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COLOR DESIGNATIONS FOR LIGHTS

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ABSTRACT

An extension of the ISCC-NBS (Inter-Society Color Council-National Bureau of Standards) system of color names for the description of the colors of drugs and medicines, has been made for describing the colors of lights. The color names consist of hue names, such as red, pink, yellowish green, or purple, without further modifiers, since they are intended to differentiate lights chiefly according to hue. The hue names are among those used in the ISCC-NBS system and carry the same meaning. The chromaticity ranges identified by each of these hue names are defined by areas on the ICI chromaticity diagram. Comparisons are made between the centers of the proposed hue-name ranges and similar values by other authorities, and with the standard colors recognized in various specifications for marine, railway, aviation, and traffic signal colors.

CONTENTS

I. INTRODUCTION

The development of the ISCC-NBS (Inter-Society Color Council-National Bureau of Standards) system of color names for the description of the colors of drugs and medicines [1, 2] [2] suggested to the author the possibility of adapting the same system of names to the description of colors of other than drugs and medicines. In this paper the possibility of applying this system to the colors of self-luminous sources is explored in the hope of offering a basis for the resolution of the conflicting terminology now used for flares, fluorescent and phosphorescent materials, and signal lights. This system could not displace precise specifications in terms of either chromaticity coordinates or standard filters such as are used for railway signal lights [3], but it is expected to provide color names recognized by the general public as appropriate. The spacing of the color-name boundaries is based on that of the ISCC-NBS system [1]; but the shape of

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the boundaries is based on the extensive data collected by the OSA subcommittee [4] on the spacing of the Munsell colors. Both spacing and shape have been modified in accordance with observations by two observers.

II. GENERAL PLAN

The suggested system of color names is composed of 19 hue names and three names indicating reddish hues of reduced saturation (orange pink, pink, and purplish pink). There are, however, no modifiers used to designate whether a light is bright or dim or strong, analogous to what is done for surface colors, because it is intended that the names shall apply to a fairly wide range of intensities and retinal adaptive conditions [5]. The changing of the intensity of the source in a source-filter combination will in some instances change the hue (the Bezold-Brücke [6] phenomenon) of the perceived color sufficiently to require the application of another color name, whereas in others the modified hue will remain in the same color-name segment. The boundaries adopted are intended to define chromaticities to which the names apply under the most common conditions of use.

The designations included in this system are 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, purplish red, purplish pink, pink, and orange pink. All of these are names used in the ISCC–NBS system for light colors of surfaces. The hue names (such as brown or olive) used for dark colors of surfaces are not appropriate for self-luminous sources.

The ISCC–NBS hue-name boundaries are specified in terms of the standards in the Munsell Book of Color [7], and it was therefore decided to base the hue-name boundaries of the proposed system on a study of the high-chroma Munsell samples in an attempt to make each of the proposed hue-name ranges include the same range of hue as for the surface color names. It was soon found that even the strongest Munsell samples would not extend these boundaries far into the region on the ICI diagram representing the lights to be designated. Recourse was then had to the constant-hue loci given in the final report [4] of the OSA subcommittee on the spacing of the Munsell colors based on the data contained in the recent paper by Kelly, Gibson, and Nickerson [8]. These curves are based on the Munsell standards and are extrapolated out to the spectrum locus by smooth curves. The minimum and maximum saturation boundaries of the pinks were also determined with the aid of the Munsell standards.

III. EXPERIMENTAL CHECKS

The locations of the several hue-name boundaries on the ICI chromaticity diagram were checked by two independent series of observations. The first check consisted in observing a series of light filters available at the National Bureau of Standards in connection with the specification of various signal colors. The colorimetric specifications of these filters were known in combination with a source at 2,842° K. From these specifications the designation was found for each source-filter combination, and the observer judged whether the designation was appropriate to the light transmitted by the filter illuminated by a source at approximately this color temperature. Boundaries in the blue and purple region, some in the red, and several elsewhere were adjusted to accord with these judgments. Light filters were not, however, available for all portions of the diagram, and certain of the boundaries remained unchecked by this method.

The colorimetric specifications of the Lovibond glasses [9] for a source of color-temperature 2,842° K are being computed at the Bureau, and the specifications of sufficient combinations of these glass filters have been completed to yield a preliminary network indicating approximately the chromaticities of these glasses and their combinations on the ICI chromaticity diagram. From this network it is now possible to determine with sufficient accuracy which glass or set of glasses will, in combination with a source at 2,842° K, give a colored light whose colorimetric specification will plot at a specified point on the hue-name diagram. In the second check, a number of these combinations were viewed in a darkened room and judgments were made by two observers (KLK, DBJ [3]) as to which of the hue names listed above was the most appropriate. In this manner it was possible to check most of the boundaries throughout their length and to obtain sufficient points on the other boundaries so that they could be drawn with fair accuracy. Through the use of the Lovibond glasses it was possible to extend these constant-hue lines far beyond the strongest Munsell samples.[4]

IV. DEFINITION OF THE DESIGNATIONS ON THE CHROMATICITY DIAGRAM

The chromaticity ranges identified by each of the color names for lights are defined by areas on the ICI chromaticity diagram [10], see figure 1. The constant-hue boundaries, if extended, would pass through the point representing ICI standard illuminant *C*, which is approximately in the center of the diagram. Around this point, corresponding to daylight surface colors of low saturation, is a region within which no color names have been assigned in this system. Bounding this region is a line representing the weakest colors that will receive a color name, and between this minimum line and the spectrum locus are the areas to which are assigned the color names offered in this paper. The region called orange pink, pink, and purplish pink lies between the central region and the purple, red, and orange segments.

