

Munsell Color System,
Company, and Foundation

by Dorothy Nickerson

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History of the Munsell Color System

Dorothy Nickerson

Editor's Note:

The inauguration of the series of *CR&A Reports* comes at a turning point in the roughly 75-year history of association of the name Munsell with the field of color. Past chapters in this history include Albert H. Munsell's development of the system which bears his name, the formation of the Munsell Color Company to market the samples and materials illustrating the Munsell System, the formation of the Munsell Color Foundation to direct the business and research of the Company, and most recently the sale of the Company to the Kollmorgen Corporation, and the establishment of the Foundation as a nonprofit organization devoted to furthering our knowledge of color. The present position of the Munsell Color Foundation was described in the following news item, reprinted with permission from the Inter-Society Color Council Newsletter No. 234, January-February, 1975:

ISCC and the Munsell Color Foundation

The aims and purposes of the ISCC and of the Munsell Color Foundation are very similar: to further the scientific and practical advancement of color knowledge, in particular knowledge relating to standardization, nomenclature, and specification of color; and to promote the practical application of these results to color problems arising in science, art, and industry.

As pointed out in the history of the Foundation, the ISCC Board of Directors for many years nominated one trustee to serve on the Foundation's seven-member Board of Trustees. To reaffirm their community of interest and cooperation, the ISCC and the Foundation have recently reestablished this custom.

In addition, at its last annual meeting the Foundation's Board of Trustees increased its membership from seven to nine. S. Leonard Davidson was nominated as Trustee by the ISCC Board of Directors. He, with Richard S. Hunter and Roland E. Derby, the immediate past president and president of the ISCC, were elected to serve on the Foundation's Board of Trustees along with the other members named in the Munsell Color Foundation history that follows. It is anticipated that this informal contact will continue.

The Munsell Color Foundation is set up for the primary purpose of using its funds, subject to limitations imposed by the Internal Revenue Service, to further the aims and purposes set forth above. These purposes parallel those of the ISCC very closely and so foster the close cooperation between the two bodies. In addition, the Munsell Color Foundation, under its IRS classification, may acquire by gift, donation, contribution, or otherwise, property and assets of every kind; and give, contribute, or otherwise dispose of property so acquired so long as any restrictions imposed on the gifts are consistent with the purposes of the Foundation. Contributions to the Foundation are tax deductible.

It is hoped that this announcement will lead to a better understanding and appreciation of the reaffirmed community of interest of ISCC and the Foundation, thus gaining for the Foundation full cooperation in adding to its present limited resources.

Since the aims and purposes of the Foundation are so similar to those of the Inter-Society Color Council, the ISCC strongly encourages and endorses contributions to the Munsell Color Foundation.

This *CR&A Report* consists of reprints of three papers which together provide a complete history of the Munsell System, Company, and Foundation from the beginnings to the present day. The first (though latest in time) of these papers is "History of the Munsell Color Foundation 1942-1974," reprinted with permission from the ISCC Newsletter No. 234, January-February, 1975. The second is "History of the Munsell Color System and its Scientific Application," reprinted with permission of the Optical Society of America from *J. Opt. Soc. Amer.*, 30, 575 (1940). The third and final article is "History of the Munsell Color System," reprinted with permission of Brentwood Publishing Corp. from *Color Engineering*, 7(5), 42 (1969).

No one could better have served as author of these three articles than Dorothy Nickerson. Miss Nickerson was associated with the Munsell Color Company from 1921 to 1926 before beginning a long and distinguished career in the U.S. Department of Agriculture. She has been a Trustee of the Munsell Color Foundation throughout its existence, serving as President from 1973 to 1975.

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I. History of Munsell Color Foundation, 1942-1974

In 1917, just prior to the death in 1918 of Prof. A. H. Munsell, originator of the Munsell system of color notation, the A. H. Munsell Color Company was formed in Boston. In 1921 it was reorganized so that all of the stock would belong to members of the Munsell family. At that time the business of the company consisted chiefly of supplying publications, papers, charts, and school supplies that would help to illustrate and teach the principles of the Munsell Color System and its method of defining color in terms of hue, value, and chroma. The Munsell family supported the company chiefly as a memorial to A. H. Munsell.

In 1922 the company moved to New York, intending to concentrate on the educational field. But Prof. Munsell's son, young A. E. O. Munsell—persuaded by his father's friends to leave Harvard Medical School and take over the direction of the company—was more interested in science than in business or education. Under his leadership the Munsell family established and supported the Munsell Research Laboratory. It started very simply in New York, but in 1924 moved to Baltimore to be closer to the Bureau of Standards and to Johns Hopkins University. At that time most of the business relating to school supplies was turned over to a school supply company in Chicago, leaving the Munsell company to devote its primary attention to production of Munsell standard papers and charts.

Between 1923-27 much significant color research was accomplished, supported by funds of the Munsell Research Laboratory. The work was carried on under the general supervision of Irwin G. Priest, in Washington at the Bureau of Standards where he was chief of colorimetry, and in Baltimore at the Munsell laboratory. (The work done in this period is reported in two histories of the Munsell system, in the December 1940 *Journal of the Optical Society of America*, and in 1969 in *Color Engineering*.) On the basis of the work done in these years, improvements were made in the scales of the Munsell system, and, as a result, a revised atlas was published in 1929 as the "Munsell Book of Color."

About this time two things occurred which made it practical to measure and standardize the Munsell system. One was the invention, by Hardy and his associates at MIT, and the production, by the General Electric Company, of a commercially feasible recording spectrophotometer; the other was the international adoption in 1931 of what we now know as CIE standards for colorimetry. It meant that Munsell samples could be measured spectrophotometrically, then transformed to CIE data, and smoothed curves could be drawn on CIE x, y -diagrams to represent the system.

On October 1, 1941, a General Electric color conference held in Schenectady adopted a coordinated

"Munsell-Spectrophotometric System" as a G.E. Standard, and on October 13 the G.E. Standards Department proposed to the American Standards Association that industry be given the opportunity to adopt the Munsell system as an American standard, with the spectrophotometer recognized as the primary standard for measurement. The spectrophotometer, through CIE conversions, would provide a primary measurement for any suitably prepared sample, and the Munsell system would provide a psychologically scaled notation understandable in terms of visually equi-stepped scales of hue, value, and chroma. This G.E. request became the basis for what was adopted in 1942 as ASA-Z44-1942.

It was in order to remove any suspicion of commercialization from the Munsell Color Company that Alex Munsell, whose interests after 1929 had turned in other directions, arranged for the establishment of the Munsell Color Foundation, to which the Munsell family turned over their stock and, thereby, the direction of policy of the Munsell Color Company. This was done after an open and well-attended meeting at which many leaders in the color field confirmed the fact that such a move would be welcome and supported. This meeting, held February 25, 1942, in New York City, was chaired by Charles G. Page, legal counsel to the Foundation from that day to this. The National Bureau of Standards and the Inter-Society Color Council each agreed to appoint a Special Trustee to serve on the original Board of Trustees. Other trustees were appointed to represent a wide variety of color interests in the scientific, industrial, and educational fields, one of them by nomination of the Optical Society of America. All served without remuneration.

The Foundation was organized in September 1942 as a nonstock, nonprofit organization, its chief purpose similar to that of the ISCC: "to further the scientific and practical advancement of color knowledge and in particular knowledge relating to standardization, nomenclature, and specification of color, and to promote the practical application of these results to color problems arising in science, art, and industry." A further purpose was "to acquire by gift, donation, contribution, or otherwise, property and assets of every kind; to give, contribute, or otherwise dispose of property so acquired as ... shall further the purposes of the Foundation__" There was no endowment other than the stock in the company. But since business was beginning to grow it was expected that any profits, other than needed to operate the company, would revert to the Foundation to be added to any other amounts that might otherwise be contributed for use in furthering the purposes of the Foundation.

The governing board of the Foundation consisted of seven trustees. There were three special trustees: Deane B. Judd, appointed by the Director of the Bureau of Standards, Dorothy Nickerson, appointed b

the Directors of the Inter-Society Color Council, and Blanche R. Bellamy, in her capacity as Manager of the company. These special trustees elected Arthur S. Allen, Loyd A. Jones, and I. H. Godlove to serve as trustees-at-large, with A. E. O. Munsell serving as representative of the donors. Each was appointed for a four-year term, most trustees being reappointed for successive terms. Others who have served in the past are D. L. MacAdam (1948-52), Dean Farnsworth (1955-59), Royal Baily Farnum (1943-67), and Leon L. Winslow (1955-66). From 1942 until his death in 1972, Dr. Judd served as Foundation president, Mrs. Bellamy as secretary-treasurer, Miss Nickerson as trustee and, since 1972, as president.

Over the years the duties of the Foundation trustees have consisted chiefly of receiving reports from the Munsell Color Company and guiding its general policy. Although year by year the market for color standards and materials provided by the company grew until, by the mid-60s, there was about a tenfold increase in sales from the less than \$20,000 gross of 1942, it was all at a very low profit margin, with expenses kept as low as possible to enable the company to keep within its income yet supply high quality standards and materials. This meant that there still were no profits to turn over to the Foundation. However, as the business grew, many projects were encouraged within the company that would serve the general good, e.g., cooperation with committee projects that varied from ISCC Color Blindness and Color Aptitude tests to ASTM and ATTCC and other committee work concerned with development of color scales for specific tests.

In the mid-60s the question of the future of the company had to be faced. A way had to be found to insure that Munsell materials and supplies, particularly those relating to color standards, would continue to remain available for the long-term future on a basis consistent with the integrity that had been demanded of them from the beginning, first by A. H. Munsell, then by his son A. E. O. Munsell, and, since 1942, by the Foundation in its guidance of company policy. The Foundation trustees published, in 1950, a "Statement of Policy for the Munsell Color Company—a Directive from the Trustees of the Munsell Color Foundation," a directive that would make clear and record this policy for all to see. It specified that "it is a chief task of the Munsell Color Company to issue papers that adhere as closely to the notation as is possible," that the primary standard or actual notation shall conform (until better data become available) to the hue, value, and chroma positions defined in the Newhall-Nickerson-Judd "Final Report of the OSA Subcommittee on the Spacing of the Munsell Colors" (*JOSA* 33, 385-418, 1943). In summary the directive made clear that "the chief tasks laid down for the Munsell Color Company are to develop and supply accurately controlled color standards at near cost and to supply literature

for describing the Munsell System and its applications." Furthermore, the policy of the company was to "restrict its service work to the supply of color standards from established sets where possible and to the development of special sets of standards if needed."

The Foundation amended its by-laws in 1966; all special requirements for designation of special members of the Board of Trustees were dropped, all trustees to serve thereafter as trustees-at-large.

Back in 1958 a new book of glossy papers had been added to the matte surface edition, the papers being produced for Munsell by Davidson & Hemmendinger, a firm that increasingly became the supplier of Munsell standard papers, although a number of regular matte surface papers and certain special scales, such as the Color Fan, were made for Munsell by the Tobey Color Card Company of St. Louis. Therefore, when it was learned that Davidson & Hemmendinger, Munsell's most important supplier, was to merge with the Kollmorgen organization as part of a new division to be devoted to problems of color and photometry, it seemed that if their staff and Munsell could work together even more closely it would solve many of Munsell's problems. With a larger group of color-trained personnel in the new division of Kollmorgen to whom the very limited Munsell staff could depend for advice and for continuity, it seemed as if inclusion of the Munsell company into the color and photometry group at Kollmorgen might effect some of the long-term future needs that Foundation trustees were seeking to answer.

At that time the seven trustees of the Foundation were Judd, (appointed 1942), Bellamy (1942), Nickerson (1942), Munsell (1942), Macbeth (1963), Billmeyer (1965), Granville (1965). Since Norman Macbeth, a Foundation trustee since 1963, was chairman of the board at Kollmorgen, with a close interest in the color and photometry division into which the Macbeth Corporation already had been merged, it was a simple matter to raise the question informally with him regarding the possibility and desirability of having the activities of the Munsell Color Company become a part of this new color and photometry division of Kollmorgen. As a consequence, a proposal for acquisition of the Munsell Color Company by Kollmorgen was submitted to the Foundation board of trustees at its May 1968 meeting. On October 18, 1968, public announcement was made of an agreement in principle between the Foundation and Kollmorgen for sale of the company stock and for obligations to be assumed by Kollmorgen that would insure that the tradition of integrity of Munsell products would be continued. In December 1969 the trustees finally approved the terms of purchase, and on or about March 2, 1970, the agreement was signed, and a check for \$235,000, the purchase price, was received, an amount in excess of the fair market value of the stock and in excess of the book value of the assets of the company.

