

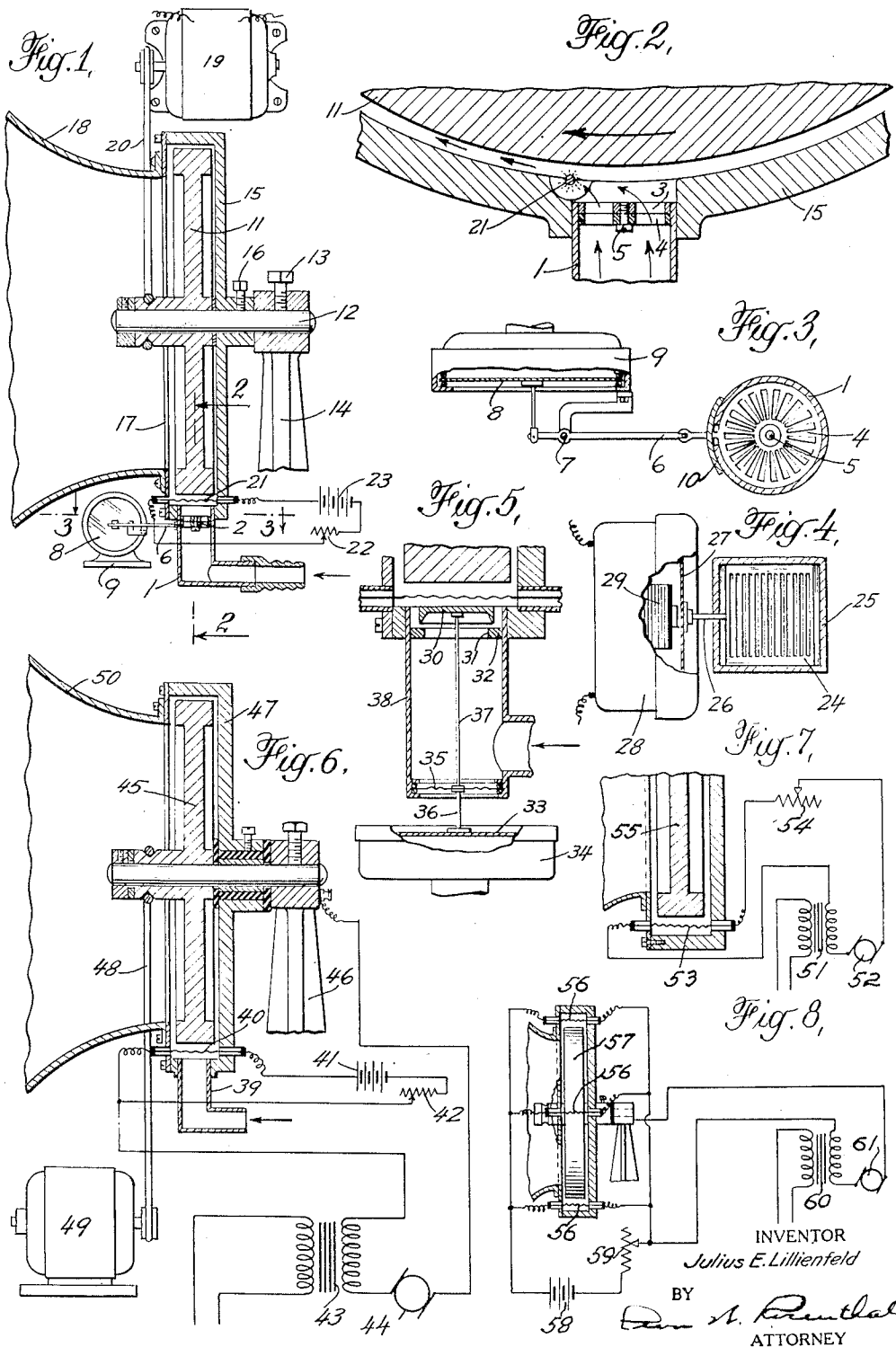
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METHOD OF AND APPARATUS FOR REPRODUCING SOUND

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METHOD OF AND APPARATUS FOR REPRODUCING SOUND.

