

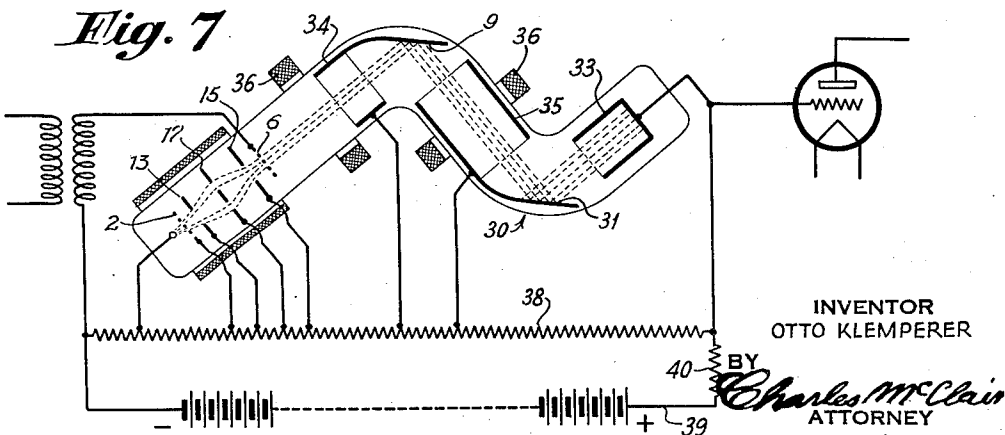
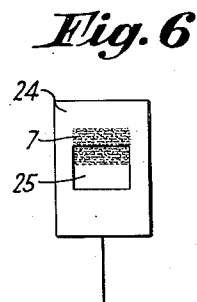
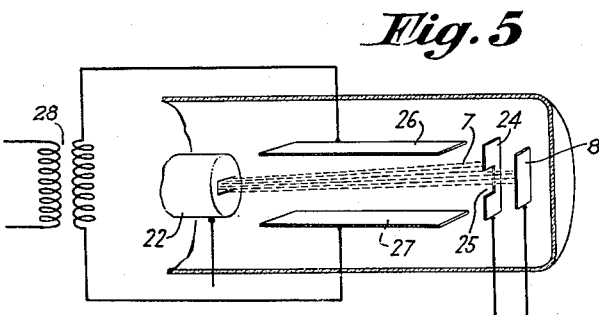
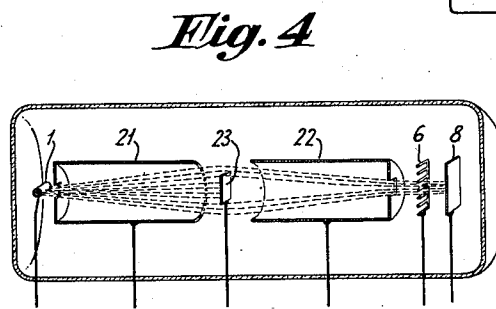
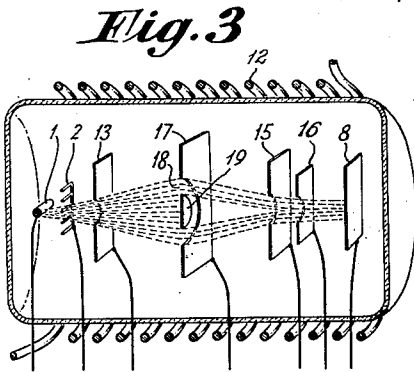
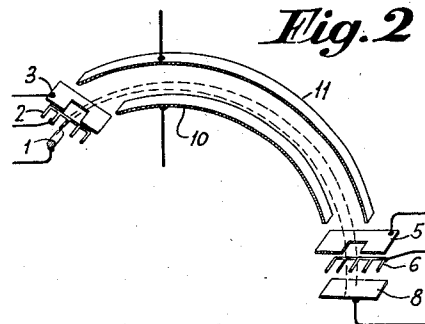
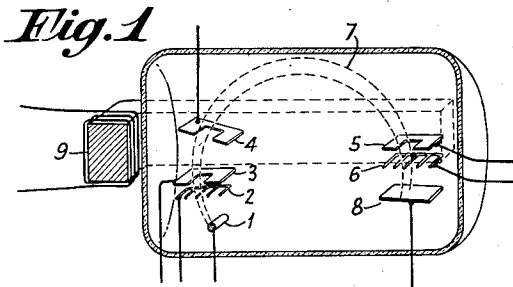
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O. KLEMPERER

2,138,928

ELECTRON DISCHARGE DEVICE

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INVENTOR
OTTO KLEMPERER

BY
Charles McClain
ATTORNEY

UNITED STATES PATENT OFFICE

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ELECTRON DISCHARGE DEVICE

Otto Klemperer, Iver, England, assignor to Electric and Musical Industries, Ltd., Hayes, England

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5 Claims. (Cl. 250—159)

The present invention relates to electron discharge devices, and especially, but not exclusively to secondary electron multipliers where a controlled input signal is amplified by a relatively large factor.

