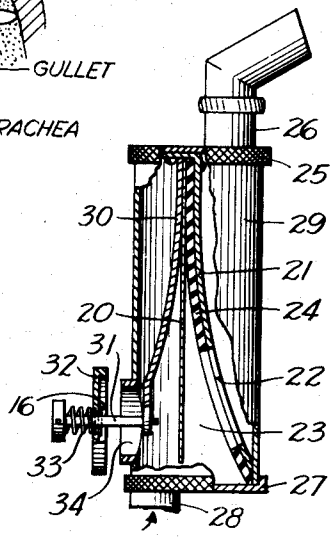


FIG. 4

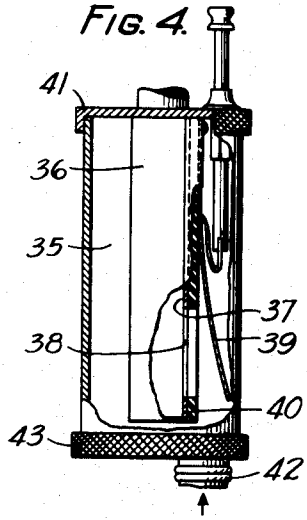


FIG. 5

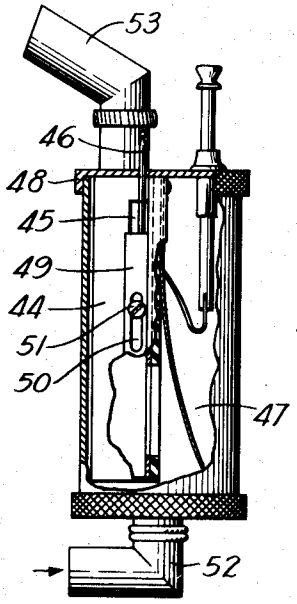
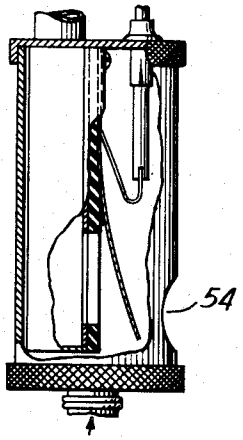


FIG. 6



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1,910,966

UNITED STATES PATENT OFFICE

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ARTIFICIAL LARYNX

Application filed July 23, 1929. Serial No. 380,279.

This invention relates to an artificial larynx which is intended to restore the power of speech to a person who has had the natural larynx removed or to others having afflictions which impair the usefulness of the natural larynx.

An object of this invention is to enable a person to reproduce speech sounds through an artificial larynx which is simple in structure and efficient in operation and which requires no attention or adjustment by the user.

Another object of this invention is to reduce the lung pressure required to maintain the vibratory member in motion by utilizing the Bernoulli effect of the air introduced into the device.

In accordance with this invention the improved artificial larynx comprises a casing having a trachea inlet opening and an outlet opening leading to the mouth of the user. The casing is divided into two compartments by a partition having an opening which forms a communicating passageway therebetween. A metallic reed is fastened to one end of the partition and extends over the opening.

In a preferred embodiment of the invention the opening in the partition is elongated and the reed is paddle-shaped to follow the contour of the opening, the free end of the reed having an upward bend to prevent blocking of the opening under strong air pressures. In the operation of the device the air under pressure from the lungs passes through the trachea, through the tracheotomy hole, into the trachea connection and is led to the inlet of the casing to start the reed vibrating over the opening in the partition. The air flowing through this opening at high velocity produces a region of low pressure on the underside of the reed and this large Bernoulli attraction pulls the reed downward and causes vibration thereof to start and to continue while the air flow lasts. The pitch of the sound produced by this reed vibration depends upon the frequency with which the reed is vibrated. The sound vibrations enter the outlet compartment and are introduced into the mouth of the user where the movement of the tongue and lips, together with the positioning of the teeth and the shaping of the nasal cavity transforms the sound vibrations into articulated sound. This device reproduces speech sound efficiently with a minimum amount of lung pressure and reduces the muscular effort on the part of the user to exert sufficient air pressure to operate the device. Furthermore, the reed type of vibrating element improves the quality and the intensity of the articulated sounds and does not block the opening when strong air pressures are used.

