THE ASTROPHYSICAL JOURNAL, 301:927–937, 1986 February 15

LATE M STARS FOUND IN A HEMISPHERIC SURVEY

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Received 1985 July 16; accepted 1985 August 20

ABSTRACT

An objective-prism survey of somewhat more than half the sky, being the portion more than 10° from the Galactic plane and north of declination −25°, has been completed, using the visual-red spectral region. From this survey we list 583 late M stars (mostly type M6 or later) not contained in the third edition of the variable star catalog or its supplements. Many identifications with the Caltech Two-Micron Survey are given. The great majority of the stars are likly to be giants. For an assumed visual absolute magnitude of −0.9, the distance of the stars from the Galactic plane is well represented by an exponential (barometric) distribution with scale height 1800 pc; or 900 pc for an assumed absolute magnitude of zero. The sample may well be related, therefore, to the recently discussed "thick disk" component of galactic structure. Carbon stars appear to be at least twice as numerous, relative to late M stars, at large Galactic Z as at small Z. Although difficult to quantify, it appears unlikely that large numbers of these late M stars are undiscovered variables of appreciable amplitude.

Subject headings: galaxies: Milky Way — galaxies: structure — stars: late-type — stars: stellar statistics

I. INTRODUCTION

We have recently completed a survey, using our 4° objective prism on the Burrell Schmidt telescope, of the entire sky north of declination −25° and more than 10° from the Galactic plane. The survey employed the 5000–6800 Å spectral region, at a dispersion of about 1000 Å mm^{-1} at Hα. It was intended to complement our similar survey of the lower latitudes, which was completed about 10 yr ago, and to complement as well a red-region but higher dispersion survey south of decl. −25° carried out some 30 years ago by K. Henize. The new S-type and carbon stars found in the present survey have been published (Stephenson 1984, 1985*a*), and the new Hα-emission stars are in press (Stephenson 1986).

M stars, usually of type M6 or later, were tagged and measured in this survey; of 412 such stars contained in the 3d ed. of the *General Catalog of Variable Stars* (Kukarkin *et al.* 1969, hereafter GCVS), 93 had no published spectral type and so were reported by me (Stephenson 1985*b*). The present paper presents data for another 583 stars not contained in the 3d ed. of the GCVS, although a few of them have been named as variables in the subsequent name lists.

II. OBSERVATIONS

At 0.2 mm spectral widening and 10 minutes exposure on Kodak 103a-F emulsion, the plates reached 13th visual mag. Visual magnitudes were determined from eye-estimated densities of the spectral images in the 5200–5800 Å region. The approximately 1300 survey plates were not calibrated individually for magnitude, but rather a mean calibration was used for all. The mean calibration itself is very well tested.

For the M stars, spectral types were estimated from the strengths of the (0, 0) and (0, 1) bands of the organge-red system of TiO. These types agree well, on the average, with types published by Bidelman (1980), Hansen and Blanco (1975), and Lockwood (1974). For M stars up to type M4–5, it is possible to segregate dwarfs from giant M stars by the great strength of the sodium D lines that dwarfs exhibit, if that spectral region is well exposed. For stars as late as the present sample, however, the (1, 0) TiO band of the organge-red system masks the D lines at our spectral dispersion, and no luminosity classification is possible. However, late M dwarfs, even near the survey limiting magnitude, should be at such small distances as to occur in the high-proper-motion star lists of Luyten and Giclas, and ~20 dwarfs have been thus weeded out from the identified late M stars. The great majority of M dwarfs within our survey have weaker TiO than the present stars, and several hundred of them have been recognized separately as dM stars and will be published in another paper. Thus the stars of Table 1 should practically all be giants.

Equatorial coordinates of usually 1″–2″ probable error have been determined from measurements of the survey plates, by means of the reduction theory discussed by Stephenson and Sanduleak (1977). A somewhat more accurate measuring engine than the one used in the paper just cited was in service during most of the plate measurements of the present paper. However, the declinations are based on positions of TiO band heads and will sometimes be less precise than quoted above.

III. DISCUSSION

a) *Variability*

It is well known that many late M stars are at least somewhat variable, and the question at once arises, to what extent are the Table 1 stars significantly variable? I know of no realistic way to assess the completeness of our census of variable stars of magnitude 13.0 and fainter, as 80% of the Table 1 stars were estimated to be when I observed them; but the great majority of the systematic variable star searches (Plaut 1965) have been in the lower Galactic latitudes, as have the newly named variables of recent years. So far as this goes, we can hardly preclude a great many of the Table 1 stars' being strongly variable.

On the other hand, the GCVS stars (3d ed.) that I also classified $\gtrsim$M6 in this survey have a very similar distribution in Galactic latitude and longitude to the Table 1 stars, and, moreover, 65% of these variable stars were also called mag

