L. DE FOREST.

AUDION CIRCUIT.

APPLICATION FILED APR. 27, 1920.

1,377,405. Patented May 10, 1921.

Fig. 1.

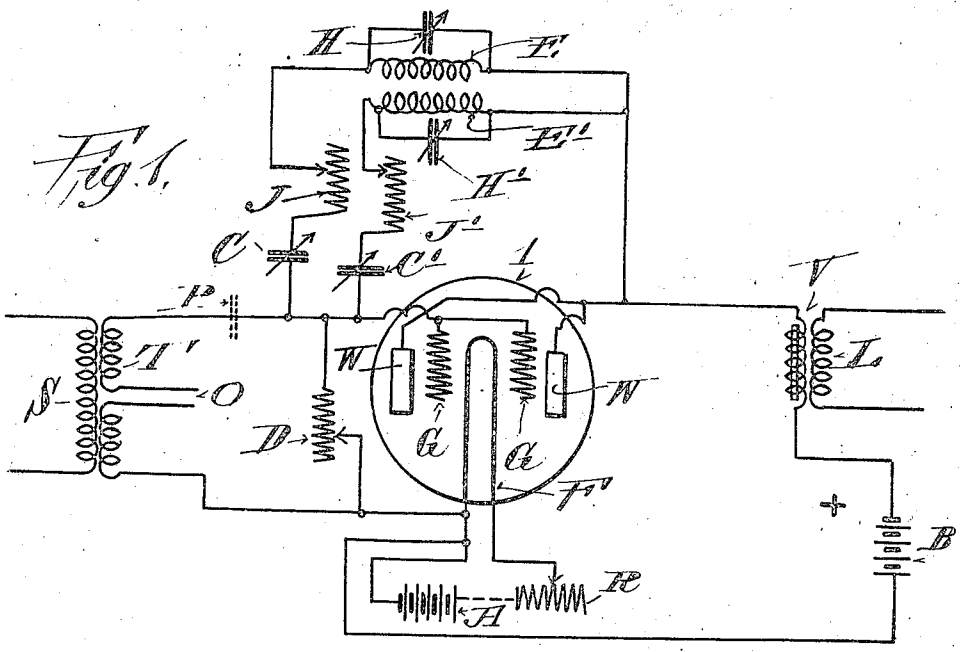
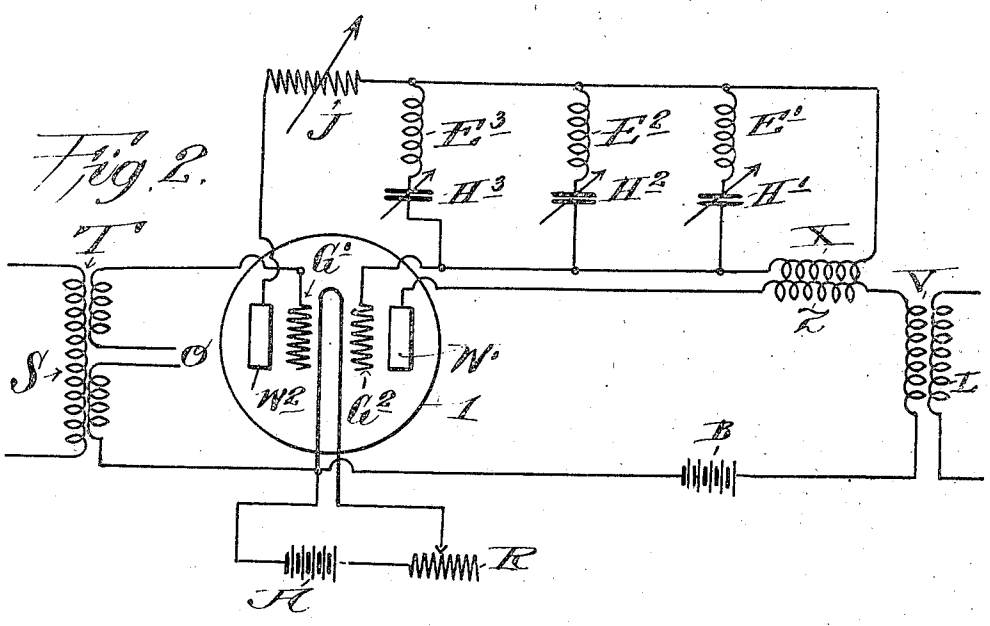


Fig. 2.



