Jan. 21, 1969 K. H. PURSER 3,423,684

PARTICLE ACCELERATION TUBE HAVING ELECTRIC FIELD CONTROL MEANS

Filed Feb. 15, 1965

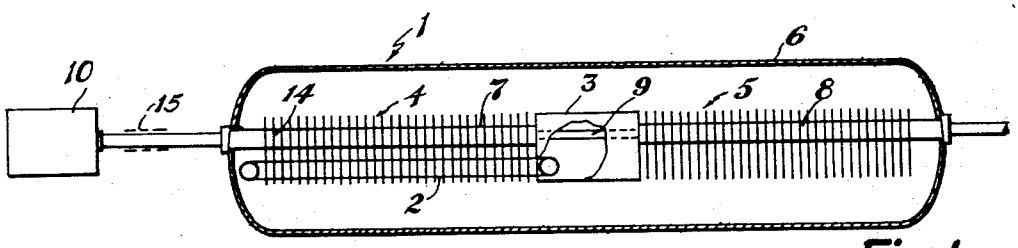
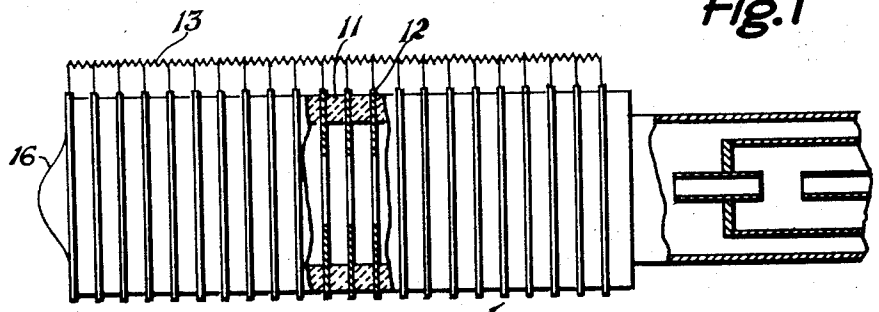


Fig. 1



PRIOR ART

Fig. 2

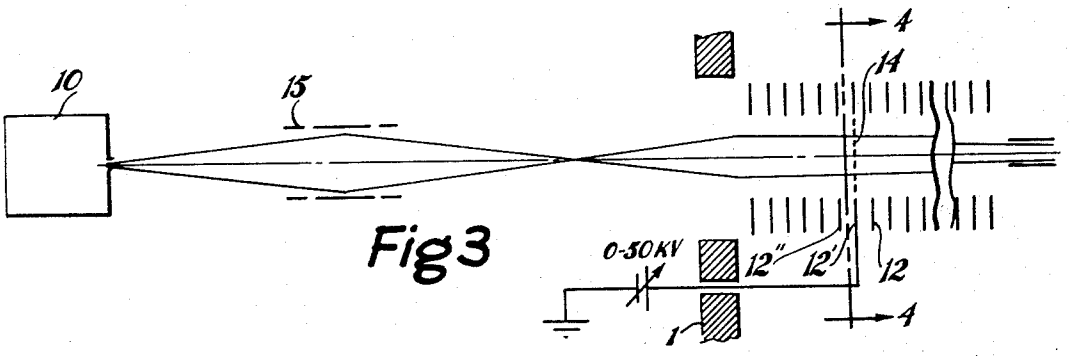


Fig 3

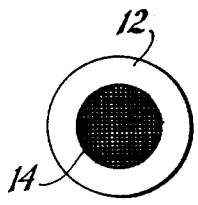


Fig. 4

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PARTICLE ACCELERATION TUBE HAVING ELECTRIC FIELD CONTROL MEANS

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U.S. Cl. 328—233 4 Claims
Int. Cl. H01j 23/00, 23/34; H05h 7/00

ABSTRACT OF THE DISCLOSURE

The invention relates to the acceleration of charged particles to high velocity, and in particular to acceleration tubes comprising a multiplicity of alternating insulating rings and apertured electrodes whose electric potential increases progressively so as to provide an electric field for the acceleration of charged particles within and along the length of the acceleration tube. When charged particles are injected into such an acceleration tube, rather than released from a source within it, it is necessary that the aperture of the apertured electrode through which the charged particles enter the acceleration tube be sufficiently large to accommodate the incoming charged particles. This large aperture, in turn, is accompanied by a relatively strong focussing action whose focal and magnification properties vary with the potential difference across the acceleration tube. The invention comprehends, in combination with such an acceleration tube, a grid-like structure covering the aperture of one of the apertured electrodes at the low-energy end of the acceleration tube, whereby the above-mentioned variable and relatively strong lens action is eliminated. In the following detailed description, the invention is described with particular reference to its application to tandem-type electrostatic accelerators of the type described in Nuclear Instruments and Methods, volume 8 (1960) at pages 195–202. However, the invention is not limited to this particular application.

The invention may best be understood from the following detailed description thereof, having reference to the accompanying drawing, in which

FIGURE 1 is a diagram showing a tandem-type electrostatic accelerator;

FIG. 2 is a central longitudinal section taken through the low-energy acceleration tube of the accelerator shown in FIGURE 1;

FIG. 3 is a detail in central longitudinal section of the acceleration tube of FIG. 2, but modified in accordance with the invention; and

FIG. 4 is a section taken along the line A—A of FIG. 3.

