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THE GALACTIC CLUSTER M25*

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ABSTRACT

Photometric data on the Johnson-Morgan B, V system are given for 1401 stars in the cluster area. Differential reddening exists across the cluster region and ranges from a minimum value of $E_{(B-V)} =$ 0.29 magnitudes to a maximum of $E_{(B-V)} = 0.60$ magnitudes. A distance modulus of 9.0 ± 0.2 magnitudes was derived through the utilization of the Johnson evolutionary deviation curve method. There appear to be two G-type red-giant members of the cluster in addition to the 6.7-day classical cepheid U Sagittarii. The cluster luminosity function was studied to $M_V = +5.0$ and tends to agree with the Salpeter initial luminosity function.

I. INTRODUCTION

The galactic cluster M25 is located in the direction of the galactic center near heavy, irregular obscuring features in Sagittarius. Its 1950.0 position is $\alpha = 18^h28^m.7$, $\delta = -19°17'.1$, and $l^{II} = 13°.6$, $b^{II} = -4°.5$. This open cluster is of particular interest because the classical cepheid U Sagittarii is optically coincident (Irwin 1955). The conjunction of the cepheid and cluster had previously been indicated by Doig (1925). The Palomar Sky Atlas shows that the cluster possesses several bright stars and many of intermediate brightness superposed upon multitudes of faint background stars. A dark lane of absorption passes near the apparent center of M25. Even a cursory glance at the 48-inch Schmidt plates shows that differential reddening exists across the face of the cluster. References to early investigations of this open cluster may be found in the *Catalogue of Star Clusters and Associations* (Alter, Ruprecht, and Vanysek 1958). Four modern photoelectric studies of the cluster have been made (Irwin 1958; Johnson 1960*a;* Sandage 1960; and Wampler, Pesch, Hiltner, and Kraft 1961). Spectroscopic studies, important since they helped to confirm the opinion that U Sagittarii is a cluster member, have been made by Feast (1957) and Wallerstein (1957).

II. PHOTOELECTRIC OBSERVATIONS

Photoelectric magnitude sequences have been established in M25 by Sandage (1960), Johnson (1960*a*), Wampler *et al.* (1961), and Irwin (1958). These authors observed 81, 131, 78, and 75 stars, respectively. Together, they observed a total of 136 different stars; 32 stars are in common to all four sequences. The yellow magnitudes of Wampler *et al.* are approximately a mean of the magnitudes for a given star in the other three sequences. This is not the case for the $(B - V)$ color where everyone except Wampler *et al.* agrees systematically to about 0.001 magnitude in the mean. The $(B - V)$ color of Wampler *et al.* is systematically 0.016 magnitudes redder than the other sequences.

The data given by Wampler *et al.* (1961) were obtained at the McDonald Observatory, whereas Sandage (1960) observed in the south from Mount Wilson in a region of high sky brightness due to the Los Angeles lights. Roughly two-thirds of Johnson's (1960*a*) observations were made at McDonald; the remainder were made at the Lowell Observatory. Irwin's (1958) data were obtained at the Radcliffe Observatory in South Africa. Sandage observed each of his stars once; Johnson averaged 2.5 observations per star

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while Wampler *et al.* observed each star about 1.8 times. Essentially all of Irwin's stars were observed twice.

The above statements indicate the difficulty in choosing any of the four photometric systems as a basic system. Intercomparison of the four sequences are displayed in Figures 1, 2, 3, and 4. Comparison of the Wampler *et al.* (1961) yellow magnitudes to the other three sequences shows the scatter to be over a range of about 0.07 magnitudes. A few stars will fall outside this limit in each sequence. The bright sky over Los Angeles and the single observation per star have not adversely affected Sandage's (1960) magnitudes and colors with respect to the other photoelectric sequences. Sandage's observational scatter in the V magnitude (Fig. 2, *c*) is only slightly greater. The same holds true for his $(B - V)$ color (Fig. 3, *a*).

The photoelectric sequence of Wampler *et al.* (1961) was chosen as the sequence to which all others would be referred. Previously published data for magnitudes and colors

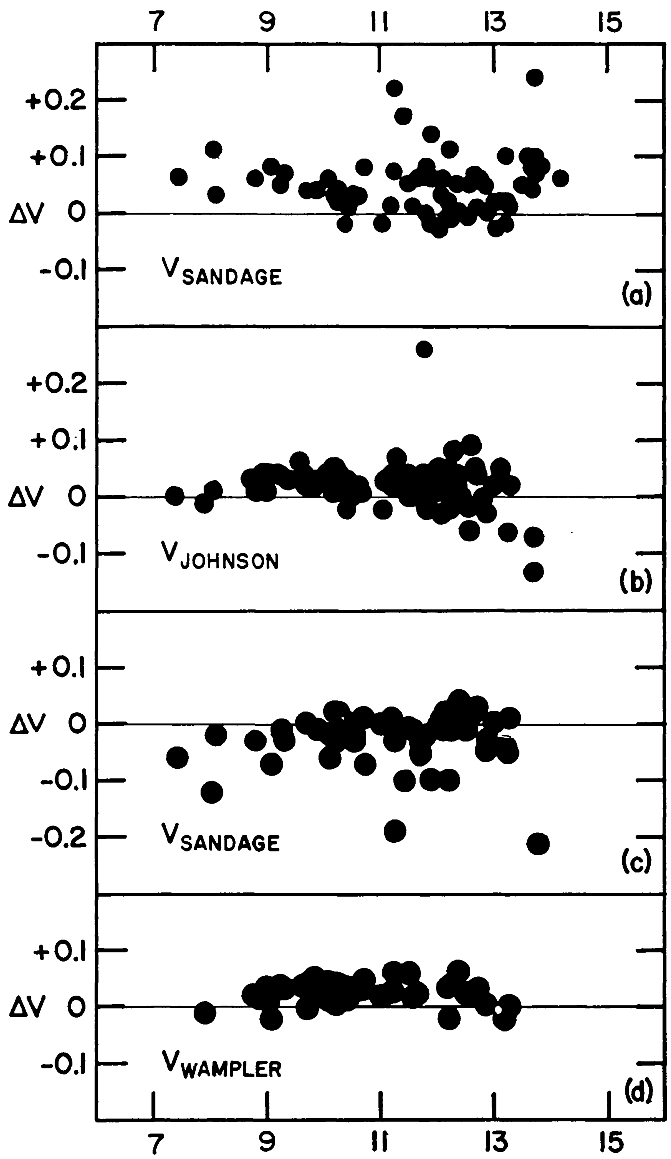

FIG. 1.—Intercomparison of the V-magnitude systems in the sense of *a*, Sandage *minus* Johnson; *b*, Wampler *minus* Johnson; *c*, Wampler *minus* Sandage; and *d*, Wampler *minus* Irwin.

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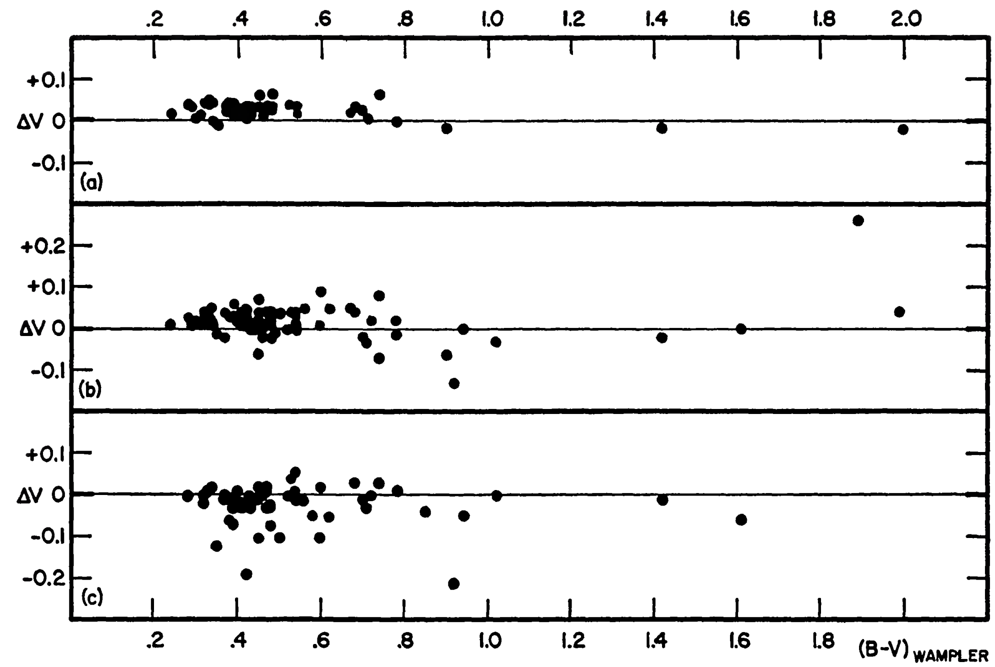

FIG. 2.—Comparison of the V-magnitude systems to Wampler's $(B - V)$ color in the sense of *a*, Wampler *minus* Irwin; *b*, Wampler *minus* Johnson; and *c*, Wampler *minus* Sandage.

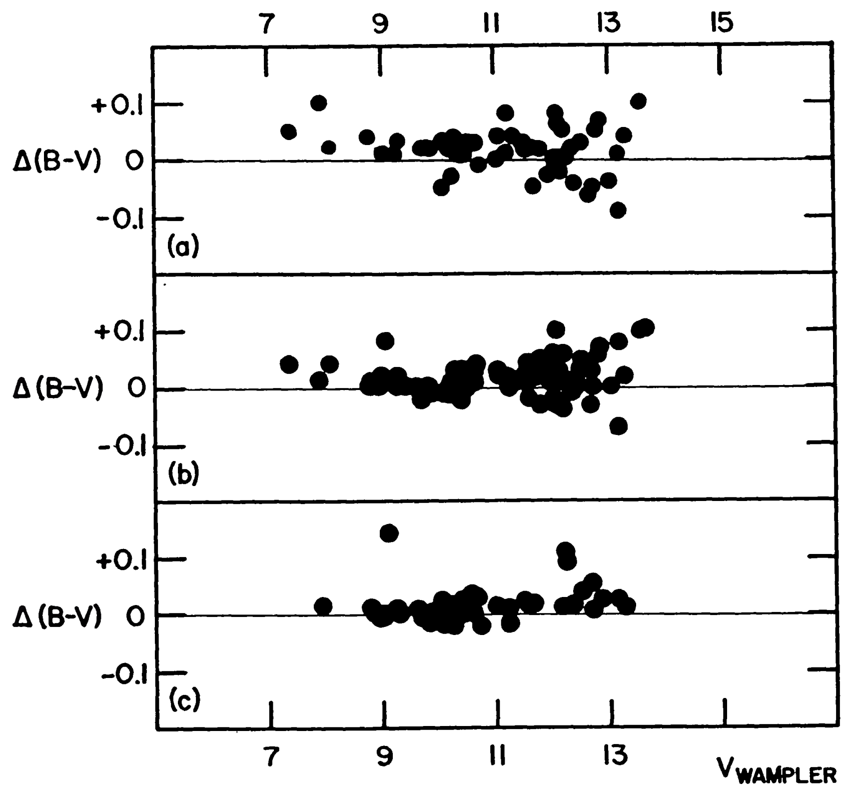

FIG. 3.—Comparison of the $(B - V)$ color systems to Wampler's V-magnitude in the sense of *a*, Wampler *minus* Sandage; *b*, Wampler *minus* Johnson, and *c*, Wampler *minus* Irwin.

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had not agreed as well as might have been suspected. Since the difficulties may have arisen from extinction problems, photometric data obtained at McDonald Observatory tied accurately to spectrograms of cluster stars classified on the MK system seem to be preferred (Wampler *et al.*, 1961). Table 1 shows the difference in the V and $(B - V)$ of each observer's photoelectric sequence as compared to the sequence of Wampler *et al.* The values tabulated are the necessary systematic corrections required to place each sequence onto the Wampler *et al.* system. The final standard photoelectric values utilized are listed in Table 2. The first column identifies the standard star in the cluster identification chart (Fig. 5). The standard star numbering system is that of Wampler *et al.*, and the standard stars are further identified in this system in the second column. The third, fourth, and fifth columns identify the standard stars in Sandage's, Johnson's, and Irwin's systems, respectively.

III. PHOTOGRAPHIC OBSERVATIONS

The present photographic data tabulated in Table 3 were obtained and treated in reduction processes in a manner similar to that of the preceding paper on the galactic

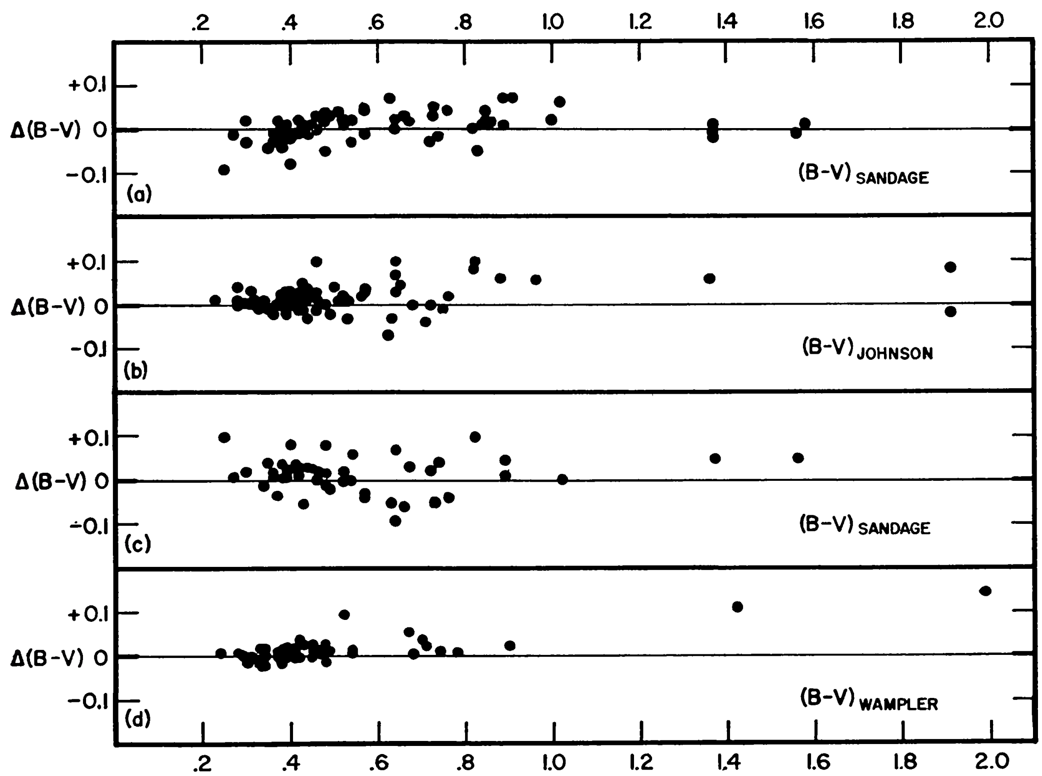

FIG. 4.—Intercomparison of the $(B - V)$ color systems in the sense of *a*, Sandage *minus* Johnson; (*b*), Wampler *minus* Johnson; *c*, Wampler *minus* Sandage; and *d*, Wampler *minus* Irwin.

