

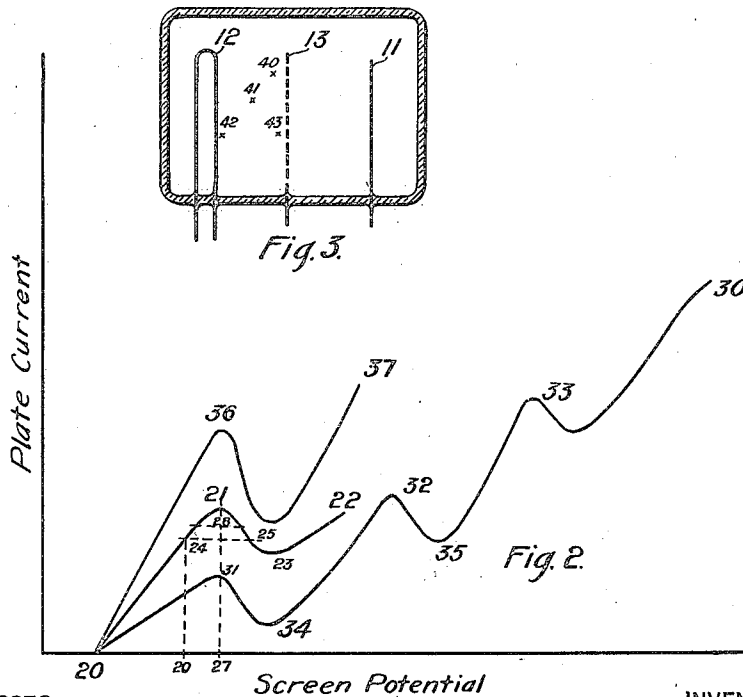
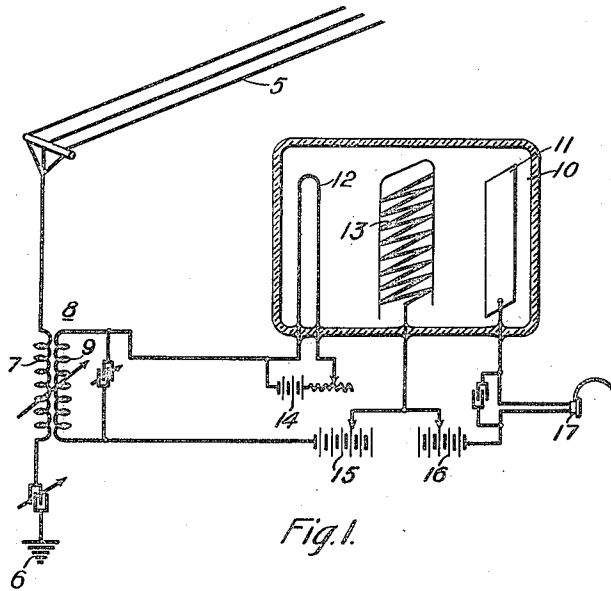
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H. C. RENTSCHLER

DETECTOR TUBE

Filed Feb. 27, 1919



WITNESSES:

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DETECTOR TUBE.

Application filed February 27, 1919. Serial No. 279,582.

To all whom it may concern:

Be it known that I, HARVEY C. RENTSCHLER, a citizen of the United States, and a resident of Wilksburg, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Detector Tubes, of which the following is a specification.

My invention relates to electron tubes, as employed for detecting in wireless work and in similar applications, and it has for its object to provide a device of the character designated that shall be simple and rugged in construction and highly effective in operation in that it shall produce a relatively large percentage-change in the modulated current with a relatively small modulating potential, thus permitting great sensitivity.

In the accompanying drawing, Fig. 1 is a diagrammatic view of a wireless receiving system embodying a tube constructed in accordance with my invention; Fig. 2 is a diagram illustrating the various operating characteristics obtainable with the tube of Fig. 1; and Fig. 3 is a sectional view of a tube illustrating the phenomenon of resonance.

