April 11, 1933. K. W. JARVIS ET AL 1,903,569

ELECTRON TUBE

Filed Sept. 15, 1926

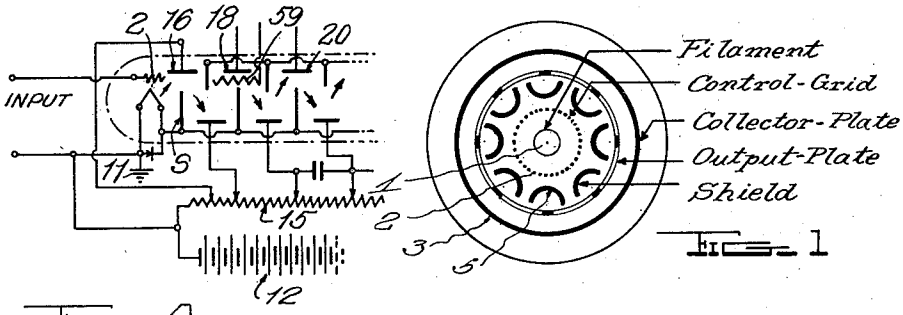


FIG. 1

FIG. 4

FIG. 2

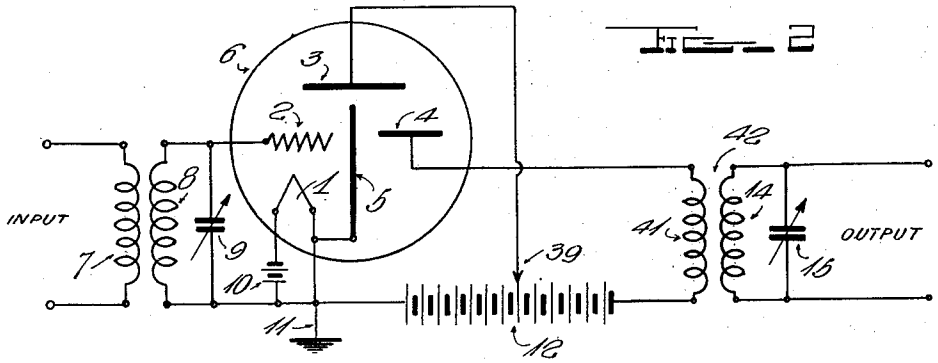
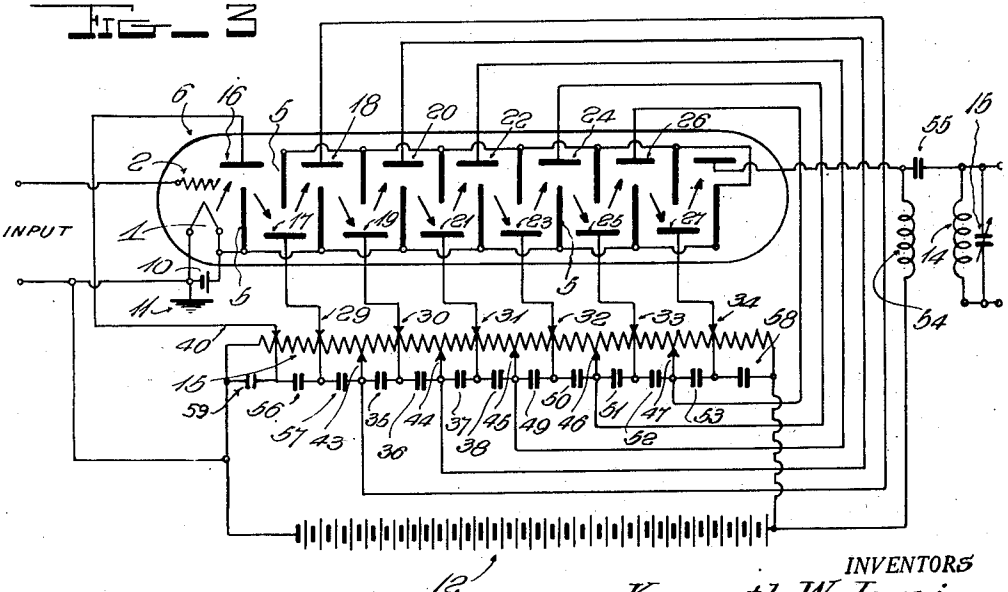


FIG. 3



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UNITED STATES PATENT OFFICE

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ELECTRON TUBE

Application filed September 15, 1926. Serial No. 135,604. REISSUED

Our invention relates broadly to electron tubes and more particularly arrangements of tube structure for securing increased operating efficiency over that heretofore obtainable.

