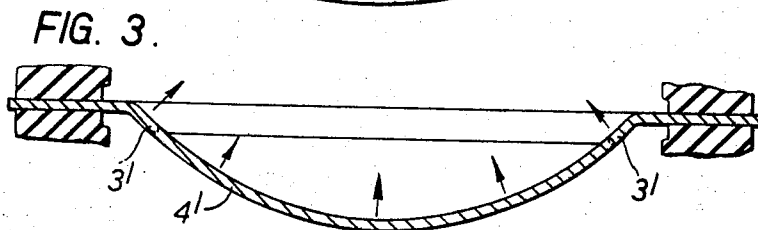
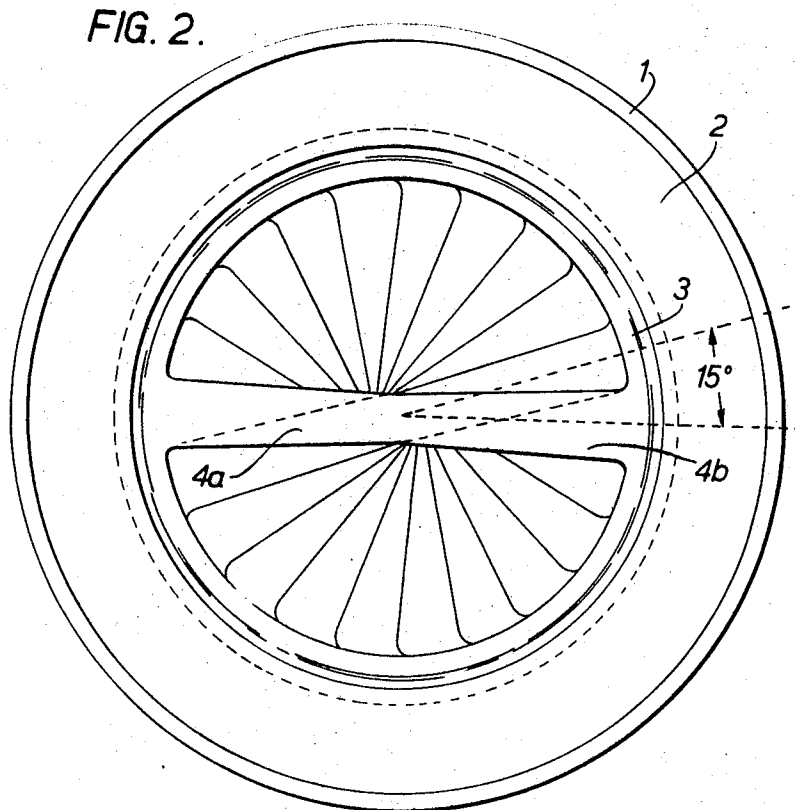
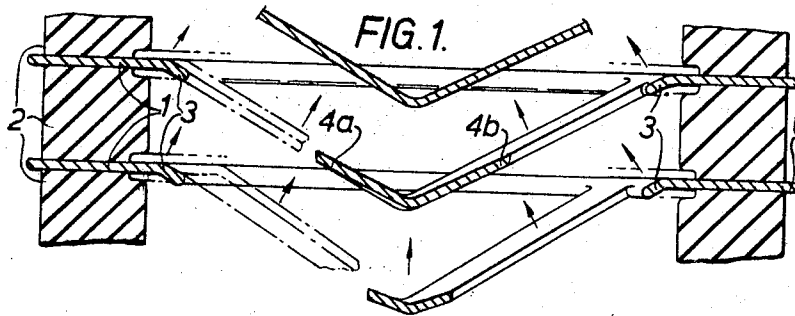


Sept. 19, 1967

F. A. HOWE ET AL
ANNULAR ELECTRODES IN DIFFERENTIAL PUMPING TUBES
FOR ELECTROSTATIC ACCELERATORS
Filed Nov. 12, 1965

3,342,404



1

3,342,404

ANNULAR ELECTRODES IN DIFFERENTIAL PUMPING TUBES FOR ELECTROSTATIC ACCELERATORS

Frederick Albert Howe, Newbury, and Ronald Inch Bell, Basingstoke, England, assignors to United Kingdom Atomic Energy Authority, London, England

Filed Nov. 12, 1965, Ser. No. 507,426

Claims priority, application Great Britain, Nov. 19, 1964, 47,158/64

5 Claims. (Cl. 230—69)

ABSTRACT OF THE DISCLOSURE

A differential pumping tube for evacuating the high-voltage portion of an electrostatic accelerator in parallel with the accelerating tube is of the type comprising a plurality of annular electrodes spaced apart by annular insulators, and is improved by including in each electrode a substantially diametrical bar which intersects the axis of the tube, the two radial halves of the bar being deflected from a plane normal to the tube axis toward one end of the tube to produce an electric field between adjacent electrodes having a component directed toward the tube axis to cause deflection of unwanted electrons into the electrodes. The inner periphery of each electrode may also be deflected from the plane toward the one end of the tube to enhance the electric field, and preferably each successive electrode has its bar circumferentially displaced through a small angle relative to the bar of the preceding electrode to provide optical baffling along the tube.

This invention relates to differential pumping tubes for electrostatic accelerators.

