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METHOD OF DESIGNATING COLORS [1]

By Deane B. Judd [2] and Kenneth L. Kelly [3]

ABSTRACT

In 1931 the first chairman of the Inter-Society Color Council, E. N. Gathercoal, proposed on behalf of the United States Pharmacopoeial Revision Committee the problem of devising a system of color designations for drugs and chemicals. He said, "A means of designating colors in the United States Pharmacopoeia, in the National Formulary, and in general pharmaceutical literature is desired; such designation to be sufficiently standardized as to be acceptable and usable by science, sufficiently broad to be appreciated and used by science, art, and industry, and sufficiently commonplace to be understood, at least in a general way, by the whole public." With the assistance of the American Pharmaceutical Association, and following plans outlined in 1933 by the Inter-Society Color Council, there has been worked out a solution for this problem, which substantially fulfills the requirements laid down by Dr. Gathercoal.

CONTENTS

[1] Recommended by the Inter-Society Color Council, June 1939, for drugs and chemicals, and tentatively suggested for general use.

[2] Physicist, National Bureau of Standards, and chairman of the Committee on Color Problems of the Inter-Society Color Council.

[3] Research Associate at the National Bureau of Standards, representing the American Pharmaceutical Association.

I. HISTORY

The problem was referred by the Inter-Society Color Council to its Committee on Measurement and Specification which, under the chairmanship of I. H. Godlove, presented several reports surveying available methods of color designation. The 1933 annual report of this committe included the outline of a recommended system of color designations. These recommendations were approved by the Council and have been followed by the authors, who have developed this system of color designations, have set the color boundaries, and have worked out methods of applying the system to drugs and chemicals in various forms. The Inter-Society Color Council in 1939 formally approved by letter ballot and recommended to the United States Pharmacopoeial Convention the method now to be described.

Member bodies of the Council whose voting delegates have approved this method of designating the colors of drugs and chemicals are: [4]

American Association of Textile Chemists and Colorists.
American Ceramic Society.
American Psychological Association.
American Society for Testing Materials.
Illuminating Engineering Society.
National Formulary, American Pharmaceutical Association.
Optical Society of America.
Technical Association of the Pulp and Paper Industry.
United States Pharmacopoeial Convention.

II. SCOPE

The recommended color designations apply to powdered drugs and chemicals and to whole crude drugs viewed in daylight. The Council is now engaged in a study of the general applicability of these designations to colors of opaque, nonmetallic surfaces with a view to official adoption for all such surfaces.

The recommended system does not give suitable color designations in its present form for liquids and solids viewed by transmitted light. An extension of the system to cover such samples has been undertaken by the Council. (See also section VIII, 3.)

III. LOGIC OF THE DESIGNATIONS

The designation for all but very grayish colors consists of a hue name (*red*, *green*, *blue*, *purple*, etc.) preceded by appropriate modifiers (such as *weak*, *moderate*, *strong*, *light*, and *dark*). The designation for very grayish colors consists of a noun (*white*, *gray*, or *black*), with modifiers appropriate to the lightness and hue of the colors (such as *dark reddish gray* or *yellowish white*).

1. SURFACE-COLOR SOLID

The relationships between the names can best be understood by a consideration of the psychological color solid. The dimensions of this solid are hue, lightness, and saturation (see fig. 1); the color of any

[4] A majority of the voting delegates representing the individual members of the Council also approved. Textile Color Card Association of the United States (not voting).

matte, opaque surface in daylight is represented by some point in it; hence it is often called the surface-color solid. Lightness starts at zero for black, represented at the bottom of the figure, and is measured by distance from the base plane, being a maximum for white represented at the top of the figure. Hue is represented by angle about the black-white axis, giving the closed series red, yellow, green, blue,

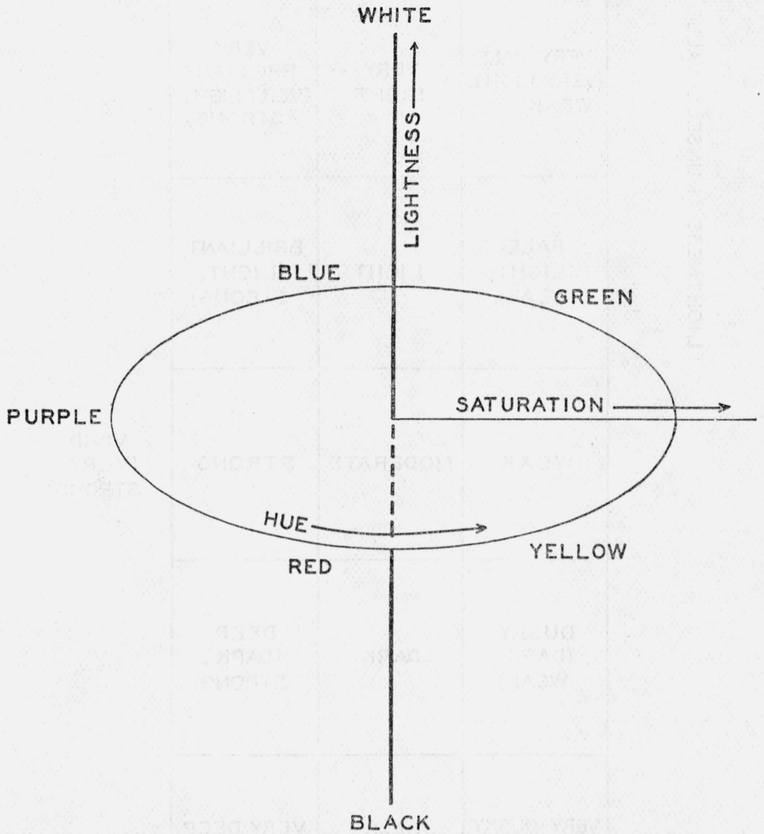

FIGURE 1.—*Dimensions of the surface-color solid.*

purple, red, with their intermediates. Saturation is represented by distance from the black-white axis, being zero for black, white and the intermediate grays, and increasing toward the boundary of the surface-color solid on which would be represented the most vivid colors producible from surfaces [1].[5]

Colors of one hue are therefore represented in the solid by points falling in a single one of the vertical planes intersecting at the black-white axis. Colors of one lightness are represented by points in any one horizontal plane; and colors of one saturation are represented by points in any one of the series of right circular cylinders concentric about the black-white axis.

[5] Figures in brackets indicate the literature references at the end of this paper.

2. BASIC PLAN OF FORMING THE DESIGNATIONS

The hue name of the color designation is intended to indicate a range of hue angle in the color solid, and other words in the designation are to indicate ranges of lightness and saturation for this hue range. The system of modifiers is indicated in figure 2. Deviations

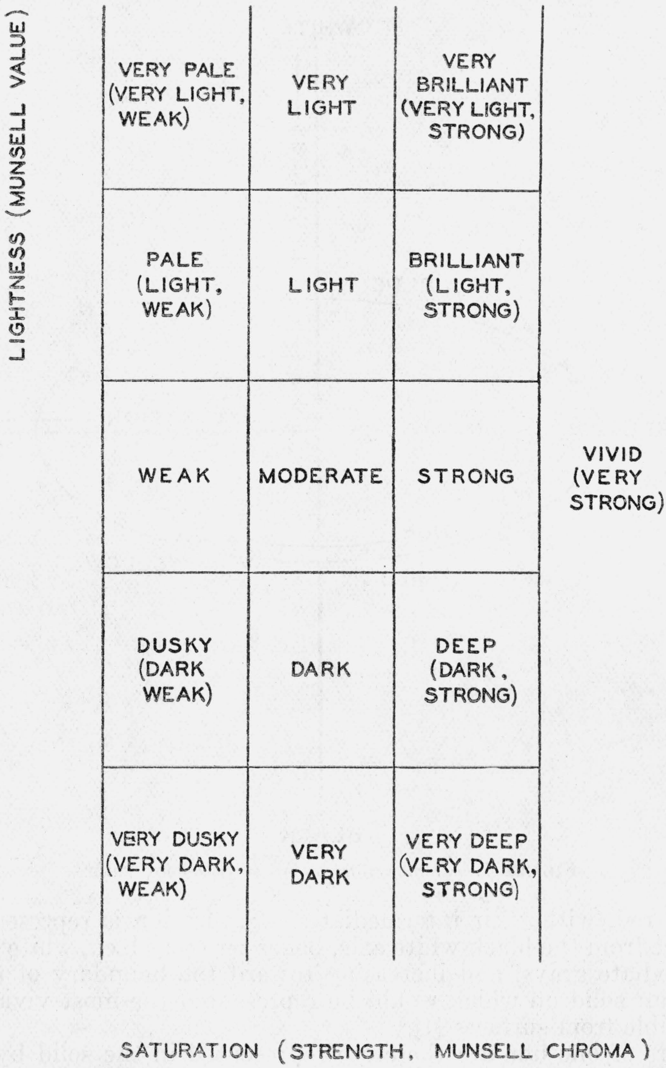

FIGURE 2.—*System of modifiers.*

The color designation, except for very grayish colors, consists of a hue name combined with one of these modifiers.

from the moderate range in lightness are indicated by the terms, *light* and *dark;* deviations in saturation by the terms *weak*, *strong*, and *vivid;* and deviations in both lightness and saturation by the terms *pale*, *deep*, *dusky*, and *brilliant*. The whole color designation, hue name and modifiers, therefore, defines a block of the surface-color solid bounded by vertical planes of constant hue, horizontal planes of constant lightness, and cylindrical sufaces of constant saturation. The surface-color solid is divided into 314 such blocks, with 5 cylindrical blocks for black, grays, and white, making 319 blocks in all.

3. DIVISIONS OF THE HUE CIRCLE

The 1933 recommendations by Dr. Godlove included a 20-point division of the hue circle for colors of moderate saturation, a 10-point division for weak colors and a 5-point division for very weak colors. By adhering to the principle of this recommendation it has been possible to make each color designation refer more nearly to the same-sized color range than would otherwise have been possible. Deviations from the 1933 recommendations have been introduced to make the color designations accord more closely with present usage, particularly usage in the United States Pharmacopoeia and National Formulary. Most of these deviations arise from our introduction of the color terms *pink*, *brown*, and *olive*, and our change to a more restricted color range for *orange*.

4. PINK, ORANGE, BROWN, AND OLIVE

Unlike the terms *green* and *blue*, which are hue names applying to all lightnesses and saturations, the term *yellow* is commonly used to designate not only a certain hue range, but also a high-lightness range within this hue range. Dark colors of the same hue as yellow are commonly called *olive* or *olive brown*. Common usage limits the term *orange* even more strictly; it is taken to refer not simply to a range of yellow-red hues but also to a medium-lightness range and a high-saturation range. Colors of the same hue but of lower lightness and saturation than the orange range are called *browns* or *reddish browns*.

To follow common usage in this respect, there is included a series of hue names applicable to dark colors only, as follows: *reddish brown*, *brown*, *yellowish brown*, *olive brown*, *olive*, and *olive green*. As a further concession to common usage, there is also included the following series of hue names applicable to very light colors only: *purplish pink*, *pink*, and *orange pink*. The chief series of hue names to which these two subsidiary series have been fitted follows closely the 20-point division recommended by Dr. Godlove; the chief series includes the names *red*, *reddish orange*, *orange*, *yellowish orange*, *yellow*, *greenish yellow*, *yellow green*, *yellowish green*, *green*, *bluish green*, *blue green*, *greenish blue*, *blue*, *purplish blue*, *bluish purple*, *purple*, *reddish purple*, *red purple*, and *purplish red*.

5. SOME UNAVOIDABLE DISADVANTAGES

A frequent objection to this system of color designations is that each designation refers to a group of distinguishable colors rather than to a single color. Since there are about ten million surface-colors distinguishable in daylight by the trained human eye and only 319 color designations in this system, it is obvious that the average color range denoted by a single designation must contain about 30,000 distinguish-

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able colors. If it is important to make distinctions among some of these thousands of colors bearing by this system identical designations, resort must be had to one of the many numerical systems of color specification available. Preeminent among these is the colorimetric coordinate system recommended in 1931 by the International Commission on Illumination [2].

A corollary to this objection is that there are many pairs of easily distinguishable colors which receive by this system the same designation, while there are also many pairs that can scarcely be distinguished which receive different designations. This property is, of course, an unavoidable result of dividing the color solid into an arbitrary number of blocks, one for each of the 319 designations. Analogous disadvantages result from identifying the time of events according to date; two events occurring on the same date may be separated by many hours, but on the other hand two scarcely separable midnight events may have to be assigned different dates. Just as identifying the time of an event by giving the date has proved to be useful, so it is anticipated that a system of color designations such as this will find many uses.

IV. DEFINITION OF THE COLOR RANGES

The adjustment of the boundaries defining the 319 color ranges has been carried out by the committees of the Inter-Society Color Council with reference to the color standards of the Munsell Book of Color [3]. These standards are arranged according to Munsell hue, Munsell value, and Munsell chroma, which are intended to be practical evaluations of the surface-color attributes: hue, lightness, and saturation, respectively. That is, all Munsell standards bearing the same Munsell hue notation are intended to have colors of the same hue; likewise, Munsell value is intended to indicate, and does closely, the lightness of the color; and Munsell chroma corresponds well with saturation. For the present, therefore, the definition of the color ranges is given in terms of Munsell hue, value, and chroma. (See the 34 name charts which form the major part of this paper.)

