THE ASTROPHYSICAL JOURNAL, 365:168–179, 1990 December 10

THE LARGE MAGELLANIC CLOUD BAR WEST FIELD

JAY A. FROGEL
Department of Astronomy, The Ohio State University
AND
V. M. BLANCO
Cerro Tololo Inter-American Observatory, National Optical Astronomy Observatories[1]
Received 1990 March 22; accepted 1990 June 8

ABSTRACT

We present and analyze infrared photometry for an unbiased sample of 128 M giants in the Bar West field of the Large Magellanic Cloud. The $m_{\rm bol}$, $J-K$ color-magnitude diagram is dominated by asymptotic giant branch stars (AGB) with properties similar to those of giants in intermediate-age clusters in the LMC. However, about 20% of the AGB population has properties similar to those of young, ≤ 100 Myr old, clusters. The luminosity function of all M giants, together with the C stars found in the same field, cuts off at an $M_{\rm bol} \sim -6.0$, about 1.5 mag brighter than the cutoff in the Galactic bulge. Although the field contains a rich population of luminous carbon stars, the *brightest* stars are all of M type. This also is characteristic of the LMC clusters.

From the infrared colors we estimate a mean [Fe/H] $= -0.5 \pm 0.3$ for the M stars in the Bar West field. This is nearly a factor of 10 lower than the mean [Fe/H] in Baade's window. The difference in metallicity is reflected in the fact that in Baade's window the M5–M7 giants dominate the light of all the M stars, whereas in the Bar West field the M0–M2 giants dominate. We find that it is easy to distinguish between Baade's window and the Bar West field in terms of the integrated photometric characteristics of their M giant populations. This result will be of importance in studying distant galaxies.

The presence of two sequences of AGB stars can be interpreted as evidence for at least two major episodes of star formation in the Bar West field. The "young" population appears to have a measurably higher metallicity than the older population. The presence of yet an older population is indicated by the RR Lyrae variables found all over the LMC. This population would correspond with the oldest star clusters in the LMC.

Subject headings: galaxies: Magellanic Clouds — galaxies: photometry — galaxies: stellar content — galaxies: structure — stars: late-type

I. INTRODUCTION

In the western part of the bar of the Large Magellanic Cloud (LMC) lies the "Bar West" field of Blanco, McCarthy, and Blanco (1980, hereafter BMB). This 0.12 deg^2 field has been the subject of several studies that have attempted to characterize the asymptotic giant branch (AGB) population of the Magellanic Clouds. BMB identified 111 luminous carbon and late-type M giants in this field. Counts of earlier type M stars in the field were reported by Blanco and McCarthy (1983). Frogel and Richer (1983) scanned about half of the field at 2.2 μm and 3.5 μm in a search for red luminous stars that might have been missed in the surveys by Blanco and his collaborators. Frogel and Blanco (1983) discussed evidence, based on an unpublished extension of the BMB survey, that star formation in the Bar West field has been episodic rather than continuous over the past ~ 5 Gyr. Recently, the stars found as a result of this extended survey were used as fiducial objects in comparing the AGB population of Magellanic Cloud clusters, classified by Searle, Wilkinson, and Bagnuolo (1980), with that of the general field (Frogel, Mould, and Blanco 1990, hereafter FMB).

The Bar West luminosity function appears to be fairly typical for the LMC although there are small but significant variations in this function with position (Reid and Mould 1984). Analysis of the luminosity function of the carbon stars in the LMC Bar West field by BMB, Richer (1981), and Cohen *et al.* (1981, hereafter CFPE), revealed two serious discrepancies with theoretical predictions (e.g., Renzini and Voli 1981): most of the observed carbon stars were fainter than the faintest predicted luminosity for these stars, and there were too few bright carbon stars. This so-called carbon star mystery and its implications have been discussed extensively in the literature (e.g., Iben 1981, 1984; Iben and Renzini 1983, 1984) and now seems close to being solved (e.g., Lattanzio 1989; FMB; and references therein).

This paper presents details and analysis of the extended survey for M stars in the Bar West field. A finding chart and spectral types for the M stars are given. Infrared photometry has been obtained for an unbiased subset of all M stars. There is some modification of previous, preliminary, analyses of the same data. Finally, the integrated colors, magnitudes, and luminosity functions for the M stars are presented in graphical and tabular form to facilitate comparisons with other stellar populations that have significant numbers of cool luminous giants and with the integrated light of galaxies.

II. THE OBSERVATIONS

a) The Survey

The survey for M stars in the LMC Bar West field has three parts. First, there is the survey of the complete field for stars of type M5.5 and later as described in BMB. These numbers are

[1] Operated by the Association of Universities for Research in Astronomy, Inc. under contract with the National Science Foundation.

TABLE 1

THE SURVEY OF THE LMC BAR WEST FIELD

Type (1)	N(found) (2)	N(obs) (3)	N(tot) (4)
M0–1	48, 95	22	367
M2	16, 95	19	336
M3	14, 28	21	108
M4	11, 5	13	28
M5	2, 12, 1	15	17
M5.5	9	9	9
M6	16	16	16
M6.5	6	6	6
M7	5	5	5
M7.5	2	2	2

given in the lower half of column (2) of Table 1. These include two stars of type M5 as indicated in the table. For the second part, Blanco resurveyed the entire field in order to obtain a representative, i.e., unbiased, sample for earlier M types. This second part is complete for M5 stars; for earlier M types it becomes progressively more incomplete but only in terms of scattered spatial coverage rather than any magnitude bias. The results from this second search are given by the first numbers in column (2) of Table 1 for types M0–4 and the " 12 " entry for M5. The third part of the survey was designed to be complete for all M types within the limitations imposed by the grism technique (Blanco and McCerthy 1983). This complete survey was carried out over a rectangle of size 8'.69 by 14'.16, or 0.296 of the area of the full grism field. The last entry in column (2) of Table 1 for types M0–5 is the number of stars of each type found in this third part of the survey. With two exceptions, no M star identified in the second part of the survey was marked in the third part. Therefore, to estimate the total number of each M type in the LMC BW field, we added the numbers from the first two parts of the survey to 1/0.296 times the number from the third part. These total numbers are given in the last column of Table 1.

There are differences between the number at each spectral type listed in Table 1 and the counts of M stars of different subtypes reported by Blanco and McCarthy (1983). The differences reflect somewhat different spectral cutoffs for the two surveys and the fact that a person's classification criteria may change with time. This is especially the cae in small-dispersion spectroscopic surveys where the spectral features of the earlier M types do not vary appreciably with advancing spectral class. In addition, in some cases the variability of the M giants may result in an apparent disagreement if the spectra are recorded at different epochs. For the present paper, the spectra of all the stars listed as M5 or later by BMB were classified again from independent plate material and with frequent comparisons with standard spectra. The new classifications agreed within one subclass for all the stars except BW-77, now classified as M5 rather than M7. As we point out later, this star is a large-amplitude variable, so spectroscopic changes are not surprising. In the case of the stars classified M5 by Blanco and McCarthy (1983), earlier types ranging from M2 to M4 were found for about half of them. Undoubtedly in that survey there was a tendency to classify early M stars somewhat later. Clearly, the uncertainties in the classification of early M stars mentioned by Blanco and McCarthy affected their results for the Bar West field. However, in the various papers jointly published by Frogel, Blanco, and their collaborators the classifications have been done in a uniform manner so that there should be no systematic differences in spectral classes for these papers. Finally, we note that three new carbon stars, numbers 206, 211, and 213, were found in the Bar West field. The first of these was missed by BMB. The other two are just outside the boundary of the grism plate used by BMB.

Figure 1 (Plates 5–8) is a finding chart for the old (BMB) and new M stars. All the M and C type stars listed by BMB are identified in Figure 1 with large printed numbers; new stars are identified with handwritten numbers. M stars found in the second part of the survey have been given numbers 112 through 215, continuing the numbering scheme of BMB. These stars are listed in Table 2. Stars found in the third part of the survey have been assigned numbers greater than 300. These constitute a representative sample of all stars found in the course of this part of the survey; this sample includes all stars for which we have obtained CCD spectra to be discussed in a subsequent publication. As indicated in the Notes column of Table 2, two of the 300 series stars had already been identified in the second part of the survey. Spectral types from the grism surveys are given in the second column of Table 2: 0 is M0, 10 is M1, etc.

b) The Photometry and Bolometric Magnitudes

All M stars contained in the original BMB survey but not observed by CFPE have new infrared observations presented in Table 2. We also observed all (with two exceptions noted in Table 2) M2–M5 stars and 60% of the M0–M1 stars found in the second part of the survey. Only a fraction of the early M stars found in the third part of the survey were observed in the infrared. These new data were obtained with the 1.5 m and, primarily, with the 4 m reflectors at CTIO between 1981 December and 1982 February. Standards are from Elias *et al.* (1982). For convenience we repeat the photometry for the Bar West M stars from CFPE in Table 2 as well. The data are corrected for reddening and extinction as in CFPE. Uncertainties of 0.03 mag or greater are indicated after the entries. Some additional photometric data are contained in Table 1 of Frogel and Richer (1983). The total number of stars at each spectral type with infrared observations is given in column (3) of Table 1.

As noted in Table 2, BMB 77 is a large-amplitude variable; this has been determined from a photographic search for such stars in the Bar West field (B. Gregory and J. Hackwell, unpublished). The large difference in the K magnitudes for the two observations given in Table 2 are consistent with such variability. CCD spectra for nearly all of the Table 2 stars indicated a few (noted in the Table) with very discrepant radial velocities. The infrared observations are consistent with the interpretation that these are foreground dwarfs.

