H. DE F. ARNOLD.

ELECTRIC WAVE AMPLIFIER.

APPLICATION FILED MAY 16, 1914.

1,128,279. Patented Feb. 16, 1915.

Fig. 1.

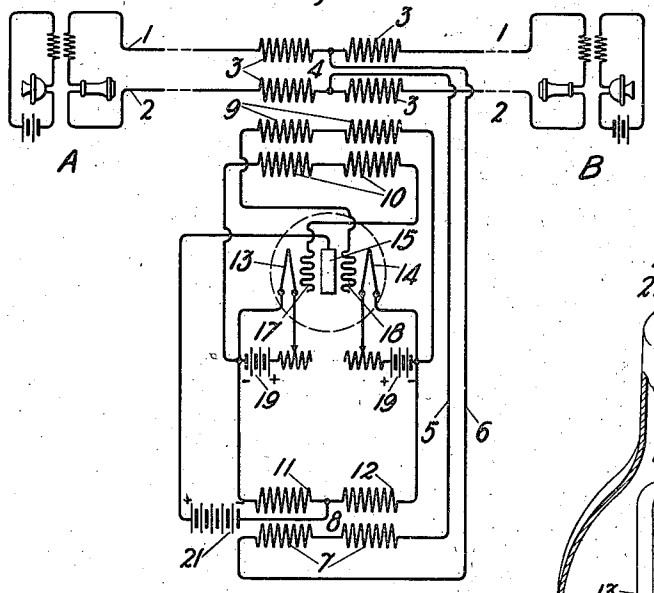


Fig. 3.

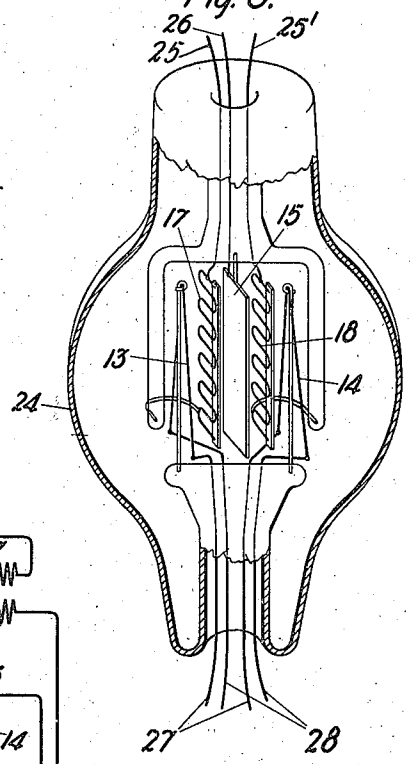
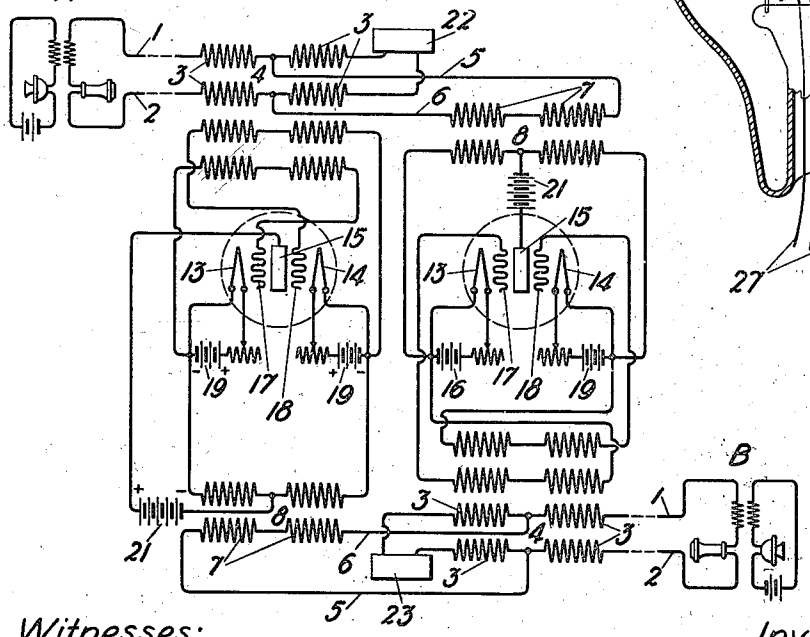


Fig. 2.