Ultimately, it will be desirable to supplement this practical definition of the color designations by giving the equivalent definition in terms of the 1931 colorimetric coordinate system [2], which does not depend upon the integrity of material standards of color. Any small uncertainty in the boundaries arising from disagreement among the various sets of Munsell color standards, or from their impermanence, will be resolved through spectrophotometric specifications, already partially available, of two sets of master standards deposited at the National Bureau of Standards in 1935 by the Munsell Color Co. A set of smoothed interpolation curves based upon spectrophotometric measurements of a set of Munsell standards by J. J. Glenn and J. T. Killian in A. C. Hardy's laboratory at the Massachusetts Institute of Technology already permits a fairly reliable transfer from Munsell notation to ICI specification to be made. These interpolation curves are available through Dorothy Nickerson, color technologist, Agricultural Marketing Service, Washington, D. C. The Maerz and Paul Dictionary of Color [4] was used to test the suitability of many of the boundaries, and because of its large number (7,056) of colors, well distributed throughout the surface-color solid, it forms the basis for a very satisfactory possible definition of the boundaries for practical use. The determination of the color names of only a few of this large number of samples has so far been completed.

V. HUE BOUNDARIES FOR VARIOUS RANGES OF MUNSELL VALUE AND CHROMA

Although the systematically arranged and graded standards of the Munsell Book of Color have proved to be invaluable aids in the choice of color-designation boundaries to accord with common usage, it has been found that best agreement with such usage is obtained by deviating in many cases from constant Munsell hue. One deviation from constant Munsell chroma has also been made (*3Y* to *8Y*, inclusive, change from 1.5 to 2.0 chroma). These deviations are shown on charts 35 and 36 which consist of the hue boundaries for various chroma ranges. Chart 35 refers to dark and medium colors; chart 36, to all light colors having hue boundaries different from the corresponding dark and medium colors. The hues are indicated by abbreviations such as *pR* for *purplish red*, *R* for *red*, *rO* for *reddish orange*, *r-Br* for *reddish brown*, *Ol-Br* for *olive brown*, *p-Pk* for *purplish pink*, *O-Pk* for *orange pink*, and so on. Munsell hue is indicated on the 100-point scale on the outer circle. These charts show at a glance for all Munsell chromas what ranges of Munsell hue are referred to by the various hue names of this system; this information is of course also obtainable from the name charts (1 to 34), themselves, but less conveniently. The central circle marked *N* for *neutral* refers to Munsell chromas less than 0.5. The 6-point division on chart 35 refers to the chroma range (with the exception noted above) 0.5 to 1.5, and yields color designations involving the hue adjectives, *reddish, brownish, olive, greenish, bluish,* and *purplish,* such as *reddish gray* and *reddish black*. The 5-point division on chart 36 similarly refers to color designations involving the hue adjectives, *pinkish, yellowish, greenish, bluish,* and *purplish*. The 10-point division on chart 35 refers to the chroma range 1.5 to 3.0 and involves the hue names: *red, brown, olive brown, olive green, green, blue green, blue, purplish blue, purple,* and *red purple*. The similar ring on chart 36 has 11 divisions: *pink, orange pink, orange, yellow, yellow green, green, blue green, blue, purplish blue, purple,* and *purplish pink*. The 19-point division on chart 35 refers to chromas greater than 3.0, and it will be noted that within the two chroma ranges, 3.0 to 5.0, and greater than 5.0, the hue boundaries for simplicity are kept at constant Munsell hue. As mentioned above, however, it has been found possible to increase agreement of these color designations with common usage by adopting in 5 out of 19 cases a different hue boundary for the chroma range 3.0 to 5.0 than is used for the chroma range 5.0 up. Many of the hue boundaries for the inner rings are also shifted in a corresponding way for the same reason.

VI. COLOR DESIGNATIONS FOR OPAQUE POWDERS

1. PREPARATION OF SAMPLE

The sample is placed slightly heaped up in a clean aluminum holder at least 2 mm deep. Over it is placed an optical-glass cover of 1 mm thickness, which is pressed down with a rotary motion, and two small rubber bands are snapped across underneath the sample holder between the opposite hooks on the back of the cover glass; see figure 3.

2. LIGHTING AND VIEWING CONDITIONS

The illumination to be used in the color-comparison work is daylight. A table placed by a window so that light reaches the table top from the operator's left or right chiefly from the sky and chiefly at an angle of 45° from the horizontal is recommended. A north window is best because no special precautions are usually required to eliminate direct sunlight, but windows facing in any direction may be used if equipped with suitable diffusing curtains. A canopy of black cloth (preferably black velvet) should be hung above the sample on the side opposite the operator in such a position as to be imaged in the mirror surfaces of the cover glass; such an arrangement eliminates errors from unwanted admixture of light reflected only from the cover glass. The sample and standard placed on the table top are viewed nearly perpendicular to the surfaces, that is, just enough off the perpendicular to avoid having the operator's face mirrored in the cover glass. Illumination at 45° and perpendicular viewing are recommended by the International Commission on Illumination [2]. A skylight or source of artificial daylight located above the sample may also be used, but in such a case the angle of view should be approximately at 45° from the horizontal, and the black cloth should be hung vertically beside the sample opposite the observer. Perpendicular illumination with viewing at 45° gives results equivalent to the recommended ICI method.

It is important that the illumination of sample and working standard be closely the same both in amount and quality; otherwise different Munsell notations will be found by interchanging them. Even with illumination of good uniformity it is best practice to make this interchange as a check during the comparison.

In any computations involving the spectral energy distribution of the illuminant, that of standard illuminant *C* recommended by the International Commission on Illumination [2] as representative of average daylight is to be used.

3. PROCEDURE

Select the two adjacent Munsell constant-hue charts between which the hue of the sample falls. Place these on each side of the sample and cover each with a small gray shield, or if using the large triple-aperture shield (shown in fig. 4), place them under the holes in the side flaps and the sample under the central rectangular opening. The Munsell hue, value, and chroma notations for a sample are found by interpolation among the standards of the Munsell charts; most operators prefer to interpolate first for value, then chroma, and finally hue. For detailed suggestions on this interpolation consult the Munsell Book of Color, Standard edition [3].

Once the Munsell notation is found for the sample, select the color-name chart referring to the hue of the sample (see Munsell hue designations near upper right-hand corner of each name chart). Plot the value and chroma of the sample on this chart, noting that chroma from 0 up to 1.5 has, for convenience, been plotted to a more open scale than the remainder (see vertical double line dividing the two scales

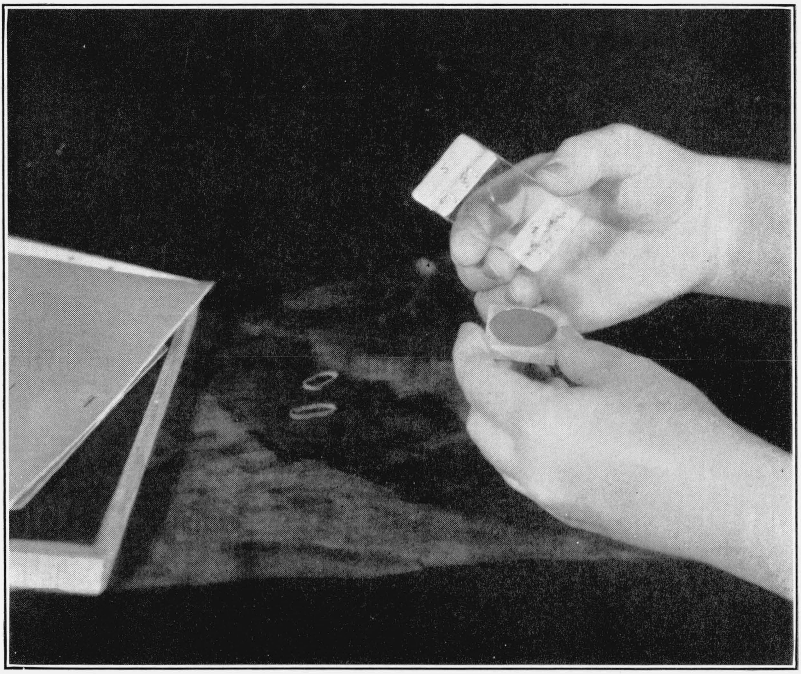

FIGURE 3.—*Preparation of an opaque-powder sample for comparison with the Munsell color standards.*

Note the hooks on the under side of the cover glass, which is attached thereby to the sample holder by means of rubber bands.

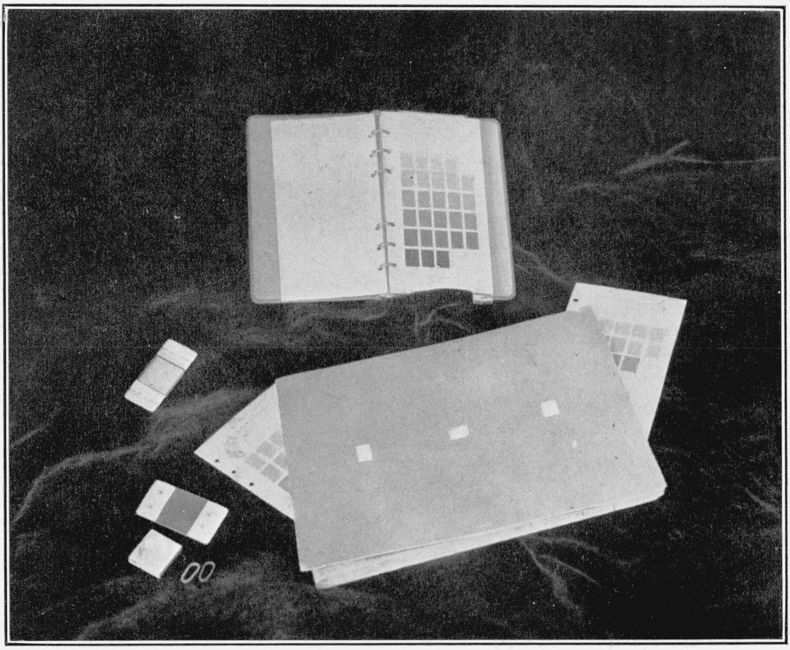

FIGURE 4.—*Triple-aperture shield.*

Sample aperture in center, apertures for Munsell color standards on each side. The abridged edition of the Munsell Book of Color is also shown, together with two sample holders, one assembled, the other taken apart.

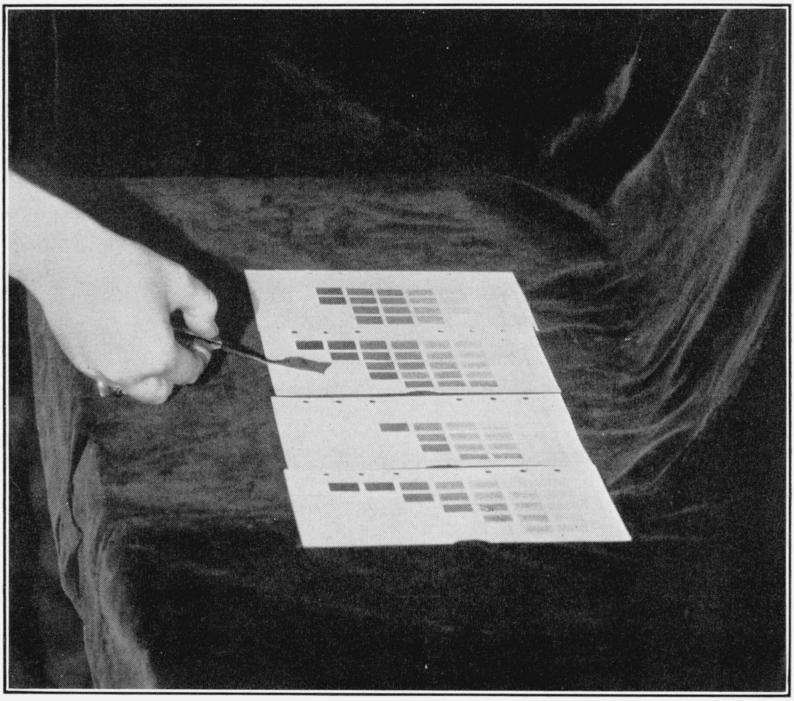

FIGURE 5.—*Comparison of whole crude drugs with the Munsell color standards.*
The crude drug shown is a leaf and is held by the tweezers a few inches above the color standards.

on each name chart). Record the name of the block in which this point falls as the color designation of the sample. If, however, the point falls on a value or chroma boundary, or if the hue notation falls exactly between successive charts yielding different color names, the names of all of the blocks touching the point apply to the sample.

4. AN EXAMPLE

Suppose that the hue of the sample falls between the *YR* (*5YR*) and the *YR–Y* (*10YR*) charts, and that its value falls between 7 and 8 value, but nearer 7, and is estimated as 7.2. Suppose, further, that its chroma is found to be closer to 4 than to 6 and is estimated as 4.5. Now compare the sample with the two Munsell 7/4 standards. Suppose that its hue is seen to be nearer to that of the *YR–Y* chart than the *YR* chart, say 4/5 of the hue difference between the charts or four hue steps from the *YR* and one from the *YR–Y* chart. Now interchange the positions of the charts and check the Munsell notation. If these are found to be unchanged, the final notation is *9YR* 7.2/4.5. Now look through the name charts until the one for *9YR* is found (chart 8, see hue designation near upper right-hand corner). Plot 7.2 value and 4.5 chroma on this chart. It falls in the block named *weak orange;* so the color designation of the sample is *a weak orange.*

VII. COLOR DESIGNATIONS FOR WHOLE CRUDE DRUGS

1. COMPARISON WITH MUNSELL COLOR STANDARDS

Hold the sample in the fingers, or in tweezers if the sample is small, a short distance above the chart or charts and move it about for comparison with the Munsell color standards. Care should be taken not to cast a shadow on the standard with which the sample is being compared; on this account the larger samples should be held higher above the charts than the small (see fig. 5). The time required for the comparison, and consequent soil and wear on the standards, will be saved if the charts are arranged in hue sequence on the table top so that each chart covers the 8- and 10-chroma columns on the preceding chart.

