and in respect of information services, to the work of the British Council. It is estimated that 1,033,000 U.S. dollars will be spent on the United Nations Expanded Programme of Technical Assistance in the British territories in 1958 compared with 1,271,000 dollars in 1957. Under the Fulbright Agreement nine American teachers were posted to schools in Western Nigeria, St. Helena, Antigua, Grenada, Jamaica and Montserrat, and nine senior research workers attached to university and research institutions in East Africa, Northern Nigeria, Hong Kong, Jamaica and Trinidad, while two scientists continued research into the preservation of wild life in the game reserves of Uganda. Travel grants enabled lecturers from University College, Ibadan, the University College of the West Indies and the University of Malaya to visit the United States for research and to give lectures. An Overseas Visual Aid Centre has been established in London with the joint support of the Government and the Nuffield Foundation to further the use of visual and audio-visual aids in education.

# SOLID STATE PHYSICS

## CONFERENCE IN BRUSSELS

AS part of the activities associated with the Brussels Universal Exhibition, a Conference on Solid State Physics and its applications to electronics and telecommunications was held in Brussels during June 2–7. The meeting had the patronage of the King of the Belgians and the support of the International Union of Pure and Applied Physics. It was regarded as appropriate because of the stress laid by many exhibitors on contemporary scientific achievements. After an introductory lecture by W. Shockley, the 750 participants from twenty-four countries divided up to listen to papers which were grouped in five parallel sessions throughout the six days of the conference.

It was inevitable that such a meeting would be dominated by discussions of the properties of semiconductors, their theory, and the main applications in transistors, phosphors and electroluminescence. There were also sessions on ferrites. Despite the extent of the field covered, its unity, so far as basic ideas are concerned, became very clear as the meeting progressed. This proved to be a stimulus to many participants, who regretted the large number of papers offered rather than the spread of topics.

The areas of activity in the field of pure semiconductors include equilibrium properties such as susceptibility measurements, transport phenomena, the study of barrier layers and surfaces, of noise, life-times and recombination, optical properties, the growth of, and imperfections in, single crystals, and the changes induced by irradiation. All these topics, and others on the more applied side, were discussed at this meeting, as they were at the last similarly international meeting at Garmisch in 1956 (see *Nature*, **198**, 1156; 1956). A slight change of emphasis has, of course, occurred. For example, at Garmisch considerable interest was shown in the newly discovered phonon drag effect, which implies, for example, that long wave-length phonons exert a drag on the charge carriers, and contribute rather strongly to thermal conduction. Little was said about this effect in Brussels. On the other hand, the properties of electrons which are not in equilibrium with the lattice owing to the effects of an applied electric field—the so-called 'hot electrons'—received much more attention than they did at Garmisch, and this promises to remain an active field.

For example, J. Bok (École Normale Supérieure, Paris) reported attempts by thermionic emission experiments to obtain direct evidence of the temperature of hot electrons. S. H. Koenig (I. B. M. Watson Laboratories, Columbia University) emphasized again that the hot electron distribution function responds very rapidly (within less than $10^{-9}$ sec.) to changes in the applied field. In many aspects of these effects theory still lags behind experiment. This became particularly clear from a talk by R. Stratton (Metropolitan-Vickers Electrical Co., Manchester), who discussed theories of the dependence of electron mobilities on the electric field.

As the applied field is increased, the hole and electron temperature rise, and in due course breakdown occurs. In *p–n* junctions the breakdown is believed to be of the avalanche type. This was discussed for germanium by B. M. Wul (Lebedew Institute, Moscow). He showed that the coefficient of impact ionization for holes is about twice that for electrons. Recent work for silicon (Chynoweth, A. G., *Phys. Rev.*, **109**, 1537; 1958) is of interest here for comparison. The properties of hot electrons may also be expected to affect the current – voltage relation of *p–n* junctions for high forward currents. This was discussed by A. K. Jonscher (General Electric Co., Wembley), the suggested form of the relation being $I^{1/2} = AV(V - B)$.

In this field of barrier-layer physics, attention was directed by several speakers to the measurement of the working temperature in the barrier (which has a pronounced effect on the properties of silicon and germanium rectifiers). Considerable interest was also shown in narrow germanium *p–n* junctions containing high concentrations ($10^{18}$ to $10^{20}$ cm.$^{-3}$) of impurities. In such structures the Fermi-level can lie below the top of the valence band on one side, and above the bottom of the conduction band on the other side. This gives rise to stability against thermal shock, and to a forward current-voltage characteristic which exhibits negative resistance (for preliminary results, see Esaki, L. (Tokyo), *Phys. Rev.*, **109**, 603; 1958). An incidental point of interest is that the direction of rectification is opposite to the usual one, and so is in agreement with that suggested in 1932 on the hypothesis of electron tunnelling.

It appears that semiconductor surfaces are being investigated increasingly by means of adsorption characteristics. The possibility of either mobile or localized adsorbed films of various kinds on germanium surfaces was envisaged by M. J. Sparnaay (Philips Research Laboratories, Eindhoven), and by H. Statz (Raytheon Co., Waltham, Mass.). Low-energy electron diffraction and work-function measurements were used by H. E. Farnsworth *et al.* (Brown University, Rhode Island) to study the structure and adsorption characteristics of clean germanium surfaces. He showed that surface atoms, displaced on a clean surface, appear to be restored to

their normal positions by the presence of a chemisorbed oxygen monolayer. The effect of oxygen adsorption on the photoelectric sensitivity of bismuth films was discussed by R. Suhrmann (Hannover).