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The present invention relates to methods of and apparatus for reproducing sound and more particularly to sound reproduction from a source other than a metallic or other rigid diaphragm.

Ordinary sound reproducers, such as telephone head sets and loud speakers and phonograph horns, reproduce sound by the interposition of a rigid diaphragm which, having mass and therefore mechanical inertia, and also being restrained and lacking in rigidity as a whole, inherently possesses a limited range of frequency and sets up distortion at substantially all audible frequencies. This results in blurred reproductions especially if different sounds have to be reproduced in quick succession. Furthermore, such a diaphragm may have within its range of audible frequency response, a resonance period of the entire section and often different resonance periods of localized sections, resulting in exaggeration of certain pitches of the reproduction which generally destroys the balance within portions of the range. Thus the reproduction is lacking in faithfulness and at large amplitudes the disturbances may become sufficiently great to prohibit reproduction beyond a moderate limit of loudness.

It is known that a sound wave accompanies a variation of the ionization of a gas, but heretofore the amplitude of the sound wave thus produced has been insufficient for practical purposes. I have found that this amplitude may be considerably increased and practically any desirable amplitude obtained by preventing a stationary average condition of the gas undergoing ionization, or, in other words, by continually removing the gas undergoing ionization or ionizing a current of gas. In effect, there is produced in proximity to the ionizing means, what may be termed a gaseous membrane, which on account of its negligible inertia, pulsates in frequency and amplitude in substantially exact accordance with the variation of the ionization. The gas so ionized may be a combustible gas, or a non-combustible gas as air, and it may be in communication with any medium, as unconfined air, in which the sound waves may be generated and through which they may travel.

The movement or current of the gas may be produced by pressure, but I prefer to produce the current by rotating a body, as a disc of metal, at such a speed as will drag the gas around on its periphery as a result of the viscosity of the gas. The ionization may be produced in any suitable way, as for instance by burning or heating the gas or by subjecting it to an electric discharge, or to an emission of electrons, or by any suitable combination thereof. Variations in the ionization may be produced in any suitable way, as for instance by changing the volume or rate of flow or mixture or temperature of the gas, or by changing the temperature of a hot body in contact with the gas, or by changing the current producing the electric discharge, or by changing the rate of emission of the electrons into the gas, or by any suitable combination thereof. The ionization, and its variation in amount or intensity, may be produced at one zone, or at a plurality of zones simultaneously, as for instance around the rotating disc; and if desired the sound waves generated in this way in unconfined air communicating therewith may be amplified by a horn.

In apparatus for carrying out these methods of sound reproduction by employing a varying volume or mixture of gas, I provide a conduit for the gas to be ionized, means for moving the gas in the conduit such as the rotating disc, and means for ionizing the gas and for varying the ionization. Preferably I provide, close to the place of admission of the gas, and also close to the rotating disc when used, a filament of metal such as platinum, or alloys of such metals as platinum and iridium or nickel and chromium, and I may coat such a filament with an oxide of earth alkalies, such as oxide of thorium, barium, etc. Upon heating such a filament to incandescence by current from any suitable source, such as a battery or generator, it not only ignites the gas if combustible or heats it if non-combustible, which gas is then ionized, but especially if the filament is coated it emits an electron stream which further increases the ionization of the gas. In such embodiment of apparatus a suitable valve, vibrated in accordance with the sound waves to be re-

produced as by the diaphragm of the sound box of a phonograph or the diaphragm of a telephone receiver, is arranged in the conduit to control the volume of gas admitted from a single source or the mixture admitted from two or more sources. In all such embodiments, the intensity of ionization of the varying volume of gas admitted may also be varied in accordance with the sound waves to be reproduced by superposing the speech current to be reproduced on the filament heating current or by causing the speech current to discharge through the gas between the filament and the rotating disc. Also, if desired, a plurality of such conduits, valves and filaments may with advantage be arranged around the periphery of the rotatable disc.

