Feb. 20, 1934. J. A. HEANY ET AL 1,947,774

ELECTRICAL TRANSLATING DEVICE

Filed July 21, 1931

Fig. 1.

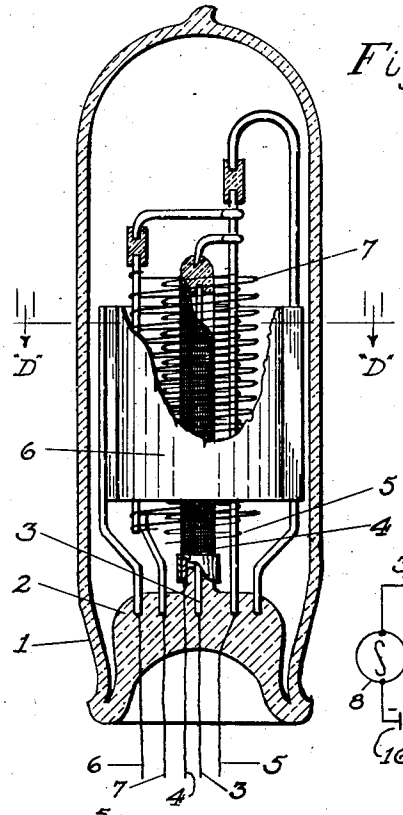

Fig. 2.

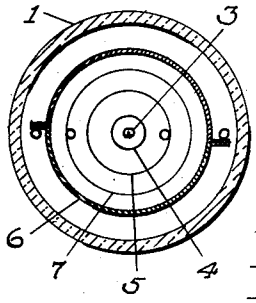

Fig. 3.

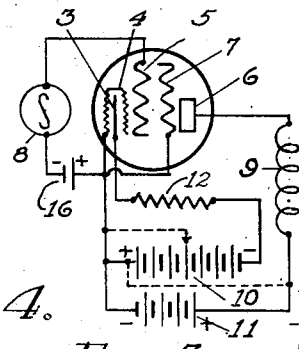

Fig. 4.

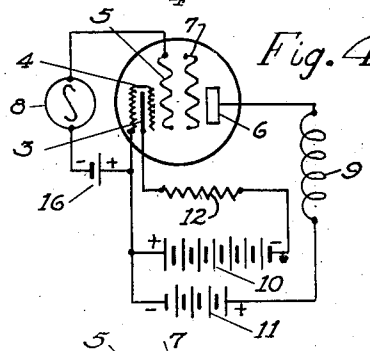

Fig. 5.

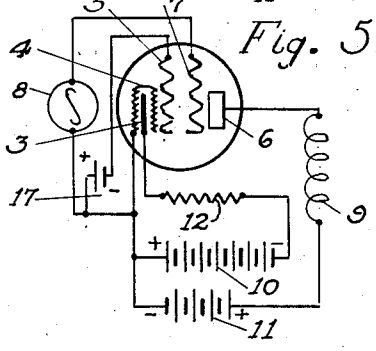

Fig. 6.

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ELECTRICAL TRANSLATING DEVICE

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Application July 21, 1931. Serial No. 552,186

18 Claims. (Cl. 179—171)

This invention relates to electrical translating device, and particularly to devices operable in casings having an appreciable gas content, and of the type disclosed in our co-pending applications, Serial No. 542,304, filed June 5, 1931, and Serial No. 548,410 filed July 2, 1931.

The basic invention disclosed in the above mentioned applications lies in the construction and operation of a gaseous tube or cell having a negative resistance characteristic, with apparent electronic conduction induced by a difference in potential between substantially cold electrodes rather than from a heated cathode. The invention resides further in positive control of the space current path between electrodes immersed in a gas.

The principal object of our present invention is to provide improvements in devices of this general type.

With this object in view, we have discovered that with the addition of an auxiliary electrode we are able to exceed the performance of our earlier tubes. The improved performance is graphically illustrated in Figure 6.

