NICKERSON COLOR FAN

MAXIMUM CHROMA

40 HUES

The selection and arrangement of the colors in this fan were made by Dorothy Nickerson, color technologist, United States Department of Agriculture. Contacts with the American Horticultural Council in 1949, while secretary of the Inter-Society Color Council, brought forcibly to Miss Nickerscn's attention the need for someone of wide experience in color and well qualified in the technical field to design a chart for horticulture that would be useful in other fields as well. A chart that would be inexpensive, easy to handle, based on sound principles of color organization, and equally useful for identification, specification, and for color harmony studies, was her aim. A design for a series of *Nickerson Color Fans* is the result.

The fan allows use of liberal sized samples, each one accessible; it can be folded and carried in the pocket; the leaves can be taken out to mount in the form of a color wheel; or the samples can be cut apart to make a color file. Relatively inexpensive production with good color control is made possible by the use of the Tobey patented process, by which a series of juxtaposed colors can be coated at one time. The Munsell system of color organization is basic to the design; its numerical notation for the three attributes of color identified in this system as — *hue* (e.g. red, yellow, green, etc.) *value* (the lightness of a color), and *chroma* (the saturation of a color) — provides an accurate and precise method of color identification.

Plans call, eventually, for four fans. This first *Maximum Chroma — 40 Hue* fan which is of particular use in the horticultural field, is to be followed by a low chroma fan in 10 hues, a moderate chroma fan in 20 hues, and a fan of near whites. A further description of these fans is given on page 8 of Supplementary Information.

There are three principle distributors for this first edition of the *Maximum Chroma — 40 Hue* fan — the American Orchid Society, the American Horticultural Council, and for the many uses outside the fields covered by the interests of these two organizations, the Munsell Color Company is the principle distributor. The name and address of the principle distributors appears on the cover of the fan each is handling; the charts are identical.

In 1955, Mrs. L. Sherman Adams, chairman of the color committee of the American Orchid Society, met with Miss Nickerson and the manager of the Munsell Color Company to discuss the possibilities of a color chart for A. O. S. She was shown the design for the color fan and made arrangements for a limited number to carry the American Orchid Society name. Later, the American Horticultural Council, following a report of the color fan development to its annual meeting, October 1956,[1] made arrangments for copies to carry its name and to be distributed by the A. H. C. for use in horticultural fields other than that of the American Orchid Society.

Description — The maximum chroma fan displays 262 color samples arranged on 40 leaves. Each leaf displays samples of a single hue ranging from dark samples at the bottom to light samples at the top. Each sample represents the highest saturation for its particular lightness and hue that can be produced in smoothed chroma contours from the materials available for the production method employed.

> Stronger chromas could have been used in a few places, but they would have interrupted the smooth transition from the colors of one hue to another and in use would have made it difficult to be sure of the hue specification. Few objects will actually match in all respects the colors on any chart, and since in practice objects will just as often be weaker, as well as stronger than the samples on the fan, a search for the very strongest chromas that can be found is not as useful as to provide samples to which the greatest number may be compared and satisfactorily identified.

On 22 of the leaves of the 40 hue fan there are seven samples (3/ through 9/), and on the other 18 there are six samples (3/ through 8/). Samples representing the lightest color on these 18 leaves are omitted because they would be so close visually to samples of the same lightness on the neighboring leaves that they would not be readily distinguishable from each other.

The Munsell hue name, and the symbol for the hue notation, appears at the top of each fan leaf. The hue notation, numbered in terms of 100 steps, is given at the bottom of each leaf, in lieu of a page number. These hue names, symbols, and numbers are in the order listed in Table 1.

Table 1.