TABLE 1

COMPARISON OF PHOTOELECTRIC SEQUENCES

	V	$(B-V)$
Wampler *minus* Sandage.......	-0^m015	$+0^m015$
Wampler *minus* Johnson.......	+ .020	+ .015
Wampler *minus* Irwin..........	+0.025	+0.015

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TABLE 2

PHOTOMETRIC STANDARDS IN M25

Star	Star Identification Numbers				Photoelectric			Photographic	
	Wampler	Sandage	Johnson	Irwin	V	B-V	E_{B-V}	V	B-V
III-2-16	1	84	84	--	11.695	0.600	(0.54)	11.68	0.63
IV-2-18	3	88	88	--	13.172	.637	(0.49)	13.21	.61
17	4	89	89	--	12.172	.483	0.45	12.18	.52
16	5	90	90	--	12.052	1.010	(0.48)	12.05	.98
15	6	91	91	--	8.085	.310	0.43	8.09	0.22
IV-2-37	9	92	92	9	11.213	0.401	0.46	11.20	0.39
34	9A	62	62	--	13.695	.863	(0.47)	13.70	.74
10	10	95	95	10	12.178	.543	(0.56)	12.19	.54
12	11	94	94	11	12.239	1.376	(0.48)	12.25	1.36
13	12	93	93	12	10.387	.383	0.49	10.27	0.36
IV-2-5	13	96	96	13	9.687	0.330	0.46	9.70	0.26
4	14	97	97	14	8.772	.388	0.54	8.72	.27
3	15	98	98	15	10.198	.417	0.54	10.13	.37
7	17	100	100	17	10.078	.412	0.54	10.05	.38
8	18	99	99	18	9.878	.387	0.52	9.89	0.42
III-2-15	19	104	104	19	13.290	0.773	(0.51)	13.29	0.76
18	23	144	144	--	13.015	.743	(0.52)	13.01	.75
10	32	109	--	32	10.089	.412	0.50	10.01	.43
III-2-3	36	106	106	228	11.219	.474	0.54	11.21	.48
II-2-20	41	147	147	41	12.882	.680	(0.50)	12.85	0.72

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TABLE 2--Continued

Star	Star Identification Numbers				Photoelectric			Photographic	
	Wampler	Sandage	Johnson	Irwin	V	B-V	E_{B-V}	V	B-V
II-2-21	42	148	148	42	13.218	0.882	(0.50)	13.18	0.96
26	43	149	149	43	10.421	.424	0.53	10.38	.47
II-3-19	44	157	157	--	11.948	.557	(0.51)	11.95	.60
17	45	159	159	45	10.210	.366	0.49	10.17	.44
II-2-2	49	135	118	49	11.030	.460	0.54	10.98	0.44
II-2-3	50	136	117	50	11.576	0.532	(0.57)	11.57	0.53
4	51	137	116	51	12.722	.702	(0.49)	12.71	.71
10	54	114	114	54	11.495	.442	0.49	11.46	.48
7	57	112	112	57	12.268	.530	(0.51)	12.27	.55
I-2-1	58	142	111	58	9.019	.397	0.47	8.97	0.44
I-2-27	60	120	56	60	10.552	0.407	0.51	10.53	0.41
3	62	115	109	62	10.684	.466	0.59	10.68	.39
IV-2-1	63	102	102	63	9.276	.468	0.60	9.20	.51
2	64	101	101	64	10.273	.440	0.53	10.20	.49
I-2-11	66	--	107	--	12.045	.528	(0.53)	12.04	0.50
I-2-12	67	54	57	67	10.526	0.424	0.52	10.53	0.39
16	68	56	59	68	11.661	.477	0.53	11.65	.45
23	69	--	58	69	12.691	.651	(0.49)	12.65	.68
29	73	119	119	73	12.334	.745	(0.49)	12.31	.75
II-3-18	77	--	158	--	13.715	.698	(0.49)	13.94	0.52
II-3-20	81	161	161	--	11.815	0.467	0.47	11.80	0.52
II-4-13	83	164	164	--	12.152	.580	(0.56)	12.13	.64
11	84	--	167	84	8.966	.321	0.46	8.95	.37
9	85	--	166	--	11.920	1.908	(0.49)	11.78	1.98
II-3-1	86	131	130	--	11.115	.410	0.49	11.03	0.49

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TABLE 2--Continued

Star	Star Identification Numbers				Photoelectric			Photographic	
	Wampler	Sandage	Johnson	Irwin	V	B-V	E_{B-V}	V	B-V
II-4-1	88	--	128	88	9.827	0.314	0.44	9.85	0.32
I-3-30	89	--	126	89	9.622	.395	0.49	9.59	.42
28	90	--	125	--	11.520	.443	0.48	11.53	.44
24	91	--	124	--	12.420	.468	0.50	12.43	.52
I-4-30	92	--	44	92	10.206	.434	(0.56)	10.16	0.44
I-4-28	93	--	45	93	10.433	0.385	0.49	10.47	0.34
26	94	46	46	--	11.822	.513	0.53	11.83	.57
I-3-22	95	47	47	--	11.352	.443	0.50	11.35	.44
21	96	--	48	--	11.590	.488	0.53	11.57	.54
17	98	--	55	--	12.205	.698	(0.50)	12.23	0.66
I-3-3	99	51	51	99	9.230	0.376	0.59	9.19	0.34
IV-4-5	100	--	17	100	10.617	.296	0.38	--	--
IV-3-10	103	67	67	103	10.443	.286	0.38	10.45	.27
IV-4-21	106	31	--	106	10.704	.349	0.41	10.71	.35
IV-3-22	107	86	86	--	12.828	.913	(0.50)	12.86	0.85
IV-3-23	108	85	85	--	12.078	0.510	(0.51)	12.10	0.47
IV-4-41	109	--	70	109	8.989	.453	0.55	8.97	.51
54	112	--	79	--	12.370	.462	0.51	12.37	.48
III-3-2	114	81	81	--	12.655	.640	(0.56)	12.69	.65
16	117	--	151	--	11.835	.483	0.51	14.44:	--
III-3-21	118	--	152	--	10.515	0.333	0.42	10.48	0.43
III-4-21	124	--	153	124	9.415	.328	0.47	9.37	.37
I-5-9	144	--	42	144	9.708	.356	0.55	9.77	.37
17	145	--	41	--	11.805	.778	(0.48)	11.88	.71
18	146	--	40	--	12.560	.443	0.47	12.53	0.52

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TABLE 2--Continued

Star	Star Identification Numbers				Photoelectric			Photographic	
	Wampler	Sandage	Johnson	Irwin	V	B-V	E_{B-V}	V	B-V
IV-4-11	190	--	18	190	10.220	0.330	0.44	10.22	0.31
I-2-26	194	52	54	194	12.529	.681	(0.55)	12.55	.63
IV-4-25	208	29	29	--	12.075	.473	0.50	12.12	.44
23	210	30	30	--	12.405	.550	(0.51)	12.46	.52
III-3-28	39	150	150	39	7.392	1.590	(0.48)	7.50	1.60
I-4-19	97	--	49	97	9.088	1.925	(0.48)	9.16	1.86
I-3-4	6881	50	50	6881	7.962	.329	0.46	7.94	.30
II-4-15	6917	--	163	6917	8.836	.244	(0.33)	8.85	.24
I-2-19	--	60	60	211	14.114	.848	(0.48)	14.21	.83
20	--	61	61	212	13.125	1.378	(0.48)	13.11	1.33
I-2-24	--	55	--	213	14.267	1.141	(0.48)	14.43	1.09
25	--	53	--	214	14.042	1.855	(0.48)	13.92	1.91
30	--	118	--	215	13.917	.852	(0.47)	13.94	.86
I-3-18	--	121	--	216	14.706	.982	(0.53)	14.71	1.05
26	--	122	122	217	11.841	1.573	0.48	11.82	1.57
I-5-5	--	127	--	218	10.856	0.467	0.54	10.85	0.48
27	--	--	24	219	10.915	.380	0.48	10.92	.39
38	--	--	10	220	10.925	.349	0.44	10.95	.34
I-6-33	--	--	7	221	10.441	.396	0.50	10.47	.36
II-2-11	--	138	115	222	13.240	.491	0.56	13.28	0.45
II-2-19	--	111	--	223	14.353	1.690	(0.48)	14.34	1.68
28	--	134	134	224	13.749	.858	(0.51)	13.74	.89
II-3-9	--	133	133	225	13.710	.599	(0.55)	13.73	.59
II-6-10	--	--	168	226	10.363	.323	0.42	10.36	.34
27	--	--	174	227	8.963	1.984	(0.48)	9.00	1.93

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TABLE 2--Continued

Star	Star Identification Numbers				Photoelectric			Photographic	
	Wampler	Sandage	Johnson	Irwin	V	B-V	E_{B-V}	V	B-V
III-2-4	--	110	--	229	14.820	0.948	(0.54)	14.84	0.87
7	--	107	--	230	14.466	1.666	(0.48	14.45	1.93
8	--	108	--	231	14.076	.886	(0.55)	14.01	.89
III-5-28	--	--	191	232	10.381	.518	0.56	10.35	.55
30	--	--	192	233	10.075	.309	0.43	9.99	0.42
III-5-38	--	--	196	234	10.890	0.320	0.40	10.90	0.34
IV-5-41	--	--	73	235	9.732	.236	0.36	9.73	.27
IV-6-51	--	--	26	236	6.835	.848	(0.48)	6.80	.98
IV-7-69	--	--	75	237	9.820	.306	0.42	9.80	.34
II-2-8	--	141	113	238	12.508	1.542	(0.48)	12.47	1.62
I-8-28	--	--	3	--	10.110	0.415	0.53	10.11	0.39
IV-7-27	--	--	6	--	9.560	.245	0.37	9.55	.24
I-5-36	--	--	8	--	11.500	.425	0.46	11.52	.43
I-4-10	--	--	15	--	11.990	.745	(0.48)	12.02	.70
IV-5-28	--	--	22	--	11.620	1.265	(0.48)	11.63	1.27
IV-5-29	--	--	23	--	12.170	0.475	0.51	12.24	0.43
I-5-14	--	--	43	--	12.570	.555	0.58	12.57	.58
IV-2-31	--	63	63	--	11.912	.450	0.47	11.88	.43
IV-3-15	--	--	65	--	11.680	.415	0.45	11.70	.35
14	--	--	66	--	12.350	.535	0.57	12.42	0.42
IV-3-16	--	68	68	--	12.752	1.390	(0.48)	12.81	1.31
IV-4-37	--	--	71	--	11.560	.365	0.29	11.56	.41
38	--	--	72	--	12.750	.535	0.58	12.92	.46
50	--	--	74	--	11.490	.375	0.41	11.53	.37
IV-6-55	--	--	76	--	10.970	.335	0.39	11.00	0.37

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TABLE 2--Continued

Star	Star Identification Numbers				Photoelectric			Photographic	
	Wampler	Sandage	Johnson	Irwin	V	B-V	E_{B-V}	V	B-V
IV-4-48	--	--	77	--	11.970	0.525	0.57	12.00	0.55
53	--	--	78	--	10.280	.725	(0.48)	10.28	.77
IV-3-30	--	82	82	--	13.562	.865	(0.49)	13.66	.78
III-3-1	--	83	83	--	13.048	.730	(0.49)	13.10	.75
IV-2-23	--	87	87	--	13.802	.890	(0.54)	13.91	0.88
I-3-25	--	--	123	--	13.750	0.735	(0.48)	13.86	0.67
II-4-2	--	--	129	--	11.360	1.665	--	11.32	1.68
II-3-8	--	132	132	--	13.612	.945	(0.48)	13.51	(1.46)
III-2-11	--	145	145	--	13.663	.855	(0.50)	13.67	.85
II-3-16	--	160	160	--	13.478	.850	(0.51)	13.45	0.83
II-4-10	--	165	165	--	13.612	1.005	(0.52)	13.64	0.98
II-5-17	--	--	172	--	12.590	.615	(0.48)	14.54	--
II-6-23	--	--	173	--	11.620	1.615	(0.47)	11.57	1.63
II-4-19	--	175	175	--	12.538	.440	0.49	12.49	.49
II-5-14	--	--	182	--	14.010	.895	(0.48)	14.01	.85
II-3-21	--	y	--	--	14.225	1.625	--	14.07	1.77

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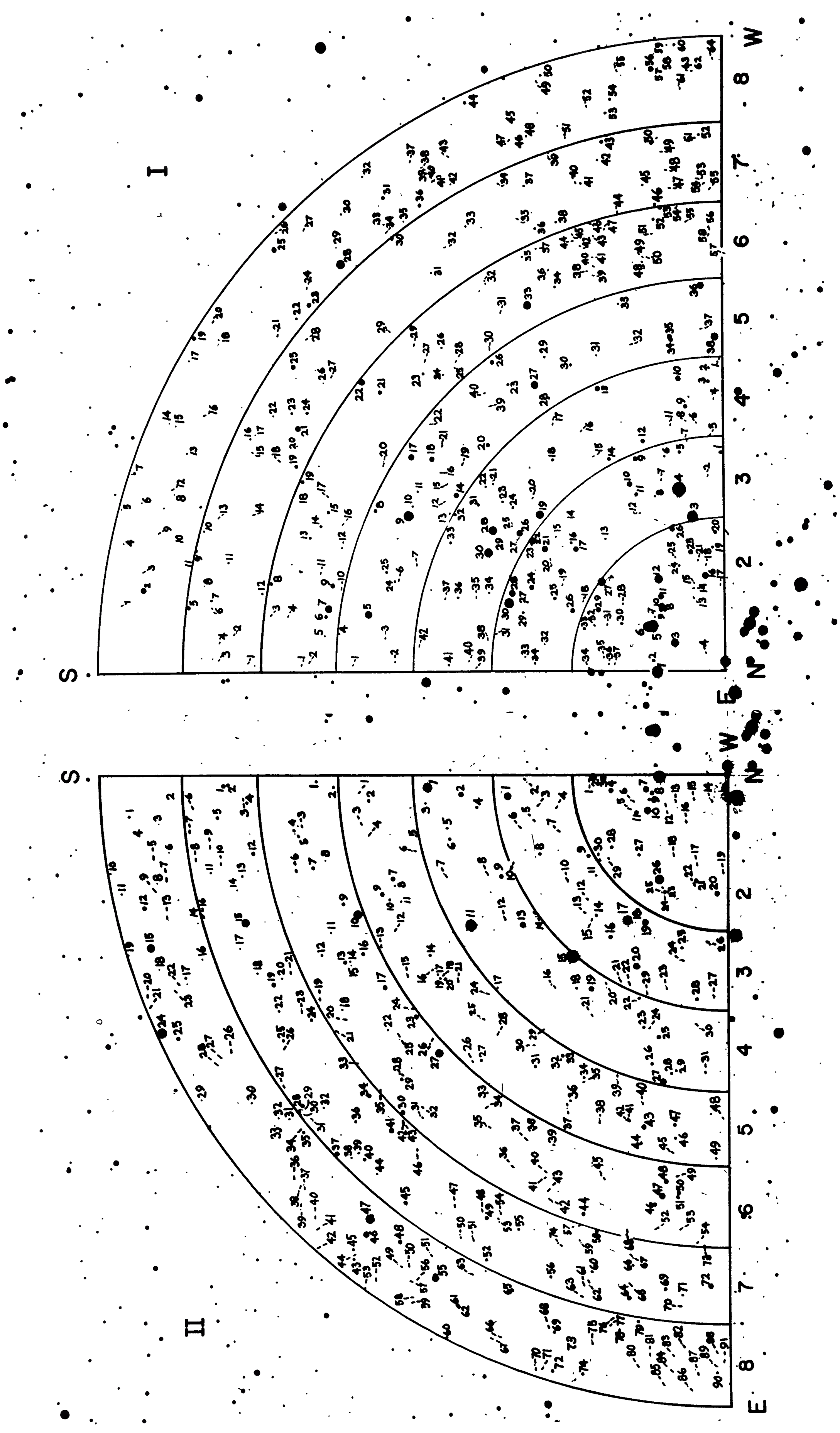

