April 14, 1942. J. W. McRAE 2,279,835

ELECTRON DISCHARGE DEVICE

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FIG. 1

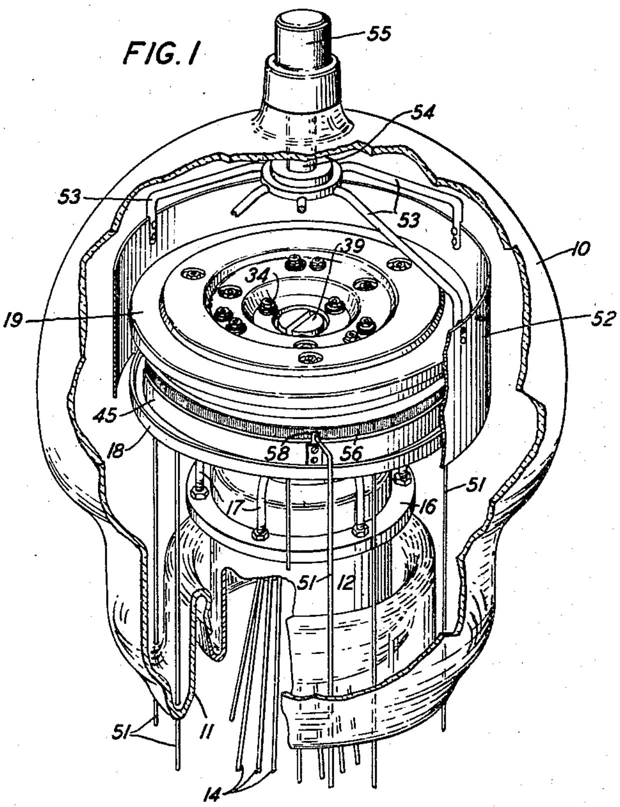

FIG. 3

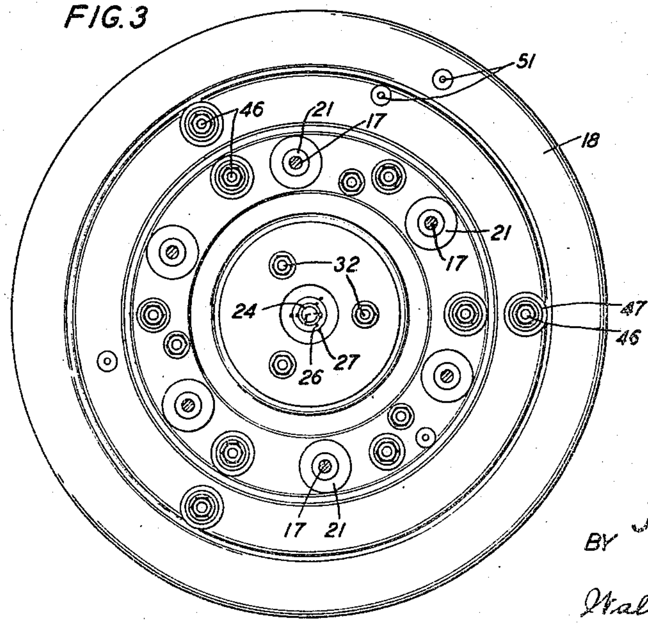

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FIG. 2

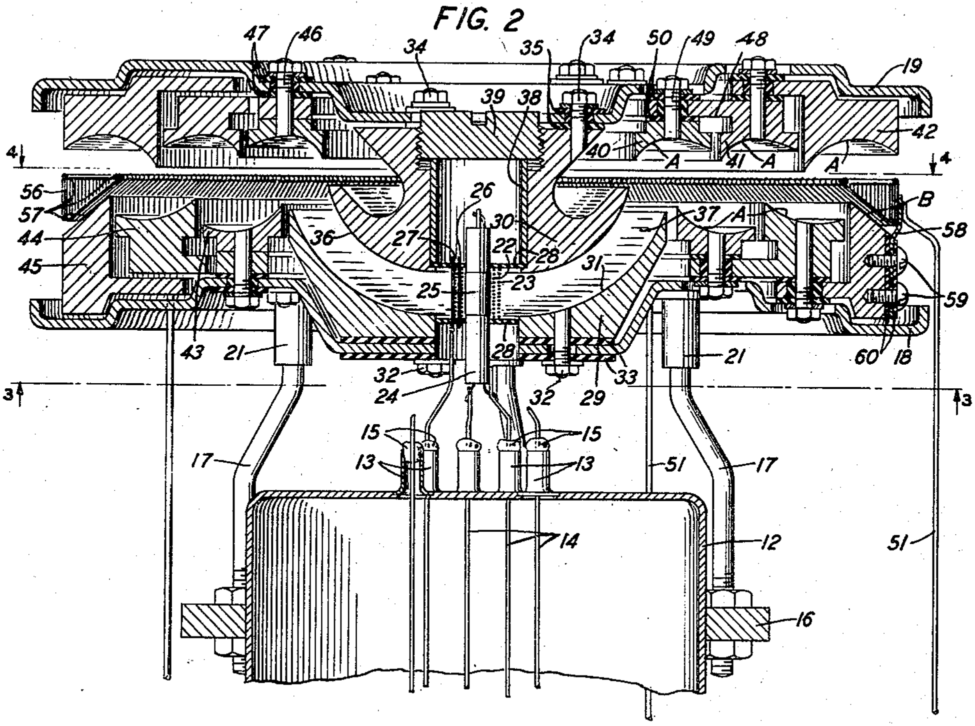


FIG. 4

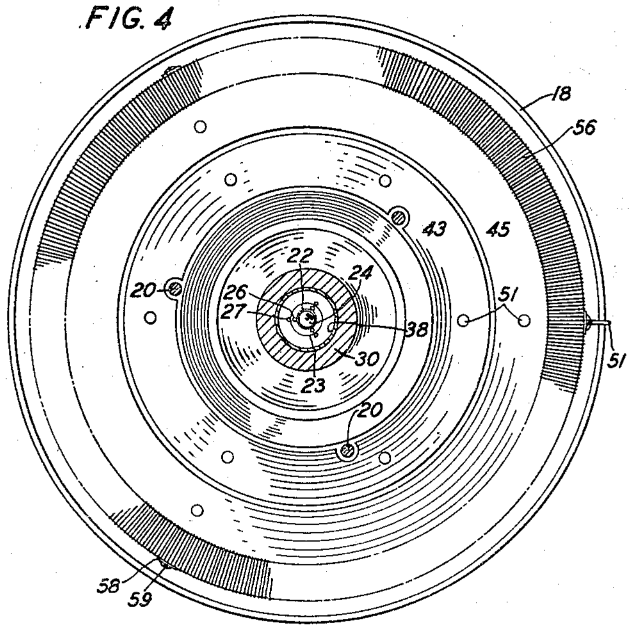
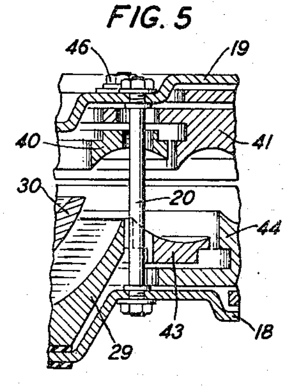


FIG. 5



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Patented Apr. 14, 1942 2,279,835

UNITED STATES PATENT OFFICE

2,279,835

ELECTRON DISCHARGE DEVICE

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Application December 21, 1940, Serial No. 371,124

6 Claims. (Cl. 250—175)

This invention relates to electron discharge devices and more particularly to such devices generally denoted as electron multipliers and including a plurality of secondary electron emissive electrodes.

