Aug. 13, 1946. O. ROBERTS 2,405,850

ARTIFICIAL LARYNX CONSTRUCTION

Filed March 22, 1945

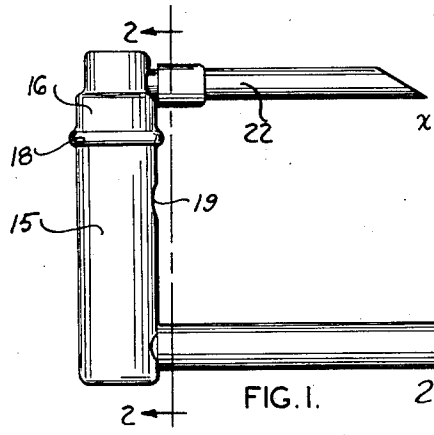


FIG. 1.

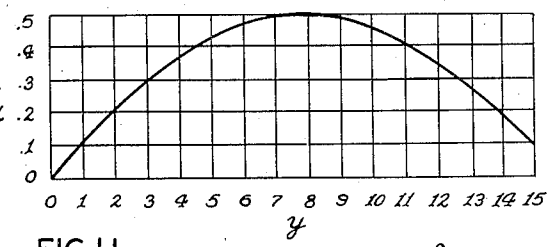


FIG. 11.

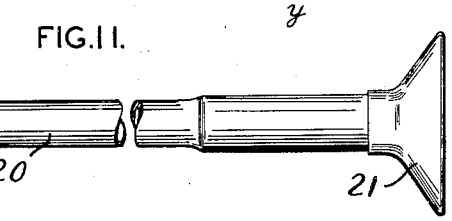


FIG. 2.

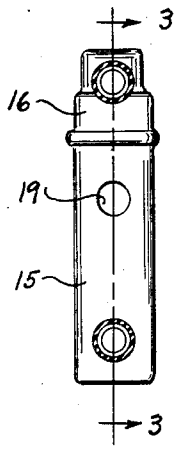


FIG. 8.

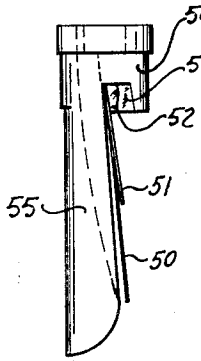


FIG. 9.

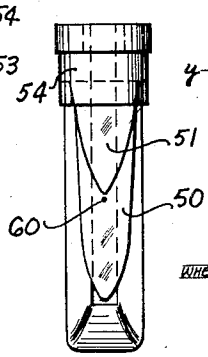
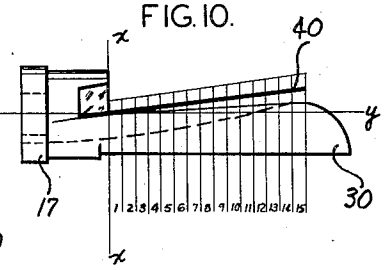


FIG. 10.



WHEN $y=$	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
$x=$	0	.11	.21	.30	.38	.44	.48	.50	.51	.49	.45	.40	.34	.27	.19	.10

FIG. 4.



FIG. 7.

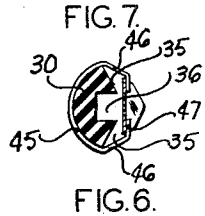


FIG. 3.

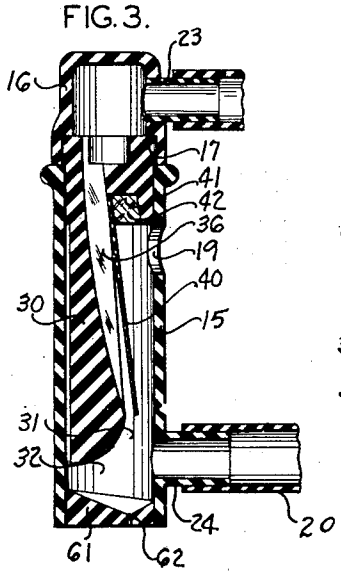


FIG. 5.

