ION DIFFUSION UNIT

Staff

Head of Unit:	Emeritus Professor L.G.H. Huxley, M.A., D.Phil., F.Inst.P., F.A.A.
Senior Fellow:	R.W. Crompton, B.Sc., Ph.D.
Research Fellows:	M.T. Elford, B.Sc., Ph.D. J.A. Rees, B.Sc., Ph.D.
Research Scholars:	J.J. Lowke, B.Sc., Dip.Ed. R.L. Jory, B.Sc.

General

The progress made by the Unit during the past year reflects the emergence from the purely developmental stage which occupied the greater part of 1961. A large amount of this kind of work has continued in the acquiring and perfection of techniques suitable for use in ultra-high vacuum work which will become increasingly more essential for the work of the group as a whole in the future. Development has also continued of techniques aimed at preparing surfaces of uniform work function, the need for which has become increasingly apparent throughout the year. The work of the group has been accelerated in several directions by the use of the 1620 electronic computer which has proved invaluable.

Research Program

In addition to the research program outlined in the report for 1961, a decision was made during the latter half of the year to re-open the work on electron attachment in view of the increasing interest shown overseas in this topic. This decision necessarily slowed progress in some other aspects of the program but has produced some results of great interest. Progress made in the various investigations is outlined below:

(i) Determination of electron and ion energies near thermal equilibrium.

Progress on this project has been slow, partly because of the necessity to record time variations in the anomalous

results obtained and partly because each modification to the electron tube involves a considerable amount of time. Nevertheless it has been established beyond doubt that non-uniformity of the work function of the surfaces exposed to the electron beam is responsible for the inconsistencies recorded in the experimental results. This conclusion was reached by a consideration of the indirect evidence afforded by the electron tube itself and confirmed by direct measurement of the contact potential differences existing over gold surfaces prepared by the same methods as those used to prepare the surfaces within the electron tube. The search for a method of preparation to meet the somewhat stringent requirements, including an extensive investigation of surfaces prepared by vacuum deposition, has so far met with little success.

(ii) Drift Velocities of Electrons.

The systematic investigation of all sources of experimental error in the drift velocity determinations using the method of Bradbury and Nielsen has been completed. This investigation included an examination of the influence of gaseous impurities by determining the change in the drift velocity when known amounts of impurity were added to the gas sample. It has been shown that although traces of hydrogen and nitrogen have little effect on the drift velocity, the results are extremely sensitive to the presence of traces of water vapour.

Measurements have been made of the drift velocity in pure hydrogen and nitrogen at room temperature and at the temperature of liquid nitrogen. In the final results that have been obtained, account has been taken of the influence of diffusion analysed earlier and the accuracy of the results is considered to be, in general, 1%. Results have also been obtained in mixtures of hydrogen and nitrogen where the percentage of hydrogen ranges from 0 to 100%.

The theoretical analysis of the effect of diffusion has been developed more fully. An expression has been obtained for the error introduced in drift velocity measurements due to

the variation of the electron energy within an electron pulse. An expression has been derived for the resolving power appropriate to the current peaks obtained using the method of Bradbury and Nielsen and this expression has enabled an independent estimate to be made of the energy of electrons in the experiments that have been conducted in water vapour.

(iii) Velocity Distributions

Developmental work associated with the determination of drift velocities by the methods of Bradbury and Nielsen and of magnetic deflection is in progress. During the year an extensive survey of the values of the ratio W/D (i.e., the drift velocity to diffusion coefficient) was made to verify that the method was capable of producing results to better than 1%. The following sources of error were investigated: finite size of the source of electrons, misalignment of the apparatus and the alternative formulae for the distribution of electron concentration in the diffusion apparatus. The method was further checked by taking measurements over a wide range of pressures using an apparatus whose geometry could be varied greatly.

(iv) Mobilities of positive ions

Since the emphasis in these measurements is on cleanliness and gas purity, work has continued on the appropriate techniques for the assembly and evacuation of the experimental tube. The ultra-high vacuum system has been completed and can achieve pressures of the order of 10^{-9} mm Hg. Techniques for supporting the electrode assembly have been devised and after some difficulties a method was found which would enable grids to be constructed capable of withstanding large temperature variations. To enable components of the electrode system to be degassed before assembly an electron beam heater was constructed. This unit has operated at powers up to 260 watts and has been used to perform vacuum brazing. Some development work has been done on the design of a combined mobility apparatus and mass spectrometer which would enable the particles whose speeds

are being measured, to be positively identified.

(v) The attachment of electrons in water vapour.

A series of simultaneous measurements of the Townsend energy factor, k_1, and of the coefficient of attachment, α_a, for electrons in water vapour has been made, using the IBM 1620 computer to analyse the experimental data. The results of the investigation showed marked differences from the results of other workers and these differences have not yet been satisfactorily explained.

To clarify some of the features of the attachment work, the drift velocities of free and attached electrons in water vapour were studied using a Bradbury and Nielsen shutter apparatus. The results obtained for free electrons are in reasonable agreement with those found by one other group of investigators, while there is no published data on the drift velocity of attached electrons in water vapour.

From the examination of the drift velocities of the free electrons, it was concluded that the mean energies of the electrons were considerably lower than those observed in the work on attachment. Further experiments were therefore carried out using two new pieces of apparatus, one of which was a Bradbury and Nielsen shutter apparatus combined with a diffusion apparatus while the second was a magnetic deflection apparatus. Both experiments have provided valuable additional information but it is not yet possible to explain fully the original results. Work on the project is continuing.

Publications

Crompton, R.W., Elford, M.T. - "On the use of Palladium osmosis tubes." J. Sci. I. 39, 480, 1962.

Huxley, L.G.H., Crompton, R.W. - "The motions of slow electrons in gases." Chapter 10 of "Atomic and Molecular Processes", edited by D.R. Bates. (Academic Press, 1962.)

Lowke, J.J. - "Errors due to diffusion in drift velocity measurements." Aust. J. Phys. 15, 1, 39, 1962.