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R. R. GOODRICH

2,384,087

CURRENT LIMITER

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FIG. 1.

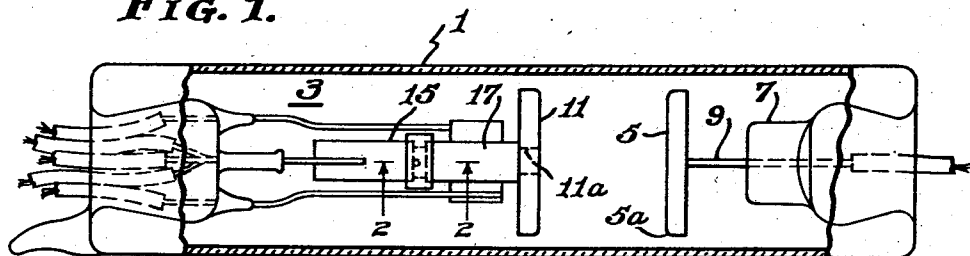


FIG. 2.

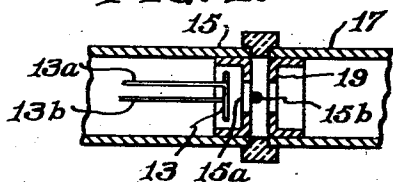
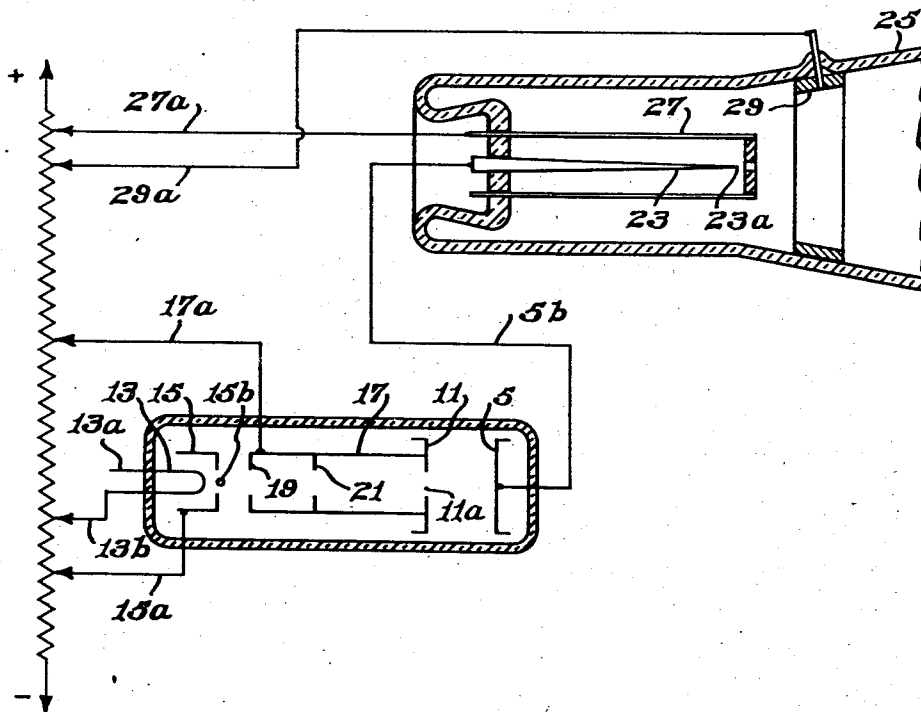


FIG. 3.



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This invention relates to the regulation of electrical current and particularly to improved current regulating means for electron discharge devices of the type normally employing operating potentials of several thousand volts.

While the invention will be disclosed as embodied in a current regulating system for a so-called "point microscope," it will be apparent that there are many other applications for the invention and that the disclosure in this respect is merely illustrative for purposes of explaining the inventive concept.

