## Photo-Electric Cells.

THE recent discussion on magnetism (see NATURE, June 7, p. 874) afforded an example of a symposium on a subject academic and in some respects aloof from the problems of everyday life. The discussion on June 4 and 5, organised jointly by the Physical and the Optical Societies, is at the opposite pole. Although the photo-electric effect both raises and resolves many recondite problems in modern physics, its applications may touch modern life at points so far distant as photo-therapy and greyhound racing, and it was in great measure on applications that the interest of the discussion centred.

That a metal plate, exposed to the light from an arc, acquires a positive potential—indicating therefore the emission of electrons—was observed so long ago as 1888 by Hallwachs, and facts of fundamental importance were rapidly accumulated by Elster and Geitel, who demonstrated in particular that, while ultra-violet light was the effective agent in establishing the positive potential of an ordinary metallic plate, the alkali metals, sodium, potassium, and rubidium, were sensitive to rays from the luminous portion of the spectrum.

Einstein in 1905, using the hypothesis of light quanta, showed that the maximum kinetic energy of electronic emission was a linear function of the frequency ($\nu$) of the light employed. In fact,

$$\tfrac{1}{2} mv^2 = h(\nu - \nu_0),$$

where $h\nu_0$ is the 'electron affinity', and is a measure of the loss of energy suffered by the electron in escaping from the interior of the atom. This equation, which is the basis of one of the most accurate methods for the determination of Planck's constant $h$, suggests that there is a light-frequency $\nu_0$, characteristic of the metal on which the light falls, and such that, if the incident light has a frequency less than $\nu_0$, no electron emission takes place.

The fact that a metal such as potassium is sensitive to ordinary light at once suggests its use in a cell in which the electronic current so produced may be measured, and its variation studied with variation of the incident light. Again, the photo-electric current may be amplified by valve circuits used outside the cell, or may be magnified within the cell by filling the cell with gas, applying a relatively large electric field and so producing ionisation by collision.

Obviously, constructional problems of no small difficulty at once present themselves, and, these problems solved, with the many applications of photo-electric cells, the question of standardisation arises. It is, for example, a matter of primary importance that the gas-filled cells now so largely used in connexion with talking films should be standardised as regards size, voltage, and terminal arrangements. This and allied matters are discussed in detail by Dr. Norman Campbell, while the problems of manufacture are very fully described in connexion with the thalofide cell (a cell sensitive to the infra-red, in which the active substance is oxidised thallium sulphide), barium photo-electric cells, sodium, and selenium cells.

Theoretical problems did not bulk largely in the discussion. Dr. Campbell described a theory of selective emission in which it is suggested that in selectively emitting surfaces an electro-negative element is universally present. Further, following a clue given by the recent work of Fowler and Wilson, the conditions for selective transmission are assumed to be fulfilled if the potential changes at the transmitting surface are such that a 'valley' of potential is formed between two 'peaks' so situated that the waves associated with the electrons are capable of forming stationary waves between the sides of the valley. Two investigations of valve-amplification of photo-electric currents complete the more important theoretical studies read during the discussion.

The papers presented may conveniently be grouped under the main headings, history and development, theory, manufacture, and applications. Naturally, the application of widest interest is to photometry, and it is not surprising that eleven out of the twenty-seven papers presented deal with various aspects of photometry. The problem is not easy. It has been well remarked of the human eye that "an instrument that will work with almost equal precision in illuminations differing in a ratio of ten thousand to one is not likely to distinguish easily small differences of illumination". Photo-electric methods are considerably more precise, but it must be carefully considered what that precision measures, in view of the fact that two lights, judged by the eye to be equal, will not be rated as equal by a photo-electric cell unless they have the same quality; and further, it may be debated whether high precision is worth while, when we remember that in problems of vision the eye is the final standard. However that may be, photo-electric photometry is coming into wide use, and the papers dealing with precision measurements in photometry, the comparison of lights of very small intensity, the photo-electric measurement of daylight and of undersea illumination, photo-electric photometry in relation to photo-therapy, and spectro-photometry, form a most helpful contribution to the discussion of this important branch of the subject.

In the section dealing with measurements, attention may be directed to a description, by Mr. Eric Moss, of a very compact null electrostatic method, involving the use of the Lindemann electrometer, for the absolute measurement of the photo-electric current.

A particularly neat application of the photo-electric cell to the measurement of small angles was described and demonstrated by Dr. Perfect, in which an image of a narrow slit is focused on the razor-sharp edge of a steel prism and is thus divided into two components, the relative intensity of which varies with the position of the image of the slit. This relative intensity is measured by allowing the components to 'flicker' on a photo-electric cell. The amplified alternating photo-electric current is rectified by a commutator, and its magnitude measures the relative intensity required. In the experiment as shown displacements of the beam of light which forms the image of the slit are compensated by means of a hollow prism containing air, the internal pressure of which may be varied. It is possible by this arrangement to measure angles of less than 15″ with a probable error of the order of 0·05″.

The discussion of the papers provided an occasion for a lively duel concerning the relative merits of the selenium cell and the photo-electric cell. But a welcome innovation, that of demonstrations, during the tea interval, of the subjects of papers of experimental interest, gave an opportunity, of which most of the members of the audience made full use, for that informal interchange of ideas which is, perhaps, one of the most valuable features of a discussion. This apart, the experimental illustrations, which included an exhibit of photo-electric cells of the type developed by Prof. Lindemann, and a demonstration by Prof. Thirring, of Vienna, made all the difference, for one hearer at least, between vague and vivid memories of a very valuable discussion.

ALLAN FERGUSON.