

Sept. 6, 1927.

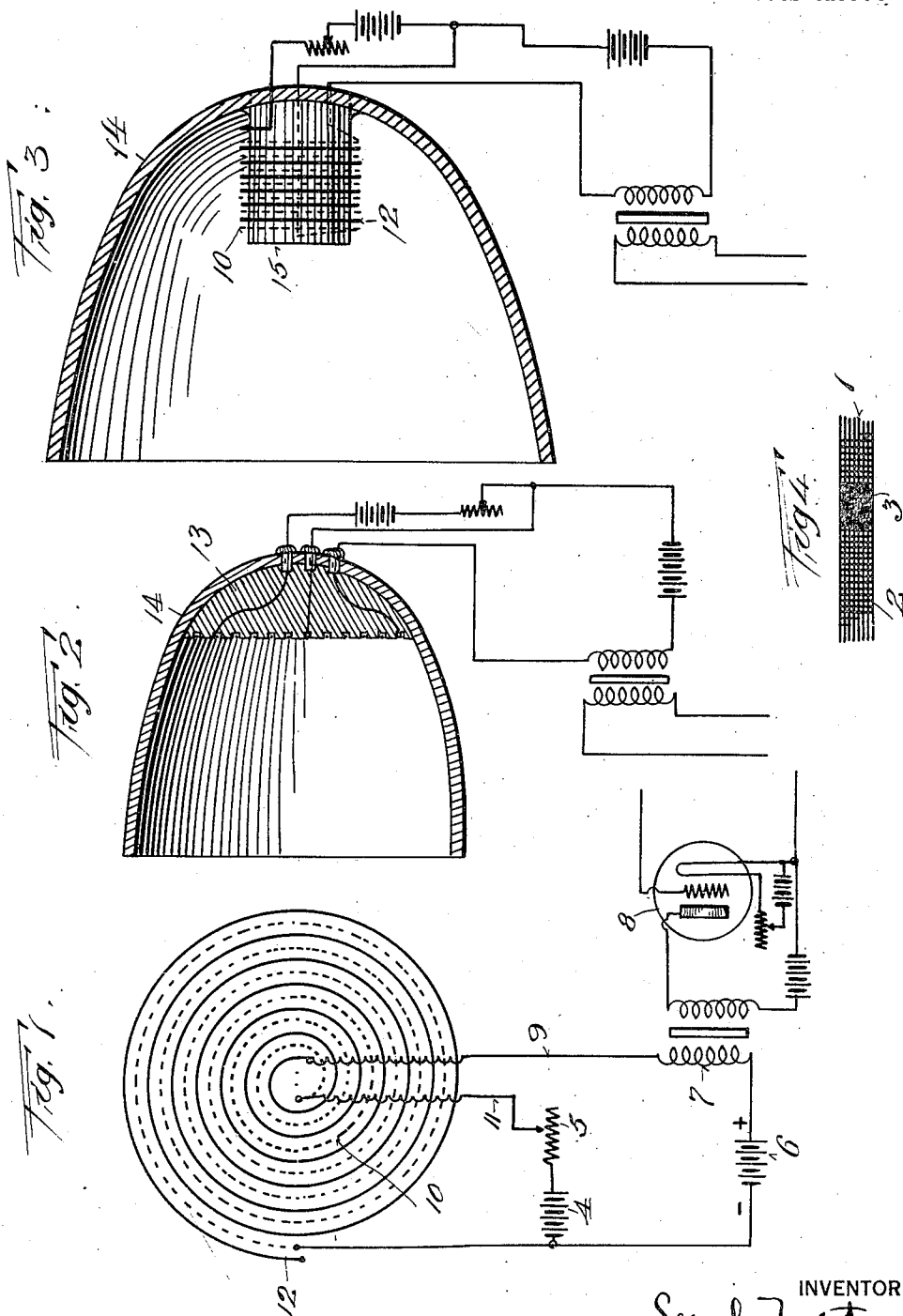
L. DE FOREST

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ELECTRICAL SOUND REPRODUCING APPARATUS

