PROTECTION FROM THE EFFECTS OF RADIATION

RADIATION protection was the subject for discussion at a joint meeting of the Industrial Radiology Group of the Institute of Physics and the Hospital Physicists Association, which was held at the Royal Institution, London, during January 16–17. From the papers given by the various speakers one could piece together the past history of this subject and the present quickening interest in it.

Dr. L. H. S. Clark described the service which had been established nearly twenty years ago at the Lambeth Hospital to ensure adequate protection of the staff of the radiological departments. Film badges of fast dental film were found satisfactory as means for measuring the doses of X-rays received by the individual in the course of his work. This was no isolated instance of the growing awareness of the need for protection against the damaging effects of ionizing radiation. Tribute was paid to the splendid work of the British X-ray and Radium Protection Committee which, from its inception under the chairmanship of the late Sir Humphry Rolleston and often without financial support, did heroic pioneer work.

Although many individual hospitals or groups of hospitals were taking steps to protect their staff, this was not universally so, and in 1942, as a result of the efforts of the late Dr. A. E. Barclay, it was deemed necessary to have an external monitoring service for those institutions in the Emergency Medical Service where no internal service was maintained. Mr. E. E. Smith described how the National Physical Laboratory was asked to undertake this office and how it solved the problem. Although the degree of blackening of film is dependent on the quality of the radiation applied, nevertheless it was chosen at that time because the available ionization chambers were fragile and liable to misuse. Moreover, with a service conducted by correspondence, the methods had to be as simple as possible. From small beginnings with the receipt of a few hundred films a month, the service supplied by the National Physical Laboratory has steadily progressed. Workers in factories and research laboratories were soon added to the list of customers, and an inspection service was set up to advise those bodies whose workers consistently recorded high doses. Now, about five thousand films a month are processed by five technicians, and happily the proportion of recorded doses above tolerance is steadily diminishing.

These early theoretical and practical aspects were by no means confined to Great Britain. An International Protection Commission had met on several occasions and reported its recommendations ; it still continues to do so, the last meeting being in 1950. Dr. J. F. Loutit recalled some medical and biological evidence of the damaging actions of ionizing radiations which the Commission has taken into account in formulating its latest recommendations on permissible doses. It has rightly been chiefly swayed by the medical evidence where man rather than the experimental animal has suffered and even died from excessive exposure. Mr. W. Binks, himself a prominent member of the Commission, also stressed the delayed action of these effects, but appealed for a balanced approach to the problem. Respect, but not fear, on one hand, or foolhardiness, on the other, is to be encouraged, and then this hazard like others can be controlled. He quoted the figures of permissible doses of the various types of radiation so far considered. As regards penetrating radiation, he issued a note of warning that many of the published tables of transmission through lead and concrete are out of date in that narrow beams only are considered. Nowadays broad beams are more frequently in operation, and the transmissions here are vastly greater. Mr. Binks appealed for still more effort in investigating the fundamental biological action of radiation and the early incorporation of new knowledge into codes of practice. He hoped that these wishes would be implemented by a new national protection organization established jointly by the Medical Research Council and Ministry of Health.

The most modern methods of measurement of dose by means of films were reviewed by Dr. G. Spiegler. It is necessary to measure, on one hand, the hard gamma-ray radiation of radioactive isotopes and, on the other, the relatively soft emissions of diagnostic X-ray machines or the scattered rays from radioactive sources. Thus the monitoring film contains an exposed portion to record the combined soft and hard radiation and a portion or portions protected by aluminium, brass, lead, cadmium or other appropriate filter to measure the harder components. By contrast, with very hard rays of energy greater than 2 MeV., there is a reversal of the usual picture and less blackening of the unfiltered area.

Whereas X-ray film is still the main standby for the measurement of dose, ionization chambers also play their part. Dr. E. Dyson described some of those in use at the Atomic Energy Research Establishment, Harwell. Large ion-chambers are used for area monitoring; but by themselves they would be inadequate because of the variation in scattering under altering conditions. The personal dosemeter is a necessary addition. For specific purposes this can be either a condenser-type chamber which is charged and after use read by various electrometers, or a quartz-fibre electrometer which the wearer can himself read and assess the rate of accumulation of dose. With radiation of 100 keV. and more, the variation of the reading with hardness of the rays is of the order of $\pm$ 10 per cent. These electrometers are somewhat sensitive to hard beta-rays.

As modern research and development makes available X-rays of greater and greater energy and radioactive sources of greater activity, industry is finding increasing use for them, particularly in engineering for testing purposes. Dr. C. Sykes noted that, while each source is obtained for a specific purpose, the applications multiply. The increasing time and scope of use of these sources make the originally devised protective arrangements inadequate. If the job is brought to the source, protection should not be difficult ; but when the source is taken to the job, it is not simple to give adequate protection without disturbing the normal routine of the workshop. This increasing use, particularly of radioactive isotopes, by firms with no previous experience of the subject and therefore no competent medical officer or physicist, exposes the need for a set of rules clear even for factory managements.

Dr. H. Harris (Babcock and Wilcox, Ltd.) and Dr. J. S. Blair (Stewart and Lloyds, Ltd.) carried the discussion further from the point of view of industry.

In their experience the literature on protection is not readily available ; but a competent engineer can solve his problems by common sense and by insisting on a rigid discipline among the operating staff.