The construction and operation of the Heany-Haffcke gas cell, as disclosed in the applications above cited, may be briefly explained as follows: two electrode elements constitute the working cathode of the cell and serve to ionize or electronize the gas, one of these electrode elements functions as an anode to the cathode element, but as a cathode to the main anode of the tube, so that we shall hereafter refer to this anode element of the cathode electrode by the designation "cathanode". An anode and a control electrode are other elements in the tube.

In a hot filament device, if we consider electrons emitted from the filament substance or coating as traveling from the filament and reaching the plate, we may draw an analogy between electron movement and a flowing stream, i. e., a particular electron may travel from a source to a point. Without attempting to explain the theoretical side of phenomena involved in the working of cells within our invention, we suggest that in our gas cell electronization of the gas in the region of the cathode caused by the difference in potential between the cathode elements effects by collision, or otherwise, electronization of the gas between the cathanode and the main anode, without forming a stream, but by forming a linked, sectional or divided path between the electrodes by reason of electronization of one molecule of gas being effected by a condition of the next preceding molecule.

In one preferred form of the invention disclosed in our prior application, Serial No. 542,304, above cited, the arrangement of the elements considered from the axis of the container is as follows: cathode, cathanode, control electrode, and an anode surrounding these electrode elements. In accordance with our application, Serial No. 548,410, the arrangement may be substantially opposite, one cathode element being arranged exterior to the other elements, the anode being preferably the innermost electrode, taken from the longitudinal axis of the container. Our present invention is applicable to cells of either the "internal cathode type" of the first application, or to the "external cathode" of the second mentioned application.

The novel features, which we believe to be characteristic of our invention, are set forth with particularity in the appended claims. The invention itself, however, both as to structure and method of operation, will be best understood by reference to the following description taken in connection with the accompanying drawing, wherein: Figure 1 represents a partly broken away view, disclosing the complete assembly of a gas cell within our invention. Figure 2 is a cross section into the elements of Figure 1 on the line D—D, looking in the direction of the arrows. Figure 3 represents diagrammatically the intake, output, and energizing connections of the cell. Similarly, Figures 4 and 5 show certain circuits in which cells within our invention are usable. Figure 6 comprises graphs showing the cells performance in comparison with a cell of our earlier invention, like figures representing similar, or corresponding, parts throughout.

By the term "cathanode" as herein used is meant any electrode which functions with the cathode to produce an ionization or glow discharge phenomena; which ionization or glow discharge acts as a primary source of electrons.

Referring now in detail to Figure 1, an enclosing receptacle or bulb is designated 1. This bulb contains a press, 2, above which are mounted the several electrode elements of the tube, and which may be supported in any suitable manner. The cathode is 3, the cathanode is 4, the control electrode, 5. The anode is 6, and may take the form of a plate, as shown in the "internal" cathode tube here illustrated. In the case of an "external" cathode tube, to which our invention is likewise applicable, the anode is the center or axial element, and may be rod-shaped, as will more fully appear in connection with the description accompanying Figure 2. In addition

to all these electrodes and electrode elements, there is another, or auxiliary electrode, 7, which may be of helical, meshed, or other apertured construction, and is preferably positioned and arranged intermediate the control electrode 5 and the anode 6, and may be substantially concentric therewith.

As in our previous cells, neither the size of spacing of the electrodes is critical, nor are the limits of gas pressure strictly confined. We have received excellent operating results with different gases from one to 50 millimeters of mercury or higher. Almost any gas may be used in the tube, even dry air, as there is no heated element in the tube to cause the gas content to be absorbed or combined therewith. By "appreciable gas content" as herein used is meant: any pressure of gas substantially above that at which old type thermionic "soft" tubes are operable, and may be measurable in millimeters or inches of mercury.

