Books

Millikan's Travels

The Autobiography of Robert A. Millikan. 311 pp. Prentice-Hall, Inc., New York, 1950. $4.50.

Robert Andrews Millikan is one of the most distinguished physicists in the world and his autobiography will interest not only the entire scientific world, but the reading public at large.

Millikan was born in 1868 in Illinois and grew up in Iowa. His parents were of New England pioneer stock and guided his childhood wisely. It was full of hard work and strenuous play in the vigorous, growing midwestern communities of that time.

Millikan attended Oberlin College and as an undergraduate student-teacher practically introduced the subject of physics there. His most time-consuming and remunerative activity at Oberlin, however, was as acting director of the college gymnasium. He later decided on physics rather than physical education for a career, but his youthful interest in sports has stood him well throughout life. Probably no scientist in modern times has reached the age of 82 with such a continuous span of health and strength with which to carry on his activities.

Millikan's Oberlin professors obtained a fellowship for him at Columbia University where he studied under the famous Michael Pupin. At Columbia University he received a thorough foundation in classical physics, and it was Pupin who made it possible for him to gain a much broader view of science by postdoctoral work at the Universities of Berlin and Göttingen in Germany. With characteristic thoroughness, Millikan first spent two months at Jena learning the language and then took a bicycle trip through Germany, Italy, and France to prepare himself for his opportunity to study with Nernst and other giants of the old Germany. During his stay at Berlin, x-rays were discovered by Röntgen, thus opening up the fields of atomic physics to which Millikan himself was later to make some of the greatest contributions.

During the summer between his years at Columbia, Millikan had gone to the new University of Chicago to study with Albert Michelson. Undoubtedly because of this acquaintance, Michelson invited him to join the physics staff at Chicago, ". . . an offer which caused me to take the next train from Göttingen to London. . . ." Millikan's first years at the University of Chicago were devoted almost entirely to the organization of physics courses. For this work he prepared physics textbooks that are still models of exposition. His *A First Course in Physics* (written with Henry G. Gale) was the fascinating and inspiring introduction to physics for countless thousands of people now engaged in professional careers in science. His association at Chicago with men like Michelson, George E. Hale, Frank B. Jewett, President Harper, James Breasted, George Birkhoff, Ostwald Veblen, and Charles E. Merriman led him quite naturally into a career as a research leader. It is refreshing and helpful for younger workers to read, however, that only after many discouraging attempts did his great researches on the determination of the electronic charge and his proof of the Einstein photoelectric law emerge. The graduate students who worked with him in these great achievements (Harvey Fletcher, H. D. Arnold, Karl K. Darrow, M. J. Kelley, and many more) include some of the outstanding leaders in the development of physics in America, especially in its industrial applications.

During World War I Millikan's energies and administrative genius were fully occupied in the war effort. Here his principal associates were George E. Hale and William H. Welch, and together they bore the chief responsibility for organizing and vitalizing the National Research Council which made such significant progress in proving to the armed services the value and need of the methods and men of science. Perhaps the greatest contribution in World War I was a start on the extremely difficult problem of submarine detection, although each of the services, and especially the air forces, were aided by the efforts of the National Research Council. The culminating achievement of the Hale-Millikan leadership was the building of the National Academy of Sciences headquarters in Washington which has since been the meeting ground for the nation's men of science and their government.

After the war, Millikan's association with George E. Hale and Arthur A. Noyes led to his decision to abandon his research career at the University of Chicago and transfer to the California Institute of Technology. Here his astonishing energy permitted him to carry on a full research program, in which his best known work has been on cosmic rays (so named by him), and in addition to create a great physics department in a technical college where the full potentialities of science for engineering have been realized. Under his leadership has grown an institution vital for the development of Southern California and the South West, and one which by the outbreak of World War II had become an important factor for the technological strength of the entire United States.

In retirement Millikan seems to be as active and energetic as ever, encouraging his younger colleagues in research and setting an example for the physicists of America in scientific leadership, human relationships, and the public service.

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Chips

Color Harmony Manual (Third Edition). Edited by Egbert Jacobson, Walter C. Granville, Carl E. Foss. 37 charts containing 973 separate color samples; 51 pp. separate text. Container Corporation of America, Chicago, Illinois, 1948. $125.00.

Collections of colored samples, systematically arranged according to various principles of manufacture or appearance, have frequently attained some popularity ever since Valentinum Boltz von Ruffach published his *Illuminierbuch* in 1549. That contained forty-seven pages on which each owner was expected to apply artists' colors mixed in accordance with instructions given in the book. *A Neuherfürgegeben Farbebuchlein* published in 1685 contained eighty-nine color samples under each of which was placed the German name in use at that date. The unsatisfactory state of color nomenclature has since led to the preparation of over thirty books or pamphlets containing color samples and the corresponding color names in every language of major importance, including classical Greek and Latin usages. Many of these had the colors arranged according to systems of nomenclature or notation advocated by the authors.