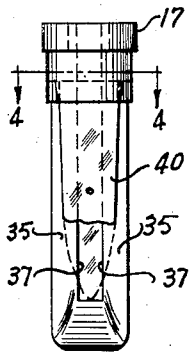
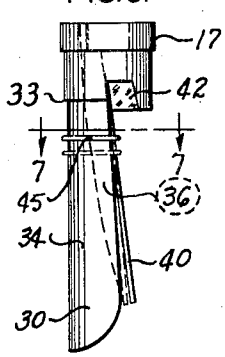


FIG. 6.



INVENTOR:
OTTIE ROBERTS

BY Robert B. Terry

ATTORNEY

Patented Aug. 13, 1946

2,405,850

UNITED STATES PATENT OFFICE

2,405,850

ARTIFICIAL LARYNX CONSTRUCTION

Ottie Roberts, East St. Louis, Ill.

Application March 22, 1945, Serial No. 584,189

15 Claims. (Cl. 3—1.1)

1

This invention relates to improvements in artificial larynx construction, and more particularly to improvements in and relating to the reed assemblies of artificial larynges, making for improvement in tone quality, timbre and modulation, and to certain improvements in sound box construction.

Exhaustive comparisons by applicant and others similarly afflicted, have revealed the irrefutable fact that artificial larynges of mechanical type, in distinction from those of electromagnetic or electrical types, are far superior to the latter. However, the principal shortcomings of artificial speech aids have heretofore included a difficulty in modulation of voice tones; a poor quality sometimes reflected in a brashness or harshness of voice, and a lack of naturalness of tone. The overcoming of these difficulties and the general improvement of artificial voice quality, accordingly constitutes a major and general objective of this invention.

More particularly stated in reference to structure, the present improvements have as an objective, an improved construction of lay, or reed-backing element, such as to improve and to result in more natural speech tones, and such as to prevent unwanted and undesirable effects often experienced otherwise, at the end of a syllable, word, or other speech sound; very importantly, this feature results in a marked reduction in air volume and velocity, hence reduces effort of the user required to produce the artificial voice in desirable volume.

Yet another object is attained in an improved relation of reed, preferably of beating type, and the companion and cooperating lay structure, such as to improve practicability of the instrument under all conditions of temperature, weather, and of use indoors as well as outdoors.

Akin to the next foregoing object is an improvement in means for removal of condensate from a sound box or similar enclosure of the instrument, without the requirement of valves or other liquid flow control expedients, and such that the condensate is automatically kept at a minimum amount under all conditions.

A still further object of the invention is attained in an improved reed construction involving the use, for certain purposes, of a multiple reed assembly in which the reeds bear a predetermined relation to each other, and each a predetermined relation to the lay.

An additional object of importance in improvement of timbre and even in relief from unwanted undesirable voice volume, is reflected in the present structure, objectively, by a careful and predetermined perforation of a reed element.

2

A further and important object is attained in an easily manipulable, fully enclosed, low cost expedient enabling a variation at will by the user or otherwise, of the pitch of the artificial voice by variation of effective vibrating length of a beating reed. This applicant is fully aware of numerous expedients for this purpose in earlier devices, over which the present structure constitutes a considerable improvement.

The foregoing and numerous other objects will more clearly appear from the following detailed description of presently preferred embodiments, particularly when considered in connection with the accompanying drawing, in which:

Fig. 1 is a side elevation of an artificial larynx assembly constructed to embody the present improvements;

Fig. 2 is an elevation of a sound or voice box as viewed from the side thereof normally adjacent the user, particularly as taken along line 2—2 of Fig. 1;

Fig. 3 is a vertical sectional view, somewhat enlarged, as taken along line 3—3 of Fig. 2;

Fig. 4 is a transverse sectional view through a reed assembly as taken along line 4—4 of Fig. 5;

Fig. 5 is an elevation in the nature of a plan view of the reed and lay assembly, a portion of the reed being broken away to reveal certain features of the lay structure therebeneath;

Fig. 6 is a side elevation of the reed and lay assembly shown by Fig. 5, and illustrating a mode of attachment and manner of use of a tone control appliance of the present invention;

Fig. 7 is a transverse sectional view as taken along line 7—7 of Fig. 6;

Figs. 8 and 9 are respectively, side and top or front elevations of a reed and lay assembly embodying a multiple reed arrangement;

Fig. 10 is a diagrammatic side elevation, illustrating graphically the development of best curvature of an irregularly curved lay surface immediately beneath or behind the reed, and

Fig. 11 is an exaggerated diagrammatic showing of the lay profile.

