

## **An artificial larynx / by T.P. Anderson Stuart.**

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1898

With the writer's Compl. to  
Prof. McKendrick.

# AN ARTIFICIAL LARYNX

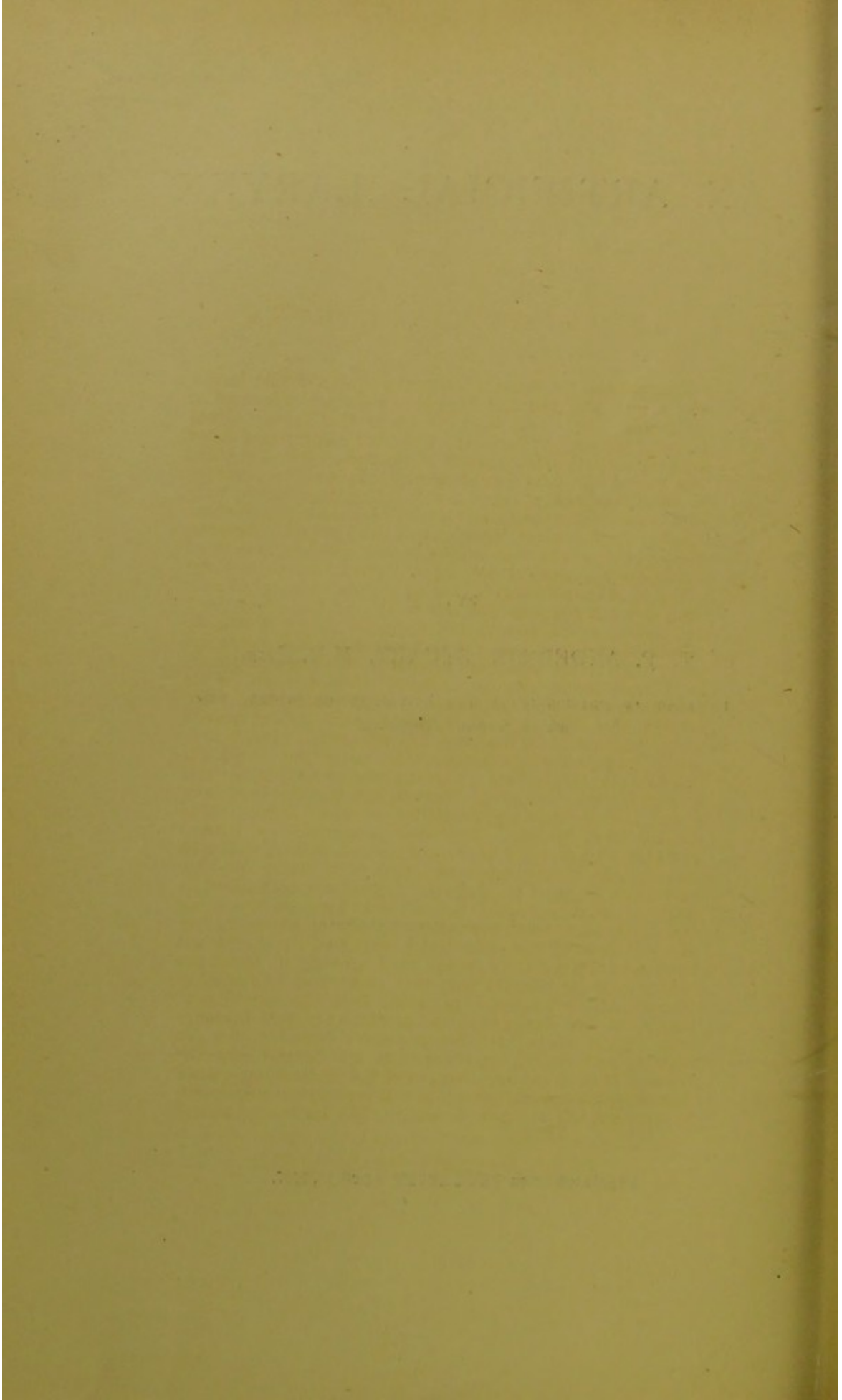
BY

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## AN ARTIFICIAL LARYNX.

