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THE INDIAN ACADEMY OF SCIENCES*

THE first annual meeting of the Indian Academy of Sciences was held at Bombay. Once again we meet in the Bombay Presidency, this time in the historic city of Poona, associated in our minds with one of the most striking periods in Indian history and to-day one of the chief centres of culture and learning in our country. To our hosts who have taken it upon themselves in these difficult times to invite us to their city and thereby made it possible for us to meet here, our grateful thanks are due.

Ten years is not a long period in the life of an individual, much less in the history of an institution. Infantile mortality is, however, notoriously high in India. Hence, it is not inappropriate for me to draw your attention to the fact that this is our tenth annual meeting and that the scientific *Proceedings* of the Academy are now running in the twentieth volume, both in the A and B series. The usefulness of these *Proceedings* as a forum for the publication to the world of the results of the scientific investigations of our Fellows and their collaborators has been abundantly demonstrated. The *Proceedings* have appeared in an unbroken sequence and with unfailing punctuality on the last day of every month ever since July 1934 which was the date of the first issue. This is a record of which we may feel justifiably proud.

The Academy is a body of scientific men interested in their work and especially in the advancement of knowledge by original research. It is an organisation which can be of immense service to science and to the country in various ways, if it is adequately supported and encouraged. I think I am speaking for all our Fellows throughout India when I say that not only are we capable of rendering such service, but are also willing to do everything in our power to demonstrate the social value of scientific research in our country. Elsewhere in the world, the Academies of Science are not merely publishing organisations for scientific research, but also function as active promoters of scientific research by building and equipping laboratories and maintaining professors and students to work in them. It is my considered opinion that the future of science in India depends to a very great extent on such a development taking place in our country and not upon the multiplication of official laboratories staffed by armies of Government servants. The history of science has demonstrated over and over again that the choicest fruits of scientific research fall into the hands of those men who seek for no reward except the discovery of truth. The mind that seeks to explore Nature and discover her secrets and the mind of a bureaucrat are as poles asunder.

It is my earnest desire that the Indian Academy of Sciences should function in the manner I have indicated and actively sponsor scientific research in a group of institutions covering the whole field of natural knowledge, from pure mathematics and astronomy at one end, physics, chemistry and mineralogy in the middle and physiology and genetics at the

* Part I of the Presidential Address by Sir C. V. Raman at the Poona Meeting, 27th December 1944.

other end. Such a group of institutions linked together and working under the general guidance of the Academy would serve as the vanguard of science in India, marching into the unknown, blazing a trail for others to follow and pointing a way to the practical applications of science. Such a scheme may seem a colossal one, but to my mind it is entirely practical and indeed realisable in a reasonably short time, if only our wealthy men could give a generous helping hand. Nothing would pleace me more than to be able to devote myself to the realisation of this idea and of its practical consequences.

Meanwhile, there is one small step which our Fellows, if they so choose can help the Academy to take immediately, and that is to provide a permanent habitation for our offices. A circular letter has been issued to our Fellows in this connection, and I greatly hope that it will meet with an immediate and generous response from them.

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I shall devote the rest of this address to a topic which is surely familiar to you all. Who does not know the classic illustration of the thermal expansion of solids which is the fitting of the iron tyre to a cart-wheel by first heating it up and then placing it in position? To know that a solid expands when heated is, however, only a first step in knowledge. To specify its magnitude and offer an explanation of the phenomenon and to predict its course over a wide range of temperature are the deeper problems of the subject.

The solids familiar to us in our daily lives are of complex structure and their thermal behaviour is naturally of great practical importance. But to the physicist who seeks to understand the fundamental aspects of the subject, the ideal materials to study are those which are relatively simple, both physically and chemically. The best choice is that of a well-developed single crystal, while such substances as pure metals, diamond, rock-salt, flourspar, calcite and quartz offer the greatest promise of a successful theoretical interpretation.

It is easy enough to observe and measure the expansion of a long bar when heated up sufficiently. When we are working with single crystals, however, it is usually possible only to get rather small specimens. The accurate determination of thermal expansion then becomes a more difficult experimental problem. The celebrated French Physicist, Fizeau, was the first to use the delicate optical method known as the interference of light for such studies. For this purpose, he worked with specially cut and polished specimens of various crystals. During a visit to Paris in the year 1937, I was fortunately enabled to discover and purchase several of Fizeau's original specimens. The collection now forms one of the most highly prized treasures in my crystal cabinet.

Another and very beautiful method which is extensively used at the present time is based on the use of X-rays. The angle at which such rays are reflected by the atomic layers in a crystal depends on the spacing of these layers, and alters with the changes of spacing, produced by the expansion or contraction of the crystal. Very small quantities of the substance are sufficient for this method, and it is also possible to use material in the form of powder. Further, by choosing the conditions such that the X-rays are reflected almost exactly backwards, very small changes in the atomic spacing produce a detectable change in the angle of reflection. The method is then both sensitive and accurate. An important aspect of the technique of the X-ray method is the maintenance of the material at the desired temperature without altering the temperature of the rest of the camera. Recently, Dr. R. S. Krishnan has reported an interesting modification in which this difficulty is avoided by the use of a divergent beam of X-rays. The X-rays fall upon a chosen face of the crystal, and the sharply-defined reflections given by it are recorded on a photographic film placed at any desired distance. Even a small expansion then produces an observable shift which can be accurately measured. It is important to hold the crystal in such a way that it does not rotate appreciably when heated or cooled, and this can be controlled by a second photograph in a different setting of the crystal. In this way, Dr. Krishnan has studied the thermal expansion of diamond over a fairly large range of temperatures.

Except in the case of a crystal belonging to the cubic system, its expansion is not the same in all directions, the nature of the differences being determined in a general way by the symmetry of the crystal, and more particularly by its internal architecture. To determine the thermal behaviour of a given crystal completely, it may thus be necessary to determine the expansion in several directions. When it is recalled that the rate of the thermal expansion per degree centigrade itself usually changes with temperature, and that this may again be different for different directions, it will be realised that a complete specification of the thermal behaviour of a crystal of low symmetry over a wide range of temperature may be somewhat complicated. Indeed, some crystals, *e.g.*, calcite, actually contract instead of expanding in certain directions when heated. It is a special advantage of the X-ray method in which powders are used is that the changes in all the atomic spacings of the crystal lying in many different planes are simultaneously recorded, thereby reducing the labour involved in the study of a particular substance.

As already remarked, the thermal expansion of a solid per degree centigrade is far from being constant over any appreciable range of temperature. The changes in the rate of expansion are particularly striking at low temperatures such as those of liquid-air. There are, however, some crystals in which the accelerated thermal expansion is noticeable even at and above room temperature. Diamond is a particularly conspicuous example, as is shown by Dr. Krishnan's recent studies with it.