Filed July 1, 1922

2 Sheets-Sheet 1



INVENTOR
See de Forest
BY his ATTORNEY S Darby Darby

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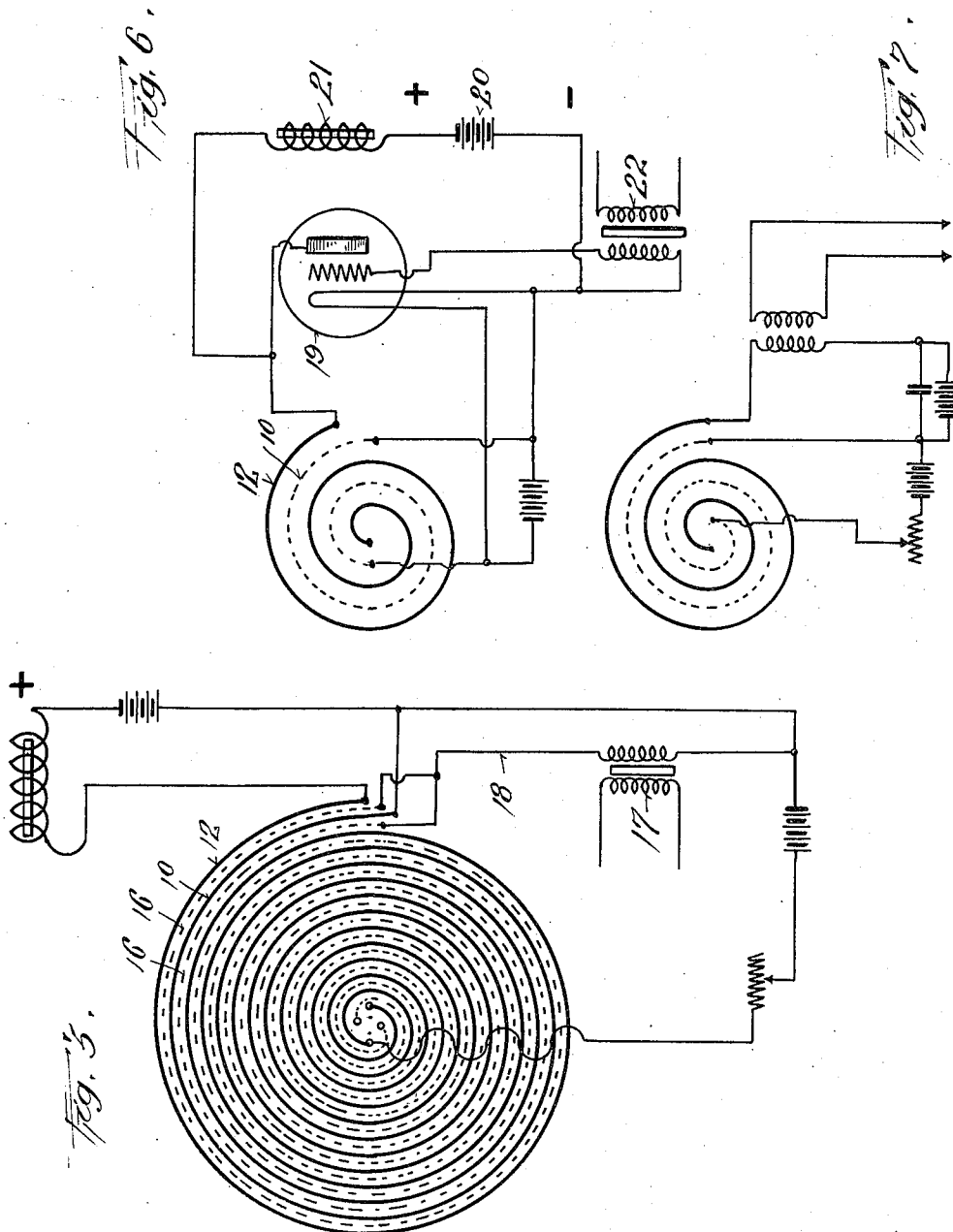
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ELECTRICAL SOUND REPRODUCING APPARATUS

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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE.

