

May 28, 1940.

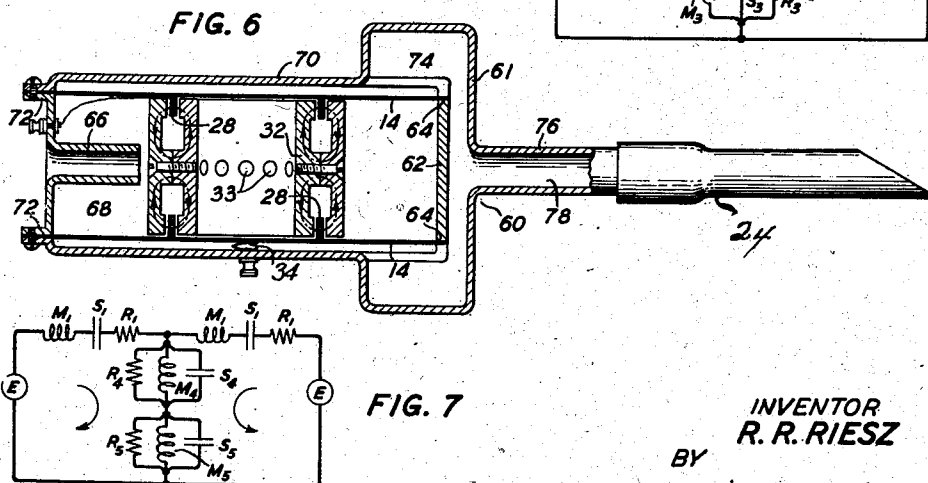
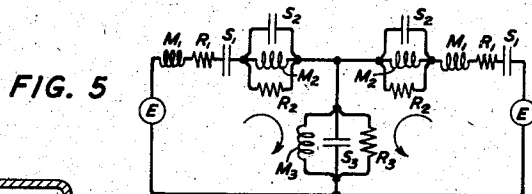
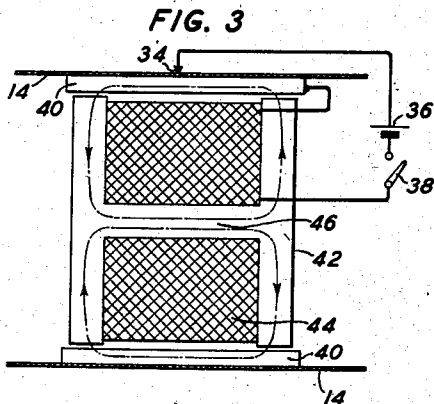
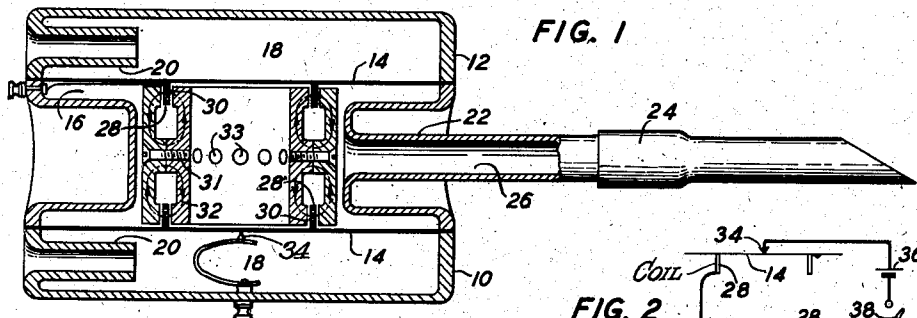
R. R. RIESZ

2,202,467

ARTIFICIAL LARYNX

Filed July 23, 1936

2 Sheets-Sheet 1



INVENTOR
R. R. RIESZ
BY
Walter C. Kiesel
ATTORNEY

May 28, 1940.