A general object of this invention is to improve the construction and operating characteristics of electron multipliers. More specifically, objects of this invention are:

To increase the power capacity of multistage electron multipliers;

To obtain a high degree of shielding between the input elements and the secondary electron emitters in multistage electron multipliers whereby such multipliers are adapted for efficient operation as radio frequency amplifiers;

To simplify the construction of multielement multipliers whereby a number of the electrodes may be fabricated in a rigid, compact unitary assembly; and

To obtain a high degree of concentration of the electrons emanating from the primary electron source in electron multipliers and acceleration of these electrons toward and focussing thereof upon the first secondary electron emissive electrode.

In one embodiment, illustrative of this invention, an electron multiplier comprises a primary cathode, a cylindrical collector electrode or anode coaxial with the primary cathode and a pair of groups of annular secondary electron emissive electrodes coaxial with one another and with the primary cathode. A control and an accelerating electrode or grid may be provided in cooperative relation with the primary cathode.

In accordance with one feature of this invention, the two groups of secondary cathodes are supported upon two plates, preferably of metal, the two plates being fixedly mounted in spaced relation and supporting also the primary cathode and the grids in cooperative relation therewith, whereby a compact unitary assembly is provided. The plates overlie the secondary cathodes and form electrostatic shields which screen the discharge paths between the secondary cathodes from extraneous fields so that distortion of the fields in these paths is prevented. In addition, the plates, being closely coupled thermally to the secondary cathodes, serve as heat radiating members whereby undue heating of the secondary cathodes, and particularly of the cathodes in the later stages of the device, is avoided.

In accordance with another feature of this invention, shields of novel construction are provided in cooperation with the input elements of the device to assure a high degree of segregation between these elements and the multiplying and output electrodes.

The invention and the foregoing and other features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawings in which:

Fig. 1 is a perspective view of an electron multiplier constructed in accordance with this invention, portions of the enclosing vessel and of the collector electrode or anode being broken away to show the internal structure more clearly;

Fig. 2 is a view in section of the unitary electrode assembly included in the multiplier shown in Fig. 1;

Fig. 3 is an end view along plane 3—3 of Fig. 2;

Fig. 4 is a view along plane 4—4 of Fig. 2, showing the configuration and relation of a number of the electrodes; and

Fig. 5 is an enlarged detail view in section showing clearly the association of the supporting plates or shields.

Referring now to the drawings, the electron discharge device illustrated therein comprises a highly evacuated enclosing vessel 10, of vitreous material, having at one end thereof an inwardly extending tubular portion 11 to which a cup-shaped metallic stem 12 is hermetically sealed, the stem 12 having thereon metallic eyelets 13 to which leading-in conductors 14 are sealed hermetically by insulating, for example glass, beads 15. Encompassing and suitably affixed to the stem 12 is a collar 16 carrying a plurality of rigid metallic supports or uprights 17 which in turn mount a unitary electrode assembly.

The unitary electrode assembly, as shown clearly in Fig. 2, comprises a pair of metallic annular flanged plates 18 and 19, which are fixed in generally parallel relation by a plurality, for example three, of spacing bolts 20, as shown clearly in Fig. 5, and are connected electrically by these bolts. The plate 18 has securely fixed thereto a plurality of sleeve or coupler members 21 in which the supports or uprights 17 are secured, as by welding.

Mounted in coaxial relation and supported by the plates 18 and 19 are a primary cathode, a control grid 22 and an accelerating grid 23. The cathode, as shown in Fig. 2, may be of the equipotential indirectly heated type and comprise a cylindrical metallic sleeve 24, a restricted portion of which is provided with a coating 25 of electron emissive material. The control grid 22 and accelerating grid 23 may be helices secured to vertical wires or supports 26 and 27, respectively. Electrical connection to the cathode and the grids may be established through the leading-in conductors 14.

