Oct. 28, 1952 P. W. CHARTON 2,616,061

ELECTROSTATICALLY-FOCUSED ROTARY RADIAL BEAM TUBE

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Fig. 1.

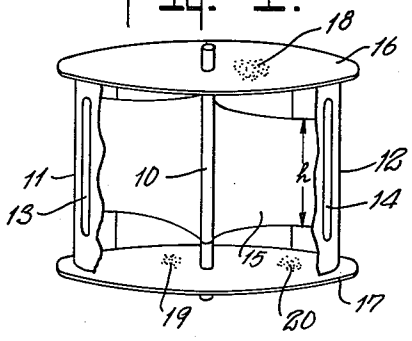
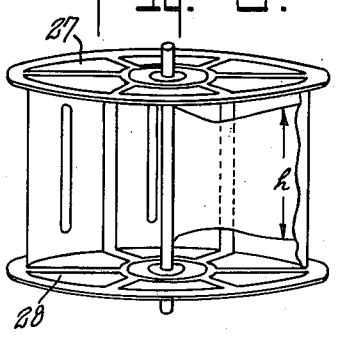



Fig. 3.



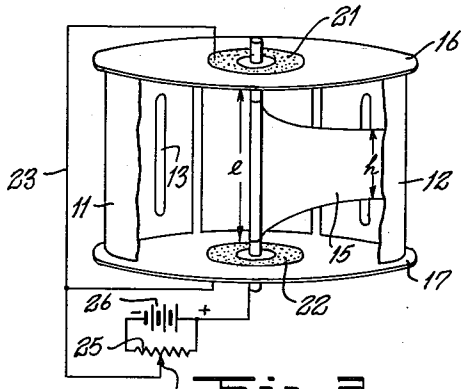




Fig. 2.

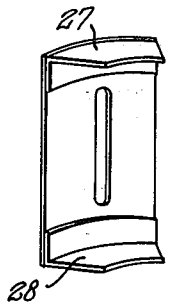



Fig. 4.

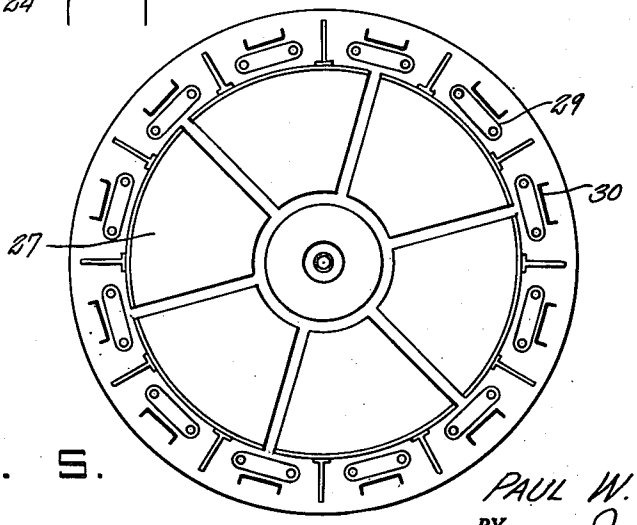



Fig. 5.

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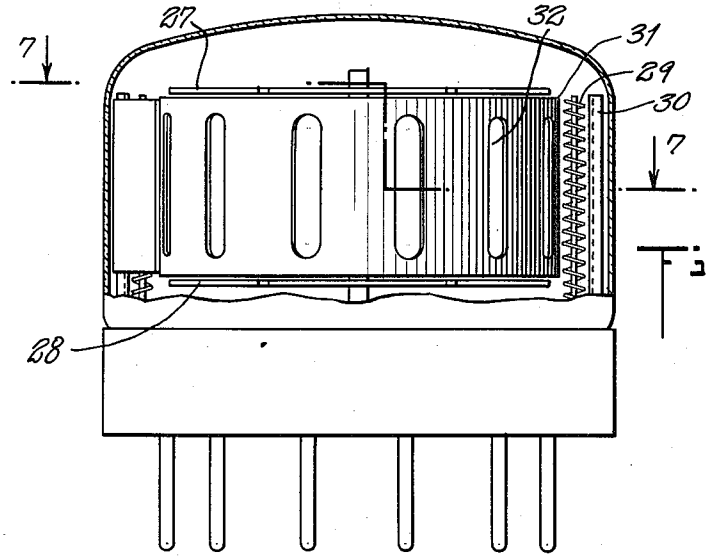



Fig. 6.

