Dec. 10, 1929. L. DE FOREST 1,738,988

SOUND ACTUATED AND PRODUCING DEVICE

Filed Oct. 29, 1926

Fig. 1.

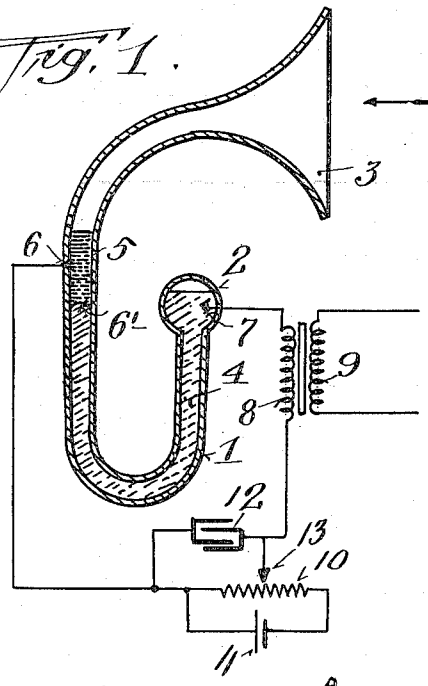


Fig. 3.

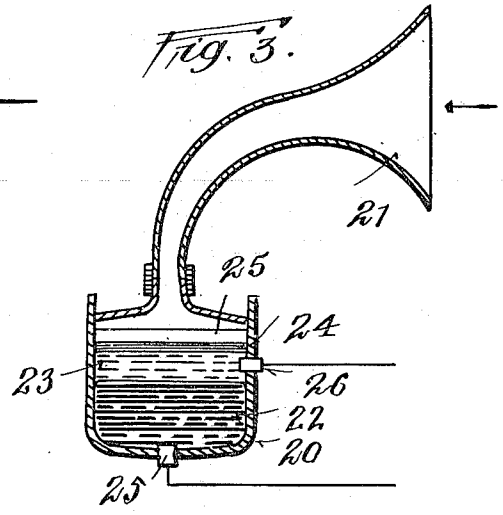


Fig. 4.

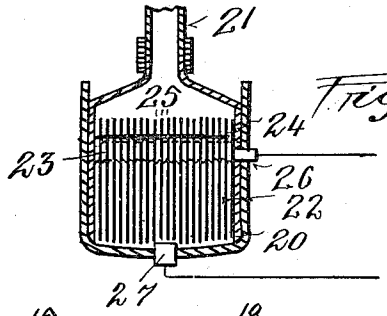


Fig. 2

Fig. 5

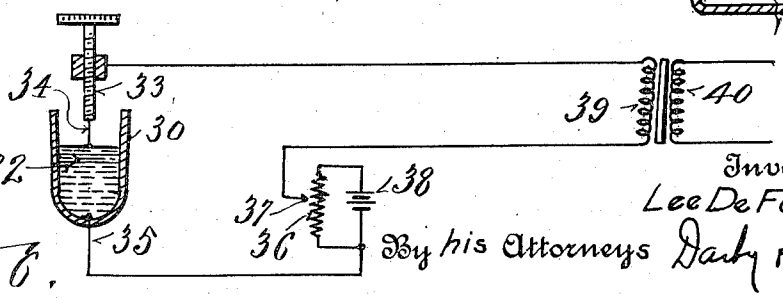


Fig. 6.

Inventor
Lee De Forest
By his Attorneys Darby & Darby

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UNITED STATES PATENT OFFICE

LEE DE FOREST, OF NEW YORK, N. Y., ASSIGNOR, BY MESNE ASSIGNMENTS, TO GENERAL TALKING PICTURES CORPORATION, A CORPORATION OF DELAWARE

SOUND ACTUATED AND PRODUCING DEVICE

Application filed October 29, 1926. Serial No. 144,976.

My invention relates to microphones and loud speaking devices.

One of the objects of this invention is the production of a microphonic or loud speaking device designed especially for use in electric recording of and reproducing from sound records.

Another object of this invention is to provide a microphonic or loud speaking device, which utilizes a capillary boundary between two liquids of different density. A further object of this invention is to utilize two different liquids in a capillary, one which wets and one which does not wet the capillary, to produce a device mentioned above. A further object of this invention is the utilization of differences in potential across a meniscus of dis-similar liquids within a capillary envelope.

Another object of this invention is the association of a device of this type with an input circuit to provide an operating connection with any type of output circuit or amplifier, such as a transformer, three electrode vacuum device and the like.

These and many other objects are successfully sought by the apparatus disclosed herein employing the principles of my invention.

This invention resides substantially in the combination, construction, arrangement and relative location of parts, as will appear more fully hereinafter.