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THE patient for whom I contrived this artificial larynx was a man who had had his larynx removed on account of carcinoma, by Dr. A. MacCormick at the Prince Alfred Hospital, Sydney, on Jan. 31st, 1895, and was brought under my notice by Dr. MacCormick in the end of the same year. The wound had duly healed, leaving the tracheal opening, in which the patient wore a soft rubber tracheotomy tube with a soft rubber shield, and leaving also above the tracheal opening a small fistula opening into the pharynx. Between these two openings was a wide groove not deep enough to contain an apparatus of any size. Further, the patient had a deal of chronic bronchitis, and so frequently coughed up a copious tough secretion that any of the artificial larynges I had read of or had seen figured appeared to me to be quite unsuited to his case, owing to the ease with which secretions could lodge on the reed and so silence it. Moreover, in all such instruments, as, for instance, Gussenbauer's or its modifications, where respiration and phonation take place through the same channel, if that channel is large enough for respiration it is too large for phonation, and if it is small enough for phonation, then it is too small for comfortable respiration. Further, where respiration and phonation are through a common opening the reed may sound during ordinary breathing—a most objectionable feature when present. This was recognised by Heine,<sup>1</sup> and Heine accordingly made the reed so that it could be moved aside during respiration—that is, it was in position only when required to phonate. I therefore determined to start on what appeared to be new lines—to make an instrument with which the patient's breathing should be free and unrestrained, and with which therefore he should not habitually breathe through the reed opening, in which the reed should be brought into play only when he desired to phonate, and which, being protected from the secretions of the air and food passages, should continue to act all day long, even during meals. It also appeared desirable that no metallic part should anywhere come into contact with the tissues. It is, moreover, obviously of the greatest importance that the patient should himself be able to apply the instrument, to remove it and to clean it easily. The instrument should

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<sup>1</sup> Böhm. : Correspondenz-Blatt, No. 17, 1874.



also be comfortable to wear and thus willingly worn. All of these conditions were fulfilled by the instrument to be presently described, so that the patient himself applied it and wore it all day long, even during meals, and removed and cleaned it himself. I mention these points somewhat prominently, because from the figures—for I never saw an artificial larynx until I had made one—I should say that, at all events, some of these larynges were anything but comfortable to wear, even if they were efficient as phonators. Indeed, comfort in the wearing of such instruments is almost as important as their efficiency as sound producers, because the patient will very soon lay them aside if they are not comfortable. Further, the flexibility of its parts and the ease with which their exact shape and dimensions can be modified to permit this larynx to be adapted to almost any conceivable case, for each case has its own peculiarities, and, moreover, it requires no very skilled workman to make it, so that it can be made almost anywhere, since there are few places where one cannot find a clock- or watch-maker or a jeweller. As a matter of fact, I have availed myself of such materials only and of such workmanship as may be had in any part of the world almost. This, however, is a distinct advantage, for cases requiring the application of substitute larynges are not so common that in practice the artificial substitutes can be kept in readiness for possible cases.

Hitherto, when speaking of the clogging of the reed, I have had in view mainly the tracheal secretions, but in truth the mouth secretions may be very copious. The difficulty has been recognised and has been met by a lid in Gussenbauer's larynx<sup>2</sup> to act like a little epiglottis, on the theory that the epiglottis acts like a lid, a theory, however, which we have shown to be incorrect.<sup>3</sup> In other modifications of Gussenbauer's larynx an obturator<sup>4</sup> is used; in others a cork or a plug of cotton-wool (Czerny), and so forth. In my instrument the difficulty is entirely got over; no saliva escaped down the pharyngeal tube, and the patient swallowed his meals without any, even liquid, food coming down; but further, even if it had come down, it would have been very easy to get rid of it before it touched the reed. I had one larynx made with such a provision (see Fig. 5, *g*), but since I eventually found that it was unnecessary I omitted it in the final form. In Gussenbauer's form the reed can readily be removed and replaced for the purpose of being cleaned, and I fancy that, owing to the secretions and coughing, this will often require to be done. By the protection afforded to the reed in my instrument the necessity

<sup>2</sup> See Fig. 1097, International Encyclopædia of Surgery, vol. v. London: Macmillan and Co., 1885.