No.	Name	Symbol	No.	Name	Symbol
2.5	2.5 Red	2.5R	52.5	2.5 Blue-Green	2.5BG
5.0	5.0 Red	5.0R	55.0	5.0 Blue-Green	5.0BG
7.5	7.5 Red	7.5R	57.5	7.5 Blue-Green	7.5BG
10.0	10.0 Red	10.0R	60.0	10.0 Blue-Green	10.0BG
12.5	2.5 Yellow-Red	2.5YR	62.5	2.5 Blue	2.5B
15.0	5.0 Yellow-Red	5.0YR	65.0	5.0 Blue	5.0B
17.5	7.5 Yellow-Red	7.5YR	67.5	7.5 Blue	7.5B
20.0	10.0 Yellow-Red	10.0YR	70.0	10.0 Blue	10.0B
22.5	2.5 Yellow	2.5Y	72.5	2.5 Purple-Blue	2.5PB
25.0	5.0 Yellow	5.0Y	75.0	5.0 Purple-Blue	5.0PB
27.5	7.5 Yellow	7.5Y	77.5	7.5 Purple-Blue	7.5PB
30.0	10.0 Yellow	10.0Y	80.0	10.0 Purple-Blue	10.0PB
32.5	2.5 Green-Yellow	2.5GY	82.5	2.5 Purple	2.5P
35.0	5.0 Green-Yellow	5.0GY	85.0	5.0 Purple	5.0P
37.5	7.5 Green-Yellow	7.5GY	87.5	7.5 Purple	7.5P
40.0	10.0 Green-Yellow	10.0GY	90.0	10.0 Purple	10.0P
42.5	2.5 Green	2.5G	92.5	2.5 Red-Purple	2.5RP
45.0	5.0 Green	5.0G	95.0	5.0 Red-Purple	5.0RP
47.5	7.5 Green	7.5G	97.5	7.5 Red-Purple	7.5RP
50.0	10.0 Green	10.0G	100.0	10.0 Red-Purple	10.0RP

The complete Munsell notation, for the hue and the nearest step of value and chroma, is printed on each sample. Color names standardized to accord with the ISCC-NBS [2] method also appear on each sample. The charts can be used without reference to either but as a student begins to use the fan the specification and its meaning clarify for him many of the problems of color organization. For a detailed explanation of the Munsell notation and the ISCC-NBS names, see Supplementary Information, pages 6 to 9.

Since color is three-dimensional, and since we are able to distinguish colors in the millions,[3] no single chart or set of charts can possibly contain samples to match all of the colors which may be encountered. It is intended, when no sample is sufficiently close to use as a designation of "closest match" for all three attributes, that color designations may be obtained for hue by interpolation *between* the samples on the fan, and for value and chroma, either by interpolation, or by *extension* beyond the values and chromas on the fan.

Use of Fan for Color Designation — Observations should be made in natural daylight, preferably under a moderately overcast sky. (For discussion of effects of illumination on color comparisons see Supplementary Information, page 11.)

To use the color scales, fan them out and select the fan leaf that displays the hue nearest to that of the sample to be judged. Hold this leaf out and fold the others toward you. If the hue of the sample appears to fall between two of the leaves, hold both of them out in a fan-like position (or remove them from the collection).

Locate the color (or colors) on the leaf (or leaves) that appears nearest to the color of the sample. If the color of the sample is a close match to one of the colors on the fan, the Munsell notation or the color name may be recorded as the designation of the sample. The choice of designation depends upon whether a general or a close color description is desired.

If the hue is not the same as that on one of the 40 hue leaves, then it must be a hue that lies between two adjacent leaves, in which case the hue can be stated in words, e.g., if it lies close to 5Y but toward 2.5Y, it may be designated as *slightly redder* than 5Y. Or, the hue can be interpolated between the notations of the two adjacent leaves, e.g., if the hue is redder than the 5Y leaf, yet greener than the 2.5Y leaf, it would be 4.0Y if it is about two-fifths of the way between them, but if it is only one-fifth of the way, just *slightly* redder, it would be 4.5Y in hue. It should be possible to obtain good agreement for hue between observers at least to the 40 hues on the fan leaves. For visual observations, even this degree of agreement seldom has been possible before. Whether it is necessary to distinguish more than 40 hues will depend upon the problem; for very fine differentiation, instrumentation may be required.

After the hue has been determined, locate the value or lightness of the sample color. If it is not equal to the value of one of the samples on the chart then it must be between two of them (unless it is lighter than 9/ or darker than 3/, which are the end values on the charts). If the value of a sample, say a yellow, looks halfway between 7/ and

8/ on one of the yellow leaves, then it may be stated so in words; or the value notation may be interpolated, and the value of the sample recorded as 7.5/. If it is only about one tenth of the value interval between 7/ and 8/, it would be recorded as 7.1/.

