

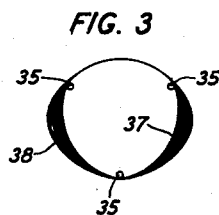
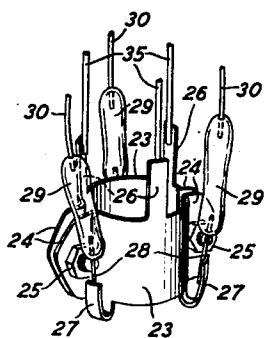
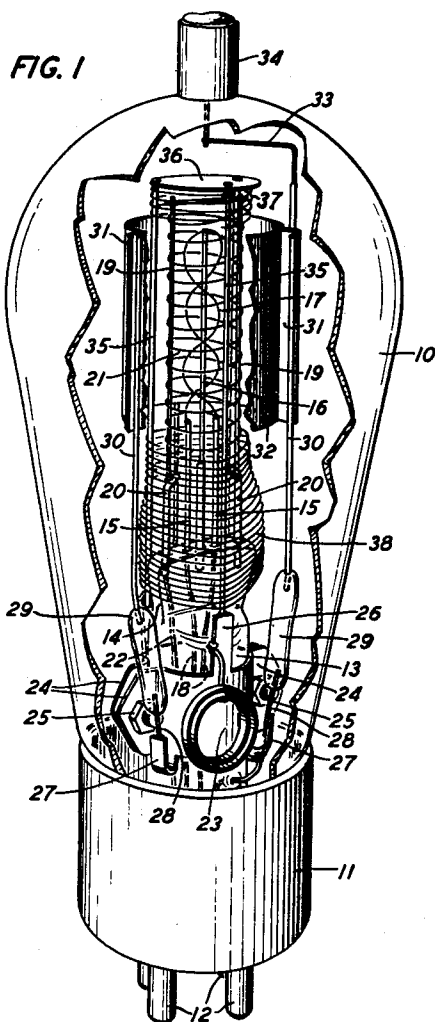
April 24, 1934.

H. E. MENDENHALL
ELECTRON DISCHARGE DEVICE

1,955,823

Filed Aug. 26, 1931

2 Sheets-Sheet 1



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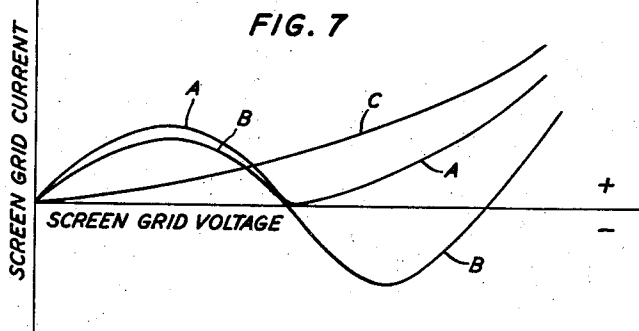
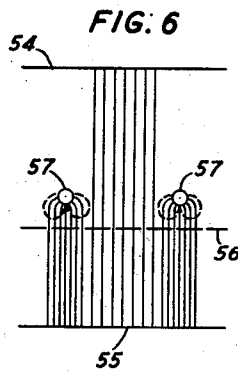
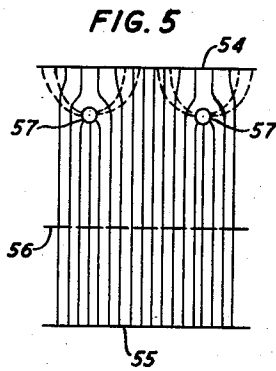
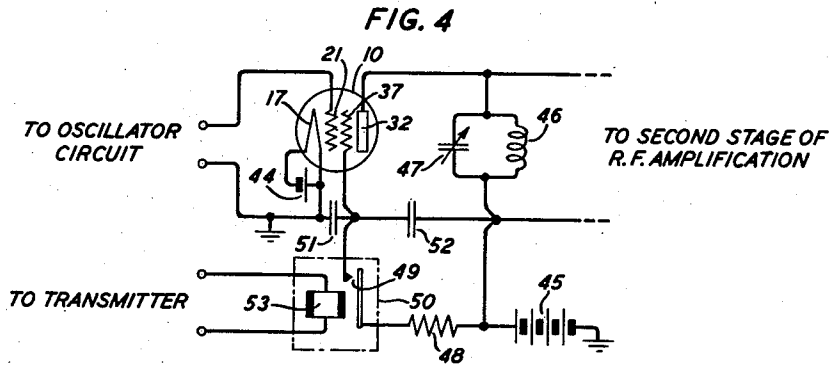
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UNITED STATES PATENT OFFICE

