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The Ideal Lovibond Color System

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Lovibond red, yellow, and blue glasses, widely used as color standards in industry, are assigned numerals in accord with the basic plan of marking each glass with the number of unit glasses of the same type through which light must be passed to produce its color. It is possible to compute from the spectral transmittances of the unit glasses defining the Lovibond scales the CIE specification of the color produced by all combinations of any number of unit glasses. Such specifications were computed in 1939 not only for all ideal red, yellow, and blue Lovibond glasses illuminated by CIE sources B (representing noon sunlight) or C (representing average daylight) but also for two-part (red-yellow, yellow-blue, or blue-red) combinations thereof. The present paper gives the results of such computations for CIE source A (representing gas-filled incandescent lamps). Although actual Lovibond glasses must unavoidably depart somewhat from this definition of the ideal Lovibond system, the computed color specifications serve to indicate with good reliability not only the CIE specification of the color produced by single glasses and two-part combinations, but also the choice of Lovibond glasses required to produce a color of any desired chromaticity within the gamut of the system.

1. Introduction

Lovibond red, yellow, and blue glasses [1][1] are widely used in color grading the various materials and articles of commerce (vegetable oils, petroleum products, Naval stores, paint vehicles, and so forth). The basic plan of the system is that each glass is marked with the number of unit glasses to which it is equivalent colorimetrically; that is, the number of unit glasses through which light from the source must be passed to produce the same color. Furthermore, the unit glasses of the red, yellow, and blue scales are related so that combinations of all three kinds of glasses of equal numbers on the Lovibond scales give a nearly neutral filter; that is, produce little or no change in chromaticity from that of the source. Because of the relation between the three scales, the chromaticity of a color matched by Lovibond glasses of all three sorts, say by glasses of numerals, R, Y, B, where R and Y are both greater than or equal to B, corresponds closely to that of the two-part combination (R_c, Y_c), where $R_c=R-B$, $Y_c=Y-B$. Thus all Lovibond chromaticities may be closely identified with those of two-part combinations, and no separate consideration of three-part combinations is required for chromaticity.

The numbers engraved on the glasses by the maker throughout the years have followed the basic plan closely, but some of the uses to which the glasses have been put require a more precise grading than has always been maintained by the maker. The present paper gives the derivation of an ideal Lovibond color system consisting of colorimetric definitions in fundamental terms against which any actual glass can be compared and a new numeral in the ideal system assigned. This system is based upon spectrophotometric determinations of 20 glasses of each series (1, 2, 3, . . . 20). Some of these data are those [2] obtained at the National Bureau of Standards for the glasses of the set (BS9940) purchased by this Bureau in 1912; others are those obtained by Tintometer Ltd. for glasses retained there as standards.

2. Method

The chromaticities of the colors of the ideal Lovibond system have been specified in the standard colorimetric coordinate system recommended in 1931 by the International Commission on Illumination (CIE) [3] in a way similar to that used by Schofield [4], and later by Haupt and Douglas [5] to express the chromaticities of two-part (red-yellow, yellow-blue, or blue-red) combinations of Lovibond glasses. The spectral transmittances, T_N, for glasses of each series (red, yellow, blue) for $N=1, 2, 3, \ldots 20$, were reduced to negative logarithms of the internal transmittances, $T_{i,N=1}$, of the unit glasses by correcting T_N for reflection losses, taking the negative logarithm of the internal transmittance so found, and dividing by the maker's numeral, N, thus:

$$-\log\ (T_{i,N=1})=(1/N)[-\log\ (T_N/0.92)]. \qquad (1)$$

The adopted negative logarithms for each unit glass were found by Schofield [4] by taking an average of these values weighted in accord with the numeral, N, engraved on the glass by the maker, and are those mentioned by Fawcett [6], to compute the chromaticities and transmittances of two-part combinations of Lovibond glasses for CIE standard sources B (representative of average noon sunlight), and C (representative of average daylight). Table 1 gives the spectral internal transmittances of the red, yellow, and blue unit glasses defining the ideal Lovibond color system.

The computations by Schofield of the chromaticities and transmittances of two-part combinations of

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

TABLE 1. *Spectral internal transmittances of the Lovibond unit red, yellow, and blue glasses*

Wave-length	$T_{i,r}$ Red	$T_{i,y}$ Yellow	$T_{i,b}$ Blue
$m\mu$			
380	0.90258	0.02889	0.99815
390	.90352	.12593	.99809
400	.90439	.25435	.99788
410	.90603	.39957	.99711
420	.90737	.52037	.99573
430	.90824	.61634	.99363
440	.90886	.70289	.99111
450	.90858	.77822	.98800
460	.90722	.84481	.98338
470	.90444	.89471	.97459
480	.89819	.92976	.96004
490	.88633	.95277	.94109
500	.86526	.96755	.92316
510	.83257	.97738	.89900
520	.79598	.98364	.87326
530	.77392	.98754	.84574
540	.78952	.99040	.83553
550	.83317	.99195	.85049
560	.87817	.99236	.86792
570	.91300	.99247	.85702
580	.93628	.99179	.81808
590	.95268	.99073	.77002
600	.96362	.98933	.76498
610	.97109	.98768	.77420
620	.97648	.98599	.77827
630	.98053	.98438	.77386
640	.98348	.98333	.76119
650	.98572	.98287	.76656
660	.98753	.98279	.78191
670	.98892	.98330	.83172
680	.99012	.98405	.88572
690	.99117	.98449	.93507
700	.99194	.98510	.96744
710	.99247	.98627	.98466
720	.99303	.98789	.99228
730	.99336	.98912	.99587
740	.99365	.99014	.99719
750	.99402	.99108	.99770
760	.99420	.99160	.99790
770	.99430	.99210	.99800

ideal Lovibond glasses for CIE sources B[4] and C[6] have been extended in the present paper to CIE source A (color temperature 2,854 °K, representative of incandescent lamps). The calculations were carried out on an automatic digital computer by the Division of Applied Mathematics of the National Bureau of Standards, as follows:

The tristimulus values, X, Y, Z, of the color of the light transmitted by a combination of R Lovibond red unit glasses, Y Lovibond yellow unit glasses, and B Lovibond blue unit glasses in a medium of refractive index equal to that of the glasses were computed for two-part combinations by setting one of the exponents, R, Y, B, equal to zero in the following expressions:

$$\left.\begin{aligned} X&=\sum_{380}^{770} T_{i,r}^{R}T_{i,y}^{Y}T_{i,b}^{B}H_A\bar{x}\Delta\lambda \\ Y&=\sum_{380}^{770} T_{i,r}^{R}T_{i,y}^{Y}T_{i,b}^{B}H_A\bar{y}\Delta\lambda \\ Z&=\sum_{380}^{770} T_{i,r}^{R}T_{i,y}^{Y}T_{i,b}^{B}H_A\bar{z}\Delta\lambda \end{aligned}\right\} \tag{2}$$

where H_A is the spectral irradiance of CIE source A, $\bar{x}$, $\bar{y}$, $\bar{z}$ are the tristimulus values of the spectrum of unit irradiance defining the 1931 CIE standard observer [3], $T_{i,r}$, $T_{i,y}$, $T_{i,b}$ are the spectral internal transmittances (table 1) by which Tintometer Ltd. defines the ideal Lovibond red, yellow, and blue units, and $\Delta\lambda$ is taken at 10 mμ.

Then the chromaticity coordinates, x, y, of the color were computed as:

$$x=X/(X+Y+Z), \quad y=Y/(X+Y+Z)$$

The chromaticity coordinate, $z=Z/(X+Y+Z)$, may be computed, if desired, from x and y as $1-x-y$.

The luminous internal transmittance, $T_{i,A}$, for CIE source A, of combinations of ideal Lovibond glasses identified by the numbers, R,Y,B, one or two of which are zero, was computed as Y/Y_0, where Y_0 is the value of Y found from eq (2) by setting $R=Y=B=0$; that is $Y_0\equiv\sum_{380}^{770}H_A\bar{y}\Delta\lambda$.

The values of luminous internal transmittance, $T_{i,A}$, for CIE source A and chromaticity coordinates, x,y, so found, are listed in table 2 for various ideal single Lovibond glasses, and for various two-glass combinations of ideal Lovibond glasses. The tristimulus values, X,Z, of these colors may be computed, if desired, as follows:

$$X=xT_{i,A}Y_0/y, \qquad Z=zT_{i,A}Y_0/y.$$

If it is desired to compute the transmittance (including reflection losses) of a single ideal Lovibond glass from its internal transmittance given in table 2, the expression 0.92 $T_{i,A}$ should be evaluated; if that of a two-part combination is desired, use the expression: $(0.92)^2T_{i,A}$.

TABLE 2. *Luminous internal transmittances in percent, 100* $T_{i,A}$, *and chromaticity coordinates*, x,y, *of single glasses and two-part combinations of ideal Lovibond glasses illuminated by CIE Source* A

The first three columns (R,Y,B) give the number of unit red, yellow, and blue glasses, respectively.

R	Y	B	$T_{i,A}$	x	y	R	Y	B	$T_{i,A}$	x	y	R	Y	B	$T_{i,A}$	x	y
0	0	0	100.00	0.44759	0.40754	10	0	0	43.610	0.55068	0.34978	20	0	0	26.281	0.61066	0.33254
1	0	0	89.879	.46022	.39834	11	0	0	41.048	.55830	.34703	22	0	0	24.202	.61917	.33068
2	0	0	81.286	.47235	.39007	12	0	0	38.744	.56550	.34461	24	0	0	22.378	.62681	.32903
3	0	0	73.949	.48396	.38266	13	0	0	36.662	.57231	.34246	26	0	0	20.763	.63367	.32753
4	0	0	67.647	.49504	.37606	14	0	0	34.772	.57874	.34056	28	0	0	19.323	.63985	.32615
5	0	0	62.202	.50559	.37021	15	0	0	33.047	.58483	.33886	30	0	0	18.029	.64542	.32483
6	0	0	57.470	.51560	.36503	16	0	0	31.468	.59058	.33734	32	0	0	16.861	.65045	.32358
7	0	0	53.332	.52510	.36047	17	0	0	30.016	.59603	.33597	34	0	0	15.801	.65499	.32236
8	0	0	49.693	.53410	.35644	18	0	0	28.675	.60118	.33472	36	0	0	14.834	.65911	.32117
9	0	0	46.474	.54262	.35290	19	0	0	27.434	.60605	.33359	38	0	0	13.950	.66284	.32001

TABLE 2. *Luminous internal transmittances in percent, 100* $T_{i,A}$, *and chromaticity coordinates,* x,y, *of single glasses and two-part combinations of ideal Lovibond glasses illuminated by CIE Source* A—Continued

R	Y	B	$T_{i,A}$	x	y
40	0	0	13.138	0.66623	0.31886
45	0	0	11.374	.67346	.31609
50	0	0	9.9158	.67926	.31345
55	0	0	8.6956	.68399	.31093
60	0	0	7.6638	.68791	.30856
65	0	0	6.7840	.69121	.30634
70	0	0	6.0283	.69403	.30426
75	0	0	5.3752	.69648	.30232
80	0	0	4.8077	.69863	.30052
90	0	0	3.8774	.70228	.29729
100	0	0	3.1567	.70528	.29448
0	0	1	82.614	.43007	.40197
1	0	1	74.030	.44257	.39284
2	0	1	66.751	.45468	.38464
3	0	1	60.544	.46637	.37730
4	0	1	55.222	.47762	.37078
5	0	1	50.633	.48840	.36501
6	0	1	46.652	.49873	.35993
7	0	1	43.178	.50861	.35546
8	0	1	40.130	.51803	.35154
9	0	1	37,440	.52702	.34811
10	0	1	35.052	.53557	.34512
11	0	1	32.922	.54371	.34250
12	0	1	31.012	.55146	.34021
13	0	1	29.290	.55883	.33821
14	0	1	27.731	.56583	.33645
15	0	1	26.313	.57248	.33490
16	0	1	25.017	.57880	.33353
17	0	1	23.829	.58480	.33231
18	0	1	22.735	.59050	.33122
19	0	1	21.724	.59592	.33024
20	0	1	20.787	.60106	.32934
22	0	1	19.104	.61058	.32776
24	0	1	17.634	.61917	.32639
26	0	1	16.338	.62691	.32515
28	0	1	15.185	.63390	.32399
30	0	1	14.154	.64020	.32289
32	0	1	13.225	.64590	.32183
34	0	1	12.384	.65104	.32078
36	0	1	11.620	.65570	.31974
38	0	1	10.922	.65991	.31871
40	0	1	10.282	.66373	.31768
45	0	1	8.8953	.67183	.31513
50	0	1	7.7530	.67826	.31264
55	0	1	6.7992	.68345	.31022
60	0	1	5.9941	.68769	.30791
65	0	1	5.3083	.69123	.30573
70	0	1	4.7197	.69421	.30367
75	0	1	4.2111	.69678	.30174
80	0	1	3.7693	.69902	.29995
90	0	1	3.0451	.70277	.29671
100	0	1	2.4838	.70583	.29390
0	0	2	68.492	.41190	.39471
1	0	2	61.196	.42415	.38569
2	0	2	55.016	.43611	.37759
3	0	2	49.754	.44775	.37037
4	0	2	45.249	.45904	.36396
5	0	2	41.369	.46997	.35831
6	0	2	38.010	.48051	.35335
7	0	2	35.086	.49067	.34902
8	0	2	32.524	.50045	.34525
9	0	2	30.269	.50984	.34197
10	0	2	28.273	.51884	.33914
11	0	2	26.496	.52748	.33669
12	0	2	24.906	.53574	.33458
13	0	2	23.477	.54365	.33275
14	0	2	22.186	.55122	.33118
15	0	2	21.015	.55844	.32982
16	0	2	19.948	.56535	.32864
17	0	2	18.971	.57193	.32761
18	0	2	18.075	.57822	.32671
19	0	2	17.249	.58421	.32592
20	0	2	16.485	.58993	.32521
22	0	2	15.118	.60056	.32399
24	0	2	13.929	.61021	.32297
26	0	2	12.884	.61894	.32205
28	0	2	11.960	.62685	.32120
30	0	2	11.135	.63401	.32037
32	0	2	10.394	.64047	.31955
34	0	2	9.7258	.64632	.31873