Bolometric magnitudes for the M stars with infrared photometry are given in the fourth column of Table 2. They are derived from the relation between $J-K$ and BC_K given in Figure 2 of Frogel, Persson, and Cohen (1980). For analyzing the luminosity function of Bar West stars, we will also need m_{bol} for the carbon stars. For those with infrared data in CFPE, m_{bol} is also from Figure 2 of Frogel, Persson, and Cohen (1980). For those without infrared data but with *RI* magnitudes and colors in BMB, we used equation (1b) of CFPE. For the few remaining carbon stars, the *RI* magnitudes and colors in Richer (1981) were used with the CFPE equation.

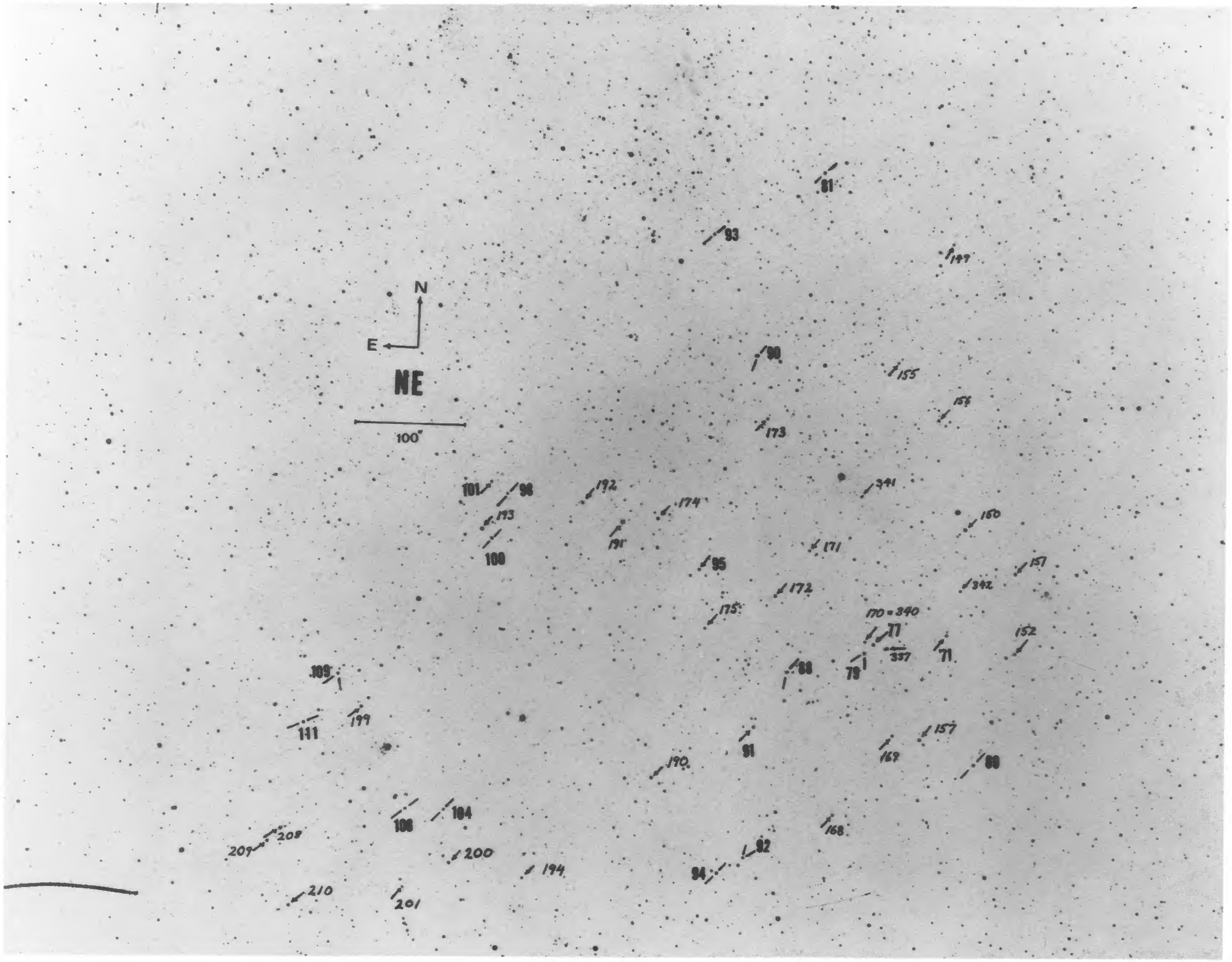

FIG. 1*a*

FIG. 1.—A finding chart for the LMC Bar West field similar to that in BMB. Large printed numbers are stars in the BMB survey. Stars with numbers from 112 to 215 are from the second part of the M star survey described in the text. Those from the third part of the survey are numbered 301 or greater.

FROGEL AND BLANCO (*see* **365**, 169)

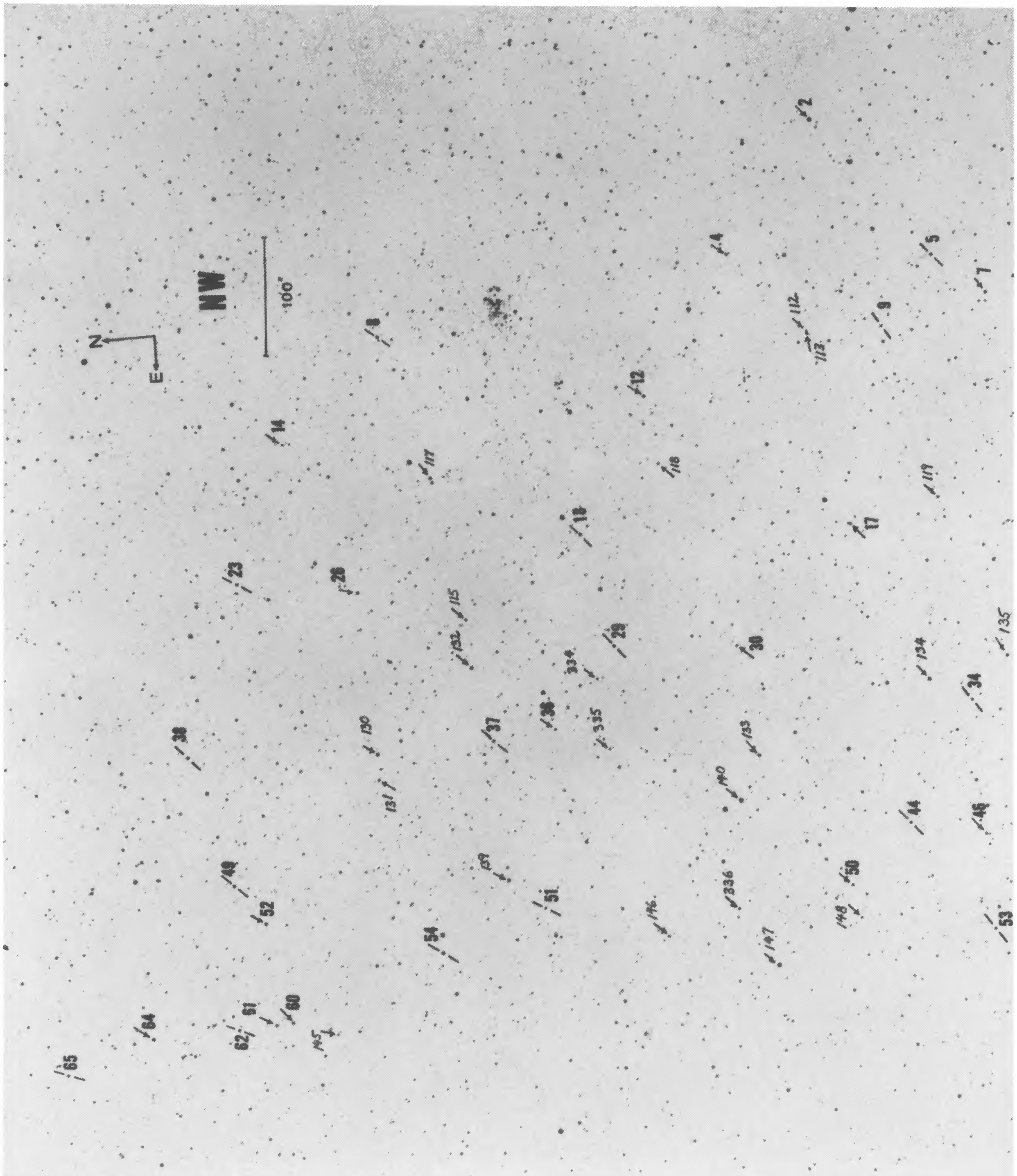

FIG. 1b

FROGEL AND BLANCO (*see* **365**, 169)