Meanwhile, in 1969, A. E. O. Munsell who had joined in approving the Foundation's sale of the company to Kollmorgen, resigned as trustee. In his place Carl E. Foss, president of the Munsell Color Company at that time, was selected to serve as trustee.

In 1968, in contemplation of the sale of the stock to Kollmorgen, a committee had been appointed by the Foundation trustees to investigate and establish guidelines for the future conduct of the Foundation and use of its money. As a consequence, the Foundation charter was amended to eliminate its duty to hold the Munsell Color Company stock and to insure that its charter was in compliance with then applicable Internal Revenue code law. After receipt of payment for sale of the company stock, the Foundation in 1970 distributed \$18,878 under grants relating to research and promotion in the color sciences, among them grants to Cleveland State University, Rensselaer Polytechnic Institute, and the National Bureau of Standards.

In June 1970 the Foundation was declared exempt from federal income tax under Section 501(c)(3) of the Internal Revenue Code. However, the Internal Revenue Service took the position that the exemption did not apply to the entire 1970 calendar year, and the Foundation—under protest—was forced to file and pay a federal income tax for 1970 (chiefly capital gains on sale of the stock) in the sum of \$66,404.27. While its protest and claim for refund was in process, the Foundation income was considerably restricted. Nevertheless modest grants were made between 1971 and 1974 to Cleveland State University, Rensselaer Polytechnic Institute, Illuminating Engineering Research Institute, Library of Congress, and Fogg Art Museum of Harvard University. In 1973 the tax case was decided in favor of the Foundation, and in 1974 an appeal by the government was dismissed. After deducting research contributions 1970-74, legal and auditing expenses connected with the sale of the company and the resulting tax case, and modest expenses required for general operations, the current assets of the Foundation, in today's depreciated market, total about \$170,000, a sum not large enough to support a truly viable color Foundation. It therefore became necessary to look about for a way to plan for the financial as well as the research future of the Foundation.

In 1973 Miss Nickerson was elected to succeed Dr. Judd as Foundation president. It was her feeling that either the money should be completely spent on some worthy color project and the Foundation dissolved, or some way would have to be found to increase available funds in order to operate as a viable Foundation, useful to the color field. The majority of trustees voted to continue the Foundation, on the basis that small amounts—even a few thousand, sometimes even a few hundred dollars—could be very helpful in support of useful projects.

During the 1972-74 period the Inter-Society Color Council had a committee at work on its by-laws. While it is tax exempt on its own income, donors of gifts to

the ISCC receive no deduction for those gifts. On the other hand, gifts made to the Munsell Color Foundation are deductible by the donors. Since the primary aims and purposes of the two organizations are very similar, it seemed that it might make the work of the ISCC by-laws committee easier and cause considerably less expense to the ISCC, to work out a method for close cooperation with the Munsell Color Foundation by which the Council would recommend and encourage contributions to the Munsell Color Foundation for color research and educational projects consistent with the purposes of the Foundation. Such an arrangement would provide a satisfactory future course for both the ISCC and the Munsell Color Foundation. A joint committee representing the ISCC and the Foundation, appointed in 1972, has therefore worked out a simple and inexpensive method for maintaining close cooperation in future between the two groups. The Foundation in effect will become an organization available for restricted gifts designed to further color research and education, when such gifts are within the Foundation's declared purposes. To make this possible the by-laws of the Foundation have been changed to provide that one of its trustees shall be officially nominated by the board of directors of the ISCC and that the membership of its board also shall be increased from seven to nine members.

Today, 1974-5, the Munsell board of trustees consists of nine members, three newly appointed members having been chosen to provide close representation of the ISCC: S. Leonard Davidson, officially nominated by the ISCC board of directors as special trustee, Roland E. Derby, ISCC president, and Richard S. Hunter, immediate past-president. As a matter of fact all other current Foundation trustees are, and have been for many years, active ISCC members, several of them past presidents. Today the Foundation board of trustees consists of: Dorothy Nickerson, serving since 1942, present four-year term ends 1975; Norman Macbeth, 1963-1975; Blanche R. Bellamy, 1942-76; Richard S. Hunter, 1974-76; Fred W. Billmeyer, Jr., 1965-77; Carl E. Foss, 1969-77; Walter C. Granville, 1965-77 (resignation received 1974); Roland E. Derby, 1974-78; S. Leonard Davidson, 1974-78.*

The way is now clear for close ISCC and Munsell Color Foundation cooperation. Gifts and bequests are solicited that will increase the total funds available for use in color research and educational projects, either general or specific, that come within the scope of the Foundation charter and meet IRS requirements for a tax exempt organization Code Sec. 501(c)(3).

*In 1975, the Munsell Color Foundation elected Miss Midge Wilson to fill the remainder of Mr. Walter C. Granville's term as Trustee, and elected the following Officers: Mr. Norman Macbeth, President; Dr. Roland E. Derby, Jr., Vice-President; Dr. Fred W. Billmeyer, Jr., Secretary; Mr. S. Leonard Davidson, Treasurer; and Mrs. Blanche R. Bellamy, Assistant Secretary-Treasurer. (F.W.B.)

*History of the Munsell Color System, Company, and Foundation. II. Its Scientific Application**

Dorothy Nickerson

Albert H. Munsell was born in Boston, Massachusetts, on January 6, 1858.¹ Following a public school education, he studied art at the Massachusetts Normal Art School, and won a fellowship for foreign study. In Paris he attended Julien Academy where his work qualified him to take the examination for the Beaux Arts. There he won second prize in his first yearly competition, and, later, the Catherine de Medici scholarship which gave him another year abroad, this time in Rome. After his return, and until 1917, he kept a studio in the Back Bay section of Boston and there he painted, chiefly portraits. For his exhibitions in Boston, New York, Pittsburgh, and Chicago he was highly praised. His painting the "Ascension of Elijah," so far as we know, still hangs in the Beaux Arts in Paris. During his entire life, boats and the open sea held an unusual interest for him, as is witnessed by his many seascapes.

From 1881 to 1918 he taught drawing and painting from the antique figure and living model, composition, and artistic anatomy¹ at the Massachusetts Normal Art School, now the Massachusetts School of Art. He was loved and respected by his students to an unusual degree—they never fail to speak of him with admiration and affection.

Except for a few publications, chiefly *A Color Notation*² and the *Atlas of the Munsell Color System*,³ it is to a color diary⁴ kept by Mr. Munsell from 1900 to 1918 that we owe most of our knowledge of the development of the Munsell system during its early history.**

¹This is the second of a three-part series. Part I, with introductory material, was published in *Color Research & Application*, 1, 7(1976). Part III will appear in a subsequent issue.

**A typewritten copy from the diary in Mr. Munsell's handwriting was made in the early 1920s by the Munsell Color Company. For the most part, charts and graphs were traced so as to represent the originals accurately. In 1939, the Inter-Society Color Council obtained permission of the Munsell Color Company, Mr. A. E. O. Munsell, and Mrs. J. E. O. Munsell (son and wife of A. H. Munsell) to have a bibliofilm record made and deposited with the American Documentation Institute of the typed copy of this diary so that it might be made available to research students. The original diary is contained in six volumes. The typed copy is contained in two volumes of approximately 250 pages each.

It is important to recognize that Mr. Munsell's purpose in developing a system of color notation, illustrated by charts of measured colors, was to make the recording of color easy and convenient in order to provide a real aid in teaching color, particularly to children. Because he believed that proper color training should begin with children, he spent much time writing outlines for primary school grades and in conferences with art teachers and supervisors. It is evident that he felt if children were properly taught, color would have more meaning and use for them all through life, and this became even more important to him when the early phases of development of his system were completed. The preface to the first edition of *A Color Notation* indicates that "the gist of these pages has been given in the form of lectures to students of the Normal Art School, the Art Teachers' Association, and the Twentieth Century Club ... and ... before the Society of Arts of the Massachusetts Institute of Technology." In the preface to the third edition in 1913, he adds: "Brewster's mistaken theory of color ... still ... gives children a false start with Froebel balls and a three-color box ... but a fine color sense may be trained by decorative studies whose simple color relations permit the student to realize in what way and by how much he falls short of a definite standard. Plates II and III reproduce children's studies with measured intervals of color-light and color-strength, which so discipline their feeling for color balance that they may then be trusted to use even the strongest pigments with discretion." An introduction to the system, prepared as an aid in teaching children, was separately published as *Color Balance, Illustrated*. There is record also of several other articles written by Mr. Munsell.⁵

In his introduction to *A Color Notation*, Professor H. E. Clifford, then Gordon McKay Professor of Electrical Engineering at Harvard University, states, "In the determination of his (Munsell's) relationships he has made use of distinctly scientific methods." In the same paragraph he acknowledges the chief purpose for which the system was built by stating that we all appreciate the necessity for improvement in our ideas of color, and "the natural inference is that the training should begin in early youth."

The subtitle of *A Color Notation*, as published by A. H. Munsell in the "fourth edition, revised and

larged," 1916, is "an illustrated system defining all colors and their relations by measured scales of hue, value, and chroma made in solid paint for the accompanying *Color Atlas*" the Atlas having been published in full in 1915.

Because they may help in understanding Mr. Munsell's exposition of his system and notation, the following definitions which he gave in *A Color Notation* are listed. These definitions appear in a glossary which accompanied the first seven editions of the book. This glossary is omitted in the 1936 edition (the definitions that still seemed applicable being incorporated in the text). In his book Mr. Munsell refers all discussion of hue, value, and chroma to these definitions taken from the 4th edition, published in 1916.

Color. Objectively that quality of a thing or appearance which is perceived by the eye alone, independently of the form of the thing; subjectively, a sensation peculiar to the organ of view, and arising from the optic nerve (p. 108).

Hue. Specifically and technically, distinctive quality of coloring in an object or on a surface; the respect in which red, yellow, green, blue, etc., differ one from another; that in which colors of equal luminosity and chroma may differ (p. 109).

Value. In painting and the allied arts, relation of one object, part, or atmospheric plane of a picture to the others, with reference to light and shade, the idea of hue being abstracted (p. 112).

Chroma. The degree of departure of a color sensation from that of white or gray; the intensity of distinctive hue, color intensity.

Scale. A graded system, by reference to which the degree, intensity, or quality of a sense perception may be estimated.

Highlights from the Color Diary

The first entry in the A. H. Munsell color diary goes back to 1879: "Studied Rood's *Modern Chromatics*—made twirling model of two triangular pyramids___" There is an entry dated 1892 when he and Denman Ross were sketching together in Venice. It says they talked over a "systematic color scheme for painters, so as to determine mentally on some sequence before laying the palette." In 1898 Munsell worked with rotary color mixture, having bought a child's globe for that purpose. It was about this time that the Munsell daylight photometer was built, a cat's eye shutter being used to cut down the amount of light entering the standard side of the instrument. Several of these instruments were built in 1900-1902. From the diary, it is evident that Munsell was quite familiar with the Fechner law, for there are many references to it during this period. The names of Rood, Bailey, Pickering, Cross (A. K. and C. R.), Clifford, Dolbeare, Ross, Pritchard, Abney, and Bowditch appear during this time, and with most of them he discussed his ideas and to most of them showed his sphere. It was in this early

period that Mr. Wm. Filene asked to have the sphere shown to the Shopkeepers' Association in Boston.

In 1901 Munsell was still wondering whether to base his hue circuit on ten or on three colors. The decimal system was finally decided upon, and five principal hues were then determined by selecting colors which, when they appeared to have equal chroma, with values equal as determined by luminosity readings on the photometer, would spin together in equal proportions to give a neutral gray. As early as 1901 (April 11) he quotes Mr. Filene as saying "The retailers want a standard system fixed at all times—charts with numbers." In 1901 (April 29) appears the first mention of contact with the Bureau of Standards; Mr. Munsell wrote to Dr. Stratton "asking about color."