It will be recalled that on page one, chroma was defined as "the saturation of a color". More specifically, chroma indicates the strength (saturation) or degree of departure of a particular hue from the neutral gray of the same value. E.g., a color may have the same hue and value but differ in the degree of color strength or weakness. It should be pointed out that the "maximum chroma" fan does not illustrate scales of chroma as defined above, or shown in figure 2, of Supplementary Information. However, once both the hue and value are clearly decided, an approximation of the notation for chroma may be evaluated. If the color is stronger or weaker than the chroma of the nearest sample (which is /10 for the 5Y 7/ example used above), it may be noted as such, e.g., "stronger," "slightly stronger," "weaker," or even "slightly weaker" than the chroma of that sample. Or, using the same yellow as an example, and perhaps finding that 5Y 7/10 is not a close enough notation, then the chroma may be estimated at /10+, or even /11, /12, or /13, etc. if the chroma of the sample seems enough stronger than the /10 chroma of the 5Y 7/10 sample on the chart. Conversely if the sample appears weaker it may be estimated at /10—, or /9, /8, or /7, etc. if the sample seems equal in this dimension to other samples on the chart.

Unless the work necessitates an extremely accurate designation, it often will be close enough to record the judgment by reference to the name or notation on the nearest matching sample. But with practice the notation may be used to express as fine a color difference as the eye can see. As knowledge is gained of the principles upon which the Munsell system of notation is based, visual judgments of the amount and direction of the departure of the samples from the scale colors, can be made and recorded by reference to the notations on the scales. There should be no difficulty for observers with normal color vision to agree regularly on the nearest hue and value, and within reasonable limits on the closest chroma.

> It might be well to point out that about one in every ten to twelve men has some degree of deficiency in his color vision.[4] Women may be color blind also, but less often, for it is an inherited characteristic that is transmitted through the female line from a first generation male through his daughter to his grandson, and only when the genes are present in both sides of the line will it be inherited by a female. There is a good brief discussion of this on pages 68 to 73 of reference 4.

For many purposes names will be enough. It will be noted that several samples may have the same name, and this is because the 267 names in the ISCC-NBS system cover about all the different colors that can be remembered as really different. When samples are placed side by side very small differences may be observed; to record such differences in a meaningful manner (that will indicate to a reader the extent and direction of difference) a numerical notation is needed.

Use of Fan as a Color Wheel — For teaching or color selection purposes, a color wheel is often used. This 40 hue fan can be converted very easily into a color wheel that can be mounted on a backing that should have a minimum diameter of 28 inches. Figure 1 shows a sketch for mounting the fan leaves to make such a wheel. The inside circle has a diameter of 11 inches; the diameter of the outside circle is 26 inches. A further allowance must be made for lettering, which leads to a 28 inch minimum for either a square or circular mounting. This allows the bases of the fan leaves of 20 intermediate hues (those marked 2.5 and 7.5) to be laid down first, touching each other. After these twenty chart leaves are in place, then the hues marked 5 and 10 may be placed with their bases touching, and centered over the bases of the intermediate hue leaves. On the outside circle this will allow about ¼ inch between the leaves of the 40 hues when they are all fastened down in a circle, or wheel. Stamp hinges (or hinges made of photographic mounting tape) or even corners such as are used for mounting pictures in albums, can be used to fasten the outer corners. Or, slots can be cut in the mounting board at appropriate places to allow the outer corners of the fan leaves to be slipped into place. The base of the fan leaves, as they form the inside circle, can be fastened with hinges, or by some other means that will allow their removal — unless, of course, one wishes to fasten them down permanently.

From such a wheel one can recognize, or select, color schemes with analagous or complementary hue relationships; the light-dark relationship within hues can be pointed out. In fact, its uses can be many!

