STATUS OF 224 CM VARIABLE ENERGY CYCLOTRON AT CALCUTTA

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Abstract

Present status of the 224 cm Variable Energy Cyclotron at Calcutta, with design energies of 70 MeV protons, 65 MeV deuterons and 130 MeV alphas, is described. Fabrication of the 262 ton main magnet frame and the main coils is complete and assembly of the magnet is in progress. A rapid mapper has been built for magnetic field measurements. The 400 kW rf system including the resonator tank and the oscillator power supply is nearing completion. The 400 kW main magnet power supply and the trim and valley coil power supplies have been tested. Deflector fabrication is underway. The 89 cm diffusion pumps, chevron baffles and gate valves are ready for installation. Control console has been installed and control wiring is in progress. Cooling water and other facilities are in final stages. Work on beam transport system components is underway. Unichannel-15 on-line computer system is being installed for data processing.

1. Introduction

The 224 cm Variable Energy Cyclotron, being constructed by the Bhabha Atomic Research Centre[1], is a 3-sectored AVF cyclotron, with design energies of $130\frac{Z^2}{A}$, in an advanced stage of construction and installation. Various sub-systems have been assembled and tested. System assemblies are in progress. Accelerator start up and calibration will be taken up in the next few months. Figure 1 gives the design parameters of the cyclotron.

2. Magnet

The 262 ton main magnet frame, fabricated at the Heavy Engineering Corporation (HEC), Ranchi, has been assembled at site. Figure 2 shows the assembled magnet. The magnet gap has been measured at a number of points, using an optical tilting level as well as an internal dial gauge. It is found that the deviations δ of the gap from the specified value are within 250 microns, the required tolerance, over most of the pole piece area. This deviation over the entire pole piece is shown in Figure 3. It is observed that only near the outer edge of the pole piece does the deviation exceed 250 microns.

Figure 4 shows the main coils along with the various series connections and the connections for the cooling water. All ten main coil pancakes were fabricated at the Bharat Heavy Electricals Limited (BHEL), Bhopsal.

The trim and valley coils, which are epoxy potted, are in an advanced stage of fabrication at the BHEL, Bhopal. Figure 5 shows the trim coils and Figure 6 shows the valley coils during fabrication.

The main magnet power supply, along with all the trim and valley coil power supplies, has been installed in the pit area, which is in the basement just below the main cyclotron vault. A schematic diagram of the main magnet power supply is shown in Figure 7. Input power to the supply is fed at 415 V $\pm$ 1%, 50 Hz from an on-load tap changing 33 kV/415 V transformer, through a motor control centre and the output is at 170 V, 2800 A. The current, regulated to better than 1 part in 10^4, is continuously adjustable from 10% to 100% of the rated output value. The design is based on a 12 phase, SCR controlled system; magnetic transductors are used as current sensors and a temperature compensated Zener diode, kept in a temperature controlled oven, is used for reference. All the power supplies have been tested using simulated resistive loads.

The magnetic field mapping, which is about to start, will be carried out in three stages. The first stage will consist of analog measurements, carried out using two identical search coils placed 120 degrees apart on a double armed jig which in turn is rotated on an indexing plate positioned in the magnet gap. The second stage will consist of mapping the magnetic field with a rapid mapper assembly mounted on the same indexing plate, so that the integrated output from a search coil moving in steps of 2.54 cm radially at a given angle is obtained. The rapid mapper will cover the entire magnet area in steps of 3° and collect field data at six principal current levels. The output is processed by an on-line NOVA mini-computer and recorded on both paper and magnetic tapes. The third stage will consist of obtaining detailed magnetic field maps over a large number of current settings.

3. Radio Frequency System

The radio frequency system utilizing the 400 kW RCA 6949 oscillator tube has been redesigned to give resonant frequencies in the range 5.5 - 18 MHz. Sub-assemblies and sub-systems, such as the oscillator cabinet, filament transformer, frequency synthesizer and the distributed amplifier, are ready.

The rf power supply (20 kV, 20 A DC) has been installed in the pit and its testing, using a simulated load, will be undertaken shortly.

All the rf panels, dee stem, dee, drive system and other mechanical components of the rf system fabricated at the Central Workshops, BARC, Bombay, are ready for installation. The resonator

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tank of dimensions 236 cm wide x 313 cm long x 239 cm high, made of 4 cm thick steel plates, is under fabrication at the Garden Reach Workshops, Calcutta. It is expected to be delivered soon. It is proposed to replace the RCA 6949 oscillator tube with another tube in the future and development work towards this end has started.

4. Injection, Extraction and Beam Diagnostic Systems

Figure 8 shows parts of the hot cathode PIG type ion source drive assembly, fabricated along with the drive system, at the Central Workshops, BARC, Bombay. The electrostatic deflector, having four electrodes made of Inconel and the deflector drive system are also being prepared. Some probes are ready and work on the three finger probe has started.

5. Control System

The control console has been fabricated at the Electronics Corporation, Hyderabad. It has been installed in the control room and wiring is in progress. A closed circuit television system will be installed shortly.

