A.E.R.E. G/R/141.

REPORT ON VISITS TO MINNEAPOLIS, CHICAGO, ROCHESTER AND CAMBRIDGE, MASS.

U N C L A S S I F I E D.

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Report on a visit to Minneapolis,

In August 1947.

A. O. Mier had in operation several mass spectrometers of a new type. These were described in the June, 1947, issue of Review of Scientific Instruments.

The 60° deflection, all metal tubes described in that paper were being used for low and high mass work, including helium and deuterium.

The ion source was much simpler than that used in the wartime instruments; this did not reduce the resolution obtainable. Mier explained that the war-time ion source was designed with the intention of ensuring high resolution, and there was never sufficient time available to determine whether a simpler source would also produce the desired resolution.

A new tube, with a flanged collector assembly for quick interchange, was being made.

Victoreen electrometers and resistors were generally used; it was stated that these did not seem to be superior to the FP54 with IRC resistors but they were, of course, more compact. The value of resistor generally used was 10^{12} ohms, and on a good machine the noise level was a few tenths millivolt. A balanced feedback amplifier as described in the Review article, operating a pen recorder, was often used; this greatly speeded the compilation of data.

Reference potentials in the electronic stabilizer were often provided by VR tubes, which had to be well aged; the VR105 seemed to be the most satisfactory.

The gas leak, used for admitting samples, consisted of a long, .006" I.D. tube, with a preset constriction on the end remote from the sample. This was found to give freedom from fractionation even with helium; the only correction necessary was for the pumping speeds of the different isotopes through the machine. The beam was adjusted by altering the pressure of the sample in the simple glass manifold, which was evacuated when necessary by a 5 litres/second oil diffusion pump.

An attempt was being made to measure small ion currents by means of an electron multiplier. A special tube, using beryllium copper electrodes, was being developed for this purpose, and a preliminary model was being tested.

Helium Work.

A standard 60° instrument was being used to examine the abundance of He^3 in samples from the following sources:-

(1) atmospheric helium.

(2) radioactive rocks.

(3) well helium.

(4) beryl.

The helium had to be very carefully purified. Not much was known about discrimination in the ion source, but the standard source was used, with a collimating field of 150 gauss. This field was opposite to the main field in direction.

The "voltage effect" was not constant, and was very large.

The He^3 peak was swept automatically, using a recorder, and then, with a change of grid resistor, the He^4 peak was swept manually, by means of a voltage change only. Then with the original voltage (used on the He^3 peak) the He^4 peak was swept manually by means of a change in the magnetic field, followed by a manual voltage sweep, to obtain the value of the voltage correction.

The He^3 peak from an atmospheric sample was just greater than the back-ground noise when the He^4 peak was 10^{-8} ampere - the greatest current which could be obtained with helium.

Indications were that the proportion of He^3 in beryl rocks was much greater than that in samples from other sources.

"Shadow" effect:-

When an ion beam had been allowed to strike a collector plate, in double collection arrangements, for some time, passing a beam over this spot subsequently produced a dip in the collected ion current. The effect could only be removed by cleaning the plate. There was no visible deposit, and the effect was observed with all elements tried.

Hydrogen:-

Standard mixtures of hydrogen and deuterium were being prepared for analysis in a standard 60° machine. It was hoped to equilibrate the mixtures by means of a hot nickel wire, over a period of about 30 minutes.

Isotope Separation:-

A large, 60° mass spectrometer was being assembled for preparation of small samples of enriched materials. Beams of about 1 microampere were anticipated.

Several 35 feet thermal diffusion columns were also in use.

Van de Graaff.

A 5 MeV vertical pressurised van de Graaff machine, built before the war, was being put into operation under the direction of Prof. John H. Williams. Troubles with the machine seemed to be confined to "gassiness" of a porcelain evacuating tube. A scattering chamber, for an accurate investigation of proton-proton scattering had been built. A small proportional counter, with an acceptance angle of 1 degree, was fitted inside the chamber, and could be rotated to any desired angular position with respect to the beam, which was to be finely collimated and magnetically analysed for homogeneity of energy. Accuracy of 1% was desired, with ability to measure scattering of very small angle.

Williams was considering the construction of a linear proton accelerator of the Alvarez type, for 30 to 40 MeV.

Reports on visits to Chicago, Rochester and Cambridge, Mass. in August 1947.

Chicago.

Cyclotron projects were discussed with Dr. M.L. Anderson and Dr. John Marshall. The new Chicago cyclotron will be approximately 170" diameter, with cyclindrical poles, It is proposed to build the magnet of 21" thick steel plates, and the coils will be copper, square section with a circular hole, and water cooled. Copper of this section can be obtained in 45 feet lengths. It is planned to operate at a magnetic field in the neighbourhood of 18,000 oersteds.

The cyclotron will be buried underground, with 10 feet of concrete overhead. Building work has not been started, and few details have been worked out. The target date is sometime in 1950. At present, the R.F. system developed by K. McKenzie for proton conversion of the 184" Berkeley cyclotron is favoured. Protons of at least 350 MeV are expected.

Rochester (Dr. S. Barnes).