One of the objects of our invention is to provide a construction of electron discharge device where substantially all electrostatic coupling between output and input electrodes is eliminated.

Another object of our invention is to provide a construction of electron discharge device wherein the phenomena of secondary emission is employed for securing substantially pure relay action for increasing the ability of the electron discharge device to function as a repeater.

Another object of our invention is to provide an arrangement in an electron tube device wherein the output power and voltage relations have substantially no effect on the tube characteristics which results in the tube functioning as a true one way repeater and also has the advantage in that it does not absorb power from either the input or output circuits.

Another object of our invention is to provide an electron tube construction and arrangement of the electrodes therein for the securing of high amplification in signal receiving systems where the principle of secondary emission current alone in the output circuit is employed as differentiated from the principle where primary emission is relied upon for the functioning of the electron tube system.

Other and further objects of our invention reside in the structural relationship of a plurality of electrodes and electrostatic shields within an electron tube embodying a novel principle of operation as will be more fully described hereinafter by reference to the accompanying drawing in which:

Figure 1 is a diagrammatic representation of the several electrodes employed in one type of electron discharge device of our invention; Fig. 2 is a diagrammatic circuit arrangement illustrating the principle of operation of the electron tube structure of our invention; Fig. 3 illustrates a multiple electron tube discharge device employing the principles of our invention; and Fig. 4 illustrates a modified circuit arrangement for the electron tube of our invention.

Heretofore in the communication art, sensitive electron tube amplification circuits have been employed in signal receiving circuits, but it has been found that their operating efficiency has been considerably limited and impaired by the existence of capacity coupling between the output and control electrodes of each of the tubes. Various methods have been proposed for compensating for the undesired capacity coupling, but such methods are merely systems of compensation which do not offer a cure for the inherent coupling. By our invention we provide a novel construction of the electron discharge device so as to substantially eliminate all output to imput capacity coupling which previously occurred between the tube electrodes.

Among other novel features in combination, we employ in the operation of the electron discharge device of our invention the phenomena of secondary emission. A primary source of electrons, such as a heated cathode, is provided within an evacuated vessel, the electronic movement therefrom being controlled by a grid electrode. This controlled electron stream impinges against a treated anode held at a positive potential with respect to the cathode. We have termed this anode the "collector plate" and while it is held at a positive potential with respect to the cathode, it is substantially grounded to the cathode so far as alternating currents are concerned. This collector plate serves as a source of secondary emission for the output plate circuit. A fourth element, the "output plate", is placed so as to receive the secondary emission of the collector plate.

The positions of the cathode, control grid, collector plate and output plate are so chosen that shielding elements, grounded to the cathode, with respect to alternating currents, may be placed between the output plate and the control grid. These shielding elements by proper design may at the same time be placed between the output plate and the cathode. The purpose of these shielding elements is two-

fold. First, to substantially prevent any electrostatic coupling between the output plate and control grid, and second to substantially prevent the output plate potential from influencing the primary emission from the cathode, and to prevent any primary emission reaching the output plate directly. To this end, the shape and position of these shielding elements should be such that it is impossible to draw a straight line between any chosen points on the grid and output plate without passing through the shielding elements. The shielding elements, hereafter termed the shield, may at the same time be placed so as to prevent any straight line being drawn from the output plate to the cathode without passing through the shield. This construction substantially frees the tube from any inherent undesired electrostatic coupling.