By January of 1902 *A Color Notation* and a *Color Atlas* were already being discussed and described. In 1903, on November 7, he describes the spinning of disks in the photometer, with value equalized by adjustments in illumination, in order to measure chroma. However, this method was dropped as unsatisfactory, for chroma scales were not finally decided upon until 1912, although charts were painted by visual estimates as early as 1901-02 in his studio by a Mr. Lyon who (evidently) prepared the original charts under Mr. Munsell's direction.

In 1904 Mr. Munsell met and talked with Jay Hambidge and notes that he was struck with points common to investigators of color and design. He lectured before many audiences, a number of them at the Massachusetts Institute of Technology, where during this early period he kept in close touch with Professor C. R. Cross and Professor Clifford, as well as with Professor Bowditch of Harvard.

During 1905 first mention is made of Arthur Howland who came to the studio and saw "all system but charts." Mention is also made of Arthur S. Allen, and of Wilhelm Ostwald. Dr. Ostwald was in Boston that year, with his son and daughter, to give a series of lectures at the Massachusetts Institute of Technology. Munsell and Ostwald had many conversations. Ostwald visited Munsell's studio, and at one of Ostwald's M.I.T. lectures he showed the Munsell color sphere and referred to the Munsell book.

About this time a first contract to supply enamels, charts, and crayons for school supplies to be used in teaching the Munsell system was made with Wadsworth-Howland & Company of Maiden, Massachusetts.*

*A Color Notation*² was published in 1905, and

*Arthur Howland later developed a system based completely on disk mixture, known as the Howland system. It was limited to as few disks as possible, using sector disks of very strong colors spun against a hole in a black box which provided his black. Mr. Howland's Color Mixer was patented, and he was always on a search for new and stronger colors for his four to seven standards that were used with a series of white sectors.

during that year first contacts were made with Favor, Ruhl and Company through Charles W. Bidwell, manager of the Chicago branch.

In 1908 Christine Ladd-Franklin and her husband returned from abroad on the same ship with Mr. Munsell. They had several color discussions on ship-board, and later at the Munsell studio in Boston. In 1908 there was also discussed the matter of an understudy for Otto Anderson, who was in charge of painting papers for Munsell charts at Wadsworth-Howland & Company, and F. A. Carlson was decided upon. (We understand from Mr. Carlson that from the beginning he did all of the painting, Anderson being the shop supervisor.)

From 1908 to 1911 there were many lectures and talks, a series at Columbia, one in Boston for art supervisors, a lecture at the Harvard Psychological Laboratory. During this period the names of Professor Dow, Professor Yerkes, of Miss Patrick, and Professor Titchener, appear among those of a number of people Mr. Munsell met and talked or worked with in relation to his system and its application in the teaching field. In 1909 there is mention that in Mr. Drisco's laboratory at the Massachusetts Institute of Technology, spectrophotometric measurements of his five middle colors were tried—"by daylight and tungsten." No figures were given. In 1910 there is mention of receiving two copies of the new *Color Atlas* while cruising on his boat, the *Ahmed II*. These charts were evidently published first as a forerunner of the more complete *Atlas*, for a note from the *Boston Journal*, December 22, 1910, describes this *Atlas* as containing at present two charts, chart A, the value scale, and chart B, chroma scales for five hues. In 1911 there is mention of meeting E. C. Andrews of Chicago when he and Arthur S. Allen visited the *Ahmed* off Annisquam, Massachusetts. Though they went sailing, the diary reads "discuss 'sequences' and E. C. A.'s color form."

In December of 1911, Mr. Munsell read a paper in Washington by invitation of the American Psychological Association, in which he described his system as "an experimental system built up with the aid of a new photometer, Maxwell disks, and the trained capacity of the painter—using a consensus of many individual decisions to gain the mean of color discrimination." At that meeting he met many of this country's leading psychologists, and they received his paper so well that he was asked to repeat it before the meeting was over. During this visit to Washington, Mr. Munsell visited the Bureau of Standards and met Dr. Nutting, in charge of colorimetry, where he left a Munsell photometer for test. On January 18, 1912 Dr. S. W. Stratton wrote that he would be pleased to examine a full set of the Munsell elementary color samples and look over the system of scales. A series of the five middle colors, and a sixth sample intended to be a neutral 5/ were sent to the Bureau, and the diary notes

TABLE I.

	Wavelength dom. hue	% White	Refl. coef.
Red	612	62	0.19
Yellow	585	50	0.23
Green	508	78	0.25
Blue	488	80	0.20
Lt. Purple	568°	31 ^b	0.22
Dk. Purple'	568°	31 ^b	0.08

"Wavelength of complementary hue. ^bPercent of added hue to match white.

^cIn Mr. Munsell's handwriting the following note is added to the report: "(Dark purple a neutral gray N 5/)." It seems probable that a sample of P 3/5 was submitted by mistake instead of the intended N5/.

that report No. 10696, dated February 28, 1912, signed by P. G. Nutting, was received from the Bureau of Standards. It contained the information given in Table I.

There is no reference in the diary to the fact that Mr. Munsell was invited to present a paper on his system before the Physiological Congress held at Groningen in 1913.⁵ But it is recorded that he sailed on June 23, 1913, and that on August 30 he went to Groningen. No mention is made of his report, but he does list about two dozen persons whom he met at the conference, Dr. Edridge-Green among them. A few weeks later he spent some time with Sir William Abney in his studio, and records meeting Dr. Parsons and his assistants. Then back to Paris, and on to Naples, Capri, and Palermo, before sailing for home on December 3. There is evidence that during this time there were numerous lectures and discussions regarding the Munsell color system.

In 1914 he returned to Europe at the request of persons who had been interested by his reports during the previous year, and again he spent about six months abroad, lecturing several times in Paris and Berlin. He was ill in London, yet he notes that the doctor permitted him to go by sea to Berlin, where his lecture was given before an audience of 300. From there he returned to London, where the notes say he was operated on by Dr. Heil on July 4, and that (I am) "remaining in Dr. Rowland's nursing home until I sail." In the early fall he was again at the Wadsworth-Howland factory, and resumed his teaching duties at the Normal Art School.

In 1915 the complete *Atlas of the Munsell Color System*¹ was published by Wadsworth-Howland & Company. From the diary it seems evident that the original charts were made by Lyon in the Munsell studio, and that the papers for the published *Atlas* charts were made at the Wadsworth-Howland factory, all colors being checked by Mr. Munsell. Disk mixture was used as a check for chroma and hue and all colors were measured for value in the Munsell photometer.

In 1915 suggestions regarding commercial de-

velopments of the Munsell idea became numerous, the Wadsworth-Howland representative reporting that "charts have been ordered by the Rockefeller Foundation, the Carnegie Institute, Heintz of Chicago, Dartmouth College, and others." There was much discussion during this year and the next regarding school supplies to teach the Munsell system, and of the means of producing and publicizing them by commercial groups.

In October, 1915, Cleland, Greenleaf, and Allen lunched with Mr. Munsell, then called on Miss Helen Dryden, indicating perhaps, that plans for *A Grammar of Color*⁶ were then being formed. On November 6, 1915, there is a record of "three colors telegraphed (by Cooper) from California to New York, this is Cooper's answer to Stevenson's difficulty."

In the summer of 1916 a summer school course was held at Boothbay Harbor, Mr. Munsell delivering 12 lectures from July 25 to August 19. He returned in the fall to take up school duties again. In the winter of 1916-17 the notes say "confined to house by rheumatism."

On March 27, 1917 there is the first mention of the Munsell Color Company, suggested to Mr. Munsell by Messrs. Allen and Greenleaf. In May he had an appendicitis operation, "not expected to survive, two nurses all summer." As a result of this illness, the studio at 221 Columbus Avenue, which he had occupied since 1901 was vacated. (It was taken over a few months later by John Singer Sargent.)

In February there is a brief note that papers for the A. H. Munsell Color Company, Inc., were "rewritten," and evidently filed at the State House, Boston, February 6, 1918.

As time went on, Mr. Munsell became somewhat dissatisfied with the handling of his materials by Wadsworth-Howland. One of the very last entries in the diary, dated February 13, 1918, tells of meeting with Judge Perkins (his lawyer) and Arthur Howland: "Discuss latter's interest in his photometer and possibility of avoiding unfair attitude toward my system. He tells of his belief in the scientific nature of his work—although I show that it ignores the fundamental law of sensation." As a result the possibility was considered of having the New York office of the Munsell Color Company take over the educational interest as well as the industrial, leaving only manufacturing of materials to Wadsworth-Howland & Company.

The last entry in the diary is dated February 16, 1918.

Late Period in Life of A. H. Munsell

The color diary contains items that concern chiefly the development and use of the Munsell system and notation, and we do not realize from it that, after the 1914 trip, Mr. Munsell returned home more or less an invalid, unable to continue the active life he had previously led. Despite physical handicaps, he was intensely interested in plans for *A Grammar of Color*⁶

which was being prepared for publication by the Strathmore Paper Company. Through Mr. Allen, Mr. Munsell kept closely in touch with this work, he wrote an "Introduction to the Munsell Color System" for it,⁵ and approved the manuscript and much of the illustrative work that appeared later in this volume. It was for this volume that T. M. Cleland wrote *A Practical Description of the Munsell Color System*,¹ which has been reprinted since and distributed widely, having become better known to many students as a description of the Munsell system than Mr. Munsell's own book.

In 1918 the Bureau of Standards was requested to make a spectrophotometric analysis of the Munsell Color System and for that purpose samples of the neutrals, and of the 3/5, 5/5, and 7/5 colors in five hues were supplied by the Munsell company. Whether this request was made for the company by Mr. Munsell, or by Mr. Allen is not entirely clear, but it certainly was with Mr. Munsell's complete approval. He speaks several times, particularly in letters to Mr. Allen, of hoping to meet Mr. Priest. Mr. Allen had already met Mr. Priest and had discussed the Munsell charts with him.

Mr. Munsell died on June 28, 1918.

1918-1921

From the diary, as well as other records, some of which have been made available by Mr. Allen from his old files of Munsell correspondence, a picture of the early period of the Munsell Color Company emerges.

The company was formed to carry on the business of handling publications of books and charts, of crayons, water colors, color spheres, colored papers, and other school supplies which had been developed for use in teaching the Munsell system.

Care was taken when forming the company to have the industrial and educational phases separated. The chief stockholders were Munsell (51%), Allen, and Greenleaf. All educational development was at first left in the hands of Wadsworth-Howland & Company; the western representatives for educational supplies continued to be Favor, Ruhl and Company where Miss Harriet Taylor became associated with them about this time in order to handle Munsell work. The Munsell company opened an office in New York City on the same floor with the Ruxton Ink Company showroom. The company in New York, under Mr. Allen and Mr. Greenleaf, was to promote and handle industrial applications of the Munsell system. After Mr. Munsell's death, D. E. Kennedy became president of the Munsell Color Company, and he opened an office in Boston to handle Munsell supplies for the educational field, work which had previously been handled by Wadsworth-Howland & Company. For a time both offices continued to function, but that did

not prove very satisfactory and the company was finally reorganized as the Munsell Color Company, with complete control in the hands of Mr. Munsell's family.

In 1919, during this period, the Bureau of Standards made its report, "An Examination of the Munsell Color System," published in 1920 as Technologic Paper No. 167.⁸ In that report it was stated that "A revised edition of the *Atlas* and *A Color Notation*, based upon the best present-day methods of measurement and specification, would be a most important contribution to the science and art of chromatics generally." Five proposals were made. They are briefly summarized as follows: (1) standardization should be made of the value scale; (2) each color should be specified in terms of physical measurement; (3) colorimetric and photometric specifications should accompany the *Atlas*; (4) value measurements should be made with reference to a standard white; and (5) general agreement in nomenclature should be obtained before issuing a revised publication.

Shortly after this, another and fundamentally important report on a comparison of the Fechner and Munsell scales of luminous sensation value was made by Elliot Q. Adams.⁹

1921-1930

In July 1921, A. E. O. Munsell, son of A. H. Munsell, after one year of medical school and just out of the U. S. Army, encouraged by his father's friends, took over the active presidency of the Munsell Color Company. Headquarters were then at 220 Tremont Street in Boston. A few months later, J. J. Roy became business manager of the company. In October of 1921 this author became associated with the company, and in November of 1921, F. A. Carlson joined the group in Boston.