In the operation of a detector bulb, the incoming impulses are applied as a modulating force to control the current strength in a local circuit, and it is desirable that the percentage change in the modulated current be as pronounced as possible, in order to detect extremely weak signals. I find that, by mounting a hot cathode, a plate anode and an intervening screen in a tube containing argon or other suitable gas or vapor and by the maintenance of the screen at a higher potential than either of the remaining electrodes, said operation may be secured in accordance with the following principles, the controlling electromotive force being connected to modulate the potential of the screen with respect to the cathode and the local current flowing in a circuit including the plate electrode and the screen.

As the potential of the screen, with respect to the cathode, is raised, the velocity of the electrons traveling from the cathode to the anode is gradually raised and the electrons, therefore, reach the anode at a constantly increasing velocity and are either reflected therefrom or cause the emission of secondary electrons therefrom, this action being initiated at different velocities with

different materials for the plate electrode. The rebounding electrons or the secondary electrons travel back toward the screen under the influence of two forces, namely, that derived from the impacting energy and that established by the fact that the screen is positive with respect to the plate electrode. As the electron velocity is raised higher and higher, these reflected or secondary electrons eventually reach the screen and tend to initiate current flow from the screen to the plate electrode in opposition to the normal current flow which is from the plate electrode, causing a dip in the characteristic obtained by plotting plate current against grid potential.

As the velocity is raised still higher, the effect of the main electron stream overpowers that of the reflected stream, and the characteristic curve again begins to rise.

Thus, a pronounced hump or maximum point is produced in the characteristic curve and, by adjusting for operation at this point, a relatively strong modulation of the local current, with a relatively weak incoming signal, may be secured.

Furthermore, the tube being filled with argon gas or some other suitable material exhibiting the phenomenon of resonance, there may be produced a characteristic curve having a series of maximum and minimum points, all as fully explained in my copending application, filed February 27, 1919, Serial No. 279,581, electron tube apparatus, and assigned to the Westinghouse Lamp Company. By proper adjustment of the tube, a maximum point due to resonance may be made to coincide with the maximum point due to electron reflection or secondary emission and thus a very pronounced maximum point may be obtained for extremely sensitive operation.

Referring to the drawing for a more detailed understanding of my invention, I show a receiving antenna at 5, connected to ground at 6 through the primary winding 7 of a coupling transformer 8 having a secondary member 9. A tube 10 is provided for detector purposes having a plate electrode 11, a filamentary cathode 12 and an intervening screen electrode or grid 13.

The filamentary cathode 12 may be maintained at incandescence, as by a battery 14, for supplying electrons to the interior of the container 10. The screen electrode 13 is

maintained positive with respect to the cathode 12, as by an adjustable battery 15 and, similarly, the screen electrode 13 is maintained positive with respect to the plate electrode 11, as by an adjustable battery 16 of lesser voltage than the battery 15.

The secondary winding 9 is connected between the cathode 12 and the screen electrode 13 through battery 15, and a receiving device 17 is connected in circuit with the cathode 12, winding 9, batteries 15 and 16 and the plate electrode 11.

In the operation of the device thus described, the batteries 15 and 16 tend to maintain a fixed difference of potential between the respective electrodes, and the effect of incoming impulses through the secondary winding 9 is to vary the potential of the screen and plate with respect to the cathode 12.

As the potential of the screen 13, with respect to the cathode 12, is raised, as by increasing the effective voltage of the battery 15, the plate current or the current circulating from the plate 11 through the tube and the battery 16, gradually increases because of the greater number of electrons drawn out from the cathode 12 by the electrostatic attraction of the screen 13. This effect may be plotted as a line 20—21 in the curve 20—22 of Fig. 2.

With the gradually increasing screen potential, the electron velocity is correspondingly increased until, at a critical velocity, dependent upon the nature of the electrode 11, electron reflection or the generation of secondary electrons by bombardment is initiated at the surface of the electrode 11 so that electrons move back therefrom toward the screen 13 and, as hitherto pointed out, these electrons travel under the joint influence of the energy of rebound and of the electrostatic attraction because of the fact that the screen member 13 is higher in potential than the plate electrode 11. As this action is increased with the increase in the action of the screen potential, the electrons eventually reach the screen in appreciable numbers, establishing current flow from the screen 13 to the plate 11 down through the receiving apparatus 17 and the battery 16 back to the screen 13, in opposition to the main local current flow which is from the electrode 11 to the electrode 12, thence through the batteries 15 and 16 and the receiving apparatus 17 to the electrode 11. The effect of this reverse-current flow is to temporarily reduce the current flowing through the receiving device 17, as indicated by the portion 21—23 of the characteristic curve 20—22.

