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Résumé. — Un accélérateur électrostatique tandem pour ions de toutes sortes, y compris les ions lourds, est en construction au Laboratoire de Daresbury. Le projet est bien avancé, et un effort considérable continue d'être consacré à un programme de recherche et développement dans la technologie des accélérateurs électrostatiques.

Abstract. — A 30 MV tandem electrostatic accelerator for ions of all types, including heavy ions, is being built at Daresbury Laboratory. Construction is well advanced, and considerable effort is continuing to be devoted to an R & D programme into the technology of electrostatic accelerators.

As far back as the 1960's British universities began discussing plans for a major new accelerator for nuclear structure research. This culminated in a proposal for a large tandem accelerator, with a terminal potential in excess of 20 MV. The Science Research Council took the next step in carrying out a detailed feasibility and design study at the Daresbury Laboratory[1]. Financial approval was obtained and construction was started at Daresbury in 1974. Daresbury Laboratory is situated in the north-west of England, about 300 km from London, and roughly midway between Liverpool and Manchester.

The tandem is designed to commence operation at 20 MV on terminal and to be capable of upgrading to 30 MV. It will accelerate all ions from hydrogen to uranium, and the design incorporates provision for polarised and pulsed beams[2]. Figure 1 shows the plan layout of the building. The tandem is vertical,
Fig. 2. - Cutaway view of accelerator.

and beams are bent by a 90° double-focusing spectrometer into any one of three shielded experimental areas. Control and counting areas, and plant associated with the accelerator and experimental equipment, are housed in the laboratory block on the left of the diagram. The building has been designed, and sited with respect to land contours and the other buildings on the site, in an attempt to leave maximum flexibility for future expansion, such as long beam lines for time-of-flight experiments or the addition of a second accelerator.

Figure 2 shows a cutaway of the accelerator. The main tower and the adjacent service tower are complete, and the injection room is at present under construction. The overall height is 70 m. The pressure vessel, 45 m in height and 8.2 m in diameter, has been fabricated inside the tower and hydraulically tested. At the operating pressure of 0.75 MPa it will contain about 140 t of pure SF₆.

Focusing of the beam within the accelerator is by four sets of magnetic quadrupole triplets. An offset quadrupole triplet in the centre terminal provides charge state separation after the first stripper, and has been tested in a heavy ion beam. An intershield is used to enable high terminal potentials to be achieved while retaining a relatively small pressure vessel diameter.

Details of the column are shown in figure 3. The insulator legs are made of glass discs glued between stainless steel electrodes formed to provide annular spark gaps. Manufacture of these in the laboratory is well advanced. Charging is by means of a laddertron. Power is transmitted to alternators in the dead sections and the centre terminal by a rotating shaft. Most items for the column are already on site. The beam tube is situated centrally and is graded by a separate resistor chain.

The control system is based on a network of small computers connected to a medium-size one, which in turn is linked to the Laboratory central computer. Figure 4 shows the control system configuration and the allocation of the small computers to specific areas of the accelerator and plant. The control system within the accelerator has to operate at potentials up to 30 MV. This is achieved by using an infra-red light link, developed in the laboratory, modulated at 10 MHz. Prototypes have now operated satisfactorily in electrostatic generators for several years. All computers are now on site and operating, and the construction of the control sys-
tem is at an advanced state. Elaborate measures have been taken to protect the control system within the accelerator from the effect of surges. To reduce the effect of any failure, three separate light link systems are incorporated in the accelerator, as shown in figure 5.

Because of the many uncertainties in the scientific and technical information on how electrostatic accelerators operate, or fail to operate, the Laboratory has maintained a substantial research and de-
Fig. 6. - Pilot machine.

development programme since the design study stage. Equipment which has been developed for this purpose includes a 1.5 MV single-ended Van de Graaff, a 1 MV Marx pulse generator, methods for measuring the surges across individual components under test voltages, and a 10 MV single-ended electrostatic accelerator. The latter is known as the pilot machine, being constructed of the components as designed for the main accelerator. Its column length is 3 m. It is shown in figure 6.

The programme carried out on these facilities has covered the design and testing of components such as resistors and resistor protection, insulator materials, spark gaps, laddertron rings and insulators, protective circuits for electronics systems. Complete systems can be thoroughly tested in the pilot machine, e.g. the laddertron charging system and the power transmission system. The control system of the pilot machine is based on the components developed for the main system: computer with floppy disc, colour TV display, and modulated light-link. All these systems have been operated for many hundreds of hours with the machine running at potentials in the range 8 MV to 10 MV, with a number of tank sparks being induced every hour. This is at present the most rigorous regime available for the testing of components under severe high voltage breakdown conditions.

The question of tube development is a subject in its own right. One of the fundamental decisions taken in the early stages of the project was to avoid a tube containing organic material. To this end the Laboratory has developed a tube based on bonding ceramic insulators directly to a titanium alloy. It turns out that while glass is preferable as the column insulating material, high density alumina is more satisfactory as a tube insulator. Extensive tests have been done on single gap sections, on multiple gap units, on electrode materials by themselves, and on long insulator sections, in order to attempt to isolate the factors relating to insulator surface, electrode materials and finish, and the effects of electric field, potential difference, and vacuum in the tube. Considerable attention has been paid to the shaping of the electric field in the tube and its influence on the trajectories of secondary particles. A prototype tube of unit modular length (about 750 mm) was tested in the pilot machine, and operated reasonably satisfactorily up to the design gradient of 2.2 MV/m. The lessons learnt from this are incorporated in an improved tube now being assembled for test.

It is anticipated that tube development will continue to form an important part of the Laboratory's R & D programme for some considerable time.

References