R	Y	B	$T_{i,A}$	x	y
36	0	2	9.1195	0.65161	0.31789
38	0	2	8.5670	.65639	.31703
40	0	2	8.0617	.66072	.31615
45	0	2	6.9701	.66985	.31391
50	0	2	6.0738	.67704	.31162
55	0	2	5.3272	.68278	.30934
60	0	2	4.6980	.68742	.30712
65	0	2	4.1628	.69123	.30499
70	0	2	3.7037	.69442	.30297
75	0	2	3.3073	.69713	.30106
80	0	2	2.9629	.69947	.29927
90	0	2	2.3983	.70334	.29604
100	0	2	1.9605	.70645	.29323
0	0	3	56.986	.39327	.38571
1	0	3	50.773	.40513	.37683
2	0	3	45.515	.41681	.36887
3	0	3	41.044	.42827	.36178
4	0	3	37.220	.43948	.35552
5	0	3	33.932	.45042	.35002
6	0	3	31.091	.46107	.34522
7	0	3	28.620	.47141	.34105
8	0	3	26.462	.48144	.33745
9	0	3	24.565	.49115	.33436
10	0	3	22.889	.50054	.33172
11	0	3	21.401	.50961	.32947
12	0	3	20.074	.51835	.32757
13	0	3	18.883	.52677	.32596
14	0	3	17.810	.53487	.32460
15	0	3	16.839	.54267	.32347
16	0	3	15.957	.55015	.32252
17	0	3	15.152	.55733	.32172
18	0	3	14.415	.56422	.32105
19	0	3	13.737	.57082	.32048
20	0	3	13.112	.57714	.32000
22	0	3	11.996	.58897	.31923
24	0	3	11.031	.59977	.31863
26	0	3	10.187	.60961	.31812
28	0	3	9.4422	.61856	.31764
30	0	3	8.7804	.62668	.31716
32	0	3	8.1882	.63403	.31665
34	0	3	7.6553	.64069	.31611
36	0	3	7.1731	.64672	.31552
38	0	3	6.7349	.65217	.31489
40	0	3	6.3349	.65710	.31421
45	0	3	5.4736	.66746	.31236
50	0	3	4.7690	.67556	.31034
55	0	3	4.1836	.68195	.30825
60	0	3	3.6912	.68706	.30616
65	0	3	3.2729	.69121	.30411
70	0	3	2.9143	.69463	.30213
75	0	3	2.6048	.69751	.30026
80	0	3	2.3360	.69997	.29849
90	0	3	1.8953	.70398	.29528
100	0	3	1.5531	.70716	.29247
0	0	4	47.585	.37441	.37499
1	0	4	42.283	.38576	.36626
2	0	4	37.801	.39702	.35846
3	0	4	33.992	.40817	.35154
4	0	4	30.738	.41916	.34544
5	0	4	27.945	.42998	.34012
6	0	4	25.534	.44060	.33549
7	0	4	23.441	.45100	.33151
8	0	4	21.616	.46118	.32811
9	0	4	20.015	.47110	.32523
10	0	4	18.604	.48078	.32280
11	0	4	17.354	.49020	.32077
12	0	4	16.241	.49934	.31910
13	0	4	15.245	.50822	.31773
14	0	4	14.350	.51682	.31663
15	0	4	13.542	.52514	.31574
16	0	4	12.810	.53318	.31505
17	0	4	12.143	.54095	.31451
18	0	4	11.534	.54844	.31411
19	0	4	10.976	.55565	.31381
20	0	4	10.462	.56260	.31359
22	0	4	9.5489	.57568	.31334
24	0	4	8.7620	.58772	.31325
26	0	4	8.0770	.59876	.31321
28	0	4	7.4752	.60886	.31319
30	0	4	6.9424	.61806	.31313

R	Y	B	$T_{i,A}$	x	y
32	0	4	6.4673	0.62643	0.31301
34	0	4	6.0410	.63402	.31282
36	0	4	5.6565	.64090	.31255
38	0	4	5.3079	.64713	.31219
40	0	4	4.9906	.65276	.31177
45	0	4	4.3094	.66457	.31042
50	0	4	3.7543	.67375	.30876
55	0	4	3.2945	.68093	.30692
60	0	4	2.9085	.68661	.30499
65	0	4	2.5809	.69116	.30305
70	0	4	2.3004	.69486	.30115
75	0	4	2.0584	.69794	.29932
80	0	4	1.8482	.70053	.29758
90	0	4	1.5035	.70470	.29440
100	0	4	1.2356	.70796	.29160
0	0	5	39.880	.35554	.36262
1	0	5	35.347	.36627	.35407
2	0	5	31.517	.37701	.34644
3	0	5	28.265	.38771	.33969
4	0	5	25.490	.39836	.33378
5	0	5	23.111	.40892	.32864
6	0	5	21.059	.41938	.32421
7	0	5	19.281	.42971	.32042
8	0	5	17.733	.43990	.31723
9	0	5	16.378	.44992	.31456
10	0	5	15.186	.45977	.31236
11	0	5	14.131	.46943	.31057
12	0	5	13.195	.47889	.30914
13	0	5	12.359	.48813	.30803
14	0	5	11.609	.49715	.30719
15	0	5	10.934	.50595	.30658
16	0	5	10.323	.51450	.30617
17	0	5	9.7690	.52282	.30592
18	0	5	9.2638	.53088	.30580
19	0	5	8.8018	.53870	.30579
20	0	5	8.3778	.54626	.30587
22	0	5	7.6268	.56061	.30621
24	0	5	6.9828	.57395	.30670
26	0	5	6.4246	.58627	.30722
28	0	5	5.9364	.59762	.30773
30	0	5	5.5058	.60802	.30817
32	0	5	5.1232	.61752	.30851
34	0	5	4.7812	.62617	.30874
36	0	5	4.4735	.63403	.30886
38	0	5	4.1954	.64115	.30886
40	0	5	3.9429	.64760	.30875
45	0	5	3.4027	.66111	.30803
50	0	5	2.9644	.67157	.30683
55	0	5	2.6025	.67968	.30530
60	0	5	2.2993	.68603	.30359
65	0	5	2.0423	.69106	.30180
70	0	5	1.8225	.69510	.30000
75	0	5	1.6329	.69841	.29823
80	0	5	1.4683	.70116	.29653
90	0	5	1.1981	.70552	.29339
100	0	5	0.98783	.70885	.29062
0	0	6	33.546	.33692	.34876
1	0	6	29.663	.34695	.34039
2	0	6	26.383	.35706	.33295
3	0	6	23.601	.36721	.32639
4	0	6	21.228	.37739	.32066
5	0	6	19.195	.38758	.31570
6	0	6	17.445	.39774	.31146
7	0	6	15.930	.40786	.30788
8	0	6	14.613	.41793	.30489
9	0	6	13.461	.42791	.30243
10	0	6	12.450	.43780	.30046
11	0	6	11.558	.44758	.29890
12	0	6	10.767	.45723	.29773
13	0	6	10.062	.46674	.29687
14	0	6	9.4316	.47609	.29630
15	0	6	8.8652	.48526	.29597
16	0	6	8.3541	.49425	.29585
17	0	6	7.8913	.50305	.29590
18	0	6	7.4704	.51164	.29609
19	0	6	7.0865	.52001	.29639
20	0	6	6.7350	.52816	.29679
22	0	6	6.1147	.54377	.29777
24	0	6	5.5853	.55841	.29889
26	0	6	5.1286	.57207	.30004
28	0	6	4.7308	.58474	.30115

TABLE 2. *Luminous internal transmittances in percent, 100* $T_{i,A}$, *and chromaticity coordinates,* x,y, *of single glasses and two-part combinations of ideal Lovibond glasses illuminated by CIE Source* A—Continued

R	*Y*	*B*	$T_{i,A}$	*x*	*y*
30	0	6	4.3814	0.59644	0.30217
32	0	6	4.0722	.60718	.30305
34	0	6	3.7967	.61701	.30379
36	0	6	3.5497	.62597	.30437
38	0	6	3.3271	.63412	.30478
40	0	6	3.1254	.64150	.30505
45	0	6	2.6959	.65698	.30511
50	0	6	2.3489	.66894	.30448
55	0	6	2.0633	.67816	.30336
60	0	6	1.8246	.68531	.30193
65	0	6	1.6227	.69090	.30032
70	0	6	1.4500	.69534	.29865
75	0	6	1.3011	.69892	.29697
80	0	6	1.1718	.70186	.29533
90	0	6	0.95955	.70642	.29226
100	0	6	.79412	.70985	.28952
0	0	7	28.324	.31880	.33361
1	0	7	24.990	.32807	.32544
2	0	7	22.176	.33747	.31819
3	0	7	19.789	.34698	.31182
4	0	7	17.755	.35660	.30627
5	0	7	16.014	.36629	.30150
6	0	7	14.517	.37604	.29745
7	0	7	13.222	.38582	.29405
8	0	7	12.098	.39563	.29126
9	0	7	11.116	.40544	.28901
10	0	7	10.256	.41524	.28724
11	0	7	9.4978	.42500	.28591
12	0	7	8.8270	.43472	.28496
13	0	7	8.2307	.44436	.28436
14	0	7	7.6983	.45391	.28405
15	0	7	7.2210	.46336	.28399
16	0	7	6.7913	.47268	.28415
17	0	7	6.4031	.48187	.28449
18	0	7	6.0510	.49090	.28499
19	0	7	5.7304	.49976	.28561
20	0	7	5.4377	.50845	.28633
22	0	7	4.9230	.52522	.28797
24	0	7	4.4858	.54114	.28977
26	0	7	4.1104	.55614	.29160
28	0	7	3.7848	.57019	.29338
30	0	7	3.5001	.58325	.29504
32	0	7	3.2492	.59533	.29654
34	0	7	3.0264	.60645	.29785
36	0	7	2.8273	.61663	.29897
38	0	7	2.6485	.62591	.29988
40	0	7	2.4869	.63435	.30060
45	0	7	2.1442	.65211	.30160
50	0	7	1.8687	.66581	.30166
55	0	7	1.6428	.67633	.30104
60	0	7	1.4544	.68441	.29996
65	0	7	1.2952	.69067	.29860
70	0	7	1.1593	.69557	.29709
75	0	7	1.0421	.69946	.29553
80	0	7	0.94029	.70262	.29397
90	0	7	.77302	.70742	.29099
100	0	7	.64242	.71095	.28831
0	0	8	24.004	.30140	.31744
1	0	8	21.137	.30987	.30947
2	0	8	18.716	.31852	.30242
3	0	8	16.664	.32734	.29624
4	0	8	14.917	.33631	.29088
5	0	8	13.422	.34541	.28629
6	0	8	12.137	.35464	.28241
7	0	8	11.027	.36398	.27919
8	0	8	10.064	.37342	.27657
9	0	8	9.2249	.38293	.27450
10	0	8	8.4901	.39250	.27292
11	0	8	7.8438	.40211	.27178
12	0	8	7.2728	.41174	.27105
13	0	8	6.7661	.42138	.27066
14	0	8	6.3146	.43100	.27058
15	0	8	5.9107	.44059	.27077
16	0	8	5.5479	.45013	.27120
17	0	8	5.2208	.45959	.27182
18	0	8	4.9248	.46896	.27260
19	0	8	4.6560	.47822	.27352
20	0	8	4.4111	.48735	.27456
22	0	8	3.9819	.50516	.27686
24	0	8	3.6191	.52226	.27935
26	0	8	3.3090	.53856	.28189
28	0	8	3.0414	.55397	.28437

R	*Y*	*B*	$T_{i,A}$	*x*	*y*
30	0	8	2.8083	0.56843	0.28673
32	0	8	2.6037	.58192	.28891
34	0	8	2.4227	.59441	.29087
36	0	8	2.2616	.60591	.29260
38	0	8	2.1173	.61646	.29408
40	0	8	1.9874	.62608	.29532
45	0	8	1.7130	.64640	.29742
50	0	8	1.4936	.66211	.29832
55	0	8	1.3142	.67413	.29831
60	0	8	1.1651	.68331	.29766
65	0	8	1.0393	.69034	.29661
70	0	8	0.93199	.69578	.29531
75	0	8	.83948	.70004	.29389
80	0	8	.75910	.70345	.29244
90	0	8	.62686	.70852	.28959
100	0	8	.52339	.71214	.28698
0	0	9	20.420	.28493	.30052
1	0	9	17.949	.29260	.29278
2	0	9	15.863	.30048	.28593
3	0	9	14.094	.30856	.27995
4	0	9	12.589	.31683	.27477
5	0	9	11.302	.32529	.27035
6	0	9	10.196	.33393	.26663
7	0	9	9.2417	.34273	.26357
8	0	9	8.4147	.35168	.26110
9	0	9	7.6946	.36078	.25918
10	0	9	7.0648	.37000	.25776
11	0	9	6.5117	.37933	.25679
12	0	9	6.0238	.38875	.25623
13	0	9	5.5916	.39825	.25603
14	0	9	5.2071	.40781	.25615
15	0	9	4.8638	.41740	.25655
16	0	9	4.5561	.42702	.25720
17	0	9	4.2792	.43662	.25806
18	0	9	4.0292	.44620	.25911
19	0	9	3.8027	.45574	.26031
20	0	9	3.5968	.46521	.26163
22	0	9	3.2372	.48386	.26456
24	0	9	2.9345	.50200	.26771
26	0	9	2.6771	.51949	.27095
28	0	9	2.4559	.53621	.27416
30	0	9	2.2642	.55207	.27725
32	0	9	2.0965	.56698	.28015
34	0	9	1.9489	.58090	.28281
36	0	9	1.8179	.59381	.28521
38	0	9	1.7010	.60571	.28732
40	0	9	1.5961	.61662	.28915
45	0	9	1.3755	.63980	.29253
50	0	9	1.2000	.65778	.29441
55	0	9	1.0572	.67153	.29513
60	0	9	0.93880	.68197	.29501
65	0	9	.83907	.68990	.29433
70	0	9	.75402	.69596	.29329
75	0	9	.68074	.70065	.29206
80	0	9	.61704	.70433	.29073
90	0	9	.51210	.70970	.28805
100	0	9	.42976	.71343	.28554
0	0	10	17.438	.26954	.28317
1	0	10	15.303	.27642	.27567
2	0	10	13.501	.28353	.26904
3	0	10	11.974	.29087	.26326
4	0	10	10.674	.29843	.25826
5	0	10	9.5622	.30621	.25400
6	0	10	8.6079	.31420	.25044
7	0	10	7.7850	.32240	.24751
8	0	10	7.0722	.33080	.24518
9	0	10	6.4523	.33939	.24339
10	0	10	5.9106	.34817	.24209
11	0	10	5.4355	.35711	.24125
12	0	10	5.0169	.36620	.24082
13	0	10	4.6467	.37544	.24076
14	0	10	4.3180	.38480	.24104
15	0	10	4.0249	.39426	.24161
16	0	10	3.7627	.40381	.24244
17	0	10	3.5273	.41343	.24350
18	0	10	3.3151	.42308	.24476
19	0	10	3.1232	.43276	.24619
20	0	10	2.9492	.44244	.24776
22	0	10	2.6463	.46170	.25124
24	0	10	2.3926	.48068	.25501
26	0	10	2.1778	.49921	.25892
28	0	10	1.9940	.51713	.26283