6. Vacuum System

Components of the vacuum system, such as the two 89 cm diffusion pumps, pneumatically operated gate valves and freon cooled chevron baffles have been fully tested and are awaiting installation. In the backing lines, two Roots pumps, other mechanical pumps and the plumbing have been installed.

7. Accelerator Services

The low conductivity water cooling system for the various magnet coils and other components is an all copper system. It is nearing completion. Compressed air system and ordinary softened water cooling system are also available.

8. Beam Transport and Data Processing

Fabrication work for the analysing magnet ($n = 1/2$, 160°) and the switching magnet is underway. Other components such as quadrupole magnets, bending magnets, collimator slits, faraday cups and wire scanners are being made at the VEC Workshops at Calcutta and Bombay. Switching magnet and quadrupole magnet power supplies have been installed after testing.

For data processing, NIM assemblies, incorporating amplifiers, coincidence units, current integrator etc. are being built at the Electronics Division, BARC, Bombay. A Unichannel -15 (PDP-15 + PDP-11) on-line computer system for data processing is under installation at present. Figure 9 shows a schematic arrangement of this system. A large computer system is also planned.

9. Research Facilities & Utilisation

Organisation of the groups for setting up a target laboratory and a detector laboratory has started. A hexagonal scattering chamber design is ready and fabrication has begun. A single gap high resolution magnetic spectrometer of the Berkeley type, a $^{7}Li(p,n)$ neutron target and an on-line mass separator are being planned. Development work has started on the ion source with a view to getting high charge states of heavy ions.

User groups from various institutions have started visiting the VEC Laboratory to prepare for utilization of the cyclotron. Some of the important fields of utilisation envisaged are nuclear physics, radiation damage material studies, radio-chemistry and isotope production.

10. Time Schedule

According to the present schedule, it is expected that the internal beam from the cyclotron will be available in early 1976. The extracted unanalysed beam will be available later during 1976 and the analysed beam in early 1977.

References

1. C. Ambasankaran and D.Y. Phadke, IEEE Tran. Nucl. Sci., NS-20, No. 3, 236 (June 1973).

DESIGN PARAMETERS – VEC CALCUTTA

BEAM		HILL GAP	19·05 cm.
MAXIMUM ENERGY	130 Q^2/A MeV	VALLEY GAP	29·97 cm.
INTERNAL BEAM CURRENT	1mA	MAX. HILL FIELD	21·1 kG.
EXTERNAL BEAM CURRENT	100 μA	MAX. VALLEY FIELD	14·1 kG.
ENERGY RESOLUTION:		**ACCELERATION SYSTEM**	
a) UNANALYSED BEAM	0·5%(FWHM)	DEE	1; 180°
b) ANALYSED BEAM (1mm Slit)	0·024%(FWHM)	FREQUENCY RANGE	5·5-16·5 MHz
MAGNET		DEE VOLTAGE	70 kV (MAX.)
POLE DIAMETER	224 cm.	**EXTRACTION SYSTEM**	
SPIRAL SECTORS	3	DEFLECTOR VOLTAGE	120 kV (MAX.)