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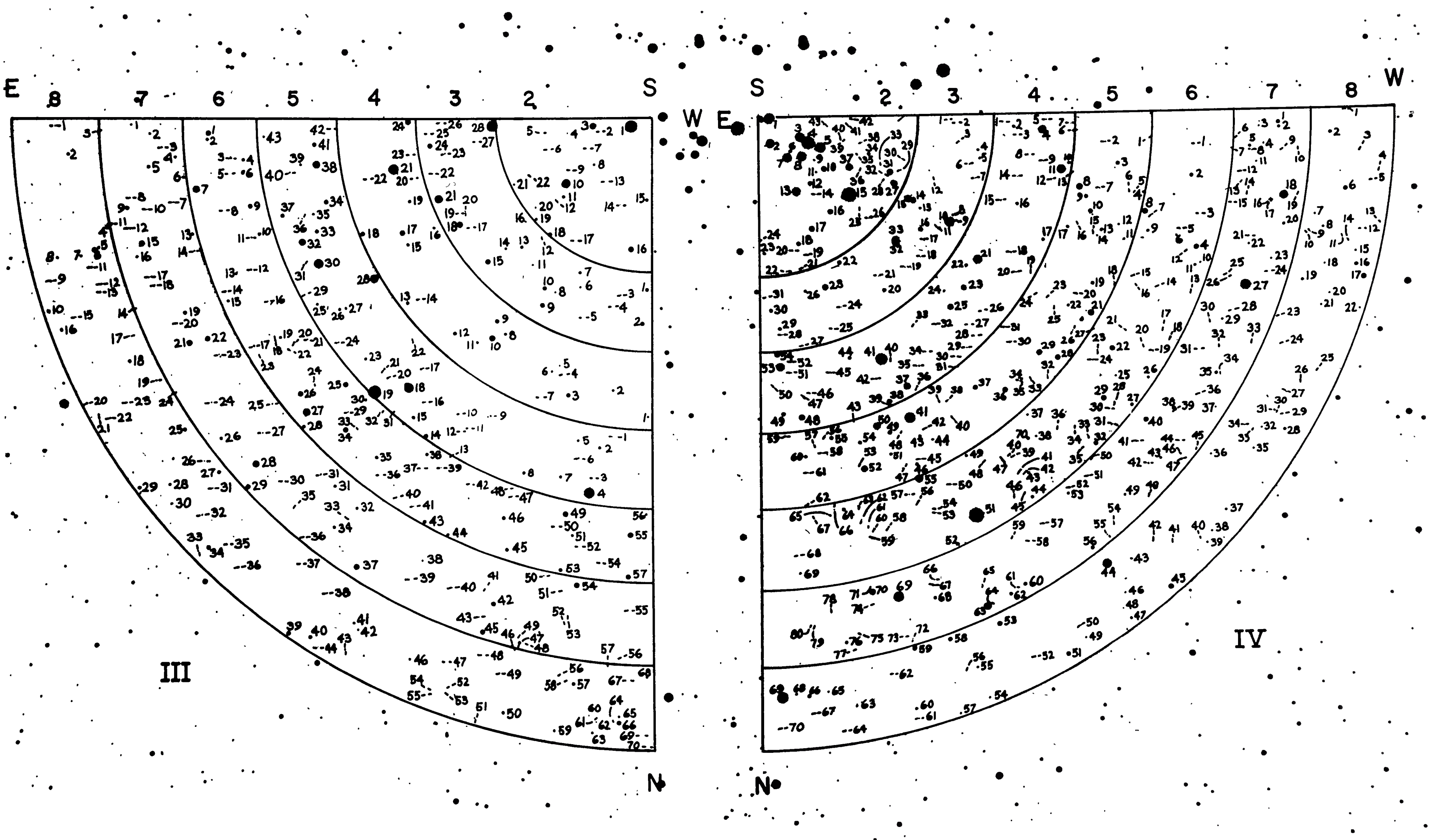

FIG. 5.—Identification chart from a blue plate of M25, quadrants I–IV. The approximate plate scale is 9 seconds of arc per millimeter

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TABLE 3

OBSERVATIONAL DATA

Plate No.	Filter-Emulsion	Date	Exposure	Remarks
41762 V	HPS + Omag 301	1957 Apr. 30	$16^h47^m.0-17^h47^m.0$	Instrument tends to trail; seeing good.
41768 V	HPS + Omag 301	1957 May 27	17 07.0-18 07.0	
41774 V	HPS + Omag 301	1957 June 20	16 46.0-17 46.0	
41779 V	103aD + Omag 301	1957 July 2	16 00.0-17 00.0	Instrument trailed few seconds; shows on brignt stars.
M128 V	103aD + Omag 301	1956 Apr. 16/17	3 10.0- 4 10.0	Seeing 1-2.
41762 P	IAZ + GG13	1957 Apr. 30	$16^h47^m.0-17^h47^m.0$	
41768 P	IAZ + GG13	1957 May 27	17 07.0-18 07.0	Part of plate broken away during development.
41774 P	IAZ + GG13	1957 June 20	16 46.0-17 46.0	
41779 P	IAZ + GG13	1957 July 2	16 00.0-17 00.0	
M127 P	103a0 + GG13	1956 Apr. 16/17	3 10.0- 4 10.0	

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cluster NGC 6087 (Landolt 1963). The stars investigated are identified in Figure 5. Corrections derived to eliminate the color equation and Purkinje effects are given in Table 4. A total of 1401 stars was investigated; the final *B*, *V* magnitudes, color, and color excess for each star may be found in Table 5. The magnitude and color of each of the photoelectric standards was read back through the photoelectric calibration curves. The magnitude and color thus obtained are recorded in the ninth and tenth columns of Table 2 for easy comparison with the photoelectric standard values. A comparison of the final *B*, *V* magnitude and color with the photoelectric values of Table 2 shows that the Purkinje effect has been successfully eliminated and the color equation effect removed. The probable error of a mean photographic magnitude in a given magnitude interval is shown in Table 6.

TABLE 4

CALIBRATION CURVE CORRECTIONS DESIGNED TO ELIMINATE COLOR EQUATION AND PURKINJE EFFECT

Magnitude Interval	Correction		Magnitude Interval	Correction	
	B	*V*		*B*	*V*
6.5	...	0.00	12.2	−0.01	0.00
6.6	...	− .01	12.3	.00	.00
6.7	...	.00	12.4–13.0	− .01	− .01
6.8–7.4	...	− .01	13.1–13.6	− .02	− .01
7.5–8.3	0.00	− .01	13.7	− .03	− .01
8.4–8.6	.00	.00	13.8–14.0	− .03	− .02
8.7–9.7	− .01	.00	14.1	− .03	− .03
9.8–10.9	.00	.00	14.2–14.3	− .03	− .04
11.0–11.5	.00	− .01	14.4–14.8	− .03	− .05
11.6–11.7	.00	− .02	14.9–15.8	− .03	−0.06
11.8–12.0	.00	− .01	15.9–16.6	− .03	...
12.1	−0.01	−0.01	16.7–17.0	−0.04	...

Since only plates in *B* and *V* were available in the present photographic study, it is necessary to determine the color excess for the stars in the present photographic investigation by studying the variable absorption across the cluster through the use of the photoelectrically determined color excesses of the stars in the adopted sequences. The color excesses determined from each individual photoelectric sequence were reduced onto the system of Wampler *et al.* (1961), in a manner similar to the one used for the *V*-magnitude and $(B - V)$ color. Table 7 shows the difference in $E_{(B-V)}$ between each observer's photoelectric sequence as compared to the sequence of Wampler *et al.* The values tabulated are the necessary systematic corrections required to place each sequence onto the Wampler *et al.* system. There are 48 stars common to Wampler and Sandage's system, 74 stars common to Wampler and Johnson, and 45 stars common to Irwin and Wampler. Sandage (1960) and Wampler *et al.* (1961) have computed and listed the color excesses for the stars which they observed in their respective papers. I computed $E_{(B-V)}$ for the Johnson (1960*a*) stars through the use of the Johnson nomogram method (1958) for stars of spectral class B9 and earlier. An average color excess was derived for the remaining later spectral-type stars by fitting the observed color-color plot to the standard color-color plot as defined by Johnson and Morgan (1953). Similarly, the color excess was determined for the Irwin (1958) data, although here the color-color plot for the Royal Cape Observatory refractor as tabulated by Irwin (1961) was used. The data from the three-color work of Irwin gave a mean value of $E_{(B-V)} = 0^{m}.48$; the mean reddening determined from Johnson's photoelectric data was $0^{m}.47$. The Sandage and the Wampler

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TABLE 5

PHOTOGRAPHIC MEASUREMENTS IN M 25

Star	V	B-V	$E_{(B-V)}$	Star	V	B-V	$E_{(B-V)}$
1-2-1	8.97	0.44	0.47	1-3-5	13.91	.80	0.45
2	13.61	1.23	.48	6	13.94	1.59	.45
3	10.68	.39	.59	7	14.63	1.53	.45
4	15.19	.80	.54	8	14.70	.95	.52
5	9.17	.35	.54	9	12.82	.65	.45
6	9.76	.13	.54	10	12.49	.54	.52
7	15.34	.98	.54	11	13.47	.76	.52
8	13.54	.74	.54	12	14.32	1.81	.52
9	13.90	.83	.54	13	14.86	.69	.52
10	11.40	.46	.54	14	14.73	1.68	.52
11	12.04	.50	.53	15	15.53	1.03	.52
12	10.53	.39	.52	16	13.72	1.25	.52
13	14.94	1.60	.54	17	12.23	.66	.50
14	15.28	.95	.54	18	14.71	1.05	.53
15	14.10	1.94	.52	19	15.39	1.05	.52
16	11.65	.45	.53	20	14.86	1.09	.52
17	15.31	.88	.45	21	11.57	.54	.53
18	15.47	.89	.52	22	11.35	.44	.50
19	14.21	.83	.48	23	14.68	1.04	.52
20	13.11	1.33	.48	24	12.43	.52	.50
21	15.24	.94	.52	25	13.86	.67	.48
22	15.09	1.09	.52	26	11.82	1.57	.48
23	12.65	.68	.49	27	13.60	1.59	.49
24	14.43	1.09	.48	28	11.53	.44	.48
25	13.92	1.91	.48	29	14.20	1.04	.49
26	12.55	.63	.55	30	9.59	.42	.49
27	10.53	.41	.51	31	14.85	.98	.49
28	15.00	1.04	.54	32	14.92	.98	.49
29	12.31	.75	.49	33	14.96	.92	.49
30	13.94	.86	.47	34	14.49	1.05	0.49
31	15.70	.90	.54				
32	15.97	.58	.54	4-1	14.58	0.98	0.45
33	13.94	.85	.54	2	14.49	.61	.45
34	15.43	.88	.54	3	13.06	1.16	.45
35	15.24	1.13	.54	4	15.57	1.03	.45
36	15.53	.93	.54	5	---	---	--
37	15.62	0.96	0.54	6	15.12	1.49	.45
				7	14.50	2.02	.45
3-1	13.73	0.78	0.45	8	15.44	1.26	.45
2	15.21	.96	.45	9	13.24	.63	.45
3	9.19	.34	.59	10	12.02	.70	.48
4	7.94	.30	0.46	11	15.10	.88	0.45

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TABLE 5--Continued

Star	V	B-V	$E_{(B-V)}$	Star	V	B-V	$E_{(B-V)}$
1-4-12	13.21	0.71	0.45	1-5-13	15.50	0.99	0.58
13	12.39	.54	.49	14	12.57	.58	.58
14	13.42	.97	.52	15	15.16	.97	.58
15	15.58	1.05	.52	16	14.73	1.15	.58
16	15.60	.98	.45	17	11.88	.71	.48
17	15.05	1.15	.49	18	12.53	.52	.47
18	14.29	.67	.52	19	15.10	1.15	.49
19	9.16	1.86	.48	20	13.19	.70	.49
20	14.85	.95	.52	21	14.77	1.07	.49
21	15.14	.97	.49	22	15.00	1.09	.49
22	14.62	.98	.49	23	14.50	.83	.49
23	13.64	1.53	.49	24	14.54	.68	.54
24	14.04	.97	.49	25	14.45	.57	.54
25	15.00	.75	.52	26	13.15	.46	.49
26	11.83	.57	.53	27	10.92	.39	.48
27	14.98	.88	.52	28	14.34	.90	.49
28	10.47	.34	.49	29	13.62	1.64	.49
29	14.82	1.24	.49	30	13.44	1.61	.49
30	10.16	.44	.56	31	14.05	1.72	.49
31	14.29	.65	.49	32	15.07	1.18	.45
32	14.55	.72	.58	33	13.36	2.08	.49
33	14.40	.60	.49	34	13.25	.47	.45
34	14.36	.96	.49	35	12.53	.55	.45
35	15.54	1.00	.49	36	11.52	.43	.46
36	14.36	.93	.49	37	15.18	1.03	.45
37	14.20	2.28	.49	38	10.95	.34	.44
38	14.28	2.06	.49	39	14.90	.98	.48
39	15.04	.90	.49	40	15.38	0.93	0.48
40	15.03	1.03	.49				
41	14.42	.98	.49	6-1	15.32	1.00	0.54
42	15.26	0.93	0.44	2	14.51	1.77	.54
				3	15.24	.93	.54
5-1	14.62	1.79	0.54	4	14.68	1.75	.54
2	15.42	1.00	.44	5	14.21	1.53	.54
3	15.56	.75	.54	6	13.60	.71	.54
4	14.55	.96	.54	7	10.94	.44	.54
5	10.85	.48	.54	8	13.70	.75	.54
6	14.74	1.55	.54	9	12.64	.68	.54
7	15.26	.88	.54	10	15.33	1.06	.54
8	13.90	.54	.54	11	14.69	1.35	.54
9	9.77	.37	.55	12	14.70	1.49	.54
10	14.80	.91	.54	13	14.13	.88	.54
11	13.56	2.19	.58	14	14.03	.85	.54
12	15.01	0.94	0.58	15	13.09	1.48	0.54