2. LIGHTING AND VIEWING CONDITIONS

The samples are to be illuminated at 45° by daylight (see section VI, 2), and viewed along the perpendicular to the surface. Since the samples are held above the plane of the color standards, it is important that the illumination on the two horizontal planes be the same in amount and quality. Care should be taken to hold the surface of the sample as nearly in the horizontal plane as possible; errors in Munsell value by as much as a whole step are possible through inadvertent tilting of the sample surface. If a source of artificial daylight is used giving a diffused even illumination over a large area from above, or if the comparison is made out of doors by diffuse light from a large part of the sky, the angle at which the sample is held with respect to the light source is less critical.

For minimizing the troubles due to uneven illumination on samples (such as roots) having approximately cylindrical surfaces, it is recommended that the axis of the cylinder be held horizontal and pointed in the direction of the light source so that neither side of the sample is shaded.

For samples having glossy surfaces the use of a black canopy or curtain will be required as described in section VI, 2.

3. WAYS OF USING THE COLOR DESIGNATIONS

The color of a crude drug may be designated either by giving the name of the average color found in the lot, if the range of color is small, or by giving the color names corresponding to the maximum range of color. This range may be of hue, lightness, or saturation, or a combination of two or all of these. Departures from such a range will frequently be an indication of deterioration or impurity. Color ranges involving chiefly variations in lightness and saturation can often be conveniently indicated by the unmodified hue name, such as *orange*, by which would be meant the color range covered by the designations, *brilliant orange*, *vivid orange*, *strong orange*, *moderate orange*, *weak orange*, *light orange*, *pale orange*, *dark orange*, and *deep orange* (see charts 4 to 6).

VIII. COLOR DESIGNATIONS FOR ANY OBJECT

The main purpose of this paper is to provide information required for obtaining color designations of powdered crude drugs, whole crude drugs, and chemicals of small particle size. To this end, specific instructions have been given in sections VI and VII. A secondary purpose, however, is to facilitate study of the suitability of these color designations to any object. Detailed procedures applicable to this wider use of the system have yet to be formulated; but some general instructions can be given.

1. FOR OPAQUE NONMETALLIC MATERIALS

(a) WITH MATTE SURFACES

Proceed as in section VI or VII. The recommended angles of illumination and viewing need not be strictly followed, because the appearance of a matte surface does not change importantly with small variations in these angular conditions.

(b) WITH GLOSSY SURFACES HAVING NO REGULAR DETAILED STRUCTURE

Samples of vitreous enamel and smooth paint films are often found with glossy surfaces having no regular detailed structure. Proceed as in section VI and VII, giving particular attention to the prescribed angles of illumination and viewing. The characteristic color of the sample is obtained only when specularly reflected light is prevented from reaching the eye of the observer.

(c) WITH GLOSSY SURFACES MADE UP OF CYLINDRICAL ELEMENTS

Samples of satin-finish textiles and glossy brush-marked paint films may be considered as made up of cylindrical elements. Proceed as in section VII, 2 for cylindrical surfaces. It is not always possible to prevent light from being specularly reflected from such glossy surfaces into the eye of the observer; but by so orienting the sample in its own plane that the specular component is reduced to a minimum, the most characteristic color of the sample is usually obtained. Particular attention is being devoted to choice of angular conditions of illuminating and viewing the satin-finish and ribbed-finish standards issued by the Textile Color Card Association of the United States with a view to obtaining designations for the characteristic colors of these standards. Some textiles require more than one angle of view or illumination to bring out the characteristic color or colors; changeable silks are extreme examples of such textiles.

2. FOR METALLIC SURFACES

The characteristic color of a metallic surface is obtained from the specularly reflected light. Proceed, therefore, as in section VI or VII, but obtain, in addition, the hue name for the specularly reflected light. These two names may possibly yield a useful designation of the color of the metallic surface, but they will not correspond well with common usage which involves color terms that apply characteristically to metallic appearance (silver, brass, gold, copper, and so on).

3. FOR MATERIALS WHICH TRANSMIT BUT DO NOT SCATTER LIGHT

Samples of liquids, glass and gelatins are often encountered which transmit but do not scatter light. The transmitted light, of course, yields the characteristic color of such materials, but the color designations of the present system are not all applicable to such materials; for example, *white* is a color designation applying characteristically to materials which *do* scatter light. The Council has undertaken an extension of the present system of color designations to colors of materials viewed by transmitted light. It is planned to compare the appearance of a white surface illuminated by daylight and viewed through a prescribed thickness of the material with the appearance of the Munsell standards similarly illuminated but viewed directly. About 25 of the 319 designations will have to be changed; for example, *white* will have to be supplanted by some such term as *colorless* or *clear*. Similarly, *pinkish white* would have to be changed to some term like *light pinkish* (*color*); and *light gray*, perhaps, to *light smoky* (or to *light smoke* if the noun form is desired). In this way it is hoped that a system in fair accord with common usage will result, but the color terms (*amber*, *claret* and so on) characteristic of materials viewed by transmitted light will not be a part of the system.

4. FOR TRANSLUCENT MATERIALS

Translucent materials both transmit some light and scatter some. The characteristic color for some of such materials is obtained by reflected light, and for others by transmitted light; if in doubt, get both.

IX. SUMMARY

A method of designating the colors of powdered drugs and chemicals and crude whole drugs has been described; this method has, furthermore, been devised with the thought of its applicability to colors of opaque, nonmetallic surfaces generally. Suggestions for its extension to the color designations of transparent and translucent media have also been given. This method is dedicated to everyone who has found it difficult to make his color descriptions intelligible, in the hope that it will eventually be elaborated into a successful system of color designation for the general use of science, art, and industry.

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WASHINGTON, July 14, 1939.

HOW TO USE THE COLOR NAME CHARTS 1 TO 34 [a]

Given: Munsell notation of the sample.

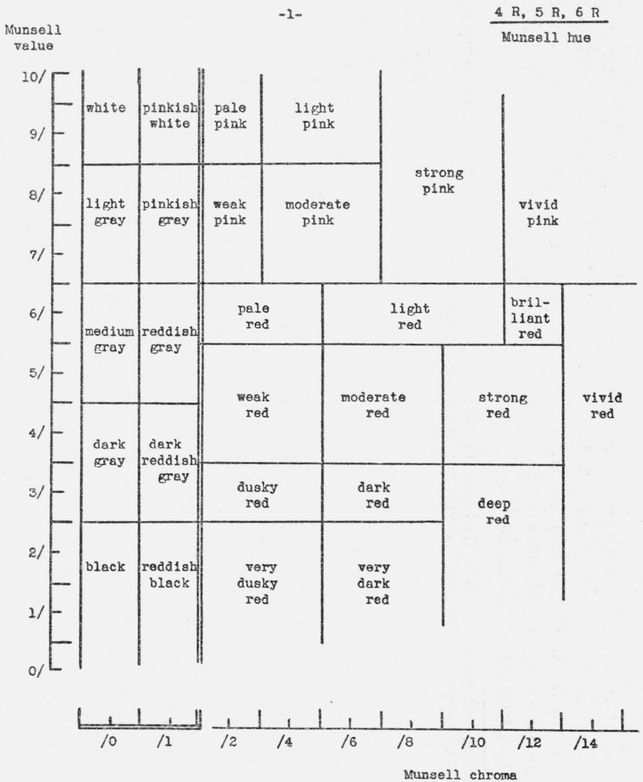
Required: The color designation.

First, turn to the particular name chart referring most closely to the Munsell hue notation of the sample (see numbers at top of chart); or, if the hue is equally close to two successive charts, use them both.

Second, find the point on the chart defined by the Munsell value and Munsell chroma of the sample; or, if two charts are to be used, plot the point on both of them. Note that the chroma scale is expanded for chromas less than 1.5; see vertical double line on each chart.

Third, read the color designation of the block within which the point falls. If the point falls on a boundary between blocks, read color designations of all blocks touching the point. If, when two charts are to be used, the second chart yields a different designation from the first, read them both.

[a] Acknowledgment is made to Miss Dorothy Nickerson, individual member of the Inter-Society Color Council, for suggesting the present simple form of these name charts.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pinkish white
pale pink
light pink
strong pink
vivid pink
light gray
pinkish gray
weak pink
moderate pink
medium gray
reddish gray
pale red
light red
bril-liant red
weak red
moderate red
strong red
vivid red
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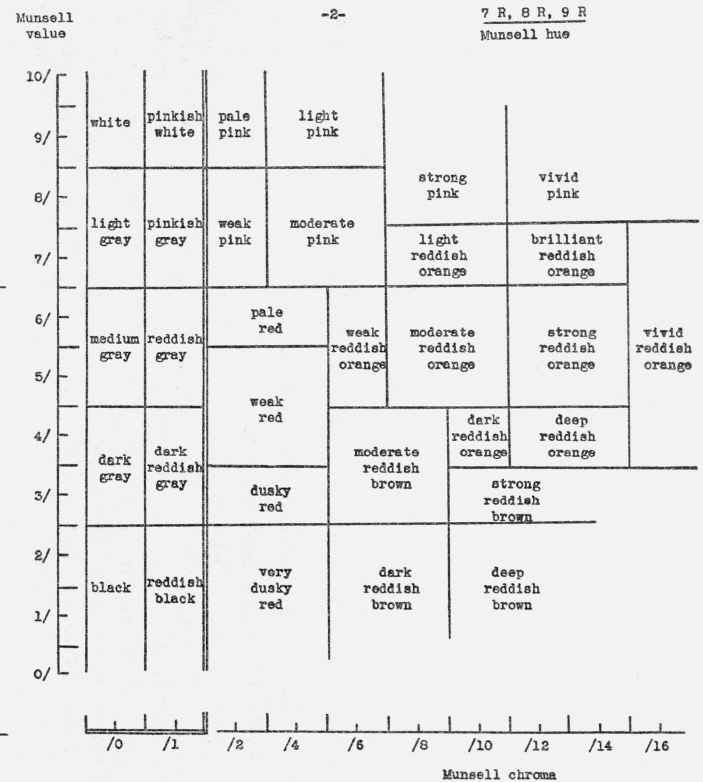
Munsell chroma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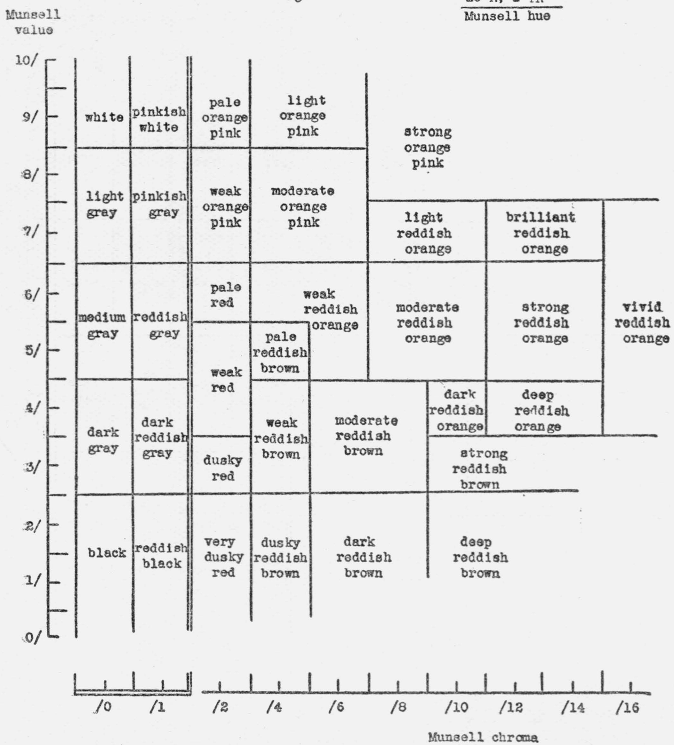
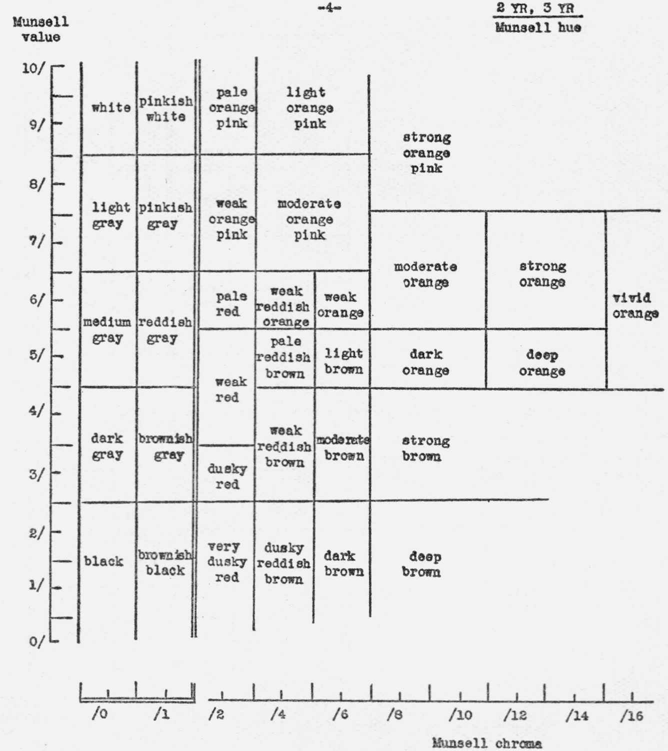
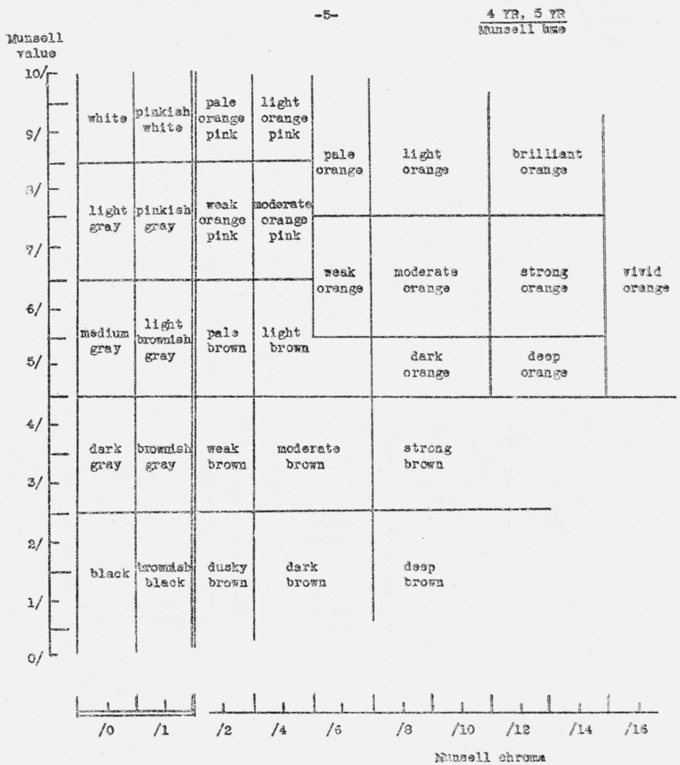
moderate reddish brown
dusky red
strong reddish brown
black
reddish black
very dusky red
dark reddish brown
deep reddish brown
/0
/1
/2
/4
/6
/8
/10
/12
/14
/16
Munsell chroma