Figure 1

Design parameters of the cyclotron

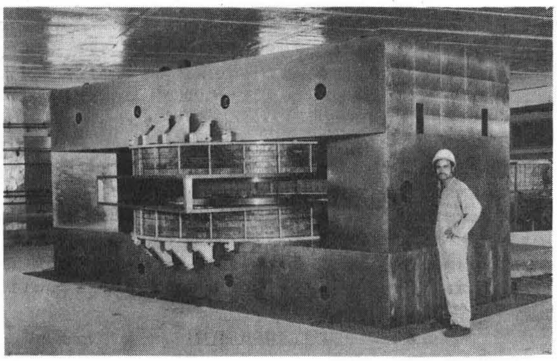

Figure 2

Assembled cyclotron magnet

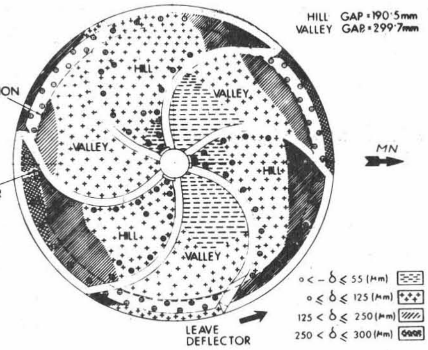

Figure 3

Measured deviations from ideal magnet gap

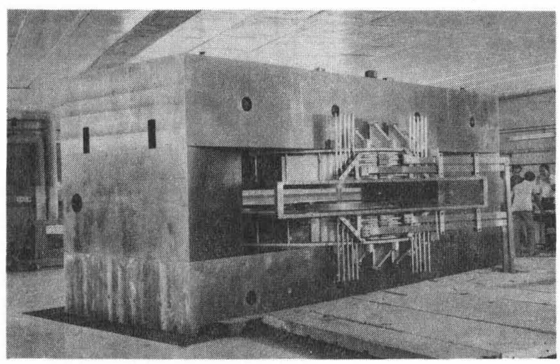

Figure 4

Assembled cyclotron magnet

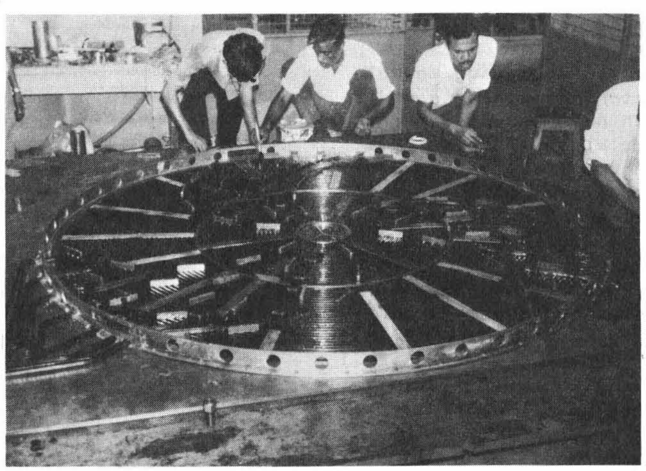

Figure 5

Fabrication of trim coils

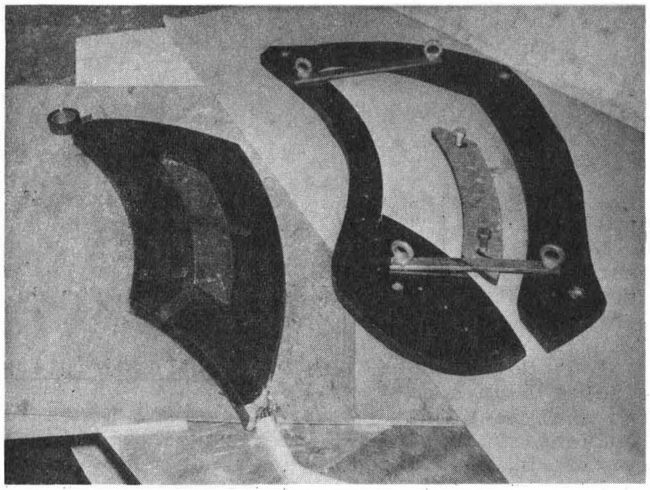

Figure 6

Layout of valley coils

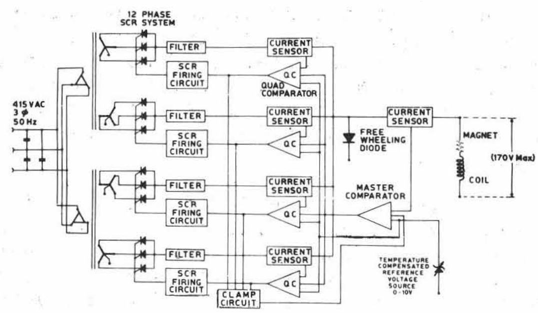

Figure 7

Schematic of main magnet power supply, 170 V, 2800 A

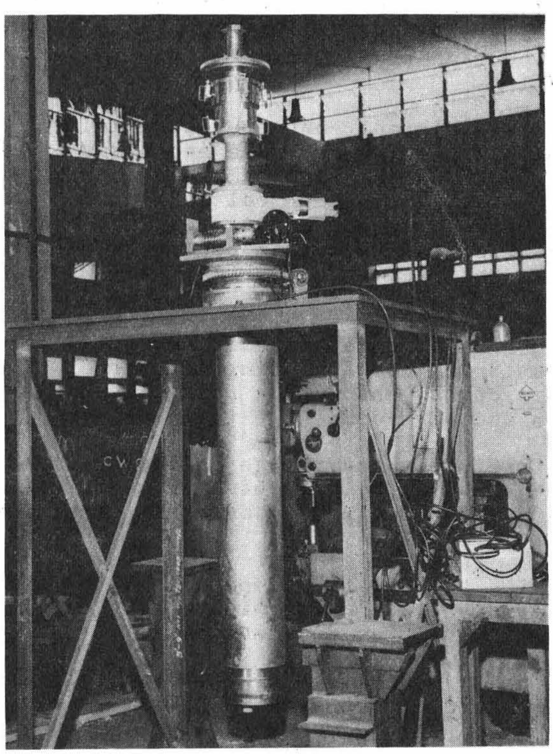

Figure 8

Ion source drive assembly

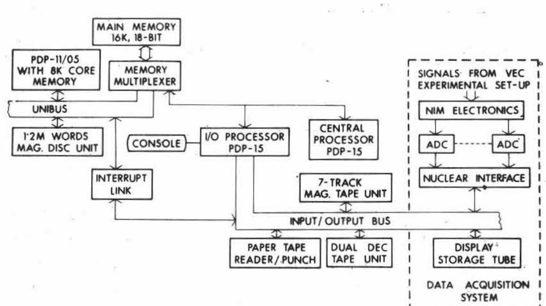

Figure 9

Unichannel-15 computer system for variable energy cyclotron, Calcutta