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The Inter-Society Color Council-National Bureau of Standards (ISCC-NBS) method of designating colors contains 267 color names. It has been possible with modern pigment technology to produce 251 of the 267 centroid colors in glossy paints.

Several years ago, when the prototype centroid colors were produced, it was possible to get only 214, so that we consider the 251 to be an important advance toward the application of this method of naming colors.

Sixteen of the centroid colors are still missing from the chart because presently there is no known way to include them.

W. W. Meinke, Chief
Office of Standard
Reference Materials

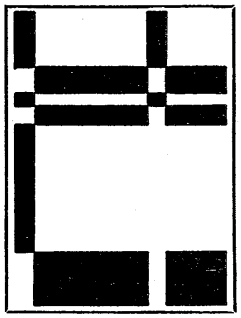
Color
ENGINEERING

March-April, 1965

A Universal Color Language

by Kenneth L. Kelly

A REPRINT



Color
ENGINEERING

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A Universal Color Language

by Kenneth L. Kelly

A method of color designation which provides a universal means of color communication for people of varying technical and occupational backgrounds, using a newly available, basically different type of color chart.

Ever since the language of man began to develop, words or expressions have been used first to indicate and then to describe colors. Today, the color names for certain colors may vary remarkably with the geographic location of their origin, with the ethnic group using them, or with the trade or occupation involved. Many of these color designations become very limited in use and therefore are not meaningful in neighboring fields of color application. Many exotic color names are developed every year in the field of sales promotion whose instrinsic value would be lost entirely if used in the field of, say, paleontology. For instance, the color described as Happy Day by Plochere *(33, 47)*, would be described as Ingenue by Maerz and Paul *(31, 40)*, as Glaucous by Ridgway *(16, 50)*, as Greige in the Descriptive Color Names Dictionary *(51)* [Color Harmony Manual *(13, 14, 20)*], and as Stramonius by Dade *(10)*. In simple terminology this color is a light purplish gray.

The latter color name, although having little sales appeal, would be understood by the whole public at least in a general way. Such a color language, by which users in different fields of color application can communicate with each other. has been urgently needed for many years. In fact, its lack has hindered development in art, science, and industry. Such a color language is now available as the result of a massive cooperative effort of organizations and individuals all interested in realizing the utmost benefits from color in every field of its application. To use a mechanical simile, it can be likened to a bridge over which flows color information between the salesman and customer, for example, or between the scientist and the manufacturer. At this point, let us consider this color language as made up of color designations, that is, color names or letter or numeral notations.

Method of Color Designation

The Inter-Society Color Council *(30)* and the National Bureau of Standards (ISCC-NBS) have cooperated for nearly 30 years in the development and application of a method of designating colors which was by definition to be accurate, and at the same time convenient and easily understood. A basic solution to this problem was published in 1939 *(22)* and was revised in 1955 under the title "The ISCC-NBS Method of Designating Colors and a Dictionary of Color Names," NBS Circular 553 *(28)*.

For convenience this publication is called the Dictionary of Color Names or the Color Names Dictionary. This method is expressed in a set of color-name charts dimensioned according to the Munsell scales *(34)* of hue, value, and chroma. The application of this method in science and industry has been increasing rapidly. One drawback to its use had been the lack of colored samples illustrating the color names of the color-name blocks.

The ISCC-NBS method also has the ability to designate colors with different degrees of accuracy. This fact was utilized in its application to the solution of the problem of designating drug and chemical colors *(1, 28, 53)* for which it was originally developed. However, it was not until 1958, when the newly formed ISCC Subcommittee on Problem 23, the Expression of Historical Color Usage *(18)*, adapted this method to the statistical expression of color trends, that this inherent ability to describe colors with different degrees of accuracy was finally tabulated in five distinct but correlated steps or levels *(26)*. This original division into five levels has through usage been refined into six levels where each higher numbered level represents a higher degree of accuracy of color designation; or to say it in another way, it represents a finer division of the whole color solid *(43)* into a greater number of smaller divisions.