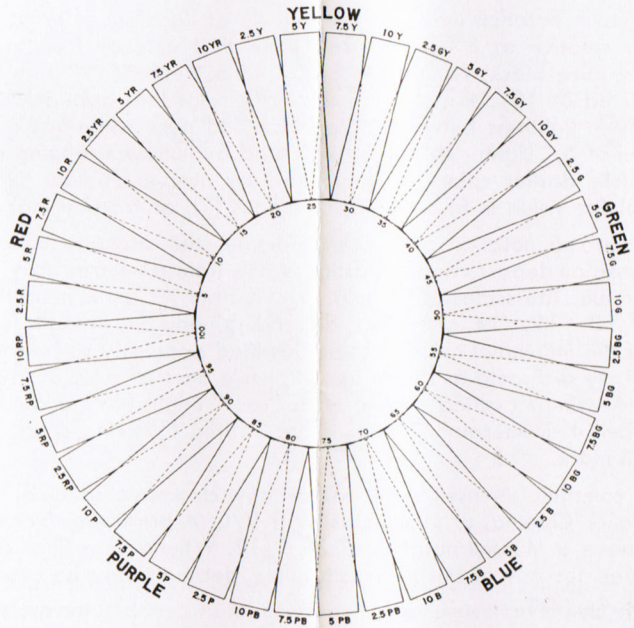

Figure 1. — Sketch to show how fan leaves may be mounted to form a color wheel with 40 hues in sequence.

The chart illustrated in figure 1 is available in full size as noted on the order blank. This is printed on heavy paper that may be mounted on cardboard. The leaves of the fan may be secured in place as indicated above.

SUPPLEMENTARY INFORMATION

The Munsell System of Color Notation — The Munsell system is essentially a scientific concept for describing and analyzing color in terms of three attributes, identified in this system as hue, value, and chroma. The method of color notation developed by A. H. Munsell[8] as the principal feature of this system, arranges the three attributes of color into orderly scales of equal visual steps, so that the attributes become dimensions or parameters by which color may be analyzed and described accurately under standard conditions of illumination.

Chromatic colors in the Munsell system of color notation are divided into five principal classes which are given the hue names of red, yellow, green, blue, and purple. A further division yields the five intermediate hue names of yellow-red, green-yellow, blue-green, purple-blue, and red-purple, these being combinations of the five principal hues. Hence the hue notation of any color indicates its relation to the five principal and intermediate hues or any of their subdivisions. Capitalized initials such as "R" for red, or "YR" for yellow-red, are used as symbols for the hue names. For finer divisions, the hues may be divided into ten steps each (1R to 10R and 1YR to 10YR), thus increasing the hue notation to 100.

The value notation indicates the degree of lightness or darkness of a color relative to a neutral gray scale that extends from a theoretically pure black, symbolized as 0/, to a theoretically pure white, symbolized as 10/. A gray or a chromatic color that appears visually halfway in lightness between pure black and pure white has a value notation of 5/. Lighter colors are indicated by numbers ranging above five, while darker colors are indicated by numbers below five. The numeral for value is followed by a solidus (/), or fraction mark.

The chroma notation of a color indicates the strength (saturation) or degree of departure of a particular hue from a neutral gray of the same value. The scales of chroma extend from /0 for a neutral gray out to /10, /12, /14, or farther, depending upon the strength (saturation) of the individual color. A color classified popularly as "vermillion" might have a chroma as strong as /12, while another color of the same hue and value classified popularly as "rose" might have a chroma as weak as /4. Numerals for chroma are written following a solidus, or fraction mark.

The complete Munsell notation for any chromatic color is written Hue Value/Chroma, or in symbols as H V/C. A particular "vermillion" might have a Munsell notation of 5R 5/12. Whenever a finer division is needed for any of the three attributes, decimals may be used, such as 2.5R 4.5/2.4.

The notation for a neutral gray is written N V/. A very dark neutral (black) would be written N 1/ or (N 1/0), and the notation for a very light neutral (white) would be written N 9/ or (N 9/0).

The system of Munsell color notation can be thought of in terms of a color solid or color space in which the neutral value scale, running vertically, in equal steps, from black at the bottom to white at the top, forms the axis of the color solid, while the various hues are located at equal angular positions around it, beginning at any arbitrary point. The chroma scales, for each value level of each hue, radiate in equal steps from the vertical neutral axis in the center to the periphery of the color solid (figure 2). The outside surface of the color solid is shown in figure 3. Figure 4 shows one quarter of the solid removed to display a diagram of a sampling of the value and chroma scales of the 5Y hue.