R	*Y*	*B*	$T_{i,A}$	*x*	*y*
30	0	10	1.8354	0.53431	0.26665
32	0	10	1.6974	.55062	.27029
34	0	10	1.5763	.56599	.27369
36	0	10	1.4692	.58035	.27680
38	0	10	1.3741	.59368	.27960
40	0	10	1.2889	.60597	.28208
45	0	10	1.1108	.63226	.28690
50	0	10	0.96996	.65280	.28991
55	0	10	.85580	.66850	.29149
60	0	10	.76139	.68038	.29199
65	0	10	.68202	.68933	.29175
70	0	10	.61439	.69609	.29103
75	0	10	.55611	.70126	.29002
80	0	10	.50541	.70526	.28886
90	0	10	.42177	.71095	.28638
100	0	10	.35593	.71479	.28401
0	0	12	12.864	.24240	.24836
1	0	12	11.261	.24785	.24139
2	0	12	9.9070	.25353	.23525
3	0	12	8.7591	.25945	.22989
4	0	12	7.7818	.26562	.22527
5	0	12	6.9465	.27204	.22133
6	0	12	6.2297	.27870	.21804
7	0	12	5.6119	.28563	.21536
8	0	12	5.0774	.29281	.21323
9	0	12	4.6130	.30024	.21162
10	0	12	4.2080	.30792	.21050
11	0	12	3.8534	.31586	.20981
12	0	12	3.5417	.32404	.20954
13	0	12	3.2667	.33245	.20964
14	0	12	3.0232	.34109	.21008
15	0	12	2.8067	.34995	.21084
16	0	12	2.6137	.35901	.21188
17	0	12	2.4410	.36826	.21318
18	0	12	2.2859	.37768	.21471
19	0	12	2.1462	.38724	.21645
20	0	12	2.0200	.39694	.21837
22	0	12	1.8017	.41663	.22264
24	0	12	1.6204	.43657	.22737
26	0	12	1.4682	.45653	.23239
28	0	12	1.3392	.47632	.23754
30	0	12	1.2289	.49572	.24270
32	0	12	1.1336	.51456	.24776
34	0	12	1.0508	.53267	.25263
36	0	12	0.97815	.54990	.25722
38	0	12	.91404	.56615	.26148
40	0	12	.85708	.58133	.26538
45	0	12	.73917	.61446	.27344
50	0	12	.64709	.64079	.27913
55	0	12	.57314	.66106	.28279
60	0	12	.51233	.67634	.28485
65	0	12	.46138	.68773	.28574
70	0	12	.41801	.69617	.28583
75	0	12	.38062	.70246	.28541
80	0	12	.34804	.70719	.28467
90	0	12	.29405	.71361	.28275
100	0	12	.25120	.71765	.28073
0	0	14	9.6392	.22034	.21505
1	0	14	8.4244	.22460	.20871
2	0	14	7.3974	.22908	.20312
3	0	14	6.5258	.23379	.19824
4	0	14	5.7834	.23873	.19403
5	0	14	5.1485	.24392	.19043
6	0	14	4.6035	.24936	.18742
7	0	14	4.1340	.25507	.18495
8	0	14	3.7278	.26104	.18300
9	0	14	3.3751	.26729	.18152
10	0	14	3.0679	.27381	.18048
11	0	14	2.7991	.28063	.17986
12	0	14	2.5633	.28772	.17963
13	0	14	2.3555	.29511	.17976
14	0	14	2.1720	.30278	.18023
15	0	14	2.0092	.31074	.18102
16	0	14	1.8644	.31897	.18209
17	0	14	1.7351	.32748	.18344
18	0	14	1.6195	.33625	.18504
19	0	14	1.5156	.34527	.18687
20	0	14	1.4221	.35453	.18890
22	0	14	1.2612	.37369	.19353
24	0	14	1.1287	.39358	.19876
26	0	14	1.0183	.41401	.20445
28	0	14	0.92555	.43476	.21046

TABLE 2. *Luminous internal transmittances in percent, 100* $T_{i,A}$, *and chromaticity coordinates,* x,y, *of single glasses and two-part combinations of ideal Lovibond glasses illuminated by CIE Source* A—Continued

R	Y	B	$T_{i,A}$	x	y
30	0	14	0.84686	0.45560	0.21664
32	0	14	.77952	.47631	.22285
34	0	14	.72143	.49663	.22899
36	0	14	.67092	.51637	.23495
38	0	14	.62667	.53532	.24063
40	0	14	.58764	.55334	.24597
45	0	14	.50773	.59356	.25751
50	0	14	.44616	.62632	.26629
55	0	14	.39717	.65187	.27245
60	0	14	.35714	.67117	.27644
65	0	14	.32371	.68545	.27877
70	0	14	.29526	.69589	.27991
75	0	14	.27070	.70351	.28025
80	0	14	.24925	.70909	.28008
90	0	14	.21346	.71631	.27891
100	0	14	.18476	.72055	.27736
0	0	16	7.3378	.20311	.18471
1	0	16	6.4085	.20646	.17907
2	0	16	5.6216	.21000	.17408
3	0	16	4.9529	.21374	.16973
4	0	16	4.3826	.21770	.16595
5	0	16	3.8944	.22188	.16273
6	0	16	3.4750	.22630	.16001
7	0	16	3.1135	.23096	.15778
8	0	16	2.8006	.23588	.15600
9	0	16	2.5290	.24107	.15464
10	0	16	2.2924	.24654	.15367
11	0	16	2.0856	.25229	.15309
12	0	16	1.9042	.25834	.15286
13	0	16	1.7446	.26469	.15296
14	0	16	1.6037	.27135	.15338
15	0	16	1.4791	.27832	.15410
16	0	16	1.3683	.28561	.15510
17	0	16	1.2697	.29322	.15637
18	0	16	1.1817	.30114	.15790
19	0	16	1.1028	.30937	.15966
20	0	16	1.0320	.31792	.16165
22	0	16	0.91076	.33589	.16625
24	0	16	.81149	.35498	.17158
26	0	16	.72943	.37502	.17751
28	0	16	.66098	.39586	.18393
30	0	16	.60336	.41727	.19070
32	0	16	.55446	.43900	.19769
34	0	16	.51260	.46080	.20476
36	0	16	.47648	.48241	.21179
38	0	16	.44509	.50356	.21867
40	0	16	.41760	.52402	.22529
45	0	16	.36193	.57088	.24019
50	0	16	.31962	.61016	.25216
55	0	16	.28629	.64132	.26107
60	0	16	.25921	.66502	.26725
65	0	16	.23665	.68252	.27126
70	0	16	.21745	.69519	.27365
75	0	16	.20084	.70427	.27490
80	0	16	.18627	.71077	.27539
90	0	16	.16176	.71885	.27513
100	0	16	.14185	.72326	.27414
0	0	18	5.6759	.19009	.15808
1	0	18	4.9578	.19277	.15316
2	0	18	4.3485	.19561	.14882
3	0	18	3.8298	.19864	.14501
4	0	18	3.3866	.20184	.14171
5	0	18	3.0066	.20525	.13888
6	0	18	2.6798	.20887	.13649
7	0	18	2.3977	.21271	.13451
8	0	18	2.1534	.21679	.13292
9	0	18	1.9412	.22112	.13170
10	0	18	1.7563	.22571	.13082
11	0	18	1.5946	.23057	.13028
12	0	18	1.4528	.23571	.13005
13	0	18	1.3281	.24115	.13012
14	0	18	1.2181	.24690	.13047
15	0	18	1.1208	.25296	.13110
16	0	18	1.0345	.25935	.13200
17	0	18	0.95777	.26607	.13315
18	0	18	.88935	.27312	.13455
19	0	18	.82820	.28052	.13618
20	0	18	.77340	.28827	.13804
22	0	18	.67987	.30479	.14240
24	0	18	.60370	.32266	.14756
26	0	18	.54112	.34180	.15342
28	0	18	.48924	.36209	.15990
30	0	18	.44588	.38335	.16689

R	Y	B	$T_{i,A}$	x	y
32	0	18	0.40933	0.40538	0.17427
34	0	18	.37827	.42791	.18190
36	0	18	.35167	.45067	.18967
38	0	18	.32871	.47335	.19743
40	0	18	.30874	.49567	.20505
45	0	18	.26874	.54814	.22284
50	0	18	.23873	.59345	.23782
55	0	18	.21532	.63010	.24949
60	0	18	.19640	.65826	.25796
65	0	18	.18066	.67907	.26375
70	0	18	.16726	.69405	.26748
75	0	18	.15561	.70465	.26973
80	0	18	.14534	.71210	.27096
90	0	18	.12791	.72103	.27166
100	0	18	.11353	.72561	.27127
0	0	20	4.4616	.18052	.13535
1	0	20	3.9008	.18272	.13114
2	0	20	3.4238	.18506	.12743
3	0	20	3.0167	.18756	.12418
4	0	20	2.6681	.19023	.12135
5	0	20	2.3687	.19306	.11892
6	0	20	2.1107	.19609	.11686
7	0	20	1.8876	.19932	.11516
8	0	20	1.6942	.20276	.11378
9	0	20	1.5259	.20642	.11272
10	0	20	1.3791	.21033	.11196
11	0	20	1.2507	.21448	.11149
12	0	20	1.1380	.21891	.11129
13	0	20	1.0389	.22361	.11135
14	0	20	0.95152	.22861	.11167
15	0	20	.87422	.23391	.11223
16	0	20	.80570	.23953	.11304
17	0	20	.74480	.24548	.11407
18	0	20	.69056	.25177	.11534
19	0	20	.64213	.25841	.11684
20	0	20	.59879	.26541	.11855
22	0	20	.52499	.28050	.12261
24	0	20	.46513	.29707	.12749
26	0	20	.41617	.31509	.13313
28	0	20	.37580	.33452	.13947
30	0	20	.34224	.35522	.14643
32	0	20	.31411	.37702	.15392
34	0	20	.29037	.39970	.16182
36	0	20	.27015	.42299	.17000
38	0	20	.25282	.44658	.17834
40	0	20	.23783	.47015	.18668
45	0	20	.20810	.52692	.20674
50	0	20	.18606	.57736	.22435
55	0	20	.16901	.61899	.23855
60	0	20	.15530	.65134	.24922
65	0	20	.14390	.67533	.25676
70	0	20	.13416	.69254	.26182
75	0	20	.12566	.70462	.26506
80	0	20	.11812	.71300	.26703
90	0	20	.10518	.72277	.26869
100	0	20	.094331	.72751	.26888
0	0	25	2.6218	.16693	.09384
1	0	25	2.3039	.16847	.09119
2	0	25	2.0314	.17013	.08886
3	0	25	1.7971	.17189	.08682
4	0	25	1.5950	.17378	.08505
5	0	25	1.4203	.17581	.08354
6	0	25	1.2688	.17798	.08227
7	0	25	1.1370	.18030	.08124
8	0	25	1.0221	.18280	.08042
9	0	25	0.92169	.18548	.07980
10	0	25	.83372	.18835	.07940
11	0	25	.75647	.19143	.07918
12	0	25	.68847	.19474	.07916
13	0	25	.62848	.19828	.07933
14	0	25	.57546	.20207	.07969
15	0	25	.52849	.20614	.08022
16	0	25	.48681	.21049	.08095
17	0	25	.44974	.21514	.08186
18	0	25	.41671	.22010	.08295
19	0	25	.38723	.22540	.08423
20	0	25	.36087	.23105	.08570
22	0	25	.31607	.24343	.08921
24	0	25	.27988	.25736	.09348
26	0	25	.25044	.27290	.09853
28	0	25	.22634	.29010	.10435

R	Y	B	$T_{i,A}$	x	y
30	0	25	0.20646	0.30893	0.11092
32	0	25	.18996	.32935	.11819
34	0	25	.17616	.35121	.12610
36	0	25	.16453	.37432	.13456
38	0	25	.15467	.39842	.14347
40	0	25	.14623	.42319	.15268
45	0	25	.12976	.48568	.17606
50	0	25	.11782	.54448	.19812
55	0	25	.10870	.59516	.21709
60	0	25	.10140	.63566	.23212
65	0	25	.095310	.66611	.24329
70	0	25	.090062	.68798	.25117
75	0	25	.085416	.70320	.25651
80	0	25	.081222	.71357	.26002
90	0	25	.073823	.72519	.26366
100	0	25	.067392	.73036	.26499
0	0	30	1.6958	.16163	.06862
1	0	30	1.5013	.16289	.06707
2	0	30	1.3329	.16424	.06572
3	0	30	1.1869	.16568	.06455
4	0	30	1.0598	.16723	.06355
5	0	30	0.94904	.16889	.06273
6	0	30	.85224	.17068	.06206
7	0	30	.76744	.17259	.06154
8	0	30	.69301	.17466	.06118
9	0	30	.62754	.17688	.06096
10	0	30	.56984	.17927	.06088
11	0	30	.51888	.18184	.06094
12	0	30	.47381	.18461	.06114
13	0	30	.43387	.18759	.06148
14	0	30	.39841	.19080	.06197
15	0	30	.36688	.19424	.06260
16	0	30	.33881	.19795	.06337
17	0	30	.31377	.20193	.06430
18	0	30	.29140	.20620	.06538
19	0	30	.27140	.21078	.06662
20	0	30	.25347	.21569	.06802
22	0	30	.22295	.22654	.07132
24	0	30	.19824	.23889	.07532
26	0	30	.17814	.25284	.08006
28	0	30	.16168	.26848	.08555
30	0	30	.14813	.28585	.09180
32	0	30	.13690	.30496	.09881
34	0	30	.12753	.32573	.10655
36	0	30	.11967	.34804	.11495
38	0	30	.11302	.37168	.12394
40	0	30	.10735	.39638	.13339
45	0	30	.096354	.46045	.15812
50	0	30	.088429	.52296	.18243
55	0	30	.082394	.57849	.20410
60	0	30	.077552	.62386	.22182
65	0	30	.073486	.65845	.23531
70	0	30	.069944	.68348	.24504
75	0	30	.066769	.70091	.25177
80	0	30	.063864	.71272	.25629
90	0	30	.058642	.72579	.26118
100	0	30	.053995	.73142	.26317
0	0	40	.90106	.15986	.04389
1	0	40	.80955	.16087	.04346
2	0	40	.72889	.16196	.04311
3	0	40	.65768	.16313	.04285
4	0	40	.59470	.16438	.04267
5	0	40	.53891	.16574	.04257
6	0	40	.48942	.16720	.04256
7	0	40	.44546	.16877	.04262
8	0	40	.40635	.17047	.04277
9	0	40	.37152	.17231	.04300
10	0	40	.34046	.17429	.04333
11	0	40	.31273	.17643	.04374
12	0	40	.28794	.17875	.04424
13	0	40	.26576	.18125	.04484
14	0	40	.24589	.18394	.04554
15	0	40	.22808	.18685	.04635
16	0	40	.21209	.18999	.04726
17	0	40	.19773	.19338	.04829
18	0	40	.18481	.19702	.04945
19	0	40	.17318	.20095	.05073
20	0	40	.16270	.20517	.05214
22	0	40	.14471	.21457	.05540
24	0	40	.13001	.22536	.05927
26	0	40	.11795	.23767	.06380
28	0	40	.10802	.25163	.06904