Centroid Colors

The ISCC-NBS colors have just become available as NBS Standard Sample Number 2106 *(19)* which can be obtained for $3.00 per set from the National Bureau of Standards. These standard colors, which already give promise of many interesting applications, are in the form of one-inch square glossy paint-on-paper samples affixed to a variable gray background so that each color is on a neutral background of approximately its own lightness. Under each color is the abbreviation of the appropriate ISCC-NBS color name with the corresponding centroid or color-name block number. Duplicates of each of 251 ISCC-NBS colors can be obtained in 9 by 12 inch sheets from the Munsell Color Company, Inc., of Baltimore, Md.

The ISCC-NBS colors supply another powerful tool for use with this six level scale of fineness of color designation. They illustrate the centers of the color-name blocks of the ISCC-NBS Method of Designating Colors *(28)*; that is, each color illustrates a typical color described by the color name of that particular block. For the first time we can now see what the average person is supposed to mean when he uses one of the ISCC-NBS color designations or color names. However, these colors go further in usefulness. They have been manufactured to match very closely the mathematically determined center of gravity *(25)* or centroid of each of the color-name blocks. Their block numbers, the corresponding ISCC-NBS color designations and Munsell renotations are listed in the table attached to each set of these charts. Thus the color chips of these charts can serve as color standards of pin-pointing accuracy in their own right.

Now what does this mean in dollars and cents? Suppose that, for instance, you are an official of an organization and you have been instructed to select two colors to be used as the flag colors of a university or of a new country, or as the corporate colors of a large company. By selecting your colors from among the chips of the centroid charts you will save considerable money and time since these colors have already been measured and specified as stated above. Also, separate sheets of these colors can be purchased at any time with the assurance that they will not only match each other sheet to sheet, but that repaints will also match the originals.

There is also a dividend to be had in the corresponding color-name block or centroid numbers. Since each number will always be connected with the same ISCC-NBS color designation, we can jot down this number when in the field and enter the full color designation in our notebook when we get back in the comfort of the laboratory. Later, if we wish to list the color of an item on an IBM card such as an acquisition or inventory card, we need only list the centroid number which will require three columns, 1 to 267. The remaining possibilities from 268 to 999 are open for use in listing the type of specimen, such as wood, metal, paint, textile, ceramic, jewel, glossy, iridescent and so forth. It is also possible to code the color of an item on a data-processing card on each of our six-levels; in fact, this has already been done on a commercial basis.

There is cause for concern that a considerable number of purchasers will misinterpret the low price of $3 *(19)* for these ISCC-NBS centroid color charts, as compared with other color-order systems costing from $25 to several hundred dollars. This very low price results from the cooperative nature of the large amount of research which went into the development and production of these centroid color charts. The Inter-Society Color Council *(30)*, the Munsell Color Company, the Tobey Color Card Company (producer of the charts), the National Bureau of Standards, and many organizations, companies and individuals have over the years given most generously of their time and talents to bring to fruition the wedding of the Color Names Dictionary and the Centroid Color Charts. This wedding had been anticipated for nearly a quarter of a century but did not come to pass until after ISCC Subcommittee 23 asked for help. Then the organizations and people listed above went back to work together. Consequently we now have the ISCC-NBS Centroid Color Charts as the Supplement to the Color Names Dictionary *(28)*.

Color Communication

First, let us dispose of another question which may have concerned you since you read the title of this article: What has all this to do with color communication? Have you ever tried to describe the color, say, of the plumage of a newly acquired bird specimen from the Congo by using the long-used and well-known Ridgway *(16, 50)* Latin color names, only to realize your color language was not understood? Or did you have a similar feeling when your wife used color names from Plochere *(47, 33)* in describing the new color scheme the interior decorator had sold her?

Fortunately, sales promotion is not a factor in everyday color communication. Therefore, an accurate and easily understood color language which can be applied and comprehended by the largest number of people will be the most useful. As a special dividend, this color language has, for the first

time, the ability to translate the color languages of Ridgway (ornithology, geology, botany, biology), Plochere (interior decorating), Color Harmony Manual (mass marketing), the Nickerson Color Fan *(41)* (flower colors) or Maerz and Paul (historical color names), into these easily understood color designations or from one of these special color languages into one of the others. It also has the ability to express itself appropriately in each of the six levels of accuracy of color designation. The rapid growth in its application is due in great part to its utilization in every phase of color designation by the Color Marketing Group *(7)*. The Color Marketing Group is a direct outgrowth of the work of ISCC Subcommittee on Problem 23, mentioned above, and consists of representatives from many organizations in industry and commerce where color is an important part of the product.