It is now appreciated by those skilled in the art of electron discharge tubes that, for certain applications, a "point cathode" is to be preferred to a conventional thermionic cathode. By way of example in so-called "beam tubes" wherein a beam of minimum cross-sectional area is desired, the use of a point cathode may reduce or obviate the necessity for employing auxiliary magnetic or electrostatic means for compressing the beam. (As to this see, by way of example, Ramberg et al. U. S. Patent 2,271,990).

The principal objection to the use of a point cathode is the tendency of the point to burn out when subjected to an excessive surge of current such as may be occasioned by an arc-over due to the presence of residual gas in the tube. Attempts to obviate this difficulty, as by the use of a protective system of the type employing a resistor in series with the load and which depends for its operation upon an increase in current through said resistor, have not been successful since such systems are based upon the "feedback" principle and possess an inherent time lag which, however small, prevents the limiting action from taking place prior to the passage of the current which the said system is designed to control.

At first glance it might appear that the foregoing objections to conventional "feedback" systems for regulating the current supplied to a point cathode might be overcome by the use in a "feed forward" system employing a conventional tube (say an RCA pentode type 6J7) possessing a substantially flat plate-current characteristic. The objection to the use of conventional tubes in such a regulating system resides not only in the fact that they are usually incapable of standing up under the voltages which they would be obliged to sustain but in the fact that their interelectrode capacitance is so great as to provide a capacitive path to the load for at least a surge of the current whose passage it is desired to prevent.

Accordingly, the principal object of the present invention is to provide an improved current regulating system for high voltage discharge tubes, and one which obviates the foregoing and other less apparent disadvantages to known regulating systems.

Another and related object of the present invention is to provide an improved current regulating discharge tube having a low internal capacitance, a compact structure, and one nevertheless capable of use in connection with a load device which is normally subject to an operating potential of several thousand volts.

The foregoing and other objects are achieved, in accordance with the invention, by the provision, in a "feed forward" regulating system, of a beam tube of special design and wherein the electron current which impinges a metal target or "second anode" is independent of variations in voltage incident to changes in the resistance of the utilization circuit.

Certain preferred details of construction together with other objects and advantages will be apparent and the invention itself will be best understood by reference to the following specification and accompanying drawing wherein

Figure 1 comprises a longitudinal sectional view of a current limiting beam tube constructed in accordance with the invention;

Figure 2 is a sectional view taken on the line 2-2 of Fig. 1, and

Figure 3 comprises a diagrammatic view partly in section showing the device of Fig. 1 connected for use, as a current limiter, with a so-called "point microscope."

In the drawing wherein like reference characters designate the same or similar parts in all figures, 1 designates a highly evacuated tubular envelope containing an electron gun 3 adjacent one end and, adjacent the other end, a second anode or target electrode 5 upon which the electrons from the gun impinge. The target electrode 5 comprises a flat metal plate which extends in a plane normal to the long axis of the gun and is shown supported upon a press 7 by means of a connector 9 which extends through the press to the exterior of the envelope. The plate or target 5 is provided with rounded edges 5a to prevent cold emission and, in order to more effectively dissipate heat, comprises a surface of an area considerably greater than required for the reception of the beam of electrons from the gun 3. A plate 11 of similar diameter and contour is mounted on the leading end of the gun in

register with the target plate 5 to ensure a symmetrical field in the space traversed by the electrons in their journey to the target. The plate 11 is provided with a central aperture 11a through which the electrons pass.

The gun 3, illustrated in Figs. 2 and 3, comprises a directly heated cathode 13, a cylindrical control grid 15, and a first anode in the form of a cylindrical conduit or shield 17 to the outer end of which the plate 11 is affixed. The cathode 13 in the instant case comprises a helically wound flat "pancake" filament which is supported, as on conductive leads 13a, 13b, within the cylindrical control electrode 15, and has its emissive surface presented to a central aperture 15a in the said cylinder. A grid wire 15b stretched across the aperture 15a and conductively secured to the cylinder 15 permits the electron current to be controlled without altering the diameter of the beam. This provides a sharp control and is especially desirable in the instant case since it prevents spreading of the beam and inhibits the generation of secondary or impact electrons which would result if the primary electrons struck the inner surface of the first anode 17 or the inner edge of the end plate 11. The first anode 17 is provided with a pair of beam forming diaphragms 19 and 21, having central apertures which are aligned with the aperture 11a in the end plate 11.

