

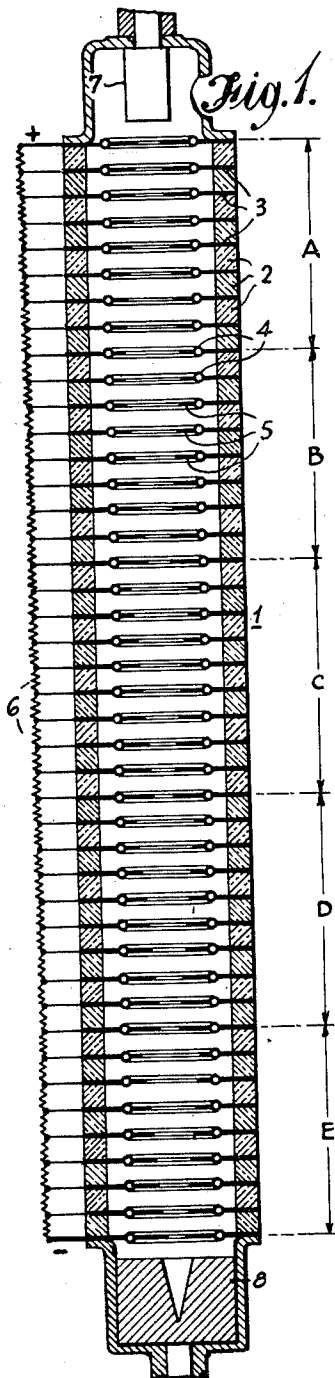
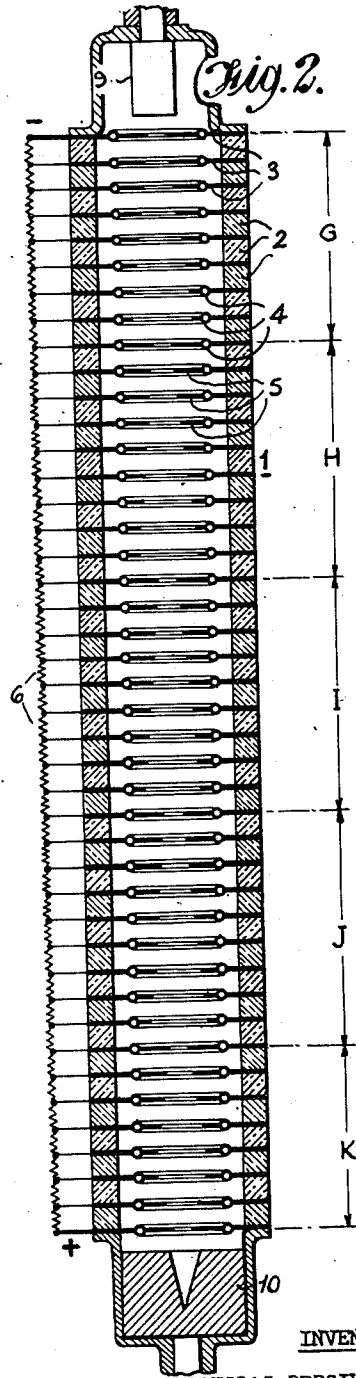
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D. P. R. PETRIE ET AL
CHARGED PARTICLE ACCELERATORS