Six-Level System

It is basic to any understanding of this six-level system of accuracy or fineness of color description, to know that in each level the whole color solid *(43)* is divided into a stated number of divisions, that the boundaries of each such division are accurately specified, and that all six levels are related through the ISCC-NBS Method of Designating Colors. Table I, which is summarized from NBS Technical Note 152, Coordinated Color Identifications for Industry *(26)*, lists the six levels, the corresponding number of divisions of the color solid in each level, the type of color designation used in each level, a typical example of the designation of a color in each of the six levels, the equivalent designations of this color in the other color-order systems and a circular diagram showing the relation of the 13 and 29 hue-name-and-neutral breakdown in levels 1 and 2. Two arrows are shown, one indicating the direction for increased accuracy of color designation, the other indicating the direction for statistical expression of color trends.

The First Level

In the first level, the color solid is divided into just 13 parts, ten described by a generic hue name and three neutrals, white, gray and black. These generic hue names are pink, red, orange, brown, yellow, olive, yellow-green, green, blue and purple; they are circled in the diagram. Thus, in this level any color may be described by using one of 13 color designations, such as a brown carpet or a yellow plastic.

The Second Level

In the second level, the color solid is divided into 29 parts, ten of the original 13 parts being further divided and assigned intermediate hue names. These intermediate hue names are yellowish pink, reddish orange, reddish brown, orange yellow, yellowish brown, olive brown, greenish yellow, olive green, yellowish green, bluish green, greenish blue, purplish blue, violet, reddish purple, purplish red and purplish pink. These intermediate hue names are shown but not circled in the diagram. The complete list of hue names with their abbreviations is found on page 4, Table I of the Color Names Dictionary. In this level, the brown carpet might better be described perhaps as a yellowish brown, and the plastic as greenish yellow.

The Third Level

In the third level, each part of the color solid described by a generic or intermediate hue name is subdivided. To each such subdivision is assigned that hue name and the appropriate modifier descriptive of its lightness and saturation, as shown in the table of modifiers on page 3 of the Color Names Dictionary. These modifiers include vivid, brilliant, strong, deep, very deep, very light, light, moderate, dark, very dark, very pale, pale, grayish, dark grayish and blackish. The part of the color solid described by the color name gray, is subdivided into three parts to each of which is assigned a modifier descriptive of its lightness; light, medium, and dark. This is the ISCC-NBS Method of Designating Colors, using the 267 color-name blocks in the Color Names Dictionary. Now we can describe our yellowish brown carpet still more accurately as, for example, a light yellowish brown (centroid 76 or color-name block 76) and the plastic as a strong greenish yellow (centroid 99).

This level of accuracy of color designation is suited for a variety of scientific and industrial uses *(3, 2)*. These designations have been used in descriptions of drugs and chemicals *(28, 1, 53)*, in qualitative chemical analysis *(32, 46)*, in dermatology *(4)*, and in the descriptions of mica *(17)*, building materials *(29, 6)*, soils *(36)* and rocks *(37)*. The centroid charts are well suited for use in statistical studies of trends in industrial color usage, and in planning lines of merchandise intended to have coordinated colors. Besides being used to designate the colors of manufactured items, chips of the centroid color charts can also be used as the standards upon which the colors of these items are based.

The Fourth Level

Level four of our coordinated series is illustrated by the Munsell Book of Color *(35, 11)*. There are about 1000 color samples in this book which have been prepared with great care to exemplify equally-spaced scales of hue, value, and chroma, on which the boundaries of the ISCC-NBS color-name blocks are based. That is, the Munsell color system *(42, 27, 15, 44, 38, 24, 49)* is a true color-appearance system and lends itself to interpolation among its colored samples. This level is retained in our system because other color-order systems can be used in it in place of the Munsell Book of Color. These other color-order systems are Maerz and Paul (first edition), Ridgway, Plochere, and the Color Harmony Manual (third edition). The number of divisions of the color solid in this level, 943 to 7056, refers to the number of colors in these color-order systems. Our light yellowish brown rug could be more accurately described by the Munsell notation 10YR 6/4 in this level.