Referring now by characters of reference to the drawing, and with particular reference first to Fig. 1, the sound box, casing, or housing, sometimes known as a voice box, includes, in the example shown, a normally vertical cylindrical body 15, of a generally tubular form provided with an upper end closure 16 and a bottom or lower end closure hereinafter described. The upper clo-

sure element or plug may be made of a single piece of material or a plurality thereof as shown, and includes, besides the hollow cap designated by numeral 16, a plug proper 17 (Fig. 3) firmly and yet frictionally fitted into a cylindrical recess therefor in the cap, the relation of these parts being such that the cap may be easily angularly displaced about the axis of box 15. The body or box 15 is shouldered externally as indicated at 18, thus providing a firm and sturdy seating surface for the lower perimeter of the cap 16. As this general type of device is now well known in the art, it is sufficient merely to note for completeness that there is provided an air supply duct or tube 20 provided with an enlarged fitting 21 which, with the device in use, is held firmly adjacent the external tracheal opening of the user, or if desired, fitted to a tracheotomy tube. The tube 20, as will be well understood, serves as an air supply duct into the voice box 15 and serves controlledly to vibrate the reed assembly later to be described.

A resonance and modulating connection is provided for by a tube 22, directed from an upper zone of the chamber within the voice box, to the mouth of the user, for the purpose of taking advantage of normal resonance effects of the oral cavity and chambers of the upper throat and of the head, such as the sinuses of the user. To promote ease of breathing, with the instrument in place, but between periods of speech, an air outlet opening 19 is provided, which may be readily finger-controlled.

It is a distinct preference to construct the device throughout, with only unimportant exceptions later noted, of non-metallic material, such as hard rubber or of any of numerous other thermoplastic materials now available to the trade, similarly to hard rubber, in sheet, rod, bar or other stock shapes or if desired, many parts of the article may be produced directly by molding. The preferred exceptions to the otherwise completely non-metallic construction are found in top and bottom connecting tubes or bushing elements indicated at 23 and 24 (Fig. 3).

A number of years of personal experience and aid to others as well as instruction in the use of artificial larynges coupled with numberless experiments and modifications of existing types of these devices, has led this applicant to the conclusion that in a mechanical larynx employing a beating reed and lay, the correct design of lay is of utmost effect on voice quality. This feature being of extreme importance, will accordingly be first described, it being first noted that the design presently preferred is predicated upon the use of a flat, non-metallic, preferably hard rubber reed, the greater part of the length of which is normally free of the lay and the vibrating length of which is of the order of one and one-half (1½) inches. In the structure shown, the plug 17 which fits snugly yet removably into the upper portion of the tubular voice box 15, is extended downwardly in an integral portion thereof, to constitute the lay generally indicated at 30. The lay extends from the plug over the greater part of the length of the chamber 31 within the box, although this chamber is characterized by a lower unobstructed portion 32 for the reception and entrapment of condensate and saliva, if any. In order accurately to position the plug 17 in the box, the latter is provided with an internal shoulder against which rests a corresponding undercut portion 33 of the plug, and

which serves to limit the insertion of the latter in the box.

The lay 30 is characterized by a rounded back surface 34. Instead of providing a more usual flattened area on the frontal surface just beneath or back of the reed, the lay 30 is laterally bevelled as at 35, and is centrally longitudinally channeled, the channel being shown at 36. From the form of the channel 36 and the bevelling resulting in portions 35, there result a pair of longitudinal parallel edge portions 37 and which bound the channel 36 at the top and which present little if any, more than line contacts in all zones possibly engageable by the reed even under extreme conditions. It is important to note that restriction of the lay area permissible to be engaged by the reed, to merely line contacts, prevents any tendency of the reed to stick to the lay in a non-vibratile position due to accumulation of condensate, saliva or phlegm between the reed and lay. These difficulties have been seriously and frequently experienced with older forms.