TABLE 2. *Luminous internal transmittances in percent, 100 $T_{i,A}$, and chromaticity coordinates, x,y, of single glasses and two-par combinations of ideal Lovibond glasses illuminated by CIE Source* A—Continued

R	Y	B	$T_{i,A}$	x	y
30	0	40	0.099785	0.26731	0.07502
32	0	40	.092931	.28477	.08176
34	0	40	.087191	.30400	.08926
36	0	40	.082354	.32496	.09750
38	0	40	.078249	.34749	.10641
40	0	40	.074741	.37139	.11591
45	0	40	.067907	.43513	.14143
50	0	40	.062946	.49974	.16749
55	0	40	.059137	.55917	.19157
60	0	40	.056050	.60913	.21188
65	0	40	.053427	.64803	.22774
70	0	40	.051114	.67658	.23940
75	0	40	.049015	.69662	.24759
80	0	40	.047074	.71025	.25317
90	0	40	.043530	.72531	.25933
100	0	40	.040322	.73171	.26193
0	0	50	.59264	.16104	.03355
1	0	50	.53782	.16193	.03353
2	0	50	.48308	.16204	.03321
3	0	50	.42704	.16088	.03244
4	0	50	.37816	.15988	.03173
5	0	50	.33704	.15935	.03122
6	0	50	.30158	.15907	.03081
7	0	50	.27033	.15889	.03047
8	0	50	.24266	.15879	.03016
9	0	50	.21811	.15875	.02989
10	0	50	.19627	.15877	.02966
11	0	50	.17679	.15884	.02945
12	0	50	.15938	.15894	.02927
13	0	50	.14381	.15907	.02911
14	0	50	.12985	.15924	.02897
15	0	50	.11734	.15943	.02885
16	0	50	.10611	.15966	.02875
17	0	50	.096030	.15992	.02867
18	0	50	.086971	.16020	.02861
19	0	50	.078828	.16053	.02857
20	0	50	.071503	.16089	.02855
22	0	50	.058008	.16087	.02814
24	0	50	.047797	.16163	.02814
26	0	50	.039645	.16273	.02830
28	0	50	.033044	.16409	.02859
30	0	50	.027677	.16571	.02901
32	0	50	.023304	.16765	.02957
34	0	50	.019734	.16995	.03029
36	0	50	.016680	.17213	.03098
38	0	50	.014307	.17530	.03210
40	0	50	.012376	.17912	.03349
45	0	50	.0089179	.19178	.03833
50	0	50	.0067682	.21023	.04567
55	0	50	.0054080	.23644	.05633
60	0	50	.0045264	.27222	.07108
65	0	50	.0039365	.31853	.09035
70	0	50	.0035257	.37445	.11374
75	0	50	.0032259	.43655	.13982
80	0	50	.0029956	.49943	.16628
90	0	50	.0026530	.60634	.21141
100	0	50	.0023925	.67324	.23972
0	1	0	98.660	.45696	.41986
1	1	0	88.597	.46946	.41042
2	1	0	80.085	.48159	.40178
3	1	0	72.830	.49320	.39396
4	1	0	66.606	.50426	.38692
5	1	0	61.231	.51475	.38062
6	1	0	56.561	.52468	.37500
7	1	0	52.479	.53404	.36999
8	1	0	48.889	.54287	.36553
9	1	0	45.714	.55118	.36157
10	1	0	42.889	.55900	.35804
11	1	0	40.362	.56636	.35490
12	1	0	38.091	.57329	.35209
13	1	0	36.038	.57980	.34958
14	1	0	34.174	.58593	.34732
15	1	0	32.474	.59171	.34529
16	1	0	30.917	.59715	.34344
17	1	0	29.485	.60227	.34176
18	1	0	28.163	.60711	.34023
19	1	0	26.939	.61167	.33881
20	1	0	25.802	.61597	.33750
22	1	0	23.752	.62388	.33514
24	1	0	21.954	.63095	.33305
26	1	0	20.362	.63728	.33115
28	1	0	18.942	.64297	.32941

R	Y	B	$T_{i,A}$	x	y
30	1	0	17.667	0.64810	0.32779
32	1	0	16.516	.65272	.32625
34	1	0	15.471	.65690	.32479
36	1	0	14.518	.66068	.32339
38	1	0	13.647	.66412	.32204
40	1	0	12.847	.66726	.32073
45	1	0	11.109	.67395	.31764
50	1	0	9.6739	.67937	.31476
55	1	0	8.4733	.68382	.31209
60	1	0	7.4587	.68754	.30962
65	1	0	6.5941	.69069	.30732
70	1	0	5.8519	.69341	.30520
75	1	0	5.2109	.69579	.30323
80	1	0	4.6542	.69789	.30141
90	1	0	3.7429	.70147	.29816
100	1	0	3.0380	.70443	.29536
0	2	0	97.368	.46417	.42917
1	2	0	87.433	.47683	.41941
2	2	0	79.034	.48907	.41042
3	2	0	71.876	.50075	.40225
4	2	0	65.733	.51182	.39485
5	2	0	60.429	.52228	.38820
6	2	0	55.821	.53213	.38222
7	2	0	51.792	.54138	.37687
8	2	0	48.250	.55007	.37207
9	2	0	45.116	.55821	.36778
10	2	0	42.329	.56584	.36394
11	2	0	39.836	.57300	.36049
12	2	0	37.594	.57970	.35739
13	2	0	35.568	.58598	.35459
14	2	0	33.728	.59187	.35206
15	2	0	32.050	.59740	.34977
16	2	0	30.513	.60259	.34767
17	2	0	29.100	.60747	.34575
18	2	0	27.795	.61205	.34399
19	2	0	26.587	.61637	.34236
20	2	0	25.464	.62043	.34084
22	2	0	23.441	.62788	.33810
24	2	0	21.665	.63452	.33567
26	2	0	20.093	.64045	.33347
28	2	0	18.691	.64577	.33146
30	2	0	17.432	.65056	.32959
32	2	0	16.295	.65488	.32785
34	2	0	15.264	.65878	.32619
36	2	0	14.323	.66233	.32463
38	2	0	13.462	.66555	.32313
40	2	0	12.672	.66849	.32169
45	2	0	10.957	.67480	.31834
50	2	0	9.5396	.67993	.31529
55	2	0	8.3543	.68418	.31249
60	2	0	7.3529	.68776	.30992
65	2	0	6.4996	.69082	.30755
70	2	0	5.7673	.69348	.30538
75	2	0	5.1349	.69581	.30338
80	2	0	4.5858	.69789	.30154
90	2	0	3.6871	.70143	.29826
100	2	0	2.9921	.70438	.29544
0	3	0	96.115	.46987	.43640
1	3	0	86.300	.48261	.42642
2	3	0	78.012	.49493	.41715
3	3	0	70.947	.50665	.40869
4	3	0	64.885	.51773	.40101
5	3	0	59.650	.52815	.39407
6	3	0	55.102	.53792	.38782
7	3	0	51.126	.54708	.38219
8	3	0	47.629	.55564	.37713
9	3	0	44.536	.56364	.37258
10	3	0	41.784	.57111	.36849
11	3	0	39.323	.57809	.36480
12	3	0	37.110	.58461	.36147
13	3	0	35.110	.59070	.35845
14	3	0	33.294	.59640	.35571
15	3	0	31.637	.60173	.35321
16	3	0	30.119	.60672	.35092
17	3	0	28.724	.61140	.34882
18	3	0	27.436	.61579	.34688
19	3	0	26.242	.61992	.34508
20	3	0	25.134	.62380	.34341
22	3	0	23.136	.63088	.34037
24	3	0	21.382	.63718	.33768
26	3	0	19.830	.64281	.33525
28	3	0	18.445	.64785	.33303

R	Y	B	$T_{i,A}$	x	y
30	3	0	17.202	0.65238	0.33098
32	3	0	16.079	.65646	.32907
34	3	0	15.060	.66016	.32728
36	3	0	14.131	.66352	.32559
38	3	0	13.281	.66658	.32398
40	3	0	12.501	.66937	.32244
45	3	0	10.807	.67539	.31890
50	3	0	9.4073	.68032	.31571
55	3	0	8.2372	.68442	.31281
60	3	0	7.2487	.68790	.31017
65	3	0	6.4066	.69089	.30775
70	3	0	5.6839	.69350	.30554
75	3	0	5.0600	.69580	.30352
80	3	0	4.5184	.69786	.30165
90	3	0	3.6321	.70139	.29834
100	3	0	2.9469	.70433	.29551
0	4	0	94.897	.47446	.44214
1	4	0	85.206	.48728	.43196
2	4	0	77.023	.49965	.42248
3	4	0	70.048	.51139	.41379
4	4	0	64.063	.52245	.40589
5	4	0	58.894	.53282	.39872
6	4	0	54.403	.54253	.39225
7	4	0	50.477	.55160	.38640
8	4	0	47.025	.56005	.38113
9	4	0	43.971	.56793	.37637
10	4	0	41.254	.57526	.37208
11	4	0	38.823	.58209	.36820
12	4	0	36.638	.58846	.36468
13	4	0	34.663	.59439	.36149
14	4	0	32.869	.59993	.35858
15	4	0	31.233	.60510	.35592
16	4	0	29.734	.60993	.35348
17	4	0	28.356	.61445	.35123
18	4	0	27.084	.61868	.34915
19	4	0	25.905	.62265	.34723
20	4	0	24.810	.62638	.34543
22	4	0	22.837	.63318	.34217
24	4	0	21.105	.63922	.33927
26	4	0	19.572	.64460	.33666
28	4	0	18.204	.64941	.33428
30	4	0	16.976	.65374	.33209
32	4	0	15.866	.65765	.33005
34	4	0	14.860	.66119	.32815
36	4	0	13.942	.66440	.32636
38	4	0	13.103	.66733	.32466
40	4	0	12.332	.67002	.32305
45	4	0	10.659	.67581	.31936
50	4	0	9.2771	.68058	.31606
55	4	0	8.1218	.68458	.31308
60	4	0	7.1461	.68798	.31038
65	4	0	6.3149	.69092	.30793
70	4	0	5.6019	.69349	.30569
75	4	0	4.9863	.69578	.30364
80	4	0	4.4520	.69782	.30176
90	4	0	3.5779	.70133	.29843
100	4	0	2.9024	.70427	.29558
0	5	0	93.709	.47823	.44679
1	5	0	84.140	.49110	.43643
2	5	0	76.058	.50350	.42678
3	5	0	69.171	.51524	.41791
4	5	0	63.260	.52628	.40982
5	5	0	58.156	.53661	.40248
6	5	0	53.721	.54625	.39582
7	5	0	49.844	.55524	.38980
8	5	0	46.435	.56359	.38436
9	5	0	43.418	.57136	.37943
10	5	0	40.735	.57858	.37498
11	5	0	38.335	.58529	.37094
12	5	0	36.176	.59152	.36728
13	5	0	34.225	.59733	.36394
14	5	0	32.454	.60273	.36090
15	5	0	30.838	.60776	.35811
16	5	0	29.357	.61246	.35554
17	5	0	27.996	.61685	.35318
18	5	0	26.739	.62095	.35099
19	5	0	25.575	.62480	.34896
20	5	0	24.493	.62840	.34706
22	5	0	22.543	.63497	.34362
24	5	0	20.832	.64079	.34056
26	5	0	19.318	.64598	.33780
28	5	0	17.966	.65061	.33530
30	5	0	16.753	.65478	.33299

TABLE 2. *Luminous internal transmittances in percent, 100* $T_{i,A}$, *and chromaticity coordinates,* x,y, *of single glasses and two-part combinations of ideal Lovibond glasses illuminated by CIE Source* A—Continued

