the teaching of electron dynamics and electromagnetism is on numerical and model methods. A large electrolytic tank is available for the rapid and accurate charting of electrostatic fields in two or three dimensions, and for certain magnetostatic fields. Electron trajectories are plotted graphically by a hand-operated tracing trolley and by other methods. In the special case of cylindrical or 'plane' electrostatic fields, a large rubber-membrane model enables the field and the electron trajectories to be obtained in one experiment, by rolling steel balls over the membrane. These methods are usually sufficient for an approximate design of the electrode shapes in valves, television tubes, electron multipliers, image tubes and other devices. For the testing and final correction of the design, demountable vacuum chambers are the most effective aids of the research and development engineer. Three large metal vacuum tanks are available, in which vacua of the order of 10^{-5} mm. mercury can be maintained while six or more mechanical adjustments are carried out from the outside without breaking the vacuum.

Once the electron-dynamical design is fixed, technological development can start, which leads ultimately to a sealed-off device, to be put in the hands of the circuit engineer. The technological equipment of the Electronics Laboratory in the Imperial College is sufficient for making up almost any type of vacuum device, and for instructing the students in most of the usual processes. The glass-blowing shop is equipped with a large horizontal glass lathe and two smaller vertical machines, with supplies of coal gas, oxygen and hydrogen for glass and quartz blowing, and with annealing ovens. Two hydrogen furnaces and a muffle oven are available for the heat treatment, in protective atmospheres, of metals for use in vacua, and a large, 30 kW. vacuum furnace is under construction for temperatures up to 3,000° K. A number of spot welders and a small atomic arc welder are provided for the assembly. The exhausting of valves up to the size of small cathode-ray tubes is done on two medium-size exhaust stands; a large stand serves for television tubes; all are supplied with high-frequency power from a large induction heater. An electroplating and cleaning plant and several stands for vacuum coating of metals complete the technological equipment.

The theoretical training of the postgraduates centres on vacuum electronics; but in view of the growing importance of semiconductor valves, they attend also a course on the physics of solids. (Laboratory equipment for germanium techniques is available.) Other items in the syllabus include electromagnetic theory, microwave techniques and circuit theory, with exercises in the Microwave and Communications Laboratories of the Department. There is ample opportunity for attending special courses on mathematics, wave mechanics, higher circuit theory, acoustics, ultrasonics and communication theory for those specially interested.

From its inception in 1953, the lectures given in the course by the teaching staff of the Imperial College have been supplemented by special lecturers from industry. Leading specialists have been invited to give comprehensive surveys of technological topics such as ceramics, metals *in vacuo* and glass, and on advanced electronic topics such as microwave valves; also on engineering economics and quality control, which are of special interest for future production engineers.

The postgraduate course of the College in applied electron physics is open to applicants holding the B.Sc. or higher degrees of British, Commonwealth or equivalent universities, but in special cases also to holders of Higher National Certificates, if the applicants have had previous experience in electronic research, development or production, and if in an interview they are judged likely to profit from the course.

In the third term the postgraduates are given problems, usually of a practical kind, which might lead to useful results and which require independent thinking, and they are provided with experimental equipment for two to three months research or development work. Those who are successful are entitled to submit a thesis for the diploma of the Imperial College (D.I.C.). This is a unique opportunity for those who for some reason have missed the university, and whose gifts have been discovered too late, to obtain an alternative award with a recognized reputation.

The British Radio Valve Manufacturers Association is aiding this course not only by financing its running expenditures, but also by sending to it some of its engineers and physicists who, in its opinion, can profit more by broad and intensive academic instruction than by the experience which they could acquire in the same interval of time in an industrial laboratory or production department. Moreover, certain companies may be willing to subsidize the training of students who have the intention of joining industry after their postgraduate year, provided they show sufficient promise. Though the present shortage of electronic physicists and engineers makes it very desirable that entry into industry should not be much delayed, those attending this course who have shown outstanding scientific ability and interest are encouraged to do a further year or two in the Research School of the Electronics Laboratory. This will enable them to acquire the M.Sc. or Ph.D., provided they have the necessary first degree. Fully trained, hard-working specialists are indispensable for maintaining the present strong position of the British electronic industry; but only exceptional engineers and physicists can put it in the lead.

