A DIFFERENTIAL PUMPING TUBE FOR ELECTROSTATIC ACCELERATORS [1]

F. A. Howe
Atomic Weapons Research Establishment
Aldermaston, England.

Summary

A situation often exists in modern electrostatic accelerators where improved pumping speed is necessary for the removal of ion source or stripper gases and the obtaining of an acceptable degree of vacuum. The tube developed for this purpose at A.W.R.E. fulfills this purpose without degradation of machine performance.

Introduction

Many electrostatic accelerators provide for the fitting of differential pumping tubes to assist in the removal of ion source or stripper gases. The rare use of such tubes to obtain better vacuum conditions in the H.V. terminal is a reflection on the problems associated with accelerator tubes in general.

Improvements to ion beam accelerator tubes are often made at the expense of gas conductance, and considerable effort has been expended on developing pumps suitable for use in the H.V. terminal. Such pumps are located where space, power supply, cooling, high gas pressure, control and servicing create special problems.

Experience with the terminal Klyston bunching facility of the A.W.R.E. 5.5 MV accelerator[2] provided evidence that poor vacuum in the source gap lens region was causing beam scatter and consequently an increase in the length of the pulses obtained.

Prototype tubes

In an effort to remedy this situation, the differential tube shown in fig 1 was constructed and installed on the machine.

Nanosecond pulse lengths previously obtained only after lengthy pump down periods were available immediately, and confirmed the desirability of the lower vacuum in the terminal buncher. The machine loading was virtually unchanged from that of the machine with the beam tube only, but tube sparking set in at 4.5 MV. No improvement in this respect resulted with conditioning and the tube was removed after a few weeks. The tube was fitted with flat electrodes of 15.3 cm diameter, D shaped apertures being introduced at regular intervals to intercept electrons and ions arising in the tube. The browning of glass insulators in the region of the baffles suggested that screening of the glasses was necessary to obtain a reasonable life. Two tubes of alternative design were then constructed, that shown in fig 2 employing dished electrodes with an inclination of 7°. The slot width of 10 cm, and a diametrical bar 1.4 cm wide on every fourth electrode allowed a maximum electron energy of some 500 keV. The tube was given a short trial indicating satisfactory performance but machine problems limited the duration of the test.

The final Tube

The tube shown in fig 3 now became available and having possible advantages over tube No. 2 was installed for assessment. In this design, the apertures are 15.3 cm in diameter, and each is subdivided across the diameter by a bar 1.9 cm wide. The inner rim of the electrode and the cross bar are dished to form an electrostatic field between electrodes which directs electrons towards the tube axis for collection on the cross bars. To remove any possibility of electrons formed near the electrode rims from passing down the tube, adjacent electrode apertures are displaced 15° relative to each other. This gives complete optical baffling at every twelfth electrode and will limit electrons moving parallel to the axis to 500 keV.

The calculated conductance of the tube assuming a continuous smooth wall tube of section similar to the aperture is 205 ℓ/sec for hydrogen. The measured conductance is 106 ℓ/sec, the difference being due to the finned nature of the tube wall and the limitation in the mean free path of gas molecules due to the spiralling.

Tube performance

This tube conditioned up quickly to 5 MV, and tank sparking set in at a threshold of 5.5 MV, this situation remained unchanged even after some weeks of running.

Experience with inclined field and magnetically suppressed tubes indicated that a somewhat lower sparking threshold was to be expected than with conventional tubes. The addition of 2% SF_6 (Sulphur hexafluoride) to the 80% Nitrogen 20% CO_2 tank gas insulant, and due regard to gas dryness - less than 20 parts per million water vapour is desirable - rectified this situation. The machine with differential tube and conventional beam tube was taken up to 6.6 MV during a short duration voltage test - about 4 hours - following a period of running around 5 MV. Tank gas pressure was 150 lbs.sq.inch, and the radiation level was that normal for the machine when fitted with the conventional tube alone.

The machine presently employs a gas stripper in the main tube for the production of doubly charged helium ions and the increased gas conductance enables optimum stripping efficiency to be obtained. Pulsed beams of mean current intensity 0.5 microamps at 11 MeV of He^{3+} ions, 3 nanosecs duration and 200 nanosec (5 Mcs) repetition rate have been used recently.

The tube has completed 5000 hrs running time, and none of the usual glass discolouration has occurred, the general appearance being virtually as new.

Conclusions

It would appear that this design, which directs electrons away from the glass insulators, provides a gas pumping tube with a long life expectancy, possibly comparable with that of the stack insulators. Larger diameter tubes giving correspondingly greater gas conductance should be quite feasible for incorporation in machines with large gas throughputs or low ultimate pressure requirements.

Acknowledments

The author acknowledges the valued assistance of Mr. A. A. Hunter and Mr. G. W. Eatwell with the tube construction, and that of Mr. G. James for the testing of the tubes in the Accelerator.

References

1. Patents pending in several countries.
2. Klyston Bunching of the Ion Beam of a 5.5 MV Van de Graaff, Nuclear Instruments and Methods, Vol. 41 (1966) No. 1.

