he emphasized the outstanding difficulties in this kind of work—the non-existence of a perfect graphite crystal as a reference standard, and the impossibility of introducing or removing in any simple way faults of a given type. The main classification was into point, line and planar faults. Point faults are the simplest type, but they are difficult to detect by direct means, although they produce relatively simple effects on physical properties (such as electrical resistivity and the Hall coefficient) and on the chemical properties, in particular the tendency to form lamellar compounds. These point faults can be subdivided in terms of substitution atoms, vacancies and interstitials. Faults associated with dislocations and with surfaces are the least simple to define and interpret, but they are detectable more directly by diffraction methods and optical and electron microscopy. Planar faults were subdivided into 'surfaces of dislocations' (such as occur between the not-quite-parallel domains in so-called single crystals of natural graphite or between hexagonal and rhombohedral regions) and errors in layer stacking (such as the orientation faults, which are particularly noticeable in artificial graphites, or random mistakes in an *AB* or *ABC* stacking sequence).

The second session of the meeting dealt with slightly more technological aspects of graphite and was opened with a paper by Mr. P. K. C. Wiggs (Morgan Crucible Co., Ltd., London) on "Elastic Properties of Graphite". Single crystals of graphite have a Young's modulus parallel to the basal planes which is about three times as high as for steel, but parallel to the *c*-axis the modulus is many times smaller. The easiest mode of deformation is, as would be expected, a shear in which neighbouring planes slide over one another. The properties of polycrystalline graphite bear little resemblance to those of the ideal single crystal, and are determined very largely by the disordered material at the junctions between crystallites and by internal voids: such anisotropy as exists is a consequence of the texture which results from the nature of the starting materials and mode of manufacture. As a consequence of this, it is found that all the elastic moduli of polycrystalline graphite are of the same order of magnitude as the low-shear modulus for the sliding of adjacent planes in the single crystal. Only for the more recent developments of pyrolytic graphite and graphite whiskers, where stresses cannot be relieved by sliding, do the high modulus and strength of the single crystal parallel to the planes become apparent. At temperatures greater than 2,000° C., electric furnace graphite is deformed plastically to a very significant extent, but on heating up to this temperature there is a two-fold increase in the elastic moduli on account of the increasing thermal motion of the carbon atoms, which reduces the ability of one plane to slide over another.

A paper by Dr. E. G. Steward (Northampton College, London) described the crystallographic changes which occur during graphitization. There is still considerable doubt about the structural details of poorly crystallized material, which gives very diffuse X-ray diffraction patterns. Recently, there has been a revival of suggestions of non-planar structures, such as a diamond-type of bonding, particularly from electron diffraction observations. As graphitization proceeds and the crystallites grow, the interpretation is much clearer: a progressive modulation of the two-dimensional bands and a general sharpening of the reflexions demonstrates the approach towards the ideal Bernal structure. The ease of graphitization depends on the structure of the crystal nuclei and whether these are separated by cross-linkages. Initial growth occurs by incorporation of non-organized carbon at the crystallite edges, but further progress depends on the existence of near-parallel orientation between neighbouring crystallites. An important characteristic of the final product may be the size of the quasi-perfect macro-units which are much larger than the regions of higher structural perfection revealed by X-ray diffraction. Recent developments in the work on pyrolytic carbons and the examination of moiré fringe patterns in the electron microscope were also discussed.

The final paper, by Prof. W. F. K. Wynne-Jones (King's College, Newcastle upon Tyne), dealt with physical and chemical studies of the graphitization process.

A number of questions and general discussion followed each of the sessions. One of the principal topics was the lack of understanding of the transformation from ordinary to rhombohedral graphite and the energy relations between the two forms. It was also evident that we still have little precise knowledge of the intergranular material which bonds together the individual crystallites, and which is so important in determining the physical and chemical properties of ordinary non-ideal material. G. E. BACON

RADIOLOGICAL UNITS AND MEASUREMENTS

RADIATION dosimetry is an immensely complicated subject and many of its problems have been only partially resolved. The difficulties are of a fundamental nature and arise: (*a*) from the complexity of the interactions of neutrons and electromagnetic radiations with matter; (*b*) from the still greater complexity of interaction of charged particles, especially electrons, with matter. So long as the understanding of these basic processes remains incomplete, there will be outstanding problems in the dosimetry of ionizing radiations. There is consequently a recurring need—it amounts to a necessity—for authoritative pronouncements on this developing subject to maintain world-wide uniformity in the units, standards and measurements of radiation and radioactivity. The National Bureau of Standards *Handbook 78** is intended to satisfy this need. It supersedes the 1956 report of the International Commission on Radiological Units and Measurements, and the chief interest lies in the difference between the two reports. There has been no major revision and the differences consist almost entirely of accretion and expansion; the new handbook is in fact twice as long as the old. The chief aim according to the preface is ". . . to improve the accuracy of the evaluation of absorbed dose in all places of interest in a patient or other objects". To this end, there is a greatly expanded section on clinical and biological applica-

* United States Department of Commerce: National Bureau of Standards. Handbook No. 78: Report of the International Commission on Radiological Units and Measurements (ICRU), 1959. Pp. x+90. (Washington, D.C.: Government Printing Office, 1961.) 65 cents.

tions, including a new and detailed treatment of energy absorption in and near bone. An important new recommendation for radiotherapists is that the routine recording of bone doses and of tumour doses should now include a statement of maximum and minimum absorbed doses in rads. There is a section entitled "Report on an Inquiry on Current Errors in Clinical Dosimetry" which is somewhat disturbing; it should be carefully studied by all concerned.