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ELECTRON DISCHARGE DEVICE

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Application August 26, 1931, Serial No. 559,442

5 Claims. (Cl. 250—27.5)

This invention relates to electron discharge devices and more particularly to such devices of the screen grid type.

In radio communication systems embodying both transmitter and receiver apparatus, it is desirable to disconnect the transmitter whenever the receiver is in operation, in order to prevent interference between the transmitter and receiver. In transmitters utilizing screen grid electron discharge devices in the radio frequency amplifier circuits, the transmitter may be automatically disconnected by using the screen grid electron discharge device in the first stage as a trigger control in which the initiation of the cathode-anode discharge is controlled by the screen grid potential.

In order that a screen grid electron discharge device in the first stage of radio frequency amplification may be utilized as a trigger control, it is necessary that the characteristics of the device be such that no appreciable electron current will flow to the anode of the device when no potential is applied to the screen grid. This condition may be obtained in part when the anode impedance is sufficiently great so that no electron current will flow to the anode with normal voltage applied thereto and zero potential on the screen grid. It has been found, however, that in electron discharge devices in which the anode impedance is of large magnitude, that the device may become conductive because of secondary emission from the screen grid and hence cannot be utilized effectively as a trigger control.

An object of this invention is to eliminate interference between the transmitter and receiver in radio communication systems.

Another object of this invention is to expedite the control of radio frequency amplifiers in radio transmission systems.

A further object of this invention is to minimize the effect of secondary emission from the screen grid of an electron discharge device so that the device may be utilized as a trigger control in which the initiation of the cathode-anode discharge may be controlled solely by the potential applied to the screen grid.

In accordance with a feature of this invention, the screen grid in an electron discharge device is so positioned with respect to the control grid and the anode that the electric fields between the several electrodes are such that secondary emission from the screen grid is of insufficient magnitude to render the device conductive with zero potential applied to the screen grid.

In an electron discharge device constructed in accordance with this invention, the initiation of the cathode-anode discharge may be controlled entirely by the screen grid potential so that the device may be effectively utilized as a trigger control. The screen grid, for example, may be con-

nected to a source of potential through a voice operated relay in series with a telephone transmitter. When the telephone transmitter is in use, the relay automatically closes the circuit between the screen grid and the source of potential and the radio frequency amplifier circuit will be rendered operative. When the telephone transmitter is not in use, the relay releases and the screen grid circuit in the first stage of amplification will automatically be opened so that no current may flow in the anode-cathode circuit of the screen grid device and the radio frequency amplifier is rendered inoperative.

The invention will be understood more fully from the following detailed description with reference to the accompanying drawings in which:

Fig. 1 is an elevational view of an electron discharge device constructed in accordance with this invention with portions of the enclosing vessel and the anode broken away to show the assembly of the various electrodes;

Fig. 2 is a detailed view in perspective showing the mounting for the anode and the screen grid in the device shown in Fig. 1;

Fig. 3 is an end view of the screen grid electrode embodied in the device shown in Fig. 1;

Fig. 4 is a diagrammatic view illustrating a portion of a transmission system utilizing an electron discharge device constructed in accordance with this invention;

Fig. 5 shows diagrammatically the electric fields between the several electrodes of an electron discharge device in which secondary emission from the screen grid is of sufficient magnitude to affect the controlling action of the screen grid potential upon the cathode-anode electron stream;

Fig. 6 shows diagrammatically the electric fields between the several electrodes of an electron discharge device constructed in accordance with this invention; and

Fig. 7 shows characteristic screen grid current-voltage curves for electron discharge devices in which the electric fields are as shown in Figs. 5 and 6.