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2 Sheets-Sheet 1



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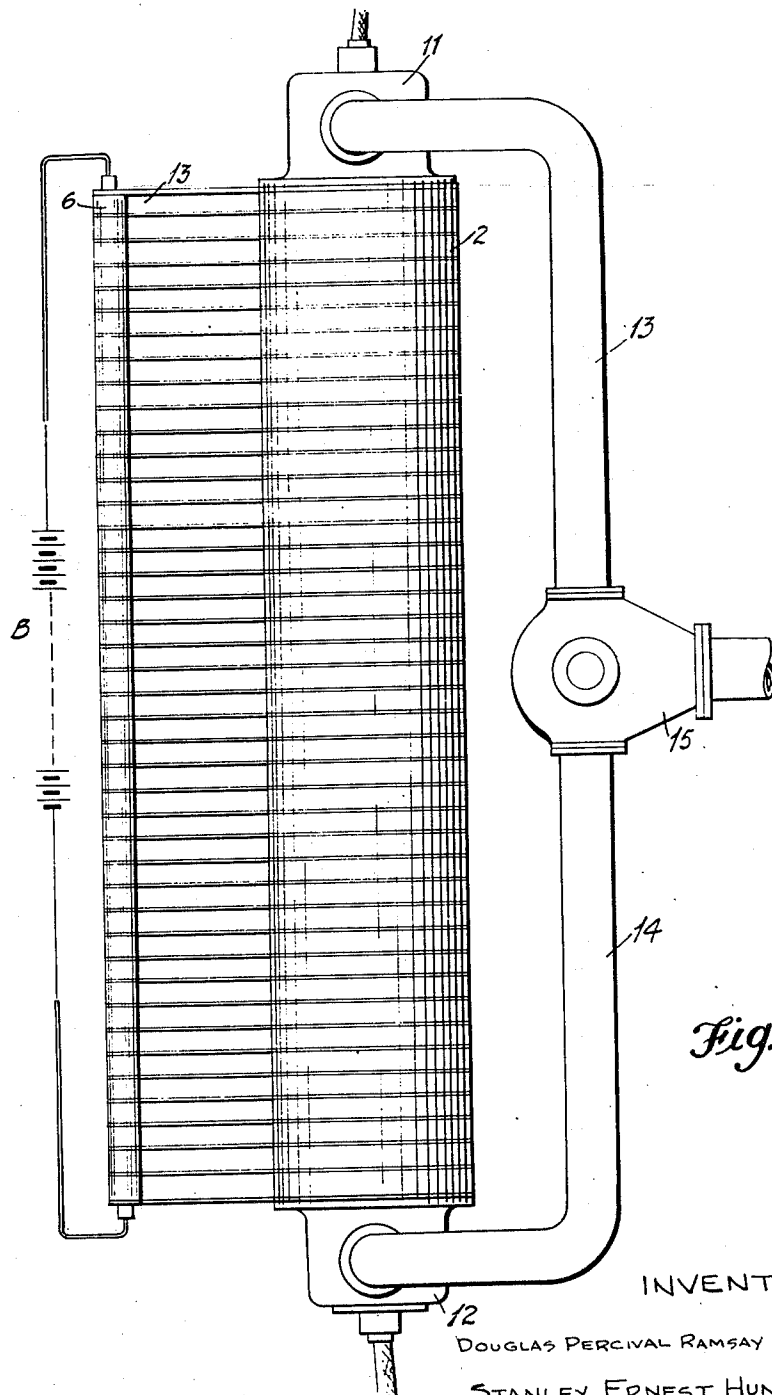


Fig. 3.

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CHARGED PARTICLE ACCELERATORS

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This invention relates to charged particle accelerators. The invention is applicable both to accelerators for positively charged particles and also to accelerators for negatively charged particles.

Charged particle accelerators such, for example, as Van de Graaff machines, Cockcroft-Walton machines, accelerate particles by allowing them to fall through a high potential difference between the ends of an accelerator tube, the inside of which is maintained under conditions of high vacuum. The tube is commonly sub-divided along its length by electrodes maintained at potentials intermediate between those existing at the ends of the tube. These internal electrodes, usually termed accelerating electrodes, ensure a more uniform potential gradient along the length of the tube and hence enable a higher over-all potential difference to be applied to the tube. Apertures are provided in the accelerating electrodes for the passage of the accelerated beam.

It is common experience that when such accelerating tubes are operating at high voltage gradients, unwanted negative currents appear in the tube. These are mainly due to secondary electrons and ions which are formed at the end of the tube which is at negative potential, and are accelerated towards the positive end by the electrostatic field. As these negative particles also strike the internal tube electrodes secondary emission takes place and the total tube current is thus increased by a cascade process.

These currents are undesirable in that they present an unwanted load on the generator producing the high potential across the tube, and that X-rays are produced when the negative particles strike the internal electrodes or the positive termination of the tube. X-rays, as well as being a potential hazard to the health of the operator of the generator, produce ionisation currents in the dielectric medium surrounding the tube and generator (this is commonly gas at high pressure in the case of Van de Graaff accelerators). The ionization current, which can be of the order of a hundred microamps or more, is an additional load on the generator, and this, together with the unwanted negative current in the tube, can limit the voltage attainable with machines of limited charging current capacity such as Van de Graaff generators.

The main object of the invention is to provide an improved arrangement which substantially avoids unwanted negative currents and these consequent drawbacks.

According to the present invention a charged particle accelerator of the kind comprising annular accelerating electrodes encircling and distributed along the particle path so as to produce an accelerating electrical field, has the electrodes divided into a plurality of groups arranged end to end, the apertures of each group of accelerating electrodes (excepting in some cases the end groups) increasing in size progressively along the direction of movement of negative particles from a minimum at the inlet end to a maximum at the outlet end which is immediately followed by the minimum sized aperture of the following group whereby stray electrons are trapped.

It will be appreciated that in the case of accelerators for positively charged particles the secondary electrons will move in the reverse direction to the positively charged

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particles whilst in the case of accelerators for negatively charged particles the electrons will follow a forward path. It follows, therefore, that in the former case, i.e. a positive particle accelerator, the electrode apertures of each group will reduce progressively in size along the accelerator whereas in the case of a negative particle accelerator the apertures will increase progressively in size. In either case negative electrons will be trapped by the discontinuity in the aperture sizes.