In apparatus for carrying out these methods of sound reproduction by varying the intensity only of the ionization, the rotatable disc, which may be used for producing the current of gas or continually removing the gas from the zone or zones of ionization, is preferably enclosed excepting at the horn or other outlet for the gas when unconfined. The intensity of ionization is then varied in any suitable way as for instance in any of the ways noted above. In such embodiments, I prefer to use air as the gas to be ionized and to provide a horn outlet centrally of one face of the disc, a plurality of filaments, supplied with heating current, being disposed around the periphery of the disc, and forming one side of the circuit for the discharge of the speech current through the air in each of those regions, or alone completing the speech current circuit, or both.

In the accompanying drawings illustrating, partly in section, partly in elevation and partly diagrammatically, several embodiments of apparatus for carrying out the methods of my intention, in which, as an example, a rotatable disc with a horn outlet for amplifying the sound waves in unconfined air is used.

Fig. 1 shows an apparatus in which the volume of a combustible gas to be ionized is varied by a valve controlled by a phonograph diaphragm; Figs. 2 and 3 are enlarged sections on lines 2-2 and 3-3, respectively, of Fig. 1; Fig. 4 shows a modified form of valve controlled in this case by a telephone receiver; Fig. 5 shows another form of valve and conduit; Fig. 6 shows an apparatus in which a combustible gas is subjected to an electric discharge between the filament and disc from the speech current circuit; Fig. 7 shows an apparatus in which unconfined air is ionized by a hot filament and the intensity thereof is varied by the speech current passing through the filament; and Fig. 8 shows on a smaller scale an apparatus in which a plurality of fila-

ments are arranged around the periphery of the disc.

Referring now to Figs. 1, 2, and 3, 1 is a conduit connected to a source (not shown) of combustible gas as illuminating gas, gasolene, hydrogen, or any other suitable gas or mixture characterized by quiet burning within the range of ordinary temperature. The valve 2 is located as near as practical to the upper end of the conduit and has one grid 3 fixed in the conduit and a second grid 4 centrally pivoted at 5 to the first so as to be angularly movable within the conduit by the jointed lever 6, which is pivoted at 7 and connected to the center of the diaphragm 8 of the sound box 9, the diaphragm being connected in the usual way to a phonograph needle (not shown). The lever 6 is connected to the grid 4 in any way that suitably prevents the discharge of gas from the conduit 1, as by a sliding cover 10 over an opening in the conduit. A disc 11 of brass or any other suitable material, preferably having a smooth periphery, is mounted for rotation on the shaft 12, which is secured against turning by the set screw 13 in the rigidly supported pedestal 14. A stationary housing 15 for the disc, fastened to the shaft by the set screw 16, supports the conduit 1 and also the ring 17 to which is attached a suitable horn 18. An electric motor 19 is adapted to drive the disc through the belt 20. A speed of about 800 R. P. M. is suitable for a disc of about 9 inches in diameter. A nickel-chromium wire 21 is insulatedly mounted between the valve 2 and the disc 11 and is adapted to be maintained at incandescence by means of the adjustable resistance 22 with current from the battery 23.

The operation of this embodiment of the apparatus is as follows: With the motor 19 rotating the disc 11, and the filament 21 heated to incandescence, a current of the combustible gas is drawn into the conduit 1 and ignited by the filament. The volume of gas, and therefore the quantity of heat, and the ionization produced by that heat, is varied in accordance with the area of registry of the openings in the grids 3 and 4 and therefore in accordance with the vibrations of the diaphragm 8. Since the diaphragm vibrates in accordance with the sound waves recorded on a phonograph record, the amount of heat and therefore the ionization of the gas varies in accordance with the recorded sound waves. The grid 4 vibrates freely, being subjected as it is to a slight difference only of pressure on both sides, and thereby the diaphragm 8 is loaded to a much lesser degree for the same amplitude of movement and for the same frequency of vibration than when it originates the sound waves in air in a horn or when the valve controls the admission of gas

