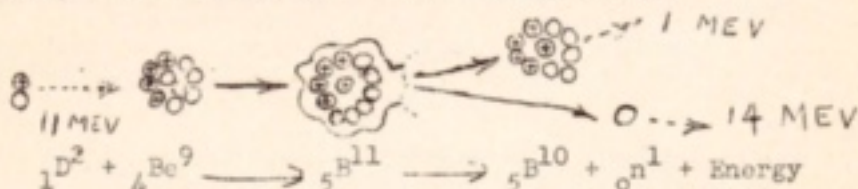


The energy of hydrogen ions (protons) and helium ions (alpha particles) produced by this cyclotron in MEV (million electron volts) is shown in Fig. 2. Deuterons (heavy hydrogen) of mass 2 are normally accelerated in this enlarged cyclotron, and the emergent beam energy at present is about 11,000,000 electron volts or 11 MEV. Under these conditions 22 MEV helium ions or 5.5 MEV protons may be produced without changing the frequency.

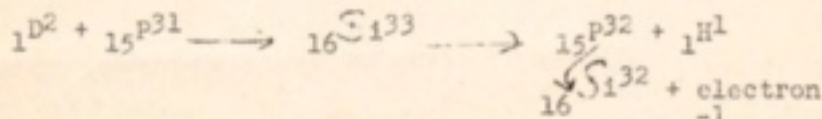
Nuclear Transformations: The beam of high energy deuterons may be used to bombard targets of various elements to produce nuclear transmutations. Such targets must be effectively water-cooled so they will not melt or be volatilized by the intense atomic ion beam. The central core or nucleus, which must be struck, is only about one ten-thousandth the diameter of the atom itself, so an atom is largely open space and the chance of hitting a particular nucleus is extremely small. However, since the high speed deuteron may go through many millions of atoms before being stopped, in some cases as much as 1% of the projectiles may score direct nuclear hits on target atoms.

The incident particle is usually captured by the struck nucleus and a highly excited compound nucleus formed. This compound nucleus is generally so unstable that it gives up its excess energy quickly and finds at least temporary stability by ejecting a high energy neutron or other particles, often accompanied by high energy gamma rays.

To produce intense neutron beams, beryllium is bombarded by deuterons, boron is produced momentarily, but it is unstable and breaks up, ejecting a high speed neutron and leaving boron of atomic weight 10 as a result of the transmutation.



Radioactive Isotopes: Often the residual nucleus is still unstable, or artificially radioactive, and later ejects an electron or positron before finally settling down as a stable atom. For example, to make radioactive phosphorous, widely used in biological work as a tracer and for therapy, the following reaction occurs.



Ordinary phosphorous of atomic weight 31 is bombarded with deuterons, forming silicon³³ momentarily. This ejects a proton leaving a phosphorous isotope of weight 32 which is artificially radioactive and has a "half-life" of 14.3 days. In 14.3 days, half of the active p³² atoms produced have emitted high speed electrons or beta ray and become ordinary stable silicon 32 atoms. (energy 1.7 MEV)

MAIN CYCLOTRON ROOM - Room 128 Pupin

The Columbia cyclotron has now been enlarged to increase the energy of the emergent ions and also the ion beam currents. The magnet has been improved with new cores and coils. A new accelerating chamber has been installed. This new construction has been made possible by the University, by the Research Corporation, by the American Cyanamid Co., and by many firms who have assisted in the construction. WPA workers have materially aided the progress.

I. MAGNET:

Total weight of steel, now 85 tons. Yoke formerly used in Poulsen Arc Transmitter at Naval Radio Station, Annapolis. Constructed by Federal Telegraph Co.

Yoke: Approximately 13 feet long and 10 feet high, base under floor.

New Pole Pieces and Cores: Armco Iron, machined by Mosler Safe Co. 44 inches diameter at bases tapered to 36 inches diameter at gap. Total gap 7.25 inches.

New Copper Coils: Approximately 13 tons. Mounted in two aluminum tanks. Replace older 5.5 ton oil-cooled coils.