As the potential of the screen electrode is still further increased, the main electron stream overpowers this reverse electron stream, and the current through the device

17 again starts to increase, as indicated by the portion 23—22 of the characteristic curve 20—22.

In the normal use of the device, the adjustment is such that functioning is obtained at the maximum point 21 or at the minimum point 23. The modulating effect of the alternating electromotive force obtained from the secondary winding is to oscillate the grid potential between a point 24 and a point 25, so that the plate current oscillates between a value 20—24 and a value 27—21, assuming an average value 27—28 materially less than the value 27—21, resulting in a marked variation of the current through the receiving apparatus.

Up to this point, the action of the bulb 10 has been somewhat the same as though highly evacuated, so that substantially pure electron emission would be involved but if, as disclosed and preferred, the tube be filled with argon gas, operation in accordance with the phenomenon of resonance is secured, as fully set forth in my copending application above referred to. Briefly stated, this action is as follows:

Under normal conditions, the impact of an electron upon a molecule of argon gas is elastic, that is to say, the electron bounds off with substantially no abstraction of energy and without affecting the gas molecule. At certain critical velocities, however, apparently bearing some critical relation to the electron velocity within the molecules, this action is radially modified and the impact becomes highly non-elastic, the energy of the impacting electron being materially reduced.

Two types of inelastic impacts between electrons and atoms in certain monatomic gases and vapors have been found to exist. The first occurs when the colliding electron displaces an electron of the atom without removing it from the atom. That is, it moves an electron from one orbit to another in the same atom. The phenomenon of electronic displacement in the atomic system without removal of an electron is called resonance. The potential through which the colliding electron must fall to acquire the necessary velocity to produce such displacement is known as the resonance potential for the gas or vapor in question. The second type of inelastic impact occurs when the colliding electron removes an electron from the atom and produces ionization.

Thus, referring to Fig. 3, let it be assumed that the potential of the screen 13 is fixed at such value that an electron emitted by the cathode 12 is accelerated to a critical velocity, corresponding to non-elastic impact, to cause resonance at a point such as 40 adjacent to the screen. The escaping electron has relatively low velocity and is, therefore, taken up by the screen 13, thus

producing a marked diminution in the number of electrons reaching the plate 11, as compared with the number that reached this plate when the electron velocity was so low that the electrons did not suffer non-elastic impact until after passing through the screen 13.

As the potential of the screen 13 is raised, the acceleration imparted to the electrons is also increased, so that the critical velocity corresponding to non-elastic impact is attained at a point, such as 41, some distance from the screen. The escaping electron, whether primary or secondary in nature, receives such acceleration from the screen before reaching the same as to, in most cases, pass therethrough and impact upon the plate electrode, thus materially increasing the plate current.

As the screen potential is still further increased, the critical velocity corresponding to non-elastic impact is attained at some such point as 42, and the escaping electron again attains this critical velocity at a point, as 43, adjacent to the screen. The resultant escaping electron is taken up, in most cases, by the screen and thus, the plate current is again diminished.

This cyclical change in the plate current continues indefinitely, with increasing screen potential until terminated by other non-pertinent phenomena.

Thus, by filling a tube 10 with argon gas and by gradually increasing the velocity of the electrons by increasing the screen potential, a characteristic curve 20-30 may be secured having maximum points 31-32-33, where non-elastic impact is initiated near the screen and having minimum points 34 and 35 where non-elastic impact adjacent the screen is discontinued.

By suitable adjustment of the electrode spacing and of the relative potentials therebetween, the maximum point 31 of the characteristic curve 20-30 may be made to occur at the same grid potential as the maximum point 21 on the curve 20-22, producing a very marked maximum point 36 on the resultant or net characteristic curve 20-37 of the entire device. By operating at this pronounced maximum point 36, an extremely sensitive device is secured.

While I have described my invention in its preferred form, it will be obvious to those skilled in the art that it is not so limited but is susceptible of various changes and modifications without departing from the spirit thereof and I desire, therefore, that only such limitations shall be placed thereupon as are imposed by the prior art or are specifically set forth in the appended claims.

