use of reception techniques, which are several orders of magnitude more sensitive than those used in other radio services.

The radio astronomer continues to improve his reception techniques, aerial systems and receiving apparatus, in order to obtain the utmost sensitivity for recording the very weak signals forming the various radiations he is studying. The conduct of this work involves him in the development and construction of very expensive equipment, and it is important to ensure that the use of this apparatus should not be unduly impaired by interference from other radio services.

In order to pursue his scientific research successfully, the radio astronomer seeks protection from interference, first, in a number of bands of frequencies distributed at approximately harmonic intervals throughout the spectrum; and secondly, more complete and specific protection for the exact frequency bands in which natural radiation from, or absorption in, cosmic gases is known or expected to occur. An example of the latter is the emission line of hydrogen at 1,400–1,427 Mc/s, which is already given an exclusive allocation in the existing Radio Regulations (1959). In all other cases in these Regulations, reference to frequencies for radio astronomy is made on a basis of sharing with other radio services. What is now sought is an improved measure of protection for a number of these frequencies distributed throughout the spectrum, from the guard bands associated with the standard frequencies of 2·5, 5, 10, 15, 20, and 25 Mc/s, to a number of other frequencies at or near the values of 40, 80, 150, 408, 610, 2,700 and 5,000 Mc/s. The widths of the bands in which, so far as practicable, an exclusive allocation is desired at these frequencies, range from 0·5 Mc/s at the lower end to 10 Mc/s at the upper end of the spectrum. In addition, and to provide for future developments in research, it is requested that radio astronomy should be regarded as a primary service in four higher regions of the spectrum at 10·6, 15·4, 19·4 and 31·5 Gc/s, where bandwidths ranging from 0·1 to 0·3 Gc/s are suggested as being necessary for the efficient pursuit of research with the most advanced type of apparatus at present available.

Space Research

The need of the space research scientist for protection of radio frequencies is somewhat different from that of the radio astronomer. Some satellites are already in use for direct application to the extension of world-wide communications. Many other satellites are, however, being placed in orbit around the Earth with the view of extending our knowledge of the upper atmosphere at increasingly great heights, and to measure various physical quantities in outer space, such as solar radiation, cosmic rays, and the density and orbits of electrons trapped in belts determined by the Earth's magnetic field. In some cases the frequencies required here are for control of instruments in the satellite or for locating it during its orbit, and, in such instances, the frequencies could be conveniently shared with the corresponding requirements of, say, communications satellites. But, bearing in mind the inaccessibility of the scientific equipment carried in the space vehicle and the need to use the measuring equipment for the maximum proportion of the available time, it is important that the results of the scientific measurements can be communicated to the ground controlling station or laboratory with the minimum of delay or interference. It is thus desirable that a number of bands of frequencies in appropriate parts of the spectrum should be allocated, without danger of interference, to the needs of scientific research being conducted with the aid of satellites in orbit.

At the recent meeting of the International Committee on Space Research (COSPAR) in Warsaw, the following general resolution was adopted. "Considering that the transmission of data from space vehicles to the ground is essential to the use of such vehicles in space research, COSPAR recommends that through IUCAF every effort should be made to guarantee the continued allocation of suitable frequency bands for this purpose."

While in some cases frequencies required by those concerned with communications by means of satellites can be shared with the scientist interested solely in scientific measurements, in many instances it is desirable to have separate allocations, so far as is practicable, in order that the elaborate and expensive equipment used in space research can be used to the utmost extent. It is thus desired that bands at approximately the following points in the spectrum should continue to be available for the purposes of space research on at least a primary, if not on an exclusive, basis: 136, 400, 1,427, 1,700 and 2,300 Mc/s, and 5·2, 8·5, 15·2 and 31·5 Gc/s. A number of other frequencies are also required for tracking and controlling satellites and for communication and telemetry services; but in some or most of these cases the actual frequency bands may be allocated on a shared basis among the various users.