One feature of this invention relates to the adjustable means to vary the pitch of the speech reproduced by providing a sliding pin in the casing which carries a spring which presses on the reed to clamp various lengths of the reed against the partition.

Another feature relates to combining this pitch adjusting means with an air valve, to control an auxiliary opening in the partition, for the purpose of allowing the user of the device to breathe regardless of whether he is speaking through the device, or not, and also for the purpose of varying the intensity of the articulated sound.

A more complete understanding of this invention may be obtained by a study of the accompanying drawing wherein

Fig. 1 illustrates the use of an artificial larynx by a person whose natural larynx has been removed and whose trachea or "wind pipe" has been terminated in an opening in the throat.

Fig. 2 illustrates, in a partial section, an artificial larynx forming one embodiment of this invention.

Fig. 2—A shows a preferred shaping of the reed member forming a feature of this invention.

Fig. 3 shows another embodiment of this invention in which the partition within the casing is curved and the reed straight. This embodiment also illustrates how a breathing vent may be provided in the casing of the artificial larynx.

Fig. 4 illustrates another embodiment of this invention wherein the partition separating the sound chamber into two com-

partments consists of a semi-circular tubular member suspended within the casing.

Fig. 5 shows still another embodiment of this invention in which a breathing valve is provided within the sound chamber of the larynx.

Fig. 6 shows still another embodiment of this invention being a modification of Fig. 4.

There is shown graphically in Fig. 1 the various resonance cavities and the speech forming members of the human head whose function and operation in producing articulated sound are well-known. The figure also illustrates how the trachea or "wind pipe", after the natural larynx has been removed from a person's throat, is terminated in an opening in the throat through which the person is enabled to breathe and how the natural passage of air to and from the lungs through the nasal or mouth cavities and the pharynx is prevented. This figure illustrates also the use of the artificial larynx comprising this invention. There is provided a tubular, hard rubber insert 1 which fits into the opening forming the termination of the trachea or "wind pipe", a trachea connection 2, preferably of hard rubber or metal, which fits tightly over or into the inlet 3 to the sound chamber of the artificial larynx 5 which is provided with an outlet 4 so shaped as to project slightly only between the open lips of the user, or, if desired, to project into his mouth, and to direct the sound waves from the artificial larynx into the mouth to be modified to produce articulated sound. The rod 6 projecting from the upper portion of the larynx casing is the external portion of a preferable means (shown in detail in the other figures) for controlling the pitch of the sound producing member in the artificial larynx.

Referring now to Fig. 2 which shows the various elements comprising the artificial larynx 5 shown in Fig. 1, there is provided a casing for a sound chamber 10 formed by a cylindrical wall 7 and circular end walls 8 and 9. In the upper portion of cylindrical wall 7 is a tubular inlet 11 to the sound chamber for the air, which passes through a trachea connection connected thereto, from the user's lungs, or from a bellows or other source of air, if the person employing the artificial larynx does not wish to use an air supply which comes from his lungs. The sound chamber 10 is divided into two compartments by a partition 12 at one end of which is an elongated opening 13 forming a connecting passage between the two compartments. A paddle-shaped reed 14 of thin phosphor bronze, tantalum, rolled nickel or other spring material, a front elevation of which is shown in Fig. 2—A, relatively curved with reference to the partition 12, is clamped at one end to said partition, its free end being capable of vibration. Between said reed and partition and fastened to the latter is a rubber membrane 15 having an opening therein of similar contour to the opening in the partition. This membrane is provided to prevent the production by the artificial larynx of a sound having a metallic quality if the vibrating reed should strike the partition. For varying the natural frequency of the reed and consequently the pitch of the sound used when the reed is vibrating there is provided a knobbed rod 6, journalled in the end wall 9 and passing through the split sleeve 17, at the end of which is a wiper 18 of spring material bearing against the surface of reed 14. By adjusting the position of said wiper, more or less of the reed may be clamped against the partition and the effective length of the reed shortened or increased with a consequent variation in natural frequency. The wall 9 is also provided with a hollow tubular portion 19 forming an exit from one of the compartments of the sound chamber. The partition 12 is preferably secured to the wall 9 and, at its edges, fits snugly against the inner surface of the sound chamber without necessarily being secured to it. This makes possible the removal of the working parts of the larynx for readjustment, replacement or maintenance by simply loosening the wall 9, which is equipped with a flanged portion for engaging with the cylindrical wall 7, and lifting the artificial larynx from the casing.