LEE DE FOREST, OF NEW YORK, N. Y., ASSIGNOR, BY MESNE ASSIGNMENTS, TO DE FOREST PHONOFILM CORPORATION, OF JERSEY CITY, NEW JERSEY, A CORPORATION OF DELAWARE.

ELECTRICAL SOUND-REPRODUCING APPARATUS.

Application filed July 1, 1922. Serial No. 572,174.

This invention relates to electrical sound reproducing apparatus.

The object of the invention is to provide an electrically controlled sound reproducer which is simple in structure, efficient in operation, and economical of manufacture.

A further object of the invention is to provide a sound reproducing apparatus where maximum strength with minimum distortion is effected.

Further objects of the invention will appear more fully hereinafter.

The invention consists substantially in the construction, combination, location, and relative arrangement of parts, all as will be more fully hereinafter set forth, as shown by the accompanying drawings, and finally pointed out in the appended claims.

Referring to the drawings,—

Fig. 1 is an enlarged diagrammatic view of an arrangement illustrating my invention.

Fig. 2 is a partially diagrammatic view and partially in section showing the reproducing mechanism of my invention.

Fig. 3 is a similar view of a modified arrangement embodying my invention.

Fig. 4 is a view of a portion of electrode element employed in accordance with my invention.

Figs. 5, 6 and 7 are views similar to Fig. 1 illustrating diagrammatically further modified arrangements embodying my invention.

The same part is designated by the same reference numeral wherever it occurs throughout the several views.

In my Patent No. 1,299,356, granted to me April 1, 1919, I disclosed my original discovery that between an open air glower, for example, a Nernst burner, or from an oxide coated platinum filament or strip, and a cold conducting member placed near to said glower and made electrically positive relative thereto, an electronic and ionic current passed. Furthermore, that such a device could be made to operate very much as does my audion, or three-electrode vacuum tube (United States Patent, No. 879,532), as a detector or amplifier (and consequently therefore as an oscillator) provided a third or control electrode, preferably in the form of a grid, be introduced into the space between the hot cathode and cold anode, and the three elements be then connected in the usual audion circuits.

I have also discovered that these ionic currents passing from anode to glowing cathode through the open air produce expansion effects upon the air molecules (either through the heating action involved, or through a chemical action related with the dissociation, ionization, or ozonization, of the air molecules). This energy involved in this expansion action is proportional to the energy represented by the ionic currents passing. As this ionic current is made to increase or decrease, the surrounding air expands or contracts, and this with no perceptible time lag, so that if a powerful telephonic current be impressed upon the external anode-cathode circuit a clear and exact reproduction in sound waves in the air surrounding the cathode is obtained. I have here therefore a novel and valuable means for reconverting telephonic currents into sound waves, and one which can be employed not merely as a new type of telephone receiver, but as a loud speaker, entirely devoid of diaphragm of any description, and therefore capable of sound reproduction of practically perfect fidelity.

In Fig. 1 I show a plan view of such a device as I have described, together with the elemental circuits involved. I have found that considerable areas of cathode and anode elements placed very close together are necessary to give the required degree of action in the surrounding, or between-lying, air, to produce sounds of the desired intensity. Accordingly I prefer to use a great length of filament or strip, preferably wound in a spiral form, as the cathode, and a corresponding length of anode strip, interwound with said cathode, close to but insulated from the same. Such cathode strip can very conveniently be made of fine woven wire, for example, of platinum, or molybdenum, or nichrome, wire, as shown in Fig. 4. The longitudinal wires 1 carry the cathode heating current, and the transverse wires 2 being interwoven merely to bind and support the heating wires 1. To render such heated cathode strip far more active for the purpose of electronic emission, I prefer to fill the meshes of the wire gauze thus formed with certain oxides of the rare earths, or with oxides of barium, strontium, or calcium, which have for years been employed to coat the cathodes in "Wehnelt

tubes" and "oxide-filaments" audions. Such material is indicated at 3, Fig. 4. In place of this wire mesh I may employ a thin strip of platinum or tantalum, or the like, similarly coated with electronic material.