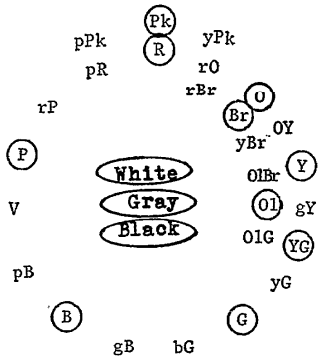
The Fifth Level

Level five is illustrated by the interpolated Munsell book notation. Since the Munsell color system is a true color-appearance system, it is possible through comparison of a color with the Munsell scales of hue, value, and chroma to interpolate visually its Munsell notation to a tenth of a value step, to a quarter of a chroma step, and to anywhere from one hue step at

TABLE I

A	1	2	3	4	5	6
B	13	29	267	943 to 7056	About 100,000	About 5,000,000
C	Generic hue names and neutrals (circled)	All hue names and neutrals	ISCC-NBS All hue names and neutrals with modifiers (NBS C553)	Color-order systems (Collections of color standards sampling the color solid systematically)	Visually interpolated Munsell notation from Munsell Book of Color	CIE (x, y, Y) x = 0.3 9 5 y = 0.3 8 2 Y = 3 5 . 6 or Interpolated Munsell renotation
	Direction for increased fineness of color definition					
	Direction for statistical expression of color usage (roll up)					
D	brown	yellowish brown	light yellowish brown (centroid #76)	10YR 6/4	$9\frac{1}{2}$ YR 6.4/$4\frac{1}{4}$	9.6YR 6.4_5/4.3

E



Munsell 1548

IGCA (9th Std.) 70128	216	M&P (1st ed) 12H6	7056
TTC-595 (1st Ed) F2310	187	Plochere	1248
H.C.C. H407	800		180 0 5-d
		Ridgway XX1X	1115 13''b
		C.H.M. (3rd Ed) 3 gc	943

A. Level of fineness of color identification
B. Number of divisions of color solid
C. Type of color designation
D. Example of color designation
E. Alternate color-order systems usable in that level

Adapted from COORDINATED COLOR IDENTIFICATION FOR INDUSTRY, National Bureau of Standards Technical Note 152 (From Interim Report of ISCC Sub-committee on Problem 23, Expression of Historical Color Usage. Also used in Color Fair of Color Marketing Group).

chroma /2 to as little as one-quarter of a hue step at chroma /10 and above. It is estimated that under these conditions, this accuracy is equivalent to the division of the color solid into about 100,000 divisions. On this basis, the color of our light yellowish brown rug can now be very accurately specified as 9½ YR 6. 4/4¼.

The Sixth Level

Level six, the level in which the greatest accuracy of color identification is possible, is illustrated by two methods of color designation which are related in our system. The basic method of color designation is that known as the CIE method *(21, 23, 45)* in which the color is specified in terms of chromaticity coordinates x, y and daylight reflectance Y. This degree of accuracy is realizable only through the measurement of the color with a spectrophotometer, and is equivalent to the division of the color solid into about 5,000,000 divisions.

The second method of color designation in level six is illustrated by the interpolated Munsell renotation *(38)* in which the hue may be interpolated to a tenth of a hue step, the value to a twentieth of a value step and the chroma to a tenth of a chroma step. The Munsell AAA tolerance, that is, the accuracy within which a repaint of a Munsell standard must color match its predecessor, is based on this level of accuracy of color identification. Now, the color of this light yellowish brown rug can be specified with the greatest accuracy as 9.6YR 6.4_6/4.3, or x = 0.395, y = 0.382 and Y = 35.6%. Further details on the different levels of fineness of color designation will be found in NBS Technical Note 152.

From the descriptions of levels four and six, it can be seen that there is a considerable variation of fineness of designation for a color in each of these levels. In level four, for instance, the Munsell Book of Color contains more than 1000 color samples, but this figure can be multiplied by approximately 100 through the use of interpolation alone, while the other color-order systems which can also be used in this level contain from 943 to 7056 color samples. In level six, the variation in fineness of color designation is accomplished by increasing the number of decimal places used in the numeri-

cal notation. This flexibility is most useful and fortunate in these levels since they will be used more and more in industry and science in the specification of colors and color differences.

