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Rutherford Memorial Lecture, 1963 The industrial development of nuclear power

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Extract

Twenty-five years ago Lord Rutherford prepared his Address as President of the 1938 Session of the Indian Association for the Advancement of Science at a time when nuclear physics was moving rapidly forward. New disintegrations produced by *α*-particles and by charged particles accelerated in high-voltage vacuum tubes and cyclotrons were being discovered with great frequency, and neutrons, especially slow neutrons, were being used to produce radioactive isotopes of many of the stable elements. By 1937 nearly a hundred of such isotopes had been discovered and Fermi and others has shown that the heaviest elements, uranium and thorium, after absorbing slow neutrons underwent a succession of *β*-disintegrations so producing elements of higher atomic number; these, Fermi called the ‘transuranic elements'. Rutherford’s Address on the ‘Transmutation of Matter’ briefly reviewed the great discoveries of the previous forty years in which he had played probably the leading role. In the first decade the transmutations of the radioactive elements were discovered, revealing ‘a new and startling subatomic world where atoms break up spontaneously with an enormous release of energy quite uninfluenced by the most powerful agencies at our disposal’; in the second decade his nuclear theory of atomic structure was born and had become generally accepted; ‘it was evident’ he said ‘ that to bring about the transmutation of an atom it was necessary in some way to alter the charge of the mass of the nucleus or both together’; and in the third decade Rutherford achieved this transformation by firing *α*-particles into nitrogen gas and observing that occasionally hydrogen nuclei endowed with very high velocity were produced—the *α*-particle had entered into the nitrogen nucleus to form a compound unstable nucleus which instantly broke up with the emission of a fast proton, leaving behind an isotope of oxygen, having a mass of 17. About a dozen of the light elements could be transformed in a similar way, and in a few cases the energy of the proton and the recoil nucleus exceeded the energy of the incident *α*-particle. At the end of this third decade Rutherford spoke, in his Anniversary Address as President of the Royal Society on 30 November 1927, of attempts to produce intense magnetic fields and high voltages for general scientific purposes. Dr Coolidge, the director of the General Electric research laboratory had constructed a variant of the Coolidge X-ray tube, fitted with a thin metallic window through which fast electrons could stream out into the air, as Lenard had shown thirty years earlier at a much lower voltage. I read Coolidge’s paper as a research student and as I had had a little experience with high voltages when employed in the research department of the Metropolitan-Vickers Electrical Company, I wrote to Rutherford to ask if I might be admitted to the Cavendish Laboratory to try to accelerate electrons to very high voltages with the object of looking for transmutations by energetic electrons. The M. -V. Co. through the good offices of the then director for research, Mr A. P. M. Fleming, offered me a Tesla transformer which could generate up to 600000 V, and with this in the Cavendish Laboratory I learned how to construct vacuum tubes which could withstand about 450000 V in air, and 600000 V when placed under oil. Intense beams of 1 mA of electrons electrostatically focused through a slit orifice in the discharge tube were obtained and were deflected in a magnetic field to obtain a roughly monochromatic beam for scattering experiments. A short time after I began, E. T. S. Walton came to the Laboratory and tried to accelerate electrons by indirect methods, using a rapidly rising magnetic field—a method which later became known as the betatron—and in both these attempts we received great encouragement from ‘The Prof. ’, for he was very hopeful of obtaining copious streams of high-speed electrons and atoms, by one way or another, ‘which have an individual energy far transcending that of the *α*- and *β*-particles from radioactive bodies’. At that time, although only *α*-particles had produced disintegrations, there was no known reason why high-energy electrons should not also enter nuclei and the Prof. was a firm believer in ‘try anything once, and see’. He did recognize that there would be formidable difficulties in obtaining particles having energies of many millions of electron volts but he always hoped that some reactions might be discovered with particles of more modest energy if the supply of them was great enough.

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