Jan. 16, 1951 J. H. FINDLAY 2,538,560

SECONDARY EMISSION ELECTRON DISCHARGE DEVICE

Filed July 13, 1948

Fig. 1.

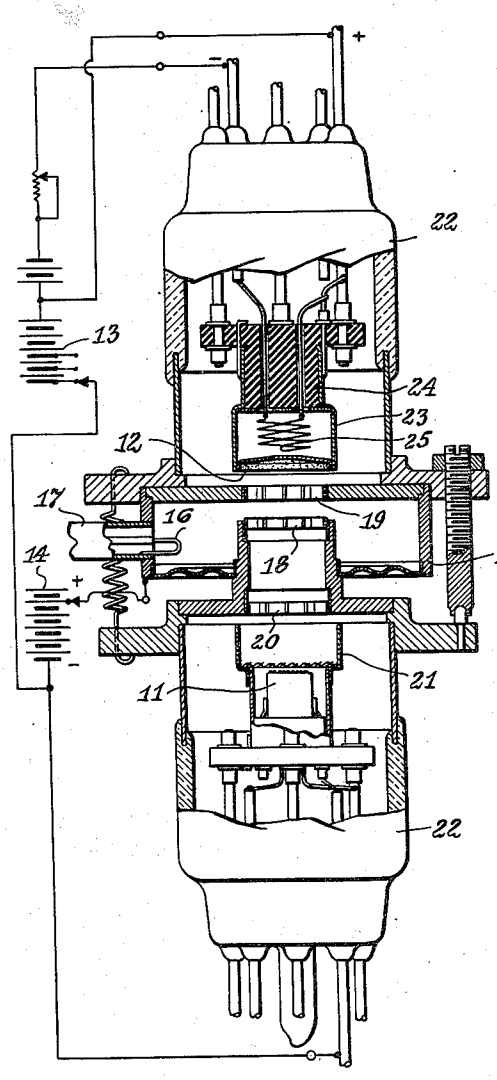


Fig. 2.

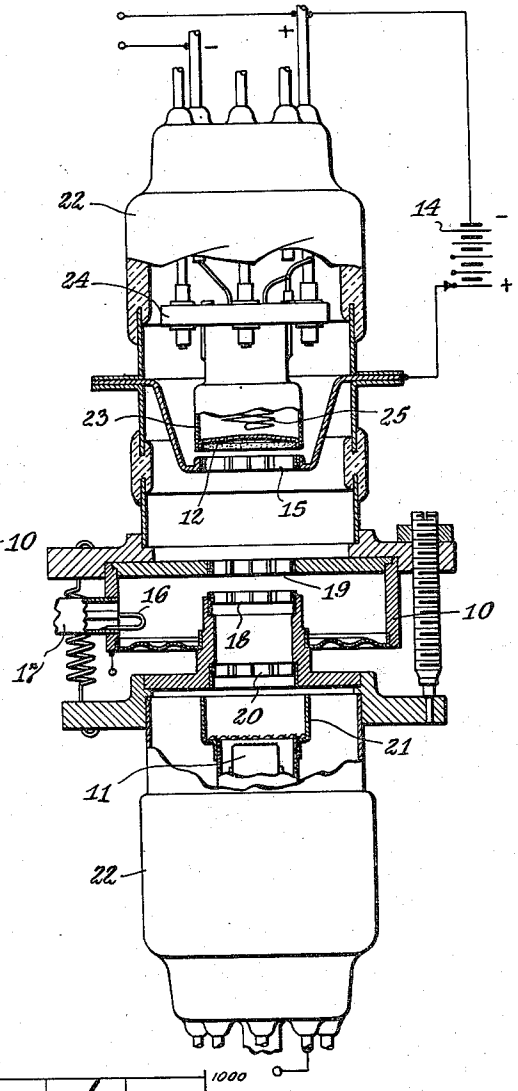
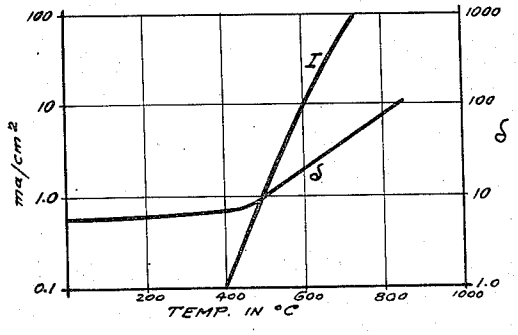


Fig. 3.



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SECONDARY EMISSION ELECTRON DISCHARGE DEVICE

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6 Claims. (Cl. 250—174)

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This invention relates to a secondary emission electron discharge device, and while the selected embodiment for exemplifying the same in this disclosure is one utilizing a beam of primary electrons from a cathode which are bunched in transit toward the opposing electrode, the invention contemplates utilization in various discharge devices wherein secondary emission is employed for enhancement of the output therefrom.