Because New York seemed to be a center of educational activities, and because a program of expansion in the educational field was expected, the company, including the three staff members mentioned above, moved to the Printing Crafts Building in New York City. There Milton E. Bond, artist, of Rochester, New York, was added to the permanent staff.

At this time, the business of the company consisted chiefly of sales of school supplies such as those already mentioned. Mr. Carlson's work was to copy those sheets of *Atlas* papers in which supplies ran low. There were, for example, more calls for the "maxima" and "middle" colors than for any others, so extra copies of these particular papers had to be made up in order to fill orders for the complete series of papers in the *Atlas*. The color chips were pasted on the charts by hand—in fact, they still are, the papers being painted in large sheets, then cut to the required size.

From his earliest days with the company, A. E. O. Munsell was influenced in his thinking by Irwin G. Priest, then chief of the colorimetry section of the Bureau of Standards. Mr. Munsell was neither a

businessman nor an artist. His interests lay, rather, in scientific fields, and, from the beginning, he left the handling of much of the business of the company to others, while he concentrated on the scientific aspects of the Munsell work. The writer's first memory of A. E. O. Munsell is that of his enthusiasm upon his return from the 1921 meeting of the Optical Society of America where he had met and talked with I. G. Priest. It was at that meeting that he first heard of Carl W. Keuffel's development of a direct-reading spectrophotometer, later described before the Optical Society by Mr. Keuffel. One was ordered on the spot and was delivered in New York to the Munsell Research Laboratory during the next year.

During 1922, artist tempera colors were produced for a brief period for the company by Martini, well-known maker of high grade artist tempera colors.

More and more, the burden of handling the details of a school supply business irked Mr. Munsell. There were no profits, so there was little interest and incentive for keeping on a business manager. Therefore, during the spring of 1923, arrangements were completed whereby the making and handling of Munsell crayons was turned over to the Binney and Smith Company, and the purchase and sale of all other Munsell school supplies, water colors, drawing papers, etc., was turned over to Favor, Ruhl and Company. The entire stock of such materials was cleared out of the Munsell stock room in New York City. The only things that the Munsell company itself intended to continue handling were the production and sale of *Atlas* papers, charts, disks, and Munsell publications.

About this time, the Munsell Research Laboratory came into being, supported by funds contributed by A. E. O. Munsell, his mother, Mrs. J. E. O. Munsell, and his sister, then Margaret Munsell. It was founded as a memorial to A. H. Munsell to carry forward the application of his particular contribution, namely; "a simple and practical notation, or method of writing color." The employment of Milton E. Bond to produce posters, paintings, and other examples of Munsell-inspired works that could be used in art educational work, the purchase of a spectrophotometer, and of artificial daylighting, and the development of a small laboratory darkroom were all part of the research laboratory work. This work had only its beginning in New York City, for while there, all work that might be classified as "laboratory" was done by Mr. Munsell himself and by the writer, who, by way of being his secretary, was also his laboratory assistant.

Soon, however, a move to Baltimore was effected, to quarters that would afford space for laboratory work, within a reasonable distance from the Bureau of Standards, and near The Johns Hopkins University, where Mr. Munsell intended to do such graduate work in physics and psychology as might help to carry out the very general laboratory plans he was developing under Mr. Priest's guidance. This move was made in

June of 1923; Munsell, Nickerson, Carlson, and Bond making the move with the company. The headquarters of the Munsell Color Company have been (1940) at 10 East Franklin Street in Baltimore since that time.

Not long after this move Blanche Robertson (Bellamy), in August 1924, and Genevieve Becker (Reimann), in January 1925, were employed by the company. Mrs. Reimann left the company in 1929 but has continued with work that has included color specification. Mrs. Bellamy at the present writing (1940) is manager of the Munsell Color Company.

Under the advice and inspiration of I. G. Priest, the Munsell Research Laboratory broadened its activities. During a three- to four-year period, it supported considerable research activity in its own laboratory, and in those of the Bureau of Standards.

Mr. Priest advised that a standard for "white light" must be adopted before color measurements, of Munsell or any other system, could be made most useful, and data for setting a standard were not available. Therefore, one of the first projects supported by the Munsell Research Laboratory at the Bureau of Standards aided in procuring fundamental data. In fact, a considerable part of the data used by Mr. Priest at the 1931 I.C.I. meeting, when a standard observer and standard illuminants were adopted, had been obtained during the course of work partially or wholly supported by the Munsell Research Laboratory.

Little of the work done either at the Bureau of Standards or at the Munsell Research Laboratory in Baltimore has been published, but the following reports of work supported by funds of the Munsell Research Laboratory have been read before the Optical Society (A designates abstract):

- I. G. Priest, Progress on the determination of normal gray light, *J. Opt. Soc. Amer. and Rev. Sci. Inst.*, 7, 72A (1923).
- I. G. Priest and C. L. Cottrell, The effect of various conditions upon the determination of the normal stimulus of gray, *J. Opt. Soc. Amer. and Rev. Sci. Inst.*, 7, 73A (1923).
- I. G. Priest, The colorimetry and photometry of daylight and incandescent illuminants by the method of rotatory dispersion, *J. Opt. Soc. Amer. and Rev. Sci. Inst.*, 7, 75A (1923); 7, 1175 (1923); *Trans. I. E. S.*, 18, 861 (1928).
- I. G. Priest, Preliminary data on the color of daylight at Washington, *J. Opt. Soc. Amer. and Rev. Sci. Inst.*, 7, 78A (1923).
- I. G. Priest, Apparatus for the determination of color in terms of dominant wavelength, purity and brightness, *J. Opt. Soc. Amer. and Rev. Sci. Inst.*, 8, 28A (1924); 8, 173 (1924).
- I. G. Priest, K. S. Gibson, and A. E. O. Munsell, A comparison of experimental values of dominant wavelength and purity with their values computed from the spectral distribution of the stimulus, *J. Opt. Soc. Amer. and Rev. Sci. Inst.*, 8, 28A (1924).
- I. G. Priest, H. J. McNicholas, and M. K. Frehafer, Some tests of the precision and reliability of measurements of spectral transmission by the König-Martens spectrophotometer, *J. Opt. Soc. Amer. and Rev. Sci. Inst.*, 8, 30A (1924); 8, 201 (1924).
- A. E. O. Munsell, I. G. Priest and K. S. Gibson, Specification of color in terms of dominant wavelength, purity and brightness, *J. Opt. Soc.*

Amer. and Rev. Sci. Inst., 10, 291A (1925).

- I. G. Priest, Gray skies and white snow, *J. Opt. Soc. Amer. and Rev. Sci. Inst.*, 11, 133A (1925); *I. Wash. Acad. Sci.*, 15, 306 (1925).
- K. S. Gibson and F. K. Harris, A spectrophotometric analysis of the Lovibond color system, *J. Opt. Soc. Amer. and Rev. Sci. Inst.*, 12, 481A (1926); *Sci. Pap. Bur. Stand.*, 22, 1 (1927-28); S547. I. G. Priest, Standard artificial sunlight for colorimetric purposes, *J. Opt. Soc. Amer. and Rev. Sci. Inst.*, 12, 479A (1926). A. E. O. Munsell and P. Reeves, Value sensitivity and value scales, *J. Opt. Soc. Amer. and Rev. Sci. Inst.*, 12, 481A (1926).
- D. B. Judd, The computation of colorimetric purity, *J. Opt. Soc. Amer. and Rev. Sci. Inst.*, 12, 482A (1926); 13, 133 (1926).
- I. G. Priest, An experiment bearing on the adoption of a standard neutral stimulus in colorimetry: the choice as between 'sun' and 'equal energy', *J. Opt. Soc. Amer. and Rev. Sci. Inst.*, 13, 306A (1926).
- I. G. Priest and F. G. Brickwedde, The minimum perceptible colorimetric purity as a function of dominant wavelength with sunlight as neutral standard, *J. Opt. Soc. Amer. and Rev. Sci. Inst.*, 13, 306A (1926); *J. Opt. Soc. Amer.*, 28, 133 (1938).
- I. G. Priest, Blue sky and white snow, a note on sensation and perception, *J. Opt. Soc. Amer. and Rev. Sci. Inst.*, 13, 308A (1926).
- I. G. Priest and K. S. Gibson, Apparatus for the determination of the visibility of energy and the fundamental scales of visual psychophysics, *J. Opt. Soc. Amer. and Rev. Sci. Inst.*, 14, 136A (1927).
- E. P. T. Tyndall, Sensibility to wavelength difference as a function of purity, *J. Opt. Soc. Amer. and Rev. Sci. Inst.*, 14, 137A (1927); *J. Opt. Soc. Amer.*, 23, 15 (1933). I. G. Priest and D. B. Judd, Sensibility to wavelength difference and the precision of measurement of dominant wavelength for yellow colors of high saturation, *J. Opt. Soc. Amer. and Rev. Sci. Inst.*, 14, 137A (1927). A. E. O. Munsell and I. H. Godlove, White glass photometric standards, *J. Opt. Soc. Amer. and Rev. Sci. Inst.*, 18, 167A (1929). I. H. Godlove, Standardization of Munsell colors, *J. Opt. Soc. Amer.*, 22, 429A (1932).
- I. H. Godlove, Comparison of Cobb's and Munsell Research Laboratory's data on neutral value scales and equations describing them, *J. Opt. Soc. Amer.*, 24, 55A (1934). I. H. Godlove, Color blending computations in psychological terms, *J. Opt. Soc. Amer.*, 25, 44A (1935).

As may be seen from the titles, and as might be expected by those who knew Mr. Priest and Mr. Munsell, there was no narrow restriction regarding what might be carried on as Munsell-supported investigations. Yet it may be seen that they all point to the development of needed information if the Munsell, or any other, color system were to be critically studied.

Among unpublished reports of Munsell-supported work at the Bureau of Standards are certain letters and reports made to the Munsell Laboratory, or to Mr. Munsell. The following three are the most important of these:

"Report on spectral reflectance of 70 representative colored cards from the Munsell color system," Bur. Stand. Test No. 46045 (September 14, 1926).

"Derivation of the trilinear coordinates specifying the colors of constant saturation," letter to Munsell Laboratory (April 13, 1927).

"Data on least perceptible purity, including Priest's

memorandum on 'Relation between the Munsell chroma scale and the data of I. G. Priest and F. G. Brickwedde on least perceptible purity,'" and notes by D. B. Judd on the memorandum, transmitted to Mr. Munsell, (May 9, 1927).

Although the work supported by the Munsell Laboratory at the Bureau of Standards covered a wide

field, most of the work in the Baltimore laboratory was aimed more directly toward the collection, under controlled conditions, of sufficient data to enable the Munsell Research Laboratory to specify an improved series of papers to represent, even more adequately than the *Atlas* papers, a psychologically sound series of equally stepped scales of hue, value, and chroma.*

Experiments regarding value were prolonged and three partial reports of this work were later published in the *J. Opt. Soc. Amer.*^{1a-n}

Although many experiments were made regarding chroma and hue scales, there is no published material. But there are available, as a result of this work, certain valuable papers made for special experiments: 100 equally stepped hues painted to represent constant value and chroma (at 5/5), 50 hues at maximum chroma, a series of 60 value papers closely stepped from black to white, and certain chroma scales of very small stepings.f

It may be of interest, and is important as a matter of record, to note that in addition to those already named as part of the Munsell staff, the following individuals have been employed at one time or another in the scientific work of the Munsell Research Laboratory: In Baltimore—Miriam E. O'Brien (Underhill), 1924-25, Louise L. Sloan (Rowland), 1925-26, Geraldine Walker (Haupt), 1925-27, I. H. Godlove, 1926-33, Carl Boechner (part time 1925), Prentice Reeves (summers of 1925, 1926) and Willard L. Valentine (summer of 1926); at the Bureau of Standards Casper L. Cottrell, Irwin G. Priest, Deane B. Judd, F. K. Harris, F. G. Brickwedde, E. P. T. Tyndall, W. Greenberg.