A beam tube incorporating an electrode assembly of the following dimensions operated successfully to maintain the operating current of a load device (in this case, a point microscope) at a constant selected value notwithstanding extreme variations, due to arcing, in the resistance of the said load: Diameter of grid and first anode cylinders $\frac{1}{4}$ ". Length of grid cylinder $\frac{3}{4}$ "; length of anode cylinder 1". Diameter of grid aperture 0.15"; diameter of grid wire 0.007". Grid-anode space 0.040". Spacing between end plate 11 and second anode 5 1". Spacing of focusing diaphragms 19, 21 0.5". Diameter of beam forming apertures 0.125". Diameter of aperture in end plate 11 0.25". The parts were made of tantalum carefully outgassed and treated with about 100 kilovolts to burn off all cold emission points.

Referring to Fig. 3, the electron current which impinges the second anode 5 of the regulator tube 1 is applied as by means of a lead 5b to a needle like point-cathode 23 of an electron discharge device 25 which, in the instant case, comprises an electron-microscope similar to the one shown in Ramberg et al. U. S. Patent 2,271,990. As disclosed in the said patent, one or more auxiliary electrodes 27 and 29, when supplied through leads 27a and 29a, respectively, with potentials several thousand (say, 5000) volts positive with respect to the cathode 23, serve to establish and maintain a "cold discharge" of electrons from the point 23a. Though it is usual to outgas such a tube just prior to use, it may happen that during its operation enough occluded gas will be driven out of the metal or glass to render the space between the tip 23a of the cathode 23 and its next adjacent electrode 27 of negligible resistance so that the voltage drop therebetween is greatly

reduced. Since the limiter tube 1 is in series with the point cathode 23 of the tube 25 the voltage across the limiter increases by the same amount that the voltage across the tube 25 drops, thus the overall voltage remains the same. In the absence of secondary emission effects in the limiter tube the large increase in voltage thereacross has no effect upon the electron current which impinges the second anode 5 since the tubular conduit 17 effectively shields the electron source 13 from the intensified electrostatic field between the end plate 11 and the second anode plate 5. Further, since the spacing between the plate 11 and 5 is so great that the capacitance therebetween is negligible there can be no capacitive discharge of current therebetween (as there would be in the case of a conventional plural grid tube) which can be transmitted to the load device 25.

I claim as my invention:

1. A system consisting of a current limiter comprising an evacuated envelope containing an electron emissive cathode and an anode, and a utilization circuit connected to said anode, said utilization circuit including a path of variable resistance, and electrode means of negligible capacitance between said cathode and anode for maintaining a constant flow of electrons therebetween substantially independent of variations in the resistance of said utilization circuit.

2. The invention as set forth in claim 1 and wherein said electrode means comprises a conduit through which said electrons pass in their journey to said anode.

3. The invention as set forth in claim 1 and wherein said utilization circuit comprises a point cathode and a discharge maintaining electrode mounted in spaced relation with respect to said point cathode.

4. The invention as set forth in claim 1 and wherein the spacing between said anode and the electrode next adjacent thereto is so great as to prevent a capacitive discharge of current therebetween when the resistance of said utilization circuit is varied.

5. A current limiter comprising an electron emissive cathode, a tubular electrode and a plate-like metal anode upon which electrons from said cathode impinge mounted in the order named in spaced relation along a common axis within an evacuated envelope, and leads individual to said tubular electrode and said anode for establishing a difference of potential therebetween, the spacing between said anode and the adjacent end of said tubular electrode being so great as to prevent a capacitive discharge of current therebetween when said device is subjected to extreme variations in the potential applied to said electrodes.

6. The invention as set forth in claim 5 and wherein said tubular electrode terminates in a plate-like surface of a diameter corresponding substantially to that of said anode, whereby a substantially uniform electrostatic field is established therebetween when said electrodes are energized.

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