scientific enlightenment to the lay public, because the problem of spreading science among scientists is just as urgent as that of spreading it among the public at large.

Mr. Maurice Goldsmith discussed the resistance of scientists to appearing on television. In producing a weekly television magazine, he has found that a proportion of scientists hesitate to co-operate. Some are needlessly afraid of being used for commercial ends, others feel it beneath their dignity to appear on television or perhaps fear the disparagement of their colleagues, while some do not feel that anything can be achieved in the space of four minutes. He believes that scientists do not realize that 'cathode ray tube time' is quite different from any other form of time they know. It provides the opportunity for a new experiment in the popularization of science, enabling the scientist to put forward what he wants to say to an audience of five million.

The communication of science to scientists and to the public may be regarded as extensions of one another. It follows, as Mr. A. L. Bacharach[1] pointed out in a preceding symposium on "The Communication of Biological Knowledge", that the same underlying principles apply to the communication of science, whatever the audience. No mind, however good, can take in unfamiliar things without effort. The scientist, familiar with his own special field, should therefore present it to others (technically qualified or not) in such a way that the effort required is not beyond their capacities. Bad presentation on any level should be suspected as a cloak for muddled thinking or poor research. The present symposium, which showed that a representative sample of scientists recognizes such truths, may become a small landmark.

H. O. J. COLLIER

[1] Bacharach, A. L., *J. Inst. Biol.*, 3, 57 (1956).

LOW-TEMPERATURE CRYSTALLOGRAPHY

MEETING IN OXFORD

THE first joint conference of the X-Ray Analysis Group of the Institute of Physics and of the Low Temperature Group of the Physical Society was held at the Clarendon Laboratory, Oxford, during April 12–13 under the joint chairmanship of Dr. K. Mendelssohn and Mr. H. P. Rooksby. The subject of the conference was "Low-Temperature Crystallography", and the invited speakers dealt with both the technical aspects of X-ray work at temperatures down to 1° K. and also with the actual type of experiments where a low temperature is an advantage.

The first session was opened with an introductory paper by Sir Francis Simon (Clarendon Laboratory, Oxford). In this he emphasized that transitions which were not thought possible a few years ago do take place at low temperatures and that X-rays are one method of investigating the nature of these transitions. X-ray analysis can be used for giving information on the state of order of a system, this order being determined by the influence of the interaction forces between the components of a system. Order can exist only at low temperatures, and perfect order is only possible at the absolute zero. What we mean by a low temperature depends, of course, on the system we are considering; for diamond 1,000° K. is low, whereas for hydrogen 50° K. is high. X-rays can also give information on the form of the vibrational spectrum, and a combination of X-ray and thermal data should prove useful in entropy calculations based on the third law.

Dr. M. Blackman (Imperial College, London) dealt with the theoretical aspects of the effect of temperature on the reflexion of X-rays. He showed that from a generalized form of the Debye–Waller theory for a complex crystal, a characteristic temperature Θ_x can be calculated, and this can be compared with the characteristic temperature, Θ_{el}, derived from elasticity theory. The theoretical value of the ratio Θ_x/Θ_{el} for sodium chloride and potassium chloride did not agree with the ratio obtained from experimental results, and this discrepancy cannot, as yet, be resolved.

In a paper on a theoretical study of the variation of vibration amplitudes with temperature in some molecular crystals, Dr. D. W. J. Cruickshank (University of Leeds) discussed how the root-mean-square amplitudes of the translational and angular oscillations in benzene and anthracene have been determined by three-dimensional Fourier refinements with anisotropic parameters. From these amplitudes the various characteristic temperatures have been determined, and the temperature variation of the vibrational and rotational oscillations has been calculated. These show that, for studying fine details of electron density, it is much more advantageous to take measurements at 90° K. (or better still at $\sim$ 20° K.) than at room temperature, but that little extra is gained in this particular work by taking readings below 20° K.