The novel relay action due to the phenomena of secondary emission is obtained by the arrangement of the electrodes within the tube. In the usual three element electron tube heretofore available in the art, the voltage across the output load adds and subtracts from the applied direct plate voltage and materially affects the amplifying characteristics. In a regenerative radio receiver it often causes the establishment of a periodic variation in current which becomes evident in the form of undesired noises. In an amplifier it may cause distortion. In an oscillator it causes a change in oscillating frequency as the output load is changed. These disadvantages are avoided in the tube of our construction. When the positive potential of the output plate is made high enough with respect to the collector plate, all of the secondary electrons from the collector plate will travel to the output plate. This positive potential necessarily is the equivalent of the plate saturation potential of a two element tube. If the secondary emission is small, a small potential difference may be sufficient. For higher values of secondary emission a correspondingly higher voltage might be necessary. It will be understood, however, that if this maintained potential difference between the output plate and collector plate, minus the maximum output potential across the load, is still greater than the plate saturation potential as defined above, changing the output load voltage will have substantially no effect on the characteristics of the tube and the system will be free from all such detrimental effects as noted above.

To an additional external voltage in the output plate circuit, (saturation potential being maintained) the tube offers an infinite impedance. Therefore the tube will absorb no power from the external system, and when applied to an electrical network will not cause any loss to that network system. As typical of the beneficial results obtained in our system, the selectivity and amplification in a radio frequency amplifier are correspondingly improved.

The relay function of the electron tube structure of our invention, due to the phenomena of secondary emission, is such that the amplifying ratio may be made very large. By the proper preparation of the collector plate the secondary emission may be made a large multiple of the primary emission and the amplifying characteristics of the tube correspondingly increased. By utilizing a multiple number of electrodes within the tube structure amplification at extremely high ratios is obtainable.

Referring to the drawing in more detail, we have represented at Fig. 1 the electron tube structure of our invention employing a filament or cathode designated by reference character 1 surrounded by a control grid 2. The collector plate is represented at 3 connected to a point of positive potential 39 on battery 12 as represented in Fig. 2. The output plate 4 is represented as separated from the control grid 2 and cathode 1 by means of the shield 5 for reducing undesired electrostatic coupling and preventing the flow of primary emission to the output plate 4.

In Fig. 2 we have shown a diagrammatic circuit arrangement such as might be used in a radio frequency amplifier system wherein the input potential is supplied through a transformer system having primary winding 7 with a secondary winding 8 coupled thereto and tuned by means of a condenser 9. The cathode 1 is heated from a suitable source 10, the cathode being grounded at 11 as is also the electrostatic shield 5, which connects to one side of the cathode. The output circuit of such a radio frequency amplifier system is represented as including the primary winding 41 of coupling transformer 42 connected between the output plate 4 and high potential battery 12. Secondary winding 14 is coupled to primary winding 41 and is shunted by the tuning condenser 15. It will be understood that while the tube structure is so devised as to make it a more efficient amplifier, the tube may also function as a detector, an oscillator, or modulator, or in other ways well known to the art.

In order to increase the amplification obtainable in the electron tube device of our invention a multiple tube may be arranged as represented in Fig. 3 for obtaining a lower effective coupling capacity between the grid electrode 2 and the output plate 17, thereby improving the characteristics of the tube system. While the capacity coupling existing in the tube circuit represented in Fig. 2 is substantially negligible, this capacity coupling is further reduced by using a number of relay stages as illustrated in Fig. 3. In addition to serving as a better amplifier an electron tube constructed in the general manner of Fig. 3

may serve in other ways, such as a detector or oscillator or modulator.