<sup>3</sup> See Anderson Stuart and MacCormick: The Position of the Epiglottis in Swallowing, Journal of Anatomy and Physiology, vol. xxvi., 1892.

<sup>4</sup> See Fig. 36, The Operations of Surgery, Jacobson, second edition. London: J. & A. Churchill, 1891.



for removing it is abolished. I did make a form in which the reed was removable, but I abandoned it when I found that the provision was not needed. Obviously the more simple one can make such things the better—so long as they act efficiently, and of this there can be no question at all in the case of the instrument now under description. The tone of the voice produced was, I dare say, monotonous, as, indeed, has been described in connexion with other instruments of the sort; yet the word monotonous conveys rather a false impression, for although modulation in the sense of varying the pitch of the sound produced within the artificial voice-box was not possible, yet the resonating chambers by variously reinforcing the fundamental tone and its overtones did introduce a sort of modulation or timbre which prevented the voice from being quite without character. The patient's family, for instance, told me that in the new voice there was a distinct reminder to them that their father was speaking, with a voice much altered of course, but still with much of the character of the old voice. The reeds which I used were of the commonest. I merely cut into segments the reed-plate of a common mouth-organ; each segment was a reed and the lowest pitched ones were used—viz. d, e, and a. Owing to the untimely death of the patient from scurvy I had not an opportunity of trying other than these reeds, otherwise I should have tried the non-metallic reeds of ivory, horn, cane, and vulcanite which Foulis<sup>5</sup> says he found to be better than the metallic. The modified Gussenbauer's larynx, with the lobster-tailed tracheal and pharyngeal tubes figured in Jacobson<sup>6</sup> shows that the desirability of having the tubes flexible had already been recognised. In the "International Encyclopædia of Surgery" already quoted similar devices are said to have been made by von Bruns and by Caselli. In truth, judging from what I saw in my own case rigid unyielding tubes would have been most comfortable. Even the lobster-tailed tubes, however, cannot have been so comfortable as the ones I adopted. First, with regard to the tracheal tube, of necessity the patient wears a rubber tracheal tube from the time of the operation, so that by the time he is ready for the substitute larynx he is quite accustomed to the rubber tracheal tube. My form of the larynx, then, is simply inserted into the mouth of this, his ordinary tracheal tube, and nothing new to him is introduced, so that the application of the artificial larynx did not at all worry the patient.

In regard to the pharyngeal tube, it must fit the fistula, or fluids will come down by the side of it, keeping the neck of the patient and the mouth of the tracheal opening continually wet. The size of the tube will vary with that of the fistula, but as the latter is more or less under control (of this more later) it is as well to keep it small, the outside diameter of the tube being a little over 6 mm. It should

<sup>5</sup> THE LANCET, Jan. 26th, 1873.

<sup>6</sup> Loc. cit.