TABLE 1A

LATE M-TYPE STARS

R.A. (1900) h m s	Decl. ° ′ ″	Sp.	Mag.	Gal. Coor. l	b	Other I.D. or Classifications	Notes
00 07 38.9	-11 34 26	M7	9.7	92	-72	-11°23, IRC -10004; M5 (HB)	
00 16 05.1	+50 23 39	M8	>13.5	118	-12	D 23164(M5), IRC +50005	
00 27 20.2	-19 12 15	M6	13.0	94	-80		
01 06 02.5	+51 14 14	M7+	13.5	126	-11		
01 08 15.5	+34 33 44	M6	>13.5	128	-28		
01 08 26.7	+49 26 46	M7+	>13.5	127	-13		
01 12 07.2	+34 59 26	M7	>13.5	129	-27	D 8710 (M5)	
01 13 41.5	+51 31 00	M7	>13.5	127	-11		
01 20 56.3	+36 00 52	M8	13.0	131	-26		
01 23 59.9	+49 38 59	M8	>13.5	129	-12		
01 30 05.6	+35 39 50	M7	13.5	133	-26		
01 34 36.0	-08 24 46	M7	13.0	156	-68		
01 43 08.2	+44 50 43	M6	13.5	133	-16		
02 15 45.4	+49 49 56	M8	13.5	138	-10	D 25628 (M3)	
02 27 19.5	-19 57 26	M7	>13.5	200	-66		
02 30 06.9	-21 20 05	M6+	13.0	204	-66		
02 32 12.4	-03 19 06	M7	13.0	174	-55	D 464 (M2ep)	
02 53 37.8	+29 26 06	M7	13.5	154	-25	IRC +30055; M8 (Vogt)	*
02 55 50.1	+21 24 28	M7	13.5	159	-32	IRC +20052, UZ Ari; M8 (Vogt)	*
02 58 27.8	-08 29 01	M5	13.5	188	-54		
03 10 15.7	+01 18 46	M6-7	10.1	179	-45	D 534 (M6), IRC +00043 (F5)	*
03 17 23.6	+01 10 19	M7	13.5	182	-44		
03 23 43.7	-15 45 01	M5-6	13.5	203	-52		
03 26 25.9	-15 45 23	M6	13.5	204	-51		
03 35 12.4	-13 58 04	M5	13.5	203	-49		
03 37 34.0	+74 27 54	M7	13.5	134	+16		
03 46 09.3	-00 34 03	M7	12.5	189	-39	IRC +00049; M8 (Vogt)	*
03 58 18.7	+18 02 37	M6-7	>13.5	174	-25		
03 58 48.6	+02 15 45	M7	13.0	188	-35	D 691 (M1), IRC +00052; M8 (HB)	
04 03 33.4	-04 55 37	M7	13.5	196	-38		
04 09 08.0	+33 35 20	M6-7	11.7	164	-12	IRC +30079; M6 (Vogt)	
04 12 23.0	-12 28 04	M6	>13.5	206	-40		
04 15 33.5	+20 01 41	≳M6	>13.5	176	-20		
04 17 46.7	-22 55 13	M6-7	10.3	220	-42	IRC -20056; M6 (HB)	
04 33 11.6	-17 52 58	M7	13.5	215	-37		
04 39 04.6	-16 38 06	M6	13.5	214	-36		
04 40 57.0	-24 02 20	M9	13.5	223	-38	IRC -20061; M8 (HB)	*
04 51 26.8	-09 50 43	M7	13.5	208	-30		
04 53 52.9	-16 50 52	M5-6	10.5	216	-32	-16°1007, IRC -20064	*
04 54 20.1	-16 19 47	M5-6	13.5	216	-32		
05 04 36.8	-20 51 41	M6	>13.5	222	-31		
05 08 05.9	+64 45 21	M7	13.5	147	+15		
05 15 27.3	-17 59 20	M5-6	12.1	220	-28	-18°1061, IRC -20069; M7 (HB)	
05 16 31.6	+02 55 32	M7	>13.5	200	-18		
05 27 23.2	+54 50 26	M7	>13.5	157	+12	D 29442 (M6), IRC +50147	
05 33 05.1	+63 16 36	M6+	>13.5	150	+17		
05 34 02.0	-20 25 03	M7	>13.5	224	-25		
05 36 43.0	-17 46 01	M6	>13.5	222	-23		
05 37 11.3	-20 49 58	M6	11.7	225	-24	IRC -20076; M5 (HB)	
05 39 15.6	+56 30 08	M7	13.5	156	14		
05 49 01.5	+63 43 00	M6+	13.5	150	19		
05 49 23.0	-20 15 10	M6	13.5	225	-22		
05 51 29.2	-15 36 59	M7-8	13.5	221	-19		
05 53 48.5	+60 29 36	M7:	>13.5	153	+18		
05 57 35.0	-21 06 20	M6	10.5	227	-20	IRC -20083; M6 (HB)	
06 01 22.7	-10 57 45	M6-7	13.5	218	-15		
06 01 25.3	-07 05 20	M7r	13.5	214	-13	IRC -10108 (K0)	*
06 06 09.2	+47 38 41	M8	>13.5	166	+14		
06 06 24.3	+50 43 23	M7	13.5	163	+15		
06 06 29.2	-22 19 00	M5-6	13.5	229	-19		
06 07 08.4	+50 03 52	M7	13.5	164	+15		
06 11 21.9	+57 53 07	M7±	>13.5	157	+19		*
06 16 52.6	+57 45 54	M7	13.5	157	+19		
06 20 13.9	-17 50 27	M5-6	13.5	226	-14		
06 20 51.5	-23 25 05	M5-6	12.1	232	-16	IRC -20094; M5 (HB)	
06 25 27.7	+61 00 48	M7+	>13.5	154	+21	D 30551 (M7), IRC +60169	*
06 26 29.3	+68 58 21:	M8-9	13.5	146	+24		
06 31 37.3	+64 55 53	M7	13.5	151	+23		
06 35 35.8	+28 02 58	M7-	12.1	187	+10	IRC +30162, M6:(Bidelman)	*
06 37 22.6	+51 39 52	M7	>13.5	164	+20		
06 41 15.1	+50 11 23	M7	12.1	166	+20		
06 48 38.4	+33 18 04	M7	>13.5	183	+15		
06 49 18.3	+24 41 13	M7	11.7	191	+12		
07 11 36.2	+18 04 14	M7	13.0	200	+14	D 12921 (M5)	
07 11 36.7	+38 13 54	M7	13.5	180	+21	D 12919, (M7), IRC +40172	
07 11 51.3	+24 52 29	M7	13.5	193	+17		
07 12 53.2	+15 45 56	M7	13.5	202	+13	D 12931 (M2)	
07 13 52.1	+45 59 17	M7	>13.5	172	+24		
07 15 41.0	+51 03 05	M7	>13.5	167	+26		
07 16 43.1	+39 45 59	M7	13.5	179	+23		
07 17 48.9	+37 47 13	M7	13.3	181	+22	D 13090 (M3), IRC +40176	
07 28 33.1	+28 58 07	M7-8	13.0	191	+22	D 13143 (M5), IRC +30189	
07 31 36.3	+56 26 24	M7-8	>13.5	161	+29	+56°1229, D 31737 (M3)	
07 32 47.3	+37 00 43	M7	13.5	183	+25	IRC +40182; M8 (Vogt)	
07 36 46.8	+23 23 54	M7	>13.5	197	+21		
07 44 59.8	+65 34 23	M8:	>13.5	151	+31		
07 45 30.0	+40 31 12	M7:	>13.5	180	+28		
07 47 31.0	-03 00 45	M6-7	>13.5	223	+12		
07 47 39.1	+57 27 38	M7:	>13.5	160	+31	IRC +60184; M9 (Vogt)	*
07 50 37.5	+32 04 50	M7	13.5	189	+27		
07 53 48.2	-01 06 23	M6-7	13.0	222	+14		
07 53 50.2	-06 45 58	M7-8	>13.5	227	+12		
07 54 26.0	+50 51 43	M7	13.5	168	+31		
07 56 33.7	+56 38 16	M8:	>13.5	161	+32		
07 58 24.5	+28 22 50	M7	13.5	194	+27		
08 08 19.5	-15 04 39	≳M6	>13.5	236	+10		
08 09 43.2	-12 44 11	M6	13.5	234	+12		
08 12 12.7	+31 27 22	M7±	13.5	191	+31		
08 12 57.0	-12 09 26	M6-7	13.5	234	+13		
08 13 29.7	-10 44 39	M8	13.5	233	+14		

TABLE 1A—*Continued*

R.A. (1900) h m s	Decl. ° ' "	Sp.	Mag.	Gal. Coor. l	Gal. Coor. b	Other I.D. or Classifications	Notes
08 18 05.2	-17 44 46	M6	13.0	240	+11		
08 20 36.3	+15 41 10	M7	13.0	209	+28		
08 22 38.9	+19 55 34	M6	13.5	205	+30	D 13557 (M3)	
08 29 25.3	-05 57 43	M6-7	>13.5	231	+20		
08 29 49.8	-16 19 06	M7	>13.5	240	+14		
08 31 04.3	-16 14 56	M7	>13.5	240	+14		
08 31 51.8	-15 41 04	M6	13.5	240	+15		
08 36 34.8	+02 32 41	M7	>13.5	224	+25		
08 37 38.6	-19 06 43	M6	13.5	244	+14		
08 39 08.3	-23 04 45	M8	13.5	247	+12		
08 39 30.7	-23 43 20	M6-7	13.5	248	+11		
08 42 44.8	-22 39 05	M5:e	>13.5	247	+13		
08 51 09.4	-18 51 24	M7	11.9	246	+17	-18°2521, IRC -20176; M6 (HB)	
08 51 17.2	-23 54 35	M7-8	11.4	250	+13	IRC -20177; M7 (HB)	
08 52 33.9	+20 08 55	M7	>13.5	208	+37		
08 59 29.0	-17 55 54	M5-6	13.5	246	+19		
09 00 35.0	-19 34 20	M6-7	13.5	248	+18		
09 02 16.5	+42 33 37	M7	>13.5	179	+43		
09 04 58.3	-21 48 45	M7	13.5	250	+17		
09 06 16.0	-15 52 54	M6p	11.4:	245	+21		
09 09 09.0	+22 22 22	M7	13.5	206	+41		
09 09 16.5	-17 22 42	M6	13.5	247	+21		
09 16 31.6	+27 51 13	M7	13.5	200	+44		
09 16 52.7	-18 58 24	M6	>13.5	250	+21		
09 18 08.0	-13 56 03	M6-7	13.5	246	+25		
09 25 35.4	-13 43 07	M7	>13.5	247	+26		
09 26 34.6	-16 38 09	M6	>13.5	249	+24		
09 27 09.6	+31 31 46	M7	12.5	195	+47	D 13939 (M3)	
09 31 28.6	-20 16 53	M7	11.4	253	+23		
09 36 29.1	-16 40 21	M7	>13.5	251	+26		
09 37 21.4	-13 41 57	M6	>13.5	249	+28		
09 45 04.4	+31 51 12	M7	10.9	196	+51	+32°1942	*
09 49 11.2	-14 14 19	M7:	>13.5	252	+30		
09 50 12.2	-18 03 30	M6	13.5	255	+27		
09 59 22.8	+43 19 32	M7	11.4	177	+53	D33149 (M5), IRC +40215	
10 06 19.7	-10 12 52	M6-7	12.5	252	+36		
10 13 19.3	-20 38 20	≳M7	13.5	261	+29		
10 20 57.0	-07 00 22	M8	13.0	252	+41		
10 26 11.6	+09 51 57	M7	13.5	234	+52	D 2956 (M3)	
10 27 08.8	-14 28 08	M6	10.9	260	+36	-14°3136	
10 30 14.0	-02 06 44	M7	13.5	250	+46	D 2966 (M3)	
10 36 44.8	+40 00 15	M7	13.5	180	+61		
10 40 01.6	-06 17 58	M8	12.1	256	+44	IRC -10245; M7 (HB)	
10 41 43.5	+59 28 36	M7-8	>13.5	148	+52		
10 42 25.0	-23 49 08	Mr,e:	10.5	270	+30		
10 42 55.2	+36 49 15	M7	10.9	186	+62	+37°2122, D 14277 (M7)	*
10 49 18.0	-21 38 22	M8	>13.5	270	+33		
11 02 45.2	-12 02 40	M5	7.5	267	+43	HD 96614, IRC -10249	*
11 03 23.1	-11 35 04	M6	11.7	267	+43		
11 13 04.4	-21 02 26	M7	>13.5	276	+36		
11 14 52.2	+65 53 48	M6-	11.7	137	+49	D 33656 (M7), IRC +70106	
11 15 36.3	-10 33 03	M7	13.5	270	+46		
11 16 54.2	-24 26 49	M7-	10.9	278	+34	-24°9703, IRC -20226	*
11 23 14.1	+50 06 35	M6	9.7	153	+62	+50°1822, D 33704 (M5)	*
11 24 29.8	-18 23 17	M7	>13.5	277	+40		
11 27 31.3	-18 38 52	M7	13.5	278	+40		
11 30 12.3	+35 25 17	M7	9.7	183	+72	HD 100698 (Mcp), D 14449 (M7)	*
11 31 20.2	-02 37 03	M7	13.5	269	+55	D 3122 (M1)	
11 36 37.1	+33 13 15	M7	>13.5	189	+74		
11 37 34.7	-11 00 15	M6	13.5	277	+48		
11 46 02.6	-06 39 38	M7:	13.5	278	+53		
11 47 02.1	+04 30 45	M6	13.5	269	+63		
11 55 25.3	-20 30 58	≳M7	>13.5	287	+40		
12 01 14.2	-12 41 30	M5-6	13.5	286	+48		
12 04 16.0	+21 36 30	M8:e	13.5	243	+79		
12 06 51.8	+45 34 41	M7	12.5	144	+70	D 33954 (M2)	
12 08 47.1	-11 49 51	M5-6	13.5	289	+49		
12 11 14.9	-13 58 12	M6:	13.5	290	+47		
12 19 00.0	-18 56 55	M7+	13.5	294	+43		
12 19 25.8	-04 28 50	M6-7,e:	12.1	290	+57	IRC +00216; M8 (Vogt)	*
12 19 55.1	+47 14 51	M7	11.4	136	+70	+47°1958, D 34050 (M6)	*
12 29 34.1	+00 18 50	M7:	>13.5	294	+62		
12 29 40.2	-14 22 09	M6	>13.5	297	+48		
12 43 58.7	+50 06 38	M5e	13.5	124	+68		
12 45 14.1	-16 37 49	M7	13.5	303	+46		
12 57 53.4	-15 31 10	≳M7	13.5	307	+47		*
12 59 34.0	-12 03 19:	M7	13.5	308	+50		
13 04 17.5	-09 11 16	M7	12.5	310	+53	IRC -10278; M5 (HB)	
13 05 19.0	+25 07 57	M7	10.1	2	+85	+25°2604, D 14707 (M5)	*
13 13 41.6	+15 50 20	M7	13.5	333	+77	D 14723 (M2)	
13 16 06.5	-13 24 44:	M7	12.5	314	+48		
13 17 19.3	-03 15 04	M7-	10.5	318	+58	-3°3455, D 3350 (M4); M6 (HB)	*
13 19 10.7	-24 00 10	M7	13.5	312	+38		
13 26 47.9	-19 09 00	M7:	13.5	316	+42		
13 31 07.4	+51 10 00	M8	13.5	106	+65		
13 37 25.0	+49 25 07	M6+	13.5	102	+66		
13 38 09.1	+58 45 38	M8	13.5	111	+58		
13 42 16.3	-20 39 12	M6-7	13.5	320	+40	IRC -20259; M6 (HB)	
13 46 36.3	-05 54 12	M7	11.7	329	+53		
13 46 48.3	-22 17 50	M7	13.0	321	+38		
13 53 35.8	-13 27 32	M7	11.7	327	+46	IRC -10296; M6 (HB)	
13 54 07.2	+28 16 44	M6+	10.3	39	+75	D 14837 (M5)	
13 57 24.6	+21 32 31	M7	>13.5	16	+73		
14 13 52.2	+27 36 33	M7	10.5	38	+71	+27°2361, D 14916 (M6)	
14 15 56.4	-24 04 30	M7	13.5	328	+34		
14 21 06.5	-16 55 34	M7	13.5	333	+40		
14 23 54.8	+61 32 20	M7	13.5	104	+52		
14 27 45.7	+42 15 51	M7:	>13.5	75	+65		
14 31 30.8	-11 02 28	M6-7	13.0	340	+44		
14 33 38.1	-22 53 42	M5	13.5	333	+33		