In Fig. 1, as illustrative of the principles involved in my invention, 4 represents the source of cathode heating current, shown in this instance to be a battery, but it may, if desired, be any other source, for example, a gas flame. 5 is a control rheostat, and 6 is the source of anode voltage, preferably of several hundred volts. One coil 7 of a telephone transformer is included in the anode circuit, the other coil of which is connected in the output circuit of the last of a series of audion amplifiers 8 supplying the telephonic current which is to be reproduced. Instead of a direct current source of voltage B between the anode and cathode as shown in Fig. 1 I can impress upon the lead 9 through a suitably designed high frequency transformer in place of the telephone transformer an alternating current high voltage, the frequency of which is above the audible limits, for example, if the audion shown at 8 was an oscillion or other suitable source of high frequency current whose amplitudes were modulated in accordance with the telephonic currents to be reproduced into sound, then I find the effect upon the air surrounding the cathode 10 is essentially the same as when simple direct current voltage is applied therebetween. This use of radio, or super-audio, frequencies possesses certain advantages in some cases. It is of course obvious that I can also employ such superimposed modulated high frequency currents in combination with the direct current source B as shown in Fig. 1. In this instance the filament or cathode 10 is wound as shown, one terminal of the lead 11 being connected to one end of the filament 10, and wound coincidentally therewith is the anode 12 but insulated therefrom, one terminal of which is connected to the lead 9.

Fig. 2 shows a sectional view of a reproducer constructed in accordance with my invention illustrating a convenient method for mounting the alternate spirals of anode and cathode in two spiral grooves cut in the face of the heat resisting insulating block 13. To amplify and direct the sound thus produced I prefer to place the spiral-shaped ionizers in the closed end of a short parabolic or conical horn or reflector 14. Fig. 3 shows an alternate arrangement, wherein instead of a flat spiral the anode and cathode strips, or strip and filament, are wound together about a non-conducting rod 15, which is preferably placed in the axis and approximate focus of a short parabolic reflector 14.

In Fig. 5 I show a three element reproducer wherein a third perforated or grid-

shaped member 16 is introduced between the cathode and anode spirals. Two such grid members are used, both connected in parallel, to prevent the anode and cathode spirals from being face to face on either side without the interposition of the control electrode therebetween. In this three electrode arrangement the telephonic currents to be reproduced are led to the grid and the cathode members, exactly as in the usual audion amplifier circuit. Such typical circuit is here illustrated. 17 illustrates the input telephone transformer, the secondary winding of which is connected in the grid-cathode circuit. If desired, a third battery or source of voltage may be introduced in this grid-filament circuit for the purpose of putting a bias charge upon the grid or control electrode, as, for example, at the point 18, Fig. 5.

In Fig. 6 I illustrate still another method for controlling telephonically the instantaneous voltage impressed between the anode and cathode elements of this novel type of sound reproducer. In this arrangement commonly known as the "constant current" modulating circuit, my anode 12 and cathode 10 are respectively connected in parallel to the plate and filament electrodes of a modulating audion 19, both devices being thus supplied from a common source of high voltage 20. A large impedance, or inertia, coil 21, is connected in this voltage supply circuit. The telephonic currents to be amplified and reproduced in sound are now supplied from the transformer 22 to the grid circuit of the modulator audion in the usual manner. By virtue of the high impedance of the coil 21 high voltage charges are impressed upon the ionized air space separating elements 10 and 12 whereby sound waves corresponding to the telephonic current impressed upon the audion grid circuit, are produced.