Referring to the drawings, Fig. 1 is a cross-sectional view of one form of my device and an associated circuit.

Fig. 2 is a somewhat modified form of my device, employing the principle of my invention connected to a different form of amplifying device.

Fig. 3 is a further modification of my invention.

Fig. 4 is a vertical cross-sectional view taken at right angles to the views in Fig. 3, with the horn broken away.

Fig. 5 is a cross-sectional view of the container or envelope used in the construction of Figs. 3 and 4, showing more clearly the arrangement of the parts; and

Fig. 6 is a cross-sectional view of a still further modification of my invention, with its associated circuits.

It is a well known physical principle that when two dis-similar liquids, such as mercury and dilute acid, are contained in the same capillary tube, a meniscus or semi-globular surface forms the boundary between the two liquids. When a small electromotive force is passed across this meniscus, from one liquid to the other, there results thereby a change in surface tension in the meniscus, which results in a sudden movement thereof, up or down, in the capillary tube. The movement of this meniscus is proportional to the amount of variation in the electromotive force and is passed across the contact surface conversely. When a constant electromotive force is impressed across this contact surface any variation in the electromotive force will cause a movement of the meniscus. The Lippman electrometer is one form of the device, known to physicists, which employs the principles pointed out above. I have found that with some adaptions this principle may be used with considerable effect in a device for changing sound waves into varying electrical currents, or in changing varying electrical currents into sound waves. When used for the former purpose, if a constant potential is impressed across the contact surface and sound waves are directed against the liquids to vary the position of the surface of contact in the capillary, the constant electromotive force will be varied by and in accordance with the sound waves directed against the liquids. It is likewise, true that if a varying electromotive force is applied across the contact surface of two dis-similar liquids within a capillary, the contact surface or meniscus will vary its position within the tube by and in accordance with the differences of electromotive force across it to produce sound waves.

Referring to the drawings, as shown in Fig. 1 a capillary tube 1 is closed with a small bulb, at one end, and diverging upwardly at the other end to form a conical horn. A liquid which does not wet the tube, such as mercury is shown at 4 and a dis-similar liquid which does wet the tube, a capillary, such as dilute acid is shown at 5. A meniscus is

formed at the surface of contact between the two liquids as shown at 6'. A terminal 6 is shown in contact with the liquid 5, and a terminal 7 is shown in contact with the liquid 4. A small air space is formed in the bulb 2 by reason of the trapped air therein. A lead from the terminal 6 is connected to one end of a resistance 10, to one terminal of a condenser 12 and to one terminal of a battery 11. The other terminal of the battery is connected to the other end of the resistance 10, and the other terminal of the condenser 12 is connected in series to the primary 8 of a transformer connected in turn to the terminal 7. A movable contact and connection is also made from some terminal of the condenser and is adapted to contact with the resistance. It will be noted that this arrangement provides a well known potentiometer. A secondary of the transformer 9 may be connected to any suitable input or output circuit depending upon whether the device is to be used as a loud speaker or a microphone.

A somewhat similar arrangement is shown in Fig. 2, where the tube 1 is provided with an open end 2 and the other end diverging into the horn 3. The two liquids 4 and 5 are shown having the terminals 7 and 6, respectively. As before, the curved surface of contact 5' is formed between the liquids. In this case the lead from the terminal 7, a lead from the battery 11 and one end of the resistance 10 are connected together. The other terminal of the battery 11 is connected to the other end of the resistance 10, and the variable contact 13 is connected to one end of a resistance coupling 14, one terminal of the battery 17, and the filament of a three electrode vacuum tube 18. The wire from the terminal 6 is connected to the other end of the resistance 14, and one terminal of the condenser 15. The other terminal of the condenser 15 is connected to one end of a suitable resistance 16, and to the grid of the three electrode tube 18. The other end of the resistance 16 is connected to the other terminal of the battery 17. The leads 19 and 19' are connected to the plate and filament respectively of the three electrode tube 18, to provide an output circuit. In this arrangement the device is shown connected to be used as a microphone. The condenser 15 is a stopping condenser to keep the current from the battery 17 from flowing directly through the two liquids. The resistance 14 provides the well known type of resistance coupling and the resistance 16 acts as a grid leak.

The modified form shown in Figs. 3, 4, and 5 comprises an insulating envelope 20 of any material, to which is connected a horn or other suitable sound collecting or directing horn 21. Within the envelope are supported a plurality of insulating plates 25 provided with holes 27 therethrough. One of the liquids, such as mercury, shown at 22 on top of which floats a lighter liquid, such as dilute acid, and a thin film of oil 24 is supported thereon to prevent evaporation. A terminal 26 connects to the upper liquid and a terminal 27 connects to a lower liquid. The holes 27 are provided to insure an even distribution of the mercury between all the plates.