TABLE 1A—*Continued*

R.A. (1900) h m s	Decl. ° ' "	Sp.	Mag.	Gal. Coor. l	b	Other I.D. or Classifications	Notes
14 34 08.6	-20 27 25	M5	13.5	334	+35		
14 34 48.6	-21 29 56	M6	>13.5	334	+34		
14 37 48.6	-19 47 17	M6	13.5	336	+35	GS Lib	
14 41 41.8	+43 47 57	M5-6	13.5	76	+62	D 34748 (M6)	
14 43 07.9	-19 52 20	M6:	>13.5	337	+35		
14 43 44.6	+00 05 21	M7-8	13.0	354	+51	D 3578 (M3)	
14 45 19.3	-24 29 08	M8	10.1	335	+31	-24°11707, IRC -20272 (F5)	*
14 46 35.8	+30 43 51	M6-7	>13.5	47	+64		
14 48 06.5	+62 44 16:	M7	>13.5	102	+50		
14 48 53.9	-21 15 22	M6	13.5	337	+33		
14 50 48.4	-03 47 13	M7	12.5	352	+47		
14 51 11.5	-20 29 40	M5-6	12.5	338	+33		
14 58 49.3	+46 22 14	M6-7e	13.5	78	+58	D 34829 (M0)	
15 00 05.6	-08 57 32	M7	13.0	349	+41		
15 03 39.1	-15 47 17	M6:	>13.5	345	+35		
15 05 15.1	-13 04 47	M5-6	13.5	347	+37		
15 05 41.2	+49 56 58	M6e	13.5	83	+55		
15 06 26.6	-22 36 32	M6	13.5	340	+30		
15 06 44.6	+59 27 17	M7	>13.5	96	+50		
15 07 30.2	-05 42 28	M7	14.2	354	+42		
15 07 30.5	-11 54 50	M5-6	13.5	349	+38		
15 08 13.2	-20 02 03	M6	>13.5	343	+31		
15 09 02.3	-12 13 22	M6	13.5	349	+37		
15 11 38.5	-21 18 47	M6	>13.5	343	+30		
15 13 02.0	-14 23 06	M7	13.5	348	+35		
15 14 14.4	-10 16 14	M7	10.5	351	+38	-10°4082; M6 (HB)	*
15 15 39.5	-14 17 40	M6:	>13.5	349	+35		
15 16 37.4	-18 18 30	M7	13.5	346	+31	IRC -20285; M7 (HB)	
15 16 42.9	+16 23 03	M7	13.5	23	+54		
15 19 41.3	-23 30 05	M6	>13.5	343	+27		
15 19 42.6	+51 01 47	M7r	13.5	83	+53		
15 20 24.3	-11 41 23	M6	13.0	352	+36		
15 20 24.6	-11 44 53	M5-6	13.0	352	+36		*
15 22 57.2	+30 02 59	M7	>13.5	47	+56		
15 23 43.6	+04 10 26	M8	>13.5	8	+46	D 3747 (M7), IRC +00266	*
15 25 08.9	+53 21 48:	M6-7	13.5:	86	+51	D 34963 (M5), IRC +50244	
15 27 25.4	+47 11 56	M6-7	11.4	76	+53		
15 28 27.9	-14 09 42	M5	13.0	351	+33		
15 32 01.1	-15 59 16	M7-8	13.5	351	+31	IRC -20290; M7 (HB)	
15 33 40.9	+13 20 23	M7	13.5	22	+48		
15 34 31.5	+26 22 50	M6	13.5	41	+53		
15 36 14.4	-06 07 28	M6-7	13.5	0	+37		
15 37 14.3	-01 49 15	M7	>13.5	4	+40		
15 37 46.2	-21 30 30	M8	>13.5	348	+26	IRC -20293; M7 (HB)	*
15 38 20.8	-22 36 35	≳M6	>13.5	347	+25		
15 38 22.2	-14 45 27	M5-6	13.0	353	+31		
15 38 24.9	-11 36 12	M7	13.0	356	+33		
15 38 30.9	+45 05 51	M7	13.0	72	+52	D 35044 (M4)	
15 39 03.4	+02 42 23	M7	13.4	10	+42	D 3813 (M0), M7 (HB)	*
15 42 12.9	-23 55 59	>M6	≳13.5	347	+23		*
15 46 01.5	+51 01 18	M7	13.5	80	+49		
15 47 23.0	-12 58 04	M6r	12.5	356	+30		
15 48 18.5	+12 45 16	M7,e:	>13.5	23	+45		
15 49 14.6	-19 59 04	M6	12.5	351	+25		
15 49 41.2	-11 58 31	M5	13.5	358	+30		*
15 49 50.7	-24 24 48	M6	13.5	348	+22		
15 53 00.6	-05 46 12	M6+	12.5	4	+34		
15 54 58.5	+35 06 09	M7±	13.5	56	+49		
15 58 42.2	-11 38 40	M6	13.5	0	+29		
15 58 50.5	+16 35 42	M7	>13.5	30	+44		
15 59 48.0	+10 53 22	M7	12.1	23	+42	D 3939 (M4), IRC +10301	
16 00 50.8	-24 42 04	M5-6	13.0	349	+20		
16 01 01.8	-20 32 02	M6	12.5	353	+23	IRC -20307; M6 (HB)	
16 02 07.8	+42 26 47	M8	>13.5	67	+48		
16 02 13.7	-23 31 33	M6r	8.8	351	+20	HD 144728 (Mb), -23°12725	*
16 02 44.3	-20 32 28	M6	13.0	353	+22		
16 03 49.8	-23 17 49	M5:e:	13.5	351	+20		
16 03 51.1	+48 58 26	M8	13.5	76	+47	D35155 (M5), IRC +50249	*
16 03 57.2	-23 35 24	M6:	>13.5	351	+20		
16 06 05.6	-20 35 24	M6	11.7	353	+22		
16 08 57.7	-20 39 32	M5	13.5	354	+21		
16 10 32.0	-14 44 05	M5-6	13.0	359	+25		
16 12 51.8	+29 25 09	M5	11.4	48	+45	+29°2804, D 15451 (M4)	
16 13 35.2	+26 32 58	~M6	>13.5	44	+44		*
16 13 40.9	+26 38 56	M7	13.0	44	+44	D 15456 (M4)	
16 14 53.6	-16 00 11	M6+	>13.5	359	+23		
16 17 22.4	-23 13 56	≳M6	>13.5	353	+18	IRC -20314; M7 (HB)	
16 17 42.7	-15 37 53	M6+	13.5	0	+23		
16 19 06.5	+44 07 46	M6+	13.5	69	+45		
16 27 14.1	-23 09 22	M4:	>13.5	355	+16		*
16 27 16.6	-23 11 05	≳M6	>13.5	355	+16		
16 27 58.0	+49 06 39	M7	12.1	76	+43		
16 28 22.0	-00 03 08	≳M7	≳14.0	15	+30	V726 Oph?	
16 32 08.0	-01 38 44	M6+	10.0	14	+29	-1°3222, D 4101 (M5); M6 (HB)	
16 32 17.3	-09 58 22	M7-	13.5	7	+24		
16 32 26.0	+36 42 39	M6-7	10.5	59	+42	D 15557 (M5), NSV 7859	
16 33 18.3	-21 39 54	M6	13.0	357	+16	IRC -20321; M6 (HB)	
16 33 35.3	+40 28 52	M7:	13.5	64	+42		
16 33 46.5	-20 40 48	M7	12.5	358	+17	IRC -20322; M6 (HB),NSV 7884	*
16 33 56.4	-13 03 25	M7-8	13.5	4	+21		
16 35 00.7	-15 22 03	M5-6	9.7	2	+20	-15°4366	
16 35 03.3	-14 05 02	M6:	13.5	4	+21		
16 35 22.2	-02 57 04	M7	>13.5	13	+27		
16 36 05.7	-20 31 30	M6	13.5	358	+17		
16 37 24.8	+17 16 02	M6-7	>13.5	35	+36		
16 38 13.1	+33 06 53	M7	12.5	54	+40	IRC +30295; M7 (Vogt)	*
16 38 24.5	+24 39 32	≳M6	>13.5	44	+38		
16 38 42.6	-09 21 46	M7	13.5	8	+23		
16 39 06.3	-22 08 54	M6	13.5	358	+15		
16 39 45.6	+55 21 41	M7:	13.5	84	+40		