For purposes of explicit description, the present concept is related herein particularly in its application to a Klystron type of electron discharge device chosen for purposes of illustration in the drawing. In the early stages of Klystron development, two resonators were ordinarily used with a drift space therebetween, the electrons passing from a cathode through the first resonator where bunching influence was exerted so that bunching would progress through the drift space and be fully accomplished by the time the electrons reached the second resonator. Energy of the bunched electrons passing through the second resonator to a collector or anode therebeyond was extracted as output from the second resonator. It was later found, however, that a single resonator could be utilized by substituting a reflector for the collector so the electrons would pass through the resonator forwardly and be affected by the bunching influence thereof and after passing through the resonator, be reflected to return in a reverse direction, at which time energy from the bunched electrons was extracted by an output from the single resonator. This type of device was known as a reflex Klystron. The next forward step in the art comprised substitution of a secondary emitter in place of the reflector, and of course a proper use of potential relations and polarities for accomplishing desired electron flow. This device has been generally referred to as a secondary emission Klystron. The present invention makes a further stride forward by providing means accomplishing a large multiplication of the secondary emission from the secondary emissive electrodes of the secondary emission Klystron.

The objects of the invention are based on the primary purpose of increasing electron flow from a secondary emissive electrode.

Also broadly, an object of the invention is to increase the efficiency of an electron discharge device utilizing secondary emission.

More specifically, an object of the invention is to obtain greater output from a secondary emissive Klystron or electron discharge device of the beam type.

In detail, the invention proposes increase of

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secondary emission by use of heat applied to the secondary emitting electrode without introduction of counteracting primary emission therefrom.

Still further objects of the invention will appear to those skilled in the art to which it appertains as the description progresses, both by direct recitation thereof and by implication from the context.

Referring to the accompanying drawing in which like numerals of reference indicate similar parts throughout the several views;

Figure 1 is a longitudinal sectional view of one form of secondary emissive Klystron embodying my invention therein;

Figure 2 is a similar sectional view of another secondary emissive Klystron embodying my invention; and

Figure 3 is a chart showing graph for increase of primary emission current due to temperature increase, and showing increase of secondary emission due to temperature.

In the specific embodiment of the invention illustrated in said drawing, both forms of Klystrons are shown in general configuration as bodies of revolution about an axis, and each provides a coaxial resonator 10 with a primary cathode 11 on the axis opposite one end of the resonator and an opposed secondary emission electrode 12 also on said axis and opposite the other end of said resonator, the ends of the resonator being perforate for passage of electrons thereinto from the cathode and from the said secondary emission electrode, so that the structure provides an axial passageway straight through from the cathode to said electrode. A more positive polarity is applied to the secondary emission electrode than to the cathode, by a potential source 13, to cause primary electron flow from the cathode to the secondary electrode, and a still more positive potential is applied in front of the secondary electrode by potential source 14 to direct flow of secondary electrons back into the resonator. In Figure 1 this more positive potential is applied to the resonator, whereas in Figure 2 a grid 15 is provided between the secondary electrode and the resonator for introducing this more positive potential. By virtue of the constructions of either Figure 1 or Figure 2 and polarities provided therefor, primary electrons are attracted to electrode 12 and produce a greater emission of secondary electrons therefrom which return, in bunched condition, to the resonator where they give up energy to an output loop 16 and coaxial line 17 provided for the purpose.

More in detail, the construction shown situates

the primary cathode emissive surface and the emissive surface of the secondary electrode transverse to the common axis on which they are located so as to be directly opposed and to constitute the ends of the passageway therebetween. The resonator has a portion thereof intervening between the primary cathode and the secondary electrode and, with the openings in the ends of said resonator, constitutes part of said passageway from the cathode to the electrode, the openings through the ends of said resonator having perforate metal members across the same and designated herein as usual in the art, as grids. Accordingly, in the order of nearness to the cathode, these two grids for the two end walls of the resonator may be referred to as the near resonator grid 18 and the far resonator grid 19. Between the near grid 18 and the cathode 11 and also in said passageway, is a focusing grid 20 and between the focusing grid 20 and cathode 11 is a focusing collar 21, the interior region of which likewise constitutes part of said passageway. An evacuated envelope 22 or enclosure, which includes the resonator in the present showing as part thereof, is provided for the cathode, secondary emission electrode, grids, and connecting passageway.

