period of uncertainty for the publishers of anything, even best-selling novels."

Since the National Research Council, so I understand, is the residuary legatee of the Troland estate, perhaps you may be willing to publish this note by way of an appeal to any interested person or organization that is in position to make the guarantee, and thus render a service to science. Unless something is done promptly, the book may be lost.

JEROME ALEXANDER

50 EAST 41ST STREET
N. Y. CITY

SCIENTIFIC BOOKS

COLORIMETRY

Handbook of Colorimetry. Prepared by the Staff of the Color Measurement Laboratory, Massachusetts Institute of Technology, under the Direction of Arthur C. Hardy. Pp. 87, Figs. 30, Charts 23. The Technology Press, Mass. Inst. of Tech., Cambridge, Mass., 1936. Price $5.00.

THIS publication contains a detailed description of the method of computing certain colorimetric quantities from spectrophotometric data, together with elaborate tables and graphs greatly facilitating the computations. Its scope can best be indicated by listing the chapter headings and giving a brief abstract of the most important features of each chapter.

(1) *The Physical Basis of Color Specification.* The material in this chapter is general, introducing the reader to the idea of spectrophotometric analysis and giving him a brief preview of the rest of the book.

(2) *Sources of Light.* This chapter discusses the types of illuminants under which samples are ordinarily viewed, such as incandescent illuminants of various color temperatures and the various phases of daylight. Special attention is properly devoted to the three illuminants recommended for colorimetric use by the International Commission on Illumination and known as I. C. I. illuminants A, B and C. Illuminant A is a Planckian radiator or black body, in practice a gas-filled tungsten lamp, operating at a specified color temperature; illuminant B is a combination of illuminant A with a specified light filter yielding a chromaticity and relative energy distribution (in the visible spectrum) approximating those of average noon sunlight; illuminant C is a combination of illuminant A with a filter yielding an approximation to average daylight. Tables are given of the relative energy distribution of each of these three illuminants, values being given at each millimicron from 380 to 780 mμ. Relative energy values are also given at every 10 mμ from 360 to 750 mμ for sunlight above the atmosphere and for average Washington noon sunlight.

(3) *Spectrophotometry.* The effect on the spectral transmission of changing the thickness of a transparent material and the concentration of a transparent solution is discussed and illustrated. The subjects of specular and diffuse transmission and reflection are briefly considered. One statement in this chapter should not be overlooked—". . . it is obvious that every color specification must be accompanied by a complete statement of the geometry of the illuminating beam and the geometry of that portion of the reflected (or transmitted) beam that is evaluated in the measurement."

(4) *The Laws of Color Mixture.* The subtractive and additive methods of mixture are briefly discussed and illustrated. A table of wave-lengths of complementary lights is given; when these lights are mixed together additively in pairs in the proper amounts, they will yield the chromaticity of I. C. I. illuminant C.

(5) *Determination of Tristimulus Values by the Weighted Ordinate Method.* Data are given and the procedure is outlined for computing from a table of spectrophotometric data the amounts of the three hypothetical I. C. I. primaries which the I. C. I. standard observer would require in additive mixture to match the color in question. The three numbers thus computed serve as a fundamental definition of the color of the sample for the specified conditions of illumination and observation used in obtaining the spectrophotometric data. Tables of the tristimulus values for the spectrum of an equal-energy stimulus and for the spectra of illuminants A, B and C, respectively, are given at each millimicron from 380 mμ to 770 mμ (to 740 mμ only for illuminant C).

(6) *Determination of Tristimulus Values by the Selected Ordinate Method.* In this alternative method of deriving tristimulus values the numerous multiplications necessary by the weighted ordinate method are eliminated and the computational labor is reduced to a determination of values of the spectral transmission or reflection quantities at the selected ordinates followed by a simple adding of the numbers so selected. Tables of 30 and 100 selected ordinates for each tristimulus distribution are given for illuminants A, B and C.

(7) *Trichromatic Coefficients.* The respective ratios of each of the tristimulus values to their sum are defined as the trichromatic coefficients (trichromatic coordinates, trilinear coordinates). These coefficients serve to specify the chromaticity of the color. Trichromatic coefficients on the I. C. I. basis are given for a few selected illuminants, and for the spectrum at each millimicron from 380 to 780 mμ.