It is an important feature of the invention to provide, within narrow limits of deviation, a particular contouring or profile of the reed-engageable surface of the lay, in the present example, this contouring being imparted to the edges 37. The profile arrived at by painstaking experience and numberless trials, is exemplified by the diagram of Fig. 10. Assuming for purposes of instruction only, that the line Y—Y be considered as horizontal and the line X—X as vertical, the curvature of irregular nature, best given the lay profile is as indicated by the legends accompanying and forming a part of Fig. 10. For this purpose it will appear that the active or vibrating length of the reed, generally indicated at 40 is divided into fifteen aliquot parts representing equal intervals along line Y—Y. In this case the several values of X proceeding along the line Y—Y, representing vertical distances therefrom to the contour line of the lay are given successively as .11, .21, .30, .38, .44, .48, .50, .51, .49, .45, .40, .34, .27, .19 and .10. The figures given are relative and may be considered as decimal portions of an inch, in constructing a lay suitable for use with a reed whose active vibration portion is of the order of one and one-half (1½) inches. In the example shown, the line Y—Y may be taken as indicating a plane containing a longitudinal center or median line, or axis of the voice box. The form of curve obtained by the ordinates and abscissae above given, is rendered more apparent by a relative exaggeration of the X dimensions to values ten times their actual proportion to the distances along Y—Y at which they are taken. From this exaggeration Fig. 11 has been derived, showing a lay profile curve which reveals that between Y values of 0 and 5, this first third of the lay profile, proceeding outwardly from the anchored portion of the reed, exhibits a relatively large slope, and is formed on a succession of large radii. Approximately the mid portion or central one third of the curve is formed on a succession of much smaller radii, and reverses its direction from about the center of the curve outwardly, but departs somewhat from true symmetry. The portions described are of much greater effect and more nearly critical in control of tone quality than the final one third of the lay underlying the free end portion of the reed, although the latter third preferably closely follows the contour shown and described, in which, as will appear from Fig. 11, the curve now converging toward Y—Y, may be considered as

formed on a succession of large radii. The slope, now opposite that of the first third of the contour, is somewhat less than that of the first third, but substantially exceeds the slope of either part of the central third of the profile or contour curve. While some minor deviation from the figures and profile given, is possible, this profile has been found optimum when employed with a rectilinear reed such as 40 which is disposed at an angle to the line Y—Y, of an order not exceeding limits of 5 to 10 degrees inclusive. The lay design contributes materially to a further important result, namely, a marked reduction in air volume and velocity required to attain a requisite and normal volume of speech. This reduction in effort of the user, enables continuous speech for several hours, without noticeable fatigue.

A further improvement in tone quality in the hands of various users, has been attained by a careful control of the depthwise profile of channel 36. The bottom of this channel, as will appear from the dotted line of Fig. 10, and from the contouring of Fig. 3, is in the form of a substantially regular curve, being an arc on a very considerable radius. This channel furthermore is of greatest depth in that portion underlying the anchored end of reed 40 and is gradually more shallow in proceeding toward the outer end of the lay underlying the outer end of the reed, the channel vanishing from the lay almost directly beneath the free tip of the reed 40.

There should be described for completeness a preferred mode of anchoring or positioning the reed in the reed holder, in the present case in plug 17; this is provided with a reed-receiving recess 41 into which is fitted an insert of a compressively resilient water-repellent material such as cork, the insert piece of which is indicated at 42 and which is normally of somewhat greater dimensions than merely enough to occupy the socket 41, and so when inserted in place over the reed is sufficiently compressed to retain the reed securely in place, yet permit its ready removal when desired.

It is regarded as of great importance to provide a seat, in the socket 41 for receiving the reed, such as to present the reed over the greater portion of its length, at such an angle to the lay that it normally lies and vibrates free of the lay. Experiments with different lay profiles and angularity of reeds lead to the conclusion that there is a distinct advantage in permitting no more than one-tenth of the vibrating length of the reed, normally to make contact with the lay. It will be noted that this is borne out by the accompanying drawing (Figs. 3 and 10), as well as in other figures.