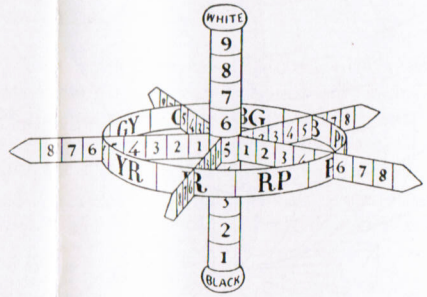

Figure 2.

Hue, value, and chroma in their relation to each other. The circular band represents the hues in sequence. The upright central axis represents the scale of value. The paths pointing outward from the center represent the steps of chroma as they increase in strength from the center outward.

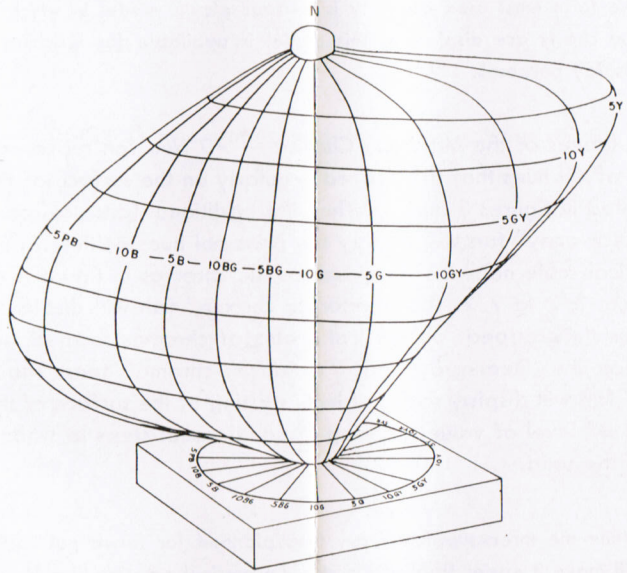

Figure 3. — Diagrammatic representation of the Munsell color space in solid form. Maximum chroma samples of each hue and value have their place on the surface of such a model. Theoretically each point inside the surface represents a different color, the colors changing gradually from one to another in each of the three attributes: hue, value, and chroma.

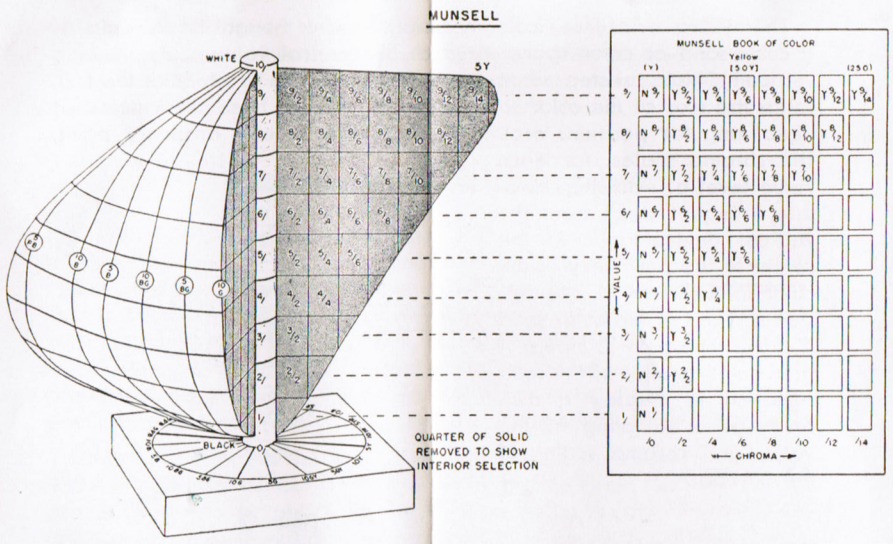

Figure 4. — Diagrammatic representation of color solid with one quarter removed to show how Munsell charts of constant hue relate to this solid form used for presentation and description of color. The hue illustrated is Yellow.