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TABLE 5--Continued

Star	V	B-V	E(B-V)	Star	V	B-V	E(B-V)
6-16	15.17	1.13	0.54	7-1	14.98	0.94	0.54
17	15.00	1.16	.54	2	14.94	.97	.54
18	15.18	1.31	.54	3	15.26	1.30	.54
19	12.76	1.68	.54	4	14.90	1.44	.54
20	15.38	.95	.54	5	11.73	1.91	.54
21	11.86	2.01	.54	6	15.29	1.05	.54
22	11.69	.51	.54	7	13.31	1.68	.54
23	13.49	1.56	.49	8	14.81	.95	.54
24	14.58	.90	.49	9	14.77	1.34	.54
25	13.78	1.77	.49	10	13.75	1.65	.54
26	13.70	1.72	.49	11	13.68	1.54	.54
27	14.41	1.96	.49	12	13.83	1.62	.54
28	15.29	.82	.49	13	15.22	1.02	.54
29	15.09	1.17	.49	14	14.26	2.09	.54
30	15.15	.94	.49	15	15.16	1.05	.54
31	15.34	.97	.49	16	13.97	1.43	.54
32	13.82	1.80	.49	17	14.01	1.67	.54
33	10.47	.36	.50	18	14.97	1.15	.54
34	14.39	.68	.49	19	13.66	.73	.54
35	14.46	.98	.49	20	14.69	1.15	.54
36	15.04	1.02	.49	21	12.21	.52	.54
37	14.93	1.39	.49	22	14.49	1.16	.54
38	14.79	.91	.49	23	13.56	1.57	.54
39	15.17	1.15	.49	24	12.61	2.08	.54
40	14.62	1.68	.49	25	11.81	1.39	.54
41	14.76	1.60	.49	26	14.11	1.78	.54
42	14.56	1.55	.49	27	13.98	2.27	.54
43	14.94	.97	.49	28	15.26	1.02	.54
44	15.26	1.09	.49	29	14.35	1.57	.54
45	14.85	.96	.49	30	13.53	.72	.49
46	14.81	.82	.49	31	13.38	2.13	.49
47	14.89	1.07	.49	32	14.61	1.67	.49
48	14.85	1.44	.49	33	13.55	1.64	.49
49	15.56	.87	.49	34	14.32	--	.49
50	14.97	1.04	.49	35	15.35	1.13	.49
51	14.56	1.61	.49	36	14.27	.89	.49
52	13.50	1.44	.49	37	13.73	1.59	.49
53	13.43	.74	.49	38	14.36	.93	.49
54	13.71	1.57	.45	39	14.94	1.09	.49
55	14.85	.99	.45	40	15.38	.98	.49
56	14.48	.85	.45	41	13.74	1.50	.49
57	14.59	1.41	.45	42	13.50	1.96	.49
58	15.20	1.15	0.45	43	13.29	.83	.49
				44	15.18	1.10	0.49

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TABLE 5--Continued

Star	V	B-V	$E_{(B-V)}$
1-7-45	14.43	0.96	0.49
46	14.10	.84	.49
47	14.93	1.47	.49
48	15.55	.90	.49
49	14.48	1.87	.49
50	15.33	1.07	.49
51	13.89	1.64	.45
52	14.10	1.19	.45
53	14.30	1.59	.45
54	14.87	.96	.45
55	14.90	1.45	0.45
8-1	14.10	1.90	0.54
2	10.45	1.88	.54
3	15.20	1.12	.54
4	14.67	1.09	.54
5	14.09	1.64	.54
6	14.58	1.20	.54
7	13.47	1.15	.54
8	14.98	.66	.54
9	15.14	1.34	.54
10	14.60	1.40	.54
11	14.95	.96	.54
12	14.20	2.05	.54
13	14.22	1.19	.54
14	14.30	1.52	.54
15	13.99	1.69	.54
16	15.63	.90	.54
17	14.66	.76	.54
18	14.85	.60	.54
19	13.26	.34	.54
20	14.99	1.07	.54
21	15.09	1.04	.54
22	14.20	.89	.54
23	11.50	1.79	.54
24	14.97	1.10	.54
25	10.93	1.96	.54
26	14.62	1.69	.54
27	15.10	1.00	.54
28	10.11	.39	.53
29	14.95	.85	.54
30	14.64	.74	.54
31	12.71	1.39	.54
32	14.54	0.88	0.54
1-8-33	15.20	0.94	0.54
34	15.02	.98	.49
35	14.47	1.30	.49
36	13.30	.58	.49
37	15.17	1.14	.49
38	15.24	.92	.49
39	15.29	1.05	.49
40	14.98	1.14	.49
41	14.81	.83	.49
42	14.61	.87	.49
43	14.85	1.11	.49
44	13.90	.42	.49
45	15.43	.89	.49
46	14.71	.92	.49
47	15.33	1.06	.49
48	14.65	.77	.49
49	13.94	2.14	.49
50	14.24	.81	.49
51	15.17	1.03	.49
52	14.27	2.03	.49
53	14.33	.85	.49
54	14.08	.86	.49
55	15.27	.94	.49
56	12.23	.70	.49
57	14.58	1.64	.49
58	14.75	1.59	.49
59	14.37	1.48	.49
60	14.17	.84	.49
61	15.10	1.00	.49
62	14.68	.82	.49
63	15.31	.88	.49
64	15.22	0.95	0.45
11-2-1	14.12	1.94	0.54
2	10.98	.44	.54
3	11.57	.53	.57
4	12.71	.71	.49
5	14.73	1.05	.54
6	15.10	1.03	.54
7	12.27	.55	.51
8	12.47	1.62	.48
9	13.99	1.10	.48
10	11.46	.48	.49
11	13.28	0.45	0.56

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TABLE 5--Continued

Star	V	B-V	$E_{(B-V)}$	Star	V	B-V	$E_{(B-V)}$
II-2-12	15.52	1.02	0.48	II-3-25	14.40	1.14	0.49
13	15.07	1.09	.48	26	14.98	1.13	.49
14	15.21	.98	.54	27	14.47	1.58	.49
15	15.68	.98	.54	28	12.86	1.74	.49
16	15.36	1.09	.54	29	15.21	1.09	0.49
17	15.21	1.56	.54				
18	15.25	1.07	.54	4-1	9.85	0.32	0.44
19	14.34	1.68	.48	2	11.32	1.68	.49
20	12.85	.72	.50	3	14.57	.87	.44
21	13.18	.96	.50	4	14.10	.85	.49
22	15.59	1.02	.54	5	13.81	1.28	.44
23	15.07	1.25	.54	6	14.22	.48	.44
24	15.42	1.00	.54	7	15.22	.98	.44
25	15.16	1.10	.54	8	13.65	2.12	.49
26	10.38	.47	.53	9	11.78	1.98	.49
27	14.30	.97	.54	10	13.64	.98	.52
28	13.74	.89	.51	11	8.95	.37	.46
29	14.88	1.09	.54	12	15.12	.98	.49
30	15.77	0.85	0.49	13	12.13	.64	.56
				14	14.91	1.13	.49
3-1	11.03	0.49	0.49	15	8.85	.24	.33
2	15.00	1.03	.49	16	14.91	.80	.49
3	15.63	.82	.49	17	14.67	.95	.49
4	14.60	1.78	.49	18	14.58	.91	.49
5	15.40	1.05	.49	19	12.49	.49	.49
6	14.70	1.59	.49	20	13.85	2.22	.49
7	15.36	1.08	.49	21	15.01	1.16	.49
8	13.51	1.46	.48	22	15.14	1.13	.49
9	13.73	.59	.55	23	14.14	.94	.49
10	14.89	.87	.49	24	15.44	1.03	.49
11	14.86	.94	.49	25	13.10	.83	.49
12	15.52	.98	.49	26	13.16	1.52	.49
13	15.70	.95	.49	27	11.01	.88	.49
14	13.79	1.37	.49	28	14.08	1.02	.49
15	15.33	1.04	.49	29	13.36	2.15	.49
16	13.45	.83	.51	30	14.83	1.45	.49
17	10.17	.44	.49	31	15.04	1.49	0.49
18	13.94	.52	.49				
19	11.95	.60	.51	5-1	14.17	2.04	0.44
20	11.80	.52	.47	2	13.77	.71	.44
21	14.07	1.77	.49	3	14.34	1.93	.44
22	15.01	.96	.49	4	14.19	1.77	.44
23	15.26	1.10	.49	5	14.26	.70	.44
24	15.45	1.08	0.49	6	14.95	1.02	0.44

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TABLE 5--Continued

Star	V	B-V	E(B-V)	Star	V	B-V	E(B-V)
II-5-7	12.69	0.79	0.44	II-6-1	13.92	0.83	0.54
8	14.59	.84	.44	2	13.77	.91	.54
9	12.86	.62	.44	3	14.92	1.15	.44
10	14.12	1.14	.44	4	14.66	1.03	.44
11	13.59	1.91	.44	5	14.67	1.10	.44
12	14.07	2.16	.44	6	14.56	1.68	.44
13	14.62	2.01	.44	7	13.58	.54	.44
14	14.01	.85	.48	8	15.00	.78	.44
15	15.04	1.18	.44	9	13.57	.74	.44
16	15.73	.83	.44	10	10.36	.34	.42
17	14.54	.95	.48	11	14.70	.88	.44
18	14.47	1.65	.44	12	14.24	.71	.44
19	14.34	.92	.44	13	12.83	1.13	.44
20	12.31	2.08	.44	14	14.65	.79	.44
21	14.10	1.81	.44	15	14.97	.86	.44
22	14.67	1.59	.44	16	13.88	.49	.44
23	15.00	1.08	.44	17	--	--	--
24	15.12	.99	.44	18	14.73	.74	.44
25	14.66	1.63	.49	19	14.93	1.29	.44
26	14.30	2.19	.49	20	15.40	.98	.44
27	14.06	.92	.49	21	14.46	1.46	.44
28	15.33	.87	.49	22	13.35	2.08	.44
29	14.37	1.20	.49	23	11.57	1.63	.47
30	15.13	1.13	.49	24	15.20	.94	.44
31	13.61	1.06	.49	25	15.24	.99	.44
32	14.27	.95	.49	26	14.87	.71	.44
33	13.37	.93	.49	27	9.00	1.93	.48
34	14.14	.96	.49	28	14.13	1.43	.44
35	14.75	1.47	.49	29	13.12	1.44	.44
36	13.29	2.01	.42	30	12.87	.68	.44
37	15.05	1.04	.42	31	14.78	1.06	.44
38	14.30	1.70	.42	32	15.27	1.06	.44
39	15.03	.93	.49	33	14.51	.79	.42
40	14.51	1.66	.42	34	15.17	.80	.42
41	14.74	1.11	.42	35	14.40	1.47	.42
42	14.99	1.15	.42	36	15.03	1.34	.42
43	12.71	.68	.42	37	15.59	.89	.42
44	13.93	1.15	.42	38	14.10	.89	.42
45	14.60	1.05	.42	39	14.22	.96	.42
46	13.77	1.45	.42	40	15.15	.98	.42
47	13.02	1.61	.42	41	14.50	1.14	.42
48	15.37	.84	.42	42	14.78	1.04	.42
49	13.95	1.45	0.42	43	15.27	1.06	.42
				44	13.25	0.97	0.42

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TABLE 5--Continued

Star	V	B-V	$E_{(B-V)}$	Star	V	B-V	$E_{(B-V)}$
II-6-45	14.97	0.96	0.42	II-7-34	13.08	0.68	0.44
46	12.84	.99	.42	35	15.28	1.15	.44
47	11.81	.44	.42	36	13.50	1.49	.44
48	12.67	.58	.42	37	12.84	.70	.44
49	14.78	1.47	.42	38	14.19	1.46	.44
50	12.40	1.51	.42	39	14.18	.99	.44
51	12.91	1.42	.42	40	13.55	.83	.44
52	14.32	1.11	.42	41	11.49	1.62	.44
53	15.07	1.05	.42	42	14.72	1.41	.44
54	15.07	1.35	0.42	43	14.64	1.47	.44
				44	14.90	.83	.42
7-1	12.84	0.61	0.54	45	12.93	.94	.42
2	13.33	.50	.54	46	14.95	1.00	.42
3	14.47	1.59	.54	47	15.02	1.35	.42
4	13.28	1.44	.54	48	14.99	.98	.42
5	12.50	1.36	.54	49	13.28	.85	.42
6	15.08	1.18	.54	50	15.08	.99	.42
7	15.01	1.12	.54	51	14.53	1.33	.42
8	15.36	1.00	.54	52	13.00	1.54	.42
9	14.26	2.10	.54	53	14.90	.97	.42
10	14.87	1.55	.54	54	14.45	1.66	.42
11	14.68	.65	.54	55	13.38	1.64	.42
12	12.56	1.17	.54	56	13.87	.79	.42
13	13.12	2.00	.44	57	14.52	1.88	.42
14	14.74	.83	.44	58	13.89	.56	.42
15	10.60	.35	.44	59	15.08	1.11	.42
16	13.82	1.93	.44	60	14.27	.90	.42
17	14.90	1.04	.44	61	14.12	1.52	.42
18	13.38	2.32	.44	62	14.66	1.39	.42
19	12.94	.47	.44	63	--	--	.42
20	13.80	1.91	.44	64	12.26	1.33	.42
21	15.09	1.06	.44	65	15.11	1.08	.42
22	14.19	1.15	.44	66	14.17	1.05	.42
23	15.02	1.10	.44	67	15.15	.99	.42
24	13.93	.77	.44	68	14.35	.95	.42
25	13.92	.85	.44	69	12.66	1.69	.42
26	15.27	1.04	.44	70	14.45	1.85	.42
27	14.25	1.74	.44	71	13.58	1.57	.42
28	13.02	.68	.44	72	12.09	.79	.42
29	14.54	1.49	.44	73	14.88	.94	.42
30	14.86	.95	.44	74	13.81	2.08	0.42
31	14.02	2.16	.44				
32	13.29	2.16	.44	8-1	13.72	0.81	0.54
33	14.80	1.07	0.44	2	14.85	1.10	0.54

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TABLE 5--Continued

Star	V	B-V	E(B-V)	Star	V	B-V	E(B-V)
11-8-3	14.84	0.94	0.54	11-8-47	9.84	0.24	0.42
4	14.54	1.30	.54	48	11.98	1.68	.42
5	15.30	1.02	.54	49	15.08	.94	.42
6	14.07	1.53	.54	50	13.94	1.83	.42
7	14.26	2.01	.54	51	14.11	1.83	.42
8	14.46	1.03	.54	52	14.33	1.69	.42
9	14.41	1.49	.54	53	14.60	1.37	.42
10	13.51	1.59	.54	54	14.27	1.35	.42
11	13.48	1.70	.54	55	10.78	.39	.42
12	12.70	.79	.44	56	15.17	1.18	.42
13	15.19	.96	.44	57	15.54	1.04	.42
14	14.05	1.69	.44	58	14.60	1.05	.42
15	10.12	.52	.44	59	14.69	1.31	.42
16	14.87	.85	.44	60	13.20	1.36	.42
17	14.01	.89	.44	61	13.46	.82	.42
18	14.02	1.69	.44	62	13.74	.74	.42
19	13.92	1.00	.44	63	14.64	1.37	.42
20	15.33	1.04	.44	64	14.65	1.02	.42
21	14.63	1.59	.44	65	14.16	.58	.42
22	15.29	1.13	.44	66	15.14	1.15	.42
23	14.20	2.06	.44	67	15.49	1.07	.42
24	8.13	1.51	.44	68	15.30	1.08	.42
25	13.15	.73	.44	69	13.83	1.57	.42
26	14.44	1.65	.44	70	14.41	1.39	.42
27	15.31	1.22	.44	71	14.92	1.34	.42
28	15.50	.98	.44	72	12.75	1.53	.42
29	14.07	1.46	.44	73	13.66	1.41	.42
30	14.18	1.11	.44	74	13.92	.72	.42
31	14.40	1.05	.44	75	15.22	1.00	.42
32	14.80	.98	.44	76	15.09	1.00	.42
33	14.17	1.60	.44	77	15.25	1.06	.42
34	14.91	1.34	.44	78	13.65	1.40	.42
35	13.87	.71	.44	79	12.96	1.67	.42
36	14.53	1.71	.44	80	15.60	1.05	.42
37	14.88	.98	.44	81	15.44	1.12	.42
38	14.72	.97	.44	82	14.63	.98	.42
39	13.91	1.99	.44	83	15.48	.99	.42
40	14.59	1.50	.44	84	14.92	1.07	.42
41	14.15	1.91	.42	85	14.46	1.71	.42
42	15.16	1.12	.42	86	14.86	1.15	.42
43	13.71	.82	.42	87	14.71	1.08	.42
44	14.50	1.66	.42	88	14.74	1.64	.42
45	13.71	.97	.42	89	14.89	.98	.42
46	10.80	1.26	0.42	90	14.24	.83	.42
				91	15.48	0.97	0.42