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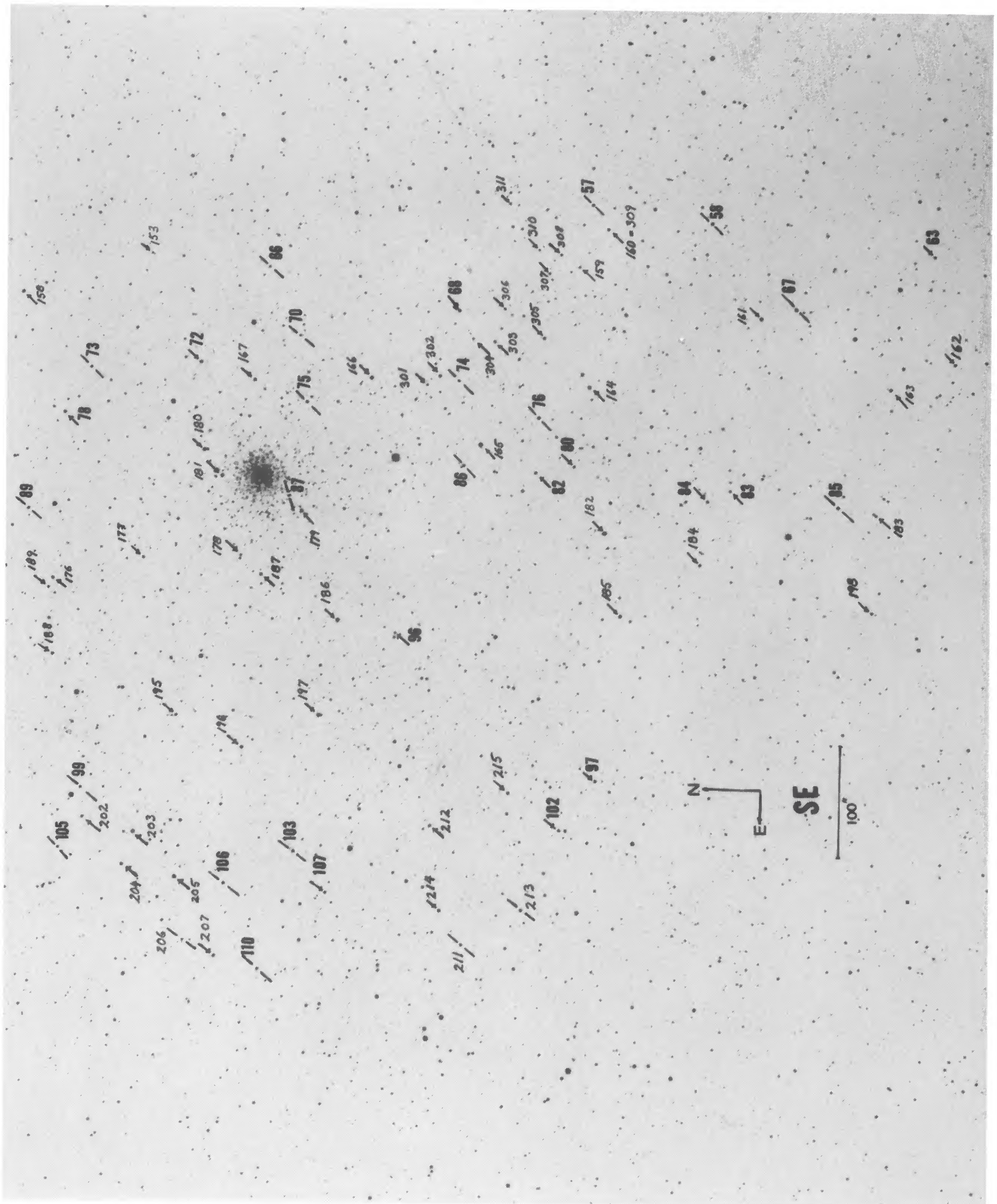

FIG. 1c

FROGEL AND BLANCO (*see* **365**, 169)

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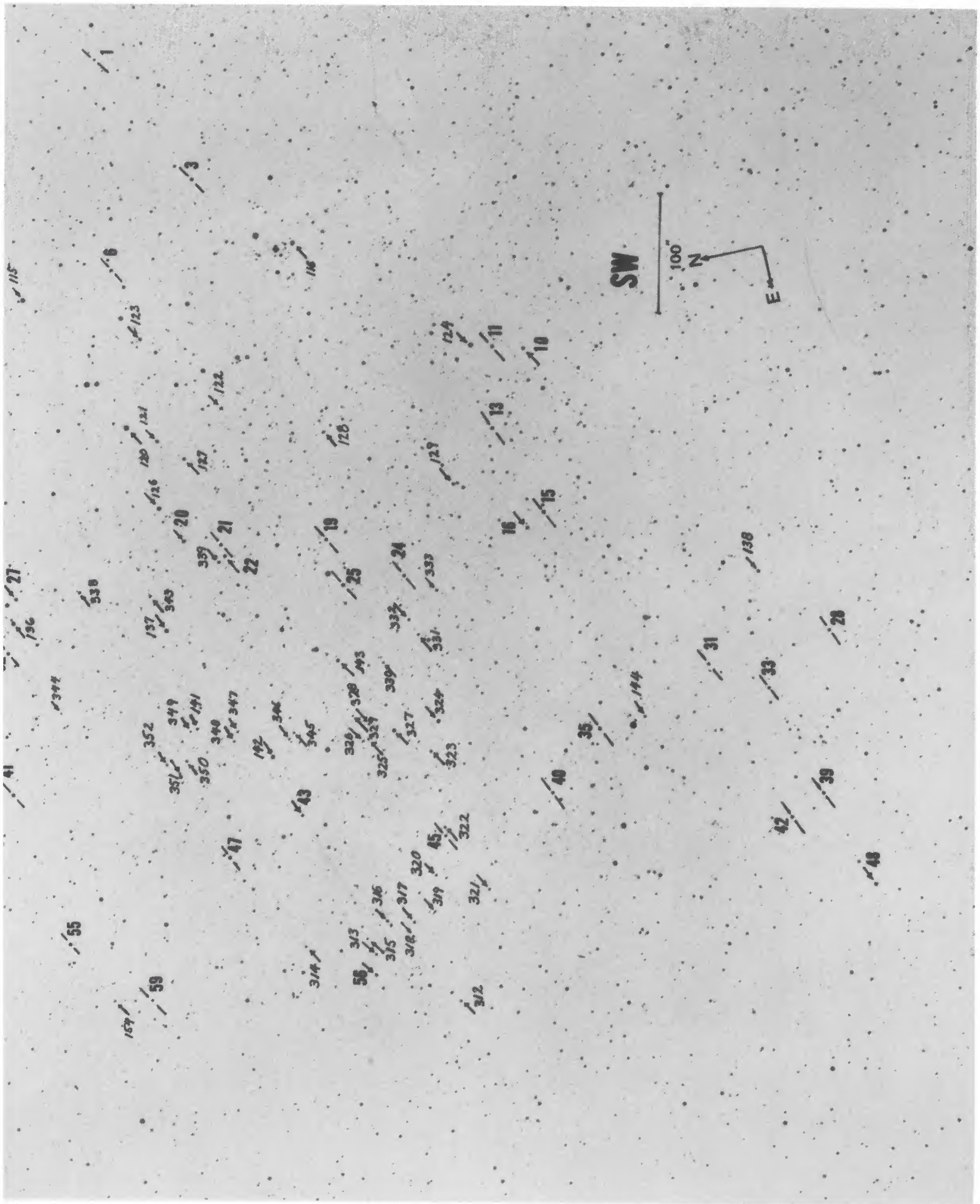

FIG. 1d

FROGEL AND BLANCO (*see* **365**, 169)

TABLE 2

REDDENING-CORRECTED PHOTOMETRY FOR M GIANTS IN THE LMC BAR WEST FIELD

BW #	type	K	m_{bol}	$J-K$	$H-K$	H_2O	CO	notes
2	55	9.46	12.46	1.12	0.24	0.16	0.25	1, y
4	70	10.72	13.77	1.17	0.31	0.26	0.27 3	1
7	60	10.95	13.95	1.12	0.25		0.17	
10	60	11.23	14.09	1.00 3	0.20	0.08 3	0.20	1
12	60	10.83	13.92	1.21	0.29		0.23	
14	70	10.76	13.77	1.14	0.33		0.26	
16	60	11.15	14.09	1.06	0.23		0.22	
17	70	10.84	13.85	1.14	0.27		0.22	
20	50	11.05	14.08	1.16	0.23		0.26	
22	60	10.94	13.94	1.12	0.26		0.30	
26	55	11.28	14.22	1.06	0.19		0.13	
27	60	11.03	13.98	1.07	0.25		0.23	
30	65	10.92	13.99	1.19	0.29		0.19	
36	55	11.86	14.77	1.03	0.28	0.33	0.10	
43	55	11.59	14.50	1.03	0.18		0.19	
46	65	10.99	13.90	1.03	0.21		0.16	
48	60	10.17	13.20	1.16	0.25	0.09	0.22	1
50	55	11.55	14.63	1.20	0.28	0.12 3	0.25 3	1
52	50	11.58	14.43	0.99	0.18			
56	55	11.28	14.21	1.05 3	0.25		0.22	
60	55	11.35	14.27	1.04	0.21		0.14 3	
61	70	10.80 3	13.87	1.19 3	0.31	0.16	0.27	1
63	60	11.13	14.10	1.09	0.24		0.23	
64	60	10.79	13.76	1.09	0.24		0.21	
68	75	10.46	13.47	1.14 3	0.32	0.21 3	0.28 3	1
71	65	10.57	13.58	1.14	0.26		0.20	
72	55	10.93 3	13.90	1.09	0.21		0.23 3	
77	70	11.07	13.80	0.94	0.24	0.22	0.13	3
78	75	10.12 3	13.10	1.10 3	0.33	0.25	0.32	1
80	60	11.73	14.68	1.07	0.22			
82	60	11.18	14.14	1.08	0.22		0.20	
83	65	11.14 3	14.11	1.09 3	0.24	0.06 3	0.25	1
84	65	10.97	13.95	1.10	0.24		0.28	
91	60	10.88	13.84	1.08	0.23		0.25	
95	55	11.56	14.48	1.04	0.20		0.20 3	
96	60	11.48 3	14.43	1.07 3	0.21			
97	65	11.02 3	14.00	1.10	0.22		0.27	
101	60	11.36	14.36	1.12	0.24		0.23 3	
102	60	11.35 3	14.28	1.05	0.20		0.22	
107	60	11.06	14.05	1.11	0.22		0.21	
112	0							2
113	20							2
114	10							
115	10							
116	0							
117	10							
118	10							
119	10							
120	0	9.61	12.36	0.95	0.18	0.06	0.23	y
121	10	11.64	14.17	0.85	0.13		0.14	y
122	50	11.38	14.32	1.06	0.22	0.22	0.29	
123	10							
124	0							
125	40	11.62	14.73	1.26	0.27		0.20	2, y
126	40	10.32	13.26	1.06	0.20	0.09	0.21	
127	50	11.48	14.44	1.08	0.22	0.10	0.18	
128	20	12.59 4	14.82	0.71 4	0.12 4		0.08 3	y
129	10	11.92	14.65	0.94	0.14		0.19	
130	0							
131	20	12.34	15.11	0.96	0.15		0.10	
132	10	11.81	14.18	0.77	0.12	0.01	0.10 3	y
133	20	11.13	14.13	1.12	0.26	0.04	0.22	
134	0							
135	20	11.17	14.16	1.11	0.24	0.19	0.25	
136	0							
137	30	10.11	13.06	1.07	0.23	0.08	0.23	
138	40	11.58	14.43	0.99	0.17	0.07 3	0.23	
139	10	10.90	13.91	1.14	0.24	0.10	0.28	
140	30	9.32	12.30	1.10	0.23	0.13	0.22	y
141	10	12.15	15.08	1.05	0.19		0.19 3	