In 1927 the investigative work came practically to a stop. Funds had been contributed up to that time, but the contributors felt that by this time some practical use should be made of the data. The research laboratory had obtained the data for a purpose: the company should now use it for this purpose. Therefore, a studied revision of the standard color papers was made, to follow essentially the newly derived scales—a revision first suggested by the I. G. Priest, K. S. Gibson, and H. J. McNicholas report.⁸

The result was the publication in 1929 of a book of charts known as the *Munsell Book of Color*,¹³ to distinguish it from the *Atlas of the Munsell Color System*³ which it was intended to replace. The work of producing the charts was completed under the direction of Walter M. Scott, service director of the Munsell Color Company, 1928-30. For the *Book of Color*, F. G. Cooper wrote a foreword and explanation of color which has been reprinted separately as a *Manual of Color*.¹⁴

*His family, who supported the laboratory for this purpose, considered this "a goal consistently striven for by Mr. Munsell."

fAll measured by W. C. Granville, D. Nickerson and C. E. Foss, ref. 27. Except to those who used Munsell papers for purposes of color measurement, the

new papers were not different enough from the old ones to cause any difficulty. In general, teachers liked the form of the new charts (made available in a pocket-size edition as well as the larger 8 1/2 x 12 charts of the standard edition), and since the charts were used by them for teaching the relation of colors, rather than for matching colors, they were well-satisfied.

The Munsell company, particularly during the period of research activity, had developed a certain amount of consulting business, chiefly in relation to the preparation of standard colors, and color scales for specific purposes. Thus there were prepared the Flagg-haemoglobinometer, and meat-grading scales for the Department of Agriculture, both washable, made on a clear celluloid base. The preparation of a color chart for use in advisory work by the Clothing Information Bureau of the Filene Company in Boston is another example. Applications of the Munsell system to the textile industry were made while Dr. Scott was with the company.¹⁵ Standards for soap colors, for scales to measure detergent power, to measure smoke deposit—all such problems, and many more, were handled during the 1921-1930 period.

Although the trend of thinking in the company during those years was along scientific, rather than art educational lines, the actual business of the company (it never has made a profit, nor has it every employed a salesman) was in supplying art educational materials for teaching the Munsell system. And this field was not entirely neglected by the research activities of the laboratory, for Milton E. Bond, while he was with the company, produced many pieces of illustrative work; Byron G. Culver of the Rochester Art Institute completed the manuscript of a book for teaching color;* a summer school session was held under the leadership of Royal B. Farnum and Byron G. Culver in 1926; and *Color News* was published by the Research Laboratory for three years, 1924-1927.¹⁶

After the publication of the *Book of Color* in 1929, Mr. Munsell, who felt that the chief object of the laboratory had now been accomplished, began to devote himself to other interests. Thus he withdrew more and more from color activities, until, in 1933, a complete break was made of all formal connection with the company. Whenever near enough, he has been available for consultation by whomever has been in charge of

*Publication of this manuscript was never made by the Munsell company, but a handbook based upon the Munsell system arranged by Mr. Culver on the same basic material was used for many years in his classes on color theory at the Department of Applied Art of the Rochester Athenaeum and Mechanics Institute. (Mr. Bond now teaches the courses on color theory, using his own unpublished material, including a large number of effective teaching charts.) From Mr. Culver, now supervisor of the Institute's newly established Department of Publishing and Printing, we understand that, in connection with the work on printing, a new handbook on color is about ready for publication.

the company, for he is still interested in the work although he prefers that it be a side line rather than a lifework.

In 1930 the Munsell Color Company attempted, for a time, to turn over the distribution of supplies to Universal Color Standards, Inc., a Baltimore company formed for that purpose. But the attempt was not successful, and the Munsell company soon resumed the handling of those supplies which they make or publish themselves.

About 1929 a new Munsell universal photometer was developed, and in the early 1930s, during the time that the late Walter T. Spry was manager of the company (1933-1938), new types of school charts were produced.¹⁷ Arrangements were also made to handle the sale of the Pfund instruments, thus adding color and paint measuring instruments to the color publications and special charts which previously had been the greater part of the Munsell business.

Since Mr. Spry's death in 1938, Blanche R. Bellamy has been manager of the company where she is continuing its scientific tradition by supplying assistance and material for use in studies of scientific color interest. She has continued the assistance given by Mr. Spry to the subcommittee of the Colorimetry Committee of the Optical Society of America on the smoothing of the Munsell data. And Mr. Carlson, without whose steady eye and hand it would be hard to imagine a satisfactory supply of all of the regular and special Munsell colors that have been made since 1912, is still painting Munsell colors, although from 1931 to 1939 he was not regularly employed full time by the company. At the present time, Mrs. J. E. O. Munsell is making provision for the development of special colors which is helping to keep Mr. Carlson with the company. Only Mrs. Bellamy and Mr. Carlson now remain of the earlier group. But the fact should be noted that a large proportion of the others connected at one time or another with the Munsell work are now employed in a wide variety of color activities. Working with the Munsell company never narrowed one to the confines of a single "system"; rather it encouraged a broad outlook on the entire color field.

Developments Outside Munsell Headquarters

Applications of the Munsell system in scientific work have been made to a greater extent from outside the Munsell laboratories than from within.

In March, 1927, this writer was employed by the United States Department of Agriculture to develop and carry on certain adaptations of the Munsell system for purposes of color measurement that had been started in connection with hay standards and color scales for meat grading. The development of a disk-type colorimeter followed, the actual spinning of disks being eliminated by spinning an optical rhomb or wedge in one side of the viewing beam. The first instrument, suggested by one made by Carl W. Keuffel as the answer to an early discussion by I. G. Priest,

A. E. O. Munsell, and himself as to whether a spinning optical part could be used for mixing colors,¹⁸ was developed for the Department of Agriculture through the cooperation of Mr. Keuffel, and a commercial model¹⁹ of this instrument was made and sold by the Keuffel and Esser Company. About the same time an eyepiece for the observation of spinning disks in comparison with a sample such as cotton or hay was developed for work in the Department of Agriculture laboratories by the Bausch and Lomb Optical Company.* In 1933, this was followed by the manufacture of a simplified form of disk colorimeter, the Bausch and Lomb HSB Color Analyzer—HSB for 1922 Optical Society terms hue, saturation, and brilliance.²⁰ When this instrument appeared, the Keuffel and Esser Company stopped making the larger type. A revised model of the Bausch and Lomb disk colorimeter is now completed, and it is hoped that the rush of optical work due to the present defense program will not unduly delay its commercial production.

In 1929, the disk method of color measurement, using Munsell disks as secondary standards, was described in a technical bulletin of the U. S. Department of Agriculture.²¹ Since that time, the method of disk colorimetry, using disks calibrated for measurement of particular products, has spread to many fields of work, sometimes with instruments, sometimes without. Three papers by this writer concerning this method have appeared in them. *Opt. Soc. Amer.*²²⁻²³ and other reports concerned with disk colorimetry have been published elsewhere.²⁴ A technical paper to serve as a handbook on disk colorimetry is now in preparation by the Department of Agriculture.

Other developments outside of the Munsell laboratories consist chiefly of the 1935 Glenn-Killian data on the Munsell papers;²⁵ the work of a subcommittee of the Colorimetry Committee of the Optical Society of America in reviewing the spacing of the Munsell system;²⁶ measurements by W. C. Granville, D. Nickerson, and C. E. Foss of the more than 400 special Munsell papers (in addition to those which appear on the regular charts);²⁷ a report by J. E. Tyler and A. C. Hardy at the October, 1939, O.S.A. meeting;²⁸ a report by D. Nickerson and W. C. Granville in the April, 1940, *J. Opt. Soc. Amer.*;²⁹ preparation of I.C.I. values for the Bureau of Standards 1926 measurements of Munsell papers;³⁰ the adoption in 1939 of a system of standardized color designations by the Inter-Society Color Council, the limits being defined in terms of the Munsell notation;³¹ the measurement of a master set of Munsell papers at the National Bureau of Standards; the conversion of the colors of the A. Maerz and M. R. Paul *Dictionary of Color*, the color standards of The

◆Members of the Optical Society might have been amused could they have been with W. B. Rayton and the writer in 1927 on a trip in downtown Rochester to find a hay dealer with enough hay in stock to demonstrate whether the idea of obtaining the average color of a hay sample by a series of out-of-focus lenses would work!

Textile Color Card Association of the United States, Inc., and of other standard color data, into Munsell notation.

Conclusion

From this review (1940) it is hoped that the reader will be able to recognize the vitality of a color system that has grown so much in usefulness since first proposed in the early 1900s. That we should know in exact detail the various plans of the originator is now more interesting than important. His simple notation for color and the descriptions and charts made available for practical work, not only for teaching and understanding color, but for color measurement and coordination, have been an outstanding contribution to color knowledge. For this contribution the science of colorimetry is truly indebted to Albert H. Munsell, artist and art teacher.

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*History of the Munsell Color System, Company,
and Foundation. III.**

Dorothy Nickerson

Essentially the history of the Munsell color system can be divided into four periods:

The early history to 1918, covering the lifetime of Albert H. Munsell.

The period 1918 to 1929, closing with publication of the revised Munsell *Book of Color*.

The period 1929 to 1942, to the establishment of the Munsell Color Foundation which assumed responsibility for direction of policy.

From 1942 to 1969, the present time.

Your attention will be called particularly to the earlier periods, and this history will be presented quite informally, sometimes rather personally, for there were a number of years when my association with the matters of which I speak was very close.

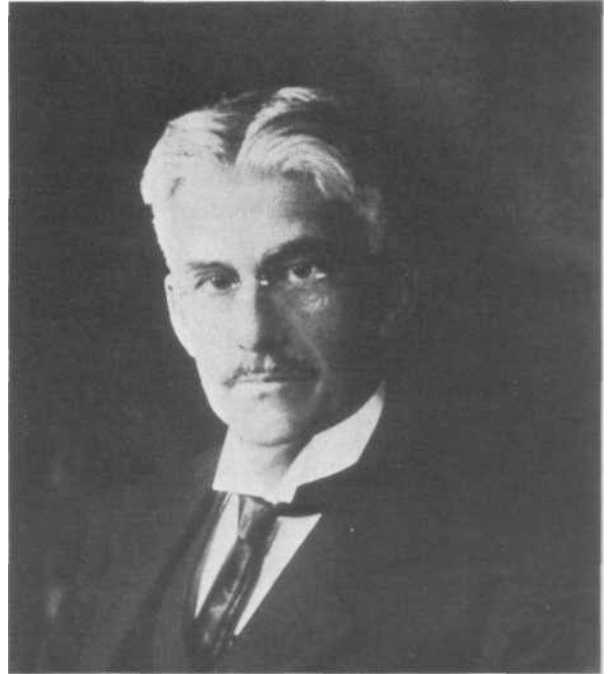
1879-1918

The earliest reprint of which I have a copy is a 12-page report of a lecture given before the New England Cotton Manufacturers Association. It is from their Transactions, No. 78, April 26, 1905; "A New Classification of Color" by A. H. Munsell.

In it Prof. Munsell deplors "the incongruous and bizarre nature of our present color names.... Music is equipped with a system by which it defines each sound in terms of its pitch, intensity, and duration.... So should color be supplied with an appropriate system?"

"This is the third of a three-part series. Part I, with introductory material, was published in *Color Research & Application*, 1(1), 7 (1976), and part II appeared in *Color Research & Application*, 1(2), 69(1976).

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Prof. Albert H. Munsell

based on the hue, value, and chroma of our sensations, and not attempting to describe them by the infinite **and** varying colors of natural objects." He proposed a system that "portrays the three dimensions of color, **and** measures each by an appropriate scale."

The advantages are summed up in the **following** conclusion to his paper:

1. Loose and unrelated color terms are **replaced** by a definite notation.
2. Each color names itself by its degree **of hue, value, and chroma.**
3. Each color can be recorded and transmitted by a code.
4. Color contracts can be drawn, and **proved** by physical tests.
5. New colors in no way disturb the orderly classification, as a place is already awaiting them.
6. Fading can be defined and plotted at **certain** intervals, showing its progress in terms of hue, **value,** and chroma.

It is well to remember that this was 1905, in days long before colorimetry was a practical science, and long before industry made any sustained use of it. I would suggest that the Munsell photometer, a daylight photometer equipped with a cat's-eye shutter, patented in 1901, was one of the earliest applications of instrumentation to industrial colorimetry as we know it today. On its development and use in producing "measured" colors, Prof. Munsell spent much time and thought. Although an artist, he had many friends in the scientific field, chiefly at Harvard and the Massachusetts Institute of Technology, with whom he consulted freely in early days.