The analogy between the interrelationships of colors and of points of space was first mentioned by Newton. This analogy was first illustrated by Mayer, who published a triangular color chart in 1758 and described a space representation of the entire domain of object colors in an unpublished manuscript written before 1775. Reimann's paper on the foundations of geometry (1854) indicates that this analogy may be unique: "The positions of objects of sense, and the colors, are probably the only simple notions whose modes of determination form a multiply extended manifold."

The modern era for color systems opened in 1886 when Ridgway published his *Nomenclature of Colors for Naturalists* which was finally illustrated in 1912, by his *Color Standards and Nomenclature*. The first description of the well known Munsell system was in *A Color Notation* published in 1906. This was first illustrated in 1915 by publication of the *Atlas of the Munsell Color System*.

Wilhelm Ostwald, winner of the Nobel Prize in chemistry in 1909, published his first *Farbatlas* in 1917 on which the *Color Harmony Manual* is based. Ostwald's system bears a striking resemblance to Ridgway's although there is no evidence that Ostwald knew of Ridgway's work. Ostwald was acquainted with Munsell's quite different arrangement of colors, having exhibited one form of it in a Lowell Institute lecture at the Massachusetts Institute of Technology in 1905. The first (1942) edition of the *Color Harmony Manual* was the first American publication of a set of colors arranged according to the Ostwald system.

As in the earlier editions, the samples in the third edition are cut out of clear cellulose acetate sheets, coated on one side with an opaque pigmented lacquer, so that both sides produce approximately the same color. One side is glossy and the other mat. The materials were selected for maximum stability and both sides are washable. There are numerous differences between the samples in the third edition and those having the same designations in the earlier editions. These changes were made "to give better interrelation of the various scales, and to provide a more useful sampling of the color domain. Also, advantage has been taken of recent developments in colorants to extend the color range in some regions without sacrifice of permanence". These changes make it imperative, however, to supplement color records based on these samples with a statement of the edition used.

The samples in the third edition are hexagons about 22-mm wide. Each sample has a tab about 10-mm wide extending about 10-mm from one side, so that it can be inserted into slots cut in the charts, to hold and exhibit the sample in its relationship to other samples, and to facilitate rearrangement of the samples. All samples of approximately the same hue are arranged on a single chart. Complete charts are given for twenty-eight different hues, four of which are newly interpolated between neighboring pairs of hues of the twenty-four indicated by Ostwald and provided in the earlier editions. Each chart contains samples varying from the one having greatest purity through a series of five samples of increasing reflectance and decreasing purity to a light, nearly gray, modification of the original hue, and through a series of five samples of decreasing reflectance and purity to a dark, nearly black, modification of the original. Between the light and dark samples of minimum purity are arranged (from top to bottom near one side of the chart) a series of five samples of the same purity but decreasing reflectance. Ten other samples of intermediate reflectances and purities are arranged systematically, in interlocking series, between the corresponding samples in the series described. This forms an equilateral triangular array of twenty-eight samples, all having approximately the same hue. Partial charts are provided for two more interpolated hues. Each has twenty-one samples, the series of minimum purity having been omitted because they would be nearly indistinguishable from samples provided in the charts for neighboring hues. Eighty-four extra samples (seven of each of twelve hues) split the visual differences between the samples of lowest purity on the regular charts and the corresponding grays. Twenty-four more extra samples split some excessively great visual differences between adjacent samples of high reflectance, on four of the regular charts.

The purpose of all arrangements of colored samples is to bring order out of the chaos of the "triply extended manifold" of colors. Ostwald advocated not merely a systematic arrangement of colors, but also "standardization" in the sense that use should be made only of colors selected from a finite and rather small (in the present instance, 943) collection. He recognized that there are myriads of colors intermediate between his selections, but made no provision for them in his system. Although his notation provides for a single, mid-point interpolation between adjacent colors, his system provides no convenient method for recording the millions of colors that are distinguishable from the selected few, nor even for recording the differences between the colors presented in successive editions.

The samples, and the charts on which they are arranged, are the most useful parts of the *Color Harmony Manual*. The latter would be more convenient if the holes for the looseleaf rings were punched at the top. Being punched at the bottom, the charts can only be examined (and the colors rearranged) at arms' length, with one cover of the large binder and the useless backs of other charts closer to the worker.