Dame Kathleen Lonsdale (University College, London), in her paper on the determination of Debye factors by intensity measurements at low temperatures, showed that there are two independent ways of determining the Debye factors for crystal diffraction spectra: one is the original method of comparing the intensities at different temperatures with due regard to the existence of zero-point motion; the other uses the intensities at one temperature only, taking account of the positions and motions of the atoms as determined through a complete structure analysis. These methods have been compared from data on urea, and they have been shown to agree better than might have been expected, bearing in mind the possibility of change of atomic parameters with temperature.

Discussing low-temperature X-ray work on alkali metals and alloys, Prof. C. S. Barrett (University of Chicago) described an X-ray spectrometer in which metals can be cold-worked at temperatures down to 5° K. The X-ray studies show that, down to this temperature, lithium and sodium are the only alkali metals which partially transform on cooling. This transition is from the body-centred cubic to the hexagonal close-packed structure, the axial ratio in the hexagonal phase being very close to 1·633, the theoretical value for close packing. The transformation in lithium occurs at 70° K. On cold-working the lithium at low temperatures, there is a further transition, this time to the face-centred cubic structure. This does not appear to occur when sodium is cold-worked; but a similar transition does occur for solid solutions of magnesium in lithium.

Dr. W. B. Pearson (National Research Council, Ottawa) described X-ray cameras which have been built for use down to liquid-helium temperatures. These have been designed to have an accuracy of

one part in 40,000, which is necessary for Debye–Scherrer photography if useful measurements of the change in lattice spacings with temperature are to be obtained. Other work to be done with these cameras includes the examination of structure changes in metals which are strained or subjected to high pressures at low temperatures.

The second session of the conference was opened with a paper by Prof. W. N. Lipscomb (University of Minnesota), who gave a general review of the techniques of low-temperature crystallography with particular reference to work on single crystals. After sketching briefly the history of single-crystal studies, he described the various methods of making single crystals for X-ray work. Many of these are gaseous or liquid at room temperature, and they require special methods for their production, the most common method being to crystallize the substance in a 'Pyrex' glass capillary. He also emphasized the need for keeping the production of frost down to a minimum, which can be done either by air-conditioning or by using a stream of dry air directed on to the apparatus. The consumption of liquid nitrogen, for cooling the specimen, can be quite considerable; for maintaining the specimen at −180° C. four litres per hour are required. Later speakers at the meeting, however, described cooling methods in which the consumption is much lower. Prof. Lipscomb's has been used for the completion of *hkl* data in B_5H_{11} and also for the investigation of transitions in ethylene chloride, hydrogen cyanide and nitrogen trioxide.

Dr. Aafje Vos (Laboratory of Inorganic and Physical Chemistry, Groningen) gave a review of recent Dutch X-ray work at low temperatures. This type of research has been done both at Amsterdam and at Groningen. In Amsterdam measurements on the electron-density projections of phthalic acid at −150° C. show an appreciable gain in resolution over those taken at room temperature. Low temperatures were also used in the investigation of the molecular compound of symmetric trinitrobenzene and benzene. At room temperature, pictures of the triclinic crystals showed a diffuse background with approximately hexagonal symmetry. This diffuse background disappeared completely at −150° C. The effect is probably due to independent thermal vibration of the individual molecules, and it seems most probable that the benzene molecules are responsible. In Groningen the crystal structure of 1,8-diphenyl-1,3,5,7-octatetraene has been examined at −100° C. in order to increase the accuracy of the determination of the bond-lengths. Standard deviations of about 0·003 A. and 0·04 A. were obtained for the co-ordinates of the carbon and hydrogen atoms, respectively. The use of low-temperature measurements has probably decreased the inaccuracy of the bond-lengths by a factor of two, and this is important if the experimental values are to be compared with theory. While in most of this work the specimens were cooled by a stream of cold air, another technique was described in which liquid nitrogen was dropped directly on to the specimen to cool it. In this apparatus the consumption of liquid nitrogen was 0·5 lit./hr.