TABLE 2—*Continued*

BW #	type	*K*	m_{bol}	*J–K*	*H–K*	H_2O	CO	notes
142	10	11.11	13.48	0.77	0.13		0.18	y
143	10	11.43	14.37	1.06	0.19	0.07	0.18	
144	40	12.11	15.01	1.02	0.18		0.20	
145	10	12.68	15.31	0.89	0.11			
146	10							
147	0	10.17	12.66	0.84	0.15	0.03	0.21	y
148	40	11.42	14.51	1.33	0.32	0.16 3	0.17	
149	20	11.28	14.28	1.12	0.27	0.18	0.27	
150	40	10.49	13.43	1.06	0.23		0.25	
151	30	11.30	14.20	1.02	0.18		0.18	
152	50	10.88	13.88	1.12	0.27		0.30	
153	50	11.72 3	14.81	1.21 3	0.28		0.23	
154	30	13.01 3	15.50	0.84	0.13 3			
155	50	13.06 3	15.46	0.79	0.10			
156	20	11.91	14.74	0.98	0.16	0.07	0.21 3	
157	10	11.79	14.14	0.76	0.11	0.04	0.10 3	y
158	10	11.21	13.59	0.78	0.15	0.11	0.04	4, y
159	50							5
160	30	11.54	14.35	0.97	0.19	0.03	0.25	
161	50	10.42	13.38	1.08	0.24	0.12	0.28	
162	50	11.41	14.32	1.03	0.20	0.05	0.18	
163	40	10.77	13.77	1.12	0.25	0.05	0.30	
164	10	10.67	13.42	0.95	0.16	0.05	0.19	y
165	0	9.87	12.60	0.94	0.18	0.04	0.23	y
166	0	11.10	13.52	0.80	0.12		0.23 3	y
167	10	11.18	13.99	0.97	0.16		0.20 3	
168	40	11.31	14.27	1.08	0.24		0.25	
169	50	11.34	14.29	1.07	0.25		0.23 3	
170	10	12.23	14.98	0.95	0.15			
171	20	12.14	14.95	0.97	0.17			
172	10							
173	30	12.10	14.87	0.96	0.16		0.25	
174	50	11.35	14.10	0.95	0.15	0.04	0.20	
175	20	11.89 3	14.79	1.02 3	0.21		0.20	
176	30	11.82	14.55	0.93	0.20		0.12 3	
177	10							
178	10							
179	30	10.16	13.25	1.23	0.28	0.05	0.37	
180	20							2
181	10							
182	0							
183	20							2
184	30	11.24	14.21	1.09	0.21		0.23	
185	50	10.20 3	13.21	1.14	0.25		0.22	
186	0	10.66	13.10	0.82	0.12			y
187	20	11.11	14.02	1.03	0.20	0.07	0.23	
188	30	11.06	14.02	1.08	0.22		0.20	
189	10							
190	40	10.92	13.85	1.05	0.20		0.20	
191	0							
192	50	11.33	14.24	1.03	0.18		0.20	
193	10							
194	30	11.60	14.53	1.05	0.20	0.20 3	0.23	
195	20	11.57	14.47	1.02	0.18	0.09	0.19	
196	10	10.53	12.99	0.83	0.10			y
197	0							
198	20	11.45	14.38	1.05	0.20	0.06	0.21	
199	30	11.69	14.57	1.01	0.18		0.19	
200	10							
201	40	12.08	14.96	1.01	0.18	0.14	0.19	
202	10							
203	0							
204	20	11.13	14.06	1.05	0.21	0.08	0.22	
205	10							
206	C							
207	10							
208	0							
209	30	11.01	13.91	1.02	0.22	0.06	0.25	
210	40	11.45	14.28	0.98	0.19	0.11	0.18	
211	C							
212	30	11.43	14.18	0.95	0.18	0.06	0.27	
213	C							
214	10							
215	50	10.83	13.81	1.10	0.26	0.08	0.31	
301	20	13.05 3	15.70	0.90 3	0.13 3			
302	40	11.55	14.32	0.95	0.17			
303	30	11.93	14.63	0.92	0.16			

TABLE 2—*Continued*

BW #	type	K	m_{bol}	$J-K$	$H-K$	H_2O	CO	notes
304	10	13.32 3	15.53	0.69 3	0.10 3			y
305	30	11.60	14.43	0.98	0.16			
306	10	12.92 3	15.15	0.70 3	0.12 3			y
307	10	12.93 3	15.07	0.66 3	0.12 3			y
308	20	12.34	15.19	0.99	0.17			
309	30							≡160
310	30	12.99 3	15.60	0.88 3	0.09			
311	20	12.89 3	15.70	0.97	0.14			
312	20	12.57	15.18	0.88	0.13			
313	20	12.44 3	15.17	0.93 3	0.14 3			
314	20	12.66 3	15.49	0.98	0.16			
315	20	13.66 3	16.12	0.82 3	0.12 3			
316	30	12.03	14.84	0.97	0.16			
317	20							
318	20							
319	20							
320	20							
321	20							
322	20							
323	10							
324	10							
325	10							
326	20							
327	10							
328	30	11.61 3	13.96	0.76 3	0.08 3			y
329	20							
330	20							
331	20							
332	20							
333	10							
334	40	12.80	15.57	0.95	0.17			
335	40							2
336	50	11.37	14.42	1.17	0.26			
337	40							2
338	40							2
339	30	12.29	15.02	0.93	0.17			
340	30							≡170
341	30							2
342	30							
343	30	11.84	14.76	1.05	0.19			
344	30							
345	30							
346	20							
347	20							
348	10							
349	20							
350	20							
351	20							
352	10							4

[1] Photometry from CFPE.
[2] Crowded; difficult or impossible to observe photometrically.
[3] Large-amplitude variable; another observation gave $K_0 = 10.68$, $(J-K) = 0.88$, $(H-K)_0 = 0.24$, CO = 0.075.
[4] Probably foreground dwarf; velocity-discrepant.
[5] Wrong star was observed in the IR.

III. THE H-R DIAGRAM AND LUMINOSITY FUNCTIONS

To easily compare the present results for field AGB stars in the LMC with those for cluster stars in FMB, we will adopt a distance modulus of 18.3 for the LMC. Arguments in favor of this value are given in Mould (1988); no conclusions in this paper are significantly affected if the older values of 18.6 or 18.7 were adopted. The 18.6 value was used in CFPE so that the absolute luminosities for carbon stars from that paper required a small adjustment. Also, we will refer to the cluster classification scheme of Searle, Wilkinson, and Bagnuolo (1980) as the SWB class. Briefly, their types I through VII appear to correspond to a sequence of increasing age and decreasing metallicity. SWB I–III clusters have ages of less than a few 100 Myr, contain luminous M stars (supergiants in the youngest clusters), and few, if any, carbon stars. SWB IV–VI clusters have typical ages of a few Gyr and contain a rich AGB population of M stars, C stars, or both. SWB VII clusters are old and metal poor; they are analogs of Galactic globular clusters (FMB).

a) *The H-R Diagram*

Figure 2 presents the bolometric magnitudes and $J-K$ colors for the stars in Table 2. For a distance modulus of 18.3 to the LMC, essentially all stars with $m_{bol} \leq 14.7$ have to be AGB members. They lie well above the maximum luminosity achieved by nonvariable giants in Galactic globular clusters of

