raising the standard of intelligence of the people as on any of the economic and agricultural remedies mentioned at the Conference.

The future betterment of European farming was discussed on the second day at sessions presided over by Mr. A. J. Drexel Biddle, the American Ambassador to the occupied countries, and by Sir John Russell.

Miss Margaret Digby recapitulated the causes of agricultural backwardness advanced by speakers on the previous day, and emphasized the military reasons for State policies aiming at keeping an excessive population on the land. She called for a reconstruction programme based on high nutritional standards, more efficient farming, freer trade within a planned international economy, freer movement of populations and a wide development of rural industry.

Dr. L. Feierabend believes that agricultural evolution in Europe must be in the direction of small, individually owned farms working co-operatively. He distinguished clearly between co-operative and capitalistic farming. The primary aim of a co-operative society should be not the making of profits, but "the support of the business of its members", that is, the improvement of the land. He agreed with other speakers that a high standard of education is a necessary element in the success of any co-operative scheme. Mr. S. Malessa stressed the inter-dependence of agricultural and industrial planning. The problem of rural overpopulation can only be solved by industrial planning to absorb the surplus.

Dr. L. Dudley Stamp outlined the geographical factors determining and limiting the types of crop production feasible in Europe, and advocated planning on a regional rather than on a political basis. Dr. J. Krnjević described the political emergence of the Croatian peasantry, comprising 90 per cent of the population, through the cultural activities of the Croat Peasant Movement.

Dr. J. Hammond gave an account of artificial insemination, which several speakers thought could play an invaluable part in restoring the quality and quantity of livestock. Mr. A. Fjelstad dealt with practical problems of the small livestock farmer in Norway, and Mr. P. H. Pedersen with practical aspects of milk production in Denmark. Both the last two speakers stressed the importance of effective co-operation in small-scale, intensive farming.

QUANTUM THEORY AND DIFFUSE X-RAY REFLEXIONS

By G. D. PRESTON

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THE origin of certain anomalous X-ray reflexions, that is to say, intensity maxima the presence of which cannot be explained by the usual diffraction theory, has recently been the subject of investigation in many laboratories. Some account of the work carried out in Great Britain was given at a discussion held in London on February 6, 1941, and a review of this discussion appeared in NATURE of April 19, 1941, p. 467; a fuller account has been published in the *Proceedings of the Royal Society*, A, **179**, 1–102, 1941. The progress made in the investigation of this interesting subject in India has recently been reported in the *Proceedings of the Indian Academy of Sciences* of October, 1941, which is wholly devoted, to quote from the cover, to a "Symposium of papers on the Quantum Theory of X-Ray Reflection and the Raman Reflection of X-Rays in Crystals". This description of the subject-matter reflects very clearly the difference in the interpretation of the phenomena which exists between French, American and British physicists on one hand, and the group of Indian physicists at Bangalore working under the leadership of Sir C. V. Raman on the other.

Before considering the nature of this difference of interpretation, it will be convenient here to indicate the scope of the papers presented to the symposium. Sir C. V. Raman contributes two papers on the theoretical aspect of quantum X-ray reflexion, and in collaboration with Dr. P. Nilakantan provides experimental confirmation from a study of diamond, a crystal the reflexion from which is also discussed by P. Rama Pisharoty. Dr. C. S. Ventakateswaran contributes six papers; one illustrates the change of intensity of the anomalous reflexions at low temperatures and the remainder deal with the patterns formed by rock salt, naphthalene, benzophenone and hexamethyl-tetramine. Benzil is investigated by R. V. Subrahmanian, and aluminium and calcite receive attention from Bisheshwar Dayal, P. Nilakantan and P. G. Nayar. This brief outline of the field covered on the experimental side will serve to show that, whatever differences of opinion exist as to the origin of the reflexions, the phenomena investigated are in fact the same as those studied in France by Laval, in the United States by Wadlund, Zachariasen and Siegel, and in Great Britain at the Royal Institution and the National Physical Laboratory.

It is perhaps worth while here recalling the salient features of the effects observed. When a single crystal of, say, aluminium, rock salt or sylvine is mounted in a beam of X-rays which traverse the crystal in a direction parallel to a cubic axis, a Laue photograph is obtained if the beam consists of 'white radiation'. In addition to the Laue spots, there appears on well-exposed plates a number of streaks, running through the Laue spots, which apparently should have no business there. When the composite X-ray beam is replaced by a monochromatic beam, the usual theory of crystal diffraction tells us that no reflexion should be observed unless the crystal is orientated in a particular way. In general, the condition for reflexion will not be satisfied, except by a lucky accident, and a blank photograph should result. However, in fact, reflexions are observed. They are faint, but have the symmetry proper to the crystal axis in which the incident X-ray beam lies. Examples have been published in the pages of NATURE (**143**, 76 (1939); **147**, 467 (1941); **148**, 112 (1941)). It is this background of 'non-Laue' diffuse reflexions that is attracting the attention of X-ray crystallographers. To what is it due?