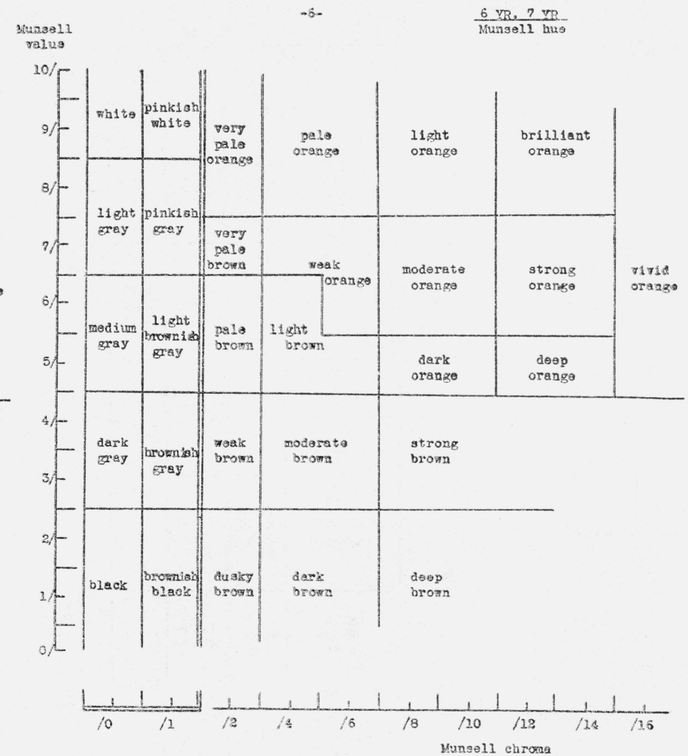
-3-

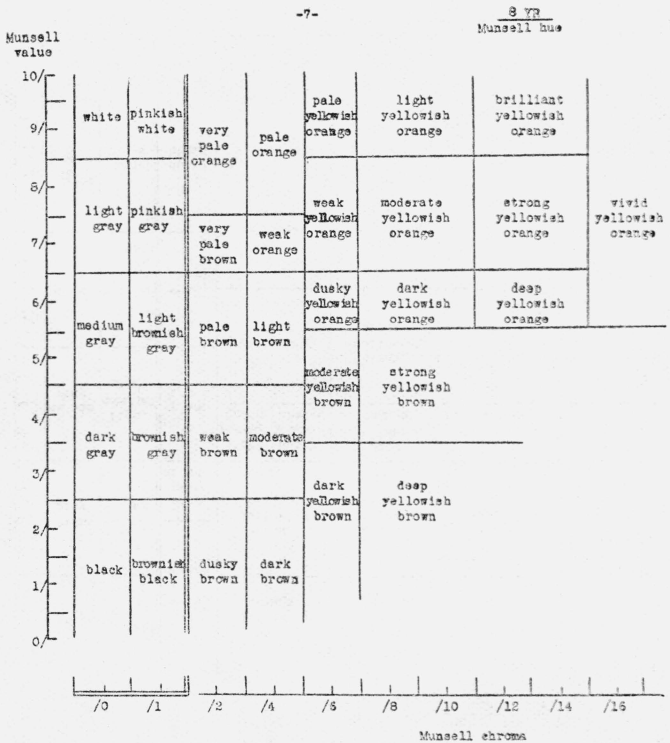

10 R, 1 YR
Munsell hue
Munsell value
10/
9/
8/
7/
6/
5/
4/
3/
2/
1/
0/
white
pinkish white
pale orange pink
light orange pink
strong orange pink
light gray
pinkish gray
weak orange pink
moderate orange pink
light reddish orange
brilliant reddish orange
medium gray
reddish gray
pale red
weak reddish orange
moderate reddish orange
strong reddish orange
vivid reddish orange
pale reddish brown
weak red
dark gray
dark reddish gray
weak reddish brown
moderate reddish brown
dark reddish orange
deep reddish orange
dusky red
strong reddish brown
black
reddish black
very dusky red
dusky reddish brown
dark reddish brown
deep reddish brown
/0
/1
/2
/4
/6
/8
/10
/12
/14
/16
Munsell chroma

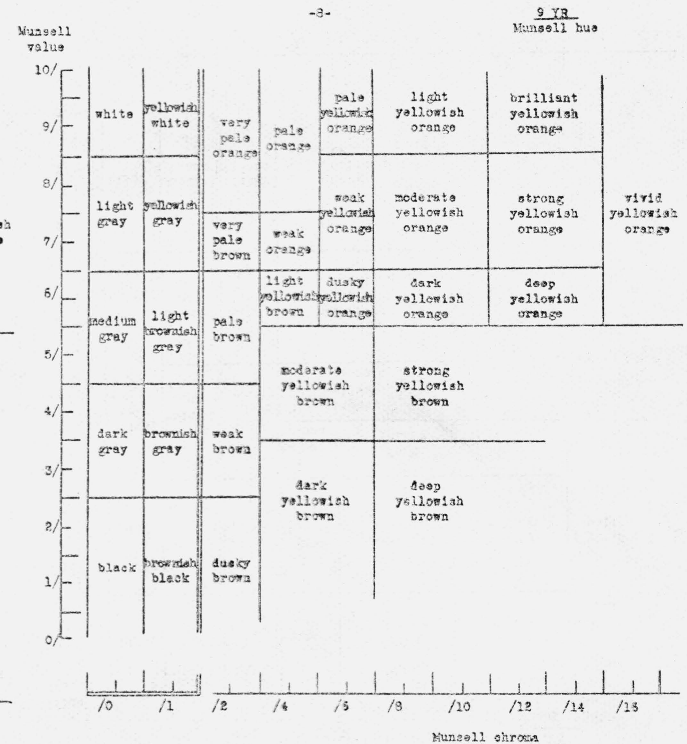
-4-


2 YR, 3 YR
Munsell hue
Munsell value
10/
9/
8/
7/
6/
5/
4/
3/
2/
1/
0/
white
pinkish white
pale orange pink
light orange pink
strong orange pink
light gray
pinkish gray
weak orange pink
moderate orange pink
moderate orange
strong orange
vivid orange
medium gray
reddish gray
pale red
weak reddish orange
weak orange
pale reddish brown
light brown
dark orange
deep orange
weak red
dark gray
brownish gray
weak reddish brown
moderate brown
strong brown
dusky red
black
brownish black
very dusky red
dusky reddish brown
dark brown
deep brown
/0
/1
/2
/4
/6
/8
/10
/12
/14
/16
Munsell chroma

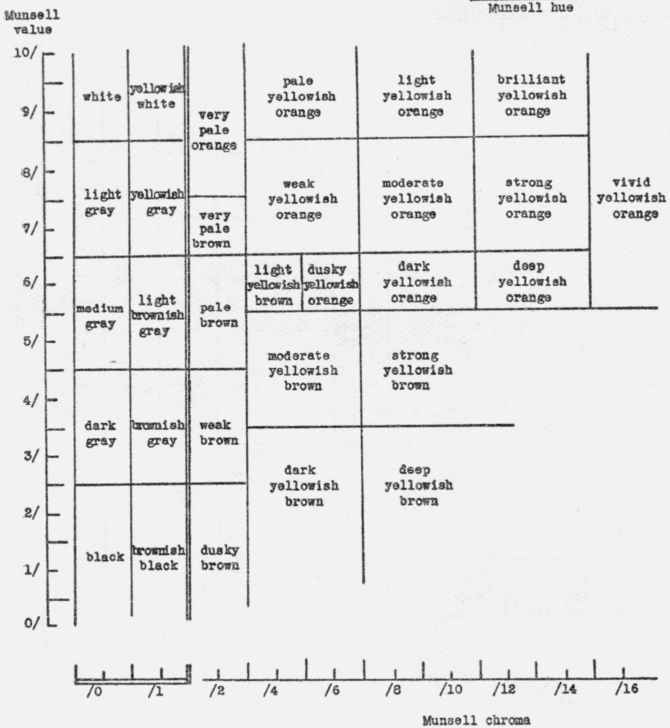

-5-
4 YR, 5 YR
Munsell hue
Munsell value
10/
9/
8/
7/
6/
5/
4/
3/
2/
1/
0/
white
pinkish white
pale orange pink
light orange pink
pale orange
light orange
brilliant orange
light gray
pinkish gray
weak orange pink
moderate orange pink
weak orange
moderate orange
strong orange
vivid orange
medium gray
light brownish gray
pale brown
light brown
dark orange
deep orange
dark gray
brownish gray
weak brown
moderate brown
strong brown
black
brownish black
dusky brown
dark brown
deep brown
/0
/1
/2
/4
/6
/8
/10
/12
/14
/16
Munsell chroma


-6-
6 YR, 7 YR
Munsell hue
Munsell value
10/
9/
8/
7/
6/
5/
4/
3/
2/
1/
0/
white
pinkish white
very pale orange
pale orange
light orange
brilliant orange
light gray
pinkish gray
very pale brown
weak orange
moderate orange
strong orange
vivid orange
medium gray
light brownish gray
pale brown
light brown
dark orange
deep orange
dark gray
brownish gray
weak brown
moderate brown
strong brown
black
brownish black
dusky brown
dark brown
deep brown
/0
/1
/2
/4
/6
/8
/10
/12
/14
/16
Munsell chroma

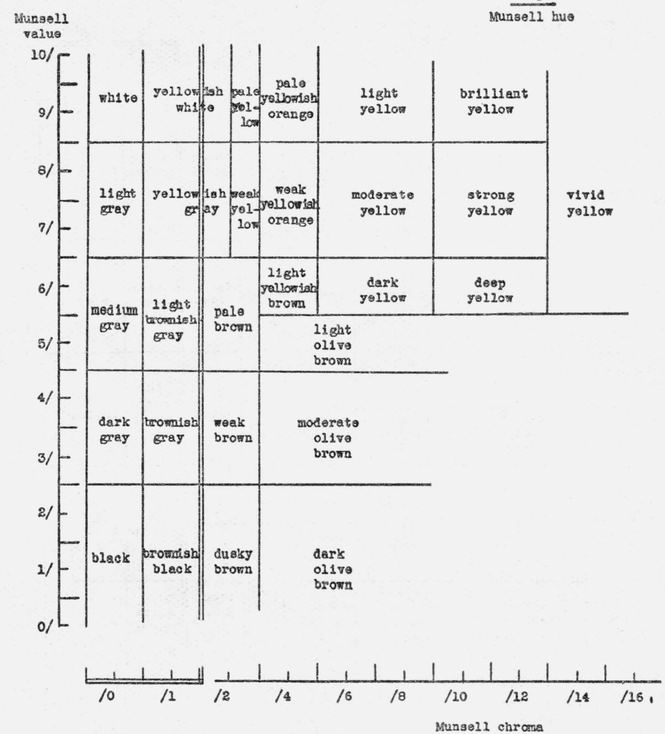

-7-
8 YR
Munsell hue
Munsell value
10/
9/
8/
7/
6/
5/
4/
3/
2/
1/
0/
white
pinkish white
very pale orange
pale orange
pale yellowish orange
light yellowish orange
brilliant yellowish orange
light gray
pinkish gray
very pale brown
weak orange
weak yellowish orange
moderate yellowish orange
strong yellowish orange
vivid yellowish orange
medium gray
light brownish gray
pale brown
light brown
dusky yellowish orange
dark yellowish orange
deep yellowish orange
moderate yellowish brown
strong yellowish brown
dark gray
brownish gray
weak brown
moderate brown
dark yellowish brown
deep yellowish brown
black
brownish black
dusky brown
dark brown
/0
/1
/2
/4
/6
/8
/10
/12
/14
/16
Munsell chroma