Maximum Accuracy

Now, let us summarize the six levels of fineness in reverse order. For maximum accuracy, a color should be measured by a spectrophotometer and the results expressed numerically either in terms of the CIE method or a Munsell renotation (level six). If this accuracy is not required, a carefully interpolated Munsell book notation may suffice (level five). When a color notation is given in or desired to be in, either Munsell or in one of the other color-order systems mentioned above, level four is used. If one wants a quick understandable color designation such as that of a moist soil sample before its color changes due to drying, a description in terms of the ISCC-NBS color names can be read from the centroid charts and recorded (level three). There are other collections of color samples, smaller than the Munsell Book of Color which can be used in level three; these are the ninth edition of the Standard Color Card *(52, 48)*, the Horticultural Colour Chart *(5, 39)*, the Nickerson Color Fan *(41)*, Federal Specification TTC-595, (first edition) *(12)*, the molded urea *(8)* and polystyrene plastic colors *(9)*, the Rock Color Chart *(37)*, and the Soil Color Chart *(36)*.

If one is interested in the color of a thin section of a sample under the microscope *(28)* where the thickness of the section is not easily controlled, the hue name of the color in question is usually sufficient (level two). Level one is useful when a quick approximate designation of a color is sufficient or when color changes or trends are being plotted.

To assist in coordinating the color designations derived from these many collections of color samples, there are listed in the third part of NBS Circular 553, the Color Names Dictionary, all of the color names used in these color-order systems with their equivalent ISCC-NBS color designations. In the second part of Circular 553, all of these color names are again listed, each under its equivalent ISCC-NBS color name. Opposite each of these color names in part two is listed the numerical or letter designation used in each collection to identify the illustrating color sample. Thus, it is possible to get from part two, a color name in one color-order system which is synonymous or nearly synonymous with a color name in one of the other color-order systems. Here it should be emphasized that the centroid numbers, besides being a shorthand designation of the centroids, are most useful in that they are used in, and tie together, the color names of the dictionary part of Circular 553 (part three), the synonyms and near-synonyms (part two), the color-name blocks in the color-name charts in the first part and the centroid colors themselves.

Conclusion

In this article, attention has been called to a method of designating colors in simple, easily understood but accurately defined color designations in definite, correlated degrees of accuracy of color designation. These designations, to use the inclusive name, all fit together as parts of a master plan and form of themselves a universal color language either spoken or written. They are not time bound but are founded upon basic measurements and observations over many years. It is a method or language that utilizes all of the well-known color-order systems and relates them. It contains of itself only one small very specialized set of color standards, relying on the other color-order systems for the larger sets of color samples. For the highest accuracy of color designation, it uses the fundamental CIE numerical system or the Munsell renotation system, which interestingly enough can be used separate from the Munsell color samples.

Actually this method welds together into a unified system all of the best known tools of color measurement and designation, some of which have been in use for many years. It is really this unity with its unlimited flexibility and applicability in so many fields of color endeavor, that makes use of the system so rewarding. The availability of the ISCC-NBS centroid color standards supplies the last missing link in our now complete universal color language.

LITERATURE REFERENCES

(1) American Pharmaceutical Association, The National Formulary (revised every five years).

(2) American Society for Testing and Materials, Committee D-1, Method of Specifying Color by the Munsell System, ASTM Designation: D1535-58T, issued 1958.

(3) American Standards Association, Standard Methods of Measuring and Specifying Color, Z58.7.1-1951, Z58.7.2-1951, and Z58.7.3-1951, issued 1951.

(4) Appel, Bernard, Decadent Descriptions in Dermatology, Archives of Dermatology and Syphilology *62*, 370 (1950).

(5) The British Colour Council in collaboration with The Royal Horticultural Society (London), Horticultural Colour Chart, 1938 and 1940. Copyright Robert F. Wilson. Also issued as the Wilson Colour Chart.

(6) Building Research Institute, Inc., Identification of Colors for Building, Washington, D. C., 1962, Publication Number 1001, pages 3-27. Also J. Am. Inst. of Architects *XXXVII*, 77 (1962).