V. DISCUSSION

It must be remembered that the determination of the hue-name boundaries, which are constant-hue curves, does not constitute a redetermination of the psychologically unitary colors, or "Urfarben", described by Dimmick [11, 13], since the boundaries describe the colors that appear to fall equally between two named hues, for example, between red and reddish orange. However, it is possible to estimate from these limits the dominant wavelengths of the chromaticities of maximum purity corresponding to the unitary hues, and

[3] Deane B. Judd, National Bureau of Standards, Washington, D. C.

[4] The points so determined and the lines connecting them have been accepted by the OSA subcommittee and are included in their final report [4].

these values are shown in table 1, together with values previously reported by various authortities [11, 12, 13] arranged in chronological order. Many of the authorities quoted find unitary red among the spectrum colors but the most careful recent determination finds all spectrum reds to be slightly yellowish, and unitary red must for this

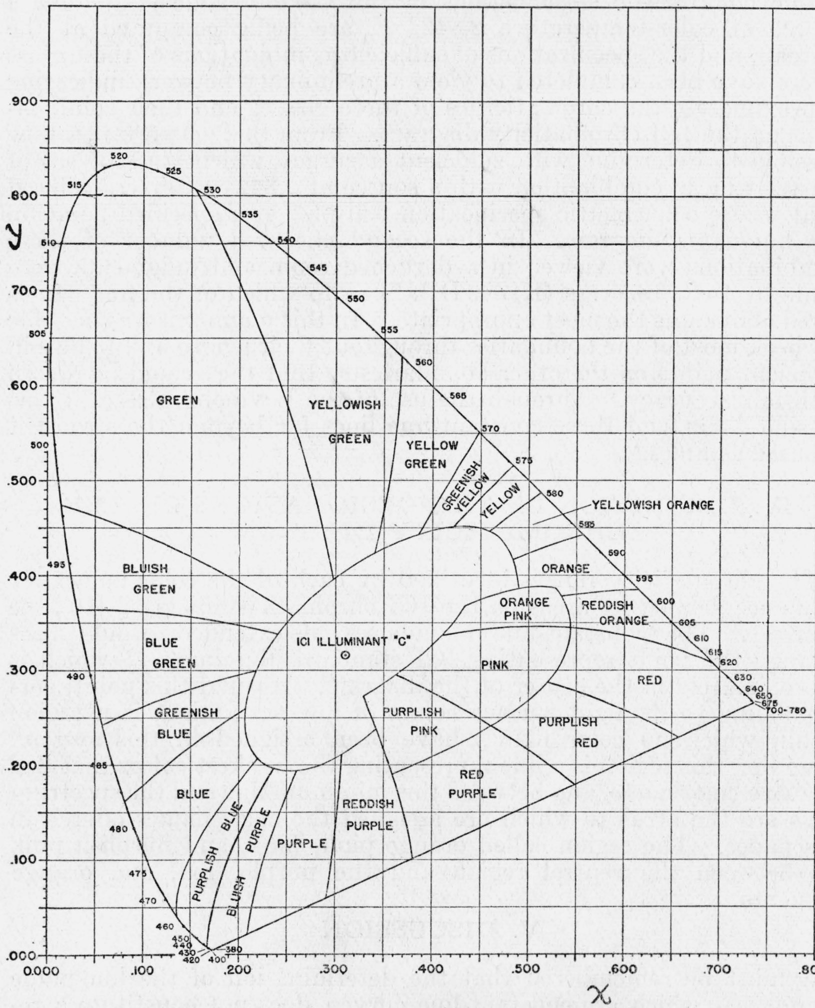

Figure 1.—*Suggested definitions of color designations for self-luminous sources.*

The chromaticities for each designation are indicated on the chromaticity diagram of the standard ICI coordinate system for colorimetry [10]. Spectrum chromaticities are also shown, the wavelengths being indicated in millimicrons.

determination be specified by the complementary wavelength. So that this recent determination may be compared to the previous determinations and an average computed, complementary wavelengths are given in table 1 in parentheses following the values of dominant wavelengths. The averages of the wavelengths for the unitary hues are equally weighted arithmetical means.