In most Van de Graaff accelerators, the gas which is fed to the ion source at the high-voltage end of the accelerating tube is pumped out via the latter tube, which therefore serves the double function of accelerating tube and vacuum duct. The form of tube suitable for accelerating particles, however, is not the most suitable for a purely pumping function, because the electrode structure used necessarily increases its impedance to gas flow. An alternative arrangement is to provide a second tube, effectively arranged in parallel with the accelerating tube, whose sole function is to extract gas from the ion source region. This second tube is known as a differential pumping tube. A tandem accelerator using two such differential pumping tubes is described, for example, in the Review of Scientific Instruments, volume 35, Jan. 1964, page 1 et seq.

A well known phenomenon in electrostatic accelerators is electron loading, in which electrons are accelerated back towards the positive end of the tube. The accelerated electrons, which can originate in various ways, e.g. by field emission from the electrodes, generate X-rays when they strike parts of the accelerator structure, which in turn ionise the high-pressure gas surrounding the structure and so reduce the insulation. Moreover the electrons themselves constitute an additional load on the generator, tending to reduce its output voltage.

Various forms of accelerating tube have been proposed to suppress the electron loading effect. These are usually designed to deflect the electrons into the tube structure before they have acquired sufficient energy to have a serious effect. It is an object of the present invention to provide a differential pumping tube which combines a high degree of electron suppression with low impedance to gas flow.

According to the present invention a differential pumping tube comprises a plurality of annular electrodes

2

spaced apart by annular insulators, each electrode including a substantially diametrical bar whereof the two radial halves are deflected from a plane normal to the tube axis towards one end of the tube to produce an electric field towards adjacent electrodes having a component directed towards the tube axis.

Preferably the inner periphery of each electrode is also deflected from said plane to enhance said field as aforesaid.

Preferably successive electrodes are arranged so that each bar is circumferentially displaced by a small angle relative to the bar of the preceding electrode to provide optical baffling along the tube.

The bars may be deflected to V-shape or arcuate form.

To enable the nature of the present invention to be more readily understood, attention is directed, by way of example, to the accompanying drawing, wherein

FIGURE 1 is a cross-sectional elevation of part of a pumping tube embodying the present invention.

FIGURE 2 is an axial view looking through the tube of FIGURE 1.

FIGURE 3 shows a modification of the tube of FIGURE 1.

Referring to FIGURE 1 a pumping tube comprises a plurality of aluminum electrodes 1 (of which only two are shown complete) separated by annular glass insulators 2 and having an inner periphery 3. Extending diametrically between two points on the inner periphery of each electrode is a bar, the two radial halves 4a and 4b of which are deflected from the plane of the electrode (which is normal to the tube axis) to meet in a V on the tube axis. The effect is to produce an electric field between adjacent electrodes, indicated by the arrows, which has a component directed towards the tube axis. This component causes any electrons within the tube to impinge on the bars instead of travelling along the tube parallel to the axis.

In peripheral regions remote from the bar, the radial component of electric field might be insufficient to prevent some movement of electrons parallel to the axis. To enhance the radial component in these regions, the entire inner periphery is itself deflected, at approximately the same angle as the two halves of the bar.

The bars are made sufficiently narrow to offer little impedance to the flow of gas along the tube. To produce even more effective electron suppression, successive electrodes are mounted with their bars circumferentially displaced through a small angle relative to the preceding bar to produce an optical baffling effect looking along the tube axis. The effect is illustrated in FIGURE 2, where the angular displacement between successive bars is 15°. It will be seen that with the dimensions shown, no electron travelling parallel to the tube axis can traverse more than eleven electrodes without impinging on a bar.

FIGURES 1 and 2 illustrate the described embodiment approximately to scale, the diameter of the edge of the inner periphery being 5¾ inches. The bars are ¾ inch wide at the periphery, tapering to ½ inch at the axis. The electrodes are spaced 1.1 inches apart by the insulators.

In another embodiment, as shown in FIGURE 3, the diametral bars 4' have the same dimensions as in FIGURES 1 and 2 and are circumferentially displaced by the same amount. However instead of being deflected to a V-shape, the bars 4' are arcuate in form, the centre of the arc (where it intersects the tube axis) being displaced about 1¾ inches from the plane of the electrode. An example of this embodiment, comprising 136 such elec-

3

trodes spaced 1.1 inches apart, has been used at voltages up to 5.5 mv. with no measurable electron loading. The pumping impedance of this tube with air was approximately 28 litres/sec.

We claim:

1. In a differential pumping tube for evacuating the high-voltage portion of an electrostatic accelerator in parallel with the accelerating tube and comprising a plurality of annular electrodes spaced apart by annular insulators, the improvement wherein each electrode includes a substantially diametrical bar which intersects the axis of the tube, the two radial halves of said bar being deflected from a plane normal to the tube axis towards one end of the tube to produce an electric field between adjacent electrodes having a component directed towards the tube axis to cause deflection of unwanted electrons into said electrodes.

2. A tube as claimed in claim 1 wherein the inner periphery of each electrode is deflected from said plane towards said one end of the tube to enhance said electric field.

4

3. A tube as claimed in claim 1 wherein each successive electrode has its bar circumferentially displaced through a small angle relative to the bar of the preceding electrode to provide optical baffling along the tube.

4. A tube as claimed in claim 1 wherein said bars are deflected to be substantially V-shaped.

5. A tube as claimed in claim 1 wherein said bars are deflected to be substantially arcuate.

References Cited

UNITED STATES PATENTS

2,570,158	10/1951	Schissel	313—36
2,917,630	12/1959	Walbank	313—61
3,174,678	3/1965	Matricon	230—69
3,175,373	3/1965	Holkeboer et al.	230—69

JAMES W. LAWRENCE, *Primary Examiner*.

C. R. CAMPBELL, *Assistant Examiner*.