The legal responsibility for the health and welfare of workers in factories, but not in research laboratories, lies with the Ministry of Labour. Mr. K. Goodall (H.M. inspectorate of factories) described how this Ministry watches for new hazards and advises on old ones. In the case of sealed sources of radioactive isotopes, the position is at present satisfactory in that the Ministry is informed from Harwell or Amersham of the delivery of all such consignments to new customers. Present records show surprisingly few accidents, and Dr. Ethel Browning's hæmatological data contain few abnormalities. With the existing policy of persuasion, results are as satisfactory as would be expected if regulations were in force ; the greatest danger, said Mr. Goodall, still remains not the closed sources of radioactivity but the open sources met with in the luminizing industry.

In industry, according to the evidence presented, the care or discipline exercised has resulted in the workers receiving doses well below tolerance (an average of about 10 mr./week in one case). By contrast, in the Ordnance Inspectorate of the Royal Navy, as it appeared from Commander P. Chandler's remarks at the meeting, policy is determined by the delivery of the goods and not by the hazard to the staff. This attitude may be necessary in the Armed Forces in time of war, but was alarming to the medical section of the audience.

ROYAL ASTRONOMICAL SOCIETY

PRESENTATION OF GOLD MEDAL

AT the meeting of the Royal Astronomical Society on February 8, 1952, at Burlington House, London, the Gold Medal of the Society was presented to Dr. John Jackson by Prof. H. Dingle, the president of the Society, who gave an address which has since been published in full (*Mon. Not. Roy. Astro. Soc.*, 112, 3 ; 1952).

Not very long after Dr. Jackson had finished his career at Cambridge he went, in 1914, as chief assistant to the Royal Observatory, Greenwich, where about twenty years of work on double stars with the 28-in. refractor awaited analysis, and this task was undertaken by Jackson in collaboration with Furner. There were also available F. G. W. Struve's results, published in 1837, which included 3,112 close pairs, and many more were added by the late Otto Struve, who continued his father's work. Jackson showed that 649 of F. G. W. Struve's stars had changed their configuration since his day ; of these, 449 showed true orbital motion, 161 were optical doubles the components of which differed in proper motion, and in 39 the nature of the motion was uncertain. Among Otto Struve's stars he found that 135 were binaries, 15 optical doubles and 5 had doubtful motion. The results of the analysis were published in a number of papers in *Monthly Notices of the Royal Astronomical Society* from 1920 onwards, and the hypothetical parallaxes deduced agreed well with the trigonometric and spectroscopic parallaxes which were then available. The next step was the determination of the cross-components of the velocities of the stars from their known proper motions, from which the apex and speed of the solar motion were determined, and these showed good agreement with those found by other methods. The absolute magnitudes of the stars were also determined from their apparent magnitudes, and this provided further evidence for the separation of the stars of the later spectral type into giants and dwarfs, which had been investigated by Hertzsprung and Russell some years previously and gave strong support to Russell's theory of stellar evolution.

During 1924–30 Jackson carried out valuable work on time measurement. Two Shortt free-pendulum clocks, the running of which was in charge of W. Bowyer, acting under Jackson's direction, were installed at the Royal Observatory in 1924 and 1926, and four papers on their behaviour up to the end of 1930 appeared in the *Monthly Notices*. An analysis of the errors showed that these could be reduced to three terms, one due to nutation causing non-uniformity of sidereal time, another arising from temperature fluctuations, and the third—the 'secular term'—the origin of which was not immediately obvious but which was later attributed to a gradual increase in the length of the invar rod of the free pendulum. Other possible causes, however, were conceivable, and subsequent observations cast doubts on the supposition that the gradual growth of the invar rod was the main cause of the secular term. The conclusion was that the most that could be hoped from these clocks in detecting fluctuations in the earth's rotation was that they might determine whether erratic changes of 1·0″ a year in the moon's longitude could be due to irregularities in the earth's rotation period. One very valuable result of the whole investigation was the discovery of the nutation effect, showing the necessity for distinguishing between apparent and mean sidereal time.

In 1930 Jackson published an analysis of observations made with the Greenwich Cookson zenith telescope ; this indicated that the value of the constant of nutation was $9{\cdot}2066'' \pm 0{\cdot}0055''$, which was smaller than the value used in the ephemerides. The latter, based on Newcomb's determination from a very long series of observations, agreed very well with a more recent determination by Przybyllok, and a discordance between this and the theoretical value, considerably larger than the probable error, requires some explanation. Jackson regarded it as "one of the outstanding discordances of the constants of the solar system" ; but, as Prof. Dingle remarked in his address, it is unlikely that the last word has yet been said concerning the theoretical value.

In 1925 Jackson began to collaborate with Knox-Shaw and Robinson, of the Radcliffe Observatory, Oxford, on the reduction of Hornsby's meridian observations. The observations selected for reduction were those made between 1774 and 1798, and included about 43,000 observations of stars, 5,200 of the sun, 4,600 of planets, and 1,200 of the moon. From the results it was possible to apply systematic corrections to Boss's "Catalogue" and also to Newcomb's tables of the sun's longitude, and to other elements of the sun's apparent orbit about the earth—the equinox, the obliquity, the eccentricity and the longitude of perigee. The main publication appeared in 1932 and was followed with a paper in the *Monthly Notices* on the observations of Mercury ; these observations were specially important in checking the motion of the planet's perihelion.

In 1933 Dr. Jackson succeeded Sir Harold Spencer Jones as His Majesty's Astronomer at the Cape of Good Hope, and until his retirement in 1950 his work