R	Y	B	$T_{i,A}$	x	y
32	5	0	15.657	0.65855	0.33085
34	5	0	14.663	.66196	.32886
36	5	0	13.756	.66506	.32699
38	5	0	12.927	.66789	.32523
40	5	0	12.166	.67049	.32356
45	5	0	10.513	.67611	.31975
50	5	0	9.1488	.68076	.31636
55	5	0	8.0082	.68467	.31332
60	5	0	7.0450	.68802	.31058
65	5	0	6.2247	69092	.30809
70	5	0	5.5210	.69347	.30583
75	5	0	4.9137	.69573	.30376
80	5	0	4.3867	.69776	.30186
90	5	0	3.5246	.70127	.29851
100	5	0	2.8586	.70422	.29565
0	6	0	92.548	.48136	.45060
1	6	0	83.098	.49428	.44012
2	6	0	75.116	.50669	.43032
3	6	0	68.314	.51842	.42130
4	6	0	62.476	.52943	.41306
5	6	0	57.435	.53972	.40556
6	6	0	53.055	.54930	.39876
7	6	0	49.225	.55821	.39259
8	6	0	45.857	.56648	.38701
9	6	0	42.878	.57415	.38195
10	6	0	40.228	.58127	.37736
11	6	0	37.856	.58787	.37320
12	6	0	35.724	.59400	.36941
13	6	0	33.797	.59969	.36596
14	6	0	32.047	.60498	.36281
15	6	0	30.450	.60990	.35991
16	6	0	28.988	.61449	.35725
17	6	0	27.642	.61877	.35479
18	6	0	26.401	.62276	.35251
19	6	0	25.251	.62650	.35039
20	6	0	24.182	.63001	.34841
22	6	0	22.255	.63638	.34482
24	6	0	20.565	.64203	.34163
26	6	0	19.068	.64705	.33875
28	6	0	17.733	.65155	.33614
30	6	0	16.534	.65559	.33375
32	6	0	15.451	.65923	.33153
34	6	0	14.469	.66254	.32946
36	6	0	13.573	.66555	.32753
38	6	0	12.754	.66831	.32571
40	6	0	12.002	.67084	.32400
45	6	0	10.370	.67632	.32009
50	6	0	9.0224	.68088	.31663
55	6	0	7.8962	.68472	.31354
60	6	0	6.9454	.68802	.31075
65	6	0	6.1357	.69089	.30824
70	6	0	5.4414	.69343	.30595
75	6	0	4.8422	.69568	.30387
80	6	0	4.3223	.69771	.30196
90	6	0	3.4721	.70121	.29859
100	6	0	2.8154	.70416	.29571
0	8	0	90.301	.48625	.45647
1	8	0	81.080	.49920	.44579
2	8	0	73.292	.51162	.43577
3	8	0	66.654	.52333	.42652
4	8	0	60.957	.53428	.41806
5	8	0	56.038	.54448	.41033
6	8	0	51.763	.55395	.40330
7	8	0	48.025	.56273	.39691
8	8	0	44.738	.57085	.39111
9	8	0	41.830	.57837	.38584
10	8	0	39.242	.58532	.38105
11	8	0	36.927	.59175	.37670
12	8	0	34.846	.59770	.37272
13	8	0	32.964	.60321	.36909
14	8	0	31.255	.60832	.36577
15	8	0	29.696	.61306	.36271
16	8	0	28.268	.61747	.35990
17	8	0	26.954	.62158	.35729
18	8	0	25.742	.62541	.35488
19	8	0	24.619	.62899	.35263
20	8	0	23.575	.63234	.35053
22	8	0	21.693	.63842	.34671
24	8	0	20.042	.64379	.34331
26	8	0	18.581	.64857	.34026
28	8	0	17.277	.65285	.33749

R	Y	B	$T_{i,A}$	x	y
30	8	0	16.106	0.65670	0.33496
32	8	0	15.049	.66017	.33261
34	8	0	14.090	.66333	.33044
36	8	0	13.216	.66621	.32841
38	8	0	12.416	.66884	.32651
40	8	0	11.682	.67127	.32472
45	8	0	10.090	.67656	.32066
50	8	0	8.7753	.68097	.31709
55	8	0	7.6773	.68473	.31392
60	8	0	6.7506	.68797	.31108
65	8	0	5.9619	.69080	.30851
70	8	0	5.2857	.69331	.30619
75	8	0	4.7024	.69555	.30408
80	8	0	4.1965	.69757	.30215
90	8	0	3.3695	.70108	.29875
100	8	0	2.7312	.70403	.29585
0	10	0	88.141	.48986	.46076
1	10	0	79.140	.50283	.44994
2	10	0	71.538	.51523	.43976
3	10	0	65.058	.52689	.43036
4	10	0	59.497	.53778	.42173
5	10	0	54.694	.54790	.41384
6	10	0	50.519	.55727	.40664
7	10	0	46.870	.56594	.40010
8	10	0	43.660	.57395	.39414
9	10	0	40.820	.58134	.38872
10	10	0	38.293	.58816	.38379
11	10	0	36.032	.59445	.37929
12	10	0	33.998	.60026	.37518
13	10	0	32.160	.60563	.37143
14	10	0	30.491	.61061	.36798
15	10	0	28.968	.61522	.36481
16	10	0	27.573	.61950	.36188
17	10	0	26.289	.62348	.35917
18	10	0	25.105	.62718	.35666
19	10	0	24.007	.63064	.35431
20	10	0	22.988	.63388	.35213
22	10	0	21.149	.63975	.34814
24	10	0	19.536	.64493	.34460
26	10	0	18.108	.64954	.34143
28	10	0	16.835	.65366	.33854
30	10	0	15.691	.65736	.33590
32	10	0	14.659	.66072	.33347
34	10	0	13.722	.66377	.33122
36	10	0	12.868	.66656	.32912
38	10	0	12.088	.66911	.32716
40	10	0	11.372	.67147	.32531
45	10	0	9.8173	.67663	.32114
50	10	0	8.5354	.68095	.31749
55	10	0	7.4648	.68465	.31426
60	10	0	6.5616	.68785	.31137
65	10	0	5.7931	.69067	.30877
70	10	0	5.1346	.69317	.30642
75	10	0	4.5668	.69540	.30429
80	10	0	4.0744	.69742	.30234
90	10	0	3.2700	.70094	.29890
100	10	0	2.6494	.70391	.29598
0	15	0	83.068	.49568	.46773
1	15	0	74.585	.50860	.45670
2	15	0	67.418	.52091	.44629
3	15	0	61.308	.53245	.43665
4	15	0	56.063	.54318	.42777
5	15	0	51.532	.55312	.41963
6	15	0	47.594	.56230	.41219
7	15	0	44.150	.57076	.40540
8	15	0	41.120	.57854	.39921
9	15	0	38.439	.58570	.39355
10	15	0	36.053	.59228	.38840
11	15	0	33.918	.59833	.38368
12	15	0	31.998	.60391	.37937
13	15	0	30.262	.60905	.37541
14	15	0	28.685	.61379	.37177
15	15	0	27.246	.61818	.36842
16	15	0	25.928	.62225	.36532
17	15	0	24.716	.62602	.36245
18	15	0	23.596	.62953	.35977
19	15	0	22.559	.63280	.35728
20	15	0	21.596	.63585	.35495
22	15	0	19.860	.64138	.35071
24	15	0	18.336	.64627	.34694
26	15	0	16.988	.65061	.34356
28	15	0	15.785	.65450	.34049

R	Y	B	$T_{i,A}$	x	y
30	15	0	14.706	0.65800	0.33769
32	15	0	13.732	.66118	.33512
34	15	0	12.848	.66408	.33273
36	15	0	12.044	.66674	.33052
38	15	0	11.308	.66918	.32845
40	15	0	10.633	.67144	.32652
45	15	0	9.1707	.67642	.32216
50	15	0	7.9654	.68064	.31836
55	15	0	6.9600	.68427	.31502
60	15	0	6.1127	.68744	.31204
65	15	0	5.3926	.69024	.30937
70	15	0	4.7761	.69274	.30697
75	15	0	4.2450	.69499	.30478
80	15	0	3.7850	.69702	.30279
90	15	0	3.0342	.70058	.29929
100	15	0	2.4559	.70358	.29632
0	20	0	78.391	.49900	.47198
1	20	0	70.384	.51182	.46086
2	20	0	63.618	.52401	.45035
3	20	0	57.848	.53542	.44059
4	20	0	52.894	.54602	.43159
5	20	0	48.613	.55581	.42332
6	20	0	44.892	.56483	.41575
7	20	0	41.637	.57313	.40883
8	20	0	38.772	.58075	.40251
9	20	0	36.237	.58775	.39673
10	20	0	33.981	.59417	.39145
11	20	0	31.961	.60007	.38661
12	20	0	30.144	.60550	.38218
13	20	0	28.502	.61049	.37811
14	20	0	27.010	.61510	.37436
15	20	0	25.649	.61935	.37090
16	20	0	24.401	.62329	.36770
17	20	0	23.254	.62694	.36473
18	20	0	22.195	.63033	.36197
19	20	0	21.214	.63349	.35939
20	20	0	20.303	.63645	.35698
22	20	0	18.660	.64180	.35259
24	20	0	17.219	.64652	.34868
26	20	0	15.945	.65072	.34517
28	20	0	14.808	.65449	.34199
30	20	0	13.789	.65790	.33909
32	20	0	12.869	.66099	.33642
34	20	0	12.035	.66382	.33396
36	20	0	11.276	.66642	.33167
38	20	0	10.582	.66881	.32954
40	20	0	9.9466	.67104	.32754
45	20	0	8.5690	.67595	.32305
50	20	0	7.4354	.68014	.31915
55	20	0	6.4909	.68376	.31572
60	20	0	5.6958	.68693	.31268
65	20	0	5.0208	.68975	.30995
70	20	0	4.4435	.69227	.30750
75	20	0	3.9466	.69454	.30527
80	20	0	3.5166	.69660	.30324
90	20	0	2.8158	.70020	.29968
100	20	0	2.2768	.70325	.29665
0	30	0	70.012	.50219	.47724
1	30	0	62.857	.51478	.46609
2	30	0	56.807	.52674	.45553
3	30	0	51.645	.53790	.44569
4	30	0	47.210	.54825	.43661
5	30	0	43.376	.55780	.42824
6	30	0	40.041	.56659	.42056
7	30	0	37.122	.57466	.41352
8	30	0	34.553	.58206	.40708
9	30	0	32.278	.58884	.40118
10	30	0	30.253	.59507	.39577
11	30	0	28.440	.60078	.39081
12	30	0	26.809	.60602	.38626
13	30	0	25.334	.61085	.38206
14	30	0	23.994	.61530	.37819
15	30	0	22.771	.61941	.37462
16	30	0	21.651	.62321	.37130
17	30	0	20.621	.62673	.36822
18	30	0	19.670	.63001	.36535
19	30	0	18.789	.63307	.36267
20	30	0	17.971	.63592	.36016
22	30	0	16.498	.64110	.35558
24	30	0	15.206	.64568	.35150
26	30	0	14.064	.64977	.34783
28	30	0	13.047	.65345	.34450

TABLE 2. *Luminous internal transmittances in percent, 100* $T_{i,A}$, *and chromaticity coordinates,* x,y, *of single glasses and two-part combinations of ideal Lovibond glasses illuminated by CIE Source* A—Continued

R	Y	B	$T_{i,A}$	x	y
30	30	0	12.136	0.65678	0.34147
32	30	0	11.314	.65982	.33868
34	30	0	10.570	.66260	.33610
36	30	0	9.8936	.66517	.33371
38	30	0	9.2760	.66755	.33148
40	30	0	8.7104	.66976	.32940
45	30	0	7.4873	.67468	.32472
50	30	0	6.4834	.67889	.32066
55	30	0	5.6490	.68256	.31709
60	30	0	4.9483	.68580	.31393
65	30	0	4.3547	.68867	.31111
70	30	0	3.8482	.69125	.30856
75	30	0	3.4130	.69359	.30625
80	30	0	3.0371	.69571	.30416
90	30	0	2.4261	.69942	.30047
100	30	0	1.9576	.70256	.29734
0	40	0	62.705	.50321	.48078
1	40	0	56.292	.51556	.46969
2	40	0	50.865	.52728	.45917
3	40	0	46.231	.53822	.44936
4	40	0	42.248	.54836	.44027
5	40	0	38.802	.55772	.43189
6	40	0	35.804	.56633	.42419
7	40	0	33.178	.57423	.41712
8	40	0	30.866	.58148	.41063
9	40	0	28.818	.58813	.40467
10	40	0	26.995	.59423	.39921
11	40	0	25.362	.59983	.39419
12	40	0	23.892	.60498	.38957
13	40	0	22.564	.60972	.38530
14	40	0	21.356	.61409	.38137
15	40	0	20.255	.61812	.37772
16	40	0	19.246	.62186	.37434
17	40	0	18.318	.62534	.37119
18	40	0	17.462	.62857	.36825
19	40	0	16.670	.63158	.36551
20	40	0	15.934	.63440	.36293
22	40	0	14.609	.63953	.35822
24	40	0	13.448	.64407	.35402
26	40	0	12.423	.64814	.35024
28	40	0	11.511	.65181	.34681
30	40	0	10.695	.65514	.34367
32	40	0	9.9594	.65818	.34079
34	40	0	9.2944	.66098	.33813
36	40	0	8.6904	.66357	.33566
38	40	0	8.1396	.66597	.33335
40	40	0	7.6358	.66821	.33119
45	40	0	6.5485	.67321	.32635
50	40	0	5.6584	.67750	.32215
55	40	0	4.9205	.68126	.31847
60	40	0	4.3023	.68458	.31520
65	40	0	3.7798	.68753	.31227
70	40	0	3.3349	.69019	.30964
75	40	0	2.9535	.69259	.30726
80	40	0	2.6247	.69478	.30509
90	40	0	2.0915	.69860	.30128
100	40	0	1.6840	.70185	.29805
0	60	0	50.611	.50246	.48625
1	60	0	45.423	.51436	.47538
2	60	0	41.026	.52565	.46504
3	60	0	37.266	.53621	.45537
4	60	0	34.030	.54600	.44639
5	60	0	31.228	.55505	.43808
6	60	0	28.786	.56339	.43041
7	60	0	26.647	.57106	.42334
8	60	0	24.761	.57811	.41684
9	60	0	23.090	.58459	.41086
10	60	0	21.602	.59054	.40534
11	60	0	20.268	.59602	.40026
12	60	0	19.068	.60107	.39556
13	60	0	17.983	.60573	.39122
14	60	0	16.997	.61004	.38720
15	60	0	16.098	.61403	.38346
16	60	0	15.275	.61774	.37998
17	60	0	14.518	.62119	.37674
18	60	0	13.820	.62441	.37370
19	60	0	13.175	.62742	.37085
20	60	0	12.576	.63024	.36818
22	60	0	11.499	.63539	.36327
24	60	0	10.557	.63998	.35888
26	60	0	9.7276	.64411	.35492
28	60	0	8.9911	.64785	.35131