be quite flexible in every direction transversely, but at the same time rigid longitudinally when compressed, so that it may be pushed into the fistula, and in the movements of the head and neck run no chance of kinking, while at the same time it freely yields to these movements. It should likewise be incompressible laterally, so that no pressure of the muscles or other parts can occlude it. Rubber tubing does not meet these conditions unless the wall be very thick, but in that case the lumen of the tube is very small, considering the size of the tube externally. Farther, I found that the valve which I adopted at the upper end of the tube was with difficulty fixed to the rubber. My first successful pharyngeal tube was the vein of an ox hardened in 2 per cent. solution of alum for forty-eight hours. The vein was supported by a closely wound spiral of piano wire half a millimetre thick. The outside measurement of the coil was 6 mm. The coil ended in a less closely wound cupola, at the apex of which the wire was turned into the interior of the whorl, so that it could not injure anything. The vein being left projecting about one-third of an inch beyond the apex of the wire coil, air could pass upwards freely, though fluids could not pass into the tube downwards. The cupolar ending of the coil prevented the wire from cutting the vein, kept the vein from being inverted into the interior of the coil, and gave a more or less pointed end for introducing the tube into the fistula. The wire was not closely wound at the cupola, and thus permitted the air to escape without obstacle. The vein, however, proved too fragile—the wire tore it during the act of introducing it, the movements of the pharynx tore it over the cupola, and the warmth and moisture softened it and made it useless. I then tried tubes of silk, cotton, and thin leather, but finally found perfect satisfaction in winding a strip, 12 mm. wide, of sheet rubber a quarter of a millimetre thick, such as is used by dentists, slightly on the stretch, obliquely around the wire coil, with its edges slightly overlapping so as to make a continuous tube. The wire coil has, as it were, a spiral bandage of rubber applied to it. The more the rubber is stretched during its application the more unyielding is the resulting tube. If the rubber available is very thin one may have two layers, and in that case one would commence below and wind upwards, and then return winding downwards to the base-collar, to which the rubber is then made fast by a thread. When only one layer of rubber is used one had better begin to wind it above, the upper end being fixed by winding one or two turns, one over the other, before commencing to descend. The valve at the upper end of the pharyngeal tube is made of a piece of suède or kid leather and is absolutely efficient, for while when wet it readily permits the sound-bearing air to pass into the pharynx it quite prevents anything from passing down into the artificial larynx, so that the patient wore the apparatus the livelong day. The valve is attached to the wire coil by a loop of thread around

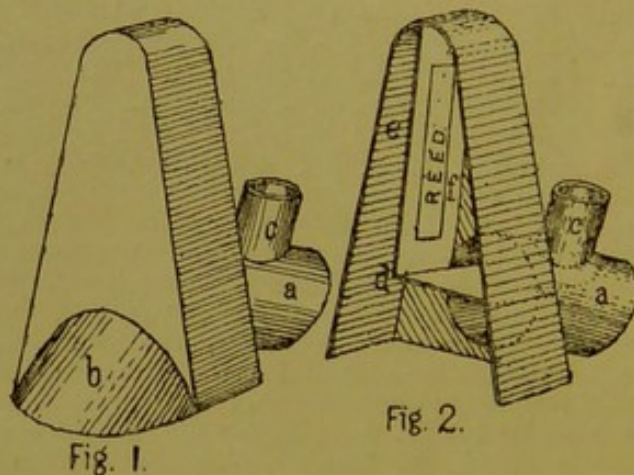


a part of the coil, where two or three turns of the wire are soldered together, so that the thread has no chance of separating the wire turns. The free part of the valve is from 12 to 15 mm. long. At its lower margin it is covered by the rubber, so that there is an easy transition from the surface of the rubber to the leather, and the rubber helps to bind the valve to the wire coil. Before introducing the tube into the fistula the valve should be wetted and rolled between finger and thumb or folded upon itself lengthwise, so that it becomes a sort of point to the tube. The patient may wet the tube with saliva as a lubricant, and whilst it is being pushed in it should be rolled round its long axis to help its progress. Coughing not infrequently is excited when the tube enters the pharynx, but in my case it very soon ceased. It is of importance that the pharyngeal tube be neither too long nor too short, for if too short the force required to drive the air through it is too great, while if it be too long it irritates the pharynx and gets in the way in swallowing. To measure accurately the length required I fixed to the base collar a small flexible rubber tube about one and a half feet long; the other end was in my own mouth, and by blowing I kept up a steady air pressure while the tube was passing up the fistula. When the air passed quite freely I marked the length of tube within the fistula, and adding a little extra to allow for movements of the parts I took this as the length of the tube to be ultimately adopted. When the leather wears out the valve can be easily replaced. Placed as I was at the Antipodes, I had, as already said, to work with the materials to be had on the spot, and I accordingly used sheet brass from  $\frac{1}{2}$  to 1 mm. thick, soldered at the joints. Owing to their non-corrosibility, gold plate and vulcanite would have been good materials in which to make the permanent form. Further, it might be advantageous to have a sort of hood on the front of the rubber shield to lodge and cover the artificial voice-box, partly to protect it and partly to make it inconspicuous, though owing to its small size this larynx was not very noticeable. I once went along a crowded street with the patient wearing the larynx and hardly anyone noticed him.