In order that the invention may be more clearly understood reference will now be made to the accompanying drawings, in which:

FIG. 1 shows diagrammatically an accelerator for positively charged particles embodying the present invention, whilst

FIG. 2 is a similar view showing an accelerator for negatively charged particles embodying the invention.

FIG. 3 is a perspective view of an accelerator.

In the accelerator for positively charged particles shown in FIG. 1 the reference 1 indicates generally the wall of the accelerator tube. This would consist in general of a series of annular rings 2 of insulating material, e.g. porcelain, acting as spacers between the plates 3 supporting the rings 4 which range in turn support accelerating disc electrodes 5. Graded potentials are applied to the electrodes 5, for example, as shown in the drawing they are connected to successive tapping points of a resistor chain 6 across which the accelerating potential is applied. The reference 7 indicates the source of the beam of positive ions to be accelerated, and 8 is a collector of such ions.

In the arrangement shown in FIG. 1 the accelerating electrodes 5 are arranged in a series of successive groups indicated by the letters A-E. In the first group A the aperture sizes progressively increase, the electrodes with smaller apertures being necessary at the top in order to shield the low energy positive particle beam at this point from the influence of electrostatic charges on the insulating walls of the tube. In the second group B the aperture sizes progressively decrease to a minimum. At the upper end of group C the aperture size is a maximum and decreases to a minimum at the lower end; similarly in each of the groups D and E the aperture sizes reduce progressively. Whilst this arrangement will not have appreciable effect on the positive particles of the main beam which are travelling downwards, any stray negative electrons will move upwards and will be trapped at the junction points between the groups B, C, D and E where they encounter an accelerating electrode having a suddenly reduced diameter.

Although in the arrangement shown protection of the beam from wall charges near the upper end of the tube is effected by constructing group A as described above, it should be realised that, if the effect of wall charges were reduced or eliminated by any other means such as by using slightly conducting material for the tube walls, it would be preferable according to the invention to make group A similar to groups B, C, D and E, thereby providing a further trapping point for stray electrons.

The annular rings 4 serve to prevent the accelerated positive particles travelling down the central axis of the tube from being deflected by electrostatic fields due to charges collected on the insulating walls of the accelerating tube and do not have an appreciable effect on the reduction of retrograde current.

FIG. 2 shows how the invention would be applied to an accelerator of negative charged particles. A beam of such particles would be emitted by the source 9 and collected on the collector 10. In this case it will be observed that the potential connected across the resistor chain is, of course, in the opposite sense to that of FIG. 1, and furthermore, the aperture diameters of the elec-

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trodes in the groups G, H, I, J, K will increase progressively downwards since in this case the stray electrons will move downwards and not upwards and hence they will be trapped by the discontinuities between the successive groups. At the same time the main charged particles of the beam travelling along its axis will not be affected noticeably.

In the perspective view shown in FIG. 3 the resistor chain 6 is shown as a stack opposite ends of which are connected to a battery B. This is shown poled for the arrangement of FIG. 1 and would be reversed for FIG. 2. At the ends of the accelerator are covers 11, 12 respectively and these are connected through ducts 13, 14 respectively with an evacuating pump 15.

What we claim is:

1. An accelerator for charged particles comprising a particle emitter, a particle collector spaced from said emitter and annular accelerating electrodes encircling the particle path between said emitter and said collector, means for applying graded potentials to said accelerating electrodes to produce an accelerating field, said electrodes being divided into a plurality of groups arranged end to end, at least some of said groups comprising annular electrodes having progressively increasing internal diameters along the direction of negative particle flow including a maximum sized aperture electrode at the downstream end for said negative particles and adjacent thereto the minimum size aperture electrode of the next group downstream with respect to the negative particle flow.

2. An accelerator for positively charged particles comprising a particle emitter, a particle collector spaced from

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said emitter and annular accelerating electrodes encircling the particle path between said emitter and said collector, means for applying graded potentials to said accelerating electrodes to produce an accelerating field, said electrodes being divided into a plurality of groups arranged end to end, said groups, excepting the group at the emitter end, comprising annular electrodes having progressively increasing internal diameters along the direction of particle flow between emitter and collector and including a minimum sized aperture electrode adjacent the maximum size aperture electrode of the next group towards the particle collector.

3. An accelerator for negatively charged particles comprising a particle emitter, a particle collector spaced from said emitter and annular accelerating electrodes encircling the particle path between said emitter and said collector, means for applying graded potentials to said accelerating electrodes to produce an accelerating field, said electrodes being divided into a plurality of groups arranged end to end, said groups, excepting the group at the collector end, comprising annular electrodes having progressively increasing internal diameters along the direction of particle flow between emitter and collector including a minimum sized aperture electrode at the downstream end adjacent the maximum size aperture electrode of the next group downstream.

References Cited in the file of this patent

UNITED STATES PATENTS

2,521,426	Trump	Sept. 5, 1950
2,899,598	Ginzton	Aug. 11, 1959