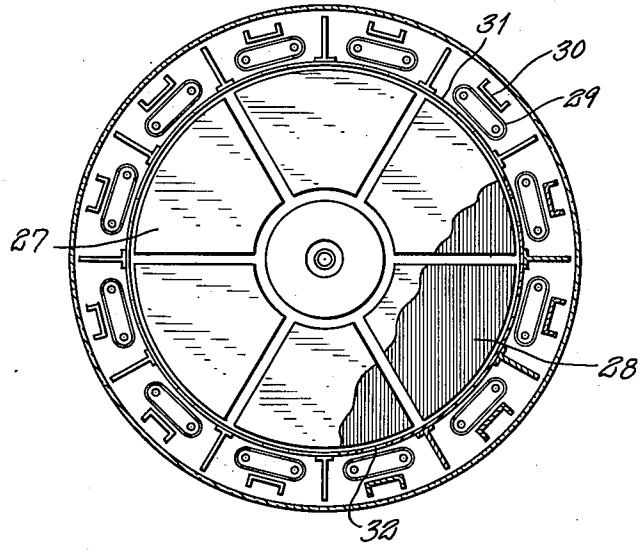



Fig. 7.

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Fig. 8.

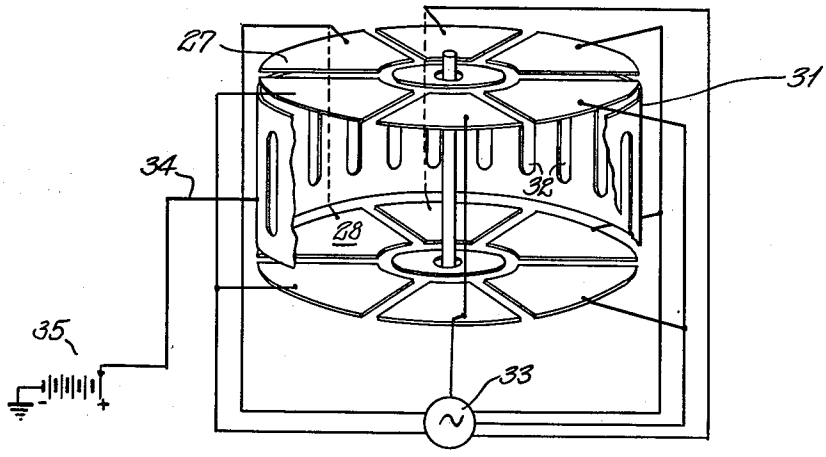
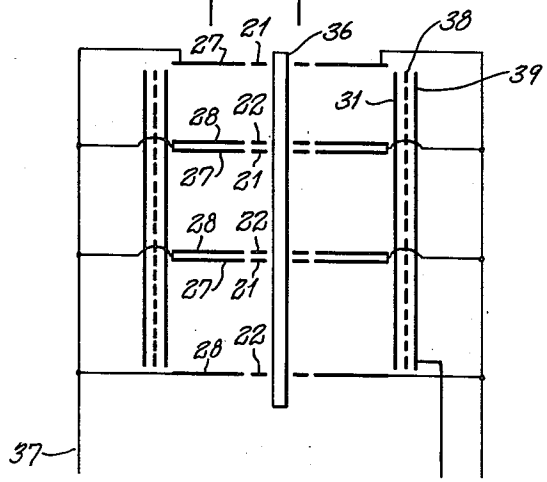



Fig. 9.




