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Thompson, Jr.

[11] **3,793,550**

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[54] **ELECTRODE CONFIGURATION FOR PARTICLE ACCELERATION TUBE**

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[52] **U.S. Cl.** **313/63**, 328/233

[51] **Int. Cl.** **H05h 5/06**

[58] **Field of Search** 313/63

[56] **References Cited**

UNITED STATES PATENTS

3,458,743 7/1969 Cleland et al. 313/63

Primary Examiner—Roy Lake
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Attorney, Agent, or Firm—Rose & Edell

[57] **ABSTRACT**

In a high vacuum particle acceleration tube of the type in which a series of spaced apertured electrodes define the acceleration path, the apertured electrodes are provided with circular depressions of asymmetric V-shaped cross-section. The asymmetry is such that adjacent electrodes are closer to one another on the radially inward side of the V than on the radially outward side. Thus, arcing, if it occurs, is directed inwardly of the V and metal vapor is not deposited on the insulator. In addition, the V-configured recess acts to intercept high energy particles which are scattered out of the main beam, thereby protecting the glass insulators at the electrode periphery from radiation damage.

9 Claims, 3 Drawing Figures

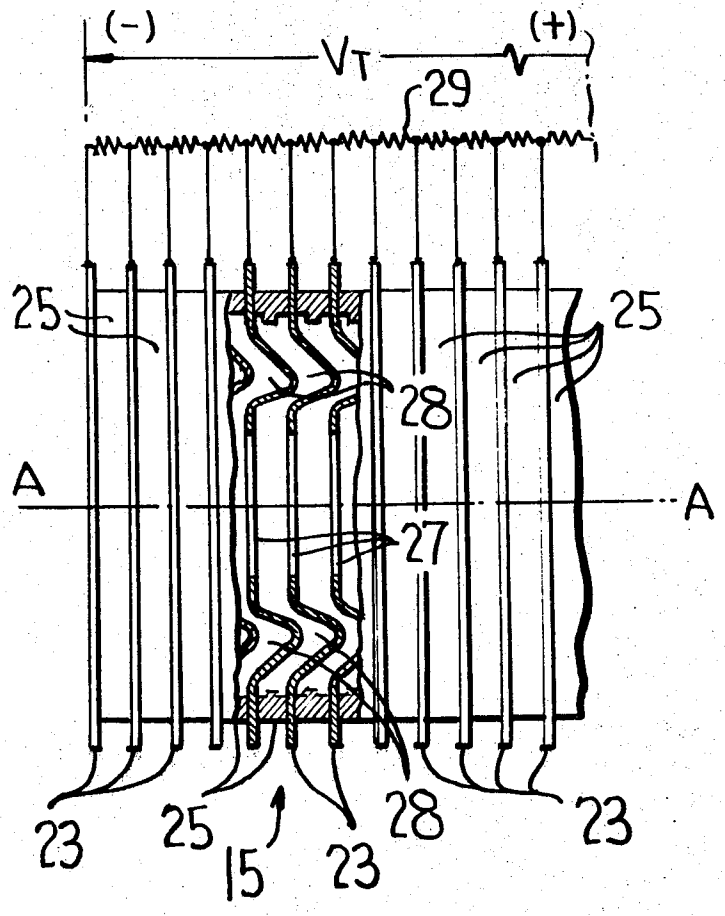


FIG. 1