As an obvious variation of the above "constant current" modulating circuit, a constant voltage circuit may be similarly employed. In this case the open air anode-cathode elements are connected in series with the plate-filament electrodes of the modulating audion, and with a common source of B voltage. Then, when the voltage drop across the audion electrodes is caused to vary by the telephonic voltages impressed upon its grid, a corresponding, or rather a reversed charge of the voltage across the open air gap of the sound reproducer is obtained, and sound waves thereby produced. Other systems for modulating or controlling the voltage or current across the ionized air gap will readily suggest themselves to persons skilled in the art without departing from the spirit and scope of my invention. I therefore desire to have the illustrations forming part hereof and the descriptions thereof regarded in an illustrative sense rather than in a limiting

sense, and I do not desire therefore to be limited or restricted in any of the details of design, construction, material or instrumentalities employed, but having now set forth the object and nature of my invention and structures embodying the principles thereof, What I claim as new and useful and of my own invention and desire to secure by Letters Patent is—

1. Means for reproducing sound through the medium of an ionized air gap which comprises a hot cathode and a cold anode separated therefrom and exposed to atmosphere, a source of current for said cathode, and means for impressing a current varying in potential in accordance with the sound to be reproduced, upon the space between said cathode and anode.

2. Means for reproducing sound comprising a long cathode strip and a long anode strip separated therefrom, and means for ionizing the air between said cathode and anode in accordance with the sounds to be reproduced.

3. Means for reproducing sound through the medium of an ionized air gap which comprises a long cathode strip and a long anode strip separated therefrom, a source of current for said cathode, and means for impressing a current varying in potential in accordance with the sounds to be reproduced upon the space between said cathode and anode.

4. Means for reproducing sound comprising a hot cathode and a cold anode separated therefrom, the effective surface areas of said cathode and anode being great relative to space of separation therebetween, and means for ionizing the air between said cathode and anode in accordance with the sounds to be reproduced.

5. Means for reproducing sound through the medium of an ionized air gap which comprises a cathode and a cold anode separated therefrom, the effective surface areas of said cathode and anode being great relative to the space of separation therebetween, a source of current for said cathode, and means for impressing a current varying in potential in accordance with the sound to be reproduced upon the space between said cathode and anode.

6. Means for reproducing sound comprising a long hot cathode strip and a long anode strip separated therefrom, and means for ionizing the air between said cathode and anode in accordance with the sounds to be reproduced, said cathode and anode being located in the open air.

7. Means for reproducing sound through the medium of an ionized air gap which comprises a long hot cathode strip and a long anode strip separated therefrom, a source of current for said cathode, and means for impressing a current varying in

potential in accordance with the sounds to be reproduced upon the space between said cathode and anode, said cathode and anode being located in the open air.

8. Means for reproducing sound comprising a hot cathode and a cold anode separated therefrom, the effective surface areas of said cathode and anode being great relative to space of separation therebetween, and means for ionizing the air between said cathode and anode in accordance with the sounds to be reproduced, said cathode and anode being located in the open air.

9. Means for reproducing sound through the medium of an ionized air gap which comprises a cathode and a cold anode separated therefrom, the effective surface areas of said cathode and anode being great relative to the space of separation therebetween, a source of current for said cathode, and means for impressing a current varying in potential in accordance with the sound to be reproduced upon the space between said cathode and anode.

10. Means for reproducing sound comprising a hot cathode wound in the form of a spiral, a cold anode wound in a similar spiral but separated therefrom throughout its length by a substantially uniform distance, and means for ionizing the air between said electrodes in accordance with the sounds to be reproduced.

11. Means for reproducing sound comprising a hot cathode wound in the form of a spiral, a cold anode wound in a similar spiral but separated therefrom throughout its length by a substantially uniform distance, and both located in the open air, and means for ionizing the air between said electrodes in accordance with the sounds to be reproduced.

12. Means for reproducing sound comprising a hot cathode wound in the form of a spiral, a cold anode wound in a similar spiral but separated therefrom throughout its length by a substantially uniform distance, and means for ionizing the air between said electrodes in accordance with the sounds to be reproduced, a loud speaking horn, said electrodes being located at the small end of said horn.