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# UNITED STATES PATENT OFFICE

2,616,061

## ELECTROSTATICALLY-FOCUSED ROTARY RADIAL BEAM TUBE

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Application September 16, 1950, Serial No. 185,280

15 Claims. (Cl. 315—21)

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This invention relates to rotary beam tubes, and more especially to rotary beam tubes of the electrostatically focussed beam category.

The invention is in the nature of an improvement on the kind of tube disclosed in U. S. Letters Patent No. 2,433,403. The tube disclosed in said patent and further disclosed in the "Proceedings of the Institute of Radio Engineers," vol. 36, No. 11, November 1948, employs a central cylindrical cathode surrounded coaxially by a series of slotted screen electrodes in arcuately cylindrical array. These screens are statically electrically biassed with respect to the cathode, and are energized by a polyphase alternating current in such a way that the electrons from the cathode are focussed into a single radial sheet-like beam which also rotates at a uniform rate around the longitudinal axis of the cathode. Each window or slot in and between adjacent screens is in radial alignment with a corresponding control grid and output anode combination which may be allotted to respective output channels. Such a tube is ideally suited to multiplex telegraphy and telephony, and to telemetering and many other fields of usefulness. The type of tube disclosed in said prior patent, employs insulating spacers or mica discs at opposite ends of the electrode assembly to preserve the proper interelectrode spacings. I have found that by reason of the physical relation between the emitting cathode and the said spacers, the latter tend to become electrically charged, which charge may be unevenly distributed thereover. This unevenly distributed charge may cause a very undesirable distortion of the required symmetrical field between the various electrodes and more particularly between the cathode and the surrounding screens. This causes, among other things, a reduction in the beam height, a reduction in the beam current, and an uneven rate of rotary displacement of the beam. These undesirable effects are more pronounced in those radial beam tubes wherein the ratio of the effective cathode length to the radial distance between the cathode and screens is large.

Accordingly, one of the principal objects of this invention is to provide improved constructions of focussed rotary radial beam tubes which overcome the above-noted and other disadvantages.

Another limitation on the type of focussed rotary radial beam tube as disclosed in said patent, is that the number of multiple output channels that can be effectively used, is tied up with the structural limitations of the tube. One of these

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limitations is that the screens are connected to the polyphase source to control the rate of beam rotation. Since serious design difficulties are encountered if the number of channels is not a multiple of the number of phases, and since excitation sources of more than six phases are difficult to design and handle, for practical purposes the prior tube is limited to six, or multiples of six, output channels.

Accordingly, it is another principal object of this invention to provide a construction of a focussed rotary radial beam tube wherein the number of output channels is not limited by the number of phases of the polyphase excitation source. For example, a two-, three-, or six-phase source can be used, and any number of output channels can be controlled.

Another object is to provide a focussed rotary radial beam tube employing a central cathode and a plurality of vertically-stacked beam focussing and rotating sections.

A feature of the invention relates to a tube of the focussed rotary radial beam type, having a series of slotted screen segments each having electrically attached thereto at opposite ends, electrically conductive flanges or radially-directed extensions to restore the height of the beam after such height has been reduced by the means which is also provided according to the invention to overcome the above-noted undesirable charges on the mica spacers.

Another feature relates to a focussed rotary radial beam tube wherein the channel-defining screens can be formed of a single circumferentially complete plate with the desired number of channel-defining slots therein. The rate of rotation of the beam is then controlled by a relatively smaller number of conductive plates extending perpendicularly and radially to the cathode, and which plates can be excited by a suitable polyphase source to effect rotation of the beam.

A still further feature relates to the novel organization, arrangement and relative location of parts which cooperate to provide a simplified and improved tube of the focussed rotary radial beam type.

Other features and advantages, not specifically enumerated, will become apparent after a consideration of the following detailed descriptions and the appended claims.

