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Tristimulus Specification of the *Munsell Book of Color* from Spectrophotometric Measurements*

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The development of the Inter-Society Color Council-National Bureau of Standards (ISCC-NBS) system of color names, based on the standards in the *Munsell Book of Color,* made it necessary to specify the master standards of this book in fundamental terms. Accordingly, spectral reflection curves were run for each of the 421 master standards on the General Electric recording spectrophotometer at the National Bureau of Standards, using slit widths of approximately 4 millimicrons. Various corrections were applied to these spectrophotometric data in accordance with methods regularly used for such work at the bureau. Colorimetric computations were then made with these data, resulting in tristimulus specifications according to the 1931 ICI standard observer and coordinate system. Four illuminants were used: ICI Illuminants *A* and *C*, representative of incandescent-lamp light and average daylight, respectively, Illuminant *D* (lightly overcast north sky), and Illuminant *S* (extremely blue sky). The colorimetric specifications of the Munsell standards for all four illuminants are thus given. The trilinear coordinates for the Munsell standards calculated for ICI Illuminant *C* have been plotted on large chromaticity (*x, y*) diagrams and constant Munsell chroma lines drawn in. (Similar values obtained by Glenn and Killian at the Massachusetts Institute of Technology in 1935 for Munsell color standards bearing the same hue-value-chroma designations have also been plotted on the diagram and differences between the two sets of data are discussed.) These diagrams serve as means for determining the Munsell notation and thereby the ISCC-NBS color name for any color whose trilinear coordinates and apparent reflectance are given.

I. INTRODUCTION

TWO of the official compendia of drugs and medicines, the United States Pharmacopoeia and the National Formulary, specify the purity and quality of drugs by a number of tests for which tolerance limits are set; with a crude drug, for example, these tests refer to ash, acid insoluble ash, size, chemical identification tests, taste, color, and so forth, these being indications of purity or quality. All of the tests except color have been under continuous study by committees entrusted with their revision. Color, on the other hand, presented a different type of problem whose solution was not attempted until 1931. Previously the color terms used in the USP and NF had enjoyed no official definition but contained among others such confusing terms as brownish green or blackish white, with seldom any reference to a color chart or standard. In the monograph of a drug, the pharmacognocist describes the colors of the outside and the inside, the colors of the various microscopic elements, and

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finally the colors of the identification tests. In each instance, no mention is made of the normality of the observer's color vision (*1*),[2] or of the conditions of lighting or viewing.

Agitation toward research for the development of a suitable system of color terminology was begun in the twenties by E. N. Gathercoal, then a member of the USP Revision Committee (*2*). After the founding of the Inter-Society Color Council, of which he was the first chairman, studies were made of the then existing color systems, and in 1933 the report (*3*) was submitted which became the basis of the system of color names now known as the ISCC-NBS system of color names (*4*). Procedures were developed at the same time for the application of these color names to the description of the colors of crude drugs, powdered drugs, chemicals, liquids, precipitates, microscopic structures, and fluorescent materials (*5*). The central notations of the color-name blocks were determined for the application of these color names to the description of the colors of soils (*6*). Recently these names have also been used to describe the colors of illuminants and a description of this method of use is in preparation.

In all of this work, the boundaries of the separate color-name blocks have been specified in terms of the Munsell color standards (*7*), (*8*). It was realized early in the project that in order to be placed on a sound basis the individual boundaries must be specified in fundamental terms. The accuracy of the system of color names would then be independent of the existence or stability of the individual system of material color standards in terms of which the system is used in practice. Since the Munsell color system provided a very satisfactory means of determining which color name best described the color of an object, it was decided to measure the spectral reflectances of all of the color standards in the *Munsell Book of Color*. The specification of the trilinear coordinates and apparent reflectances of each of the Munsell samples would provide an invariable specification of the color of that sample and thereby of a definite point in the framework of the system by which the relative position of each color name is indicated.

Tristimulus specifications of the *Munsell Book of Color* have been published by Glenn and Killian (*8*) and were available for some time before that date. Instead of using the Glenn-Killian data, however, it seemed preferable to define the ISCC-NBS system of color names by way of the Munsell samples actually used in the color-names work. This involved a nominal repetition of the spectrophotometric and colorimetric work carried out by Glenn and Killian, but avoided uncertainties arising out of the possible differences between the respective Munsell samples bearing the same color designation as well as those arising from the unknown history and usage of the Glenn-Killian samples prior to their measurement. Furthermore, the present authors desired to use in the spectrophotometric measurements certain methods of calibration regularly used at the National Bureau of Standards for such work. The measurements and computations described below were accordingly undertaken, and the diagrams and tables included in the present paper provide a means by which a color may be named without reference to a color chart, or by which the boundaries of the color-name blocks may be specified in terms of a fundamental color system. It is now possible to select the appropriate color name for a color when the fundamental specifications for that color are given.

Since the application of this system of color names will be made in the plant or in the field where the illumination used will usually be daylight, all of the techniques and computations both for the color names and for the Munsell system have primarily been made on the basis of ICI Illuminant *C*. However, colorimetric data on the Munsell standards for other illuminants are also of interest. Accordingly, based on the same spectrophotometric data, tristimulus values have been computed for four illuminants—ICI Illuminant *C* (*9*) (representative of average daylight), ICI Illuminant *A* (*9*) (2842°K (*10*), representative of incandescent illuminants), Illuminant *D* (*11*), (*12*) (representative of lightly overcast north sky), and Illuminant *S* (*13*), (*14*) (representative of extremely blue sky).

[2] Figures in parentheses indicate the literature references at the end of this paper.

II. SAMPLES MEASURED

Prior to his death, Walter T. Spry, then manager of the Munsell Color Company, deposited one or more samples of all of the original paintings of the standards in the *Munsell Book of Color* with the Colorimetry Section of the Bureau. He also deposited repaints of all colors the original paintings of which had become depleted, together with new colors prepared up to 1935. In selecting the samples of each color to be measured, that painting was chosen which matched the color chip of the same designation in the *Munsell Book of Color*. In most instances the color differences between the originals and their repaints were negligible but in several it was important to specify which painting was used. Therefore, for the purpose of accuracy and as a matter of record, the painting number of each sample measured is given.

The 2-value 2-chroma samples for the intermediate hues (10R, 10YR, 10Y, etc.) were painted independently of the other 2-value 2-chroma samples and the colors and the data are not as congruent with the other samples as they are with each other. These samples, as well as several 8-value 2-chroma samples for the intermediate hues, are not included in the *Munsell Book of Color*, but they were measured and the data are included in the present paper for the sake of completeness. One new sample, 10YR 8/8, recently received, is included. The complete list of samples measured is given in Table II.

The samples in the *Munsell Book of Color* were inspected under a strong source of ultraviolet radiant energy and also under a strong yellowish green light for fluorescence which might vitiate the spectrophotometric measurements (*15*). No fluorescence was observed under either illuminant.

III. METHODS OF MEASUREMENT AND COMPUTATION

Spectral reflection curves of all of the samples noted and listed in Table II were run on the General Electric recording spectrophotometer at the National Bureau of Standards. The samples were run relative to magnesium oxide (*16*), with approximately 4-mμ slits and over a wave-length range from 400 to 750 mμ. The samples were backed with black paper for these measurements. Calibration curves were run on each sheet enabling corrections to be applied to the data for wave-length errors, for 100 percent and zero curve deviations, and for aging of the magnesium oxide comparison surface, in accordance with methods regularly used at the National Bureau of Standards (*17*), (*18*).

As already noted, the colorimetric computations were made for four different illuminants. ICI Illuminants *A* and *C* have become well established in colorimetric work. Illuminant *A* is the Plankian radiator or blackbody at 2842°K ($C_2=14{,}320$ micron-degrees, or 2848°K with $C_2=14{,}350$); the color temperatures of common incandescent illuminants vary from about 2600°K to about 3100°K. Illuminant *C* is that produced by a source at 2842°K combined with a certain Davis-Gibson daylight liquid filter (*19*). On the "OSA excitations" basis (used in the design of the Davis-Gibson filters) the resulting color matched that of a Plankian radiator at 6500°K. On the basis of the ICI data the approximate color temperature of this lamp-and-filter combination is 6800°K. The color and spectral energy distribution of ICI Illuminant *C* satisfactorily match those of overcast sky or average daylight for colorimetric use. Illuminant *D* is that produced by an illuminant at 3000°K combined with a Macbeth (Corning) daylight glass filter giving a color temperature of approximately

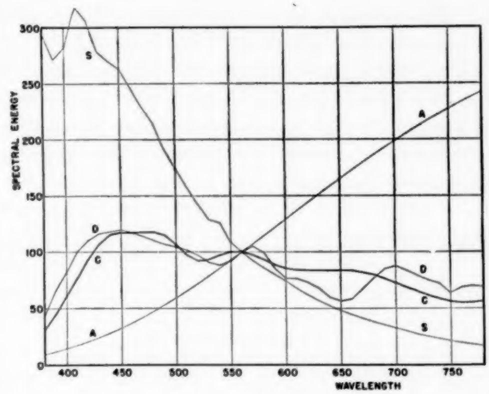

FIG. 1. Spectral energy distributions of the four illuminants used in deriving the colorimetric data on the Munsell standards. Note: ICI Illuminant *A*, 2842°K, representative of incandescent illuminants. ICI Illuminant *C*, representative of average daylight. Illuminant *D*, representative of lightly overcast sky. Illuminant *S*, representative of "limit blue sky."

7500°K. The color of Illuminant *D*, found to be the optimum color for cotton grading, is also being widely used for agricultural grading and textile color matching. Its color closely matches that of the lightly overcast north sky most desired for such work. Illuminant *S* was designed as the blue end point for a series of illuminants representing the range from fully overcast to maximally clear sky. It was devised by weighting Abbot's "sun-outside-atmosphere" energy data by the inverse λ^4 scattering relation. Illuminant *S* has been designated as "limit blue sky."

The colorimetric data on the Munsell samples for ICI Illuminant *C*, representative of average daylight, are of primary interest and the computations were carried out both at the National Bureau of Standards and in the U. S. Department of Agriculture. Those for the other three illuminants were made in the Department of Agriculture. All of the computations in the Department of Agriculture were done by using Hollerith cards and automatically punching sums obtained by the method of progressive digiting. The authors are indebted to Lila F. Knudsen, mathematical statistician of the Food and Drug Administration, for suggesting this rapid method of computation (*20*). All of the computations were made by the weighted ordinate method.

The spectral energy distributions of the four illuminants are shown in Fig. 1, and in Table I are given the tristimulus data for the spectrum of each of the four illuminants used in the computations of *X*, *Y*, *Z* and *x*, *y*, *z*.

TABLE I. ICI tristimulus data for the four illuminants, *A*, *C*, *D*, and *S*, used in deriving the colorimetric data on the Munsell standards.

Wave-length (mμ)	For Illuminant *A*			For Illuminant *C*			For Illuminant *D*			For Illuminant *S*		
	$\bar{x}E$	$\bar{y}E$	$\bar{z}E$	$\bar{x}E$	$\bar{y}E$	$\bar{z}E$	$\bar{x}E$	$\bar{y}E$	$\bar{z}E$	$\bar{x}E$	$\bar{y}E$	$\bar{z}E$
380	1		6	4		20	6		30	36		165
390	5		23	19		89	27	1	128	99	3	473
400	19	1	93	85	2	404	119	3	567	349	10	1658
410	71	2	340	329	9	1570	446	12	2125	1199	33	5719
420	262	8	1256	1238	37	5949	1504	45	7223	3567	107	17137
430	649	27	3167	2997	122	14628	3373	138	16461	6852	280	33442
440	926	61	4647	3975	262	19938	4202	277	21077	8143	538	40845
450	1031	117	5435	3915	443	20638	4100	463	21613	7652	865	40332
460	1019	210	5851	3362	694	19299	3476	717	19952	6194	1278	35554
470	776	362	5116	2272	1058	14972	2274	1059	14982	3870	1803	25503
480	428	622	3636	1112	1618	9461	1070	1556	9099	1742	2533	14815
490	160	1039	2324	363	2358	5274	347	2258	5049	530	3444	7703
500	27	1792	1509	52	3401	2864	52	3451	2906	74	4871	4102
510	57	3080	969	89	4833	1520	96	5214	1640	127	6870	2160
520	425	4771	525	576	6462	712	626	7023	774	781	8757	965
530	1214	6322	309	1523	7934	388	1533	7986	391	1847	9618	471
540	2313	7600	162	2785	9149	195	2610	8574	182	2958	9717	207
550	3732	8568	75	4282	9832	86	4062	9324	82	4070	9343	81
560	5510	9222	36	5880	9841	39	6072	10162	40	5148	8615	34
570	7571	9457	21	7322	9147	20	8160	10194	22	6092	7610	16
580	9719	9228	18	8417	7992	16	9310	8840	17	6798	6454	13
590	11579	8540	12	8984	6627	10	8946	6599	10	7090	5229	7
600	12704	7547	10	8949	5316	7	8343	4956	6	6798	4038	5
610	12669	6356	4	8325	4176	2	7800	3913	2	5871	2945	2
620	11373	5071	3	7070	3153	2	6372	2841	1	4585	2044	1
630	8980	3704		5309	2190		4477	1847		3160	1303	
640	6558	2562		3693	1443		2732	1067		2030	793	
650	4336	1637		2349	886		1640	619		1183	447	
660	2628	972		1361	504		988	365		636	236	
670	1448	530		708	259		603	221		313	114	
680	804	292		369	134		367	133		155	56	
690	404	146		171	62		197	71		69	25	
700	209	75		82	29		102	37		32	11	
710	110	40		39	14		49	18		15	5	
720	57	19		19	6		23	8		7	3	
730	28	10		8	3		11	4		3	1	
740	14	6		4	2		5	2		2	1	
750	6	2		2	1		2	1		1		
760	4	2		1	1		1	1				
770	2			1			1					
Σ =	109828	100000	35547	98041	100000	118103	96124	100000	124379	100078	100000	231410
x, *y*, *z* =	.44759	.40754	.14487	.31012	.31631	.37357	.29992	.31201	.38807	.23194	.23176	.53630

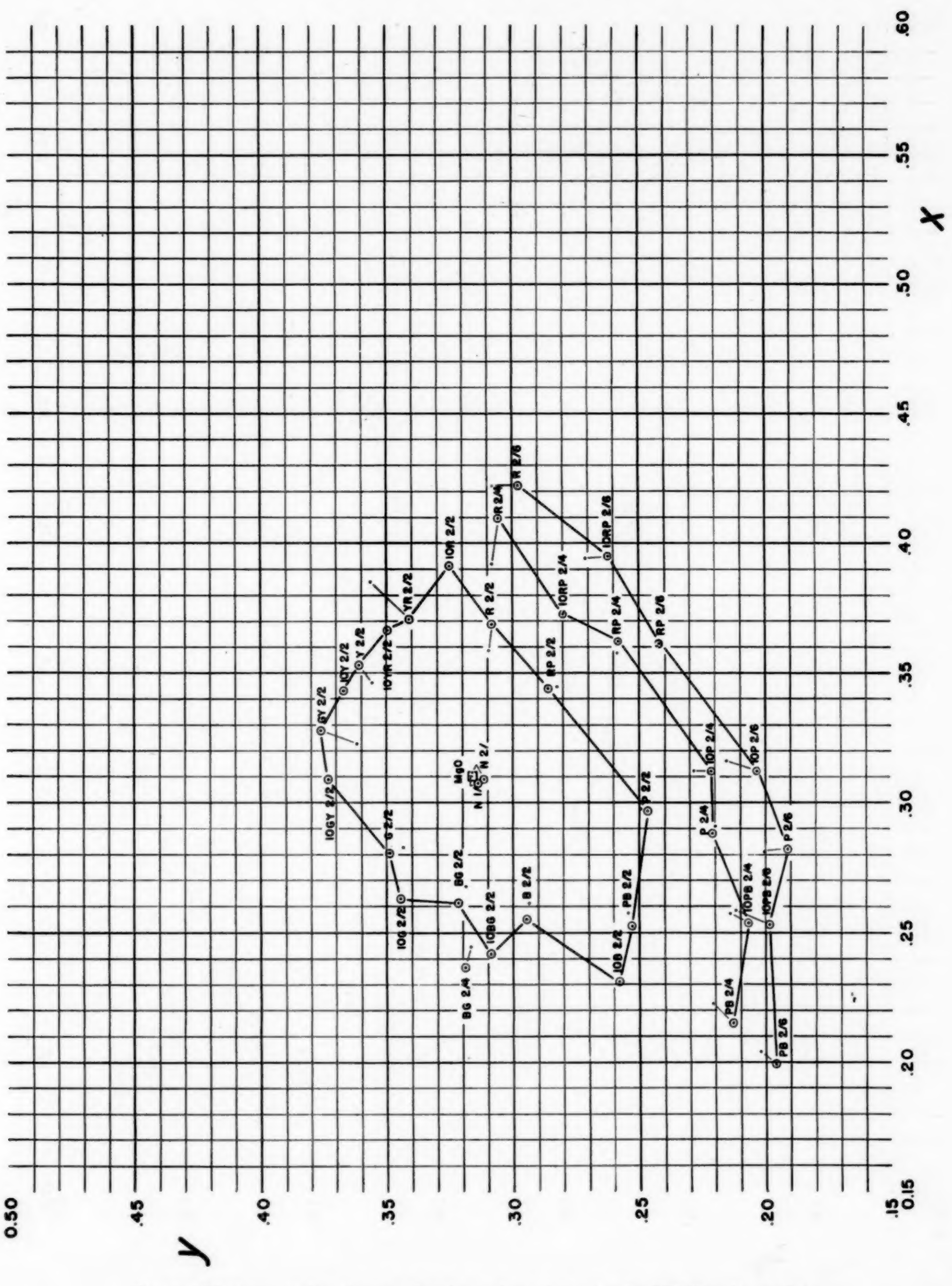

FIG. 2. ICI chromaticity diagram showing values of *x* and *y* for ICI Illuminant *C* for Munsell standards of value level 2/.

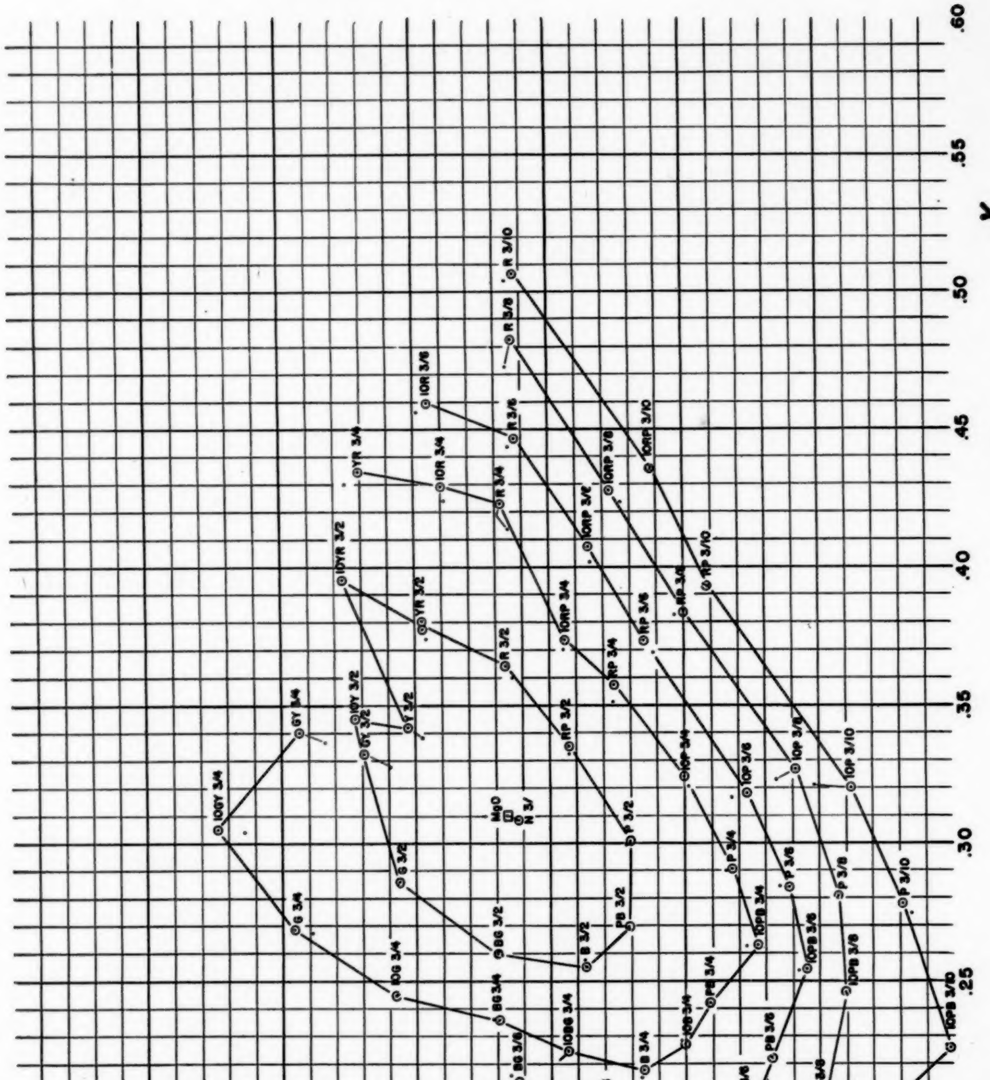

FIG. 3. ICI chromaticity diagram showing values of *x* and *y* for ICI Illuminant *C* for Munsell standards of value level 3/.

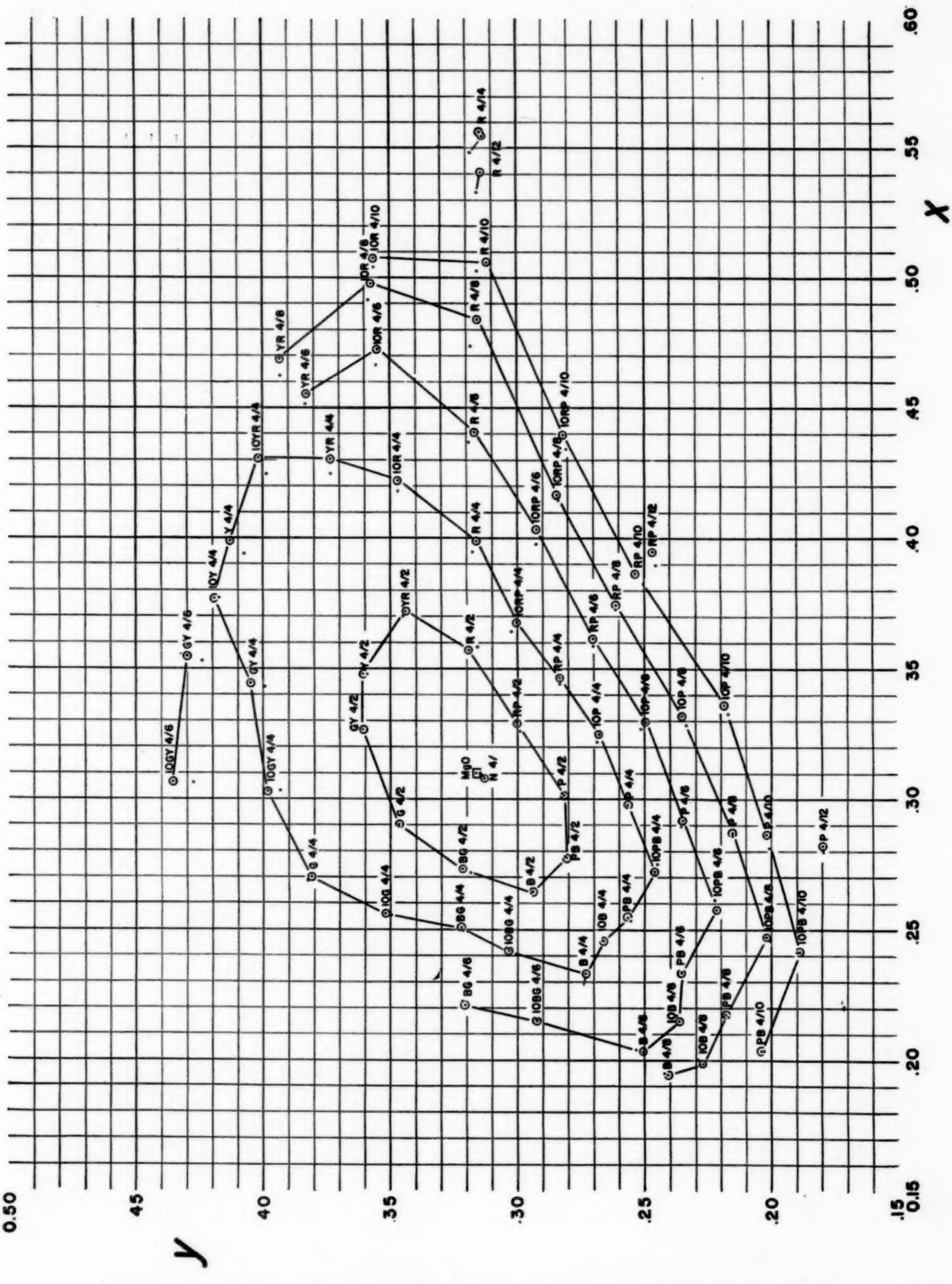

FIG. 4. ICI chromaticity diagram showing values of x and y for ICI Illuminant C for Munsell standards of value level 4/.

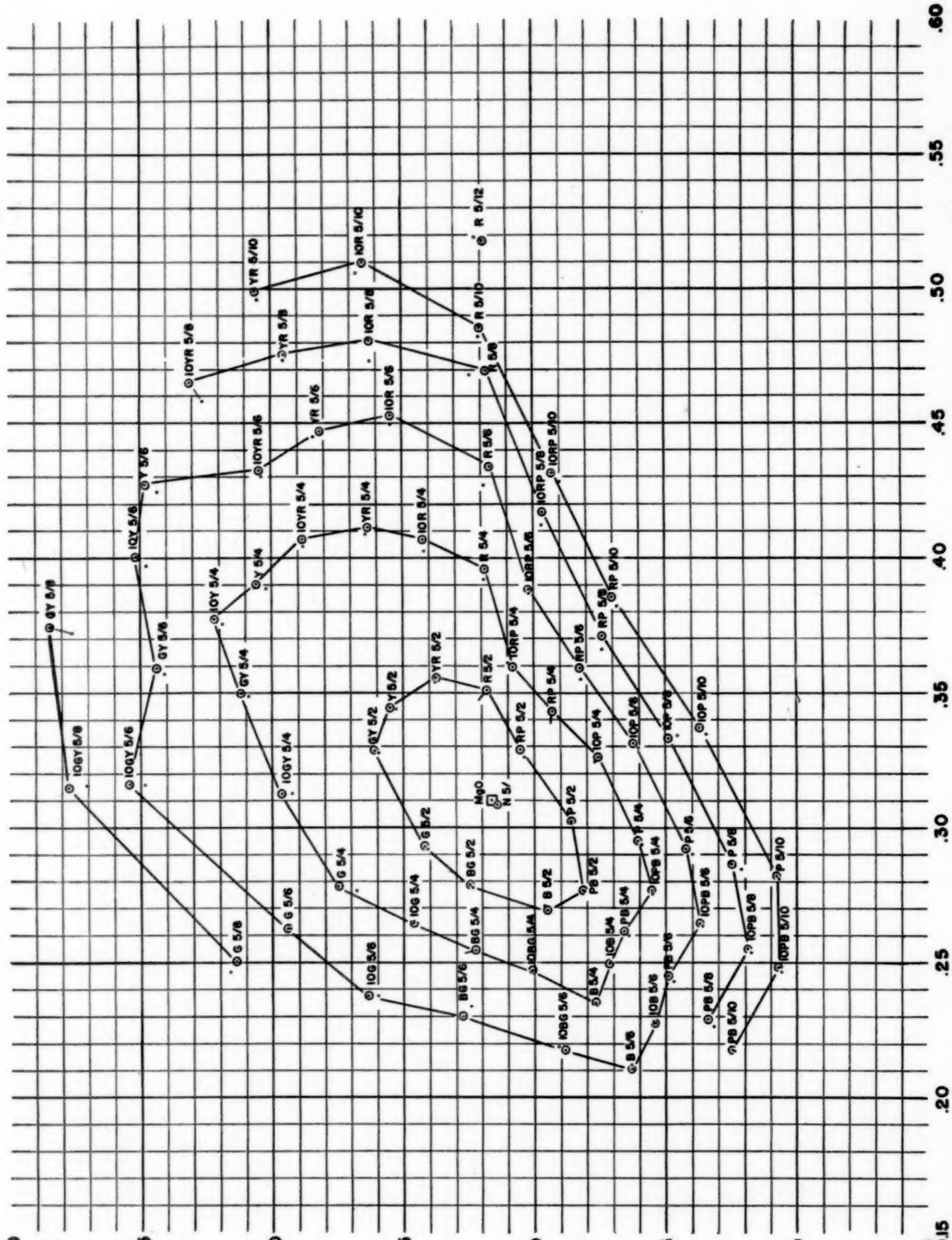

FIG. 5. ICI chromaticity diagram showing values of x and y for ICI Illuminant C for Munsell standards of value level 5/.

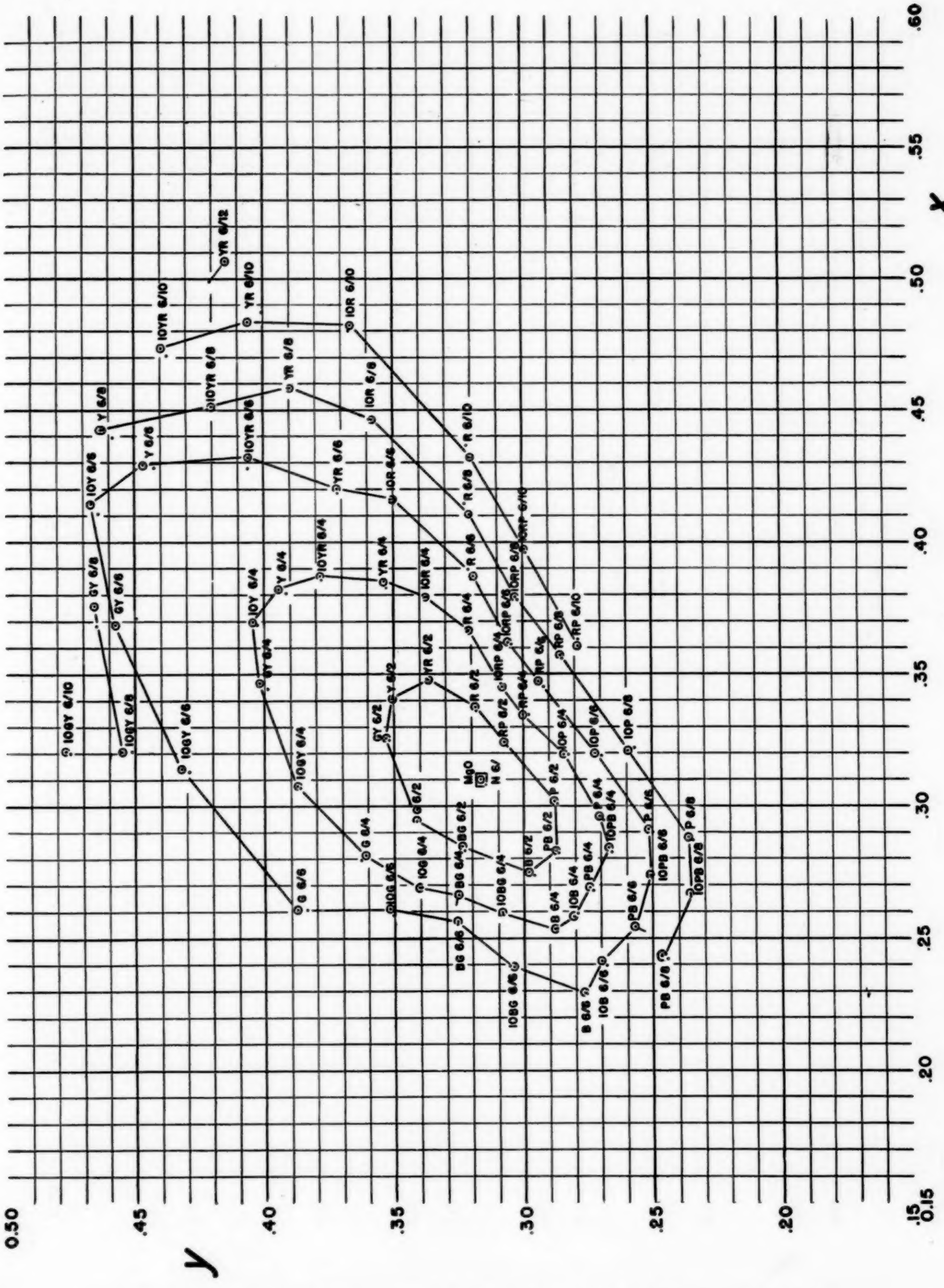

FIG. 6. ICI chromaticity diagram showing values of *x* and *y* for ICI Illuminant *C* for Munsell standards of value level 6/.

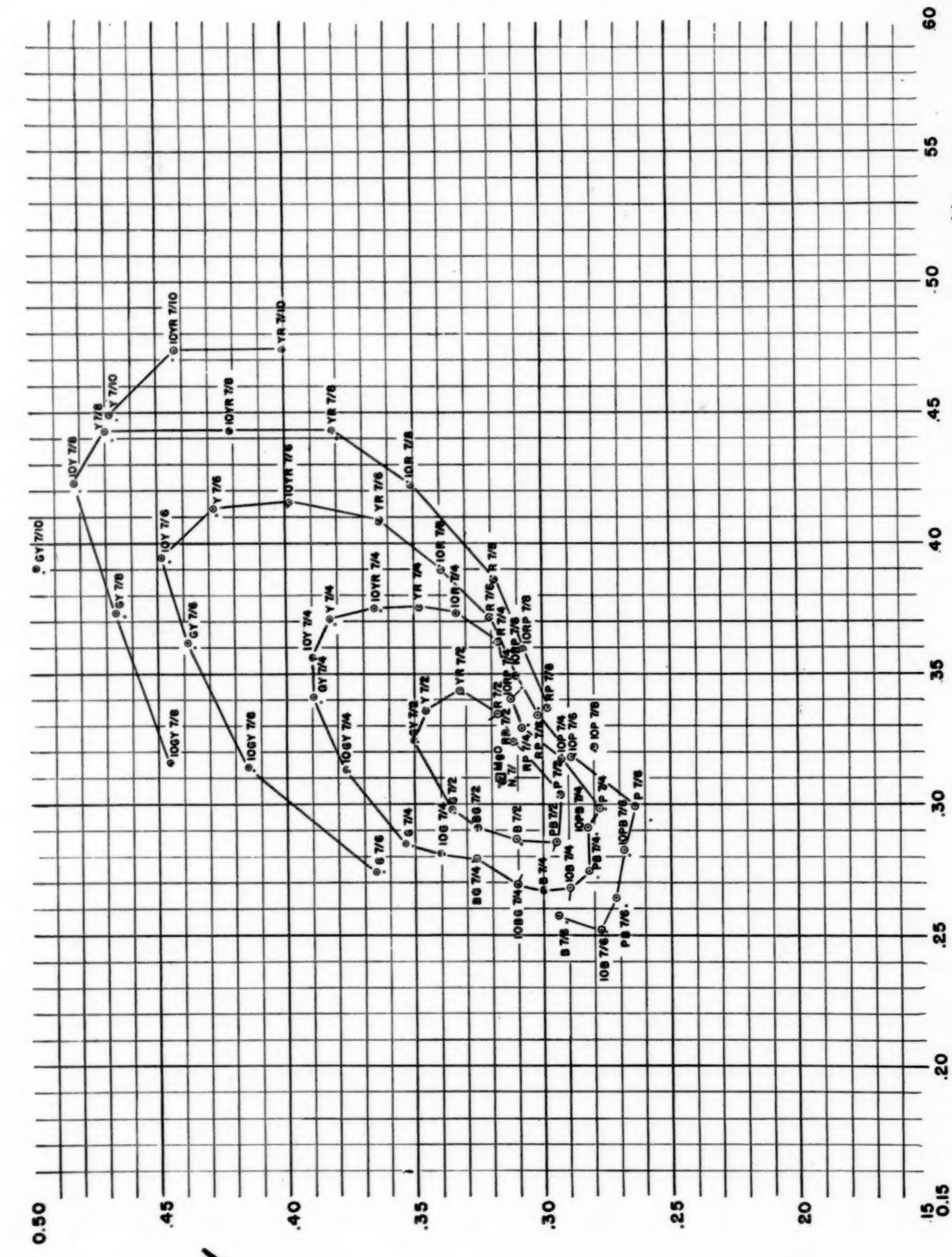

FIG. 7. ICI chromaticity diagram showing values of x and y for ICI Illuminant C for Munsell standards of value level 7/.

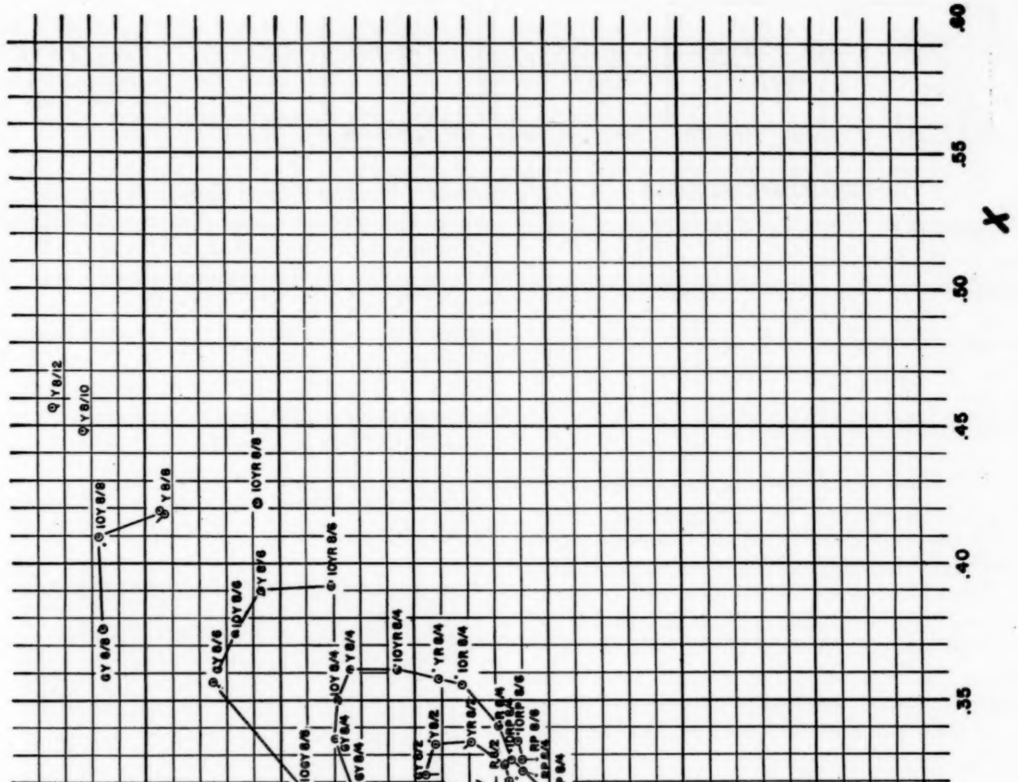

FIG. 8. ICI chromaticity diagram showing values of x and y for ICI Illuminant C for Munsell standards of value level 8/.

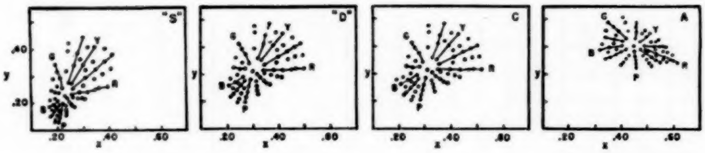

FIG. 9. Values of x and y for samples of Munsell value 5/ for illuminats A, C, D, and S. This graph shows the effect of illuminant on the location and shape of the Munsell network.

IV. COLORIMETRIC DATA

Values of X, Y, Z, x, and y for all of the samples and for the four illuminants, as explained above, together with the Munsell notations, H V/C (hue, value, and chroma), and the Munsell painting number for each sample, are given in Table II. Values for the neutrals are at the end of the table. Values of z are omitted, since $z=1-x-y$.

Values of the trilinear coordinates, x and y, for ICI Illuminant C, are plotted in Figs. 2 to 8 for Munsell values 2 to 8, respectively. The x and y values for ICI Illuminant C, and therefore for magnesium oxide and for any other spectrally non-selective sample, are given in each diagram at $x=0.3101$, $y=0.3163$. Values of x and y for the Munsell samples obtained at the National Bureau of Standards are plotted as circled points. The data obtained by Glenn and Killian (*8*) at the Massachusetts Institute of Technology in 1935 are plotted as uncircled points for comparison with the present data. When the two points for a sample coincide, the combination is plotted as a circled point with a short line attached; in many cases, to avoid confusion, the two points are joined by a fine line. Lines are drawn connecting all of the NBS points of constant chroma on each diagram, resulting in the spiderweb-like figures shown.

Graphs similar to Figs. 2 to 8 could of course be plotted for the other illuminants using the data given in Table II. While this has not been done for the present paper it has seemed of interest to show the effect of the illuminant on the location and shape of the network. This is done in Fig. 9, where the values of x and y for Munsell value 5 are plotted to the same scale for the four illuminants.

V. COMPARISON WITH GLENN-KILLIAN DATA

Differences between the methods used by Glenn and Killian and those used at the National Bureau of Standards are understood to be as follows: 1. The Glenn-Killian spectrophotometric data were obtained with samples backed by "a standard white substance," the National Bureau of Standards data with samples backed with black paper. 2. The calibration curves (see above) run on each sheet at the National Bureau of Standards were not used by Glenn and Killian. 3. The Glenn-Killian colorimetric computations were made by the selected-ordinate method, the NBS data by the weighted ordinate method.

Spectrophotometric differences caused by the backing are illustrated in Fig. 10, in which are

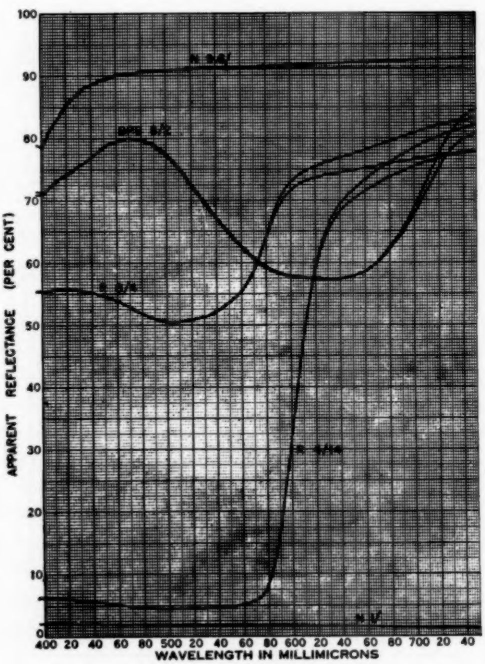

FIG. 10. Effect of backing on the spectral apparent reflectance of Munsell samples. The upper curve of each pair was obtained with the sample backed with a white paper (N 9.6/), the lower curve with the sample backed with a black paper (N 1/). Note that no difference in curves caused by difference in backing is apparent for values of reflectance less than 0.6 or at the shorter wavelengths.

TABLE II. The tristimulus specifications and trilinear coordinates of the Munsell standards for the four illuminants, *A*, *C*, *D*, and *S*, based on spectrophotometric data obtained at the National Bureau of Standards.

Munsell notation	For ICI Illuminant *A*					For ICI Illuminant *C*					For Illuminant *D*					For Illuminant *S*					Munsell painting number
	X	*Y*	*Z*	*x*	*y*	*X*	*Y*	*Z*	*x*	*y*	*X*	*Y*	*Z*	*x*	*y*	*X*	*Y*	*Z*	*x*	*y*	
R 8/4	.7432	.6147	.1874	.4809	.3978	.6261	.5862	.6264	.3405	.3188	.6075	.5832	.6604	.3282	.3150	.6044	.5667	1.2317	.2516	.2358	1168
2	.7160	.6179	.2036	.4657	.4019	.6199	.6021	.6793	.3261	.3167	.6047	.6007	.7158	.3148	.3127	.6147	.5908	1.3338	.2421	.2327	342
7/8	.6564	.4769	.1168	.5251	.3815	.5144	.4244	.3936	.3861	.3185	.4909	.4178	.4159	.3706	.3154	.4614	.3903	.7794	.2829	.2393	84
6	.6445	.4886	.1276	.5112	.3876	.5157	.4452	.4279	.3713	.3206	.4946	.4400	.4515	.3568	.3174	.4722	.4167	.8437	.2725	.2405	880
4	.6173	.4777	.1324	.5030	.3892	.5020	.4402	.4449	.3619	.3174	.4835	.4361	.4696	.3480	.3139	.4682	.4153	.8784	.2657	.2357	82
2	.5586	.4699	.1485	.4746	.3993	.4763	.4521	.4965	.3343	.3173	.4632	.4503	.5234	.3224	.3134	.4655	.4396	.9765	.2474	.2336	80
6/10	.5912	.3874	.0740	.5616	.3681	.4369	.3236	.2514	.4318	.3198	.4102	.3146	.2662	.4139	.3174	.3666	.2834	.5014	.3184	.2461	1156
8	.5461	.3758	.0804	.5448	.3749	.4142	.3236	.2717	.4103	.3205	.3920	.3167	.2873	.3936	.3180	.3579	.2902	.5396	.3013	.2443	338
6	.5121	.3721	.0903	.5255	.3818	.4013	.3308	.3053	.3868	.3189	.3831	.3259	.3229	.3713	.3158	.3598	.3036	.6064	.2834	.2391	728
4	.4673	.3611	.0958	.5056	.3907	.3787	.3313	.3228	.3667	.3208	.3649	.3284	.3411	.3528	.3175	.3510	.3106	.6393	.2698	.2388	726
2	.4007	.3345	.1037	.4776	.3987	.3396	.3205	.3464	.3374	.3184	.3298	.3190	.3651	.3253	.3146	.3295	.3108	.6805	.2496	.2353	32
5/12	.4675	.2596	.0293	.6181	.3432	.3149	.1938	.0995	.5177	.3187	.2858	.1825	.1055	.4981	.3181	.2346	.1545	.1989	.3990	.2628	732
10	.4651	.2732	.0381	.5990	.3519	.3226	.2128	.1291	.4855	.3202	.2962	.2030	.1367	.4659	.3192	.2501	.1760	.2572	.3660	.2576	731
8	.4099	.2477	.0388	.5886	.3557	.2900	.1963	.1315	.4694	.3178	.2684	.1884	.1391	.4504	.3162	.2306	.1650	.2612	.3511	.2512	738
6	.3713	.2407	.0465	.5639	.3656	.2736	.1998	.1574	.4338	.3167	.2567	.1940	.1663	.4161	.3144	.2289	.1744	.3120	.3200	.2438	314
4	.3074	.2183	.0510	.5331	.3785	.2379	.1915	.1715	.3959	.3187	.2264	.1881	.1810	.3801	.3159	.2100	.1743	.3386	.2905	.2411	312
2	.2604	.2084	.0610	.4915	.3934	.2158	.1954	.2041	.3507	.3176	.2087	.1941	.2150	.3378	.3141	.2047	.1865	.4007	.2585	.2356	1124
4/14	.3644	.1881	.0163	.6406	.3308	.2360	.1334	.0550	.5561	.3143	.2104	.1231	.0581	.5373	.3144	.1666	.1015	.1089	.4420	.2692	860
	.3653	.1882	.0166	.6408	.3301	.2361	.1335	.0563	.5544	.3135	.2100	.1231	.0595	.5348	.3135	.1664	.1015	.1119	.4382	.2673	322
12	.3580	.1884	.0187	.6336	.3333	.2341	.1360	.0631	.5404	.3139	.2094	.1262	.0667	.5207	.3136	.1680	.1055	.1250	.4216	.2647	332
10	.3166	.1736	.0226	.6173	.3386	.2116	.1303	.0762	.5061	.3117	.1905	.1221	.0805	.4847	.3106	.1574	.1050	.1510	.3807	.2540	894
8	.2890	.1683	.0245	.5997	.3493	.2004	.1306	.0831	.4839	.3155	.1837	.1243	.0878	.4642	.3140	.1557	.1082	.1648	.3632	.2524	729
6	.2374	.1516	.0282	.5691	.3634	.1734	.1247	.0955	.4406	.3167	.1622	.1207	.1010	.4225	.3144	.1437	.1080	.1897	.3255	.2447	18
4	.2023	.1418	.0330	.5365	.3760	.1559	.1236	.1115	.3987	.3161	.1481	.1212	.1178	.3825	.3131	.1373	.1119	.2210	.2920	.2381	16
2	.1748	.1377	.0388	.4976	.3920	.1433	.1280	.1299	.3572	.3190	.1383	.1269	.1369	.3439	.3156	.1345	.1213	.2555	.2630	.2373	14
3/10	.1799	.0991	.0126	.6168	.3400	.1206	.0744	.0431	.5065	.3124	.1088	.0698	.0457	.4851	.3113	.0900	.0596	.0862	.3818	.2528	12
8	.1662	.0958	.0142	.6017	.3468	.1143	.0743	.0484	.4824	.3135	.1041	.0704	.0512	.4613	.3120	.0882	.0613	.0963	.3588	.2495	42R
6	.1653	.1021	.0188	.5776	.3569	.1185	.0829	.0639	.4466	.3125	.1098	.0797	.0677	.4268	.3100	.0967	.0712	.1276	.3272	.2411	1151
4	.1320	.0870	.0178	.5576	.3673	.0977	.0734	.0599	.4228	.3179	.0914	.0713	.0632	.4047	.3155	.0823	.0651	.1183	.3098	.2450	40
2	.1022	.0780	.0216	.5067	.3864	.0824	.0716	.0722	.3643	.3164	.0790	.0707	.0761	.3499	.3130	.0762	.0674	.1420	.2669	.2360	730
2/6	.0885	.0558	.0124	.5647	.3559	.0653	.0461	.0434	.4219	.2977	.0609	.0445	.0462	.4019	.2934	.0558	.0401	.0877	.3037	.2186	38R
4	.0687	.0453	.0105	.5522	.3639	.0516	.0384	.0359	.4094	.3053	.0484	.0373	.0381	.3907	.3015	.0447	.0342	.0720	.2960	.2268	36R
2	.0598	.0442	.0123	.5143	.3803	.0479	.0400	.0420	.3686	.3083	.0457	.0394	.0445	.3529	.3041	.0444	.0373	.0839	.2679	.2253	34
10R 8/4	.7899	.6491	.1724	.4902	.4028	.6539	.6115	.5744	.3554	.3324	.6339	.6087	.6056	.3430	.3294	.6136	.5823	1.1293	.2639	.2504	722
7/8	.6797	.4921	.0833	.5416	.3921	.5161	.4290	.2776	.4221	.3509	.4914	.4228	.2934	.4069	.3501	.4366	.3842	.5489	.3188	.2805	882
6	.6605	.5044	.1085	.5187	.3961	.5222	.4550	.3635	.3895	.3394	.5018	.4508	.3839	.3755	.3373	.4646	.4180	.7181	.2903	.2611	714
4	.6288	.4937	.1194	.5064	.3976	.5075	.4537	.3997	.3729	.3334	.4893	.4502	.4219	.3594	.3307	.4634	.4236	.7881	.2767	.2529	667
6/10	.5891	.3948	.0404	.5751	.3854	.4268	.3243	.1345	.4820	.3662	.4031	.3181	.1422	.4668	.3684	.3354	.2732	.2664	.3833	.3122	583
8	.5585	.3931	.0547	.5550	.3907	.4170	.3345	.1828	.4463	.3580	.3965	.3295	.1934	.4313	.3584	.3426	.2913	.3623	.3439	.2924	585
6	.5243	.3853	.0677	.5365	.3942	.4022	.3384	.2261	.4161	.3501	.3843	.3344	.2388	.4014	.3492	.3434	.3037	.4465	.3140	.2777	733
4	.4556	.3569	.0817	.5096	.3991	.3663	.3262	.2743	.3789	.3374	.3535	.3239	.2899	.3654	.3349	.3322	.3026	.5431	.2820	.2569	587
4	.4710	.3673	.0802	.5128	.3999	.3755	.3347	.2667	.3844	.3426	.3621	.3326	.2814	.3710	.3407	.3360	.3095	.5254	.2870	.2643	1860
5/10	.3965	.2488	.0208	.5953	.3735	.2761	.1977	.0678	.5098	.3650	.2562	.1912	.0716	.4937	.3684	.2078	.1633	.1331	.4121	.3239	590
8	.3990	.2653	.0284	.5761	.3830	.2884	.2175	.0943	.4806	.3624	.2719	.2130	.0996	.4652	.3644	.2266	.1833	.1861	.3802	.3076	734
6	.3591	.2465	.0339	.5615	.3855	.2650	.2073	.1130	.4527	.3542	.2508	.2035	.1194	.4371	.3547	.2155	.1796	.2234	.3485	.2904	588
4	.3102	.2297	.0442	.5311	.3932	.2409	.2028	.1484	.4069	.3425	.2309	.2007	.1568	.3924	.3411	.2093	.1829	.2937	.3052	.2666	580
4/10	.3031	.1891	.0172	.5950	.3712	.2127	.1493	.0571	.5075	.3563	.1981	.1446	.0603	.4916	.3587	.1619	.1225	.1126	.4078	.3086	761
8	.2811	.1786	.0176	.5890	.3742	.1989	.1428	.0580	.4976	.3573	.1858	.1387	.0611	.4818	.3598	.1528	.1183	.1138	.3970	.3075	747
6	.2627	.1734	.0209	.5749	.3794	.1897	.1424	.0693	.4726	.3549	.1783	.1392	.0730	.4567	.3563	.1500	.1210	.1359	.3686	.2974	735
4	.2158	.1550	.0269	.5426	.3898	.1638	.1348	.0896	.4220	.3472	.1559	.1328	.0946	.4067	.3464	.1385	.1203	.1766	.3182	.2763	591
3/6	.1440	.0951	.0133	.5705	.3766	.1047	.0786	.0446	.4594	.3448	.0984	.0766	.0472	.4428	.3449	.0844	.0674	.0884	.3513	.2808	736
4	.1250	.0866	.0151	.5515	.3820	.0935	.0741	.0502	.4291	.3402	.0884	.0726	.0530	.4129	.3393	.0782	.0658	.0990	.3219	.2706	595
2/2	.0711	.0515	.0119	.5288	.3828	.0551	.0458	.0399	.3913	.3252	.0523	.0450	.0421	.3753	.3226	.0486	.0420	.0788	.2870	.2478	915
YR 8/4	.7567	.6314	.1590	.4891	.4081	.6255	.5970	.5271	.3575	.3412	.6068	.5950	.5557	.3453	.3386	.5829	.5690	1.0348	.2666	.2602	385
2	.7041	.6096	.1824	.4706	.4075	.6007	.5917	.6039	.3344	.3294	.5849	.5904	.6358	.3230	.3260	.5825	.5777	1.1813	.2488	.2467	384
7/10	.6736	.4888	.0415	.5595	.4060	.4941	.4178	.1309	.4738	.4007	.4696	.4129	.1378	.4603	.4047	.3870	.3629	.2534	.3857	.3617	867
8	.6729	.4991	.0629	.5449	.4042	.5054	.4356	.2002	.4429	.3817	.4826	.4314	.2097	.4295	.3839	.4108	.3860	.3843	.3478	.3268	740
6	.6086	.4657	.0808	.5269	.4032	.4703	.4180	.2635	.4084	.3629	.4504	.4140	.2776	.3944	.3626	.4022	.3816	.5151	.3097	.2938	739
	.6194	.4746	.0822	.5266	.4035	.4787	.4262	.2676	.4083	.3635	.4584	.4223	.2817	.3944	.3633	.4090	.3894	.5219	.3098	.2949	739
4	.5867	.4724	.1052	.5039	.4057	.4723	.4376	.3484	.3753	.3478	.4556	.4349	.3674	.3622	.3457	.4268	.4110	.6840	.2805	.2701	154
2	.5362	.4561	.1287	.4783	.4069	.4521	.4375	.4275	.3433	.3322	.4396	.4362	.4505	.3315	.3289	.4325	.4229	.8385	.2553	.2497	152