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TABLE 5--Continued

Star	V	B-V	$E_{(B-V)}$	Star	V	B-V	$E_{(B-V)}$
III-2-1	U Sagittarius			III-3-22	15.87	0.91	0.47
2	15.38	1.11	0.54	23	14.80	1.02	.47
3	11.21	.48	.54	24	11.55	1.52	.47
4	14.84	.87	.54	25	15.62	.91	.47
5	14.98	1.46	.54	26	15.06	.83	.49
6	15.82	1.03	.54	27	15.25	1.15	.47
7	14.45	1.93	.48	28	7.50	1.60	0.48
8	14.01	.89	.55				
9	15.05	1.03	.50	4-1	14.13	0.87	0.40
10	10.01	.43	.50	2	14.03	.83	.50
11	13.67	.85	.50	3	12.72	.76	.50
12	15.22	.98	.50	4	15.04	1.15	.50
13	15.50	.95	.50	5	14.72	.94	.50
14	15.09	.80	.50	6	14.44	.73	.50
15	13.29	.76	.51	7	14.19	2.01	.50
16	11.68	.63	.50	8	13.93	.84	.50
17	15.16	1.19	.50	9	12.74	.80	.50
18	13.01	.75	.52	10	11.51	.67	.50
19	14.36	.69	.50	11	13.99	.95	.50
20	14.64	1.07	.50	12	13.28	.73	.50
21	14.49	.98	.50	13	13.10	1.49	.50
22	14.54	2.05	0.50	14	15.37	.95	.50
				15	13.95	1.05	.47
3-1	13.10	0.75	0.49	16	13.33	1.84	.47
2	12.69	.65	.56	17	12.14	.75	.47
3	14.06	1.61	.50	18	13.09	.44	.47
4	14.65	1.46	.50	19	13.77	.84	.47
5	14.80	1.12	.50	20	15.10	1.16	.47
6	14.34	1.02	.50	21	9.37	.37	.47
7	13.38	1.42	.50	22	15.15	1.03	.47
8	13.89	1.77	.50	23	15.05	.94	.47
9	12.64	.67	.50	24	11.98	0.54	0.49
10	13.00	.75	.50				
11	14.55	.91	.50	5-1	15.07	0.81	0.40
12	15.24	1.08	.50	2	13.76	.82	.40
13	13.99	.59	.50	3	14.14	1.96	.40
14	13.61	1.61	.50	4	8.95	.38	.40
15	12.36	.59	.50	5	14.12	.88	.40
16	14.44:	--	.51	6	14.55	.89	.40
17	14.36	1.68	.50	7	13.96	.83	.40
18	11.83	.50	.47	8	13.60	.88	.42
19	15.24	1.10	.47	9	14.35	1.08	.42
20	15.00	1.19	.47	10	14.47	1.77	.42
21	10.48	0.43	0.42	11	14.18	2.14	0.42

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TABLE 5--Continued

Star	V	B-V	$E_{(B-V)}$	Star	V	B-V	$E_{(B-V)}$
III-5-12	14.70	1.69	0.42	III-6-12	14.55	0.92	0.42
13	13.68	2.05	.42	13	14.28	.88	.42
14	13.06	.63	.42	14	14.24	1.61	.42
15	12.94	1.54	.42	15	14.23	.71	.42
16	14.94	1.11	.42	16	15.02	1.14	.42
17	14.72	1.12	.42	17	14.64	1.07	.42
18	9.71	.41	.42	18	14.29	1.49	.42
19	7.04	1.50	.42	19	14.17	1.05	.42
20	14.96	1.08	.42	20	13.93	1.99	.42
21	14.37	1.18	.42	21	15.03	.94	.42
22	14.40	1.15	.50	22	15.05	1.06	.42
23	14.06	.76	.42	23	14.65	1.50	.42
24	13.82	2.08	.42	24	14.96	1.04	.42
25	13.68	1.51	.42	25	12.28	.75	.42
26	14.16	.98	.42	26	12.29	.87	.42
27	14.37	1.07	.42	27	11.08	.50	.42
28	10.35	.55	.56	28	13.73	.99	.42
29	15.27	1.09	.42	29	14.24	1.94	.42
30	9.99	.42	.42	30	14.21	.93	.42
31	14.70	.88	.42	31	14.50	1.04	.42
32	11.41	.48	.42	32	14.77	1.10	.42
33	13.21	.95	.42	33	14.30	1.38	.42
34	12.78	.62	.42	34	12.48	.69	.42
35	13.39	1.92	.42	35	13.91	.65	.42
36	14.69	1.28	.42	36	15.09	1.16	.42
37	13.55	.66	.42	37	15.13	1.19	.42
38	10.90	.34	.40	38	13.72	1.03	.42
39	14.35	.93	.42	39	14.35	1.66	.42
40	14.91	.82	.42	40	14.99	1.15	.42
41	11.71	2.01	.42	41	14.83	1.14	.42
42	15.23	.93	.42	42	14.93	.89	.42
43	14.55	0.89	0.42	43	13.23	.98	.42
				44	13.57	1.16	.42
6-1	12.65	0.53	0.42	45	13.87	.45	.42
2	14.16	.94	.42	46	13.44	.62	.42
3	14.93	1.08	.42	47	14.11	1.68	.42
4	13.98	.64	.42	48	14.29	1.51	.42
5	15.34	1.09	.42	49	11.87	.69	.42
6	15.29	1.08	.42	50	14.28	1.61	.42
7	11.53	.59	.42	51	13.92	.98	.40
8	15.24	1.11	.42	52	15.20	1.06	.40
9	12.26	1.36	.42	53	13.04	.74	.42
10	13.96	.73	.42	54	14.22	1.69	.40
11	14.89	0.84	0.42	55	11.76	0.44	0.40

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TABLE 5--Continued

Star	V	B-V	$E_{(B-V)}$	Star	V	B-V	$E_{(B-V)}$
III-6-56	14.07	0.90	0.40	III-7-42	12.64	0.52	0.42
57	12.03	0.81	0.40	43	14.38	1.46	.42
				44	11.69	1.30	.42
7-1	13.62	2.01	0.42	45	14.76	1.53	.42
2	13.76	1.63	.42	46	14.15	1.00	.42
3	15.04	1.07	.42	47	13.68	.76	.42
4	14.05	1.48	.42	48	14.89	1.02	.42
5	12.77	2.27	.42	49	14.07	1.61	.42
6	13.81	1.91	.42	50	14.75	.93	.42
7	14.29	1.93	.42	51	14.89	1.04	.42
8	14.57	1.61	.42	52	15.10	1.02	.42
9	13.31	.93	.42	53	15.14	.93	.42
10	14.20	2.18	.42	54	11.92	.40	.42
11	14.40	.96	.42	55	15.15	.98	.40
12	14.61	1.03	.42	56	14.86	1.00	.42
13	13.93	.90	.42	57	14.40	1.65	0.42
14	13.97	2.26	.42				
15	12.02	.87	.42	8-1	14.72	1.26	0.42
16	14.66	.85	.42	2	14.03	.79	.42
17	14.30	1.98	.42	3	12.91	1.82	.42
18	13.87	1.98	.42	4	12.67	1.03	.42
19	13.39	.97	.42	5	14.47	1.10	.42
20	14.27	1.79	.42	6	11.88	1.40	.42
21	11.60	1.09	.42	7	13.83	1.65	.42
22	12.66	.61	.42	8	13.74	1.64	.42
23	14.04	2.17	.42	9	14.82	.82	.42
24	14.14	2.26	.42	10	13.06	1.77	.42
25	15.11	1.10	.42	11	14.88	1.10	.42
26	14.37	.81	.42	12	14.66	1.21	.42
27	14.85	1.31	.42	13	14.92	1.39	.42
28	11.74	.47	.42	14	14.34	1.54	.42
29	12.24	.91	.42	15	14.87	1.06	.42
30	15.13	1.05	.42	16	14.28	1.23	.42
31	14.19	.66	.42	17	14.40	1.81	.42
32	14.11	.85	.42	18	13.73	.89	.42
33	15.14	.95	.42	19	14.33	1.63	.42
34	14.07	.83	.42	20	14.49	1.26	.42
35	14.24	2.14	.42	21	14.85	1.09	.42
36	14.85	1.16	.42	22	14.72	1.27	.42
37	12.14	.53	.42	23	14.84	1.00	.42
38	14.62	.90	.42	24	14.47	1.72	.42
39	14.16	2.10	.42	25	13.68	1.04	.42
40	14.89	1.00	.42	26	15.08	1.19	.42
41	14.55	1.97	0.42	27	13.36	1.18	0.42

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TABLE 5--Continued

Star	V	B-V	$E_{(B-V)}$	Star	V	B-V	$E_{(B-V)}$
III-8-28	14.45	1.19	0.42	IV-2-1	9.20	0.51	0.60
29	14.20	.71	.42	2	10.20	.49	.53
30	14.50	1.12	.42	3	10.13	.37	.54
31	15.26	1.04	.42	4	8.72	.27	.54
32	14.81	1.06	.42	5	9.70	.26	.46
33	14.07	1.94	.42	6	13.87	.89	.54
34	13.26	.67	.42	7	10.05	.38	.54
35	15.06	1.13	.42	8	9.89	.42	.52
36	14.04	2.04	.42	9	14.51	1.05	.54
37	14.69	1.58	.42	10	12.19	.54	.56
38	14.59	1.24	.42	11	14.82	.93	.45
39	12.46	1.14	.42	12	12.25	1.36	.48
40	13.11	.84	.42	13	10.27	.36	.49
41	13.47	1.77	.42	14	14.40	2.08	.45
42	14.42	1.14	.42	15	8.09	.22	.43
43	14.72	.98	.42	16	12.05	.98	.48
44	14.98	1.15	.42	17	12.18	.52	.45
45	14.30	1.58	.42	18	13.21	.61	.49
46	14.20	.83	.42	19	14.19	1.61	.50
47	14.26	1.76	.42	20	15.39	1.15	.50
48	14.40	1.58	.42	21	14.28	1.90	.50
49	14.80	.79	.42	22	14.72	1.41	.50
50	13.94	.51	.42	23	13.91	.88	.54
51	14.08	1.52	.42	24	--	--	--
52	15.61	.74	.42	25	14.91	1.69	.45
53	14.71	1.37	.42	26	15.09	1.12	.45
54	14.78	1.49	.42	27	11.80	.39	.45
55	15.33	.94	.42	28	15.39	.96	.45
56	15.16	.90	.42	29	15.12	1.92	.45
57	13.41	.65	.42	30	15.41	.67	.45
58	15.37	1.10	.42	31	11.88	.43	.47
59	14.43	-0.15	.42	32	15.47	.83	.45
60	14.18	1.51	.42	33	15.38	1.09	.45
61	15.08	1.13	.42	34	13.70	.74	.47
62	14.79	.86	.42	35	15.78	.91	.45
63	13.29	1.87	.42	36	14.12	1.96	.45
64	14.87	.94	.42	37	11.20	.39	.46
65	13.67	1.34	.42	38	15.30	.98	.45
66	12.63	.53	.42	39	15.57	1.06	.45
67	14.71	1.37	.42	40	14.86	1.13	.45
68	13.12	1.46	.40	41	14.15	1.92	.45
69	14.02	2.00	.42	42	14.69	1.05	.45
70	14.94	0.87	0.42	43	15.09	0.99	0.54

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TABLE 5--Continued

Star	V	B-V	$E_{(B-V)}$	Star	V	B-V	$E_{(B-V)}$
IV-3-1	15.48	0.98	0.45	IV-4-11	10.22	0.31	0.44
2	14.56	1.76	.45	12	14.61	.80	.45
3	15.35	1.02	.45	13	14.27	1.89	.45
4	14.56	.80	.45	14	15.34	.98	.45
5	14.26	1.04	.45	15	15.07	.98	.45
6	15.13	1.03	.45	16	13.95	.68	.45
7	14.60	1.65	.45	17	13.48	1.24	.45
8	15.02	.85	.45	18	15.11	.94	.45
9	15.25	1.02	.45	19	15.26	.83	.45
10	10.45	.27	.38	20	15.42	.73	.45
11	14.71	.91	.45	21	10.71	.35	.41
12	15.39	1.17	.45	22	14.02	.98	.45
13	14.67	1.02	.45	23	12.46	.52	.50
14	12.42	.42	.45	24	14.74	1.05	.50
15	11.70	.35	.45	25	12.12	.44	.50
16	12.81	1.31	.48	26	15.82	.79	.50
17	14.79	1.04	.45	27	15.60	.69	.50
18	15.12	1.31	.45	28	15.39	1.08	.50
19	15.15	1.09	.50	29	15.23	.97	.50
20	12.48	1.95	.50	30	15.28	1.07	.50
21	15.24	1.07	.50	31	14.97	.98	.40
22	12.86	.85	.50	32	14.97	1.08	.50
23	12.10	.47	.51	33	15.45	1.17	.50
24	15.28	1.06	.50	34	15.40	1.17	.40
25	14.66	1.73	.50	35	14.49	1.45	.40
26	13.89	1.31	.50	36	13.81	1.91	.40
27	15.06	1.26	.50	37	11.56	.41	.29
28	14.14	2.19	.50	38	12.92	.46	.57
29	13.79	.68	.50	39	14.99	.91	.57
30	13.66	.78	.49	40	15.47	1.04	.57
31	14.92	1.65	.50	41	8.97	.51	.55
32	11.49	.33	.50	42	14.72	1.08	.57
33	11.16	0.35	0.50	43	15.00	1.11	.57
				44	13.90	.84	.57
4-1	15.56	1.00	0.45	45	14.85	1.26	.57
2	14.04	.69	.45	46	15.20	1.30	.57
3	15.35	.99	.45	47	14.72	.85	.57
4	10.63	.27	.45	48	12.00	.55	.57
5	--	--	--	49	13.38	.67	.57
6	14.21	.82	.45	50	15.10	1.26	.50
7	14.64	1.66	.45	51	14.24	2.04	.50
8	14.91	1.52	.45	52	14.54	1.00	.50
9	14.92	1.05	.45	53	10.28	.77	.48
10	14.27	0.57	0.45	54	12.37	0.48	0.50