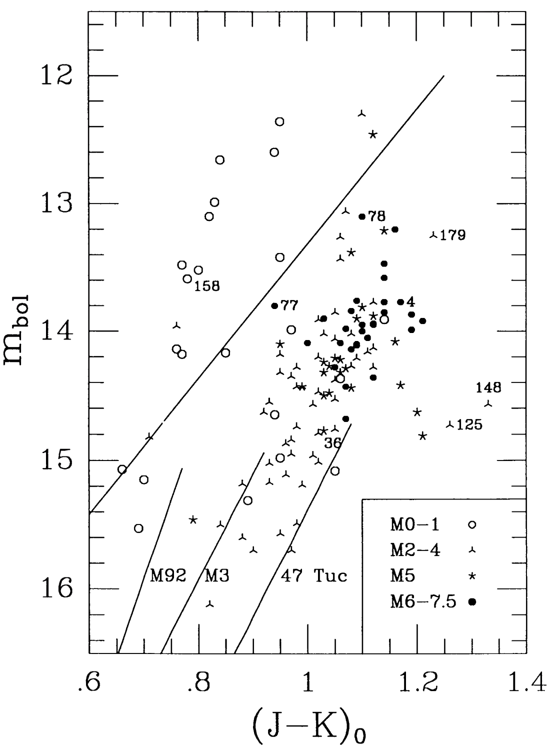

FIG. 2.—A color-magnitude diagram for all stars in Table 2. The long sloping straight line (Frogel, Mould, and Blanco 1990), divides AGB stars from LMC clusters of SWB types I–III (*left-hand side*) from all other types (*right-hand side*). Stars with extreme locations in this and succeeding plots are marked. Giant branches for three globular clusters (Frogel, Persson, and Cohen 1981) are indicated for an $(m-M)_0 = 18.3$ for the LMC.

all metallicities. The bulk of the stars lie on a well-defined though broad AGB. There is, however, a small number of giants—mostly of type M0–M1—that are quite a bit brighter than the majority of stars of similar color and spectral type. The long sloping straight line in Figure 2 has the same position as that drawn by FMB to separate stars in SWB I–III clusters from those in clusters of types IV–VI. The presence of a "bright" and "faint" AGB was pointed out by Frogel and Blanco (1983) and will be discussed further in § VI. For the moment we will refer to the fainter branch as the "old population" of the Bar West and the bright one as the "young population." A few stars of intermediate to late spectral type with $J-K$ between 1.05 and 1.15 are intermediate in magnitude to the two branches.

There is an excess of M giants with $J-K$ greater than 1.05 and brighter than m_{bol} of 14 in the Bar West field relative to the numbers found in LMC clusters (FMB). Such an excess could arise from an enhancement in [Fe/H] among the field stars with ages corresponding to the SWB IV–VI clusters. It could also result from small differences in the rates of field star formation and cluster formation as a function of time.

b) *Luminosity Functions*

Table 3 gives luminosity functions for various subsets of the M giants in the LMC Bar West field. The first column lists the centers of 0.2 mag wide bins in m_{bol}. The second column is the luminosity function for all carbon stars in this field (CFPE). Bolometric magnitudes have been calculated as described in § II*b*. The third through fifth columns are for spectral subsets

TABLE 3

LUMINOSITY FUNCTIONS FOR AGB STARS IN THE LMC BAR WEST FIELD

m_{bol} (bin center) (1)	C (2)	Young and Old M M0-7 (3)	M2-7 (4)	M3-7 (5)	Old M Only M0-7 (6)	M2-7 (7)	M3-7 (8)
12.10	0	0	0	0	0	0	0
12.30	0	22	5	5	0	0	0
12.50	0	18	1	1	0	0	0
12.70	1	17	0	0	0	0	0
12.90	3	17	0	0	0	0	0
13.10	4	24	7	7	7	7	7
13.30	7	9	9	9	9	9	9
13.50	8	71	4	4	4	4	4
13.70	10	5	5	5	5	5	5
13.90	13	61	28	28	56	23	23
14.10	14	139	89	18	89	89	18
14.30	3	84	67	31	84	67	31
14.50	2	49	49	31	49	49	31
14.70	3	68	51	16	68	51	16
14.90	1	66	49	14	48	31	14
15.10	1	128	78	7	95	78	7
15.30	0	17	0	0	17	0	0
15.50	0	48	31	14	31	31	14
15.70	0	35	35	0	35	35	0
15.90	0	0	0	0	0	0	0
16.10	0	18	18	0	18	18	0
totals	70	895	527	191	615	498	180

of the young and old populations together, while the sixth through eighth columns are for the old M stars only, i.e., the faint AGB. In order to construct the third through fifth we first determined the *observed* luminosity function for each subtype individually and then multiplied each entry by N(tot)/N(obs) from Table 1. Entries for half subtypes, e.g., M5.5, were included in the next earlier subtype, in this case M5. All subtypes were then added together to produce the numbers in Table 3. To calculate the numbers in the last three columns of this table, the same procedure was followed but with the young population eliminated. Appropriate weights for each spectral subtype of the old population only are given by the ratio of the last two columns of Table 5 (see below). Note that the carbon stars have *not* been included in the luminosity functions for either the old or young populations. Entries for the three faintest bins in Table 3 are all M2 or earlier and therefore the most uncertain.

Figure 3*a* displays various luminosity functions. The cross-hatched area is that for the C stars from the second column of Table 3. The upper bound to the singly hatched area is for the C stars plus the young and old M2–M7 stars (the fourth column of Table 3), i.e., M0–M1 stars, are excluded. Finally, the highest upper bound for each bin in the figure includes all young, and old M stars (the third column of Table 3) as well as the C stars. The earliest type stars dominate the luminosity function for $m_{bol} \leq 13.0$ but contribute more or less equally, in terms of percentage, to the fainter bins. The C stars dominate the luminosity function for $m_{bol} \leq 14.0$ but have a bright side cutoff, $m_{bol} = 12.8$, that is noticeably fainter than that of the earliest M stars. These results are similar to those obtained for AGB stars in Magellanic Cloud clusters (FMB).

The "a" luminosity function for AGB stars with $V-I > 1.6$, found in a photographic survey of the LMC by Reid and

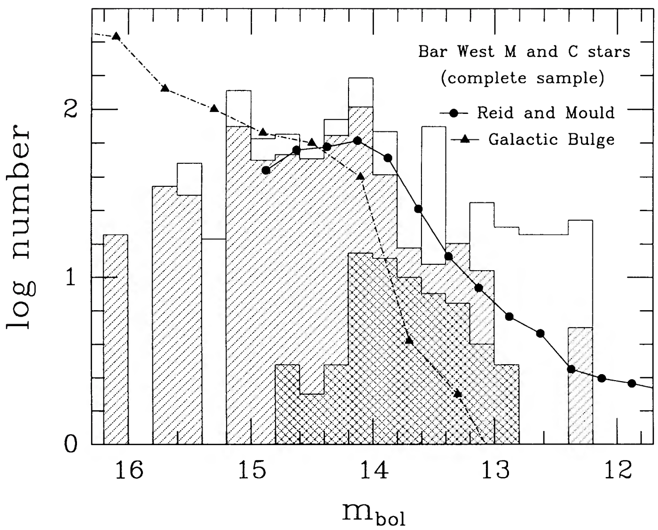

FIG. 3a

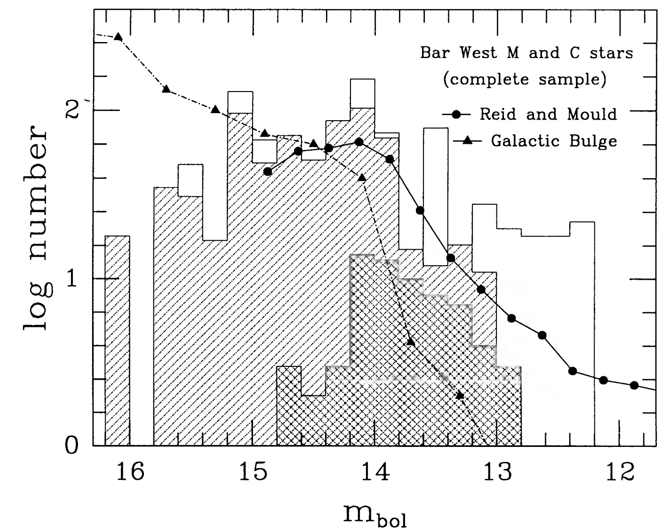

FIG. 3b

FIG. 3.—(*a*) The uppermost bound to the histogram is the luminosity function for all M stars plus C stars in the Bar West field (the second and third columns of Table 3). The upper bound to the lightly shaded area is the same but with M0–M1 stars excluded. The cross-hatched area is for C stars alone. The M star survey may be incomplete for $m_{bol} \leq$ about 12.2 because of saturation effects and for $m_{bol} \geq 14.5$ because of incompleteness for the earliest spectral types. The "a" luminosity function for the LMC from Reid and Mould (1984) and the Galactic bulge luminosity function (Frogel *et al.* 1990) for all bulge fields except that at $b = -12°$ have been shifted vertically for ease of comparison. (*b*) Same as (*a*) except the lightly shaded area is the function for all *old* Ms plus the C stars.

Mould (1984), is also shown in Figure 3*a*. It has been shifted vertically to match the Bar West function for m_{bol} between 14.0 and 14.5. Since the Reid and Mould luminosity function is based on a much larger sample of stars than is ours, it is less noisy. Its shape agrees well with ours for the C and M2 and later stars in Figure 3*a*. In the Cousins photometric system used by Reid and Mould, $V-I > 1.6$ corresponds to type M1 if reddening is negligible (Blanco 1965, Table 3). Therefore, the limit $V-I > 1.6$ tends to leave out the M0 and M1 stars that are included in our spectroscopic survey between m_{bol} of 12 and 13. However, the Reid and Mould luminosity function extends to an m_{bol} nearly as bright as 11.0. Inclusion of the brightest stars found in the infrared survey by Frogel and Richer (1983) would bring the two luminosity functions into closer agreement at this bright end. These bright Ms are missing from the grism survey because they would have been over exposed.

