SCIENTIFIC BOOKS

The Elementary Principles of Lighting and Photometry. By JOHN W. T. WALSH. E. P. Dutton & Co., New York.

THE task which the author of this book has set himself is a very difficult and important one. The science and art of illumination has developed within recent years to such an extent that no one man can hope to be an expert in all its branches. Photometry, as a branch of physics, more particularly of radiometry, is a subject which in itself requires a book of considerable size for its adequate treatment. Light production is a branch of applied science calling for the most profound knowledge of physics and chemistry. The utilization of light—illuminating engineering—is a branch of engineering which is second to none in its importance in modern life, and because of the intertwining of engineering, ocular hygiene and esthetics involved, requires a very special talent and training. To present a survey of the whole subject of lighting which shall be truly informative, accurate and well balanced, requires, therefore, a rather exceptional fund of knowledge and experience, and the use of excellent judgment in the selection and presentation of material.

This task Mr. Walsh has performed in a very creditable way. The point of view of the book is well given in the statement that it "is mainly intended to give a description of the nature and amount of the illumination required for different purposes, and of the way in which the desired result may be attained and its attainment checked by photometric measurement." The book is written for readers who have an elementary scientific and technical education. It opens with a chapter on "Light, vision and the eye," in which the various factors involved in lighting are outlined. This is followed by chapters dealing with the measurement of candle power and illumination, together with some discussion of the characteristics of modern light sources. The practical aspects of illumination are then treated, under the headings of "Indoor lighting," "Industrial and school lighting," "Outdoor illumination," "Daylight illumination" and "Light projection."

In handling the measurement of light the author has made some radical departures from the ordinary treatment in text-books on photometry and certain of these departures are to be commended. Thus the whole subject of standards of light is very properly compressed into the statement that the standards consist of seasoned incandescent electric lamps which are preserved in the National Standardizing Laboratories and occasionally intercompared. This treatment deletes the usual lengthy discussion of the Hefner and other flame standards which are practically superseded. On the other hand, the rating of illuminants in terms of "average candle power" instead of lumens, as is the American practice, is open to criticism. The lumen is the exact analogue of the watt, and is an appropriate unit for the engineer. Its use tends to a clear understanding of the processes of transformation of energy involved in light production. In this connection it appears unfortunate that in his treatment of modern light sources Mr. Walsh has given no discussion of luminous efficiency, nor an adequate presentation of the physical characteristics of the radiations emitted. The fact that present-day light sources are only 2 or 3 per cent. efficient is of considerable economic interest, and the possibilities of improvement indicated by spectrum analysis of their radiations are among the most fascinating in modern applied science.

Mr. Walsh's treatment of photometric instruments and methods may be criticized in places as being too sketchy to give a clear idea to a reader not already familiar with the subject. For instance, the descriptions and illustrations of the Bunsen grease spot and the Lummer-Brodhun contrast photometers are much less clear than the excellent drawings in Liebenthal, which might easily have been copied. In his analysis of methods of colored light photometry Mr. Walsh is rather superficial. One gathers that the "cascade method" alone possesses the merit of averaging the results of a large group of observers; and the simple division of the subject into fundamental methods of evaluating luminosity differences in the presence of color and of auxiliary colored standards for practical use, calibrated by these fundamental methods, is quite lost sight of.

The treatment of color is in other respects not entirely satisfactory. His relegation of all questions of color to a late chapter on "Color in illumination and photometry" rather than their treatment early in the book, in connection with the physics of light production and the phenomena of color vision, does not seem a good arrangement. What the student of illumination needs is a knowledge of the spectral distribution of emission, in light sources, and of transmitting and reflecting power in material bodies, and the significance of these spectral characteristics in terms of color appearance. This latter calls for some knowledge of the elementary facts of color mixture. No knowledge of theories of color vision is really necessary, but if it is thought desirable to refer to any theories, it would appear to the reviewer that the Edridge Green theory, which Mr. Walsh selects, is the least useful in connection with the facts of color mixture and appearance just mentioned. The statement in the chapter on "Color" that a glass to simulate daylight in connection with a tungsten lamp has only recently been achieved must be interpreted, as is evidently the case for several statements of illumination practice, as applying to England, since daylight glass

has been an article of commerce in this country for some years.