TABLE 1A—*Continued*

R.A. (1900) h m s	Decl. ° ' "	Sp.	Mag.	Gal. Coor. l	b	Other I.D. or Classifications	Notes
16 40 44.4	+54 41 02	M7	13.5	83	+40		
16 44 41.8	-22 47 31	M6	>13.5	358	+13		
16 44 49.5	+27 08 52	M5-6	12.5	47	+38		
16 46 22.0	+10 31 11	M8	13.0	29	+31	IRC +10313; M8 (Vogt)	
16 46 28.9	-18 20 27	M7	>13.5	2	+16		
16 46 30.2	+27 37 09	≳M6	13.5	48	+37		
16 46 58.1	+15 59 38	M7	>13.5	35	+34	D 15664 (M7)	
16 47 14.5	-20 45 15	M6:	>13.5	0	+14		
16 47 20.7	-04 32 19	M8	13.5	14	+24		
16 48 22.3	-22 24 18	≳M6	>13.5	359	+13		
16 49 18.1	+02 15 12	M7	13.5	21	+27		
16 49 19.2	-21 51 23	M7:	>13.5	359	+13		
16 49 31.1	-21 26 26	M5-6	>13.5	0	+13		
16 50 44.2	+25 05 15	≳M6	>13.5	45	+36		
16 51 15.0	-10 15 07	M7	12.5	9	+20	IRC -10352; M6 (HB)	
16 51 57.8	+43 02 04	M8	>13.5	68	+39		
16 52 50.0	+24 51 16	M6-7	13.5	45	+35	D 15695 (M3)	
16 52 53.0	-13 37 20	M6	>13.5	7	+17		
16 53 26.2	+08 25 29	M7	13.5	27	+29		
16 53 49.8	-12 45 57	M5-6	13.5	8	+18		*
16 53 51.7	+53 34 52	M7	13.5	81	+38	D 35517 (M6), IRC +50260	*
16 54 23.7	-15 14 21	M6	>13.5	6	+16		
16 55 29.7	+54 00 30	M6+	13.5	82	+38		
16 55 35.0	-14 50 38	M5-6	13.5	6	+16		
16 55 45.4	+02 17 21	M6+	11.7	22	+25	+2°3224, D 4201 (M3)	
16 55 55.4	-15 47 53	M6	13.5	5	+16		
16 56 19.5	-23 33 44	M7:	>13.5	359	+11		
16 56 40.2	-24 17 28	≳M6	>13.5	358	+10		
16 58 02.0	-24 15 09	M6-7	13.5	359	+10		
16 58 17.2	-21 03 34	M6:	13.5	1	+12		
16 59 13.0	-24 39 05	M6:	>13.5	358	+10		
16 59 16.6	+12 41 47	M7	13.0	32	+30	NSV 8154	
16 59 42.8	+26 13 35	M6:	13.0	47	+34		
17 00 21.1	-20 30 06	≳M6	>13.5	2	+12		
17 05 56.4	-17 05 26	≳M6	>13.5	6	+13		
17 06 27.2	+28 06 08	M6	13.5	50	+33		
17 06 46.9	-14 16 24	M6+	>13.5	8	+14		
17 07 17.3	-15 27 30	M6	13.5	7	+14		
17 07 25.1	+41 06 21	≳M7	>13.1	66	+36		
17 08 34.1	+19 37 54	≳M6	>13.5	41	+30		
17 09 04.8	-04 37 22	M7	>13.5	17	+19	IRC +00296; M7 (HB), NSV 8374	*
17 09 08.5	-17 39 10	M6	13.0	6	+12		
17 09 21.3	+18 07 24	M6	10.9	39	+29	D 15847 (M6), IRC +20315	
17 11 35.0	-16 11 23	M6:	>13.5	7	+12		
17 11 42.1	-17 46 20	M7	13.0	6	+11		
17 11 46.5	-15 47 44	M6	13.5	8	+12		
17 11 51.2	-17 57 54	M6	13.0	6	+11		
17 12 11.8	-15 45 00	M6	13.5	8	+12		
17 12 16.6	-14 40 02	M6	>13.5	9	+13		
17 13 17.3	-13 07 23	M6:	>13.5	10	+14		
17 13 19.7	-13 01 33	M6	13.5	10	+14		
17 14 17.4	-15 49 57	≳M6	>13.5	8	+12		
17 15 12.6	+18 13 07	M6	>13.5	40	+28	+18°3349, D 15814 (M5)	
17 15 24.5	-15 18 42	M6	13.0	8	+12		
17 16 03.0	-16 34 05	M6	13.5	7	+11		
17 16 05.6	-11 58 07	M7	13.0	11	+14		
17 17 55.2	-13 34 03	M6	>13.5	10	+12		
17 18 21.4	-12 31 22	M6-7	>13.5	11	+13		
17 19 08.0	-13 01 25	M5-6	13.5	11	+13		
17 19 09.8	+09 02 54	M6-7	13.5	31	+24		*
17 19 29.2	-13 30 07	M5r	13.5	10	+12		
17 19 47.4	+43 57 16	M7	13.5	69	+34		
17 20 30.6	-15 34 17	≳M6	13.5	9	+11		
17 20 32.4	-17 49 44	M6	13.5	7	+10		
17 20 51.7	-14 42 37	M7	>13.5	10	+11		
17 20 54.8	+27 11 14	M7	13.5	50	+30		
17 21 09.4	-15 24 30	M6	12.5	9	+11		
17 21 36.6	-11 37 10	M6	13.5	13	+13		
17 21 37.6	+20 17 24	M6	11.4	43	+27	D 15978 (M5)	
17 21 38.2	+15 59 42	M6	13.5	38	+26	D 15975 (M0)	
17 22 04.9	-10 01 16	M7	>13.5	14	+14		
17 22 17.5	+59 10 40	M7	12.1	88	+34		
17 23 12.1	+05 07 14	M7	13.5	28	+21	IRC +10329; M9 (Vogt)	*
17 23 30.0	-14 45 33	M6	13.5	10	+11		
17 23 47.4	-07 22 48	M7	10.5	16	+14	-7°4447, IRC -10369; M6: (HB)	
17 23 53.1	-11 53 42	M6	13.5	13	+12		
17 24 48.2	-15 22 18	M6	13.5	10	+10		
17 26 07.9	+02 06 56	M7	>13.5	25	+19		
17 27 17.9	-15 38 18	M6-7	>13.5	10	+10		
17 27 41.8	-12 09 57	M6	>13.5	13	+11		
17 28 06.7	-12 40 24	M6	>13.5	12	+11		
17 28 13.1	+15 31 46	M6-7	>13.5	38	+24		
17 28 48.9	-01 54 32	M7	11.4	22	+16	HD 159272, D 4308 (M0); M7 (HB)	*
17 29 11.6	+00 56 44:	M6-7	13.5	25	+18		
17 29 20.9	-14 12 13	M6	13.5	11	+10		
17 29 49.1	-15 07 56	M6	>13.5	11	+09		
17 29 56.9	-14 12 01	M6	13.5	11	+10	IRC -10372; M7 (HB)	
17 29 59.8	+44 14 54	≳M7	>13.5	70	+32		
17 30 04.2	-16 12 37	M6	>13.5	10	+09		
17 32 10.9	+17 08 10	M6	>13.5	41	+24		
17 32 37.6	+35 27 08	M8	11.7	60	+30	D 16107, IRC +40298	
17 32 43.7	-14 47 17	M6	>13.5	11	+09		
17 34 30.1	-09 28 38	M7	>13.5	16	+11		
17 34 31.8	+24 52 18	M6	>13.5	49	+26		
17 35 02.0	-15 22 31	M6	13.0	11	+08		
17 36 31.2	+48 50 53	M9	13.5	76	+32		
17 37 31.5	+16 35 52	M5	13.5	41	+23		
17 37 48.1	+29 17 10	>M6	≳13.5	54	+27		
17 38 59.7	+11 35 27	M6-7	13.5	36	+20		
17 39 20.0	+19 39 56	M6	13.5	44	+24		