It will be noted that in this arrangement instead of having only one meniscus surface of contact, there are a large number of them, that is one between each two adjacent plates. By means of this arrangement a much greater effect is produced than would be secured from the forms in Figs. 1 and 2.

A modified form is shown in Fig. 6 in which the insulating envelope 30 contains dilute acid 32. An adjustable thumb screw 33 is provided at its lower end with a short length of fine wire 34, such as Wollaston wire, which contacts lightly with the liquid. A thin film of oil may be disposed upon the solution to prevent evaporation when desirable. The wire 35 is in contact with the lower liquid, and is connected to one end of the resistance 36 and one terminal of the battery 38. The other terminal of the resistance 36 is connected to the other terminal of the battery 38. A wire leads from the thumb screw 33 to one terminal of the primary 39 of the transformer, the other end of which is connected to a movable contact 37, which cooperates with the resistance 36. The secondary 40 of the transformer provides the output circuit when the device is used as a microphone.

It will be seen from the foregoing description that I have provided several forms of apparatus suitable for being actuated by or producing sound waves employing the principles which I carefully pointed out above. above.

With an arrangement, such as I have described I obtain a novel and very satisfactory loud speaker. If the meniscus surfaces are small enough, or in other words, if the mass of the liquids in the capillary or in the narrow space between the adjacent plates is sufficiently small, a slight change in applied electromotive force across the contact surfaces produces a relatively large displacement thereof with corresponding displacement of the acidulated water of such surface, up or down, as the case may be in accordance with the reversals of the applied electromotive force. There is no appreciable lag to this device for electrical frequencies, such as are involved in sound reproduction. The air above the acidulated water is thereby subjected to very rapid alternating compression and rarefaction resulting in sound waves which are forced out of the sound directing horn.

One of the valuable features of a device of this type is that it has no natural period of vibration corresponding to a natural period of resonance of the diaphragm or arma-

ture system of the ordinary electromagnetic sound device, and I have found that the device is non-selective over a wide range of frequencies.

I do not desire to be limited to the particular constructions and arrangements shown and described for purposes of illustration. For instance, I do not desire to be limited to the particular liquids disclosed by me as suitable, since it is possible that other dissimilar liquids may readily be employed.

I do not desire to be limited to the particular mechanical forms of the device, nor with the materials used to construct them, and in fact I contemplate any form of device employing the principles of this invention, which would occur to those skilled in the art. I further do not desire to be limited to the particular circuits which I have associated with the device since many other arrangements and combinations of circuit elements may be used in conjunction with my novel device.

I do not, therefore, desire to be limited to the illustrative embodiments of my invention, but rather to the spirit and scope thereof, as I define them in the appended claims.

What I seek to secure by United States Letters Patent is:—

1. In a sound reproducing device of the type described, an elongated container having a relatively small cross section, said container having an enlarged conical portion at one end forming a horn, two liquids of different density in surface contact in said container at least one of said liquids being open to the atmosphere through said conical portion, a terminal in each liquid and means for impressing varying electrical currents on said terminals to produce sounds in accordance with the varying electrical currents causing physical displacement of the liquids in said container whereby the atmosphere in contact therewith is subjected to rarefactions and compressions.

2. In a sound reproducing device of the type described, a container having a portion thereof enlarged to form a horn, two liquids of different densities in surface contact within the container, means for confining the two liquids into at least one body of small cross sectioned area, the body of liquid being exposed to the atmosphere through said horn, a terminal in each liquid and means for impressing varying electrical currents on the terminals to produce sounds by the varying electrical currents causing physical displacement of the liquids in said container whereby the atmosphere in contact therewith is subjected to rarefactions and compressions.

3. In a sound reproducing device of the type described, a container having a portion thereof enlarged to form a horn, two liquids of different densities in surface contact within the container, means for confining the two liquids into at least one body of small cross sectional area, the body of liquid being exposed to the atmosphere through said horn, a terminal in each liquid, external means for maintaining a difference of potential across the terminals and means for varying the potential across said terminals by and in accordance with speech currents to cause displacement of said liquids resulting in the production of sound waves.

4. In a device for reproducing sound from electrical currents which comprises a container having at least one portion of capillary cross section and a portion formed to provide sound directing means, two immiscible conducting fluids in surface contact at the portion of capillary cross section, a plurality of terminals in respective contact with each of said liquids whereby when varying potentials are impressed across said terminals the currents flowing across said surface of contact cause electro-physical displacements of the liquid with a resultant production of sound waves.

In testimony whereof I have hereunto set my hand on this 25th day of Oct., A. D. 1926.

LEE DE FOREST.