in a siren. Thus the diaphragm follows the vibrations of the needle with less distortion and therefore with more faithfulness to the sound waves recorded on the phonograph record. So also the gas is continually removed from the zone of the incandescent filament 21 which ignites it since the gas is drawn around by the disc 11 as a result of the viscosity of the gas in contact with the periphery of the disc. There is produced between the filament 21 and the disc 11 a gaseous layer, in effect a gaseous membrane, which remains stationary when no variation occurs in the ionization of the gas, that is in this case when the volume of gas admitted by the valve 2 is at a constant rate. But when the ionization varies, that is in this case when the grid 4 is moved to change the volume of gas admitted, the variation in the amount of heat instantly causes a like variation of pressure against the gaseous membrane which results in a pulsation of the gaseous membrane and therefore the generation of sound waves in the air in communication with it. These sound waves are then suitably amplified by the horn 18. The amplitude of this movement of the membrane is always in substantially exact proportion to the amplitude of the movement of the diaphragm 8, thus faithfully reproducing the balance throughout the range of the recorded sound waves, and the frequency of the movement of the membrane is always in substantially exact accordance with the frequency of the movement of the diaphragm 8, thus faithfully reproducing the pitch of the recorded sound waves.

In Fig. 4 the grid 24 of the valve has parallel slots, instead of radial slots, and is reciprocated across the other grid of the valve in the conduit 25, instead of being turned therein, by direct connection of the straight lever 26 fastened centrally of the diaphragm 27 of the telephone receiver 28. No change is introduced in the method of operation excepting that the variation of volume of the combustible gas admitted, and therefore the resulting ionization, is in accordance with the speech current flowing into the electromagnetic winding 29 which is electrically connected in the usual way to the source of sound signals to be reproduced.

In Fig. 5 the valve member 30 is vibrated up and down over the opening 31 in the co-operative valve member 32 by means of the diaphragm 33 of a phonograph sound box or a telephone receiver 34, through the instrumentality of a flexible diaphragm 35 operated by the lever 36 and operating the lever 37 to thereby maintain a gas seal for the conduit 38. The method of operation of this modification will now be readily understood.

In Fig. 6 there is no valve for varying the volume of gas admitted through the conduit 39 and it is the intensity of the ionization of the gas that is varied. This is accomplished by utilizing an incandescent filament to keep the incoming combustible gas ignited and then subjecting that ionized gas to an electric discharge between the filament and disc from the speech current circuit. The filament 40 is supplied with current from the battery 41 through the variable resistance 42 as before, but in addition the speech current, after being passed through the step-up audio-frequency transformer 43 and superposed on a direct current from the generator 44, is passed between the filament 40 and the disc 45, which together with the pedestal 46, is insulated from the housing 47. As before, the disc is rotated by a belt 48 driven from the motor 49, and the housing is provided with the horn 50.

A gaseous membrane is formed as before but its pulsation is substantially exact accordance with the amplitude and frequency of the sound waves to be reproduced is caused by the variation of the electric discharge of the speech current passing between the filament and the disc, thereby generating the sound waves in the air which is in communication with the membrane. These sound waves are then amplified by the horn. The audio-transformer increases the voltage of the speech current to a more suitable value and the direct current on which it is superposed increases the variation in the intensity of the electric discharge, as is well known.

If desired, a valve of any suitable kind, such as the one illustrated in the foregoing embodiments, may be incorporated in the conduit 39 of Fig. 6 and operated by a phonograph sound box or a telephone receiver. In this way not only would the ionization of the gas be varied in accordance with the volume admitted by the valve, but the intensity of ionization of the gas would be varied in accordance with the speech current. As will now be clearly understood, this would combine the effects of the embodiments of Figs. 1 and 6.