R. R. RIESZ

2,202,467

ARTIFICIAL LARYNX

Filed July 23, 1936

2 Sheets-Sheet 2

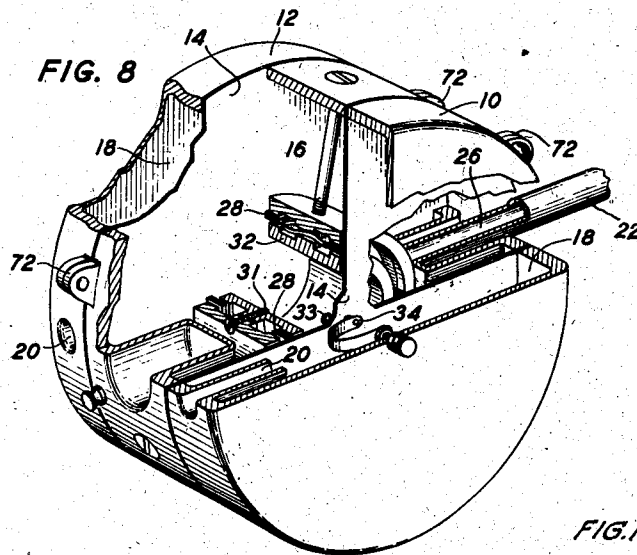


FIG. 10.

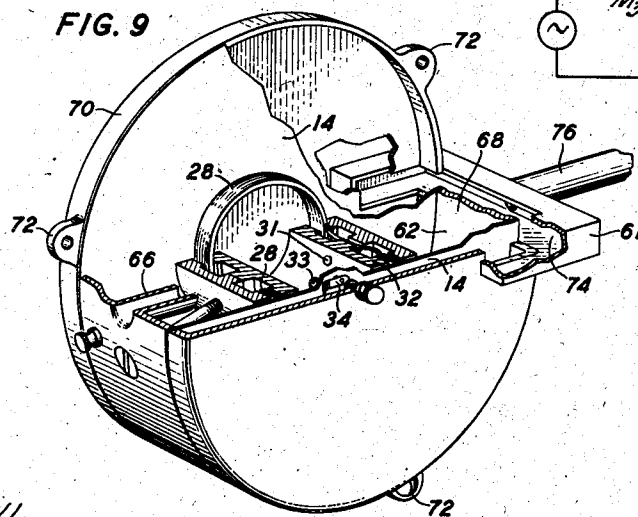
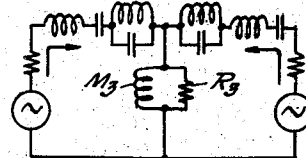
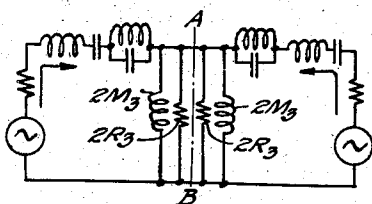


FIG. 11.



INVENTOR
R. R. RIESZ
BY
Walter C. Kiesel
ATTORNEY

UNITED STATES PATENT OFFICE

2,202,467

ARTIFICIAL LARYNX

Robert E. Riesz, Mount Vernon, N. Y., assignor
to Bell Telephone Laboratories, Incorporated,
New York, N. Y., a corporation of New York

Application July 23, 1936, Serial No. 92,107

11 Claims. (Cl. 3—1)

This invention relates to artificial larynges.

An object of the invention is to enable a person to produce artificial articulate sounds that simulate articulate sounds produced in the natural manner.

Artificial larynges, particularly of the electrical type, have, up to the present time, the disadvantage of large size. Experience with individuals using such artificial speech aids indicates that to be generally satisfactory and commercially acceptable, they should be as small and as inconspicuous as possible. The size of the larynx tone generating or producing member or diaphragm, of the chambers associated with the diaphragm, and of the driving mechanism, are factors.

A large diaphragm is desirable because of the large amount of fluctuating air flow that must be pumped out of and sucked into the mouth tube of the larynx and the difficulty of making a small diaphragm vibrate with a large amplitude. In accordance with the invention, a marked reduction in size may be obtained if several diaphragms are made to vibrate in phase and to pump air into and out of the larynx mouth tube. A single diaphragm may be replaced by two diaphragms that move to and from each other in synchronism and vibrate with the same amplitude as the single diaphragm, each diaphragm having a diameter .707 times that of the single diaphragm; the chambers associated with the two diaphragms may be made more shallow; and the diaphragms may be coil driven or electromagnetically driven in accordance with this invention.

Another object, therefore, is to reduce the size, simplify the structure and increase the efficiency of the artificial larynx, particularly of the electrical type.

A feature of the invention comprises an artificial larynx comprising a plurality of larynx tone producing or generating members or diaphragms.

Another feature comprises such a larynx in which the diaphragms move toward and away from each other in synchronism.

Still another feature comprises such a larynx in which the diaphragms are driven by coils attached thereto and disposed in suitable magnetic air-gaps.