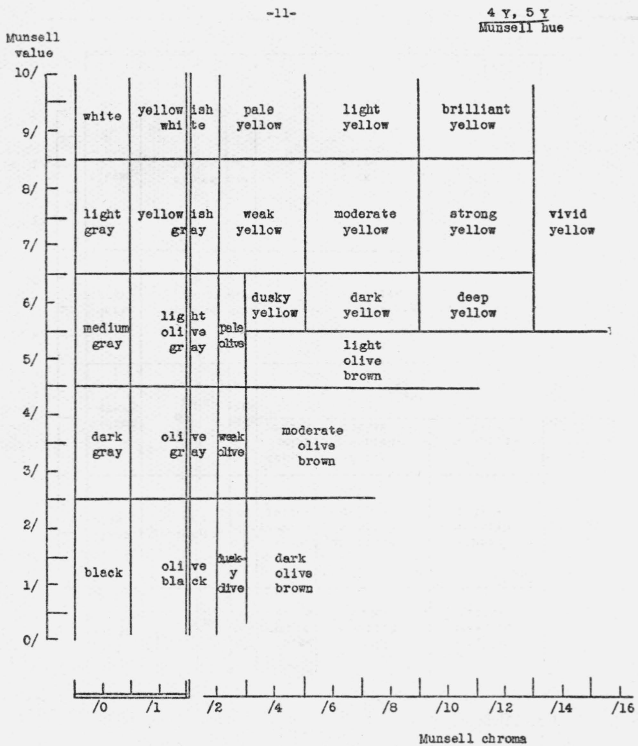

-8-
9 YR
Munsell hue
Munsell value
10/
9/
8/
7/
6/
5/
4/
3/
2/
1/
0/
white
yellowish white
very pale orange
pale orange
pale yellowish orange
light yellowish orange
brilliant yellowish orange
light gray
yellowish gray
very pale brown
weak orange
weak yellowish orange
moderate yellowish orange
strong yellowish orange
vivid yellowish orange
light yellowish brown
dusky yellowish orange
dark yellowish orange
deep yellowish orange
medium gray
light brownish gray
pale brown
moderate yellowish brown
strong yellowish brown
dark gray
brownish gray
weak brown
dark yellowish brown
deep yellowish brown
black
brownish black
dusky brown
/0
/1
/2
/4
/6
/8
/10
/12
/14
/16
Munsell chroma

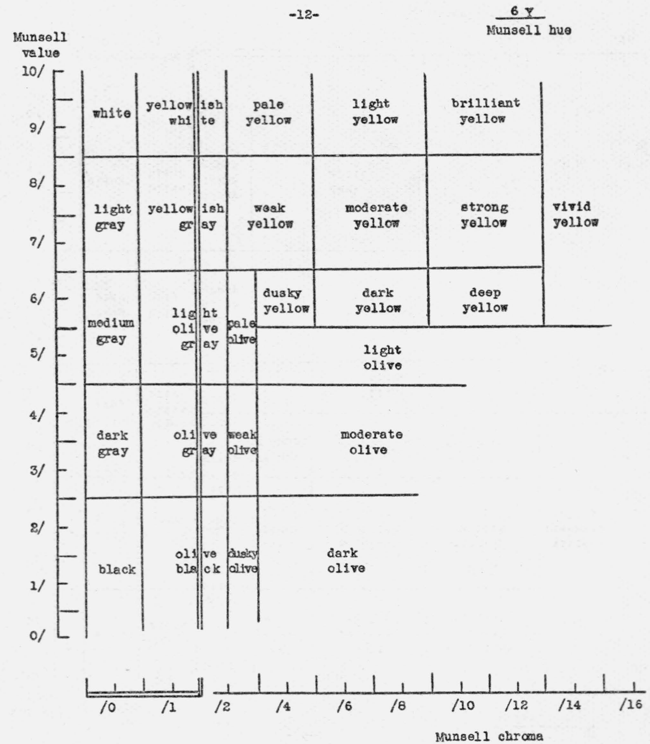
-9-

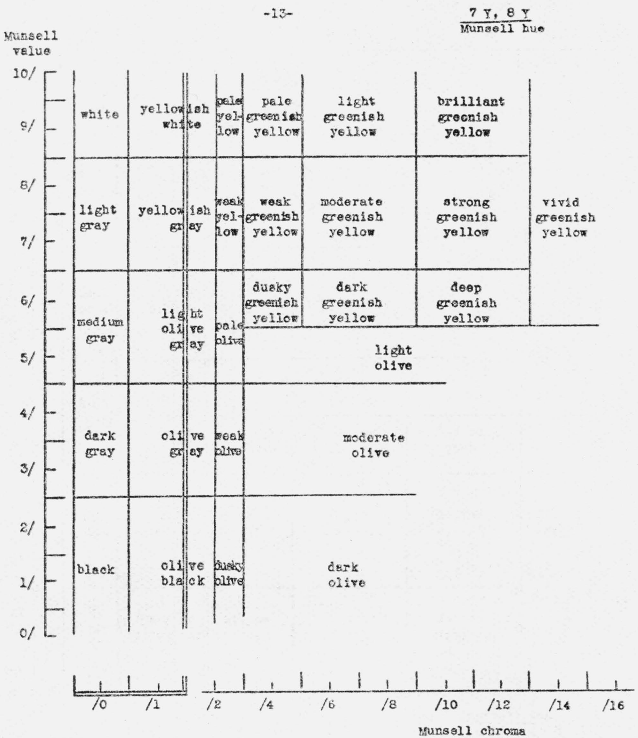

10 YR, 1 Y, 2 Y
Munsell hue
Munsell value
10/
9/
8/
7/
6/
5/
4/
3/
2/
1/
0/
white
yellowish white
very pale orange
pale yellowish orange
light yellowish orange
brilliant yellowish orange
light gray
yellowish gray
very pale brown
weak yellowish orange
moderate yellowish orange
strong yellowish orange
vivid yellowish orange
light yellowish brown
dusky yellowish orange
dark yellowish orange
deep yellowish orange
medium gray
light brownish gray
pale brown
moderate yellowish brown
strong yellowish brown
dark gray
brownish gray
weak brown
dark yellowish brown
deep yellowish brown
black
brownish black
dusky brown
/0
/1
/2
/4
/6
/8
/10
/12
/14
/16
Munsell chroma

-10-

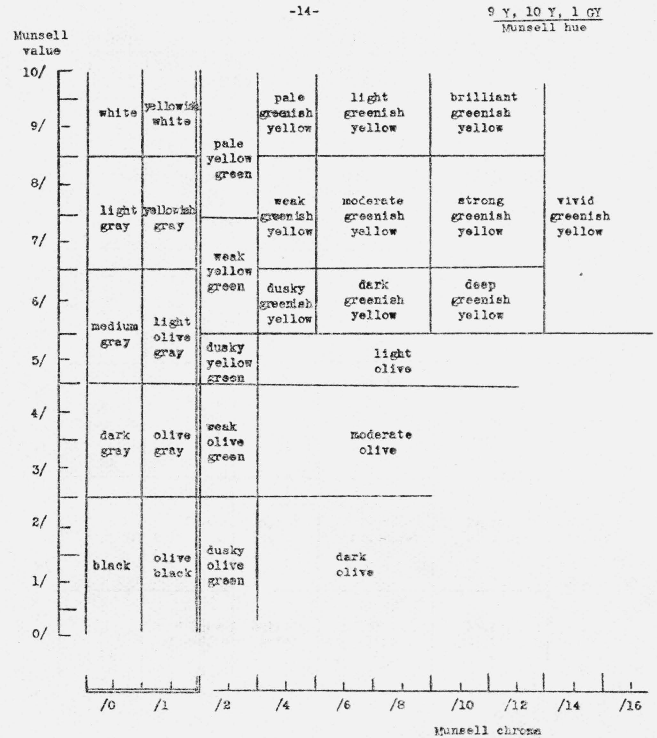

3 Y
Munsell hue
Munsell value
10/
9/
8/
7/
6/
5/
4/
3/
2/
1/
0/
white
yellowish white
pale yellow
pale yellowish orange
light yellow
brilliant yellow
light gray
yellowish gray
weak yellow
weak yellowish orange
moderate yellow
strong yellow
vivid yellow
light yellowish brown
dark yellow
deep yellow
medium gray
light brownish gray
pale brown
light olive brown
dark gray
brownish gray
weak brown
moderate olive brown
black
brownish black
dusky brown
dark olive brown
/0
/1
/2
/4
/6
/8
/10
/12
/14
/16
Munsell chroma


-11-
4 Y, 5 Y
Munsell hue
Munsell value
10/
9/
8/
7/
6/
5/
4/
3/
2/
1/
0/
white
yellowish white
pale yellow
light yellow
brilliant yellow
light gray
yellowish gray
weak yellow
moderate yellow
strong yellow
vivid yellow
dusky yellow
dark yellow
deep yellow
medium gray
light olive gray
pale olive
light olive brown
dark gray
olive gray
weak olive
moderate olive brown
black
olive black
dusky olive
dark olive brown
/0
/1
/2
/4
/6
/8
/10
/12
/14
/16
Munsell chroma


-12-
6 Y
Munsell hue
Munsell value
10/
9/
8/
7/
6/
5/
4/
3/
2/
1/
0/
white
yellowish white
pale yellow
light yellow
brilliant yellow
light gray
yellowish gray
weak yellow
moderate yellow
strong yellow
vivid yellow
dusky yellow
dark yellow
deep yellow
medium gray
light olive gray
pale olive
light olive
dark gray
olive gray
weak olive
moderate olive
black
olive black
dusky olive
dark olive
/0
/1
/2
/4
/6
/8
/10
/12
/14
/16
Munsell chroma



-13-
7 Y, 8 Y
Munsell hue
Munsell value
10/ 9/ 8/ 7/ 6/ 5/ 4/ 3/ 2/ 1/ 0/
white
yellowish white
pale yel-low
pale greenish yellow
light greenish yellow
brilliant greenish yellow
light gray
yellowish gray
weak yel-low
weak greenish yellow
moderate greenish yellow
strong greenish yellow
vivid greenish yellow
dusky greenish yellow
dark greenish yellow
deep greenish yellow
medium gray
light olive gray
pale olive
light olive
dark gray
olive gray
weak olive
moderate olive
black
olive black
dusky olive
dark olive
/0 /1 /2 /4 /6 /8 /10 /12 /14 /16
Munsell chroma

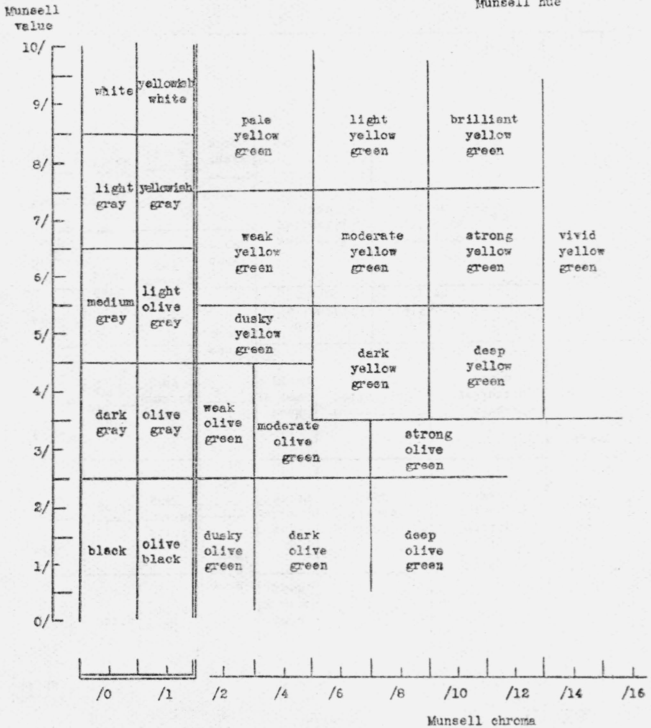


-14-
9 Y, 10 Y, 1 GY
Munsell hue
Munsell value
10/ 9/ 8/ 7/ 6/ 5/ 4/ 3/ 2/ 1/ 0/
white
yellowish white
pale yellow green
pale greenish yellow
light greenish yellow
brilliant greenish yellow
light gray
yellowish gray
weak greenish yellow
moderate greenish yellow
strong greenish yellow
vivid greenish yellow
weak yellow green
dusky greenish yellow
dark greenish yellow
deep greenish yellow
medium gray
light olive gray
dusky yellow green
light olive
dark gray
olive gray
weak olive green
moderate olive
black
olive black
dusky olive green
dark olive
/0 /1 /2 /4 /6 /8 /10 /12 /14 /16
Munsell chroma

168819—39——4

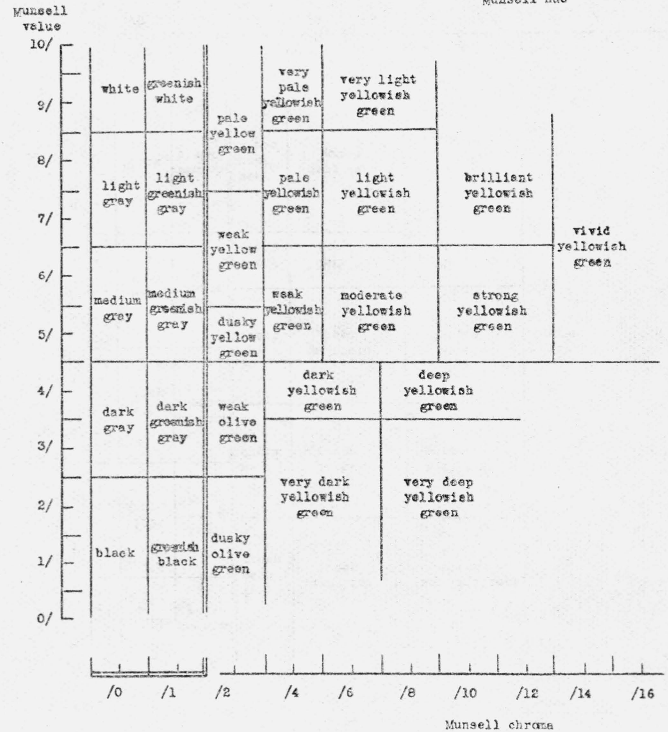
-15-

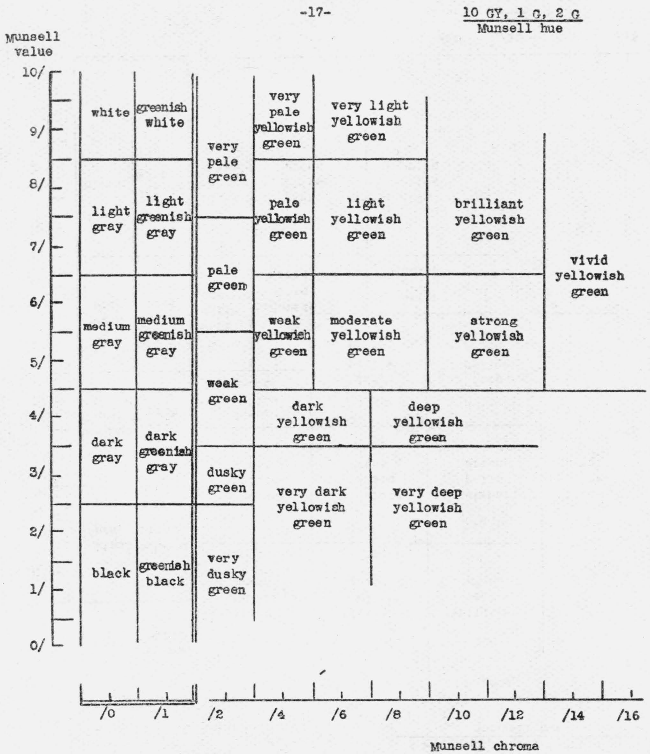
2 GY, 3 GY, 4 GY, 5 GY, 6 GY
Munsell hue