TABLE 1A—*Continued*

R.A. (1900) h m s	Decl. ° ' "	Sp.	Mag.	Gal. Coor. l	b	Other I.D. or Classifications	Notes
17 42 32.8	+45 41 39	M7	13.5	72	+30	D 35900 (M4)	
17 43 49.2	+28 25 01	M6	09.0	53	+26	+28°2834, D 16237 (M7)	*
17 45 00.2	+19 48 05	M6-7	>>13.5	45	+22		
17 45 12.5	+25 01 00	M6	>13.5	50	+24		
17 45 43.5	+13 53 43	M7	13.0	39	+20		
17 45 43.9	-07 59 37	M8	>13.5	19	+09	IRC -10381; M9 (HB), NSV 9764	
17 47 16.2	+27 33 04	M5-6	13.5	53	+25		
17 48 15.4	+26 31 47	M5-6	9.3	52	+24	+26°3102, D 16284 (M7)	*
17 49 02.4	-10 13 20	M7-8	13.5	17	+08	IRC -10384; M7 (HB)	
17 49 56.3	+16 42 32	M7:	>>13.5	42	+20		*
17 50 29.1	+17 02 32	M7	>13.5	42	+20	V665 Her	
17 51 36.9	+10 38 07	M8	12.1	36	+17	D 4490 (M6), IRC +10340	
17 52 51.1	+15 55 22	M7	13.5	42	+19	IRC +20338; M8 (Vogt)	*
17 53 21.2	+24 30 55	M7	>13.5	50	+22	D 16339 (M2)	
17 56 33.2	+25 53 53	M6	>13.5	52	+22		
17 57 38.6	+20 06 13	M7	>13.5	46	+20		
18 00 02.2	+20 11 52	M8	13.5	46	+19		
18 00 25.5	+44 52 22	M7-	13.0	72	+27	D 36034 (M5)	
18 01 06.4	+47 10 47	M8	13.5	74	+27		
18 01 34.0	+15 57 20	M6+	>13.5	42	+17		
18 05 31.2	+49 22 15	≳M7	>13.5	77	+27		
18 07 46.1	+54 56 44	M6-7	13.5	83	+28		
18 08 43.4	+25 04 20	M8	>13.5	52	+19	IRC +30329; M6 (Bidelman)	
18 09 16.6	+05 36 46	M6-7	13.5	34	+11		
18 10 25.5	+15 31 19	M6	9.5	43	+15	+15°3408, D 16595 (M5)	*
18 11 07.1	+51 36 20	M7	>13.5	80	+27		
18 12 51.8	+16 43 10	M6+	>13.5	44	+15		
18 15 51.8	+09 23 45	M7	>13.5	38	+11		
18 18 10.2	+17 55 12	M6	>13.5	46	+14		
18 18 29.0	+50 28 50	M7	13.2	79	+25	IRC +50278 (G0); M9 (Vogt)	*
18 19 27.4	+51 21 19	M7	>13.5	80	+25		
18 21 13.5	+18 16 09	M6+	>13.5	47	+14		
18 23 37.0	+50 52 12	M9	>13.5	79	+25		
18 26 46.7	+43 38 22	M7	13.0	72	+22	D 36275 (M6)	
18 32 03.8	+42 28 38	M7	13.5	71	+21		
18 33 57.0	+19 32 59	M7	>13.5	49	+12		
18 37 02.6	+44 47 55	≳M7	>13.5	74	+21		
18 38 17.7	+15 43 04	M7	>13.5	46	+09		
18 46 28.9	+40 51 00	M7,e:	13.5	71	+18		
18 47 43.5	+18 57 58	M6	>13.5	50	+08		
18 48 35.0	+46 09 48	M7-8	>13.5	76	+19		
18 51 31.0	+18 44 17	≳M6	>13.5	50	+07		
18 58 09.0	-19 32 36	M6	13.5	17	-11	IRC -20535; M6 (HB), NSV 11696	
18 59 44.5	-19 13 37	M6	>13.5	17	-12		
19 03 07.7	-14 12 37	M6	13.5	22	-10		
19 03 29.1	-12 46 25	>M6	≳13.5	24	-09		
19 03 34.8	-15 12 12	M7	11.7	21	-11	IRC -20541; M7 (HB)	
19 04 19.4	-15 37 33	M6	12.5	21	-11		
19 04 26.8	+43 07 07	M6	13.5	74	+16		
19 05 30.9	+43 51 23	M7	13.5	75	+16		
19 06 09.5	-11 37 42	M6	13.5	25	-10		
19 06 34.9	-12 44 49	≳M6	>13.5	24	-10		
19 08 55.0	+47 35 24	M7	13.0	79	+17		
19 09 14.1	-24 43 33	M7	13.5	13	-16		
19 10 46.1	-13 05 00	M6	>13.5	24	-11		
19 11 03.6	-16 05 37	M5-6	13.0	21	-13		
19 11 13.6	-13 56 56	M6	13.5	23	-12		
19 12 14.0	-12 44 59	M7	>13.5	25	-11		
19 12 44.3	+45 51 24	M7:	>13.5	77	+15		
19 13 07.9	-09 02 30	≳M7	>13.5	28	-10		
19 13 08.2	-13 53 19	M5-6	13.5	24	-12		
19 13 15.4	-13 53 54	M6	13.5	24	-12		*
19 13 15.5	-13 54 59	M6	13.5	24	-12		*
19 13 18.6	-11 55 44	M6	13.0	25	-11		
19 14 04.0	-12 08 05	M6	13.5	25	-12		
19 14 13.3	-06 57 58	M7+	13.5	30	-09		
19 14 32.9	-12 26 32	M6:	>13.5	25	-12		
19 14 48.9	-14 27 10	M6	>13.5	23	-13		
19 14 58.0	-13 12 54	M6	13.0	24	-12		
19 15 06.8	-07 13 46	M6-7	12.5	30	-10	IRC -10504; M8 (HB)	
19 15 56.7	-15 56 37	M5-6	13.5	22	-14		
19 16 45.2	-23 32 51	M7	13.5	15	-17		
19 17 13.4	-14 51 06	M7	>13.5	23	-13		
19 18 05.4	-11 19 25	M6	12.5	27	-12	IRC -10508; M7 (HB)	
19 19 09.4	-13 30 11	M6	>13.5	25	-13		
19 19 28.4	-12 17 54	M6	13.5	26	-13		
19 19 31.8	-09 02 35	M7	13.5	29	-12	IRC -10510; M6 (HB)	
19 19 34.7	-11 23 15	M7+	13.5	27	-13		
19 21 21.9	+35 49 51:	M8	12.5	69	+09	D 17733 (M3), IRC +40346 (AD)	*
19 21 26.0	-12 30 06	M6	13.5	26	-13		
19 22 27.4	-15 51 40	M6	13.5	23	-15	V3957 Sgr	
19 22 31.8	+45 40 48	M8	>13.5	78	+14		
19 23 23.2	-20 47 09:	M7	>13.5	18	-17		
19 23 38.3	-11 28 39	≳M6	>13.5	27	-14		
19 23 55.8	-13 26 00	M6:	13.5	25	-14		
19 24 19.0	-21 10 33	M7	>13.5	18	-18		
19 28 14.6	-07 56 10	M7	13.0	31	-13		
19 28 43.7	+35 17 41	M6-7	13.5	69	+08		
19 29 15.8	-07 47 18	M8e	>13.5	31	-13		
19 29 28.1	-14 25 36	M6+	>13.5	25	-16		
19 30 17.1	-13 16 27	M7	>13.5	26	-16		
19 31 15.2	+42 19 05	M7	>13.5	75	+11		
19 31 19.8	-03 02 11	≳M7	13.5	36	-11		
19 31 41.4	-15 08 06	M6:	>13.5	25	-17		
19 33 15.6	-14 38 07	M5-6	13.5	25	-17		
19 33 28.5	-11 31 39	M6	>13.5	28	-15		
19 34 48.0	-15 01 26	M7	>13.5	25	-17		
19 35 04.7	-08 59 07	M7-8	13.5	31	-15		
19 35 49.4	-06 04 06	≳M7	>13.5	33	-14		
19 39 01.4	-14 37 12	M6	13.5	26	-18		