For fuller understanding of the invention it is desirable to explain briefly theories involved, with a mathematical approach. Due to electron discharge from cathode 11 to electrode 12 a current I may be considered as leaving the cathode, but since some electrons are intercepted by the grids or otherwise fail to reach electrode 12 a fraction α less than unity makes the complete transit. The effective current therefore is represented by αI at the secondary electrode. Secondary electrons emitted from electrode 12 are a multiple of the primary electrons received, and with prior art practice has usually been in the range of a three to ten times increase, which can be designated δ, so that output efficiency of a secondary emitter Klystron will be δ times that of a purely reflex device. Each is subject to the same operating and resonator constants k and β so that whereas the power output for a reflex Klystron is

$$P_1 = k\alpha\beta I$$

the power output for a secondary emission Klystron is

$$P_2 = k\alpha\beta\delta I$$

The desideratum of the present invention is to increase the value of δ to thereby increase output efficiency of the device.

The commonly employed silver-magnesium for secondary emitters gives an increase of secondary in the range of about three to five times over primary electrons. It has been found that this multiplication range with silver-magnesium is approximately four to seven times secondary emission to primary emission, by an activated oxide secondary emitter, at ordinary anode operating temperature. The secondary emitting electrode of the present invention preferably comprises a nickel or other suitable metal base member coated with an emission mixture, such as barium and strontium carbonate which, during exhaust, is broken down to barium and strontium oxide by energizing the heater. The oxide coating is also activated in a manner similar to the coating on a cathode. The secondary emission of such an electrode, as shown by the δ curve in Figure 3 is nearly constant up to 400° C. which is a temperature above that encountered in secondary emitters of the prior art.

According to the present invention, I heat the secondary emitter during operation thereof, and it will be observed in Figure 3 that the δ curve has an upward slope between 500° to 850° C. and shows δ as acquiring a value of about 100 at 850° C. Thus by raising the temperature of the secondary emitter to 850° C. the secondary emission becomes of the order of a hundred times the primary emission and thus accomplishes a very much greater output from the resonator than heretofore attainable. However, heating of the secondary emitter should not materially exceed the 850° C. temperature mentioned, since at about 900° C. the electrode would begin discharging primary electrons in objectionable quantity, primary emission therefrom being undesirable for the reason that the primary electrons therefrom would not be bunched whereas secondary electrons instigated by primary electrons from the cathode do have the desired bunching.

Carrying out the concept outlined above, the construction herein shown provides a secondary emitting electrode 12 having substantially the structural arrangement of the primary cathode, and in more detail, comprises a hollow shell 23 supported at its rear by an insulator 24 and hollow at its forward portion to provide a chamber for a heater 25 therein. The forward face of the shell disposed between the heater and the resonator is the aforementioned base member coated with an activated emissive oxide or other mixture copiously emissive of secondary electrons and capable of being heated for obtaining an augmented supply of the secondary electrons. Said member is made concave, as shown, to provide focusing of the secondary electrons in a beam toward the opening of the resonator. Appropriate lead-in wires for the heater and electrode are provided. The temperature of the secondary emitter electrode will depend upon the power delivered by the primary electron beam, the heat dissipation from the secondary emitter and the power supplied by its heater 25, and may therefore be controlled to give maximum secondary emission without undue primary emission therefrom.

I claim:

1. A secondary emission electron discharge device comprising a primary emitter, a secondary emitter opposite the primary emitter, and a heater for the secondary emitter for increasing proportion of secondary emission of the secondary emitter to primary emission from the primary emitter.

2. A secondary emission electron discharge device comprising a cathode emissive of primary electrons, means for directing said electrons in a beam, a secondary emissive electrode opposite said cathode for receiving primary electrons therefrom, and a heater for said electrode for increasing proportion of secondary electrons from said secondary emitter to primary electrons for the primary emitter.

3. A secondary emission electron discharge device comprising a cathode emissive of primary electrons in one direction, means for focusing said electrons in a beam in said direction, a secondary emissive electrode spaced from and opposite the cathode in the direction of focusing of said beam, and a heater on the far side of said electrode from the cathode for heating said electrode and thereby increase secondary emission

therefrom on impact of primary electrons of said beam on said electrode.

4. A secondary emission electron discharge device comprising a primary emitter, a hollow electrode opposed to said emitter and having a surface emissive of secondary electrons, said surface being directed toward said primary emitter, and a heater within the hollow of said electrode for increasing proportion of secondary electrons from the electrode to primary electrons from said primary emitter.

5. A secondary emission electron discharge device comprising a primary emitter, a secondary emitter having an electron emissive oxide coating thereon directed toward the said primary emitter and adapted to emit secondary electrons from impact of primary electrons thereon from the primary emitter, and means for heating said secondary emitter for increasing proportion of secondary electrons therefrom by impact of primary electrons on said secondary emitter.

6. A secondary emission electron discharge device having primary and secondary emitters spaced from each other, and thermal means in closer proximity to the secondary emitter than to the primary emitter for operating said secondary emitter in the steep slope of the δ curve of secondary to primary emission.

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