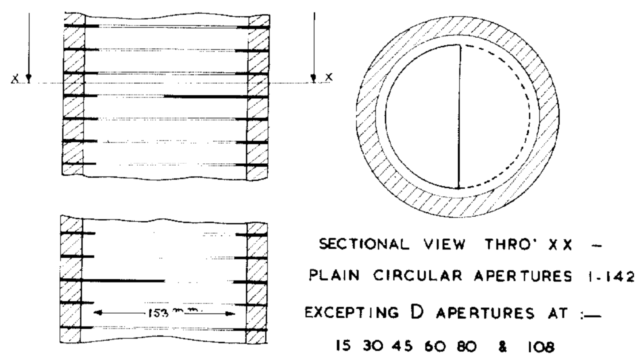


Fig. 1.

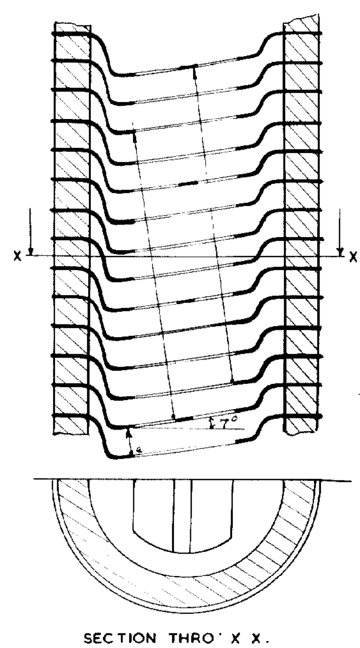


Fig. 2.

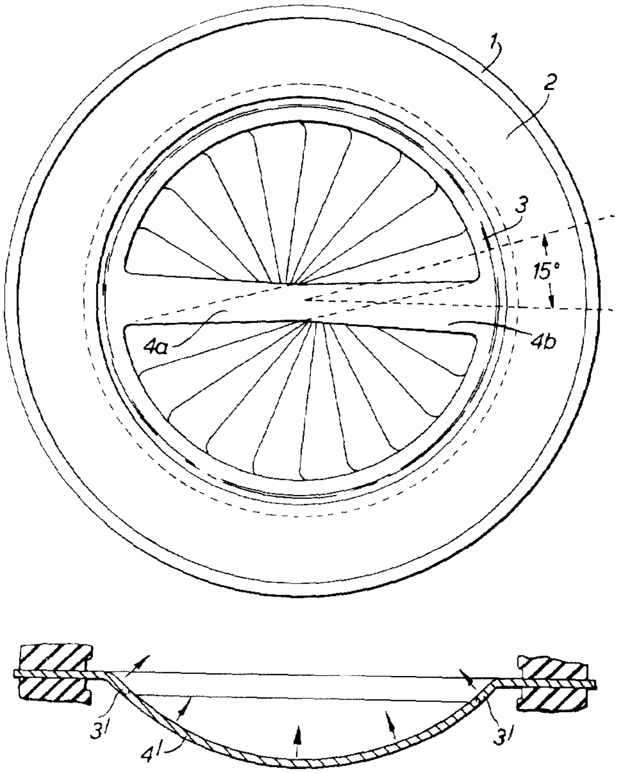
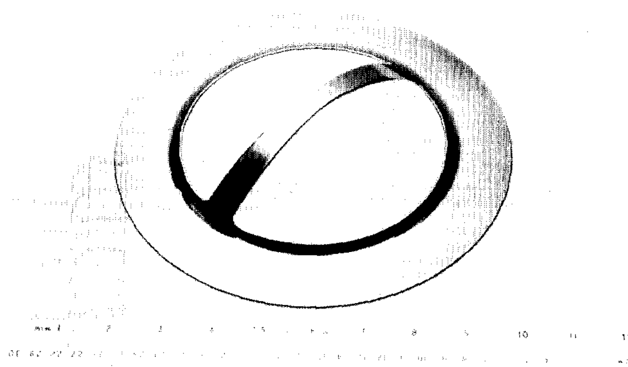
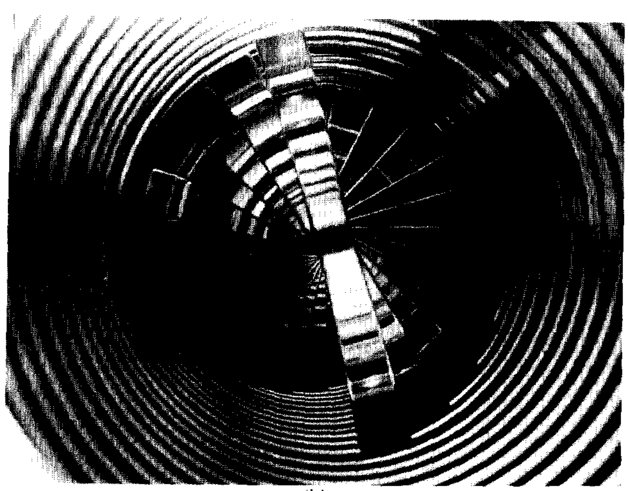


Fig. 3. (a) Electrode. (b) End View of Tube.



(a)



(b)