TABLE II.—*Continued.*

Munsell notation	For ICI Illuminant A X	Y	Z	x	y	For ICI Illuminant C X	Y	Z	x	y	For Illuminant D X	Y	Z	x	y	For Illuminant S X	Y	Z	x	y	Munsell painting number
YR 6/12	.5511	.3886	.0203	.5740	.4048	.3962	.3241	.0617	.5067	.4145	.3757	.3199	.0647	.4941	.4208	.2994	.2742	.1175	.4333	.3967	383
10	.5465	.3945	.0290	.5634	.4067	.3989	.3350	.0915	.4833	.4059	.3787	.3307	.0963	.4700	.4105	.3095	.2886	.1771	.3992	.3723	745
8	.5163	.3798	.0394	.5519	.4060	.3849	.3274	.1278	.4582	.3897	.3677	.3243	.1348	.4448	.3922	.3092	.2862	.2500	.3657	.3385	896
6	.4721	.3620	.0549	.5477	.4072	.3640	.3221	.1804	.4201	.3717	.3496	.3199	.1904	.4066	.3720	.3077	.2902	.3543	.3232	.3048	379
4	.4231	.3390	.0693	.5089	.4077	.3389	.3113	.2300	.3850	.3537	.3275	.3099	.2428	.3721	.3521	.3024	.2886	.4528	.2897	.2765	377
2	.3834	.3266	.0883	.4803	.4091	.3225	.3124	.2936	.3473	.3364	.3139	.3117	.3097	.3356	.3333	.3066	.3003	.5772	.2590	.2536	375
5/10	.3490	.2462	.0155	.5715	.4032	.2528	.2056	.0482	.4990	.4058	.2402	.2032	.0506	.4862	.4113	.1933	.1740	.0924	.4205	.3785	868
8	.3392	.2450	.0215	.5601	.4044	.2503	.2081	.0680	.4755	.3953	.2393	.2063	.0714	.4628	.3991	.1969	.1790	.1311	.3883	.3531	748
6	.3095	.2282	.0275	.5477	.4037	.2320	.1981	.0892	.4468	.3815	.2212	.1960	.0939	.4328	.3834	.1887	.1750	.1741	.3509	.3254	741
4	.2787	.2131	.0359	.5282	.4039	.2156	.1905	.1181	.4113	.3633	.2067	.1888	.1246	.3975	.3630	.1844	.1730	.2318	.3129	.2937	144
2	.2443	.2037	.0527	.4880	.4069	.2029	.1927	.1755	.3553	.3374	.1969	.1920	.1852	.3430	.3344	.1905	.1839	.3457	.2646	.2554	142
4/8	.2159	.1585	.0147	.5549	.4074	.1614	.1354	.0474	.4689	.3935	.1551	.1348	.0498	.4566	.3968	.1286	.1166	.0919	.3816	.3458	902
6	.2320	.1678	.0191	.5539	.4006	.1717	.1445	.0610	.4552	.3830	.1630	.1425	.0642	.4409	.3855	.1376	.1271	.1183	.3592	.3319	875
4	.2167	.1610	.0229	.5410	.4018	.1632	.1416	.0744	.4303	.3735	.1551	.1397	.0784	.4157	.3743	.1350	.1276	.1452	.3310	.3129	987
2	.1685	.1366	.0314	.5008	.4059	.1370	.1268	.1044	.3720	.3444	.1326	.1262	.1100	.3594	.3423	.1248	.1189	.2049	.2783	.2650	584
3/4	.1212	.0897	.0127	.5422	.4012	.0918	.0783	.0412	.4344	.3705	.0878	.0775	.0434	.4206	.3714	.0761	.0697	.0805	.3362	.3079	988
2	.0955	.0759	.0165	.5084	.4038	.0764	.0698	.0548	.3803	.3473	.0737	.0693	.0578	.3669	.3453	.0687	.0653	.1078	.2841	.2700	989
	.0949	.0759	.0168	.5058	.4045	.0761	.0701	.0556	.3774	.3473	.0734	.0696	.0585	.3643	.3454	.0685	.0657	.1088	.2820	.2702	1201
2/2	.0592	.0473	.0113	.5026	.4017	.0477	.0439	.0371	.3707	.3411	.0461	.0436	.0391	.3576	.3387	.0434	.0415	.0726	.2757	.2634	857
10YR 8/8	.8119	.6627	.0804	.5221	.4262	.6249	.6049	.2514	.4219	.4084	.6004	.6019	.2644	.4094	.4104	.5177	.5546	.4849	.3325	.3562	1595
6	.7891	.6583	.1118	.5061	.4222	.6282	.6114	.3648	.3916	.3811	.6067	.6090	.3846	.3791	.3806	.5494	.5700	.7139	.2997	.3109	593
4	.7339	.6279	.1436	.4875	.4171	.6048	.5972	.4732	.3610	.3565	.5868	.5955	.4989	.3490	.3542	.5575	.5706	.9277	.2712	.2775	589
7/10	.5991	.4740	.0264	.5449	.4311	.4470	.4179	.0793	.4734	.4426	.4288	.4157	.0834	.4621	.4480	.3487	.3676	.1515	.4018	.4237	603
8	.6084	.4895	.0450	.5323	.4283	.4621	.4397	.1411	.4431	.4216	.4434	.4371	.1487	.4308	.4247	.3738	.3958	.2733	.3584	.3795	744
6	.5817	.4763	.0628	.5190	.4250	.4533	.4347	.2029	.4155	.3985	.4371	.4330	.2141	.4031	.3994	.3827	.3979	.3971	.3250	.3378	601
4	.5815	.4899	.0994	.4967	.4184	.4716	.4602	.3268	.3747	.3656	.4567	.4588	.3448	.3624	.3640	.4251	.4346	.6417	.2831	.2895	600
6/10	.5214	.4084	.0245	.5464	.4280	.3873	.3595	.0711	.4735	.4396	.3713	.3579	.0742	.4621	.4455	.3006	.3172	.1322	.4008	.4230	1422
8	.4912	.3887	.0342	.5374	.4252	.3713	.3457	.1060	.4512	.4201	.3569	.3443	.1114	.4393	.4237	.2978	.3084	.2037	.3677	.3808	749
6	.4721	.3770	.0425	.5295	.4229	.3611	.3392	.1352	.4322	.4059	.3468	.3373	.1425	.4196	.4081	.2971	.3068	.2629	.3428	.3540	750
4	.4011	.3376	.0596	.5024	.4229	.3218	.3149	.1952	.3869	.3786	.3116	.3141	.2060	.3747	.3777	.2843	.2946	.3833	.2955	.3062	605
5/8	.2999	.2379	.0166	.5409	.4292	.2266	.2099	.0507	.4651	.4308	.2191	.2099	.0532	.4544	.4353	.1795	.1844	.0966	.3898	.4005	612
6	.2966	.2360	.0269	.5301	.4218	.2267	.2121	.0853	.4325	.4047	.2177	.2109	.0898	.4199	.4069	.1864	.1918	.1654	.3428	.3529	743
4	.2719	.2236	.0331	.5143	.4230	.2145	.2048	.1077	.4070	.3885	.2078	.2045	.1137	.3951	.3888	.1841	.1878	.2111	.3159	.3221	610
4/4	.1819	.1467	.0171	.5262	.4243	.1413	.1318	.0548	.4309	.4019	.1372	.1320	.0577	.4198	.4037	.1174	.1181	.1063	.3435	.3455	613
3/2	.0915	.0755	.0130	.5084	.4195	.0730	.0696	.0421	.3953	.3768	.0709	.0696	.0443	.3836	.3765	.0638	.0644	.0820	.3035	.3064	933
2/2	.0650	.0537	.0124	.4956	.4098	.0529	.0505	.0410	.3664	.3496	.0511	.0502	.0432	.3538	.3474	.0483	.0479	.0803	.2739	.2711	934
Y 8/12	.7051	.6199	.0257	.5220	.4589	.5374	.5706	.0697	.4563	.4845	.5178	.5685	.0731	.4466	.4903	.4218	.5167	.1288	.3952	.4841	62
12	.6855	.5924	.0285	.5247	.4535	.5178	.5443	.0744	.4556	.4789	.4978	.5427	.0774	.4453	.4855	.4038	.4958	.1333	.3909	.4800	2054
10	.7190	.6269	.0343	.5209	.4542	.5474	.5784	.0959	.4481	.4734	.5265	.5760	.1004	.4377	.4789	.4328	.5281	.1780	.3800	.4638	857a
8	.7015	.6109	.0625	.5102	.4443	.5406	.5732	.1804	.4177	.4429	.5205	.5722	.1883	.4063	.4467	.4409	.5373	.3358	.3355	.4089	852
	.7093	.6177	.0617	.5108	.4448	.5457	.5794	.1770	.4191	.4450	.5253	.5783	.1847	.4078	.4489	.4438	.5429	.3284	.3375	.4128	852
6	.6938	.6110	.0904	.4973	.4379	.5539	.5784	.2874	.3902	.4074	.5357	.5769	.3025	.3785	.4077	.4798	.5459	.5572	.3031	.3449	58
6	.6633	.5858	.0901	.4953	.4374	.5305	.5566	.2834	.3871	.4061	.5136	.5558	.2978	.3757	.4065	.4602	.5273	.5459	.3001	.3439	1221
4	.6626	.5871	.1239	.4824	.4274	.5455	.5651	.4007	.3609	.3739	.5293	.5640	.4214	.3494	.3724	.4974	.5440	.7781	.2734	.2990	56
2	.6357	.5680	.1610	.4658	.4162	.5427	.5570	.5265	.3337	.3425	.5287	.5563	.5533	.3227	.3395	.5224	.5469	1.0233	.2496	.2614	54
7/10	.5248	.4558	.0258	.5215	.4530	.4018	.4189	.0738	.4492	.4683	.3881	.4183	.0775	.4391	.4733	.3192	.3802	.1387	.3809	.4536	904
8	.5161	.4557	.0272	.5166	.4562	.3975	.4220	.0786	.4426	.4698	.3842	.4211	.0825	.4327	.4743	.3180	.3848	.1482	.3737	.4522	70
6	.5124	.4455	.0500	.5084	.4420	.4014	.4158	.1549	.4129	.4278	.3882	.4153	.1628	.4018	.4298	.3354	.3861	.2974	.3292	.3789	390
4	.5079	.4479	.0856	.4877	.4301	.4143	.4282	.2756	.3706	.3830	.4022	.4278	.2901	.3591	.3820	.3720	.4091	.5357	.2825	.3107	388
2	.5054	.4546	.1250	.4658	.4190	.4326	.4454	.4113	.3356	.3454	.4225	.4453	.4334	.3247	.3422	.4172	.4361	.8053	.2515	.2630	387
6/8	.3880	.3410	.0220	.5167	.4540	.3009	.3145	.0649	.4423	.4623	.2922	.3151	.0681	.4327	.4665	.2424	.2858	.1228	.3723	.4390	903
	.3994	.3513	.0224	.5166	.4544	.3095	.3242	.0658	.4425	.4635	.3006	.3247	.0690	.4329	.4678	.2490	.2948	.1240	.3729	.4414	903
6	.3954	.3429	.0298	.5148	.4465	.3055	.3179	.0888	.4289	.4464	.2951	.3177	.0933	.4180	.4499	.2487	.2932	.1686	.3501	.4126	1212
4	.3715	.3266	.0548	.4934	.4338	.3000	.3100	.1755	.3819	.3946	.2913	.3099	.1848	.3706	.3943	.2643	.2935	.3410	.2941	.3265	392
2	.3675	.3292	.0862	.4694	.4205	.3121	.3211	.2828	.3407	.3505	.3045	.3210	.2980	.3297	.3476	.2977	.3131	.5534	.2557	.2690	391
5/6	.2406	.2136	.0180	.5095	.4523	.1893	.1984	.0554	.4271	.4479	.1846	.1993	.0583	.4175	.4506	.1561	.1815	.1066	.3514	.4086	947
4	.2372	.2101	.0314	.4956	.4389	.1910	.1987	.0998	.3902	.4059	.1860	.1991	.1051	.3794	.4061	.1662	.1867	.1936	.3041	.3417	394
2	.2436	.2177	.0549	.4720	.4217	.2057	.2117	.1795	.3446	.3548	.2005	.2116	.1889	.3336	.3522	.1943	.2059	.3501	.2590	.2744	395
4/4	.1495	.1322	.0180	.4989	.4411	.1200	.1243	.0566	.3988	.4131	.1172	.1247	.0594	.3888	.4140	.1031	.1156	.1089	.3146	.3529	412
2	.1628	.1461	.0351	.4733	.4247	.1369	.1419	.1145	.3481	.3609	.1335	.1419	.1205	.3371	.3584	.1284	.1377	.2233	.2624	.2813	397
3/2	.0788	.0707	.0183	.4698	.4213	.0668	.0689	.0596	.3419	.3529	.0652	.0689	.0627	.3312	.3502	.0634	.0671	.1161	.2570	.2723	398
2/2	.0557	.0489	.0117	.4793	.4204	.0461	.0472	.0374	.3528	.3610	.0449	.0472	.0392	.3420	.3593	.0425	.0456	.0721	.2653	.2849	858

TABLE II.—*Continued.*

Munsell notation	For ICI Illuminant A X	Y	Z	x	y	For ICI Illuminant C X	Y	Z	x	y	For Illuminant D X	Y	Z	x	y	For Illuminant S X	Y	Z	x	y	Munsell painting number
10Y 8/8	.6737	.6292	.0563	.4956	.4629	.5283	.6035	.1587	.4094	.4676	.5113	.6037	.1656	.3993	.4714	.4340	.5727	.2932	.3339	.4406	599
6	.6619	.6171	.0971	.4810	.4485	.5380	.5996	.3002	.3742	.4170	.5230	.6001	.3150	.3637	.4173	.4725	.5781	.5747	.2907	.3557	581
4	.6590	.6119	.1333	.4693	.4358	.5541	.5997	.4294	.3500	.3788	.5410	.6004	.4515	.3396	.3769	.5143	.5839	.8330	.2663	.3023	578
7/8	.4940	.4662	.0316	.4980	.4701	.3894	.4440	.0872	.4230	.4823	.3792	.4454	.0910	.4141	.4864	.3169	.4149	.1600	.3553	.4653	862
6	.4723	.4497	.0493	.4863	.4629	.3809	.4334	.1518	.3943	.4486	.3712	.4341	.1598	.3846	.4498	.3255	.4109	.2920	.3165	.3995	604
4	.4832	.4541	.0895	.4706	.4422	.4055	.4439	.2894	.3561	.3898	.3966	.4449	.3050	.3459	.3880	.3733	.4296	.5648	.2729	.3141	608
6/6	.3665	.3437	.0291	.4957	.4649	.2909	.3278	.0830	.4145	.4671	.2838	.3292	.0866	.4056	.4706	.2398	.3072	.1536	.3423	.4385	617
4	.3671	.3393	.0583	.4800	.4437	.3007	.3291	.1842	.3694	.4043	.2926	.3294	.1937	.3587	.4038	.2681	.3170	.3559	.2849	.3369	615
5/6	.2480	.2345	.0245	.4892	.4626	.1996	.2250	.0736	.4006	.4517	.1952	.2262	.0772	.3916	.4536	.1687	.2119	.1395	.3243	.4074	921
4	.2431	.2292	.0342	.4800	.4525	.1989	.2224	.1059	.3773	.4219	.1943	.2232	.1111	.3676	.4223	.1745	.2131	.2028	.2956	.3610	619
4/4	.1510	.1430	.0212	.4791	.4537	.1245	.1385	.0672	.3771	.4194	.1221	.1392	.0707	.3677	.4192	.1102	.1320	.1302	.2959	.3544	622
3/2	.0863	.0801	.0186	.4665	.4330	.0730	.0788	.0598	.3449	.3726	.0713	.0789	.0627	.3348	.3706	.0683	.0772	.1154	.2617	.2959	935
2/2	.0535	.0493	.0119	.4666	.4299	.0453	.0484	.0382	.3431	.3672	.0443	.0485	.0401	.3331	.3653	.0424	.0473	.0737	.2597	.2897	939
GY 8/8	.5994	.6050	.0728	.4693	.4737	.4857	.6022	.2046	.3758	.4659	.4731	.6045	.2130	.3666	.4684	.4139	.5903	.3753	.3000	.4279	432
6	.6046	.5941	.1017	.4650	.4568	.4977	.5929	.3048	.3567	.4249	.4847	.5944	.3186	.3468	.4253	.4422	.5858	.5741	.2760	.3657	433
4	.6293	.6035	.1436	.4572	.4384	.5341	.6041	.4522	.3358	.3799	.5215	.6052	.4740	.3258	.3781	.5015	.6008	.8675	.2546	.3050	434
2	.6266	.5850	.1727	.4527	.4226	.5451	.5851	.5606	.3224	.3461	.5333	.5856	.5891	.3123	.3429	.5341	.5833	1.0881	.2422	.2645	435
7/10	.4121	.4295	.0355	.4699	.4897	.3344	.4263	.0961	.3903	.4975	.3270	.4282	.1002	.3822	.5006	.2800	.4128	.1749	.3227	.4757	908
8	.4413	.4524	.0540	.4657	.4774	.3606	.4512	.1555	.3728	.4665	.3519	.4529	.1624	.3639	.4683	.3104	.4419	.2892	.2981	.4243	442
6	.4507	.4518	.0689	.4640	.4651	.3716	.4509	.2057	.3614	.4386	.3625	.4524	.2151	.3519	.4393	.3279	.4439	.3874	.2829	.3829	441
4	.4523	.4372	.0964	.4588	.4434	.3822	.4369	.3023	.3408	.3896	.3733	.4379	.3170	.3309	.3882	.3552	.4330	.5796	.2597	.3166	439
2	.4539	.4260	.1224	.4528	.4250	.3944	.4261	.3970	.3239	.3500	.3860	.4266	.4173	.3138	.3469	.3851	.4244	.7711	.2436	.2685	437
6/8	.3183	.3257	.0380	.4667	.4776	.2612	.3238	.1104	.3756	.4657	.2554	.3253	.1153	.3669	.4674	.2251	.3154	.2059	.3016	.4226	715
6	.3113	.3210	.0403	.4629	.4772	.2576	.3200	.1216	.3685	.4577	.2519	.3211	.1277	.3596	.4582	.2261	.3126	.2317	.2935	.4058	446
4	.3296	.3223	.0644	.4601	.4500	.2772	.3217	.2013	.3464	.4020	.2708	.3225	.2113	.3366	.4009	.2549	.3178	.3865	.2657	.3313	445
2	.3443	.3247	.0906	.4533	.4274	.2991	.3245	.2949	.3257	.3533	.2928	.3249	.3104	.3155	.3501	.2917	.3226	.5747	.2453	.2714	444
5/8	.1948	.2096	.0208	.4582	.4929	.1621	.2100	.0612	.3742	.4846	.1593	.2110	.0643	.3666	.4856	.1405	.2041	.1158	.3053	.4432	450
6	.1990	.2062	.0298	.4575	.4741	.1669	.2066	.0915	.3589	.4443	.1636	.2075	.0962	.3501	.4440	.1495	.2028	.1757	.2832	.3842	720
4	.2078	.2074	.0379	.4587	.4576	.1756	.2070	.1196	.3497	.4121	.1720	.2077	.1259	.3403	.4108	.1613	.2035	.2314	.2705	.3414	449
2	.2201	.2098	.0555	.4535	.4323	.1908	.2097	.1804	.3284	.3611	.1868	.2101	.1900	.3184	.3580	.1849	.2083	.3520	.2481	.2795	448
4/6	.1219	.1248	.0202	.4568	.4677	.1031	.1249	.0626	.3547	.4298	.1013	.1256	.0658	.3462	.4292	.0934	.1224	.1202	.2780	.3642	907
4	.1307	.1311	.0257	.4546	.4560	.1117	.1313	.0814	.3442	.4048	.1098	.1320	.0856	.3353	.4031	.1038	.1293	.1575	.2658	.3311	460
2	.1413	.1354	.0362	.4515	.4327	.1229	.1357	.1176	.3266	.3607	.1204	.1360	.1238	.3168	.3577	.1193	.1349	.2289	.2470	.2792	459
3/4	.0742	.0737	.0158	.4531	.4505	.0638	.0739	.0501	.3399	.3935	.0628	.0743	.0525	.3312	.3918	.0598	.0727	.0962	.2614	.3178	766
2	.0780	.0749	.0187	.4543	.4367	.0673	.0748	.0604	.3323	.3694	.0660	.0750	.0636	.3224	.3668	.0646	.0741	.1175	.2520	.2892	462
2/2	.0466	.0457	.0115	.4489	.4399	.0402	.0461	.0363	.3278	.3762	.0394	.0463	.0379	.3188	.3746	.0382	.0460	.0690	.2491	.3004	859
10GY 8/6	.5302	.5600	.1396	.4312	.4554	.4695	.5793	.4334	.3168	.3908	.4629	.5828	.4526	.3089	.3890	.4531	.5876	.8207	.2434	.3157	863
4	.5840	.6002	.1659	.4326	.4446	.5203	.6181	.5252	.3128	.3715	.5126	.6211	.5498	.3045	.3689	.5115	.6262	1.0049	.2387	.2923	611
7/8	.3503	.4147	.0810	.4141	.4902	.3115	.4399	.2359	.3155	.4455	.3085	.4439	.2447	.3094	.4452	.2922	.4520	.4332	.2482	.3839	635
6	.3861	.4298	.0963	.4233	.4712	.3409	.4507	.2948	.3138	.4149	.3360	.4536	.3090	.3059	.4129	.3275	.4623	.5618	.2423	.3420	616
4	.4241	.4433	.1173	.4307	.4502	.3793	.4571	.3761	.3128	.3770	.3741	.4594	.3956	.3044	.3738	.3752	.4628	.7297	.2393	.2952	614
6/10	.2321	.2845	.0459	.4125	.5058	.2037	.3032	.1284	.3207	.4772	.2015	.3060	.1331	.3145	.4777	.1866	.3125	.2327	.2550	.4271	634
8	.2597	.3049	.0558	.4186	.4914	.2273	.3224	.1594	.3206	.4548	.2243	.3250	.1649	.3141	.4550	.2095	.3309	.2898	.2524	.3986	751
6	.2604	.3000	.0618	.4185	.4822	.2301	.3168	.1861	.3139	.4322	.2270	.3190	.1948	.3064	.4306	.2191	.3260	.3522	.2442	.3633	624
4	.2738	.2969	.0773	.4225	.4582	.2461	.3101	.2438	.3076	.3876	.2431	.3120	.2561	.2997	.3846	.2436	.3172	.4704	.2362	.3076	621
5/8	.1421	.1785	.0288	.4068	.5107	.1260	.1910	.0833	.3147	.4772	.1244	.1925	.0869	.3081	.4768	.1175	.1978	.1544	.2501	.4211	881
6	.1699	.2016	.0371	.4158	.4935	.1490	.2141	.1081	.3161	.4544	.1469	.2158	.1129	.3089	.4538	.1392	.2212	.2017	.2476	.3935	628
4	.1796	.1943	.0476	.4260	.4610	.1595	.2025	.1487	.3123	.3966	.1573	.2037	.1560	.3042	.3941	.1554	.2069	.2853	.2400	.3195	626
4/6	.1074	.1268	.0271	.4109	.4852	.0954	.1355	.0803	.3066	.4354	.0941	.1365	.0837	.2994	.4343	.0911	.1408	.1500	.2385	.3688	727
4	.1128	.1264	.0323	.4154	.4656	.1016	.1337	.1002	.3028	.3985	.1003	.1345	.1050	.2951	.3959	.1003	.1382	.1917	.2331	.3213	630
3/4	.0612	.0709	.0161	.4127	.4786	.0544	.0756	.0483	.3050	.4240	.0536	.0761	.0504	.2975	.4227	.0523	.0785	.0905	.2362	.3546	633
2/2	.0411	.0425	.0119	.4307	.4447	.0364	.0440	.0375	.3087	.3731	.0357	.0442	.0393	.2998	.3707	.0358	.0450	.0717	.2347	.2949	937
G 8/6	.4751	.5243	.1810	.4025	.4442	.4479	.5595	.5677	.2844	.3552	.4443	.5635	.5906	.2780	.3526	.4632	.5826	1.0682	.2191	.2756	214
4	.5440	.5626	.1912	.4192	.4335	.5003	.5881	.6123	.2942	.3458	.4939	.5909	.6409	.2862	.3424	.5139	.6052	1.1743	.2241	.2639	753
2	.5584	.5537	.1868	.4299	.4263	.5075	.5694	.6053	.3017	.3385	.5001	.5714	.6345	.2931	.3349	.5177	.5789	1.1675	.2287	.2557	212
7/6	.3433	.4019	.1402	.3878	.4539	.3286	.4381	.4328	.2739	.3652	.3264	.4418	.4496	.2681	.3628	.3431	.4639	.8087	.2124	.2871	755
4	.3703	.4072	.1403	.4035	.4436	.3491	.4340	.4431	.2847	.3540	.3462	.4370	.4621	.2780	.3509	.3624	.4518	.8400	.2191	.2731	184
2	.4095	.4095	.1424	.4260	.4259	.3755	.4231	.4626	.2977	.3355	.3705	.4248	.4853	.2894	.3317	.3870	.4317	.8945	.2259	.2520	182
6/6	.2084	.2707	.0925	.3645	.4736	.2043	.3040	.2765	.2604	.3873	.2037	.3070	.2858	.2557	.3855	.2146	.3283	.5070	.2044	.3127	206
4	.2587	.2929	.0997	.3972	.4497	.2453	.3151	.3128	.2809	.3609	.2436	.3175	.3262	.2745	.3578	.2554	.3301	.5917	.2169	.2804	204
2	.2834	.2909	.1001	.4203	.4314	.2614	.3032	.3237	.2943	.3413	.2584	.3046	.3398	.2862	.3374	.2707	.3112	.6267	.2240	.2575	202

TABLE II.—*Continued.*

Munsell notation	For ICI Illuminant *A* X	Y	Z	x	y	For ICI Illuminant *C* X	Y	Z	x	y	For Illuminant *D* X	Y	Z	x	y	For Illuminant *S* X	Y	Z	x	y	Munsell painting number
G 5/8	.1158	.1631	.0528	.3492	.4916	.1134	.1875	.1521	.2503	.4139	.1128	.1896	.1568	.2457	.4128	.1182	.2067	.2747	.1972	.3447	1260
6	.1298	.1666	.0541	.3703	.4755	.1244	.1869	.1626	.2626	.3943	.1235	.1886	.1694	.2565	.3917	.1304	.2029	.3044	.2045	.3182	756
4	.1450	.1708	.0551	.3910	.4605	.1376	.1856	.1717	.2781	.3749	.1367	.1871	.1796	.2715	.3717	.1435	.1960	.3267	.2153	.2942	174
2	.1749	.1807	.0623	.4184	.4324	.1618	.1888	.2017	.2929	.3419	.1600	.1898	.2119	.2849	.3378	.1681	.1942	.3913	.2230	.2577	172
4/4	.0958	.1170	.0383	.3816	.4660	.0914	.1291	.1183	.2698	.3810	.0908	.1302	.1240	.2633	.3774	.0964	.1383	.2261	.2092	.3002	194
2	.1154	.1218	.0417	.4138	.4368	.1073	.1282	.1343	.2902	.3467	.1062	.1289	.1411	.2823	.3426	.1118	.1325	.2604	.2215	.2625	192
3/4	.0581	.0722	.0226	.3799	.4723	.0545	.0803	.0682	.2685	.3956	.0539	.0810	.0712	.2615	.3931	.0563	.0869	.1281	.2077	.3202	1264
2	.0608	.0661	.0222	.4080	.4432	.0564	.0703	.0706	.2859	.3565	.0557	.0707	.0741	.2779	.3527	.0586	.0735	.1361	.2184	.2741	188
2/2	.0329	.0348	.0126	.4097	.4332	.0300	.0373	.0396	.2805	.3487	.0293	.0374	.0414	.2714	.3457	.0310	.0395	.0753	.2123	.2711	752
10G 8/2	.5883	.5799	.1993	.4302	.4241	.5340	.5965	.6447	.3008	.3360	.5257	.5984	.6754	.2921	.3326	.5448	.6075	1.2407	.2277	.2539	938
7/4	.4088	.4389	.1629	.4045	.4344	.3864	.4672	.5197	.2813	.3402	.3825	.4699	.5429	.2741	.3368	.4067	.4879	.9906	.2157	.2588	627
6/6	.2669	.3193	.1259	.3748	.4483	.2623	.3538	.3901	.2607	.3517	.2608	.3568	.4051	.2551	.3488	.2825	.3805	.7290	.2029	.2733	757
4	.2810	.3179	.1237	.3889	.4400	.2720	.3458	.3935	.2690	.3420	.2700	.3480	.4118	.2622	.3379	.2938	.3674	.7534	.2077	.2597	625
5/6	.1285	.1738	.0743	.3413	.4615	.1315	.2013	.2210	.2375	.3635	.1311	.2034	.2277	.2331	.3619	.1446	.2239	.4017	.1878	.2907	644
4	.1597	.1864	.0727	.3814	.4450	.1563	.2047	.2302	.2644	.3463	.1555	.2063	.2409	.2580	.3423	.1701	.2191	.4405	.2050	.2641	643
4/4	.0941	.1149	.0457	.3696	.4510	.0933	.1283	.1429	.2560	.3520	.0929	.1294	.1493	.2500	.3483	.1025	.1392	.2715	.1997	.2713	646
3/4	.0521	.0660	.0275	.3577	.4533	.0516	.0754	.0838	.2447	.3577	.0512	.0761	.0873	.2386	.3547	.0569	.0837	.1572	.1909	.2811	649
2/2	.0326	.0369	.0148	.3864	.4378	.0311	.0407	.0463	.2632	.3445	.0307	.0409	.0483	.2557	.3411	.0334	.0439	.0879	.2021	.2659	939
BG 8/2	.5955	.5887	.2146	.4257	.4208	.5473	.6082	.6981	.2953	.3281	.5394	.6101	.7318	.2867	.3243	.5673	.6219	1.3470	.2237	.2452	1107
7/4	.4169	.4367	.1736	.4058	.4251	.3963	.4634	.5613	.2789	.3261	.3924	.4657	.5880	.2713	.3221	.4240	.4839	1.0803	.2133	.2434	454
2	.4559	.4549	.1716	.4212	.4203	.4224	.4729	.5575	.2908	.3255	.4167	.4746	.5841	.2824	.3217	.4416	.4863	1.0742	.2206	.2429	768
6/6	.2738	.3143	.1406	.3757	.4313	.2731	.3473	.4458	.2561	.3257	.2716	.3498	.4650	.2500	.3220	.3034	.3743	.8460	.1991	.2456	910
4	.2868	.3156	.1344	.3893	.4284	.2801	.3425	.4304	.2660	.3253	.2781	.3447	.4501	.2592	.3213	.3066	.3640	.8238	.2052	.2436	457
2	.3223	.3267	.1280	.4148	.4205	.3015	.3429	.4150	.2846	.3237	.2976	.3443	.4350	.2764	.3197	.3190	.3558	.8004	.2163	.2412	769
5/6	.1397	.1803	.0915	.3396	.4382	.1472	.2097	.2837	.2298	.3273	.1471	.2117	.2955	.2248	.3236	.1719	.2354	.5351	.1824	.2498	1115
4	.1667	.1908	.0874	.3747	.4289	.1667	.2112	.2773	.2545	.3224	.1659	.2128	.2893	.2483	.3185	.1862	.2281	.5270	.1978	.2423	476
2	.1875	.1958	.0781	.4064	.4243	.1782	.2077	.2538	.2785	.3247	.1764	.2087	.2664	.2707	.3204	.1915	.2171	.4918	.2127	.2411	767
4/6	.0868	.1147	.0634	.3278	.4328	.0934	.1354	.1937	.2211	.3205	.0933	.1368	.2003	.2168	.3179	.1098	.1538	.3574	.1769	.2476	478
4	.1087	.1267	.0591	.3690	.4303	.1100	.1413	.1876	.2506	.3218	.1096	.1423	.1958	.2447	.3179	.1240	.1533	.3566	.1957	.2418	480
2	.1221	.1291	.0539	.4002	.4230	.1171	.1382	.1742	.2727	.3217	.1160	.1389	.1826	.2652	.3175	.1270	.1456	.3358	.2088	.2393	770
3/6	.0482	.0640	.0380	.3209	.4262	.0525	.0767	.1165	.2135	.3123	.0524	.0775	.1210	.2088	.3090	.0635	.0886	.2179	.1716	.2394	773
4	.0515	.0624	.0321	.3528	.4273	.0528	.0716	.0997	.2357	.3196	.0525	.0722	.1037	.2299	.3161	.0607	.0800	.1876	.1850	.2437	486
2	.0602	.0665	.0298	.3848	.4249	.0591	.0727	.0953	.2602	.3202	.0586	.0731	.0998	.2532	.3158	.0656	.0780	.1831	.2008	.2388	771
2/4	.0296	.0344	.0180	.3610	.4198	.0293	.0395	.0550	.2367	.3190	.0289	.0398	.0572	.2299	.3159	.0331	.0444	.1030	.1834	.2462	488
2	.0323	.0347	.0155	.3912	.4204	.0308	.0379	.0492	.2613	.3216	.0304	.0381	.0514	.2533	.3178	.0336	.0410	.0939	.1996	.2432	772
10BG 8/2	.6173	.6057	.2293	.4251	.4171	.5695	.6258	.7475	.2931	.3221	.5614	.6277	.7834	.2846	.3182	.5940	.6406	1.4423	.2219	.2393	940
7/4	.4052	.4256	.1892	.3972	.4173	.3953	.4555	.6179	.2692	.3102	.3924	.4579	.6481	.2619	.3056	.4366	.4795	1.1954	.2068	.2271	645
6/6	.2518	.2983	.1589	.3552	.4208	.2653	.3375	.5073	.2390	.3041	.2651	.3402	.5289	.2337	.3000	.3102	.3706	.9631	.1887	.2254	648
4	.2795	.3045	.1431	.3844	.4188	.2792	.3316	.4650	.2595	.3083	.2778	.3337	.4873	.2528	.3037	.3145	.3538	.8973	.2009	.2260	631
5/6	.1453	.1832	.1174	.3260	.4108	.1627	.2160	.3699	.2173	.2886	.1631	.2180	.3846	.2130	.2847	.2004	.2454	.6967	.1754	.2148	658
4	.1644	.1853	.0957	.3692	.4160	.1691	.2062	.3096	.2469	.3010	.1688	.2076	.3246	.2407	.2962	.1965	.2241	.5977	.1930	.2201	651
4/6	.0891	.1135	.0730	.3233	.4118	.0992	.1349	.2276	.2149	.2922	.0993	.1361	.2361	.2105	.2887	.1216	.1543	.4256	.1733	.2199	662
4	.0991	.1146	.0603	.3617	.4183	.1027	.1290	.1933	.2416	.3036	.1025	.1300	.2023	.2357	.2991	.1200	.1417	.3715	.1895	.2238	660
3/6	.0427	.0584	.0446	.2930	.4006	.0503	.0727	.1365	.1940	.2801	.0505	.0735	.1412	.1903	.2773	.0648	.0864	.2527	.1604	.2139	668
4	.0553	.0669	.0405	.3399	.4111	.0595	.0778	.1276	.2246	.2937	.0594	.0784	.1329	.2195	.2897	.0717	.0878	.2414	.1788	.2190	665
2/2	.0355	.0403	.0211	.3667	.4159	.0357	.0455	.0663	.2421	.3086	.0354	.0459	.0692	.2353	.3047	.0409	.0505	.1261	.1880	.2321	941
B 8/4	.5768	.5749	.2457	.4128	.4114	.5481	.6025	.8080	.2798	.3076	.5419	.6046	.8484	.2716	.3031	.5934	.6252	1.5691	.2129	.2243	464
2	.6151	.5973	.2424	.4228	.4106	.5735	.6179	.7989	.2882	.3105	.5657	.6195	.8393	.2794	.3060	.6100	.6346	1.5540	.2180	.2268	797
7/6	.3851	.4085	.2067	.3850	.4084	.3877	.4436	.6773	.2570	.2941	.3857	.4460	.7103	.2502	.2892	.4433	.4737	1.3110	.1990	.2126	911
4	.4159	.4283	.2011	.3979	.4097	.4077	.4575	.6605	.2672	.2998	.4045	.4595	.6932	.2598	.2951	.4548	.4819	1.2809	.2051	.2173	467
2	.4654	.4546	.1863	.4207	.4109	.4354	.4718	.6134	.2864	.3103	.4297	.4731	.6444	.2777	.3058	.4647	.4858	1.1930	.2168	.2266	775
6/6	.2370	.2739	.1726	.3467	.4008	.2595	.3128	.5595	.2293	.2764	.2600	.3152	.5849	.2241	.2717	.3177	.3473	1.0730	.1828	.1998	469
4	.2811	.2981	.1575	.3816	.4046	.2861	.3250	.5174	.2535	.2880	.2849	.3268	.5428	.2468	.2831	.3310	.3483	1.0028	.1968	.2071	470
2	.3096	.3074	.1401	.4089	.4060	.2980	.3234	.4637	.2747	.2981	.2951	.3245	.4876	.2665	.2931	.3287	.3371	.9048	.2093	.2147	798
5/6	.1331	.1632	.1212	.3187	.3910	.1553	.1940	.3881	.2106	.2631	.1562	.1957	.4046	.2065	.2587	.1996	.2222	.7385	.1720	.1915	1276
4	.1539	.1737	.1057	.3552	.4008	.1662	.1959	.3455	.2349	.2768	.1664	.1972	.3617	.2294	.2719	.2015	.2153	.6658	.1862	.1989	114
2	.1793	.1807	.0858	.4023	.4053	.1749	.1917	.2831	.2692	.2951	.1733	.1925	.2971	.2615	.2904	.1947	.2012	.5493	.2060	.2129	112
4/8	.0760	.0949	.0865	.2953	.3688	.0946	.1172	.2747	.1945	.2409	.0954	.1183	.2855	.1911	.2370	.1276	.1383	.5183	.1627	.1764	1273
8	.0735	.0906	.0823	.2983	.3677	.0900	.1119	.2610	.1945	.2418	.0907	.1131	.2710	.1910	.2382	.1206	.1328	.4908	.1620	.1785	2052
6	.0868	.1067	.0877	.3087	.3795	.1045	.1287	.2806	.2033	.2506	.1052	.1299	.2921	.1995	.2464	.1375	.1493	.5322	.1679	.1823	776
4	.1163	.1278	.0805	.3583	.3937	.1237	.1447	.2621	.2331	.2728	.1236	.1457	.2749	.2271	.2677	.1505	.1606	.5076	.1838	.1962	914

TABLE II.—*Continued.*

Munsell notation		For ICI Illuminant *A*					For ICI Illuminant *C*					For Illuminant *D*					For Illuminant *S*					Munsell painting number
		X	*Y*	*Z*	*x*	*y*	*X*	*Y*	*Z*	*x*	*y*	*X*	*Y*	*Z*	*x*	*y*	*X*	*Y*	*Z*	*x*	*y*	
B	4/2	.1250	.1282	.0624	.3961	.4061	.1231	.1374	.2057	.2640	.2947	.1221	.1380	.2162	.2564	.2897	.1388	.1455	.4007	.2026	.2124	777
	3/6	.0509	.0644	.0586	.2927	.3704	.0626	.0802	.1830	.1920	.2463	.0628	.0809	.1894	.1886	.2430	.0833	.0954	.3411	.1603	.1835	494
	4	.0510	.0599	.0425	.3326	.3904	.0574	.0700	.1363	.2177	.2656	.0576	.0706	.1422	.2129	.2612	.0722	.0795	.2600	.1755	.1931	495
	2	.0627	.0658	.0346	.3844	.4036	.0635	.0715	.1140	.2551	.2872	.0633	.0719	.1199	.2481	.2819	.0736	.0765	.2227	.1975	.2053	496
	2/2	.0335	.0349	.0180	.3877	.4038	.0330	.0381	.0583	.2552	.2946	.0326	.0383	.0611	.2474	.2900	.0374	.0412	.1124	.1960	.2157	779
10B	8/2	.6610	.6302	.2745	.4222	.4025	.6208	.6514	.9106	.2844	.2984	.6122	.6526	.9575	.2755	.2937	.6699	.6706	1.7770	.2149	.2151	942
	7/6	.4053	.4205	.2348	.3821	.3965	.4150	.4576	.7761	.2517	.2776	.4133	.4599	.8145	.2449	.2725	.4851	.4906	1.5072	.1954	.1976	673
	4	.4285	.4267	.2092	.4026	.4009	.4186	.4526	.6921	.2678	.2895	.4148	.4542	.7271	.2599	.2846	.4693	.4757	1.3474	.2047	.2075	780
	6/6	.2806	.2995	.1824	.3680	.3928	.2969	.3320	.6015	.2413	.2699	.2965	.3339	.6310	.2351	.2647	.3571	.3612	1.1668	.1894	.1916	675
	4	.3127	.3173	.1699	.3909	.3967	.3140	.3415	.5626	.2578	.2804	.3120	.3430	.5910	.2504	.2753	.3618	.3635	1.0954	.1987	.1996	781
	5/6	.1714	.1877	.1316	.3493	.3825	.1907	.2132	.4344	.2275	.2543	.1913	.2146	.4555	.2221	.2491	.2397	.2366	.8423	.1818	.1794	670
	4	.1894	.1959	.1131	.3800	.3930	.1963	.2134	.3768	.2495	.2714	.1957	.2145	.3964	.2427	.2659	.2329	.2292	.7371	.1942	.1911	640
	4/8	.0903	.1064	.1009	.3035	.3575	.1131	.1292	.3271	.1986	.2270	.1141	.1303	.3410	.1949	.2226	.1539	.1510	.6239	.1658	.1626	669
	6	.1022	.1132	.0924	.3321	.3677	.1196	.1316	.3051	.2150	.2366	.1204	.1326	.3196	.2103	.2315	.1567	.1491	.5901	.1749	.1664	782
	4	.1142	.1185	.0715	.3753	.3895	.1198	.1299	.2384	.2454	.2661	.1196	.1305	.2509	.2387	.2605	.1440	.1402	.4668	.1918	.1867	652
	3/8	.0506	.0630	.0750	.2684	.3340	.0697	.0812	.2382	.1790	.2088	.0704	.0820	.2467	.1765	.2054	.0997	.0990	.4454	.1547	.1537	661
	6	.0547	.0632	.0598	.3081	.3555	.0673	.0765	.1929	.1998	.2273	.0677	.0771	.2009	.1959	.2230	.0907	.0894	.3669	.1659	.1635	659
	4	.0581	.0623	.0450	.3511	.3768	.0642	.0708	.1480	.2268	.2502	.0642	.0712	.1551	.2209	.2451	.0805	.0789	.2863	.1807	.1770	657
	2/2	.0326	.0345	.0237	.3594	.3797	.0349	.0390	.0773	.2311	.2577	.0348	.0392	.0810	.2248	.2528	.0429	.0434	.1493	.1822	.1841	943a
PB	8/2	.6675	.6223	.2709	.4277	.3987	.6218	.6380	.9034	.2875	.2949	.6122	.6386	.9509	.2781	.2900	.6686	.6535	1.7686	.2163	.2114	808
	7/6	.4482	.4311	.2329	.4030	.3876	.4430	.4556	.7802	.2639	.2714	.4390	.4567	.8211	.2557	.2660	.5074	.4794	1.5282	.2017	.1906	506
	4	.4800	.4551	.2232	.4144	.3929	.4614	.4743	.7466	.2743	.2819	.4559	.4751	.7860	.2655	.2767	.5138	.4930	1.4635	.2080	.1996	786
	2	.5079	.4771	.2097	.4251	.3994	.4757	.4907	.6988	.2857	.2947	.4688	.4914	.7354	.2765	.2898	.5137	.5037	1.3678	.2154	.2112	807
	6/8	.3097	.3055	.1926	.3834	.3782	.3214	.3310	.6461	.2475	.2549	.3200	.3322	.6798	.2403	.2494	.3860	.3558	1.2655	.1923	.1773	1307
	8	.3114	.3059	.2037	.3793	.3726	.3283	.3329	.6864	.2436	.2470	.3274	.3341	.7227	.2365	.2414	.4007	.3595	1.3476	.1901	.1706	513
	6	.3297	.3184	.1918	.3926	.3791	.3364	.3404	.6472	.2541	.2571	.3345	.3413	.6818	.2464	.2514	.3986	.3621	1.2727	.1960	.1781	512
	4	.3608	.3426	.1779	.4094	.3888	.3520	.3589	.5973	.2691	.2744	.3483	.3596	.6293	.2605	.2689	.3987	.3751	1.1736	.2048	.1926	787
	2	.3587	.3338	.1532	.4241	.3947	.3383	.3432	.5132	.2831	.2873	.3336	.3436	.5407	.2739	.2821	.3694	.3528	1.0078	.2135	.2039	784
	5/10	.1867	.1969	.1681	.3384	.3569	.2188	.2263	.5620	.2173	.2247	.2202	.2277	.5899	.2122	.2194	.2887	.2546	1.0945	.1763	.1554	1303
	8	.2056	.2094	.1598	.3577	.3643	.2293	.2345	.5378	.2289	.2341	.2299	.2356	.5659	.2229	.2284	.2929	.2587	1.0544	.1824	.1611	517
	6	.2090	.2063	.1347	.3800	.3751	.2202	.2241	.4551	.2448	.2492	.2198	.2250	.4797	.2377	.2434	.2687	.2414	.8965	.1910	.1717	516
	4	.2133	.2051	.1143	.4005	.3851	.2135	.2170	.3859	.2615	.2658	.2121	.2176	.4071	.2534	.2600	.2484	.2286	.7617	.2005	.1845	515
	2	.2137	.2013	.0973	.4171	.3929	.2052	.2087	.3277	.2767	.2814	.2029	.2090	.3457	.2678	.2759	.2287	.2159	.6464	.2096	.1979	785
	4/10	.1142	.1219	.1253	.3160	.3373	.1443	.1446	.4202	.2035	.2039	.1460	.1456	.4409	.1993	.1987	.2009	.1668	.8182	.1694	.1406	532
	8	.1173	.1211	.1065	.3401	.3511	.1384	.1387	.3597	.2174	.2178	.1395	.1395	.3784	.2122	.2122	.1846	.1558	.7053	.1766	.1490	522
	6	.1227	.1232	.0908	.3645	.3658	.1353	.1364	.3078	.2334	.2354	.1356	.1370	.3245	.2271	.2295	.1716	.1493	.6070	.1850	.1609	521
	4	.1313	.1268	.0762	.3927	.3794	.1344	.1355	.2583	.2544	.2565	.1338	.1358	.2727	.2467	.2505	.1600	.1439	.5109	.1964	.1766	520
	2	.1350	.1268	.0612	.4179	.3927	.1296	.1313	.2064	.2774	.2809	.1282	.1315	.2179	.2684	.2753	.1446	.1356	.4080	.2101	.1970	519
	3/12	.0574	.0627	.0907	.2725	.2974	.0832	.0802	.2983	.1803	.1737	.0847	.0808	.3109	.1778	.1697	.1246	.0977	.5700	.1573	.1233	537
	12	.0563	.0608	.0872	.2756	.2975	.0814	.0775	.2909	.1810	.1723	.0830	.0781	.3043	.1783	.1679	.1233	.0946	.5622	.1580	.1213	2053
	10	.0651	.0692	.0836	.2987	.3175	.0871	.0844	.2790	.1934	.1873	.0884	.0850	.2921	.1899	.1825	.1257	.0995	.5400	.1643	.1300	534
	8	.0621	.0649	.0686	.3175	.3319	.0786	.0768	.2306	.2036	.1990	.0796	.0773	.2421	.1994	.1938	.1099	.0886	.4500	.1695	.1366	532
	6	.0661	.0663	.0568	.3493	.3506	.0763	.0749	.1923	.2222	.2180	.0768	.0753	.2025	.2166	.2123	.1007	.0834	.3784	.1790	.1483	530
	4	.0659	.0643	.0441	.3779	.3689	.0703	.0699	.1500	.2422	.2409	.0702	.0701	.1583	.2352	.2348	.0871	.0755	.2968	.1896	.1643	528
	2	.0698	.0660	.0345	.4100	.3876	.0685	.0689	.1168	.2695	.2711	.0679	.0690	.1234	.2608	.2652	.0783	.0718	.2315	.2052	.1882	526
	2/6	.0326	.0337	.0377	.3138	.3238	.0412	.0405	.1251	.1993	.1959	.0416	.0407	.1310	.1950	.1910	.0577	.0475	.2421	.1662	.1367	804
	4	.0330	.0334	.0309	.3395	.3432	.0388	.0385	.1033	.2150	.2129	.0390	.0386	.1085	.2096	.2076	.0518	.0436	.2015	.1745	.1469	805
	2	.0342	.0329	.0204	.3906	.3759	.0352	.0353	.0689	.2523	.2530	.0350	.0353	.0726	.2447	.2473	.0419	.0376	.1356	.1950	.1747	806
	2	.0363	.0353	.0231	.3834	.3725	.0378	.0383	.0776	.2459	.2490	.0376	.0384	.0817	.2384	.2433	.0457	.0413	.1524	.1910	.1724	
10PB	8/2	.7035	.6393	.2801	.4335	.3940	.6498	.6499	.9357	.2907	.2907	.6384	.6496	.9846	.2809	.2858	.6949	.6625	1.8314	.2179	.2078	945
	7/6	.4889	.4300	.2155	.4309	.3791	.4598	.4365	.7316	.2825	.2681	.4519	.4357	.7717	.2723	.2626	.5077	.4463	1.4440	.2117	.1861	796
	4	.5023	.4454	.2019	.4369	.3875	.4634	.4498	.6798	.2909	.2824	.4547	.4491	.7163	.2807	.2772	.4982	.4571	1.3366	.2174	.1994	790
	6/8	.3680	.3132	.1952	.4199	.3574	.3623	.3200	.6768	.2666	.2354	.3577	.3190	.7165	.2567	.2290	.4253	.3310	1.3520	.2017	.1570	800
	6	.3587	.3100	.1751	.4251	.3673	.3447	.3161	.5988	.2737	.2509	.3392	.3152	.6322	.2637	.2450	.3920	.3258	1.1860	.2059	.1712	797a
	4	.3849	.3354	.1681	.4332	.3776	.3606	.3394	.5708	.2838	.2671	.3541	.3385	.6023	.2735	.2614	.3974	.3467	1.1278	.2123	.1852	791
	5/10	.2291	.1933	.1503	.4001	.3375	.2413	.2014	.5291	.2483	.2072	.2401	.2009	.5616	.2395	.2004	.3038	.2126	1.0662	.1920	.1344	803
	8	.2419	.2054	.1464	.4075	.3460	.2476	.2126	.5110	.2550	.2189	.2455	.2121	.5415	.2457	.2123	.3029	.2230	1.0244	.1954	.1439	801
	6	.2423	.2090	.1309	.4162	.3589	.2399	.2149	.4519	.2645	.2371	.2369	.2144	.4780	.2549	.2307	.2822	.2235	.9006	.2007	.1589	798a
	4	.2467	.2144	.1167	.4270	.3711	.2363	.2180	.3999	.2766	.2553	.2327	.2175	.4227	.2666	.2492	.2675	.2238	.7948	.2080	.1740	792
	4/10	.1439	.1174	.1035	.3944	.3217	.1563	.1224	.3688	.2414	.1890	.1560	.1220	.3923	.2327	.1820	.2038	.1300	.7483	.1884	.1201	696
	8	.1490	.1241	.0996	.3998	.3329	.1578	.1291	.3517	.2470	.2021	.1570	.1287	.3736	.2381	.1952	.2001	.1364	.7103	.1912	.1303	802
	6	.1512	.1281	.0890	.4106	.3479	.1535	.1321	.3104	.2576	.2217	.1520	.1317	.3290	.2481	.2150	.1863	.1381	.6227	.1967	.1458	799