Recent low-temperature crystallographic studies in France were described by Dr. A. J. Richard (Kodak-Pathé, Paris). This work was done at the Laboratoire Central des Services Chimiques de l'État. A Weissenberg camera was used in the temperature range −160° to 20° C., the specimen being cooled by nitrogen gas obtained by boiling liquid nitrogen with an electric heater. The temperature variation over several hours was not more than five degrees, and during a period of one hour it was less than one degree. Structure studies were undertaken on nitric acid and its one- and three-molecule hydrates (V. Luzzati); one-, two-, three-, four-, five- and seven-molecule hydrates of sodium hydroxide (P. W. Hemily); sulphuric acid and several compounds of the tertiary system nitrogen pentoxide–sulphur trioxide–water (R. Pascard); salicylic anhydride (Mme. P. Bourre); and acetaldehyde (A. J. Richard).

Another apparatus for maintaining specimens at low temperatures was described by Dr. J. H. Robertson (University of Leeds). In this the cold gas stream is again used for cooling, in order to give the minimum of interference with the X-rays, and by careful design the consumption of liquid nitrogen has been reduced to 1/7 lit./hr. The gas flow is very steady, the variation being only about 1 per cent over a period of 4½ hr. While the apparatus has not as yet been used with liquid hydrogen, it is hoped that it will be satisfactory in the temperature range down to 20° K.

Mr. M. H. Francombe (Research Laboratories, General Electric Co., Ltd., Wembley) gave a paper on the application of low-temperature powder photography to studies of magnetic and dielectric phenomena. A 19-cm. camera which incorporates a gas cooling system for the specimen was described and exhibited. The apparatus has been used for studying structural changes which occur in antiferromagnetic, ferrimagnetic and ferroelectric powders.

A paper by Dr. J. A. S. Smith (University of Leeds) showed how nuclear magnetic resonance measurements at low temperatures can give additional information in structural analysis. A general review of nuclear magnetic resonance methods was given, taking as an example work on benzene and ammonium chloride in which the behaviour below and above their nuclear magnetic resonance transitions was compared. From the variation of the line-width and relaxation-time in and above the transition region, the predominant molecular motions in the crystals could be investigated. In another series of experiments low temperatures were used to remove the narrowing effects of molecular motion on the line-width. This work has been done with sodium borohydride, hydrazinium oxalates and several hydrates. The results seem to cast further doubt on the existence of the ion H_4O^{++}.

Dr. C. H. Shaw (Ohio State University) read a paper on an X-ray determination of the structure of liquid helium. This work, which was done in collaboration with W. L. Gordon and J. G. Daunt, used proportional counter techniques for determining the intensity of the X-rays scattered by the liquid helium. Beryllium windows, 0·002 in. thick, were used to admit the X-rays through the vacuum jacket into the cryostat. The background count was reduced to 4 per minute. At scattering angles greater than 60°, no difference was found in the form of the diffraction patterns at 1·4 and 4·2° K. The low-angle results, however, which were taken at 1·4, 2·4 and 4·2° K., showed that there was a change in correlation number as the temperature was reduced, but that there seemed to be no definite change associated with the lambda point. X-ray measurements on tungsten showed that there was a maximum in the characteristic temperature, Θ, at 17° K. The existence of

such a maximum can also be derived from measurements of specific heat. In the discussion, Dr. M. Blackman stated that on theoretical grounds this maximum is very difficult to explain.

In a paper on measurement of lattice parameters and thermal expansion at low temperatures, Prof. G. O. Jones (Queen Mary College, London) described work done in collaboration with B. S. Figgins and D. P. Riley. The apparatus was designed so that only the specimen was at the low temperature, and an accuracy of 1 in 10^5 in the measurement of the lattice parameter could be achieved. The temperature could be kept constant to 0·05 deg. at the lowest temperatures. So far, measurements of the lattice parameter (and hence of the thermal expansion) of aluminium have been carried out between 20° and 125° K. The results confirm earlier work of Bijl and Pullan, that at low temperatures there is a considerable deviation from Grüneisen's law. Measurements on solid argon are also in progress. In connexion with this work, Dr. E. R. Dobbs (Queen Mary College, London) gave a short contribution in which he described a simple back-reflexion camera for experiments on solidified gases down to 77° K. This has been used for work on solid krypton.