Proceeding now to a description of the presently preferred means for modifying tone by control of the effective vibrating length of the reed, there is best shown by Figs. 6 and 7, a slidable clip for this purpose. This consists of a wide U-shaped element formed of flat, non-rusting metal stock, or of wire stock as shown. The tone control clip consists of an arcuate intermediate bridge portion 45 which is or may be of regular curvature and which conforms to and snugly embraces what may be referred to as the bottom surface of the lay 30. Connected to the arcuate portion 45 are a pair of convergent arms 46 (Fig. 7), these arms lying closely adjacent correspondingly shaped portions of the lay, in the region thereof gripped by the clip. Each of the arms 46 terminates in an inturned tang 47, the tangs 47 transversely overlying that portion of

the reed near the anchored reed end. The clip, as will appear from Fig. 6, is susceptible of sliding movement along the reed, as indicated by a comparison of the full line and dotted views of the clip. The U-shaped clip 45—47 is, by preference, formed of a tempered stock, or tempered after formation, so that it possesses a considerable constrictive effect and thereby affords a sufficient degree of frictional engagement with the lay, to remain in any practical adjusted position thereof. The advantages of this form of tone adjustment are found particularly in the facts that it may be formed as a one-piece, low cost element; embracing the reed and lay snugly, it adds nothing to space requirements of the assembly incident to the provision of tone adjustment; it is normally completely concealed, since disposed within the voice box, and the entirely internal arrangement avoids the otherwise unsightly protuberances externally of the voice box which characterize some of the older devices attempting the same result. The provision of a simple tone adjustment of this type enables a procedure which is of tremendous value in personalizing the instrument to the individual. In some cases wherein, for example, removal of the larynx is contemplated as by surgery, voice recordings of the individual may be taken in advance of surgery so as definitely to establish not only the pitch but other qualities of the voice. Following surgery or loss of speech for other reasons, the phonographic reproductions may be used as a standard of comparison for the several adjustments attainable by the present improvements.

For the purpose of personalizing the instrument to a degree heretofore unattainable, this applicant has determined that in certain cases an improved quality of artificial voice may be attained by the use of a multiple reed assembly as suggested by Figs. 8 and 9 for example, showing a highly satisfactory form of double reed. In this arrangement, each reed, a longer one being indicated at 50 and a shorter reed at 51, may consist of beating type reeds of flat sheet hard rubber, or other preferably non-metallic material. A similar anchorage provision is provided in the slot or socket 52 in which is disposed the compressed cork filler element, as indicated at 53. The reeds are inserted in the position shown by the drawing in the socket 53 of a plug 54 integrally depending from which is the lay 55 which is or may be similar in all respects to the lay element 30 heretofore described. In the double reed assembly, the arrangement is preferred such that the vibrating length of reed 50 is approximately twice that of the reed 51, with the clip 45 in zero position. Although by no means exclusively employed to advantage with women patients, this arrangement enables a close approximation of the natural female voice. It will be understood of course that, as may be desired, the tone or pitch control clip 45—47 may be employed with the combination shown by Figs. 8 and 9.

Yet another improvement which has been found of tremendous advantage in relieving the vibratile assembly of certain objections which appear in the hands of some users, is the expedient of perforating the beating reed, or the lowermost such reed as indicated at 50, in the case of multiple reed assembly. The perforation, one example of which is indicated by the small circular opening 60 (Fig. 9), is preferably located about centrally of the length of the reed and

preferably also about centrally of the reed in a transverse direction. In any event, in the case of a multiple reed assembly, the opening **60** is located so that it will not be covered or obscured by the overlying reed end. Various forms of opening **60** have been tried, and while all thereof have proven useful for their intended purpose, it is preferred to provide the opening **60** with rounded margins rather than rectilinear or square margins characterized by corners. The most satisfactory arrangement is a simple drilled or reamed opening which is small, usually not exceeding $\frac{1}{32}$'' in diameter and in most cases, $\frac{1}{64}$''. In making tests with this improvement, a small opening is first provided which may be re-drilled or reamed gradually to enlarge the opening to ascertain optimum results. This feature has been found particularly useful in the case of certain male users whose artificial voices are characterized by an unwanted volume and who experience a difficulty in modulation of air volume and pressure applied to the instrument. The provision of the reed aperture renders much less critical the varying amounts of air supplied to the instrument.