TABLE II.—*Continued.*

Munsell notation	For ICI Illuminant *A*					For ICI Illuminant *C*					For Illuminant *D*					For Illuminant *S*					Munsell painting number
	X	*Y*	*Z*	*x*	*y*	*X*	*Y*	*Z*	*x*	*y*	*X*	*Y*	*Z*	*x*	*y*	*X*	*Y*	*Z*	*x*	*y*	
10PB 4/4	.1468	.1264	.0732	.4239	.3649	.1426	.1288	.2526	.2721	.2458	.1406	.1285	.2674	.2620	.2395	.1644	.1326	.5046	.2051	.1655	793
3/10	.0868	.0659	.0777	.3769	.2859	.1031	.0693	.2843	.2258	.1517	.1039	.0690	.3041	.2179	.1446	.1465	.0750	.5864	.1813	.0929	864
8	.0874	.0703	.0599	.4019	.3230	.0936	.0724	.2143	.2461	.1903	.0933	.0720	.2283	.2370	.1830	.1208	.0760	.4365	.1908	.1201	701
6	.0855	.0696	.0528	.4114	.3348	.0883	.0711	.1874	.2546	.2050	.0876	.0708	.1993	.2449	.1979	.1100	.0741	.3801	.1950	.1313	700
4	.0841	.0700	.0469	.4184	.3483	.0841	.0713	.1643	.2630	.2232	.0831	.0711	.1743	.2530	.2163	.1009	.0739	.3308	.1996	.1461	794
2/6	.0433	.0351	.0277	.4081	.3306	.0455	.0358	.0988	.2529	.1985	.0454	.0356	.1051	.2437	.1916	.0574	.0372	.2002	.1947	.1261	707
4	.0447	.0370	.0281	.4074	.3369	.0466	.0380	.0992	.2535	.2067	.0463	.0378	.1054	.2444	.1997	.0581	.0397	.2005	.1949	.1331	878
P 8/4	.7006	.5974	.2643	.4484	.3824	.6318	.5940	.8897	.2986	.2808	.6167	.5913	.9372	.2875	.2756	.6671	.5984	1.7480	.2214	.1986	284
2	.6706	.5915	.2313	.4490	.3961	.5992	.5897	.7723	.3055	.3007	.5858	.5884	.8133	.2947	.2960	.6193	.5918	1.5143	.2272	.2171	282
7/6	.5577	.4476	.2133	.4577	.3673	.4972	.4381	.7256	.2994	.2638	.4824	.4341	.7654	.2868	.2581	.5274	.4391	1.4333	.2198	.1830	1337
4	.5314	.4492	.2013	.4496	.3801	.4790	.4457	.6795	.2986	.2778	.4674	.4434	.7162	.2873	.2725	.5072	.4487	1.3380	.2211	.1956	274
2	.4740	.4129	.1685	.4491	.3912	.4256	.4108	.5658	.3035	.2930	.4161	.4096	.5964	.2926	.2880	.4441	.4123	1.1132	.2255	.2093	272
6/8	.4211	.3232	.1848	.4533	.3479	.3846	.3157	.6363	.2877	.2362	.3735	.3118	.6721	.2751	.2297	.4246	.3187	1.2633	.2116	.1588	268
8	.4344	.3328	.1800	.4587	.3513	.3921	.3227	.6218	.2934	.2414	.3802	.3187	.6575	.2803	.2350	.4276	.3233	1.2384	.2149	.1625	2057
6	.4044	.3230	.1693	.4510	.3602	.3681	.3179	.5788	.2910	.2514	.3582	.3150	.6111	.2789	.2453	.4009	.3211	1.1465	.2146	.1718	266
4	.3984	.3330	.1562	.4489	.3751	.3610	.3301	.5296	.2958	.2704	.3522	.3282	.5588	.2843	.2648	.3863	.3329	1.0460	.2188	.1886	264
2	.3764	.3257	.1368	.4487	.3882	.3391	.3238	.4610	.3017	.2881	.3315	.3227	.4863	.2907	.2830	.3563	.3253	.9092	.2240	.2045	262
5/10	.3004	.2129	.1422	.4583	.3248	.2768	.2039	.5008	.2820	.2078	.2680	.2002	.5310	.2683	.2003	.3156	.2049	1.0065	.2067	.1342	228
8	.2930	.2177	.1313	.4564	.3391	.2682	.2107	.4574	.2864	.2250	.2601	.2076	.4843	.2732	.2181	.2998	.2120	.9150	.2102	.1486	226
6	.2612	.2018	.1094	.4563	.3526	.2368	.1965	.3774	.2921	.2424	.2299	.1942	.3992	.2793	.2359	.2591	.1974	.7520	.2144	.1633	224
4	.2413	.1964	.0964	.4518	.3677	.2188	.1934	.3297	.2950	.2606	.2133	.1919	.3484	.2830	.2546	.2362	.1945	.6545	.2176	.1792	222
2	.2299	.1976	.0833	.4500	.3868	.2070	.1959	.2818	.3023	.2861	.2024	.1952	.2975	.2912	.2808	.2179	.1964	.5574	.2243	.2021	220
4/12	.2177	.1362	.1054	.4740	.2966	.1966	.1252	.3748	.2823	.1797	.1885	.1213	.3976	.2665	.1715	.2256	.1243	.7550	.2042	.1125	693
12	.2381	.1474	.1060	.4844	.2999	.2101	.1336	.3802	.2902	.1845	.2007	.1292	.4044	.2733	.1759	.2372	.1307	.7721	.2081	.1146	2058
10	.2027	.1373	.0930	.4681	.3171	.1832	.1292	.3276	.2863	.2019	.1763	.1261	.3471	.2714	.1942	.2065	.1289	.6577	.2079	.1298	250
8	.1851	.1339	.0829	.4605	.3332	.1704	.1278	.2954	.2871	.2153	.1655	.1258	.3146	.2732	.2076	.1938	.1270	.6011	.2102	.1377	816
6	.1700	.1282	.0721	.4590	.3463	.1539	.1240	.2503	.2914	.2348	.1492	.1223	.2649	.2781	.2281	.1694	.1243	.5001	.2134	.1566	246
4	.1668	.1322	.0654	.4578	.3628	.1496	.1289	.2240	.2977	.2566	.1453	.1277	.2367	.2851	.2505	.1605	.1291	.4449	.2186	.1758	244
2	.1481	.1262	.0545	.4506	.3837	.1337	.1248	.1850	.3015	.2814	.1308	.1243	.1955	.2903	.2759	.1416	.1250	.3670	.2235	.1973	242
3/10	.1360	.0843	.0687	.4706	.2918	.1263	.0769	.2514	.2779	.1692	.1221	.0746	.2686	.2624	.1603	.1506	.0756	.5174	.2025	.1017	1319
8	.1189	.0806	.0579	.4620	.3133	.1105	.0759	.2072	.2807	.1929	.1070	.0743	.2204	.2664	.1850	.1284	.0756	.4207	.2055	.1210	298
6	.1079	.0777	.0502	.4576	.3295	.0999	.0744	.1778	.2837	.2113	.0970	.0732	.1889	.2701	.2039	.1141	.0744	.3593	.2083	.1358	296
4	.0966	.0730	.0414	.4579	.3460	.0881	.0705	.1446	.2906	.2325	.0856	.0696	.1533	.2774	.2257	.0977	.0704	.2900	.2132	.1538	294
2	.0909	.0749	.0341	.4546	.3746	.0817	.0736	.1166	.3006	.2706	.0797	.0731	.1232	.2887	.2650	.0869	.0735	.2313	.2218	.1877	292
2/6	.0544	.0371	.0259	.4631	.3160	.0511	.0346	.0955	.2820	.1911	.0498	.0340	.1024	.2676	.1824	.0606	.0340	.1985	.2068	.1160	306
4	.0503	.0373	.0223	.4577	.3398	.0467	.0358	.0796	.2879	.2208	.0455	.0353	.0849	.2746	.2132	.0532	.0355	.1627	.2116	.1412	1313
4	.0551	.0410	.0248	.4558	.3393	.0515	.0394	.0885	.2869	.2196	.0502	.0389	.0944	.2738	.2119	.0590	.0392	.1808	.2113	.1405	2059
2	.0460	.0363	.0184	.4569	.3599	.0422	.0351	.0650	.2966	.2466	.0412	.0348	.0691	.2843	.2397	.0465	.0347	.1316	.2186	.1632	877
2	.0503	.0390	.0208	.4564	.3544	.0460	.0378	.0733	.2930	.2406	.0450	.0374	.0779	.2804	.2335	.0511	.0376	.1483	.2157	.1587	2060
10P 8/4	.7343	.6280	.2446	.4570	.3908	.6490	.6182	.8230	.3105	.2958	.6327	.6158	.8677	.2990	.2910	.6667	.6146	1.6201	.2298	.2118	810
7/8	.6373	.4972	.1983	.4782	.3731	.5445	.4735	.6745	.3217	.2798	.5251	.4679	.7121	.3079	.2744	.5498	.4635	1.3347	.2342	.1974	1541
6	.5944	.4839	.1886	.4692	.3820	.5152	.4675	.6383	.3178	.2884	.4995	.4640	.6736	.3051	.2834	.5233	.4606	1.2607	.2331	.2052	1540
4	.5797	.4799	.1837	.4662	.3860	.5048	.4657	.6210	.3172	.2926	.4907	.4628	.6554	.3050	.2877	.5134	.4593	1.2268	.2334	.2088	1539
6/8	.4729	.3471	.1520	.4866	.3571	.4011	.3245	.5250	.3207	.2595	.3847	.3191	.5558	.3054	.2533	.4093	.3152	1.0485	.2309	.1778	1538
6	.4544	.3487	.1447	.4795	.3679	.3887	.3307	.4951	.3200	.2723	.3745	.3265	.5233	.3059	.2667	.3952	.3230	.9833	.2323	.1898	1537
4	.4220	.3372	.1332	.4729	.3779	.3637	.3238	.4515	.3193	.2843	.3518	.3209	.4764	.3062	.2792	.3683	.3179	.8916	.2334	.2015	1536
5/10	.3908	.2520	.1140	.5164	.3330	.3161	.2226	.3999	.3368	.2371	.2979	.2154	.4244	.3178	.2297	.3141	.2097	.8051	.2364	.1578	1535
8	.3559	.2406	.1052	.5072	.3429	.2905	.2174	.3644	.3331	.2492	.2751	.2116	.3858	.3153	.2425	.2886	.2075	.7286	.2356	.1694	1534
6	.3236	.2315	.0955	.4974	.3558	.2688	.2129	.3299	.3312	.2623	.2568	.2088	.3494	.3151	.2562	.2684	.2044	.6592	.2371	.1806	1533
4	.2985	.2277	.0904	.4841	.3693	.2534	.2143	.3098	.3259	.2757	.2441	.2116	.3274	.3117	.2702	.2549	.2079	.6154	.2364	.1928	1532
4/10	.2542	.1546	.0759	.5244	.3190	.2045	.1331	.2713	.3359	.2186	.1920	.1278	.2890	.3154	.2100	.2060	.1236	.5528	.2334	.1401	1531
8	.2419	.1581	.0734	.5110	.3340	.1983	.1406	.2589	.3317	.2352	.1878	.1364	.2752	.3133	.2276	.2003	.1330	.5238	.2337	.1551	1530
6	.2232	.1548	.0678	.5006	.3472	.1860	.1407	.2377	.3295	.2493	.1775	.1375	.2525	.3128	.2424	.1885	.1343	.4796	.2349	.1674	1529
4	.2031	.1525	.0627	.4855	.3646	.1730	.1428	.2170	.3247	.2680	.1668	.1408	.2299	.3102	.2620	.1759	.1381	.4342	.2350	.1846	1528
3/10	.1328	.0765	.0461	.5199	.2996	.1101	.0648	.1694	.3198	.1883	.1038	.0619	.1814	.2990	.1784	.1175	.0599	.3508	.2224	.1135	1527
8	.1331	.0810	.0431	.5175	.3149	.1095	.0700	.1560	.3265	.2087	.1034	.0674	.1666	.3065	.1996	.1139	.0652	.3205	.2279	.1306	1526
6	.1191	.0798	.0406	.4972	.3332	.1011	.0722	.1448	.3179	.2270	.0966	.0704	.1543	.3007	.2191	.1064	.0691	.2952	.2261	.1469	1525
4	.1117	.0795	.0354	.4927	.3510	.0948	.0731	.1245	.3242	.2500	.0910	.0718	.1324	.3084	.2430	.0977	.0702	.2524	.2325	.1670	1524
2/6	.0670	.0426	.0244	.4999	.3178	.0579	.0377	.0898	.3123	.2032	.0555	.0366	.0964	.2945	.1941	.0634	.0355	.1869	.2217	.1243	1523
4	.0601	.0407	.0216	.4910	.3327	.0521	.0370	.0779	.3119	.2215	.0501	.0362	.0834	.2954	.2133	.0563	.0354	.1606	.2230	.1404	723
RP 8/6	.7512	.6268	.2126	.4723	.3941	.6411	.6058	.7081	.3279	.3099	.6215	.6019	.7454	.3157	.3057	.6316	.5947	1.3862	.2418	.2276	1369
4	.7344	.6219	.2144	.4676	.3959	.6321	.6050	.7136	.3240	.3101	.6140	.6019	.7511	.3122	.3060	.6272	.5961	1.3963	.2394	.2276	1368
2	.7511	.6548	.2244	.4607	.4017	.6540	.6435	.7454	.3201	.3150	.6375	.6417	.7844	.3089	.3110	.6531	.6368	1.4572	.2377	.2318	1367

TABLE II.—*Continued.*

Munsell notation	For ICI Illuminant *A* X	Y	Z	x	y	For ICI Illuminant *C* X	Y	Z	x	y	For Illuminant *D* X	Y	Z	x	y	For Illuminant *S* X	Y	Z	x	y	Munsell painting number
RP 7/8	.6536	.5137	.1760	.4866	.3824	.5474	.4845	.5937	.3367	.2980	.5277	.4792	.6264	.3231	.2934	.5346	.4690	1.1712	.2458	.2157	1366
6	.6500	.5213	.1776	.4819	.3864	.5482	.4955	.5975	.3340	.3019	.5297	.4910	.6301	.3209	.2974	.5373	.4814	1.1771	.2447	.2192	1365
4	.6096	.5070	.1719	.4731	.3935	.5214	.4885	.5757	.3288	.3081	.5061	.4857	.6068	.3166	.3038	.5151	.4777	1.1319	.2424	.2248	1364
2	.5671	.4851	.1660	.4655	.3982	.4913	.4727	.5547	.3235	.3113	.4786	.4710	.5845	.3119	.3070	.4898	.4651	1.0893	.2396	.2275	1363
6/10	.5504	.3810	.1278	.5197	.3597	.4384	.3389	.4388	.3605	.2787	.4160	.3307	.4644	.3435	.2731	.4139	.3173	.8747	.2577	.1976	1362
8	.5213	.3715	.1229	.5132	.3658	.4186	.3349	.4197	.3568	.2855	.3987	.3282	.4438	.3406	.2804	.3963	.3152	.8344	.2563	.2039	575
6	.4803	.3622	.1202	.4989	.3762	.3951	.3345	.4084	.3472	.2939	.3794	.3298	.4316	.3326	.2891	.3805	.3192	.8102	.2520	.2114	1360
4	.4552	.3641	.1247	.4822	.3857	.3850	.3454	.4214	.3343	.2998	.3726	.3424	.4450	.3212	.2952	.3789	.3347	.8333	.2449	.2164	1359
2	.3851	.3263	.1133	.4670	.3957	.3337	.3169	.3799	.3238	.3075	.3250	.3156	.4006	.3121	.3031	.3335	.3112	.7476	.2395	.2235	1358
5/10	.4308	.2724	.0840	.5472	.3460	.3283	.2301	.2934	.3854	.2702	.3073	.2219	.3116	.3655	.2639	.2980	.2074	.5915	.2717	.1890	1357
8	.3813	.2537	.0824	.5316	.3536	.2984	.2206	.2858	.3708	.2741	.2818	.2143	.3031	.3525	.2682	.2778	.2029	.5739	.2634	.1924	1356
6	.3330	.2346	.0772	.5164	.3639	.2670	.2099	.2661	.3593	.2826	.2542	.2055	.2820	.3428	.2771	.2531	.1964	.5327	.2577	.1999	1355
4	.2968	.2271	.0768	.4941	.3780	.2470	.2110	.2623	.3429	.2929	.2379	.2084	.2776	.3287	.2879	.2406	.2017	.5222	.2494	.2091	1354
2	.2692	.2225	.0762	.4740	.3918	.2304	.2138	.2559	.3291	.3054	.2237	.2125	.2698	.3169	.3010	.2280	.2089	.5035	.2425	.2221	1353
4/12	.3037	.1734	.0573	.5683	.3245	.2231	.1396	.2029	.3945	.2467	.2050	.1322	.2158	.3707	.2390	.1985	.1220	.4114	.2712	.1667	1352
10	.2776	.1650	.0547	.5582	.3318	.2072	.1359	.1934	.3862	.2534	.1916	.1297	.2059	.3634	.2461	.1871	.1206	.3932	.2670	.1721	1351
8	.2503	.1577	.0530	.5429	.3421	.1921	.1341	.1873	.3742	.2612	.1796	.1294	.1995	.3532	.2544	.1778	.1212	.3812	.2612	.1782	1350
6	.2365	.1598	.0553	.5236	.3539	.1881	.1406	.1918	.3614	.2701	.1784	.1371	.2033	.3439	.2642	.1783	.1304	.3846	.2572	.1881	554
4	.2104	.1550	.0538	.5019	.3698	.1734	.1418	.1855	.3464	.2833	.1665	.1397	.1966	.3311	.2778	.1688	.1344	.3717	.2501	.1991	1348
2	.1847	.1509	.0528	.4755	.3886	.1582	.1445	.1785	.3288	.3003	.1536	.1435	.1885	.3163	.2955	.1575	.1408	.3531	.2418	.2161	1347
3/10	.1654	.0932	.0311	.5710	.3217	.1209	.0743	.1126	.3928	.2413	.1110	.0703	.1206	.3677	.2329	.1084	.0642	.2327	.2674	.1583	1346
8	.1445	.0858	.0288	.5576	.3312	.1082	.0706	.1033	.3836	.2502	.1003	.0674	.1103	.3607	.2425	.0987	.0623	.2120	.2646	.1671	1345
6	.1210	.0776	.0257	.5396	.3460	.0935	.0664	.0906	.3732	.2652	.0877	.0643	.0965	.3529	.2586	.0868	.0603	.1845	.2619	.1818	1344
4	.1087	.0757	.0257	.5174	.3602	.0873	.0675	.0895	.3573	.2762	.0831	.0660	.0952	.3401	.2702	.0835	.0629	.1809	.2552	.1923	1370
2	.0884	.0695	.0243	.4851	.3816	.0749	.0654	.0831	.3351	.2930	.0725	.0648	.0880	.3217	.2879	.0742	.0631	.1657	.2448	.2081	1343
2/6	.0843	.0520	.0199	.5397	.3328	.0656	.0440	.0721	.3609	.2421	.0615	.0424	.0773	.3395	.2339	.0630	.0397	.1493	.2500	.1576	1342
4	.0736	.0476	.0170	.5327	.3445	.0577	.0411	.0605	.3621	.2582	.0543	.0399	.0646	.3421	.2511	.0549	.0376	.1239	.2537	.1736	1341
2	.0565	.0420	.0145	.5002	.3715	.0465	.0386	.0499	.3442	.2859	.0445	.0380	.0529	.3287	.2806	.0452	.0367	.0999	.2484	.2018	1340
10RP 8/6	.7907	.6533	.2106	.4779	.3949	.6712	.6251	.7068	.3351	.3121	.6513	.6215	.7456	.3227	.3079	.6562	.6066	1.3929	.2471	.2284	853
4	.7438	.6301	.2084	.4701	.3982	.6378	.6107	.6948	.3282	.3143	.6198	.6079	.7320	.3163	.3102	.6287	.5987	1.3630	.2427	.2311	1392
7/8	.6363	.4810	.1415	.5055	.3821	.5152	.4412	.4777	.3593	.3077	.4941	.4354	.5045	.3445	.3036	.4830	.4169	.9452	.2618	.2259	1391
6	.6237	.4877	.1483	.4951	.3871	.5129	.4551	.4983	.3498	.3104	.4935	.4502	.5257	.3359	.3064	.4873	.4350	.9820	.2559	.2284	1390
4	.5697	.4632	.1458	.4833	.3930	.4789	.4397	.4896	.3401	.3122	.4639	.4368	.5166	.3273	.3082	.4639	.4244	.9653	.2503	.2290	1389
6/10	.5586	.3737	.0953	.5435	.3637	.4255	.3210	.3256	.3969	.2994	.4009	.3123	.3447	.3790	.2952	.3764	.2902	.6492	.2861	.2205	1388
8	.5182	.3668	.1004	.5259	.3722	.4066	.3248	.3414	.3790	.3027	.3867	.3183	.3612	.3627	.2986	.3703	.2998	.6792	.2745	.2222	1387
6	.4751	.3553	.1039	.5085	.3803	.3835	.3240	.3521	.3620	.3057	.3676	.3195	.3721	.3471	.3016	.3589	.3049	.6983	.2635	.2238	1386
4	.4356	.3451	.1083	.4900	.3882	.3627	.3239	.3652	.3448	.3080	.3504	.3212	.3855	.3315	.3039	.3491	.3107	.7215	.2527	.2249	1385
5/10	.4431	.2690	.0594	.5743	.3486	.3208	.2180	.2048	.4315	.2931	.2971	.2088	.2173	.4108	.2887	.2691	.1888	.4111	.3097	.2173	1384
8	.4005	.2540	.0591	.5612	.3560	.2966	.2111	.2040	.4168	.2966	.2771	.2039	.2165	.3973	.2923	.2549	.1856	.4103	.2996	.2182	1383
6	.3638	.2512	.0657	.5344	.3691	.2819	.2191	.2251	.3882	.3018	.2673	.2143	.2386	.3712	.2976	.2536	.1996	.4504	.2806	.2210	1382
4	.3229	.2463	.0717	.5038	.3843	.2634	.2260	.2435	.3594	.3083	.2537	.2235	.2576	.3452	.3042	.2484	.2130	.4843	.2627	.2252	1381
4/10	.2988	.1724	.0384	.5864	.3383	.2119	.1358	.1345	.4395	.2817	.1943	.1289	.1431	.4167	.2764	.1754	.1151	.2728	.3114	.2044	1380
8	.2649	.1625	.0402	.5665	.3475	.1948	.1332	.1400	.4163	.2846	.1810	.1278	.1488	.3955	.2793	.1678	.1164	.2829	.2959	.2053	1379
6	.2310	.1495	.0379	.5521	.3574	.1740	.1262	.1312	.4035	.2924	.1633	.1222	.1393	.3844	.2876	.1532	.1125	.2643	.2890	.2123	1378
4	.1947	.1420	.0412	.5153	.3758	.1561	.1277	.1409	.3676	.3006	.1495	.1257	.1493	.3521	.2962	.1457	.1189	.2814	.2668	.2178	1377
3/10	.1756	.0958	.0237	.5952	.3246	.1223	.0735	.0849	.4356	.2621	.1107	.0690	.0907	.4094	.2552	.1010	.0612	.1744	.3002	.1818	1376
8	.1502	.0875	.0210	.5805	.3383	.1074	.0698	.0742	.4273	.2776	.0986	.0664	.0791	.4039	.2719	.0904	.0597	.1513	.3000	.1979	1375
6	.1371	.0856	.0219	.5603	.3500	.1016	.0712	.0765	.4075	.2855	.0945	.0685	.0814	.3867	.2803	.0885	.0628	.1550	.2889	.2051	1374
4	.1057	.0743	.0215	.5247	.3686	.0834	.0658	.0741	.3735	.2945	.0793	.0644	.0787	.3566	.2896	.0771	.0607	.1489	.2689	.2118	1373
2/6	.0844	.0506	.0152	.5620	.3367	.0626	.0416	.0544	.3949	.2621	.0579	.0397	.0581	.3718	.2551	.0558	.0364	.1115	.2740	.1788	1372
4	.0676	.0453	.0140	.5326	.3571	.0526	.0395	.0491	.3726	.2799	.0496	.0385	.0522	.3536	.2744	.0486	.0361	.0991	.2643	.1966	1371
N 9.6/	.9974	.9085	.3158	.4489	.4089	.8863	.9076	1.0461	.3121	.3196	.8684	.9075	1.1006	.3019	.3155	.8983	.9066	2.0429	.2335	.2356	60
No. 57	.9166	.8344	.2867	.4498	.4095	.8123	.8329	.9476	.3133	.3212	.7955	.8328	.9966	.3031	.3173	.8201	.8313	1.8482	.2343	.2376	1486
N 9.4/	.9171	.8333	.2859	.4504	.4092	.8119	.8311	.9455	.3137	.3211	.7950	.8310	.9944	.3034	.3171	.8193	.8292	1.8445	.2346	.2374	1486
N 9/	.7994	.7266	.2529	.4494	.4085	.7095	.7256	.8367	.3123	.3194	.6948	.7254	.8801	.3021	.3153	.7183	.7247	1.6330	.2335	.2356	1177
N 8/	.6315	.5759	.1966	.4498	.4102	.5591	.5751	.6484	.3136	.3226	.5474	.5750	.6815	.3035	.3188	.5632	.5741	1.2625	.2347	.2392	1176
N 7/	.4839	.4424	.1590	.4459	.4077	.4337	.4433	.5285	.3086	.3154	.4257	.4434	.5565	.2986	.3111	.4444	.4438	1.0349	.2311	.2308	1175
N 6/	.3324	.3032	.1076	.4473	.4079	.2972	.3032	.3579	.3102	.3164	.2916	.3033	.3768	.3001	.3121	.3036	.3030	.7010	.2322	.2317	1071
N 5/	.2085	.1904	.0687	.4459	.4072	.1872	.1906	.2292	.3084	.3140	.1838	.1907	.2415	.2984	.3095	.1924	.1907	.4501	.2309	.2289	997
N 4/	.1323	.1207	.0438	.4457	.4068	.1189	.1209	.1462	.3080	.3131	.1167	.1209	.1542	.2979	.3086	.1224	.1209	.2875	.2306	.2278	1070
N 3/	.0717	.0651	.0237	.4469	.4054	.0643	.0651	.0792	.3084	.3119	.0631	.0651	.0835	.2981	.3073	.0662	.0651	.1558	.2306	.2267	1171
N 2/	.0333	.0301	.0109	.4479	.4051	.0298	.0300	.0366	.3091	.3114	.0292	.0300	.0386	.2987	.3069	.0306	.0300	.0720	.2310	.2262	1068
N 1/	.0168	.0153	.0056	.4461	.4066	.0151	.0154	.0185	.3075	.3137	.0147	.0153	.0195	.2970	.3093	.0155	.0154	.0364	.2298	.2291	1169

TABLE III. Effect of backing on colors of Munsell samples. Values are computed from the spectrophotometric curves shown in Fig. 10.

Munsell sample	Values obtained with white backing minus values obtained with black backing ΔY	Δx	Δy
R 4/14	+0.0007	+0.0010	−0.0002
R 8/4	+.0043	+.0023	+.0001
BPB 8/2	$+.0000_1$	$+.0000_1$	$.0000_0$
N 9.6/	+.0034	+.0007	+.0003

shown the curves obtained on four Munsell samples, each sample being run first with white backing and then with black backing. The spectral reflections of the backings used for Fig. 10 are shown in the figure. It will be noted that the effect of backing becomes appreciable at wave-lengths greater than 550 mμ, approximately, if the values of apparent reflectance are greater than 0.60 or 0.65. (The slight separation of the curves for PBP 8/2 between 480 and 600 millimicrons is not considered significant. It is probably caused by non-uniformity of the sample. Differences of this magnitude can be obtained when a sample is re-run with the same backing if the sample and backing have been removed and reinserted between runs.)

The effects of such spectrophotometric differences on the computed values of Y, x, and y are shown in Table III. Since these samples probably illustrate the maximum effects to be expected from the two backings it is apparent that the differences in color caused by measurement with white or with black backing are mostly unimportant.

The use of calibration curves on each record sheet—those enabling corrections of wave-length errors, 100 percent and zero curve deviations, and aging of the MgO comparison surface, as used at the National Bureau of Standards—enables spectrophotometric data to be obtained with much less care and worry regarding certain details of operation than if these calibration curves were omitted. Omission of the curves makes it necessary for the operator to take great care, for example, in the insertion of the graph sheet in the instrument, in continually checking the wave-length calibration of the instrument and in controlling or watching the graph paper for expansion or shrinkage with change of humidity. A new MgO comparison surface must be prepared each day and the question of reproducibility of such surfaces thus enters. The possibility of erratic differences in results between the two investigations is thus present but since different actual samples were measured no further conclusions can be reached regarding the erratic differences between the Glenn-Killian and the National Bureau of Standards data.

With respect to differences between values of X, Y, Z, x, y, and z resulting from differences in computational procedure—30 selected ordinates as against weighted ordinates at every 10 mμ—it has been shown (*21*) that such differences are small for samples such as those considered here, much less than some of the differences shown. Only small and unimportant errors are therefore to be expected from this difference in computational procedure.

Detailed comparison of the values of x and y obtained by Glenn and Killian with those obtained at the National Bureau of Standards may be made by inspection of Figs. 2 to 8 or by study of the published data. Only two additional points will be noted here.

1. Certain consistent differences in the respective chromaticities are apparent when the (x, y)-data for certain groups of samples having the same hue designations (Figs. 2 to 8) are replotted in a single graph regardless of value level. This is particularly noticeable for the 10GY, GY, P, 10RP, and R samples. However, although the maximum (x, y) difference[3] between the Glenn-Killian and the National Bureau of Standards data is $\Delta x=0.0143$ and $\Delta y=0.0156$, inspection of Figs. 2 to 8 shows that in the great

TABLE IV.

Munsell value	Average differences in Y, Glenn-Killian values minus National Bureau of Standards values
8	+0.0031
7	+.0019
6	−.0006
5	+.0018
4	+.0020
3	+.0029
2	+.0039
Average	+.002

[3] For YR 2/2. As is to be expected the discrepancies in chromaticity are greatest at the lowest value level.

majority of cases there is good agreement between the two sets of data. Further effort to resolve the differences would seem unwarranted.

2. Differences in the average values of Y obtained in the two investigations are shown in Table IV. The greatest differences are at the extremes. That for Munsell value 8 may be caused partially by the differences in backing. That for Munsell value 2 may indicate a real instrumental difference relating to the zero readings of the respective instruments; none of the 33 individual differences going into this average is negative. While the individual differences on which the values of Table IV are based reached a maximum of 0.036 (sample P 7/2), the final average value of +0.002 for all of the data is very small.[4]

VI. DERIVATION OF ISCC-NBS COLOR NAMES FROM ICI TRISTIMULUS DATA

The Munsell notations for chroma and hue may be determined from Figs. 2 to 8 for any color whose chromaticity falls within these diagrams by plotting its trilinear coordinates on the appropriate value-level diagrams and estimating the relative position of this point with respect to the points representing the nearest samples of constant hue and the nearest lines of constant chroma. The Munsell value of the color is found by interpolation or extrapolation between the values of apparent reflectance (Y) of the Munsell standards for Illuminant C in Table II. By referring to the color-name charts in RP 1239, the ISCC-NBS color name descriptive of that color will be found. Likewise in disk colorimetry (*21*), given percentages of a certain set of disks may be transformed into trilinear coordinates, plotted in a similar-manner, and the corresponding color name found. Thus the ISCC-NBS color name for a color may be found by the use of any spectrophotometer or colorimeter (*22*), (*23*) whose resultant values may be transformed into data based on the ICI standard observer and coordinate system. Likewise, any color system may be used as a comparison standard if the trilinear coordinates of each sample in that system are plotted on the (x, y)-diagrams and the ISCC-NBS color name determined through conversion to the Munsell notation.

[4] Differences in Munsell value corresponding to the average differences in Y shown in Table IV are significant only at the lowest values. The difference, $\Delta Y=0.0039$, corresponds to $\Delta V=0.15$ at value level 2. It is believed that the NBS data are more reliable than the Glenn-Killian data at these low value levels. For the neutral samples $N1/$, $N2/$, and $N3/$, the Glenn-Killian values of Y are from 0.005 to 0.006 higher than the NBS values given in Table II. Independent check of these samples visually on the Priest-Lange reflectometer gave values lower than the Glenn-Killian values by 0.004, and closely agreeing with the NBS data of Table II.

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Trichromatic Specifications for Intermediate and Special Colors of the Munsell System*

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THE Munsell concept of hue, value, and chroma (*1*), (*2*),[1] and the Munsell notation for recording colors in terms of numerical scales of these three attributes, are daily proving themselves useful in color work (*3*), (*4*). The usefulness of the Munsell charts in color measurement grows in direct ratio to the accuracy and availability of standard colorimetric data that become available regarding the colors on those charts. Actually no one color is more a "Munsell color" than any other, but the charts are devised so that selected points of intersection in the color solid are illustrated, and these are often called "Munsell colors."

The 1929 edition of the *Munsell Book of Color* (*5*) contained chips representing 10 major hues on value levels 2/ to 8/, at all even steps of chroma, and 10 hues intermediate between these major hues on value levels 2/ to 8/, at even steps of chroma beginning with /4 chroma. These are the standard colors for which I.C.I. tristimulus values and trilinear coordinates have been reported for Illuminant *C* by Glenn and Killian (*6*), for Illuminants *A*, *C*, Macbeth 7500°K, and a limit blue sky by Kelly, Gibson, and Nickerson (*7*).

Because many people find that direct reference to color charts is the simplest method for obtaining color notations, and because many people are not able satisfactorily to interpolate between hues that are as far apart as one-twentieth of the hue circuit, "Munsell colors" now appear in an additional series of 20 hues, each of the 20 new hues being intermediate between a pair of the earlier standard 20 hues. All /2 chromas omitted in the 1929 edition have been added. These colors total 561 samples (in addition to the 421 samples of the standard series). In addition to these colors for new charts to be inserted in the early series, several other series of colors have been made available for special purposes. Thus, there is a series of 100 hues at 5/5, 50 hues at their maxima chromas, a 50-step value scale, a 20-step value scale, a series of pinks, of browns, and others. Each of these series becomes more useful as standard I.C.I. colorimetric data become available for it.

The authors have therefore measured these colors spectrophotometrically and have com-

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[1] Numbers in parentheses refer to literature cited.

TABLE I. Trichromatic specification, dominant wave-length, and excitation purity for intermediate 20 Munsell hues, and for /2 chromas omitted in (*6*) and (*7*).

Munsell notation		Tristimulus values X	Y	Z	Trilinear coordinates x	y	Dominant wave-length	Excitation purity	Munsell production no.
2.5R	8/4	.5997	.5656	.6190	.336	.317	611.0	7.0	1593**
	2	.5926	.5738	.6323	.330	.319	602.0	6.0	1899*
	7/8	.5023	.4243	.4315	.370	.312	631.0	15.0	1584
	6	.5025	.4424	.4625	.357	.314	625.0	12.0	1583
	4	.5061	.4666	.4909	.346	.319	609.0	10.2	1898**
	2	.4648	.4448	.4897	.332	.318	609.0	6.2	1897**
	6/10	.4172	.3102	.2804	.414	.308	638.0	25.5	1582
	8	.3870	.3062	.2938	.392	.310	634.0	20.4	1581
	6	.3810	.3216	.3282	.370	.312	633.0	14.8	1580
	4	.3739	.3342	.3482	.354	.316	617.0	11.8	1896
	2	.3320	.3100	.3404	.338	.316	620.0	7.5	1895
	5/10	.3043	.2064	.1713	.446	.303	650.0	32.8	1586
	8	.2779	.1957	.1713	.431	.304	660.0	29.0	1585
	6	.2672	.2039	.1917	.403	.308	646.0	22.5	1579
	4	.2516	.2083	.2088	.376	.312	635.0	16.5	1894
	2	.2218	.2004	.2130	.349	.316	620.0	10.4	1893
	4/10	.1972	.1261	.1074	.458	.293	492.8*c*	37.2	1587
	8	.1866	.1263	.1124	.439	.297	492.6*c*	32.0	1588
	6	.1682	.1228	.1145	.415	.303	492.5*c*	25.2	1589
	4	.1575	.1248	.1246	.387	.306	700.0	19.0	1892
	2	.1427	.1248	.1333	.356	.311	670.0	11.0	1891
	3/10	.1261	.0771	.0701	.461	.282	493.7*c*	42.0	1592
	8	.1079	.0714	.0650	.442	.292	493.2*c*	34.3	1591
	6	.1057	.0749	.0730	.417	.295	493.3*c*	28.4	1590
	4	.0926	.0712	.0713	.394	.303	492.8*c*	21.5	1890
	2	.0814	.0693	.0738	.363	.309	492.0*c*	13.0	1889
	2/6	.0647	.0460	.0493	.404	.287	494.6*c*	29.5	1596
	4	.0566	.0436	.0489	.380	.292	495.0*c*	22.5	1888
	2	.0491	.0408	.0461	.361	.300	495.0*c*	16.2	1887
7.5R	8/4	.5982	.5548	.5477	.352	.326	596.0	14.0	1543**
	2	.5703	.5517	.5635	.338	.327	590.5	10.5	1911*
	7/8	.4912	.4040	.3118	.407	.335	599.3	30.8	1544
	6	.4942	.4257	.3715	.383	.330	599.8	23.0	1542*A*
	4	.4742	.4328	.4071	.361	.329	595.8	17.1	1910**
	2	.4577	.4373	.4423	.342	.327	592.5	11.4	1909**
	6/10	.4033	.3030	.1791	.456	.342	599.9	46.0	1531*A*
	8	.3867	.3049	.2057	.431	.340	599.0	38.5	1530*A*
	6	.3791	.3156	.2454	.403	.336	598.2	30.1	1529*A*
	4	.3614	.3194	.2849	.374	.331	597.5	21.0	1908
	2	.3326	.3115	.3113	.348	.326	595.9	12.7	1907
	5/12	.2974	.1911	.0669	.535	.344	603.5	67.8	1537*A*
	10	.2830	.1946	.0933	.496	.341	603.0	56.1	1536*A*
	8	.2697	.1934	.1084	.472	.338	602.5	49.2	1535*A*
	6	.2580	.1961	.1331	.439	.334	602.5	39.2	1534*A*
	4	.2459	.2045	.1687	.397	.330	600.3	27.2	1906
	2	.2242	.2029	.1968	.359	.325	599.6	15.7	1905
	4/12	.2208	.1370	.0505	.541	.335	606.8	67.0	1541*A*
	10	.2011	.1337	.0653	.503	.334	606.4	56.3	1540*A*
	8	.1857	.1272	.0694	.486	.333	605.8	51.5	1539*A*
	6	.1762	.1302	.0817	.454	.335	602.8	43.6	1538*A*
	4	.1585	.1266	.0983	.413	.330	602.8	31.4	1904
	2	.1476	.1295	.1220	.370	.324	602.0	18.0	1903
	3/10	.1380	.0894	.0408	.514	.333	607.0	59.2	1525*A*
	8	.1226	.0840	.0478	.482	.330	607.0	49.8	1527*A*
	6	.1080	.0797	.0557	.444	.327	607.0	38.8	1528*A*
	4	.1015	.0786	.0614	.420	.325	607.0	32.0	1902
	2	.0869	.0741	.0709	.375	.320	609.8	18.1	1901
	2/4	.0631	.0491	.0447	.402	.313	623.0	23.8	1526*A*
	2	.0485	.0418	.0420	.366	.316	612.0	15.6	1900
10R	8/2	.5946	.5795	.5842	.338	.330	588.0	11.0	1862*
	7/2	.4766	.4516	.4544	.345	.327	593.5	12.0	1861*
	6/2	.3544	.3349	.3232	.350	.331	591.0	14.5	1859
	5/2	.2364	.2185	.2055	.358	.331	594.0	16.8	1858
	4/2	.1501	.1348	.1193	.371	.333	594.5	21.0	1857
	3/2	.0890	.0785	.0701	.374	.330	597.5	21.0	1856
	2/2	.0544	.0462	.0413	.383	.326	603.0	22.2	915*
2.5YR	8/4	.6121	,5806	.5003	.362	.343	587.0	20.8	1569**
	2	.5844	.5730	.5627	.340	.333	585.2	12.5	1873**
2.5YR	7/10	.5024	.4041	.1597	.471	.379	590.5	60.0	1555
	8	.4703	.4004	.2271	.428	.365	590.0	44.5	1553
	6	.4765	.4229	.3041	.396	.351	589.9	32.3	1554
	4	.4726	.4372	.3740	.368	.341	590.0	22.2	1872**
	2	.4656	.4491	.4380	.344	.332	588.0	13.5	1871**
	6/13	.4240	.3250	.0613	.523	.401	590.3	80.1	1578
	12	.4102	.3173	.0745	.511	.396	590.5	75.2	1546
	10	.3992	.3170	.1103	.483	.384	590.6	64.2	1550
	8	.3742	.3063	.1372	.458	.375	590.4	55.2	1549
	6	.3644	.3121	.1854	.423	.362	589.9	42.3	1548
	4	.3702	.3326	.2576	.386	.346	590.0	28.8	1870
	2	.3304	.3157	.2944	.351	.336	588.0	16.2	1869
	5/10	.2634	.2004	.0592	.504	.383	592.0	70.0	1551
	8	.2585	.2040	.0819	.475	.375	591.8	59.7	1532*A*
	6	.2448	.2002	.0998	.449	.367	591.3	51.0	1533*A*
	4	.2321	.1980	.1340	.412	.351	592.2	36.2	1868
	2	.2302	.2142	.1910	.362	.337	590.0	19.8	1867
	4/8	.1802	.1384	.0524	.486	.373	593.0	62.0	1547
	6	.1747	.1386	.0662	.460	.365	592.9	53.5	1545
	4	.1703	.1444	.0968	.414	.351	592.5	37.0	1866
	2	.1461	.1320	.1120	.374	.338	592.2	23.1	1865
	3/6	.1123	.0876	.0380	.472	.368	593.0	57.5	1886
	4	.0933	.0769	.0485	.427	.351	593.8	40.6	1552
	2	.0851	.0761	.0632	.379	.339	592.5	24.8	1864
	2/3	.0632	.0538	.0431	.395	.336	597.0	28.0	1556
	2	.0481	.0438	.0402	.364	.332	594.5	18.5	1863
7.5YR	8/6	.6079	.5792	.3883	.386	.368	583.0	34.0	1565
	4	.5922	.5796	.5004	.354	.347	583.0	20.0	1849
	2	.5705	.5684	.5494	.338	.337	582.0	13.0	1848**
	7/10	.4533	.4023	.1039	.472	.419	584.0	71.0	1564
	8	.4605	.4178	.1635	.442	.401	583.8	58.0	1563
	6	.4533	.4195	.2292	.411	.381	584.0	44.4	1562
	4	.4427	.4267	.3399	.366	.353	584.0	25.0	1847
	2	.4274	.4228	.4029	.341	.337	583.0	14.0	1846
	6/10	.3645	.3207	.0773	.478	.420	584.3	73.0	1561
	8	.3689	.3298	.1134	.454	.406	584.2	62.8	1560
	6	.3425	.3140	.1503	.424	.389	583.9	50.2	1559
	4	.3409	.3243	.2459	.374	.356	584.5	26.0	1845
	2	.3235	.3168	.2908	.348	.340	583.8	16.5	1844
	5/8	.2318	.2036	.0600	.468	.411	584.8	67.8	1558
	6	.2204	.1974	.0813	.441	.395	584.7	56.4	1557
	4	.2058	.1916	.1198	.398	.370	584.3	38.0	1843
	2	.2002	.1935	.1740	.353	.341	585.5	18.0	1842
	4/4	.1522	.1367	.0677	.427	.383	585.3	49.5	1594
	2	.1313	.1252	.0950	.374	.356	584.0	27.5	1841
	3/2	.0792	.0734	.0485	.394	.365	585.0	35.0	1840
10YR	8/2	.5684	.5718	.5685	.333	.335	573.0	8.4	1855*
	7/2	.4461	.4479	.4134	.341	.343	580.0	15.5	1754*
	6/2	.2864	.2843	.2499	.349	.346	581.0	18.5	1755*
	5/2	.2170	.2143	.1780	.356	.352	581.0	22.0	1756*
	4/2	.1387	.1349	.0995	.372	.362	581.8	28.5	1851*
	3/2	.0851	.0819	.0543	.384	.370	582.2	34.2	1758*
	2/2	.0538	.0515	.0411	.367	.352	584.3	25.0	934*
2.5Y	9^{25}/4	.8208	.8353	.7147	.346	.352	578.0	19.5	1752
	2	.7996	.8166	.7907	.332	.339	577.0	12.0	1751
	9/8	.7321	.7401	.3639	.399	.403	577.8	47.0	1730
	6	.7049	.7142	.4749	.372	.377	578.0	33.0	1729
	4	.7212	.7352	.5770	.355	.362	577.5	24.0	1728
	2	.7070	.7242	.7116	.330	.338	576.5	11.5	1727
	8/12	.5789	.5783	.0897	.464	.464	578.3	81.0	1577
	10	.5930	.5981	.1489	.443	.446	577.8	70.4	1567
	8	.5797	.5816	.2200	.420	.421	578.1	57.6	1566
	6	.5526	.5579	.3036	.391	.395	578.0	42.5	1568
	4	.5665	.5761	.4101	.365	.371	577.5	29.5	1733
	2	.5627	.5728	.5564	.333	.339	578.0	12.0	1732
	7/10	.4079	.4084	.0723	.459	.460	578.2	78.5	1576
	8	.4101	.4108	.1121	.440	.440	578.2	68.0	1575
	6	.4216	.4212	.1760	.414	.413	578.5	53.8	1574
	4	.4140	.4177	.2620	.379	.382	578.2	36.0	1735
	2	.4296	.4364	.3954	.341	.346	578.0	16.0	1734*A**

* More than one lot of this color has been made (March, 1943).

** These colors are to be replaced as soon as repaints can be made.

TABLE I.—*Continued.*

Munsell notation		Tristimulus values X	Y	Z	Trilinear coordinates x	y	Dominant wave-length	Excitation purity	Munsell production no.
2.5Y	6/8	.3263	.3273	.0850	.442	.443	578.1	69.5	1573
	6	.3210	.3180	.1071	.430	.426	578.8	61.8	1572
	4	.3310	.3347	.1867	.388	.393	578.0	41.5	1737
	2	.3137	.3185	.2685	.348	.354	578.0	20.0	1736
	5/6	.2124	.2096	.0577	.443	.437	578.9	67.9	1571
	4	.2058	.2072	.1115	.392	.395	578.5	43.5	1739
	2	.2073	.2094	.1789	.348	.352	579.0	19.8	1738
	4/4	.1294	.1272	.0604	.408	.401	579.5	49.0	1570
	2	.1257	.1260	.1006	.357	.358	579.0	23.5	1740
	3/2	.0827	.0828	.0604	.366	.366	579.0	28.2	1741
5Y	9^{25}/6	.7541	.7956	.5137	.366	.386	574.6	33.6	1713
	4	.7532	.7864	.6448	.345	.360	574.3	21.0	1712
	2	.7694	.7936	.7566	.332	.341	575.5	12.5	1711
	9/14	.6168	.6597	.0760	.456	.488	575.4	85.2	1705
	12	.6283	.6688	.1773	.426	.454	575.3	68.0	1704
	10	.6317	.6706	.2289	.413	.438	575.2	60.0	1703
	8	.6375	.6728	.3090	.394	.416	575.2	49.1	1702
	6	.6443	.6826	.4031	.372	.395	574.5	37.8	1701
	4	.6523	.6851	.4911	.357	.375	574.8	28.0	1700
	2	.6824	.7018	.6844	.330	.339	575.0	11.5	1699
7.5Y	9^{25}/8	.7686	.8404	.3232	.398	.435	573.5	55.0	1726
	6	.7754	.8370	.4670	.373	.403	573.2	40.0	1725
	4	.7929	.8440	.6182	.352	.374	573.0	26.7	1724
	2	.7823	.8160	.7698	.330	.345	573.0	13.0	1723
	9/10	.6029	.6786	.1174	.431	.485	573.0	78.0	1718
	8	.6097	.6730	.2529	.397	.438	573.0	56.0	1717
	6	.6165	.6668	.3841	.370	.400	573.0	38.1	1716
	4	.6490	.6894	.5222	.349	.370	573.5	25.0	1715
	2	.6679	.6968	.6677	.329	.343	573.0	12.0	1714
	8/10	.5076	.5688	.0763	.440	.493	573.4	82.3	1710
	8	.5077	.5597	.1898	.404	.445	573.0	60.0	1709
	6	.5367	.5821	.3189	.373	.405	573.0	40.8	1708
	4	.5447	.5810	.4135	.354	.378	573.5	28.0	1707
	2	.5568	.5826	.5381	.332	.347	572.8	14.2	1706
	7/10	.4030	.4457	.0685	.439	.486	573.9	80.0	1722
	8	.4031	.4415	.1210	.417	.458	573.9	66.4	1884
	6	.3979	.4284	.1791	.396	.426	574.1	52.2	1721
	4	.3997	.4233	.2700	.366	.387	574.2	34.0	1720
	2	.4155	.4324	.3956	.334	.348	574.0	15.0	1719
	6/8	.2719	.3005	.0597	.430	.475	573.9	74.4	1883
	6	.2899	.3134	.1170	.402	.435	574.2	56.5	1882
	4	.2984	.3188	.1889	.370	.396	574.0	37.5	1881
	2	.3048	.3177	.2783	.338	.353	574.0	17.5	1880
	5/6	.1987	.2168	.0590	.419	.457	574.0	66.5	1879
	4	.1955	.2088	.1110	.380	.405	574.2	42.5	1878
	2	.1876	.1969	.1599	.344	.362	574.0	21.5	1877
	4/4	.1213	.1313	.0533	.397	.429	574.0	53.5	1876
	2	.1181	.1247	.0960	.349	.368	573.8	24.0	1875
	3/2	.0655	.0690	.0452	.365	.384	577.0	35.5	1874
10Y	8/2	.5529	.5850	.5486	.328	.347	570.5	13.0	2133
	7/2	.4168	.4414	.3926	.333	.353	571.5	16.0	2132
	6/2	.3112	.3310	.2840	.336	.357	571.3	18.0	2131
	5/2	.2135	.2292	.1798	.343	.368	571.8	22.8	2130
	4/2	.1390	.1501	.1144	.344	.372	571.0	24.2	2129
	3/2	.0684	.0743	.0596	.338	.367	569.8	21.2	2128*
	2/2	.0495	.0535	.0408	.344	.372	571.0	24.2	2127*
2.5GY	8/10	.5010	.6088	.1096	.411	.499	569.8	76.2	2205
	8	.4962	.6021	.1452	.399	.484	569.2	69.0	2204
	6	.5122	.5989	.2686	.371	.434	569.0	48.0	2203
	4	.5277	.5880	.4086	.346	.386	569.1	28.3	2202
	2	.5585	.5986	.5295	.331	.355	569.7	16.0	2201
	7/8	.3516	.4317	.0894	.403	.495	569.1	72.8	2200
	6	.3692	.4376	.1655	.380	.450	569.1	56.0	2199
	4	.3883	.4385	.2833	.350	.395	568.7	31.8	2198
	2	.3960	.4263	.3835	.328	.354	568.4	15.0	2197
	6/8	.2725	.3290	.0647	.409	.494	569.9	74.1	2196
	6	.2701	.3232	.1028	.388	.464	569.2	60.6	2195
	4	.2800	.3195	.1735	.362	.413	569.5	40.0	2194
	2	.2815	.3041	.2496	.337	.364	570.2	20.0	2193
	5/6	.1784	.2101	.0715	.388	.457	569.8	58.5	2192
	4	.1800	.2091	.1011	.367	.427	569.0	45.0	2191
	2	.1953	.2145	.1560	.345	.379	569.8	26.3	2190

Munsell notation		Tristimulus values X	Y	Z	Trilinear coordinates x	y	Dominant wave-length	Excitation purity	Munsell production no.
2.5GY	4/4	.1167	.1344	.0641	.370	.426	569.7	45.7	2189
	2	.1233	.1350	.1008	.343	.376	570.0	25.0	2188
	3/2	.0677	.0748	.0576	.338	.374	568.4	23.0	2187
7.5GY	8/8	.4553	.5828	.2857	.344	.440	562.3	42.5	2185
	6	.4798	.5892	.3614	.336	.411	562.3	32.5	2184
	4	.4931	.5786	.4286	.329	.386	563.2	23.7	2183
	2	.5357	.5853	.5576	.319	.349	562.5	11.1	2182
	7/10	.3336	.4628	.1425	.355	.493	561.8	59.7	2181
	8	.3318	.4460	.1756	.348	.468	561.5	50.9	2180
	6	.3503	.4504	.2240	.342	.440	561.8	41.7	2179
	4	.3745	.4474	.3067	.332	.396	562.2	27.5	2178
	2	.3909	.4310	.4070	.318	.351	561.0	11.5	2177
	6/10	.2355	.3274	.0947	.358	.498	562.0	61.7	2176
	8	.2422	.3253	.1184	.353	.474	562.3	54.2	2175
	6	.2369	.3110	.1404	.344	.452	561.7	45.7	2174
	4	.2527	.3105	.2034	.330	.405	560.5	29.1	2173
	2	.2753	.3088	.2754	.320	.359	561.1	14.3	2172
	5/6	.1568	.2100	.0887	.344	.461	561.1	48.2	2171
	4	.1601	.1979	.1256	.331	.409	560.8	30.6	2170
	2	.1887	.2137	.1842	.322	.364	561.2	16.0	2169
	4/6	.1032	.1348	.0711	.334	.436	559.8	38.7	2168
	4	.1082	.1353	.0870	.327	.409	559.4	29.8	2167
	2	.1278	.1461	.1219	.323	.369	561.2	17.7	2166
	3/4	.0631	.0799	.0515	.324	.411	558.0	29.5	2165
	2	.0633	.0742	.0585	.323	.379	559.9	20.0	2164
	2/2	.0458	.0524	.0458	.318	.364	558.3	15.0	2163
10GY	8/2	.5124	.5667	.5601	.313	.346	556.0	8.8	2107
	7/2	.3847	.4279	.4257	.311	.346	553.0	8.2	2106
	6/2	.2642	.2995	.2874	.310	.352	551.0	9.8	2105
	5/2	.1766	.2017	.1873	.312	.357	553.8	11.5	2104
	4/2	.1139	.1312	.1215	.311	.358	552.0	11.5	2103
	3/2	.0611	.0731	.0620	.311	.373	552.0	15.6	2102
	2/2	.0424	.0496	.0454	.308	.361	549.2	11.8	2101*
2.5G	8/6	.4626	.5869	.5002	.298	.379	539.0	14.2	2162
	4	.5047	.6007	.5540	.304	.362	543.5	11.0	2161
	2	.5255	.5922	.5939	.307	.346	546.0	7.2	2160
	7/8	.3217	.4637	.3355	.287	.414	536.0	21.3	2159
	6	.3335	.4475	.3627	.292	.391	535.8	16.2	2158
	4	.3498	.4348	.3933	.297	.369	535.8	11.3	2157
	2	.3746	.4473	.4410	.297	.354	528.0	7.6	2156
	6/8	.1886	.3047	.1912	.276	.445	533.8	27.5	2155
	6	.2142	.3076	.2252	.287	.412	535.5	20.5	2154
	4	.2479	.3162	.2780	.294	.376	534.0	12.6	2153
	2	.2746	.3168	.3170	.302	.349	536.0	7.0	2152
	5/8	.1217	.2002	.1193	.276	.454	535.2	29.7	2151
	6	.1435	.2087	.1437	.289	.421	539.0	23.6	2150
	4	.1580	.2106	.1672	.295	.393	538.5	17.4	2149
	2	.1774	.2075	.2035	.302	.353	536.0	8.0	2148
	4/6	.0869	.1366	.0906	.277	.435	432.3	24.8	2147
	4	.0978	.1352	.1068	.288	.398	533.0	17.2	2146
	2	.1169	.1401	.1298	.302	.362	540.2	10.6	2145
	3/4	.0562	.0828	.0591	.284	.418	534.0	21.8	2144
	2	.0667	.0839	.0717	.300	.378	541.0	14.2	2143
	2/2	.0398	.0477	.0459	.298	.357	532.0	8.5	2142
7.5G	8/4	.4785	.5634	.6287	.286	.337	502.0	7.8	2126**
	2	.5215	.5800	.6413	.299	.333	510.0	3.8	2125**
	7/6	.3401	.4465	.4644	.272	.357	504.5	12.4	2124
	4	.3527	.4336	.4768	.279	.343	502.0	10.2	2123**
	2	.3975	.4488	.5000	.295	.333	506.0	4.8	2122
	6/6	.2244	.3226	.3274	.257	.369	503.5	17.4	2121
	4	.2453	.3224	.3379	.271	.356	503.8	12.8	2120
	2	.2617	.3081	.3315	.290	.342	508.0	6.5	2119
	5/6	.1304	.1930	.1967	.251	.371	502.6	19.4	2118
	4	.1529	.2059	.2102	.269	.363	505.0	13.5	2117
	2	.1692	.1991	.2132	.291	.342	508.8	6.3	2116
	4/6	.0867	.1352	.1381	.241	.375	501.6	22.5	2115
	4	.0976	.1372	.1378	.262	.368	504.6	15.7	2114
	2	.1166	.1405	.1506	.286	.345	506.0	7.9	2113