Conclusion

It will be seen from the foregoing brief survey that the rapidity with which advances in both radio astronomy and space science are taking place at the present time renders it most important that careful consideration should be given to the allocation, on either an exclusive or on a primary basis, of various bands of frequencies within the radio spectrum. The forthcoming Conference at Geneva will have the most difficult task of debating the claims of the various users, anxious to advance radio astronomy and space science as well as the practical operation of world-wide communications by means of Earth satellites. But it is the decisions and recommendations of this Conference that will determine the ease with which scientists will be able to pursue their work with the maximum degree of protection from interference from other radio services.

OBITUARIES

Prof. E. D. Hughes, F.R.S.

The untimely death in London on June 30, after a short illness, of Prof. E. D. Hughes, head of the William Ramsay and Ralph Forster Laboratories, and professor of chemistry in University College, London, deprives British science of a man of wisdom and authority at the height of his powers.

Edward David Hughes was born on June 18, 1906, of a farming family in Criccieth. He studied chemistry at the University College of North Wales, at Bangor, under Prof. K. J. P. Orton, whose pioneering work in mechanistic organic chemistry inspired his early enthusiasm for this field. His first scientific papers, on kinetic aspects of keto-enol tautomerism, were published with Orton and with H. B. Watson. He took a Ph.D. degree of the University of Wales in 1930, and in that year he joined Prof. C. K. Ingold in the Chemistry Department of University College, London, as a post-doctoral Fellow. In 1936 he became Ramsay Memorial Fellow, and then successively assistant lecturer and lecturer on the staff of that Department. This period marked the beginning of the long scientific collaboration which, continuing as it has until his death, is almost without parallel in the history of English science, and inextricably links the names of Hughes and Ingold as the foremost contributors

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to a change in approach to organic chemistry, which now is manifest both in the terminology and teaching of the subject, and at the forefront of progress in the field.

His first investigations at University College, London, were in the field of nucleophilic displacement and elimination reactions. The simple concept that several limiting mechanisms for such reactions could be identified and characterized kinetically led quickly to the recognition of fundamental patterns of behaviour which until then had been obscured by apparently conflicting observations. Perhaps the major triumph of this period was the elucidation of the main factors determining whether racemization, retention or inversion accompanies nucleophilic displacement at a saturated carbon atom—the problem of the 'Walden inversion'. His brilliant reviews in the *Discussions of the Faraday Society* in 1937 and 1941 still provide the fundamental basis of any mechanistic account of these reactions. They anticipate also many of the later developments in this field; stereochemical, structural and environmental factors, determining the course of these reactions and the rearrangements which can accompany them, are all discussed in these early summaries, though the elaboration of details required many years of later investigation, to which he and his associates no less than other workers in the field have since contributed.

From 1939 he was one of a very small staff maintaining the Department of Chemistry of University College, London, through its evacuation to Aberystwyth and Bangor. In 1943 he was appointed to the chair of chemistry in the University College of North Wales at Bangor where he had first studied. There he spent five years, and was responsible for the rapid post-war rebuilding and expansion of his Department. At the same time he gathered around him a group of enthusiasts in the application of isotopes to the study of reaction mechanisms. Their pioneering work on the large-scale separation of the heavy isotope of oxygen now has fruitful offshoots in several departments and countries.

Through this period, Hughes maintained his interest and participation in the work in progress in the Chemistry Department of University College, London. His direct and critical approach led during these years towards simplification of the interpretation of the kinetic forms observed for aromatic substitution, and to the general acceptance of the view that the nitronium ion is the most important entity involved in aromatic nitration.