Another form used to relate the three color attributes is a Color Tree. The form most used currently is a clear plastic model in which 20 hue charts are displayed. This model is available for teaching or display purposes.

The leaves of the *Maximum Chroma — 40 Hue* fan represent value scales of 40 hues that are spaced regularly on the surface of the solid illustrated in figures 3 and 4. When the additional fans are completed, the "near-gray" fan will display ten principal hues as they appear on a vertical scale near the axis, such as the chromas in figure 4 marked /2, from 2/2 to 9/2. The "moderate chroma" fan will display twenty hues as they appear on vertical scales at chromas located between those on the "near-gray" and "maximum chroma" fans. The "near-white" fan will display scales of hues starting at the surface of the solid on the 8/ level of value, grading in equal visual steps to white at the top of the solid.

While the three supplementary fans planned for future publication will make it easier to obtain a closer numerical notation than by use of this single maximum chroma fan, it is pointed out that standard papers and charts that cover a large representative sampling of colors are available in a more expensive form in the regular editions of the MUNSELL BOOK OF COLOR:[5] These have found wide use for

many years in science, industry, and education.* In fact, the Munsell notation is so widely accepted and used in scientific and industrial color fields[6,7] that it has become part of the American Standard Method of Measuring Color (ASA Z58.7.3.1951) and at the time of this writing Committee D-1 (Paints) of the American Society for Testing Materials is in the process of developing an ASTM standard method for obtaining Munsell notations.

The ISCC-NBS Method of Designating Colors — The color names printed on the leaves of the Color Fan are those of the Inter-Society Color Council — National Bureau of Standards (ISCC-NBS) Method of Designating Colors[2] published in 1955 in a revision of a 1939 edition. The names follow a simple standardized method which differentiates 267 blocks in the color solid, about the limit of different colors that one can remember.

The method is simple in principle. The terms *light, medium,* and *dark* designate degrees of value, and the adverb *very* extends this scale to "very light" and "very dark". The adjectives *grayish, moderate, strong,* and *vivid* designate increasing degrees of chroma. These and a series of hue names, used both as nouns and in adjective forms, are combined to form names for describing color in terms of its three perceptual attributes: hue, value, and chroma. Certain adjectives cover combinations of values and chroma, as *brilliant* for "light, strong," *pale* for "light, grayish," and *deep* for "dark, strong." Table 2 contains all the hue names and abbreviations used in the ISCC-NBS system, and figure 5 shows the scheme of hue modifiers, the "-ish" grays and the neutrals with their modifiers.

Table 2. — Hue names used in the ISCC-NBS system, and their abbreviations.

Name	Abbreviation	Name	Abbreviation
red	R	purple	P
reddish orange	rO	reddish purple	rP
orange	O	purplish red	pR
orange yellow	OY	purplish pink	pPk
yellow	Y	pink	PK
greenish yellow	gY	yellowish pink	yPk
yellow green	YG	brownish pink	brPk
yellowish green	yG	brownish orange	brO
green	G	reddish brown	rBr
bluish green	bG	brown	Br
greenish blue	gB	yellowish brown	yBr
blue	B	olive brown	OlBr
purplish blue	pB	olive	Ol
violet	V	olive green	OlG

*Descriptive literature of Munsell publications and materials, with a price schedule, will be sent upon request to the Munsell Color Company, Inc., 10 East Franklin Street, Baltimore 2, Maryland.

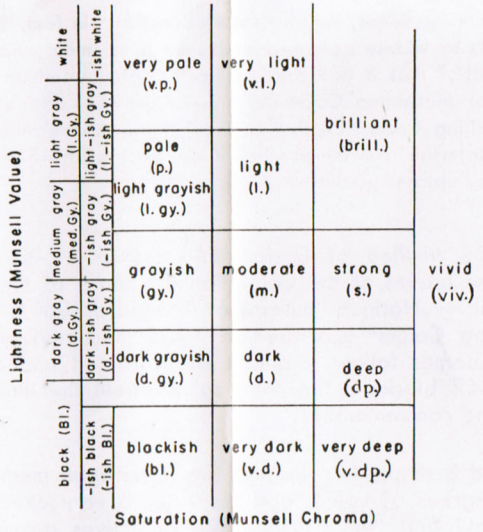

Figure 5. — Scheme of the hue modifiers, the "-ish" grays, and the neutrals with their modifiers, as used in the ISCC-NBS system.