TABLE I.—*Continued.*

Munsell notation		Tristimulus values X	Y	Z	Trilinear coordinates x	y	Dominant wave-length	Excitation purity	Munsell production no.
7.5G	3/4	.0557	.0814	.0823	.254	.371	503.2	18.3	2112
	2	.0572	.0733	.0757	.277	.356	506.2	10.6	2111
	2/2	.0334	.0431	.0480	.268	.346	499.8	13.8	2110
10G	8/2	.5333	.5892	.6519	.301	.332	512.8	3.3	2067*
	7/2	.3942	.4427	.5039	.294	.330	502.0	5.2	2066
	6/2	.2793	.3188	.3644	.290	.331	500.3	6.5	2065
	5/2	.1776	.2060	.2336	.288	.334	500.9	7.3	2064
	4/2	.1120	.1325	.1528	.282	.334	498.7	9.5	2063
	3/2	.0572	.0720	.0810	.272	.343	499.4	12.5	2062
	2/2	.0347	.0428	.0495	.274	.337	497.7	12.3	2061*
2.5BG	8/2	.5348	.5897	.6637	.299	.330	507.4	3.6	2084
	7/4	.3880	.4598	.5338	.281	.333	498.0	10.0	2083
	2	.4170	.4698	.5370	.293	.330	501.0	5.7	2082**
	6/6	.2610	.3428	.4047	.259	.340	496.6	17.5	2081
	4	.2718	.3376	.4063	.268	.332	496.2	14.6	2080
	2	.2965	.3411	.3991	.286	.329	495.5	8.2	2079
	5/6	.1480	.2151	.2647	.236	.343	495.2	25.8	2078
	4	.1574	.2027	.2473	.259	.334	495.0	17.7	2077
	2	.1781	.2083	.2442	.282	.330	497.1	9.3	2076
	4/6	.0938	.1389	.1785	.228	.338	494.1	29.0	2075
	4	.1038	.1388	.1732	.250	.334	494.5	21.2	2074
	2	.1106	.1331	.1592	.275	.330	495.8	12.2	2073
	3/6	.0519	.0762	.1001	.228	.334	493.5	29.4	2072
	4	.0623	.0860	.1104	.241	.332	493.7	24.6	2071
	2	.0602	.0757	.0936	.262	.330	494.5	16.8	2070
	2/4	.0359	.0467	.0626	.248	.322	491.9	22.9	2069
	2	.0337	.0410	.0528	.264	.322	492.3	16.5	2068
7.5BG	8/4	.4924	.5621	.7137	.279	.318	491.5	11.5	2029*A***
	2	.5156	.5641	.6865	.292	.319	493.0	6.5	2029
	7/4	.3884	.4549	.5943	.270	.316	491.0	14.7	2028
	2	.4085	.4474	.5507	.290	.318	492.0	7.0	2027
	6/6	.2794	.3512	.4834	.251	.315	490.8	22.1	2026
	4	.2877	.3406	.4559	.265	.314	490.5	16.7	2025
	2	.2994	.3304	.4143	.287	.317	491.0	8.5	2024
	5/6	.1525	.2089	.3197	.224	.307	489.5	32.8	2023
	4	.1654	.2060	.2939	.249	.310	489.5	23.5	2022
	2	.1879	.2111	.2730	.280	.314	490.0	11.5	2021
	4/6	.0962	.1371	.2202	.212	.302	489.3	37.5	2020
	4	.1124	.1412	.2148	.240	.301	488.2	27.5	2019**
	2	.1180	.1337	.1826	.272	.308	488.3	15.3	2018**
	3/4	.0567	.0751	.1187	.226	.300	488.5	32.2	2017**
	2	.0638	.0745	.1026	.265	.309	489.0	17.5	2016**
	2/2	.0356	.0417	.0582	.263	.308	488.5	18.2	2015
10BG	8/2	.5332	.5794	.7117	.292	.318	492.0	6.5	2014*
	7/2	.4053	.4423	.5658	.287	.313	489.0	8.7	2013
	6/2	.2888	.3192	.4169	.282	.312	488.5	11.0	2012
	5/2	.1820	.2043	.2790	.274	.307	488.0	14.5	2011
	4/2	.1119	.1254	.1724	.273	.306	487.8	14.5	2010**
	3/2	.0647	.0746	.1042	.266	.306	488.2	17.5	2009
2.5B	8/4	.5638	.6238	.8148	.282	.312	488.6	11.0	2049**
	2	.5617	.6005	.7696	.291	.311	488.0	7.8	2048**
	7/6	.3858	.4571	.7012	.250	.296	486.8	24.1	2047
	4	.4120	.4673	.6605	.268	.304	487.3	16.8	2293*
	2	.4301	.4662	.6193	.284	.308	487.0	10.5	2045
	6/6	.2499	.3066	.5161	.233	.286	486.0	31.5	2044
	4	.2792	.3201	.4900	.256	.294	485.6	22.0	2043
	2	.2919	.3174	.4378	.279	.303	486.0	12.8	2042
	5/6	.1567	.1984	.3686	.217	.274	485.5	38.5	2041
	4	.1689	.1977	.3187	.246	.289	485.6	26.0	2040
	2	.1792	.1952	.2801	.274	.298	484.7	15.2	2039
	4/8	.0949	.1304	.2735	.190	.261	485.3	49.5	2038
	6	.1051	.1349	.2547	.212	.273	485.5	40.0	2037
	4	.1144	.1357	.2213	.243	.288	485.8	27.5	2036
	2	.1157	.1275	.1813	.273	.300	485.8	15.2	2035
	3/6	.0640	.0831	.1772	.197	.256	484.4	47.5	2034
	4	.0699	.0849	.1618	.221	.268	484.2	37.6	2033**
	2	.0680	.0746	.1182	.261	.286	483.5	21.0	2032
	2/2	.0385	.0479	.0824	.228	.284	486.1	33.6	2031*
7.5B	8/4	.5315	.5744	.8460	.272	.294	483.6	16.0	2008
	2	.5399	.5738	.7643	.288	.306	485.0	9.5	2007
	7/6	.3784	.4245	.6917	.253	.284	484.0	24.3	2006
	4	.3975	.4372	.6499	.268	.294	484.6	17.8	2297*
	2	.4242	.4494	.6026	.287	.304	484.5	9.5	2004
	6/6	.2741	.3148	.5638	.238	.273	483.0	30.5	2003
	4	.2924	.3198	.5042	.262	.286	483.0	20.8	1999
	2	.2985	.3164	.4366	.284	.301	483.5	11.5	1998
	5/6	.1837	.2122	.4296	.223	.257	482.3	38.0	1997
	4	.1963	.2176	.3813	.247	.274	482.5	27.5	1996
	2	.1981	.2110	.3122	.275	.292	482.2	15.5	1995
	4/6	.1112	.1287	.2998	.206	.238	481.4	46.2	1994
	4	.1228	.1362	.2594	.237	.263	481.5	32.5	1993
	2	.1258	.1348	.2158	.264	.283	482.0	21.0	1992
	3/4	.0701	.0800	.1678	.220	.252	481.8	39.5	1991
	2	.0754	.0821	.1374	.256	.278	482.0	24.0	1990
	2/2	.0357	.0390	.0692	.248	.271	481.7	27.5	2296*
10B	8/4	.5423	.5802	.8396	.276	.296	483.0	14.5	1988
	2	.5418	.5682	.7541	.291	.305	483.0	8.0	1987*
	7/2	.4103	.4305	.5980	.285	.299	482.0	10.8	1986
	6/2	.3159	.3353	.4842	.278	.295	482.5	14.0	1985
	5/2	.2121	.2229	.3292	.278	.292	481.0	14.5	1984
	4/2	.1253	.1316	.2013	.273	.287	480.5	16.5	1983
	3/2	.0700	.0732	.1157	.270	.283	480.0	18.0	1982
	2/4	.0378	.0416	.0890	.224	.247	480.5	38.5	1981
	2	.0338	.0361	.0676	.246	.262	480.0	29.5	1980*
2.5PB	8/4	.5730	.5980	.8849	.279	.291	480.0	14.2	1978
	2	.5622	.5798	.7852	.292	.301	480.0	8.2	1977
	7/6	.4204	.4407	.7702	.258	.270	479.5	24.0	1976
	4	.4175	.4329	.6964	.270	.280	479.0	19.0	1975
	2	.4294	.4429	.6043	.291	.300	480.0	9.0	1974
	6/8	.3231	.3444	.7268	.232	.247	479.5	36.0	1973
	6	.3186	.3326	.6271	.249	.260	478.5	28.2	1972
	4	.3221	.3356	.5620	.264	.275	479.2	21.5	1971
	2	.3246	.3342	.4755	.286	.295	479.0	11.0	1970
	5/10	.2140	.2313	.5725	.210	.227	479.2	46.2	1969
	8	.2135	.2272	.5349	.219	.233	479.0	42.5	1968
	6	.2030	.2126	.4350	.239	.250	478.5	33.5	1967
	4	.2045	.2129	.3749	.258	.269	478.5	24.0	1966
	2	.1972	.2032	.2989	.282	.290	478.5	13.2	1965
	4/10	.1313	.1405	.4053	.194	.208	478.5	54.2	1964
	8	.1357	.1435	.3689	.209	.221	478.5	47.5	1963
	6	.1233	.1286	.2942	.226	.236	478.2	40.0	1962
	4	.1257	.1305	.2511	.248	.257	478.5	29.5	1961
	2	.1287	.1313	.2179	.269	.275	477.0	19.8	1960
	3/8	.0755	.0806	.2284	.196	.210	478.5	53.6	1959
	6	.0735	.0769	.2024	.208	.218	478.0	48.2	1958
	4	.0716	.0741	.1614	.233	.241	477.9	36.5	1957
	2	.0694	.0711	.1232	.263	.270	477.6	22.4	1956
	2/4	.0404	.0419	.0994	.222	.231	477.9	41.8	1955
	2	.0374	.0384	.0748	.248	.255	477.8	29.5	1954
7.5PB	8/4	.5881	.5949	.8600	.288	.291	477.0	11.0	1681
	2	.5744	.5834	.7524	.301	.305	475.0	4.8	1680**
	7/8	.4579	.4555	.8100	.266	.264	475.0	22.2	1675
	6	.4581	.4524	.7753	.272	.268	473.0	19.9	1674
	4	.4460	.4461	.6737	.285	.285	473.0	13.1	1673**
	2	.4388	.4455	.5963	.296	.301	475.0	6.8	1672**
	6/10	.3376	.3207	.7289	.243	.231	473.0	34.8	1671
	8	.3344	.3215	.6643	.253	.244	472.0	29.6	1670
	6	.3202	.3110	.5834	.264	.256	472.0	24.3	1669
	4	.3238	.3182	.5188	.279	.274	471.0	16.4	1668
	2	.3224	.3234	.4598	.292	.292	473.0	9.8	1667**
	5/14	.2202	.1966	.5978	.217	.194	471.8	49.0	1666
	12	.2219	.1996	.5672	.224	.202	471.0	45.2	1665
	10	.2135	.1952	.5064	.233	.213	471.0	40.4	1664
	8	.2156	.2002	.4643	.245	.228	470.5	34.6	1663
	6	.2109	.1999	.4097	.257	.244	470.5	28.3	1662
	4	.2056	.2005	.3472	.273	.266	471.5	19.9	1661
	2	.2055	.2035	.3036	.288	.286	469.0	11.9	1660

TABLE I.—*Continued.*

Munsell notation		Tristimulus values X	Y	Z	Trilinear coordinates x	y	Dominant wave-length	Excitation purity	Munsell production no.
7.5PB	4/16	.1591	.1297	.5233	.196	.160	470.5	61.0	1659
	14	.1606	.1337	.5080	.200	.167	470.5	58.3	1658
	12	.1514	.1296	.4380	.211	.180	470.5	53.2	1657
	10	.1478	.1299	.3921	.221	.194	470.0	47.9	1656
	8	.1437	.1296	.3469	.232	.209	471.0	42.0	1655
	6	.1365	.1266	.2948	.245	.227	470.5	35.0	1654
	4	.1319	.1254	.2433	.264	.250	470.0	25.2	1653
	2	.1308	.1280	.2027	.283	.277	468.0	14.8	1652
	3/14	.0998	.0732	.3631	.186	.136	468.5	68.0	1645
	12	.0944	.0728	.3154	.196	.151	469.0	62.6	1644
	10	.0861	.0674	.2734	.202	.158	468.2	59.9	1643
	8	.0815	.0679	.2316	.214	.178	469.0	52.4	1642
	6	.0793	.0686	.1972	.230	.199	468.2	44.1	1641
	4	.0775	.0702	.1633	.249	.226	467.5	33.8	1640
	2	.0690	.0660	.1162	.275	.263	467.5	20.0	1639
	2/10	.0582	.0429	.2173	.183	.135	469.0	69.5	1637**
	8	.0528	.0403	.1822	.192	.146	469.0	64.4	1679**
	6	.0496	.0394	.1574	.201	.160	469.0	59.5	1678**
	4	.0439	.0374	.1179	.220	.188	469.0	48.8	1677**
	2	.0410	.0375	.0860	.249	.228	468.0	33.3	1676**
10PB	8/2	.5990	.5977	.8072	.299	.298	460.0	6.5	1953*
	7/2	.4410	.4355	.6014	.298	.295	440.0	7.0	1952
	6/2	.3535	.3448	.5020	.294	.287	455.0	10.0	1951
	5/2	.2199	.2118	.3301	.289	.278	455.0	13.0	1950
	4/2	.1362	.1298	.2048	.289	.276	450.0	13.6	1949
	3/2	.0814	.0744	.1313	.284	.259	430.0	18.5	1948
	2/2	.0427	.0364	.0782	.272	.232	420.0	27.5	1947
2.5P	8/4	.5837	.5575	.8230	.297	.284	566.0c	10.7	1946
	2	.5760	.5681	.7435	.305	.301	564.0c	5.2	1945
	7/6	.4877	.4446	.7508	.290	.264	566.0c	17.2	1944
	4	.4848	.4583	.6905	.297	.280	565.0c	11.9	1943
	2	.4611	.4546	.6008	.304	.300	566.0c	5.6	1942**
	6/8	.3716	.3181	.6535	.277	.237	567.0c	25.8	1941
	6	.3545	.3121	.5900	.282	.248	567.0c	22.2	1940
	4	.3445	.3209	.5133	.292	.272	566.0c	14.2	1939
	2	.3362	.3248	.4687	.298	.288	567.0c	9.2	1938
	5/10	.2739	.2036	.5824	.258	.192	567.0c	40.2	1937
	8	.2597	.2023	.5228	.264	.205	567.0c	36.0	1936
	6	.2404	.1997	.4347	.275	.228	566.0c	28.5	1935
	4	.2255	.1989	.3682	.284	.251	565.8c	21.7	1934
	2	.2069	.1945	.3016	.294	.277	565.0c	13.5	1933
	4/10	.1821	.1268	.4013	.256	.179	565.8c	45.5	1932
	8	.1763	.1310	.3532	.267	.198	565.2c	39.6	1931
	6	.1628	.1272	.3091	.272	.212	565.2c	34.5	1930
	4	.1498	.1261	.2585	.280	.236	565.0c	26.7	1929
	2	.1374	.1233	.2144	.289	.260	565.0c	19.0	1928
	3/10	.1248	.0787	.2990	.248	.157	565.7c	52.5	1927
	8	.1144	.0767	.2483	.260	.174	564.6c	48.0	1926
	6	.1048	.0748	.2145	.266	.190	564.6c	43.0	1925
	4	.0984	.0751	.1816	.277	.211	563.5c	36.0	1924
	2	.0843	.0721	.1402	.284	.243	564.5c	24.5	1923
	2/8	.0626	.0409	.1376	.260	.170	564.5c	50.0	1922
	6	.0553	.0399	.1104	.269	.194	564.2c	41.6	1921
	4	.0476	.0376	.0824	.284	.224	563.0c	32.0	1920
	2	.0425	.0347	.0656	.298	.243	559.0c	27.0	1919
7.5P	8/2	.6150	.5873	.7778	.311	.297	550.0c	8.0	1839
	7/4	.4981	.4525	.6596	.309	.281	552.0c	14.0	1838
	2	.4800	.4568	.6102	.310	.295	549.5c	8.5	1837
	6/6	.3916	.3231	.5484	.310	.256	551.0c	24.5	1836
	4	.3730	.3265	.5034	.310	.271	551.0c	18.0	1835
	2	.3185	.3003	.4139	.308	.291	554.0c	9.8	1834
	5/8	.2758	.1982	.4059	.313	.225	549.0c	37.2	1833
	6	.2556	.1978	.3548	.316	.245	546.6c	30.0	1832
	4	.2417	.2036	.3239	.314	.265	546.9c	21.4	1831
	2	.2164	.2006	.2720	.314	.291	540.0c	10.8	1830
	4/8	.1889	.1246	.2897	.313	.207	549.8c	44.4	1829
	6	.1638	.1222	.2363	.314	.234	549.0c	33.8	1828
	4	.1544	.1266	.2083	.316	.259	546.0c	24.0	1827
	2	.1395	.1265	.1796	.313	.284	546.0c	13.5	1826
	3/8	.1128	.0714	.1901	.301	.191	555.0c	49.0	1825
	6	.1003	.0691	.1600	.304	.210	553.5c	42.0	1824
	4	.0870	.0682	.1303	.305	.239	554.4c	30.0	1823
	2	.0726	.0638	.0970	.311	.273	550.0c	17.7	1822

Munsell notation		Tristimulus values X	Y	Z	Trilinear coordinates x	y	Dominant wave-length	Excitation purity	Munsell production no.
7.5P	2/6	.0578	.0391	.0952	.301	.204	555.5c	43.5	1821
	4	.0512	.0373	.0800	.304	.221	554.5c	37.0	1820
	2	.0434	.0360	.0597	.312	.259	549.5c	23.8	1819
10P	8/2	.6515	.6383	.7896	.313	.307	537.0c	5.8	2140
	7/2	.4845	.4692	.5918	.314	.304	533.0c	5.8	2139
	6/2	.3481	.3293	.4309	.314	.297	538.0c	8.4	2138
	5/2	.2256	.2092	.2751	.318	.295	527.0c	10.1	2137
	4/2	.1502	.1376	.1888	.315	.289	540.3c	12.0	2136
	3/2	.0793	.0694	.1002	.319	.279	536.7c	16.7	2135
	2/2	.0517	.0417	.0661	.324	.261	534.5c	14.5	2134
2.5RP	8/4	.6539	.6075	.7833	.320	.297	517.0c	9.5	1818
	2	.6035	.5851	.7267	.315	.306	520.0c	5.3	1817*
	7/6	.5434	.4750	.6325	.329	.288	510.0c	15.2	1816
	4	.5061	.4582	.5909	.325	.295	510.0c	11.6	1815
	2	.4903	.4709	.5822	.318	.305	510.0c	5.9	1814
	6/8	.4407	.3478	.5050	.341	.269	511.0c	24.8	1812
	6	.4135	.3412	.4830	.334	.276	513.0c	20.8	1811
	4	.3710	.3251	.4339	.328	.288	511.4c	15.0	1809
	2	.3390	.3197	.4074	.318	.300	518.0c	8.2	1808
	5/10	.3302	.2290	.3580	.360	.250	508.1c	36.2	1807
	8	.3107	.2293	.3415	.352	.260	508.0c	30.5	1806
	6	.2786	.2189	.3115	.344	.271	508.1c	24.7	1805
	4	.2424	.2062	.2788	.333	.284	509.0c	17.6	1804
	2	.2195	.2021	.2603	.322	.296	513.0c	10.2	1803
	4/10	.2194	.1403	.2514	.359	.230	514.3c	44.1	1802
	8	.2067	.1388	.2413	.352	.236	515.8c	40.0	1801
	6	.1826	.1342	.2116	.346	.254	514.0c	31.7	1800
	4	.1607	.1319	.1876	.335	.275	513.0c	21.3	1799
	2	.1459	.1297	.1718	.326	.290	512.3c	13.7	1798
	3/10	.1231	.0720	.1446	.362	.212	517.1c	51.9	1796
	8	.1161	.0749	.1395	.351	.227	519.5c	43.8	1795
	6	.1072	.0758	.1252	.348	.246	515.5c	35.6	1794
	4	.0888	.0688	.1044	.339	.262	516.0c	27.0	1793
	2	.0769	.0681	.0913	.326	.288	515.0c	14.0	1792
	2/8	.0722	.0452	.0914	.346	.216	527.0c	46.8	1791
	6	.0688	.0447	.0902	.338	.219	532.2c	44.2	1790
	4	.0581	.0411	.0747	.334	.236	531.2c	36.5	1789
	2	.0461	.0378	.0592	.322	.264	536.1c	23.2	1788
7.5RP	8/4	.6678	.6214	.7301	.331	.308	496.0c	7.5	1787**
	2	.5806	.5663	.6502	.323	.315	492.0c	3.3	1786*
	7/6	.5444	.4765	.5584	.345	.302	496.0c	12.4	1785
	4	.5175	.4778	.5612	.332	.307	496.0c	8.0	1784
	2	.4656	.4491	.5181	.325	.313	493.5c	4.0	1783
	6/10	.4357	.3326	.3807	.380	.289	495.8c	24.0	1782
	8	.4213	.3361	.3841	.369	.294	495.7c	19.5	1781
	6	.3763	.3186	.3706	.353	.299	494.9c	15.0	1780
	4	.3586	.3214	.3706	.341	.306	495.0c	10.0	1779
	2	.3245	.3091	.3604	.326	.311	495.0c	5.1	1778
	5/10	.3320	.2327	.2715	.397	.278	496.3c	31.8	1777
	8	.2884	.2100	.2439	.389	.283	496.1c	28.2	1776
	6	.2626	.2052	.2430	.369	.289	496.6c	22.3	1775
	4	.2435	.2059	.2411	.353	.298	496.2c	15.4	1774
	2	.2238	.2062	.2419	.333	.307	496.0c	8.0	1773
	4/10	.2181	.1398	.1730	.411	.263	497.3c	40.2	1772
	8	.2092	.1438	.1756	.396	.272	497.2c	34.0	1771
	6	.1866	.1393	.1666	.379	.283	496.9c	26.5	1770
	4	.1701	.1395	.1626	.360	.295	496.0c	18.0	1769
	2	.1506	.1347	.1589	.339	.303	496.8c	10.9	1768
	3/10	.1358	.0801	.1107	.416	.245	499.2c	48.4	1767
	8	.1188	.0760	.0994	.404	.258	498.5c	40.8	1766
	6	.1099	.0773	.0982	.385	.271	498.4c	32.4	1765**
	4	.0928	.0735	.0902	.362	.287	498.0c	21.6	1764
	2	.0897	.0788	.0940	.342	.300	497.0c	12.6	1763
	2/6	.0644	.0415	.0632	.381	.246	503.5c	41.8	1762
	4	.0595	.0417	.0602	.369	.258	503.5c	34.3	1761
	2	.0483	.0386	.0519	.348	.278	503.8c	22.6	1760
10RP	8/2	.6151	.6024	.6690	.326	.319	599.0	5.0	1918*
	7/2	.4777	.4574	.5039	.332	.318	608.0	6.3	1917**
	6/2	.3306	.3109	.3507	.333	.313	700.0	5.5	1916
	5/2	.2426	.2229	.2453	.341	.314	642.0	7.8	1915
	4/2	.1578	.1394	.1537	.350	.309	493.0c	10.4	1914
	3/2	.0802	.0692	.0776	.353	.305	493.5c	12.8	1913
	2/2	.0530	.0430	.0542	.353	.286	499.7c	20.1	1912

TABLE II. Trichromatic specification, dominant wave-length, and excitation purity for neutral grays; half-steps of Munsell value, and a special series of small value steps.

Munsell notation	Tristimulus values X	Tristimulus values Y	Tristimulus values Z	Trilinear coordinates x	Trilinear coordinates y	Dominant wave-length	Excitation purity	Munsell production no.
Neutrals N 8.5/	.6205	.6365	.7266	.313	.321	570	2.0	2228*
7.5/	.4860	.4993	.5716	.312	.321	567	1.7	2227*
6.5/	.3634	.3732	.4379	.309	.318	515	0.4	2211*
5.5/	.2419	.2483	.2889	.310	.319	558	0.8	2210*
4.5/	.1579	.1614	.1905	.310	.317	550	0.2	2224*
3.5/	.0948	.0964	.1135	.311	.316	700	0.2	2223*
2.5/	.0524	.0531	.0609	.315	.319	700	2.0	2222*
1.5/	.0245	.0250	.0295	.310	.316	—	0.0	2221*
Special "60-step" value scale	.8696	.8953	1.0158	.313	.322	568	2.2	60
	.8843	.9058	1.0418	.312	.320	568	1.5	58
	.8177	.8399	.9367	.315	.324	572	3.5	57
	.7804	.7996	.9154	.313	.320	570	1.8	56*
	.7451	.7641	.8658	.313	.322	572	2.3	55
	.7059	.7239	.8280	.313	.321	570	2.0	54
	.6735	.6895	.7973	.312	.319	570	1.2	53
	.6686	.6851	.7890	.312	.320	568	1.5	52
	.6422	.6580	.7619	.311	.319	565	1.2	51
	.6196	.6345	.7394	.311	.318	570	0.8	50
	.5912	.6048	.7064	.311	.318	570	0.8	49
	.5853	.5985	.6981	.311	.318	570	0.8	48
	.5637	.5767	.6916	.309	.316	490	0.5	47
	.5216	.5340	.6260	.310	.318	555	0.4	45
	.5255	.5384	.6260	.311	.319	565	1.2	44
	.5216	.5340	.6213	.311	.318	570	0.8	43
	.4849	.4959	.5835	.310	.317	550	0.2	42
	.4706	.4816	.5658	.310	.317	550	0.2	41
	.4461	.4566	.5398	.309	.316	490	0.5	40
	.4255	.4344	.5197	.309	.315	470	0.6	39
	.4049	.4134	.4855	.311	.317	580	0.2	37 old
	.4049	.4159	.4819	.311	.319	565	1.2	37 new
	.3794	.3882	.4548	.310	.318	555	0.4	36
	.3373	.3452	.4075	.309	.317	500	0.2	34
	.3186	.3258	.3851	.310	.316	—	0.0	33
	.3049	.3107	.3697	.310	.315	400	0.3	32
	.2892	.2956	.3485	.310	.317	550	0.2	31
	.2794	.2859	.3319	.311	.319	565	1.2	30
	.2627	.2682	.3107	.312	.319	570	1.2	28
	.2480	.2529	.2941	.312	.318	580	1.0	27
	.2274	.2326	.2693	.312	.319	570	1.2	26
	.1941	.1978	.2270	.314	.320	578	2.0	24
	.1782	.1820	.2081	.314	.320	578	2.0	23
	.1710	.1744	.2001	.314	.320	578	2.0	22
	.1610	.1642	.1908	.312	.318	580	1.0	21
	.1553	.1584	.1831	.313	.319	578	1.4	20
	.1345	.1372	.1585	.313	.319	578	1.4	18
	.1332	.1358	.1571	.313	.319	578	1.4	17
	.1186	.1208	.1412	.312	.317	590	0.8	16
	.1106	.1126	.1310	.312	.318	580	1.0	15
	.0967	.0984	.1162	.311	.316	700	0.2	14
	.0939	.0956	.1117	.312	.317	590	0.8	13
	.0861	.0878	.1025	.312	.318	580	1.0	12
	.0755	.0768	.0905	.311	.316	700	0.2	11
	.0726	.0738	.0864	.312	.317	590	0.8	10
	.0667	.0678	.0791	.312	.317	590	0.8	8A
	.0596	.0608	.0716	.310	.317	550	0.2	8
	.0520	.0528	.0616	.312	.317	590	0.8	6
	.0457	.0464	.0536	.314	.318	585	1.5	5
	.0394	.0400	.0472	.311	.316	700	0.2	4
	.0277	.0280	.0328	.313	.316	650	0.8	61
	.0237	.0240	.0283	.312	.316	680	0.5	63
	.0255	.0260	.0305	.311	.317	580	0.2	62
	.0184	.0188	.0224	.309	.316	490	0.5	64
	.0173	.0174	.0212	.309	.311	560	1.7	65

* More than one lot of this color has been made (March, 1943).

puted colorimetric values for the curves.[2] About 1000 colors were involved.

Spectral apparent reflectance curves were made on the General Electric Recording Spectrophotometer. The standard of reflectance was the surface of a freshly prepared layer, 0.06 inch thick, of magnesium oxide. All samples were backed by a non-selective diffusing surface having an apparent reflectance of 0.005.

[2] Mimeographed tables for portions of these data have been available since 1938–39.

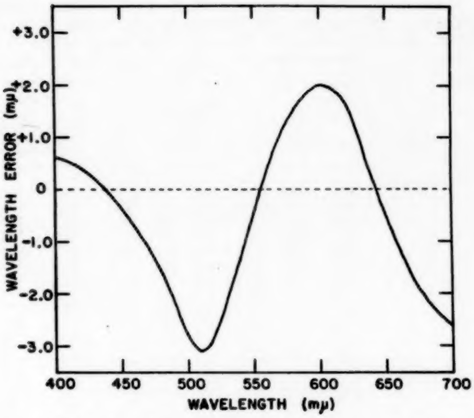

FIG. 1. Wave-length calibration of the spectrophotometer.

The wave-length calibration of the spectrophotometer is shown by the curve in Fig. 1. This curve was obtained by drawing a smooth line through the mean of points representing the wave-length error as determined by observation of a mercury discharge tube, and measurements on two filters calibrated by the National Bureau of Standards and the Color Measurements Laboratory at the Massachusetts Institute of Technology. It is believed that this calibration was maintained within ± 0.5 mμ in the wave-length region used for the colorimetric computations.

The General Electric Recording Spectrophotometer as originally manufactured allows the sample and standard to be irradiated normally and viewed diffusely, except that approximately one-half of the specular component is lost by being reflected through the entrance apertures. During the course of this work, the viewing geometry was changed to permit total inclusion or exclusion of the specular component. This change allowed the sample and standard to be irradiated at 5° from the normal, and viewed diffusely, with provision to include or exclude the specular component.

Therefore, some of the reflectance curves were made with the original viewing geometry, while the remainder were run with the new viewing geometry,[3] specular component included. Experi-

[3] This is the type of viewing geometry adopted several years ago by the Color Measurements Laboratory at the Massachusetts Institute of Technology.

TABLE III. Trichromatic specification, dominant wave-length, and excitation purity for several series of special Munsell samples: 100 hues at 5/5; 50 hues at maximum chroma; a series of "Pinks;" of "Browns;" odd chromas at value levels of maximum chroma for 10 hues; high value series (9/) for 5 hues; weak chromas (/1), values 2/ to 8/ for 5 hues; a series specially produced in strong chromas; and glossy surface papers for matching tomato colors.

Munsell notation	Tristimulus values X	Y	Z	Trilinear coordinates x	y	Dominant wave-length	Excitation purity	Munsell production no.
100hues at 5/5[1]								
5R	.2794	.2308[1]	.1966	.395	.325	603.8	25.6	101
6	.2840	.2335	.1874	.403	.331	600.7	28.8	102
7	.2697	.2228	.1758	.404	.333	599.5	29.7	103
8	.2654	.2209	.1657	.407	.339	597.0	32.0	104
9	.2648	.2209	.1564	.412	.344	595.0	34.9	105
10	.2652	.2241	.1505	.414	.350	592.9	37.2	106
1YR	.2512	.2142	.1353	.418	.357	591.1	39.8	107
2	.2513	.2167	.1313	.419	.362	589.7	41.5	108
3	.2473	.2144	.1202	.425	.368	588.6	44.8	109
4	.2412	.2121	.1102	.428	.376	587.0	47.9	110
5	.2452	.2213	.1126	.423	.382	585.2	48.1	111
6	.2382	.2156	.1042	.427	.386	584.7	50.2	112
7	.2391	.2184	.0994	.429	.392	584.0	52.4	113
8	.2370	.2205	.0918	.431	.401	582.6	55.4	114
9	.2459	.2333	.0944	.429	.407	581.4	56.1	115
10	.2424	.2343	.0910	.427	.413	580.2	57.2	116
1Y	.2539	.2508	.0908	.426	.421	579.1	59.4	117
2	.2492	.2488	.0878	.425	.425	578.5	60.0	118
3	.2430	.2462	.0862	.422	.428	577.7	60.0	119
4	.2523	.2605	.0882	.420	.433	576.7	60.8	120
5	.2500	.2639	.0943	.411	.434	575.6	58.7	121
6	.2536	.2690	.1019	.406	.431	575.2	56.3	122
7	.2598	.2791	.1090	.401	.431	574.5	55.1	123
8	.2454	.2658	.1118	.394	.427	573.9	52.1	124
9	.2518	.2766	.1175	.390	.428	573.0	51.5	125
10	.2539	.2841	.1295	.380	.425	571.8	48.2	126
1GY	.2496	.2867	.1328	.373	.428	570.0	47.1	127
2	.2350	.2730	.1337	.366	.425	569.0	44.3	128
3	.2403	.2831	.1422	.361	.425	567.8	43.0	129
4	.2378	.2829	.1533	.353	.420	566.4	39.3	130
5	.2288	.2742	.1644	.343	.411	564.6	34.1	131
6	.2347	.2850	.1709	.340	.413	563.4	34.0	132
7	.2335	.2870	.1807	.333	.409	561.4	31.3	133
8	.2313	.2891	.1892	.326	.407	558.9	28.8	134
9	.2323	.2909	.2008	.321	.402	556.8	26.1	135
10	.2364	.2986	.2152	.315	.398	554.2	23.4	136
1G	.2305	.2944	.2234	.308	.393	549.7	20.4	137
2	.2190	.2849	.2218	.302	.393	545.0	18.8	138
3	.2301	.2994	.2462	.297	.386	539.1	15.9	139
4	.2123	.2804	.2398	.290	.383	530.5	13.7	140
5	.2019	.2646	.2434	.283	.373	520.0	11.0	141
6	.2033	.2682	.2539	.280	.370	514.4	11.0	142
7	.2087	.2746	.2711	.277	.364	509.6	11.2	143
8	.2076	.2739	.2810	.272	.359	505.5	12.3	144
9	.2050	.2716	.2889	.268	.355	502.3	13.9	145
10	.2102	.2778	.3074	.264	.349	499.8	15.2	146
1BG	.2030	.2689	.3096	.260	.344	497.8	17.2	147
2	.2009	.2660	.3184	.256	.339	495.9	18.8	148
3	.2080	.2720	.3380	.254	.333	494.4	19.5	149
4	.2142	.2789	.3614	.251	.326	493.0	21.4	150
5	.1994	.2557	.3384	.251	.322	492.2	21.5	151
6	.2117	.2719	.3642	.250	.321	491.9	22.1	152
7	.2076	.2643	.3730	.246	.313	490.3	24.2	153
8	.2027	.2569	.3700	.244	.310	489.8	25.0	154
9	.2106	.2617	.3836	.246	.306	489.0	24.6	155
10	.2200	.2720	.4090	.244	.302	488.2	25.7	156
1B	.2211	.2688	.4201	.243	.295	487.1	26.6	157
2	.2135	.2555	.4224	.240	.287	485.8	29.0	158
3	.2160	.2554	.4295	.240	.282	485.2	29.2	159
4	.2116	.2486	.4254	.239	.281	484.7	29.9	160
5	.2054	.2355	.3992	.245	.280	484.1	27.7	161
6	.2200	.2502	.4364	.243	.276	483.3	28.9	162
7	.2237	.2510	.4423	.244	.274	482.8	28.7	163
8	.2255	.2513	.4459	.244	.272	482.4	28.6	164
9	.2342	.2563	.4532	.248	.272	481.7	27.3	165
10	.2369	.2550	.4541	.250	.270	480.8	26.8	166
1PB	.2417	.2568	.4615	.252	.267	480.1	26.4	167
2	.2453	.2567	.4619	.254	.266	479.1	25.8	168
3	.2506	.2586	.4672	.257	.265	478.1	25.3	169
4	.2642	.2674	.4897	.259	.262	476.5	25.0	170
5	.2515	.2529	.4506	.263	.265	475.9	23.0	171
6	.2525	.2510	.4507	.265	.263	474.8	22.9	172
7	.2537	.2471	.4527	.266	.259	472.3	23.0	173
8	.2644	.2549	.4566	.271	.261	469.8	21.2	174
9	.2649	.2522	.4401	.277	.263	465.0	19.3	175
10	.2638	.2473	.4350	.279	.261	459.0	19.1	176
1P	.2697	.2526	.4207	.286	.268	445.0	16.0	177
2	.2710	.2496	.4180	.289	.266	566.9*c*	16.3	178
3	.2810	.2563	.4167	.295	.269	564.0*c*	16.2	179
4	.2649	.2385	.3914	.296	.267	562.7*c*	17.5	180
5	.2886	.2589	.4069	.302	.271	559.0*c*	16.6	181
6	.3014	.2668	.4067	.309	.274	552.0*c*	17.1	182
7	.2909	.2517	.3867	.313	.271	547.7*c*	18.9	183
8	.2949	.2546	.3836	.316	.273	543.2*c*	18.7	184
9	.2898	.2489	.3654	.321	.275	535.0*c*	18.4	185
10	.2918	.2485	.3616	.323	.275	529.2*c*	19.0	186
1RP	.2927	.2465	.3484	.330	.278	517.3*c*	19.2	187
2	.3000	.2529	.3454	.334	.282	509.8*c*	18.5	188
3	.3088	.2589	.3411	.340	.285	504.9*c*	18.2	189
4	.2965	.2454	.3041	.350	.290	499.0*c*	18.1	190
5RP	.2841	.2341	.2943	.350	.288	499.7*c*	18.6	191
6	.2992	.2454	.2996	.354	.291	498.1*c*	18.6	192
7	.3027	.2467	.2953	.358	.292	496.9*c*	18.9	193
8	.3042	.2472	.2876	.363	.295	496.0*c*	18.5	194
9	.3018	.2455	.2760	.367	.298	494.8*c*	17.8	195
10	.2876	.2350	.2479	.373	.305	493.0*c*	16.3	196
1R	.2971	.2428	.2489	.377	.308	492.5*c*	16.0	197
2	.2853	.2311	.2269	.384	.311	633.0	18.2	198
3	.2851	.2330	.2115	.391	.319	610.8	22.4	199
4	.2870	.2345	.2050	.395	.323	607.5	24.3	200
50 hues at maximum chroma								
1R	.3044	.2030	.1834	.441	.294	493.0*c*	33.8	999
3	.3148	.2115	.1618	.458	.307	629.0	37.2	998
5	.3107	.2095	.1263	.481	.324	610.0	47.8	1008
7	.3648	.2491	.1112	.503	.344	602.2	59.2	893
9	.4092	.2928	.1036	.508	.363	596.6	65.8	892
1YR	.4328	.3234	.0882	.512	.383	592.8	72.0	891
3	.4325	.3339	.0581	.525	.405	589.8	81.2	890
5	.4278	.3483	.0621	.510	.416	587.4	80.1	870
7	.4099	.3553	.0619	.496	.430	584.5	80.0	884
9	.4282	.3913	.0609	.486	.445	582.0	81.8	883
1Y	.4671	.4488	.0634	.477	.458	579.8	82.8	946
3	.5107	.5177	.0710	.465	.471	577.6	82.9	945*A*
5	.4951	.5274	.0822	.448	.477	575.5	80.2	1128*
7	.4450	.4907	.0780	.439	.484	574.0	79.8	1130
9	.4296	.4890	.0826	.429	.488	572.7	78.1	1131*
1GY	.3909	.4559	.0850	.420	.489	571.5	76.0	1132*
3	.3586	.4293	.0914	.408	.488	570.1	72.2	952
5	.3321	.4218	.0957	.391	.496	567.3	70.1	1105
7	.2792	.3599	.1072	.374	.482	565.6	62.0	960
9	.2342	.3224	.1194	.347	.477	560.8	53.0	961
1G	.1889	.2808	.1324	.314	.466	552.3	41.8	1103
3	.1480	.2284	.1435	.285	.439	538.2	27.5	1102
5	.1302	.2059	.1706	.257	.406	513.2	18.9	1101
7	.1271	.1944	.1934	.247	.378	503.0	20.9	1100
9	.1231	.1869	.2015	.241	.365	499.7	23.0	1099
1BG	.1320	.1971	.2269	.237	.354	497.4	24.8	1098
3	.1339	.1982	.2520	.229	.339	494.4	28.3	1097
5	.1263	.1865	.2577	.221	.327	492.4	32.1	1096
7	.1172	.1694	.2551	.216	.313	490.5	35.0	1095
9	.1065	.1513	.2422	.213	.303	489.3	37.3	1094
1B	.1008	.1396	.2458	.207	.287	487.6	40.4	1093
3	.0998	.1329	.2681	.199	.265	485.3	45.7	1092
5	.0957	.1198	.2806	.193	.241	482.8	50.9	1087
7	.0868	.1067	.2705	.187	.230	482.0	54.0	1086
9	.0777	.0931	.2519	.184	.220	481.2	56.5	1063
1PB	.0770	.0876	.2553	.183	.209	480.0	58.1	1061
3	.0816	.0871	.2756	.184	.196	478.3	59.5	1060*
5	.0869	.0836	.2981	.185	.178	475.7	61.5	1059
7	.1080	.0888	.3404	.201	.165	470.1	58.5	1133*
9	.1241	.0924	.3416	.222	.165	460.0	52.7	1134*
1P	.1483	.1035	.3535	.245	.171	420.0	47.0	1135
3	.1758	.1200	.3553	.270	.184	563.4*c*	45.8	1136
5	.2021	.1310	.3776	.284	.184	559.6*c*	48.2	1007
7	.2140	.1412	.3587	.300	.198	555.5*c*	46.0	1006
9	.2265	.1487	.3378	.318	.209	547.2*c*	44.8	1005
1RP	.2444	.1658	.3195	.335	.227	532.7*c*	40.6	1004
3	.2721	.1886	.3008	.357	.248	510.0*c*	36.5	1003
5	.2812	.1931	.2757	.375	.257	502.2*c*	36.0	1002
7	.2805	.1901	.2317	.399	.271	497.1*c*	35.2	1001
9	.2889	.1929	.2015	.423	.282	494.5*c*	34.7	1000
"Pinks"								
1RP 8/6	.6395	.6086	.7727	.316	.301	522.0*c*	7.2	1043
4	.6216	.5985	.7517	.315	.304	522.0*c*	6.0	1035
7/8	.5208	.4640	.6296	.323	.287	521.0*c*	14.2	1051
6	.5034	.4601	.5985	.322	.295	514.0*c*	11.0	1027
4	.4956	.4581	.5910	.321	.297	515.0*c*	10.0	1019
3RP 8/6	.6375	.6041	.7389	.322	.305	504.0*c*	6.7	1044
4	.6321	.6088	.7420	.319	.307	505.0*c*	5.5	1036

[1] This series was made to be 5/5 on the old value scale in which $R=25$ for $V=5 (V=\sqrt{R})$.

* More than one lot of this color has been made (March, 1943).

TABLE III.—*Continued.*

Munsell notation		Tristimulus values X	Y	Z	Trilinear coordinates x	y	Dominant wave-length	Excitation purity	Munsell production no.
"Pinks"									
3RP	7/8	.5305	.4729	.6170	.327	.292	509.5*c*	13.2	1052
	6	.5195	.4705	.5962	.328	.297	505.0*c*	11.0	1028
	4	.5062	.4740	.5827	.324	.303	503.0*c*	8.0	1020
7RP	8/6	.6597	.6186	.7165	.331	.310	496.0*c*	6.3	1045
	4	.6083	.5891	.6605	.327	.317	610.0	4.8	1037
	7/8	.5284	.4691	.5471	.342	.304	496.0*c*	11.0	1053
	6	.5190	.4671	.5526	.337	.304	497.0*c*	10.2	1029
	4	.4947	.4590	.5357	.332	.308	496.0*c*	7.5	1021
9RP	8/6	.6651	.6220	.7049	.334	.312	493.5*c*	6.2	1046
	4	.6105	.5883	.6500	.330	.318	606.0	6.0	1038
	7/8	.5158	.4482	.4947	.354	.307	493.5*c*	12.0	1054
	6	.4992	.4445	.5080	.344	.306	494.5*c*	10.5	1030
	4	.4827	.4430	.5080	.337	.309	494.0*c*	8.0	1022
1R	8/6	.6246	.5851	.6476	.336	.315	630.0	6.5	1047
	4	.6179	.5923	.6432	.333	.320	600.0	7.0	1039
	7/8	.5142	.4415	.4764	.359	.308	493.5*c*	12.8	1055
	6	.4922	.4378	.4749	.350	.312	650.0	9.5	1031
	4	.4820	.4371	.4764	.345	.313	645.0	8.6	1023
3R	8/6	.6327	.5880	.6375	.340	.316	620.0	8.0	1048
	4	.5974	.5656	.6009	.339	.321	600.0	9.0	1040
	7/8	.5005	.4256	.4385	.367	.312	636.0	14.0	1056
	6	.4982	.4384	.4450	.360	.317	615.0	13.5	1032
	4	.4775	.4274	.4481	.353	.316	620.0	11.5	1024
5R	8/6	.6295	.5817	.6018	.347	.321	604.0	11.0	1074
7R	8/6	.6192	.5681	.5585	.355	.325	599.0	14.3	1049
	4	.6041	.5662	.5725	.347	.325	597.0	12.0	1041
	7/8	.4927	.4117	.3463	.394	.329	601.5	26.0	1057
	6	.5004	.4352	.3961	.376	.327	601.5	20.2	1033
	4	.4834	.4257	.4060	.368	.324	603.0	17.5	1025
9R	8/6	.6367	.5880	.5518	.358	.331	593.0	16.5	1050
	4	.6064	.5676	.5514	.352	.329	593.0	14.5	1042
	7/8	.4795	.4018	.2870	.410	.344	595.0	34.2	1058
	6	.5038	.4392	.3683	.384	.335	596.0	24.8	1034
	4	.4898	.4372	.3963	.370	.330	596.5	20.0	1026
"Browns"									
7R	4/6	.1774	.1306	.0803	.457	.336	602.7	44.3	988*A*
	4	.1592	.1294	.1051	.404	.329	602.8	28.5	979
	3/6	.1118	.0810	.0574	.447	.324	609.6	38.5	974
	4	.1008	.0775	.0613	.421	.323	608.2	31.7	972
9R	4/6	.1745	.1320	.0745	.458	.346	598.4	47.8	987*A*
	4	.1540	.1264	.0908	.415	.341	597.0	34.3	980
	3/6	.1098	.0816	.0521	.451	.335	602.5	42.8	975
	4	.0971	.0761	.0561	.423	.332	602.4	34.3	970
1YR	4/6	.1762	.1364	.0659	.465	.360	594.8	53.7	989*A*
	4	.1569	.1312	.0818	.424	.355	592.5	41.0	981
	3/6	.0989	.0773	.0421	.453	.354	595.3	49.0	995*
	4	.0915	.0736	.0500	.425	.342	597.0	38.0	971
3YR	4/6	.1712	.1394	.0639	.457	.372	591.0	54.6	990
	4	.1597	.1376	.0790	.424	.366	589.2	44.0	982
	3/6	.1066	.0866	.0418	.454	.368	591.5	52.4	996*
	4	.0897	.0746	.0453	.428	.356	592.5	42.0	990*A**
7YR	4/6	.1664	.1455	.0583	.450	.393	586.0	58.0	991*A*
	4	.1587	.1411	.0693	.430	.382	585.9	50.0	983
	3/4	.0872	.0775	.0441	.418	.371	587.0	43.6	991*
9YR	4/6	.1598	.1451	.0528	.447	.406	583.5	60.3	992*A*
	4	.1568	.1416	.0673	.429	.387	584.8	51.0	984
	3/4	.0863	.0796	.0441	.411	.379	584.3	44.0	992*
1Y	4/4	.1394	.1331	.0596	.420	.401	581.2	52.0	985
	3/4	.0848	.0782	.0449	.408	.376	584.5	42.2	993*
3Y	4/4	.1295	.1285	.0592	.408	.405	579.0	50.0	986
	3/4	.0780	.0771	.0473	.385	.381	579.8	37.5	994*
5Y	3/4	.0744	.0767	.0451	.379	.391	576.5	38.5	973

Munsell notation		Tristimulus values X	Y	Z	Trilinear coordinates x	y	Dominant wave-length	Excitation purity	Munsell production no.
Odd chromas									
R	4/13	.2187	.1283	.0631	.533	.313	619.5	58.8	895
	11	.2057	.1256	.0722	.510	.311	621.0	52.1	1614*
	9	.1944	.1235	.0791	.490	.311	622.0	46.6	38
	7	.1734	.1195	.0885	.455	.313	619.5	38.0	1613*
	5	.1608	.1222	.1071	.412	.313	621.0	26.5	1612*
	3	.1457	.1225	.1216	.374	.314	621.0	16.8	1610*
	1	.1377	.1318	.1463	.331	.317	610.0	6.0	1611*
YR	6/11	.3928	.3253	.0719	.497	.412	587.0	75.9	898
	9	.3703	.3155	.1047	.468	.399	586.6	64.8	897*
	7	.3629	.3159	.1492	.438	.382	587.0	52.0	380
	5	.3415	.3096	.2039	.399	.362	586.9	36.2	378
	3	.3084	.2909	.2454	.365	.344	587.0	22.3	376
	1	.2998	.2974	.3132	.329	.327	580.0	8.0	374
Y	8/11	.5378	.5690	.0878	.450	.476	575.8	80.3	906
	9	.5341	.5642	.1197	.438	.463	575.8	74.0	905
	7	.5214	.5492	.2182	.405	.426	575.5	54.8	860
	5	.5288	.5528	.3390	.372	.389	575.4	36.1	874
	3	.5246	.5432	.4364	.349	.361	574.8	22.3	873
	1	.5211	.5389	.5425	.325	.336	574.0	9.8	872
GY	7/9	.3485	.4421	.1303	.378	.480	566.5	62.5	901*
	7	.3635	.4444	.1809	.368	.449	567.0	51.3	900
	5	.3705	.4363	.2462	.352	.414	566.8	37.6	926
	3	.3734	.4150	.3396	.331	.368	566.0	19.2	925
	1	.3982	.4188	.4330	.319	.335	568.0	7.5	924
G	5/7	.1166	.1850	.1559	.255	.404	512.0	19.1	922
	5	.1275	.1839	.1655	.267	.386	512.0	14.8	175
	3	.1523	.1895	.1899	.286	.356	513.0	8.4	173
	1	.1722	.1874	.2111	.302	.328	510.0	3.0	171
BG	4/7	.0887	.1320	.1852	.218	.325	492.2	33.0	927
	5	.0989	.1342	.1820	.238	.323	492.2	26.0	479
	3	.1140	.1384	.1779	.265	.322	492.4	16.3	481
	1	.1234	.1378	.1682	.287	.321	493.2	8.0	923*
B	4/7	.1054	.1297	.2913	.200	.246	482.9	47.4	930*
	5	.1105	.1313	.2589	.221	.262	483.4	38.2	929*
	3	.1255	.1434	.2346	.249	.285	484.3	15.5	932*
	1	.1252	.1334	.1789	.286	.305	484.8	10.0	928*
PB	3/11	.0842	.0805	.2841	.188	.179	475.5	60.3	535
	9	.0825	.0804	.2483	.201	.196	475.7	53.8	533
	7	.0784	.0762	.2085	.216	.210	475.2	47.0	531
	5	.0710	.0697	.1613	.235	.231	475.0	37.5	529
	3	.0724	.0725	.1386	.255	.256	475.8	26.8	527
	1	.0699	.0706	.1025	.288	.290	475.0	11.2	525
P	4/11	.1835	.1222	.3540	.278	.185	561.5*c*	46.5	252
	9	.1773	.1295	.3114	.287	.210	560.6*c*	38.2	943*
	7	.1590	.1241	.2658	.290	.226	560.9*c*	32.2	944*
	5	.1501	.1257	.2379	.292	.245	561.5*c*	25.3	245
	3	.1370	.1235	.1988	.298	.269	561.5*c*	17.0	243
	1	.1285	.1255	.1676	.305	.298	563.0*c*	6.3	241
RP	4/11	.2267	.1440	.2134	.388	.246	502.2*c*	42.5	937*A**
	9	.2108	.1437	.2073	.375	.256	502.6*c*	36.5	939*A*
	7	.1920	.1396	.1938	.365	.266	502.3*c*	30.6	938*A*
	5	.1744	.1372	.1849	.351	.276	503.8*c*	22.8	940*A*
	3	.1615	.1407	.1795	.335	.292	503.0*c*	14.2	941*A*
	1	.1491	.1421	.1756	.319	.304	507.0*c*	6.3	942*A*
High value series (9/) for 5 hues[2]									
5R	9/3	.7294	.7110	.8012	.325	.317	609.5	4.3	2237
	2	.7274	.7203	.8239	.320	.317	608.0	2.9	2236
	1	.7183	.7184	.8277	.317	.317	604.0	2.2	2235
	0.5	.7084	.7187	.8163	.316	.320	582.0	2.6	2234
5Y	9/3	.6642	.6920	.5742	.344	.358	574.5	20.4	2290
	2	.6717	.6910	.6650	.331	.341	575.6	12.2	1699
	1	.6910	.7108	.7398	.323	.332	574.5	7.6	2239
	0.5	.6994	.7191	.7751	.319	.328	573.3	5.4	2238
5G	9/3	.6370	.7164	.7793	.299	.336	513.8	4.1	2244
	2	.6634	.7231	.8043	.303	.330	516.0	2.8	2243
	1	.6918	.7334	.8224	.308	.326	537.0	2.2	2242
	0.5	.6871	.7147	.8135	.310	.323	550.0	1.7	2241
5B	9/3	.6779	.7349	.9632	.285	.309	487.5	9.8	2248
	2	.6971	.7433	.9277	.294	.314	489.0	6.0	2247
	1	.7076	.7510	.9208	.297	.316	490.3	4.7	2246
	0.5	.7064	.7407	.8759	.304	.319	496.0	2.0	2245
5P	9/2	.7355	.7198	.9355	.308	.301	558.5*c*	5.7	2251
	1	.7267	.7419	.9114	.305	.312	479.0	2.3	2250
	0.5	.7199	.7283	.8625	.312	.315	500.0*c*	0.8	2249

[2] See Table I for chromas to /14 for Y 9/, and for other high values of 2.5Y, 5Y, 7.5Y.

TABLE III.—*Continued.*

Munsell notation	Tristimulus values X	Y	Z	Trilinear coordinates x	y	Dominant wave-length	Excitation purity	Munsell production no.
Weak chromas (/1), values 2/ to 8/, for 5 hues								
5R 8/1	.5607	.5516	.6246	.323	.318	602.0	3.7	2260
7/1	.4382	.4330	.4902	.322	.318	602.0	3.6	2259
6/1	.3134	.3082	.3504	.322	.317	609.0	3.6	2258
5/1	.2008	.1927	.2103	.333	.319	604.0	6.8	2257
4/1	.1283	.1219	.1319	.336	.319	606.0	7.7	2256
3/1	.0758	.0705	.0755	.342	.318	610.0	8.9	2255
2/1	.0414	.0376	.0408	.346	.314	635.0	9.0	2254
5Y 8/1	.5440	.5622	.5651	.326	.336	574.0	9.5	2267
7/1	.4253	.4390	.4339	.328	.338	574.6	10.5	2266
6/1	.3034	.3133	.3013	.330	.341	574.7	12.2	2265
5/1	.2011	.2076	.1966	.332	.343	575.0	13.0	2264
4/1	.1312	.1352	.1282	.333	.343	575.4	13.2	2263
3/1	.0709	.0735	.0647	.339	.351	575.0	17.2	2262
2/1	.0386	.0400	.0381	.330	.343	574.0	12.7	2261
5G 8/1	.5155	.5499	.6109	.308	.328	537.0	2.7	2274
7/1	.4015	.4302	.4890	.304	.326	512.0	2.1	2273
6/1	.2845	.3092	.3503	.301	.328	508.0	2.9	2272
5/1	.1805	.1962	.2247	.300	.326	503.6	3.3	2271
4/1	.1212	.1333	.1500	.300	.330	507.7	3.5	2270
3/1	.0604	.0686	.0731	.299	.340	518.0	4.5	2269
2/1	.0353	.0401	.0444	.295	.335	507.0	5.0	2268
5B 8/1	.5385	.5659	.7118	.296	.312	487.0	5.4	2282
7/1	.4241	.4451	.5618	.296	.311	486.0	5.5	2281
6/1	.2965	.3137	.4088	.291	.308	485.5	7.8	2280
5/1	.1923	.2052	.2756	.286	.305	485.1	10.1	2279
4/1	.1218	.1308	.1815	.281	.301	484.5	12.2	2278
3/1	.0638	.0692	.0983	.276	.299	484.7	14.2	2276
2/1	.0377	.0404	.0580	.277	.297	483.0	14.2	2275
5P 8/1	.5503	.5505	.6922	.307	.307	564.4c	3.2	2289
7/1	.4466	.4423	.5657	.307	.304	561.9c	4.3	2288
6/1	.3286	.3207	.4286	.305	.298	562.8c	6.6	2287
5/1	.2160	.2100	.2787	.306	.298	560.0c	6.8	2286
4/1	.1435	.1366	.1872	.307	.292	557.0c	9.0	2285
3/1	.0795	.0742	.1083	.303	.283	560.0c	12.2	2284
2/1	.0419	.0373	.0597	.302	.269	559.0c	17.7	2283

Munsell notation	Tristimulus values X	Y	Z	Trilinear coordinates x	y	Dominant wave-length	Excitation purity	Munsell production no.
A series specially produced in strong chromas[3]								
4 R 3.4/10.4	.1479	.0846	.0491	.525	.300	635.0	53.5	2325
4.5R 4.0/13.1	.2223	.1203	.0552	.559	.302	628.2	62.8	2299
8.5R 4.8/14.7	.3020	.1759	.0370	.587	.342	606.0	80.8	2300
8.5R 5.0/14.5	.3307	.1980	.0458	.576	.345	604.8	78.6	2301
10 R 5.7/14.6	.4002	.2623	.0458	.565	.370	598.0	82.7	2302
5 YR 6.6/13.9	.4726	.3718	.0474	.530	.417	588.3	86.2	2303
0.5Y 7.7/13.0	.5750	.5335	.0698	.488	.453	581.3	84.3	2304
4.5Y 8.4/13.3	.6468	.6708	.0745	.464	.482	576.7	86.0	2305
9.5Y 8.8/12.2	.6547	.7476	.1150	.432	.493	572.6	80.0	2320
0.5GY 9.2/10.8	.7193	.8326	.1835	.414	.480	571.6	71.8	2306
3 GY 7.5/11.2	.4052	.5079	.0771	.409	.513	568.7	79.5	2307
8 GY 7.1/10.4	.3090	.4515	.1451	.341	.498	558.8	57.5	2308
4.5G 5.5/11.5	.1280	.2491	.1804	.230	.447	512.0	28.0	2309
6 G 2.7/5.6	.0324	.0531	.0469	.245	.401	507.6	21.5	2321
4.5BG 3.3/8.4	.0410	.0778	.1209	.171	.324	491.7	51.1	2310
1.5B 3.1/7.3	.0453	.0695	.1624	.164	.251	485.4	60.2	2311
8.5B 3.0/6.8	.0567	.0672	.1941	.178	.211	480.7	59.3	2322
3 PB 3.1/10.7	.0706	.0689	.3149	.155	.152	476.4	75.2	2312
7 PB 3.5/19.4	.1339	.0777	.5833	.168	.098	466.2	80.1	2313
1 P 2.2/12.9	.0692	.0364	.2058	.222	.117	400.0	64.0	2323
2 P 2.6/14.3	.0985	.0496	.2670	.237	.120	565.2c	65.7	2314
5 P 3.2/14.6	.1430	.0749	.3102	.271	.142	560.8c	62.9	2315
2 RP 3.3/15.3	.1706	.0784	.2107	.371	.171	522.5c	70.0	2316
4.5RP 2.8/9.3	.0996	.0557	.1004	.390	.218	507.0c	54.6	2324
8 RP 3.4/12.1	.1649	.0866	.1013	.467	.245	496.4c	58.0	2317
1 R 3.7/11.8	.1881	.1002	.0821	.508	.270	473.8c	55.4	2318
Glossy surface papers for matching tomato colors[4]								
R[5]	.1427	.0961	.0599	.478	.322	612.0	46.3	2208*
R[6]	.1192	.0704	.0292	.545	.322	613.2	64.4	2208*
YR[5]	.3350	.2549	.0826	.498	.379	592.6	67.2	2207*
YR[6]	.3231	.2422	.0690	.509	.382	592.8	71.0	2207*
N 1/[5]	.0431	.0439	.0530	.308	.314	473.0	1.2	2209*
N 1/[6]	.0128	.0130	.0161	.305	.311	477.0	2.3	2209*

[3] All but seven of the following 26 papers are made from different pigments; seven are mixtures in order to fill up wide hue gaps. This series is particularly useful in disk colorimetry.