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TABLE 5--Continued

Star	V	B-V	E(B-V)	Star	V	B-V	E(B-V)
IV-5-1	15.41	0.95	0.45	IV-5-45	15.00	1.04	0.40
2	14.14	1.84	.45	46	14.05	.58	.40
3	13.31	.77	.45	47	13.93	2.02	.40
4	13.55	1.52	.45	48	14.49	1.88	.40
5	15.66	.96	.45	49	13.47	.61	.40
6	15.17	.98	.45	50	11.53	.37	.40
7	14.11	1.89	.45	51	14.14	.79	.40
8	11.79	.37	.45	52	11.63	.53	.40
9	13.71	.46	.45	53	15.22	1.10	.40
10	12.71	.84	.45	54	13.85	.86	.40
11	14.46	.90	.45	55	13.60	.68	.40
12	14.74	.88	.45	56	15.26	.87	.40
13	13.26	1.40	.45	57	15.28	1.13	.40
14	14.84	.97	.45	58	15.08	1.09	.40
15	14.72	1.66	.45	59	13.74	1.71	.40
16	15.35	1.07	.45	60	14.11	.78	.40
17	12.52	2.17	.45	61	14.49	1.74	.40
18	15.27	1.03	.45	62	14.90	0.98	0.40
19	13.73	.42	.45				
20	14.79	1.55	.45	6-1	14.65	1.78	0.45
21	12.04	.36	.45	2	12.54	1.57	.45
22	14.37	1.11	.45	3	15.26	1.02	.45
23	15.71	1.00	.45	4	12.69	.34	.45
24	15.54	1.12	.45	5	14.28	2.03	.45
25	14.93	1.40	.45	6	13.68	1.63	.45
26	15.14	1.05	.45	7	14.99	.85	.45
27	15.17	1.02	.45	8	12.43	.41	.45
28	11.63	1.27	.50	9	13.57	1.32	.45
29	12.24	.43	.51	10	14.09	1.55	.45
30	15.23	.92	.50	11	14.11	.91	.45
31	14.73	.98	.50	12	15.46	.96	.45
32	14.55	1.68	.50	13	14.77	.85	.45
33	14.91	.85	.50	14	14.09	2.07	.45
34	14.69	.72	.50	15	14.74	.88	.45
35	15.36	.96	.50	16	15.15	1.14	.45
36	11.41	1.37	.40	17	15.12	1.35	.45
37	12.94	.59	.40	18	14.60	.76	.45
38	15.51	1.11	.40	19	14.65	.94	.45
39	15.17	.94	.40	20	15.58	.87	.45
40	15.15	.98	.40	21	14.48	1.79	.45
41	9.73	.27	.36	22	12.45	.49	.45
42	15.24	.92	.40	23	15.05	.98	.45
43	14.15	.88	.40	24	13.92	1.84	.40
44	14.57	0.87	0.40	25	14.57	0.97	0.40

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TABLE 5--Continued

Star	V	B-V	$E_{(B-V)}$	Star	V	B-V	$E_{(B-V)}$
IV-6-26	14.11	0.98	0.45	IV-7-1	13.05	0.71	0.45
27	13.24	1.43	.40	2	14.06	.71	.45
28	14.77	.88	.40	3	14.74	.87	.45
29	12.57	.50	.40	4	14.57	1.00	.45
30	15.12	1.15	.40	5	13.62	1.06	.45
31	14.65	.90	.40	6	15.22	.87	.45
32	13.16	.58	.40	7	15.31	.73	.45
33	14.91	1.13	.40	8	15.05	.85	.45
34	15.41	1.03	.40	9	15.28	.95	.45
35	14.55	.98	.40	10	15.48	.94	.45
36	14.89	1.51	.40	11	14.59	.91	.45
37	13.60	2.18	.40	12	14.20	1.63	.45
38	14.74	.84	.40	13	15.16	.96	.45
39	14.58	1.53	.40	14	15.30	1.11	.45
40	15.04	.99	.40	15	15.28	1.19	.45
41	14.81	.80	.40	16	14.89	.92	.45
42	14.49	1.25	.40	17	15.03	.93	.45
43	13.16	2.00	.40	18	10.51	.25	.45
44	13.50	1.45	.40	19	15.32	.91	.45
45	15.04	.82	.40	20	12.89	1.85	.45
46	15.19	.95	.40	21	15.25	.94	.45
47	14.54	.87	.40	22	14.75	.68	.45
48	15.08	1.00	.40	23	13.99	1.52	.45
49	14.66	.66	.40	24	14.72	1.43	.45
50	15.07	.92	.40	25	15.18	.89	.45
51	6.80	.98	.48	26	14.62	1.45	.45
52	13.40	.68	.40	27	9.55	.24	.37
53	15.19	.93	.40	28	15.91	1.10	.45
54	14.63	1.24	.40	29	13.76	1.44	.45
55	11.00	.37	.39	30	14.66	1.61	.45
56	14.83	.96	.40	31	15.32	.98	.45
57	15.25	1.09	.40	32	14.41	2.00	.45
58	15.19	1.03	.40	33	14.04	2.04	.45
59	14.59	.85	.40	34	15.56	.77	.45
60	14.88	1.14	.40	35	13.58	.61	.45
61	15.25	1.05	.40	36	14.15	1.76	.45
62	15.32	.98	.40	37	14.79	.91	.45
63	14.63	1.19	.40	38	13.04	.84	.40
64	13.88	.69	.40	39	14.38	.97	.40
65	14.96	1.02	.40	40	11.82	1.32	.40
66	15.39	1.00	.40	41	14.41	1.60	.40
67	15.39	1.12	.40	42	14.82	.81	.40
68	15.30	1.17	.40	43	14.19	.94	.40
69	13.74	1.50	.40	44	14.68	1.68	0.40
70	13.82	0.71	0.40				

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TABLE 5--Continued

Star	V	B-V	$E_{(B-V)}$	Star	V	B-V	$E_{(B-V)}$
IV-7-45	15.27	0.95	0.40	IV-8-8	14.43	0.75	0.45
46	15.15	.91	.40	9	15.19	.92	.45
47	15.46	.67	.40	10	15.25	.94	.45
48	14.77	.97	.40	11	13.94	1.91	.45
49	14.66	.62	.40	12	14.19	1.88	.45
50	14.70	1.50	.40	13	14.61	1.50	.45
51	13.96	1.80	.40	14	15.09	1.06	.45
52	14.67	1.07	.40	15	14.46	.88	.45
53	13.35	1.99	.40	16	13.54	.37	.45
54	15.24	.93	.40	17	12.24	.45	.45
55	15.16	.76	.40	18	14.53	.90	.45
56	12.73	2.28	.40	19	13.52	1.33	.45
57	14.39	1.52	.40	20	14.76	.77	.45
58	15.00	.97	.40	21	14.67	.74	.45
59	15.35	.98	.40	22	14.46	.90	.45
60	13.55	.53	.40	23	15.11	1.03	.45
61	14.78	.83	.40	24	15.00	1.03	.45
62	13.90	.39	.40	25	14.22	1.86	.45
63	10.58	.55	.40	26	14.89	.89	.45
64	14.52	.92	.40	27	14.86	.93	.45
65	15.11	.83	.40	28	13.37	1.19	.45
66	15.04	.98	.40	29	15.50	.88	.45
67	14.52	.89	.40	30	15.28	.92	.45
68	13.63	1.10	.40	31	14.92	1.40	.45
69	9.80	.34	.42	32	13.90	1.56	.45
70	11.95	.41	.40	33	15.24	.88	.45
71	14.95	.98	.40	34	14.84:	--	.45
72	14.44	1.93	.40	35	13.55	1.97	.45
73	14.70	1.27	.40	36	14.54	.96	.40
74	15.22	1.12	.40	37	14.21	.98	.40
75	15.61	.90	.40	38	14.69	.83	.40
76	14.16	.80	.40	39	13.40	1.97	.40
77	14.63	1.56	.40	40	14.94	1.40	.40
78	15.03	1.05	.40	41	14.77	.99	.40
79	15.18	1.03	.40	42	14.61	1.40	.40
80	14.23	1.72	0.40	43	14.10	1.48	.40
				44	10.09	.33	.40
8-1	14.98	0.95	0.45	45	12.08	.66	.40
2	13.58	.47	.45	46	14.66	.91	.40
3	14.40	1.54	.45	47	14.23	.70	.40
4	14.81	.74	.45	48	14.71	1.00	.40
5	15.18	1.02	.45	49	14.63	.92	.40
6	13.00	.37	.45	50	15.00	.99	.40
7	13.76	1.46	0.45	51	13.21	0.40	0.40

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TABLE 5--Continued

Star	V	B-V	$E_{(B-V)}$	Star	V	B-V	$E_{(B-V)}$
IV-8-52	15.04	0.95	0.40	IV-8-62	14.86	1.28	0.40
53	12.82	.53	.40	63	14.67	.69	.40
54	14.54	.94	.40	64	15.17	1.08	.40
55	14.54	.96	.40	65	14.73	1.10	.40
56	15.42	.90	.40	66	13.78	.55	.40
57	14.45	.95	.40	67	15.11	.89	.40
58	13.32	.51	.40	68	13.36	1.94	.40
59	12.47	1.36	.40	69	9.40	.33	.40
60	14.10	.84	.40	70	14.99	1.08	0.40
61	15.11	0.83	0.40				

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et al. photoelectric three-color discussions both gave a mean reddening value of $E_{(B-V)} = 0^{m}.50$.

After the stars in each individual photoelectric system had been placed on the system of Wampler *et al.*, an average value of the color excess was determined from each individual star. Stars whose color excesses were in doubt as indicated by a colon or parenthesis in any of the published papers were not included in the following study, although they were tabulated in Table 2. Theoretically, the color excesses would then be used to construct iso-reddening contours on the M25 region of the sky. Unfortunately, too few stars were available for true contours to be drawn; rather, with the aid of the 48-inch Schmidt Sky Atlas print and the seventy-three stars whose color excesses were not in doubt, areas suffering similar amounts of absorption were outlined. The same numerical value of the color excess was applied to all stars within the boundary of a given area as shown in Figure 6.

The minimum value found for $E_{(B-V)}$ was $0^{m}.29$ for standard star 71 = IV-4-37; the maximum value was $E_{(B-V)} = 0^{m}.60$ for standard star 63 = IV-2-1. Hence, there is a

TABLE 6

PROBABLE ERRORS OF A MEAN PHOTOGRAPHIC MAGNITUDE

MAGNITUDE INTERVAL	PROBABLE ERROR		MAGNITUDE INTERVAL	PROBABLE ERROR	
	B	*V*		*B*	*V*
7–8	....	0.04	12–13	0.03	0.04
8–9	0.06:	.05	13–14	.03	.04
9–10	.05:	.05	14–15	.03	.05
10–11	.04	.04	15–16	.04	0.08
11–12	0.03	0.04	16–17	0.06	....

TABLE 7

COMPARISON OF COLOR EXCESSES

	$E_{(B-V)}$
Wampler *minus* Sandage	$+0^{m}.016$
Wampler *minus* Johnson	+ .018
Wampler *minus* Irwin	+0.017

range of $0^{m}.30$ in color excess, giving an absorption variation of the order of 1.5 magnitudes. The majority of the color excesses were found to be in the interval $0^{m}.42$–$0^{m}.56$. The probable error in the color excess is estimated to be ± 0.014 magnitudes. Support for an error of this magnitude comes from the range in the average reddening for an individual star as determined by various authors (Irwin 1958; Johnson 1960*a;* Sandage 1960; and Wampler *et al.*, 1961).

The presence of some differential reddening across the cluster region gives rise to the possibility of checking the usually accepted value of 3.0 for the ratio of selective to total absorption using the photoelectric magnitudes and color excesses available from the standard star three-color photometry. An initial pair of plots was made of V_0 versus $(B - V)_0$ and of V_0 versus $(U - B)_0$ for the assumed ratio of 3.0; the plots are illustrated in Figures 7*a* and 7*b*. The data plotted came from Table 2 for the stars whose color excesses were considered best known. The assumption implicit in this method is that the stars are all in the cluster and hence at the same distance. Scatter is apparent in Figures 7*a* and 7*b* and may be accounted for in part by the possible inclusion of field

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stars, possible binary cluster members, observational errors, and cosmical scatter. The total spread in magnitude for an assumed cluster diameter of 7.8 pc is only 0.02 magnitudes.

Free-hand curves denoting the position of the main sequence were carefully drawn through the points in each of the several plots, as illustrated in Figures 7*a* and 7*b*. Stars outside the magnitude range $8.31 > V_0 > 10.33$ and the color range $-0.13 > (B - V)_0 > -0.03$ or $-0.50 > (U - B)_0 > -0.09$ were not used to help define the position of the main sequence. The bright blue stars have evolved off the original cluster main sequence, and fainter stars are mixed with the field stars. The magnitude and color ranges used essentially define only the straight-line portion of the main sequence.

The individual vertical residuals, denoted as Δm and measured in magnitudes, are plotted in Figure 8 against the color excesses for the stars. The delta magnitudes were taken from Figures 7*a* and 7*b* and are considered to be positive for stars positioned above the main sequence and negative for stars which fall below the main sequence. If the assumed ratio of 3.0 utilized in Figures 7*a* and 7*b* is correct, then the slope of the lines

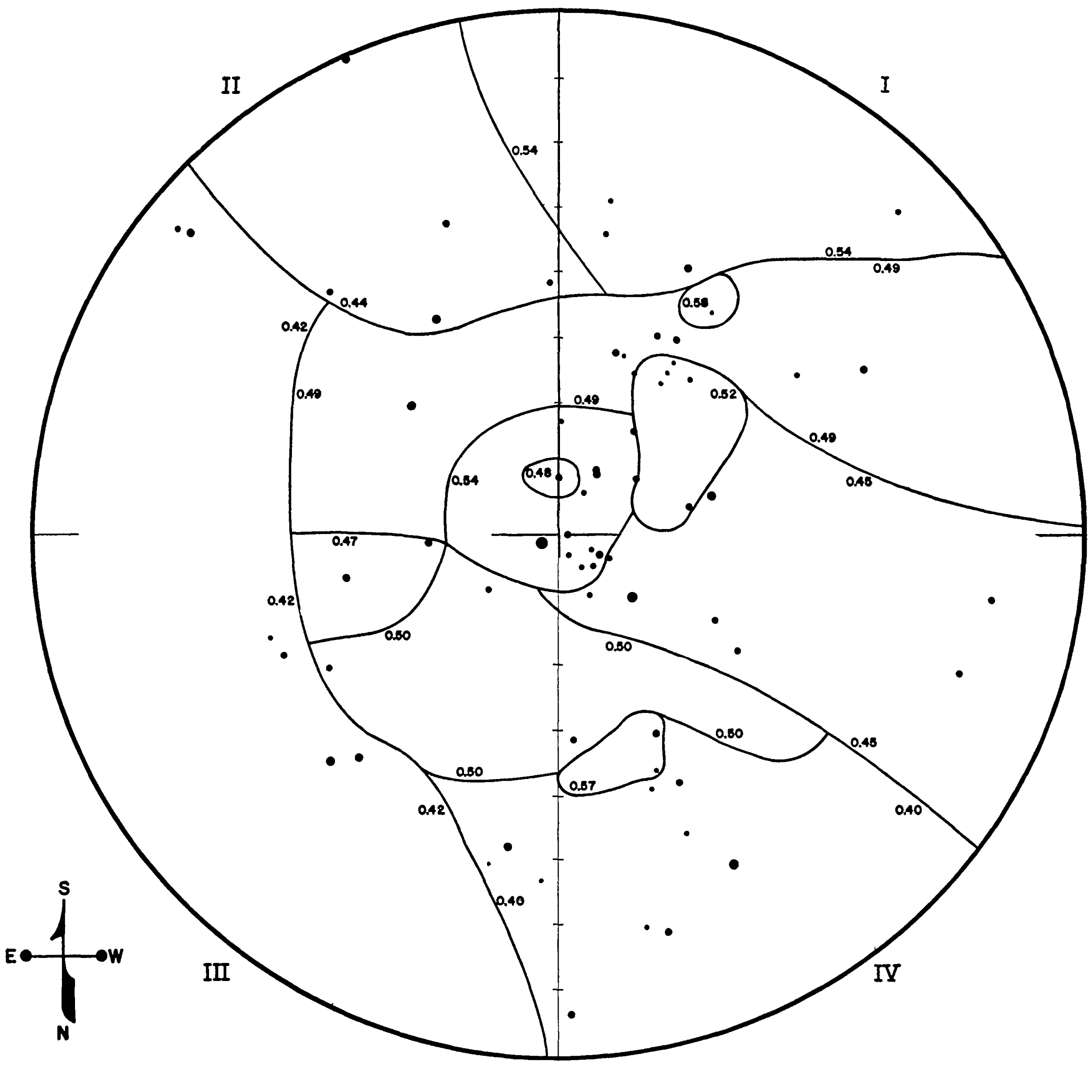

FIG. 6.—The chart outlines the variation in reddening across the cluster. The brighter stars are indicated to facilitate orientation. The number in a given area indicates the value of the color excess in that section of the cluster. The fiducial marks on the north-south line indicate the individual ring positions as defined in Fig. 5.