In 1948 he was appointed professor of chemistry at University College, London. Here he remained until his death. His scientific distinction was marked in 1949 by his election to fellowship of the Royal Society. In 1961 he became head of the Department of Chemistry at University College, London. His contributions to the elucidation of reaction mechanism ranged in these years over a wide field. He initiated important and imaginative studies of structural and stereochemical effects in nucleophilic and aliphatic replacement reactions; of Wagner–Meerwein and related rearrangements; of anionotropic rearrangements; of electrophilic aromatic and aliphatic substitution; of aromatic rearrangements; and of prototropic shifts. Alongside these developments he maintained a policy of encouraging and fostering independence in his younger colleagues, who owe a great debt to his generosity and to his faith in their ability and promise.

In 1961 he undertook editorship of a series of monographs to be published by Elsevier on special topics in physical organic chemistry; the first of these was at the proof stage at the time of his death.

His services to academic life, which were marked by his election to fellowship of the University of Wales and of University College, London, were by no means solely in the field of research. A valued teacher and colleague both at Bangor and at University College, London, where he was dean of the Faculty of Science from 1958 until 1961, he contributed also in a most valuable and important way as an appointed teacher of the University of London, particularly through his chairmanship (1955–60) of the University Board of Studies in Chemistry. Here his wise and efficient guidance gained him many friends, and he will be much missed from the academic councils of the University during the times of change ahead. He was greatly in demand as external examiner for first degrees and for higher degrees of universities throughout Britain. He performed an extremely important task as honorary secretary (1949–61) and then as chairman of the Advisory Council of the Ramsay Memorial Fellowship Trust; and on committees of selection for Imperial Chemical Industries, Ltd., and other senior research fellowships, where his judgment, common-sense and powers of assessment were regarded highly.

Outside the University he played many important parts. He was a governor of the Northern Polytechnic (1950–60). He was a Fellow (1938) and member of the Council (1961–63) of the Royal Institute of Chemistry, and acted for the Institute as assessor in organic chemistry for Higher National Certificates and Diplomas, and as a special examiner; he was honoured by the Society as a Meldola Medallist in 1936. Perhaps his greatest contribution, however, was to the Chemical Society, to the publications of which he personally contributed so much. He served on almost every sub-committee of this great Society, being chairman of the Library Committee from 1959 onwards, an honorary secretary from 1950 until 1956, and a vice-president (1956–59). He was honorary secretary of the Chemical Council (1953–55).

Hughes's scientific lifetime has seen an enormous change in organic chemistry. All its many aspects have been affected by the realization that the complicated patterns of yield and reactivity can be interpreted and already in part predicted in terms of the accessibility of the various transition states leading from starting-materials to products. Few have contributed to the acceptance of this approach, bitterly contested as it has been, more than Hughes. His work has always been characterized by steadfast belief in the importance of mechanistic investigations, an insistence on experimental verification of each point as it has come under scrutiny, and an intuitive recognition of the quality of crucial experimental observations.

He was a man of outstanding humanity. His actions and his advice led directly to the heart of any problem through clear recognition of general principles. His friends will remember him for his deep sense of loyalty; for his unshirking sense of responsibility; and for his devotion to the Department where so much of his work was done.

In 1934 he married Ray Fortune Christine, daughter of the Rev. Ll. Davies, of Brecon. She survives him with their daughter.

P. B. D. de la Mare

Dr. Annie Porter

Parasitologists the world over will mourn the loss of Annie Porter, who died in London at the advanced age of eighty-three on May 9, after a protracted and debilitating illness.

Born at Shoreham-on-Sea, Sussex, on February 20, 1880, Annie was the elder daughter of Samuel Porter. The family early moved to Brighton where she received her school education, whence she proceeded to University College, London. There her first love was mycology—a subject in which she retained an interest throughout her life—although animal parasitology, and especially protozoology, demanded most of her professional time in later years.

From University College she proceeded in 1914 for a time to the Quick Laboratory in Cambridge, where she met and worked with H. B. Fantham (and whom she married in 1915). At Cambridge Dr. Porter held a Beit Memorial research fellowship for two years and taught as an assistant helminthologist.

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