Munsell's Diary

Much of what we know about those early days, as they concern development of the Munsell color system, comes from a six-volume color diary kept by Prof. Munsell from 1900 to 1918 (Fig. 1). A typewritten copy, with traced diagrams, is contained in two volumes of approximately 250 pages each. (Note: The Inter-Society Color Council in 1939 arranged to have a bibliofilm record made of this for deposit with the American Documentation Institute.)

In fact, much of the early history, up to 1940, was published in the December, 1940, *Journal of the Optical Society*. This was the first *J. Opt. Soc. Amer.* number devoted entirely to Munsell. Another appeared in July 1943, this one contained Munsell renotation loci on diagrams of the CIE 1931, x, y, z -coordinate system. Both issues of *J. Opt. Soc. Amer.* have articles that contain extensive lists of references.

It might interest you to know how I happened to prepare the 1940 history. Its origin really goes back to picnics we used to have when the Munsell Color Company was first based in Baltimore. The company had started in Boston, moved in 1922 to New York, and in



Fig. 1. The original six volumes of Munsell's Color Diary. 122

June, 1923, to Baltimore. Several of us, including Alex Munsell and Ferdinand A. Carlson (who painted all of the Munsell papers for many years) had started with the company in Boston after its reorganization in 1921. In New York we were joined by Milton E. Bond, a Rochester artist and art teacher, and in Baltimore by Miriam O'Brien (Underhill) of Boston. All of us were away from home, liked picnics, and as a result often got together with wives and friends working with us in Baltimore, including at one time or another Louise Sloan (Rowland), Geraldine Walker (Haupt), Blanche Robertson (Bellamy), Genevieve Becker (Gorman), Prentice Reeves, Deane Judd, and others. We found an old quarry where we would picnic, swim, and have some good talks.

Six years later, after I had left Munsell and gone to the U.S. Department of Agriculture in Washington, Capt. Charles Bittinger, the artist and expert in camouflage, invited Alex Munsell, Kasson S. Gibson, Deane Judd, and me, to lunch with him at the Cosmos Club. During lunch someone remarked that this seemed like old times, getting a group of local color people together; it reminded us of our Baltimore picnics. Capt. Bittinger was enthusiastic. Why couldn't we get a group regularly together in Washington, he asked? And so was born the Washington and Baltimore Colorists; its first meeting held November 21, 1933. In January, 1940, when an unusually large number of persons happened to be in Washington who had been connected at one time or another with work of the Munsell company or laboratory, we scheduled a "Munsell meeting."

Munsell Meeting

As secretary, I compiled and attached to the meeting notice a five-page outline, by dates, of a Brief History of the Munsell System, Its Scientific Development and Use. This was in order that members might be informed in a general way of the Munsell history, and thus be better able to get the most out of the meeting. There were no prepared papers; each person present was asked to identify himself and discuss the various phases of Munsell studies with which he was best acquainted.

It was a full and interesting meeting, for at least a score of those present had at one time or another worked with, or been supported by the Munsell company or research laboratory. After the meeting Dr. E. C. Crittenden, then assistant director of the Bureau of Standards (from 1903 until 1934 the official name omitted "National"; since 1934 it is officially the "National Bureau of Standards"), wrote to urge that the historical information be published. I demurred, for it was prepared in outline form only, and would take a lot of work to prepare for publication.

However, fate seemed to step in, for about that time J. E. Tyler and A. C. Hardy submitted to the

J. Opt. Soc. Amer. a paper analyzing the original system denned in terms of disk mixture according to specifications by A. H. Munsell. Because they did not agree that the Tyler-Hardy conclusions were supported by the 1915 *Atlas of the Munsell Color System*, K. S. Gibson and D. Nickerson were led to analyze the system based on measurements made at the Bureau of Standards in 1919 and 1926. A report by J. J. Glenn and J. T. Killian providing CIE measurements of the 1929 Munsell *Book of Color* papers, and a preliminary report by S. Newhall, chairman of an Optical Society subcommittee on the spacing of the Munsell colors, were also ready. When the editors decided that all four papers should appear in a single issue, a request was again made for the history, and this time I agreed to prepare it.

And so, from picnics to the birth of the Washington-Baltimore Colorists, and because of this, publication of a history of Munsell! That was 29 years ago and in the intervening years much has happened.

Now back to the Munsell diary. Pages 1 and 3 are missing, but the first entry on page 2 goes back to 1879 when Munsell studied Rood's *Modern Chromatics*. In 1887 he reviewed Chevreul at the library of the Beaux Arts where he was studying, and he visited the Gobelins to see their scale of yarns. In 1889 he recalls giving his students at the Normal Art School in Boston (now the Massachusetts School of Art) sketches of various diagrams and models to illustrate color balance. He noted sketching and talking with Denman Ross of Harvard in New England and later in Venice. By 1900 he was discussing his photometer, and the sphere on which he placed his "middle chroma" colors at the circumference. In 1901 the photometer was patented. In these early days Mr. William Filene, the well-known Boston retailer, asked to have the sphere shown to the Shopkeepers' Association in Boston. In 1901, first mention appears of contact with the Bureau of Standards. By January 1902 *A Color Notation* and a *Color Atlas* were being described.

In 1905 Munsell's book, *A Color Notation*, was published. (It is still available.) In 1905, as noted, Mr. Munsell talked to the New England Cotton Manufacturers. He published a paper, "On a New Scale of Color Values and a Visual Photometer," in the *Technology Quarterly*, perhaps at the instigation of Prof. A. K. Cross.

In 1905 the diary mentions Dr. W. Ostwald. Dr. Ostwald was in Boston with his son and daughter, to give a series of lectures at the Massachusetts Institute of Technology. They had many conversations. Dr. Ostwald and his daughter visited the Munsell studio, and at one of his MIT lectures he showed the Munsell sphere and referred to the Munsell book.

In 1905 mention is made of A. Howland and A. S. Allen. By 1906 the first charts of the *Color Atlas* were patented (June 26, 1906).

From 1908 to 1911 there were many lectures and talks; a series at Columbia, one in Boston for art

supervisors and a lecture at the Harvard Psychological Laboratory.

In 1908 Christine Ladd-Franklin and her husband returned on the same ship from Europe with Mr. Munsell. They had several color discussions on shipboard, and later at the Munsell studio in Boston.

Papers began to appear in the *Psychological Bulletin* and the *American Journal of Psychology*. In December of 1911 Prof. Munsell read a paper in Washington by invitation of the American Psychological Association. It was so well received that he was asked to repeat it before the meeting was over. (Can you imagine such a thing happening at a similar scientific meeting in these days?)

During the 1911 trip to Washington, Prof. Munsell visited the Bureau of Standards and met Dr. P. G. Nutting, then in charge of work that included colorimetry. He left a Munsell photometer for test. In January, 1912, Dr. Stratton, director of the bureau, wrote that he would be pleased to examine a full set of Munsell samples and look over the system of scales. This resulted in NBS test No. 10696, dated February 28, 1912, and signed by P. G. Nutting. It contained measurements of six color samples in terms of dominant wavelength, percent of white and reflection coefficient.

I. G. Priest

Let me digress here to emphasize how little we knew about color measurement in those days, even at the Bureau of Standards. I. G. Priest was brought in to the bureau to take charge of spectroscopy and applied optics in 1907. In 1915 he became head of a new colorimetry section, set up in the optics division. I have taken this from the NBS history, *Measures for Progress*, published in 1966 by the Bureau, following its 50th anniversary celebration in 1951. On page 270, the book tells us that "available to Priest and his group were the Lovibond scale ... and the recently published (1915) Munsell color system, both of them excellent, but of narrow application and uncertain foundation. The Bureau made plans to establish a broad scientific basis for color specification, color standards, and color grading." It goes on to say that, limited during World War I to color and light investigations for the military, and to the development of spectrophotometric methods of color analysis, Priest became convinced of the paramount need for a standard white light. Later, in 1921, in a pioneer report of the Optical Society to which Priest contributed, it was pointed out that it is as necessary to specify the spectral characteristics of the object and the observer as the light source, and that psychological relationships are involved. This led to the experimental determination at the Bureau of Standards of the Gibson and Tyndall luminosity curve which, through Dr. Crittenden's diplomatic skill, was adopted by the International Commission on Illumina-

tion in 1924, thus providing us to this day with what is called "the cornerstone of all photometry and colorimetry."

(Does it seem possible that an artist, sensing this need for color measurement, should anticipate these needs before there were any solid practical foundations on which to standardize whatever scales he should produce? Yet such is the case as our color history tells us!)

Now back to Prof. Munsell who, in 1911, left his photometer and color samples at the Bureau of Standards for testing. In 1912 he received the test results. The next year, he was asked to present a paper before the International Physiological Congress at Groningen, in the Netherlands. He sailed on June 23, and on August 30 went to Groningen, where he met, among others, Dr. Edridge-Green. Later he spent some time with Sir William Abney, and met Dr. Parsons and his assistants. On December 3 he sailed for home. His Groningen paper, "A Quantitative Classification of Color," was published in the 1913 *International Archives of Physiologie*.

In 1914 Munsell returned to Europe and again spent about six months there. He was ill in London, but went on by sea to Berlin where he lectured to an audience of 300. He returned to London where he was operated on July 4, and remained in a nursing home until his return home—in time to resume his teaching duties at the Normal Art School.

Ostwald Letter

I would like to call attention to a letter of July 7, 1914, written by Dr. Ostwald to Dr. P. Kraiss of Tübingen, a copy of which was sent to me several years ago by Grete, Dr. Ostwald's daughter. She recalled having visited the Munsell studio with her father, and knew the letter would interest me. Since she gave it to me to do with it whatever I liked, I wrote it up for the *ISCC News Letter* (Sept. 1956, No. 126). Dr. Ostwald wrote Dr. Kraiss (in translation) that "another member of our International Commission (for this *Color Atlas*) should be Munsell of Boston from whom some years ago I received my first stimulation to work on this subject. He is also completely on the right track and I shall soon send you some of his papers —"

The date is important. It was July, 1914. Who can tell what might have happened in the color field had the first World War not come at just that time? It disrupted the usual lines of communication. On the other hand, it provided Dr. Ostwald with time to devote to the development of his system. This he did in the years 1914-1918, during a time when he suffered the disadvantage of few contacts with other workers in the color field. Who can tell what might have happened had his 1914 ideas of an international commission for a color atlas been worked out? (I might note here that the July, 1944, *J. Opt. Soc. Amer.* contains reports of a symposium on the Ostwald color system.) In 1915 the

charts of the early *Munsell Atlas of Color* were finally published in complete form and suggestions first appear regarding commercial developments of the Munsell idea. Charts had been ordered by the Rockefeller Foundation, Carnegie Institution, Heinz and Dartmouth. There was discussion of producing school supplies to teach the Munsell system. In October, 1915, the diary indicates that plans already were afoot for production of *A Grammar of Color* by the Strathmore Paper Company. On November 6, 1915, there is a record of three colors telegraphed by F. G. Cooper from California. "Cooper's answer to Stevenson's difficulty" in describing the colors he wanted. (You may recall that *A Color Notation* opens with a quotation from a Robert Louis Stevenson letter in which he pleads for samples of an "exact shade" that he has tried to describe!)

A summer school course was held at Boothbay Harbor in 1916 with 12 lectures by Munsell.

On March 17, 1917, first mention is made of a Munsell Color Company, suggested by A. S. Allen and R. Greenleaf. In May Prof. Munsell underwent an appendicitis operation which he barely survived; he had two nurses with him all summer. As a result of this illness, his studio, at 221 Columbus Avenue in Boston, which he had occupied since 1901, was vacated. (A few months later it was taken over by John Singer Sargent.)

A brief note in February, 1918, reports that the papers of incorporation for the A. H. Munsell Color Company were rewritten, and evidently filed at the State House in Boston on February 6, 1918.

In 1918 the Bureau of Standards was requested to make a spectrophotometric analysis of the Munsell Color System. In letters to Allen, Prof. Munsell speaks several times of hoping to meet I. G. Priest of NBS. The last entry in the diary is February 16, 1918. A. H. Munsell died on June 28, 1918, without having had an opportunity to meet Priest. Born January 6, 1858, in Boston, Albert H. Munsell was 60 years old when he died.