[4] These papers have semi-gloss surfaces as evidenced by the difference in the Y tristimulus values for the two conditions of viewing, and as a result, the corresponding values of P_e for the R and YR papers differ considerably. If these papers were very glossy, a difference in the Y values as great as 0.04 would be obtained for the two conditions of viewing, with a correspondingly greater difference in P_e. Thus, viewing and illuminating geometry become increasingly critical as surfaces depart from non-specularity, and if the geometry is not known, measurements on glossy chromatic samples are subject to misinterpretation.

[5] Specular component included in spectrophotometric measurement.

[6] Specular component excluded in spectrophotometric measurement.

ments have indicated that the viewing geometries of the spectrophotometer as originally manufactured, as well as the new geometry with specular component both included and excluded, give similar values of reflectance for samples of matt surfaces. Since the usual Munsell color chips have nearly matt surfaces, the two methods of viewing geometry are believed to give values of apparent reflectance that differ by less than 0.002. A few "special" papers possessed glossy surfaces, and are so noted in the tables. They were measured with the specular component both included and excluded.[4]

Some of the samples also exhibit a slight iridescence which often has been termed as "bronze." As bronze increases, viewing and illuminating geometry become increasingly critical.

Tristimulus values and trilinear coordinates have been determined for I.C.I. Illuminant *C*, using the 30 selected ordinate method. The graph paper on which the spectrophotometric curve was recorded had the selected ordinates printed thereon. Dominant wave-length and purity were read from large-scale sections of the I.C.I. mixture diagram in the *Handbook of Colorimetry* (*8*). Trilinear coordinates are reported to three decimal places, instead of the usual four, in order to call attention to the fact that the fourth place is accurate only when corrections for all instrumental and recording errors are applied.

The spectrophotometric measurements were made in the Interchemical Corporation Research Laboratories, and a complete set of calculations were compiled in the laboratories of the Food Distribution Administration. Each of the authors has had a part in checking the data.

This work was started in order to supply hue sensibility data for surface colors (*9*), also in

[4] See Table III, reference 4.

connection with the work of the Newhall subcommittee (OSA Colorimetry Committee) on Review of Spacing of the Munsell Colors (*10*), (*11*). It was completed in order to make full information available to all color workers who may have use for any of the Munsell papers. The data for the 20 new hues, and the /2 chromas originally omitted in the 10 intermediates of the regular 20 hue series, are placed in order by hue in Table I. Data for half-value step and special neutrals are assembled in Table II. Data for other special series are placed together by title in Table III.

The authors are indebted to the Munsell Color Company for supplying samples and production numbers, and to their respective laboratories for permission to carry on and publish this work.

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Final Report of the O.S.A. Subcommittee on the Spacing of the Munsell Colors*

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This report presents the characteristics of a modified and enlarged Munsell solid which has been evolved from the 1940 visual estimates of the *Munsell Book of Color* samples. All three dimensions have been carefully reviewed and extensively revised. The newly defined loci of constant hue have been extended closer to the extremes of value while the loci of constant chroma have been extrapolated to the pigment maximum. The dimension of value has been redefined without substantial departure from the Munsell-Sloan-Godlove scale. By the above changes a solid is achieved which approaches more closely to A. H. Munsell's dual ideal of psychological equispacing and precise applicability. The new solid is defined in terms of the I.C.I. standard coordinate system and Illuminant *C*.

TABLE OF CONTENTS

INTRODUCTION

THE original purpose of the subcommittee[1] was to reduce the psychological irregu-

* Paper presented at the meeting of the Optical Society of America, New York, New York, March 5–6, 1943.

[1] This subcommittee was appointed by L. A. Jones in 1937 as a Subcommittee of the Colorimetry Committee of the Optical Society of America. It includes H. P. Gage, D. B. Judd, Dorothy Nickerson, W. B. VanArsdel, and

larities in the spacing of the samples of the *Munsell Book of Color*. To this end, constant-value and constant-hue charts of the form found in the standard library edition of the *Book of Color* (*25*)[2] were systematically examined by 40 observers using the ratio method (*27*) and totaling some 3,000,000 color judgments. The data were summarized in the form of averaged visual estimates of the correct notations of the hue, value, and chroma of each sample. These estimates were then published in Table II of the preliminary report of 1940 (*28*).

The present report is concerned with the remaining aim of the subcommittee which was to produce a psychophysical system of surface colors which should be based upon the above data and which should correspond as closely to the ideal psychological color solid as is consonant with practical usefulness. The general method for achieving this aim was: (*a*) To eliminate minor variations in the averaged visual estimates by drawing through plotted points representing them, smooth curves defining new loci of constant hue and constant chroma; (*b*) to extrapolate the chroma loci beyond the Munsell samples and out to the theoretical pigment maximum (*22*); (*c*) to extrapolate the hue loci as far as feasible, that is, to the 1/ and 9/ value levels; (*d*) to adjust the value dimension by applying a new formula which eliminates irregularities in the Munsell-Sloan-Godlove function (*24*); (*e*) to express in terms of the I.C.I. notation (*15*) (Illuminant *C*) enough surface colors corresponding to this recommended psychophysical system to define it adequately; and finally, (*f*) for the sake of comparison, to redesignate all current samples with the revised Munsell notation.

RECOMMENDATIONS

The charts and tables in this report constitute the definition and standards of the new system. These tables and charts are recommended for general use in determining the Munsell *re-notation* of a given color sample when the I.C.I. (Y and x, y) specification is known, or for determining the I.C.I. specification when the Munsell notation is given. If the chromaticity of the given color is specified in terms of dominant wave-length and purity, the I.C.I. trichromatic coordinates (x, y) must be found first, and then with reflectance given (Y), the Munsell value, hue, and chroma may be obtained.

Figures 1–9 present 40 hue loci corresponding to the full complement of samples in the latest edition of the *Book of Color* (*25*) together with the locus for every even chroma. Standard I.C.I. Illuminant *C*, which approximates 6700°K, has been taken as neutral origin for both the hue and chroma loci. The aim has been to make, as nearly as feasible, both series of loci perceptually equi-spaced. Of course, the spacing of the hue loci is not even approximately the same as that of the chroma loci, nor for that matter of the value loci. While some data on the subject are available (*29*), (*4*), no attempt was made in this study to equate the dimensional scales. It was felt that the greatly altered notation would detract seriously from the utility of the proposed system.

The charts presented are located at the recommended value levels indicated on the figures and presently to be described. It should be noted that Figs. 1–9 do not extend at all points to the theoretical pigment limit. It seemed more useful to include here only the more frequently used portions of color space, and thus obtain the advantage of a correspondingly larger scale. Table I was read from large unpublished charts which extend to the pigment limits at all points and from which the fourth place could be estimated.[3] The Y entries in this table must be multiplied by 100 to obtain Y percentages, as in Table II.

Table II presents the I.C.I. luminous reflectance Y equivalents (percent form) of the recommended Munsell value scale. For convenience in computation the value-step intervals are given to 0.01. It should be noted that the reflectances indicated are not absolute but relative to magnesium oxide; whereas the maximum at value 10/ was formerly 100 percent, it is now 102.57. Use of this relation facilitates results and also avoids the somewhat dubious conversion to absolute scale, by permitting Y determinations with a MgO standard to be converted directly to

S. M. Newhall, chairman. Dr. Gage and Mr. VanArsdel have been unable to participate in the work of reducing the data to this form, but both have indicated approval of the report.

[2] Italic numbers in parentheses refer to literature cited.

[3] This table can be used for plotting complete charts.

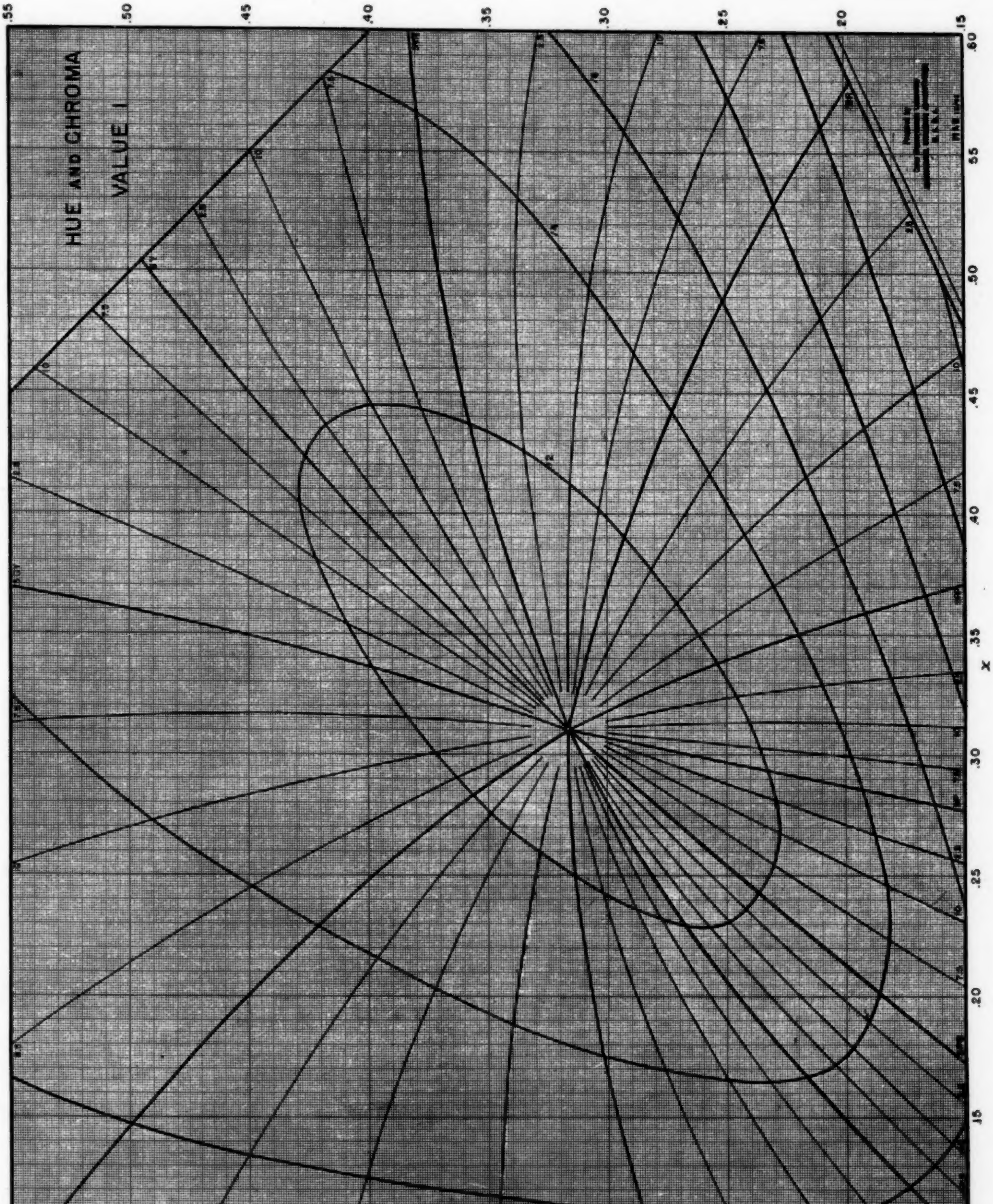

FIG. 1. Loci of constant hue and constant chroma in I.C.I. (x, y)-coordinates, at value 1/.

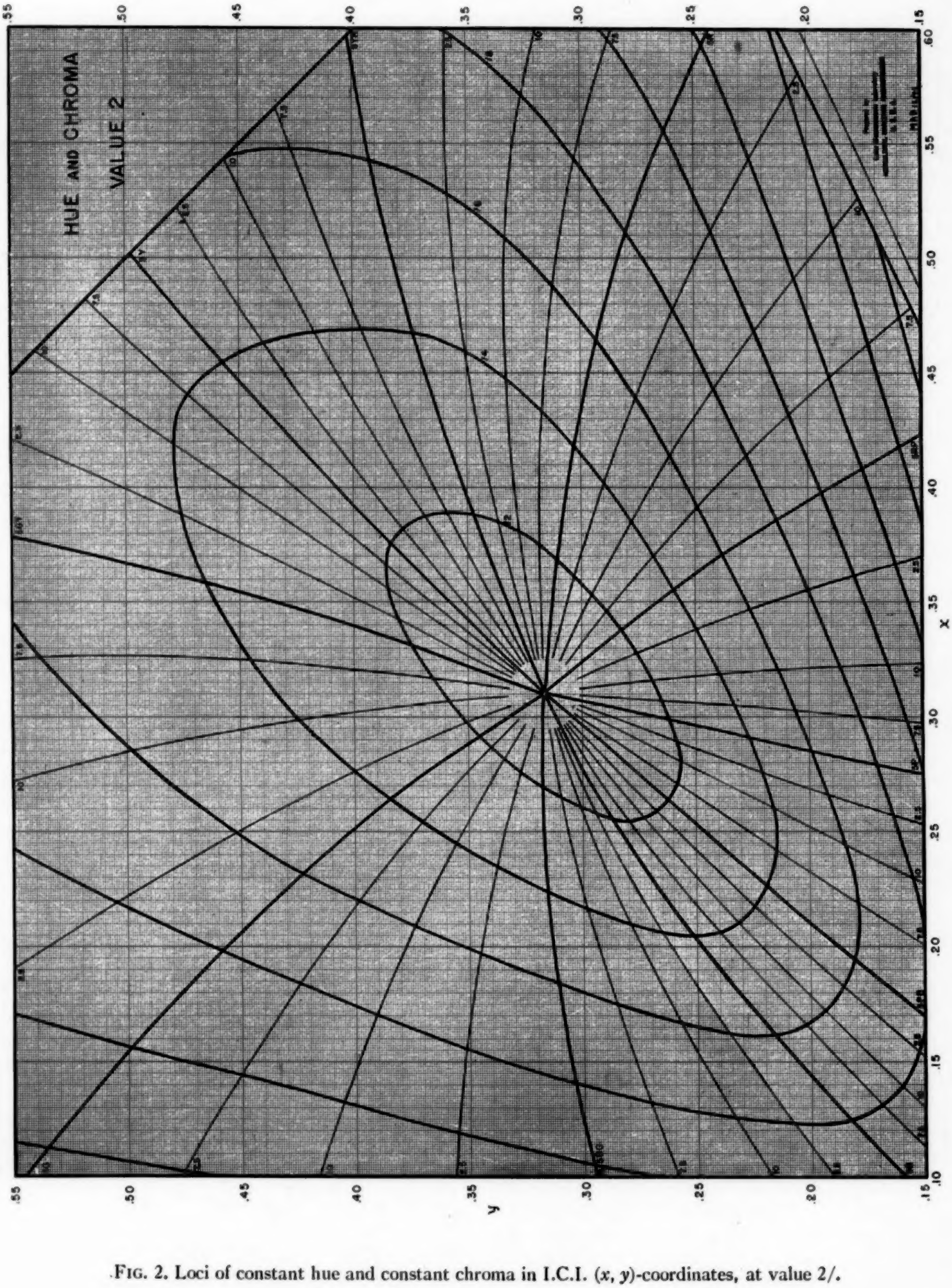

FIG. 2. Loci of constant hue and constant chroma in I.C.I. (x, y)-coordinates, at value 2/.

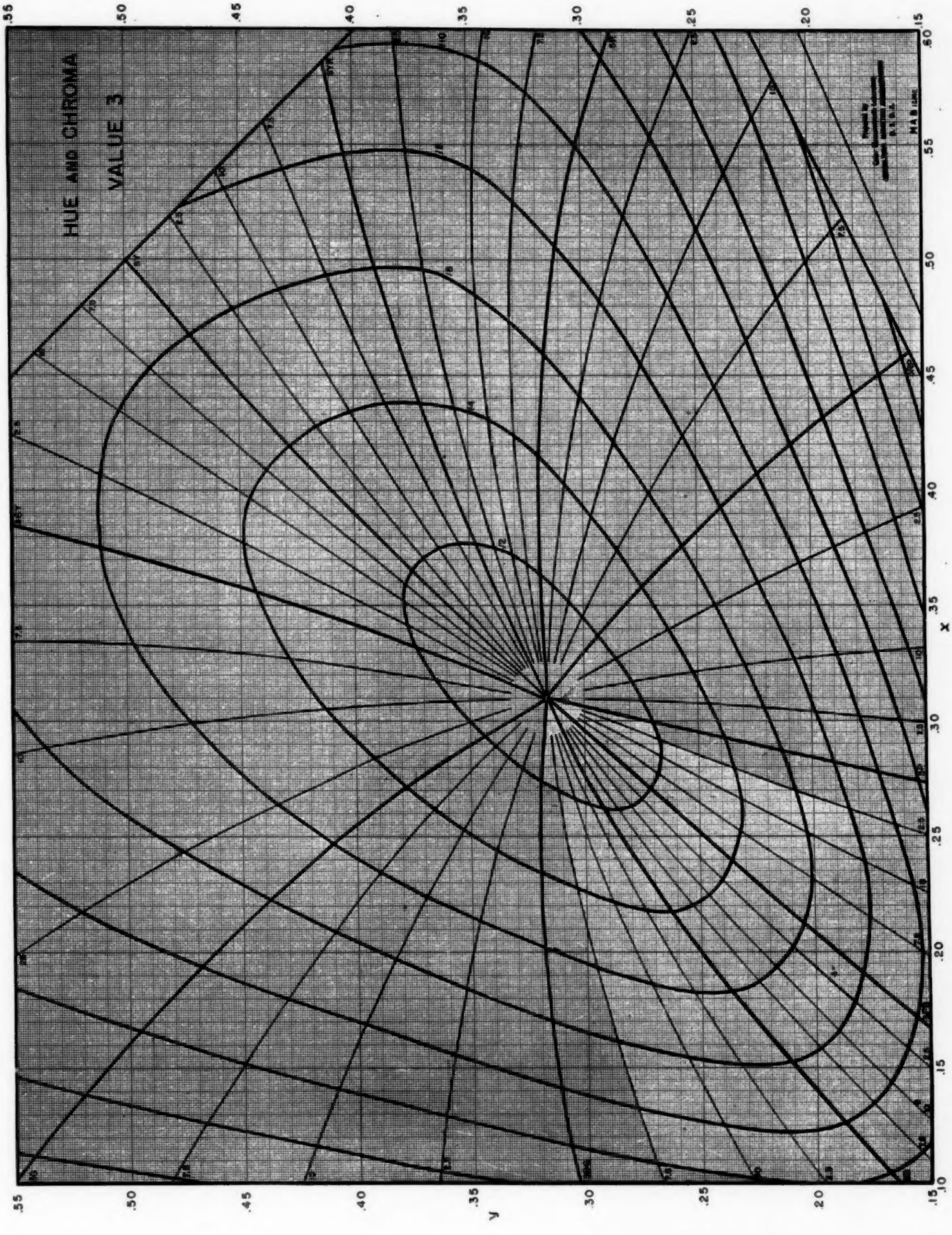

FIG. 3. Loci of constant hue and constant chroma in I.C.I. (x, y)-coordinates, at value 3/.

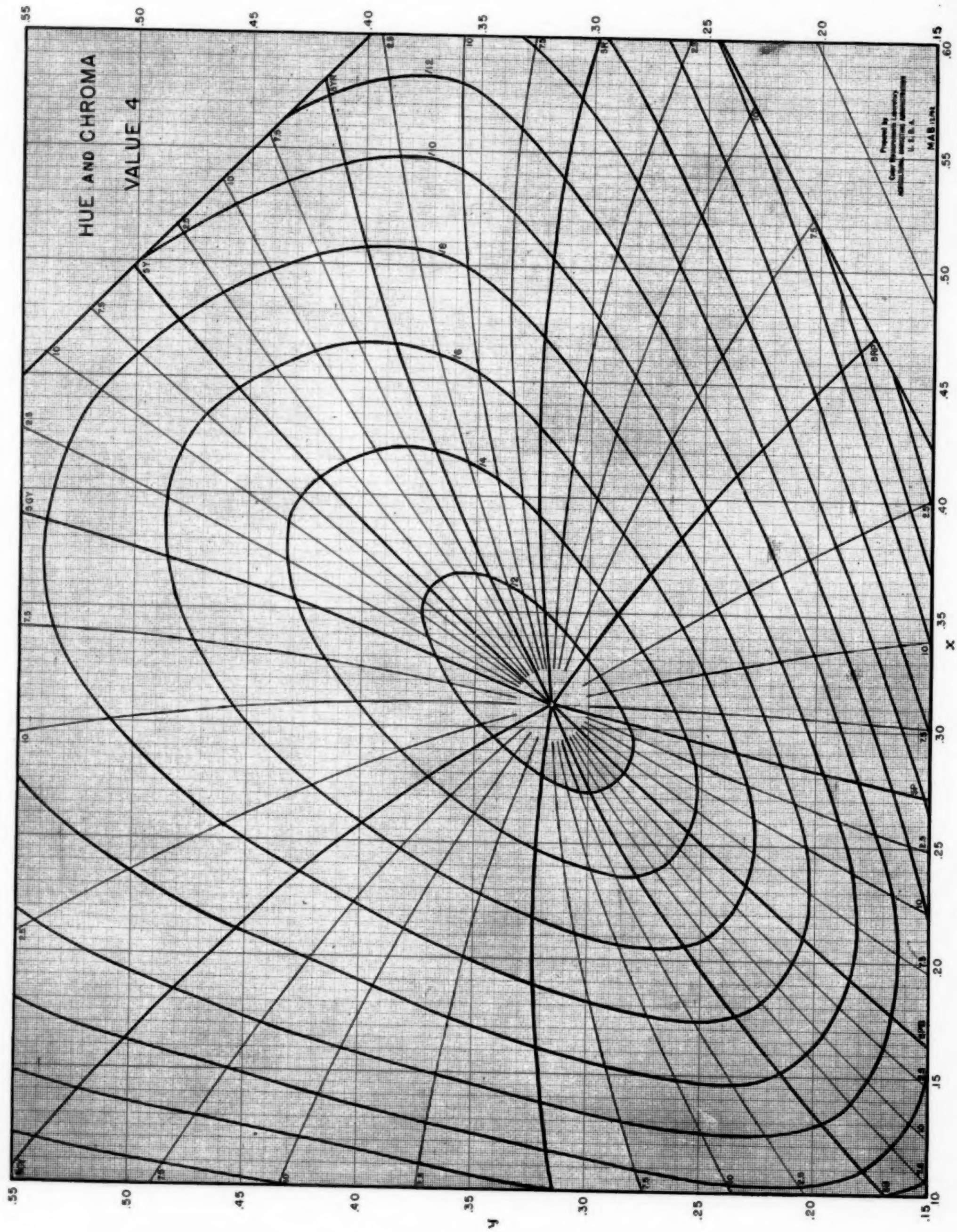

FIG. 4. Loci of constant hue and constant chroma in I.C.I. (x, y)-coordinates, at value 4/.

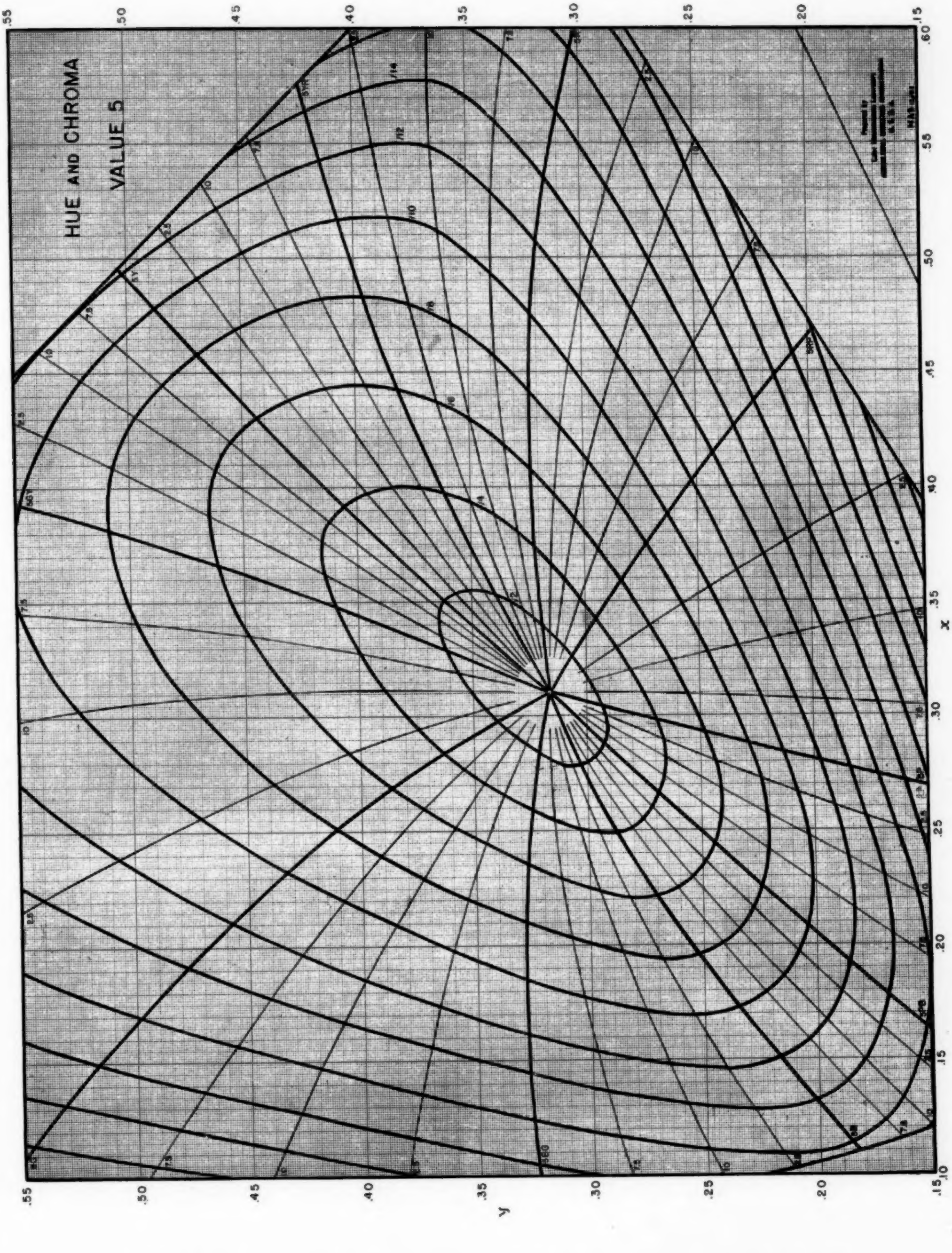

FIG. 5. Loci of constant hue and constant chroma in I.C.I. (x, y)-coordinates, at value 5/.

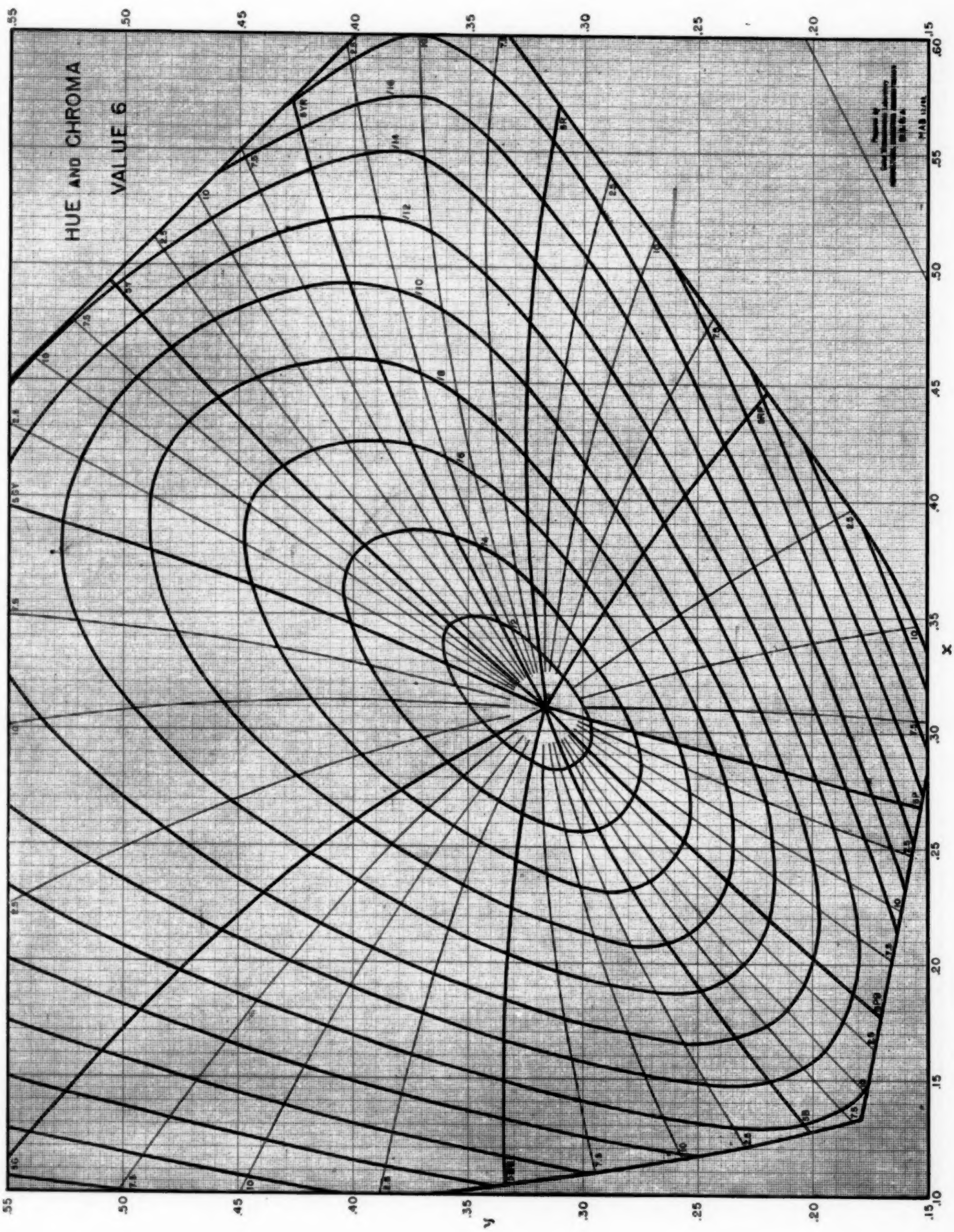

FIG. 6. Loci of constant hue and constant chroma in I.C.I. (x, y)-coordinates, at value 6/.

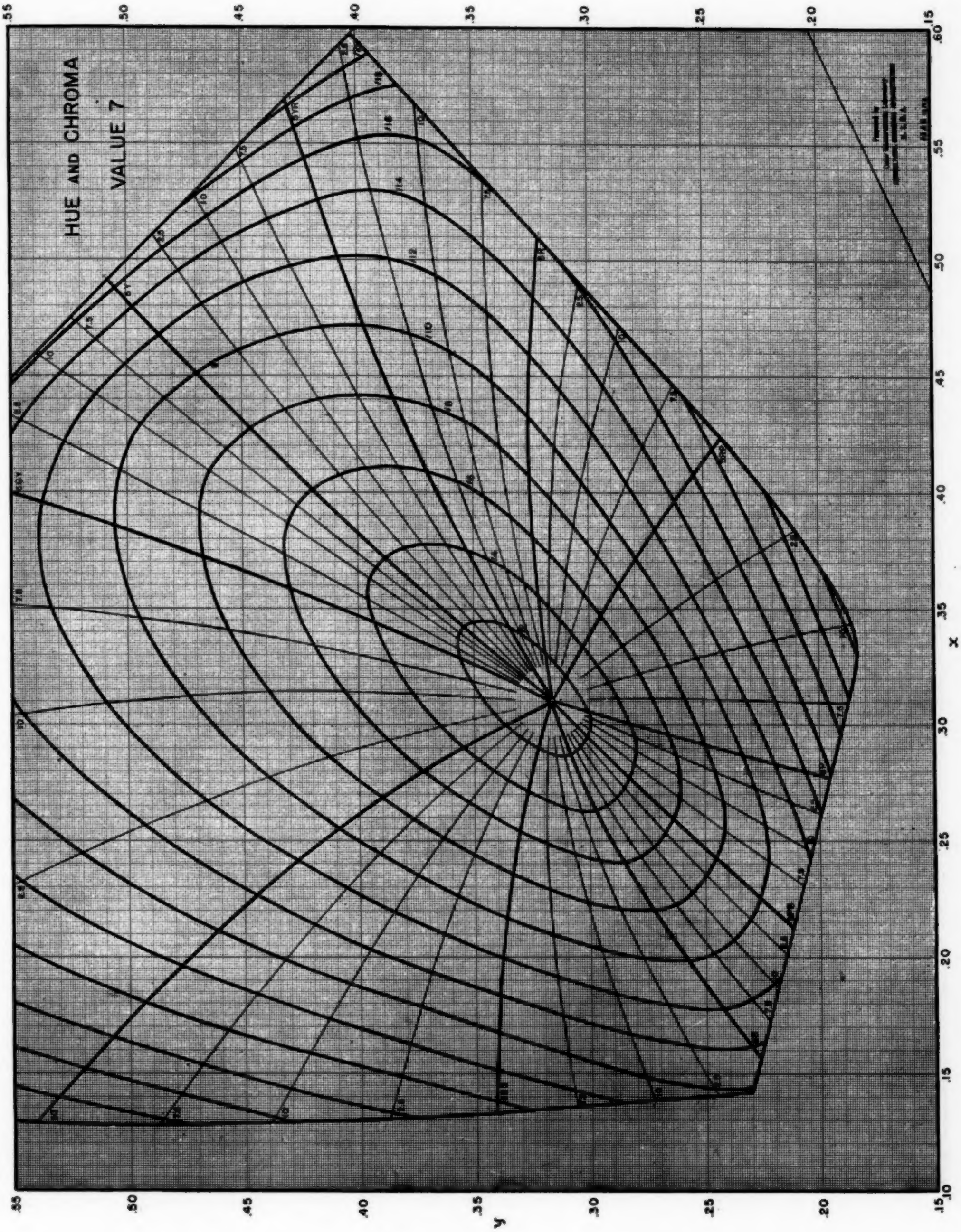

FIG. 7. Loci of constant hue and constant chroma in I.C.I. (x, y)-coordinates, at value 7/.

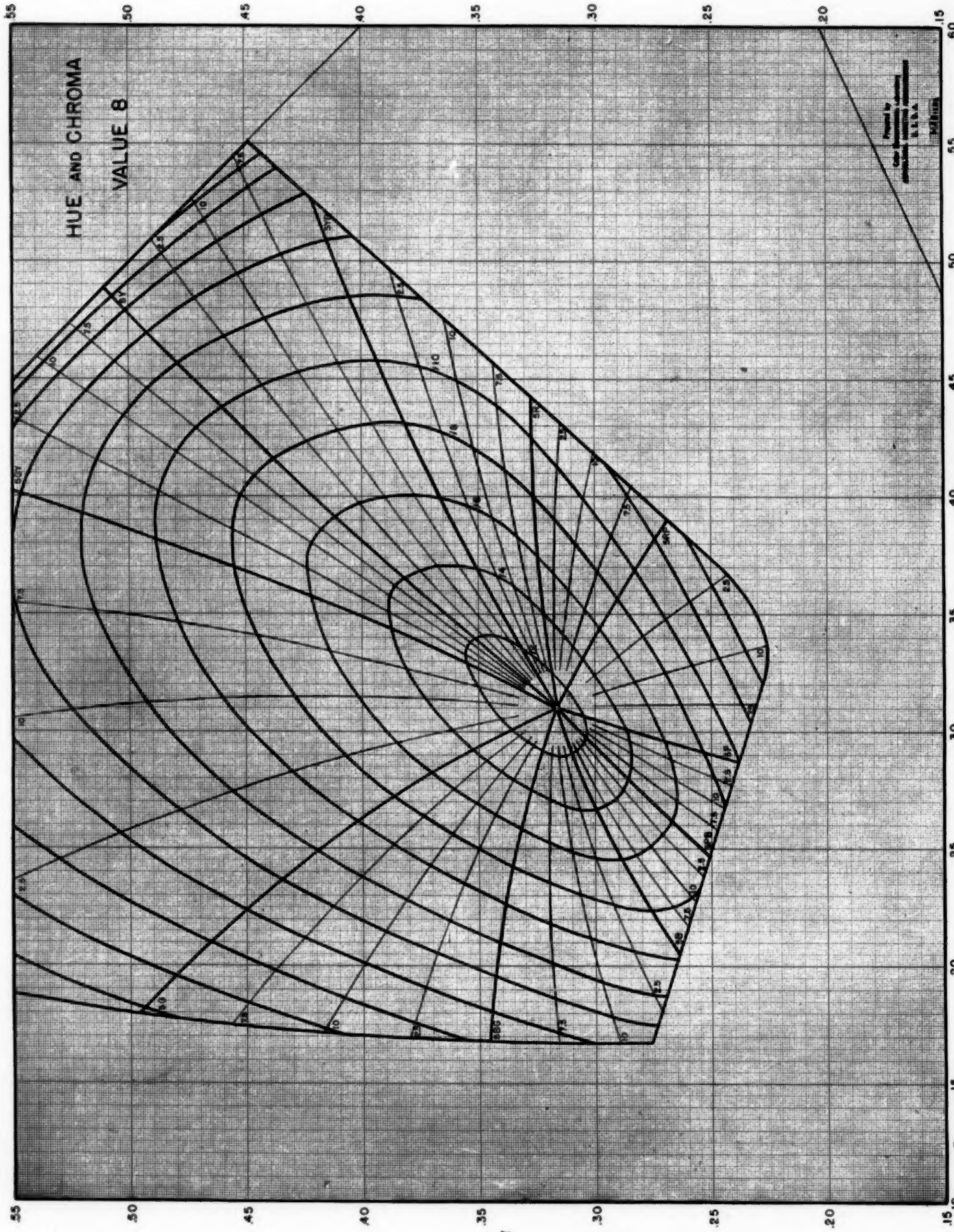

FIG. 8. Loci of constant hue and constant chroma in I.C.I. (x, y)-coordinates, at value 8/.

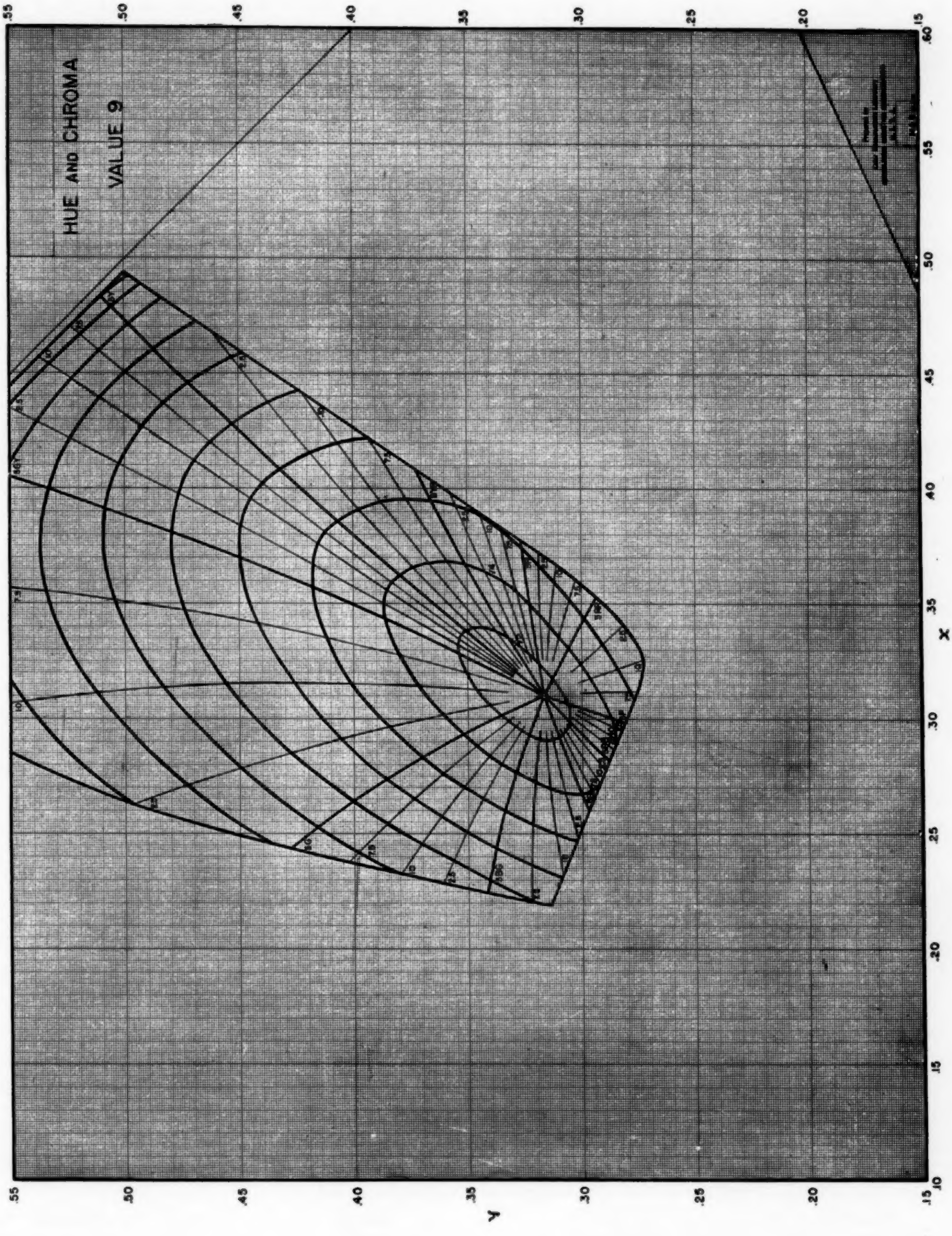

FIG. 9. Loci of constant hue and constant chroma in I.C.I. (x, y)-coordinates, at value 9/.

Munsell value. The reflectances corresponding to the principal value steps are seen to be somewhat different from the Munsell-Sloan-Godlove data (*24*).

Table I, or Figs. 1–9, together with Table II provide the means of complete specification of the given surface color sample. When the sample falls, as it usually does, between adjacent value levels and off the intersection of hue and chroma loci, interpolation is required. First the particular value (or luminous reflectance) is read from Table II. Then hue and chroma (or x, y) are spotted on both the adjacent value-level charts. Finally the hue and chroma (or x, y) for the sample are found by linear interpolation. For instance, to obtain Munsell equivalents for $Y=0.4602$, $x=0.500$, $y=0.454$:

(1) From Table II it is found that for $Y=46.02$ percent, Munsell value $(V)=7.20/$.

(2) Since $V=7.20/$, Munsell hue and chroma will be found by interpolation between the charts for values 8/ and 7/. On Fig. 8, for $x=0.500$, $y=0.454$, the Munsell hue is just redder than 10.0YR. Since the difference is less than ± 0.25 hue step, it usually will be read as 10.0YR. The chroma lies between /14 and /16 at /14.6. On Fig. 7, for $x=0.500$, $y=0.454$, the hue falls at 10.0YR, the chroma between /12 and /14, at /13.1.

(3) Since 7.20 is 0.2 of the distance between 7.00 and 8.00, the interpolated hue will be that of value 7/ plus 0.2 of the difference between the hues read from Figs. 8 and 7. Since the hue on Fig. 8 is 10.0YR, and on Fig. 7 is 10.0YR, the interpolated hue will be 10.0YR+[0.2 (10.0YR−10.0YR)] =10.0YR. Obviously, in this case, the interpolation formula was unnecessary, for hue could be read by inspection. The interpolated chroma will be the chroma at 7/ plus 0.2 of the difference between the chromas as read from Figs. 8 and 7. Since the chroma on Fig. 8 is /14.6, and on Fig. 7 is /13.1, the interpolated chroma will be $13.1+[0.2\ (14.6-13.1)]=13.4$.

(4) The complete notation for the sample is 10.0YR 7.2/13.4.

The Munsell hues at the higher values are generally so little different on adjacent value levels that they can be read by inspection. Chroma, however, varies considerably at all value levels, and interpolation usually will be required. The hues at the lower values—particularly in the red and red-purple region—will vary considerably between adjacent value levels. An example for this region is given below.

To obtain Munsell equivalents for $Y=0.0428$, $x=0.550$, $y=0.280$:

(1) From Table II it is found that for $Y=4.28$ percent, Munsell value $(V)=2.40/$.

(2) Since $V=2.40/$, hue and chroma are found by interpolation between charts for values 3/ and 2/. On Fig. 3, for $x=0.550$, $y=0.280$, the hue is between 2.5R and 5.0R at 3.25R. The chroma lies between /10 and /12 at /11.2. On Fig. 2, for $x=0.550$, $y=0.280$, the hue falls between 5.0R and 7.5R at 6.0R, the chroma between /8 and /10 at /9.0.

(3) Since 2.40 is 0.4 of the distance from 2.00 toward 3.00, the interpolated Munsell hue will be that of value 2/ plus 0.4 of the difference resulting when the hue read from Fig. 2 is subtracted from the hue read from Fig. 3. Since the hue on Fig. 3 is 3.25R and that on Fig. 2 is 6.0R, the interpolated hue will be 6.0R+0.4 (3.25R−6.0R)=4.9R. Usually it is sufficient to report hue to the nearest 0.5 hue step. Thus, this figure would be rounded to 5.0R. The interpolated chroma will be the chroma at 2/ plus 0.4 of the difference between the chromas read from Figs. 3 and 2. Since the chroma on Fig. 3 is /11.2 and on Fig. 2 is /9.0, the interpolated chroma will be

$$9.0+[0.4\ (11.2-9.0)]=9.9.$$

(4) The complete Munsell notation for the sample is 5.0R 2.4/9.9.

The protractor adapted for linear measurement which is illustrated in Fig. 10 is convenient for reading between the hue and chroma loci on Figs. 1–9.

The following example is included to illustrate the reverse conversion, that is, from Munsell notation to I.C.I.

To obtain I.C.I. (Y, x, y) equivalents for Munsell hue $(H)=5.0$R, value $(V)=2.4$, and chroma $(C)=/9.9$:

TABLE I. The I.C.I. (Y, x, y) equivalents of the recommended Munsell notation for 40 hues and 9 values (V), at every second chroma (C) step from zero to the theoretical pigment maximum.

Reds

V/C	Y	2.5R x	2.5R y	5.0R x	5.0R y	7.5R x	7.5R y	10.0R x	10.0R y
9/6	0.7866	0.3665	0.3183	0.3734	0.3256	0.3812	0.3348	0.3880	0.3439
4		.3445	.3179	.3495	.3226	.3551	.3283	.3600	.3348
2		.3210	.3168	.3240	.3188	.3263	.3210	.3284	.3233
8/10	0.5910	.4125	.3160	.4249	.3270	.4388	.3419	.4490	.3589
8		.3900	.3171	.4001	.3263	.4118	.3385	.4212	.3526
6		.3671	.3175	.3743	.3248	.3830	.3335	.3910	.3442
4		.3460	.3177	.3510	.3224	.3564	.3279	.3621	.3349
2		.3236	.3169	.3254	.3186	.3277	.3211	.3301	.3237
7/16	0.4306	.4885	.3039			.5341	.3452	.5519	.3729
14		.4660	.3082	.4848	.3238	.5059	.3450	.5234	.3700
12		.4435	.3119	.4595	.3252	.4777	.3435	.4930	.3659
10		.4183	.3144	.4320	.3260	.4470	.3413	.4600	.3596
8		.3961	.3160	.4067	.3256	.4196	.3382	.4308	.3533
6		.3728	.3170	.3805	.3244	.3888	.3336	.3984	.3452
4		.3499	.3171	.3552	.3222	.3611	.3282	.3671	.3360
2		.3284	.3170	.3306	.3190	.3335	.3220	.3360	.3253
6/18	0.3005	.5262	.2928	.5552	.3138	.5829	.3396	.6009	.3720
16		.5041	.2983	.5297	.3179	.5560	.3420	.5741	.3713
14		.4790	.3041	.5020	.3212	.5265	.3431	.5468	.3697
12		.4568	.3082	.4760	.3234	.4961	.3428	.5150	.3667
10		.4320	.3118	.4480	.3250	.4655	.3412	.4812	.3619
8		.4065	.3144	.4187	.3251	.4318	.3383	.4449	.3550
6		.3832	.3158	.3921	.3244	.4000	.3340	.4103	.3473
4		.3566	.3163	.3628	.3221	.3692	.3291	.3768	.3381
2		.3318	.3166	.3343	.3190	.3381	.3228	.3417	.3268
5/20	0.1977	.5784	.2719	.6142	.2970	.6388	.3216		
18		.5540	.2804	.5918	.3038	.6161	.3277	.6297	.3642
16		.5300	.2880	.5637	.3102	.5901	.3331	.6037	.3657
14		.5047	.2950	.5341	.3158	.5590	.3370	.5771	.3664
12		.4820	.3002	.5071	.3194	.5280	.3389	.5481	.3660
10		.4533	.3058	.4747	.3227	.4927	.3399	.5113	.3630
8		.4252	.3101	.4413	.3240	.4563	.3387	.4713	.3575
6		.3960	.3130	.4078	.3238	.4180	.3348	.4299	.3499
4		.3660	.3148	.3740	.3220	.3806	.3294	.3879	.3398
2		.3360	.3158	.3392	.3192	.3425	.3229	.3465	.3278
4/20	0.1200					.6806	.2988		
18		.5898	.2622	.6329	.2881	.6538	.3100		
16		.5620	.2724	.6039	.2978	.6260	.3192	.6409	.3533
14		.5369	.2810	.5734	.3057	.5959	.3269	.6154	.3568
12		.5072	.2897	.5385	.3129	.5603	.3321	.5801	.3588
10		.4774	.2969	.5043	.3176	.5235	.3351	.5418	.3580
8		.4472	.3031	.4690	.3209	.4850	.3359	.4995	.3557
6		.4141	.3085	.4299	.3226	.4415	.3340	.4535	.3500
4		.3806	.3125	.3916	.3223	.3990	.3300	.4078	.3412
2		.3461	.3150	.3508	.3200	.3538	.3236	.3582	.3294

Yellow-Reds

V/C	Y	2.5YR x	2.5YR y	5.0YR x	5.0YR y	7.5YR x	7.5YR y	10.0YR x	10.0YR y
9/8	0.7866					0.4220	0.3930	0.4199	0.4069
6		0.3927	0.3550	0.3948	0.3659	.3950	.3763	.3941	.3877
4		.3641	.3422	.3668	.3509	.3679	.3585	.3677	.3668
2		.3320	.3273	.3353	.3325	.3380	.3377	.3392	.3430
8/20	0.5910					.5391	.4518	.5245	.4709
18						.5316	.4480	.5179	.4670
16						.5195	.4424	.5079	.4613
14				.5088	.4145	.5025	.4338	.4940	.4530
12		.4852	.3847	.4849	.4050	.4816	.4232	.4753	.4414
10		.4552	.3761	.4576	.3938	.4568	.4100	.4527	.4268
8		.4275	.3662	.4310	.3820	.4306	.3952	.4280	.4102
6		.3960	.3547	.3988	.3663	.4000	.3770	.3994	.3896
4		.3667	.3429	.3690	.3510	.3699	.3586	.3701	.3674
2		.3334	.3276	.3373	.3330	.3395	.3379	.3407	.3434
7/20	0.4306	.5824	.4046	.5657	.4298				
18		.5695	.4024	.5564	.4267	.5417	.4492	.5276	.4700
16		.5522	.3989	.5437	.4228	.5319	.4449	.5188	.4650
14		.5297	.3938	.5252	.4168	.5174	.4381	.5074	.4581
12		.5001	.3861	.5007	.4081	.4970	.4282	.4900	.4480
10		.4671	.3768	.4711	.3972	.4704	.4151	.4667	.4335
8		.4371	.3679	.4402	.3842	.4415	.3996	.4399	.4164
6		.4053	.3570	.4091	.3701	.4107	.3820	.4102	.3960
4		.3715	.3439	.3750	.3530	.3772	.3613	.3778	.3719
2		.3392	.3298	.3421	.3349	.3437	.3397	.3443	.3454
6/18	0.3005	.5879	.4021	.5715	.4270				
16		.5698	.3990	.5597	.4239	.5468	.4478		
14		.5488	.3947	.5423	.4188	.5320	.4412	.5200	.4623
12		.5215	.3887	.5199	.4119	.5145	.4331	.5050	.4536
10		.4891	.3806	.4921	.4022	.4904	.4220	.4843	.4416
8		.4533	.3708	.4592	.3900	.4596	.4064	.4570	.4249
6		.4180	.3600	.4229	.3750	.4242	.3876	.4240	.4030
4		.3806	.3467	.3840	.3564	.3860	.3652	.3861	.3767
2		.3453	.3321	.3474	.3373	.3487	.3421	.3491	.3483
5/16	0.1977	.5933	.3989						
14		.5731	.3953	.5642	.4201	.5506	.4450		
12		.5482	.3909	.5422	.4141	.5335	.4378	.5211	.4600
10		.5175	.3844	.5161	.4064	.5108	.4276	.5025	.4489
8		.4795	.3758	.4830	.3960	.4820	.4141	.4770	.4338
6		.4365	.3640	.4420	.3808	.4440	.3954	.4428	.4128
4		.3925	.3494	.3968	.3614	.3991	.3714	.3995	.3840
2		.3506	.3337	.3530	.3395	.3540	.3445	.3546	.3514
4/12	0.1200	.5809	.3910	.5729	.4169				
10		.5475	.3856	.5432	.4097	.5356	.4342	.5250	.4573
8		.5071	.3777	.5070	.3994	.5038	.4204	.4965	.4414
6		.4612	.3674	.4651	.3859	.4655	.4029	.4618	.4213
4		.4141	.3539	.4187	.3679	.4208	.3809	.4189	.3948
2		.3624	.3367	.3651	.3442	.3662	.3504	.3660	.3590

TABLE I.—*Continued.*

Reds (*continued*)

V/C	Y	2.5R x	2.5R y	5.0R x	5.0R y	7.5R x	7.5R y	10.0R x	10.0R y
3/16	0.06555	.6116	.2456	.6520	.2660	.6817	.2872		
14		.5828	.2579	.6204	.2789	.6492	.3012	.6703	.3249
12		.5536	.2691	.5884	.2904	.6158	.3129	.6322	.3361
10		.5191	.2811	.5500	.3024	.5730	.3240	.5871	.3440
8		.4821	.2918	.5064	.3114	.5251	.3297	.5393	.3477
6		.4409	.3009	.4592	.3168	.4738	.3316	.4854	.3467
4		.4021	.3076	.4148	.3190	.4240	.3302	.4308	.3412
2		.3591	.3130	.3645	.3190	.3690	.3248	.3728	.3314
2/14	0.03126	.5734	.2083	.6302	.2287	.6791	.2520	.7165	.2734
12		.5438	.2254	.5930	.2465	.6392	.2704	.6732	.2937
10		.5122	.2428	.5557	.2633	.5952	.2874	.6247	.3120
8		.4776	.2593	.5143	.2800	.5433	.3027	.5713	.3259
6		.4390	.2760	.4642	.2934	.4875	.3123	.5095	.3331
4		.4021	.2900	.4184	.3032	.4335	.3169	.4481	.3330
2		.3614	.3033	.3692	.3111	.3751	.3181	.3811	.3274
1/10	0.01210	.5058	.1900	.5604	.2100	.6111	.2290	.6661	.2499
8		.4812	.2103	.5282	.2297	.5722	.2487	.6178	.2713
6		.4515	.2329	.4885	.2515	.5235	.2698	.5584	.2921
4		.4166	.2569	.4420	.2728	.4660	.2888	.4933	.3068
2		.3768	.2816	.3908	.2929	.4020	.3034	.4128	.3154