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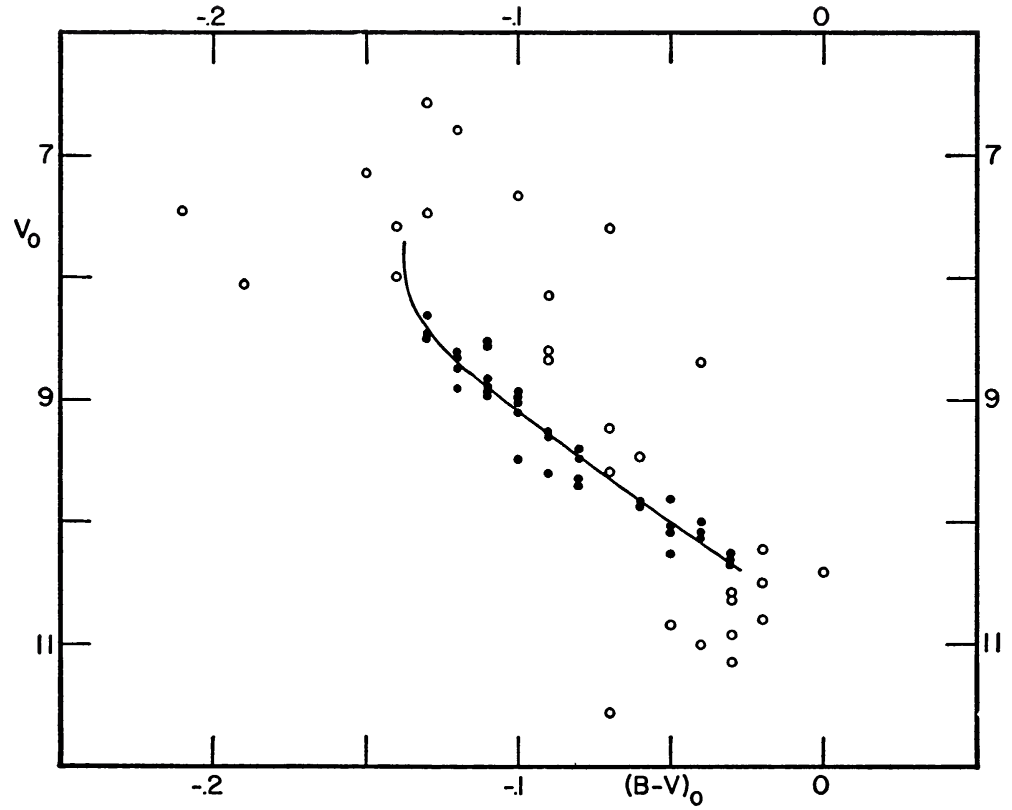

FIG. 7*a*.—The color-magnitude diagram defined by the photoelectric standard stars of Table 2; the ratio of selective to total absorption was assumed to be 3.0. Open circles represent stars not included in the ratio study.

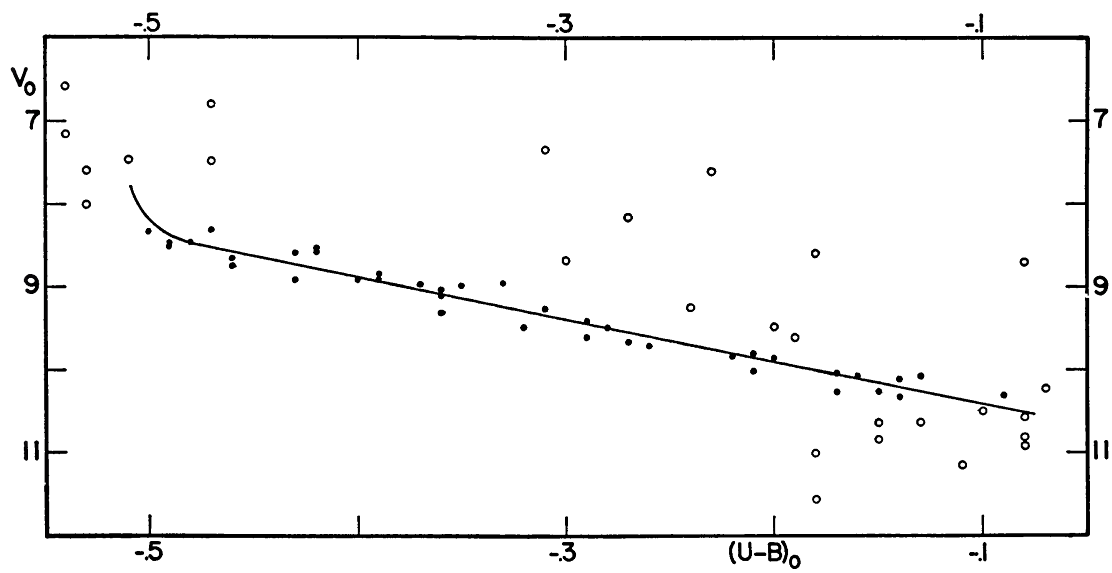

FIG. 7*b*.—The color-magnitude diagram defined by the photoelectric standard stars of Table 2; the ratio of selective to total absorption was assumed to be 3.0. Open circles represent stars not included in the ratio study.

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in Figure 8, *a* and *b*, should be zero. However, a least-squares solution of the Δm versus $E_{(B-V)}$ plot (Fig. 8, *a*) for the $(B - V)_0$ data gave a slope of -0.10 ± 0.29. Hence, the ratio here is 3.1 ± 0.29. Figure 8, *b*, developed from the $(U - B)_0$ data, gave a slope of $+0.22 \pm 0.27$. Therefore, the ratio would be 2.8 ± 0.27 for the $(U - B)_0$ color region. Inasmuch as the Δm's are not completely independent, we adopt 2.9 ± 0.3.

The above value for the ratio of total to selective absorption is in general agreement with the work of others (Blanco 1955; Hiltner and Johnson 1956; and Whitford 1958). It supplies additional confirmation of the apparent variability of the law of interstellar reddening with galactic longitude (Hallam 1959; Wampler 1961, 1962; and Walker 1962).

IV. COLOR-MAGNITUDE DIAGRAM

The color-magnitude diagram for M25, corrected for the effects of interstellar absorption, is given in Figure 9. The adopted standards of Table 2 together with the evolutionary deviation curve method of Johnson (1960*b*) were used to determine the dis-

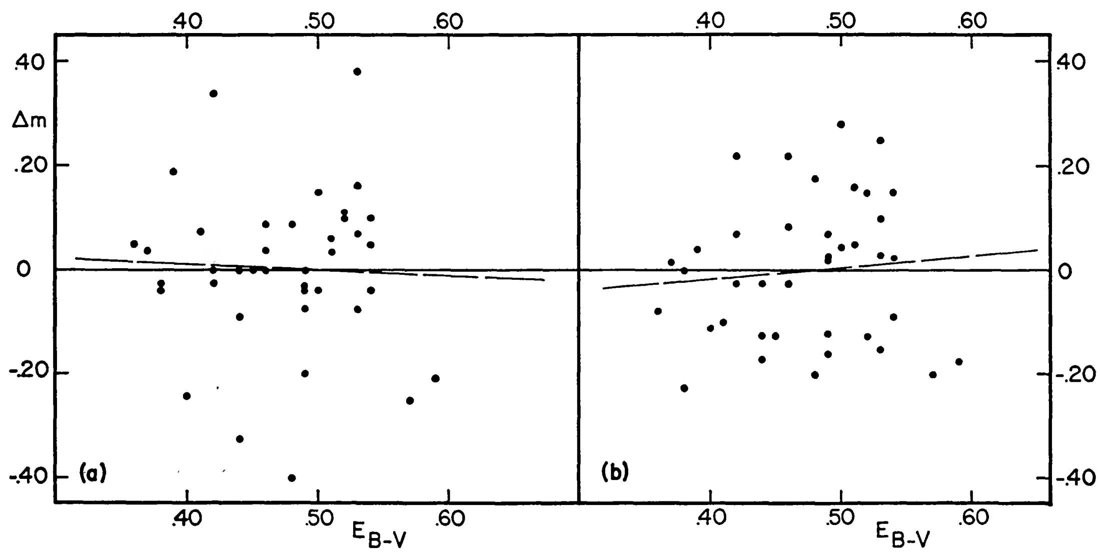

FIG. 8.—Vertical distance above or below the main sequence for a star in Figs. 7*a* and 7*b* plotted against that star's color excess. The plot on the left is from the $(B - V)_0$ data of Fig. 7*a*; that on the right from the $(U - B)_0$ data of Fig. 7*b*.

tance modulus of the cluster. The scatter in the data is sufficient for a range of distance moduli from 8.8 to 9.2 magnitudes to be found. A distance modulus of 9.0 ± 0.2 magnitudes or a true distance of 630 pc was adopted, a value in satisfactory agreement with the determination of 8.9 ± 0.2 magnitudes by Johnson. Distance moduli obtained by Sandage (1960) and by Wampler *et al.* (1961) were 8.90 ± 0.2 and 9.08 ± 0.2 magnitudes, respectively.

Feast (1957) has published radial velocities and discussed the possible membership of some of the stars in the cluster M25. His work confirms membership for the majority of the stars brighter than magnitude 9.0 in the cluster vicinity. These stars may be checked photometrically for cluster membership through the use of the intrinsic-color-MK spectral-type relations established by Kraft and Hiltner (1961). The photometric and spectroscopic data for nine bright stars in the cluster vicinity are presented in Table 8. The first three columns give the star's identification, magnitude, and color from the present investigation. The spectral types in the fourth column are from Feast (1957) and Wallerstein (1960), while the predicted colors come from the Kraft and Hiltner (1961) paper. The absolute magnitudes in the sixth column are derived for each star

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assuming a distance modulus of 9.0 for the cluster. The conclusion as to cluster membership for each star is recorded under the heading "Remarks."

Stars IV-6-51, I-4-19, and IV-4-41 are too blue to be members. The calculated absolute magnitudes for stars III-5-30 and III-4-21 are too low for their observed luminosity classes. Radial-velocity studies (Feast 1957) indicate cluster membership for the G-type giants numbered III-3-28 and III-5-19 in Table 5. Although their derived absolute magnitudes make the stars too luminous for their observed spectroscopic luminosities (Keenan and Morgan 1951), and their colors are slightly too red for the quoted

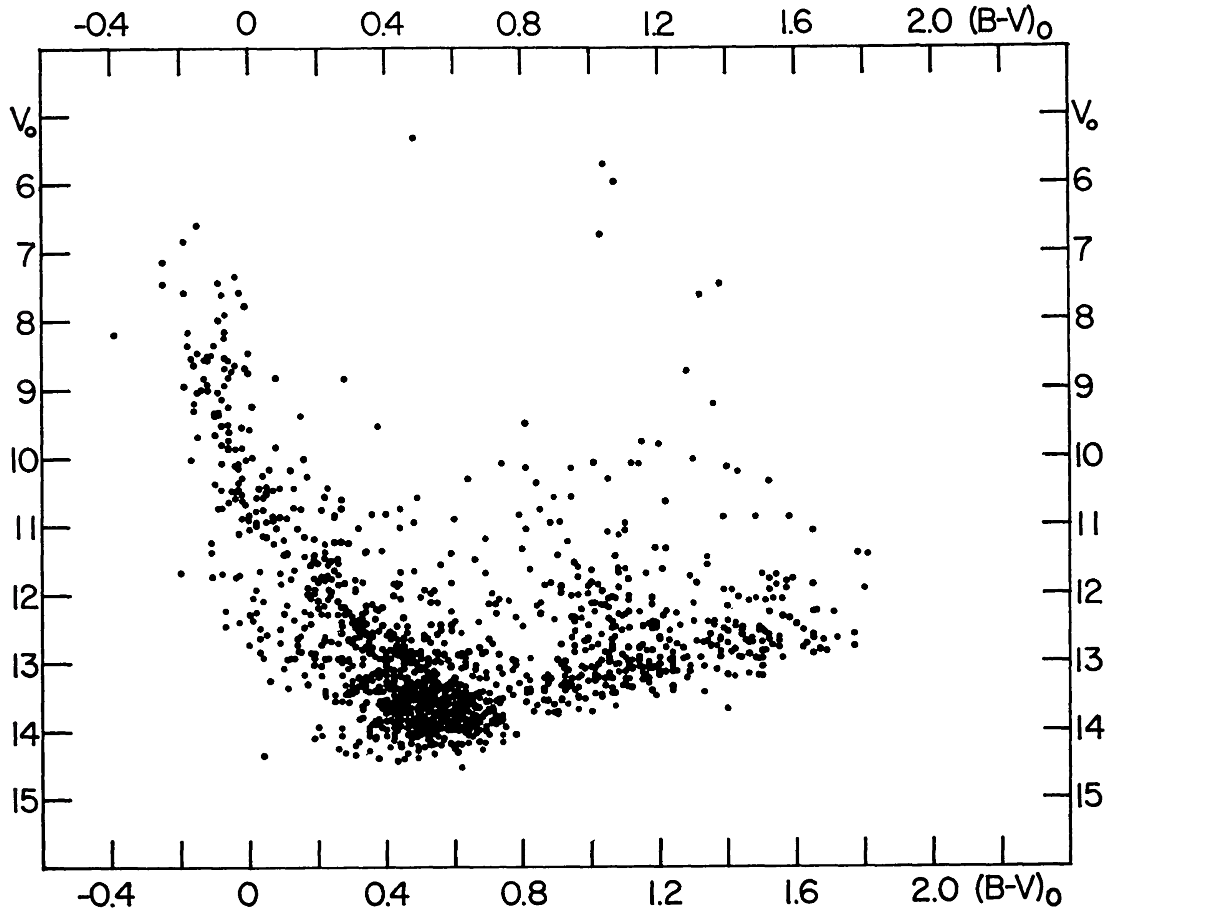

FIG. 9.—The color-magnitude diagram for all stars measured in the region of M25, corrected for the effects of interstellar absorption.