This brings to an end the first period of Munsell color history. But before leaving it something should be said of Prof. Munsell's art history, for he was a successful artist as well as art teacher.

Munsell as Artist

He studied at the Massachusetts Normal Art School and won a fellowship for foreign study. At the Julien Academy in Paris his work qualified him to take the examination for the Beaux Arts. There he won second prize in his first yearly competition, and later the Catherine de Medici scholarship which gave him another year abroad, this time in Rome. On his return he kept a studio in the Back Bay section of Boston where he painted, chiefly portraits. He was highly praised for exhibitions in Boston, New York, Pitts-

burgh, and Chicago. During his entire life, boats and the open sea held an unusual interest for Prof. Munsell, as is witnessed by the many seascapes he painted. From 1881 to 1918 he taught at the Massachusetts Normal Art School. He was loved and respected by his students to an unusual degree; they never fail to speak of him with admiration and affection, and I have met several of them.

1918-1929

In the interval between 1918 and 1921 two significant events should be mentioned. In 1919 the Munsell Company received from the Bureau of Standards report No. 23,998, which provided spectrophotometric data on nine neutral grays and three samples of each of the five principal hues. This report was amplified and published in 1920 as Technologic Paper of the Bureau of Standards No. 167, "An Examination of the Munsell Color System" (33 pages). Of equal importance, the Strathmore Paper Company published, in March, 1921, *A Grammar of Color*, a significant addition to the Munsell literature. It was designed in its general form, and the color sheets patented, by A. S. Allen. It carried color plates by H. Dryden, decorative designs by R. Ruzicka, an introduction by Prof. Munsell, and an explanatory text and diagrams by T. M. Cleland, illustrating the application of the system to graphic arts. This Cleland description, "A Practical Description of the Munsell Color System and Suggestions for Its Use," with its 25 delightful diagrams in the artist's superb style, has been reprinted many times throughout the years. Many of these diagrams are borrowed, even today, for use in books and articles on color, although the pamphlet itself is now out of print.

Original Stockholders

As originally formed, the A. H. Munsell Color Company had three principal stockholders, Munsell, Allen and Greenleaf. (The latter two in the graphic arts field.) From 1918 to 1921, following the death of A. H. Munsell, the business was handled by several individuals—Allen and Greenleaf in New York, and a business manager, D. E. Kennedy, in Boston. This did not work out satisfactorily and led to a reorganization of the company as the Munsell Color Company, with all of the stock belonging to members of the Munsell family. Alexander E. O. Munsell, son of A. H. Munsell, just out of the U.S. Army and having completed one year of medical school, took over the active presidency of the company in July, 1921, in Boston. Messrs. Allen and Greenleaf urged him to do this. He tells me that he remembers well the day that Allen called on him in December, 1920, in the histology laboratory of the Harvard Medical School.

From his earliest days with the company Alex Munsell was influenced in his thinking by I. G. Priest, then chief of the colorimetry section of the Bureau of Standards. Alex Munsell was neither a businessman

nor an artist. His interests lay, rather, in scientific fields, and from the beginning the handling of much of the business of the company was left to others, while he concentrated on the scientific aspects of the Munsell work.

When I joined the company in Boston in October, 1921, other staff members were Munsell, a business manager and a secretary-bookkeeper. My first memory of Alex Munsell is of his enthusiasm upon his return from the 1921 fall meeting of the Optical Society of America, where he had met and talked with I. G. Priest. At that meeting he first heard of C. Keuffel's development of a direct-reading spectrophotometer, and one was ordered on the spot. It was delivered in New York to the Munsell Research Laboratory the next year, and it was my job to operate it! Remember, it was a visual instrument!

(Probably most of you today cannot imagine a day when it would take ten painstaking visual matches at every 40, 20, or sometimes 10 nanometer intervals, to measure a single color sample! The ten visual matches for each point usually were punched directly into an adding machine that sat on the table beside the spectrophotometer. I wonder how many of you would have stayed long in color work in those days! Yet those were exciting days, for we knew that we were pioneering-)

In November, F. A. Carlson joined the group in Boston. He had been painting Munsell papers at the Wadsworth-Howland Company in Maiden, and would continue to paint new supplies of *Atlas* papers. Papers were painted in large sheets, then cut to the required size. Color chips were pasted on the charts by hand. In fact, it is still chiefly a hand operation.

In 1922 the company moved to New York, because a program of expansion was planned for the educational field. At that time the business consisted primarily of handling publication of books and charts, selling school supplies that included Munsell crayons, water colors, color spheres, colored papers, and other supplies developed for use in teaching the Munsell system to school children. In 1922 a line of Martini high grade artist tempera colors was added to the line.

But more and more the burden of handling details of a school supply business irked Alex Munsell. There were no profits, so something had to be done. In the spring of 1923 arrangements were completed to turn over to Favor, Ruhl and Company of Chicago the handling and sale of all supplies except those relating to the *Atlas* papers, charts, disks, and Munsell publications. At Favor, Ruhl in Chicago, the late H. J. Taylor became well known throughout art education circles for her interest and sponsorship of the Munsell system.

At about the same time a Munsell Research Laboratory was set up, supported by funds contributed by the Munsell family—Alex Munsell, his mother, and

three sisters. It was founded as a memorial to A. H. Munsell to carry forward the application of his particular contribution, "a simple and practical notation, or method of writing color."

The employment of a staff artist to produce work that could be used in art educational work, the purchase of a spectrophotometer and of artificial daylighting, and the development of a small laboratory dark room, were all part of the research laboratory plans. This work began in New York on a small scale. All of it that could be classified as "laboratory" was done by Munsell or by me, his general office and laboratory assistant at that time.

Move to Baltimore

Soon, however, a move was made to Baltimore, to quarters with better laboratory space and facilities, which was within a reasonable distance from the Bureau of Standards and near Johns Hopkins University. Munsell intended to do graduate work in physics and psychology at Johns Hopkins, which might help to carry out the very general research plans he was developing under Priest's guidance.

During the next few years much significant color research was accomplished. In the 1940 *J. Opt. Soc. Amer.* history, 23 papers were listed which had been read before the Optical Society that were the result of work supported by funds of the Munsell Research Laboratory, carried out either at the Bureau of Standards or at the Munsell Research Laboratory in Baltimore. There was no narrow restriction as to what might be carried on as Munsell-supported investigations. Yet they all point to the development of basic information necessary if Munsell, or any other color system, was to be critically studied or standardized.

While the work supported at the Bureau of Standards covered a wide field, most of the work in Baltimore was directed more specifically toward the collection, under controlled conditions, of sufficient data to enable the Munsell Research Laboratory to specify an improved series of papers to represent, even more adequately than the Atlas papers, a psychologically sound series of equally spaced scales of hue, value, and chroma. The value results were published in three papers in the *J. Opt. Soc. Amer.* 1933 and 1934, by A. E. O. Munsell, L. L. Sloan, and I. H. Godlove. Results of experiments relating to chroma and hue scales were never put into shape for publication, but they did provide certain valuable papers made for special experiments. Among them were a series of 100 equally stepped hues painted to represent constant value and chroma (at 5/5), 50 hues at maximum chroma, a series of 60 value papers closely stepped from black to white, and certain chroma scales of very small steps.

In the period 1923-1926, in addition to the regular company staff, there were employed at one time or another, in the strictly scientific work in the Munsell Research Laboratory, seven persons in the Baltimore

laboratories and seven others at the Bureau of Standards. In Washington these included C. L. Cottrell, I. G. Priest, D. B. Judd, F. K. Harris, F. G. Brickwedde, E. P. T. Tyndall and W. Greenberg. In Baltimore they included M. O'Brien, L. Sloan, G. Walker (Haupt), I. H. Godlove, C. Boechner, P. Reeves and W. Valentine. A number of these names should be familiar to many of you, for several have continued to work in color.

On the outside there were others who continued to lecture and apply Munsell principles to business and industrial needs, particularly A. S. Allen, known throughout the graphic arts field, and E. C. Andrews of Chicago, where at the Ruxton Company he had set up a Color Vault and a Ten Commandments of Color that became widely known to printers in that area.

Meanwhile, the regular work of the company continued. Charts had to be made, papers painted, and our artist was regularly at work. In Baltimore, B. Robertson (Bellamy) and G. Becker (Gorman) were added to the production staff.

Outside the company others were beginning to study Munsell scales. The first paper in the *J. Opt. Soc. Amer.* that I can locate is one by E. Q. Adams in 1922 which is a comparison of the Fechner and Munsell scales of luminous sensation value. In 1922 the Troland report of the Optical Society of America Committee on Colorimetry was published, and it caused much ferment in the color field.

In 1924 in Baltimore the Munsell Research Laboratory began a quarterly publication, *Color News*, but the project ended upon completion of its third year.

By 1927 financial support for the laboratory investigations came practically to a stop. Funds had been contributed in order to obtain information needed to specify improvements in the system, and it now seemed to the financial contributors as if that goal had been reached and the company should take over and make use of the information. Godlove was the only research man to remain after 1927; he had joined the staff in 1926 and remained until 1933. I left the company toward the end of 1926, following a summer school session held in Wolfeboro, N.H. under the leadership of R. B. Farnum and B. G. Culver, during which we completed editing the manuscript of a book by Culver for teaching color.

A studied revision of the standard color papers was made in the light of the research that had been completed. The company itself went through several changes, one of which brought in T. Spry as production manager in 1927, and W. M. Scott as service director, 1928-1930. Scott had been chief chemist for Cheney Brothers Silk Mills where there was much interest in the new Munsell system. It was under the joint direction of Scott, Godlove, and Spry that production of a new book of charts was announced in 1929, known as the Munsell *Book of Color* to distinguish it from the Munsell *Atlas of the Munsell Color*

System, which it replaced. There followed a brief period when sales were turned over exclusively to a specially formed company, Universal Color Standards, Inc., headed by H. L. Hoffman of Baltimore.

During the period of research activity, a considerable amount of consulting business had developed, particularly in relation to the preparation of standard colors and color scales for specific purposes.

Consulting Business

Among the items for consulting business were a haemoglobinometer for Dr. P. J. Flagg of New York, meat grading scales for the Department of Agriculture, standards for soap colors, scales to measure detergent power and to measure smoke deposit. Among color problems of the Department of Agriculture was one concerning standardization of grades for various types of hay—alfalfa, timothy, Johnson grass, clover, etc. At the Munsell Company I worked as a consultant on this problem for the Department of Agriculture. When the USDA Hay Division people first suggested that I work on their problems full time, I was not interested. But early in 1927, having left the Munsell Company in October of 1926, I made contact with the U.S. Department of Agriculture and in the spring of 1927 went to work on color standardization, not only for grades of hay but for cotton and meats as well. This led to the establishment of a color measurements laboratory in which the method of disk colorimetry was applied and improved. By 1929, others in the USDA with color problems were beginning to use our laboratory as a consulting service, which continued throughout the many years that I remained with the Department of Agriculture.

Standardizing Color

By the end of 1929 a USDA technical bulletin was published, "A Method of Determining the Color of Agricultural Products," which described the method of disk colorimetry, using disks of known Munsell notation to measure an ever increasing variety of agricultural products and calculating the results in terms of Munsell notation. For work with the Dairy Division we measured the color of chocolate cakes and angel food cakes. In those first early years I never knew what sort of product would be brought into the laboratory for measurement—milk, butter, tuna fish, potato chips and canned foods of all varieties. Representatives of many of the large canners visited and worked in our laboratory. Standardization of the color of tomato soup and of mayonnaise seemed of particular importance to canners. But hay, and more particularly cotton in later years, were the two products with which I became most closely involved.

As standards we used disks of Munsell papers, four of them to cover the range of color for each particular product. From the proportions of each

disk used, an approximate Munsell notation of the match would be calculated from a formula developed for the purpose. The Bureau of Standards painstakingly made visual spectrophotometric measurements of samples of the four disks used, and thus standardized the basic disks employed in our method. Remember, this was in 1929, two years before international standards were adopted for colorimetry.

Meanwhile, in Cambridge, Massachusetts, an instrument was under development that soon would revolutionize our methods of disk measurement and computation.

