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H. VOGT ET AL  
SOUND TRANSLATING APPARATUS  
Filed April 4, 1921

FIG. 1.

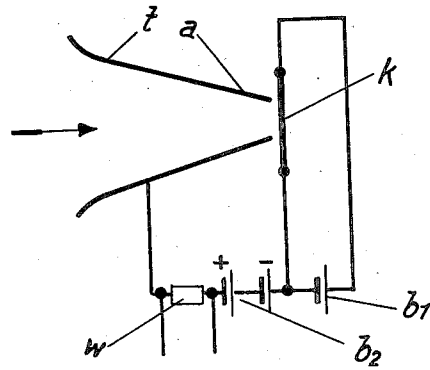
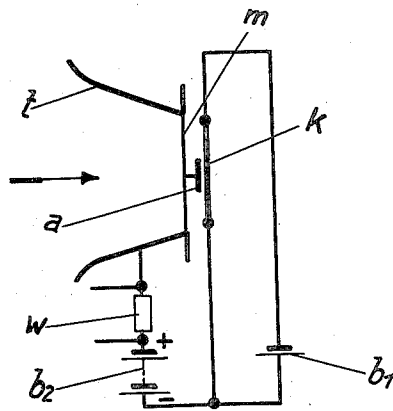


FIG. 2.



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# UNITED STATES PATENT OFFICE.

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## SOUND-TRANSLATING APPARATUS.

Application filed April 4, 1921. Serial No. 458,632.

*To all whom it may concern:*

Be it known that we, HANS VOGT, JOSEF ENGL, and JOSEPH MASSOLLE, citizens of the German Republic, residing at the 1st Berlin-Schoneberg, the 2nd and 3rd of Grunewald, Germany, have invented certain new and useful Improvements in Sound-Translating Apparatus (for which application has been filed in Germany, August 2, 1919; Great Britain, January 10, 1921; Italy, January 29, 1921; Sweden, December 31, 1920; Belgium, December 29, 1920; and Norway, December 30, 1920), of which the following is a specification.

The invention relates to improvements in sound translating apparatus, which is particularly useful for devices whereby sound waves are received and cause the production of corresponding electrical currents of a particularly true and undistorted character. These acoustically produced electric currents may be utilized in various manners as will be obvious. It will be noted, for example, that the form of microphonic apparatus comprising this invention is for various reasons particularly well adapted for the control or operation of vacuum amplifiers.

The control of electric currents by the power of sound can in addition to being effected by purely mechanical methods (granular carbon microphones and the like) be also effected by causing the variations of the sound pressure to act on an arc discharge. (Hissing arc.) Although the latter method has the advantage that no mechanical means at all (e. g. diaphragms etc.) are employed, and the distortion of the form of the sound curve which is always caused by mechanical vibrating bodies is therefore precluded, this method has not been found practical. Among the reasons for this, may be noted, first, that the maintenance of the continuous arc discharge requires a rather considerable current. Accordingly the alternating current corresponding to the sound vibrations, which current is superposed by the controlling action of the sound forces upon the continuous current of the arc, is very small in proportion to the direct carrying current of the arc. Secondly, such a discharge, in the free atmosphere, as is present, for example, in a carbon arc, (known as an independent discharge), has hissing and individual noises of such a nature that these

overpower the very weak speaking currents, and constitute disturbances. These hissing and other distorting noises of the arc are caused by a lack of constancy of the discharge of the arc, this being caused predominantly by the combustion and vaporization of the cathode. An arc discharge is characterized by a great consumption of power, this being explained by the high heating of the cathode necessary for the ionization of the air in the gap traversed by the arc. With an independent discharge of the character of the carbon arc discharge this ionization is necessarily effected by the current flowing across the gap between the anode and the cathode, which current heats the cathode and thus causes the ionization.