R	Y	B	$T_{i,A}$	x	y
30	60	0	8.3332	0.65126	0.34801
32	60	0	7.7423	.65439	.34497
34	60	0	7.2091	.65728	.34215
36	60	0	6.7259	.65996	.33953
38	60	0	6.2864	.66246	.33709
40	60	0	5.8854	.66479	.33481
45	60	0	5.0232	.67001	.32966
50	60	0	4.3213	.67453	.32520
55	60	0	3.7425	.67849	.32128
60	60	0	3.2600	.68200	.31780
65	60	0	2.8542	.68513	.31469
70	60	0	2.5101	.68795	.31188
75	60	0	2.2163	.69051	.30934
80	60	0	1.9640	.69283	.30703
90	60	0	1.5571	.69691	.30297
100	60	0	1.2482	.70037	.29953
0	100	0	33.551	.49699	.49557
1	100	0	30.090	.50806	.48526
2	100	0	27.148	.51862	.47539
3	100	0	24.626	.52852	.46612
4	100	0	22.450	.53776	.45745
5	100	0	20.561	.54634	.44938
6	100	0	18.912	.55428	.44189
7	100	0	17.465	.56164	.43494
8	100	0	16.189	.56844	.42850
9	100	0	15.056	.57472	.42254
10	100	0	14.047	.58053	.41701
11	100	0	13.143	.58592	.41187
12	100	0	12.329	.59091	.40710
13	100	0	11.593	.59554	.40266
14	100	0	10.925	.59985	.39852
15	100	0	10.316	.60386	.39466
16	100	0	9.7598	.60761	.39104
17	100	0	9.2489	.61112	.38765
18	100	0	8.7784	.61442	.38446
19	100	0	8.3439	.61751	.38145
20	100	0	7.9416	.62043	.37862
22	100	0	7.2202	.62579	.37339
24	100	0	6.5924	.63061	.36868
26	100	0	6.0418	.63498	.36439
28	100	0	5.5553	.63896	.36048
30	100	0	5.1230	.64262	.35688
32	100	0	4.7366	.64600	.35355
34	100	0	4.3896	.64913	.35045
36	100	0	4.0768	.65205	.34757
38	100	0	3.7937	.65477	.34487
40	100	0	3.5366	.65733	.34234
45	100	0	2.9883	.66309	.33662
50	100	0	2.5471	.66810	.33164
55	100	0	2.1871	.67251	.32725
60	100	0	1.8901	.67644	.32335
65	100	0	1.6426	.67996	.31985
70	100	0	1.4347	.68313	.31670
75	100	0	1.2587	.68600	.31383
80	100	0	1.1087	.68862	.31122
90	100	0	0.86949	.69323	.30664
100	100	0	.69032	.69714	.30275
0	1	0	98.660	.45696	.41986
0	1	1	81.476	.44053	.41634
0	1	2	67.519	.42342	.41128
0	1	3	56.148	.40577	.40458
0	1	4	46.858	.38775	.39620
0	1	5	39.244	.36957	.38614
0	1	6	32.987	.35143	.37447
0	1	7	27.827	.33355	.36132
0	1	8	23.561	.31617	.34687
0	1	9	20.022	.29946	.33135
0	1	10	17.078	.28363	.31502
0	1	12	12.564	.25506	.28109
0	1	14	9.3830	.23113	.24724
0	1	16	7.1150	.21189	.21524
0	1	18	5.4789	.19695	.18624
0	1	20	4.2850	.18569	.16081
0	1	25	2.4807	.16914	.11278
0	1	30	1.5775	.16236	.08260
0	1	40	0.81067	.15973	.05236
0	1	50	.51933	.16099	.03965
0	2	0	97.368	.46417	.42917
0	2	1	80.383	.44867	.42728
0	2	2	66.587	.43248	.42401
0	2	3	55.350	.41573	.41924
0	2	4	46.168	.39854	.41287

R	Y	B	$T_{i,A}$	x	y
0	2	5	38.645	0.38107	0.40487
0	2	6	32.462	.36352	.39524
0	2	7	27.365	.34607	.38403
0	2	8	23.150	.32892	.37138
0	2	9	19.655	.31227	.35745
0	2	10	16.748	.29629	.34244
0	2	12	12.292	.26692	.31023
0	2	14	9.1542	.24167	.27679
0	2	16	6.9186	.22084	.24406
0	2	18	5.3073	.20427	.21348
0	2	20	4.1328	.19149	.18596
0	2	25	2.3620	.17209	.13215
0	2	30	1.4800	.16376	.09715
0	2	40	0.73833	.16020	.06126
0	2	50	.46197	.16153	.04605
0	3	0	96.115	.46987	.43640
0	3	1	79.327	.45515	.43582
0	3	2	65.691	.43976	.43401
0	3	3	54.583	.42380	.43084
0	3	4	45.509	.40738	.42619
0	3	5	38.074	.39063	.41998
0	3	6	31.964	.37369	.41218
0	3	7	26.928	.35675	.40280
0	3	8	22.765	.33998	.39190
0	3	9	19.312	.32354	.37959
0	3	10	16.441	.30763	.36604
0	3	12	12.042	.27793	.33602
0	3	14	8.9463	.25182	.30370
0	3	16	6.7419	.22979	.27100
0	3	18	5.1545	.21188	.23955
0	3	20	3.9986	.19777	.21051
0	3	25	2.2597	.17569	.15178
0	3	30	1.3974	.16581	.11220
0	3	40	0.67884	.16128	.07058
0	3	50	.41579	.16270	.05278
0	4	0	94.897	.47446	.44214
0	4	1	78.301	.46041	.44263
0	4	2	64.823	.44571	.44201
0	4	3	53.844	.43046	.44017
0	4	4	44.875	.41473	.43697
0	4	5	37.528	.39864	.43231
0	4	6	31.490	.38232	.42613
0	4	7	26.513	.36591	.41840
0	4	8	22.400	.34957	.40913
0	4	9	18.989	.33347	.39840
0	4	10	16.153	.31775	.38632
0	4	12	11.810	.28806	.35875
0	4	14	8.7548	.26147	.32801
0	4	16	6.5808	.23859	.29594
0	4	18	5.0165	.21961	.26422
0	4	20	3.8785	.20438	.23420
0	4	25	2.1699	.17986	.17142
0	4	30	1.3262	.16847	.12758
0	4	40	0.62890	.16295	.08028
0	4	50	.37779	.16450	.05981
0	5	0	93.709	.47823	.44679
0	5	1	77.304	.46474	.44813
0	5	2	63.980	.45064	.44851
0	5	3	53.128	.43600	.44778
0	5	4	44.263	.42090	.44580
0	5	5	37.001	.40542	.44248
0	5	6	31.034	.38968	.43771
0	5	7	26.116	.37381	.43145
0	5	8	22.052	.35794	.42368
0	5	9	18.683	.34222	.41443
0	5	10	15.882	.32678	.40377
0	5	12	11.593	.29733	.37872
0	5	14	8.5768	.27055	.34986
0	5	16	6.4322	.24712	.31884
0	5	18	4.8903	.22734	.28734
0	5	20	3.7696	.21119	.25683
0	5	25	2.0901	.18451	.19088
0	5	30	1.2639	.17168	.14317
0	5	40	0.58630	.16521	.09028
0	5	50	.34599	.16694	.06711
0	6	0	92.548	.48136	.45060
0	6	1	76.331	.46836	.45266
0	6	2	63.160	.45478	.45387
0	6	3	52.433	.44069	.45406
0	6	4	43.671	.42614	.45313

TABLE 2. *Luminous internal transmittances in percent, 100* $T_{i,A}$, *and chromaticity coordinates,* x,y, *of single glasses and two-part combinations of ideal Lovibond glasses illuminated by CIE Source* A—Continued

R	Y	B	$T_{i,A}$	x	y	R	Y	B	$T_{i,A}$	x	y	R	Y	B	$T_{i,A}$	x	y
0	6	5	36.492	0.41122	0.45094	0	15	5	32.480	0.43998	0.48912	0	40	5	24.314	0.46045	0.51249
0	6	6	30.595	.39603	.44740	0	15	6	27.163	.42811	.49158	0	40	6	20.277	.45185	.51820
0	6	7	25.735	.38067	.44244	0	15	7	22.784	.41611	.49320	0	40	7	16.953	.44333	.52357
0	6	8	21.719	.36527	.43602	0	15	8	19.168	.40402	.49391	0	40	8	14.210	.43494	.52854
0	6	9	18.390	.34995	.42813	0	15	9	16.173	.39193	.49361	0	40	9	11.940	.42670	.53307
0	6	10	15.623	.33485	.41882	0	15	10	13.685	.37987	.49224	0	40	10	10.057	.41867	.53710
0	6	12	11.387	.30580	.39627	0	15	12	9.8850	.35615	.48608	0	40	12	7.1861	.40334	.54345
0	6	14	8.4099	.27906	.36943	0	15	14	7.2220	.33337	.47526	0	40	14	5.1822	.38926	.54726
0	6	16	6.2941	.25532	.33975	0	15	16	5.3367	.31200	.45989	0	40	16	3.7709	.37666	.54822
0	6	18	4.7738	.23497	.30887	0	15	18	3.9885	.29245	.44045	0	40	18	2.7684	.36578	.54613
0	6	20	3.6698	.21810	.27827	0	15	20	3.0151	.27504	.41773	0	40	20	2.0505	.35683	.54088
0	6	25	2.0182	.18956	.20999	0	15	25	1.5762	.24188	.35304	0	40	25	1.0074	.34397	.51415
0	6	30	1.2087	.17541	.15883	0	15	30	0.88827	.22298	.28919	0	40	30	0.52632	.34588	.47125
0	6	40	0.54946	.16805	.10054	0	15	40	.35472	.21479	.19596	0	40	40	.17870	.38863	.36958
0	6	50	.31899	.17004	.07465	0	15	50	.18580	.22451	.14807	0	40	50	.083866	.45450	.29516
0	8	0	90.301	.48625	.45647	0	20	0	78.391	.49900	.47198	0	60	0	50.611	.50246	.48625
0	8	1	74.452	.47404	.45964	0	20	1	64.552	.48918	.47778	0	60	1	41.656	.49475	.49289
0	8	2	61.580	.46132	.46211	0	20	2	53.313	.47910	.48335	0	60	2	34.373	.48700	.49948
0	8	3	51.097	.44813	.46377	0	20	3	44.160	.46877	.48862	0	60	3	28.436	.47923	.50598
0	8	4	42.534	.43453	.46447	0	20	4	36.685	.45824	.49350	0	60	4	23.583	.47150	.51234
0	8	5	35.521	.42058	.46411	0	20	5	30.565	.44755	.49791	0	60	5	19.606	.46384	.51853
0	8	6	29.759	.40635	.46258	0	20	6	25.539	.43673	.50175	0	60	6	16.340	.45628	.52450
0	8	7	25.012	.39194	.45977	0	20	7	21.400	.42585	.50496	0	60	7	13.650	.44888	.53020
0	8	8	21.090	.37744	.45562	0	20	8	17.983	.41494	.50744	0	60	8	11.429	.44167	.53558
0	8	9	17.839	.36294	.45010	0	20	9	15.154	.40405	.50912	0	60	9	9.5912	.43468	.54061
0	8	10	15.138	.34857	.44318	0	20	10	12.806	.39323	.50993	0	60	10	8.0667	.42796	.54525
0	8	12	11.006	.32060	.42529	0	20	12	9.2199	.37202	.50869	0	60	12	5.7430	.41544	.55317
0	8	14	8.1033	.29437	.40257	0	20	14	6.7101	.35168	.50337	0	60	14	4.1228	.40438	.55906
0	8	16	6.0428	.27056	.37609	0	20	16	4.9360	.33259	.49383	0	60	16	2.9835	.39502	.56266
0	8	18	4.5641	.24965	.34721	0	20	18	3.6697	.31507	.48021	0	60	18	2.1762	.38758	.56374
0	8	20	3.4920	.23186	.31739	0	20	20	2.7575	.29940	.46289	0	60	20	1.5998	.38229	.56213
0	8	25	1.8931	.20052	.24665	0	20	25	1.4156	.26940	.40778	0	60	25	0.76789	.37974	.54556
0	8	30	1.1146	.18416	.18993	0	20	30	0.78034	.25286	.34633	0	60	30	.38974	.39423	.51146
0	8	40	0.48880	.17537	.12158	0	20	40	.29717	.25100	.24487	0	60	40	.12440	.46852	.41232
0	8	50	.27566	.17814	.09030	0	20	50	.15024	.27000	.18822	0	60	50	.056520	.55951	.32823
0	10	0	88.141	.48986	.46076	0	30	0	70.012	.50219	.47724	0	100	0	33.551	.49699	.49557
0	10	1	72.650	.47827	.46472	0	30	1	57.626	.49326	.48362	0	100	1	27.646	.49004	.50198
0	10	2	60.069	.46622	.46812	0	30	2	47.565	.48415	.48988	0	100	2	22.835	.48313	.50832
0	10	3	49.823	.45376	.47083	0	30	3	39.371	.47489	.49598	0	100	3	18.905	.47629	.51456
0	10	4	41.454	.44092	.47276	0	30	4	32.679	.46553	.50183	0	100	4	15.688	.46955	.52067
0	10	5	34.600	.42777	.47377	0	30	5	27.199	.45610	.50738	0	100	5	13.047	.46296	.52661
0	10	6	28.971	.41436	.47375	0	30	6	22.699	.44665	.51257	0	100	6	10.875	.45654	.53233
0	10	7	24.333	.40077	.47262	0	30	7	18.995	.43722	.51732	0	100	7	9.0835	.45033	.53781
0	10	8	20.501	.38707	.47027	0	30	8	15.937	.42786	.52157	0	100	8	7.6028	.44436	.54302
0	10	9	17.327	.37335	.46666	0	30	9	13.407	.41859	.52525	0	100	9	6.3762	.43867	.54792
0	10	10	14.690	.35970	.46173	0	30	10	11.307	.40947	.52831	0	100	10	5.3579	.43329	.55248
0	10	12	10.656	.33297	.44793	0	30	12	8.1037	.39183	.53233	0	100	12	3.8046	.42355	.56046
0	10	14	7.8256	.30760	.42912	0	30	14	5.8656	.37523	.53323	0	100	14	2.7210	.41538	.56674
0	10	16	5.8178	.28421	.40603	0	30	16	4.2869	.35996	.53074	0	100	16	1.9594	.40896	.57112
0	10	18	4.3786	.26331	.37974	0	30	18	3.1634	.34626	.52470	0	100	18	1.4204	.40453	.57340
0	10	20	3.3365	.24518	.35153	0	30	20	2.3568	.33434	.51513	0	100	20	1.0365	.40228	.57338
0	10	25	1.7869	.21220	.28072	0	30	25	1.1789	.31341	.47732	0	100	25	0.48572	.40768	.56204
0	10	30	1.0368	.19427	.22018	0	30	30	0.62958	.30599	.42585	0	100	30	.23889	.43124	.53295
0	10	40	0.44075	.18467	.14299	0	30	40	.22400	.32575	.32159	0	100	40	.070943	.52792	.43224
0	10	50	.24245	.18871	.10652	0	30	50	.10811	.36914	.25394	0	100	50	.030968	.63142	.33697
0	15	0	83.068	.49568	.46773	0	40	0	62.705	.50321	.48078						
0	15	1	68.430	.48517	.47289	0	40	1	51.603	.49482	.48736						
0	15	2	56.542	.47430	.47771	0	40	2	42.582	.48631	.49388						
0	15	3	46.861	.46313	.48208	0	40	3	35.233	.47772	.50027						
0	15	4	38.955	.45167	.48592	0	40	4	29.230	.46908	.50649						