In going over old records recently, I found copies of early travel authorizations. One was dated July 1927, in which I was authorized to consult with specialists in Boston and Rochester. In Boston I visited the Massachusetts Institute of Technology where F. W. Cunningham either showed me or talked to me about the spectrophotometer, which he and A. C. Hardy had under development. Two years later, in June 1929, another travel order was issued specifically for conferring with "officials at the Massachusetts Institute of Technology." This time Prof. Hardy expected me and the cotton samples I took with me. But the morning I visited him the instrument in Cambridge had developed trouble, as instruments sometimes will. He suggested that since its twin in Schenectady was in working order, and since he was driving to Schenectady that afternoon, why not ride with him and have the samples measured there. This I did.

Colorimetric Data

During that memorable drive our discussions on color covered a wide range. I remember that Prof. Hardy expressed the hope that eventually, along with the spectrophotometric curve, numbers could be punched out to provide colorimetric data. My hope was that these could be in terms of appearance attributes, preferably Munsell hue, value, and chroma.

In Schenectady I saw the automatic spectrophotometer in operation and obtained curves for each of my samples. It was an occasion I well remember, for even at the time I knew that color history was being made!

This brings us to the close of the second period of Munsell history, with the production of the 1929 Munsell *Book of Color*, and a glimpse of what lay ahead now that we were to have an automatic electronic means of rapidly producing basic spectrophotometric data.

1929-1942

The next two periods I shall go over more rapidly, for their history is better known to many of you. If not, it can be followed through reports that have appeared in

the *Opt. Soc. Amer.*, and in journals of several other member bodies of the Inter-Society Color Council for whom color symposia were arranged in the 40s.

The period that began in late 1929 was helped enormously by rapid growth and interest in the general field of colorimetry. In 1931 standards for colorimetry, standard light sources A, B, and C, a standard observer, and standard conditions for illuminating and viewing color samples, were internationally agreed upon by the CIE. In 1931 the Inter-Society Color Council was formed.

The 1922 OSA Colorimetry Committee report had represented the most authoritative compilation regarding color that was available at that time. But in 1933, because of the many new developments, a new committee was appointed under the chairmanship of L. A. Jones of the Eastman Kodak Research Laboratories. Its early meetings and discussions are reported in the introduction to the report, which, in 1953, was published as a book, *The Science of Color*. In 1937 this committee appointed a subcommittee to study the spacing of the Munsell colors with S. M. Newhall as chairman. Newhall was on the staff of the psychology department of Johns Hopkins University at the time.

Publications concerning, or based on Munsell continued, including: "On The Value Scale," by Munsell, Sloan, and Godlove; "On Color Preferences," by Guilford; "On Color Tolerances," and an "Index of Fading," by Nickerson; the "ISCC-NBS Method of Naming Colors," by Kelly and Judd, in which name boundaries were specified in Munsell notation; "On The Application of Munsell Notations to Problems of Philately," by Beck; "On Soil Colors," by Nickerson, Rice, and others. Disk colorimeters were produced, first by Keuffel and Esser, then by Bausch and Lomb. By use of spinning optical parts these avoided the necessity for spinning the disks. In 1935 the original Glenn-Killian measurements of the Munsell papers were privately circulated. By 1939 Nickerson published "On The Use of CIE in Disk Colorimetry."

During the 1930s Munsell student charts were developed by the Munsell company under the joint direction of Spry and Bellamy. Spry was particularly interested in instrumentation, and as a consequence worked with A. H. Pfund of Johns Hopkins University in the development of several Pfund instruments for which Munsell handled the sales. Following Spry's death in 1938, Bellamy became manager of the Munsell company. During this early period Newhall served as adviser on many technical and business problems.

In 1940 came publication of the first issue of the *J. Opt. Soc. Amer.* devoted entirely to Munsell. It contained a foreword by Judd, a history by Nickerson, analyses of the early *Atlas* system by Tyler and Hardy, and Gibson and Nickerson, trichromatic analyses of the 1929 *Book of Color* by Glenn and Killian, and Newhall's preliminary report of the OSA subcommittee. System Used in War On October 1, 1941, a General

Electric color conference held in Schenectady adopted a coordinated "Munsell-Spectrophotometric System" as a G.E. standard. On October 13, the G.E. Standards Department wrote the American Standards Association suggesting that industry be given the opportunity to adopt the Munsell system as an American standard, with the spectrophotometer recognized as the primary standard for measurement. American entry into the second World War in December created the need for provisional standards in many fields not yet covered by the American Standards Association, and as a consequence this early G.E. request, entitled "Color Standardization by Coordinated Munsell-Spectrophotometric System," became the basis for developing an American War Standard for the Specification and Description of Color (ASA-Z44-1942). Munsell was included in it, although no longer as the principal standard. This ASA standard provided the beginning of having the Munsell notation universally adopted as a standard for appearance specification.

In order to make this easier to accomplish and to cast off any taint of commercialism from the Munsell Color Company, Alex Munsell, no longer closely connected with the business of the company since his interests, after 1929, had turned in other directions, arranged for the establishment in 1942 of the Munsell Color Foundation, to which the Munsell family turned over their stock, and thereby the direction of policy of the Munsell Color Company. This was done after an open and well-attended meeting where many of the leaders in the color field confirmed the fact that such a move would be welcome and supported. The National Bureau of Standards and the Inter-Society Color Council each agreed to appoint a special trustee to serve on the original Board of Trustees. Other trustees were appointed to represent a wide variety of color interests in the scientific and educational fields. All served without remuneration.

The foundation is a nonprofit organization whose purpose is similar to that of the ISCC: "to further the scientific and practical advancement of color knowledge and in particular knowledge relating to standardization, nomenclature, and specification of color, and to promote the practical application of these results to color problems arising in science, art, and industry." As original trustees, Judd was appointed by the director of the National Bureau of Standard, I was appointed by the Board of Directors of the Inter-Society Color Council, and Bellamy was appointed in her capacity as manager of the company. Each has served continuously since then; Judd as foundation president, Bellamy as secretary. Other members, appointed originally or as vacancies occurred, include a distinguished list of colorists. From the time of their appointment until death, the following have served: A. S. Allen,

I. H. Godlove, R. B. Farnum and L. L. Winslow. L. A. Jones served on the original board, and was followed briefly by D. L. MacAdam. The trustees today include the names of D. B. Judd, D. Nickerson, B. Bellamy, A. E. O. Munsell, N. Macbeth, F. W. Billmeyer and W. C. Granville.

The establishment of the foundation marks the end of the third period of Munsell growth, and the beginning of another.

1942-1969

Until 1942 the company had always spent more money than it made, the difference being made up by the generous support of members of the Munsell family. But from 1942 the company was on its own, for no endowment went with the foundation. In the intervening years the company has managed to live within its income, and while it has shown a steady growth, it has not had funds to develop in a number of fields as it would like. It has made no profits that it could turn over to the foundation to expend, as the foundation trustees had originally hoped. However, the foundation *has* set the policy for the company, to insure that it developed along lines compatible with the stated purposes of the foundation. It has appointed the directors of the Munsell Color Company, and it has issued directives that have led to the support of a number of useful projects.

It might interest you to know something of the company organization. P. G. Gravenhorst, legal adviser to the Munsell family, served as president of the company for many years, serving in a legal rather than an active business capacity. In 1942, after establishment of the foundation, and because of his considerable personal interest in the affairs of the company, he remained a director and was regularly elected president by his fellow directors. These included C. Foss, S. Newhall and B. Bellamy. Gravenhorst died in 1951, and was followed as president by Foss in 1951 and 1952, then by Newhall in 1953 until 1962 when Foss again became president, a position he still holds. Bellamy has served as secretary since 1942 and as secretary-treasurer much of that time. Since 1942 C. G. Page of Baltimore has served as legal counsel for the company and foundation, and since 1951 as a director and vice-president of the company. In 1961 W. N. Hale was appointed assistant secretary-treasurer.

Research Papers

1943 was a year in which there came a new burst of research papers; four of them were published in the July 1943 *J. Opt. Soc. Amer.* These include two that provide tristimulus measurements of Munsell papers. One is the final report of the OSA subcommittee report on the Munsell system and the other is a discussion of a psychological color solid as represented by Munsell.

The 1943 report, written by Newhall, Nickerson, and Judd, defines a modified and enlarged Munsell solid with renotation diagrams that illustrate loci of constant hue and chroma at nine value levels. Value is redefined without substantial departure from the Munsell-Sloan-Godlove scale. This solid "approaches more closely (than the 1915 or 1929 papers) to A. H. Munsell's dual ideal of psychological equi-spacing and precise applicability," for it eliminates such local irregularities as may be shown by papers representing the system. It has the added advantage of being defined in terms of Illuminant C, and thus serves to interrelate in appearance terms any system that is measured in CIE terms. This makes it possible to convert instrument measurements directly and accurately into terms of appearance scales. One such method is described in a USDA publication of 1946 which provides a handbook on the method of disk colorimetry as applied to the "Color Measurement of Agricultural Products," USDA Misc. Publ. No. 580 (reprinted 1958).

This interrelation in terms of CIE and Munsell has made it possible for color appearance specifications in terms of Munsell hue, value, and chroma renotation scales to become standard all over the world, both in planning and reporting color research. Munsell specifications are used in Federal specifications, in ASTM definitions, and in ASA standards in this country. They are used in color charts by soil scientists all over the world and were adopted in 1958 as a Japanese industrial standard for the specification of color (JIS Z8721, Mar. 29, 1958). They appear in the 1958 British standard BS2660, "Colours for Building and Decorative Paints," and Munsell equivalents appear with the 1960-62 charts of the official German standard for color specification (DIN-6164, charts 1-25, 1960-62). Indeed, the Japanese have produced a quite beautiful book of Munsell renotation charts under the direction of the late S. Wada, Chief Director of the Japan Color Research Institute (JCRI).

In 1958 Munsell produced a new book of glossy papers, made to renotation specification by Davidson and Hemmendinger. A few years ago Munsell matte papers were finally adjusted quite completely to renotation specifications.

As I have said, many things have happened since 1943. There has been a publication and development explosion in technical colorimetry both in literature and instrumentation. Most of the early literature will be found in scientific periodicals, but today there are several good books, on color and color science. All of these publications contain references to, some of them whole sections on, Munsell. Indeed, as Judd said in 1943 when the Newhall, Nickerson, and Judd report on Munsell spacing was in manuscript form, "This will prove to be as important some day to colorimetry as was the adoption in 1931 of the CIE standards for colorimetry."

One of the most recent and popular things that has happened in the Munsell educational field is a series of five TV programs, two in color, developed by the cooperative extension services of the State of California and the Federal government in their programs for consumer education.

All of this means that the company has come a long way under the general direction of the foundation. Yet there are many things that it has not been able to do. As for the foundation, it has not had the funds to study or promote some of the projects for which it was set up, and in which the trustees hold a continuing interest. Therefore, both for the good of the company and of the foundation, during the past year [1969] an agreement in principle has been reached with Kollmorgen Corporation whereby they will acquire the Munsell Color Company for cash. The company will maintain its corporate identity as a subsidiary, at its present location, and its present staff. In this way it can join the several color-oriented companies already a part, or about to become a part, of the Macbeth Color and Photometry Group of Kollmorgen, a group that now includes Macbeth Corporation, Instrument Development Laboratories, Davidson and Hemmendinger, Photo Research and Leres (of France). On the completion of this acquisition, the Munsell Color Foundation will thus immediately be provided with funds that will enable it to proceed more actively, though still very modestly, towards its announced goal

of supporting research in color that will "further the scientific and practical advancement of color knowledge, in particular those relating to standardization, nomenclature, and specification of color."

We hope that by this move the practical matters of producing and distributing Munsell standard papers and equipment for using and teaching the system can be handled by the Munsell Color Company, while the foundation will be relieved of its business responsibilities in order to devote its energies and funds to the purposes for which it was established, including technical advice regarding the maintenance and improvement in the quality of Munsell material color standards and related services.

In this history, which we believe is now about to enter into a fifth period of growth and usefulness, I hope you have been given an adequate picture of the vitality of the Munsell idea, developed in the very early 1900s, that has grown into the useful and well-standardized hue, value, and chroma (H V/C) specification by which color may now be defined in terms of its appearance attributes.

Author's Note:

An early draft of this history was prepared and given, at the request of the late Harry J. Keegan, at the Color Measurements and Computer Seminar Banquet, Clemson University, July 24, 1968.

The present draft was given at a meeting of the Inter-Society Color Council held on April 15, 1969