The operation of this device is as follows: The air from the lungs of the user of the larynx, or from a suitable source of air, enters the first compartment of the sound chamber 10 through the inlet 11, strikes against the reed 14 and is deflected thereabouts to pass through the opening 13 in the partition 12 into the second compartment and therethrough to the outlet 19 of the user's mouth. The air in flowing through the opening 13 will produce a region of low pressure on that side of the reed and will cause it to move toward the opening until its elastic restoring force acts to return it to its original position whereupon, if the air flow is maintained, this cycle will be repeated until the air flow stops. This vibration of the reed will produce pulsations in the flow of air to the mouth and, depending upon the frequency of vibration of the reed, will cause a sound of definite pitch and intensity to be emitted by the artificial larynx. This single or compound sound when introduced into the mouth may be changed to articulated sound by the proper positioning of the speech forming members therein.

It is the Bernoulli effect of the air rushing under the reed which causes it to be

drawn down close to the partition and to start vibrating when both the reed and the partition are straight. It is only when the latter is fairly close to the partition that this effect is great enough for moderate air flows to exert an appreciable force on the reed, therefore, to make the reed easier to start, this effect must be amplified. This might be done by having the reed initially close to the opening in the partition. In that case, however, the elastic restoring forces of the reed are not great enough to prevent freezing of the reed and the consequent blocking of the larynx. This latter can be avoided, however, by making the reed paddle-shaped and the opening in the partition of similar contour for a considerable distance between the edge of the reed and the edge of the opening. Thus by providing a fairly long slit through which the air flow may take place and by giving the paddle end of the reed a sharp upward bend it will be impossible to block the larynx unless excessive pressures are used. Any desired degree of blowing can be obtained by giving the reed the proper curvature. The larynx must not blow too easily or the user will not be able to articulate many of the important consonants which give intelligibility to the spoken word, nor must the curvature of the reed be such that too much air is required to "blow" or sound the larynx as this would place too much of a strain on the lungs of the user. The best balance of the various characteristics, it has been found, occurs when the reed is bent into the arc of a circle and the tip is given a slightly greater curvature whereby the artificial larynx can be made to block or freeze outside the frequency range of practical importance for air pressures such as can conveniently be developed by the human lungs.

Fig. 2—A shows to a reduced scale, the preferred contour of the reed 14, the dotted lines thereon indicating the position of the opening 13 in the partition 12.

Fig. 3 illustrating another embodiment of this invention shows the relative curvature discussed heretofore existing between a straight reed 20 and a curved partition 21 to which the former is clamped at its upper edge. The partition 21 is provided with an opening 22 which serves as a passageway between the two compartments of the sound chamber 23. Between the reed and the partition is clamped a rubber membrane 24 cemented to the partition 21 and having an opening of the same contour as the opening 22. The partition is, preferably, secured to the upper circular wall 25 of the sound chamber and fits in a fairly air tight manner against the inner surface of the cylindrical sound chamber wall 29. This arrangement is preferable inasmuch as it permits the ready removal of the reed and partition for readjustment, replacement or maintenance. The upper wall 25 is provided with an outlet 26 and the lower wall 27 with an inlet 28 to which a trachea connection similar to that shown in Fig. 1 may be secured. A stiff curved spring 30 is connected at one end to the reed and at the other to a thumb pin 31 upon which slides a pad 32 similar to those employed for varying the pitch of a clarinet. Encircling said pin is a spring 33 which fits into a recessed portion in the pad 32. A pin 16 passes through an opening in the thumb pin 34 just below the pad 32. A circular outlet 34 is provided in the cylindrical wall 29 through which the user of the device may breathe when he is not talking. The size of this opening is preferably such that the resistance to air flow therethrough is not greater than that in the nasal passage of normal individuals. The outlet 28 from the trachea connection to the artificial larynx serves therefore also as an air inlet to the larynx when the user is breathing, or when he is not talking.

The operation of this embodiment of the invention is similar to that outlined with reference to Fig. 2 except that in use the larynx is held in the hand with the thumb holding the pad 32 down and blocking the opening 34. Further depression of the thumb pin against the restoring action of the springs 33 and 30 raises the pitch of the reed as the spring 30 grips a greater length of reed. The action of the reed under the influence of an air flow is similar to that already described. When the user stops talking he raises his thumb permitting the restoring force of the spring 30 to return the pad 32 to its initial position.