Mme. L. Couture (Centre National de la Recherche Scientifique, Bellevue) described work, done in collaboration with P. Jacquinot and I. Tsujikawa, on optical observations of transition in crystalline hydrates at low temperatures. The experiments showed that the absorption spectra of some substances (in particular, certain of the alums) changed at low temperatures, and these results were compared with corresponding changes which had been found in measurements of paramagnetic resonance. Complete agreement between paramagnetic and optical results was not achieved, but nevertheless the optical experiments confirmed that changes in crystalline structure do occur at low temperatures, especially in some of the chromium alums.

The conference showed that, while a large amount of X-ray work is already being done at temperatures down to 77° K., using liquid nitrogen as the coolant, not very many experiments have been done at lower temperatures, using liquid hydrogen or liquid helium as the coolant. There is still a very wide field of research open to anyone who has the necessary cryogenic facilities. In addition to the lectures already described, an evening discourse, entitled "Molecular Crystals", was given by Prof. J. D. Bernal (Birkbeck College, London).

In a meeting of the X-Ray Analysis Group which preceded the joint conference, a discussion was held on the collection and classification of crystallographic data for determinative and reference purposes. The discussion was opened with contributions by Dr. J. W. Hughes (University College, Cardiff) on the A.S.T.M. index, Prof. E. G. Cox (University of Leeds) on the single-crystal index, Dr. M. H. Hey (British Museum) on the Barker index of crystals, and Dr. L. E. Sutton (University of Oxford) on a bond-length index. Dr. W. B. Pearson (Ottawa) gave details of the index of metals and alloys which should soon be available. Several speakers in this discussion emphasized the need for research workers to send in their crystallographic and X-ray data to the compilers of the various indexes. Many of the data are obtained as an incidental part of some other research, and very often they are not published. Hence, they are overlooked when reference books are being written.

A full account of the conference will be given in the *British Journal of Applied Physics*. The next conference of the X-Ray Analysis Group will be held in London during November 16–17; two sessions will be devoted to biological structures, and one session to computational methods.

H. M. Rosenberg

DIGITAL COMPUTER TECHNIQUES

A CONVENTION on "Digital Computer Techniques" was held in London at the Institution of Electrical Engineers during April 9–14, at which more than fourteen hundred persons attended, including 127 delegates from overseas countries. These figures emphasize the rapid growth of interest in this field, since at a similar convention, held three years ago, only two hundred in all were present. On the evening of April 9, after the convention had been opened by the president of the Institution, Sir George Nelson, an inaugural address was given by the president of the Royal Society, Sir Cyril Hinshelwood, and this was followed by an introductory lecture by Prof. F. C. Williams. During the next three days, fifty-eight papers were read. The papers had been divided into two groups: those of general interest, and those of interest to specialists. Normally, a general and a specialist session were held simultaneously, so that in this way both the non-expert and specialist were satisfactorily accommodated. On the last two days of the convention, visits to typical computer installations were made. These visits had been arranged with the co-operation of commercial companies, government establishments and universities; nearly nine hundred delegates availed themselves of these opportunities.

In his address, Sir Cyril Hinshelwood referred to the diverse lines of thought which have been successfully combined in the computing machine of to-day. Essential contributions have come from the theory of numbers, the relations between mathematics and logic, the discovery of various electric and magnetic phenomena, and the invention of the thermionic valve. He emphasized that the philosophy, in this case of machine design, preceded the actual construction and thus was not an afterthought about results, as it sometimes is. Having introduced the computing machine in this way, he then turned to view and speculate upon the interesting and exciting panorama which is beginning to unfold before us. On the scientific side there is now the prospect of solution of hitherto intractable problems; in the business world the mechanization of all kinds of clerical work and accountancy can be contemplated; and in industry the process of automatic control can be improved and carried a further step towards the final goal of complete 'automation'. The use of machines in this way must effect a displacement of man-power, and could amount to another industrial revolution. Sir Cyril Hinshelwood expressed the hope that any necessary redistribution of labour would be carried out without any serious results from the human and economic points of view. Finally, after a brief excursion into the seemingly age-old problems of 'Can machines think?' and the 'machine–brain analogy', he concluded by expressing his admiration of this work and his great confidence in its future.

In his lecture, Prof. Williams indicated the rapid development in the field of digital computers by con-