(7) Color Marketing Group, Executive Secretary, 1000 Vermont Avenue, N.W., Washington, D. C. 20005.

(8) Colors for Molded Urea Plastics, Commercial Standard CS147-47, U. S. Department of Commerce, 12/15/47.

(9) Colors for Polystyrene Plastics, Commercial Standard CS156-49, U. S. Department of Commerce, 1/1/49.

(10) Dade, H. A., Colour Terminology in Biology, Mycological Papers No. 6, The Imperial Mycological Institute, Kew, Surrey, England, 1-25 (July 1943).

(11) Davidson, H. R. and Luttringhaus, H. A., A Munsell Color Book in Textiles, J. Opt. Soc. Am. *41*, 623-625 (Sept. 1951).

(12) Federal Specification TT-C-595, Colors: (for) Ready-Mixed Paints. Procurable from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. for $4.50. Dated January 12, 1950 and issued in 1951.

(13) Granville, W. C., Munsell Renotations of Color Harmony Manual Chips (third edition) from Spectrophotometric Measurements. Unpublished. Available from Container Corporation of America.

(14) Granville, W. C., Foss, C. E., and Godlove, I. H., Color Harmony Manual: Colorimetric Analysis of Third Edition, J. Opt. Soc. Am. *40*, 265A (1950).

(15) Granville, Walter C., Nickerson, Dorothy, and Foss, Carl E., Trichromatic Specifications for Intermediate and Special Colors of the Munsell System, J. Opt. Soc. Am. *33*, 376 (1943).

(16) Hamly, D. H., The Ridgway Color Standards with a Munsell Notation Key, J. Opt. Soc. Am. *39*, 592 (1949).

(17) Hidnert, P. and Dickson, G., Some Physical Properties of Mica, J. Research NBS *35*, 309 (1945); RP1675.

(18) Inter-Society Color Council, Interim Report of the ISCC Subcommittee on Problem 23, Expression of Historical Color Usage, Nov. 20, 1960. Also Building Research Institute, Inc., Identification of Colors for Building, 1962, Washington, D. C. Publication Number 1001, Appendix pages 49-63.

(19) ISCC-NBS Centroid Color Charts, Standard Sample No. 2106, obtainable from the Office of Standard Reference Materials, Room 215, Chemistry Building, National Bureau of Standards, Washington, D. C. 20234. $3.00 per set.

(20) Jacobson, Egbert, Granville, Walter C., and Foss, Carl E., Color Harmony Manual, Container Corporation of America, Chicago, Illinois, third edition, 1948.

(21) Judd, D. B., The 1931 I.C.I. Standard Observer and Coordinate System for Colorimetry, J. Opt. Soc. Am. *23*, 359 (1933).

(22) Judd, D. B. and Kelly, K. L., Method of Designating Colors, J. Research NBS *23*, 355 (1939); RP1239.

(23) Judd, Deane B. and Wyszecki, Günter, Color in Business, Science and Industry, John Wiley & Sons, Inc., New York and London, second edition, 1963.

(24) Judd, Deane B. and Wyszecki, Günter, Extension of the Munsell Renotation System to Very Dark Colors, J. Opt. Soc. Am. *46*, 281 (1956).

(25) Kelly, K. L., Central Notations for the Revised ISCC-NBS Color-name Blocks, J. Research NBS *61*, 427 (1958); RP2911.

(26) Kelly, Kenneth L., Coordinated Color Identifications for Industry, National Bureau of Standards Technical Note 152, November 1962.

(27) Kelly, K. L., Gibson, K. S., and Nickerson, D., Tristimulus Specification of the Munsell Book of Color from Spectrophotometric Measurements, J. Research NBS *31*, 55 (1943); RP1549; also J. Opt. Soc. Am. *33*, 355 (1943).

(28) Kelly, K. L. and Judd, D. B., The ISCC-NBS Method of Designating Colors and a Dictionary of Color Names, NBS Circular 553, Nov. 1, 1955.

(29) Kessler, D. W., Hockman, A., and Anderson, R. E., Physical Properties of Terrazzo Aggregates, NBS Building Materials and Structures Report BMS98, May 20, 1943.