Yellow-Reds (*continued*)

V/C	Y	2.5YR x	2.5YR y	5.0YR x	5.0YR y	7.5YR x	7.5YR y	10.0YR x	10.0YR y
3/10	0.06555	.5941	.3818						
8		.5475	.3771	.5456	.4040	.5390	.4306	.5305	.4559
6		.4954	.3692	.4966	.3908	.4930	.4116	.4872	.4326
4		.4360	.3563	.4376	.3715	.4378	.3865	.4341	.4018
2		.3757	.3391	.3771	.3476	.3771	.3549	.3747	.3630
2/8	0.03126	.5995	.3590						
6		.5280	.3581	.5426	.3925	.5475	.4271		
4		.4598	.3508	.4674	.3738	.4690	.3964	.4676	.4168
2		.3852	.3365	.3880	.3476	.3889	.3590	.3872	.3688
1/8	0.01210	.6721	.3058						
6		.6048	.3270						
4		.5311	.3371	.5660	.3795				
2		.4258	.3344	.4377	.3580	.4430	.3775	.4446	.3982

Yellows

V/C	Y	2.5Y x	2.5Y y	5.0Y x	5.0Y y	7.5Y x	7.5Y y	10.0Y x	10.0Y y
9/20	0.7866			0.4830	0.5092				
18				.4782	.5049	0.4663	0.5188	0.4540	0.5320
16				.4711	.4977	.4595	.5104	.4477	.5225
14				.4602	.4869	.4503	.4993	.4393	.5101
12		0.4569	0.4527	.4455	.4719	.4369	.4829	.4271	.4920
10		.4370	.4369	.4275	.4529	.4201	.4622	.4120	.4694
8		.4154	.4186	.4080	.4319	.4019	.4392	.3957	.4450
6		.3910	.3972	.3858	.4071	.3811	.4123	.3761	.4155
4		.3655	.3738	.3621	.3799	.3591	.3832	.3558	.3852
2		.3390	.3472	.3378	.3504	.3365	.3527	.3349	.3537
8/20	0.5910	.5091	.4900						
18		.5033	.4855	.4847	.5069	.4709	.5220	.4570	.5366
16		.4957	.4800	.4791	.5012	.4658	.5158	.4525	.5295
14		.4842	.4712	.4699	.4920	.4574	.5062	.4450	.5181
12		.4678	.4589	.4562	.4788	.4455	.4917	.4341	.5020
10		.4469	.4423	.4376	.4601	.4283	.4712	.4190	.4791
8		.4231	.4231	.4158	.4378	.4088	.4466	.4008	.4520
6		.3969	.4009	.3913	.4117	.3862	.4175	.3803	.4216
4		.3684	.3751	.3650	.3826	.3622	.3861	.3581	.3883
2		.3406	.3484	.3394	.3518	.3379	.3540	.3359	.3552

Green-Yellows

V/C	Y	2.5GY x	2.5GY y	5.0GY x	5.0GY y	7.5GY x	7.5GY y	10.0GY x	10.0GY y
9/18	0.7866	0.4354	0.5508	0.4108	0.5699	0.3602	0.5920	0.3032	0.5748
16		.4288	.5383	.4058	.5541	.3581	.5654	.3079	.5440
14		.4212	.5237	.3993	.5329	.3551	.5339	.3115	.5129
12		.4108	.5028	.3911	.5082	.3518	.5042	.3139	.4829
10		.3973	.4761	.3810	.4791	.3471	.4735	.3155	.4558
8		.3834	.4490	.3698	.4497	.3414	.4415	.3157	.4259
6		.3670	.4178	.3572	.4179	.3351	.4111	.3153	.4008
4		.3499	.3866	.3437	.3861	.3274	.3793	.3144	.3711
2		.3321	.3539	.3284	.3534	.3198	.3500	.3124	.3454
8/24	0.5910							.2781	.6840
22								.2846	.6564
20				.4127	.5855	.3592	.6235	.2918	.6255
18		.4371	.5557	.4104	.5785	.3585	.6063	.2987	.5919
16		.4327	.5475	.4061	.5641	.3569	.5798	.3043	.5578
14		.4261	.5344	.4011	.5468	.3546	.5490	.3091	.5247
12		.4154	.5133	.3924	.5199	.3511	.5144	.3124	.4926
10		.4021	.4869	.3816	.4879	.3463	.4791	.3140	.4601
8		.3858	.4550	.3696	.4542	.3408	.4452	.3149	.4284
6		.3690	.4230	.3573	.4214	.3339	.4129	.3150	.4014
4		.3504	.3887	.3433	.3872	.3266	.3809	.3140	.3727
2		.3327	.3555	.3284	.3542	.3194	.3502	.3121	.3459

TABLE I.—*Continued.*

Yellows (*continued*)

V/C	Y	2.5Y x	2.5Y y	5.0Y x	5.0Y y	7.5Y x	7.5Y y	10.0Y x	10.0Y y
7/16	0.4306	.5049	.4843	.4875	.5047	.4728	.5215	.4582	.5375
14		.4950	.4773	.4791	.4965	.4652	.5128	.4516	.5277
12		.4806	.4666	.4677	.4857	.4547	.5005	.4420	.5131
10		.4606	.4516	.4509	.4696	.4400	.4830	.4289	.4937
8		.4353	.4312	.4271	.4462	.4184	.4568	.4090	.4641
6		.4073	.4073	.4009	.4198	.3943	.4264	.3864	.4305
4		.3761	.3800	.3718	.3885	.3677	.3925	.3624	.3951
2		.3436	.3507	.3419	.3540	.3396	.3558	.3369	.3569
6/14	0.3005	.5061	.4829	.4905	.5038	.4754	.5220	.4593	.5392
12		.4928	.4730	.4780	.4920	.4638	.5087	.4488	.5237
10		.4760	.4607	.4639	.4790	.4512	.4943	.4372	.5068
8		.4517	.4421	.4426	.4588	.4321	.4719	.4201	.4812
6		.4203	.4176	.4140	.4305	.4060	.4400	.3960	.4452
4		.3840	.3867	.3794	.3955	.3745	.4004	.3679	.4033
2		.3480	.3540	.3457	.3580	.3431	.3601	.3398	.3611
5/12	0.1977	.5082	.4812	.4932	.5019	.4767	.5208	.4590	.5390
10		.4905	.4683	.4777	.4876	.4632	.5057	.4468	.5209
8		.4685	.4524	.4579	.4692	.4450	.4850	.4307	.4967
6		.4380	.4292	.4302	.4435	.4199	.4551	.4072	.4621
4		.3968	.3954	.3915	.4057	.3850	.4120	.3762	.4158
2		.3534	.3570	.3500	.3620	.3470	.3640	.3422	.3648
4/10	0.1200	.5120	.4800						
8		.4865	.4625	.4745	.4810	.4595	.4990	.4430	.5153
6		.4542	.4391	.4451	.4550	.4331	.4688	.4190	.4795
4		.4138	.4076	.4069	.4188	.3982	.4272	.3871	.4321
2		.3633	.3654	.3590	.3701	.3542	.3727	.3476	.3732
3/6	0.06555	.4784	.4531	.4670	.4711	.4526	.4889	.4345	.5026
4		.4277	.4166	.4191	.4283	.4086	.4379	.3961	.4452
2		.3703	.3700	.3646	.3748	.3589	.3778	.3513	.3789
2/4	0.03126	.4627	.4392	.4543	.4573	.4401	.4723	.4188	.4789
2		.3825	.3785	.3757	.3839	.3660	.3858	.3556	.3848
1/2	0.01210	.4362	.4177	.4230	.4265	.4042	.4287	.3802	.4212

Green-Yellows (*continued*)

V/C	Y	2.5GY x	2.5GY y	5.0GY x	5.0GY y	7.5GY x	7.5GY y	10.0GY x	10.0GY y
7/22	0.4306							.2728	.6893
20								.2816	.6563
18						.3555	.6242	.2905	.6186
16		.4366	.5578	.4076	.5783	.3549	.6000	.2981	.5835
14		.4309	.5459	.4027	.5615	.3532	.5700	.3047	.5458
12		.4213	.5270	.3949	.5367	.3502	.5328	.3092	.5095
10		.4091	.5030	.3852	.5051	.3461	.4950	.3123	.4732
8		.3919	.4684	.3722	.4669	.3406	.4558	.3140	.4387
6		.3728	.4316	.3581	.4291	.3341	.4191	.3142	.4058
4		.3534	.3953	.3437	.3929	.3267	.3848	.3133	.3764
2		.3328	.3569	.3284	.3559	.3190	.3516	.3117	.3469
6/20	0.3005							.2648	.7004
18								.2763	.6616
16						.3498	.6282	.2872	.6199
14		.4354	.5594	.4042	.5788	.3498	.5985	.2962	.5802
12		.4269	.5414	.3980	.5564	.3488	.5596	.3037	.5358
10		.4159	.5190	.3891	.5264	.3463	.5196	.3086	.4949
8		.4006	.4885	.3772	.4880	.3418	.4768	.3116	.4563
6		.3799	.4470	.3622	.4438	.3351	.4321	.3128	.4175
4		.3572	.4038	.3461	.4008	.3275	.3922	.3124	.3822
2		.3342	.3607	.3288	.3592	.3193	.3550	.3112	.3496
5/18	0.1977							.2549	.7179
16								.2702	.6700
14						.3429	.6335	.2838	.6208
12		.4333	.5602	.4011	.5802	.3450	.5949	.2940	.5751
10		.4224	.5369	.3928	.5485	.3451	.5490	.3028	.5237
8		.4088	.5068	.3815	.5093	.3412	.4976	.3080	.4759
6		.3879	.4646	.3663	.4614	.3354	.4483	.3108	.4301
4		.3621	.4143	.3482	.4097	.3274	.3994	.3111	.3881
2		.3352	.3636	.3289	.3612	.3188	.3560	.3110	.3508
4/16	0.1200							.2422	.7360
14								.2590	.6858
12						.3348	.6468	.2758	.6282
10				.3983	.5850	.3395	.5913	.2908	.5672
8		.4174	.5300	.3868	.5384	.3400	.5348	.3008	.5095
6		.3968	.4857	.3718	.4852	.3355	.4739	.3069	.4550
4		.3708	.4329	.3538	.4284	.3281	.4157	.3100	.4018
2		.3382	.3706	.3312	.3678	.3185	.3604	.3109	.3550
3/14	0.06555							.2283	.7423
12								.2531	.6700
10						.3266	.6448	.2724	.6026
8				.3924	.5832	.3341	.5700	.2887	.5361
6		.4069	.5110	.3750	.5109	.3333	.4967	.2992	.4717
4		.3772	.4484	.3554	.4429	.3270	.4288	.3053	.4123
2		.3412	.3768	.3319	.3729	.3180	.3644	.3088	.3578
2/12	0.03126							.1907	.7798
10								.2307	.6814
8						.3160	.6509	.2628	.5837
6				.3839	.5748	.3260	.5379	.2852	.4972
4		.3881	.4752	.3582	.4650	.3248	.4457	.2986	.4240
2		.3421	.3803	.3309	.3743	.3165	.3650	.3069	.3580
1/6	0.01210							.2232	.6392
4				.3765	.5942	.3133	.5380	.2722	.4903
2		.3540	.4088	.3359	.3982	.3154	.3840	.3006	.3720

TABLE I.—*Continued.*

V/C	Y	Greens 2.5G x	2.5G y	5.0G x	5.0G y	7.5G x	7.5G y	10.0G x	10.0G y
9/16	0.7866	0.2630	0.4966						
14		.2711	.4726						
12		.2786	.4491	0.2528	0.4160	0.2419	0.3985	0.2325	0.3796
10		.2851	.4275	.2639	.4001	.2545	.3855	.2457	.3702
8		.2912	.4054	.2735	.3854	.2652	.3738	.2574	.3618
6		.2966	.3846	.2832	.3697	.2763	.3607	.2703	.3513
4		.3018	.3606	.2933	.3519	.2882	.3461	.2840	.3402
2		.3058	.3400	.3017	.3357	.2987	.3323	.2965	.3293
8/24	0.5910	.2091	.6033						
22		.2221	.5799	.1821	.4940				
20		.2339	.5561	.1956	.4806	.1845	.4492	.1734	.4164
18		.2451	.5309	.2103	.4652	.1980	.4372	.1866	.4086
16		.2563	.5045	.2240	.4500	.2120	.4252	.2012	.3992
14		.2661	.4780	.2368	.4348	.2254	.4125	.2148	.3903
12		.2743	.4554	.2489	.4191	.2380	.4002	.2282	.3811
10		.2829	.4301	.2613	.4026	.2515	.3867	.2430	.3710
8		.2896	.4065	.2723	.3865	.2639	.3733	.2564	.3611
6		.2952	.3851	.2822	.3702	.2754	.3608	.2693	.3512
4		.3009	.3614	.2924	.3523	.2874	.3464	.2828	.3403
2		.3053	.3404	.3009	.3359	.2981	.3326	.2957	.3293
7/26	0.4306	.1689	.6549	.1397	.5312	.1303	.4858		
24		.1875	.6265	.1521	.5200	.1415	.4778	.1310	.4377
22		.2029	.6017	.1659	.5074	.1539	.4683	.1434	.4306
20		.2181	.5744	.1805	.4933	.1688	.4570	.1589	.4220
18		.2328	.5467	.1967	.4771	.1841	.4448	.1734	.4135
16		.2448	.5203	.2111	.4616	.1982	.4330	.1881	.4049
14		.2568	.4931	.2262	.4450	.2139	.4199	.2033	.3956
12		.2672	.4667	.2416	.4267	.2295	.4058	.2195	.3854
10		.2775	.4395	.2554	.4087	.2445	.3914	.2352	.3748
8		.2861	.4129	.2687	.3901	.2595	.3764	.2513	.3635
6		.2933	.3873	.2801	.3721	.2728	.3622	.2662	.3526
4		.2992	.3644	.2902	.3548	.2850	.3482	.2803	.3415
2		.3047	.3413	.3001	.3366	.2972	.3333	.2945	.3297
6/28	0.3005	.1145	.7122	.0908	.5695	.0858	.5127		
26		.1340	.6871	.1079	.5560	.1010	.5018	.0941	.4520
24		.1536	.6605	.1252	.5408	.1159	.4910	.1070	.4458
22		.1739	.6318	.1432	.5252	.1325	.4795	.1230	.4378
20		.1922	.6035	.1609	.5091	.1485	.4677	.1382	.4299
18		.2102	.5737	.1785	.4924	.1654	.4551	.1551	.4208
16		.2278	.5430	.1960	.4751	.1832	.4414	.1722	.4113
14		.2426	.5133	.2130	.4571	.2001	.4278	.1895	.4015
12		.2574	.4814	.2293	.4390	.2171	.4138	.2060	.3914
10		.2690	.4530	.2466	.4181	.2350	.3979	.2247	.3796
8		.2799	.4239	.2612	.3990	.2510	.3829	.2420	.3679
6		.2892	.3963	.2748	.3795	.2662	.3672	.2591	.3558
4		.2967	.3695	.2868	.3595	.2807	.3522	.2749	.3443
2		.3039	.3437	.2988	.3382	.2958	.3344	.2929	.3303

V/C	Y	Blue-Greens 2.5BG x	2.5BG y	5.0BG x	5.0BG y	7.5BG x	7.5BG y	10.0BG x	10.0BG y
9/10	0.7866	0.2382	0.3568	0.2301	0.3405	0.2215	0.3226		
8		.2509	.3507	.2437	.3378	.2361	.3225		
6		.2652	.3433	.2599	.3338	.2543	.3220	0.2501	0.3118
4		.2805	.3349	.2768	.3287	.2728	.3208	.2700	.3140
2		.2947	.3267	.2930	.3232	.2911	.3188	.2907	.3159
8/18	0.5910	.1759	.3782						
16		.1915	.3732	.1814	.3450	.1721	.3168		
14		.2057	.3681	.1958	.3432	.1868	.3179	.1788	.2936
12		.2196	.3630	.2101	.3412	.2010	.3188	.1937	.2978
10		.2352	.3566	.2264	.3383	.2184	.3196	.2120	.3025
8		.2500	.3500	.2419	.3352	.2352	.3198	.2302	.3063
6		.2647	.3429	.2588	.3318	.2525	.3198	.2489	.3099
4		.2791	.3351	.2752	.3278	.2718	.3200	.2686	.3130
2		.2940	.3268	.2919	.3228	.2900	.3183	.2894	.3152
7/22	0.4306	.1334	.3870						
20		.1490	.3827	.1380	.3412				
18		.1626	.3788	.1515	.3410	.1427	.3076		
16		.1788	.3739	.1675	.3401	.1584	.3101	.1489	.2768
14		.1932	.3694	.1838	.3390	.1751	.3129	.1671	.2832
12		.2102	.3636	.1997	.3379	.1914	.3148	.1841	.2892
10		.2264	.3576	.2163	.3361	.2094	.3165	.2035	.2956
8		.2439	.3508	.2354	.3335	.2292	.3178	.2235	.3014
6		.2608	.3430	.2543	.3302	.2490	.3186	.2448	.3069
4		.2764	.3354	.2712	.3269	.2671	.3189	.2642	.3109
2		.2927	.3269	.2898	.3225	.2878	.3182	.2869	.3143
6/22	0.3005	.1120	.3860						
20		.1269	.3829	.1168	.3344				
18		.1428	.3790	.1325	.3345	.1248	.2981	.1181	.2581
16		.1600	.3748	.1491	.3345	.1408	.3017	.1337	.2651
14		.1779	.3699	.1662	.3343	.1585	.3052	.1518	.2729
12		.1954	.3645	.1844	.3337	.1762	.3081	.1698	.2802
10		.2148	.3584	.2037	.3329	.1961	.3110	.1909	.2881
8		.2332	.3522	.2236	.3311	.2171	.3138	.2116	.2950
6		.2526	.3448	.2441	.3290	.2384	.3155	.2335	.3015
4		.2702	.3369	.2648	.3262	.2604	.3169	.2578	.3078
2		.2902	.3268	.2872	.3219	.2849	.3172	.2837	.3132

TABLE I.—*Continued.*

		Greens (*continued*)							
		2.5G		5.0G		7.5G		10.0G	
V/C	Y	x	y	x	y	x	y	x	y
5/28	0.1977	.0794	.7385	.0609	.5898	.0585	.5224	.0572	.4590
26		.0992	.7155	.0784	.5761	.0730	.5131	.0690	.4542
24		.1188	.6918	.0953	.5628	.0878	.5039	.0811	.4491
22		.1377	.6674	.1144	.5463	.1050	.4927	.0958	.4428
20		.1579	.6392	.1318	.5321	.1212	.4817	.1120	.4360
18		.1782	.6095	.1489	.5171	.1372	.4705	.1275	.4288
16		.2005	.5759	.1695	.4981	.1571	.4561	.1469	.4192
14		.2211	.5411	.1912	.4773	.1776	.4415	.1671	.4089
12		.2385	.5071	.2104	.4578	.1964	.4271	.1852	.3992
10		.2565	.4705	.2329	.4331	.2200	.4082	.2095	.3853
8		.2710	.4380	.2511	.4107	.2395	.3915	.2297	.3730
6		.2841	.4045	.2690	.3860	.2598	.3724	.2519	.3587
4		.2943	.3735	.2841	.3628	.2775	.3545	.2711	.3455
2		.3030	.3445	.2978	.3392	.2945	.3355	.2910	.3310
4/26	0.1200	.0528	.7502	.0407	.6010	.0392	.5258	.0400	.4545
24		.0760	.7250	.0614	.5857	.0581	.5151	.0553	.4492
22		.1009	.6975	.0841	.5684	.0770	.5040	.0702	.4440
20		.1230	.6706	.1018	.5543	.0928	.4942	.0850	.4388
18		.1446	.6431	.1188	.5400	.1086	.4842	.1006	.4330
16		.1682	.6111	.1402	.5214	.1293	.4703	.1212	.4245
14		.1909	.5779	.1627	.5015	.1500	.4562	.1398	.4168
12		.2128	.5425	.1843	.4807	.1706	.4419	.1602	.4070
10		.2355	.5006	.2115	.4532	.1989	.4219	.1876	.3933
8		.2561	.4597	.2359	.4266	.2232	.4022	.2124	.3799
6		.2735	.4215	.2581	.3992	.2467	.3822	.2374	.3655
4		.2891	.3821	.2781	.3704	.2702	.3602	.2628	.3498
2		.3012	.3470	.2959	.3417	.2919	.3371	.2880	.3327
3/22	0.06555	.0390	.7468	.0340	.6011	.0332	.5206	.0333	.4444
20		.0720	.7127	.0620	.5802	.0568	.5082	.0528	.4393
18		.1049	.6766	.0882	.5605	.0798	.4954	.0718	.4340
16		.1341	.6420	.1120	.5414	.1023	.4818	.0925	.4275
14		.1626	.6052	.1382	.5197	.1262	.4667	.1161	.4192
12		.1902	.5642	.1660	.4948	.1516	.4505	.1411	.4095
10		.2170	.5211	.1935	.4682	.1800	.4310	.1688	.3974
8		.2435	.4752	.2228	.4380	.2088	.4101	.1970	.3841
6		.2642	.4342	.2471	.4100	.2346	.3901	.2240	.3699
4		.2836	.3915	.2711	.3780	.2618	.3667	.2525	.3537
2		.2999	.3500	.2935	.3439	.2890	.3391	.2844	.3337
2/16	0.03126	.0329	.7358	.0277	.5986	.0276	.5153	.0285	.4327
14		.0820	.6860	.0688	.5691	.0629	.4973	.0599	.4270
12		.1307	.6308	.1120	.5358	.1022	.4759	.0934	.4183
10		.1773	.5698	.1560	.4981	.1442	.4505	.1321	.4059
8		.2192	.5042	.1979	.4583	.1842	.4244	.1705	.3911
6		.2493	.4522	.2318	.4231	.2200	.3983	.2092	.3739
4		.2763	.3998	.2640	.3845	.2540	.3705	.2442	.3559
2		.2978	.3507	.2918	.3450	.2869	.3400	.2820	.3341
1/8	0.01210	.0620	.6896	.0559	.5710	.0530	.4943	.0511	.4158
6		.1711	.5619	.1468	.4996	.1344	.4505	.1249	.4019
4		.2454	.4489	.2290	.4218	.2159	.3967	.2040	.3724
2		.2910	.3634	.2833	.3564	.2758	.3484	.2689	.3407

		Blue-Greens (*continued*)							
		2.5BG		5.0BG		7.5BG		10.0BG	
V/C	Y	x	y	x	y	x	y	x	y
5/24	0.1977	.0738	.3851						
22		.0861	.3832	.0781	.3211				
20		.1005	.3814	.0904	.3231				
18		.1165	.3785	.1046	.3244	.0982	.2828		
16		.1348	.3750	.1243	.3261	.1167	.2880	.1108	.2489
14		.1559	.3708	.1448	.3275	.1364	.2932	.1308	.2582
12		.1735	.3668	.1614	.3280	.1537	.2976	.1485	.2662
10		.1980	.3606	.1850	.3280	.1776	.3032	.1716	.2760
8		.2205	.3537	.2100	.3280	.2030	.3082	.1970	.2860
6		.2448	.3452	.2360	.3270	.2292	.3125	.2234	.2952
4		.2659	.3369	.2591	.3246	.2550	.3150	.2512	.3040
2		.2880	.3270	.2841	.3210	.2812	.3161	.2796	.3111
4/24	0.1200	.0510	.3800						
22		.0636	.3788						
20		.0768	.3773	.0675	.3075				
18		.0915	.3754	.0828	.3108	.0768	.2667		
16		.1102	.3720	.0992	.3141	.0922	.2718	.0888	.2298
14		.1283	.3688	.1170	.3170	.1092	.2774	.1033	.2376
12		.1492	.3649	.1379	.3198	.1298	.2840	.1248	.2484
10		.1738	.3600	.1618	.3219	.1540	.2910	.1480	.2600
8		.2006	.3540	.1890	.3234	.1815	.2985	.1760	.2730
6		.2278	.3463	.2182	.3240	.2113	.3052	.2065	.2863
4		.2552	.3375	.2480	.3232	.2429	.3108	.2384	.2984
2		.2840	.3270	.2799	.3208	.2764	.3148	.2740	.3091
3/20	0.06555	.0482	.3695						
18		.0648	.3682	.0580	.2940				
16		.0843	.3667	.0735	.2979	.0691	.2559		
14		.1051	.3648	.0940	.3027	.0874	.2627	.0798	.2151
12		.1288	.3620	.1158	.3071	.1086	.2706	.1018	.2281
10		.1552	.3580	.1410	.3118	.1326	.2784	.1250	.2411
8		.1845	.3531	.1703	.3159	.1620	.2872	.1551	.2571
6		.2132	.3468	.2020	.3188	.1928	.2958	.1861	.2722
4		.2437	.3386	.2343	.3200	.2272	.3041	.2221	.2886
2		.2799	.3271	.2742	.3192	.2699	.3120	.2660	.3050
2/14	0.03126	.0555	.3588						
12		.0851	.3576	.0769	.2880	.0724	.2478		
10		.1190	.3551	.1050	.2956	.0991	.2582	.0929	.2133
8		.1557	.3517	.1405	.3037	.1325	.2710	.1258	.2331
6		.1971	.3452	.1843	.3110	.1747	.2853	.1669	.2570
4		.2343	.3378	.2234	.3150	.2162	.2981	.2096	.2790
2		.2765	.3271	.2697	.3175	.2651	.3098	.2606	.3010
1/8	0.01210	.0476	.3458						
6		.1169	.3452	.1093	.2860	.1059	.2485	.1074	.2129
4		.1883	.3406	.1753	.3021	.1702	.2768	.1658	.2496
2		.2600	.3289	.2500	.3141	.2430	.3023	.2362	.2882

TABLE I.—*Continued.*

Blues

V/C	Y	2.5B x	2.5B y	5.0B x	5.0B y	7.5B x	7.5B y	10.0B x	10.0B y
9/4	0.7866	0.2680	0.3073	0.2675	0.3005	0.2688	0.2961	0.2712	0.2924
2		.2909	.3125	.2919	.3102	.2937	.3087	.2949	.3076
8/12	0.5910	.1877	.2752						
10		.2066	.2839						
8		.2264	.2923	.2237	.2761	.2252	.2668	.2294	.2587
6		.2462	.3000	.2457	.2888	.2472	.2821	.2512	.2760
4		.2668	.3067	.2671	.2998	.2688	.2956	.2718	.2911
2		.2897	.3124	.2908	.3096	.2922	.3077	.2935	.3062
7/16	0.4306	.1435	.2472						
14		.1624	.2581	.1615	.2307				
12		.1797	.2672	.1778	.2430	.1818	.2303	.1883	.2203
10		.1994	.2775	.1986	.2579	.2016	.2466	.2078	.2382
8		.2208	.2871	.2204	.2729	.2225	.2631	.2277	.2559
6		.2418	.2960	.2410	.2854	.2436	.2787	.2478	.2728
4		.2629	.3038	.2633	.2972	.2651	.2927	.2685	.2886
2		.2867	.3110	.2875	.3078	.2888	.3058	.2908	.3039
6/16	0.3005	.1294	.2348	.1310	.2048	.1376	.1879	.1454	.1778
14		.1480	.2459	.1496	.2193	.1556	.2043	.1629	.1947
12		.1660	.2561	.1685	.2339	.1734	.2203	.1803	.2114
10		.1879	.2682	.1883	.2487	.1934	.2374	.2000	.2298
8		.2080	.2789	.2088	.2635	.2132	.2537	.2189	.2468
6		.2312	.2899	.2320	.2789	.2352	.2708	.2399	.2650
4		.2571	.3008	.2579	.2938	.2602	.2881	.2637	.2840
2		.2835	.3097	.2842	.3063	.2854	.3037	.2871	.3012
5/18	0.1977							.1203	.1505
16		.1090	.2166	.1132	.1863	.1230	.1711	.1326	.1632
14		.1283	.2292	.1320	.2021	.1404	.1878	.1492	.1797
12		.1461	.2406	.1505	.2172	.1584	.2042	.1666	.1964
10		.1697	.2549	.1729	.2347	.1792	.2230	.1860	.2149
8		.1947	.2687	.1958	.2519	.2007	.2417	.2067	.2344
6		.2210	.2823	.2215	.2701	.2248	.2612	.2299	.2548
4		.2492	.2954	.2493	.2879	.2511	.2808	.2547	.2757
2		.2791	.3071	.2794	.3032	.2803	.3000	.2821	.2966
4/16	0.1200	.0908	.1973					.1155	.1416
14		.1027	.2057	.1098	.1785	.1204	.1655	.1310	.1580
12		.1247	.2209	.1299	.1963	.1393	.1837	.1487	.1760
10		.1463	.2354	.1512	.2148	.1601	.2028	.1681	.1954
8		.1737	.2524	.1759	.2345	.1821	.2232	.1893	.2160
6		.2048	.2708	.2060	.2572	.2102	.2470	.2157	.2407
4		.2360	.2872	.2363	.2782	.2388	.2704	.2429	.2648
2		.2727	.3038	.2723	.2992	.2733	.2947	.2753	.2910

Purple-Blues

V/C	Y	2.5PB x	2.5PB y	5.0PB x	5.0PB y	7.5PB x	7.5PB y	10.0PB x	10.0PB y
9/4	0.7866							0.2910	0.2850
2		0.2975	0.3063	0.2991	0.3057	0.3015	0.3052	.3038	.3054
8/8	0.5910							.2677	.2443
6		.2562	.2709	.2614	.2670	.2702	.2648	.2792	.2649
4		.2758	.2879	.2798	.2861	.2856	.2846	.3011	.2848
2		.2957	.3047	.2974	.3039	.3003	.3034	.3027	.3035
7/12	0.4306							.2465	.2058
10		.2162	.2309	.2254	.2267	.2410	.2224	.2563	.2240
8		.2352	.2498	.2427	.2458	.2546	.2418	.2670	.2425
6		.2538	.2677	.2596	.2643	.2687	.2612	.2776	.2612
4		.2729	.2848	.2773	.2828	.2833	.2809	.2886	.2801
2		.2932	.3025	.2952	.3011	.2982	.3003	.3005	.3000
6/16	0.3005							.2265	.1671
14		.1754	.1868	.1873	.1822	.2119	.1799	.2352	.1839
12		.1913	.2038	.2026	.1999	.2241	.1975	.2440	.1998
10		.2095	.2225	.2197	.2188	.2378	.2168	.2540	.2176
8		.2274	.2406	.2360	.2365	.2505	.2347	.2637	.2352
6		.2465	.2599	.2533	.2558	.2638	.2531	.2740	.2533
4		.2684	.2804	.2734	.2778	.2798	.2752	.2863	.2747
2		.2897	.2991	.2923	.2978	.2955	.2963	.2988	.2961
5/22	0.1977							.2082	.1225
20						.1794	.1239	.2121	.1329
18		.1363	.1410	.1518	.1365	.1862	.1365	.2174	.1444
16		.1495	.1559	.1638	.1521	.1945	.1511	.2224	.1555
14		.1642	.1728	.1773	.1689	.2042	.1661	.2299	.1698
12		.1793	.1894	.1918	.1858	.2157	.1830	.2384	.1857
10		.1968	.2078	.2080	.2041	.2285	.2020	.2478	.2030
8		.2157	.2278	.2255	.2239	.2417	.2204	.2572	.2211
6		.2365	.2488	.2447	.2449	.2563	.2417	.2686	.2412
4		.2600	.2720	.2662	.2687	.2739	.2666	.2821	.2659
2		.2847	.2942	.2882	.2923	.2918	.2908	.2959	.2905
4/30	0.1200							.1952	.0778
28								.1971	.0840
26						.1659	.0825	.1994	.0904
24						.1684	.0899	.2020	.0985
22						.1713	.0980	.2048	.1064
20				.1288	.1027	.1742	.1058	.2075	.1140
18		.1218	.1208	.1392	.1167	.1798	.1185	.2120	.1256
16		.1336	.1349	.1504	.1317	.1861	.1316	.2170	.1373
14		.1473	.1513	.1627	.1479	.1941	.1468	.2220	.1503
12		.1634	.1698	.1773	.1659	.2037	.1629	.2298	.1659
10		.1805	.1888	.1925	.1843	.2158	.1811	.2388	.1837
8		.1995	.2094	.2103	.2050	.2304	.2023	.2497	.2038
6		.2235	.2343	.2325	.2300	.2471	.2266	.2618	.2263
4		.2487	.2597	.2562	.2560	.2657	.2528	.2759	.2522
2		.2782	.2876	.2816	.2842	.2861	.2819	.2911	.2804

TABLE I.—*Continued.*

V/C	Y	Blues (*continued*) 2.5B x	2.5B y	5.0B x	5.0B y	7.5B x	7.5B y	10.0B x	10.0B y
3/14	0.06555							.1065	.1285
12		.0989	.1963	.1042	.1681	.1131	.1542	.1228	.1460
10		.1220	.2132	.1259	.1879	.1343	.1756	.1432	.1675
8		.1511	.2331	.1527	.2119	.1583	.1987	.1658	.1905
6		.1826	.2536	.1835	.2375	.1875	.2258	.1933	.2173
4		.2183	.2748	.2176	.2632	.2200	.2536	.2246	.2467
2		.2636	.2983	.2617	.2921	.2616	.2857	.2631	.2801
2/10	0.03126	.0911	.1828	.0965	.1558	.1051	.1422	.1157	.1346
8		.1230	.2076	.1245	.1827	.1313	.1692	.1396	.1603
6		.1621	.2358	.1617	.2162	.1658	.2026	.1716	.1937
4		.2060	.2649	.2048	.2518	.2063	.2400	.2102	.2313
2		.2578	.2940	.2559	.2874	.2545	.2799	.2558	.2725
1/8	0.01210					.0968	.1280	.1077	.1218
6		.1118	.1908	.1212	.1745	.1303	.1639	.1392	.1563
4		.1649	.2324	.1667	.2168	.1716	.2048	.1783	.1974
2		.2322	.2781	.2291	.2677	.2291	.2579	.2309	.2491

V/C	Y	Purple-Blues (*continued*) 2.5PB x	2.5PB y	5.0PB x	5.0PB y	7.5PB x	7.5PB y	10.0PB x	10.0PB y
3/34	0.06555					.1608	.0480	.1918	.0503
32						.1612	.0511	.1926	.0542
30						.1621	.0556	.1938	.0599
28						.1632	.0609	.1950	.0650
26						.1642	.0655	.1963	.0708
24						.1658	.0711	.1982	.0772
22						.1677	.0782	.2004	.0847
20						.1702	.0867	.2030	.0930
18				.1228	.0895	.1730	.0948	.2060	.1020
16				.1318	.1024	.1765	.1048	.2092	.1118
14		.1251	.1218	.1431	.1184	.1824	.1188	.2142	.1250
12		.1398	.1395	.1557	.1356	.1903	.1353	.2206	.1407
10		.1576	.1600	.1718	.1562	.2005	.1536	.2278	.1565
8		.1780	.1833	.1908	.1799	.2149	.1761	.2387	.1786
6		.2022	.2101	.2122	.2052	.2311	.2010	.2511	.2031
4		.2312	.2405	.2393	.2361	.2520	.2319	.2660	.2319
2		.2663	.2756	.2708	.2719	.2777	.2687	.2847	.2670
2/38	0.03126					.1623	.0280		
36						.1628	.0310		
34						.1630	.0340	.1911	.0344
32						.1635	.0373	.1918	.0379
30						.1640	.0409	.1925	.0420
28						.1647	.0451	.1937	.0471
26						.1653	.0492	.1949	.0520
24						.1660	.0538	.1962	.0578
22						.1670	.0594	.1978	.0643
20						.1685	.0666	.1998	.0718
18						.1701	.0742	.2021	.0808
16						.1728	.0839	.2052	.0910
14				.1253	.0873	.1762	.0955	.2087	.1026
12		.1166	.1076	.1363	.1048	.1813	.1094	.2139	.1170
10		.1332	.1278	.1500	.1240	.1882	.1258	.2200	.1330
8		.1540	.1530	.1685	.1491	.2005	.1495	.2294	.1551
6		.1825	.1857	.1942	.1811	.2189	.1790	.2440	.1840
4		.2175	.2245	.2263	.2192	.2420	.2148	.2600	.2162
2		.2592	.2675	.2638	.2624	.2712	.2582	.2803	.2567
1/38	0.01210					.1680	.0140		
36						.1681	.0160		
34						.1682	.0180		
32						.1682	.0202		
30						.1684	.0234	.1928	.0240
28						.1686	.0270	.1936	.0281
26						.1689	.0309	.1942	.0326
24						.1691	.0352	.1952	.0380
22						.1696	.0402	.1965	.0436
20						.1701	.0454	.1976	.0493
18						.1709	.0518	.1991	.0564
16						.1720	.0583	.2008	.0638
14						.1738	.0688	.2038	.0745
12						.1763	.0804	.2070	.0869
10				.1285	.0870	.1804	.0950	.2120	.1029
8		.1273	.1157	.1447	.1124	.1872	.1141	.2190	.1228
6		.1539	.1491	.1678	.1447	.2000	.1422	.2290	.1470
4		.1895	.1911	.2012	.1867	.2232	.1821	.2459	.1828
2		.2360	.2420	.2427	.2368	.2547	.2310	.2677	.2280

TABLE I.—*Continued.*

		Purples							
		2.5P		5.0P		7.5P		10.0P	
V/C	Y	x	y	x	y	x	y	x	y
9/6	0.7866					0.3120	0.2788	0.3218	0.2845
4		0.2963	0.2865	0.3003	0.2870	.3117	.2928	.3176	.2966
2		.3050	.3051	.3067	.3060	.3107	.3081	.3128	.3094
8/14	0.5910							.3342	.2349
12						.3117	.2370	.3312	.2470
10				.2870	.2380	.3116	.2497	.3282	.2582
8		.2800	.2488	.2914	.2534	.3116	.2626	.3250	.2700
6		.2881	.2671	.2963	.2704	.3114	.2785	.3213	.2829
4		.2962	.2850	.3012	.2868	.3114	.2915	.3175	.2955
2		.3048	.3040	.3065	.3047	.3107	.3070	.3131	.3084
7/22	0.4306							.3430	.1883
20								.3410	.1988
18						.3093	.1962	.3391	.2088
16						.3099	.2074	.3368	.2192
14				.2801	.2068	.3101	.2192	.3341	.2308
12		.2664	.2127	.2833	.2197	.3104	.2320	.3314	.2423
10		.2729	.2289	.2872	.2343	.3108	.2442	.3288	.2531
8		.2799	.2459	.2918	.2504	.3109	.2584	.3256	.2654
6		.2873	.2633	.2961	.2663	.3111	.2730	.3221	.2786
4		.2950	.2810	.3009	.2831	.3111	.2880	.3181	.2920
2		.3031	.3000	.3059	.3010	.3109	.3037	.3138	.3054
6/26	0.3005							.3457	.1604
24						.3058	.1547	.3441	.1698
22						.3062	.1638	.3426	.1785
20				.2702	.1621	.3069	.1745	.3409	.1882
18		.2504	.1658	.2731	.1738	.3075	.1870	.3388	.1995
16		.2548	.1768	.2761	.1852	.3080	.1976	.3370	.2095
14		.2593	.1909	.2794	.1979	.3084	.2095	.3349	.2203
12		.2647	.2052	.2829	.2121	.3090	.2222	.3321	.2329
10		.2703	.2204	.2862	.2260	.3092	.2350	.3293	.2450
8		.2770	.2372	.2905	.2421	.3099	.2502	.3259	.2584
6		.2842	.2550	.2950	.2585	.3101	.2650	.3226	.2716
4		.2932	.2759	.3001	.2778	.3107	.2831	.3181	.2871
2		.3016	.2960	.3050	.2967	.3107	.2993	.3146	.3018
5/30	0.1977					.3010	.1170	.3490	.1308
28				.2618	.1135	.3018	.1253	.3478	.1388
26		.2348	.1140	.2635	.1224	.3022	.1331	.3468	.1460
24		.2372	.1223	.2652	.1304	.3030	.1423	.3450	.1555
22		.2402	.1315	.2673	.1398	.3038	.1500	.3437	.1644
20		.2438	.1419	.2694	.1499	.3042	.1606	.3422	.1735
18		.2476	.1532	.2718	.1604	.3052	.1711	.3401	.1840
16		.2515	.1644	.2744	.1718	.3060	.1830	.3382	.1951
14		.2560	.1774	.2775	.1847	.3068	.1951	.3360	.2066
12		.2608	.1913	.2806	.1977	.3071	.2080	.3335	.2187
10		.2665	.2075	.2845	.2137	.3080	.2230	.3308	.2328
8		.2728	.2240	.2885	.2296	.3087	.2375	.3280	.2464
6		.2806	.2444	.2932	.2487	.3093	.2555	.3243	.2630
4		.2898	.2667	.2986	.2699	.3100	.2750	.3198	.2807
2		.3000	.2912	.3045	.2928	.3103	.2959	.3148	.2986
4/32	0.1200	.2265	.0774	.2574	.0833	.2962	.0906		
30		.2285	.0847	.2588	.0907	.2969	.0979	.3440	.1080
28		.2302	.0909	.2600	.0971	.2979	.1062	.3432	.1172
26		.2322	.0978	.2618	.1052	.2986	.1135	.3428	.1248
24		.2348	.1062	.2635	.1132	.2993	.1225	.3421	.1337

		Red-Purples							
		2.5RP		5.0RP		7.5RP		10.0RP	
V/C	Y	x	y	x	y	x	y	x	y
9/6	0.7866	0.3322	0.2910	0.3431	0.2988	0.3512	0.3052	0.3590	0.3118
4		.3234	.3010	.3301	.3060	.3350	.3099	.3400	.3140
2		.3149	.3108	.3172	.3126	.3190	.3141	.3205	.3155
8/14	0.5910	.3621	.2496						
12		.3552	.2594	.3818	.2742	.4002	.2859		
10		.3479	.2699	.3685	.2828	.3830	.2930	.3983	.3049
8		.3406	.2793	.3570	.2900	.3682	.2983	.3800	.3082
6		.3327	.2898	.3440	.2978	.3521	.3042	.3600	.3112
4		.3239	.3000	.3308	.3052	.3360	.3092	.3412	.3135
2		.3154	.3100	.3180	.3120	.3200	.3136	.3218	.3152
7/20	0.4306	.3811	.2143						
18		.3751	.2241	.4186	.2459				
16		.3688	.2342	.4076	.2540	.4346	.2689	.4648	.2878
14		.3620	.2448	.3958	.2628	.4195	.2762	.4456	.2931
12		.3555	.2545	.3841	.2710	.4040	.2834	.4260	.2980
10		.3487	.2648	.3713	.2798	.3871	.2906	.4040	.3030
8		.3417	.2745	.3603	.2869	.3722	.2963	.3851	.3067
6		.3338	.2854	.3470	.2949	.3562	.3022	.3648	.3098
4		.3254	.2971	.3332	.3032	.3389	.3079	.3446	.3125
2		.3170	.3076	.3206	.3104	.3232	.3125	.3258	.3148
6/24	0.3005	.3927	.1892						
22		.3877	.1978	.4449	.2219				
20		.3833	.2056	.4368	.2283	.4735	.2464		
18		.3773	.2158	.4245	.2382	.4581	.2549	.4961	.2751
16		.3718	.2251	.4136	.2467	.4448	.2622	.4781	.2812
14		.3652	.2355	.4023	.2552	.4285	.2705	.4552	.2881
12		.3582	.2462	.3900	.2646	.4125	.2784	.4360	.2936
10		.3509	.2578	.3769	.2738	.3960	.2860	.4150	.2989
8		.3437	.2688	.3648	.2820	.3791	.2929	.3930	.3038
6		.3362	.2799	.3520	.2904	.3635	.2987	.3740	.3074
4		.3272	.2929	.3371	.3001	.3439	.3056	.3508	.3112
2		.3188	.3048	.3232	.3085	.3261	.3113	.3292	.3141
5/26	0.1997	.4011	.1652						
24		.3965	.1738	.4683	.1978				
22		.3924	.1814	.4581	.2068	.5045	.2248		
20		.3873	.1909	.4484	.2150	.4915	.2330	.5396	.2535
18		.3821	.2007	.4372	.2242	.4761	.2421	.5185	.2620
16		.3763	.2108	.4261	.2331	.4617	.2506	.4986	.2695
14		.3703	.2211	.4142	.2428	.4454	.2596	.4767	.2776
12		.3635	.2325	.4022	.2523	.4303	.2675	.4579	.2841
10		.3560	.2452	.3880	.2630	.4108	.2773	.4332	.2918
8		.3490	.2570	.3748	.2729	.3932	.2852	.4105	.2980
6		.3396	.2718	.3585	.2842	.3726	.2941	.3851	.3039
4		.3298	.2869	.3421	.2954	.3515	.3024	.3594	.3090
2		.3199	.3019	.3256	.3065	.3296	.3098	.3332	.3131
4/26	0.1200	.4048	.1428						
24		.4011	.1504						

TABLE I.—*Continued.*

		Purples (*continued*)							
		2.5P		5.0P		7.5P		10.0P	
V/C	Y	x	y	x	y	x	y	x	y
22		.2371	.1143	.2652	.1218	.3001	.1306	.3411	.1424
20		.2394	.1221	.2670	.1300	.3010	.1396	.3400	.1500
18		.2430	.1332	.2693	.1408	.3016	.1500	.3386	.1626
16		.2467	.1452	.2718	.1520	.3028	.1621	.3370	.1756
14		.2509	.1585	.2747	.1660	.3035	.1755	.3351	.1875
12		.2559	.1730	.2778	.1808	.3045	.1905	.3331	.2014
10		.2619	.1903	.2814	.1967	.3056	.2060	.3306	.2162
8		.2685	.2089	.2855	.2150	.3066	.2228	.3280	.2318
6		.2763	.2300	.2903	.2347	.3076	.2416	.3248	.2493
4		.2855	.2531	.2958	.2565	.3084	.2622	.3210	.2686
2		.2962	.2807	.3022	.2825	.3093	.2859	.3162	.2902
3/34	0.06555	.2230	.0543						
32		.2242	.0587	.2557	.0630				
30		.2252	.0638	.2568	.0690	.2922	.0750		
28		.2268	.0698	.2579	.0750	.2930	.0812		
26		.2286	.0765	.2590	.0822	.2938	.0892	.3343	.0978
24		.2305	.0832	.2602	.0891	.2944	.0967	.3341	.1055
22		.2329	.0911	.2620	.0978	.2953	.1057	.3340	.1146
20		.2354	.1003	.2639	.1074	.2961	.1151	.3332	.1240
18		.2380	.1094	.2657	.1163	.2969	.1239	.3329	.1332
16		.2410	.1198	.2680	.1272	.2981	.1356	.3320	.1456
14		.2449	.1325	.2707	.1397	.2992	.1475	.3309	.1572
12		.2498	.1480	.2739	.1539	.3003	.1618	.3301	.1715
10		.2548	.1638	.2772	.1707	.3020	.1794	.3286	.1889
8		.2615	.1845	.2819	.1910	.3037	.1981	.3269	.2075
6		.2691	.2072	.2870	.2135	.3057	.2208	.3243	.2293
4		.2792	.2342	.2928	.2386	.3072	.2448	.3214	.2517
2		.2922	.2680	.2997	.2700	.3088	.2740	.3170	.2790
2/30	0.03126	.2231	.0432						
28		.2245	.0491	.2559	.0525				
26		.2260	.0555	.2569	.0594				
24		.2277	.0621	.2582	.0669	.2882	.0719		
22		.2298	.0696	.2597	.0750	.2890	.0799	.3230	.0861
20		.2320	.0779	.2612	.0838	.2902	.0901	.3231	.0962
18		.2345	.0873	.2632	.0935	.2912	.0995	.3233	.1063
16		.2372	.0980	.2652	.1045	.2922	.1106	.3235	.1181
14		.2406	.1100	.2676	.1163	.2938	.1235	.3235	.1317
12		.2449	.1245	.2709	.1320	.2956	.1392	.3233	.1477
10		.2501	.1422	.2748	.1500	.2979	.1569	.3230	.1659
8		.2570	.1635	.2791	.1707	.3000	.1781	.3219	.1862
6		.2661	.1921	.2850	.1992	.3025	.2058	.3207	.2132
4		.2758	.2208	.2908	.2261	.3048	.2321	.3189	.2390
2		.2892	.2583	.2984	.2612	.3071	.2647	.3161	.2691
1/26	0.01210	.2251	.0355						
24		.2266	.0418						
22		.2279	.0473	.2590	.0509				
20		.2295	.0542	.2601	.0586	.2831	.0625		
18		.2312	.0618	.2612	.0667	.2841	.0706	.3069	.0748
16		.2331	.0696	.2625	.0746	.2852	.0790	.3078	.0839
14		.2361	.0810	.2645	.0863	.2868	.0903	.3084	.0952
12		.2394	.0940	.2670	.1006	.2884	.1059	.3094	.1110
10		.2441	.1112	.2701	.1178	.2905	.1229	.3102	.1282
8		.2496	.1303	.2742	.1375	.2932	.1429	.3114	.1481
6		.2570	.1559	.2794	.1628	.2960	.1682	.3126	.1737
4		.2668	.1874	.2854	.1927	.2991	.1974	.3132	.2032
2		.2808	.2296	.2936	.2330	.3030	.2361	.3132	.2404

		Red-Purples (*continued*)							
		2.5RP		5.0RP		7.5RP		10.0RP	
V/C	Y	x	y	x	y	x	y	x	y
22		.3967	.1593	.4656	.1821				
20		.3926	.1679	.4571	.1906	.5130	.2101	.5674	.2319
18		.3865	.1802	.4455	.2023	.4965	.2217	.5466	.2424
16		.3807	.1923	.4339	.2139	.4799	.2329	.5234	.2530
14		.3748	.2039	.4225	.2249	.4629	.2437	.5020	.2623
12		.3683	.2162	.4104	.2361	.4450	.2541	.4789	.2717
10		.3608	.2301	.3960	.2489	.4259	.2651	.4528	.2811
8		.3533	.2438	.3833	.2600	.4072	.2750	.4282	.2890
6		.3442	.2595	.3671	.2733	.3850	.2859	.3999	.2972
4		.3340	.2770	.3491	.2872	.3612	.2963	.3715	.3042
2		.3231	.2951	.3310	.3010	.3371	.3061	.3417	.3106
3/22	0.06555	.4018	.1304						
20		.3969	.1413	.4577	.1593				
18		.3929	.1506	.4503	.1695	.5130	.1893		
16		.3876	.1629	.4418	.1809	.4991	.2011	.5628	.2241
14		.3818	.1758	.4313	.1944	.4831	.2140	.5380	.2369
12		.3754	.1898	.4199	.2089	.4654	.2273	.5139	.2489
10		.3681	.2054	.4073	.2235	.4445	.2419	.4851	.2618
8		.3598	.2233	.3930	.2395	.4234	.2556	.4552	.2741
6		.3501	.2425	.3765	.2569	.3990	.2708	.4218	.2864
4		.3400	.2624	.3586	.2742	.3739	.2851	.3889	.2969
2		.3272	.2861	.3370	.2940	.3450	.3001	.3526	.3068
2/20	0.03126	.3802	.1080						
18		.3778	.1188	.4338	.1340				
16		.3748	.1310	.4269	.1454	.4744	.1595		
14		.3711	.1449	.4180	.1598	.4624	.1737	.5129	.1888
12		.3668	.1618	.4080	.1764	.4481	.1903	.4911	.2060
10		.3617	.1800	.3971	.1939	.4321	.2082	.4678	.2237
8		.3555	.2003	.3858	.2140	.4137	.2276	.4428	.2419
6		.3470	.2259	.3708	.2380	.3918	.2490	.4139	.2608
4		.3382	.2496	.3558	.2597	.3702	.2683	.3850	.2778
2		.3279	.2754	.3383	.2829	.3459	.2892	.3532	.2957
1/16	0.01210	.3368	.0902						
14		.3368	.1020	.3811	.1138				
12		.3361	.1181	.3772	.1283	.4240	.1400	.4668	.1514
10		.3354	.1351	.3727	.1458	.4132	.1580	.4521	.1710
8		.3342	.1551	.3660	.1662	.4005	.1793	.4357	.1921
6		.3321	.1811	.3588	.1920	.3865	.2036	.4151	.2169
4		.3290	.2095	.3503	.2196	.3705	.2300	.3920	.2423
2		.3240	.2459	.3378	.2542	.3498	.2617	.3629	.2710

TABLE II. I.C.I. (Y) equivalents (in percent relative to MgO) of the recommended Munsell value scale (V) from 0/ to 10/.