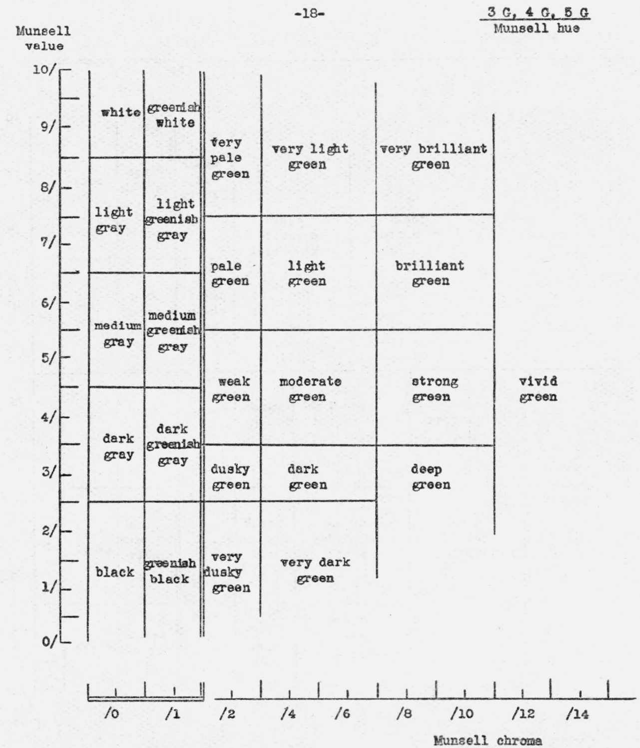


-16-

7 GY, 8 GY, 9 GY
Munsell hue

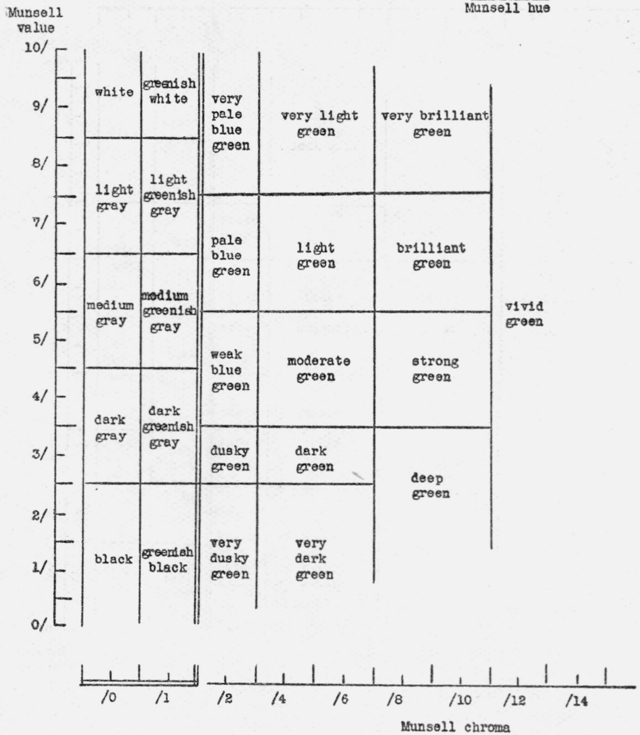



-17-
10 GY, 1 G, 2 G
Munsell hue
Munsell value
10/
9/
8/
7/
6/
5/
4/
3/
2/
1/
0/
white
greenish white
light gray
light greenish gray
medium gray
medium greenish gray
dark gray
dark greenish gray
black
greenish black
very pale green
pale green
weak green
dusky green
very dusky green
very pale yellowish green
very light yellowish green
pale yellowish green
light yellowish green
brilliant yellowish green
weak yellowish green
moderate yellowish green
strong yellowish green
vivid yellowish green
dark yellowish green
deep yellowish green
very dark yellowish green
very deep yellowish green
/0
/1
/2
/4
/6
/8
/10
/12
/14
/16
Munsell chroma


-18-
3 G, 4 G, 5 G
Munsell hue
Munsell value
10/
9/
8/
7/
6/
5/
4/
3/
2/
1/
0/
white
greenish white
light gray
light greenish gray
medium gray
medium greenish gray
dark gray
dark greenish gray
black
greenish black
very pale green
very light green
very brilliant green
pale green
light green
brilliant green
weak green
moderate green
strong green
vivid green
dusky green
dark green
deep green
very dusky green
very dark green
/0
/1
/2
/4
/6
/8
/10
/12
/14
Munsell chroma

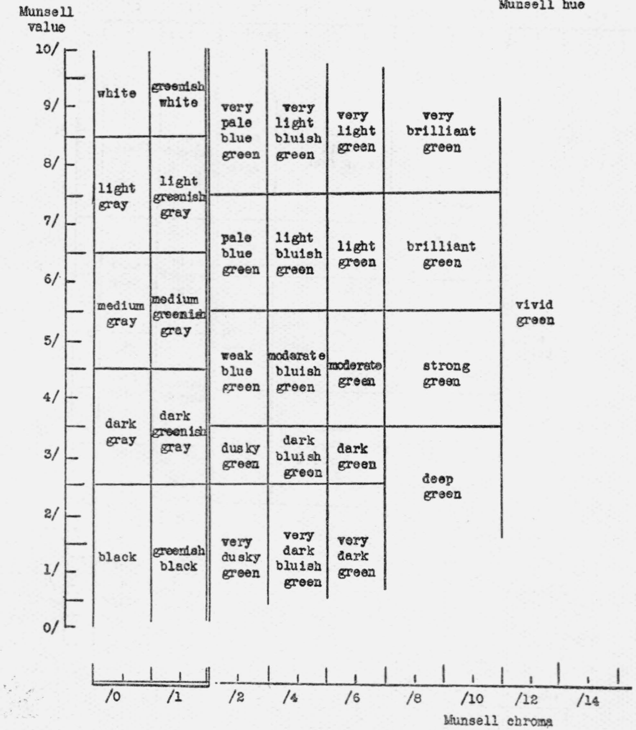
-19-

6 G, 7 G
Munsell hue

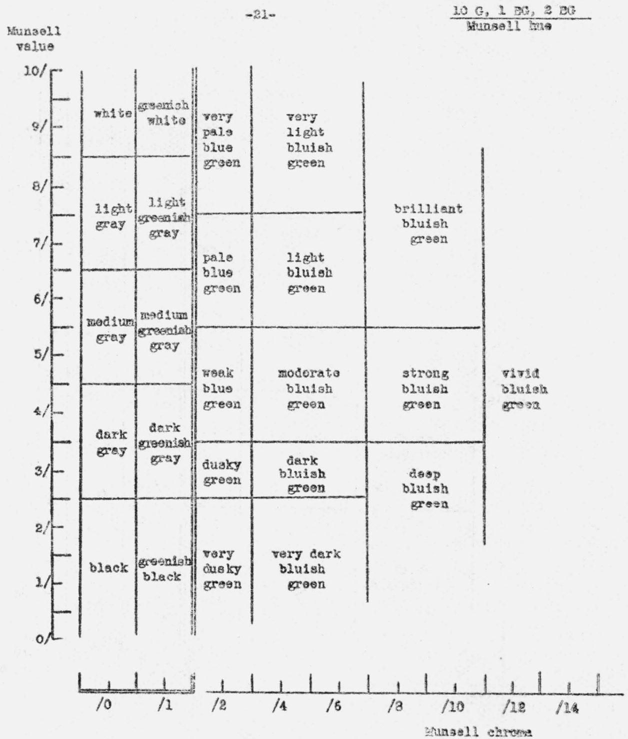


-20-

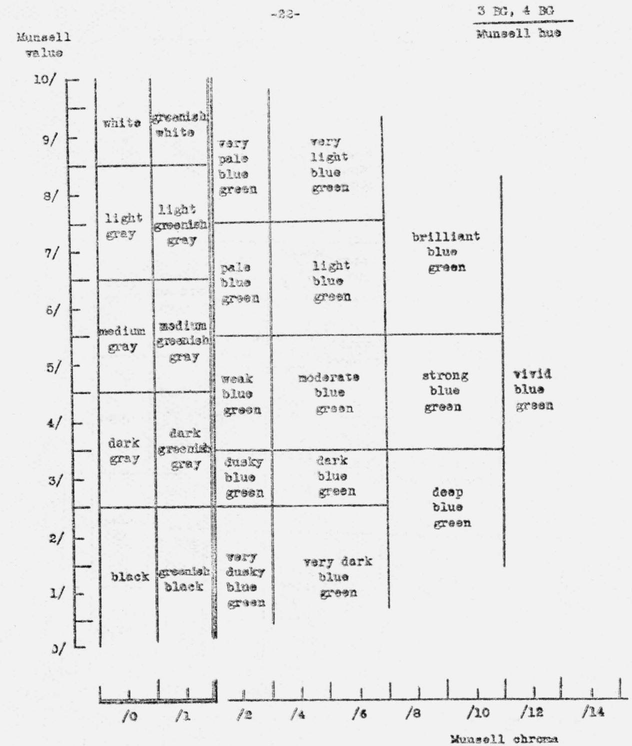
8 G, 9 G
Munsell hue



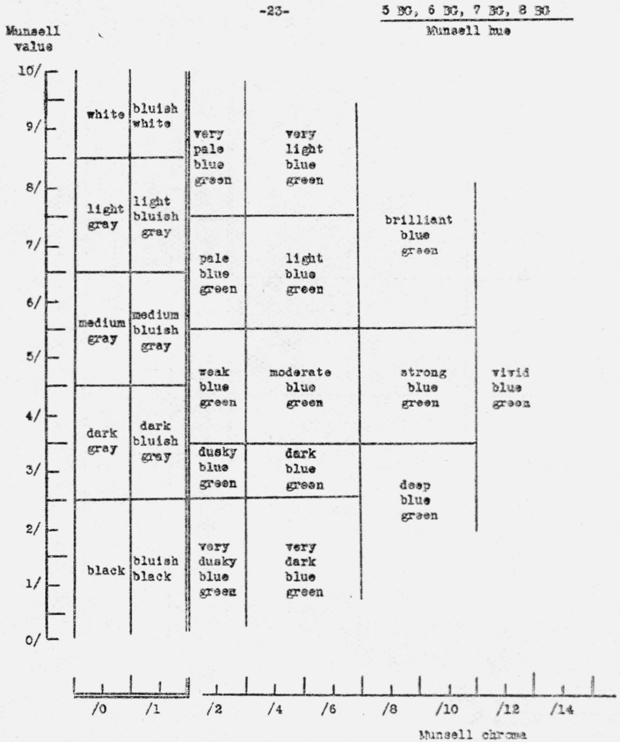
-21-


10 G, 1 BG, 2 BG
Munsell hue
Munsell value
10/
9/
8/
7/
6/
5/
4/
3/
2/
1/
0/
white
greenish white
very pale blue green
very light bluish green
light gray
light greenish gray
brilliant bluish green
pale blue green
light bluish green
medium gray
medium greenish gray
weak blue green
moderate bluish green
strong bluish green
vivid bluish green
dark gray
dark greenish gray
dusky green
dark bluish green
deep bluish green
black
greenish black
very dusky green
very dark bluish green
/0
/1
/2
/4
/6
/8
/10
/12
/14
Munsell chroma

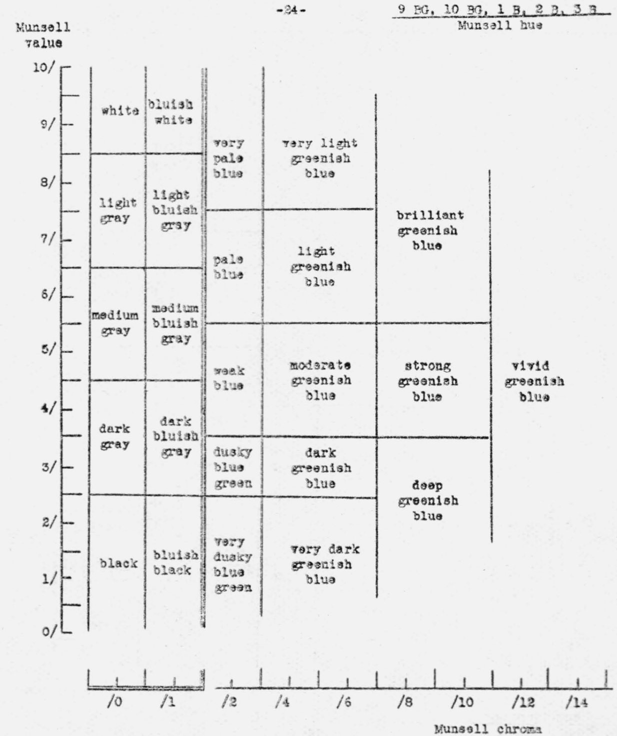
-22-


3 BG, 4 BG
Munsell hue
Munsell value
10/
9/
8/
7/
6/
5/
4/
3/
2/
1/
0/
white
greenish white
very pale blue green
very light blue green
light gray
light greenish gray
brilliant blue green
pale blue green
light blue green
medium gray
medium greenish gray
weak blue green
moderate blue green
strong blue green
vivid blue green
dark gray
dark greenish gray
dusky blue green
dark blue green
deep blue green
black
greenish black
very dusky blue green
very dark blue green
/0
/1
/2
/4
/6
/8
/10
/12
/14
Munsell chroma

