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Hechtel

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[54] **ELECTRON BEAM GENERATOR FOR TRANSIT-TIME ELECTRON DISCHARGE TUBES**

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[73] Assignee: **Siemens Aktiengesellschaft,** Berlin, Germany

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** **313/449,** 313/348, 313/457, 313/460; 315/3.6

[51] **Int. Cl.** **H01j 29/00**

[58] **Field of Search** 313/82, 69, 338, 348; 315/3.5, 3.6

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Assistant Examiner—Saxfield Chatmon, Jr.
Attorney, Agent, or Firm—Hill, Gross, Simpson, Van Santen, Steadman, Chiara & Simpson

[57] **ABSTRACT**

An electron beam generator for transit-time tubes employs a cathode for emission of an electron beam, a control grid spaced from the cathode, and an anode, the control grid having a section which surrounds a central portion of the emissive area of the cathode whereby emission from the area surrounded by the central portion can be controlled independently of the emission from the central portion.

7 Claims, 9 Drawing Figures

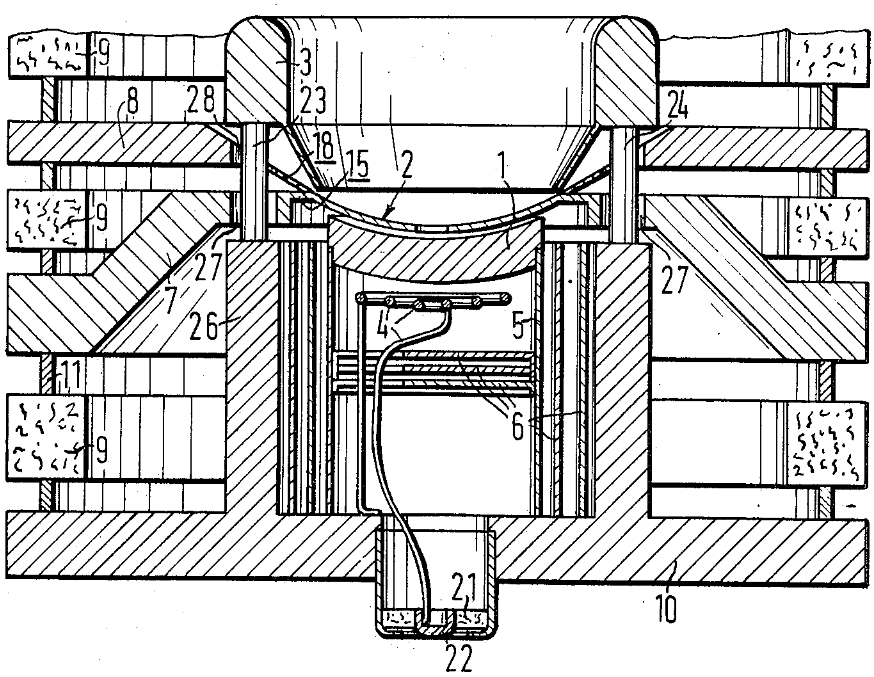


Fig.1

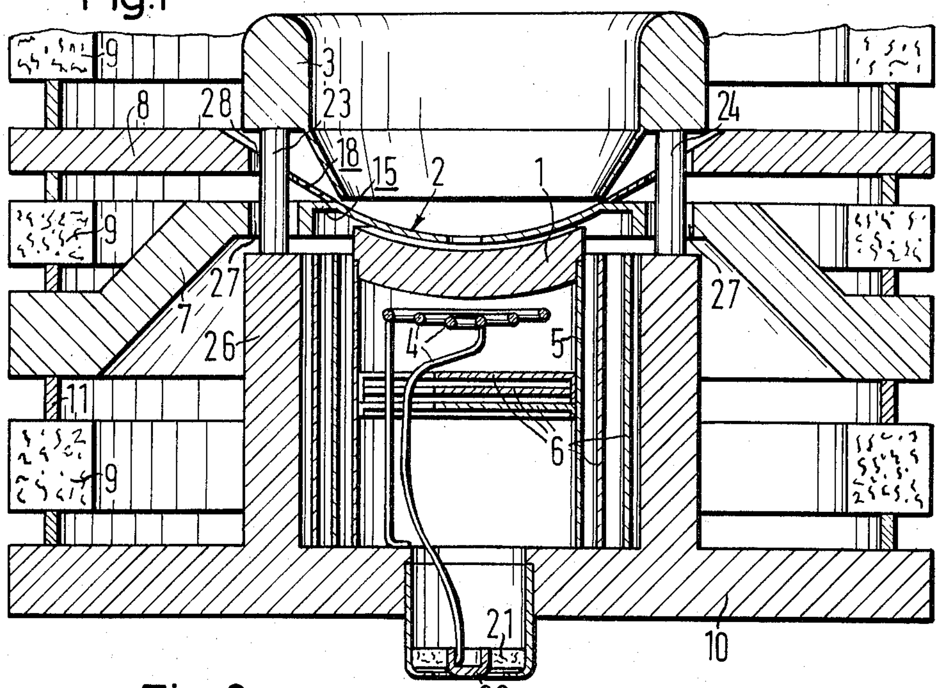


Fig. 2

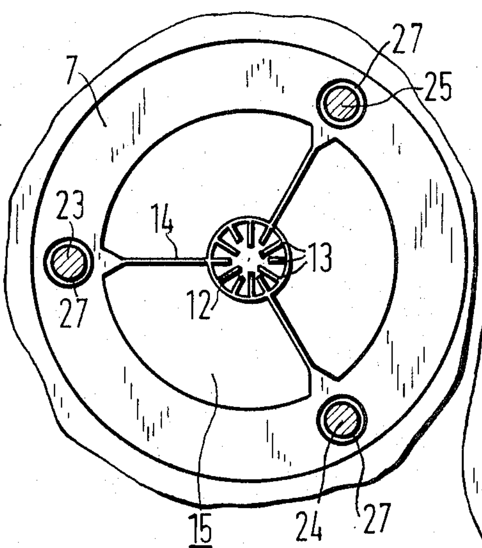


Fig.3

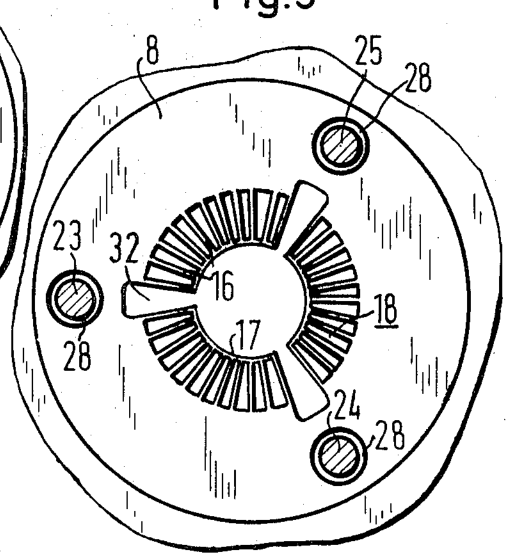
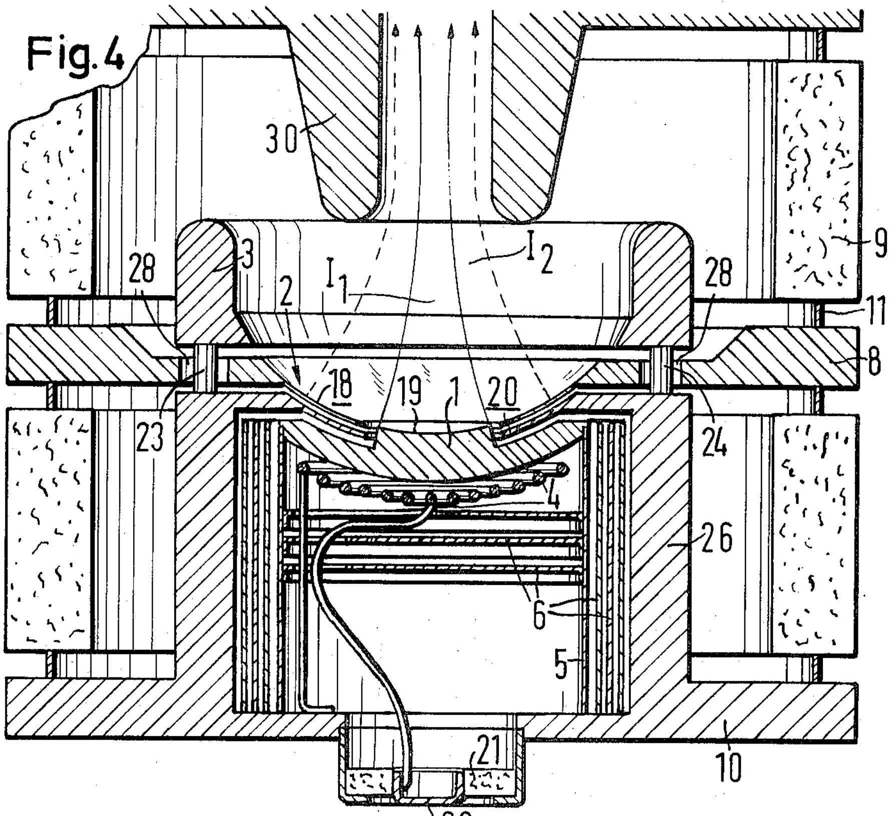