Magnet:-

At the time of the author's visit to Rochester (August 20th) the magnet was almost complete. The yoke, with 130" cylindrical poles, is made of 8 large forgings of low carbon steel. The shims, for focussing and "build-up" near the periphery, are machined on the pole tip. The coils are wound with aluminium strip 4" x 5/16" interleaved by 3 layers of paper which are painted with zinc oxide paint during winding. The conductor is in 200 feet lengths and welds are made during winding as required. Resistance welding is used, and the strip passed over the table of a milling machine, so that excess metal may be removed after welding. Water jackets consisting of sections of aluminium, in which are embedded water cooling pipes, also of aluminium are used to interleave each pair of pancakes. Insulation between the pancakes and the water jackets is provided by bakelite sheets.

Vacuum tank

The vacuum tank is a welded stainless steel structure, 28" deep, with a large port 2' by 15' to accommodate the dee assembly, and with 6 other ports disposed all around the side walls. It is on the site. Two 20" oil diffusion pumps, backed by 8" pumps, are to be used.

R.F. system

A single dee, supported by 2 short rectangular stubs each making an angle 45° with the diametral edge, is used.

The dee is not insulated from ground, and it is intended to overcome the effect of low voltage discharges by the use of a "tickler" oscillator of 1 K.W. output driving the main oscillator. Coaxial lines will connect the oscillator to the dee. Direct tappings of the inner conductors of the lines to the grounded tank liner through slots in the top and bottom surfaces of the dee will be used. The total effective line length, including the effect of the end connections and the distance between those in the tank will be one wavelength at a frequency near the middle of the F.M. range. Adjustment of this length will be provided by a line-lengthener in the plate coupling line, and an adjustable lumped capacity in the cathode line. The physical length of each line is then about $\lambda/4$. The cathode capacitor will also insulate the oscillator cathode from ground; an H.T. supply with positive grounded is to be used. The oscillator is being made by Collins Radio; four type 880 tubes in parallel, in a grounded grid circuit, will be used. A modulating condenser, with copper plated alumina moving vanes to reduce eddy current losses will be connected along the rear of the dee. The alumina discs are made by Messrs. Coors of Denver; they are very expensive. A half scale model of the system has been used for tests over a considerable period. The condenser has 38 discs, each with 9 blades, and one rotating blade of each disc is in mesh with a blade fixed to the rear of the dee. The remaining blades on each disc have a high capacity to ground, through the proximity of a plain, grounded plate. In this way, the R.F. currents flowing through the shaft, brushes and rotor mounting assembly are reduced. In the model experiments, considerable modification to the condenser had to be made in order to reduce its inductance. The model now satisfactorily covers the frequency range required for protons of 250 Mev, with a variation of about 10% in the voltage distribution across the dee at any one frequency, and a variation of about a factor 3 in dee voltage over the F.M. band. There is a large drop in voltage at one frequency in the band, attributed to a resonance in the plate line. This is not expected to occur on the full scale equipment. A VR 92 probe was used for measuring the dee voltage distribution. In August, the framework of the dee was complete, and the oscillator was almost complete. The target date for operation is the beginning of 1948.

Harvard (Professor Bainbridge).

The Harvard cyclotron will have a pole tip diameter of 95", with a pole root diameter of 112". It seems to be the only F.M. cyclotron under construction in U.S.A. with tapered poles.

The magnet is being constructed by an outside firm, and is not yet on the site; delivery is expected at the end of the year. Like the Rochester magnet, it will consist of 8 forgings, plus separate pole tips. A new building, with laboratory annexes, has been erected. The machine is to be installed above ground, in a room which has concrete walls and roof several feet in thickness.

The wall towards which the beam is expected to emerge has a large removable section; outside this wall there is an open space about 200 yards in length.

Cooling water is to be obtained from a well; a pipe has been sunk for this purpose.

Vacuum tank;-

The vacuum tank has the conventional square shape, with large removable cover plates on all four side-walls. It is a welded structure of non-magnetic steel. A single 20" oil diffusion pump, backed by an 8" pump and a Kinney mechanical pump, will be used. A larger Kinney pump will be used for roughing purposes.

R.F. System

A single dee will be supported by two coaxial shorted stubs, perpendicular to the diametral edge. The rotating condenser will be connected to the rear of the dee, between the stubs. The long coupling lines (similar to those at Rochester) will be tapped directly onto the inner conductors of the stubs; the plate line will have a "trombone" section and the cathode line an adjustable series capacity. Thus the system is electrically equivalent to that used at Rochester; on account of the use of circular section stubs external to the vacuum tank, however, the maximum frequency obtainable does not correspond to the highest flux density obtainable from the magnet. For this reason the proton energy will be about 130 MeV, as against the 170 MeV of which the magnet is capable.

There is a half-scale model of the R.F. system. This, like the model at Rochester, is accurately made, and includes for example, all the projections incidental to the mechanical design of the full-scale dee. The design data for the rotating condenser and coupling lines have been obtained by means of measurement on the model.

A single 9C21 triode is to be used in the full-scale oscillator.

<u>Deflection of the beam;</u>

Plans, which were made some time ago, for a 3-section deflector and septum to be fitted inside the dee, have beentemporarily abandoned. In view of the difficulty experienced at Berkeley on account of the beam "blow up" at n=0.2, it has been decided to make measurements on the circulating beam before attempting to design a deflection system. It is possible that a pulse technique, similar to that developed at Berkeley may be used.

The same decision was made at Rochester.