Table 1.—*Dominant wavelengths (millimicrons) corresponding to various hues*

Authority	Date	Red	Reddish orange	Orange	Yellowish orange	Yellow	Greenish yellow	Yellow-green	Yellowish green	Green	Bluish green	Blue-green	Greenish blue	Blue	Purplish blue	Blue-violet	Violet	Bluish purple	Purple	Reddish purple	Red-purple	Purplish red
Helmholtz	1866	687 (492. 4c)	656							527						431						
Bezold	1874		656		589	578		558		532		502		468		432						
Donders	1884					582				535				485								
Rood	1890	700 (492. 4c)	621	597	588	581				527		502		473		438	406					
Voeste	1902					577				498				476								
v. Kries	1907					574				503												
Westphal	1909					574				506				479								
Dreher	1911					575				509				477								
Ridgway	1912	644 (492. 1c)		598		577				520				473			410					
Goldytsch	1916													468								
Bradley	1920	656 (492. 2c)		608		579				514				469			421					
Goldmann	1922					568				504				468								
Priest	1926	680 (492. 4c)				583				515				475								
Brückner	1927					578				498				471								
Shubert	1928					574				500				467								
Purdy	1931					576				504				476								
Drever	1932		640			568				508				471								
Weld	1932		622		597			577				492				456						
Gage	1933		625		600																	
Ornstein	1934			596		575		562		515		492		475								
Verbeek	1935		605	598	587	580		569		530		496										
Terpstra	1935		604	592	585	577		563		510		487		470		440						
Seguy	1936	700 (492. 4c)		597		581				527				473		438	406					
Dimmick	1939	493. 6c				582				515				476								
Averages		492. 5c	629	598	591	577		566		514		495		474		439	411					
Proposed system	1943	493c	606	592	583	578	573	565	545	508	495	490	485	476	454			566c	560c	545c	506c	496c

These averages of wavelengths for the various hues also are compared in table 1 with the wavelengths corresponding to the centers of the proposed hue ranges at the edges of the diagram (fig. 1). It will be noted that the agreement for red, yellow, yellow-green, green, and blue is good, but that for reddish orange, orange, and yellowish orange somewhat inferior. Only four values have been previously reported for violet and none for the purples; so it is impossible to make any comparisons with these data in the purplish blue to red region. From the wavelengths reported, blue-violet and violet fall between the centers of the suggested purplish blue and bluish purple areas. Except for yellowish orange, the suggested system gives wavelengths intermediate to those reported by the various authorities for the corresponding hues.

In table 2 the chromaticity ranges of these proposed color designations are compared with those defined in the standard specifications for the several marine [14], traffic [15], railroad [3], and aviation [16] signal-light colors. The colors of lights permitted by the specifications are grouped in table 2 according to hue, and opposite them in the next column are given the corresponding proposed color designation or designations. It will be noted, for example, that ANC [16] (Army, Navy, Civil Aeronautics Administration) aviation red includes not only chromaticities described here as red, but also some described as reddish orange. This is correct, since the orange limit of aviation red is the color of light from a neon discharge tube, which is reddish orange. ANC identification yellow is quite reddish so as to be distinguishable from the color of the incandescent lamp (which is often called "white"). Because of its reddish hue, the name orange might be more appropriate than yellow to describe the color of this signal. The color designation "amber" has sometimes been used for yellow signal colors. The railroad, marine, and traffic signal-green chromaticity ranges have been purposely inclined toward bluish green so as to be distinguishable from yellow and red signal lights by a red-green-blind observer; the name bluish green is quite suited to part of this range. Although the standard specifications for railroad signal blue and aviation blue spread into the bluish purple area, the lights actually used would be called by this system either blue or purplish blue.

TABLE 2.—*Comparison of formal color specifications with the proposed color names*

Color specification	Color name in proposed system	Remarks
Marine and traffic signal red	Red	
Railroad signal red	do	
Railroad highway crossing red	Red and reddish orange	
ANC aviation red	do	Neon light is one limit and would be called reddish orange.
ANC identification red	Red	
Marine and traffic signal yellow	Yellowish orange and orange	
Railroad signal yellow	Orange	
ANC aviation yellow	Yellowish orange and orange	
ANC identification yellow	Reddish orange and orange	
Marine and traffic signal green	Green and bluish green	Colorblind see this as nearly neutral.
Railroad signal green	do	
ANC aviation green	Yellowish green, green, and bluish green.	
ANC identification green	Yellowish green and green	
Railroad signal blue ANC aviation blue	Blue, purplish blue, and bluish purple.	Actual signals are either blue or purplish blue.
Railroad signal purple	Purplish blue, bluish purple, and purple.	Railroad signal purple is not used as a chromaticity term in the usual sense but designates a spectral composition separated into red and blue components by the chromatic aberration of the eye.

Thus from the tables, the agreement of these data both with the previously reported data for unitary and other hues and with the names used in the standard specifications, although not perfect, is fairly good. It must be remembered in this connection that the suggested system embodies a greater number of color names than were used in previous studies of signal-light color systems, such as those by McNicholas [17] and Holmes [5]. In those studies a limited number of color names was allowed, and each name therefore applied to a wide range of hue. These ranges were selected for maximum visual contrast between adjacent named color ranges, and they apply to signal-light systems of the corresponding number of colors. The names applied to the ranges, however, are somewhat arbitrary and not necessarily true descriptions of the color ranges selected. The suggested system, on the other hand, is intended to provide appropriate color names for the colors of all self-luminous bodies. However, considerable work remains to be done before the diagram defining these color designations can be recommended in final form.

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