There appear to be several possible answers to this question. The most comprehensive is perhaps to say that the diffuse background arises as a direct result of departures from geometrical perfection in the crystal architecture. A periodic flaw, a regular precipitation of an impurity such as produces a Widmanstätten pattern, and the temperature vibrations of the atoms are all possible and probable causes. It is the task of the experimenter to devise means of identifying the different causes so that use may be made of the machinery provided by the mathematician to enlarge our knowledge of the solid state. Those features of the background reflexions which occur in crystals of pure substances, so that

flaws and chemical segregation are excluded from consideration, are evidently of great importance. There is general agreement on all sides that this background is due to movement of the atoms or molecules of the crystal from their positions of perfect geometrical alinement. The differences of interpretation arise in assigning the cause of the movement and in the mechanism of X-ray scattering. In Great Britain and in the United States, the whole effect is ascribed to the thermal vibrations of the crystal lattice. Just as the Laue and Bragg reflexions are a picture of the static geometry of the crystal, so the diffuse background is a picture of the dynamic vibrations of the crystal. The undisturbed crystal can be regarded as a medium in which the density varies periodically in space, and the effect of the temperature vibrations is to superimpose a spectrum of much longer elastic waves on the natural periodicity of the crystal. The whole crystal then diffracts as a unit and the resulting pattern consists of the usual Laue reflexions plus a background due to the motion of the atoms.

The point of view adopted by the Bangalore group of physicists is rather different. In places I find it obscure and can only hope that the following brief paraphrase of their views does them no injustice. To begin with, the quantum aspect of the interaction of X-rays with the atoms of the crystal is emphasized. The radiation scattered from an oscillating atom is stated to consist of three components, the amplitudes of which depend on the amplitude of oscillation of the atom, and which differ in frequency. The first component, which gives rise to the normal reflexions, has the frequency ν of the primary X-ray beam, while the other two have frequencies $\nu \pm \nu'$, where ν' is the frequency of the atomic oscillation. The frequency change is unfortunately too small to be measured directly.

The atomic oscillations which produce the frequency modulation are supposed, according to Raman, either to arise as a result of direct excitation by the incident beam or to be present as thermal vibrations. The existence of the latter does not seem to be essential ; it is sufficient that the atoms are capable of being set in motion by absorbing energy from the X-ray beam—the interaction of the primary X-ray beam with the oscillating atoms then produces the effect. The character of the possible atomic movements is classified into two essentially different parts falling in the infra-red and the elastic ranges of frequency respectively. Raman imagines the elastic low-frequency vibrations of the crystal lattice to arise from the displacement of the lattice cell as a whole from its equilibrium position. Interaction between these vibrations and the X-ray beam gives a background of diffuse scattering of low intensity proportional to the number of lattice cells irradiated. The scattered energy is spread over a wide range of angles so that the elastic waves, it is stated, cannot produce a sharp reflexion.

To the infra-red modes of vibration is ascribed the principal role in producing the observed reflexions, with intensities proportional to the square of the number of lattice cells. These modes of vibration are supposed to arise from the movements of the atoms within the cells of the lattice. There is a difficulty here : the classification of the vibrations will hold for molecular crystals such as benzil, say. In these we might suppose the (infra-red) vibrations of atoms within one molecule to be controlled by forces different from those which control the vibration of the molecules as a whole (elastic waves). But in metal crystals we can choose a cell containing but one atom, and there is no distinction to be drawn between the vibrations of the atoms as a whole and those of the lattice. The metals aluminium, sodium and lead all show, however, pronounced diffuse reflexions, although the elastic waves are not supposed to be capable of producing such an effect. Moreover, Raman explicitly assumes, as a limiting case it is true, that the infra-red vibrations have identically the same frequency, amplitude and phase in all the lattice cells of the crystal : in order that the centre of gravity of the cell may remain fixed, some atoms must move in opposite directions to others, an idea that leads to difficulties as the number of atoms in the cell diminishes.

When the assumption just mentioned as to the identity of phase of the infra-red vibrations in all lattice cells is abandoned, it is assumed that the phase varies slowly from place to place in the crystal. We are then presented with the difficulty that the variation of phase is propagated through the crystal, a process which must involve the elastic properties of the lattice ; yet these are supposed to be without effect in producing the most salient features of the X-ray pattern.

It seems unlikely that the quantum hypothesis as set out by Raman can be reconciled with the elastic wave explanation unless one or other hypothesis is radically altered. Although Sir C. V. Raman is confident that his quantum mechanism is essential, it must be admitted that the "thermal-elastic" theory does give a reasonably accurate account of the observed facts.

OBITUARIES

Prof. L. J. Henderson

BY the death of Lawrence Joseph Henderson, the U.S. National Academy has lost its foreign secretary, Harvard University a notable personality, and the United States an outstanding man of science.

Henderson was born in 1878. He graduated at Harvard in arts and medicine. A couple of years were spent in Strassburg, principally in Hoffmeister's laboratory, but he spent some time acquiring technique in organic chemistry in Thiele's institute, and his mind at that time was in close contact with that of Faust and the work of Schmiedeberg's laboratory. On returning to Harvard, Henderson was made lecturer in biological chemistry ; in 1910 he became assistant professor, and in 1919 professor.

A remarkable range of knowledge enabled Henderson to contribute in ways not open to those whose intellectual background is more restricted. Versed in the disciplines of mathematics, science, and philosophy, he could place a physiological problem either in a more mathematical or a more philosophical frame than could most of his contemporary biologists. On the other hand, the manipulative aspect of experimental science made little appeal to him, and probably the particular satisfaction of 'bringing off' a difficult experiment was something which he was content to leave to others.

About the time when Henderson graduated, the buffering of fluids was one of the growing points both of physical and biological science, and Henderson's first notable work dealt with that subject (for example,