X-RAY ANALYSIS GROUP OF THE INSTITUTE OF PHYSICS

SPRING CONFERENCE

THE spring conference of the X-Ray Analysis Group of the Institute of Physics was held in the H. H. Wills Laboratory of the University of Bristol during March 30–April 1. The communications which were read by members of the Group and others covered a wide range of interests and were not restricted to any one particular aspect of X-ray crystallography. A particularly stimulating evening discourse was delivered by Prof. H. C. Longuet-Higgins, who discussed the peculiar problems posed by the structures of the hydrides of boron.

The first paper, by Prof. A. J. C. Wilson, dealt with his further investigations on the effects of various symmetry elements on intensity distribution functions. He has extended earlier studies to cover cases where molecules possessing centres of symmetry are placed in space groups containing other symmetry

elements in addition to centres of symmetry. The resulting distributions have been evaluated approximately: they are found to lie somewhere between the centric distribution (asymmetric molecules in a space group containing only a centre of symmetry) and the bicentric distribution (that is, molecules containing a symmetry centre in a space group with only a centre of symmetry). Expressions for the variance of the new distributions were given. Dr. T. H. Goodwin then described some results of applying the molecular orbital technique of wave mechanics to the calculation of bond-lengths in conjugated compounds. In the cases of a number of hydrocarbons excellent agreement was obtained between calculated bond-lengths and those observed by X-ray methods. Dr. W. Cochran and Mr. M. M. Woolfson have extended their studies of direct structure determination by calculating expressions for the probability of the correctness of sign relations for additional space groups. Their results, which are in good agreement with observations, show that in most practically important cases of reasonably complex structures the probability of obtaining correct signs directly from the observed intensities is low; no routine solution of the phase problem is as yet possible. Dr. A. Klug described new methods for the determination of absolute intensities of X-ray reflexions. In essence, the mean intensity curve is equated to the sum of the coherent and incoherent scattering at large values of $\sin\theta/\lambda$; where the course of the intensity curve is not directly observable in this region, it can often be calculated from that portion of the radial distribution function due to nearest neighbours. In the subsequent discussion it was suggested that it might be simpler to obtain the necessary information directly from powder patterns rather than to calculate it from single crystal data.

The next group of papers dealt with structure determinations. Dr. D. F. Grant and Dr. D. Rogers presented their results on the structure of hydroxydihydroeremophilone, a bicyclic sesquiterpenoid, which confirm the configuration proposed by Simonson. This conforms to current theories of the biogenetic origin of the terpenes. The structure determination was presented as an example of the use of direct methods. The Sayre-Cochran relations proved to be of great value in the (100) projection in which the molecules are seen edgewise and in which there is much overlap of peaks, but not in the (010) projection—the plane of the molecules—since with about seventeen resolved atomic peaks there was little statistical bias in favour of the true sign. Mr. H. P. Rooksby discussed the crystal growth of barium and strontium oxides in oxide cathodes. Semi-micro beam methods were used, and the grain sizes were found to be of the order of a few microns. This technique revealed the presence at some stages of crystals several times larger than the mean size which had previously been estimated from line-broadening. In addition to crystal growth, the thermal treatment produces progressive lattice parameter changes not as yet fully explained. Considerable disturbances in the atomic arrangement are also indicated by the line-broadening which accompanies the crystal growth. Dr. J. C. Speakman had investigated the crystal structure of the acid salts of a number of monobasic organic acids. The majority of these salts, but not all, were shown to form symmetrical hydrogen bonds. Dr. H. D. Megaw and Miss C. H. Kelsey presented work on the unit cell of