Fig. 4


30
I1
I2
3
2
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28
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Fig. 5

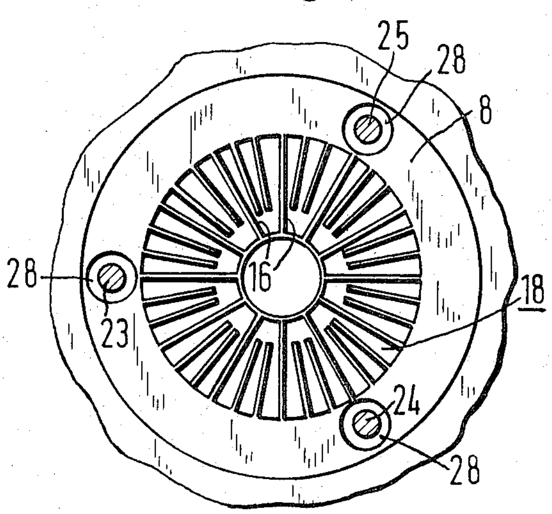
25
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Fig. 6

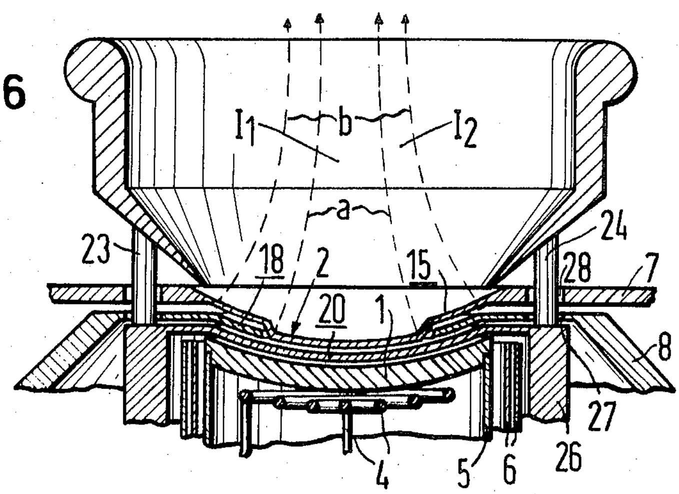


Fig.7

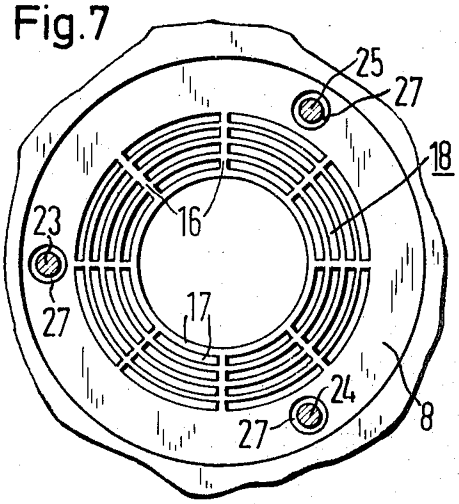


Fig.8

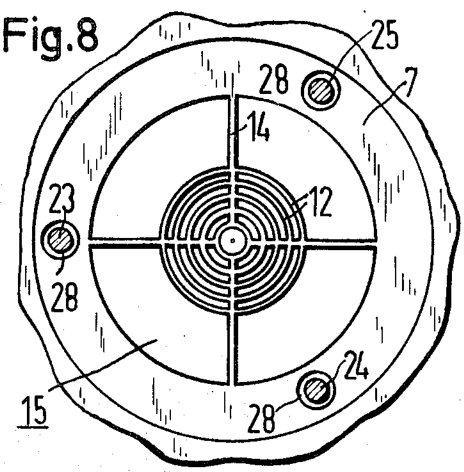
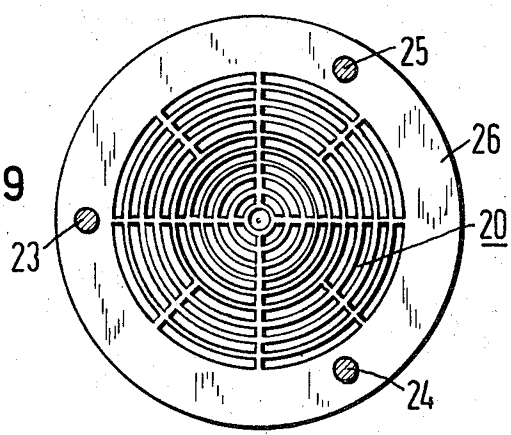


Fig. 9



ELECTRON BEAM GENERATOR FOR TRANSIT-TIME ELECTRON DISCHARGE TUBES

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to electron beam generators, and more particularly to electron beam generators for transit time electron discharge tubes having a cathode for emission of an electron beam, a control grid spaced from the cathode, and an anode, and which features independent control of emission of an area surrounding the central portion of the cathode with respect to the central portion.

2. Description of the Prior Art

In modern microwave installations for communications and radar applications, the transmitter tube is frequently required to be capable of operation at two different power levels. The two power levels may differ from one another, for example by a factor of 5 or 10. The lower power level is used in normal operation for reasons of power economy, and the higher power level is only used under 3ertain tircumstances, 5.g. zn the event of interference from another transmitter.

In the case of a transit time tube, this type of power regulation can only be effected through a control of the electron beam current. A change in the beam voltage is unsuitable for this purpose, because of the phase relationship which must be maintained between the electron beam and the signal beam amplifier. The necessary adjustment of the beam current in an electron beam generator is a very difficult problem, and one which has not thus far been satisfactorily solved. Attempts to adjust the beam current by varying the focusing or modulating electrode voltage or the anode voltage only produce undesirable modifications in the electron-optical behavior of the electron beam generator. The same holds true if the beam current is adjusted by varying the voltage on a control electrode.

SUMMARY OF THE INVENTION