In Fig. 3 of the drawing reference character 1 represents the cathode serving as a source of electrons which are directed to an intermediate collector plate 16 by virtue of the positive charge imparted to collector plate 16 from a potential source such as the tap 40 on the potentiometer 15 across battery 12. The grid electrode 2 serves to control the primary emission of cathode 1 with respect to the intermediate collector plate 16, but thereafter the intermediate collector plate 16, which is properly treated to produce secondary emission, serves as a cathode for the intermediate output plate 17 connected to a point of higher positive potential 29 on potentiometer 15. The output intermediate plate 17 is treated to produce secondary emission and serves as a cathode for the next succeeding plate element 18, which connects to point 43 on potentiometer 15 at the next higher positive potential. The plate element 18 serves as a cathode for plate 19 which connects to the positive point 30 along potentiometer 15. In a similar manner plate members 20, 22, 24 and 26 are arranged to receive and emit electrons to the succeeding plates 21, 23, 25 and 27 with an electrostatic shield 5 interposed between the successive plate electrodes. The plate member 27 finally emits electrons which bombard the output plate 4 connected to the output circuit. It will be observed that plate members 20, 21, 22, 23, 24, 25, 26 and 27 connected to points 44, 31, 45, 32, 46, 33, 47 and 34 along potentiometer 15, which are maintained at successively higher potentials. Condensers 35, 36, 37, 38, 49, 50, 51, 52, 53, 56, 57, 58 and 59 may be connected between the successive plate electrodes for avoiding undue resistance coupling, due to the method of applying the positive potential to the intermediate collector plates.

All of the electrodes may be mounted within the same envelope 6. The control electrode may be placed as represented between cathode 1 and intermediate collector plate 16 or between any other two electrodes in the series as indicated in Fig. 4 by reference character 59, or in combination between any multiple pairs of electrodes. The multiplying action of each secondary emission relay times the number of stages may total to a large ratio. In some instances the electron emitting body may be a substantially self-sustaining source of electrons such as radio active material. The plate elements 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26 and 27 do not depend upon incandescence for their operation but upon the ability of the elements to effect secondary emission under conditions of bombardment.

The output of the tube system may be coupled to the succeeding circuit by means of the radio frequency choke coil 54 and condenser 55 to the tuned output circuit 14—15.

The principles of our invention may be embodied in a variety of different constructions of electron tubes, and we desire that it be understood that various modifications in the construction and arrangement of the electrodes may be employed for carrying out the principles of our invention without departing from the spirit of our invention. We may in some instances provide connections between a source of positive potential and the electrostatic shields. Other changes or improvements may be made, as will readily suggest themselves to those skilled in the art, and we intend no limitations other than are imposed by the scope of the appended claims.

What we claim as new and desire to secure by Letters Patent of the United States is as follows:

1. An electron tube device comprising an evacuated vessel, a plurality of electrodes within said vessel, one of said electrodes comprising an electron emitting body, a grid electrode mounted adjacent said electron emitting body, a pair of plate electrodes adapted to be charged to different positive potentials mounted adjacent said grid electrode, and a shield connected inside of said vessel with said electron emitting body and having a solid portion thereof physically interposed between said electron emitting body and the plate electrode of largest positive potential for substantially eliminating the effects of capacity coupling between said grid electrode and the plate electrode of largest positive potential.

2. An electron tube comprising an evacuated vessel, a plurality of electrodes within said vessel, one of said electrodes comprising an electron emitting body, another of said electrodes being a control member, and a plurality of plate electrodes adapted to be charged at successively increasing positive potentials relative to their distance from said electron emitting body, one of said plate electrodes being mounted adjacent said control member, and electrostatic shields interposed between said electron emitting body and the plate electrode immediately adjacent said control member for eliminating the effects of capacity coupling.

3. An electron tube comprising an evacuated vessel containing an electron emitting body, a control electrode, an output plate electrode and a plurality of collector plates, means interposed between the first of said collector plates and said electron emitting body and control electrode and between each of said succeeding collector plates for eliminating capacity coupling between said output plate and said control electrode.

4. An electron tube comprising an evacuated vessel, an electron emitting body in said vessel, a control electrode, an output plate electrode and a plurality of collector plates adapted to be charged at successively increasing positive potentials interposed between

said control electrode and said output plate, and means interposed between succeeding collector plates for electrostatically shielding said output plate from said electron emitting body and said control electrode.