spectral types and luminosity classes (Kraft and Hiltner 1961), neither of the differences is large. Hence, the two stars are probably members. Two additional stars, II-6-27 and II-8-24, appear in the giant region of the M25 color-magnitude diagram in Figure 9. Even though their spectral types are not known, Table 8 shows the latter to have a color and absolute magnitude similar to the giants discussed above. Although its color is somewhat too red, its derived absolute magnitude allows the statement that star II-8-24 may be a member of the cluster. Even though the spectral characteristics are unknown, note that star II-6-27 falls near star I-4-19 in the color-magnitude diagram; the latter has been classified M1 III (Feast 1957). Since II-6-27 falls farther to the right in the color-magnitude diagram than does star I-4-19, assign a spectral type of, say, M3. The derived absolute magnitude of -1.44 causes the star to fall between luminosity classes

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TABLE 8

PHOTOMETRIC AND SPECTROSCOPIC DATA USED IN DISCUSSION

OF CLUSTER MEMBERSHIP

Star	V_o	$(B-V)_o$	Spectral Type	Predicted $(B-V)_o$ *	M_V +	Remarks
IV-6-51	5.36	+0.50	K2: ‡	+1.30	-3.64	nonmember
I-4-19	7.72	+1.38	M1 III ‡ M2 II-III ξ	+1.56 +1.62	-1.28	probable nonmember
IV-4-41	7.32	-0.04	A9V ‡	-----	-1.68	nonmember
III-5-30	8.73	0.00	A0I ‡	-----	-0.27	probable nonmember
III-4-21	7.96	-0.10	A1I ‡	-----	-1.04	nonmember
III-3-28	6.06	+1.12	G5III ‡ G6II ξ	+0.95:	-2.94	probable member
III-5-19	5.78	+1.08	G2III ‡ G3II ξ	+0.95:	-3.26	probable member
II-6-27	7.56	+1.45	-----	+1.60	-1.44	possible member
II-8-24	6.81	+1.07	-----	-----	-2.19	possible member

*The predicted $(B-V)_o$ values are from Kraft and Hiltner (1961).

+The absolute magnitudes are derived assuming (m-M) = 9.0.

‡Spectral type by Feast (1957).

ξ Spectral type by Wallerstein (1960).

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II and III at spectral type M3. The work of Kraft and Hiltner (1961) predicts an intrinsic color of +1.60, which does not agree too well with the derived color of $(B - V)_0 = +1.45$. Considering all of the uncertainties involved, the star has a fair chance of being a cluster member. Spectroscopic confirmation is needed.

Since only plates in two colors were available, it is impossible to determine definitely whether an individual star is a cluster member. However, the three stars which fall to the blue of the main sequence at $V_0 = 8.14$, 11.64, and 14.35 are not cluster members. They are foreground objects appearing very blue because they were corrected for absorption and reddening as were all of the stars investigated, since in the first approximation they were all considered to be cluster members; hence, these three have been overcorrected. Also consider the two stars to the red of the main sequence, IV-4-53 and II-4-27, respectively, at $V_0 = 8.84$, $(B - V)_0 = +0.29$; and $V_0 = 9.54$, $(B - V)_0 = +0.39$. It is possible to show roughly through the work of Keenan and Morgan (1951) and Kraft and Hiltner (1961) that these two objects are probably foreground early giants which in Figure 9 have been overcorrected for reddening.

A final check on the cluster membership for some of the stars investigated in the region of M25 may be made from a study of proper motion by Vyssotsky and Williams (1948). Table 9 tabulates proper motions on the FK3 system for thirty-five stars in the cluster vicinity. The first column identifies an individual star in Figure 5 of the present work; the second and third columns indicate the star designation in the *Bonner Durchmusterung*, the *Boss General Catalogue*, or in the *Cape Photographic Durchmusterung*. The final two columns list the proper motions in seconds of arc per year, with a probable error of about ±0.006 seconds of arc, as measured on photographic plates oriented to the equator of 1900.0. The stars marked with an asterisk in the third column are known to be cluster members (Feast 1957); from these members, the mean proper motion for the cluster was determined to be $\mu_x = -0.008$ and $\mu_y = +0.003$ seconds of arc per year. Assume the criterion that stars whose proper motions deviate from the mean motion by three times the probable error are non-members. On this basis, the data in Table 8 confirm that star IV-6-51 is not a member of the cluster. The radial-velocity study by Feast (1957) and the present photometric work indicate that star I-4-19 is most probably not a cluster member. The proper motion data at hand leave membership questionable. Star I-5-5 in Table 8 may not be a member, although it falls on the main sequence in Figure 9. Its value of μ_x falls just outside the bounds set up by the criterion defined earlier, a good chance for membership. It is comforting to note that the proper motion for the classical cepheid U Sagittarii is essentially the same as the cluster's mean motion.

V. ALLOWANCE FOR FIELD STARS

Again data on proper motion and $(U - B)_0$ colors are lacking for the majority of the stars studied in the region of M25. All stars populating the main sequence in Figure 9 which are bluer than $(B - V)_0 = +0.80$ will be called main-sequence stars. The fourth column in Table 10 gives the total number of main-sequence stars counted in each apparent magnitude interval, including possible foreground and background objects. Let the above be known as Case I. Not all of the stars visible on the original identification chart were measured, however. Therefore, an incompleteness factor, the ratio of the total number of stars visible per apparent magnitude interval in a given ring to the actual number of stars measured in that ring, was determined. Such a factor was found for each ring; they are tabulated in Table 11. The star counts in the fourth column of Table 10 have been adjusted for this incompleteness factor.

Differentiation between field stars and cluster members was accomplished by *assuming* that *all* stars measured in the outer annulus are field stars. This assumption is reasonable, since the mean distance of the outer annulus from the adopted cluster center is 20 minutes of arc, whereas the cluster radius is of the order of 17 minutes of arc (Hogg 1959). The ratio of the area of the total cluster region investigated to the area of the outer annulus,

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TABLE 9

PROPER MOTIONS IN M 25

Star	BD or GC	C.P.D.	μ_x	μ_y
U Sgr	-19° 5047	-19° 6907	-0″.006	+0″.002
I-6-33	--	--	-0.013	+0.002
IV-8-44	-18° 4985	--	-0.008	+0.002
I-5-38	--	--	-0.019	-0.003
IV-4-11	-19° 5034	-19° 6877*	-0.009	+0.012
IV-4-4	--	--	-0.011	+0.004
IV-7-65	--	--	-0.015	+0.014
IV-6-51	25276	-18° 414	-0.140	-0.218
I-3-4	-19° 5036	-19° 6881*	0.000	+0.005
IV-6-55	--	--	-0.016	+0.007
I-4-19	-19° 5038	-19° 6883	+0.011	+0.007
I-3-3	-19° 5037	-19° 6882*	-0.003	+0.002
IV-5-41	-19° 5040	-19° 6885*	-0.011	+0.002
I-5-9	-19° 5039	-19° 6884*	-0.003	+0.013
I-4-28	--	-19° 6886*	-0.014	+0.001
IV-7-69	-18° 4989	--	-0.002	-0.006
I-4-30	--	-19° 6889*	-0.009	0.000
IV-2-15	-19° 5042	-19° 6892*	-0.011	-0.007
I-2-12	--	-19° 6890*	-0.010	-0.001
I-2-27	--	--	-0.010	+0.004
I-3-30	-19° 5043	-19° 6893	-0.012	+0.010
I-5-5	--	--	-0.028	+0.001
IV-8-69	--	--	-0.005	-0.004
II-2-2	--	-19° 6891*	-0.005	-0.013
II-4-1	--	-19° 6906*	-0.014	+0.010
II-3-1	--	--	-0.011	-0.002
II-6-10	-19° 5051	-19° 6911*	-0.019	+0.008
II-4-11	-19° 5052	--	+0.002	+0.009
III-3-28	25300	-19° 6915	-0.010	-0.003
II-4-15	-19° 5055	-19° 6917*	+0.005	+0.005
III-5-19	25306	-19° 6921	-0.006	-0.006
II-6-27	-19° 5060	--	-0.005	+0.004
II-8-47	-19° 5061	--	-0.013	+0.011
II-8-46	--	--	-0.012	+0.013
II-8-55	--	--	-0.010	-0.009

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multiplied by the number of stars counted per apparent magnitude interval, predicts the total number of field stars per apparent magnitude interval in the cluster region under investigation. The actual cluster members for Case II are, therefore, represented by the difference between the number of main-sequence stars measured per apparent magnitude interval adjusted by the incompleteness factor and the number of stars counted in the outer annulus per apparent magnitude interval, the latter count also having been adjusted by the incompleteness factor. The stars comprising Case II are listed in the fifth column in Table 10.

A method has been discussed (Landolt 1963) whereby it is possible to predict from evolutionary theory the point on a cluster's main sequence at which stars are still contracting onto the main sequence. For the open cluster M25, this point turns out to be at $M_V = +3.75$. The effective plate limit in Figure 9 is seen to be $V_0 = 14.2$ or $M_V = +5.2$. Hence, the stars are still contracting onto the main sequence at a point 1.5 magnitudes above the plate limit in the present study. Although this means that perhaps some of the stars redder than $(B - V)_0 = +0.80$ should be included in the luminosity function, inspection of Figure 9 shows the apparent Hertzsprung gap of the field stars to be rather well defined, so that the number of contracting stars to be added to the cluster luminosity function would in any event be small.

TABLE 10

LUMINOSITY FUNCTION FOR M25

M_V	log $\Phi_{m.s.}$+10	No. of Stars Predicted by Φ m.s.	Case I	Case II	log $\psi_{m.s.}$+10	No. of Stars Predicted by ψ m.s.
−4.......	3.18	0.00	1	5.30	6.08	11.24
−3.......	3.82	0.20	0	0.00	6.41	25.29
−2.......	4.42	0.60	6	31.79	6.68	45.90
−1.......	5.04	2.22	18	74.17	6.92	79.63
0.......	5.60	8.26	39	100.66	7.10	121.78
+1.......	6.17	31.22	50	243.71	7.26	171.43
+2.......	6.60	82.79	92	291.39	7.25	171.43
+3.......	7.00	126.91	158	169.54	7.23	164.88
+4.......	7.30	404.49	417	26.49	7.30	188.30
+5.......	7.45	604.32	480	317.88	7.45	281.04
Σ_{-4}^{+5}.......	....	1261	1261	1261	....	1261

TABLE 11

INCOMPLETENESS FACTORS FOR STARS MEASURED IN M25

Ring	No. of Stars Counted	No. of Stars Measured	Ratio
2..........	135	132	1.023
3..........	150	124	1.210
4..........	198	151	1.311
5..........	255	194	1.314
6..........	321	239	1.343
7..........	337	266	1.267
8..........	383	295	1.298

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VI. THE CLUSTER LUMINOSITY FUNCTION

Troubles may be expected in trying to derive the luminosity function for M25 from the present data since plates in only two colors are available. The determinations are weaker still, as differential reddening exists across the face of the cluster. This means that the reddening and absorption cannot be accurately determined for each individual star.

The second, third, sixth, and seventh columns of Table 10 present the general and initial luminosity functions respectively as tabulated by Sandage (1957); they are plotted in Figure 10. Case I of the preceding section represented all apparent main-sequence stars in the direction of the cluster. Case II, the general luminosity function, and the initial luminosity function have all been normalized to the total number of apparent main-sequence stars counted in Case I. Since Case I included non-cluster members, it would be expected that the slope of its luminosity function would parallel that of the general luminosity function for field stars; this it tends to do, as may be seen in Figure 10. Case

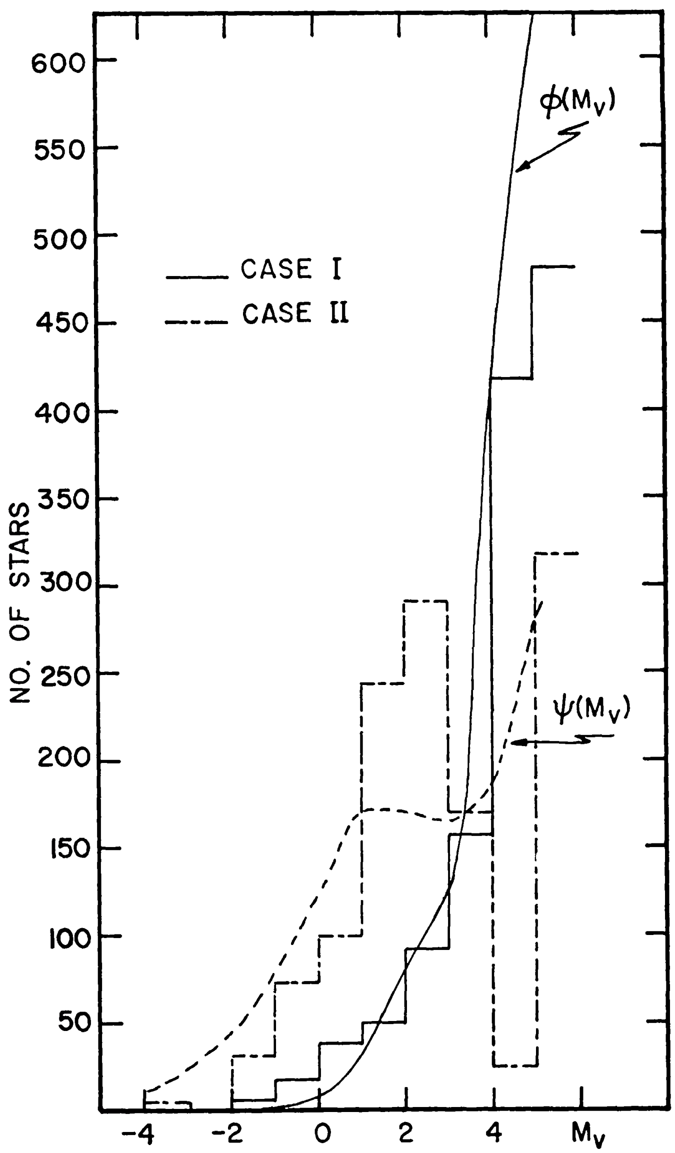

FIG. 10.—The luminosity function for M25. Solid lines are the initial and general luminosity functions as indicated. The two cases represented are discussed in Section VI.

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II contained only stars considered to be cluster members; therefore, the slope of the luminosity function derived for this case might be expected to follow that of the initial luminosity function. Again, Figure 10 shows that the luminosity function for Case II does approach the $\psi(M_V)$ function. Inclusion of the two apparent giant cluster members would improve the fit of the bright end of the luminosity function for Case II to Salpeter's initial luminosity function. Work by Sandage (1957), Roberts (1958), and van den Bergh and Sher (1960) also shows that the Salpeter initial luminosity function agrees with the observational data for galactic clusters.

This investigation has shown that the general field luminosity function most nearly fits the mixture of field stars and cluster members comprising Case I, and that the luminosity function represented by Case II approaches the Salpeter function $\psi(M_V)$.

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