INVENTOR

Lee de Forest

BY his ATTORNEY Samuel E. Darby

UNITED STATES PATENT OFFICE.

LEE DE FOREST, OF NEW YORK, N. Y., ASSIGNOR TO DE FOREST RADIO TELEPHONE AND TELEGRAPH COMPANY, OF NEW YORK, N. Y., A CORPORATION OF DELAWARE.

AUDION-CIRCUIT.

1,377,405. Specification of Letters Patent. Patented May 10, 1921.

Original application filed April 9, 1915, Serial No. 20,173. Divided and this application filed April 27, 1920. Serial No. 377,051.

To all whom it may concern:

Be it known that I, LEE DE FOREST, a citizen of the United States, residing at New York, county and State of New York, have made a certain new and useful Invention in Audion-Circuits, of which the following is a specification.

This invention relates to audion circuits, and is directed to subject matter divided from my co-pending application, Serial Number 20173, filed April 9, 1915, for selective audion amplifier.

The object of the invention is to provide an audion circuit which is simple and particularly adapted for amplification usage of the audion where the same is used as a relay as one illustration for either wire or wireless purposes.

It has been found by experiment that relays of the audion type become paralyzed when certain conditions in the normal operation exist. For example, where the device is used as an amplifier or relay with the current to be relayed and amplified received through an input circuit and the amplified current delivered by an output circuit, if the incoming current is excessive too large a charge upon the grid electrode of the audion causes the same to paralyze. Similarly, it frequently happens that a sudden signal impulse will effect the same result, namely, the paralysis of the audion. Also, if the plate current is excessive the effect of the paralysis is likewise produced. And if a critical adjustment of the plate and filament current sources is secured the normal incoming signal is apt to produce the paralyzed condition of the audion. So it will be apparent that while the effect is the same, that is, the audion becomes paralyzed, the causes of this condition of the audion may be any one of a number.

Where a perfect vacuum has not been obtained in the bulb this paralyzed condition of the audion is frequently evidenced by a blue glow or haze although the paralyzed condition may frequently occur without any such visual evidence thereof, and is detected by the operator who at once generally knows that when the audion is not properly functioning it has become paralyzed.

The special purpose of my present invention is to provide means for effectively preventing and overcoming this paralyzed condition of the audion, and while I have shown and will now describe my invention as applied to an audion with all of the cathode and anode electrodes inclosed therein and as used as an amplifier or relay, I do not desire to be limited or restricted either to this construction or particular application of an audion.

Referring to the drawings,—

I show in Figure 1 one audion circuit arrangement embodying my invention, and which is a substantial duplication of Fig. 1, of my co-pending application above identified.

Fig. 2 shows a similar but slightly modified arrangement.

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

Referring to Fig. 1, I show my present invention applied to a selective amplifier system of the audion type wherein the audion will perform its amplifying function selectively. In other words, incoming currents or currents of certain frequencies received by the audion will be amplified to a greater degree than currents of other frequencies, and especially currents of lower frequencies. In addition thereto, the principle of selective amplification can be emphasized as much as desired or necessary so that, if desired, the normal voice currents before going in on a telephone line, for example, can first be distorted and the higher harmonics thereof made of greater amplitudes so that after these latter currents are reduced in amplitude by the distributed capacity of the telephone line, the composite current will arrive at the distant receiving station in its normal or original form. This feature of selective amplification forms the subject matter of my application, Se-

rial No. 20173 above identified, and does not *per se* form the subject matter of the present invention except in that the present invention is disclosed therein.