By this invention these advantages are obviated; one of its characteristic features consists in producing the ionization of the discharge gap not by the energy of the discharging or anode current (independent discharge) but by special additional ionization means independent of the anode tension or anode current (non-independent discharge). For such special ionizing means high temperatures, Roentgen rays (X-rays), Becquerel rays (rays from a source of radio activity) and light rays of short wave length. (ultra violet rays, etc), and chemical processes and the like may be employed. Preferably, however, an electrically heated metal cathode may be used, the outer surface of which, in a preferred form of the invention, is prepared with substances which strongly further the ionization.

By the invention a constant electron discharge is caused to pass across a small gap in such a manner as to produce a comparatively small constant direct current across the gap and in the circuit connected therewith. Sound vibrations are received adjacent to this gap and caused to modify the electrical conditions in the gap in such manner as to superpose on the direct current an alternating current which corresponds to the sound vibrations very accurately. Preferably, the sound vibrations impinge directly upon the ionized gap.

An advantage of the non-independent discharge for reception of and control by sound vibrations, in accordance with our invention, consists in the fact that the discharge current, when no sound vibrations are

received is absolutely continuous, i. e., constant. This may be evidenced by the fact that a highly sensitive indicating instrument, inserted in the anode current circuit, shows  
 5 no fluctuations of current at all, at a time when no sound vibrations are being received. When, however, the discharge gap is acoustically influenced the said gap alters its resistance in exact correspondence with the sound  
 10 vibrations. These fluctuations of the resistance in the discharge gap cause the superimposition on the direct current traversing the gap of an alternating current corresponding to the controlling sound vibrations, and these fluctuations of current are much  
 15 larger relatively to the normal current across the gap, (i. e., the current when no sound is being received), than is the case with an independent discharge, for example, in the  
 20 case of a carbon arc discharge.

It should also be noted that, in comparison, for example, with the independent discharge of the carbon arc, the hissing and other foreign sounds present in the carbon  
 25 arc discharge are eliminated because, in accordance with the present invention, there is no need of using a cathode which is subject to combustion and vaporization. The form of cathode which we prefer to use does  
 30 not volatilize in the open air at the temperatures used, it being noted that in practicing our invention a comparatively small current traverses the discharge gap, this in contradistinction, for example, to the carbon arc  
 35 in which a high discharge current is required to effect the ionization of the air or other gas.

The use of the form of the invention, referred to above, in which the sound waves  
 40 pass directly into the discharge gap, ensures the production of perfectly originally true, pure, and undistorted speaking currents, i. e., currents corresponding to the controlling sound vibrations, as all oscillating mechanical intermediate parts are eliminated, and  
 45 the distorting effects of independent discharges of the type of the carbon arc discharge are also done away with. There are however other possible forms of carrying out the invention in which for example the  
 50 variations in the resistance of the ionized discharge gap are dependent on variations of the distance apart of the electrodes, in which case mechanical intermediate parts and the like are necessary. Also, the degree  
 55 of ionization of the discharge gap may also be varied in acoustic rhythm, that is, in accordance with the controlling sound vibrations, by causing a strongly ionized gas to pass continuously into the discharge gap and  
 60 causing the rate at which this gas passes into the gap to be varied, in accordance with the controlling sound waves. This may be accomplished, for example, by the use of what  
 65 is termed a "discharge capsule," i. e., a pas-

sage through which the ionized gas passes, and which has a diaphragm mounted in its wall, against which the sound waves strike.