In the embodiment shown in Figs. 7 and 8, no combustible gas is employed, but the ionization occurs directly in the unconfined air in which the sound waves are generated. As before, there is produced in effect a gaseous membrane between the filament or each of the filaments and the rotating disc, and this membrane or these membranes pulsate in accordance with the variations in the intensity of ionization as a result of the pressure acting thereon.

In Fig. 7 the speech current stepped up by the audio-frequency transformer 51 is super-

posed on the direct current from the generator 52 to supply the filament 53 through the adjustable resistance 54. The temperature of the filament is thus varied in accordance with the speech current, thereby varying the intensity of the ionization of the air which is constantly removed from the zone of the filament by means of the rotating disc 55.

10 The embodiment of Fig. 8 is similar to that of Fig. 7 excepting that there are a plurality of like filaments 56 located around the periphery of the rotating disc 57, and these filaments are supplied in parallel with heating current from the direct current source 58 through the adjustable resistance 59, the speech current circuit, containing the step-up audio-frequency transformer 60 and the direct current generator 61, being connected to the disc and to the filaments in parallel to accordingly vary the electric discharge through the air at all the ionizing zones simultaneously.

It will now be obvious that if desired the speech current circuit of Fig. 7 may be connected between the filament and disc, as in Fig. 6. It will also be obvious that the parallel branches of the speech current circuit of Fig. 8 may be connected to the filaments alone as in Fig. 7, or in one or more cases to the filaments alone and in the others between the filament and disc. Also the filaments of Fig. 8 may be connected in series, instead of in parallel, in the heating current circuit.

Having thus described my invention, what I claim is:

1. The method of reproducing sound waves, which consists in providing a zone of ionized gaseous medium, causing at the point of provision of said zone the said medium to pulsate in accordance with sound waves to be reproduced, and continually removing at substantially constant velocity gaseous medium from said ionized zone.

2. The method of reproducing sound waves, which consists in providing a zone of ionized gaseous medium, causing at the point of provision of said zone the said medium to pulsate in accordance with sound waves to be reproduced, subjecting unconfined air to said pulsations to thereby generate sound waves therein, and continually removing a substantially constant velocity gaseous medium from said ionized zone.

3. The method of reproducing sound waves, which consists in providing a zone of ionized gaseous medium, causing at the point of provision of said zone the said medium to pulsate in accordance with sound waves to be reproduced, subjecting unconfined air to said pulsations to thereby generate sound waves therein, amplifying the sound waves in said unconfined air, and continually removing at substantially constant

velocity gaseous medium from said ionized zone.

4. The method of reproducing sound waves, which consists in providing a zone of ionized gaseous medium in unconfined air, causing at the point of provision of said zone the said medium to pulsate in accordance with the waves to be reproduced to thereby generate the sound waves in the air, and continually removing at substantially constant velocity the air from said ionized zone.

5. The method of reproducing sound waves, which consists in varying the ionization of a gas at the point of production of ionization in accordance with the sound waves to be reproduced, and continually removing the gas from the zone of ionization.

6. The method of reproducing sound waves, which consists in ionizing a gas, varying the ionization at the point of production of ionization in accordance with the sound waves to be reproduced, and continually removing at substantially constant velocity the gas from the zone of ionization.

7. The method of reproducing sound waves, which consists in ionizing a gas by heating it, varying the ionization at the point of production of ionization in accordance with sound waves to be reproduced, and continually removing at substantially constant velocity the gas from the zone of heating.

8. The method of reproducing sound waves, which consists in heating a gas, subjecting the gas to an electronic emission, varying the electronic emission at its point of production in accordance with the sound waves to be reproduced, and continually removing at substantially constant velocity the gas from the zone of emission.

9. The method of reproducing speech sound waves, which consists in heating a gas, subjecting the gas to an electric discharge of the speech current to be reproduced, and continually removing at substantially constant velocity the gas from the zone of discharge.