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UNITED STATES PATENT OFFICE.

HAROLD DE FOREST ARNOLD, OF EAST ORANGE, NEW JERSEY, ASSIGNOR TO WESTERN ELECTRIC COMPANY, OF NEW YORK, N. Y., A CORPORATION OF ILLINOIS.

ELECTRIC-WAVE AMPLIFIER.

1,128,279. Specification of Letters Patent. Patented Feb. 16, 1915.

Application filed May 16, 1914. Serial No. 839,057.

To all whom it may concern:

Be it known that I, HAROLD DE FOREST ARNOLD, a citizen of the United States, residing at East Orange, in the county of Essex and State of New Jersey, have invented a certain new and useful Improvement in Electric-Wave Amplifiers, of which the following is a full, clear, concise, and exact description.

This invention relates to electric wave repeating apparatus and particularly to the use of the so-called "audion" for repeating and amplifying in an output circuit waves of electric energy received in an input circuit. Its object is to improve the quality of transmission by producing in the output circuit electric waves free from distortion with respect to the input waves.

The invention is especially useful in telephone and telegraph service for repeating and amplifying alternating current waves of small magnitude.

The principal parts of an audion element or structure are a heated filament or other source of ionization, an anode usually called a "plate", and an electrode, preferably located intermediate the filament and the plate, said electrode being usually called a "grid". These are preferably inclosed in an evacuated glass vessel. Characteristic features of the audion are that current can flow in one direction only in the ionized stream, and that the strength of current in the stream flowing from its source to the plate is modified by electrostatic rather than by electromagnetic force as in some other types of "gaseous" repeaters.

A simple arrangement for using a single audion element as a repeater is as follows: The input circuit is connected, one side to the filament and the other to the grid, while the output circuit is connected, one side to the filament and the other to the plate. Repeating coils are preferably employed in the input and output circuits respectively, and a battery is included in the output circuit in series with the primary winding of the output repeating coil. The audion repeater as thus used, although a powerful amplifying agent, does not repeat in the output circuit a perfect form reproduction of the electric wave received in the input circuit. This is due to the fact that the space between the filament and the grid has unilateral conductivity. When an alternating potential is applied between the filament and the grid, current flows during that part of each wave cycle in which the grid is positive, but little or no current flows in this circuit during the other part when the grid is negative. This unsymmetrical action results in a certain amount of distortion in the output waves which is avoided, in accordance with this invention, by employing two audion elements, one of which operates to repeat the positive parts and the other the negative parts of the input waves. Two audion elements may be combined in one structure for this purpose, and the present invention is an improvement in that disclosed in the application of Edwin H. Colpitts, Ser. No. 810,196, filed Jan. 3, 1914.

In the drawings—Figure 1 represents a commercial telephone line equipped with one repeater set for two-way service; Fig. 2 represents another commercial system of circuits for telephonic transmission in which the line is divided and each part equipped with a separate repeater set, and Fig. 3 is a perspective view of a single structure comprising two audion elements adapted for the systems shown in Figs. 1 and 2.

The same reference characters are used to designate like parts in the several figures.

Incoming and outgoing conductors to and from the repeating apparatus of this invention are represented in the several views by the wires 1, 2 terminating in the primary winding 3 of an input repeating coil 4, and the wires 5, 6 terminating in the secondary winding 7 of an output repeating coil 8 respectively. The secondary of the repeating coil 4 comprises two distinct windings 9 and 10, and the primary winding of the repeating coil 8 is divided into two coils 11 and 12. Two audion elements are combined and included in each of the circuits. They comprise two heated filaments 13 and 14, an anode or plate 15, and two intermediate electrodes or grids 17 and 18. Each of the filaments is heated by current from a battery 19. The output circuit, including the primary coils 11 and 12 of the repeating coil 8, has included in a common portion of it a battery 21. In each of the systems, shown in Figs. 1 and 2, there are employed three classes of circuits exclusive of the incoming and outgoing line circuits. One is

the circuit of each of the heated filaments fed by the battery 19. In the second class are the two oppositely connected input circuits, each of which includes one of the secondary windings 9, 10 of the repeating coil 4, one of the grids 17 and 18, a portion of the ionized stream and one of the filaments. The third is the divided output circuit which includes in the common portion the battery 21 and in the divided portions the heated filaments 13, 14, the ionized streams, the anode 15, and the primary coils 11, 12 of the repeating coil 8.