3. Relation Between the Ideal and Actual Lovibond Scales

The ideal Lovibond system specified by calculation from the spectral internal transmittances of the ideal unit glasses given in table 1 necessarily yields perfectly smooth loci of constant numbers of red, yellow, or blue units (see figs. 2–6) on the chromaticity diagram, and also necessarily meets perfectly the additivity condition that a glass designated R on the ideal Lovibond red scale have the same chromaticity for the specified source as the light from that source after transmission through R ideal Lovibond red unit glasses in succession. The actual Lovibond scales identify the glasses issued by Tintometer Ltd.

by the numbers, N_r, N_y, N_b, engraved on the red, yellow, and blue glasses, respectively. These numbers are assigned to the glasses by visual comparison with the master standards of the Lovibond system, and, in general, the glasses to which they are assigned deviate slightly from the spectral characteristics of the ideal Lovibond glasses given in table 1. This deviation arises from the fact that slight variations in the spectral characteristics of the glasses have to be tolerated to permit Lovibond glasses to be distributed at prices making feasible their application to the practical problems of color grading. As a result of these deviations, a plot of the spectrophotometrically determined chromaticity points for either the red, the yellow, or the blue series does not yield a perfectly smooth locus. Furthermore, as a result of errors in the visual grading, the spacing of points along the locus is irregular. If the portion of the glass measured spectrophotometrically is different from that graded visually rather large irregularities may result [5]. However, this error due to portion measured which is introduced when grading glasses visually refers to glasses purchased in 1912 which are 2 in. x ¾ in. in size. For the past 10 years rectangles ⅜ in. x ¾ in. in size only have been supplied by the maker and deviations between visual and spectrophotometric measurements due to portion of glass should be eliminated. The manufacturing tolerances adopted are such that deviations between the ideal (R,Y,B) notation and the nominal (N_r,N_y,N_b) are undetectable, or nearly so, in a viewing field subtending 2° or less at the eye of the observer.

4. Uses of the Ideal Lovibond Scales

By means of the relation shown in table 2 between the CIE x- and y-scales and the ideal Lovibond R-, Y- and B-scales for CIE source A, it is possible to obtain a close estimate of the nominal N_r-, N_y-, N_b-values of the two-part combination of Lovibond glasses required to change the chromaticity of incandescent-lamp light to any chromaticity (x,y) within the Lovibond gamut. To facilitate such determinations, the loci of chromaticity points corresponding to two-part combinations have been plotted on the CIE chromaticity diagram. Each locus corresponds to variations of one of R, Y, or B, with one of the other two held constant. Figure 1 shows a few of these loci to a small scale, and figures 2 to 6 show more of the loci for five sections of the chromaticity gamut shown completely in figure 1.

These chromaticity networks would appear also to be useful to assign regrade numerals to Lovibond glasses on the ideal Lovibond system which would be more precise than the nominal Lovibond grades. If the chromaticity point of the glass to be regraded falls precisely on the corresponding single-glass locus, a one-number regrade value may be assigned by one-dimensional interpolation; for example, a nominal 16.0 Lovibond red glass ($N_r=16.0$) might by spectrophotometric measurement be found to correspond to the chromaticity point for $R=15.8$, and might therefore be regraded as 15.8 on the ideal Lovibond red scale. This regrade could be taken as valid in combinations with other Lovibond glasses of whatever color (red, yellow, blue) or number, because the agreement of the spectrophotometrically determined chromaticity point with the single-glass locus corroborates the correctness of the spectral character of the glass. If, on the other hand, the spectrophotometrically determined chromaticity point fails to fall precisely on the corresponding single-glass locus, the regrade would have to consist of two numerals found by two-dimensional interpolation on the chromaticity network (figs. 2 to 6). For example, a nominally 16.0 Lovibond red glass ($N_r=16.0$) might be regraded as $R=16.0$, $Y=0.10$. This two-numeral regrade is approximately valid in combinations of this glass with other single Lovibond glasses of any color (red, yellow, or blue). The failure of this two-numeral regrade to apply strictly arises from the fact that the off-locus glass must depart somewhat (perhaps within manufacturing tolerances) from the intended spectral character, and also may, and almost certainly will, depart from the spectral character implied by the two-numeral regrade. This failure constitutes a restriction on this use of the chromaticity network of the ideal Lovibond system (figs. 2 to 6) until such time as improvements in glass-making techniques make possible the provision by the Tintometer Company of Lovibond glasses conforming to the ideal. A practical restriction on this use is that the cost of determining the chromaticity coordinates (x,y) accurately by spectrophotometric measurements is likely to be several times the cost of the Lovibond glass itself.

5. Summary

The basic definitions of the ideal Lovibond color scales are given; see table 1. These definitions permit, for any defined source, the correlation of the ideal Lovibond color scales with the internationally recognized CIE coordinate system for colorimetry. Such correlations are available from Tintometer Ltd. in the form of large scale graphs [4,6] for CIE sources B and C, and are supplied in the present paper for CIE source A; see table 2 and figures 1 to 6.

6. References

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[5] G. W. Haupt and F. L. Douglas, Chromaticities of Lovibond glasses, J. Research NBS **39,** 11 (1947) RP 1808; J. Opt. Soc. Am. **37,** 698 (1947)

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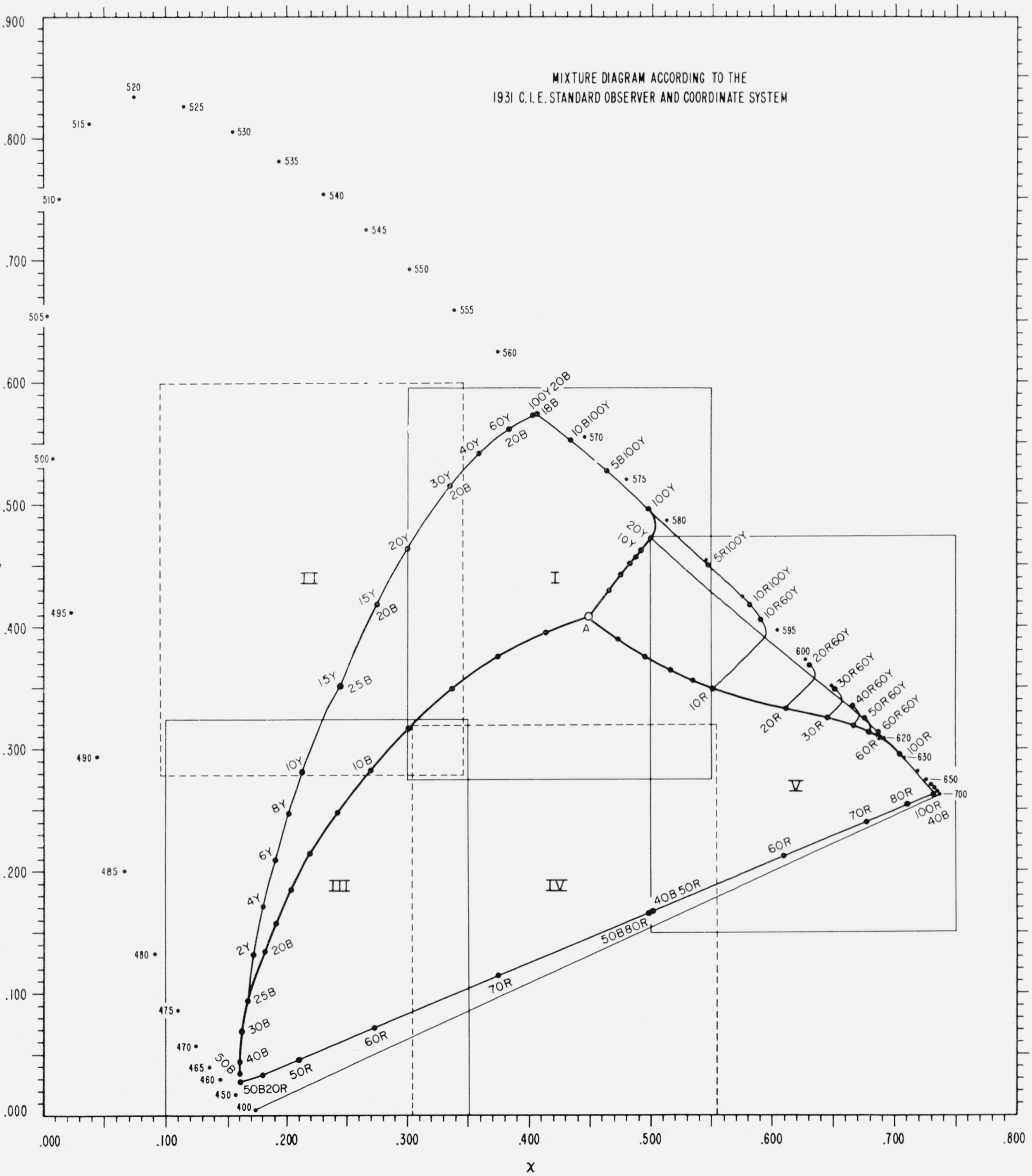

FIGURE 1. *Chromaticity gamut of the ideal Lovibond color system showing the relation between the x- and y-scales and the ideal Lovibond* R-, Y-, *and* B-*scales for CIE Source* A.