An object of the invention is to provide an electron beam generator, in particular for O-type transit time tubes, by which a transit time tube can be operated at two different power levels without the production of unwanted disturbing electron-optical influences.

The invention resides in the provision of an electron beam generator for transit time tubes, comprising a cathode for the emission of an electron beam, a control grid spaced from the cathode, and an anode, wherein the control grid comprises a section which surrounds a central portion of the emissive area of the cathode. whereby the emission from the area of the cathode surrounding the central portion can be controlled independently of the emission from the central portion.

The section of the control grid which surrounds the central portion of the emissive area of the cathode is not necessarily an annular ring, since the electron beam may not have a circular cross section, and may, for example, be a flat beam.

The beam current is set by a control grid or grids which are located in close proximity to and in front of the emissive area of the cathode. Control grids of this type are known in a variety of forms. They can be constructed either by single grids which, in the pass range, intercept a certain portion of the current, for example as described in U.S. Pat. No. 2,967,260, or by double grids, one of which is a so-called shadow grid which absorbs no current are only a comparatively small amount of current. A double grid of this kind is described, for example, in German published application 1,764,860. The invention can be practiced by splitting the area of the control grid and electrically insulating the two partial areas from each other. In this manner, power level control of transit time tubes can be carried out by control of the emission from the cathode of the electron beam generator, more specifically by applying potentials of different polarity to that of the cathode to the section of the control grid which surrounds the central area. This kind of current control requires only relatively small voltage changes in order to switch the beam current from one value to another and is free of any undesirable secondary electron-optical effects. It can be applied both in electron beam generators of the continuous-rating type, and also to pulsed electron beam generators.