(8) *Graphical Representation of Colorimetric Data.* This final chapter contains 25 charts, in which the coordinates are the trichromatic coefficients, x and y, on the I. C. I. basis, and on which are plotted lines at suitable intervals to enable one to read values of dominant wave-length and excitation purity for the I. C. I. standard observer and with illuminant C as the reference point from which the dominant wave-length loci diverge. Formulas are given for the interconversion of excitation purity and colorimetric purity. These charts are called "chromaticity diagrams," but it should be remembered in any use of such charts that the I. C. I. coordinate system is such that equal distances in various directions, or in the same direction on various parts of the complete diagram, do not indicate equal chromaticity intervals. The lack of proportionality is often many-fold.

It is well known to experts in colorimetry that the colorimetric method described in this book—*viz.*, spectrophotometry accompanied by colorimetric computations based on data fairly representative of an average normal observer—is the most analytical and fundamental which it is possible to use. As such, it is extremely valuable for record and specification purposes. It enables a control to be placed on master color standards otherwise impossible. Of course, there are various types of work where the spectrophotometric data are sufficient in themselves for the purpose. For such, the Handbook would be of little use. But for those who wish to convert such data to colorimetric terms, so that differences in spectrophotometric data may be understood and expressed colorimetrically, the Handbook is of considerable value. It supplements the work of Judd[1] by enabling dominant wave-lengths and purities to be derived graphically instead of algebraically, although the solution is restricted to illuminant C used both as illuminant and reference point.

In addition to the graphs, the parts of the book which are essentially new are the one-millimicron interpolations of the various functions and the wave-lengths of the selected ordinates. These data are undoubtedly of high accuracy and should be of permanent value, particularly to those wishing to make transformations from the International Commission on Illumination coordinate system to other coordinate systems. However, the usefulness of this work does not depend solely on the amount of new material in it, but on the fact that it contains an exposition of the method and a compilation of data brought together in one volume from diverse sources.

In addition to summarizing what may be found in the "Handbook of Colorimetry," it is equally important to indicate those possibly pertinent things which will not be found in it, things which were obviously outside the purpose of the authors in producing such a work, but which those interested in the subject might expect to find included. One might feel handicapped by the lack of references. One must look elsewhere for a thorough discussion of the controversial subject of the definition of color. Psychometric methods applied to color are not considered. There is no discussion of specific systems of material color standards—color cards, atlases, dictionaries, etc.—and but little about colorimeters or filter photometers, visual or photoelectric.

The chapter on spectrophotometry deals with the quantities measured rather than with the methods of measurement. In the discussion of reflection measurements, however, the distinction between *reflectance* and *apparent reflectance* is not brought out. This distinction is particularly important in the colorimetry of glossy materials, where it is usually desirable to exclude the specular component of the reflected light. The International Commission on Illumination, at the same time that it recommended the use of data defining the standard observer and coordinate system and illuminants A, B and C, also recommended that in the colorimetry of opaque materials, except for special cases, the sample be illuminated unidirectionally at 45° and the reflected light be taken for measurement in a direction normal to the surface. This 45°-normal condition of illumination and observation, or some other condition eliminating the specular component of the reflected light from the measurements, must be used if the colors of glossy materials are to be properly specified. The Handbook ignores this I. C. I. recommendation.

One might differ with the authors on various other matters of definition and emphasis and on certain minor details, but to raise these questions here would detract attention from the main purpose of this review, which is to indicate in brief space the nature and scope of the information to be found in the book. The title appears too broad in that there are many phases of colorimetry not included. However, the authors are to be heartily commended for the emphasis which this work places on the most fundamental of all colorimetric methods. In view of the recent improvements in recording spectrophotometers, to which Professor Hardy has so largely contributed, it becomes of increasing importance that methods of colorimetric computation be speeded up to keep pace. To this end the Handbook is another step forward in the science and practice of colorimetry.

KASSON S. GIBSON
NATIONAL BUREAU OF STANDARDS

[1] The 1931 I. C. I. standard observer and coordinate system for Colorimetry, *Jour. Opt. Soc. Am.*, 23: 359, 1933.