An interesting group of papers on silicon was submitted from the British Associated Electrical Industries group of companies. R. C. Newman and J. Wakefield (A.E.I. Laboratory, Aldermaston) pointed out the possibility of a connexion between the formation on silicon surfaces of etch pits on one hand and of silicon carbide on the other. The distribution of impurities in pulled silicon crystals was discussed, among other topics, in two papers (N. R. Howard; P. Ransom, British Thomson-Houston Co., Rugby). H. F. Mataré (Sylvania Electric Products, Inc., Bayside, N.Y.) reported electrical experiments on bicrystals having known angles of misfit, and drew conclusions about the overlap of wave-functions of dangling bonds which occur at grain boundaries. Further information about these effects was expected at the meeting being held at Rochester, New York, at which a session is being devoted to grain boundaries and dislocations. An interesting aspect of crystal imperfections is their effect on mechanical damping. In silicon and germanium single crystals the damping usually shows two peaks when regarded as a function of temperature. The low-temperature peak at about two-thirds the melting point may perhaps be associated with the movement of dislocations. The high-temperature peak is probably connected with the motion of dissolved oxygen. A paper on these effects was read by P. D. Southgate (Mullard Laboratories, Salford).

Because of their applications to thermoelectric refrigeration a session was devoted to tellurides. The theory of remanent magnetization, important in connexion with magnetic recording tapes, was discussed by E. P. Wohlfarth (Imperial College of Science and Technology, London). Other applications which were considered included the use of impact ionization of impurities for low-temperature computing elements, applications of fluorescence to post office sorting problems, and several papers on transistor technology. As in the case of the earlier meeting at Garmisch, band calculations were discussed only incidentally. Impurity band conduction was mentioned somewhat more prominently—for example, in some speculations about the transition to metallic impurity band conductivity. The apparent absence of impurity band conduction down to 2° K. in some specimens of InSb was pointed out by E. H. Putley (Royal Radar Establishment, Malvern).

Other stimulating contributions, for example, in magneto-optics, are not mentioned here, since they are included in other conferences this summer. The proceedings of the Brussels meeting have been promised for the end of this year. Those of the 1956 Garmisch meeting are still expected.

P. T. Landsberg

# STERIC EFFECTS IN CONJUGATED SYSTEMS

THE consequences of steric interactions in organic molecules are of wide practical and theoretical interest to chemists, but the entire field of steric effects in organic chemistry is too vast to be covered in one conference. "Steric Effects in Conjugated Systems" was therefore chosen as the title for the Chemical Society symposium, held in Hull during July 15–17, because this topic is still of wide appeal to chemists and yet is sufficiently specialized to be treated in considerable detail by some fifteen papers, dealing with the study of steric effects by spectroscopic, kinetic, and other physical methods.

The introductory paper was read by Prof. E. E. Turner (Bedford College, London). He traced the chemical developments which led away from the Kaufler formula for diphenyl to the concept of a molecule comprised of two collinear benzene nuclei which will tend to be planar. This structure allowed an explanation of the optical isomerism of suitable diphenyls carrying four, three, two, or even one substituent in the sterically sensitive *ortho*-positions. This marked the discovery of molecular dissymmetry arising from restricted rotation about a bond—one of the most important steric effects which may arise in a conjugated system—and led to more recent work on 2 : 2′-bridged diphenyls. The conformational stabilities and molecular configurations for compounds containing two or more atoms in the bridge are now being studied by ultra-violet absorption spectroscopy.

Steric effects in diphenyl were also treated by Dr. G. H. Beaven (National Institute for Medical Research), who discussed the ultra-violet absorption spectra of pure alkyldiphenyls. While a 4-methyl substituent gives a red shift and an intensity increase of the conjugation band, 2-methyl substitution gives a blue shift and an intensity decrease. Further methyl substitution in the *ortho*-positions increases this effect, and the results are consistent with the hypothesis that progressive introduction of methyl groups into these positions gives progressive deviation from coplanarity and decrease in conjugation. Higher alkyl groups, unless branched, do not increase the steric effect, and the spectrum of 2 : 2′-dimethyldiphenyl suggests that the molecule has the *cis*-configuration already reported for 2 : 2′-dihalogenodiphenyls. The vapour-phase chromatography of these alkyldiphenyls was discussed by Dr. E. A. Johnson (National Institute for Medical Research), who has shown that the retention volumes for a single stationary phase depend on the position of the alkyl groups. Thus, 2-alkyldiphenyls have smaller retention volumes than the 3- or 4-isomers, presumably because the lower conjugation in the 2-isomer gives rise to less interaction with the stationary phase. The results confirm the conclusions reached from ultra-violet spectra relating conjugation to position and number of alkyl groups, and it has been possible to identify the peaks of a gas–liquid chromatogram of 21 isomeric tetramethyldiphenyls. Conjugation in 2 : 2′-bridged diphenyls and in halogenodiphenyls was also discussed in the light of the relative retention volumes for the compounds.

The influence of steric interactions upon the mesomorphic behaviour of 4-*p*-*n*-alkoxybenzylideneaminodiphenyls and 4 : 4′-di-(*p*-*n*-alkoxybenzylideneamino) diphenyls was discussed by Dr. G. W. Gray (University of Hull). A 2- or 2′-substituent in the diphenyl