In a preferred embodiment of the invention, for pulse operation, the electron beam generator has a control grid which comprises a first partial grid section surrounding and mechanically and electrically isolated from a second partial grid section which covers the central area of the emissive surface of the cathode.

An electron beam generator of this form, in which the inner partial grid section is circular and the outer section is ring-shaped, has the following properties. The beam current I_s is determined, in accordance with the applied potentials, by the relative areas of the two partial grid sections. If I_1 is the smaller of the two currents and I_2 is the larger of the two currents, then the following relationship holds

$$F_1/F_2 = I_1/I_2 \quad 1.$$

where F_1 is the area covered by the inner grid section and F_2 is the total cathode area.

As far as the beam current I_s is concerned, three different operating conditions can be distinguished.

1. $I_s = I_1$

The inner partial grid section is positive and the outer partial grid section is negative with respect to the cathode. The voltage on the inner control grid section, in relation to the cathode, is about 1/25th to 1/50th of the anode voltage. The voltage on the external partial grid section is of the same order magnitude, but of negative polarity.

2. $I_s = I_2$

Both partial grid sections are positive with respect to the cathode. The voltages applied to these grid sections are about 1/25th to 1/50th of the anode voltage.

3. $I_s = I_0$ (blocked condition)

Both of the partial grid sections are negative with respect to the cathode. The voltage difference between the cathode and the partial grid sections is of the order of magnitude of 1/50th to 1/100th of the anode-cathode voltage.

In a preferred embodiment of the invention the electron beam generator has axial symmetry, in which the first partial grid section is in the form of an annular ring surrounding the second partial grid section which has a circular periphery. Consequently, and in accordance with equation 1, the following approximation holds true, provided that the radius of curvature of the cathode surface is not too small:

$$D_1/D_2 = \sqrt{I_1/I_2} \quad 2.$$

where D_1 is the diameter of the inner partial grid section and D_2 is the diameter of the cathode. From this relationship we obtained:

$$d_1/d_2 = D_1/D_2 = \sqrt{I_1/I_2} \quad 3.$$

where d_1 and d_2 are the diameter of the electron beams corresponding to the currents I_1 and I_2, respectively. This equation (3) can also be written in the form

$$\sqrt{I_1/d_1} = \sqrt{I_2/d_2} \quad 3a.$$

Because the magnetic field required to focus a circular beam of a diameter d and current I is proportional to the ratio I/d, the same magnetic field can be employed for focusing beam currents I_1 and I_2. Therefore, in both cases a beam of constant diameter is obtained without necessity for electron-optical correction.

In another embodiment of the invention, the control grid has only one section and surrounds the central portion of the emissive area of the cathode which projects toward the anode so as to be flush with the surface of the control grid. This embodiment is particularly suitable for a continuous-rating electron beam generator. The electron beam generator behaves in a manner similar to that of one using an inner partial grid section, as far as two possible beam currents are concerned, but in order to completely block the beam current, the anode potential must be changed rather than the cathode potential.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects, features and advantages of the invention, its organization, construction and operation will be best understood from the following detailed description of embodiments of the invention taken in conjunction with the accompanying drawings, on which:

FIG. **1** is a longitudinal sectional view of a first embodiment of an electron beam generator;

FIG. **2** is a plan view of the inner grid of the apparatus illustrated in FIG. **1**;

FIG. **3** is a plan view of the outer grid of the apparatus illustrated in FIG. **1**;

FIG. **4** is a longitudinal sectional view of a second embodiment of an electron beam generator;

FIG. **5** is a plan view of the outer partial grid of the embodiment illustrated in FIG. **4**;

FIG. **6** is a longitudinal sectional view of a third embodiment of an electron beam generator;

FIG. **7** is a plan view of the inner partial grid structure of the control grid of the apparatus illustrated in FIG. **6**;

FIG. **8** is a plan view of the outer partial grid of the control grid of the apparatus illustrated in FIG. **6**; and

FIG. **9** is a plan view of the shadow grid of the apparatus illustrated in FIG. **6**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Parts not essential to the invention, as well as the apparatus for applying the desired potentials to the partial grids of the control grid, with respect to the cathode, have been omitted from the drawings for reasons of simplicity and clarity.