Referring now to Fig. 4 still another embodiment of this invention is shown. A cylindrical sound chamber 35 is divided into two compartments by a semi-circular tubular member 36 in whose flat surface 37 an elongated opening 38 is provided to form a passageway between the compartments. A paddle-shaped curved reed 39 secured at its end to the surface 37 is positioned before the opening therein. A pitch adjusting means similar to that described with reference to Fig. 2 is also provided. The rubber membrane 40 is designed to prevent the production of metallic sounds by the larynx. An extension of the tubular member 36 through the flat circular wall 41 of the sound chamber provides a suitable outlet to the mouth and the inlet 42 forms a part of the other sound chamber wall 43. The operation of this embodiment differs from that of the embodiment shown in Fig. 2 only in that the air flow passes directly under the reed to the opening in the partition.

Fig. 5 shows a modified form of the embodiment illustrated by Fig. 4 and also a feature not incorporated in any of those previously discussed. The semi-circular tubular member 36 of Fig. 4 is shown as the

member 44 in Fig. 5 and is provided with an opening 45 therein whose area may be controlled from the exterior of the larynx by means of rod 46 which projects through the upper wall 48 of the cylindrical sound chamber 47. The rod 46 is connected to a slide 49 having a slot 50 therein. The movement of the slide is limited by a screw 51 in the space traveled over by the slot. Providing a second opening in the partition separating the sound chamber 47 into two compartments is an expedient for reducing the intensity of the sound emitted by the larynx and, at the same time, maintaining the air flow and the blowing pressure constant. All the air passes into the mouth and the ability of the user of the artificial larynx to articulate consonants is not impaired. The opening 45 acts to reduce the low frequency content of the output of the artificial larynx in simulating what in an electrical system would be a shunt inductance. The air from the trachea connection (shown in Fig. 1) enters the sound chamber 47 through inlet 52, passes through the opening under the reed and also along the outer surface of the tubular member 44 and through the opening 45, if the rod 46 has been adjusted for that condition, and passes through the outlet 53 to the user's mouth.

The embodiment of the invention shown in Fig. 6 differs from that illustrated in Fig. 5 only in not having a sound intensity modifier and in having a breathing vent 54 over which the thumb or other finger may be placed when the artificial larynx is being used. It is to be understood, of course, that in each of the embodiments of this invention previously described in which a breathing vent in the larynx casing is not provided such a vent could be provided if desired but becomes unnecessary in all embodiments if the user of the larynx uses an air source other than his lungs.

What is claimed is:

1. An artificial larynx comprising a paddle-shaped vibratory reed, a portion of which has a finite radius of curvature of constant value.

2. An artificial larynx comprising a paddle-shaped vibratory reed one portion of which has a radius of curvature of constant value, the remaining portion having a relatively smaller radius of curvature.

3. An artificial larynx comprising a casing providing a sound chamber, an apertured partition member in said chamber, said partition having a breathing vent, sounding means within said sound chamber, a fluid inlet to said sound chamber, means connected to said inlet providing a conduit for a fluid to be passed through and modulated by said sounding means, a fluid outlet from said chamber, means connected to said outlet for insertion in the mouth of the user so that the fluid modulated may be introduced into the mouth of a user of the larynx, and means on said partition for controlling said breathing vent and for adjusting the intensity of the sound emitted by the larynx.

4. An artificial larynx comprising an elongated hollow casing that may be held in the hand of a user, said casing being closed at one end by a wall and open at its other end, means within said casing dividing it into two compartments, said means comprising a partition member having an opening therein and a vibratile reed having one end free to vibrate and positioned over said opening, said partition member fitting in a substantially air-tight manner against the inner surface of the casing, a removable cover member over the open end of said casing, said partition member and reed being supported thereby and removable therewith, said cover member providing a fluid outlet from one of said compartments, tubular means connected to said outlet for insertion in the mouth of a user of the larynx, means providing a fluid inlet to the other of said compartments, and means connected to said inlet and providing a conduit for fluid to be passed through and modulated by said larynx.

In witness whereof, we hereunto subscribe out names this 22 day of July, 1929.

ROBERT R. RIESZ.
GEORGE W. BURCHETT.