A further improvement of a highly practical nature consists in a novel provision for relieving the sound box **15** of moisture accumulating internally thereof incident to protracted usage. Such accumulation of moisture is primarily condensate, but may in some cases consist in minor proportion of saliva entering the box through the mouth tube **22**. The provision of manual valves and other expedients for removing this moisture introduces a structurally undesirable condition and renders the instrument less susceptible of thorough sanitation. Accordingly, in lieu thereof, there has now been provided a self-clearing moisture removal feature found in the construction of the bottom closure element **61**. It will best be noted from Fig. 3, that this plug or closure is located appreciably below the lowest part of the connection **20—24** so as to form a well in the lower portion of the unobstructed chamber **32**. The upper portion of member **61** is formed as an irregular funnel, so that its surfaces converge from the box walls and from the upper funnel margins toward a capillary drain conduit **62**. The provision of a capillary passage in this zone acts, through surface tension, normally to retain a slight amount of moisture, as same accumulates, in the bottom of the sound box. Any unwanted excess is however periodically expelled through the opening **62** due to normal air inlet pulsations. Only a very moderate pressure in the chamber **32** being necessary to overcome the surface tension of the liquid and to aid in its periodic expulsion by gravity, this arrangement has been found very satisfactory, particularly under conditions of long outdoor usage of the instrument in cold weather, but is also of advantage under all temperature and humidity conditions.

The device as described and embodying present improvements or some thereof, has been found more nearly to approximate the human voice after a moderate period of experience therewith by the user, than any instrument for a similar purpose now in existence. By making it throughout, with only unimportant exceptions, of non-metallic, impervious non-resonant materials, it may be at the same time constructed of minimum weight and bulk. It should be noted that the tube **22** through the provision for rotation of cap **16** may be easily swung aside for any desired purpose so as to enable shipment, or carrying the instrument in the pocket, in the least possible compass. It will now have appeared that the device in its present highly developed construction serves fully to attain each of the several objects specifically above enumerated, and many others implied from or expressed in the ensuing description.

Although the invention has been described by making detailed reference to certain presently preferred examples, the detail of description is to be understood solely as instructive, and not in any limiting sense, numerous variants being possible within the scope of the claims hereunto appended.

I claim as my invention:

1. In a reed assembly of an artificial larynx, a reed of beating type, a reed backing element or lay, a lay and reed support by which one end of the reed and one end of the lay are carried, and a sound box enclosing the reed and lay, the lay being longitudinally channelled over that portion of its length which is coincident with the reed, the lay being irregularly curved in longitudinal section, in such manner that the portion of substantially one-third of the length of lay proper, just beyond the supported end of the reed, is characterized by a succession of relatively large radii of curvature and a high degree of slope, the intermediate one-third of the effective length of the lay being convexly curved on distinctly lesser radii and exhibiting a markedly lesser degree of slope, and the outermost effective portion of the lay being characterized by a succession of relatively large radii of curvature and a greater slope than any portion of the intermediate portion.

2. A reed assembly for an artificial larynx, including a reed of beating type, a lay, an element supporting corresponding ends of the reed and lay, a sound box about the reed and lay, closed at one end by said supporting element, the lay being curved over its effective length underlying the reed and characterized by a curvature on a succession of large radii at each end portion and a succession of much lesser radii of curvature and of convex form in its intermediate portion, the reed being supported so as, when in non-vibrating relation, to be disposed distinctly out of contact with the reed over at least ninety percent of the effective vibrating reed length.

3. The combination and arrangement of elements as recited by claim 2, but further characterized in that the lay is formed to provide a pair of distinctly outstanding, substantially parallel edge portions, the transverse spacing of which is substantially less than the width of the reed, and in which arrangement the said irregular curvature is imparted to said edge portions, the edge portions being presented toward the reed.

4. In the reed assembly of an artificial larynx, a beating type reed, a reed lay, the reed and lay being supported in a voice box or the like with the reed free of the lay over at least 90 percent of the vibrating reed length, the reed being substantially flat and rectilinear in longitudinal and transverse sections, the lay being formed to provide a surface in the region of and opposite the reed, which surface is of irregular curvature, being formed on a succession of relatively large radii close to the anchored end of the reed, characterized by an arched intermediate portion curved on substantially lesser radii, and an outer portion curved on large radii and approaching a flat aspect, but with all said curved portions of the lay formed on substantial radii markedly exceeding the length

of the reed, the reed being disposed at an angle to a chord line connecting the ends of the said curved lay portion, which angle is within limits of the order of 5 to 10 degrees.