An object of the present invention is to provide an electron discharge amplifying device which has a relatively steep characteristic at relatively low values for emission current.

10 An electron discharge amplifying device in accordance with the present invention has a cathode adapted to emit electrons, a collector or anode adapted to receive electrons emitted by said cathode, control means for varying the magnitude of the electron current flowing from said cathode to said anode, and means for selecting from among the electrons emitted by said cathode, for transmission to said collector or anode, only those electrons emitted with an initial velocity lying within a predetermined velocity range. The variations in electron current are utilized in a circuit including a signal impedance connected between said anode and said cathode, and means for utilizing signals developed across the signal impedance.

The term "cathode" is intended to include any suitable electron-emitting element, for example, a hot cathode or a photoelectrically active surface.

30 There may be provided means, either electrostatic or electromagnetic, or both, for deflecting electrons emitted by the cathode, to an extent dependent upon their velocity of emission, associated with an apertured electrode which is arranged to pass only the electrons emitted with velocities lying within the predetermined range.

35 The signal impedance may be directly connected between said cathode and said anode, but preferably the anode forms the first target electrode of an electron multiplier, and the signal impedance is connected in series with the electron multiplier, being interposed in a circuit connecting said cathode with a multiplier electrode adapted to receive secondary electrons.

40 In order that the invention may be more clearly understood and readily carried into effect, some arrangements of cathodes, electron selecting means and control electrodes arranged in accordance with the invention will now be described by way of example with reference to the accompanying drawing, in which Figures 1-5 represent diagrammatically in longitudinal section arrangements or relative dispositions of electrodes in an electron discharge device; Figure 6

shown in Figure 5; and Figure 7 shows diagrammatically the electrode arrangement of Figure 3 embodied in an electron multiplier.

Referring to the drawing, Figure 1 shows one arrangement of electrodes. The electrode elements include a cathode 1, an accelerating grid 2 next to the cathode, electron selecting means including diaphragms such as a diaphragm 3 next to the grid 2 and having a centrally disposed narrow slit, a further diaphragm 4 having a centrally disposed slit wider than that in the diaphragm 3, and a further diaphragm 5 formed with a centrally disposed narrow slit for delivering a stream of electrons of preselected velocity, and a control grid 6, the electrode elements being positioned to permit the discharge to follow curved or arcuate paths 7 from the cathode 1 to the control grid 6 and on to a collector or anode 8. The slits in the diaphragms 3, 4, and 5 are arranged to be perpendicular to the plane of the curved path of the discharge 7. The electrons emitted by the cathode 1 and accelerated by the grid 2 are caused to traverse arcuate paths, the radii of which depends upon the velocities of the electrons, the arcuate paths being determined by a magnetic field perpendicular to the plane of the discharge and set up by coils, or a magnet, such as 9, shown diagrammatically in the drawing for the purpose of assisting in the selection of electrons of differing velocities. The arrangement described acts as an electron velocity filter which permits passage of electrons having a predetermined velocity and ensures that only electrons having that velocity are delivered by the electron selecting means and are subject to the influence of the control grid 6.

In Figure 2 of the drawing is shown an arrangement of electrodes employing electrostatic focusing, the electrode elements extending over a circular arc of about 127°. The arrangement, in general similar to that shown in Figure 1, includes the cathode 1, accelerator grid 2, diaphragm 3, further diaphragm 5, and control grid 6. Between the diaphragms 3 and 5 are disposed two curved and partly cylindrical plates 10 and 11 to which voltages are applied for the purpose of establishing an electric field which causes the electrons emitted from the cathode 1 to follow the arcuate paths 7. The radii of these arcuate paths depend upon the velocity of the electrons and selection of the operating voltages permits control such that only electrons emitted with velocities lying within a predetermined range reach the control grid 6. If, for example, the plates 10 and 11 have radii of 5 and 6 cms. 55

respectively, voltages of the order of 15 and 25 should be applied to these plates in order to deflect and to focus electrons having a velocity of 20 volts. If the width of the aperture in the diaphragm 5 is 1 m. m., electrons having a velocity of 20 volts can be separated from electrons having a velocity of 20.3 volts provided that the electron current is so small that strong repulsion between the electrons does not occur. Thus, the electron current to the collector or anode should be less than about 100 microamperes.