I claim as my invention:

1. In an electron-tube system, the combination with a tube provided with an elec-

tron-emitting cathode, an anode and an intervening conducting screen in a medium exhibiting the phenomenon of resonance, of means for maintaining said anode positive with respect to said cathode, means for maintaining said screen positive with respect to each of the remaining electrodes, said last-named means being so adjusted that the plate current is at a maximum or a minimum value because of the effect of electron reflection or secondary emission from the anode, and means for modulating the potential of said screen with respect to said cathode.

2. In an electron-tube system, the combination with a tube provided with an electron-emitting cathode, a plate anode and an intervening screen electrode, of means for maintaining said screen positive with respect to each of the remaining electrodes and for maintaining said anode positive with respect to said cathode, whereby the screen potential, plate-current characteristic may be represented by a curve having a definite maximum and a definite minimum point, a filling of gas within said tube exhibiting the phenomenon of resonance, whereby the characteristic may be represented by a curve exhibiting a plurality of maximum and minimum points, the adjustment being such that a critical point of one characteristic curve coincides in screen potential with a similar critical point of the other characteristic curve, and means for modulating the screen potential about said value.

3. In a three-electrode, electron-tube system, the combination with means for producing a situation which may be represented by a plate-current, screen-potential characteristic curve having a point where the slope changes sign and dependent upon electron reflection or the production of secondary electrons, said means also serving to produce a situation which may be represented by a plate-current, screen-potential characteristic curve having a point where the slope changes sign because of resonance, said two points occurring at a similar screen-potential, and means for modulating the screen potential about said point.

4. The combination with a three-element tube comprising a cathode, grid and anode arranged in the order mentioned in a medium exhibiting the phenomenon of resonance, of means for maintaining the grid at a positive potential with respect to both the anode and the cathode, means for impressing a controlling potential upon the grid, and means for utilizing the resultant current flowing in the anode, the constants being so adjusted that electron reflection or secondary-emission effects are produced in said anode of such nature as to produce a change in the sign of the slope

of the curve plotted between anode-current and grid potential.

5 5. The combination with a three-element tube comprising a cathode, grid and anode arranged, in the order mentioned, in a medium exhibiting the phenomenon of resonance, of means for maintaining the grid at a positive potential with respect to both the anode and the cathode, means for im-
10 pressing a controlling potential upon the grid, and means for utilizing the resultant current flowing in the anode; the material of the anode, the distances between electrodes, the grid potential, the intervening medium
15 and the pressure being so chosen that the irregularities, due to secondary emission or reflection from the anode, in the curve plotted between anode-current and grid potential, substantially correspond with similar
20 irregularities due to the resonance phenomenon.

6. The method of operating an electron tube including a cathode, an anode and an intervening screen electrode in a medium
25 exhibiting the phenomenon of resonance; comprising maintaining the screen electrode positive with respect to both of the other electrodes and adjusting the potentials applied to the tube so that the plate current
30 thereof assumes a value where the slope of its characteristic, when plotted as a plate-current, screen-potential curve, changes sign, because of the effect of electron reflection or secondary emission from the anode.

7. The method of operating an electron tube including a cathode, an anode and an intervening screen electrode in a medium exhibiting the phenomenon of resonance; comprising maintaining the screen electrode
35 more positive than the anode, adjusting the potentials applied to the tube so that, because of electron reflections or secondary emission from the anode, the characteristic curve, plotted to show the relation between the plate current and the potentials of the
40 screen, changes sign, and modulating the screen potential at such a point, whereby great sensitivity is obtained.

8. The method of operating an electron tube including a cathode, an anode and an intervening screen electrode enclosed in a medium exhibiting the phenomenon of resonance; comprising adjusting the impressed potentials, so that the effects of electron reflection or secondary emission from the
55 anode and resonance in the medium are cumulative, so that the maximum points of the separate characteristics, represented as plate-current, screen-potential curves, correspond at a definite screen potential, and
60 modulating such screen potential to obtain great sensitivity in using the tube as a detector.

In testimony whereof I have hereunto subscribed my name this 24th day of Feb.,
65 1919.

HARVEY C. RENTSCHLER.