TABLE 1A—*Continued*

R.A. (1900)	Decl.	Sp.	Mag.	Gal. Coor. l	Gal. Coor. b	Other I.D. or Classifications	Notes
h m s	° ' "			l	b		
19 40 26.4	-06 42 09	M7	13.5	33	-15		
19 41 14.0	-04 04 06	M7	13.5	36	-14		
19 41 51.2	-15 30 54	M7	>13.5	25	-19		
19 43 53.0	-13 21 28	M6	13.5	27	-19		
19 45 28.8	-15 43 44	M6+	>13.5	25	-20		
19 45 31.5	-11 39 32	M6	13.5	29	-18		
19 47 15.7	+76 23 51	M9-10	13.5	109	+23		
19 49 18.1	-13 18 36	M6	13.5	28	-20		
19 54 37.4	-04 16 16	M7	>13.5	37	-17	IRC +00460; M8 (Vogt), M7 (HB)	
19 55 38.3	-15 19 13	M6	11.7	27	-22	IRC -20579; M7 (HB)	
19 57 08.6	-10 43 57	M6-7	>13.5	31	-20		
20 02 32.2	-09 23 29	M7:e	13.5	33	-21		
20 02 42.1	-06 25 39	M8	>13.5	36	-20		
20 06 44.2	-11 30 09	M7	10.1	32	-23	-11°5255, IRC -10530	*
20 08 11.7	+14 05 58	M6+	13.5	55	-11		
20 09 45.8	+10 04 18	M7,e:	13.5	52	-11		
20 10 03.8	+06 45 52	M7	>13.5	49	-15		
20 10 48.2	-09 06 43	M7	13.0	35	-23		
20 22 40.5	-02 09 30	M7:	>13.5	43	-22		
20 23 22.4	-03 01 10	M7+	>13.5	42	-23		
20 29 35.8	-07 47 42	M8	10.1	38	-26	-7°5332, IRC -10541; M6 (HB)	*
20 29 38.6	-03 03 32	M7	>13.5	43	-24		
20 30 39.9	-01 57 08	M7+	11.7	44	-24	D 6856 (M0)	*
20 38 20.2	-22 39 46:	M6-7	11.7	23	-34		
20 38 30.9	-02 48 27:	≳M8	>13.5	44	-26		
20 41 26.2	-00 35 25	M7	>13.5	47	-26	D 6973 (M2)	
20 41 27.5	-01 16 06	M9	13.5	46	-26	IRC +00490; M8 (Vogt)	*
20 44 59.2	+11 14 39	M6	12.1	58	-20	+11°4392, D 7013 (M7)	*
20 45 58.6	-11 28 40	M7	11.5	36	-32	-11°5443, IRC -10550; M7 (HB)	*
20 46 57.4	-07 03 00	M6-7	13.5	41	-30		
20 49 50.4	+18 44 34	M6-7	>13.5	65	-16		
20 51 30.0	-21 31 51	M6-7	13.0	26	-37		
20 53 01.4	+11 36 06	M5-6	13.5	60	-21		
20 57 30.2	+17 47 01	M9	13.5	66	-18	D 19862 (M6)	
21 00 23.8	+01 59 07	M6	>13.5	52	-28		
21 03 33.7	+23 19 31	M7:	>13.5	71	-16		
21 05 28.9	+28 08 58	M7	>13.5	75	-13		
21 07 59.4	+21 05 23	M7	>13.5	70	-18	D 20113 (M5)	
21 11 16.4	+23 42 12	M6-7	>13.5	72	-17		
21 25 21.0	+27 48 45	M7	13.5	78	-16		
21 27 07.5	+33 39 34	M7	>13.5	82	-13		
21 28 09.1	+36 28 58	M7	>13.5	85	-11		
21 31 40.8	+15 49 03	M6-7	13.0	70	-26		
21 31 59.0	+32 04 11	≳M6	13.5	82	-14	IRC +30475; M9 (Vogt)	*
21 33 30.1	-11 31 12	M7-	11.4	43	-42		
21 35 06	-02 14.4	M8	8.8	53	-38	-2°5597, D 7540 (M5)	*
21 52 16.0	-04 38 48	≳M6	13.0	54	-43		
21 54 40.0	+35 08 13	M7-8	13.0	88	-15	D 21064 (M4), IRC +40499	*
21 57 48.7	-00 24 44	M7	9.3	60	-41	-0°4298, D 7686 (M7)	*
22 01 07.9	+37 18 38	M7:	>13.5	90	-14		
22 03 50.4	+36 38 02	M7	13.5	90	-15		
22 17 24.5	-14 44 37	M5-6	13.5	46	-53		
22 36 55.2	+28 43 12	M7	11.7	92	-26		
22 49 10.0	+08 22 14	M7	>13.5	81	-44	D 7912 (M7), IRC +10523	*
22 52 43.1	+33 10 08	M7	13.0	97	-23	D 21908 (M3)	
23 28 41.4	+05 44 48	M6	10.5	91	-52	IRC +10537; M7 (Vogt)	*
23 39 22.3	+38 46 02	M5:	13.5	109	-22		
23 54 45.2	-12 25 00	M6	13.5	82	-71		

NOTES.—The entry " >13.5 " in the Mag. column, which purports to give visual magnitudes, means that the spectral region shortward of 5800 Å was below the plate limit. The remainder of the spectrum can be fairly well exposed, because of either the decrease in spectral dispersion with increasing wavelength or the redness of the star, or both.

An asterisk in the "Notes" column refers to an entry in Table 1B.

SOURCES.—HB, Hansen and Blanco 1975; D, tables of red stars found in the Dearborn Observatory objective-prism survey (Lee *et al.* 1943, 1944, 1947). Vogt, Vogt 1973; Bidelman, Bidelman 1980; NSV, 1982 edition of the catalog of suspected variable stars (Kholopov 1982); Lockwood, Lockwood 1974.