Field Exciting Coils: 16 pancake coils, each 128 turns of 0.1" x 1 1/2" copper strap. Diameter 6'5". Weight of each 1,275 pounds. Linen tape insulation. Operated as two banks in parallel, each of 8 coils in series. Approximate resistance of each bank 1.08 ohms, 0.54 ohms when in parallel.

Water Cooling Coils: 16 flat coils 6'5" diameter, wound of rectangular section copper tubing 1/2" x 3/8". Assembled alternately between exciting coils with fibroid insulation. Coils fabricated by Metropolitan Device Corporation.

Performance: Produces fields as high as 19,000 gauss in 7.25" air gap. 150 KW may be dissipated continuously. Present operation 16,500 gauss, 150 volts, 280 amperes (42 KW) input.

Field Stabilization: The magnetic field must be held within about + .03% to maintain synchronism with the frequency of the spiralling ions. A vacuum tube inverse feed-back amplifier automatically controls field excitation of the 150 KW motor-generator unit in E 129 which supplies the magnet coils.

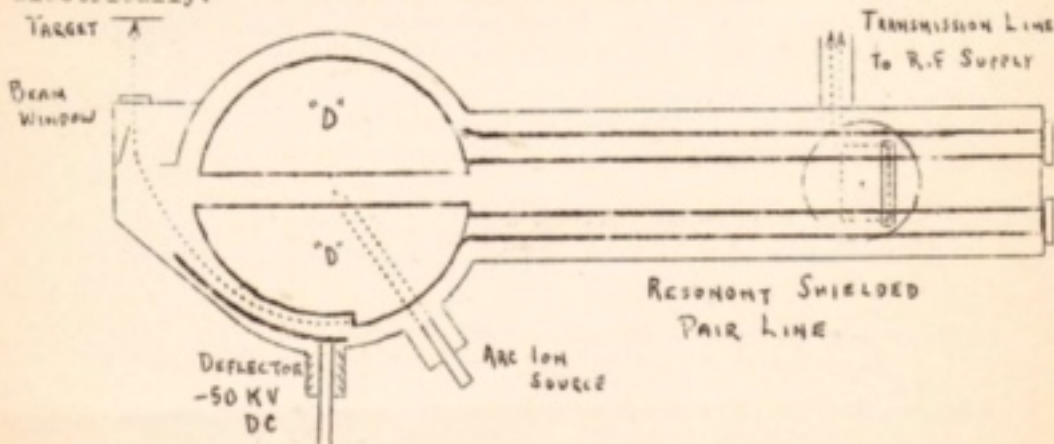
II. HIGH FREQUENCY SYSTEM

The Columbia cyclotron employs a number of new developments in the system for charging the accelerating electrodes at frequencies of 10 to 25 megacycles. Present operation: 24 meters wave length or 12.5 megacycles.

Radio-Frequency Power Source, Room 129: A master oscillator power amplifier system is utilized in which two Western Electric 240-A (10 kilowatt) water-cooled tubes are used to drive two Western Electric 298-A (100 kilowatt) tubes. The 100-kilowatt tubes are operated with the grids grounded, the filaments being excited. Efficiencies of about 65% are secured up to 20 m.c.

Transmission Line: R.F. power is fed from power-amplifier in Room 129 to the large resonant cyclotron chamber line in Room 128 by small non-resonant "shielded pair" transmission line. Characteristic impedance is approximately 160 ohms. Inductive coupling employed.

Cyclotron "Shielded Pair" Resonant System: The two accelerating electrodes of "D's" are supported on the ends of the two inner conductors of the large "shielded pair" resonant line, so that the electrodes are in effect at the high voltage ends of loaded quarter wave lines. The "Q" of this system is approximately 5000. In the original Columbia cyclotron, each "D" was supported on the end of the inner conductor of a concentric line. The present system is mechanically simpler and in some respects better electrically.



This system offers many advantages: Higher efficiency, low radio frequency resistance, high electrode voltages, higher frequency operation, elimination of high voltage insulators, complete shielding, as well as other electrical and mechanical improvements. Potentials of 125,000 to 175,000 volts between the "D's" may be obtained with this unit. About 50,000,000 circulating volt-amperes are present in the line-electrode system during operation.