Referring to FIG. **1**, an axially-symmetrical electron beam generator of a transit time tube is illustrated as having a cathode **1**, a focusing electrode **3** and a control grid **2** which comprises an inner partial grid **15** and an outer partial grid **18**. The control grid **2** and the emissive area of the cathode **1** are of concave form and have a common center of curvature. The mechanical and electrical isolation of the two partial grids from one another and from the other components which carry potentials is provided by means of a carrier plate **7** for the inner partial grid **15** and a carrier plate **8** for the outer partial grid **18** with openings **27** and **28** for receiving three supporting bolts **23, 24, 25** of the focusing or modulating cylindrical electrode **3** and are in different planes and lead to the tube wall **11**. In addition, the tube wall **11** is interrupted at appropriate points by insulating ceramic cylinders **9**. The supporting bolts, of which the bolts **23** and **24** are illustrated in FIG. **1**, rest upon a support cylinder **26**. The cathode itself is conventional and comprises a heating element **4** having a current supply lead **22** embedded in a ceramic disc **21**, the mounting cylinder **26** resting on a base plate **10**, and a plurality of radiation shields **6**.

FIG. **2** is a plan view of the inner partial grid **15** together with its mounting apparatus. The partial grid **15** comprises a number of radially-disposed spokes **13** connected together by a circular ring **12**, a number of the spokes **13** being extended beyond the ring **12** as supporting stays **14**. The supporting stays **14** terminate in a first carrier plate **7** which has good thermal conductivity. The openings **27** are provided for the passage of the supporting bolts **23, 24, 25** of the focusing electrode **3**.

FIG. **3** is a plan view of the outer partial grid **18** and its mounting apparatus. The partial grid **18** also comprises a number of radially disposed spokes **16** attached at their inner ends to a circular ring **17** and whose outer ends terminate in a second carrier plate **8** having good thermal conductivity. The partial grid **18** is provided with a plurality of openings **32** for receiving the supporting stay **14** of the inner partial grid **15**. The openings **28** in the carrier plate **18** are provide for the passage of the supporting bolts **23, 24, 25**.

In the embodiment of the invention illustrated in FIG. **4**, which also has an axially-symmetrical electron beam generator, there is no inner partial grid. In order to avoid unwanted electron-optical effects, a central area **19** of the emissive surface of the cathode, more specifically the area not covered by the ring-shaped outer partial grid **18**, projects toward the anode so as to be flush with the surface of the control grid **18**. Between the control grid **18** and the cathode **1** there is provided a shadow grid **20** which is supported by the support cylinder **26** of the focusing electrode **3** and which is at cathode potential when the electron beam generator is operating. This double grid structure and the emissive area of the cathode **1** are curved and the curve surfaces have a common center of curvature. As viewed from the center of curvature, the grid elements of the control grid and the shadow grid are in alignment. A focusing anode **30**, which has an appropriate electron-optical shape, draws an electron current I_1 when the control grid **2** has a negative potential with respect to the cathode **1** applied thereto, and draws an electron current I_2 from the cathode surface if the potential is positive. All of the other designed features correspond to those illustrated in FIG. **1.** The use of this embodiment of the invention is recommended if the transit time tube is operating on a continuous-rating basis.

Referring to FIG. **5,** the outer partial grid **18** of the apparatus illustrated in FIG. **4** is shown in greater detail. The grid elements comprise a plurality of radial spokes **16** which, as in the outer partial grid illustrated in FIG. **3,** terminate in the carrier plate **8** having the openings **28** for receiving the bolts **23, 24, 25.**

FIG. **6** is a schematic longitudinal sectional view of the central part of a third embodiment of an electron beam generator which is primarily confined to the cathode surface and the control grid structure. The electron beam generator in this embodiment is again axially symmetrical and employs a double grid (control grid and shadow grid) the surfaces of which and the cathode surface have a common center of curvature. As viewed from the center curvature, the control grid and the shadow grid elements are in alignment. In this schematic illustration, the beam current boundaries have been illustrated by broken lines to correspond to the two different power levels of the tube, the boundary *a* representing the partial current I_1 and the boundary *b* representing the full current I_2.