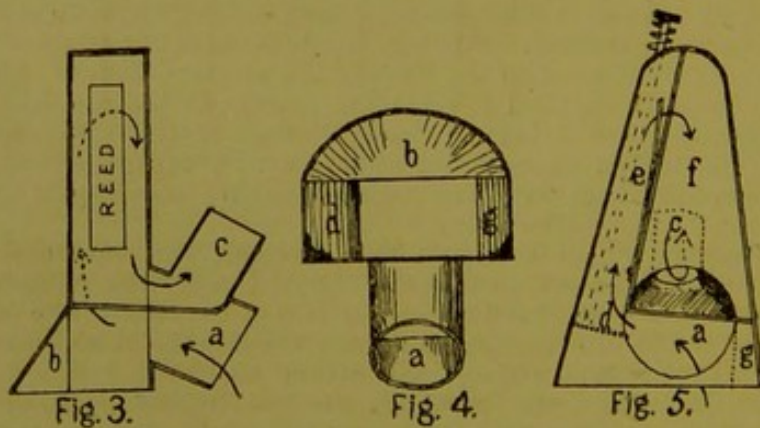
The pharyngeal fistula in this case was the upper end of the original wound, so that the line of the cicatrix extended downwards from the fistula. As it was found that the presence of the tube seemed to stretch the cicatricial tissue and dilate the fistula unduly, the fistula was by a subsequent operation closed, and at the same time a new opening in sound tissue was made just below the hyoid bone. A small rubber tube closed at the upper end was kept in the new opening until granulation was complete, and the pharyngeal tube now inserted gave entire satisfaction. I may mention in passing that the epiglottis was absent. At this stage the question was raised whether it would not be desirable when practicable to close the œsophageal wound at the time of the first operation. The pharyngeal opening for the artificial



larynx could be made at the same time or subsequently. Meanwhile, the closure of the gullet would prevent the escape of fluids which is such a source of trouble and danger. Should another opportunity of performing the operation present itself Dr. MacCormick proposes, immediately after stitching the trachea to the edges of the skin, to bring together the



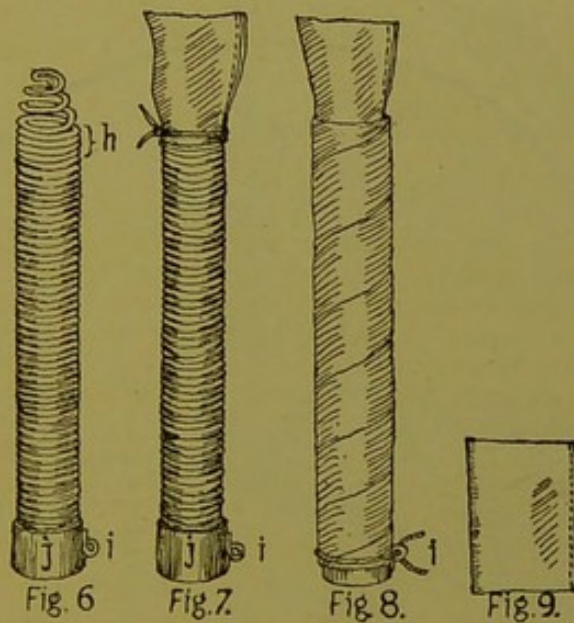
edges of the mucous membrane of the alimentary canal and secure them with interrupted sutures of catgut, and then to bring together and secure in like manner the edges of the skin with sutures of horsehair. Feeding would thus be from the first by tube through the nose or the mouth, so as to avoid interference with the oesophageal wound, and when



the time came for the fitting of the artificial larynx an opening—if not already made at the time of the first operation—would be made just below the hyoid bone, and either in the middle line or to the side, according to circumstances. In the event of the new opening for the pharyngeal tube being made at the time of the first operation the new open-

ing might be made use of to feed the patient by pumping the food through a fine catheter.