In Figure 3, is shown an arrangement employing electrode elements distributed along a common axis lying parallel to the direction of a magnetic field set up by means such as a cylindrical coil 12. In this device use is made of cathode 1, accelerator grid 2, a diaphragm 13, a further diaphragm 15, and a control grid which may be like control grid 6 or may be, as shown, a control element 16 of the apertured diaphragm type. An additional element in the form of a diaphragm 17 having an annular aperture 18 around the disc 19 is situated between the diaphragms 13 and 15. Each of the diaphragms 13 and 15 is formed with a relatively small circular aperture and electrons passing through the aperture in the diaphragm 13, except those electrons moving parallel to the magnetic field produced by the coil 12, follow helical paths the radius of the helix depending upon the radial component of their velocity and the pitch of the helix depending upon their axial velocity.

The focal length of the electron lens formed by the system is so chosen in relation to the strength of the magnetic field that the cross sectional area of the electron beam at the diaphragm 17 is greater than the area within the annular aperture 18 and only those electrons having axial velocities within a selected range pass through the annular aperture 18 and on through the aperture in the diaphragm 15 to the control element 16. In effect the core of the cylindrical beam from the diaphragm 13 is intercepted, and only the outer portion of the beam passes on to the anode 8.

Figure 4 shows another arrangement employing electrostatic focusing. In this case cathode 1, is followed by electron selecting means including an accelerator electrode 21 in the form of a cylinder having an apertured diaphragm at the end adjacent the cathode, a decelerator 22 in the form of a similar cylinder arranged next to the accelerator electrode 21, but with the apertured diaphragm at the end remote from the cathode, and a small disc 23 placed between the accelerator 21 and the decelerator 22 to stop electrons which travel parallel to the axis of the system and are therefore not subject to the selective action due to refraction in the electron lens. This disc may be mounted on thin wires not shown in the drawing, and in order that it shall not distort the potential distribution, it is preferably associated with means which serve to maintain it at space potential, that is, at the potential existing in its locality. Electrons pass through the aperture in the accelerator electrode 21 in a divergent ray, and only those having velocities within a selected range are focused by the electron lens system, formed by the accelerator 21 and decelerator 22, into the aperture of the latter so as to pass on to the control or modulating grid 6.

The electrodes employed to select electrons of the desired velocity range may give rise to scattered and secondary electrons which have velocities below the selected range. The effect of

these as influencing the foot of the characteristic curve is, however, unimportant as they do not affect the high velocity side of the selected range.

Grid modulation is used in the arrangements above described, and although a space charge region may exist in front of the control grid or modulator 6, and introduce a new velocity distribution the space charge will not be large enough, with the very small electron currents here under consideration, to have an appreciable effect. A diaphragm or shield electrode having a circular aperture may be employed as a control element as in Figure 3, in which case the effective diameter of the aperture, that is, the diameter of the circle through which electrons can pass, is preferably made proportional to the potential of the diaphragm, so that the number of electrons passing the aperture is proportional to the square of this potential, the modulation characteristic curve being parabolic and meeting the potential axis tangentially. The slope can be made steeper by the use of a diaphragm modulator having a small aperture, or of a fine mesh screen.

Deflector modulation may be used where it is desirable to secure a strictly linear characteristic right down to the potential axis and very high frequencies are not employed. One arrangement for effecting such deflection modulation, shown in Figures 5 and 6, comprises a diaphragm 24 having an aperture 25 of rectangular form which passes a beam of electrons of substantially uniform velocity and of the same cross section as the aperture. A pair of deflecting plates 26 and 27 are disposed, one on each side of the beam path, on the entry side of the diaphragm, and modulating potential differences are applied to these plates through an input circuit 28 so that the beam is deflected, the proportion able to pass through the aperture to the collector 8 being dependent upon the modulation potential. Figure 6 shows the case where about half the electrons following the paths 7 in Figure 5 are free to pass through the aperture 25, the remainder impinging on the plate 24. To ensure satisfactory operation of such an arrangement, use should be made of a sharply defined beam of electrons of substantial velocity, such as may be obtained from the various embodiments of the present invention, such as Figure 4, for example.