Reference character 1 designates an exhausted audion bulb, in this instance of the usual well known double plate and double grid structure both located within the bulb. It is apparent, however, that I do not desire to be limited with respect to the particular construction of the audion, or whether or not the electrodes are all located within the bulb or exterior thereof, as it is well known that audions vary somewhat in their construction and in the number of electrodes employed therein or therewith. As is customary, however, I have shown a filament electrode F which is heated from the current source A and controlled by the variable resistance R in the usual well known manner. The grid elements or input electrodes G, G, are preferably arranged on either side of the filament F and are connected in parallel. The wing or plate electrodes W, W, are also arranged on respectively opposite sides of the filament F and at a different distance therefrom relative to the grid electrodes, G, G. The incoming current to be amplified is led from the line to the primary coil S of a transformer T, preferably a step-up transformer. While I am not to be limited to the specific arrangement shown, I prefer to have the secondary coil of the transformer T wound in two parts disconnected from each other as shown at O, the parts thereof possessing a large capacity relative to each other. One end of one winding of the secondary coil of the transformer T is connected directly to the filament F of the audion 1, while one end of the other coil is connected to the grids G, G, of the audion 1. If desired, in the transformer and grid circuit, a condenser may be inserted, as shown in dotted lines at P. The plate or wing electrodes W, W, are connected through an inductance coil of a transformer V to one terminal, preferably the positive terminal of a source of current such as a battery B, the current, preferably the negative, terminal of which is connected to the filament F of the audion 1. The outgoing circuit L is connected to the secondary of the transformer V. An oscillating circuit consisting of the inductance E and capacity H in parallel thereto is connected by one terminal to the wing or plate electrodes W, W, and the other terminal to the grid electrodes G, G. If desired, and as shown, a capacity preferably in the form of a variable condenser C, may be inserted in this circuit. In accordance with my invention I insert a resistance J in this circuit, preferably in the lead to the grid electrodes G, G, and preferably, as shown, to make the resistance variable. By making the resistance variable I utilize the same in addition to the uses hereinbefore set forth as a damping resistance to reduce the amplitude of the potential surges delivered from the oscillating circuit H, E, to the grid electrodes, as above described.

The natural period of vibration of this oscillating or parasitic circuit depends to a great extent upon the amount of inductance of the coil E and the amount of the capacity of the condenser H. This frequency also depends upon the constants of the audion itself, the brightness of the filament F, the applied potential from the battery B, the amount of resistance J, and the amount of resistance D which forms a leak path between the grids G, G, and filament F, and is likewise made variable.

In addition to the first oscillating or parasitic circuit, if desired, a second similar circuit comprising elements C′, J′, E′, H′, identical with the corresponding elements of the first circuit may be connected between the grid and plate electrodes, but the oscillating circuit E′, H′, should be tuned to a different frequency or natural rate of oscillation than that of the first oscillating circuit. Similarly, a number of oscillating circuits, each tuned to a different frequency, can be connected to the audion.

It is not necessary, however, to connect such a parasitic or reinforcing circuit to the audion for each different frequency it is desired to amplify. I have found that one such circuit, the natural fundamental frequency of which may be such as to cause it to tend to oscillate approximately 1500 times per second, will cause incoming currents having frequencies considerably higher than 1500 to be amplified to almost the same degree, while at the same time not permitting currents having considerably lower frequencies to be thus auto-amplified. I have found that two such reinforcing circuits, the natural period of one of which is such as would cause the audion to deliver a sustained note of a frequency of about 1500 per second, if free to oscillate; and the natural period of the other of which is such as would cause the audion to deliver, if free to oscillate, a sustained note of about 2500 per second, will reinforce currents of all frequencies between 1200 and 3000 per second. It is therefore possible to arrange a single audion with reinforcing circuits to so selectively amplify voice currents that all the higher harmonics are amplified over those of the lower or fundamental frequencies.

The principles involved in enabling an audion to amplify different frequency currents unequally is set forth in my co-pending application above identified, from which the subject matter of this present application has been divided, and while I have gone rather fully into the description of the

selective amplifier circuit it should be remembered that my present invention is directed solely to the resistance leak path between the elements of the audion, and the full description of the selective amplifier has been given to enable a clear understanding of one application of my present invention to a specific system.

In Fig. 2 I have shown another circuit arrangement wherein the incoming currents are conducted to one of the grid electrodes as G′. One of the wing or plate electrodes W′ is connected to the outgoing line in the usual manner. The oscillating or "reinforcing" circuits are connected to the other electrodes W^2, G^2, of the audion bulb 1. Each of the oscillating circuits contains a common inductance X associated with the coil Z in the output circuit. The individual inductances E^1, E^2, E^3, etc., each in series with the capacity H^1, H^2, H^3, etc., respectively, determine the period of the reinforcing circuits, of which in this figure I have shown three. The effect of these reflection circuits associated with the output circuit is to impart to the audion the tendency to disproportionately amplify currents having frequencies generally approximately those of the three reinforcing circuits. In this arrangement the resistance J is inserted in the audion path of these circuits to prevent the audion from singing, and to afford a high resistance leak path as hereinbefore described.