The text supplied with the charts perpetuates many of Ostwald's misconceptions and dogmas. The most serious instance, which pervades the whole discussion, is misuse of the word "sensation". On page 8, the statement is made that "If to any full color F (say hue 6) we add the sensation of white progressively, we shall complete a series between full color and white". If the phrase "add the sensation of white" means anything, it implies that hue is not changed. Yet hue obviously is changed, not only in Figures 2 and 3 of the text, but also in the array of samples on the chart for hue 6. The sample (ca) having maximum reflectance and minimum purity is very evidently bluish compared to the full color (pa), which is a distinctly yellowish red. Likewise, the (ca) sample of hue 19 is bluish green although the full color is yellowish green. The (ca) and (ec) samples of hue 12½ are distinctly reddish compared to the blue full color (pa). Finally, the Bezold-Brücke effect is very noticeable in the chart for hue 1½, making the dark, grayish sample (pn) appear distinctly greenish compared to the yellow full color (pa). The method of printing Figures 2 and 3, Ostwald's own account of the physical basis of his system, and theoretical and practical analyses of the first edition of the *Color Harmony Manual* (see *J. Opt. Soc. Am.*, July, 1944) all indicate that dominant wavelength is approximately constant, and is intended to be exactly constant, in each chart. Since, in general, hue is not constant in series of constant dominant wavelength, it is misleading to say that the series are constructed by adding the "sensations" of white and black to the full colors. Similar ambiguities concerning white and black "contents" necessitate great care in interpreting quantitative data given in the text. According to the announcement of the third edition, purchasers will be entitled to "basic colorimetric specifications in terms of ICI standard observer and coordinate system for both mat and glossy sides of all colors" now in preparation. These will provide unambiguous specifications of the colors exhibited in the charts, which the present notations and text do not.

The collection of samples possesses two interesting features which are not available in any other obtainable system. It is curious that these features are not mentioned in the text. All samples on a single chart have nearly the same dominant wavelength, and all samples in any vertical row on any one chart are nearly equal in both dominant wavelength and purity, exhibiting only different reflectances. There are few, if any, series of various chromaticities having constant luminous reflectance. We may turn to the Munsell system for this feature, as well as for series of constant hue as distinguished from constant dominant wavelength.

Any fully systematic arrangement of colors facilitates the examination of series of related colors, and gives the impression of harmony both in its parts and in its totality. Although the Manual purports to give principles of color harmony, it actually only makes clear various possible relationships of colors. It does little more than facilitate trials and modifications of color combinations. Artistic experience, taste, and intention govern the final choice in any case. Every user will want to create his own color harmonies even after examining the most nearly satisfactory combinations obtainable in the Manual. Such users may appreciate having their attention directed toward various possible harmonies. They will probably forgive the Manual if they find that it does not measure up to its ambitious title.

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Methuen's Monographs

Distribution in the United States of the series of pocket size books on physics originated by Methuen and Company, Ltd. of London has been undertaken by the New York publishing house, John Wiley and Sons, Inc. The list of Methuen monographs on physical subjects available at present has reached a total of 27, which is something more than half the number issued by the British publishers. The series, under the general editorship of B. L. Worsnop, has been intended as a collection of compact statements of the contemporary position in each of a variety of physical subjects. John Wiley's list as it now stands includes the following monographs:

Electron Diffraction; by R. Beeching; $1.25. **The M.K.S. System of Electrical Units;** by R. K. Sas and F. B. Pidduck; $1.00. **Dipole Moments;** by R. J. W. LeFevre; $1.25. **The Physical Principles of Wireless;** by J. A. Ratcliffe; $1.25. **The Commutator Motor;** by F. J. Teago; $1.25. **Hyperfine Structure in Line Spectra and Nuclear Spin;** by R. Tolansky; $1.50. **X-Ray Optics;** by A. J. C. Wilson; $1.50. **Mercury Arcs;** by F. J. Teago and J. F. Gill; $1.50. **Fundamentals of Discharge Tube Circuits;** by V. J. Francis; $1.50. **An Introduction to the LaPlace Transformation;** by J. C. Jaeger; $1.50. **Cosmological Theory;** by G. C. McVittie; $1.50. **Magnetism;** by E. C. Stoner; $1.25. **The Cyclotron;** by W. B. Mann; $1.25. **Physical Constants;** by W. H. J. Childs; $1.25. **The General Principles of Quantum Theory;** by G. Temple; $1.25. **Low Temperature Physics;** by L. C. Jackson; $1.50. **Collision Processes in Gases;** by F. L. Arnot; $1.25. **An Introduction to Vector Analysis for Physicists and Engineers;** by B. Hague; $1.25. **X-Ray Crystallography;** by R. W. James; $1.25. **Atomic Spectra;** by R. C. Johnson; $1.25. **The Kinetic Theory of Gases;** by M. Knudsen; $1.25. **X-Rays;** by B. L. Worsnop and F. C. Chalklin; $1.25. **Applications of Interferometry;** by W. E. Williams; $1.25. **Heaviside's Electric Circuit Theory;** by H. J. Josephs; $1.25. **Wave Mechanics;** by H. T. Flint; $1.25. **Atmospheric Turbulence;** by O. G. Sutton; $1.50. **Wave Filters;** by L. C. Jackson; $1.25.

Books Received

NONLINEAR VIBRATIONS IN MECHANICAL AND ELECTRICAL SYSTEMS. By J. J. Stoker. 273 pp. Interscience Publishers, Inc., New York, 1950. $5.00.

SOME EARLY TOOLS OF AMERICAN SCIENCE. By I. Bernard Cohen. 201 pp. Harvard University Press, Cambridge, Massachusetts, 1950. $4.75.

PHYSICAL CHEMISTRY OF HYDROCARBONS. VOLUME I. Edited by Adalbert Farkas. 453 pp. Academic Press, Inc., New York, 1950. $8.50.