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TABLE 1B

Notes to Table 1A

$02^h53^m37^s.8$.........	M8 (Lockwood).
02 55 50.1.........	M8 (Lockwood).
03 10 15.7.........	The IRC identifies with HD 20246 (F5), mag 9.0. The M star is 50″ in p.a. 155° from the HD star. M6 (HB).
03 46 09.3.........	M7 (Lockwood, HB).
04 40 57.0.........	The M star is 95″ in 225° from the HD star identified by the IRC. Incorrectly identified with a Cordoba Durchmusterung star by Bidelman (1980).
04 53 52.9.........	M5 (Bidelman).
06 01 25.3.........	The IRC position is that of the M star, not the HD star that they identify with.
06 11 21.9.........	D 30223 (K5) is seen nearby.
06 25 27.7.........	M8 (Lockwood and McMillin 1970).
06 35 35.8.........	D 12451 (M0) is seen nearby.
07 47 39.1.........	M8 (Lockwood).
09 06 16.0.........	The TiO λ6150 is exceptionally strong for the weakness of the TiO λ6600.
09 45 04.4.........	D 14011 = 32°1941, a brighter and earlier M star, is nearby.
10 42 55.2.........	NSV 4977, IRC +40220. M8 (Vyssotsky and Balz 1958).
11 02 45.2.........	−11°3030. M2 (Yale zone catalog).
11 16 54.2.........	M6 (Yale zone catalog).
11 23 14.1.........	IRC +50212. M8 (Balz 1956).
11 30 12.3.........	+35°2265, IRC +40226.
12 19 25.8.........	M6 (HB); M5 (Wyckoff and Wehinger 1974).
12 19 55.1.........	M6 III (Upgren 1960).
12 57 53.4.........	M8e, Mira-type spectrum, by Bidelman and MacConnell (1973), hence NSV.
13 05 19 0	IRC +20257.
13 17 ·19.3.........	IRC +00233.
14 45 19.3.........	NSV 6828; M6 (HB). The IRC position agrees better with that of the M star than with the HD star picked by the IRC, as does the $I-K$ color index of 3.8.
15 14 14.4.........	IRC −10318.
15 20 24.6.........	Near another late M, both stars seen on the same plate.
15 23 43.6.........	NSV 7098. M8 (Lockwood); late M (HB); M9 (Solf 1978).
15 37 46.2.........	NSV 7216. M8 (Lockwood).
15 39 03.4.........	IRC +00270. Despite the disparity in spectral types, our star is the only candidate for the Dearborn star.
15 42 12.9.........	Me according to Stock and Wroblewski (1971).
16 02 13.7.........	IRC −20309 (M3). M3 in the Yale zone catalog.
16 03 51.1.........	V649 Her. M7 (Vogt); M8 (Lockwood); M6 (Wyckoff and Wehinger 1974).
16 13 35.2.........	Different from the nearby Dearborn star at $16^h13^m40^s.9$. Both are seen on the same plate.
16 27 14.1.........	Included here although earlier than the other stars in the table, because only 100″ from a later M.
16 32 08.0.........	IRC +00289.
16 33 46.5.........	Mira-type Me (Bidelman and MacConnell 1973).
16 38 13.1.........	M5 (Wyckoff and Wehinger 1974).
16 46 22.0.........	V2066 Oph. M9 (Lockwood).
16 49 19.2.........	Not SY Oph, separately seen nearby.
16 53 49.8.........	Near, but unconnected with, the old nova V841 Oph.
16 53 51.7.........	M7 (Lockwood).
17 09 04.8.........	NSV 8374. M8 (Lockwood).
17 19 09.8.........	An IRC star, HD type K1, is seen on my survey plate 5′ south.
17 23 12.1.........	M8: (Wyckoff and Wehinger 1974).
17 28 48.9.........	IRC +00307? The M star is not the nearby HD 159272 (K0), with which the IRC identifies.
17 43 49.2.........	IRC +30313. M1 (Yale zone catalog).
17 48 15.4.........	IRC +30318. M2 (Yale zone catalog).
17 49 56.3.........	D 16308 (K5) is probably seen nearby.
17 52 51.1.........	M7 (Wyckoff and Wehinger 1974).
18 10 25.5.........	IRC +20354.
18 18 29.0.........	NSV 10701. M7 (Wyckoff and Wehinger 1974). The $I-K$ color index makes it clear that the M star, and not the G0 star cited in the IRC, is the IRC source.
19 13 15.4.........	Separately seen on the same plate as the two nearby stars in the table.
19 13 15.5.........	One of a close group of three late M stars.
19 21 21.9.........	NSV 12009. The $I-K$ color index of 5.0 mags assures that the M star, and not the IRC-quoted A0 HD star, is the infrared source. The positions also support this. Type M8 by Bidelman.
20 06 44.2.........	M6 (Bidelman).
20 29 35.8.........	NSV 13155.
20 30 39.9.........	Our star is the most plausible candidate for the Dearborn star despite the disparity in spectral types.
20 41 27.5.........	NSV 13284; M7 (HB).
20 44 59.2.........	IRC +10478. M7 (Bidelman).
20 45 58.6.........	The IRC suggests the Algol variable BX Aqr for an identification, but the variable's R.A. differs by 18 s from the IRC, and the large $I-K$ color index strongly supports the source being the M star.
21 31 59.0.........	NSV 13806.
21 35 06.0	IRC +00507. This plate not measured; the position given here is the IRC one, but the BD identification is independent.
21 54 40.0.........	M8 (Bidelman). The IRC missed this Dearborn identification, but there is on my plate only one M star in the region, and the infrared color index is $+4\frac{1}{2}$.
21 57 48.7.........	IRC +00511.
22 49 10.0.........	NSV 14352. M9 (Lockwood).
23 28 41.4.........	NSV 14611.

13.0 or fainter on my plates. Of the Mira stars, at least, I tended to pick them up nearer to minimum than maximum, doubtless because of my policy of retaining only quite late M stars. The circumstances just cited make it appear a bit unlikely that a large proportion of the Table 1 stars are strongly variable. The same negative conclusion is suggested by the agreement between my spectral classifications and those of Vogt, Hansen and Blanco, and Lockwood. On balance, I think it unlikely that a major portion of the Table 1 stars are strongly variable.

b) Galactic Distribution

I have already stated that the distribution in Galactic coordinates of the Table 1 stars is quite similar to that of the late M GCVS stars that I found. The longitude distribution is also quite similar, as far as it goes, to that of the lower latitude M giants discussed by Blanco (1965), which are generally heavily concentrated into the hemisphere centered on the Galactic center.

It is tempting to use this new sample of late M stars to study their distribution in height above the Galactic plane, since the available information on this point is so meager. Unfortunately, even given the large scope of the present survey, such a study has several serious drawbacks. The worst of these are: (1) imperfect knowledge of the individual absolute magnitudes; (2) the missing volume of space below Galactic latitude $\pm 10°$, which corresponds to Z distances up to several hundred pc and so weakens any determination of the scale height of the space density; (3) the missing declinations south of $-25°$; (4) we lack determinations of the interstellar absorption for these stars. Point (4) is less serious than the others, because of our restriction to relatively high Galactic latitudes. Since I propose, nonetheless, to examine the apparent space distribution of these stars, I shall next take up these four difficulties in turn, not that they are the only weaknesses to be faced.

1. Somewhat widely varying estimates have been made of the visual absolute magnitudes of M giants, and as a first approximation I shall use Blanco's (1965) adopted value of -0.9 for the later spectral types.

2. The problem here is that our survey of low-Z values is incomplete. It is not, however, nonexistent, to the extent that there are nearby stars at the higher latitudes. I have attempted to limit the study sample to a spatial volume defined by a right circular cylinder C with axis perpendicular to the Galactic plane. The missing low-Z space in the survey has been approximately allowed for by weighting each star that does occur within the range of defective Z values by the ratio of excluded to included survey volume at the star's Z value. The definition of the study volume C will be completed in the next paragraphs.

3. To avoid the complication of the missing southern declinations, the volume C was limited to northern Galactic latitudes and to longitudes between 0° and 240°. One base of the (now sectored) cylinder is assumed to lie in the Galactic plane and to contain the Sun.

4. I have applied a mean interstellar absorption, defined by the local absorption decreasing exponentially away from the Galactic plane, with scale height 150 pc and visual extinction of 1 mag kpc^{-1} in the plane. This model produces 0.15 mag total absorption at the Galactic pole.

The size of the volume C was specified by assigning mag 13.8 to the numerous " >13.5 " stars, and adopting a base radius of C that makes an M star on the lateral surface at $b = 10°$ have mag 13.8 in consequence of the assumptions about absolute magnitude and interstellar absorption. It turns out that stars on the lateral surface at somewhat greater heights are brighter than 13.8 because of lessened model absorption, and when the height of a still higher lateral-surface star is great enough to make the magnitude again 13.8, we have reached the top of the cylinder. The height thus defined is 5500 pc, and the radius 5770 pc.

To review the space-distribution program: We seek to learn how these M stars are distributed in distance Z from the Galactic plane by examining a sample that is preselected by Z only in having $Z < 5500$ pc (apart from complication No. 2). We pick such a subset from Table 1 by limiting them to positive Galactic latitude and to longitudes 0°–240°. We further exclude stars if their apparent distance puts them beyond the test volume C; at the Galactic pole, this means excluding stars fainter than mag 13.0.

The subset of M stars, limited as just described, contains only 159 stars. Their Z-values, derived from the stated assumptions, have been grouped into 250 pc intervals, and these normal points in $N(Z)$ are plotted in Figure 1. The point based on $Z \leq 250$ pc has been omitted because it would have been defined by a single star, normalized by an enormous weight. The range of Z values within which the survey is incomplete because of the $b \geq 10°$ limitation is 0–1000 (1018) pc; thus the three leftmost points of Figure 1 are the only ones involving partially unsampled Z values.