tobermorite, a hydrated calcium silicate. The structure is best described by reference to an orthorhombic unit cell; systematic absences indicate that the true lattice has a and b axes along the face diagonals of the orthorhombic cell, and is probably monoclinic A -face-centred. The crystal samples studied showed a variety of stacking faults and intergrowth phenomena. Dr. G. A. Jeffrey and Dr. G. S. Parry had re-examined the structure of aluminium nitride, which was shown to differ slightly from the ideal wurtzite structure with its tetrahedral arrangement of bonds, both as regards axial ratio and u parameter. Since, in determining the crystal structure it was only necessary to adjust the latter parameter and the temperature factors, it was found possible to use powder diffraction data. Dr. R. D. Lowde described a study of neutron diffuse reflexions produced by a Type I diamond selected for showing strong 'extra' X-ray reflexions. Similar neutron effects were found which showed that the structure fault characteristic of Type I diamonds is one which affects the atomic positions and is not an exclusively electronic phenomenon. The shape of the reciprocal lattice spikes as here determined by neutron diffraction and as studied by Wooster and Hoerni by X-ray methods lends weight to a suggestion that in Type I diamonds some parts of the structure have gone some way towards graphite, so that quite large changes of atomic positions are taking place. Small changes are ruled out by the X-ray results.

The most ambitious structure determination to be reported, and, indeed, perhaps the most complicated ever carried out, was that of a nucleotide-free degradation product of vitamin B₁₂ by Miss J. Pickworth and Dr. D. Hodgkin. A three-dimensional Fourier synthesis based on the cobalt atom phases was first calculated. It indicated, together with information from similar calculations on the vitamin itself, the positions of some twenty-five atoms surrounding the cobalt atom in a porphyrin-like structure. From further Fourier syntheses, side-chains, mainly succinyl and acetyl attached to the inner porphyrin-like group, were identified and finally the positions of sixty-two atoms were calculated. The molecule contains about seventy atoms, other than hydrogen, its approximate formula being $\text{CoN}_6\text{C}_{47}\text{H}_{67}\text{O}_{18}\text{Cl}$, and although all the positions are not yet certain, the general nature of the molecule is now evident.

The remainder of the conference was devoted to apparatus and techniques. Dr. B. T. M. Willis described the use of gratings representing structures with stacking faults and of modulations of lattice parameter and scattering factor in a Lipson diffraction spectroscopy. The gratings are prepared by moving a fine-grain photographic plate past a point image by means of micrometer movements: they contain at least 100×100 'atoms' and can be prepared in about one hour. Mr. E. F. Priestley showed how rapid fluorescence analysis can be carried out using photographic recording and curved lithium fluoride crystals as analysers. In order to detect fractions present to the extent of one part in ten thousand, exposure times of about half an hour are required: normally exposures of about one minute suffice. All elements heavier than potassium can be detected. In another paper he described the methods used for perfecting the monochromator technique and its application in conjunction with focusing powder diffraction cameras. Dr. W. C. Nixon gave an account of his point-source X-ray tube. Using magnetic

focusing, it has been found possible to produce a source less than one micron square on an air-cooled foil transmission target which can be loaded to a power of one watt. Thus the brightness is about 1,000 kW./mm.², as compared with an effective brightness of about 1 kW./mm.² in a normal foreshortened diffraction X-ray tube focus. The new point source has been employed principally in shadow microscopy, when a resolution of about 1000 Å. has been obtained; applications in microbeam diffraction are being studied. Dr. J. W. Jeffrey analysed modern practice in intensity estimation where insufficient attention is often paid to experimental accuracy. He described methods of grinding specimens to a spherical shape to facilitate absorption corrections; the use of some form of integrating mechanism on moving-film cameras permits the employment of a very simple densitometer. Dr. U. W. Arndt reported only moderate success in the use of radioiodine for silver estimation in photographic images; the method gives a measure of the integrated intensities of single crystal spots. In spite of a number of ingenious suggestions to obviate this, it is generally necessary to punch out each spot individually before measuring the activity. The use of emulsions considerably thicker than normal increases the sensitivity to X-rays and the reproducibility of measured intensities at the expense of much more elaborate processing requirements. Dr. R. L. Gordon discussed methods of making 'lost counts' corrections in monitored Geiger-Müller counter systems and described a direct way of measuring the form factor for a self-rectifying X-ray tube. Dr. G. S. Parry and Dr. S. C. Abrahams gave brief descriptions of the General Electric and Norelco counter diffractometers, respectively.