It should also be noted that the effectiveness of our invention may be increased by  
 70 the use of easily ionizable gases, and also by the use of forms of electrodes which favour the most favorable distribution of the field across the gap, and also by the use of sufficiently great anode potentials.  
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The invention is specially suitable in cases where the quality of the electrical current oscillations transmitted corresponding to the original sound vibrations, plays an important  
 80 part. Our improved microphone or sound translating device is also highly suitable, on account of its ordinarily high internal resistance, for the control of vacuum amplifying tubes. The vacuum amplifying tube also  
 85 has a high internal resistance which is conformable to that of the microphone or translating device disclosed herein, and the microphone and amplifier are particularly well adapted to be connected together by a  
 90 resistance coupling, as is shown in the drawings herein. By this means the use of a low frequency transformer in the connection to the vacuum tube or tubes may be done  
 95 away with, and this is an advantage in the use of the form of microphone described herein in many cases as when for reasons of clearness of speech the use of the low  
 100 frequency transformers is injurious. This is so, because currents corresponding to sound vibrations cannot be transmitted with clearness and lack of distortion, when low frequency transformers are used.

The invention consists in the sound translating apparatus described herein, and in  
 105 the various combinations of elements and forms of constructions which are described herein, and which will be claimed in the appended claims.

In order that the invention may be more clearly understood attention is hereby directed to the accompanying drawings, illustrating two forms of construction which  
 110 may be used, and which are included within the invention.

In the drawings

115 Fig. 1 represents diagrammatically a form of construction in which the sound waves act directly upon the discharge current in the gap without the use of any mechanical intermediate parts, and  
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Fig. 2 is a similar diagrammatic view showing a constructional form in which the sound waves strike against and operate a  
 125 mechanical oscillating body by which the distance between the cathode and anode is controlled.

Referring first to Fig. 1 of the drawings, the sound waves enter the funnel, or sound receiving device *t* in the direction of the  
 130 arrow, which funnel preferably terminates

in a flat nozzle. The funnel, as illustrated, may be of a tapering form to condense the sound waves which pass through the same. The nozzle, at the smaller or inner end of the funnel forms, or carries, the anode *a*.  
 5 The anode is placed a very short distance in front of the cathode *k*, whereas the distance between the electrodes in a carbon arc discharge is relatively considerable. It is  
 10 well known that in a carbon arc device the arc cannot be formed and maintained when the electrodes are as close together as they are, or may be in an electron discharge type of apparatus of the character here described.

In the construction shown in the drawings the cathode is heated by battery *b*<sup>1</sup>, which, as illustrated, is included in series with the cathode in a local heating circuit. The anode and cathode together with the discharge gap between them are connected in series in a circuit including the source of potential represented by battery *b*<sup>2</sup> and a suitably dimensioned resistance *w*. Battery *b*<sup>2</sup> supplies a high potential drop through resistance *w*, at the discharge gap, *a*, *k*. This resistance may, for example, be the windings of a telephone receiver or it may for example be a suitable coupling resistance for vacuum amplifying tubes. The circuit leading away from the anode-cathode circuit illustrated, in which the acoustically modified current which is desired is to be transmitted, is represented by the wires, illustrated in Fig. 1, connected one on each side of the resistance *w*. If this circuit is to include vacuum amplifying tubes for intensifying the speaking current produced, the resistance *w* should be a proper ohmic coupling resistance for such tubes.  
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If, now, the cathode be heated by the battery *b*<sup>1</sup>, it ionizes the space between anode *a* and cathode *k* and an electron discharge takes place between the cathode and anode, with a consequent flow of current across the gap. This current will be greater or less in strength in accordance with the degree of ionization of the discharge gap and also in accordance with the anode potential and in accordance with the form of the anode, certain forms of anode being more favorable for the distribution of the field to produce a strong current than other forms, as has already been indicated. By the means described a direct current of marked uniformity will flow across the discharge gap at all times when no sound waves are received by the funnel *t*. When, however, sound waves are thus received, an alternating current component corresponding quite exactly to the sound vibrations will be superposed upon this direct current, as has been stated, this acoustically influenced alternating current being caused by the impingement of the sound vibrations directly upon the discharge gap. It is believed that this modification of the current flowing across the gap is caused largely by the vibratory motion of the air corresponding to the sound waves, and partly to the pressure induced by the sound waves.  
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It should be noted that the path of the sound waves through funnel *t*, in the construction shown in Fig. 1, is directly in alignment with the lengthwise direction of the discharge gap extending from the anode to the cathode, and we believe that this is the most favorable arrangement and this constitutes the form of our device which is at present believed by us to be preferable. It will also be noted that the source of current for the anode circuit is, as has been stated, preferably one of high voltage and that the current effective at the discharge gap is relatively small.  
 A similar effect is obtained by the arrangement shown in Fig. 2, in which the same reference numerals are used to indicate corresponding parts. In Fig. 2, however, the funnel *t* is closed at its inner end by a diaphragm *m* to which is mechanically connected the anode *a*. The sound waves entering funnel *t* act upon diaphragm *m* and set the same into vibration as a result of which the anode carried by the diaphragm moves to greater or less extent towards the cathode *k*. The resistance of the discharge gap is varied in accordance with the variation in distance between the cathode and anode thus produced, and the current flowing across the gap and in the anode circuit will accordingly be varied in accordance with the sound vibrations which produce the movement of diaphragm *m*.