In Part 3 ("Physical Aspects of Dosimetry") linear energy transfer and neutron dosimetry are treated in much greater detail, and there are entirely new sections on chemical, solid state, calorimetric and photographic dosimetry. The appendixes contain some interesting and often impressive accounts of international comparisons of various radioactivity standards, and it is noteworthy that Hönigschmid's weighings of radium standards, in which he estimated an error of about 0·02 mgm. (in around 20 mgm.), have now been accurately confirmed by ionization and calorimetric measurements. There are new appendixes on focal spots and the estimation of integral absorbed dose and the final appendix states the International Commission on Radiological Units and Measurements Position Plan adopted at Geneva in September 1958.

Many of the larger criticisms that could be raised against this report are now under active debate in preparation for the major revision referred to in the preface. In a composite production of this nature it is very difficult to preserve consistency. Thus, in referring to the calculated values of mass stopping power ratios (s_m) in Table 8·3, it is stated in footnote 24 "... that an uncertainty of the order of 1 per cent exists in s_m ..." yet later in the same section on page 37 it is recognized that the basis of these calculations is incorrect. The earlier admission on page 1 of errors "... of the order of a *few* per cent ..." would appear to convey the requisite degree of caution. The symbolism is not always consistent and in some places (for example, p. 40 and Figs. 8·6 *b–d*), 'E' is used to denote particle kinetic energy, whereas in other places (for example, p. 51 and Figs. 8·3 *a–c*), 'T' is used for the same purpose.

It is almost superfluous to add that this *Handbook* is essential reading for all radiation physicists, radiotherapists, radiologists and radiobiologists. Unfortunately it is rather unattractively produced, it has several misprints and grammatical errors, and the numerous footnotes are scarcely legible without the aid of magnification.

P. R. J. BURCH

THE RED DEER COMMISSION

THE Red Deer Commission was constituted in October 1959 with the general aim of furthering the conservation and control of red deer in Scotland. Its setting up marked the first comprehensive attempt to deal with a controversial problem which has vexed the Highlands for the best part of two centuries.

The introduction of large-scale sheep farming into the Highlands in the latter half of the eighteenth century, replacing the old population of farmers with their primitive breeds of cattle and sheep, resulted, towards the end of that century, in the reduction of deer stocks to probably their lowest level. At the beginning of the nineteenth century another influence was introduced by the development of the sport of stalking, giving a new value to the deer. When prices of wool and mutton declined towards the end of that century, the area given over to deer forests increased rapidly, from less than two million acres in 1883 to more than three and a half million acres at its peak in 1912. In 1952, however, the area of deer forests was estimated to have been reduced to about three million acres.

The influence of these developments on the range and population of deer affected every aspect of highland life, causing deep dissensions. Between 1872 and 1952 six different committees or commissions were appointed by Parliament to make recommendations with regard to conservation and control, but little or nothing was achieved until 1939. The Deer and Ground Game (Scotland) Bill introduced in that year provided powers to control deer, to be exercised by the Department of Agriculture with the assistance of an Advisory Committee and local committees. Developments were prevented by the War, and it was not until 1959 that an Act of Parliament was passed to introduce close seasons for deer in Scotland.

The Act is divided into five parts. Part 1 deals with the setting up of a Commission and its powers. Part 2 specifies close seasons for stags during October 21–June 30 and for hinds during February 16–October 20, to come into force on October 21, 1962. The Commission has now issued its first report*, and, in it, states that, "we consider that if viable stocks of deer are to be maintained throughout the traditional deer forest areas of the Highlands they should not be broken up into isolated fragments. At the same time, if they are not to continue as a serious liability to agriculture and forestry, they must be kept under control. In other words, as grazing animals they should be subject to reasonable standards of management."

The numbers and population densities of deer, unlike those of many other wild animals, do not appear to be self-limiting. In the absence of natural predators such as wolves, or of sufficient killing, deer will increase until they overgraze and damage their habitat, die in large numbers from starvation, or overspill on to agricultural land. Persistent overgrazing must lead to the progressive impoverishment of the hill pastures, on which they depend for their food, and a declining productivity. For the past two centuries, man has provided the only check against this deterioration. The fact that he has not everywhere been exercising sufficient control is the prime reason for the setting up of the Red Deer Commission, with certain over-riding powers, including authority to go on private land in the exercise of its functions.

During the period under review, the Commission has been concerned primarily with the control of marauding deer. Experience this year has shown that it is both widespread and continuous. Where estates are under good management, effective measures are taken to protect tenants and neigh-

* The Red Deer Commission. Report for the period 1st October 1959, to 31st December, 1960. Pp. 22. (London: H.M. Stationery Office, 1961.) 1s. 3d. net.