In the drawing,

Fig. 1 is a perspective view of certain parts of a focussed rotary radial beam tube useful in explaining the invention.

Fig. 2 shows an arrangement, according to the invention, for overcoming the beam distortion shown in Fig. 1.

Fig. 3 shows a modification of Fig. 2, wherein additional means are provided for overcoming the beam-height reduction shown in Fig. 2.

Fig. 4 is a detail perspective view of one of the slotted screen elements of Fig. 3 showing its integral elements for restoring the beam height.

Fig. 5 is a plan schematic view of a tube embodying the improvements of Figs. 2 and 3.

Fig. 6 is a front elevational view of a modification of Fig. 5.

Fig. 7 is a sectional view of Fig. 6, taken along the line 7—7 thereof.

Fig. 8 is a composite perspective and schematic view of certain parts of the tube of Figs. 6 and 7, to illustrate more clearly certain electrical connections.

Fig. 9 is an elevational schematic view of a modification applicable either to the tube of Figs. 2 to 5, or to the tube of Figs. 6 to 8.

Referring to Fig. 1, there is shown in perspective and schematic form, a portion of a typical focussed rotary radial beam tube. For simplicity, Fig. 1 shows merely the central electron-emitting cathode 10 and 2 of the surrounding slotted screen electrodes 11, 12, etc., with their respective channel-defining windows or slots 13, 14. For a detailed description of the remaining elements of such a tube, reference may be had to said U. S. Letters Patent No. 2,433,403. As described in detail in said patent, when the cathode 10 is suitably biased, and the screens 11, 12, etc. are connected to a suitable polyphase source, the electrons from the cathode are formed into a sheet-like radially-extending beam which rotates at a rate determined by the polyphase source. I have found that, depending upon the voltages that are used and upon the configurations of the various tube electrodes, the insulator or mica spacers 16, 17, which are used to space the electrodes, become unevenly charged, as represented schematically by the stippled areas 18, 19, 20. These uneven charges produce a corresponding uneven electrostatic field acting on the electron sheet, so that its desired planar sheet-like form is distorted. This distortion may effect a reduction in the beam height $h$ at the region where the beam intersects the screens 11, 12, etc. during its rotation. It also may reduce the amount of beam current flowing to the output anodes, and may even prevent uniform rotary displacement of the beam.

In accordance with one feature fo the invention, each of the insulator discs 16, 17, as shown in Fig. 2, carries at its central region surrounding the ends of the cathode, a pair of conductor discs 21, 22. These discs may be in the form of metal members suitably fastened to the respective insulators, or they may be in the form of conductive coatings deposited on the said insulators. The conductive discs 21, 22 are insulated from the cathode sleeve, and for that purpose they may be in the form of annular members or coatings. While the drawing shows the members 21 and 22 as circular or annular elements, it will be understood that any other desired shape may be employed. However, since the beam is to rotate at a uniform rate, it is preferable to make the elements 21, 22 of symmetrical annular conformation around the cathode. The members 21 and 22 are connected together by a suitable conductor 23 which is connected to the adjustable arm 24 of a potentiometer resistance 25, connected to a direct current bias source. The source 26 is so connected that



by adjusting the arm 24, the members 21 and 22 are biased negatively with respect to the cathode. As a result, the beam 15 is rendered symmetrical both at its upper and lower edges, and its planar shape is preserved during rotation.