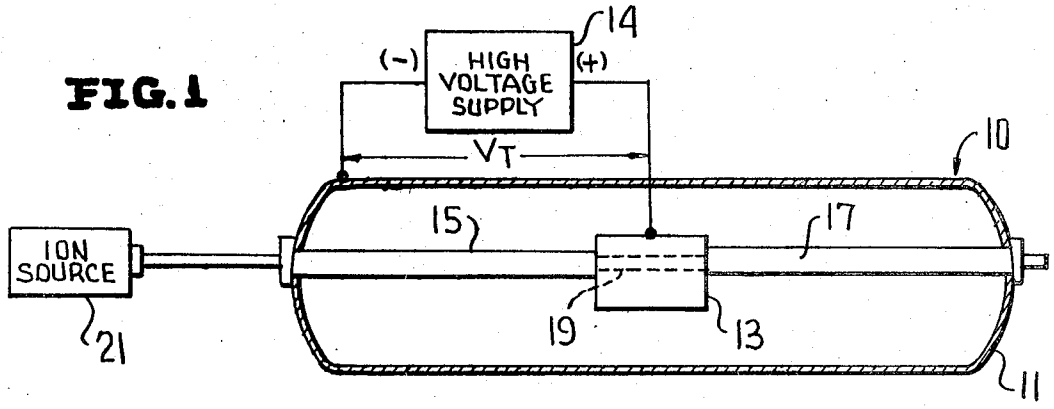
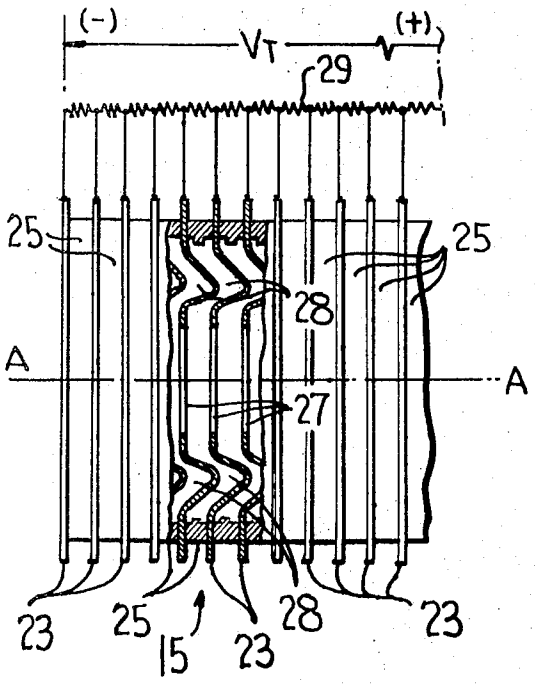


FIG. 2



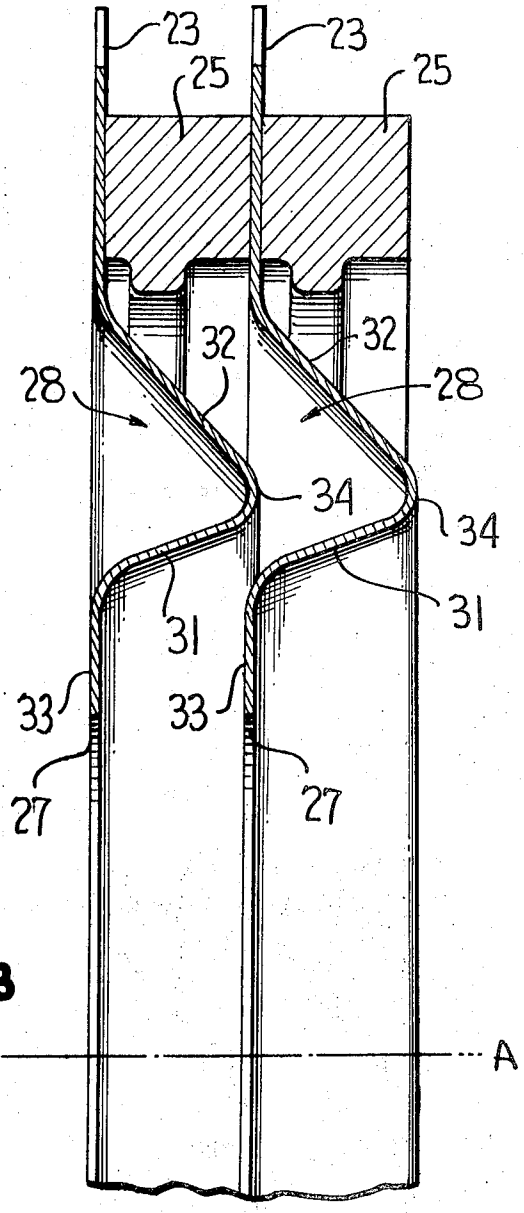


FIG. 3

ELECTRODE CONFIGURATION FOR PARTICLE ACCELERATION TUBE

BACKGROUND OF THE INVENTION

The present invention relates to high vacuum particle acceleration tubes and, more particularly, to improvements in such tubes whereby damage due to arcing is minimized.

High vacuum particle accelerators generally include a series of apertured electrodes positioned between anode and cathode to define a path for the accelerated particle beam. These apertured electrodes are connected to progressively increasing potentials and spaced by a series of insulating rings made from glass or the like. Inadvertent arcing within the tube is a fact of life the tube desgner must live with. Such arcing may be initiated by a stray particle escaping from the beam and striking an electrode, resulting in secondary emission from the electrode and arcing between adjacent electrodes. Alternatively, the arcing may result from the presence of one or more stray gas molecules finding their way into the evacuated tube. The component most subject to permanent damage by such arcing is the insulating spacer ring between electrodes. Specifically, when an arc occurs between two adjacent electrodes it tends to pit, burn, or otherwise damage the insulator.