V	Y_V(%)	V	Y_V(%)	V	Y_V(%)	V	Y_V(%)	V	Y_V(%)	V	Y_V(%)	V	Y_V(%)	V	Y_V(%)	V	Y_V(%)	V	Y_V(%)	V	Y_V(%)	V	Y_V(%)
10.00	102.56																						
9.99	102.30	9.14	81.73	8.29	64.38	7.44	49.72	6.59	37.38	5.74	27.12	4.89	18.79	4.04	12.26	3.19	7.423	2.34	4.092	1.49	2.002	0.64	0.747
8	102.04	3	81.50	8	64.19	3	49.56	8	37.25	3	27.02	8	18.70	3	12.19	8	7.375	3	4.060	8	1.983	3	.735
7	101.78	2	81.28	7	64.01	2	49.41	7	37.12	2	26.91	7	18.62	2	12.12	7	7.328	2	4.029	7	1.965	2	.723
6	101.52	1	81.06	6	63.82	1	49.25	6	36.99	1	26.80	6	18.53	1	12.06	6	7.281	1	3.998	6	1.947	1	.711
5	101.25	0	80.84	5	63.63	0	49.09	5	36.86	0	26.69	5	18.44	0	12.00	5	7.234	0	3.968	5	1.929	0	.699
9.94	100.99	9.09	80.62	8.24	63.45	7.39	48.93	6.54	36.72	5.69	26.58	4.84	18.36	3.99	11.935	3.14	7.187	2.29	3.938	1.44	1.910	0.59	.687
3	100.73	8	80.40	3	63.26	8	48.78	3	36.59	8	26.48	3	18.27	8	11.870	3	7.140	8	3.907	3	1.892	8	.675
2	100.47	7	80.18	2	63.08	7	48.62	2	36.46	7	26.37	2	18.19	7	11.805	2	7.094	7	3.877	2	1.874	7	.663
1	100.21	6	79.97	1	62.89	6	48.47	1	36.33	6	26.26	1	18.10	6	11.740	1	7.048	6	3.847	1	1.856	6	.651
0	99.95	5	79.75	0	62.71	5	48.31	0	36.20	5	26.15	0	18.02	5	11.675	0	7.002	5	3.817	0	1.838	5	.640
9.89	99.69	9.04	79.53	8.19	62.52	7.34	48.16	6.49	36.07	5.64	26.05	4.79	17.93	3.94	11.611	3.09	6.956	2.24	3.787	1.39	1.821	0.54	.628
8	99.44	3	79.31	8	62.34	3	48.00	8	35.94	3	25.94	8	17.85	3	11.547	8	6.911	3	3.758	8	1.803	3	.617
7	99.18	2	79.10	7	62.16	2	47.85	7	35.81	2	25.84	7	17.76	2	11.483	7	6.866	2	3.729	7	1.786	2	.605
6	98.92	1	78.88	6	61.98	1	47.69	6	35.68	1	25.73	6	17.68	1	11.419	6	6.821	1	3.700	6	1.769	1	.593
5	98.66	0	78.66	5	61.79	0	47.54	5	35.56	0	25.62	5	17.60	0	11.356	5	6.776	0	3.671	5	1.752	0	.581
9.84	98.41	8.99	78.45	8.14	61.61	7.29	47.38	6.44	35.43	5.59	25.52	4.74	17.51	3.89	11.292	3.04	6.731	2.19	3.642	1.34	1.735	0.49	.570
3	98.15	8	78.23	3	61.43	8	47.23	3	35.30	8	25.41	3	17.43	8	11.229	3	6.687	8	3.613	3	1.718	8	.559
2	97.90	7	78.02	2	61.25	7	47.08	2	35.17	7	25.31	2	17.34	7	11.167	2	6.643	7	3.585	2	1.701	7	.547
1	97.64	6	77.80	1	61.07	6	46.92	1	35.04	6	25.20	1	17.26	6	11.104	1	6.599	6	3.557	1	1.684	6	.535
0	97.39	5	77.59	0	60.88	5	46.77	0	34.92	5	25.10	0	17.18	5	11.042	0	6.555	5	3.529	0	1.667	5	.524
9.79	97.14	8.94	77.38	8.09	60.70	7.24	46.62	6.39	34.79	5.54	25.00	4.69	17.10	3.84	10.980	2.99	6.511	2.14	3.501	1.29	1.650	0.44	.513
8	96.88	3	77.16	8	60.52	3	46.47	8	34.66	3	24.89	8	17.02	3	10.918	8	6.468	3	3.473	8	1.634	3	.501
7	96.63	2	76.95	7	60.35	2	46.32	7	34.54	2	24.79	7	16.93	2	10.856	7	6.425	2	3.445	7	1.618	2	.489
6	96.38	1	76.74	6	60.17	1	46.17	6	34.41	1	24.69	6	16.85	1	10.795	6	6.382	1	3.418	6	1.601	1	.478
5	96.13	0	76.53	5	59.99	0	46.02	5	34.28	0	24.58	5	16.77	0	10.734	5	6.339	0	3.391	5	1.585	0	.467
9.74	95.88	8.89	76.32	8.04	59.81	7.19	45.87	6.34	34.16	5.49	24.48	4.64	16.69	3.79	10.673	2.94	6.296	2.09	3.364	1.24	1.569	0.39	.455
3	95.63	8	76.11	3	59.63	8	45.72	3	34.03	8	24.38	3	16.61	8	10.612	3	6.254	8	3.337	3	1.553	8	.444
2	95.38	7	75.90	2	59.45	7	45.57	2	33.91	7	24.28	2	16.53	7	10.551	2	6.212	7	3.310	2	1.537	7	.432
1	95.13	6	75.69	1	59.28	6	45.42	1	33.78	6	24.17	1	16.45	6	10.491	1	6.170	6	3.283	1	1.521	6	.421
0	94.88	5	75.48	0	59.10	5	45.27	0	33.66	5	24.07	0	16.37	5	10.431	0	6.128	5	3.256	0	1.506	5	.409
9.69	94.63	8.84	75.27	7.99	58.92	7.14	45.12	6.29	33.54	5.44	23.97	4.59	16.29	3.74	10.371	2.89	6.086	2.04	3.230	1.19	1.490	0.34	.398
8	94.38	3	75.06	8	58.74	3	44.97	8	33.41	3	23.87	8	16.21	3	10.311	8	6.045	3	3.204	8	1.475	3	.386
7	94.14	2	74.85	7	58.57	2	44.82	7	33.29	2	23.77	7	16.13	2	10.252	7	6.003	2	3.178	7	1.459	2	.375
6	93.89	1	74.64	6	58.39	1	44.67	6	33.16	1	23.67	6	16.05	1	10.193	6	5.962	1	3.152	6	1.444	1	.363
5	93.64	0	74.44	5	58.22	0	44.52	5	33.04	0	23.57	5	15.97	0	10.134	5	5.921	0	3.126	5	1.429	0	.352
9.64	93.40	8.79	74.23	7.94	58.04	7.09	44.38	6.24	32.92	5.39	23.47	4.54	15.89	3.69	10.075	2.84	5.881	1.99	3.100	1.14	1.413	0.29	.341
3	93.15	8	74.02	3	57.87	8	44.23	3	32.80	8	23.37	3	15.81	8	10.017	3	5.841	8	3.075	3	1.398	8	.329
2	92.91	7	73.82	2	57.69	7	44.08	2	32.67	7	23.27	2	15.74	7	9.959	2	5.800	7	3.050	2	1.383	7	.318
1	92.66	6	76.61	1	57.52	6	43.94	1	32.55	6	23.17	1	15.66	6	9.901	1	5.760	6	3.025	1	1.368	6	.306
0	92.42	5	73.40	0	57.35	5	43.79	0	32.43	5	23.07	0	15.57	5	9.843	0	5.720	5	3.000	0	1.354	5	.295
9.59	92.18	8.74	73.20	7.89	57.17	7.04	43.64	6.19	32.31	5.34	22.97	4.49	15.49	3.64	9.785	2.79	5.680	1.94	2.975	1.09	1.339	0.24	.283
8	91.93	3	72.99	8	57.00	3	43.50	8	32.19	3	22.87	8	15.42	3	9.728	8	5.641	3	2.950	8	1.324	3	.272
7	91.69	2	72.79	7	56.83	2	43.35	7	32.07	2	22.78	7	15.34	2	9.671	7	5.602	2	2.925	7	1.310	2	.260
6	91.45	1	72.59	6	56.66	1	43.21	6	31.95	1	22.68	6	15.26	1	9.614	6	5.563	1	2.901	6	1.295	1	.248
5	91.21	0	72.38	5	56.48	0	43.06	5	31.83	0	22.58	5	15.18	0	9.557	5	5.524	0	2.877	5	1.281	0	.237
9.54	90.97	8.69	72.18	7.84	56.31	6.99	42.92	6.14	31.71	5.29	22.48	4.44	15.11	3.59	9.501	2.74	5.485	1.89	2.853	1.04	1.267	0.19	.225
3	90.73	8	71.98	3	56.14	8	42.77	3	31.59	8	22.38	3	15.03	8	9.445	3	5.447	8	2.829	3	1.253	8	.214
2	90.49	7	71.78	2	55.97	7	42.63	2	31.47	7	22.29	2	14.96	7	9.389	2	5.408	7	2.805	2	1.238	7	.202
1	90.25	6	71.57	1	55.80	6	42.49	1	31.35	6	22.19	1	14.88	6	9.333	1	5.370	6	2.781	1	1.224	6	.191
0	90.01	5	71.37	0	55.63	5	42.34	0	31.23	5	22.09	0	14.81	5	9.277	0	5.332	5	2.758	0	1.210	5	.179
9.49	89.77	8.64	71.17	7.79	55.46	6.94	42.20	6.09	31.11	5.24	22.00	4.39	14.73	3.54	9.222	2.69	5.295	1.84	2.735	0.99	1.196	0.14	.167
8	89.53	3	70.97	8	55.29	3	42.06	8	30.99	3	21.90	8	14.66	3	9.167	8	5.257	3	2.712	8	1.182	3	.155
7	89.30	2	70.77	7	55.12	2	41.92	7	30.87	2	21.81	7	14.58	2	9.112	7	5.220	2	2.688	7	1.168	2	.143
6	89.06	1	70.57	6	54.95	1	41.77	6	30.75	1	21.71	6	14.51	1	9.058	6	5.183	1	2.665	6	1.154	1	.131
5	88.82	0	70.37	5	54.78	0	41.63	5	30.64	0	21.62	5	14.43	0	9.003	5	5.146	0	2.642	5	1.141	0	.120
9.44	88.59	8.59	70.17	7.74	54.62	6.89	41.49	6.04	30.52	5.19	21.52	4.34	14.36	3.49	8.949	2.64	5.109	1.79	2.620	0.94	1.128	0.09	.108
3	88.35	8	69.97	3	54.45	8	41.35	3	30.40	8	21.43	3	14.28	8	8.895	3	5.072	8	2.598	3	1.114	8	.096
2	88.12	7	69.78	2	54.28	7	41.21	2	30.28	7	21.33	2	14.21	7	8.841	2	5.036	7	2.575	2	1.101	7	.084
1	87.88	6	69.58	1	54.11	6	41.07	1	30.17	6	21.24	1	14.14	6	8.787	1	5.000	6	2.553	1	1.087	6	.073
0	87.65	5	69.38	0	53.94	5	40.93	0	30.05	5	21.14	0	14.07	5	8.734	0	4.964	5	2.531	0	1.074	5	.061
9.39	87.41	8.54	69.18	7.69	53.78	6.84	40.79	5.99	29.94	5.14	21.05	4.29	13.99	3.44	8.681	2.59	4.928	1.74	2.509	0.89	1.060	0.04	.049
8	87.18	3	68.99	8	53.61	3	40.65	8	29.82	3	20.96	8	13.92	3	8.628	8	4.892	3	2.487	8	1.047	3	.036
7	86.95	2	68.79	7	53.45	2	40.51	7	29.71	2	20.86	7	13.85	2	8.575	7	4.857	2	2.465	7	1.034	2	.024
6	86.72	1	68.59	6	53.28	1	40.37	6	29.59	1	20.77	6	13.78	1	8.523	6	4.822	1	2.443	6	1.021	1	.012
5	86.48	0	68.40	5	53.12	0	40.23	5	29.48	0	20.68	5	13.70	0	8.471	5	4.787	0	2.422	5	1.008	0	.000
9.34	86.25	8.49	68.20	7.64	52.95	6.79	40.09	5.94	29.36	5.09	20.59	4.24	13.63	3.39	8.419	2.54	4.752	1.69	2.401	0.84	0.995		
3	86.02	8	68.01	3	52.79	8	39.95	3	29.25	8	20.49	3	13.56	8	8.367	3	4.717	8	2.380	3	.982		
2	85.79	7	67.81	2	52.62	7	39.82	2	29.13	7	20.40	2	13.49	7	8.316	2	4.682	7	2.359	2	.969		
1	85.56	6	67.62	1	52.46	6	39.68	1	29.02	6	20.31	1	13.42	6	8.264	1	4.648	6	2.338	1	.956		
0	85.33	5	67.43	0	52.30	5	39.54	0	28.90	5	20.22	0	13.35	5	8.213	0	4.614	5	2.317	0	.943		
9.29	85.10	8.44	67.23	7.59	52.13	6.74	39.40	5.89	28.79	5.04	20.13	4.19	13.28	3.34	8.162	2.49	4.580	1.64	2.296	0.79	.931		
8	84.88	3	67.04	8	51.97	3	39.27	8	28.68	3	20.04	8	13.21	3	8.111	8	4.546	3	2.276	8	.918		
7	84.65	2	66.85	7	51.81	2	39.13	7	28.57	2	19.95	7	13.14	2	8.060	7	4.512	2	2.256	7	.906		
6	84.42	1	66.66	6	51.64	1	39.00	6	28.45	1	19.86	6	13.07	1	8.010	6	4.479	1	2.236	6	.893		
5	84.19	0	66.46	5	51.48	0	38.86	5	28.34	0	19.77	5	13.00	0	7.960	5	4.446	0	2.216	5	.881		
9.24	83.97	8.39	66.27	7.54	51.32	6.69	38.72	5.84	28.23	4.99	19.68	4.14	12.93	3.29	7.910	2.44	4.413	1.59	2.196	0.74	.868		
3	83.74	8	66.08	3	51.16	8	38.59	3	28.12	8	19.59	3	12.86	8	7.860	3	4.380	8	2.176	3	.856		
2	83.52	7	65.89	2	51.00	7	38.45	2	28.01	7	19.50	2	12.80	7	7.811	2	4.347	7	2.156	2	.844		
1	83.29	6	65.70	1	50.84	6	38.32	1	27.90	6	19.41	1	12.73	6	7.762	1	4.314	6	2.136	1	.832		
0	83.07	5	65.51	0	50.68	5	38.18	0	27.78	5	19.32	0	12.66	5	7.713	0	4.282	5	2.116	0	.819		
9.19	82.84	8.34	65.32	7.49	50.52	6.64	38.05	5.79	27.67	4.94	19.23	4.09	12.59	3.24	7.664	2.39	4.250	1.54	2.097	0.69	.807		
8	82.62	3	65.13	8	50.36	3	37.92	8	27.56	3	19.14	8	12.52	3	7.615	8	4.218	3	2.078	8	.795		
7	82.39	2	64.94	7	50.20	2	37.78	7	27.45	2	19.06	7	12.46	2	7.567	7	4.186	2	2.059	7	.783		
6	82.17	1	64.76	6	50.04	1	37.65	6	27.34	1	18.97	6	12.39	1	7.519	6	4.154	1	2.040	6	.771		
5	81.95	0	64.57	5	49.88	0	37.52	5	27.23	0	18.88	5	12.32	0	7.471	5	4.123	0	2.021	5	.759		

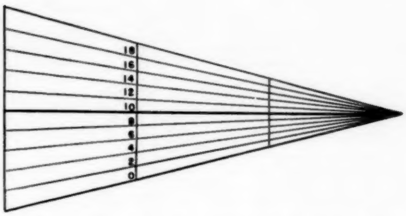

Fig. 10. Illustration of transparent scale for reading fractional hue or chroma between adjacent loci in Figs. 1–9.

(1) From Table II it is found that for $V=2.4$, I.C.I. $Y=4.28$ percent.

(2) Since $V=2.4/$, x and y will be found by interpolation between the charts for values 3/ and 2/. On Fig. 3 for 5.0R 3.0/9.9, I.C.I. $x=0.548$ and $y=0.303$. On Fig. 2 for 5.0R 2.0/9.9, I.C.I. $x=0.553$ and $y=0.264$.

(3) Since 2.4 is 0.4 of the distance from 2.0 toward 3.0, the interpolated chromaticity (x, y) will be that of value 2/ plus 0.4 of the difference resulting when the chromaticity read from Fig. 2 is subtracted from that of Fig. 3. Since x on Fig. 2 is 0.553 and on Fig. 3 is 0.548, the interpolated x will be

$$0.553+[0.4\ (0.548-0.553)]=0.551.$$

Similarly, the interpolated y will be

$$0.264+[0.4\ (0.303-0.264)]=0.280.$$

(4) The complete notation for the sample is $Y=0.043$ (or 4.3 percent); $x=0.551$, $y=0.280$.

Still another illustration of the use of the above data is shown in Table III. This table shows the effect of the revision on the notation of the Munsell samples by presenting revised designations for them. The entries for this table were obtained as follows: (*a*) Given the Munsell sample, the I.C.I. data for them were taken from reports of the National Bureau of Standards (*21*), Glenn-Killian (*9*), and Granville-Nickerson-Foss (*10*); (*b*) then the value was read from the subcommittee's Table II and the hue and chroma were interpolated by use of the large originals of Figs. 1–9.[4] There are larger irregularities in the chroma series than in the hue or value series, presumably because of the special difficulties in recognizing chroma and in producing a painted series to represent it.

Color samples are often evaluated by direct reference to charts of the *Munsell Book of Color*. This evaluation may be sufficient; if not, conversion to the recommended notation may be made directly by use of Table III or, when interpolations are necessary, by use of Figs. 1–9 on which points representing the *Book of Color* samples have first been spotted (*21*), (*9*), (*10*).

REVISION PROCEDURES

Details of the various procedures employed in arriving at the recommendations[5] above may now be summarized conveniently in relation to each of the Munsell attributes taken separately.

Chroma Adjustments

The chromaticity surface provided by the I.C.I. coordinates themselves is far from perceptual equi-spacing, as several investigators (*16*), (*23*), (*30*) have shown. Even when Nickerson published the first smoothed chroma loci for Munsell colors, the smoothing of averaged visual estimates directly in such a system was recognized as a difficult task. The present smoothing operations demand more guidance for they involve the added complication of extrapolating beyond the published samples.

While an ideal system for psychological smoothing is not available, Adams' coordinates of chromatic-value afford some of the needed guidance. Plots of Munsell chroma loci on his charts at values 2/ to 8/, inclusive (*2*), evince sufficient approximation to circularity to facilitate considerably the actual smoothing operation. Once the smooth loci of chroma are located in the Adams' coordinates they remain smooth when converted to the (x, y)-coordinates.

A given point in chromatic-value is defined by

[4] The National Bureau of Standards and Glenn-Killian data provided a good check on the samples of the standard 20 hues. When there was doubt because of a large discrepancy, National Bureau of Standards data were used because special calibration precautions had been taken to obtain accurate wave-length and photometric values. The National Bureau of Standards data were used for all value conversions. For the 20 intermediate hues only one set of data was available. It is important to recognize that the table depends upon the accuracy of the I.C.I. colorimetric data supplied for the samples.

[5] These recommendations provide smoothed curves that supersede those given in references 10 and 11 in ASA War Standard (*3*).

TABLE III. Re-notations for the *Munsell Book of Color* samples in accordance with the recommended spacing and smoothing adjustments.

Munsell Book Notation H	Munsell Book Notation V/C	Munsell Re-notation According to Recommended Curves H	V	C
2.5R	8/4	2.0R	7.8	3.1
	2	4.0R	7.9	2.4
	7/8	1.0R	7.0	6.2
	6	1.0R	7.1	5.0
	4	3.5R	7.2	3.5
	2	3.0R	7.1	2.3
	6/10	1.5R	6.1	9.2
	8	1.5R	6.0	7.3
	6	1.0R	6.2	5.5
	4	2.5R	6.3	4.0
	2	2.5R	6.1	2.5
	5/10	2.0R	5.1	10.1
	8	1.5R	5.0	8.9
	6	1.5R	5.1	6.8
	4	2.0R	5.1	5.0
	2	2.5R	5.0	2.9
	4/10	1.5R	4.1	9.4
	8	1.5R	4.1	8.2
	6	1.5R	4.0	6.3
	4	1.5R	4.1	4.6
	2	1.5R	4.1	2.6
	3/10	1.0R	3.2	8.3
	8	1.5R	3.1	6.7
	6	1.0R	3.2	5.6
	4	1.5R	3.1	4.1
	2	1.5R	3.1	2.3
	2/6	0.5R	2.5	4.8
	4	0.5R	2.4	3.5
	2	0.5R	2.3	2.3
5R	8/4	3.5R	8.0	3.6
	2	2.0R	8.1	2.2
	7/8	3.5R	7.0	7.0
	6	3.5R	7.1	5.7
	4	3.0R	7.1	5.2
	2	2.5R	7.2	2.6
	6/10	4.0R	6.2	9.7
	8	4.0R	6.2	8.1
	6	3.5R	6.2	6.3
	4	4.5R	6.3	4.5
	2	4.0R	6.2	2.3
	5/12	5.5R	5.0	12.8
	10	5.0R	5.2	10.9
	8	4.5R	5.0	10.0
	6	4.0R	5.0	8.0
	4	4.0R	4.9	5.3
	2	4.0R	5.0	2.8
	4/14	{5.5R	4.2	13.2
		{5.5R	4.2	13.2
	12	5.0R	4.2	12.6
	10	4.5R	4.2	10.8
	8	4.5R	4.2	9.4
	6	4.5R	4.1	6.8
	4	3.5R	4.1	4.7
	2	4.0R	4.1	2.6
	3/10	5.0R	3.2	8.3
	8	5.0R	3.2	7.4
	6	4.5R	3.4	6.2
	4	5.0R	3.2	4.6
	2	3.5R	3.1	2.1
	2/6	3.0R	2.5	4.8
	4	4.0R	2.3	3.8
	2	3.5R	2.3	2.2
7.5R	8/4	7.0R	7.8	3.7
	2	10.0R	7.8	2.4
	7/8	7.5R	6.8	7.0
	6	6.5R	7.0	5.9
	4	7.5R	7.0	4.0
	2	10.0R	7.0	2.4
	6/10	7.5R	6.0	9.3
	8	7.5R	6.0	7.8
	6	7.5R	6.1	6.2
	4	7.5R	6.2	4.3
	2	8.5R	6.1	2.6
7.5R (*cont'd*)	5/12	8.0R	4.9	11.9
	10	7.5R	5.0	10.1
	8	7.5R	5.0	8.9
	6	7.0R	5.0	7.2
	4	7.0R	5.1	5.0
	2	7.0R	5.1	2.9
	4/12	7.5R	4.2	11.4
	10	7.5R	4.2	9.4
	8	7.0R	4.1	8.4
	6	7.5R	4.2	6.7
	4	7.5R	4.1	4.7
	2	7.0R	4.1	2.8
	3/10	7.5R	3.5	8.5
	8	7.5R	3.4	7.1
	6	7.0R	3.3	5.4
	4	6.5R	3.3	4.3
	2	5.0R	3.2	2.6
	2/4	4.5R	2.6	3.5
	2	5.5R	2.4	1.9
10R	8/4	10.0R	8.1	3.7
	2	2.5YR	7.9	2.2
	7/8	10.0R	7.0	7.5
	6	9.0R	7.2	5.7
	4	8.5R	7.2	4.7
	2	9.0R	7.1	2.7
	6/10	0.5YR	6.2	10.1
	8	0.5YR	6.3	8.2
	6	0.5YR	6.3	6.5
	4	9.0R	6.2	4.2
	2	1.0YR	6.3	2.5
	5/10	10.0R	5.0	9.9
	8	0.5YR	5.2	8.7
	6	10.0R	5.1	7.1
	4	9.5R	5.1	4.9
	2	10.0R	5.2	2.6
	4/10	9.5R	4.4	9.0
	8	10.0R	4.3	8.4
	6	10.0R	4.3	7.3
	4	0.5YR	4.2	4.7
	2	10.0R	4.2	2.7
	3/6	10.0R	3.3	5.4
	4	10.0R	3.2	4.1
	2	9.0R	3.3	2.2
	2/2	{8.5R	2.5	2.6
		{8.5R	2.5	2.3
2.5YR	8/4	3.5YR	7.9	3.7
	2	4.0YR	7.9	2.3
	7/10	2.5YR	6.8	10.0
	8	2.5YR	6.8	7.2
	6	2.0YR	7.0	5.6
	4	2.0YR	7.0	3.9
	2	2.5YR	7.1	2.3
	6/13	3.5YR	6.2	12.5
	12	3.5YR	6.1	11.5
	10	3.0YR	6.1	9.8
	8	3.0YR	6.0	8.2
	6	2.5YR	6.1	6.4
	4	2.0YR	6.3	4.5
	2	3.5YR	6.1	2.4
	5/10	2.5YR	5.0	9.3
	8	2.5YR	5.1	7.8
	6	2.5YR	5.0	6.6
	4	1.5YR	5.0	4.9
	2	2.0YR	5.2	2.6
	4/8	2.5YR	4.3	7.5
	6	2.5YR	4.3	6.3
	4	2.0YR	4.4	4.4
	2	2.0YR	4.2	2.6
	3/6	3.0YR	3.5	5.8
	4	2.0YR	3.3	3.9
	2	2.0YR	3.2	2.2
	2/3	0.5YR	2.7	2.6
	2	2.0YR	2.4	1.5
5YR	8/4	4.0YR	8.0	3.5
	2	4.0YR	8.0	2.0
	7/10	5.5YR	6.9	10.1
	8	4.5YR	7.0	8.2
	6	{3.5YR	6.9	5.9
		{3.5YR	7.0	6.0
	4	3.0YR	7.0	4.1
	2	3.0YR	7.0	2.1
	6/12	6.0YR	6.2	11.5
	10	6.0YR	6.3	9.8
	8	5.0YR	6.2	8.3
	6	4.5YR	6.2	6.0
	4	4.0YR	6.1	4.0
	2	4.5YR	6.1	2.0
	5/10	5.5YR	5.1	9.0
	8	5.5YR	5.1	7.7
	6	5.0YR	5.0	6.2
	4	4.5YR	4.9	4.6
	2	4.0YR	4.9	2.1
	4/8	6.0YR	4.2	6.3
	6	5.0YR	4.4	5.8
	4	5.0YR	4.3	4.6
	2	4.0YR	4.1	2.3
	3/4	5.0YR	3.3	4.1
	2	{5.0YR	3.1	2.0
		{5.0YR	3.1	2.1
	2/2	4.5YR	2.4	1.8
7.5YR	8/6	7.5YR	7.9	5.1
	4	7.5YR	7.9	2.9
	2	8.0YR	7.9	1.9
	7/10	8.0YR	6.8	9.9
	8	7.5YR	6.9	8.0
	6	7.5YR	6.9	6.0
	4	7.0YR	7.0	3.4
	2	6.5YR	7.0	1.8
	6/10	8.0YR	6.2	9.5
	8	7.5YR	6.2	8.0
	6	7.5YR	6.1	6.1
	4	7.0YR	6.2	3.5
	2	6.5YR	6.1	2.0
	5/8	8.0YR	5.1	7.4
	6	7.5YR	5.0	5.9
	4	7.5YR	4.9	3.8
	2	6.0YR	5.0	2.0
	4/4	7.5YR	4.2	4.5
	2	8.0YR	4.1	2.3
	3/2	7.5YR	3.2	2.6
10YR	8/6	9.0YR	8.1	5.5
	4	9.0YR	8.0	3.4
	2	9.0YR	7.9	1.5
	7/10	1.0Y	6.9	10.5
	8	0.5Y	7.1	8.3
	6	10.0YR	7.0	6.3
	4	9.0YR	7.2	3.8
	2	10.0YR	7.1	1.8
	6/10	10.0YR	6.5	9.8
	8	9.5YR	6.4	8.0
	6	9.5YR	6.3	6.7
	4	0.5Y	6.1	4.1
	2	9.0YR	5.9	2.0
	5/8	0.5Y	5.1	7.6
	6	10.0YR	5.2	5.7
	4	10.0YR	5.1	4.4
	2	10.0YR	5.2	2.0
	4/4	10.0YR	4.2	4.6
	2	9.5YR	4.2	2.4
	3/2	{10.0YR	3.1	2.7
		{10.0YR	3.4	2.4
	2/2	{7.5YR	2.6	1.6
		{9.0YR	2.6	1.6
2.5Y	9.25/4	1.5Y	9.2	2.5
	2	2.0Y	9.1	1.5
	9/8	2.5Y	8.8	6.5
	6	2.0Y	8.6	4.4
	4	2.0Y	8.8	3.2
	2	2.5Y	8.7	1.4
	8/12	3.5Y	7.9	11.9
	10	3.5Y	8.0	9.9
	8	2.5Y	8.0	7.8
	6	2.5Y	7.8	5.5
	4	2.0Y	7.9	3.7
	2	1.5Y	7.9	1.6
	7/10	3.5Y	6.8	10.0
	8	3.0Y	6.9	8.3
	6	2.5Y	6.9	6.4
	4	2.5Y	6.9	4.2
	2	1.5Y	7.0	1.8
	6/8	3.5Y	6.2	7.8
	6	2.5Y	6.2	6.8
	4	3.0Y	6.3	4.4
	2	2.5Y	6.2	2.0
	5/6	3.0Y	5.1	6.5
	4	3.0Y	5.1	3.9
	2	2.5Y	5.1	1.7
	4/4	2.5Y	4.1	3.9
	2	2.0Y	4.1	1.7
	3/2	2.5Y	3.4	1.9
5Y	9.25/6	5.5Y	9.0	4.4
	4	5.0Y	9.0	2.6
	2	3.5Y	9.0	1.5
	9/14	6.0Y	8.4	13.0
	12	6.0Y	8.4	9.5
	10	5.0Y	8.4	8.2
	8	5.0Y	8.4	6.5
	6	6.0Y	8.5	4.8
	4	5.5Y	8.5	3.5
	2	3.5Y	8.6	1.4
	8/12	5.5Y	7.9	12.3
	10	5.5Y	7.9	11.1
	8	{5.5Y	7.9	8.2
		{5.5Y	7.9	8.3
	6	4.5Y	7.9	5.8
	4	4.0Y	7.8	3.5
	2	3.5Y	7.8	1.6
	7/10	5.0Y	6.9	9.7
	8	6.0Y	6.9	9.5
	6	4.5Y	6.9	6.6
	4	4.0Y	7.0	3.8
	2	4.0Y	7.1	1.6
	6/8	{5.5Y	6.1	8.1
		{5.5Y	6.2	8.3
	6	5.0Y	6.2	7.2
	4	4.5Y	6.1	4.0
	2	4.0Y	6.2	1.7
	5/6	6.0Y	5.0	6.0
	4	5.0Y	5.0	3.9
	2	4.5Y	5.2	1.7
	4/4	5.0Y	4.1	3.6
	2	5.5Y	4.3	1.7
	3/2	6.0Y	3.1	1.1
	2/2	5.0Y	2.5	1.4
7.5Y	9.25/8	7.5Y	9.2	7.6
	6	8.0Y	9.2	5.3
	4	7.5Y	9.3	3.4
	2	8.0Y	9.1	1.6
	9/10	8.5Y	8.5	11.4
	8	8.0Y	8.4	7.5
	6	8.0Y	8.4	5.0
	4	8.0Y	8.5	3.1
	2	8.0Y	8.6	1.5

Table III.—*Continued.*

Munsell Book Notation H	Munsell Book Notation V/C	Munsell Re-notation According to Recommended Curves H	V	C
7.5Y (*cont'd*)	8/10	8.5Y	7.9	11.7
	8	8.0Y	7.8	7.7
	6	8.5Y	8.0	5.1
	4	8.5Y	7.9	3.5
	2	8.5Y	8.0	1.6
	7/10	8.0Y	7.1	10.2
	8	7.5Y	7.1	8.0
	6	7.0Y	7.0	6.0
	4	6.5Y	7.0	3.8
	2	6.5Y	7.0	1.6
	6/8	8.0Y	6.0	8.1
	6	7.5Y	6.1	5.9
	4	7.5Y	6.2	3.8
	2	7.5Y	6.1	1.7
	5/6	7.5Y	5.2	6.3
	4	7.5Y	5.1	3.8
	2	8.0Y	5.0	1.9
	4/4	8.0Y	4.2	4.2
	2	8.0Y	4.1	1.8
	3/2	7.0Y	3.1	2.2
10Y	8/8	0.5GY	8.1	9.1
	6	0.5GY	8.0	5.7
	4	1.0GY	8.0	3.4
	2	2.0GY	8.0	1.6
	7/8	10.0Y	7.1	9.3
	6	0.5GY	7.0	6.9
	4	1.0GY	7.1	3.6
	2	1.0GY	7.1	1.8
	6/6	9.5Y	6.2	7.4
	4	10.0Y	6.2	4.1
	2	0.5GY	6.3	1.8
	5/6	10.0Y	5.3	5.8
	4	0.5GY	5.3	4.4
	2	0.5GY	5.3	2.1
	4/4	10.0Y	4.3	3.7
	2	1.0GY	4.4	2.1
	3/2	{0.5GY	3.3	1.8
		1.5GY	3.2	1.7
	2/2	{10.0Y	2.6	1.6
		1.0GY	2.7	1.8
2.5GY	8/10	2.5GY	8.1	11.0
	8	2.5GY	8.1	9.7
	6	3.0GY	8.0	6.7
	4	3.5GY	8.0	3.9
	2	3.5GY	8.0	2.0
	7/8	2.5GY	7.0	9.5
	6	2.5GY	7.0	7.0
	4	3.5GY	7.0	4.0
	2	4.5GY	7.0	1.9
	6/8	2.0GY	6.2	8.7
	6	2.5GY	6.2	7.0
	4	2.5GY	6.2	4.5
	2	2.0GY	6.0	2.2
	5/6	2.0GY	5.1	5.8
	4	2.5GY	5.1	4.6
	2	2.0GY	5.2	2.6
	4/4	2.0GY	4.2	3.9
	2	2.0GY	4.2	2.3
	3/2	3.0GY	3.2	1.9
5GY	8/8	4.5GY	8.1	8.7
	6	5.5GY	8.0	6.2
	4	6.0GY	8.1	3.6
	2	6.0GY	8.0	1.6
	7/10	4.0GY	7.0	9.5
	8	5.0GY	7.1	8.0
	6	5.0GY	7.1	6.4
	4	5.5GY	7.0	3.8
	2	5.5GY	7.0	1.8
5GY (*cont'd*)	6/8	4.0GY	6.2	7.2
	6	5.0GY	6.2	6.7
	4	5.0GY	6.2	4.0
	2	5.0GY	6.2	1.7
	5/8	5.0GY	5.1	7.1
	6	5.0GY	5.1	5.4
	4	5.0GY	5.1	4.1
	2	5.0GY	5.1	2.0
	4/6	5.0GY	4.1	4.0
	4	5.0GY	4.2	3.2
	2	5.5GY	4.2	1.7
	3/4	5.0GY	3.2	2.6
	2	4.5GY	3.2	1.9
	2/2	5.5GY	2.5	2.2
7.5GY	8/8	7.0GY	8.0	7.6
	6	7.5GY	8.0	5.8
	4	7.5GY	8.0	4.3
	2	7.5GY	8.0	1.9
	7/10	7.0GY	7.2	9.9
	8	7.0GY	7.1	8.6
	6	7.0GY	7.1	7.1
	4	7.0GY	7.1	4.5
	2	7.5GY	7.0	2.0
	6/10	6.5GY	6.2	9.0
	8	6.5GY	6.2	7.9
	6	7.0GY	6.1	6.9
	4	7.5GY	6.1	4.7
	2	7.5GY	6.1	2.2
	5/6	7.0GY	5.1	6.5
	4	7.5GY	5.0	4.4
	2	7.0GY	5.2	2.3
	4/6	7.0GY	4.2	4.9
	4	7.5GY	4.2	3.9
	2	7.0GY	4.4	2.3
	3/4	7.5GY	3.3	3.7
	2	7.0GY	3.2	2.4
	2/2	7.5GY	2.7	2.0
10GY	8/6	9.5GY	7.9	5.1
	4	0.5G	8.2	4.0
	2	9.5GY	7.9	2.0
	7/8	10.0GY	7.1	8.3
	6	10.0GY	7.1	6.5
	4	10.0GY	7.2	4.1
	2	10.0GY	7.0	2.0
	6/10	9.0GY	6.0	8.7
	8	9.0GY	6.2	7.7
	6	10.0GY	6.1	6.7
	4	0.5G	6.1	4.4
	2	0.5G	6.0	2.2
	5/8	9.5GY	4.9	7.8
	6	9.5GY	5.2	7.1
	4	10.0GY	5.0	4.3
	2	9.5GY	5.0	2.3
	4/6	10.0GY	4.2	5.4
	4	1.0G	4.2	4.1
	2	10.0GY	4.2	2.2
	3/4	10.0GY	3.2	4.5
	2	9.5GY	3.2	2.5
	2/2	{9.5GY	2.4	2.5
		10.0GY	2.6	2.1
2.5G	8/6	2.5G	8.0	5.4
	4	2.0G	8.0	3.8
	2	1.5G	8.0	2.3
	7/8	2.5G	7.2	8.1
	6	2.5G	7.1	6.3
	4	2.5G	7.0	4.4
	2	3.5G	7.1	3.6
	6/8	2.5G	6.0	9.3
	6	2.5G	6.1	7.0
	4	2.5G	6.1	4.6
	2	2.5G	6.1	2.5
2.5G (*cont'd*)	5/8	2.0G	5.0	8.4
	6	2.0G	5.1	6.6
	4	2.0G	5.1	5.0
	2	2.5G	5.1	2.5
	4/6	2.0G	4.2	6.6
	4	2.0G	4.2	4.9
	2	1.5G	4.3	2.7
	3/4	1.5G	3.4	5.0
	2	1.0G	3.4	3.1
	2/2	2.5G	2.6	2.3
5G	8/6	6.5G	7.8	4.7
	4	5.5G	8.0	3.3
	2	4.5G	7.9	2.1
	7/6	7.0G	7.0	6.1
	4	6.5G	7.0	4.3
	2	6.5G	7.0	2.1
	6/6	6.0G	6.0	7.4
	4	6.0G	6.1	4.6
	2	6.0G	6.0	2.4
	5/8	5.0G	4.9	8.2
	6	5.0G	4.9	6.6
	4	5.0G	4.9	4.8
	2	6.5G	4.9	2.4
	4/4	5.0G	4.1	4.9
	2	6.0G	4.1	2.4
	3/4	4.0G	3.3	4.8
	2	5.0G	3.1	2.7
	2/2	7.0G	2.2	2.4
7.5G	8/4	0.5BG	7.8	3.4
	2	7.0G	7.9	1.9
	7/6	8.5G	7.1	5.8
	4	10.0G	7.0	4.2
	2	8.5G	7.1	2.1
	6/6	8.5G	6.2	7.0
	4	8.5G	6.2	5.1
	2	7.5G	6.1	2.8
	5/6	8.5G	5.0	6.4
	4	7.5G	5.1	5.0
	2	7.0G	5.0	2.5
	4/6	8.5G	4.2	6.4
	4	7.5G	4.2	5.0
	2	7.5G	4.3	2.7
	3/4	7.5G	3.3	4.8
	2	7.0G	3.2	3.1
	2/2	9.5G	2.4	2.9
10G	8/2	{5.0G	8.0	2.0
		6.5G	8.0	1.8
	7/4	0.5BG	7.2	3.9
	2	10.0G	7.1	2.0
	6/6	1.0BG	6.4	6.0
	4	2.0BG	6.4	4.5
	2	0.5BG	6.2	2.2
	5/6	1.0BG	5.0	7.0
	4	0.5BG	5.1	4.6
	2	9.5G	5.1	2.3
	4/4	0.5BG	4.1	4.5
	2	0.5BG	4.2	2.5
	3/4	10.0G	3.2	4.7
	2	10.0G	3.1	2.9
	2/2	{10.0G	2.3	3.1
		0.5BG	2.4	2.4
2.5BG	8/2	8.0G	8.0	1.8
	7/4	2.5BG	7.2	3.5
	2	0.5BG	7.3	2.1
	6/6	2.5BG	6.4	5.5
	4	3.5BG	6.3	4.2
	2	2.5BG	6.3	2.4
2.5BG (*cont'd*)	5/6	3.0BG	5.2	6.7
	4	3.5BG	5.1	4.4
	2	2.5BG	5.1	2.5
	4/6	3.0BG	4.3	6.1
	4	2.5BG	4.3	4.5
	2	2.5BG	4.2	2.7
	3/6	3.5BG	3.2	5.0
	4	3.5BG	3.4	4.3
	2	3.0BG	3.2	3.0
	2/4	4.5BG	2.5	3.3
	2	4.0BG	2.3	2.5
5BG	8/2	1.0BG	8.1	2.0
	7/4	4.5BG	7.2	3.4
	2	3.5BG	7.3	2.1
	6/6	5.5BG	6.4	5.2
	4	5.5BG	6.4	4.1
	2	5.0BG	6.4	2.4
	5/6	5.0BG	5.1	6.4
	4	5.5BG	5.2	4.4
	2	4.5BG	5.1	2.5
	4/6	5.5BG	4.2	6.0
	4	5.5BG	4.3	4.0
	2	5.5BG	4.3	2.5
	3/6	6.0BG	3.2	5.3
	4	5.0BG	3.1	4.1
	2	5.0BG	3.2	2.8
	2/4	5.0BG	2.3	3.7
	2	4.5BG	2.2	2.5
7.5BG	8/4	8.0BG	7.8	3.2
	2	7.5BG	7.8	1.8
	7/4	8.5BG	7.2	3.7
	2	7.5BG	7.1	1.8
	6/6	7.5BG	6.4	5.1
	4	8.5BG	6.3	3.7
	2	7.5BG	6.3	1.8
	5/6	8.5BG	5.1	6.4
	4	8.5BG	5.1	4.4
	2	8.5BG	5.2	2.0
	4/6	8.0BG	4.2	6.2
	4	9.5BG	4.3	4.2
	2	10.0BG	4.2	2.3
	3/4	8.0BG	3.2	4.2
	2	8.5BG	3.2	2.2
	2/2	8.0BG	2.4	2.1
10BG	8/2	{5.0BG	8.2	1.9
		8.0BG	7.9	1.8
	7/4	0.5B	7.2	3.6
	2	1.5B	7.1	1.9
	6/6	10.0BG	6.3	5.8
	4	10.0BG	6.3	4.1
	2	0.5B	6.2	2.1
	5/6	1.0B	5.2	6.5
	4	0.5B	5.1	4.4
	2	2.0B	5.1	2.3
	4/6	10.0BG	4.2	5.7
	4	9.5BG	4.1	4.0
	2	1.5B	4.1	2.0
	3/6	9.5BG	3.2	5.8
	4	9.5BG	3.3	4.3
	2	10.0BG	3.2	2.1
	2/2	7.0BG	2.5	3.1
2.5B	8/4	2.0B	8.2	2.6
	2	4.0B	8.0	1.9
	7/6	3.5B	7.2	5.3
	4	4.5B	7.2	3.7
	2	4.0B	7.2	2.2

TABLE III.—*Continued.*

Munsell Book Notation H	V/C	Munsell Re-notation According to Recommended Curves H	V	C
2.5B (*cont'd*)	6/6	3.5B	6.0	5.9
	4	4.5B	6.2	4.2
	2	5.5B	6.1	2.4
	5/6	3.5B	5.0	6.3
	4	4.0B	5.0	4.2
	2	6.5B	5.0	2.3
	4/8	2.5B	4.2	7.2
	6	2.5B	4.2	5.8
	4	3.0B	4.2	3.8
	2	4.5B	4.1	2.0
	3/6	3.5B	3.4	5.7
	4	4.5B	3.4	4.1
	2	7.5B	3.2	2.2
	2/2	1.5B	2.6	3.5
5B	8/4	4.0B	8.1	2.9
	2	4.0B	8.2	2.2
	7/6	5.0B	7.1	4.7
	4	5.0B	7.2	3.7
	2	3.5B	7.3	2.2
	6/6	5.5B	6.1	6.4
	4	6.5B	6.2	4.5
	2	7.5B	6.2	3.0
	5/6	5.0B	5.0	6.8
	4	5.5B	5.0	5.1
	2	6.5B	4.9	2.6
	4/8	6.5B	4.0	6.9
	6	5.5B	4.1	6.4
	4	6.0B	4.4	4.6
	2	5.0B	4.3	2.7
	3/6	5.0B	3.3	5.9
	4	4.5B	3.1	4.2
	2	5.5B	3.1	2.3
	2/2	2.0B	2.2	2.2
7.5B	8/4	9.0B	7.9	3.8
	2	7.5B	7.9	2.3
	7/6	8.0B	7.0	5.1
	4	9.0B	7.1	4.2
	2	8.5B	7.1	2.2
	6/6	7.5B	6.1	5.9
	4	8.5B	6.2	4.1
	2	8.5B	6.1	2.2
	5/6	8.0B	5.2	6.5
	4	8.5B	5.2	4.6
	2	10.0B	5.2	2.6
	4/6	8.5B	4.1	6.6
	4	9.0B	4.2	4.5
	2	9.5B	4.2	2.7
	3/4	8.0B	3.3	4.4
	2	9.0B	3.4	2.5
	2/2	7.0B	2.4	2.5
10B	8/4	9.5B	7.9	3.5
	2	{1.0PB	8.3	3.0
		{9.5B	7.9	2.2
	7/6	9.5B	7.2	5.7
	4	9.0	7.2	4.0
	2	1.0PB	7.0	2.5
	6/6	9.0B	6.3	6.3
	4	10.0B	6.3	4.6
	2	10.0B	6.3	2.9
	5/6	9.5B	5.2	6.3
	4	10.0B	5.2	4.6
	2	1.0PB	5.3	2.5
	4/8	10.0B	4.1	7.3
	6	0.5PB	4.2	6.3
	4	0.5PB	4.2	4.1
	2	1.0PB	4.2	2.3
10B (*cont'd*)	3/8	9.0B	3.3	7.1
	6	9.5B	3.2	5.6
	4	9.5B	3.1	3.9
	2	1.0PB	3.2	1.9
	2/4	9.5B	2.4	3.5
	2	{8.5B	2.2	3.1
		{0.5PB	2.2	2.6
2.5PB	8/4	2.5PB	8.0	3.6
	2	3.5PB	7.9	2.4
	7/6	3.0PB	7.1	5.6
	4	3.5PB	7.0	4.4
	2	3.5PB	7.1	2.2
	6/8	2.5PB	6.4	7.7
	6	2.5PB	6.3	6.1
	4	2.5PB	6.3	4.7
	2	2.5PB	6.3	2.5
	5/10	1.5PB	5.4	8.8
	8	2.5PB	5.3	8.0
	6	2.5PB	5.2	6.0
	4	2.5PB	5.2	4.3
	2	3.5PB	5.1	2.3
	4/10	2.0PB	4.3	8.9
	8	2.5PB	4.3	7.6
	6	2.5PB	4.1	6.1
	4	2.5PB	4.2	4.2
	2	3.5PB	4.2	2.9
	3/8	1.5PB	3.3	6.8
	6	2.5PB	3.2	6.0
	4	2.5PB	3.2	4.2
	2	3.0PB	3.1	2.3
	2/4	2.5PB	2.4	4.0
	2	2.5PB	2.3	2.7
5PB	8/2	5.0PB	8.3	3.2
	7/6	4.0PB	7.2	5.6
	4	4.0PB	7.3	4.5
	2	3.5PB	7.4	3.0
	6/8	5.0PB	6.3	7.4
	6	5.0PB	6.3	6.2
	4	5.0PB	6.5	4.7
	2	5.0PB	6.4	3.2
	5/10	3.5PB	5.3	8.6
	8	4.0PB	5.4	7.9
	6	4.0PB	5.3	6.2
	4	4.5PB	5.2	4.4
	2	5.0PB	5.1	3.1
	4/10	4.0PB	4.4	8.9
	8	4.5PB	4.3	7.4
	6	4.5PB	4.2	6.0
	4	5.0PB	4.2	4.3
	2	5.0PB	4.2	2.5
	3/12	4.0PB	3.3	9.4
	10	4.5PB	3.4	8.5
	8	4.5PB	3.2	7.0
	6	5.0PB	3.2	5.6
	4	5.0PB	3.1	3.9
	2	5.0PB	3.1	2.1
	2/6	4.0PB	2.3	5.9
	4	4.0PB	2.3	4.8
	2	4.5PB	2.2	2.6
7.5PB	8/4	6.5PB	8.0	3.4
	2	7.5PB	8.0	1.8
	7/8	6.5PB	7.2	5.8
	6	7.0PB	7.2	5.3
	4	7.0PB	7.1	3.6
	2	6.5PB	7.1	2.0
	6/10	7.0PB	6.2	8.6
	8	7.0PB	6.2	7.1
	6	7.5PB	6.1	5.9
	4	7.5PB	6.2	4.2
	2	7.5PB	6.2	2.5
7.5PB (*cont'd*)	5/14	7.0PB	5.0	10.8
	12	7.0PB	5.0	10.0
	10	7.0PB	5.0	8.7
	8	7.5PB	5.0	7.3
	6	7.5PB	5.0	5.8
	4	7.5PB	5.0	4.0
	2	7.5PB	5.1	2.4
	4/16	7.0PB	4.2	12.9
	14	7.0PB	4.2	12.1
	12	7.0PB	4.1	10.5
	10	7.5PB	4.2	9.1
	8	7.5PB	4.1	7.7
	6	7.5PB	4.1	6.1
	4	7.5PB	4.1	4.3
	2	7.5PB	4.1	2.4
	3/14	7.5PB	3.2	12.6
	12	7.5PB	3.2	10.7
	10	7.5PB	3.0	9.5
	8	7.5PB	3.1	7.8
	6	7.5PB	3.1	6.1
	4	7.5PB	3.1	4.3
	2	7.5PB	3.0	2.2
	2/10	6.5PB	2.4	10.4
	8	7.0PB	2.3	9.1
	6	7.0PB	2.3	8.0
	4	7.0PB	2.2	5.9
	2	7.0PB	2.2	3.7
10PB	8/2	{7.5PB	8.3	3.4
		{10.0PB	8.0	2.5
	7/6	10.0PB	7.0	5.3
	4	10.0PB	7.1	4.0
	2	0.5P	7.0	2.4
	6/8	0.5P	6.2	8.0
	6	10.0PB	6.1	6.3
	4	0.5P	6.3	4.8
	2	10.0PB	6.4	3.0
	5/10	10.0PB	5.0	9.6
	8	10.0PB	5.2	8.4
	6	10.0PB	5.2	6.8
	4	10.0PB	5.2	5.0
	2	10.0PB	5.2	3.1
	4/10	10.0PB	4.0	9.7
	8	10.0PB	4.1	8.5
	6	10.0PB	4.2	6.6
	4	10.0PB	4.1	4.6
	2	10.0PB	4.2	2.4
	3/10	10.0PB	3.1	10.6
	8	10.0PB	3.2	7.4
	6	10.0PB	3.1	6.1
	4	10.0PB	3.1	4.7
	2	1.0P	3.2	2.7
	2/6	10.0PB	2.2	5.5
	4	10.0PB	2.2	4.8
	2	1.0P	2.2	3.5
2.5P	8/4	3.5P	7.8	4.1
	2	4.0P	7.9	2.4
	7/6	3.0P	7.1	6.0
	4	3.5P	7.2	4.3
	2	3.5P	7.2	2.1
	6/8	2.5P	6.2	8.2
	6	2.5P	6.1	6.8
	4	2.5P	6.2	4.3
	2	2.5P	6.2	2.8
	5/10	2.5P	5.1	12.1
	8	2.5P	5.0	10.2
	6	2.5P	5.0	7.6
	4	2.5P	5.0	5.4
	2	2.5P	5.0	3.2
	4/10	2.5P	4.1	11.5
	8	2.5P	4.2	9.5
	6	2.5P	4.1	8.0
	4	2.5P	4.1	5.6
	2	2.5P	4.0	3.5
2.5P (*cont'd*)	3/10	2.0P	3.3	11.6
	8	2.5P	3.2	9.7
	6	3.0P	3.2	8.1
	4	3.5P	3.2	6.4
	2	2.5P	3.1	3.5
	2/8	2.5P	2.3	8.2
	6	2.5P	2.3	6.4
	4	3.5P	2.2	4.2
	2	5.5P	2.1	3.2
5P	8/4	4.5P	8.0	4.8
	2	5.0P	8.0	2.5
	7/6	5.5P	7.0	6.4
	4	5.0P	7.1	4.8
	2	4.5P	6.9	2.7
	6/8	5.0P	6.1	9.1
	6	4.5P	6.2	7.1
	4	4.0P	6.2	4.9
	2	4.5P	6.2	3.0
	5/10	5.0P	5.1	10.9
	8	5.0P	5.1	8.9
	6	5.0P	5.0	6.8
	4	4.5P	5.0	4.7
	2	5.0P	5.0	2.5
	4/12	5.5P	4.1	12.6
	10	5.0P	4.1	10.1
	8	5.0P	4.1	8.2
	6	5.0P	4.1	6.1
	4	5.0P	4.1	4.2
	2	5.0P	4.1	2.2
	3/10	5.0P	3.3	11.2
	8	5.0P	3.2	8.4
	6	4.5P	3.2	6.4
	4	5.0P	3.1	4.5
	2	5.0P	3.2	2.2
	2/6	5.0P	2.1	6.8
	4	5.0P	2.2	4.6
	2	5.5P	2.1	2.9
7.5P	8/2	7.5P	8.0	3.3
	7/4	7.0P	7.2	4.9
	2	7.5P	7.2	3.0
	6/6	7.5P	6.2	7.3
	4	7.5P	6.2	5.5
	2	7.0P	6.0	2.8
	5/8	8.0P	5.0	10.0
	6	8.5P	5.0	7.5
	4	8.5P	5.1	5.3
	2	9.0P	5.0	2.6
	4/8	8.5P	4.1	10.3
	6	8.5P	4.0	7.0
	4	9.0P	4.1	4.7
	2	8.5P	4.1	2.4
	3/8	7.5P	3.1	9.1
	6	7.5P	3.1	7.1
	4	7.5P	3.1	4.4
	2	8.0P	3.0	2.2
	2/6	7.5P	2.3	6.4
	4	7.5P	2.2	5.1
	2	8.5P	2.2	2.5
10P	8/4	7.5P	8.2	3.5
	2	10.0P	8.3	2.1
	7/8	9.5P	7.3	6.0
	6	9.5P	7.2	4.6
	4	10.0P	7.2	4.0
	22	10.0P	7.3	2.3
	6/8	9.0P	6.2	8.0
	6	9.5P	6.2	6.2
	4	10.0P	6.2	4.6
	2	9.0P	6.2	2.8

TABLE III.—*Continued.*

Munsell Book Notation *H*	*V/C*	Munsell Re-notation According to Recommended Curves *H*	*V*	*C*
10P (*cont'd*)	5/10	0.5RP	5.3	10.4
	8	1.0RP	5.2	8.6
	6	1.0RP	5.2	6.7
	4	1.0RP	5.2	4.9
	2	0.5RP	5.1	2.5
	4/10	0.5RP	4.2	10.4
	8	0.5RP	4.3	8.5
	6	0.5RP	4.3	6.6
	4	0.5RP	4.3	4.5
	2	9.5P	4.3	2.2
	3/10	9.0P	3.0	9.8
	8	10.0P	3.1	8.3
	6	9.0P	3.2	6.3
	4	10.0P	3.2	4.5
	2	0.5RP	3.1	2.2
	2/6	9.0P	2.2	6.8
	4	9.0P	2.2	5.3
	2	1.0RP	2.4	2.8
2.5RP	8/4	1.0RP	8.1	4.1
	2	1.0RP	8.0	2.5
	7/6	2.0RP	7.3	5.7
	4	2.0RP	7.2	4.3
	2	2.0RP	7.3	2.5
	6/8	2.5RP	6.4	8.2
	6	2.0RP	6.3	6.5
	4	2.0RP	6.2	4.7
	2	1.5RP	6.2	2.5
	5/10	3.0RP	5.3	10.4
	8	3.5RP	5.3	9.1
	6	2.5RP	5.2	6.6
	4	2.5RP	5.1	4.5
	2	2.5RP	5.0	2.6
	4/10	2.5RP	4.3	10.5
	8	2.0RP	4.3	9.2
	6	2.5RP	4.2	6.8
	4	2.5RP	4.2	4.4
	2	2.5RP	4.2	2.6
2.5RP (*cont'd*)	3/10	2.5RP	3.1	9.6
	8	2.0RP	3.2	7.8
	6	2.5RP	3.2	6.0
	4	2.5RP	3.1	4.1
	2	2.5RP	3.1	1.9
	2/8	2.0RP	2.5	7.3
	6	1.5RP	2.5	6.7
	4	1.5RP	2.4	5.1
	2	1.0RP	2.2	2.6
5RP	8/6	6.5RP	8.1	3.4
	4	5.5RP	8.1	2.8
	2	8.0RP	8.3	1.9
	7/8	4.5RP	7.4	4.9
	6	5.0RP	7.4	4.4
	4	6.0RP	7.4	3.3
	2	6.5RP	7.3	2.3
	6/10	4.5RP	6.3	8.5
	8	5.0RP	6.3	7.3
	6	4.5RP	6.3	5.6
	4	4.5RP	6.4	4.2
	2	4.0RP	6.1	2.2
	5/10	5.5RP	5.3	9.7
	8	4.5RP	5.2	8.0
	6	4.5RP	5.1	6.2
	4	5.0RP	5.2	4.3
	2	5.0RP	5.2	2.3
	4/12	5.0RP	4.3	10.7
	10	4.5RP	4.2	9.4
	8	4.5RP	4.2	7.9
	6	4.5RP	4.3	6.4
	4	4.0RP	4.3	4.4
	2	4.0RP	4.4	2.1
	3/10	5.0RP	3.2	8.4
	8	5.0RP	3.1	6.8
	6	5.0RP	3.0	5.2
	4	5.0RP	3.0	3.7
	2	4.5RP	3.0	1.9
5RP (*cont'd*)	2/6	4.0RP	2.4	5.9
	4	5.0RP	2.4	4.6
	2	6.0RP	2.3	2.3
7.5RP	8/4	6.0RP	8.2	3.8
	2	9.5RP	7.9	2.1
	7/6	6.5RP	7.3	5.3
	4	6.0RP	7.3	3.6
	2	8.0RP	7.1	2.2
	6/10	7.0RP	6.3	8.8
	8	7.5RP	6.3	7.3
	6	7.0RP	6.1	5.3
	4	7.5RP	6.2	3.8
	2	7.5RP	6.1	2.0
	5/10	7.0RP	5.4	9.7
	8	7.0RP	5.1	8.2
	6	7.5RP	5.1	6.3
	4	6.5RP	5.1	4.5
	2	6.5RP	5.1	2.4
	4/10	6.5RP	4.3	10.0
	8	6.5RP	4.3	8.3
	6	7.0RP	4.3	6.3
	4	7.5RP	4.3	4.3
	2	7.0RP	4.2	2.5
	3/10	6.5RP	3.3	9.4
	8	6.5RP	3.2	7.6
	6	6.5RP	3.2	5.8
	4	6.5RP	3.2	3.6
	2	7.0RP	3.3	2.1
	2/6	6.0RP	2.4	6.3
	4	6.0RP	2.4	5.0
	2	5.5RP	2.3	2.8
10RP	8/6	8.5RP	8.2	3.6
	4	9.5RP	8.1	2.7
	2	5.0R	8.1	2.1
	7/8	9.0RP	7.1	5.8
	6	9.5RP	7.2	4.7
	4	9.5RP	7.1	3.5
	2	3.0R	7.2	2.3
10RP (*cont'd*)	6/10	9.5RP	6.2	8.8
	8	9.0RP	6.2	7.0
	6	9.0RP	6.2	5.5
	4	8.5RP	6.2	4.0
	2	10.0RP	6.1	2.3
	5/10	10.0RP	5.2	10.3
	8	10.0RP	5.2	8.6
	6	10.0RP	5.2	6.6
	4	10.0RP	5.3	4.2
	2	1.0R	5.3	2.6
	4/10	9.5RP	4.2	9.5
	8	9.0RP	4.2	8.2
	6	9.5RP	4.1	6.4
	4	9.0RP	4.1	4.1
	2	10.0RP	4.3	2.8
	3/10	8.5RP	3.2	8.5
	8	9.0RP	3.1	7.0
	6	9.0RP	3.1	5.6
	4	9.0RP	3.0	3.4
	2	9.5RP	3.1	2.2
	2/6	8.0RP	2.4	5.6
	4	8.0RP	2.3	3.7
	2	7.0RP	2.4	2.7
Neutrals				
N 9.6/		2.5YR	9.5	0.2
No. 57		10.0Y	9.2	0.2
N 9.4/		10.0Y	9.2	0.2
N 9/		7.5Y	8.7	0.1
N 8/		2.5GY	7.9	0.3
N 7/		7.5PB	7.1	0.1
N 6/		—	6.0	0.0
N 5/		5.0PB	4.9	0.1
N 4/		5.0PB	4.0	0.1
N 3/		2.5P	3.0	0.2
N 2/		5.0P	2.0	0.2
N 1/		2.5PB	1.2	0.1

coordinates $(V_X - V_Y)$ and $(V_Z - V_Y)$, which are simple functions (*2*) of X, Y, Z, the corresponding tristimulus specifications. The conversion is easily made with suitable tables (*31*). The illuminant point serves as origin for the chromatic-value. Another advantageous feature of chromatic-value is that the constant chroma loci plotted at one value level approximate in diameter those at the other values. Furthermore, it was found feasible to employ a single system of chroma curves for all value levels. This curve equivalence for all value levels vanishes on conversion to the I.C.I. (x, y)-system, but smooth inter-value-level transitions remain.