Points which the foregoing description may not have made clear will most likely be understood on reference to the figures. Fig. 1 : The artificial larynx before its tracheal tube *a* is inserted into the rubber tracheal tube, as seen in Figs. 10 and 11. The hood *b* widens the inferior opening of the larynx; owing to this enlarged inferior opening the escape of the air in expiration is made so easy that very little of it passes upwards through the passage *d* to the reed, and thus the reed does not sound except when the inferior opening is closed during phonation. The closure being effected by grasping the larynx between finger and thumb (the finger on the apex of the larynx and the thumb over the inferior opening), the closure is rendered



more easy by filling the right angles of the inferior opening with solder, as is seen in Fig. 4. The complete septum between the butt of the pharyngeal tube *c* and the tracheal tube *a* is partly indicated by a dotted line in Fig. 2, but is seen best in Fig. 3. The arrows in Fig. 3 and Fig. 5 show the direction taken by the air during phonation. Fig. 2: The larynx with front removed, showing the opening *d* leading out of the inferior chamber of the apparatus into the chamber *e*, whence the reed opening leads into the chamber *f*, which now leads into the pharyngeal tube *c*. These relations are seen also in Fig. 5. Fig. 3: A vertical and antero-posterior section. The dotted parts of the arrows are within the chamber *e*. The lower arrow passes through the opening *d* and the upper arrow through the reed opening.



The course of the air in phonation is thus *a, d, e, f, c*.  
 Fig. 4: The larynx as seen from below. The space *g* is in the simpler form of the apparatus a part of the general inferior opening, but where the chamber *f* is drained, as in Fig. 5, the space *g* is the lower end of the drain; in that case the dotted line alongside *g* in Fig. 5 is a solid septum, and the septum between *a* and *f* is wanting above *g*. By