13. Means for reproducing sound comprising a hot cathode wound in the form of a spiral, a cold anode wound in a similar spiral but separated therefrom throughout its length by a substantially uniform distance, and both located in the open air; and means for ionizing the air between said electrodes in accordance with the sounds to be reproduced, a loud speaking horn, said electrodes being located at the small end of said horn.

14. Means for reproducing sound comprising a hot cathode wound in the form of a spiral, a cold anode wound in a similar

spiral but separated therefrom throughout its length by a substantially uniform distance, and means for ionizing the air between said electrodes in accordance with the sounds to be reproduced, a parabolic horn, said electrodes being located at the apex of said horn.

15. Means for reproducing sound comprising a hot cathode wound in the form of a spiral, a cold anode wound in a similar spiral but separated therefrom throughout its length by a substantially uniform distance, and both located in the open air, and means for ionizing the air between said electrodes in accordance with the sounds to be reproduced, a parabolic horn, said electrodes being located at the apex of said horn.

16. Means for reproducing sound comprising a hot cathode and a cold anode separated therefrom, and both exposed to atmosphere, and means for ionizing the air between said cathode and anode in accordance with the sounds to be reproduced through the medium of a third electrode positioned between said cathode and anode, but separated therefrom.

17. Means for reproducing sound through the medium of an ionized air gap which comprises a cathode and a cold anode separated therefrom and exposed to atmosphere, a source of current for said cathode, and means for impressing a current varying in potential in accordance with the sound to be reproduced, upon the space between said cathode and anode, through the medium of a third electrode positioned between said cathode and anode, but separated therefrom.

18. Means for reproducing sound comprising a long cathode strip and a long anode strip separated therefrom, and means for ionizing the air between said cathode and anode in accordance with the sounds to be reproduced through the medium of a third electrode positioned between said cathode and anode, but separated therefrom.

19. Means for reproducing sound comprising a hot cathode and a cold anode separated therefrom, the effective surface areas of said cathodes and anode being great relative to space of separation therebetween, and means for ionizing the air between said cathode and anode in accordance with the sounds to be reproduced, through the medium of a third electrode positioned between said cathode and anode, but separated therefrom.

20. Means for reproducing sound through the medium of an ionized air gap which

comprises a cathode and a cold anode separated therefrom, the effective surface area of said cathode and anode being great relative to the space of separation therebetween, a source of current for said cathode, and means for impressing a current varying in potential in accordance with the sound to be reproduced upon the space between said cathode and anode through the medium of a third electrode positioned between said cathode and anode, but separated therefrom.

21. Means for reproducing sound comprising a long cathode strip and a long anode strip separated therefrom, and means for ionizing the air between said cathode and anode in accordance with the sounds to be reproduced, said cathode and anode being located in the open air, through the medium of a third electrode positioned between said cathode and anode, but separated therefrom.

22. Means for reproducing sound through the medium of an ionized air gap which comprises a long cathode strip and a long anode strip separated therefrom, a source of current for said cathode, and means for impressing a current varying in potential in accordance with the sounds to be reproduced upon the space between said cathode and anode, said cathode and anode being located in the open air, through the medium of a third electrode positioned between said cathode and anode, but separated therefrom.

23. Means for reproducing sound comprising a hot cathode wound in the form of a spiral, a cold anode wound in a similar spiral but separated therefrom throughout its length by a substantially uniform distance, and means for ionizing the air between said electrodes in accordance with the sounds to be reproduced through the medium of a third electrode positioned between said cathode and anode, but separated therefrom.

24. Means for reproducing sound comprising a hot cathode wound in the form of a spiral, a cold anode wound in a similar spiral but separated therefrom throughout its length by a substantially uniform distance, and both located in the open air, and means for ionizing the air between said electrodes in accordance with the sounds to be reproduced through the medium of a third electrode positioned between said cathode and anode, but separated therefrom.

In testimony whereof I have hereunto set my hand on this 24th day of April A. D., 1922.

LEE DE FOREST.