Referring now to the drawings, an electron discharge device, such as an amplifier for radio frequencies, in accordance with this invention comprises an evacuated enclosing vessel 10 suitably secured, as by cementing, to an insulating base 11 carrying terminal prongs 12 for associating the device with an electrical circuit. The enclosing vessel is provided with a reentrant stem 13 which terminates in a substantially rectangular press 14. A pair of relatively rigid wires 15 are embedded in the press 14 and extend longitudinally of the enclosing vessel and parallel to each other. A rigid wire 16, likewise embedded in the press 14, is positioned substantially midway between the wires 15 and extends parallel

therewith. A double helical incandescible cathode 17, which may be of thoriated tungsten, has its ends secured to the wires 15 and its midpoint secured to the free end of the wire 16. 5 Leading-in wires 18, disposed within the stem 13, connect the ends of the cathode 17 with certain of the terminal prongs 12. A plurality of parallel metallic uprights or rods 19 extend parallel to the cathode supporting wires 15 and 16 10 from short rigid rods 20 embedded in the press 14 and support a helical control electrode or grid 21 which is coaxial with and uniformly disposed about the cathode 17. A leading-in wire 22 for the control electrode or grid 21 is sealed 15 in the press 14 and electrically connected to one of the terminal prongs 12.

A split metallic band comprising two similar oppositely disposed substantially semi-circular portions 23 provided with outwardly extending flanges 24 is clamped about the stem 13 by bolts 25 extending through the flanges 24. Each of the semi-circular portions 23 is formed with integral arms or projections 26 extending from one edge of the semi-circular portions 23 and with 20 integral reversely bent arms 27 extending from the opposite edge of the portions 23. The arms 27 are uniformly spaced and each has a short wire stub 28 attached thereto, as by welding, which has an end embedded in an insulator or bead 29, preferably of Pyrex glass. Each of the 30 insulators 29 supports a rigid rod 30 having an end embedded in the insulator and a rectilinear portion extending parallel to the longitudinal axis of the enclosing vessel 10. The rods 30 are secured, as by welding, to integral flanges 31 of a 35 multi-section cylindrical anode 32 which is coaxial with the cathode 17 and control electrode or grid 21 and uniformly disposed thereabout. The anode is preferably of carborundum blasted molybdenum or other metal treated to increase 40 the heat radiating capacity thereof. A leading-in wire 33 for the anode 32 is secured at one end to one of the flanges 31, sealed in the dome-shaped end of the enclosing vessel 10 at the other end and connected to a metallic terminal cap 34 attached, as by cementing, to the 45 seal in the dome-shaped end of the enclosing vessel 10.

A plurality of parallel metallic uprights or rods 50 35 each having an end secured, as by welding, to one of the arms or extensions 26, and fixedly spaced at the other end by a metallic disc or plate 36 secured thereto, support a helical wire screen electrode or grid. The screen electrode or grid comprises a cylindrical portion 37 concentrically disposed between the control electrode or grid 21 and the anode 32 and a deformed 55 oval portion 38 encircling the cathode and control electrode or grid leading-in wires 18 and 22, respectively, and a portion of the stem 13. The deformed oval portion 38 completely shields the cathode and control grid leading-in wires from the anode and reduces the electrostatic capacity therebetween and thereby stabilizes the 60 operation of the device. The metallic disc or plate 36 serves to effectively shield the end of the cathode 17 and control grid 21 from the anode leading-in wire 33.