While the arrangement of Fig. 2 results in a uniformly-focussed and uniformly-rotated beam, it has the disadvantage that the portion of the beam $h$ at the region where it intersects the screen electrodes 11, 12, etc., is less than the height of the corresponding screen slots or windows. In other words, the members 21 and 22 tend to compress the beam to a height $h$ which is appreciably smaller than the effective length $l$ of the cathode. Fig. 3 shows an arrangement whereby this height compression can be overcome. In Fig. 3, each of the slotted screen electrodes has electrically connected to it, at its upper and lower ends, a pair of radially and inwardly extending conducting sectors or flanges 27, 28, etc. Preferably these flanges are welded or otherwise integrally attached to the respective screen elements, one of which is shown in perspective in Fig. 4. These flanges or sectors are of course separate from each other, as are the slotted screens themselves. Since each of the screen electrodes is, during a certain portion of the polyphase supply cycle, at a positive potential as explained in said publication, the flanges 27, 28, etc. are therefore also positive at the same instant that the beam is in radial alignment with the corresponding window or slot. This positive potential on the flanges tends to restore the height $h$ of the beam, as shown in Fig. 3. A the same time, it results in an increased beam current, and maintains uniformity of rotation of the beam.

One of the limitations on the type of tube shown in Figs. 1–5 is that the number of output channels is fixed by the number of phases of the polyphase source. Thus as shown in Fig. 5, the tube is designed to be operated from a three-phase or six-phase source, or even from a single-phase source which is effectively split into six phases as illustrated in Fig. 7 of the said publication. Consequently six slotted screen electrodes with their upper and lower beam-restoring flanges are used. Since the space between the edges of adjacent screen electrodes is also used as a channel-defining slot, it is possible to use twelve output channels, each comprising a signal control grid 29 and its respective output anode 30. In any event, the number of output channels must bear an integral relation to the number of phases used for the excitation of the screen electrodes to rotate the beam. In some cases it may be desirable to have a non-integral relation. For example, where a three-phase or six-phase source is available, it may be required to have eleven, twenty-one, or some other non-integral number of output channels.

Figs. 6, 7 and 8 show a tube wherein this result can be accomplished. The parts of the tube of Figs. 6 to 8 which are identical with those of Fig. 5, bear the same designation numerals. The main point of difference is that in the tube of Figs. 6 to 8, instead of using a series of discrete arcuate-shaped slotted screen electrodes, a single continuous metal plate 31 is employed, having the required number of slots 32 therein corresponding to the number of output channels. Each of these slots is in radial alignment with the corresponding control grid 29 and output anode 30 of its respective channel. In order to be able to use a greater and non-integral number of channel-defining slots 32 as compared with the

number of phases in the polyphase supply, the flanges 27, 28, instead of being electrically connected to the slotted electrode 31, are insulated or separate therefrom. Each pair of upper and lower flanges is connected together electrically by a conductor, and these conductors are connected to a suitable polyphase supply 33 (Fig. 8). A single separate conductor 34 is provided for the single continuous slotted electrode 31, which may be connected to a suitable positive direct current potential 35.

Fig. 9 shows a still further modification, wherein the tube may be constituted of a series of vertically-stacked sections. A single continuous electron-emitting cathode 36 may be provided for all the sections. The remaining elements of Fig. 9 which perform the same function as those of the preceding figures are designated alike. Thus in Fig. 9, the cathode 36 at each section is provided with charge neutralizing plates 21, 22, and with respective beam-restoring plates or flanges 27, 28, similar to those illustrated in Figs. 3 to 8. A single slotted shield electrode 31, similar to the corresponding electrode of Fig. 8, is connected to a suitable direct current supply as in Fig. 8. The vertically-aligned flanges 27, 28, for each section, are connected in multiple to a corresponding conductor 37. Likewise the corresponding vertically-aligned beam-restoring flanges are connected to respective similar conductors 37, and thence to a polyphase source such as the source 33. The vertically-aligned slots in the screen electrode 31 have in alignment therewith, a corresponding grid 38 which extends vertically past all the stacked sections. Likewise in radial alignment with each grid 38 is a corresponding output anode 39. In other words, the tube of Fig. 9 will be constructed by vertically superposing three sections similar to that shown in Fig. 8, and by extending each of the grids and anodes shown in Fig. 7 so that they are in alignment respectively with the vertically-aligned slots in the electrode 31. It will be understood that it is not necessary to have each grid and its corresponding anode as a continuous one-piece element extending past the windows in the successive tiers or levels. Each window in each tier may have an individual grid and anode so that all the windows can then be used to define separate respective channels at each tier or level.