5. An electron discharge device, comprising an evacuated vessel, a cathode to emit primary electrons a plurality of electrodes, a collector plate electrode mounted to emit secondary electrons under bombardment of primary electrons, an output plate electrode positioned with respect to said collector plate to receive the secondary electron emission from said collector plate electrode, and a shielding element connected with said cathode and disposed adjacent said output plate for substantially shielding the output plate electrode from all electrodes except the collector plate electrode.

6. An electron discharge device comprising an evacuated vessel containing a source of primary electrons, a control member, a plate electrode mounted to receive electronic bombardment from said source and emit secondary electrons, an output plate and a shielding element connected with said source of primary electrons and disposed between said output plate and said control member in such manner that a straight line cannot be drawn through any point on the output plate and said control member without passing through said shielding element.

7. An electron tube comprising an evacuated vessel, an electron emitting body in said vessel, a control electrode, an output plate electrode, and a plurality of collector plates adapted to be maintained at positive potential with respect to the cathode and each with respect to the preceding collector plate interposed between the output plate and the cathode, the control electrode being interposed between any pair of said collector plates and an electrostatic shield interposed between said control electrode and said output plate and connected to said cathode for eliminating output to input capacity coupling between said electrodes.

8. An electron tube comprising an evacuated vessel, an electron emitter disposed therein, a control electrode adjacent thereto, a collector plate, an output plate adjacent said collector plate, said output plate having a plurality of alternate, solid and open portions, and a shield having a plurality of solid portions disposed adjacent the solid portions of said output plate in alignment with said electron emitter and said solid portions, whereby electrons from said electron emitter are prevented from reaching said output plate.

9. An electron tube comprising an evacuated vessel, a primary source of electrons therein, a pair of concentrically positioned plate electrodes disposed about said primary source of electrons at different radial distances therefrom, the outermost plate electrode constituting a collector plate with respect to the electrons emitted by the primary source of electrons, the innermost plate electrode consituting an output plate and having a multiplicity of alternate, solid and open portions, a control electrode disposed about said primary source of electrons, and a shield constituted by a plurality of alternate, solid and open portions with the solid portions thereof radially aligned with said electron emitter and with the solid portions of said output plate and the open portions thereof aligned with the open portions of said output plate, whereby said output plate is screened from electron discharge from said primary source of electrons while said output plate is subject to bombardment by secondary discharge from said collector plate.

10. An electron tube comprising an evacuated vessel, a primary source of electrons therein, a pair of plate electrodes concentrically disposed about said primary source of electrons at different radial distances therefrom, the outermost plate electrode constituting a collector plate with respect to electron discharge from said primary source of electrons, the innermost plate electrode constituting an output plate subject to secondary bombardment with respect to said collector plate, said output plate having a plurality of alternate, solid and open portions, a control electrode adjacent said primary source of electrons, and a plurality of shielding elements disposed intermediate said primary source of electrons and said output plate, one of said shielding elements being individual to each of the solid portions of said output plate for preventing primary emission from said primary source of electrons from reaching said output plate while permitting the bombardment of said collector plate by electrons from said primary source of electrons.

11. An electron tube comprising an evacuated vesself, a primary source of electrons therein, a control electrode disposed adjacent thereto, a plurality of plate electrodes disposed at different radial distances from said primary source of electrons, the outermost plate electrode constituting a collector plate, the innermost plate electrode constituting an output plate and having a plurality of alternate, solid and open portions, and a shield having a plurality of substantially semi-circular solid portions separated by open portions, the solid portions thereof being disposed in alignment with the solid portions of said output plate and the open portions therebetween being disposed in alignment with the open portions of said output plate whereby primary emission from said primary source of electrons is prevented from reaching said output plate while bombarding said collector plate.

12. An electron tube device comprising an

evacuated vessel, a filament electrode, a control electrode, a pair of plate electrodes adapted to be charged at differing positive potentials, one of said plate electrodes comprising an output plate and the other of said plate electrodes constituting an electron emitting body, and means connected with said filament electrode and interposed between said output plate and said filament electrode for eliminating the effect of electrostatic capacity between said control electrode and said output plate.

In testimony whereof we affix our signatures.

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