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THE ACCELERATOR TUBE DEVELOPMENT PROGRAMME AT DARESBUURY LABORATORY

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Résumé. — Nous présentons une revue des progrès faits à Daresbury dans le développement d'un tube accélérateur entièrement en métal et céramique.

Abstract. — A review of progress being made at Daresbury towards the development of an all metal-ceramic tube is presented.

1. **Introduction.** — The basic philosophy behind the design of the Daresbury accelerator tube has been presented elsewhere [1] but it may be helpful to restate the main aims of the systematic development programme which is going on at Daresbury. These were to achieve clean, high vacuum operation ($\sim 10^{-5}$ Pa) with freedom from hydrocarbons and good transmission of heavy ion beams through a long machine with up to 3 stripping stages. The tube gradient was required to be adequate to match an overall stack gradient of 1.3 to 2.0 MV/m (excluding major dead sections) corresponding to a terminal voltage of 20 to 30 MV.

2. **Construction.** — Early work on the development of a diffusion bonding process suitable for constructing an organic free tube was concentrated on achieving the high precision, atmospheric control and consistent materials preparation needed for reliable bonding.

The conditions necessary for bonding pure titanium to ceramic were soon established. However a harder alloy of titanium which had a better resistance to creep at high temperatures was investigated in order to achieve the dimensional tolerances required on the electrodes. This had satisfactory electrical properties but required entirely different conditions for consistent bonding. These were established towards the end of 1975 after a study of the effects on bonding of time, temperature, pressure, intermediate layer thickness, surface preparation and environment.

A submodular design, figures 1 and 2, has been adopted and these can now be routinely produced for voltage trials. Six submodules make up the standard modular length and two submodules are bonded simultaneously during one pressing operation. The

FIG. 1. — Accelerator tube submodule.

advantages of the submodular design for a development tube are obvious and it allows the inclusion between sections of apertures, field shaping electrodes or suppression magnets. The disadvantages are the multiplicity of seals and the loss of insulating length.

Difficulties were encountered in bonding end flanges directly to ceramic due to thermal expansion imbalance and a more reliable method of welding to the end electrode was developed.

Each completed submodule is leak checked before voltage testing with an external pressure of 1.033 MPa of helium.

Externally the resistance bridge and annular spark gaps are similar to those tried on the prototype titanium-glass tube described at the 1973 SNEAP Conference [2]. The resistors are metal oxide coated ceramic and have proved to be virtually trouble-free during a long series of voltage tests.

FIG. 2. — Component parts of submodule.

FIG. 3. — Accelerator tube module installed in the pilot machine.

3. Voltage Test Programme. — In parallel with the research on the construction technology a series of experiments was begun to determine the important electrical parameters of the accelerator tube. The influence of the insulator profile and geometry of the metal-ceramic junction on high voltage breakdown were studied initially in a single gap test rig. These results have been discussed elsewhere [3]. They showed, for example, that, within the uncertainties inherent in this type of measurement, a profiled ceramic appeared to offer significant advantages. These ideas were tested in individual submodules in a 1.5 MV Van de Graaff [4] and complete modules in the pilot machine in march 1976, figure 3. Both machines are equipped with sensitive diagnostic equipment including solid state particle detectors for direct monitoring of particle activity inside the tube.

Operation was possible up to the design gradient but behaviour was often erratic with high radiation levels after sparking. There were clear weaknesses in the design both internally and on the gas side of the metal — ceramic bonds where the higher stored energy had occasionally damaged ceramics in a way that had not been possible in the single gap experiments. However, further investigation of the effects of ceramic profiles, the metal-ceramic junction and surface treatments has enabled us to make significant improvements in microdischarge activity, field emission and in the ability to withstand repeated sparking without damage. The d.c. operating voltage per submodule is 278 kV and quiet operation at over 400 kV is now possible.

In october 1976 a further series of tests started on the pilot machine with more comprehensive diagnostic equipment. The vacuum system has been rebuilt and a 90° magnet of $ME/q^2 \approx 20$ has been included in readiness for eventual tests with a direct extraction duoplasmatron source. This magnet provides a useful momentum analyzer for the heavy ion components of the exchange processes in the tube which are then detected by a surface barrier detector. The latest module has operated at up to 1.8 MV and the more stable operation has made it possible to carry out a series of observations on microdischarge activity in an attempt to understand better the problems involved in going to longer lengths of tube. The magnetic rigidity and the energy of the ions are measured giving both the origin in the tube and the mass distribution of ions from the discharge [5]. Using a computer programme to plot ion trajectories it has been possible to correlate the origin of the discharge with the trajectories in the tube and to eliminate microdischarges in one module by control of the aperture geometry. This work is complemented by studies of single submodules in the 1.5 MV Van de Graaff where the normal apertures are replaced by ones which allow the ion exchange to develop without significant losses from the tube ends. The threshold voltage for the onset of microdischarges has been measured for a variety of surface finishes and cleaning procedures and this data will be used to decide the final electrode preparation for the long tube tests.

Experiments have also restarted on systems for trapping ions to prevent ion exchanges spreading

through the tube. Previous work at Daresbury has shown that traps can be made to operate but, particularly in poor vacuum conditions, the exchanges are suppressed at the expense of inhibiting the natural conditioning processes. The d.c. operating level re-

ched can then be one of unstable equilibrium and breakdowns are often quite catastrophic. However, our recent experiments on the correlation of exchange thresholds with surface preparation suggests that a satisfactory degree of control should be achieved.

References

- [1] AITKEN T. W. *et al.*, *Nucl. Instrum. Methods* **122** (1974) 235.
- [2] SNEAP 73, *Proc. of 1973 Symp. of North American Accelerator Personnel*, Brookhaven National Laboratory, BNL 19125.
- [3] EASTHAM D. A., JOY T. and GROOME A. E., *Proc. of the VI Int. Symp. on Discharges and Electrical Insulation in Vacuum* (july 1974), Swansea.
- [4] EASTHAM D. A., GROOME A. E. and POWELL P. S., *Proc. of the VII Int. Symp. on Discharges and Electrical Insulation in Vacuum* (august 1976), Novosibirsk.
- [5] EASTHAM D. A. and THORN R. - To be published.