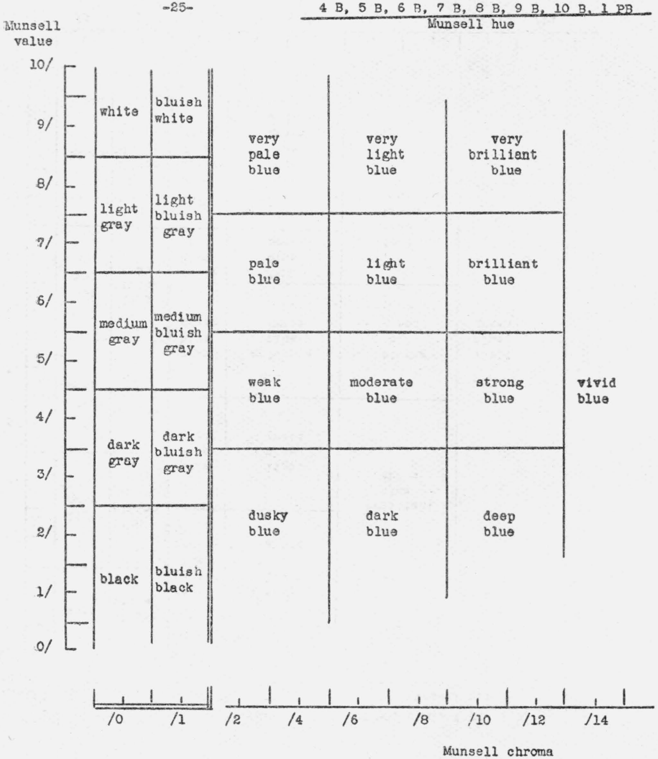
-23-


5 BG, 6 BG, 7 BG, 8 BG
Munsell hue
Munsell value
10/
9/
8/
7/
6/
5/
4/
3/
2/
1/
0/
white
bluish white
light gray
light bluish gray
medium gray
medium bluish gray
dark gray
dark bluish gray
black
bluish black
very pale blue green
very light blue green
pale blue green
light blue green
brilliant blue green
weak blue green
moderate blue green
strong blue green
vivid blue green
dusky blue green
dark blue green
deep blue green
very dusky blue green
very dark blue green
/0
/1
/2
/4
/6
/8
/10
/12
/14
Munsell chroma

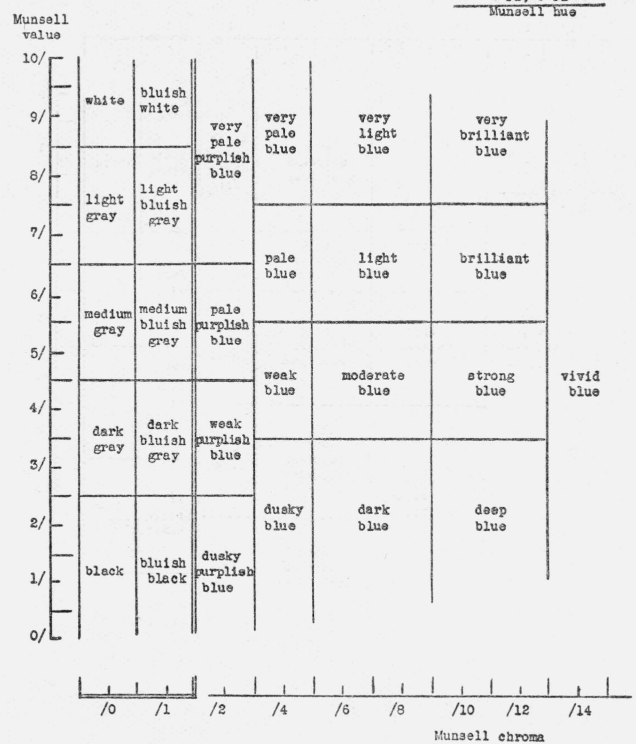
-24-


9 BG, 10 BG, 1 B, 2 B, 3 B
Munsell hue
Munsell value
10/
9/
8/
7/
6/
5/
4/
3/
2/
1/
0/
white
bluish white
light gray
light bluish gray
medium gray
medium bluish gray
dark gray
dark bluish gray
black
bluish black
very pale blue
very light greenish blue
pale blue
light greenish blue
brilliant greenish blue
weak blue
moderate greenish blue
strong greenish blue
vivid greenish blue
dusky blue green
dark greenish blue
deep greenish blue
very dusky blue green
very dark greenish blue
/0
/1
/2
/4
/6
/8
/10
/12
/14
Munsell chroma

-25-

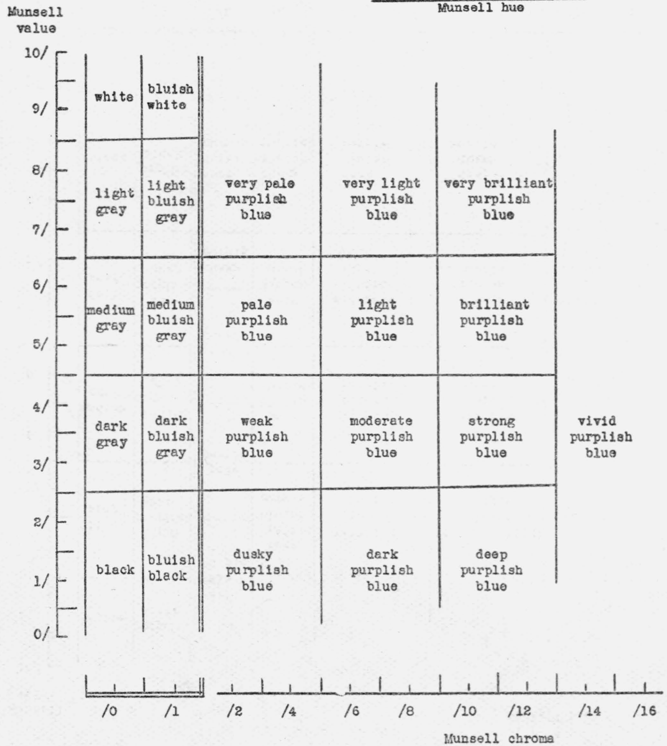

4 B, 5 B, 6 B, 7 B, 8 B, 9 B, 10 B, 1 PB
Munsell hue
Munsell value
10/
9/
8/
7/
6/
5/
4/
3/
2/
1/
0/
white
bluish white
light gray
light bluish gray
medium gray
medium bluish gray
dark gray
dark bluish gray
black
bluish black
very pale blue
very light blue
very brilliant blue
pale blue
light blue
brilliant blue
weak blue
moderate blue
strong blue
vivid blue
dusky blue
dark blue
deep blue
/0
/1
/2
/4
/6
/8
/10
/12
/14
Munsell chroma

-26-


2 PB, 3 PB
Munsell hue
Munsell value
10/
9/
8/
7/
6/
5/
4/
3/
2/
1/
0/
white
bluish white
light gray
light bluish gray
medium gray
medium bluish gray
dark gray
dark bluish gray
black
bluish black
very pale purplish blue
pale purplish blue
weak purplish blue
dusky purplish blue
very pale blue
very light blue
very brilliant blue
pale blue
light blue
brilliant blue
weak blue
moderate blue
strong blue
vivid blue
dusky blue
dark blue
deep blue
/0
/1
/2
/4
/6
/8
/10
/12
/14
Munsell chroma