Figure 2 is a cross-sectional view of Figure 1 taken on the line D—D, and looking in the direction of the arrows. As previously mentioned, our invention, as herein described, is applicable not only to internal cathode type cells, but also to external cathode type cells. In the external type cell described in our co-pending application, Serial No. 548,410 the arrangement of electrodes may be substantially opposite to that of the internal cathode type illustrated in Figure 1, therefore, in applying our invention to the external type, the central electrode 3 is the anode, and is preferably a rod-shaped member, 4 the auxiliary electrode, 5 the control electrode, 6 the cathode, and 7 the cathanode. However, we shall, for the purpose of simplification and clearness, here confine our description to the internal type of cathode tube here illustrated in cross section wherein 1 is the tube wall, 3 the cathode, 4 the cathanode, 5 the control electrode, 6 the anode, and 7 the auxiliary electrode.

The auxiliary electrode 7, as shown in circuit in Figure 3, may be similar in form and relative location to the "screen grid" in so-called "shield" or "screen grid" and "pentode" tubes. It functions in an entirely different manner, however, and should not be confused therewith. In screen grid and pentode tubes, the "screen grid" is connected to a positive potential somewhat lower than the anode plate potential, and its function is to screen the normal grid (or control grid, as it is called) from the electro-static effects of the plate, and as a result lowering the plate impedance and also reducing the effective plate-to-control-grid capacity, thereby allowing the screen grid to be used for high voltage amplification. In the pentode tube, the other, or "auxiliary grid," is operated at cathode potential in order to neutralize the effect of secondary emission, whereby increased power may be taken from the plate circuit. In cells within our present invention the auxiliary electrode 7 functions as neither of the foregoing.

In the preferred form, as shown in Figure 3, the auxiliary electrode 7 is connected at a suitable point to the cathanode 4, whereby it is at the same potential as the cathanode. It is more positive than control electrode 5, as the negative terminal of a suitable polarizing source 16 is connected through the input 8 with the control electrode 5. The auxiliary electrode 7, however, is less positive than the anode 3. As energizing sources 10 and 11 are in series, the total value of the anode voltage is the sum of the voltages of the sources 10 and 11. The output coupling is symbolically represented by coil 9. 12 is a ballast resistor which serves to limit the current through the cell.

In our earlier tubes, as described in the applications previously cited, the cathanode is cathode to the anode, and carries some of the anode current. In the present invention, however, the auxiliary electrode becomes cathode to the main anode 6 and carries a major proportion of the anode circuit current. There is no need for any control electrode to be interposed between the auxiliary electrode 7 and the anode 6, since the control electrode 5 functions perfectly to give control of the anode current over a wide range of grid swing. Apparently, the control electrode 5 acts to control ionization, or electronization, between the auxiliary electrode 7 and the anode 6, thereby controlling the conductivity of the path between the said auxiliary electrode 7 and the anode 6. In operation there is a distinct ionization glow between the cathode 3 and the cathanode 4, and extending toward or to the control electrode 5. There is also a pronounced glow between the anode 6 and auxiliary electrode 7. But, between control electrode 5 and the auxiliary electrode 7 there is a well defined dark space which persists through all normal operation of the cell unless the potential is raised too far above the ionization and practical working point when arcing takes place.

Cells within our invention may be used in connection with a strictly single source of supply. In this event the cathanode connection may be made to a mid tap of the voltage divider of an ordinary power pack, the cathode connection to the negative terminal and the anode to the positive terminal. All of these connections are symbolically represented by dotted lines in Figure 3.

In the "internal cathode type" cells described in application Serial No. 542,304, previously referred to, as well as "internal cathode type" cells of the present invention, as so far described, the anode-cathanode potential is quite low for most gases, and may be of the order of 15 to 20 volts, being substantially just below the ionization voltage of the gas. However, we have discovered a novel arrangement whereby very much higher plate potentials may be used and effectively controlled in tubes or cells of this type. Thus, as in Figure 4, instead of connecting the auxiliary electrode to the cathanode, as in Figure 3, it is left entirely free of any connection to the other elements, or the circuit; or, as we term it, remains "floating" with regard to the other elements. In this relation, it apparently acts as an anode to the cathanode, and as a cathode to the anode, so that the potential across each of these spaces is substantially at or above ionization voltage, and the total plate potential may be, therefore, several times what it is in the earlier type cells, or in the preferred form of the present invention, as shown in Figure 3. This phenomenon may be carried still further by interposing more than one auxiliary electrode 7 between the control electrode and anode, with all of said auxiliary electrodes left unconnected, or floating. Each individual section then acts as a single ionization space and raises the total plate potential in proportion to the number of the auxiliary grids.