In the prior art it is known to configure each apertured electrode with a circular recess disposed about the aperture and having a symmetrical V configuration. An example of such electrodes may be seen in U.S. Pat. No. 3,458,743, particularly in FIG. **4.** Such electrodes, because of the recesses, tend to interrupt the radial path between the tube axis and the insulating rings. Thus, stray beam particles are intercepted by the electrodes and are not permitted to cause direct radiation damage to the insulators. However, since the V-shaped recesses in the electrodes are symmetrical, arcing between successive electrodes is just as likely to occur between the outer legs of the V as between the similarly spaced inner legs. Consequently, arcing proximate the insulators is not significantly minimized by the recess.

It is therefore an object of the present invention to provide an electrode structure in a high vacuum particle accelerator tube which substantially reduces the possibility of damage to the insulating rings.

It is still another object of the present invention to provide an electrode structure for a tube of the type described whereby damage to the insulator rings both by arcing and direct impingement by stray beam particles is substantially eliminated.

SUMMARY OF THE INVENTION

According to the present invention, the V cross-section of the electrode recess is asymmetrical such that the radially inward legs of successive V's are closer to one another than the radially outward legs. Arcing, if it occurs, will therefore tend to remain inward of the apex of the V, substantially reducing the possibility of arcing damage to the insulators.

BRIEF DESCRIPTION OF DRAWINGS

The above and still further objects, features and advantages of the present invention will become apparent upon consideration of the following detailed description of one specific embodiment thereof, especially when taken in conjunction with the accompanying drawings, wherein:

FIG. **1** is a diagrammatic illustration of a particle accelerator of the type in which the present invention may be utilized;

FIG. **2** is a plan view in partial section of a portion of one of the accelerator tubes of FIG. **1**; and

FIG. **3** is a detailed plan view in section of the configuration of two successively disposed electrodes of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now specifically to FIG. **1** of the accompanying drawing there is illustrated a tandem-type particle accelerator **10** having a grounded casing **11.** A high voltage terminal **13** is supported substantially at the longitudinal center of casing **11.** High voltage is applied across terminal **13** and casing **11,** plus to minus respectively, from a high voltage supply **14,** for example of the type disclosed in U.S. Pat. No. 3,178,604. Evacuated acceleration tubes **15** and **17** are supported within casing **11,** extending longitudinally therein from respective casing ends to high voltage terminal **13.** Tubes **15** and **17** are aligned with one another and with a stripper element **19** located within terminal **13.** Negative ions are emitted from an ion source **21** and injected in a beam into acceleration tube **15** within which they are accelerated toward high voltage terminal **13.** Electrons are removed from the negative ions in stripper element **19,** and the positive ions thus formed are accelerated through tube **17** to the other end of accelerator **10.**

By way of example only, stripper element **19** may be of the type disclosed in the article "A High Efficiency Ion Optical System For Tandem Accelerators" by Brooks, et al, appearing in the June, 1965 issue of *I.E.E.E. Transactions On Nuclear Science*, pages 313 through 316; however any conventional electron stripping unit may be employed.

Referring now to FIG. **2** of the accompanying drawings there is illustrated a partial section of the upstream end of acceleration tube **15** of FIG. **1.** By "upstream end" is meant the end through which the ion beam enters tube **15.** As illustrated, tube **15** comprises a series of alternating apertured electrodes **23** and insulating rings **25.** The apertures **27** in the electrodes are axially aligned to define a path for the ion beam through tube **15.** The extreme upstream electrode is at casing potential (ground).

The terminal voltage V_t applied between terminal **13** and casing **11** is subdivided by a resistor column or string **29.** Successive electrodes **23** are connected to successive points along resistor string **29** to define a uniform electric field along the length of tube **15.**

Each electrode **23** takes the form of a disk having a central circular aperture **27** and a circular recess **28** disposed concentrically about the aperture. As is the case with aperture **27,** the recess **28** of successive disks are aligned throughout the length of tube **15.** The cross-section of recess is V-shaped, the V being asymmetrical. Specifically, and reference made to FIG. **3,** inner leg **31** of each V, which is closer to the tube axis than outer leg **32,** is shorter than outer leg **32.** In addition, inner leg **31** subtends a smaller angle with tube axis A-A than does outer leg **32.**

Still referring to FIG. 3, the apex **34** of the V-configured recess **28** extends a very short distance into the recess region of the next electrode. That is, the apex **34** of the V extends slightly beyond the plane of the unrecessed upstream surface **33** of the next downstream electrode **23.** By this feature the recesses block the radial path between tube axis A-A and insulators **25,** thereby intercepting stray particles which escape from the beam and preventing their impingement against the insulators.