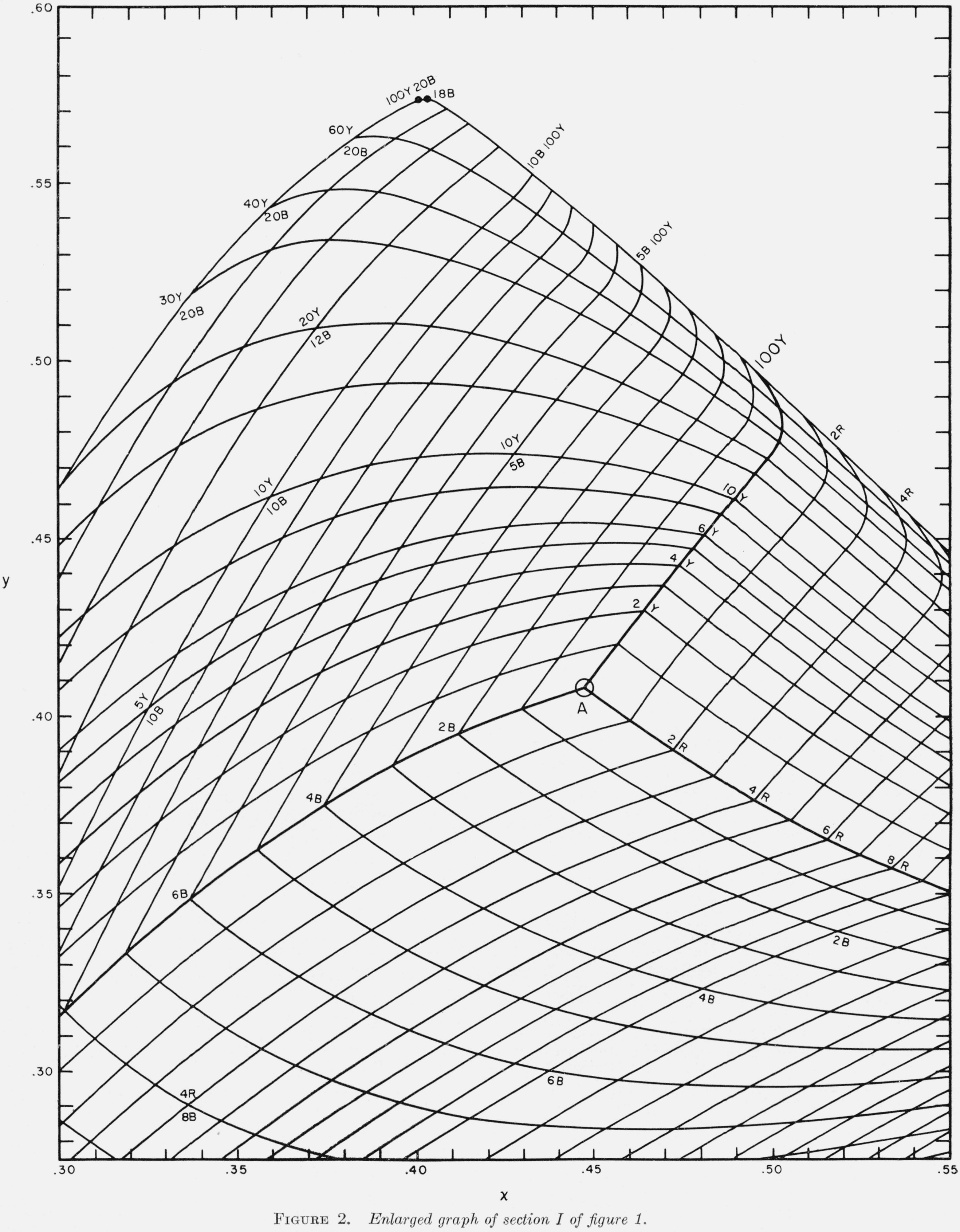

FIGURE 2. *Enlarged graph of section I of figure 1.*

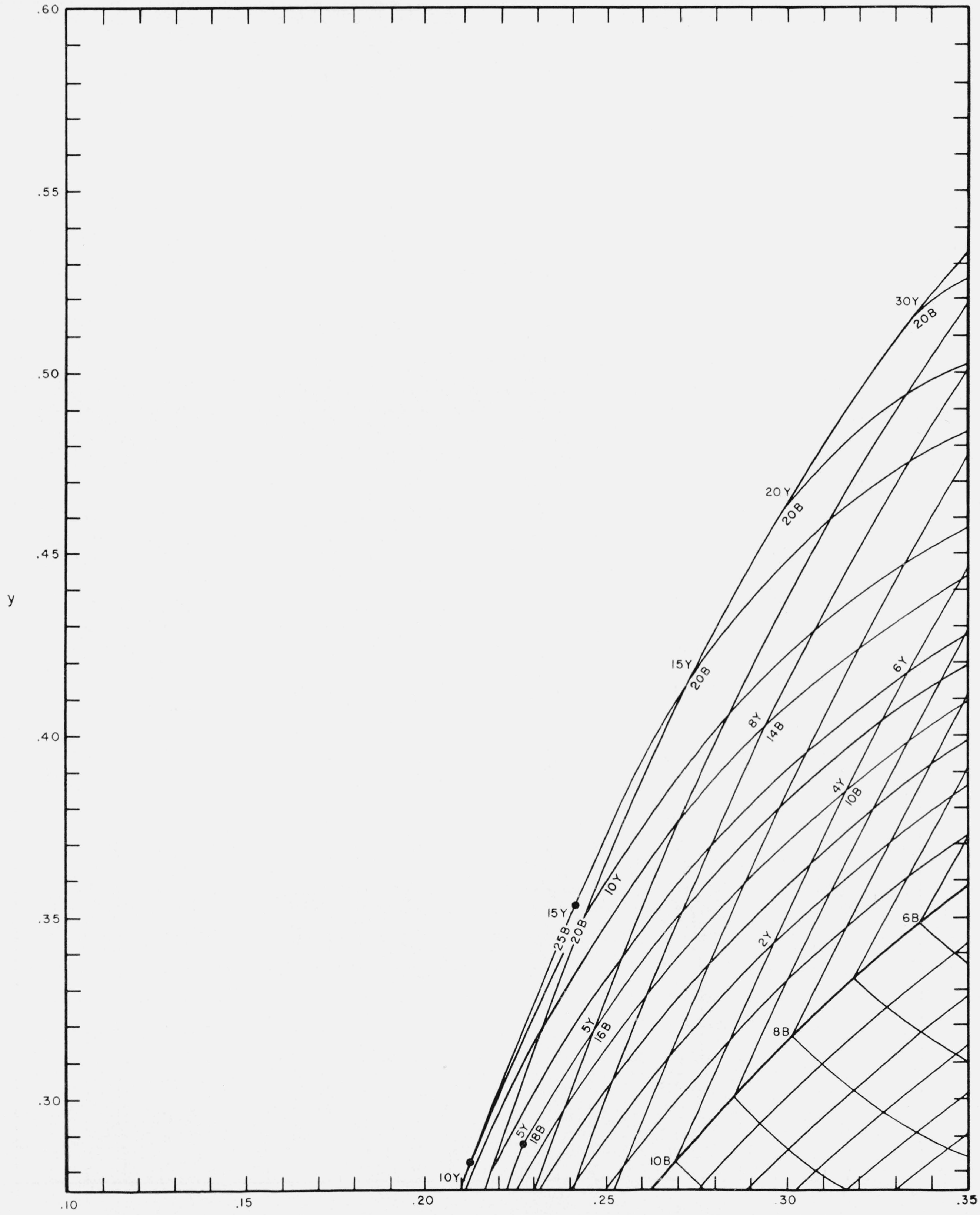

FIGURE 3. *Enlarged graph of section II of figure 1.*

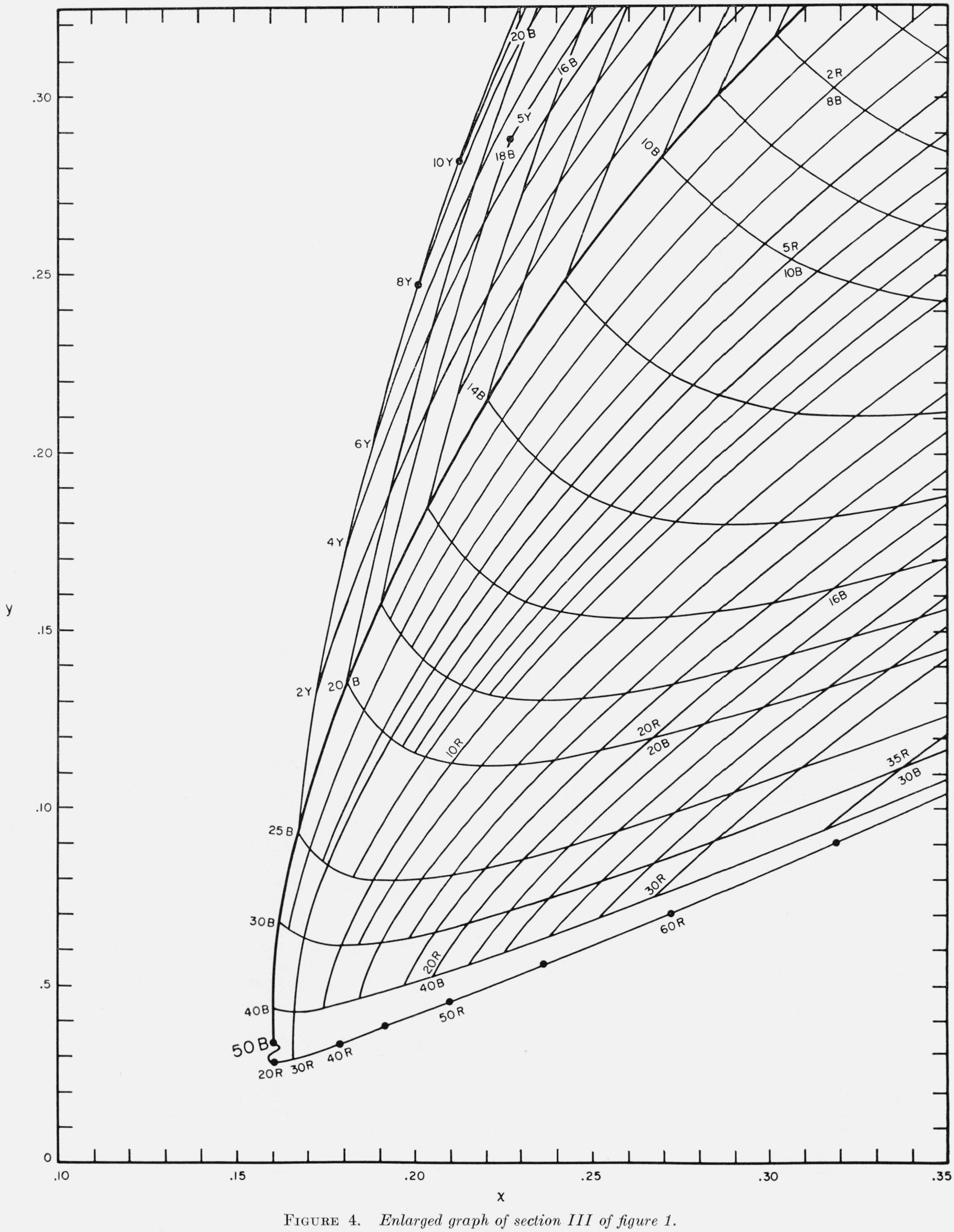

Figure 4. *Enlarged graph of section III of figure 1.*

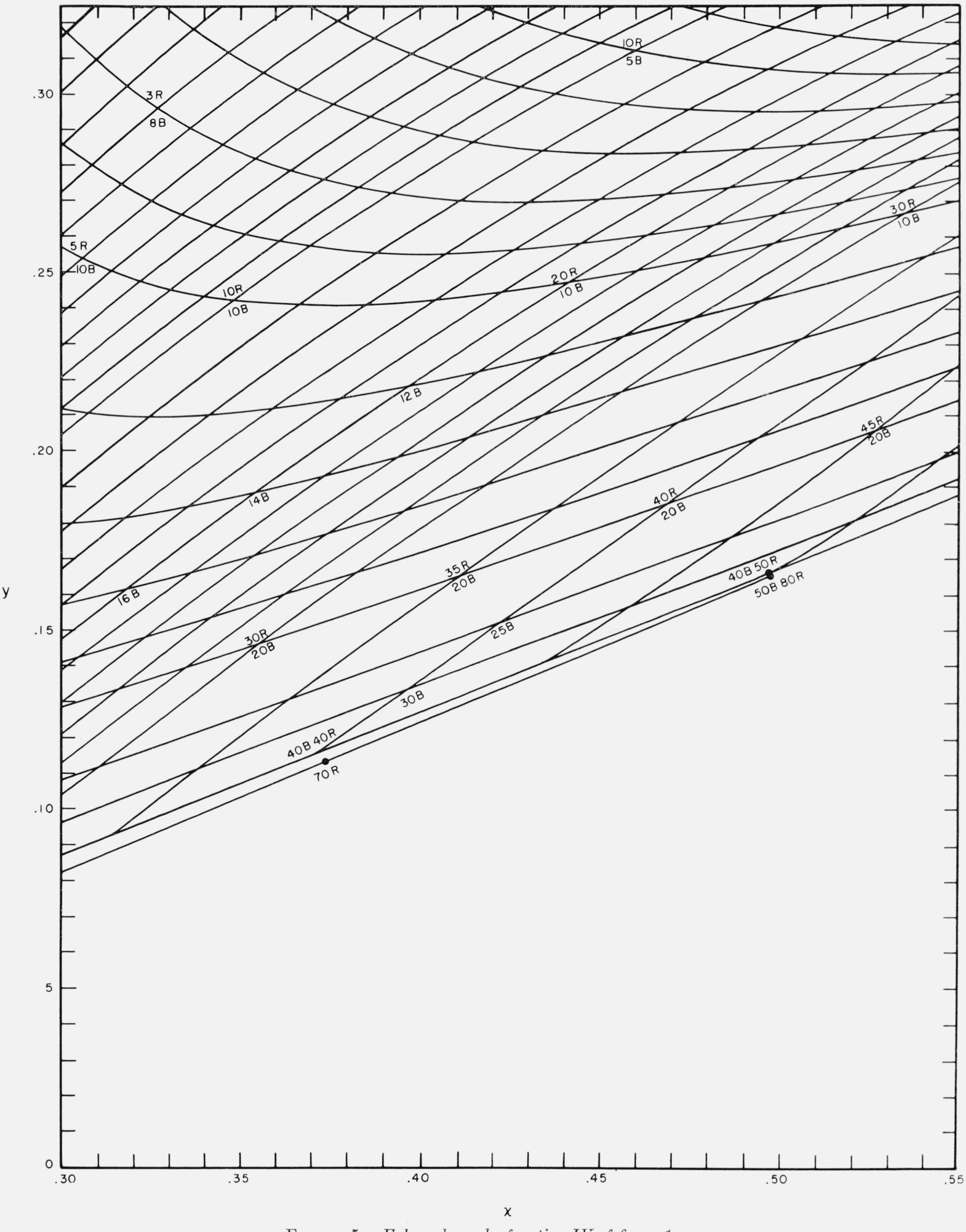

Figure 5. *Enlarged graph of section IV of figure 1.*

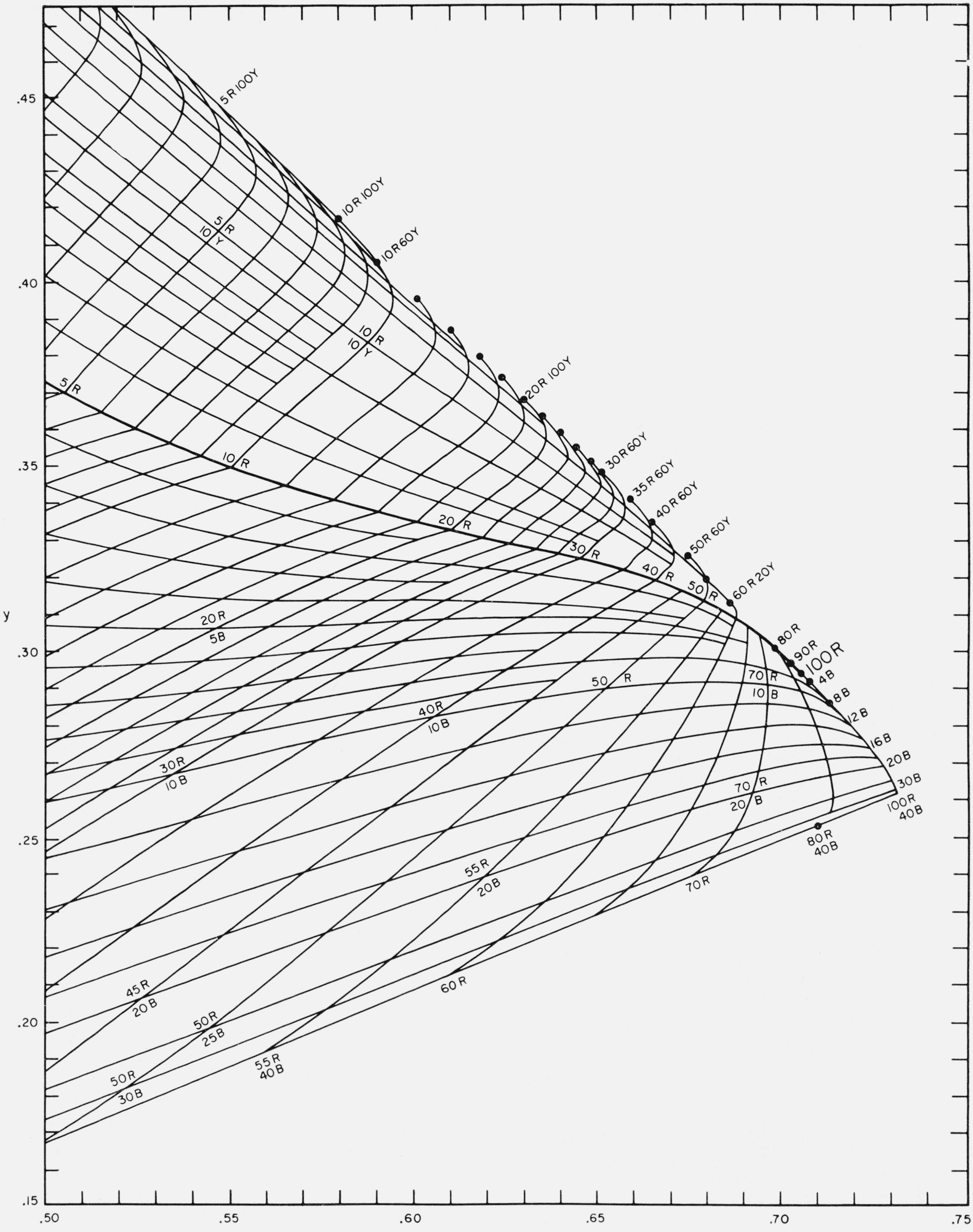

Figure 6. *Enlarged graph of section V of figure 1.*