A further feature comprises such a larynx in which the diaphragms are tuned to the same or different frequencies.

Another feature comprises an artificial larynx comprising an acoustical system having the characteristics of a band pass filter.

Other and further features will be apparent from the description that follows hereinafter.

A more complete understanding of this invention will be obtained from the following detailed description, read with reference to the appended drawings, wherein:

Fig. 1 is a cross-sectional view of an electrical artificial larynx embodying the invention;

Fig. 2 is a schematic diagram of a circuit for the device of Fig. 1;

Figs. 3 and 4 show alternative arrangements for actuating or vibrating the larynx tone generating members or diaphragms;

Fig. 5 represents an electric circuit analogue of the acoustical system of the device of Fig. 1;

Fig. 6 is a cross-sectional view of another electrical artificial larynx embodying the invention;

Fig. 7 represents an electric circuit analogue of the acoustical system of the device of Fig. 6.

Fig. 8 is a perspective view of the device shown in Fig. 1 with parts broken away to show internal structure;

Fig. 9 is a similar perspective view of the device of Fig. 6;

Fig. 10 is a simplification of Fig. 5 omitting R₁, R₂ and S₃; and

Fig. 11 is the equivalent circuit of Fig. 10.

The device of Fig. 1 is an electrical artificial larynx, designated generally as 10, comprising a hollow enclosure, casing or shell 12, containing a pair of spaced larynx tone producing members or diaphragms 14 that may be of metal and that divide the interior of the casing into a central air chamber 16 and outer air chambers 18. The casing is provided with inwardly projecting tubular portions 20, connecting the chambers 18 with the air outside of the casing, and, with the chambers 18, proportioned so as to provide resonators on the outer side of each diaphragm that resonate at a frequency preferably between the first and second harmonics of the associated larynx tone producing member or diaphragm. The central chamber has an outlet constituted by the reentrant portion 22 of the casing, a mouth tube 24, for example, of hard or soft rubber, providing a continuation of the tubular passage 26, whereby, when a larynx tone is generated, it may be introduced into the user's vocal cavities, there to be modulated as in the case of natural speech. The diaphragms are vibrated, preferably, by electrodynamic means comprising annular coils 28 secured to but insulated from the inner surfaces of the diaphragms and disposed in the air-gaps 30 in a permanent magnet 32, suitably supported in the central chamber. The magnet may

be in two parts secured together at the portion intermediate the air-gaps by suitable fastening means, such as the screws 31, the same portion containing a plurality of drillings or passages 33, connecting the cylindrical space within the magnet with the rest of the space constituting the chamber 16, the holes being sufficiently large and numerous so that the chamber constitutes a single acoustical stiffness in the frequency range of interest. As shown in Fig. 2, the coils are connected in series with each other and with the circuit making and breaking contact 34, battery 35 and a circuit controlling switch 38. When the switch 38 is closed, current flows through the coils, and the interaction of the permanent magnet field and that developed by the current in the coils causes the coils to move in the air-gaps to produce a corresponding displacement of the diaphragms. To have the diaphragms move toward one another simultaneously and to move away from one another simultaneously, the current in one coil should circulate in a direction opposite to that in the other coil. The contact 34 may be associated with either diaphragm, and may be on either side of the diaphragm depending on the polarity of the battery. Although the coils 28 are as a whole insulated from the diaphragms 14 with which they are associated, the winding comprising the coil 28 on the diaphragm 14 which cooperates with contact 34 has one end electrically connected to said diaphragm. It is apparent, a soft iron magnetic structure with a suitable magnetizing winding could be substituted for the permanent magnet 32. The diaphragms, furthermore, may be tuned or made to have the same or different fundamental frequencies of vibration. In the arrangement of Figs. 1 and 2, the diaphragms move toward each other initially, the circuit is opened between a diaphragm and the contact 34, current ceases to flow in the coils, and the diaphragms return to their original positions, which causes the circuit to be closed again at the contact 34, and the cycle is repeated. In this way, as long as the switch 38 is closed, the diaphragms are caused to vibrate and to generate a larynx tone that is introduced into the user's vocal cavities through the tubular passage 26 and the mouth tube 24.