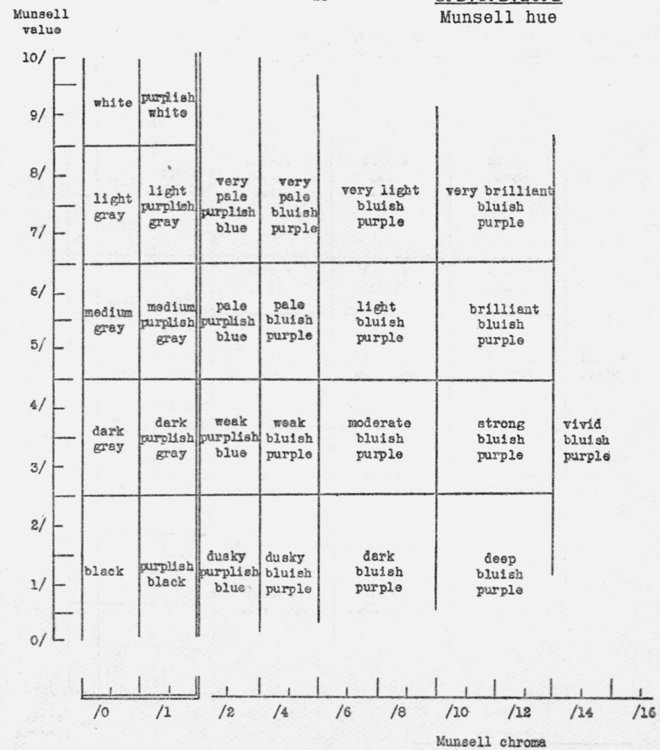
-27-

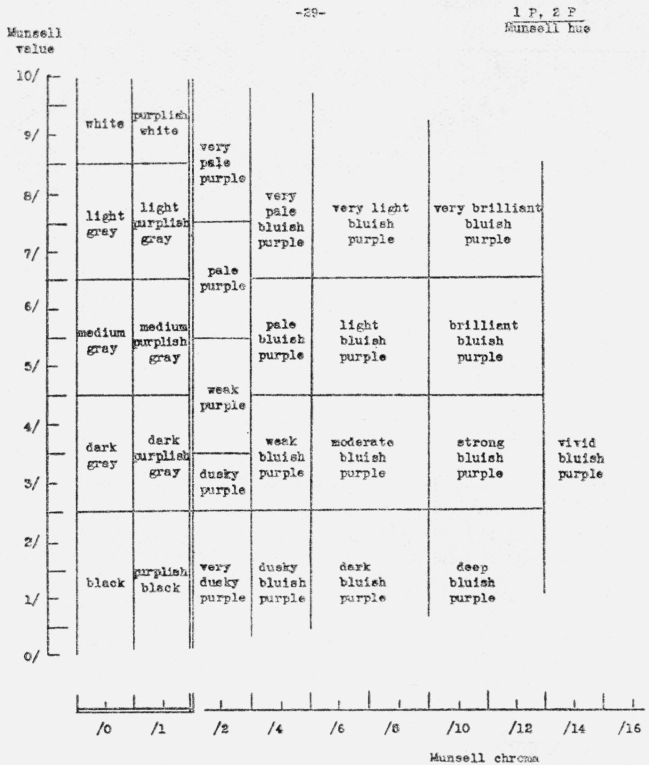
4 PB, 5 PB, 6 PB, 7 PB
Munsell hue

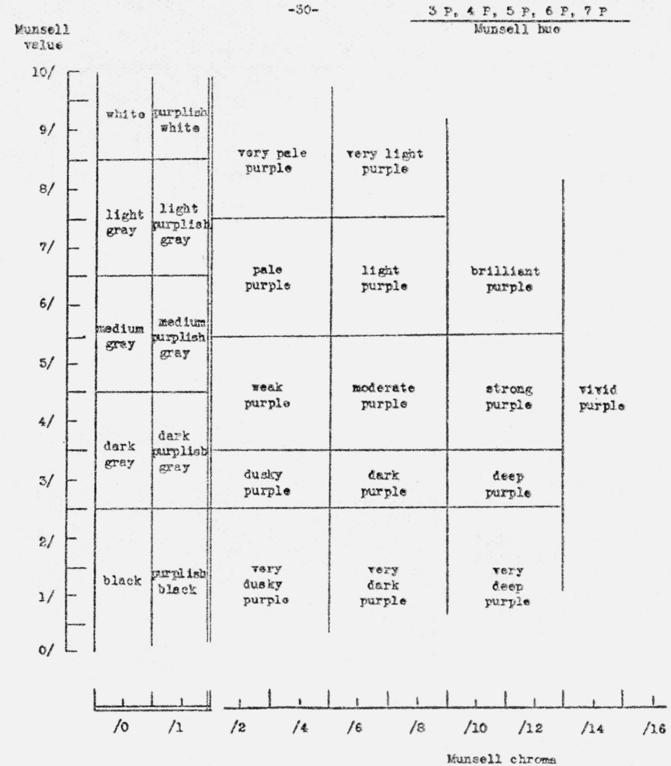


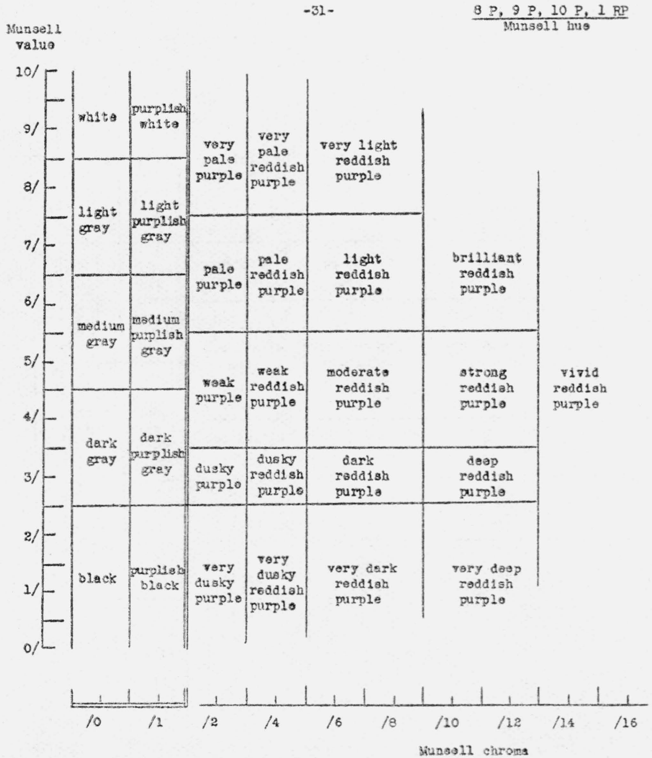
-28 -

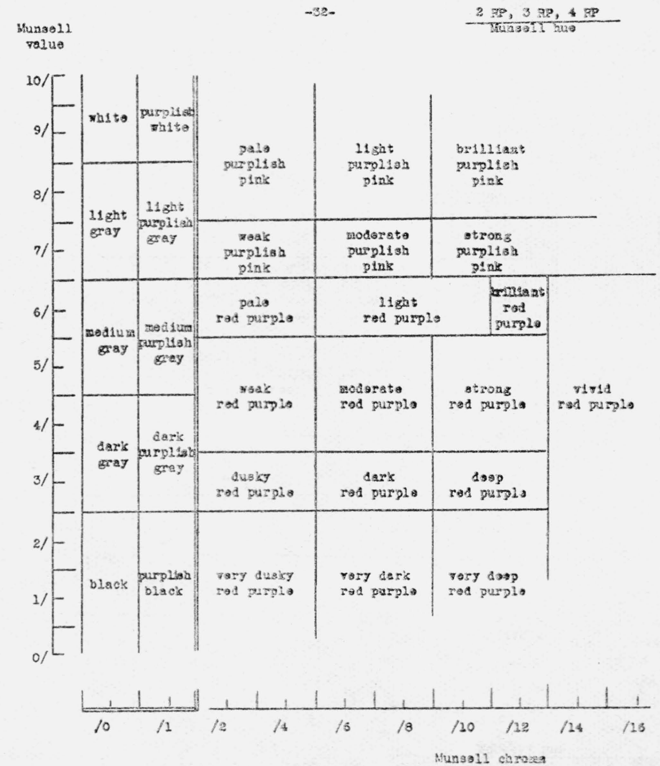
8PB.9PB.10PB
Munsell hue

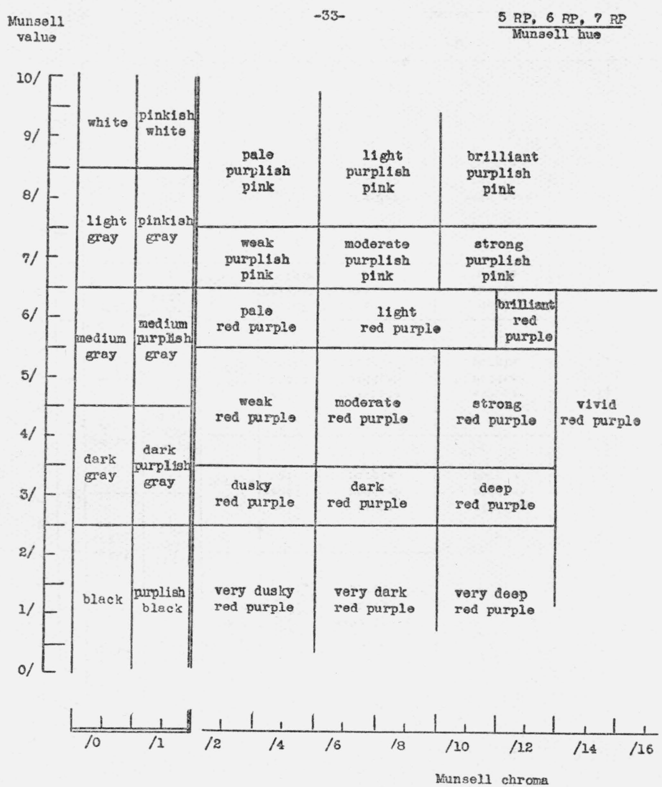


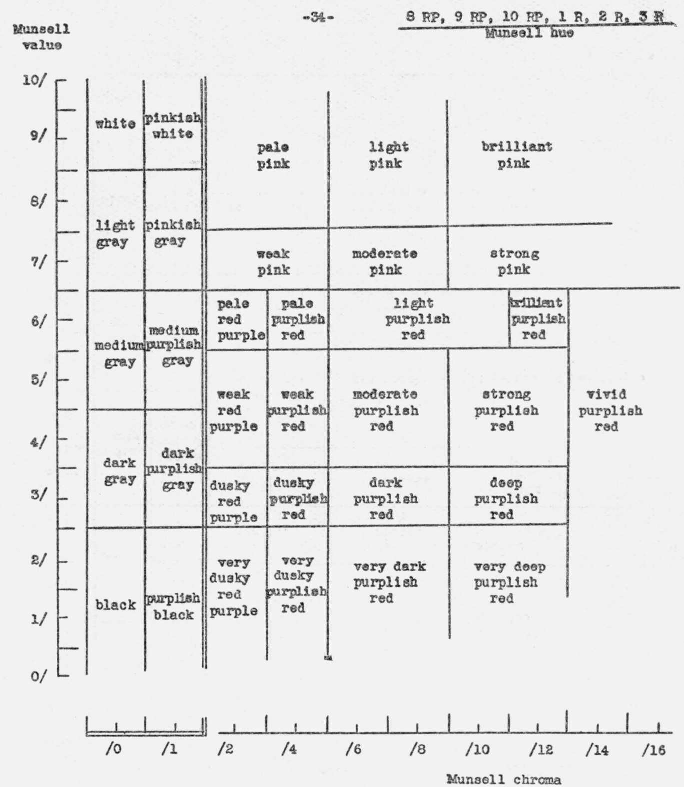

-29-
1 P, 2 P
Munsell hue
Munsell value
10/
9/
8/
7/
6/
5/
4/
3/
2/
1/
0/
white
purplish white
light gray
light purplish gray
medium gray
medium purplish gray
dark gray
dark purplish gray
black
purplish black
very pale purple
pale purple
weak purple
dusky purple
very dusky purple
very pale bluish purple
pale bluish purple
weak bluish purple
dusky bluish purple
very light bluish purple
light bluish purple
moderate bluish purple
dark bluish purple
very brilliant bluish purple
brilliant bluish purple
strong bluish purple
deep bluish purple
vivid bluish purple
/0
/1
/2
/4
/6
/8
/10
/12
/14
/16
Munsell chroma


-30-
3 P, 4 P, 5 P, 6 P, 7 P
Munsell hue
Munsell value
10/
9/
8/
7/
6/
5/
4/
3/
2/
1/
0/
white
purplish white
light gray
light purplish gray
medium gray
medium purplish gray
dark gray
dark purplish gray
black
purplish black
very pale purple
very light purple
pale purple
light purple
brilliant purple
weak purple
moderate purple
strong purple
vivid purple
dusky purple
dark purple
deep purple
very dusky purple
very dark purple
very deep purple
/0
/1
/2
/4
/6
/8
/10
/12
/14
/16
Munsell chroma

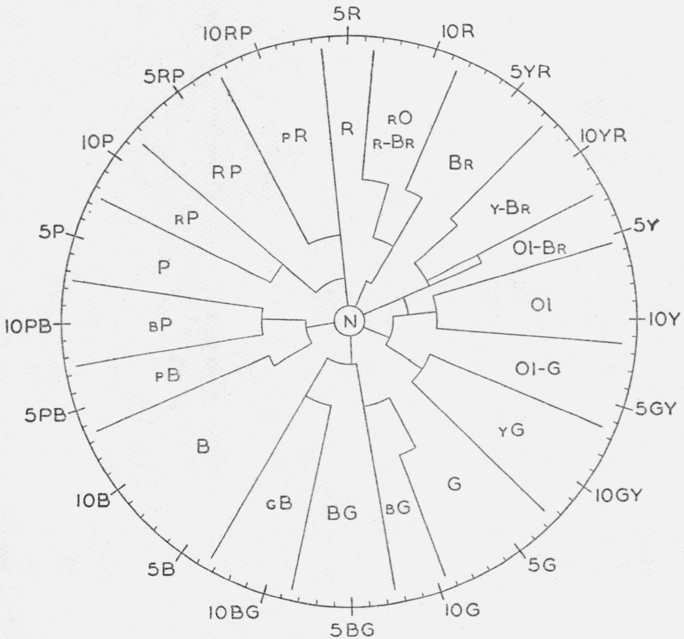

-31-
8 P, 9 P, 10 P, 1 RP
Munsell hue
Munsell value
10/
9/
8/
7/
6/
5/
4/
3/
2/
1/
0/
white
purplish white
very pale purple
very pale reddish purple
very light reddish purple
light gray
light purplish gray
pale purple
pale reddish purple
light reddish purple
brilliant reddish purple
medium gray
medium purplish gray
weak purple
weak reddish purple
moderate reddish purple
strong reddish purple
vivid reddish purple
dark gray
dark purplish gray
dusky purple
dusky reddish purple
dark reddish purple
deep reddish purple
black
purplish black
very dusky purple
very dusky reddish purple
very dark reddish purple
very deep reddish purple
/0
/1
/2
/4
/6
/8
/10
/12
/14
/16
Munsell chroma


-32-
2 RP, 3 RP, 4 RP
Munsell hue
Munsell value
10/
9/
8/
7/
6/
5/
4/
3/
2/
1/
0/
white
purplish white
pale purplish pink
light purplish pink
brilliant purplish pink
light gray
light purplish gray
weak purplish pink
moderate purplish pink
strong purplish pink
pale red purple
light red purple
brilliant red purple
medium gray
medium purplish gray
weak red purple
moderate red purple
strong red purple
vivid red purple
dark gray
dark purplish gray
dusky red purple
dark red purple
deep red purple
black
purplish black
very dusky red purple
very dark red purple
very deep red purple
/0
/1
/2
/4
/6
/8
/10
/12
/14
/16
Munsell chroma

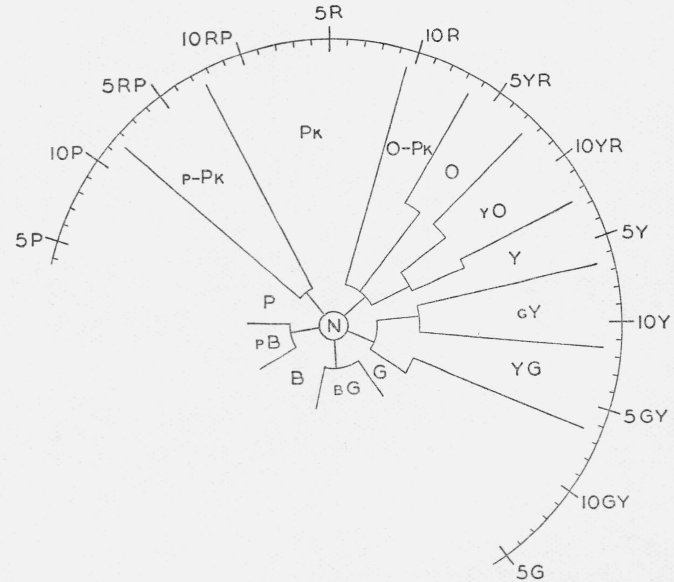

-33-
5 RP, 6 RP, 7 RP
Munsell hue
Munsell value
10/
9/
8/
7/
6/
5/
4/
3/
2/
1/
0/
white
pinkish white
light gray
pinkish gray
medium gray
medium purplish gray
dark gray
dark purplish gray
black
purplish black
pale purplish pink
light purplish pink
brilliant purplish pink
weak purplish pink
moderate purplish pink
strong purplish pink
pale red purple
light red purple
brilliant red purple
weak red purple
moderate red purple
strong red purple
vivid red purple
dusky red purple
dark red purple
deep red purple
very dusky red purple
very dark red purple
very deep red purple
/0
/1
/2
/4
/6
/8
/10
/12
/14
/16
Munsell chroma


-34-
8 RP, 9 RP, 10 RP, 1 R, 2 R, 3 R
Munsell hue
Munsell value
10/
9/
8/
7/
6/
5/
4/
3/
2/
1/
0/
white
pinkish white
light gray
pinkish gray
medium gray
medium purplish gray
dark gray
dark purplish gray
black
purplish black
pale pink
light pink
brilliant pink
weak pink
moderate pink
strong pink
pale red purple
pale purplish red
light purplish red
brilliant purplish red
weak red purple
weak purplish red
moderate purplish red
strong purplish red
vivid purplish red
dusky red purple
dusky purplish red
dark purplish red
deep purplish red
very dusky red purple
very dusky purplish red
very dark purplish red
very deep purplish red
/0
/1
/2
/4
/6
/8
/10
/12
/14
/16
Munsell chroma

-35-


5R
10R
5YR
10YR
5Y
10Y
5GY
10GY
5G
10G
5BG
10BG
5B
10B
5PB
10PB
5P
10P
5RP
10RP
N
R
rO
r-Br
Br
y-Br
Ol-Br
Ol
Ol-G
yG
G
bG
BG
gB
B
pB
bP
P
rP
RP
pR

-36-


5R
10R
5YR
10YR
5Y
10Y
5GY
10GY
5G
5P
10P
5RP
10RP
N
Pk
O-Pk
O
yO
Y
gY
YG
G
bG
B
pB
P
p-Pk