Dr. R. W. Cahn had used the Buerger precession camera for metallurgical problems where the orientations of very small regions had to be verified, such as in the examination of mechanical twins in molybdenum. The very low background scattering allows very weak reflexions to stand out. Mr. H. J. Goldschmidt commented on some of the problems in high-temperature powder photography: his new camera, which was sponsored by the X-Ray Analysis Group of the Institute of Physics, provides the most satisfactory solutions to date. The greatest difficulties are those of specimen mounting and of evaporation of furnace windings; periodic calibration of thermocouples is always necessary owing to vapour contamination. Dr. R. Witty reported on his studies of X-ray tube characteristics. He pointed out the advantages of d.c. operation which, for the type of stationary anode design common in demountable X-ray tubes, permits a doubling of the target loading as compared with self-rectifying operation. Similar gains are possible with rotating anodes. He gave focal spot and saturation current characteristics as a function of bias voltage. This bias is most conveniently provided from a separate bias supply as distinct from a bias resistance. Mr. P. Holroyd and Dr. D. L. Smare had studied similar phenomena in micro-focus tubes. For fixed bias resistance the anode current rises exponentially, and the focal spot diameter falls exponentially, with decrease in anode-cathode separation. Dr. A. L. MacKay described a miniature Weissenberg camera and a miniature retigraph designed to take full advantage of the properties of a micro-focus X-ray tube in the examination of very small crystals. A number of novel features are incorporated, particularly in the design of the goniometer heads.

U. W. ARNDT

SOUTH-EASTERN UNION OF SCIENTIFIC SOCIETIES

ANNUAL CONGRESS

THE South-Eastern Union of Scientific Societies held its sixtieth annual congress in Folkestone during April 14-17, under the presidency of Dr. Russell J. Reynolds. Throughout the congress an exhibition of geological, archaeological, botanical, zoological and general interest was on display at the Leas Cliff Hall, and the programme included a young naturalists' evening, when questions from children were answered by a panel of experts, and a lecture by Maxwell Knight on the habits of the cuckoo, illustrated by a film.

Dr. Russell Reynolds's presidential address to the Union was on "Cineradiography". He commenced by outlining the technique and application of his subject. Röntgen made his discovery in November 1895, and Dr. Reynolds still has a plate taken by himself by X-ray photography in 1896. Two years afterwards John Macintyre produced an X-ray cinematograph film by re-photographing on an ordinary cinematograph film a series of radiographs of a frog's leg which had been slightly moved between the exposures. Gradually the apparatus improved, tubes were more reliable and fluorescent screens gave greater luminosity. Sensitivity of film emulsion increased, and lenses of wide aperture were made. Two methods of making cineradiograph films became possible—the direct and indirect. The first utilizes the power X-rays have of affecting a sensitized photographic emulsion; in the second the rays passing through the subject strike a fluorescent screen, and the shadow cast is photographed. X-rays cannot be focused, and this limits the direct method. Difficulties with the indirect method include the weakness of the intensity of light emitted by the fluorescent screen; when this is increased, the exposure risk to the subject is also increased. Dr. Reynolds said that he began his cineradiographic experiments in 1921 using the indirect method. Later he introduced a switch which synchronized the excitation of the tube with the opening of the camera shutter, thus reducing both the exposure of the patient to risk and the strain on the tube by half. Improvements continued, and at the present time the method used is reliable and safe. The cost has been reduced and does not exceed that of a complete X-ray examination in the usual way. Modern apparatus has a specially designed transformer unit, and the X-ray tube has a double-focus cathode. The camera lenses have a wide field, the apertures being $f/0.7$ and $f/1.5$; the speed of the camera can be adjusted at will from 3 to 100 frames per second. The technique in making cineradiographic film differs little from that employed in normal radiography. Dr. Reynolds stressed the importance of the use of short coils of film that can be projected continuously, not only for the purpose of medical diagnosis, but also for training students.

The presidential address to the Archaeological Section was given by Major H. M. Rand, who spoke on "The Saxon Shore Forts of Kent". He said that historical evidence, often not contemporaneous, can be misleading and that muddy boots are sometimes better than documents. The archaeological approach is the correct one, and excavation may solve the problem of the 'lost centuries'. There is an absence