The cathode, as noted above, should be formed of a conducting material which is incombustible, and not volatilizable at the temperatures used, such a material being, for example, a suitable metal. Also, as has been stated, this cathode may be coated with, or its surface prepared with, a material which will tend to increase, when heated, the ionization of the air or other gas in the discharge gap. Such substances are known, such for example as certain oxides of the alkaline earth metals, such as the oxides of calcium or strontium or barium, which may be used for this purpose.  
 It should be noted that, in the claims, the statement that the constant electron discharge across the gap when no sound vibrations are received, produces a comparatively small direct current, should be understood to mean that this current is small in comparison with that which is required to maintain a carbon arc discharge.

It should be understood that the invention is not limited strictly to the details of construction which have been particularly described, but that the invention is of a con-

siderable breadth, and that a wide range of equivalents for the constructions which have particularly been described are included within the scope of the invention.

5 We claim:—

1. Sound translating apparatus, comprising the combination of a circuit including an anode and cathode adjacent thereto with a gas discharge path between them and a source of potential, ionizing means for said path separate from said source, and means for causing sound waves to be directed through the air upon said discharge path to modify the electrical conditions in said path.

2. Sound translating apparatus, comprising the combination of a sound receiving member, a circuit including a pair of electrodes with an air gap forming a gas discharge path between them and a source of potential, and ionizing means for said path separate from said source, said sound receiving member and discharge path being adjacent to each other and so arranged that current flowing along said path will be modified in accordance with the sound vibrations.

3. Sound translating apparatus, comprising the combination of a circuit including an anode and cathode with an air gap forming a gas discharge gap between them, means for producing a constant electron discharge across said gap producing a comparatively small constant direct current in said circuit, said current being insufficient to volatilize the cathode, and a sound receiving member adjacent to said gap so arranged in relation thereto as to cause sound vibrations received to cause the superimposition on the direct current in the gap of an alternating current fluctuating in accordance with the sound vibrations.

4. Sound translating apparatus, comprising the combination of a circuit including an anode and a non-volatilizing cathode with an air gap forming a gas discharge gap between them, means for producing a constant electron discharge across said gap, producing a small constant direct current in said circuit, said means comprising a source of potential in said circuit and a separate heating circuit for said cathode, and a sound transmitting member adjacent to said gap so arranged in relation thereto as to cause sound vibrations received to cause the superimposition on the direct current in the gap of an alternating current fluctuating in accordance with the sound vibrations.

5. Sound translating apparatus, comprising the combination of a circuit including an anode and cathode adjacent thereto with a gas discharge path between them and a source of potential, ionizing means for said path comprising a separate heating circuit for said cathode, and means for causing sound waves to be directed through a fluid

medium upon said discharge path to modify the electrical conditions in said path.