Graph "C" in Figure 6 shows the effect on the anode current of leaving the auxiliary electrode free, or floating. It is substantially the same as

graph "B" in the same figure, part of it being steeper, and requiring a lower grid swing to give the same effect as obtainable with the auxiliary electrode connected to the cathanode, as in Figure 3.

One of the uses to which the Heany-Haffcke cell may be put, and a use which is unknown in the thermionic art, is this: the cell is an effective voltage divider, and is usable as such, or for any other useful purpose to which it may be adapted, and instead of being connected to the cathanode, or left floating, the auxiliary electrode, or electrodes, may be brought out to independent terminals on the outside of the container and be used as individual taps on a common source of applied voltage.

Another possible variation shown in Figure 5 is to use the outside, or auxiliary electrode 7, as the control electrode, in which case electrode 5 becomes the auxiliary electrode. In operation, by properly biasing electrode 5, which is otherwise floating, either positively or negatively as may be required in the particular circuit, by a source of potential 17, which is now the control electrode 7, may be made to control with zero bias and so do away with any necessity for using an additional applied potential to the now control electrode 7. As stated, the charge for the electrode 5 will be either positive or negative, whichever is required to make the electrode 7 control with zero bias.

In Figure 6, curve "A" was made with a 4 element "internal cathode type" tube of our previous invention. Curve "B" was made with an "internal cathode type" within the present invention, with the auxiliary electrode connected as in Figure 3. Curve "C" was made with a cell within the present invention, with the auxiliary electrode left "floating," as in Figure 4. It will be apparent from an inspection of curves "A", "B" and "C" that the slope of curves "B" and "C" is considerably steeper and straighter than that of curve "A". Since the degree of amplification obtained is dependent upon the slope of the characteristic curve, it is evident that curves "B" and "C" represent an improvement in the degree of amplification which may be obtained with cells of our previous invention, the characteristic of which is represented by curve "A". Considering the unusual steepness and straightness of the substantially assymmetric plate current curve, which in our device is positively controlled over its entire useful range, it will be readily apparent to those skilled in the art to which our invention relates, that we obtain many useful characteristics with our tube entirely unobtainable with any old type tube, and, therefore, as a number of possible embodiments may be made of the above invention, and as changes may be made in the embodiment of said set forth, without departing from the spirit and scope of the invention, it is to be understood that the above is interpreted as illustrative and not in a limiting sense, except as required by the appended claims and by the prior art.

We claim:

1. A system for repeating electrical variations including a receptacle having a useful gas content containing at least five cold electrode members, means including a source of potential for creating a glow discharge in said gas and means for localizing said discharge between certain of said members.

2. A system for repeating electrical variations including a receptacle having a useful gas content maintained interiorly in a condition of molecular activity and containing at least five cold electrode members, all of said members being arranged in successive array providing four inter-electrode gas columns, a source of potential for said device, means dividing said potential among said electrodes, the relative values of said divisions in potential being such that operation of the device is characterized by a glow discharge localized in certain of said columns.

3. A system in accordance with claim 2 wherein all of said members are concentrically arranged.

4. A system for amplifying electrical variations including a device having a useful gas content containing a cathode and a cathanode for ionizing said gas, a plate, a grid, and an auxiliary electrode, an input device connected between said cathanode and grid, an output device connected across said anode and one of said electrodes, and circuit and potential arrangements for giving to said system a substantially linear rising Eg—Ip characteristic, and a substantially linear falling Eg—Ip characteristic over the operating range.