An exponential function has been fitted to the Figure 1 data by least squares, and the result shown fits quite well. The discrepant point at 375 pc is based on a sample volume that is six-sevenths incomplete (but see the discussion to follow). The solution for $N(Z)$ is

$$N(Z) = 32.8(^{+8}_{-6}) \exp\left[-Z/(1800 \pm 200)\right] . \qquad (1)$$

The quoted errors are mean errors, and $N(Z)$ gives numbers within 250 pc thick C-sections.

The scale height of 1800 pc in equation (1) is very large, comparable to that of the longer-period RR Lyrae stars and much greater than the 700 pc for the M5–M8 long-period

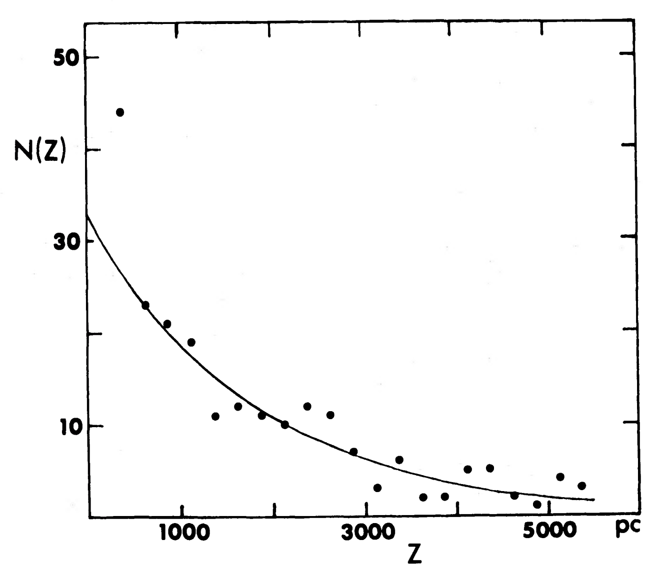

FIG. 1.—$N(Z)$, numbers of late M stars within 250 pc slabs parallel to the Galactic plane, vs. Z, distance from the plane. Dots are observations and the curve is eq. (1).

variables quoted by Mihalas and Binney (1981). The long-period variables, in turn, are supposed to have a larger scale height than the M giants in general (Plaut 1965).

The very large exponential scale height in equation (1) need not be viewed with surprise. Virtually all the stars of Table 1 are in the Galactic halo, more or less by definition. They may well form a different population from the bulk of the M giants so far studied, and so be not merely an extension of the latter. From this point of view the high point in Figure 1 at $Z = 375$ pc, for all its uncertainty, is probably real and reflects the addition of a significant Galactic disk component to an otherwise essentially halo component. It is then not surprising, either, that the coefficient of equation (1) predicts, within 125 pc of the Galactic plane, a space density of giant M stars later than type M5 of 0.002 stars per 10^6 pc^3, versus 0.1 for the same quantity estimated by Blanco (1965) from a low-latitude survey. A factor of 2 of this 50-fold difference may be an artifact of my omitted longitudes 270°–0°, where approximately half of Blanco's stars are found; but most of the remaining factor of 25 discrepancy is probably real. But for the lack of low-latitude fields in this survey, one could have modeled the Z distribution with a low-Z component superposed on an extended-Z component.

The conclusions of the last paragraph overlap appreciably with recent remarks by Gilmore (1985), who has posited an intermediate ("thick disk") Galactic population with an exponential scale height of 1.5 kpc and having about 2% of the solar neighborhood stars belonging to it. I have no evidence from my low-resolution spectra that my M stars are metal-deficient, as the thick-disk stars are supposed to be (Gilmore suggests a mode of -0.75 in [Fe/H]), however. Neither do I have any evidence that these stars are not metal-deficient. The mere presence of TiO bands in strength is not proof of near-solar metals abundance, because a metal-deficient model stellar atmosphere may be given a TiO-prominent spectrum by a relatively small lowering of the temperature relative to a solar-abundance model (cf. Johnson, Mould, and Bernat 1982).

It is next incumbent to inquire to what extent my derived large scale heights for these M stars depends on their assumed absolute magnitudes. To address this, I have repeated the computions, using instead of -0.9 an assumed absolute magnitude of 0, which is nearer to another estimate (Mikami and Heck 1982; Blanco, McCarthy, and Blanco 1984). The change leaves practically the same stars in a shrunken volume of space and so diminishes the derived scale height, to 900 pc. The modified value is now comparable to that of the later M-type long-period variables but is still large compared to other estimates for M giants in general; Mikami and Ishida (1981), using stars selected in a very different way from mine, at distances less than 1 kpc, find about 400 pc. For both assumed absolute magnitudes, a simple barometric formula like equation (1) furnished a much better fit to the data than a Gaussian fit, which agrees with all previous experience for stars this far from the Galactic plane.

Since we lack a confident estimate of the absolute magnitudes, it is pointless to attempt to force the issue further at present, beyond proposing that despite the great uncertainties there is a definite likelihood that these stars define quite a large scale height in Z.

c) *Completeness of Surveys for Late* M *Stars*

The present survey was not undertaken with late M stars as the primary target, and in fact in our low-latitude surveys using the same spectral region, M stars were never singled out for position measurement or even tagged for possible future reference. We followed this policy in the northern sky because doing otherwise would too much have duplicated the Case infrared survey, and in the south we expected that future infrared surveys would extend the Case ones. In fact, to this day there is no catalog of M stars for the southern sky based on either a red or an infrared spectral region survey, whether at low or high Galactic latitudes.

Between the Case infrared surveys (Stephenson 1966) and the present red survey, a gap of about 4° in Galactic latitude exists. This is of consequence mainly for tasks such as *IRAS* source identifications, and north of declination $-4°$ the gap is substantially filled by the Dearborn red-star catalogs.

d) *Comparison of Carbon and* M *Stars*

The proportion of carbon to M giants is known to increase with distance from the Galactic center (Blanco 1965; Fuenmayor 1981; Blanco, McCarthy, and Blanco 1984). Keen interest has arisen in recent years in differences in the carbon star–to–M giant ratio between different nearby galaxies, in particular between the two Magellanic Clouds. This is most often interpreted in terms of metallicity differences, and one is naturally curious about how the carbon star–to–M star ratio in our own Galaxy behaves as a function of distance from the Galactic plane.

Unfortunately, making this relatively local comparison with any precision requires rather accurate knowledge of absolute magnitudes. Even if we were confident of this information in the case of the M stars, which we are not, the best indications that we have for the carbon stars (Gordon 1968) make their visual absolute magnitudes range through about 4 mag as a function of spectral type. We lack the appropriate spectral type information for most of the carbon stars that we would like to use for the comparison.

Probably the best that we can do is to compare in directions that are far enough from the Galactic plane that the low interstellar absorption and large Z-heights reached make it unlikely that we are missing many stars in either group. I have chosen to make the comparison for Galactic latitudes north of $+40°$. For this zone, all longitudes are covered by my red survey, there being no declinations south of $-25°$. For the carbon stars, I have used my carbon star catalog (Stephenson 1973), augmented by a number of published and unpublished subsequent lists, including the new carbon stars found by me in the present survey. The carbon star catalog includes finds based on a number of different spectral regions, but above latitude $+40°$ the vast majority of carbon stars were either found or (more often) rediscovered in the present survey, so the two lists have similar, not to say identical, limiting magnitudes.

The best low-latitude comparison would employ the Case infrared surveys. Since we are begging the question of space densities, consider the discussion of stars of class M5 and later by Nassau, Blanco, and Cameron (1956). This paper reported that 7963 stars, essentially all expected to be giants, had been found within 6° of the (system I) Galactic equator in the longitudes accessible from Cleveland. From Blanco's (1965) discussion, we infer that a third of these or a bit more than 2600 stars were M6 or later. The same survey found 693 carbon stars, for a ratio of 3.8:1 for $\geq$M6:C. The greater part of these carbon stars are expected to be N-type, which (Gordon 1968) are much more luminous than the R-type carbon stars known to predominate at high Galactic latitudes; hence the low-latitude ratio actually favors carbon stars.

Above latitude 40°, my counts give 95 M stars versus 50 carbon, 1.9 times as many $\geq$M6 stars as carbon. The red survey, as asserted earlier, has probably found the great majority of both kinds of stars that are there to find; since the infrared survey should if anything have favored carbon stars somewhat, we have a secure result that carbon stars are at least twice as numerous relative to late M stars in the Galactic halo as near the Galactic plane—in each case, in the general solar neighborhood.

The factor of 2 ratio change between the low-Z and high-Z M giant: carbon star numbers is in the direction to be expected from the known Galactic center-to-anticenter differences (Blanco 1965; Fuenmayor 1981; Blanco, McCarthy, and Blanco 1984). In both cases we may be seeing a consequence of systematic variations in mean metallicity within the Galaxy.

I am indebted to Dr. W. P. Bidelman for the use of his data file, to Dr. Earle Luck for helpful discussions, and to the National Science Foundation for vital support.

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