In Fig. 1 a telephone line is represented in which one repeating set of two audion elements may be employed to provide for commercial two-way telephonic transmission between two stations A and B. The primary winding 3 of the input repeating coil 4 is divided into four coils, as shown, and its several coils are included serially in the telephone line, while the secondary winding 7 of the output repeating coil 8 is placed in bridge of the telephone line and connected symmetrically with respect to the several coils of the primary winding 3.

In Fig. 2 are shown two similar repeating sets to provide, in another way, for commercial two-way service. The telephone line is divided and the two parts separately balanced by networks 22 and 23, respectively. The primary winding 3 of the input repeating coil 4 of one of the repeater sets is divided into four coils which are included serially in the telephone line extending between the telephone station A and the network 22. In the same way four coils of the primary winding 3 of the repeating coil 4 of the other set are included serially in the line extending between the telephone station B and the net work 23.

The operation is as follows: Telephonic currents or other electric current waves incoming by way of conductors 1, 2 are received in the primary winding 3 of the input repeating coil 4, and reproduced by the secondary windings 9, 10 thereof in the input circuit. At any instant of time, except of course at the moment when a wave is passing the point of zero current flow, there will be positive potential impressed on one of the grids, say 17, and a corresponding negative potential impressed on the other grid, 18. As current can flow between the heated filament and the grid of either audion element only when the grid is at positive potential with respect to the filament, the effect on the current in the ionized stream flowing between the filament and plate will be different in the two audion elements. The grid which is for the moment positive will materially alter the flow of current in the stream in which it is interposed, but the grid which at the same moment is negative will have little or no effect. As the electric current wave progresses in the input circuit, the potential conditions on the two grids become reversed so that the negative portion of the wave (assuming the other portion considered to have been positive) will be repeated due to positive potential on the previously ineffective grid. Thus every variation in current produced by the input waves is repeated by one or the other of the two audion elements.

A suitable structure for the two combined audion elements is shown in Fig. 3, wherein the filaments 13, 14 are supported from one end of the glass bulb or vessel 24. The two grids 17, 18 and the plate 15 are supported at the other end of the vessel and held in their proper positions in any suitable manner. The grids 17, 18 are connected to the leading-in wires 25, 25′ respectively. A leading-in wire 26 is provided for the plate 15, and a pair of leading-in wires 27, 28 are provided for each of the filaments 13, 14.

What is claimed is:

1. In an electric wave repeating apparatus, a unitary audion structure comprising a plurality of filaments, input electrodes individual to said filaments, and an anode common to said filaments.

2. In an electric wave repeating apparatus, a plurality of audion elements having a common anode.

3. In an electric wave repeating apparatus, two audion elements included in a unitary structure comprising two filaments and their corresponding grids and an anode common to said audion elements.

4. In an electric wave repeating apparatus, a plurality of audion elements included in a unitary structure comprising a plurality of filaments and their corresponding grids and an anode common to said audion elements.

5. In an electric wave repeating apparatus, two audion elements included in a unitary structure comprising two filaments, two grids located between said filaments, and a plate between said grids.

6. In an electric wave repeating apparatus, the combination of two repeating elements comprising a cathode and an anode individual to each of said elements and an anode common to said elements, an input repeating coil having two secondary windings oppositely connected each in series with one of said cathodes and its corresponding individual anode, and an output repeating coil having its primary winding divided, said common anode being connected to an intermediate point of said divided primary winding and the ends of said primary winding being connected to said filaments, respectively.

7. In an electric wave repeating apparatus, the combination of two audion elements having a common plate and individual

filaments and grids, an input repeating coil having secondary windings oppositely connected in circuit with said filaments and grids, and an output repeating coil, the primary winding of which is connected at an intermediate point to said plate and at its opposite terminals to said filaments.

In witness whereof, I hereunto subscribe my name this 14 day of May A. D., 1914.

HAROLD DE FOREST ARNOLD.

Witnesses:
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ELLA EDLER.