Figure 3*b* is identical to Figure 3*a* except that now the upper bound to the lightly shaded bins represents the subset of all old Ms (the sixth column of Table 3) plus the C stars. A comparison of Figures 3*b* and 3*a* shows that the luminosity function for all old Ms is nearly identical to that for all Ms without the M0–M1 stars. This is not surprising, since only 5% of the M2–M7 stars are considered to be in the young population. The only obvious difference between these two samples is the presence of a few young stars of type M2 and later in the bin centered at $m_{bol} = 12.3$.

IV. COLORS AND INDICES FOR THE LMC BAR WEST M STARS

In this section we will consider the colors and the CO and H_2O indices of the LMC Bar West M giants. Their distribution and mean values will be compared with those for other stellar populations. A few stars have colors and indices that differ markedly from those that characterize nearly all of the remaining stars. These objects will be discussed at the end of the section.

a) *J−H*, *H−K* Colors

Figure 4 is a two-color diagram for the stars from Table 2. Most of the Bar West stars lie between the mean lines for Galactic globular cluster and solar neighborhood giants. In particular, note that the mean line for LMC supergiants is on the *opposite* side of the solar neighborhood giant line from most of the Bar West stars. From this we infer that the displacement of the Bar West stars from the field line is not due to

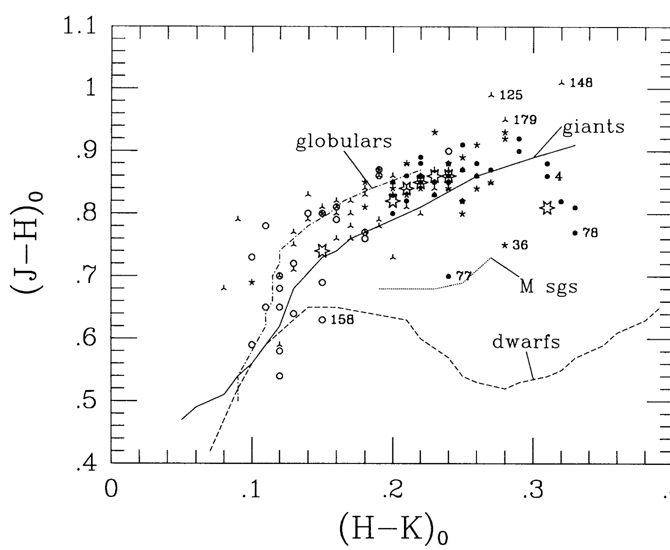

FIG. 4.—The relation between $J-H$ and $H-K$ for the LMC Bar West stars in Table 2. The mean lines for solar neighborhood giants and dwarfs are from Fogel *et al.* (1978); for globular cluster giants, from Frogel, Persson, and Cohen (1983); that for LMC M supergiants (Elias, Frogel, and Humphreys 1985) is an average for types Ia and Ib. The symbol code is as in Fig. 2 with the addition that the big stars indicate the mean colors for each spectral group from Table 4.

TABLE 4

REDDENING-CORRECTED FLUX-WEIGHTED MEAN COLORS AND MAGNITUDES FOR ALL LMC BAR WEST M GIANTS

Type	$J-K$	$H-K$	K	CO	m_{bol}	K_{tot}	%J	%H	%K	N(obs)	N(tot)
M0-1	0.89	0.15	11.03	0.20	13.64	4.62	0.55	0.53	0.59	22	367
M2	1.02	0.20	11.84	0.21	14.71	5.53	0.21	0.22	0.20	19	336
M3	1.05	0.21	11.11	0.24	14.01	6.03	0.13	0.14	0.12	21	108
M4	1.07	0.22	11.23	0.22	14.17	7.61	0.03	0.03	0.03	13	28
M5-5.5	1.09	0.23	11.05	0.23	14.01	7.51	0.03	0.03	0.03	24	26
M6-6.5	1.10	0.24	10.99	0.22	13.98	7.64	0.03	0.03	0.03	22	22
M7-7.5	1.12	0.31	10.64	0.26	13.63	8.53	0.01	0.01	0.01	7	7
M0-7.5	0.96	0.18	3.91	0.21	6.64						
M2-7.5	1.05	0.21	4.70	0.225	7.60						

their relatively high luminosity but, following the discussion in Frogel and Whitford (1987), that it arises from a subsolar mean metallicity for the stars. AGB stars from SWB V clusters (Fig. 3 of FMB) also occupy the region between the globular cluster and field mean lines, although they do not extend to colors as red as the colors of the Bar West stars. SWB V clusters have a mean [Fe/H] of -0.6. Stars from the $-12°$ field of the Galactic bulge have a similar location (Frogel *et al.* 1990). Their mean [Fe/H] is about -0.3. Although our understanding of the effects of age, metallicity, and luminosity on the *JHK* colors of giants is incomplete (cf. Bessell *et al.* 1989), we tentatively assign a value of -0.5 ± 0.3 to the mean [Fe/H] of the Bar West M giants on the basis of the above comparisons.

b) CO *and* H_2O *Indices*

A CO index was determined for most of the stars in Table 2. Figure 5 displays these data as a function of $J-K$. The scatter in CO at constant color is considerable and greater than that for Galactic bulge fields (Frogel and Whitford 1987; Frogel *et al.* 1990). The flux-weighted mean values of CO as a function of $J-K$ (Table 4), indicated by large stars in Figure 5, lie close to or slightly above the mean line for local giants in Figure 5. Since giants in the most metal-rich globular clusters (Frogel, Cohen, and Persson 1983) also have CO indices at or above the mean local field line, the location of the Bar West M giants in Figure 5 would appear to be consistent with the mean value of [Fe/H] for these giants of 2–3 times less than solar estimated in the previous section. The CO index in giants is positively correlated with luminosity (Baldwin, Frogel, and Persson 1973) and metallicity (Cohen, Frogel, and Persson 1978). Nearly all of LMC stars in Figure 5 have luminosities greater than the top of the first giant branch. These high luminosities could explain the rather strong CO indices (cf. discussion in Frogel *et al.* 1990 of a similar problem that arises in interpreting observations of bulge stars).

Figure 6 illustrates the dependence of CO on bolometric magnitude for the stars of Table 2. Ignoring for the moment those with $m_{bol} \leq 13.0$, we see a weak trend of increasing CO strength with increasing luminosity. Some, but not all, of this trend can be attributed to the fact that m_{bol} also gets brighter with later spectral type since stronger CO is associated with cooler stars. However, as Table 4 and Figure 5 show, this temperature dependence can account for only about half of the total CO change in Figure 6. Since the range in luminosity at constant color is substantial (Fig. 2), this same range in lumin-

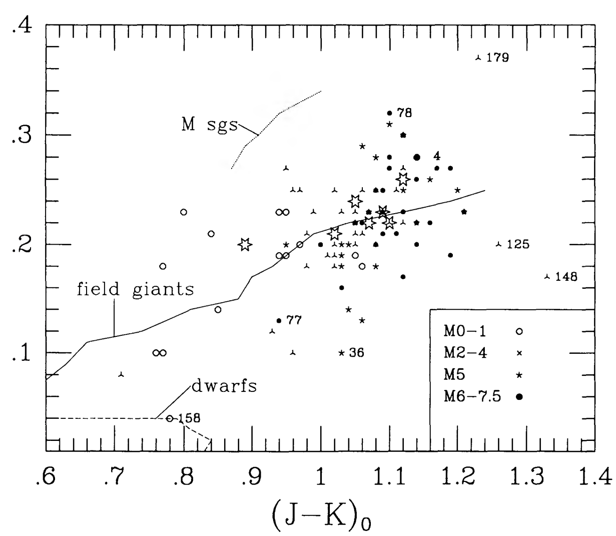

FIG. 5.—The relation between the CO absorption index and $J-K$ for the LMC Bar West stars in Table 2. Mean lines for solar neighborhood giants and dwarfs and for LMC M supergiants are as in Fig. 4. The large stars are the mean values for each M subtype for all M stars from Table 4. Note the location of star 158 near the mean line for dwarfs.

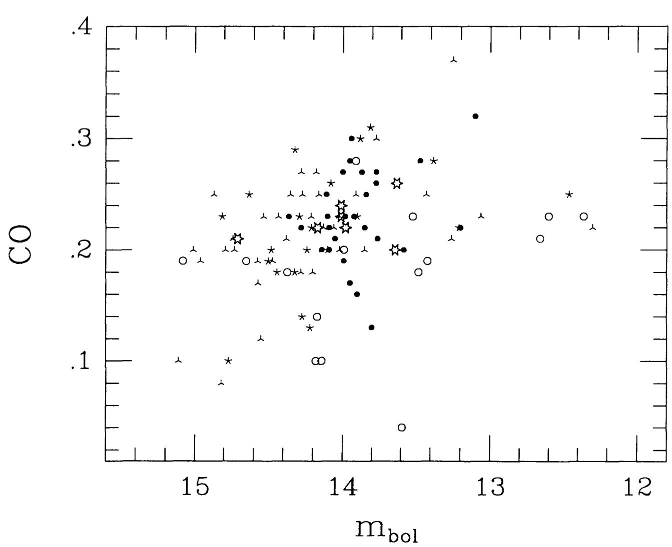

FIG. 6.—The CO index as a function of m_{bol} for the LMC Bar West stars in Table 2. The symbol key is as in Figs. 2 and 5.