While certain embodiments have been described herein, it will be understood that various changes and modifications may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. In an electron tube and in combination, a central electron-emitting cathode, channel-defining screen electrode means surrounding said cathode to form the electrons from the cathode into a focussed sheet-like beam, insulator spacer means to maintain a predetermined spaced relation between the cathode and screen electrode means, annular cnnductive means carried by said insulator means surrounding the ends of the cathode but restricted to the central region of said insulator means, and separate lead-in means for said conductive means for applying a positive potential thereto to dissipate undesired electric charges on said insulator means which tend to distort said beam.

2. An electron tube according to claim 1, in which each of said conductive means is in the form of an annular disc attached to the corresponding one of said insulators but surrounding the cathode in spaced relation thereto.



3. An electron tube according to claim 2, in which each of said conductive means is in the form of an annular coating on the corresponding one of said insulators.

4. An electron tube according to claim 1, in which said conductive means tends to reduce the height of the focussed beam, and additional conductive means are provided for restoring the beam height adjacent said screen electrode means.

5. An electron tube according to claim 1, in which each of said insulator means carries additional conductive elements to neutralize the beam-narrowing effect of the said conductive means.

6. An electron tube according to claim 1, in which said screen electrode means comprises a series of spaced arcuately-shaped metal plates, and a plurality of other conductive elements are carried by said insulator means one for each of said plates to neutralize the beam-narrowing effect of said conductive means.

7. An electron tube according to claim 6, in which each of said conductive elements is integrally attached to a corresponding one of said metal plates.

8. An electron tube according to claim 6, in which each of said conductive elements is in the form of a flange carried by a respective one of said plates and extending radially toward the cathode.

9. A channel-defining screen electrode for an electron tube of the focussed rotary radial beam type, comprising an arcuately-curved metal plate having a channel-defining window therein, and a flange at each end for the purpose described.

10. In an electron tube of the focussed rotary beam kind and in combination, a central electron-emitting cathode, metal screen electrode means surrounding said cathode, and a plurality of conductive elements surrounding the ends of the cathode but separate from said screen electrode means and arranged to be excited by a polyphase current to rotate said beam at a uniform rate.

11. An electron tube according to claim 10, in which said screen electrode means has a series of channel-defining windows whose total number is non-integrally related to the number of said conductive elements.

12. An electron tube according to claim 10, in which said screen electrode means is in the form of a single continuous metal plate surrounding the cathode.

13. An electron tube according to claim 10, in which said screen electrode means has a series of channel-defining windows, and a corresponding series of output anodes each in radial alignment with a corresponding one of said windows.

14. Electron tube apparatus, comprising, a central electron-emitting cathode, screen electrode means surrounding the cathode and having a series of channel-defining windows, said screen electrode means arranged to be biassed with respect to the cathode to focus the electrons from the cathode into a sheet-like beam, insulator spacers between the cathode and screen electrode means, conductive means adjacent the cathode ends and negatively biassed to inhibit the irregular charging of said spacers by the electrons from the cathode, and a plurality of other conductive elements between the cathode and screen electrode means and arranged to be excited by a polyphase current to cause the beam to rotate

while simultaneously overcoming the tendency of said conductive means to limit the beam current.

15. An electron tube according to claim 1, in which the focussed beam is sub-divided along the length of the cathode into a plurality of sections, each section having at its upper and lower ends a set of said conductive means, and a plurality of sets of other conductive elements to control the beam rotation and to overcome the tendency of said conductive means to limit the beam current.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

| Number | Name | Date |
|---|---|---|
| 2,054,221 | Krahl | Sept. 15, 1936 |
| 2,391,967 | Hecht et al. | Jan. 1, 1946 |