THE HARWELL VARIABLE ENERGY CYCLOTRON

Notes for Press Visit, Nov. 9th 1966

WHAT IS THE VARIABLE ENERGY CYCLOTRON?

The V.E.C. belongs to a family of machines known as 'sector focused cyclotrons' of which there are now about twenty operating throughout the world and about the same number are under construction. There are three other smaller machines of this type in England, the pioneering 40 inch cyclotron at Birmingham, a cyclotron used for isotope production at R.C.C. Amersham and a small 'model' at the Rutherford Laboratory.

The special feature of this cyclotron is its versatility. Many machines accelerate only one or two types of particle to a fixed energy; this machine will accelerate different ions to an energy which can be varied over a wide range by changing the machine parameters. Furthermore, an attempt is being made to produce beams of particles which are very intense. These multiple requirements mean that the design is very complicated. Many features which are normally fixed, such as the intensity and shape of the magnetic field, the frequency of the accelerating field, and the position of the ion source and extractor electrodes must be made adjustable and capable of being set to pre-determined values with very high precision. One of the most difficult aspects is to choose a design and method of construction consistent with the tight tolerances required for successful operation.

The layout of the cyclotron is shown on page 3 of the accompanying reprint. Ions, of the type required, are produced in an arc discharge at the centre of the magnet gap. They are accelerated to the required energy by an alternating radio-frequency electric field, being constrained to move in spiral paths by the magnetic field. When they reach the magnet edge they are pulled out by an electrostatic extractor, after which they travel down evacuated pipes, through bending and focusing magnets into one of the three 'target rooms' where experimental apparatus will be set up.

The machine is located in a concrete vault, with walls 8ft. thick and a 4ft. roof, access to which is provided by two massive concrete doors mounted on bogies.

Ancillary rooms round the vault house a large amount of electrical and mechanical plant. For example, the radio frequency power is being provided by a 250KW radio transmitter, and some thirty independent stabilized power supplies are needed. All are controlled from a central control room. A fuller description of the machine may be found in Rutherford Laboratory Report R/85.

A SHORT HISTORY OF THE PROJECT

The first discussions about the possibility of a cyclotron designed specifically for radio-chemical and irradiation studies took place in 1958 between AERE and NIRNS (later to become the Rutherford Laboratory). In 1961 serious design work was started and Treasury approval was granted in April 1962. Many of the larger external contracts were placed during that year. The first ground for the building was broken in August.

Erection of the magnet in the partly finished building started in September 1963; installation of the transmitter started in March 1964 and the resonator arrived at the end of the year. The deflector and beam handling magnets arrived during 1965.

The first internal beam in the machine, of 25 MeV H_2^+ ions, was obtained on 16th December 1965 less than 24 hours after switching on. Further operating experience was obtained early in 1966, when other ions and energies designed to test the full range of operation were tried. After a shutdown in May - June the extractor was installed and commissioned, and the first beam was extracted on 30th June 1966. After testing the extraction over a range of operating conditions the machine was again shut down to finalize the extractor and the beam transport equipment. At the end of September 1966 the machine was again operated, and a usable beam obtained in the target rooms.

THE RESEARCH PROGRAMME OF THE V.E.C.

The machine was built primarily for use by chemists and metallurgists whose requirements for energy resolution are generally less stringent than for nuclear physics, though some experiments will be done by physicists.

Successful design of nuclear power reactors requires intensive study of the physical and chemical effects of irradiation on all the components of cores and shields - gaseous, liquid and solid. The results of specific tests in Materials Testing Reactors often require complementary experiments with accelerator beams, if proper understanding of the phenomena is to be achieved, as more precise control of irradiation conditions and more rapid build up of damage can be obtained. Studies will be made of the heavy-particle radiation chemistry of homogeneous fluids and the chemical reactivity of irradiated solids. Metallurgists will study damage in crystalline materials and effects such as sputtering, channelling phenomena and the effects of interstitial gas atoms and bubbles (e.g. of helium) on mechanical properties.

