CURRENT SCIENCE—50 YEARS AGO

PROF. E. O. LAWRENCE*

ERNEST ORLANDO LAWRENCE, who has won the signal distinction of a Nobel Prize for Physics for 1939, began his research career at the University of Chicago in the year 1924, under Professor Swann, on the photo-electric effect in potassium vapour as a function of the frequency of light. With Prof. Swann, Lawrence moved to the University of Yale where he completed these investigations which formed the subject of a dissertation for his Ph.D. degree. In 1928 Lawrence migrated to the University of California at Berkeley and there he is now continuing his investigations which have brought him fame and the approbation of the scientific world. Much of Lawrence's earlier work was concerned with studies of photo-electric phenomena. It was in 1931 that Lawrence began to tackle the problem of production of high speed ions. R. Wideroe had by then suggested an apparently simple method of producing high voltage ions using only relatively low applied voltages, and had himself succeeded in obtaining $50{,}000^{v}$ potassium ions in a tube to which a maximum voltage of half that value had been applied. Lawrence took up the idea and improved upon it with perseverence and ingenuity.

The principle of the method of Wideroe as at first developed by Lawrence is as follows: A series of cylindrical electrodes arranged along the length of an evacuated tube are attached alternately to either terminal of the inductance of a high frequency oscillatory circuit. A high frequency voltage applied in this manner, produces at any instant, electric fields of opposite direction and equal magnitude between successive electrodes. If at any one instant an ion finds itself between the first and second tubes it will be accelerated into the second tube, and if the time consumed in passing through the field-free space inside this tube is equal to the half period of the oscillator, the ion will arrive between the second and third tubes, with the field reversed in direction in such a manner that it will receive an additional acceleration while passing into the third tube. If the tubes are made successively longer to take account of the increasing velocity of the ion, for every frequency of applied oscillations there will be a corresponding voltage applied such as will cause the ion to move up through the series of tubes in synchronism with the oscillating field, gaining between each pair of tubes an increase in kinetic energy corresponding to the applied potential difference. Sloan and Lawrence showed that by the above method they could produce mercury ions of 1,260,000 volts using 30 accelerator brass tubes and a high frequency voltage of 42,000 on a wavelength of 30 meters.

The difficulty with the above type of apparatus is that the lengths of the accelerator tubes used towards the end of the path become very large even for heavy ions like Hg ion and the whole apparatus becomes inordinately long. To overcome this difficulty Lawrence conceived the idea of bending the path of the ions into circular orbits by a magnetic field and thus the first 'cyclotron' was born. In this device the electrodes in the form of semicircular hollow brass plates are mounted with their diametral edges adjacent in a vacuum and in a uniform magnetic field perpendicular to the plane of the plates. An oscillating electric field is produced by high frequency oscillations applied to the electrodes in the diametral region where ions are accelerated. They then describe semi-circles inside the electrodes, the time taken being arranged to be a half period of the oscillations. When they re-emerge into the diametral region they are again accelerated and then describe second semi-circles. Repetition of this process gives the ions very high velocities. The focussing action of the electric and magnetic fields gives narrow intense beams. Using a magnet with pole faces 11 inches diameter a narrow beam of current of 10^{-9} amperes consisting of protons of 1.22×10^{6} volts velocity has been obtained from a maximum applied voltage of 4,000.

In 1934, Lawrence and Livingston constructed an improved and larger apparatus of the above type, and attained a maximum speed of the hydrogen atoms corresponding to 5,000,000 electron volts the ionic current being 1/3 microampere.

Lawrence and Cooksey have recently described their latest cyclotron called also 'magnetic resonance accelerator'. The pole faces of the magnet are 3½" apart and have a diameter of 27½" although the

*Published in *Curr. Sci.*, 1939, 8, 544.

actual effective diameter of the pole faces is 42". The atomic beams can be led out into the air through thin platinum windows and their range amounts to several centimeters in air. A still larger cyclotron is now in the making.

When high speed deuteron streams are made to fall on berylium atoms, streams of neutrons are produced so powerful in their biological action that they are equivalent to the gamma radiations from 100 grams of radium. Accordingly, for the protection of the operator, the cyclotron is controlled from a distance of 40 feet from the apparatus with suitable intervening absorbing materials. With the deuteron streams, Lawrence has produced radioactive isotopes of many of the different elements known in the periodic table. In many cases the yields of the radio-active substances are quite large; as for example, a day's bombardment of sodium metal with 20 micro-amperes of 5 million volts deuterons produces more than 200 milligrams equivalent of radio-sodium, i.e. an amount of radio-sodium having a γ-ray activity equivalent to that of 200 milligrams of radium. That such large amounts of radio-active forms of many of the elements can be manufactured in the laboratory is of immense importance in opening up new avenues of research both in the physical and in the biological sciences. Many striking results have been obtained by Lawrence himself and his co-workers, while of course, similar work on nuclear transformations is being carried out in different physical laboratories of the world by other methods as well. But the cyclotron holds a unique position in that it can provide very large yields and possesses potentialities of even greater developments which stagger the imagination of the world.

Most of Lawrence's researches were encouraged by substantial public support. The Federal Telegraph Company donated the steel castings of the magnet. The Research Corporation and the Chemical Foundation provided funds for the construction and installation of the magnet and accessory apparatus, while the operating expenses were met by the University Research Board. But above all it was the genius and the single-minded devotion of Prof. Lawrence that overcame all the practical difficulties and brought to a very successful fruition an idea that must well nigh have looked fantastic when it was originally conceived; no wonder, the world applauds.

B. DASANNACHARYA

Benares Hindu University,
November 20, 1939.

SEDOV ARCTIC EXPEDITION*

THE Second Anniversary of the drift of the Soviet ice breaker 'Sedov' fell on the 23rd October. The drift of this breaker which bears the name of the celebrated arctic explorer, Georgi Sedov, began on October 27, 1937, in the Laptev Sea at 75° 19′ N lat. and 132° 25′ E long. The bearings on October 20 were 80° 36′ N lat. and 26° 12′ E long.

From the astronomical and meteorological data collected, it has now been established that the ice moves along isobars. This conclusion is of much practical significance, for from the data relating to the distribution of atmospheric pressures in the Arctic basin it would be possible to determine the shift of sections of ice in the central Arctic region. The hypothesis that ice moves from East to West under the influence of winds in a circular clockwise direction, with its centre near the 'pole of inaccessibility' situated between 83° and 85° N lat., first enunciated by the Russian Arctic Expedition, headed by Toll in 1900–03, has now been confirmed. The cause for such a remarkable phenomenon is the existence of more or less permanent stretches of open water or fissures in the region north of Greenland and north of the New Siberian Islands and Wrangal Island. The depth soundings taken by the Sedov showed that at 86° 26′ N lat. and 39° 85′ E long. the depth was greater than 5,180 meters.

*Published in *Curr. Sci.*, 1939, **8**, 545.

Edited and published by Prof. S. Ramaseshan, Current Science Association, Bangalore 560 080.
Typeset and printed at Book-Makers (I) Pvt. Ltd., Bangalore 560 003.