All the embodiments of the invention herein described may be applied to an electron multiplier, and Figure 6 shows, as an example the application of the embodiment of Figure 3 to an electron multiplier such as is disclosed in the British Patent No. 443,777. An evacuated envelope 30, which contains the cathode, the electron-selecting means and the control electrode, has a portion containing electrodes arranged as in Figure 3 and an extended portion in the form of a zig-zag tube. The collector or anode 9 is disposed adjacent to one end of this tube at the first bend of the tube and at another bend there is disposed a target electrode 31, and so on. The anode 9 and the other target electrodes are adapted when bombarded with electrons to emit an increased number of secondary electrons. Means are provided for maintaining the anode 9 which forms the first target electrode, at a positive potential with respect to the cathode and the succeeding target electrodes at progressively higher positive potentials. In the end of the zig-zag tube remote from the first target electrode is placed an output electrode 33. Screen members 34 and 35 in the form of metal cylinders, preferably connected to the target electrodes, and

assisted by coils 36 direct the discharge to the target electrodes. The potential for operation may be derived from a potential divider 38 in parallel with a voltage source 39. The electron current to the output electrode 33, which may be much greater than the original primary electron current to the first target electrode 9, passes through an output or signal impedance 40 included in a circuit associated with the cathode and serving to maintain the output electrode at a higher positive potential than the last target electrode. Electrical variation applied to the control grid 6 which controls the primary electrons of predetermined velocity passing to the anode or first target electrode 9, causes corresponding amplified potential variations to appear across the signal impedance 40, which is to be connected to translating devices and forms part of a utilization circuit.

In operation, electrons emitted from the cathode with velocities within the predetermined range are selected from the whole emission and after passing the control electrode strike the anode or first target electrode. The increased number of secondary electrons thereby liberated flow to the second target electrode, there liberating a still larger number of secondary electrons, and this process is repeated from target to target, so that signals fed to the control electrode and serving to modulate the electron current flowing from the cathode to the anode are reproduced in a greatly amplified form across the signal impedance.

I claim:

1. An electron multiplier comprising an electron emitting cathode, an anode having a secondary electron emission ratio greater than unity, a control electrode between said cathode and said anode, an output electrode adjacent said anode to receive secondary electrons from said anode, means intermediate said cathode and said control element comprising a diaphragm having an aperture of less area than the cross section of the electron discharge from said cathode to said anode at said element for abstracting from the discharge those electrons emitted by the cathode with an initial velocity outside a predetermined velocity range and passing along to said anode only those electrons with an initial velocity lying within a predetermined velocity range.

2. An electron multiplier according to claim 1, including a plurality of target electrodes having a secondary electron emission ratio greater than unity and positioned along a path between the anode and the output electrode, and means for directing the discharge from the anode to said target electrodes in cascade and thence to the output electrode.

3. An electron discharge modulator comprising an electron discharge device having an electron emitting cathode, an anode, electron beam forming means between said cathode and said anode for forming the electron discharge from said cathode to said anode into an electron beam, a diaphragm between said cathode and said anode and having in the path of the beam an annular aperture with an inner diameter less than the diameter of the beam at said diaphragm, and control means between said diaphragm and said anode for the electron stream passed through said diaphragm to said anode.

4. An electron discharge modulator comprising an electron discharge device having an electron emitting cathode, an anode, electron beam forming means between said cathode and said anode for forming the electron discharge from said cathode to said anode into a cylindrical beam, a circular disc mounted transversely of the path of the beam and concentric with the longitudinal axis of the beam to intercept the core of the beam only and of less area than the cross-section of the beam at said disc, and means adjacent said anode for controlling the magnitude of the electron current passing said element to said anode.

5. An electron discharge modulator comprising an electron discharge device having an electron emitting cathode, an anode, electron beam forming means for forming the electron discharge from said cathode to said anode into an electron beam, an element mounted in the path of said electron beam and of the same shape and of lesser area than the cross-section of the beam at said element to intercept the core of the beam only, and means adjacent said anode for controlling the magnitude of the electron current passing said element to said anode.

OTTO KLEMPERER. 50