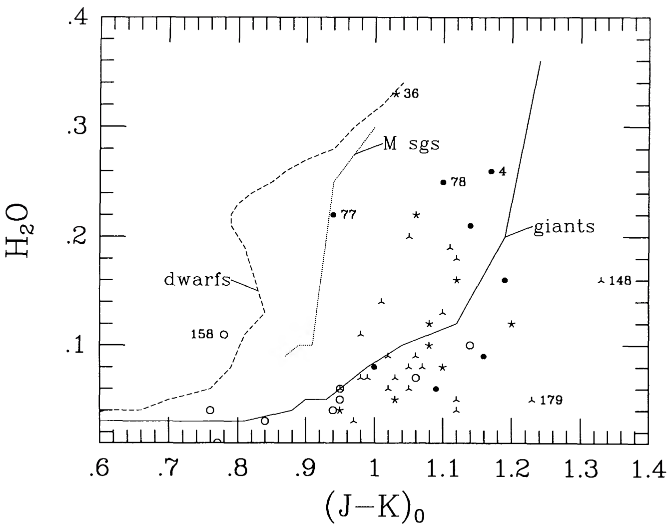

FIG. 7.—The relation between the H_2O absorption index and $J-K$ for the LMC Bar West stars in Table 2. Mean lines for solar neighborhood giants and dwarfs, for LMC M supergiants, and the symbols are as in Figs. 2 and 5. Note the location of star 158 near the mean line for dwarfs.

osity can be expected to contribute to a range in CO at constant color and thus account for a significant part of the scatter in Figure 5. Further contributing to this scatter will be the range in [Fe/H] of the M stars. From their location in the H-R diagram of Figure 2, the corresponding SWB cluster types range between III and VI (FMB). This corresponds to a range in [Fe/H] of nearly 1.0 dex (Table 3 of FMB). While the slope of the dependence of CO on [Fe/H] for AGB stars such as those in the Bar West field is unknown, for globular cluster giants a change in [Fe/H] of 1.0 causes a change in CO of 0.07 at constant color (Frogel, Cohen, and Persson 1983).

H_2O indices were determined for only a fraction of the stars in Table 2. The data obtained are illustrated in Figure 7. Most of the data points are close to the mean line for solar neighborhood giants. The systematic deviation from this line that is exhibited by stars with $J-K$ between 0.95 and 1.15 is similar to that seen for Galactic bulge giants (Fig. 6 of Frogel and Whitford 1987). None of the stars has the strong H_2O absorption shown by the later M types in the Galactic bulge.

c) *Mean Magnitudes and Colors*

To compare the LMC Bar West M stars with other M star populations classified in a similar way, it is useful to determine the mean magnitudes and colors for each spectral subtype as well as for the integrated M star light. Table 4 gives these quantities for the entire sample of M stars in the Bar West field. The mean *JHK* colors are flux-weighted; that is, the contribution of each star to a given wavelength is weighted by its relative flux at that wavelength. The mean CO index has been derived by weighting each star's contribution by its *K* flux. The mean *K* and bolometric magnitudes are flux weighted as well. The column headed K_{tot} is the total *K* magnitude for all stars of a given spectral group. The percent contribution of each spectral group to the total M giant light in each filter is also given. For convenience, the last two columns of Table 4 repeat the numbers from Table 1.

The penultimate line of Table 4 gives the integrated colors and magnitudes for all M stars in the Bar West Field. Now the contribution of each spectral group to a given filter is weighted by its flux in that filter. Since the number of stars of the earliest spectral group is particularly uncertain, we give, on the last line of the table, integrated colors and magnitudes for the M2–7.5 stars only.

The derivation of mean values in Table 4 for all M stars was repeated for the old population of M stars alone. These results are given in Table 5. As noted earlier, most of the young population consists of M0–1 stars with only a small number of later types. This may also be seen from the percent contributions to the various filters from the M subtypes. Since the old population in Table 5 contains only one-third of the number of M0–1 stars in the total population of M stars (Table 4), eliminating the remaining earliest M types from the old population has little effect on the integrated colors as given on the last two lines of Table 5. In fact the total old population has characteristics that are nearly indistinguishable from the combined old and young M star population without the M0–M1 giants.

We can compare the colors in Tables 4 and 5 with similar quantities for Baade's window given in Table 3A of Frogel and Whitford (1987). At all colors and M subtypes, the LMC stars are about 0.5–2.0 mag brighter than their Galactic bulge counterparts. Except for the latest type, the LMC M stars have redder colors and stronger CO absorption than stars *of the same spectral type* in Baade's window. For stars of the same $J-K$ colors, on the other hand, LMC and Baade's window stars with $J-K \leq 1.06$ have comparable CO strengths. Redder than this, the Baade's window M giants have significantly stronger CO at the same color. If we leave in the M0–M1 stars, then the integrated colors and indices of the M giants in the Bar West field are significantly bluer and weaker than those for Baade's Window (Frogel and Whitford 1987,

TABLE 5

REDDENING-CORRECTED FLUX-WEIGHTED MEAN COLORS AND MAGNITUDES FOR OLD LMC BAR WEST M GIANTS

Type	*J–K*	*H–K*	*K*	CO	m_{bol}	K_{tot}	%*J*	%*H*	%*K*	N(obs)	N(tot)
M0-1	1.03	0.18	11.63	0.22	14.50	6.46	0.19	0.19	0.18	7	117
M2	1.03	0.20	11.82	0.215	14.71	5.56	0.42	0.42	0.42	18	319
M3	1.05	0.21	11.36	0.25	14.26	6.39	0.19	0.19	0.19	19	98
M4	1.07	0.22	11.23	0.22	14.16	7.61	0.06	0.06	0.06	13	28
M5-5.5	1.08	0.23	11.22	0.225	14.17	7.73	0.05	0.06	0.06	23	25
M6-6.5	1.10	0.24	10.99	0.22	13.98	7.64	0.06	0.06	0.06	22	22
M7-7.5	1.12	0.31	10.64	0.26	13.63	8.53	0.03	0.02	0.03	7	7
M0-7.5	1.05	0.21	4.61	0.225	7.51						
M2-7.5	1.05	0.21	4.82	0.225	7.73						

Table 4). If we exclude these earliest types, or consider just the "old" subset of stars, the integrated $J-K$ and CO values are comparable for the LMC and bulge samples but $H-K$ for the bulge is considerably redder. Most likely this is because relatively more giants with strong H_2O absorption exist in the bulge. Comparison of the integrated light of the total sample of Bar West M stars with that for higher latitude Galactic bulge fields (Frogel *et al.* 1990, Table 8) reveals closer similatities than for Baade's window.

This comparison between the integrated properties of the M giant populations of the LMC and the Galactic bulge indicates that the two types of populations should be relatively easy to tell apart from their colors alone. Inclusion of the carbon stars would only enhance the differences. This result is important for interpreting the integrated infrared light of galaxies.

There are other differences between the two populations. The bulge fields, particularly the lower latitude ones, have a significant population of M giants redder and of later spectral type than any found in the Bar West field. There are no luminous carbon stars in the bulge. The bulge also has a much higher relative number of large-amplitude variables, most of which have measurable infrared excess emission indicative of high mass-loss rates. Finally, nearly all of the *IRAS* sources detected in the bulge fields are faint enough that they would have fallen well below the *IRAS* survey limit at the distance of the LMC. These major differences must arise because the bulge population is many times older and nearly an order of magnitude more metal-rich than the Bar West population. Differences in the detailed dependence of colors and indices on each other and on spectral type arise from the rather complicated interplay between the effects of age, luminosity, and metallicity on the observable parameters.

d) *Outlying Data Points*

Six stars are located at a significant distance from the main body of the Bar West stars in almost all of the figures presented so far. These six are identified in the figures with the numbers from Table 2. CCD spectra in the 7500–9000 Å region were obtained for all but one of them in the course of our spectroscopic study of the Bar West field. These spectra will be discussed elsewhere. We refer to them here as an aid in understanding the nature of these outlying stars. Descriptions of continuum shape are based on plots of F_ν versus ν rather than F_λ.

BW-158.—The *JHK* colors and CO and H_2O indices of this star indicate that it is a foreground dwarf of early type. Since its radial velocity is near zero, its identification as a dwarf seems certain.

BW-78.—The spectrum of this star has the strongest TiO absorption bands of any observed in the Bar West field. Its strong (for the LMC) H_2O absorption, and resultant red *JHK* colors, are consistent with a late spectral type. It might be a variable.

BW-179.—The spectrum of this star exhibits strong Ca II infrared triplet absorption and CN bands at 7900 and 8100 Å. These characteristics together with strong CO but weak H_2O are indicative of an S or SC type. The fact that it is brighter than most of the M stars observed is consistent with such a transitional spectral type (cf. Bessell, Wood, and Lloyd Evans 1983). From Figure 14 of FMB, we would infer that this star is of an age comparable to or younger than that corresponding to SWB IV clusters. LMC cluster stars with similar 7500–9000 Å spectra (unpublished data) include NGC 121-V8 and NGC 1783 G6 (star 8 in the list of FMB).

BW-148.—Shortward of 8300 Å, this star has a red, steeply sloping continuum. Aside from a TiO band at 8500 Å and the Ca II triplet, the spectrum is basically featureless. BW-17 has a nearly identical spectrum but somewhat different *JHK* colors; also, the former is classified as M7 whereas BW-148 is M4 (Table 2). A moderate-amplitude variable with some spectral veiling seems like a reasonable interpretation for BW-148.

BW-125.—No spectrum was obtained for this star, but since its infrared properties are quite similar to those of BW-148, we suggest that it too is a variable of moderate amplitude.

BW-77.—The continuum of this star is flat and featureless except for weak Ca II triplet absorption. Its spectrum is similar to that of NGC 121-V1; their *JHK* colors (FMB) are also similar. Its relatively strong H_2O absorption (Fig. 7) is consistent with the *JHK* colors (Fig. 4). As noted in Table 2, BW-77 is a large-amplitude variable. The fact that it lies somewhat to the blue of the old giant branch (Fig. 2) may be indicative of qualitative similarities to the peculiar globular cluster variables discussed by Frogel and Elias (1988).