From the foregoing it will be apparent that while it is preferable to connect the high resistance between the two cold electrodes, especially where the device is to operate as a relay, as shown in Fig. 2, the high resistance path may equally well be connected between either of the cold electrodes and the hot electrode, in the latter case preferably between the grid and filament.

Having now set forth the objects and nature of my invention, and having shown and described a construction 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. An electric relay comprising an incoming circuit, an outgoing circuit including a gaseous conductor, forming a part of each of said circuits, and a conductive leakage path connected to two points in said gaseous conductor.

2. An electric relay comprising an incoming circuit, an outgoing circuit including a gaseous conductor forming a part of each of said circuits, and a high resistance conductive leakage path connected to two points in said gaseous conductor.

3. An electric relay comprising an evacuated vessel, a heated member, a conducting member and a conducting plate sealed therein, an incoming circuit connected across said heated member, and said conducting member, an outgoing circuit connected across said heated member, and said conducting plate, and an additional metallic circuit connecting said conducting member and said plate.

4. An electric relay comprising an evacuated vessel, an incoming circuit, an outgoing circuit, a cathode common to said circuits and anodes individual to said circuits sealed in said vessel, and a shunt circuit including a high resistance connecting said anodes.

5. An electric relay comprising an evacuated vessel, a heated electrode, a grid shaped member and a plate sealed therein, an incoming circuit including said heated electrode, a condenser and said grid member; an outgoing circuit including said heated electrode, a source of potential and said plate; and a shunt circuit including said grid member and said plate.

6. In an electric relay, the combination with an audion, of a circuit including a resistance in shunt of two of the elements of said audion.

7. An electric relay, comprising an incoming and an outgoing circuit, a gaseous conductor interposed between such circuits, and a conductive shunt circuit connected around said gaseous conductor.

8. An electric relay, an incoming circuit, an outgoing circuit including a gaseous conductor forming a part of each of said circuits and a conductive leakage path connected in parallel with a part of said gaseous conductor.

9. An electric relay comprising an evacuated vessel, a heated member, a conducting member and a conducting plate sealed therein, and a conductive circuit connected to said conducting member and said plate.

10. The combination with an evacuated vessel having associated therewith a hot and two cold electrodes, each of said cold electrodes being located at a relatively different distance from said hot electrode, electrical circuits connecting said electrodes, and a conductive leakage path connected to two of said electrodes.

11. The combination with an evacuated vessel having associated therewith a hot and two cold electrodes, each of said cold electrodes being located at a relatively different distance from said hot electrode, electrical circuits connecting said electrodes, and a high resistance conductive leakage path connected to two of said electrodes.

12. The combination with an evacuated vessel having associated therewith a hot and two cold electrodes, each of said cold electrodes being located at a relatively different distance from said hot electrode, electrical

circuits connecting said electrodes, and a metallic resistance permanently connected between two of said electrodes.

13. The combination with an evacuated vessel having associated therewith filament, grid and plate electrodes, circuits connecting said electrodes, and a conductive leakage path connected between the grid and plate electrodes independent of the evacuated space between said grid and plate electrodes.

14. The combination with an evacuated vessel having associated therewith filament, grid and plate electrodes, circuits connecting said electrodes, and a high resistance leakage path connected between the grid and plate electrodes independent of the evacuated space between said grid and plate electrodes.

15. The combination with an evacuated vessel having associated therewith filament, grid and plate electrodes, circuits connecting said electrodes, and a metallic high resistance path permanently connected between the grid and plate electrodes.

16. The combination with an evacuated vessel having associated therewith filament, grid and plate electrodes, circuits connecting said electrodes, and an aperiodic circuit connected between two of said electrodes.

17. The combination with an evacuated vessel having associated therewith filament, grid and plate electrodes, circuits connecting said electrodes, and an aperiodic circuit connected between the grid and plate electrodes.

In testimony whereof I have hereunto set my hand on this 21st day of April, A. D. 1920.

LEE DE FOREST.