(30) Kiernan, William J., A Story About the Inter-Society Color Council, Inter-Society Color Council News Letter, Number 173, 1 (Sept.-Dec. 1964). Inter-Society Color Council, Ralph M. Evans, Secretary, Photographic Technology Div., Bldg. 65, Eastman Kodak Co., Rochester, N. Y. 14650.

(31) Maerz, A. and Paul, M. Rea, A Dictionary of Color. First Edition, McGraw-Hill Book Company, Inc., 1930.

(32) Mellon, M. G., Analytical Absorption Spectroscopy, John Wiley & Sons, Inc., New York. (1950).

(33) Middleton, W. E. Knowles, The Plochere Color System; A Descriptive Analysis, Canadian J. Research, F. 27, 1-21 (1949); N.R.C. No. 1856. Also J. Opt. Soc. Am. *39*, 633A (1949).

(34) Munsell, A. H., A Color Notation, 11th edition, Munsell Color Company Inc., Baltimore, Md. 1961.

(35) Munsell Color Company, Munsell Book of Color, 1960 edition, Munsell Color Company Inc., 2441 North Calvert Street, Baltimore, Md. 21218.

(36) Munsell Color Company, Munsell Soil Color Charts, Special Form for Use of Soil Scientists, Geologists and Archeologists, 1954.

(37) National Research Council, Rock-Color Chart, Prepared by the Rock-Color Chart Committee (sponsored by 5 Geological Organizations), New York, N. Y., 1951.

(38) Newhall, S. M., Nickerson, D., and Judd, D. B., Final Report of the OSA Subcommittee on the Spacing of the Munsell Colors, J. Opt. Soc. Am. *33*, 385 (1943).

(39) Nickerson, Dorothy, Horticultural Colour Chart Names with Munsell Key, J. Opt. Soc. Am. *47*, 619 (1957).

(40) Nickerson, Dorothy, Interrelation of Color Specifications, Paper Trade J. *125*, 153 (1947).

(41) Nickerson, Dorothy, Modern Color Science is the Background for a New and Useful Color Chart for Horticulture, Proc. 11th Annual Am. Horticultural Congress and Annual Meeting Am. Horticultural Council, p. 3-11, Oct. 1956.

(42) Nickerson, Dorothy, The Munsell Color System, Illum. Eng. *XLI*, 549-560 (July 1946).

(43) Nickerson, Dorothy and Newhall, S. M., A Psychological Color Solid, J. Opt. Soc. Am. *33*, 419-422 (July 1943).

(44) Nickerson, D., Tomaszewski, J. J., and Boyd, T. F., Colorimetric Specifications of Munsell Repaints, J. Opt. Soc. Am. *43*, 163 (1953).

(45) Optical Society of America, Committee on Colorimetry. The Science of Color, Thomas Y. Crowell Co., New York, 1953.

(46) Pearce, D. W., Chemical Equilibrium and Qualitative Analysis, Edwards Brothers, Ann Arbor, Mich. (1946).

(47) Plochere, G. and Plochere, G., Plochere Color System, A Guide to Color and Color Harmony, Fox Printing Co., Los Angeles, California, 1948.

(48) Reimann, G., Judd, D. B., and Keegan, H. J., Spectrophotometric and Colorimetric Determination of the Colors of the TCCA Standard Color Cards, J. Research NBS *36*, 209 (1946); RP1700; J. Opt. Soc. Am. *36*, 128 (1946).

(49) Rheinboldt, W. C. and Menard, J. P., Mechanized Conversion of Colorimetric Data to Munsell Renotations, J. Opt. Soc. Am. *50*, 802-807 (Aug. 1960).

(50) Ridgway, Robert, Color Standards and Color Nomenclature, Washington, D. C. 1912 (Color plates by Alfred Hoen of Baltimore, Md.)

(51) Taylor, Helen D., Knoche, Lucille, and Granville, Walter C., Descriptive Color Names Dictionary, Container Corporation of America, Chicago, Illinois, 1950.

(52) Textile Color Card Association of the United States, Inc., Standard Color Card of America, 9th Edition, Color Association of the United States, 200 Madison Avenue, New York, N. Y., 1941.

(53) United States Pharmacopoeial Convention, The Pharmacopoeia of the United States of America (revised every five years).

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