BW-36.—The colors and indices of this star (Table 2) are comparable to or a bit more extreme than those of BW-77. Its spectrum has a redder continuum with weak TiO at 8500 Å and slightly stronger Ca II than that of BW-77. The slope of the continuum is quite similar to that of BW-56, although the later has considerably stronger Ca II.

V. HISTORY OF STAR FORMATION IN THE BAR WEST FIELD

The slanted straight line in Figure 2 is from Figure 4 of FMB and approximately separates stars from Magellanic Cloud clusters of SWB types I–III from those of all later types. From our unpublished spectra of Bar West M stars, we find no indication that the stars on the bright AGB are foreground objects: their radial velocities do not appear to differ systematically from those for stars on the fainter AGB. Therefore, it seems reasonable to consider that the Bar West AGB stars have ages comparable to those of the cluster groups with which they may be identified. Frogel and Blanco (1983) inferred that the division of Bar West AGB stars into two distinct branches of different ages corresponded to two distinct epoches of star formation in the field. FMB further suggested that the rate of cluster formation peaked at these two epoches as well. The older epoch of star formation could correspond with that identified by Butcher (1977) and Hardy *et al.* (1984) from optical c-m diagrams.

As is obvious from Figure 2 the young AGB is populated primarily with M0–M1 (and M2) stars. Figure 8*a* presents a comparison of the $J-H$, $H-K$ colors of the young and old M0–M2 giants (a preliminary version of this figure is in Frogel and Blanco 1983). The brighter, younger giants lie closer to the mean solar neighborhood line than the fainter, older stars of the same spectral type. The younger stars have *JHK* colors similar to those from clusters of type I–III (FMB). These clusters have a mean metallicity that is probably within a few tenths of a dex of solar. This similarity reinforces the identification of these bright AGB stars with those from the Type I–III clusters as deduced from their location in C-M diagrams.

Further support for the above interpretation of the two AGBs in the Bar West field is found in differences in the CO indices of the two groups of M stars. Figure 8*b* compares the CO indices of the bright and faint M0–M1 stars. It is evident that CO indices of about half of the bright AGB stars are

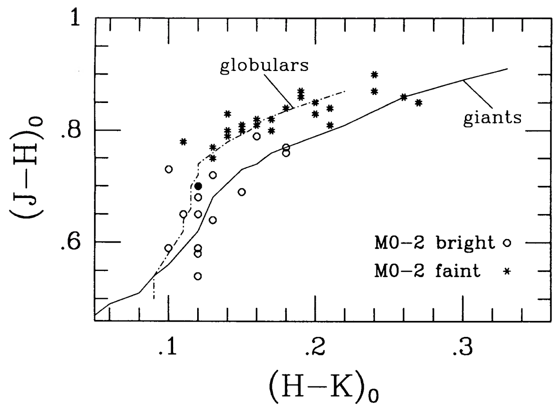

FIG. 8*a*

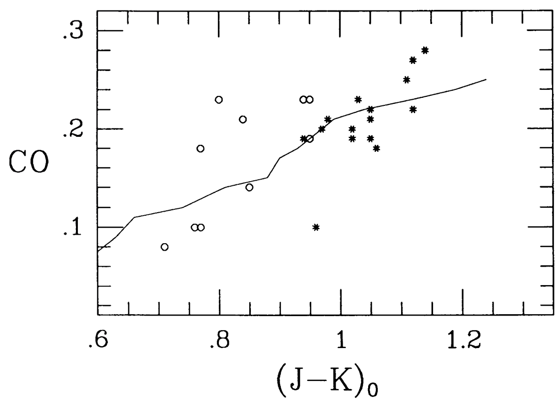

FIG. 8*b*

FIG. 8.—(*a*) The two-color relation for M0–2 stars only. Symbols distinguish those that are associated with the bright (young) AGB from those that are on the faint (old) AGB. (*b*) Same as (*a*) except what is plotted is CO against $J-K$.

considerably stronger than would be expected from their color. Some of this relative difference undoubtedly arises from the previously deduced metallicity difference between the two groups. We have already used this explanation to interpret differences in the $J-H$, $H-K$ colors of Figure 8*a*. However, the extreme strength of the CO index in a few of the stars in Figure 8*b* (and Fig. 5) is more reasonably attributed to their high luminosity. We see in Figure 5 that the three M0–M1 stars with CO ~ 0.2 and $J-K \sim 0.8$ lie on an extension of the mean relation for LMC supergiants.

In addition to young and intermediate-age stellar populations, both the field and the clusters show evidence for a measurable population of stars with ages of 10 Gyr or greater. For example, there are RR Lyrae stars and the type VII clusters; the latter correspond closely in age and metallicity range to metal-poor globular clusters in the Milky Way (FMB). Frogel (1984) estimated that this old population makes up about 6% of the total mass of the LMC. Was the formation of this old metal-poor population isolated in time or did star formation go on in a rather desultory fashion until the big burst of a few Gyr ago? Unfortunately, there are no sensitive age discriminators to be used in 5–10 Gyr range. Jensen, Mould, and Reid (1988) were unable to find any clusters with ages in the 4–10 Gyr range in the LMC. This would suggest that the oldest LMC clusters, and perhaps the oldest field stars as well, were formed in their own burst of star formation. In contrast, a different analysis of the distribution of cluster ages by Elson and Fall (1988) points to a constant rate of formation.

VI. DISCUSSION AND SUMMARY

We have presented infrared photometry for an unbiased sample of M giants in the Bar west field of the LMC. Nearly all are more luminous than the point of helium core flash on the first giant branch and therefore must be on the AGB. Except for some uncertainty regarding the numbers of M0–M1 stars, the luminosity function of the Bar West M stars plus carbon stars (from CFPE) is well defined down to m_{bol} of about 14.5. For m_{bol} between 14.0 and 13.0–13.2, it is dominated by carbon stars. Brighter than this, there are only M stars, mostly of early type. These results and other comparisons between clusters and the field presented here and in FMB are consistent with the Bar West field having a composite stellar population that is drawn from Magellanic Cloud clusters of intermediate- to young age. As for the clusters, the brightest stars in the Bar West field are oxygen-rich rather than carbon-rich, i.e., it seems unlikely that the stars at the top of the luminosity function for either clusters or field have experienced the third dredge-up episode (cf. Mould and Reid 1987).

Although the Bar West luminosity function extends one to two magnitudes brighter than the function for the Galactic bulge, there is still an absence of significant numbers of stars with $M_{bol} \leq -6$. Frogel and Richer (1983) showed that this is not due to extreme redness that could cause their being missed in the grism surveys. The results of Lundgren's (1988) extensive spectroscopic survey are compatible with these results. He too finds that the most luminous stars are not carbon stars. His medium-resolution spectra reveal that many of the most luminous stars are of type MS. Examination of our spectroscopic data base will be needed to distinguish between M and MS stars in the sample of Table 2. Therefore, as FMB concluded for the clusters, a high mass-loss rate during a "superwind" phase, convective overshooting, or both must be operative to eliminate essentially all AGB stars much more luminous than M_{bol} of -6.0 to -6.5 and to make the most luminous stars that can be found M (or MS) type rather than C type. Hot bottom burning does not seem to be a viable alternative.

There are two distinct AGBs in the Bar West field. One of them consists of stars with colors and luminosities similar to those that characterize stars in SWB IV–VI clusters, while the other is populated by stars similar to those in the younger SWB I–III clusters (Frogel and Blanco 1983; FMB). We originally interpreted these two AGBs as indicative of two separate epoches of star formation, both in the field (Frogel and Blanco 1983) and in the clusters (FWB). Wood, Bessell, and Paltoglou (1985) reached a similar conclusion from a study of long-period variables in the bar of the LMC. Initially, Reid and Mould's (1984) simple model for star formation in the LMC could not be made to fit the observed luminosity function if that model included a "two-epoch" scenario as proposed by Frogel and Blanco (1983). Subsequently, though, Reid and Mould (1985) suggested that a recent, i.e., less than 100 Myr old, burst of star formation could explain the differences in the luminosity functions they observe and be consistent with the Frogel and Blanco interpretation. As we have already mentioned, Elson and Fall (1988) find that the cluster age frequency function is well fitted by a constant formation rate. Even though the interpretation of two AGBs as representative of two episodes of star formation remains controversial, the identification of two groups of M giants in the Bar West field with two distinct cluster types is secure.

Significant differences between the Bar West and the Galactic bulge M star populations most probably arise from differences in age and composition. For example, the bulge has a significant population of stars of type M7 and later, whereas there are very few of these in the LMC. Second, the M5–M7 stars in the bulge contribute nearly 60% of the total light from M stars in the near-infrared. In the Bar West, on the other hand, stars of these spectral types contribute only 7% to the light of the total sample or 14% to the old AGB sample. It is the M0–M2 stars that contribute 60%–70% of the near-infrared light of the Bar West M stars. As already mentioned, the luminosity function of the Bar West AGB stars extends to a considerably brighter magnitude than that for the bulge. Finally, there are no luminous carbon stars in the bulge. These differences result in easily measurable differences in the integrated light of the two populations and thus will have important consequences for the interpretation of light from distant galaxies.

We would like to thank Marcelo Bass for preparation of the photographic reproductions of the Bar West field. Kris Sellgren suggested a number of improvements in presentation that have been incorporated in the final manuscript.

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V. M. Blanco: Cerro Tololo Inter-American Observatory, Casilla 603, La Serena, Chile

Jay A. Frogel: Department of Astronomy, The Ohio State University, 174 West 18th Avenue, Colombus, OH 43210