Prof. H. Hartridge said that he could confirm the old observation of Holmgren that a bright yellow point centrally fixated could be seen as red, white, green or yellow and a blue point as green, white, blue or violet. How was it possible to reconcile this observation with the existence of only two receptor types in the central fovea?

Dr. M. H. L. Pirenne suggested that more use might be made of the opto-motor reaction in investigating the colour-vision of animals by a method similar to that used by Hecht in determining acuity.

Dr. Willmer, in reply to Dr. Thomson and Prof. Hartridge, said that it was not really relevant to argue about whether or not a colour sensation was aroused in the subject. The crucial question was whether the sensation, whatever its subjective nature, could be matched tri-, di- or mono-chromatically.

Dr. Pumphrey, in reply to Dr. Pirenne, said that the difficulties of the technique suggested, if not insuperable, were so formidable that suspicion might attach to the results. The method had, in fact, been tried by Birukow on the frog with results in conflict with those of other workers.

R. J. P.

PHYSICAL AND PSYCHO-PHYSIOLOGICAL ASPECTS OF COLOUR

THE British Psychological Society and the Colour Group of the Physical Society held a joint meeting, their first, in the Hastings Hall, Tavistock House, London, on February 12, when a number of problems about colour were discussed. Mr. J. G. Holmes, chairman of the Colour Group, was in the chair. Three main topics were introduced by members of a panel consisting of Dr. L. C. Thomson (Vision Research Unit, Medical Research Council), Mr. R. C. Oldfield (Institute of Experimental Psychology, Oxford), Dr. R. W. Pickford (Department of Psychology, Glasgow), Dr. W. D. Wright (Department of Optics, Imperial College of Science and Technology, London) and Mr. W. A. Allen (Building Research Station, Department of Scientific and Industrial Research). General discussion of each subject followed the contributions of the panel.

Dr. Thomson spoke first, on "The Measurement and Meaning of the Luminosity Curve". He emphasized the difficulties of determining accurately the forms of this curve, and outlined the two principal methods, namely, (a) obtaining brightness matches for a series of monochromatic stimuli against a standard monochromatic stimulus; (b) determining the absolute intensity-threshold for a series of wavelengths. By these methods the photopic and scotopic curves are obtained, and their form and relative position in the spectrum suggest a number of problems, of which Dr. Thomson detailed two. The first of these is that of the shift in the position of the luminosity curve as conditions are changed from scotopic to photopic, and in this connexion he made reference to Dartnall's suggestion that such a shift might be produced by selective absorption by increasing concentrations of the breakdown product of rhodopsin—indicator yellow—under increasing light intensities. Such a hypothesis would, he remarked, predict a limited shift of about the correct amount. The second problem about the luminosity curves raised by Dr. Thomson was that of the secondary maxima, or 'humps' found on the photopic curve. He pointed out that if these are connected with

independent colour mechanisms, doubts must arise regarding that part of the Young-Helmholtz trichromatic theory which postulates that a sensation of white is the product of the activity of the three colour receptors alone, and of no other mechanism.

Mr. Oldfield referred briefly to some of the problems, physical and psychological, which arise concerning the position of the luminosity curve in the electromagnetic spectrum, and the biological utility of colour vision. He cited Wall's view that, since the vertebrate eye evolved in an aqueous environment, the absorption spectrum of water must be one of the factors determining the position and extent of the sensitivity curve of the eye. He mentioned other physical factors which impose similar limitations. On the question of the biological utility of colour vision, he referred to the difficulties of determining accurately its incidence among animal species, and remarked upon its somewhat odd occurrence. He suggested that its chief utility lies in the enormous variety of discriminable patterns of visual stimulation that it affords, compared to the resources offered by mere intensity discrimination. He asked whether the actual incidence of colour mechanisms might not be bound up with the food habits of the species concerned.

Dr. Pickford spoke next on "The Inadequacy of Existing Tests of Colour Vision". He remarked first that most tests are vitiated by the fact that they were devised with a theory of colour defect in mind. Indeed, he said, most would be quite useless if the phenomena of colour-blindness did not show marked discontinuities. The tests are satisfactory only in so far as they are responsive to distinctions between the colour-blind and the normal. They have little capacity to separate out the anomalies. He then briefly criticized a number of tests in common use. Holmgren's wool-test had been effectively disposed of by Edridge-Green, who showed that it failed in many cases to detect defects of occupational significance. Tests of the Stilling and Ishi-Hara type serve to reveal the chief discontinuous classes of colour defect, but scarcely do much to distinguish the protanope from the deuteranope. Edridge-Green's bead test depends on naming, and no test should depend on this alone; further, its yellow-blue section is ineffective, and the test generally is too easily passed by defectives. Lantern tests such as those of Edridge-Green and Martin depend on naming, itself a complex function. They also suffer from extreme intricacy of procedure, if the instructions are fully complied with. Spectrometer tests, again, rely on the expression of discrimination in terms of names, and suffer from the disadvantage that they require an experienced worker to administer them. They are also unable to deal with the red-green anomalies. The anomaloscope, finally, is excellent for the detection and measurement of red-green anomalies, but is unsuitable for use on other types of defect.