10. The method of reproducing speech sound waves, which consists in ionizing a gas, subjecting the ionized gas to an electric discharge of the speech current to be reproduced, and continually removing at substantially constant velocity the gas from the zone of the discharge.

11. In apparatus for reproducing sound waves, means for producing a zone of ionized gaseous medium, means acting upon the ionization producing means for causing said medium to pulsate in accordance with the sound waves to be reproduced, and means for continually removing at substantially constant velocity gaseous medium from said ionized zone.

12. In apparatus for reproducing sound waves in air, means for producing a zone of ionized gaseous medium, means acting upon the ionization producing means for causing said medium to pulsate in accordance with the sound waves to be reproduced, means for subjecting unconfined air to said pulsations to thereby generate sound waves therein, and means for continually removing at substantially constant velocity gaseous medium from said ionized zone.

13. In apparatus for reproducing sound waves in air, means for producing a zone of ionized gaseous medium, means acting upon the ionization producing means for causing said medium to pulsate in accordance with the sound waves to be reproduced, means for subjecting unconfined air to said pulsations to thereby generate sound waves therein, means for amplifying the sound waves in said unconfined air, and means for continually removing at substantially constant velocity gaseous medium from said ionized zone.

14. In apparatus for reproducing sound waves in air, means for producing a zone of ionized gaseous medium in unconfined air, means for causing the said medium to pulsate in accordance with the sound waves to be reproduced to thereby generate sound waves in the air, and means for continually removing at substantially constant velocity gaseous medium from said ionized zone.

15. In apparatus for reproducing sound waves, a filament, means for supplying current to said filament for heating it to produce a zone of ionized gaseous medium about the same, a housing for said filament, means to vary the intensity of the supplying current to vary the degree of ionization produced by said filament and means for continually removing the gas from the zone of said filament in said housing.

16. In apparatus for reproducing sound waves, a filament, means for supplying current to said filament for heating it to produce a zone of ionized gaseous medium about the same, a housing surrounding said filament and having a sound wave outlet, means to vary the intensity of the supplying current to vary the degree of ionization produced by said filament and means for continually removing the gas from the zone of said filament in said housing.

17. In apparatus for reproducing sound waves, a filament, means for supplying current to said filament for heating it to pro-

duce a zone of ionized gaseous medium about the same, a rotatable member in proximity to said filament to continually remove gaseous medium from the ionized zone surrounding the filament, and housing surrounding said filament and said member.

18. In apparatus for reproducing sound waves, a filament, means for supplying current to said filament for heating it to produce a zone of ionized gaseous medium about the same, a rotatable disc in proximity to said filament, to continually remove gaseous medium from the ionized zone surrounding the filament, and a housing surrounding said filament and disc and having a sound wave outlet on one side of the disc.

19. In apparatus for reproducing sound waves, a filament, means for supplying heating current to said filament, means for supplying speech current to said filament, a housing for said filament, and means for continually removing the gas from the zone of said filament in said housing.

20. In apparatus for reproducing sound waves, a filament, means for supplying heating current to said filament, means for supplying speech current to said filament, a rotatable member in proximity to said filament for continually removing gas from the zone of said filament, and a housing for said filament and member.

21. In apparatus for reproducing sound waves, means for heating a gas, means at the point of heating for subjecting the gas to an electric discharge of the speech current to be reproduced, and means for continually removing at substantially constant velocity the gas from the zone of discharge.

22. In apparatus for reproducing sound waves, a filament, mean for heating the filament to produce a zone of ionized gaseous medium about the same, a rotatable member in proximity to said filament for continually removing gaseous medium from said ionized zone, a speech current circuit connected to said filament and said member for varying the degree of ionization, and a housing surrounding said filament and said member.

23. The method of reproducing sound waves, which consists in establishing a gaseous medium in the form of a continually moving adherent film, providing a zone of ionization in said film, and causing the same to pulsate in accordance with sound waves to be reproduced.

In testimony whereof I affix my signature.

JULIUS E. LILIENFELD.