Electron discharge devices of the type comprehended in this invention are frequently used in 65 radio frequency amplifier circuits in radio communication systems embodying both transmitting and receiving apparatus. In such systems it is desirable to disconnect the transmitting apparatus whenever the receiver is in operation, in

order to prevent interference, such as inductive crosstalk, between the transmitting and receiving circuits. This end may be attained in one way, 70 as shown in Fig. 4, by utilizing the screen grid electron discharge device in the first stage of radio frequency amplification in the transmitting circuit as a trigger device. In this figure an 75 electron discharge device, in accordance with this invention, is designated as 10 and comprises an incandescible cathode 17, a control electrode or grid 21, a screen grid 37, and an anode 32. A source, such as a battery 44, is provided for 80 supplying the heating current for the cathode 17. The cathode 17 and control grid 21 are connected to the oscillator circuit, not shown. A source of D. C. potential, such as a battery 45, is connected to the anode 32 in series with a tuning 85 circuit comprising an inductance 46 and a variable condenser 47 in shunt with the inductance 46. A suitable potential may be applied to the screen grid 37 through an appropriate resistance 90 48 and the contacts 49 of a relay 50. Suitable blocking condensers 51 and 52 are provided between the battery 45 and the cathode 17 and screen grid 37. The energizing winding 53 of the relay 50 is connected with a telephone transmitter, microphone, or other sound responsive 95 device, not shown.

In accordance with this invention the anode impedance of the electron discharge device 10 is 100 normally sufficiently great to prevent any appreciable electron flow between the cathode and the anode when no potential is applied to the screen grid 37. When the transmitter, microphone or the like is used, the winding 53 of the relay 50 105 is energized so that the contacts 49 close and the battery 45 is connected in series with the screen grid 37 through the resistance 48 and contacts 49. When the transmitter or equivalent unit is not 110 in use, for example, when the receiving apparatus is in operation, the relay 50 is deenergized, and the battery 45 is disconnected from the screen grid 37 whereby the device 10 becomes non-conductive and functions as a trigger device to render 115 the transmitting system inoperative.

It has been found in electron discharge devices utilized as trigger controls in systems such as 120 described above, that the device may become conductive because of secondary emission from the screen grid so that the screen grid potential no longer serves as the controlling element for the initiation and discontinuance of the cathode-anode electron discharge. 125

In accordance with a feature of this invention, the screen grid is so positioned relative to the 130 control grid and anode that the electric fields between the several electrodes are such that secondary emission from the screen grid is of insufficient magnitude to render the device conductive when the screen grid is at zero potential. 135

The effect of the positioning of the screen grid upon secondary emission therefrom may be understood with reference to Figs. 5, 6 and 7. In 140 Figs. 5 and 6, 54 designates an anode, 55 denotes an incandescible cathode, 56 denotes a control electrode or grid and 57 designates a wire of a screen grid disposed between the anode and the control grid. The full lines represent the paths 145 traversed by electrons emitted from the cathode and the dotted lines indicate the paths traversed by secondary electrons released from the screen grid through the impact of electrons from the cathode which strike the screen grid wire 57. 150 If the screen grid is positioned relatively distant from the cathode, the electric field in the vicinity

of the screen grid will be somewhat of the form shown by the full lines in Fig. 5. Some of the secondary electrons released from the screen grid by the impact energy of the primary electrons will be returned to the screen grid; however, other of the secondary electrons, under the influence of the anode potential and the primary electron stream, will flow to the anode so that a change in the magnitude of, or a reversal of, current occurs through the resistance 48 in the circuit shown in Fig. 4. The screen grid current-voltage relation for a device in which the electric fields are as shown in Fig. 5, may be of the form shown by curves A and B of Fig. 7 in which the abscissæ represent screen grid voltage and the ordinates denote screen grid current. A characteristic of either of the forms shown by curves A and B results in unstable operation of an electron discharge device of the type shown in Fig. 1. A characteristic particularly, one of the form shown by curve B in Fig. 7 indicates that more electrons are leaving the screen grid because of the secondary emission, than are owing to the screen grid from the cathode. The emission of electrons from the screen grid necessarily leaves the screen grid with a positive charge, the magnitude of which is dependent upon the degree of secondary emission. This positive charge may be of a magnitude sufficient to render the device conductive even when the applied screen grid potential is at zero, as when the relay 50 in Fig. 4 releases and the contacts 49 are opened. Under such conditions the device 10 could not, therefore, be utilized as a trigger control for the transmitting system.