5. The combination, structure and arrangement of elements as recited by claim 4, but further characterized in that the irregularly curved section of the lay is imparted to edge-like projecting portions extended toward the reed from the lay, which edge portions constitute the sole zones of engagement of the greater part of the reed length, with the lay.

6. The combination and arrangement of elements as recited by claim 4, in which the said chord line connecting extremities of the irregularly curved portion of the lay, lies substantially parallel and close to a longitudinal median plane of the voice box.

7. In a reed assembly of an artificial larynx, a reed of beating type, a lay, a voice box enclosing the reed and lay and including a lay and reed support, the lay being longitudinally channelled over that portion of its length coincident with the reed, and the lay being irregularly curved in the portion presented toward and in the region of the reed and being characterized by a relatively high slope and formed on large radii of curvature, both near the supported end of the reed and near the free end of the reed, with a distinctly arched portion formed entirely on lesser radii of curvature and located between the first said portions, the lay being formed to present said curved portions as edge-like elements toward the reed, with the channel of the lay therebetween, said channel being depthwise formed substantially as a regular arc on a substantial radius, and gradually increasing in depth, from a zone near the free end of the reed, rearwardly or toward the anchored end thereof.

8. The combination and arrangement of elements as recited by claim 7, but further characterized in that the reed is a substantially flat beating type element of sheet hard rubber, and when in non-vibrating position, is free of engagement with the lay over at least ninety percent of the vibrating length of the reed.

9. In an artificial larynx, a beating reed assembly including a lay and two beating reeds of substantially different length and mounted in superposed relation.

10. In a reed assembly for an artificial larynx, a reed holder including a lay and a pair of beating type reeds, the reed holder having a socket adapted to receive the supported ends of both reeds, the reeds being of substantially similar shape, but of substantially different length, the anchored end of each reed extending into the socket therefor, and a reed-anchoring element compressed in the socket and overlying the adjacent ends of the reeds.

11. In the reed assembly of an artificial larynx,

a combined reed holder and lay, an inner reed and an outer reed, the reeds being of beating type, the outer reed being of a length substantially of the order of one-half of that of the inner reed, the outer reed overlying that portion of the inner reed nearest the zones of anchorage of the reeds, and both said reeds being of a flat non-metallic sheet material.

12. The combination, structure and arrangement of elements as recited by claim 11, but further characterized in that the inner reed is provided with an aperture substantially intermediate the vibrating length of the reed, and intermediate its side margins, the aperture being located beyond the outer reed, so as not to be obstructed thereby.

13. In a reed and lay assembly for an artificial larynx, a reed of beating type, a lay, an element supporting corresponding ends of the reed and lay, a sound box about the reed and lay, the lay being curved over its effective length underlying the reed, substantially the first one-third of the lay, beyond its supported end, closely approaching a rectilinear contour but exhibiting a slight convexity, the adjacent portion of substantially one-third of the effective length of the lay being appreciably arched and convexly presented toward the reed, the lay surface being continued into a portion most remote from the supported end of the reed, in a distinctly diverging relation thereto.

14. The combination, arrangement and conformity of elements as recited by claim 13, but further characterized in that the lay is provided with a longitudinal channel, and in which the stated irregularity of curvature is imparted to a pair of parallel edge portions extending longitudinally of the lay, and constituting the sole areas of possible contact of the lay by the reed.

15. In a reed and lay assembly of an artificial larynx, a beating type reed element, a lay element, a spring member substantially embracing both said elements and freely slidable therealong, the spring member being constrictively resilient and thereby tending frictionally to maintain an adjusted position along said elements, the lay element being of irregular curvature, characterized by a slight convexity over substantially one-third of the vibrating length of the reed element, and therebeyond being characterized by a distinctly curved portion arched convexly toward the reed element, thence being extended from the said arched portion in a markedly divergent relation to the reed element, said irregular lay curvature and the relation of said elements and the spring member being such that movement of the spring member for adjusting purposes, serves simultaneously to effect both a variation in vibrating length of reed, and the cooperative relationship between the reed and lay elements.

OTTIE ROBERTS.