The cathode and grids 22 and 23 are maintained in coaxial relation by a pair of insulating, for example mica, discs 28, the cathode sleeve 24 being fitted in central apertures in the discs and the supports 26 and 27 likewise being fitted in apertures in the discs. The discs 28 are fitted in coaxial apertures in a pair of guiding or beam forming electrodes 29 and 30 supported on and insulated from the plates 18 and 19, respectively. The electrode 29 has a concave surface of revolution 31 and is affixed to the plate 18 by a plurality of bolts 32 the shanks of which are tightly fitted in taps in the electrode 29. The bolts 32 and the electrode 29, as shown clearly in Fig. 2, are insulated from the plate 18 by insulating washers 33. The electrode 30 is similarly mounted on and insulated from the plate 19 by bolts 34 and insulating washers 35, and has a convex surface of revolution 36 concentric with the surface 31 and defining therewith a dished annular passageway 37. A cylindrical sleeve 38 is fitted within the central aperture on the electrode 30, is locked therein by a plug 39 and clamps the insulating disc 28 against a lip on the electrode 30 as shown.

Mounted upon and insulated from the plate 19 is a group of annular electrodes 40, 41 and 42, coaxial with each other and with the cathode, each of the electrodes 40, 41 and 42 having a dished surface A coated with a material having good secondary electron emissive characteristics. A second group of annular electrodes 43, 44 and 45, coaxial with one another and with the cathode and in staggered relation with the electrodes of the first-mentioned group, is mounted upon and insulated from the plate 18, the electrodes 43 and 44 having dished surfaces A coated with a material having good secondary electron emissive characteristics and the electrode 45 having an inclined surface B similarly coated.

Each of the secondary electron emissive electrodes 40 to 45, inclusive, is securely fixed to the plate 18 or 19 on which it is supported and is also fixed securely to the adjacent electrode or electrodes of the same group. For example, the electrode 40 is secured to the plate 19 by a plurality of bolts 46 having shanks fitted in taps in the electrode 40, the electrode 40 and bolts 46 being insulated from the plate 19 by insulating members 47. The electrode 40 is also fixed rigidly with respect to the electrode 41. Specifically, the electrode 41 is provided with an inwardly extending flange 48 which is secured to the electrode 40 by a plurality, for example three, of bolts 49 and insulated therefrom by insulating members 50, the bolts extending into oversize apertures in the plate 19. Similarly, as shown in Fig. 2, each of the other secondary electron emissive electrodes is secured to and insulated from both the plate 18 or 19 on which it is supported and the next adjacent electrode or electrodes of the same group. This construction, it will be appreciated, enables the assembly of each group of electrodes as a unit with the electrodes fixed in the desired space relation, prior to the mounting of the electrodes upon the plates 18 and 19 and also enables the attainment of relatively small potentials across the various insulating members.

Electrical connection may be established individually to the various secondary electron emissive electrodes by leading-in conductors 51 which are sealed in the base end of the vessel 10 and each of which is connected to a corresponding one of the electrodes 40 to 45. The leading-in conductors 51 for the upper electrodes extend through the electrode assembly.

The electrode assembly described above is encompassed by a cylindrical anode 52 which is supported in coaxial relation with the electrodes of the assembly by a plurality of rigid metallic supports or arms 53 extending from a metallic stud 54 sealed in the vessel 10 and connected to a terminal 55.

Mounted opposite the surface B of the secondary electron emissive electrode 45 is an annular formed screen grid, V-shaped in section, which comprises spaced wires 56 secured to rigid support wires or frames 57. The screen grid is supported from the electrode 45 by a plurality of spaced tabs 58 secured to the electrode 45 by screws 59 and insulated therefrom by insulating spaces 60. Electrical connection to the screen grid may be established through one of the conductors 51 secured to one of the tabs 58.

During operation of the device, the secondary electron emissive electrodes 40 to 45 are maintained at successively higher positive potentials with respect to the cathode. That is, each secondary electron emissive electrode is maintained at a higher potential than the next succeeding electrode. For example, the first secondary electron emissive electrode 40 may be maintained at a potential of the order of 200 volts positive with respect to the cathode 24, 25, the electrode 43 may be operated at a potential 200 volts positive with respect to the electrode 40 and so on. The electrode 29 may be operated at a potential of 50 volts positive with respect to the cathode and the electrode 30 may be maintained positive with respect to the electrode 29, for example at 100 volts. The screen grid may be maintained at a potential of 1,400 volts positive with respect to the cathode and the collector electrode or anode 52 may be operated at 2,000 volts. The plates 18 and 19 preferably are grounded. The accelerating grid may be biased 100 volts positive with respect to the cathode.