Dr. Wright maintained that the available tests are not entirely unsatisfactory, provided they are used for purposes to which they are suited. In occupational testing it is important in the first place to pick out the grosser defects, and to select those subjects who require further testing of a more special character. The Ishi-Hara test and the anomaloscope together will achieve this. The more special tests should be devised so as to provide as close an imitation of the occupational working conditions as possible. Dr. Wright emphasized that, as an occu-

pational problem, colour-blindness cannot be treated in terms of discontinuities. The appropriate borderline must be fixed in the light of each type of occupational requirement and circumstance. For the scientific investigation of colour defect, all that is required of the tests is that they should be able to pick out with reasonable reliability those individuals requiring more intense study by specialized laboratory methods. Existing tests such as the Ishi-Hara satisfy this requirement.

The discussion was then thrown open to the meeting, and a number of members took part. Several commented on the usefulness of the Ishi-Hara test in examining school-children, and the view was expressed that, if used in suitably defined and standardized conditions, especially as regards illumination, the test is an effective one. Some discussion took place on the relationship of intelligence to colour-vision test performance; and the implications of supernormal colour discrimination were briefly examined, together with the part played by training and practice. A number of remarks were also made concerning the conditions and significance of binocular chromatic fusion.

Mr. Allen then spoke on "The Effect of Colourful Decoration and Lighting". He explained that these problems, which are of great importance to the architect, builder, and industrial manager, fall into two types. In the first place, colour effects can be used in factories and other places of work to promote, through broadly æsthetic channels, cheerful and pleasant states of mind conducive to efficient work and the avoidance of fatigue. In the second, there are more specific problems of promoting physiological well-being by such factors as the avoidance of glare, the production of a feeling of warmth, and so forth. The first, more æsthetic, group of effects allows considerable latitude in the choice of suitable colour schemes. But in the case of the second, choice is dictated by the particular problems to be solved. Mr. Allen gave examples in which such choice had been successfully made. In one case lighting conditions, and particularly the absence of glare, in recently built schools caused the teachers to insist that they felt markedly less strain in their work, while the children showed a smaller tendency to somnolence in the afternoons. Mr. Allen concluded by remarking that what had hitherto been done towards a solution of these problems had been upon a somewhat intuitive and *ad hoc* basis, and he appealed for an attempt to be made towards a scientific formulation of the necessary principles.

In the course of the subsequent discussion, attention was directed to the difficulties of investigation in this field. Mr. Oldfield emphasized the danger of drawing conclusions from short-term experiments. At the same time, he said, there is a natural hesitancy in embarking on long-term investigations involving great expenditure of time and effort where so little is known of the individual factors that may play a part. Mr. H. D. Murray expressed himself as disappointed with what the psychologists had at present to offer. He had hoped that some relatively simple indicator of the effect of these factors might be devised, though he acknowledged that those commonly used, such as output, minor accident-rates, etc., in investigation of the effects of more specific environmental conditions were inappropriate in this field. He said that any good suggestions, even if they afforded only partial solutions, would be very welcome to people in industry.

The chairman, in both his opening and closing remarks, stressed the importance of bringing psychologists, physicists and physiologists together for the common discussion of the problems of colour. He was sure, he said, that such contacts would be very fruitful in suggesting valuable and novel experiments.

R. C. OLDFIELD

THE ROYAL INSTITUTION AND SCIENTIFIC RESEARCH*

By PROF. E. K. RIDEAL, O.B.E., F.R.S.

THE free and unfettered pursuit of knowledge which Rumford and Davy laid down as the object of the Royal Institution has had surprising results. This is not the place to catalogue the vast list of scientific discoveries which have emanated from the laboratories and desks in this building from the time of Rumford to the time of Dale. We usually associate the names of workers in science with some particular achievement, because that particular piece of work has had a great influence either on modern philosophical thought, or on some modern branch of experimental or theoretical science, or again, in some field of technological endeavour; but their other and less-known achievements in different fields are not to be ignored.

The spirit of freedom and of inquiry is like the wind which bloweth whithersoever it listeth, and it may be of interest to examine the contributions which workers in the Royal Institution have made to the subject of the physics and chemistry of surfaces and colloids, a field in which the laboratory is especially interested at the present time, and to compare the methods of experimental approach adopted by them with those now current.

We usually associate the name of Count Rumford himself with the concept of the mechanical equivalent of heat; but we find that he was interested in surface tension, and held several classes on the subject. In a similar manner, Davy, associated by us with the discovery of the alkali metals by electrolysis, the definition of acidity and the physiological effects of nitrous oxide, was interested in the movement of crystals of potassium acetate on the surface of water, and remarked that their lively motion was retarded by a layer of oil.

Observing that small solid objects could float on a water surface and that it was generally attributed to air adhering to the surface, Rumford devised experiments to prove this was not the case. One simple experiment consisted in allowing a needle to fall on a water surface under ether, when the needle remained suspended at the ether-oil interface. He concluded that the particles of water adhere strongly to each other, forming, in consequence, a kind of pellicle at the upper surface. With this concept he interpreted the concavity of a water surface confined in a small vessel, the suspension of water in a capillary tube and the like. He inquired as to the form of the sessile drop and noted that the resulting film at the surface must be extremely thin.

Rumford observed that Laplace's attractive forces in that writer's theory of surface tension are to be identified with his adhesional forces. He commented on the great author of "Mécanique Céleste" as follows: "I must confess that I am not sufficiently

* From a Friday Evening Discourse at the Royal Institution on March 4, in commemoration of its foundation on March 7, 1799.