Referring to the drawing, FIGURE 1 thereof shows a typical tandem-type electrostatic accelerator **1**. In such an accelerator, positive electric charge is transported by means of a belt **2** of insulating material onto a high-voltage terminal **3** which is supported by insulating columns **4**, **5** within a grounded tank **6** containing insulating gas under pressure. Evacuated acceleration tubes **7**, **8** are supported within each column **4**, **5**, respectively, and aligned with each other and with a stripping device **9** within the high-voltage terminal **3**. Negative ions are injected from a negative ion source **10** into one **7** of the acceleration tubes, and are then accelerated towards the high-voltage terminal **3**. In traveling through the stripping device **9**, electrons are removed from some of the negative ions, and the positive ions thus formed are further accelerated through the second acceleration tube **8**.

In such an accelerator, it is generally desirable to be able to vary the energy of the charged-particle beam, and this is generally done by varying the electric potential of the high-voltage terminal **3**. This, in turn, varies the voltage gradient throughout both acceleration tubes **7**, **8**.

Referring now to FIG. 2, therein is shown the first acceleration tube **7** of the accelerator shown in FIGURE 1. Such an acceleration tube comprises a multiplicity of alternating insulating rings **11** and apertured electrodes **12**. A resistor column **13** subdivides the total voltage of the high-voltage terminal **3**, and successive apertured electrodes **12** are connected to progressive points along the resistor column **13**, so that each apertured electrode **12** defines an equipotential surface. These equipotential surfaces are substantially planar except at the extremities of the acceleration tube **7**, where there is an outward bulge **16**. Moreover, the potential increase along the acceleration tube is substantially uniform, so that the electric field within the acceleration tube is substantially uniform. Although there is an electric field and hence some lens action throughout the acceleration tube **7**, the bulges at the extremities of the acceleration tube tend to provide a more pronounced lens action. At the high-energy end of the tube, the beam is "stiff" and therefore not much influenced by the lens action; moreover, the ultimate aperture, and hence the bulge, is relatively small. At the low-energy end of the tube, however, the incoming particles are easily deflected because of their low energy. As a result, there is a pronounced lens action. This pronounced lens action is somewhat undesirable in itself, but what makes it particularly undesirable is the fact that the focal properties and magnification thereof vary with the voltage applied to the high-voltage terminal. Consequently, if the point from which the particles are injected into the acceleration tube is fixed, it is necessary to vary the injection energy for various voltages on the high-voltage terminal. The invention not only eliminates this need to vary injection energy, but also permits the use of velocity modulation of the beam at this fixed injection point for bunching purposes.

I have discovered a way to remove these variable focal properties and that the beam currents attainable in tandem accelerators may be increased as much as tenfold by elimination of the terminal-voltage-dependent lens action at the low-energy end of the low-energy acceleration tube, and I accomplish the elimination of this lens action by providing a grid across the aperture of that apertured electrode at the low energy end of the acceleration tube which constitutes the boundary of the uniform electric field. Such a grid is shown in FIGS. 3 and 4. Referring thereto, a grid **14** comprising a metallic mesh screen is affixed to an apertured electrode **12** so as to cover the aperture thereof and produce a flat equipotential plane. In order to get a point image at the stripper canal **9**, it is necessary to provide a point object. Ordinarily it is inconvenient to use the point of creation of the ions for this purpose, and so a lens such as an einzel lens **15** is used to provide the necessary point object at the proper distance from the entrance to the acceleration tube **7'**. Since the beam diverges from this point object, a positive lens is provided close to the entrance of the acceleration tube in order to focus the beam to form a point image at the stripper canal. Such a positive lens may be provided by applying appropriate potentials to additional electrodes **12''** anterior to the gridded electrode **12'**.

Although the uniform electric field in the region between the grid and the high-voltage terminal provides some lens action due to the acceleration itself, this action is relatively weak, particularly with respect to the paraxial beam. Consequently any variations in the voltage of the high-voltage terminal will have a negligible effect on the beam trajectory.

Concisely stated, the invention provides an acceleration tube having focal properties which are essentially zero, except for the focussing action produced by the acceleration itself.

Having thus described the principles of the invention, together with an illustrative embodiment thereof, it is to be understood that although specific terms are employed, they are used in a generic and descriptive sense, and not for purposes of limitation, the scope of the invention being set forth in the following claims.

I claim:

1. Apparatus for the acceleration of ions comprising an acceleration tube having a multiplicity of alternating insulating rings and apertured electrodes, mean sfor applying successive voltage increments across adjacent electrodes, whereby a substantially uniform electric field is produced in said acceleration tube, and a grid-like structure covering the aperture of that apertured electrode which constitutes the boundary of the uniform electric field.

2. Apparatus for the acceleration of ions towards a region of high electric potential comprising, in combination with an acceleration tube having a multiplicity of alternating insulating rings and apertured electrodes, means for applying progressively higher electric potentials to said apertured electrodes, and a grid-like structure covering the aperture of at least one of said apertured electrodes having relatively low electric potential.

3. Apparatus for the acceleration of ions comprising an acceleration tube having a multiplicity of alternating insulating rings and apertured electrodes, means for applying successive voltage increments across adjacent electrodes, whereby a substantially uniform electric field is produced in said acceleration tube, a grid-like structure covering the aperture of that apertured electrode which constitutes the boundary of the uniform electric field, and means for injecting a beam of ions into said uniform electric field via said grid-like structure.

4. Apparatus for the acceleration of ions comprising, in combination with an acceleration tube having a multiplicity of alternating insulating rings and apertured electrodes, means for applying progressively higher electric potentials to said apertured electrodes, said means including a high-voltage terminal whose potential may be set at various levels with a corresponding variation in the potentials of said apertured electrodes, a grid-like structure covering the aperture of at least one of said apertured electrodes having relatively low electric potential, and means for injecting a beam of ions into said acceleration tube via said grid-like structure.

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U.S. Cl. X.R.

250—41.9; 313—63, 82, 265