In the nuclear chemistry field, excitation functions for production of certain rare heavy element isotopes will be studied, and a small amount of production of short lived isotopes may be undertaken. The fission process, which is fundamental to nuclear energy will be examined both by measuring the independent fission yields of short lived isotopes and by angular correlation studies during fission, and by comparing the results of neutron and proton induced fission. Methods of charged-particle activation analysis will also be developed, particularly for the light elements, carbon, oxygen and nitrogen, for which neutron activation analysis is not suitable.

University and other external workers will come to Harwell to use the machine.

SOME FIGURES

Maximum Energy, protons	50 MeV
other ions (atomic weight A, charge N)	80 N^2/A MeV
Energy range	about 10 : 1
Maximum current (not yet achieved)	protons 100 μA
	heavy ions 1-10 μA
Diameter of magnet pole	70 inches
Number of independent "trim" coils to vary field shape	21
Mean magnetic field at top energy	17 kilogauss
Maximum power in magnet and trim coils	600 kW
Maximum dee voltage	100 kV
R.F. frequency range	7.6 - 23 Mc/sec.
Maximum R.F. power	200 kW
Operating pressure	2×10^{-6} mm Hg.

Maximum electric field gradient in deflector	100 kV/cm
Cost of cyclotron: capital	£660,000
R & D	£465,000
building	£500,000

LIST OF PRINCIPAL CONTRACTORS

We are indebted to the many firms who have contributed to the cyclotron by supplying various (often unconventional) components; some of the larger contributions are listed below.

Magnet:

Castings supplied by Edgar Allen, Sheffield.
Machining, ridges, and vacuum box by Foster, Yates & Thom, Blackburn.
Copper for coil conductors from Yorkshire Imperial Metals, Leeds.
Main magnet coil wound by G.E.C., Witton.
Mineral insulated cable was supplied both by Pryotenax, Hebburn and Smith (Industrial Instruments) London.
Trim coil assemblies by A.E.R.E. workshops, brazed in furnace at Edgar Allen's, Sheffield.

Power Supply:

Motor generator set supplied by Crompton-Parkinson, Chelmsford.
Solid state rectifier units from Brentfords, Crawley and Gresham Transformers, Feltham.

R.F.:

Transmitter from Marconi, Chelmsford.
Resonator from Wm. Neills, St. Helens (copper work partly subcontracted to Robinson's, Stockport).
Short mechanism and push rods by A.E.R.E. workshops.

Deflector:

Deflector construction by Graviners, Gosport.
Deflector electrodes by A.W.R.E. Aldermaston, Smith's Jig & Tool, Colnbrook and Metpresco Engineering, Feltham.
Power supply by Miles Hivolt, Shoreham.

Beam Handling Equipment:

Bending and Switching magnets by Lintotts, Horsham.
Quadrupoles by N. Taylors, Parkstone.
Moveable shield plugs by Hall Engineering, Shrewsbury.

Vacuum Equipment:

Diffusion pumps from Leybold, Cologne and Edwards, Crawley.
Roots blower, backing pumps and valves from General Engineering, Manchester.
Header valves, Fairlede Engineering, Chatteris.

Ion Source:

Ion Source, and mechanism for moving it by A.E.R.E. workshops.

Probes:

A.E.R.E. workshops.
M.C. Engineering, Parkstone, Dorset.
Moorgreen Metal Industries, Southampton.
Fairey Engineering, Stockport.

Cooling:

The cooling system was installed by Alden's, Oxford.

Controls and Cabling:

Main power cabling installed by B. French, Kidderminster.
Control cabling installed by Read and Partners, London, S.E.1.
Control room suite by Wm. McGeoch, Birmingham.
Electronic control equipment was supplied by C and N, Gosport, Calne Electronics, Chippenham, and S. Duvall, Greenford.
A.E.I. Cable Division, London.

Detail Draughting:

Portsmouth Aviation Ltd., Portsmouth.
T. D. & Tool Co., Reading.

Principal Civil Contractors:

Chivers & Sons, Devizes.

Mechanical Construction:

Geo. E. Taylor, London.

Building Services:

Robert Hudson Ltd. Leeds.
Midland Heating & Engineering Ltd. Birmingham.
Andrews Weatherfoil Ltd. Slough.