Electrons emanating from the cathode 24, 25 are concentrated into a beam by the guiding electrodes 29 and 30 and are accelerated toward and impinge upon the surface A of the emissive electrode 40 whereby secondary electrons are emitted from this surface. These secondary electrons are directed upon the surface A of the electrode 43. This action is repeated at each of the other surfaces A and B and the electrons emanating from the electrode 45 flow to the collector electrode or anode 52. At each of the secondary electron emissive surfaces A and B, the secondary electron current therefrom is greater than the electron current thereto. Hence, an electron multiplication occurs at each of these surfaces whereby, in effect, a multifold amplification of the current flowing to the electrode 40 is realized. The magnitude of the current flowing to the electrode 40 may be controlled, of course, by the control grid 22.

It will be noted that the discharge paths between the secondary electron emissive electrodes are highly screened from extraneous fields, by the plates 18 and 19 and screen grid wires 56 and are highly screened also, by the plates 18 and 19, electrodes 29 and 30 and the stem 12 from the input elements of the device. Hence, variations in the potentials of the input elements, and extraneous fields will not alter the fields in the discharge paths between the secondary electron emissive surfaces. It will be appreciated also that the construction shown and described provides relatively large secondary electron emissive surfaces so that the device has a high power capacity. Furthermore, it is evident that the plates 18 and 19 are closely coupled thermally with the several secondary electron emissive electrodes and have large radiating surfaces. Hence, these plates increase the rate of heat radiation from these electrodes and thereby assure the maintenance of the emissive surfaces A and B at a safe operating temperature.

It will be understood, of course, that the particular structure disclosed is but illustrative of this invention and that various 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 multiplier comprising a primary cathode, a pair of spaced metallic plate members, a group of annular secondary electron emissive electrodes mounted on one of said plate members and coaxial with said primary cathode, a second group of annular secondary electron emissive electrodes mounted on the other of said plate members, coaxial with said cathode and facing said first group of electrodes, and a collector electrode coaxial with said cathode.

2. An electron multiplier in accordance with claim 1 comprising a pair of beam forming electrodes coaxial with said cathode and carried by said plate members, said beam forming electrodes being spaced and defining an annular discharge path between said cathode and one of said secondary electron emissive electrodes.

3. An electron multiplier unitary electrode assembly comprising a pair of metallic discs, means mounting said discs in spaced coaxial relation, a primary cathode coaxial with said discs, a plurality of annular secondary electron emissive electrodes insulatingly mounted on one of said discs in concentric relation and coaxial with said cathode, and a plurality of concentric annular secondary electron emissive electrodes insulatingly mounted on the other of said discs in coaxial relation with said cathode.

4. An electron multiplier comprising an input element including a cathode and a control electrode in cooperative relation therewith, leading-in conductors connected to said cathode and control electrode, a plurality of annular secondary electron emissive electrodes coaxial with said input element, and means screening said secondary electron emissive electrodes from said input element including a shield encompassing said leading-in conductors.

5. An electron multiplier in accordance with claim 4 wherein said screening means includes also a pair of annular electrodes encompassing the end portions of said cathode.

6. An electron multiplier comprising an enclosing vessel having a cylindrical metallic stem, a unitary electrode assembly comprising a pair of metallic discs secured together in spaced substantially parallel relation, a group of concentric annular secondary electron emissive electrodes mounted on one of said discs and insulated therefrom, and a second group of concentric annular secondary electron emissive electrodes mounted on the other of said discs, insulated therefrom and in staggered relation with the electrodes of said first group, means supporting said unitary assembly from said stem, a collector electrode encompassing said assembly, an input element coaxial with said secondary electron emissive electrodes and including a cathode and a grid in cooperative relation therewith, said input element having portions between said discs, and leading-in conductors connected to said input element substantially enclosed by said metallic stem.

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