Fig. 1 is an electric circuit analogue of the acoustical system of the device of Fig. 1. M_1 , R_1 and S_1 represent the acoustical mass, resistance and stiffness of each diaphragm 14; S_2 , the acoustical stiffness of the chamber 16 on the outside surface of the diaphragm; and M_2 and R_2 , the acoustical mass and resistance of the tubular portion 20 extending into the chamber S_3 represents the acoustical stiffness of the central chamber; M_3 and R_3 , the acoustical mass and resistance of the outlet and mouth tube; and E , the driving force exerted through each coil. When the larynx is operated, the driving forces tend to send current in the directions indicated by the arrows so that they send currents in phase through the shunt impedance. The energy dissipated in the shunt resistance represents the useful sound energy that is introduced into the mouth of the user of the larynx. In the frequency range of interest, that is, from about 100 to about 3000 cycles per second, the shunt stiffness S_3 is of such high impedance that it may be neglected, the shunt impedance being considered as comprising the inductance M_3 and the resistance R_3 . This is a band pass filter with two passed bands, the attenuation being sufficient over the frequency range of interest so that the

currents all flow through the shunt impedance, attained by proportioning the elements of the filter to this end.

If Fig. 5 is simplified by omission of R_1 and R_2 and of S_3 , the circuit of Fig. 10 is obtained.

Since it is desired to have large currents flow in the shunt arm of Fig. 10, the useful frequency range must fall within one of the theoretical attenuation bands of the filter. However, to have the insertion loss curve of a filter follow the theoretical attenuation curve, the filter must always be terminated in its image impedance. In the attenuation bands, this image impedance is a reactance that usually varies rapidly with frequency, and if the filter is terminated in resistances, reflections occur that will make the insertion loss depart widely from the theoretical attenuation. This must be taken into account in proportioning the parts of the larynx to insure that, in the useful frequency range, large currents flow in the resistance R_3 so that maximum power is radiated into the mouth of the speaker.

The problem of satisfying this last condition can be simplified if we desire from Fig. 10 the exactly equivalent circuit shown in Fig. 11. Due to the symmetry of the system, no current flows across the line AB so that each filter is terminated in a resistance $2R_3$. The elements of the filter and the resistance $2R_3$ must be proportioned so that the resistance termination matches the filter impedance at some frequency within its pass-band. Since no current flows across the line AB, we are then certain that the filter elements can be proportioned so that, in the useful frequency range, large currents flow through the resistance $2R_3$.

Instead of the moving coil arrangement of Fig. 1, that of Fig. 3 or Fig. 4 may be used. In Fig. 3, armatures 40 are secured to the inner surfaces of the diaphragms 14, and an H-shaped, soft iron magnetic core 42 is disposed between the armatures. A magnetizing coil 44 is wound around the cross-bar 46 of the core, and is connected, as shown, in series with the switch 38, battery 36, and contact 34, one armature and diaphragm forming part of the current path. In Fig. 4, a pair of soft iron magnetic core members 48 and serially connected magnetizing coils 50 wound thereon, are disposed between the armatures 40. The coils are connected in series with contact 34, battery 36 and switch 38. In the arrangements of Figs. 3 and 4, closure of switch 38 closes a circuit from battery through contact 34, diaphragm, armature, magnetizing coil, switch to battery. Current flow magnetizes the core and causes the armatures and consequently the diaphragms to be attracted to the cores. The circuit is opened at contact 34, current ceases to flow, the cores demagnetize, and the armatures and diaphragms return to their original positions. This closes the circuit again and the cycle is repeated, and continues as long as the switch 38 is closed, to produce a sustained tone.

The device of Fig. 6 is an electrical artificial larynx, designated generally as 60. It comprises an enclosure, casing or shell 61 comprising an annular central member or support 62 to the opposite rim portions 64 of which diaphragms 14 are secured, for example, by cement. The support has an inwardly extending tubular portion 66 connecting the chamber 68 with the air outside the casing. The tubular portion and chamber are proportioned so that together they constitute a resonator, resonating at a frequency in

the region between the first and second harmonics of the diaphragms. Annular coils 28 disposed in the air-gaps of the magnet 32, are attached to the diaphragms and connected in a circuit as shown in Fig. 2. An outer member 70 is secured to the flange portions 72 of the support, and defines an outer chamber 74 having a tubular outlet 76 to which a mouth tube 24 may be coupled.