6. Sound translating apparatus, comprising the combination of a circuit including an anode and cathode adjacent thereto with a gas discharge path between them and a source of potential, ionizing means for said path separate from said source, and means for causing sound waves to be directed entirely through a fluid medium upon said discharge path in the direction of the path from the anode to the cathode, to modify the electrical conditions in said path.

7. Sound translating apparatus, comprising the combination of a circuit including an anode and a cathode with a gas discharge gap between them, means for producing a constant electron discharge across said gap producing a comparatively small constant direct current in said circuit, and a sound receiving member extending adjacent to said anode in the direction of the path from the anode to the cathode, to cause sound vibrations received to be directed through the air upon said path, to cause the superimposition on the direct current in the gap of an alternating current fluctuating in accordance with the sound vibrations.

8. Sound translating apparatus, comprising the combination of a sound receiving and transmitting member, an anode carried by the inner end thereof, a cathode beyond said anode and closely adjacent thereto, with a gas discharge gap between them, and means for producing a constant electron discharge across said gap, modified in accordance with sound vibrations when the same are received by said sound receiving member.

9. Sound translating apparatus, comprising the combination of a circuit including an anode and a cathode adjacent thereto with an air gap comprising a gas discharge path between them, and a source of potential, means separate from said source for heating said cathode to ionize said gap, said source and circuit being arranged to cause a relatively small current to flow through said circuit and across said gap, and a sound receiving member leading to said gap, arranged to cause sound vibrations received to modify the electrical conditions in said gap.

10. Sound translating apparatus, comprising the combination of a circuit including an anode and cathode adjacent thereto with a gas discharge gap between them and a source of high voltage and a resistance, ionizing means for said gap separate from said source, and a sound receiving member leading to said gap, arranged to cause sound vibrations received to modify the electrical conditions in said gap.

11. Sound translating apparatus, comprising the combination of a circuit includ-

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ing an anode and a cathode with an air gap forming a gas discharge gap between them, the cathode being of metal with an external surface composed of a substance which upon being heated tends to increase ionization in the gap, means for producing a constant electron discharge across said gap producing a comparatively small constant direct current in said circuit, said current being insufficient to volatilize said cathode, and a sound receiving member closely adjacent to said gap so arranged in relation thereto as to cause sound vibrations received to cause the superimposition on the direct current in the gap of an alternating current fluctuating in accordance with the sound vibrations.

12. Sound translating apparatus, comprising the combination of a sound receiving conduit, a circuit including an anode and cathode adjacent thereto with an air gap forming a gas discharge path between them, a source of potential and a high ohmic resistance, suitable as coupling resistance for a vacuum amplifier, an ionizing means for said path separate from said source, said sound receiving conduit and discharge path being adjacent to each other and so arranged that current flowing along said path will be modified in accordance with the sound vibrations, and output circuit connections connected across the ends of said resistance.

13. Sound translating apparatus, comprising the combination of a circuit includ-

ing an anode and cathode adjacent thereto with a gas discharge path between them and a source of potential, ionizing means for said path separate from said source, and a sound transmitting conduit one end of which extends to and opens directly upon said path.

14. Sound translating apparatus, comprising the combination of a circuit including an anode and cathode adjacent thereto with a gas discharge path between them and a source of potential, a separate heating circuit for said cathode, and a sound transmitting conduit one end of which extends to and opens directly upon said path.

15. Sound translating apparatus, comprising the combination of a circuit including an anode and cathode adjacent thereto with an air gap forming a gas discharge path between them and a source of potential, a separate heating circuit for said cathode, and a sound transmitting conduit one end of which extends closely adjacent to said path, said sound transmitting device being aligned with the anode-cathode path.

In testimony whereof we affix our signatures in presence of two witnesses.

HANS VOGT.  
DR. JOSEF ENGL.  
JOSEPH MASSOLLE.

Witnesses:

FRITZ WAMPFENDS,  
DR. OTTO SCHNEIDER.