The particular ovoid form finally chosen to define all loci of constant chroma, in Adams' coordinates, is illustrated in Fig. 11. This shape was the outcome of many trial smoothings on Adams' charts bearing vector arrows representing the averaged visual estimates previously published. The familiar end-effect of chroma whereby extreme strong samples tend to look stronger than they would elsewhere in the series was estimated to be of the order of half a chroma step and compensated where required. The shape was arrived at independently by two investigators both of whom followed a procedure of progressive approximation in which intra-value-level and inter-value smoothing were alternately employed. There was some question about the purple-blue region, but aside from that the shape was felt to fit the data acceptably at every value level, with the aid of a small systematic decentering adjustment. At value 5/[6] the coordinates of the ovoid origin are $(V_X - V_Y) = -0.02$; $(V_Z - V_Y) = -0.075$. The center is shifted by small equal amounts from 5/ down to 1/ which

[6] Refers to Munsell-Sloan-Godlove value-reflectance relation, since the new recommended value scale had not then been developed.

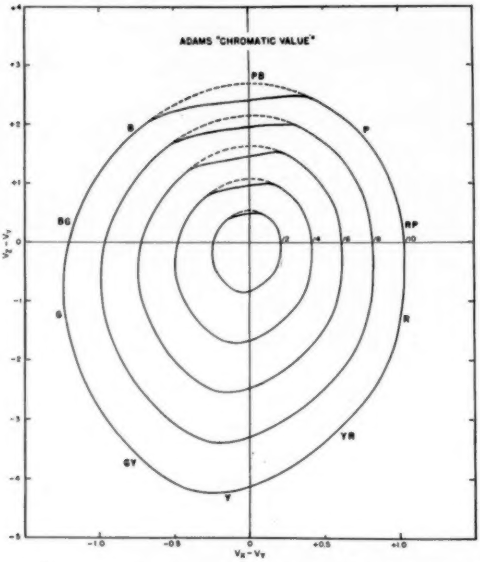

FIG. 11. The recommended loci for constant chroma /2 to /10 as plotted in Adams' chromatic-value coordinates. Dotted lines indicate original contour in the purple-blue region.

falls at $(V_X - V_Y) = 0.06$; $(V_Z - V_Y) = 0.085$; and from 5/ up to 9/ which falls at $(V_X - V_Y) = -0.10$; $(V_Z - V_Y) = -0.235$. Figure 11 shows the appearance of the family of concentric constant chroma loci at the region of the 5/ value level in the Adams' coordinates. Each chroma locus is seen to be not only of the same shape but also at the same distance from adjacent loci as measured along any radius.

The achievement of these relations not only involved the adoption of the decentering expedient but also some considerable local departures from the data. On the other hand, the specification of chroma is greatly simplified and a much needed basis is provided for its extrapolation beyond the data through much used areas to the theoretical maximum (*22*). This extrapolation was accomplished as follows: First a listing was made of the I.C.I. (x, y)-figures for the MacAdam limits corresponding to 40 hues at each of nine values. Approximations to these limits are given in Table IV. Then the new chroma loci were extended at equal intervals (in Adams' space), up to the last even step which would come within the MacAdam limit (Table I).

When the system of ovoids established in Adams' space was transformed into I.C.I. (x, y)-space, the results at the various value levels[6] were as shown in Fig. 12. All the loci are seen to be smoothly transitional at a given value level or from one value to another. The chroma loci in Figs. 1–9 and Table I are adjusted for the differences required by the recommended value scale as compared to the Munsell-Sloan-Godlove value scale.

The spacing on the I.C.I. diagram is drastically affected by the major departures from perceptual uniformity of the I.C.I. system. The marked bunching of the chroma loci in the purple region emphasizes the difficulty which was avoided by smoothing in the more regular space employed.

After charts for 1/ to 9/ value levels had been completed, visual comparisons of chromatic samples were found to agree very well with the new chroma loci. There was, however, a marked exception in the blue and purple-blue region, especially at the lower and intermediate value levels. Although the sample comparisons pointed to real discrepancies between 5.0B and 7.5PB, on either side of this rather narrow range the agreement was good. The most pronounced bulge in the entire sweep of the chroma loci occurred at

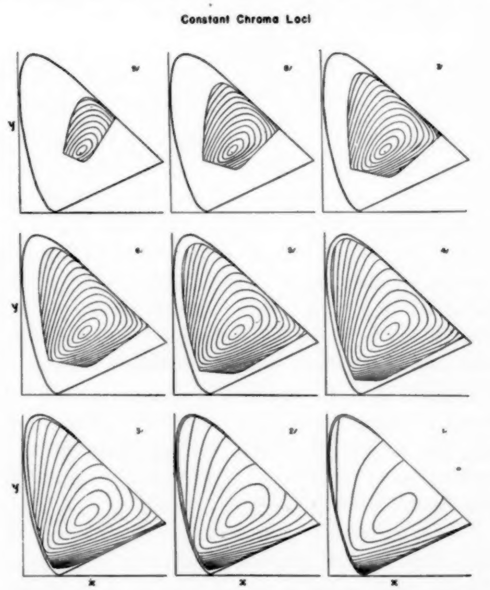

FIG. 12. Master chroma chart in the I.C.I. standard coordinate system showing the recommended loci of constant chroma for every second chroma step from zero to the theoretical maximum at every value level from 1/ through 9/.

about the middle of this range, but reference to the corresponding part of the ovoid developed in Adams' space showed that it was flattest there. Furthermore, the ovoid would need not only to be more flat, but actually concave in order to produce agreement with visual observation. The plots of the data in the Adams' space originally had suggested concavity in this one limited region, but the evidence had seemed insufficient to justify such a drastic localized departure from what the Adams' space was believed to represent. The low chromas indicated the type of curve first used (dotted line, Fig. 11) but higher chromas indicated concavity. In the original smoothing, the curve was pushed to the limit of the data in this region in order to afford some agreement with the rest of the curve. Now, however, visual check on the result provided reason for giving the strong-chroma data more weight, and so the ovoid pattern was reduced to virtually a straight line (Fig. 11) in the region under discussion. Transformation to the I.C.I. (x, y)-diagram now resulted in chroma loci which partially correct the observed discrepancy; and the corresponding revisions were made in Figs. 1 to 9 and Table I. But the loci still are not really satisfactory in this region. Why, one might ask, should very sudden transitions be required in this particular region and nowhere else? This exception may be due, not to the Munsell samples or to the Adams' conversion, but to the I.C.I. system itself. The chromatic data, on which the standard observer is based, were taken with a 2° field centrally fixated. The luminosity data probably represent

TABLE IV. The I.C.I. (x, y) equivalents of the theoretical pigment maxima for 40 hues on nine value levels.*

	Munsell Value																	
	9		8		7		6		5		4		3		2		1	
Hue	x	y	x	y	x	y	x	y	x	y	x	y	x	y	x	y	x	y
2.5R	0.372	0.318	0.432	0.315	0.490	0.304	0.540	0.289	0.585	0.269	0.613	0.253	0.627	0.238	0.580	0.204	0.526	0.172
5.0	.378	.326	.442	.327	.510	.322	.570	.311	.624	.294	.659	.278	.668	.259	.632	.228	.581	.198
7.5	.384	.335	.458	.344	.535	.345	.604	.336	.658	.315	.690	.294	.703	.277	.680	.251	.628	.220
10.0	.390	.344	.476	.364	.567	.374	.627	.372	.635	.364	.647	.353	.677	.322	.721	.271	.679	.244
2.5YR	.399	.358	.497	.388	.593	.407	.596	.403	.600	.400	.605	.394	.617	.382	.646	.353	.713	.287
5.0	.409	.373	.527	.422	.569	.431	.572	.427	.576	.423	.581	.419	.586	.413	.598	.402	.616	.384
7.5	.423	.393	.545	.455	.547	.452	.550	.449	.553	.446	.556	.443	.560	.439	.566	.434	.581	.418
10.0	.442	.422	.527	.472	.529	.471	.530	.468	.533	.466	.536	.463	.539	.460	.543	.456	.550	.449
2.5Y	.468	.461	.509	.490	.511	.489	.512	.487	.514	.485	.516	.483	.519	.480	.522	.477	.526	.473
5.0	.484	.510	.488	.510	.491	.508	.493	.506	.495	.504	.498	.502	.500	.500	.502	.497	.504	.495
7.5	.470	.523	.474	.526	.475	.524	.476	.523	.478	.522	.479	.520	.480	.519	.482	.517	.484	.515
10.0	.457	.537	.460	.540	.459	.539	.460	.540	.459	.540	.459	.540	.459	.540	.459	.540	.459	.540
2.5GY	.438	.555	.439	.560	.438	.561	.437	.562	.435	.563	.434	.565	.432	.567	.430	.570	.424	.575
5.0	.413	.576	.413	.586	.410	.588	.407	.591	.404	.594	.401	.597	.396	.602	.390	.607	.380	.618
7.5	.361	.603	.360	.632	.356	.640	.349	.648	.342	.655	.333	.663	.322	.673	.311	.683	.292	.701
10.0	.303	.579	.278	.686	.267	.711	.257	.726	.247	.740	.238	.747	.222	.760	.188	.785	.147	.810
2.5G	.263	.497	.202	.615	.149	.682	.105	.724	.066	.753	.042	.762	.027	.759	.019	.750	.013	.737
5.0	.244	.428	.180	.496	.129	.541	.085	.574	.047	.600	.023	.614	.012	.617	.008	.612	.006	.605
7.5	.238	.403	.175	.456	.128	.488	.086	.513	.049	.528	.027	.532	.017	.529	.014	.522	.012	.513
10.0	.232	.380	.172	.417	.129	.439	.091	.454	.057	.459	.036	.456	.028	.446	.025	.433	.024	.417
2.5BG	.229	.361	.170	.380	.130	.388	.097	.389	.068	.386	.048	.380	.040	.370	.037	.359	.037	.345
5.0	.225	.342	.168	.346	.133	.342	.104	.334	.078	.321	.062	.306	.056	.294	.053	.280	.053	.267
7.5	.221	.323	.168	.316	.136	.306	.110	.295	.086	.280	.072	.265	.065	.254	.062	.244	.063	.227
10.0	.232	.309	.168	.290	.138	.273	.116	.257	.095	.241	.082	.226	.076	.213	.073	.200	.074	.190
2.5B	.248	.302	.181	.272	.141	.246	.121	.230	.102	.212	.090	.197	.084	.185	.082	.175	.082	.166
5.0	.259	.297	.205	.264	.156	.226	.127	.202	.110	.183	.100	.170	.094	.158	.090	.149	.090	.143
7.5	.265	.295	.217	.260	.172	.222	.132	.183	.115	.164	.106	.151	.100	.141	.096	.133	.096	.127
10.0	.271	.292	.227	.257	.186	.219	.144	.177	.120	.150	.111	.137	.105	.127	.102	.119	.101	.114
2.5PB	.277	.290	.238	.254	.201	.215	.163	.173	.127	.130	.119	.117	.113	.107	.110	.099	.109	.093
5.0	.281	.288	.246	.251	.213	.212	.177	.170	.140	.122	.127	.100	.121	.087	.119	.078	.119	.071
7.5	.286	.286	.258	.247	.230	.207	.202	.166	.177	.118	.164	.078	.160	.046	.162	.026	.168	.013
10.0	.290	.284	.268	.244	.245	.204	.224	.161	.205	.115	.195	.076	.191	.048	.191	.032	.192	.022
2.5P	.295	.283	.277	.241	.261	.200	.247	.157	.234	.112	.226	.075	.223	.053	.222	.040	.225	.035
5.0	.298	.281	.287	.238	.277	.196	.268	.152	.261	.109	.257	.079	.255	.062	.256	.052	.259	.048
7.5	.312	.275	.312	.230	.309	.187	.305	.146	.301	.108	.296	.088	.292	.075	.288	.065	.283	.059
10.0	.325	.273	.336	.226	.343	.186	.347	.154	.250	.126	.344	.108	.335	.092	.323	.081	.306	.070
2.5RP	.340	.282	.366	.243	.383	.211	.396	.183	.405	.158	.406	.141	.403	.126	.380	.108	.337	.083
5.0	.352	.294	.390	.268	.423	.242	.447	.220	.469	.197	.472	.176	.461	.155	.434	.133	.383	.105
7.5	.360	.302	.404	.284	.446	.263	.479	.243	.509	.222	.522	.203	.519	.185	.478	.154	.431	.128
10.0	.367	.311	.419	.301	.471	.286	.514	.269	.551	.248	.571	.230	.579	.215	.526	.178	.470	.146

* The figures for these limit colors were obtained from a diagram supplied by Dr. MacAdam (22). They are approximations which depend upon the accuracy with which it was possible to interpolate and read curves representing Munsell values 1/ through 9/.

an admixture of a slight degree of rod vision. The Munsell samples, on the other hand, have been observed under a degree of light adaptation insuring a greater approach to pure cone vision, but with fields so greatly exceeding two degrees that the macular pigment probably exerted little influence. Perhaps these differences in observing conditions account for the peculiarity in the purple-blue region. Since definite justification for a sudden transition is lacking, the curves were not altered as radically as they might otherwise have been.

Hue Adjustments

Originally it was believed that the chromatic-value charts would also simplify the smoothing of the constant-hue lines by permitting them to be drawn with a straightedge. The number of irregularities to be contended with, however, soon made it apparent that the simplest thing to do was to smooth directly in the I.C.I. (x, y)-diagram. Accordingly, the visual estimates for the 20 principal hues, corresponding to the 1929 Munsell samples, were plotted in vector arrow notation with respect to both the National Bureau of Standards and the Glenn-Killian points; and then tentative loci of constant hue were drawn in for each value level.

An attempt was made in the first smoothing to hold to lines of constant dominant wave-length, but degrees of curvature which could not be ignored were soon apparent in some hue lines. When the curved smoothed lines of hue for separate value levels were put together, a picture of fairly regular progression emerged (Fig. 13). In numerous instances it was necessary to extrapolate the hue lines far beyond the Munsell data to reach the theoretical pigment limit. One working rule was to carry to the limit the trend of the curve which seemed best to fit the data. Another rule was to err in the direction of straightness rather than of curvature. Of course, the loci for a given hue on different value levels had to be smoothed and adjusted to provide smooth inter-value-level transitions. Tracings of the several loci for a given hue were compared and adjusted, after which the smoother reviewed the arrangement at each value level. Thus, as in the chroma smoothing, by reverting back and forth from the intra-value to the inter-value operation, discrepancies were progressively reduced until the optimal hue lines were eventually approximated.

In certain extended regions beyond the Munsell data, the problem of determining the exact courses of the hue loci is formidable. In some instances, fortunately, the results of other studies were available to supplement the visual estimates, and proved helpful in reaching or confirming a decision. In spite of our practical precept favoring straightness, observations of strong colors by Judd (*17*), and by Kelly and Judd (*20*) made it clear that a number of our provisional curved loci should be increased in curvature toward their extremes. In particular, the PB line was kept nearly straight while the 7.5PB line was altered from nearly straight to considerable curvature toward its limit on the basis of Judd's previous data and check observations by Judd, Nickerson, and Newhall. The greatest curvature occurs immediately following the PB, and is not shown since it lies between the PB and 7.5PB lines. Hue lines between 7.5PB and 5.0P were adjusted toward their ends to conform with a curvature gradient decreasing toward P, as observed by Kelly and Judd. Their observations are also responsible for increased curvature of the line ending at 620 mμ on the spectrum locus. This line represents a local curvature maximum, the loci on either side being altered slightly to conform to a progressive change in curve.

There is also older evidence that the loci of constant hue cannot be expected to coincide with those of dominant wave-length, even when luminance is constant. This question has been considered by Müller (*33*), Abney (*1*), Schrödinger (*34*), and Judd (*18*). Hue appears to be an imperfectly known function of purity when luminance and dominant wave-length are constant. Around the spectrum locus the effect seems to be in different directions in different regions, with several hues invariable, or nearly invariable in this regard. In Fig. 13 an invariable (straight line) at 10Y and another between 5P and 7.5P may be noted.

The recommended hue loci also seem to be affected by the well-established Bezold-Brücke phenomenon (*5*), (*6*), (*14*), (*35*), (*32*), that is, the hue shift with luminance, apart from purity and

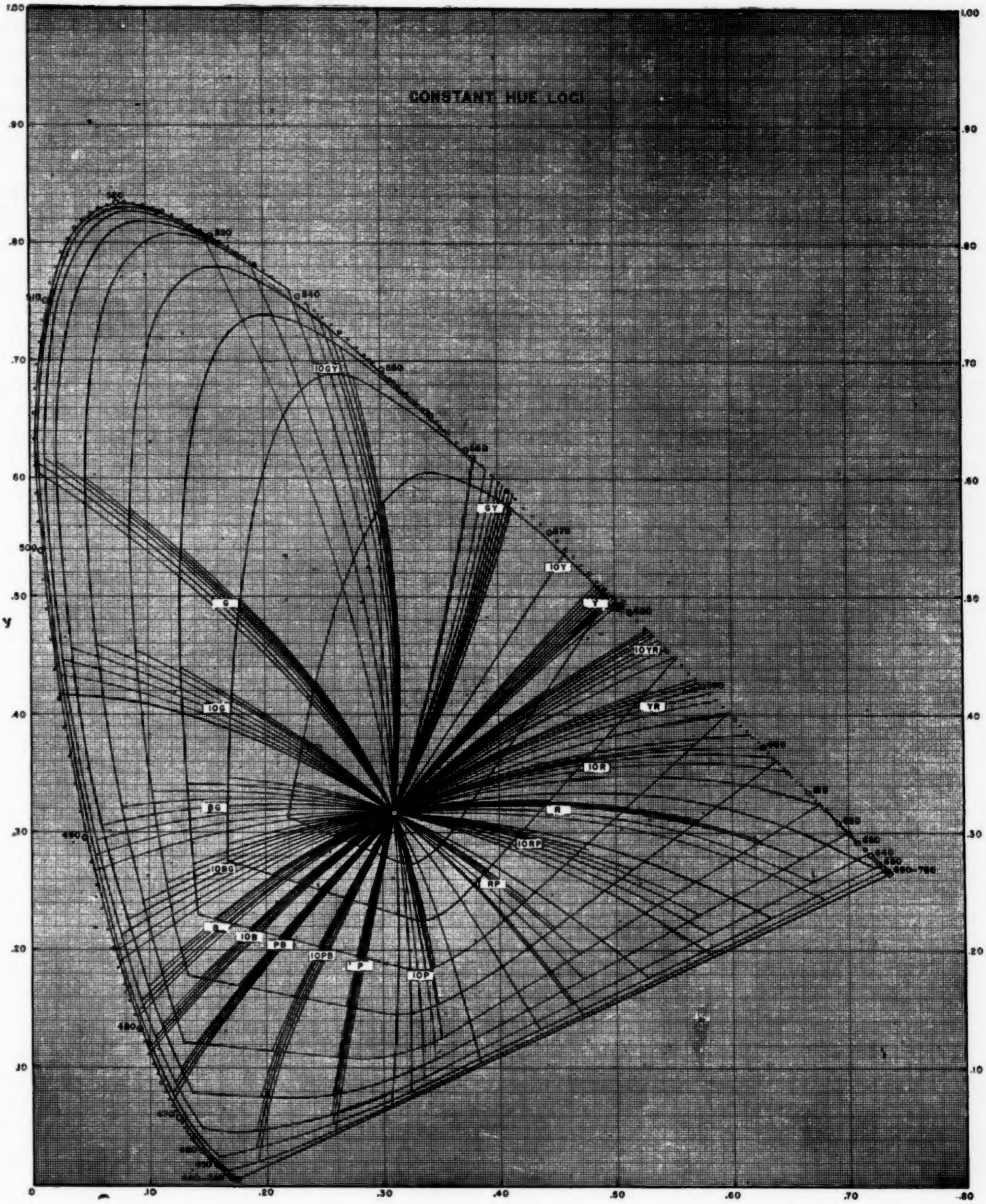

FIG. 13. Master hue chart in the I.C.I. standard coordinate system showing the recommended loci of constant hue for the 20 standard hues at value levels 1/ through 9/.

wave-length. Reference to Fig. 13 shows that the loci representing the same hue at different values are in some regions much more closely grouped than in others. The 10Y line, for example, is nearly the same at all value levels. This agrees with findings of Purdy (*32*) and of Exner (*7*) in their investigations of the Bezold-Brücke effect. Figure 13 also suggests invariables of this type at

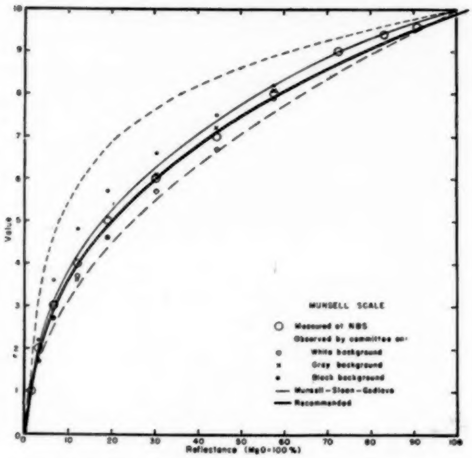

FIG. 14. Munsell value (*Book of Color* samples) as a function of reflectance. This figure shows the curve of the recommended value scale (heavy line) in comparison with the Munsell-Sloan-Godlove value function (fine line); and also with the subcommittee's observations on white (open circles), on gray (crosses), and on black (closed circles) grounds. The large open circles indicate National Bureau of Standards measurements of the samples. Nearly all of these results are seen to fall within the limits of $R=V^2$ (lower dashed curve) and $R=k$ anti-log V (upper dashed curve). *Note:* The three solid dots which appear below the heavy line should be open circles with crosses in the center.

5PB; between 5P and 7.5P; and near 5G, probably toward 10GY. The averages of these hue lines cut the spectrum locus at 572.2, 505, 473.5 mμ, and the purples at 559*c*. Purdy reported invariables at 571, 506, and 474 mμ and Exner at 577, 508, and 475 mμ. Evidence of this changing relation between hue and dominant wave-length is found in the earliest Munsell papers [(*8*), Fig. 5], and the observations on which this report is based (*28*) emphasize it.

As a precautionary measure, it seems well to emphasize the fact that the establishment of standard hue loci was a difficult problem. Considerable judgment and inference were necessarily relied upon, and the complete result is not to be regarded as more than a first approximation to uniform hue spacing. The problem was especially difficult at the 1/ and the 9/ value levels to which it seemed very desirable to try to extrapolate but at which there were no chromatic Munsell samples. Such extrapolation is hazardous and tentative as sudden changes may readily occur in these extreme regions of the solid; however, it seemed best to make a beginning and thus provide some basis for future refinement.

After the 20 principal hue lines had been established at all value levels, the final step of drawing in 20 more intermediate lines to correspond approximately to the recently released third intermediate hues was a simple one. The latter 20 were drawn in simply to fit into the sequences of the original 20 which are based upon the visual estimates of the 1929 samples. The interpolated 20 fit the corresponding data fairly well. This latter group of hue lines was plotted in a figure—not shown—similar to Fig. 13. The entries in Table I were read from large master charts on which the extrapolated hue and chroma lines had been carefully traced. Then check readings were made from the originals of the charts shown in Figs. 1–9. The entries were read from the original penciled charts before inking.

The tables and charts of the chroma and hue loci were worked out so that they would be correct for the new value-reflectance relations given in Table II. The procedure for determining the latter is described in the next section.

Value Adjustments

The hue and chroma adjustments were made on the basis of visual estimates which had been averaged for all three observing grounds. This average was taken because under our conditions of observation the influence of background reflectance on hue and saturation comparisons was neither systematic nor dependable, and is therefore to be regarded as insignificant. The influence of background reflectance on value estimates, however, was found to be significant. The general nature of this effect is evident from intercomparison of the three curves in Fig. 14 which correspond to the observations on the white, gray, and black grounds. In some of the more extreme cases encountered in practice it will be worth while to make an adjustment for this effect of simultaneous contrast, and this can be done by reference to the corresponding graph. In general and for intermediate reflectances, however, it seemed desirable to standardize on a single value function suitable for use with a light ground, otherwise complications would arise in the hue and chroma dimensions. This decision was supported further by the discovery that only the function for the black background was greatly out of line.

The value adjustments were made on the neutral or near-neutral samples with the assumption that a constant value-reflectance (V to Y) relation holds for all colors regardless of chroma.

The heavy curve in Fig. 14 represents the recommended value function, while the other curves have been at some time or for some reason considered indicative of the relation between reflectance and value. It should be noted that the Munsell-Sloan-Godlove scale, which is represented by the finer line, is not far from the curve of the recommended value scale. A double adjustment was made, the nature of which deserves some explanation.

The recent National Bureau of Standards (*21*) measurements of the neutral samples indicate reflectances higher by 6 percent or more than the averages of Munsell-Sloan-Godlove. This considerable discrepancy may be due in part to the use of different reflectance standards but is not yet completely explained. Investigation has revealed that it was not due to failure by the painter of the samples to reproduce to a narrow tolerance the specifications furnished him. The indicated double adjustment consisted in (*a*) increasing the reflectances reported by Munsell-Sloan-Godlove by 6 percent for values 2/ to 8/, inclusive, and (*b*) making the reflectance scale relative to magnesium oxide taken as 97.5 percent (*26*). This adjustment amounts to multiplying the Munsell-Sloan-Godlove reflectances from 0/ to 9/ by 1.0871 and then smoothing to 10/ which is set at 102.56 percent in order that value 10/ be equivalent to 100 percent absolute reflectance. On such a scale Y values, in terms of MgO at 100 percent, may be read directly.

Despite these adjustments and its superficially smooth appearance a curve drawn through these points was found still to contain a number of inflections. By trial and error, a quintic parabola was found which fits closely the adjusted Munsell-Sloan-Godlove reflectances and has but one trivial inflection. This equation is:

$$R_Y = 1.2219V - 0.23111V^2 + 0.23951V^3 - 0.021009V^4 + 0.0008404V^5.$$

This formula was employed in computing the various reflectances in Table II which presents I.C.I. Y (or percent reflectance relative to magnesium oxide) as a function of value.

SUMMARY

A psychophysical system of surface colors has been developed from the extended observations by numerous observers of the *Munsell Book of Color* samples. This system is aimed toward the double ideal of practicability and perceptual uniformity. The necessity of considerable reliance on color judgment, the scattered data, and extrapolation make it clear that this system is to be regarded only as an approximation to the ideal.

The visual conditions appropriate to the employment of the system are evident from the procedure followed in taking the basic data. The observers made their color comparisons by looking at groups of related samples on the Munsell type of constant hue and constant value charts. Thus, at the time of an observation, the observer's eyes were adapted to the chart as a whole rather than to, for example, I.C.I. Illuminant *C*. This is the usual situation in the visual specification of a color sample by reference to a standard chart, a type of situation which has been discussed by Helmholtz (*11*), Helson (*12*), and Judd (*18*).

During the experimental investigation of the subcommittee, no simultaneous comparisons were made of samples on backgrounds of different reflectance. White, gray, and black grounds were used at different times, but a single ground was always used in observations of a given set of samples. This uniformity of background is, also, a fairly usual situation for color comparisons. The separate use of the several achromatic grounds explains the lack of influence of ground evident in the hue and saturation estimates of our observers. The striking effects of ground under other viewing conditions (*18*), (*12*), (*13*), were absent here, presumably because of the relativity of the judgments and the tendency toward constancy from adaptation (*19*). Lightness, of course, was significantly affected by ground in our work, for the comparison of lightnesses always included the achromatic ground itself. Even here most of the effect was due to the black ground while the white and the gray were in fair agreement.

The question whether to make the system right for trained or untrained observers was raised in the preliminary report. The possibility of significant differences in the dimensional relations reported by visual color experts as compared with others seemed worthy of consideration. It

was felt in particular that inexperienced observers either might not notice or be reluctant to indicate significant points and might possibly, therefore, mask more valid indications of experts. To check this matter, the data from several visual color experts who participated in the preliminary study were analyzed and summarized separately. Comparison with the results from the main group showed no systematic trends which could justify the fractionation of the results in the final report.

The point of view of the subcommittee has changed considerably during the course of more than five years' work on its problem. The problem now seems more complicated than at first; and it may be that greater compromises with the ideal of perceptual uniformity have been made in order to secure a workable system than was anticipated.

The specific recommendations of the subcommittee are presented in the form of standard tables and charts (Tables I and II, Figs. 1–9), defining the new loci for Munsell hue, chroma, and value in terms of the I.C.I. system. It is expected that these forms will prove useful until such time as the whole problem may be vigorously reinvestigated and a closer approximation toward the double ideal realized.

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A Psychological Color Solid*

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VARIOUS geometrical solids have been designed in an attempt to describe the color space of normal human perception. Such solids, it should be emphasized, are concerned exclusively with the conscious color responses of the organism and have nothing to do with the stimuli except insofar as psychophysical equivalents may prove useful for standardization or conversion purposes.

The most familiar and promising procedure has been to represent the principal dimensions of perceived color by the coordinate axes of a cylindrical system in which lightness is indicated by altitude on the central axis, hue by angle about the axis, and saturation by distance from the axis (*1*)–(*3*).†

The ideal psychological solid in cylindrical coordinates would fulfill the following requirements: The dimensional scales would be calibrated in perceptually uniform steps; the units of the several scales would be equated; the surface of the solid would represent all colors of maximum saturation; the volume would be representative of all colors which are perceptibly different; the conditions of stimulation or viewing would be prescribed; and finally, the scales would be standardized in terms of a generally recognized psychophysical system.

In the preparation of a report on the smoothing of the Munsell colors (*4*), (*5*), data became available which permit, for the first time, an approximate fulfillment of all of these requirements. By reference to Adams' plots of "chromatic value" (*6*) and MacAdam's theoretical pigment limits (*7*), it was possible to lay down loci for constant chromas from zero to maximum. Table I presents (to the nearest half step) the maximum Munsell chromas corresponding to nine equi-spaced value levels and 40 equi-spaced hues. These figures serve to define the surface of the new solid.

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† Numbers in parentheses refer to literature cited.

Two models have been constructed, one to portray the proportions of a solid when the lightness and saturation dimensions have been equated at a supraliminal level of color difference, and the other when they have been equated at the liminal level. Thus the relatively short model, Fig. 1a, represents color as perceived under more or less usual conditions when no special tax is imposed upon the discriminatory power of the normal observer; the proportions are about right for readily perceived differences of the order of a chroma or value step (*8*). The taller model,

Table I. Chromas[1] at theoretical pigment limits for 40 hues, Munsell values 1/ through 9/.

Hue	Munsell value 9	8	7	6	5	4	3	2	1
2.5 R	6.5	12.0	16.0	19.5	21.0	20.0	17.5	15.0	12.0
5	6.5	11.5	16.0	19.5	21.0	20.0	17.0	14.0	11.5
7.5	6.0	11.5	16.0	19.5	21.5	20.5	17.5	14.0	11.0
10	6.0	11.5	17.0	20.0	18.5	16.5	14.5	14.0	10.5
2.5 YR	6.5	13.0	22.0	18.5	16.5	13.5	11.0	9.5	9.5
5	7.0	16.0	21.0	18.0	15.5	12.5	10.0	7.5	4.0
7.5	8.0	22.0	19.5	16.5	15.5	11.5	9.0	6.5	3.0
10	10.0	21.0	18.0	15.5	13.5	11.0	8.0	6.0	3.0
2.5 Y	13.0	20.0	17.5	15.0	13.0	10.5	8.0	5.0	3.0
5	20.0	19.5	17.0	14.5	12.5	10.0	7.5	5.0	3.0
7.5	20.0	19.0	16.5	14.0	12.0	9.5	7.0	5.0	3.0
10	19.5	19.0	16.5	14.0	12.0	9.5	7.0	5.0	3.5
2.5 GY	19.0	19.0	16.5	14.5	12.0	10.0	8.0	5.5	3.5
5	19.0	20.0	18.0	15.0	13.0	10.5	8.5	6.5	4.0
7.5	18.5	20.5	20.0	17.5	15.0	12.5	11.0	8.5	6.0
10	18.0	24.0	23.0	21.5	19.0	16.5	15.0	12.0	7.5
2.5 G	16.0	25.0	28.0	29.0	29.5	27.5	23.0	16.5	9.0
5	13.5	22.0	27.5	28.5	29.5	28.0	23.5	17.0	8.5
7.5	12.5	21.5	26.0	28.0	29.0	27.5	23.0	16.5	8.5
10	12.0	20.0	24.0	26.5	28.0	26.5	22.5	16.0	8.5
2.5 BG	11.5	19.0	22.5	24.0	23.5	24.0	21.0	15.0	8.5
5	11.0	18.0	20.5	22.0	22.0	21.0	18.0	14.0	8.0
7.5	10.0	16.5	19.0	20.0	19.5	19.0	16.5	12.5	7.5
10	7.5	16.0	17.5	18.5	17.5	17.0	14.5	11.5	7.0
2.5 B	6.0	13.0	16.5	17.5	17.0	16.0	13.5	11.0	7.0
5	5.0	10.0	15.0	16.5	16.5	15.0	13.5	10.5	8.0
7.5	4.5	9.0	13.5	17.0	17.5	16.0	13.5	11.0	8.0
10	4.0	8.0	12.0	17.0	18.0	17.0	14.0	12.0	9.0
2.5 PB	4.0	8.0	11.5	16.5	19.0	18.5	16.0	13.0	10.0
5	4.0	7.5	11.5	16.0	19.5	20.5	18.5	15.5	12.0
7.5	4.0	7.5	11.5	15.5	21.0	27.0	35.0	40.0	38.5
10	4.0	8.0	12.0	16.5	23.5	30.5	35.5	35.0	31.0
2.5 P	4.5	9.0	14.0	19.0	26.5	32.5	34.0	31.0	26.0
5	5.0	10.0	16.0	21.5	29.0	33.0	32.5	28.0	23.0
7.5	6.5	13.0	19.5	26.0	32.0	33.5	30.0	26.0	21.0
10	8.0	16.0	22.5	27.0	31.5	30.0	27.5	23.5	19.0
2.5 RP	8.0	15.0	21.0	26.0	28.0	26.5	23.0	20.0	17.5
5	7.5	13.5	19.0	22.5	24.0	23.5	21.0	18.0	15.5
7.5	7.5	12.5	18.0	21.0	23.0	22.0	19.0	17.0	14.0
10	7.0	12.0	16.5	20.0	22.0	20.5	18.0	16.0	13.0

[1] To nearest 0.5 step of chroma.

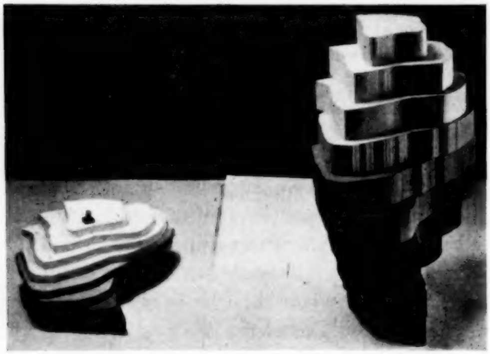

FIG. 1. Psychological color solid: (a) *Left*, for colors perceived under good visual color matching conditions such as those of a textile color matcher; (b) *Right*, for colors perceived under supraliminal conditions, as when using a good instrument.

Fig. 1b, has the same horizontal dimensions as the shorter one; but the vertical dimension has been increased by a factor of 4 to take account of the relatively greater lightness valence at the limen. Thus this model is designed to suggest the equation of the scales for the smallest, or just perceptible, color differences (*9*). Just why different equations should be required for perceived color steps of different orders of magnitude is still an unsettled question.

It may be noted that the conditions of viewing or method of observation were taken into account in the design of these models of a psychological, or "equal-sense-step," color solid. Much as a single standard observer with standard observing conditions is assumed for all I.C.I. diagrams, so a normal observer with a set of standard observing conditions is required for the psychological color solid.

There is an important difference between the psychological solid presented in Fig. 1 and the analogous psychophysical solid in I.C.I. color space described and illustrated by MacAdam (7). The conditions for the psychological solid must be realizable in practice because this solid by definition represents real conscious responses. The I.C.I. system, on the other hand, fulfills its valuable functions of specification and transformation without the necessity of realizing its standard observer.

Figure 2 shows horizontal sections through the solid at Munsell value levels 1/ to 9/. The

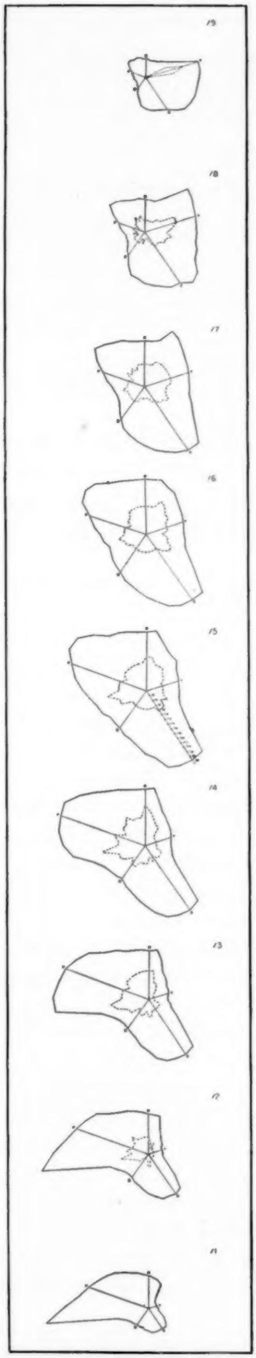

FIG. 2. Horizontal sections through the psychological color solid at Munsell values 1/ to 9/.

shapes of these sections appear strange, but those at the lower value levels make some suggestion of the shape of the plane to which Spencer (*10*) reduced the MacAdam data from the Nutting observations (*11*). Figure 3 shows five plane vertical sections spaced, roughly, according to the five principal Munsell hues and their complementaries. The dotted lines on the planes in Fig. 2 and Fig. 3 give a good idea of size and shape relative to the solid that can be constructed of available Munsell samples.

Estimates have been made of the total number of perceptibly different colors, that is, the volume of the psychological solid graduated in terms of the differential threshold or of the just noticeable difference. In general, the size of the estimate has increased with the passage of time. Titchener's figure in 1896 was about 33,000 (*12*) while Boring's in 1939 was 300,000 (*13*). Since these writers did not distinguish between solids for surface colors and for illuminant colors, their estimates may be taken as maxima. Judd (*2*) recently estimated that about 10,000,000 surface colors are distinguishable in daylight by a trained observer.

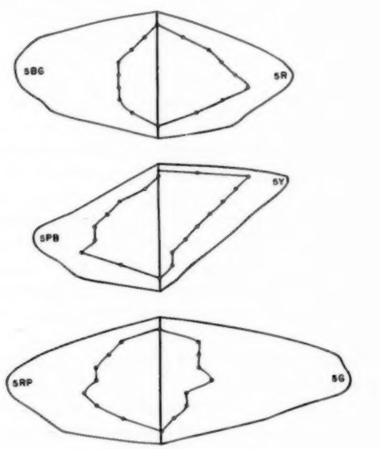

FIG. 3. Vertical sections through the psychological color solid for five hues and their complementaries.

The present model for liminal differences, Fig. 1b, would seem to provide a fair basis for a new estimate. Table I shows numbers that total 5836 full chroma steps for 40 hues spaced 2.5 hue steps apart, and nine values spaced one value step apart. Representative difference limen figures for chroma, hue, and value, are 0.2, 0.5, and 0.02 (*9*), respectively. Since these figures are in terms of the corresponding scale units: 1 chroma step $\doteq$ 5 just perceptible increments, 2.5 hue steps $\doteq$ 5 just perceptible increments, and 1 value step $\doteq$ 50 just perceptible increments. Multiplying the given number of chroma steps by these products, we have: $5836\times50\times5\times5 = 7{,}295{,}000$ which does not include the extreme space near 0/ and 10/ value. If this result is increased somewhat to include the extremes, and rounded to 7,500,000, we have an estimate of the number of surface-colors that may be distinguished under the best observational conditions (Fig. 1b). If this number is divided by 4, the result will be 1,875,000, which roughly corresponds to the number expected to be distinguished under the more usual observational conditions of visual color matching work (Fig. 1a).

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Necrology

Robert E. Oltman

DR. ROBERT E. OLTMAN, Chief Chemist with the Minnesota Valley Canning Company, died on July 25, 1942, at his home, 517 South Second Street, Le Sueur, Minnesota, as a result of pulmonary embolism. Dr. Oltman was born in Cleveland, Ohio, December 5, 1908, and received most of his education in the East Cleveland schools, graduating from Shaw High School. He was awarded the Bachelor of Arts degree, with major in botany, from Oberlin College in 1932. The following year he went to the University of Minnesota as a teaching assistant in plant physiology and received the Doctor of Philosophy degree there in 1936. Immediately after his graduation he entered the employ of the Minnesota Valley Canning Company and has been with that company ever since. During this time he resided in Le Sueur, with the exception of two years spent in Toronto, Canada, as Director of Research with Fine Foods of Canada, Limited.

Dr. Oltman was a member of Sigma Xi, and was a Fellow of the Canadian Institute of Chemistry and a member of the Canadian Society of Technical Agriculturists, the American Chemical Society, the American Association for the Advancement of Science, and the Optical Society of America. He leaves a wife, formerly Miss Sophia Ann Krenik of Montgomery, and a son, Eric, six years old.

—G. C. SCOTT

Carl Pfanstiehl

CARL PFANSTIEHL, Vice President and Director of Research of the Pfanstiehl Chemical Company of Waukegan, Illinois, was born in Columbia, Missouri, September 17, 1888. He was founder of the present Fansteel Metallurgical Corporation of North Chicago, Illinois. Granted well over a hundred patents, it is possible to touch only the highlights of his inventions: the first efficient "pancake" wound spark coil for gasoline engines; the process of making tungsten malleable, for the first time commercially available, and thus releasing the precious metal platinum during the World War; the first bar of tantalum made ductile by forging . . . the beginning of the tantalum industry; a means of welding tungsten to steel from which came the tungsten points used for contacts in magnetos; the single calibrated dial for radios; the development and manufacture of a line of rare chemicals, previously made only in Germany, vital in medical research and imperative in time of war; countless valuable developments in the pen field; and shortly before his death, a completely new type of precious metal alloy now being used for phonograph needles and precision instrument parts.

His inspired and untiring pioneer work in powder metallurgy and diffusion, particularly with the rare metals, in electricity and welding techniques, in rare chemicals and the phenomenon of fluorescence, have opened unlimited and as yet untouched fields for application and development.

Mr. Pfanstiehl was a member of the American Chemical Society, the Electrochemical Society, the American Association for the Advancement of Science, the New York Academy of Science, the American Physical Society, the Optical Society of America, the American Institute of Mining and Metallurgical Engineers, and the American Society for Metals. He was a recipient of the 1940 Modern Pioneer Award for invention and discovery.

—B. G. FRANCIS

Charles W. Frederick

CHARLES W. FREDERICK, research scientist at the Hawk-Eye Works of the Eastman Kodak Company in Rochester, New York, who pioneered in the design of lenses for aerial photography and the development of a new type of optical glass, died on November 29, 1942.

Mr. Frederick had been associated with Eastman Kodak Company from 1914 to 1939 as head of the scientific and lens-designing staff of the Hawk-Eye Works. In 1939, Mr. Frederick withdrew from active industrial research, but continued as head of the research division of the Hawk-Eye scientific staff.

Mr. Frederick was born in Des Moines, Iowa, in 1870. After graduating from Kansas State University, he was for thirteen years a civilian scientist and teacher with the Navy before joining the Hawk-Eye Works. He served as a computer at the Naval Observatory in Washington and was assistant astronomer assigned to the Observatory's equatorial telescope from 1902 to 1904.

During the two years following he took part in supervising the construction of an observatory at Tutuila, Samoa. In 1906 he returned to the mainland and spent several years in research at the Washington Naval Observatory, later going to the Naval Academy at Annapolis where he taught mathematics for five years.

Mr. Frederick designed some of the first aerial lenses used for military photography in the first World War, and during the last three years has evolved several new types of lenses used in the present conflict. His study of the possibilities of non-silica glass led to the development by Kodak researchers of the first new optical glass discovered since the 1880's, and this was subsequently adopted for manufacturing purposes by the Eastman Kodak Company.

Clarence Errol Ferree

CLARENCE ERROL FERREE was born in Sidney, Ohio, March 11, 1877. He received the degrees of B.S., M.A., and M.S. from Ohio Wesleyan University in 1900 and 1901; of Ph.D. from Cornell University in 1909; and of D.Sc. (hon.) from Ohio Wesleyan in 1938. From 1907 to 1928 he was a member of the Faculty of Bryn Mawr College, serving as Associate Professor of Experimental Psychology 1912–1917 and Professor 1917–1928. He was also Director of the Psychological Laboratory 1912–1928 and succeeded in building up a very active department of his chosen subject in those pioneer days, creating among his students a group of able and enthusiastic researchers. His early interests lay in the fields of attention, audition, and vision, but in later years he devoted himself almost entirely to the last-named field, extending his scientific studies to their applications in ophthalmology and lighting. From 1928–1935 he was Director of the Laboratory of Physiological Optics, Wilmer Ophthalmological Institute, The Johns Hopkins University School of Medicine, and held the additional title of Adjunct Professor of Physiological Optics. Forced by poor health to retire from active service in 1935, he was able to continue research, writing, and consultation work from his private laboratory. His sudden death of coronary occlusion occurred at his home on July 26, 1942. He is survived by his wife and collaborator, Dr. Gertrude Rand.

Ferree was an intensive worker, publishing more than 250 articles. He possessed a constructive and inventive mind, and it may be fairly said that his chief interest in teaching and research lay in the development of methods and the devising of apparatus to carry out these methods. In 1911, in collaboration with Gertrude Rand, he was the first to use stimuli, whose physical energy was directly measured, in the study of visual processes and the determination of sensitivities in any part of the retina. Various spectro-radiometric instruments were devised for this work and a number of quantitative studies were made under his direction using this technique. Among these instruments is a quantitative color-mixer with which 2, 3, or 4 spectrum colors can be mixed and the energy of the colors used and of the mixture can be measured. He was also one of the first to recognize the need for a systematic study of light and lighting in relation to the eye, and the first to show by test, in 1912, that one system of lighting is better than another for the eye. His many studies on lighting in relation to the comfort and hygiene of the eye culminated in the devising of a series of glareless lighting units and devices, prominent among which are the Ferree-Rand hospital ward light used in leading hospitals throughout the country, the louvered direct-indirect type of fixture in current use, and the Ferree-Rand variable illuminator. He invented also a number of optical and ophthalmological instruments. Also may be mentioned his studies on the light and color sense, central and peripheral; normal and pathologic perimetry and scotometry; theory of flicker photometry in relation to the rise of visual sensation; the refraction of the peripheral retina; visual acuity and the construction of a standard visual acuity and astigmatism test chart for testing and rating vision; and dynamic speed of vision in testing fitness for aviation and for general and ocular fatigue—another of the researches conducted during the last war and for which the multiple-exposure tachistoscope was constructed. Ferree was the holder of 12 U. S. patents.

Ferree's work was aptly summed up in the following citation by Acting-President Edward L. Rice on the occasion of the award of the degree of Doctor of Science by Ohio Wesleyan University: "By your intensive theoretical study you have brought light into the borderland where physics, physiology, and psychology meet; by the application of your studies in practical invention you have aided oculists and opticians to bring light to defective eyesight."

—GERTRUDE K. RAND

Hans Georg Beutler

HANS GEORG BEUTLER was born in Reichenbach, Germany in 1896. He received his Ph.D. in 1922 at the University of Greifswald. From 1923 to 1933 he was associated with Dr. F. Haber at the Kaiser Wilhelm Institute of Physical Chemistry. From 1930 to 1936 he was Privat-dozent and Dozent at the University of Berlin. From 1936 to 1937 he was Research Physicist and Lecturer at the University of Michigan, and from 1937 on, Research Associate in Physics at the University of Chicago. He devoted the years from 1923 to 1927 to problems of highly diluted flames, from 1927 to 1932 to elementary processes of atoms and molecules, and, perhaps his most important work, from 1932 to 1936, to the inner spectra of atoms. While at Ryerson Laboratory he developed a generalized theory of the concave grating, a masterly and exhaustive treatment leaving little to be added in detail. He also spent a great deal of time improving the performance of the 30-foot grating spectrograph. Much other equipment at Ryerson bears the stamp of his expert direction. All his research was exhaustive in detail; he could bear with nothing short of completeness, accuracy, precision. At the time of his death he was finishing, in collaboration with R. A. Sawyer, a much needed volume on spectroscopic technique. During the short time he was with us, his comprehensive knowledge of spectroscopy was freely and courteously at the disposal of everyone. His early death is a serious loss to the field of spectroscopy. He was a member of Sigma Xi, the Optical Society of America, and a Fellow of the American Physical Society.

—GEORGE S. MONK

E. H. Anthes

E. H. ANTHES, manager of the New York Branch of the Bausch & Lomb Optical Company since 1933, died on August 3, 1942 following a short illness. He had been associated with the company for 33 years. Prior to coming to the United States he was associate manager of the London Office. He was widely known in educational and industrial circles as an authority on the use and history of the microscope.

Alfred Nelson Finn

ALFRED NELSON FINN, Chief of the Glass Section of the National Bureau of Standards, Washington, D. C., died at the home of his brother in Lincoln, Nebraska, on September 21, 1942. Because of continued serious illness he had withdrawn from active work about one year earlier.

Mr. Finn was born in Denver, Colorado, on August 10, 1882. He attended the University of Denver where he received a bachelor's degree in chemistry and mathematics in 1909. He was Instructor in Chemistry at that university until 1911 when he received an appointment to the National Bureau of Standards.

As chemist in the Structural Materials Laboratory of the Bureau, Mr. Finn tested and analyzed cement, paints, oils, varnishes, coated metals, non-ferrous alloys, boiler waters, boiler compounds, and protective coatings for metals. He resigned from the National Bureau of Standards in 1919 to become Chief Chemist and Metallurgist for the Hydraulic Steel Company, Cleveland, Ohio. In 1920, he returned to the Bureau to assume the position he held until the time of his death.

At the beginning of the first World War this country had no satisfactory domestic source of optical glass. The resulting difficulty in producing military optical instruments focused attention upon the desirability of having a government-controlled source of supply for optical glass, and it was during Mr. Finn's tenure of office that the Glass Section of the National Bureau of Standards was expanded into a glass plant of sufficient capacity to produce an important part of the optical glass required to meet present war needs. Mr. Finn and his associates made the seventy-inch glass disk for the telescope mirror now in use at Ohio Wesleyan University, Delaware, Ohio. The annealing and cooling required more than eight months, and at the time of its production (1927–28) this disk was the largest that had been produced in this country and the second largest for the entire world. Although interested in all phases of glass technology, Mr. Finn was particularly active in improving the quality of optical glass. In this work he made a careful study of annealing procedures and of tests for freedom from strain. Under his direction, important fundamental research was done on the properties of glass; many of his later papers dealing with the relations between density, index of refraction, dispersion, and chemical composition of optical glasses. A complete list of his publications will be found in *The Bulletin of the American Ceramic Society*.[1]

Mr. Finn was a member of the Optical Society of America, Washington Academy of Sciences, American Chemical Society, American Ceramic Society, American Society for Testing Materials, and American Institute of Chemists.

—I. C. GARDNER

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Orrin W. Pineo

ORRIN W. PINEO, physicist, died September 5, 1942, at his home in Milo, Maine. He was born at Katahden Iron Works, Maine, on September 28, 1908. He graduated from Massachusetts Institute of Technology with a S.B. degree in 1929. From 1929 to 1933 he worked with Professor A. C. Hardy at Massachusetts Institute of Technology on the development of an automatic recording visual range spectrophotometer which was later commercialized by the General Electric Company. During 1932–33 he held the Textile Foundation's senior fellowship. From 1933 to 1934 he worked independently on the development of automatic spectrophotometers with Adam Hilger, Ltd., in London and contributed to a book published by this company on the subject of "The Practice of Absorption Spectrophotometry."

From 1935 to 1940 he was employed by the Calco Chemical Division, American Cyanamid Company, at Bound Brook, New Jersey, where he did further work on the development of spectrophotometers, taking out many patents and publishing a paper on "Residual photometric errors in the commercial recording spectrophotometer."

During the last two years Mr. Pineo was engaged in work for the war effort, being located in Washington, D. C., and Princeton, New Jersey.

He was a member of the following scientific organizations: American Association for the Advancement of Science, Optical Society of America, American Association of Textile Colorists and Chemists, and the Society of Dyers and Colorists.

—G. L. ROYER

Harry John McNicholas

HARRY JOHN McNICHOLAS was born in 1892. He was graduated from Ripon College in 1915 with an A.B. degree. He came to the National Bureau of Standards in 1916, entering the Colorimetry Section under Irwin G. Priest. He remained in that Section until 1926, getting his M.A. degree in 1925 and his Ph.D. degree in 1926, both from Johns Hopkins University. Since 1926 he has been a member of the Photometry Section and of the *p*H Standards Section at the Bureau, being in this latter Section at the time of his death on July 23, 1942.

Dr. McNicholas was the author of a series of important research papers in the optical field, all published in the Bureau of Standards Journal of Research since 1928. Although he was perhaps best known for his development of the concept of apparent reflectance,[1] which is basic to present practice in the measurement of gloss and color of surfaces, Dr. McNicholas has also contributed importantly to visual and photographic spectrophotometry (RP30, RP33, and RP704), to choice of the colors of signal lights (RP956), to basic data on vegetable pigments and oils (RP337, RP815), and to the use of the diffraction method for the grading of wool and other fibers. Dr. McNicholas' work was marked throughout by care in the design of equipment, by painstaking treatment of data, and by penetrating analysis thereof.

—K. S. GIBSON

[1] Bur. Stand. J. Research, RP 3.