5. A system for repeating electrical oscillations including a device having a useful gas content, a cathode, a cathanode, a control electrode, an auxiliary electrode and an anode, a connection between the control electrode and cathanode including a source of oscillations to be amplified, an output circuit for amplified oscillations between the anode and one of said electrodes, a source of operating potential for said device, means ensuring a predetermined potential distribution among said electrodes, the relative values of said divisions in potential being such that the system has a rising and falling Eg—Ip characteristic over its signal operating range.

6. A system in accordance with claim 5 wherein said Eg—Ip characteristic is sharply peaked.

7. A system for repeating electrical variations including a receptacle having a useful gas content, a non-thermionic cathode, a cathanode, a control electrode, an auxiliary electrode and an anode, means including a source of potential for creating a glow discharge in said gas and means for localizing said glow discharge between the cathode and cathanode, cathanode and grid, and between the auxiliary electrode and anode.

8. A system for repeating electrical variations including a receptacle having a useful gas content, a non-thermionic cathode, a cathanode, a control electrode, an auxiliary electrode and an anode, means including a source of potential for creating a glow discharge in said gas and means for localizing said glow discharge between the cathode and cathanode and between the auxiliary electrode and anode.

9. A wave repeating system including a cathode, a cathanode, an anode, a control electrode between said cathanode and anode electrodes, an auxiliary electrode on the side of said control electrode nearest said anode, and means for applying to said auxiliary electrode the same potential as applied to said cathanode.

10. A wave repeating system including a cathode, a cathanode, an anode, a control electrode between said cathanode and anode electrodes, an auxiliary electrode on the side of said control electrode nearest said anode, and a direct connection between said auxiliary electrode and said cathanode.

11. A system for amplifying electrical oscillations comprising a device having a useful gas

content, a cold cathode and cathanode, an anode, a control electrode, an auxiliary electrode, means for applying a direct current potential to said cold cathode and cathanode sufficient to create a glow discharge therebetween, means for maintaining said control electrode at a potential relatively negative with respect to said cathanode, an input circuit including the control electrode and the cathanode, and an output circuit including the anode and the auxiliary electrode, said auxiliary electrode being located between the control electrode and the anode.

12. Apparatus in accordance with claim 11 wherein the auxiliary electrode is electrically connected to the cathanode.

13. An electrical translating system including a receptacle having a useful gas content, a non-thermionic cathode, a cathanode, a source of potential and means including said cathode and cathanode for rendering said gas electrically conductive, an anode, a grid, an input circuit including the grid and the cathanode, an output circuit including the anode and the grid and a "floating" electrode intermediate the grid and the anode.

14. An electrical translating system including a non-thermionic cathode, a cathanode, a grid, an auxiliary electrode and an anode arranged in an ionized medium, means for maintaining said grid at a potential negative with respect to said cathanode, circuit means for impressing a potential to be controlled on the said anode and said grid, second circuit means having a section in common with said first circuit, means for impressing a controlling potential between said grid and cathanode, said auxiliary electrode remaining "floating" with respect to said other electrodes.

15. An electrical translating system including a device having a useful gas content, a non-thermionic cathode, a cathanode, a grid, an anode; means for impressing operating potentials on cathode, cathanode, grid and anode, an input circuit including the grid and cathanode, an output circuit including the anode and the grid and an auxiliary electrode intermediate the cathanode and the anode.

16. A system in accordance with claim 15 in which the instantaneous potential of said auxiliary electrode is determined solely by its potential position relative to said other electrodes in said ionized medium.

17. A system in accordance with claim 15 in which the auxiliary electrode is intermediate the cathanode and the grid.

18. A system for amplifying electrical oscillations comprising a device having a useful gas content, a cold cathode and cathanode, an anode, a control electrode, an auxiliary electrode, means for applying a direct current potential to said cold cathode and cathanode sufficient to create a glow discharge therebetween, means for impressing a controlling potential for said discharge upon said auxiliary electrode, an input circuit including the grid and cathanode, an output circuit including the anode and the grid, said auxiliary electrode being located between the cathanode and the grid.

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