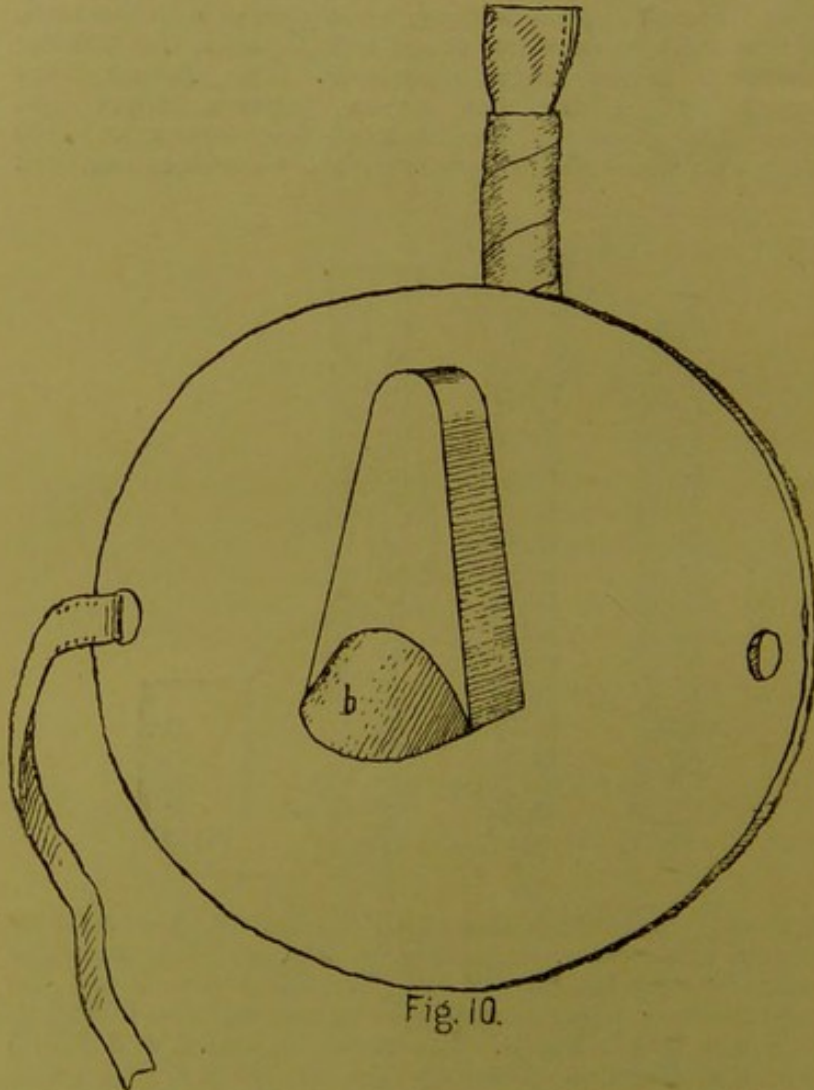


Fig. 10.

the filling up of the posterior angles of the wide inferior opening of the instrument closure by the thumb in phonation is more easily accomplished. Fig. 5: A vertical transverse section. This figure shows two modifications which may perhaps be useful in particular cases, though neither was needed in my case. The opening *d* may be closed by

the valve shown when, in violent coughing, secretion is forced up into the chamber *e*. This valve is depressed when the larynx is grasped by the finger and thumb during phonation, and it is raised again by the spiral spring shown around its stem. The chamber *f* may be drained by the channel *g*, if it is found that secretions get into the chamber *f*. This channel also is closed by the thumb in phonation.

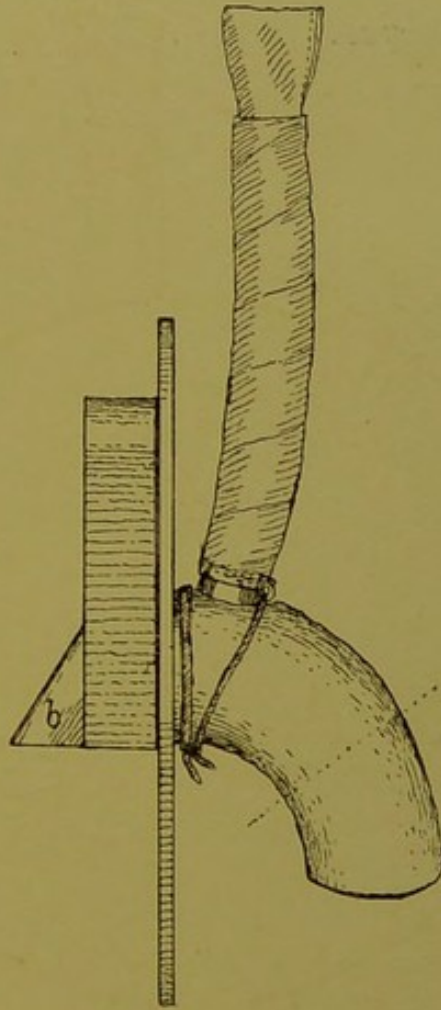


Fig. II.

Figs. 6, 7, 8, and 9 show the pharyngeal tube and its parts; the wire collar is soldered to the brass collar *j*, which fits upon the butt of the pharyngeal tube *c*. The three turns at *h* are soldered together, so that the leather valve, Fig. 9, may be tied upon the coil here. The turns in the dome are somewhat widely separated, so as to offer less resistance to the sound-bearing air. The end of the wire is turned within the dome, so that it cannot injure anything. The end of the



thread by which the rubber bandage is secured to the brass collar is brought through the ring *i* and then round the tracheal tube as in Fig. 11, so that the whole is secure. Figs. 10 and 11: Almost a full face view and a full profile view of the entire apparatus fitted up ready for use. The obliquity of the tubes *c* and *a*, as shown in Fig. 3, enables the larynx to accommodate itself to the direction of the pharyngeal and tracheal openings.

Sydney, New South Wales.