In his treatment of the practical side of illumination Mr. Walsh gives primary emphasis to the problem of getting an adequate amount of light on the object or plane of interest; "the important factor in seeing is the brightness of the thing looked at and this is the product of the illumination and the reflection ratio." At the same time the almost equally important matter of keeping bright lights out of the field of vision, and the avoidance of glare in general are not lost sight of. Practically every important problem of lighting, in the home, the factory and the public institution, is treated in a manner sufficiently detailed so that the reader should have an intelligent idea of the fundamental requirements and the best practice in meeting these. The latest lighting legislation, both British and American, is extensively quoted.

The points to which exception has been taken are minor ones, and are such as are almost inevitable in any book which attempts to cover a large field. They do not prevent the book from giving, on the whole, an excellent view of the subject, and it can be cordially recommended to all who wish to obtain a good idea of the scope of modern lighting science and practice. The bibliography at the end is well chosen as a guide to further study of the subject. The book is excellently printed and attractively bound.

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WESTERN ELECTRIC COMPANY,
NEW YORK, N. Y.

SPECIAL ARTICLES

PROBABILITY-INCREASE IN SHUFFLING, AND THE ASYMMETRY OF TIME[1]

A MACROSCOPIC model to illustrate the nature of the Boltzmann H-theorem[2] has been described by P. and T. Ehrenfest. It will be recalled that the H-function is a measure of the probability P of a given state (configuration, velocity distribution) of a system of particles. It is related to the entropy S of the system through the relation $S = k \log P = -kH$. As the system approaches the steady state, the entropy S increases and the function H decreases, each approaching a limiting value. The Ehrenfest model, which operates by successive drafts of numbered tickets from urns, illustrates very effectively several characteristic properties of the H-function; in particular, its tendency to decrease continually when its value is remote from the ultimate "steady" value; the occasional lapses in which H momentarily increases, even in states remote from the steady state; the essentially discontinuous character of H, which, strictly speaking, renders the derivative (dH/dt) meaningless; and, finally, the small fluctuations of H above its minimum value when the statistically steady condition has become perceptibly established.[3]

One feature of special interest, however, the Ehrenfest model fails to exhibit, namely, the occurrence of long-continued and extended series of increases in H, such as must, according to the theorem, take place upon very rare occasions. Indeed, it seems at first sight hopeless to attempt to devise any experiment which should illustrate these exceptional high peaks in the H-curve. It seems like a contradiction of terms to speak of producing, at will, and within a closely limited period of time, an excessively rare (improbable) event. We know, indeed, that any truly representative model of an H-curve must have such high peaks at long intervals, corresponding, it may be, to billions of years or more; but how can we bring it about that such a peak shall occur during our experiment; that the particular piece of the curve under observation shall be the one containing the monstrosity?

By a simple artifice this effect can be secured. Two similar urns (boxes) are charged with a set of numbered tickets or the like. Box A receives tickets 1 to 50, which, for brevity, we may speak of as tickets a. Box B receives tickets 51 to 100, tickets b. The two boxes are thoroughly shaken to shuffle the tickets. A ticket is then drawn blindly from A, and another from B, the numbers drawn are recorded, and the tickets are returned to *opposite* urns. The urns are again thoroughly shaken and the same process is repeated as many time as may be desired. In the experiment here recorded, a series of 50 such double drafts was made.

At the termination of this first series of drafts the contents of box A are carefully noted. While this can be done from the records alone, as a matter of additional certainty, to guard against error, box A was opened and a note was made of all the tickets contained therein. They may, to distinguish them, be blackened on their back; but in any case it will now be convenient to speak of them as *black* tickets, while the remaining 50 tickets, contained in box B at the end of the first series, may be spoken of as white tickets.

The black tickets are put back in box A, and a second series of drafts precisely similar to the first is

[1] Papers from the Department of Biometry and Vital Statistics, School of Hygiene and Public Health, Johns Hopkins University, No. 91.

[2] P. and T. Ehrenfest, *Physikal Zeitschr.*, Vol. 8, 1907, p. 311; Schaefer, Einführung in die theoretische Physik, 1921, Vol. 2, p. 417.

[3] The experimental demonstration of the occurrence of these fluctuations near the steady state is one of the many remarkable developments of recent years in the physics of small dimensions. In this connection reference may be made to the work of The Svedberg (Die Existenz der Molekühle, Leipzig, 1912) and Smoluchowski (Bull. Acad. Cracovie, 1916, p. 218).