In accordance with this invention the effect of secondary emission from the screen grid is overcome by so positioning the screen grid that the electric fields are somewhat of the form shown in Fig. 6. As shown by the dotted lines of this figure, any electrons which are released from the screen grid by impact of the primary electrons, under the influence of the fields adjacent the screen grid return to the screen grid so that the number of electrons between the screen grid and anode is substantially equal to, or less than, the number of electrons traversing the space between the cathode and the screen grid. The current-voltage characteristic is then of the form shown by curve C in Fig. 7. In a device constructed in accordance with this invention, in which the screen grid is relatively near the cathode, then the screen grid is at zero potential, the anode impedance is of such magnitude that no current can traverse the anode-cathode circuit and the device may be used efficiently as a trigger control in such a system as the transmitting circuit shown in Fig. 4.

In a specific embodiment of this invention, an electron discharge device of the construction shown in Fig. 1 comprises a helical thoriated tungsten cathode having a diameter of 0.25 inch, a carborundum blasted molybdenum anode, a control grid and a carbonized molybdenum screen grid. The anode has a diameter of approximately 1 inch and the anode-cathode spacing is approximately 0.375 inch; the screen grid is placed as close as is mechanically and electrically feasible to the control grid and has a diameter of approximately 0.562 inch and is spaced approximately 0.156 inch from the cathode. The ratio of anode-cathode to screen grid-cathode spacing is, therefore, about 2.4 and the diameters of the cathode, screen grid and anode are

in the ratio of 1:2.25:4. If this ratio is decreased appreciably, it has been found that the effect of secondary emission is of sufficient magnitude to render the device unstable and unsuitable for utilization as a trigger control.

Although a specific embodiment of the invention has been shown and described hereinabove, it is to be understood, of course, that many modifications may be made therein without departing from the scope and spirit of this invention as defined in the appended claims.

What is claimed is:

1. An electron discharge device comprising a cathode, a grid, an anode, and an auxiliary electrode between said grid and anode, said anode being widely spaced from said cathode so that the anode impedance is sufficiently great to substantially prevent electron flow between said cathode and anode when said auxiliary electrode is at zero potential, said auxiliary electrode being positioned immediately adjacent said grid and remote from said anode, whereby secondary emission from said auxiliary electrode will be of insufficient magnitude to affect the stability of the device.

2. An electron discharge device comprising a cathode, a grid, an anode concentrically disposed about said cathode and grid, and an auxiliary electrode positioned between said grid and anode and concentric therewith, said anode being widely spaced from said cathode whereby the anode impedance is so great that substantially no electrons can flow between said cathode and anode when the auxiliary electrode is at zero potential, said auxiliary electrode being positioned in immediate proximity to said grid and remote from said anode so that secondary emission from said auxiliary electrode will be of insufficient magnitude to affect the controlling action of said auxiliary electrode upon the cathode-anode electron stream.

3. An electron discharge device comprising a cathode, a grid, an anode, and an auxiliary electrode between said grid and anode, said anode being widely spaced from said cathode so that the anode impedance is of such magnitude that no electrons can flow between said cathode and anode when said auxiliary electrode is at zero potential, the ratio of the anode-cathode to auxiliary electrode-cathode spacing being not less than 2.4.

4. An electron discharge device comprising a cathode, a grid, an anode, and an auxiliary electrode presenting substantially concentric surfaces to one another, said anode being disposed remote from said cathode so that the anode impedance is of such magnitude that no electrons can flow between said anode and cathode when said auxiliary electrode is at zero potential, the diameters of the cathode, auxiliary electrode and anode being substantially in the ratio of 1:2.25:4.

5. An electron discharge device comprising a cathode, a grid, an anode concentrically disposed about said cathode and grid, and an auxiliary electrode concentrically disposed between said grid and anode, said anode being widely spaced from said cathode whereby the anode impedance is so great that no electrons can flow between the cathode and anode when the auxiliary electrode is at zero potential, said auxiliary electrode being located in close proximity to said grid electrode and approximately midway between said anode and cathode.

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