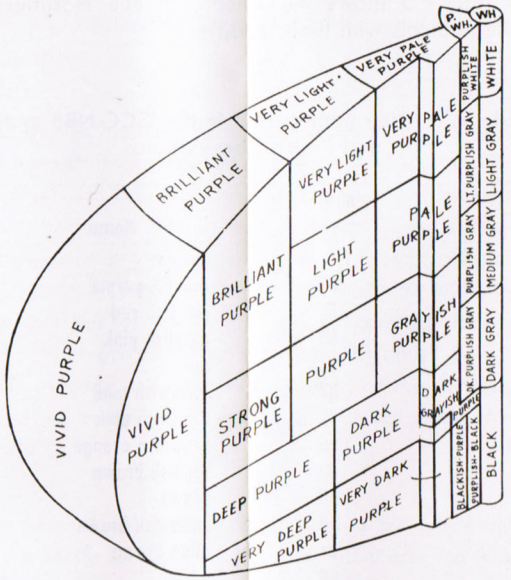

Figure 6. — Purple section of Munsell color solid illustrated to show relation of ISCC-NBS system of color names. Color name blocks are illustrated for the purples and neutrals. All colors that may be distinguished within one block are called by the same name.

The important thing about this method that distinguishes it from all others is that the boundaries of each name designation are fixed. The limits are defined in terms of the Munsell notation so that each designation defines a block in the color solid bounded by vertical planes of constant hue, horizontal planes of constant value, and cylindrical surfaces of constant chroma. As illustrated in figure 6 for the purple color names, each block covers a range of colors, and this means that ISCC-NBS names *describe* but do not *pinpoint* the color as does a Munsell notation. It follows that all colors which fall within each name block are called by the same name, and it is for this reason that several adjacent colors on the Color Fan may bear the same descriptive name. When it is important to make close distinctions among the many colors that in this system might bear the same designation, the practical usefulness of a numerical system, such as the Munsell, becomes quite evident.

Illumination for Color Matching is Important — It is possible, since the paints used in these charts may not be made of the same pigments as those in the sample being matched (e.g., a flower), that the closest match for a sample under daylight may be to a different sample on the fan than it is under light from a man-made source, whether an incandescent tungsten lamp or any one of the several white fluorescent lamps. Therefore, to obtain observations that will be reported the same as for average daylight, the lighting conditions should be those of average daylight. When the conditions of illumination depart in any important way from average daylight (which may be described as light from a moderately overcast sky), it should be mentioned.

When glossy samples are in question, or small differences, or samples with pigments that have unusual spectral absorption characteristics, then standard conditions of lighting (both for the spectral quality of the light and for the geometry of its placement and use) may become very important in order to obtain consistent results between observers, or even by the same observer at different times. For the small percentage of technical workers whose color problems are critical enough to require strict standardization of lighting and of other surrounding conditions, laboratory equipment is available.* But for much of the work for which these fans will be used this will not be necessary; it is sufficient here to call the reader's attention to this possible source of error.

To summarize — *Use average daylight or the closest equivalent available. If artificial light is the only source convenient for routine observations, it is advisable, occasionally, to make comparisons of a number of the same samples under average daylight and under the artificial light used generally. Records from these observations will indicate how much shift there may be that is caused by the illumination.*

*Descriptive literature on laboratory units providing standardized conditions of illuminating and viewing may be obtained for the Munsell Color Company, Inc., 10 East Franklin Street, Baltimore 2, Maryland.

Keys to Other Color Charts are Available — Munsell notations for color samples of several of the better known color charts, such as Ridgway (RCS) and the British Horticultural Colour Chart (HCC), are published in tables [9] that make it possible to convert from one system of designation to another. Reference 9 not only provides a Munsell key to the HCC color names but it lists references to the Ridgway-Munsell key and to several others.

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(2) Kelly, K. L. and Judd, D. B.
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(9) Nickerson, D.
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