FIGS. **7, 8** and **9** respectively illustrate in plan views the outer partial grid **18,** the inner partial grid **15** and the shadow grid **20** of the apparatus illustrated in FIG. **6.** In this embodiment the two partial grids of the control grid are formed such that the shadow grid, while in full alignment, can take the form of a single mechanical structure which is therefore relatively simple to manufacture. All of the grids comprise predominately ring-shaped elements with only a few radial spokes. If the shadow grid is placed at cathode potential and the two partial grids at a moderately high positive potential with respect to the cathode (1/10th to 1/100th of the anode voltage), then the current drawn by the partial grids is negligible. Typical values are between 0.01 and 0.1 percent of the total cathode current. The rules hereinbefore listed apply to the three operating conditions (I_0, I_1, I_2).

The invention is not restricted to the embodiments illustrated. For example, the electron beam generator need not be axially-symmetrical, but can have a form which is suitable for the production of flat ribbon type beams. Moreover, the invention can be applied in a corresponding manner if the transit time tubes are to be operated not merely in two, but in several operating conditions.

Many other changes and modifications of my invention may become apparent to those skilled in the art without departing from the spirit and scope of the invention. I therefore intend to include within the patent warranted hereon all such changes and modifications as may reasonably and properly be included within the scope of my contribution to the art.

I claim:

1. An electron beam generator for transit time tubes with single beam operation at more than one power level and different beam cross sections corresponding to respective power levels and current intensities, comprising: a cathode for the emission of a single beam; a control grid spaced from said cathode; and an anode for receiving the electron beam, said control grid comprising a section which surrounds a central portion of the emissive area of said cathode for selectively receiving control potential for either blocking or permitting emission from the area of the cathode surrounding the central portion independently of the emission from the central portion to provide single beam operation with or without emission from said surrounding portion.

2. An electron beam generator, as claimed in claim **1,** wherein said control grid comprises a first partial grid section and a second partial grid section, said first partial grid section surrounding and mechanically and electrically isolated from said second partial grid section, said second partial grid section covering the central area of the emissive surface of said cathode.

3. An electron beam generator for transit time tubes which operate at more than one power level, comprising: a cathode for the emission of an electron beam; a control grid spaced from said cathode; and an anode for receiving the electron beam, said control grid comprising a section which surrounds a central portion of the emissive area of said cathode for selectively receiving control potential for controlling the emission from the area of the cathode surrounding the central portion independently of the emission from the central portion, said control grid comprising a first partial grid section and a second partial grid section, said first partial grid section surrounding and mechanically and electrically isolated from said second partial grid section, said section partial grid section covering the central area of the emissive surface of said cathode, wherein said cathode is an axially-symmetrical cathode, wherein said second partial grid section comprises a plurality of radially-disposed spokes, a circular ring connecting said plurality of radially disposed spokes together, some of said spokes extending beyond said ring as supporting stays, a first carrier plate for said second partial grid section, said supporting stays terminating in said first carrier plate, said first carrier plate having good thermal conductivity, said first partial grid section comprising a plurality of radially disposed spokes, a circular ring connected to the inner ends of the last-mentioned spokes, and a second carrier plate having good thermal conductivity and connected to the outer ends of the last-mentioned radially disposed spokes, said first partial grid section including means defining openings to accommodate said supporting stays of said second partial grid section, and said two carrier plates disposed in different planes.

4. An electron beam generator, as claimed in claim **1,** wherein said central portion of the emissive area of said cathode projects towards said anode and lies flush with the surface of said control grid section which surrounds said central portion of the emissive area of said cathode.

5. An electron beam generator, as claimed in claim **1,** wherein the emissive surface of said cathode and said control grid surface are concave and have a common center of curvature.

6. An electron beam generator, as claimed in claim **5,** comprising a shadow grid disposed between said control grid and said cathode for operation at cathode potential, said shadow grid including grid elements which are aligned with those of said control grid as viewed from said cathode or from said common center of curvature.

7. An electron beam generator, as claimed in claim **1,** comprising a shadow grid disposed between said control grid and said cathode for operation at cathode potential, said shadow grid including grid elements which are aligned with those of said control grid.

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