The asymmetry of recesses **28** results in the spacing between inner legs **31** of successive electrodes being the shortest distance between these electrodes. Thus arcing, if it occurs at all, tends to occur between legs **31.** Importantly, this arcing path is radially inward of apex **34** and not at all proximate insulators **25.** Consequently, the possibility of insulator damage, such as pitting, deposition of metal vapors, etc. due to arcing is significantly minimized.

While the preferred embodiment has been described as utilized in a tandem accelerator, tandem operation is obviously not necessary for the asymmetrical recess to have utility. Nor is the polarity of the accelerated particle limiting. The important point is that the asymmetry of the electrode recess acts, in a high vacuum accelerator tube, to restrict the arcing between successive electrodes to a region close to the tube axis, thereby protecting the insulators from arc damage.

While I have described and illustrated one specific embodiment of my invention, it will be clear that variations of the details of construction which are specifically illustrated and described may be resorted to without departing from the true spirit and scope of the invention as defined in the appended claims.

I claim:

1. A high-vacuum particle accelerator tube of the type in which successive apertured electrodes are spaced by insulators at their peripheries and have their apertures aligned to define a path for an accelerated particle beam along the length of the tube, said tube being characterized in that each electrode includes a continuous recess disposed about said aperture, the recesses of suscessive electrodes being aligned in a direction parallel to the alignment of said apertures, said recess having an asymmetrical cross-section configured such that the closest points between successive electrodes are located along the side of the recesses of those electrodes which is closest to said apertures.

2. The combination according to claim **1** wherein said recess includes an apex about which said recess is asymmetrical, successive electrodes being positioned such that the apex of the recess of each electrode extends a short distance into the recess of the next successive electrode.

3. The combination according to claim **2** wherein said recess has an asymmetrical V cross-section, the leg of the V closest to said aperture being shorter than the leg disposed more remote from said aperture, said closest leg subtending a smaller angle with said particle beam path than said remote leg.

4. The combination according to claim **1** wherein said recess has an asymmetrical V cross-section, the leg of the V closest to said aperture being shorter than the leg disposed more remote from said aperture, said closest leg subtending a smaller angle with said particle beam path than said remote leg.

5. A device for accelerating ions injected thereinto in a downstream direction, said device comprising an acceleration tube having a series of alternating insulating rings and apertured electrodes, and means for applying successive voltage increments across adjacent electrodes to provide a substantially uniform electric field in said acceleration tube, wherein said apertured electrodes include a flac upstream surface in which a continuing downstream-directed recess is formed concentrically about the electrode aperture, the recesses of said electrodes being aligned in a downstream direction, each recess having an asymmetric cross-sectional configuration about an apex such that the side of said recess between said apex and said aperture is closer to the next downstream electrode than is the side of said recess remote from said aperture.

6. The device according to claim **5** wherein the apex of each electrode recess extends a short distance into the recess region of the next downstream electrode.

7. The device according to claim **6** wherein the cross-section of said recess is in the form of a V which is asymmetric about the apex, the side of the V closest to the aperture being shorter than the side remote from said aperture.

8. A device for accelerating charged particles comprising:

an acceleration tube having an upstream end and a downstream end and comprising a multiplicity of alternating apertured electrodes and insulating rings, the apertures of said electrodes being axially aligned to define a path for said charged particles therethrough between the upstream and downstream ends of said tube;

means for applying successive voltage increments across adjacent electrodes to provide an electric field between the upstream, and downstream ends of said tube; and

means for injecting a beam of said charged particles into said tube at the upstream end thereof and directed generally toward the downstream end thereof;

wherein each electrode includes a continuous recess disposed concentrically about said aperture and having an asymmetric V-configured cross-section, the apices of the recesses in successive electrodes being aligned along the length of the tube.

9. The device according to claim **8** wherein said tube is part of a tandem-type accelerator further comprising an electrode stripper element disposed at the downstream end of said tube and toward which said beam is focused.

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