Fig. 7 is an electric circuit analogue of the acoustical system of the larynx of Fig. 6. M_1, R_1, S_1 represent the acoustical mass, resistance and stiffness of the diaphragms; S_4 , the acoustical stiffness of chamber 68; M_4 and R_4 , the acoustical mass and resistance of the tubular passage of portion 66; S_5 , the acoustical stiffness of chamber 74; and M_5 and R_5 , the acoustical mass and resistance of the tubular passage 78 leading to the user's vocal cavities. In the frequency range of interest, that is, between about 100 and 3000 cycles per second, the front chamber simplifies to a resistance and an inductance, to give a band pass structure with one passed band. The elements of the filter are proportioned so that the useful frequency range of the device falls in the region of attenuation. This may be explained in a manner similar to that employed with respect to Fig. 5.

While this invention has been described with reference to specific embodiments thereof, it will be understood that it is not restricted thereto, but is to be considered as limited only by the scope of the appended claims.

What is claimed is:

1. An artificial larynx comprising a case, larynx tone generating members in said case dividing it into three chambers, said members being spaced apart to define one of said chambers between them, means for actuating said members, a tube from said one chamber for conducting the tone generated to the mouth cavity of a user, and tubular means connecting each of the other chambers with the atmosphere.

2. An artificial larynx comprising a pair of larynx tone producing members, means to vibrate said members toward and away from each other in synchronism, said means comprising a coil attached to each member and magnetic structure containing air-gaps in which said coils are disposed, a casing for said members and means, and means for conducting the tone produced by said members into the vocal cavities of a user.

3. An artificial larynx comprising a casing, a pair of larynx tone producing members, means to cause said members to vibrate toward and away from each other in synchronism, said means comprising an armature attached to each member, an H-shaped magnetic core between said armatures, and a magnetizing winding around the cross-bar of the core, a casing for said members, and means for conducting the tone produced by said members into the vocal cavities of a user.

4. An artificial larynx comprising an annular support, two diaphragms, each respectively secured at its periphery at each end of said support, the inner surfaces of said diaphragms defining a sound chamber with said support, said support having a tubular portion connecting said chamber with the outside air, and an outer member forming a sound chamber with the

outer surfaces of said diaphragms, means for causing said diaphragms to generate a larynx tone, and means for conducting said tone into the vocal cavities of a user.

5. An artificial larynx comprising a pair of larynx tone producing diaphragms spaced apart to form a central sound chamber, means forming an outer sound chamber on the outer side of each said diaphragms, tubular means connecting said outer chambers with the outside air, and tubular means for conducting larynx tone from said central chamber to the mouth cavities of a user, said diaphragms, chambers and tubular means proportioned to constitute a band pass filter.

6. An artificial larynx comprising a pair of diaphragms spaced apart to form a sound chamber between their inner surfaces, a resonator on the outer surface of each diaphragm, means for causing the diaphragms to generate a larynx tone, and means connected with the sound chamber for introducing such tone into a user's vocal cavities.

7. An artificial larynx comprising a pair of larynx tone producing members in a sound chamber and spaced apart to form a second sound chamber between their inner surfaces, tubular means connecting said second sound chamber with the atmosphere, and tubular means for conducting the larynx tone from said first-mentioned sound chamber into a user's vocal cavities, said members, chambers and tubular means proportioned to constitute a band pass filter.

8. An artificial larynx comprising a hollow enclosure, a pair of spaced larynx tone producing diaphragms in said enclosure dividing it into a chamber common to opposed surfaces of said diaphragms and a second chamber, means connecting one of said chambers with the outside air, and means for conducting larynx tone produced by said diaphragms from the other chamber to the vocal cavities of a user.

9. An artificial larynx comprising a pair of larynx tone producing members tuned to resonate at different frequencies, an enclosure providing air chambers on opposite sides of said members, means connecting one chamber with the outside air, and means for conducting larynx tone from another chamber to the vocal cavities of a user.

10. An artificial larynx comprising larynx tone producing means, and means defining sound chambers with restricted outlets coupled to said tone producing means, said tone producing means, sound chambers and outlets being proportioned to provide an acoustical system having the characteristics of a band pass filter, the frequency range of the larynx falling in the region of attenuation.

11. An artificial larynx comprising a casing, larynx tone producing diaphragms in said casing spaced apart to form a sound chamber, a coil attached to each diaphragm, a magnetic structure having air-gaps for said coils and having a central space extending between the diaphragms constituting a part of said chamber, said structure containing a passage connecting said central space with the rest of said chamber, and means for conducting larynx tones into the vocal cavities of a user.

ROBERT R. RIESZ.