UBVRI PHOTOMETRIC STANDARD STARS AROUND THE CELESTIAL EQUATOR[a)]

ARLO U. LANDOLT[b)]
LSU Observatory, Baton Rouge, Louisiana 70803
Received 8 November 1982

ABSTRACT

UBVRI photoelectric observations have been made of 223 stars mostly in an approximate two degree band centered on the celestial equator. The observing program was planned to provide new *UBVRI* standard stars, available to telescopes of a variety of sizes in both hemispheres, on an internally consistent homogeneous system around the sky. Most of the stars are in Selected Areas 92–115. The stars average 20.7 measures each on 12.2 different nights. The stars in this paper fall in the range $7 \lesssim V \lesssim 12.5$ and $-0.3 \lesssim (B-V) \lesssim +2.0$.

I. INTRODUCTION

Accurate, internally consistent, and readily accessible standard star photometric sequences are necessary for the calibration of the intensity and color data that astronomers obtain at the telescope. The most used photometric system during the past twenty-five years has been the *UBV* system, developed by Johnson and Morgan (1953). Additional refinements were published by Johnson and Harris (1954) and by Johnson (1955). Landolt (1973) published an extensive list of several hundred stars tied into the Johnson *UBV* photometric system. These stars, designed to be used as standards, were located in the celestial equatorial Selected Areas, and hence were available to astronomers in both hemispheres.

The *UBV* photometric system has been expanded to two additional spectral regions, *R* (7000Å) and *I* (9000Å). This expanded photometric system also was developed under the guidance of H. L. Johnson (Johnson, Mitchell, Iriarte, and Wisniewski 1966, and references therein). Another *RI* system had been defined via observations published by Kron, White, and Gascoigne (1953). The effective wavelengths of their *RI* filters, though, were located at shorter wavelengths: *R* at 6800Å and *I* at 8250Å. This latter *RI* system was modified and extended by Cousins (1976).

II. THE PROGRAM

The photometric results in this paper represent the first part of an effort to provide *UBVRI* photoelectric photometric standard stars in the magnitude range $7 < V < 17$ over as broad a range in color as possible. The stars that were observed are located in a band centered on the celestial equator, and therefore are easily accessible to telescopes of all sizes in both hemispheres. The observational data were tied into the *UBV* standard stars of Landolt (1973) and the *RI* standards of Cousins (1976).

The observing plan by necessity focused on a bootstrapping theme. The Cousins (1976) *RI* standard stars available at the time that the project began were bright, mostly $V < 7.0$. Therefore, it was necessary to begin the manufacture of new standard stars at the 0.4-m telescope. Even then, several of the stars of more extreme color were unobservable because they were just too bright for the 0.4-m telescope RCA 31034 pulse counting combination. Stars made into standard stars via the 0.4-m telescope were then to be used as standard stars at the 0.9-m telescope, and so on, using larger telescopes at each step of the process. Such bootstrapping also would lessen demand for telescope time on the larger instruments.

The Cerro Tololo Inter-American Observatory (CTIO) 0.4-m and 0.9-m telescopes were scheduled for 89 and 91 nights, respectively, in the interval September 1977 through October 1981. Acceptable photometric data were obtained for this program on 53 0.4-m telescope nights and on 41 0.9-m telescope nights. As will be shown elsewhere (Landolt 1983, in preparation), additional nights on these two telescopes were used to check equipment stability. Sixty-six percent of the telescope time assigned to this part of the project was photometric.

All of the photometric observations were made with an RCA 31034 type photomultiplier used in a pulse counting mode. The various photomultipliers available to guest observers at CTIO were operated at voltages recommended by the CTIO operations staff. The data obtained at the 0.4-m telescope were printed on paper tape. The data were averaged by hand and entered into a computer program which subsequently did the processing. Data obtained at the 0.9-m telescope were recorded on magnetic tape and hence were easily transferable for final reduction. All data reductions were accomplished via an IBM 3033 computer at the Louisiana State University System Network Computer Center.

[a)]Contribution of the Louisiana State University Observatory No. 174.

[b)]Visiting Astronomer, 1977–1981, at Cerro Tololo Inter-American Observatory which is operated by the Association of Universities for Research in Astronomy, Inc., under contract with the National Science Foundation.

a) The 0.4-m Telescope Observations

Some 15 to 25 standard stars chosen from Cousins' lists (1973, 1976) in the E-regions were observed each night along with the program stars. *UBVRI* standard stars were observed periodically throughout the night. They were observed in groups of at least three to four, each group containing stars in as wide a color range as possible. In general, the standard stars were observed over an air mass range at least as great as the program stars. The vast majority of the program star observations were obtained at less than 1.5 air masses.

The data were obtained in a series of measures *VBURIIRUBV* star plus sky followed by *VBURI* sky measures. A 27-second of arc diaphragm was used on most occasions. Ten-second counting intervals normally proved sufficient for the magnitude range encountered. The reduction of the observational data followed the precepts outlined by Schulte and Crawford (1961).

The standard stars also were used to provide extinction information. A given night's data were reduced using extinction coefficients derived from that night whenever possible. This technique was adopted for this project after finding overall results with smaller errors than were obtained through the use of mean extinction coefficients for the same data. As a point of information, the average extinction coefficients found over the fifty-month interval during which these data were obtained are presented in Table I.

All observational data were timed via an Accutron clock in the 0.4-m telescope dome or via the computer clock in the 0.9-m telescope dome. One piece of information included on the final computer printout was the magnitude and color indice residuals for each of the standard stars. Hence, it was possible to plot the residuals in the V magnitude and the different color indices for each standard star against Universal Time for a given night. These plots permitted small corrections to be made to all program star measures. The corrections normally were less than a few hundredths of a magnitude. Such corrections took into account small changes in both atmospheric and instrumental conditions. Proof of the need for this kind of correction is shown by the improvement in the accuracy of the final results.

TABLE I. Average CTIO extinction coefficients.

Magnitude or color index	Coefficient symbol	Coefficient value
V	Q_v	+0.172
$B-V$	k_1	+0.111
	k_2	−0.026
$U-B$	k_3	+0.318
	k_4	−0.020
$V-R$	k_5	+0.042
	k_6	0.0
$R-I$	k_7	+0.046
	k_8	0.0
$V-I$	k_9	+0.087
	k_{10}	0.0

TABLE II. Filters used early in program.

V	Corning 3384 + Corning 9780
B	Corning 5030 + GG 385
U	Corning 9863 + solid Cu SO_4 crystal
R	4 mm Schott KG 1 + 2 mm OG 5 + 1.5 mm RG 6
I	3 mm Schott RG 715 + 1 mm RG 780

An extensive effort was undertaken by Dr. John A. Graham of the CTIO staff during 1977 and early 1978 to determine the best filter combination to be used in conjunction with the RCA 31034 photomultiplier. The goal, of course, was to match as best one could, the *UBV* photometric system as well as the Cousins *RI* photometry. Since then, a similar extensive study has been published by Bessell (1976, 1979). His work shows that even the temperature level to which the photomultiplier is cooled (Bessel 1979, Appendix I) has an effect upon the transformation relations. An observer, therefore, needs to match filters as closely as circumstances allow, should use the same type photomultiplier, and should cool to some "standard stable" temperature (usually dry ice) to ensure the best possible transformation.

The first three observing runs, September 1977, January 1978, and April 1978, saw use of the filter combinations listed in Table II. At that point, following Graham's efforts, a switch was made to the filters given in Table III. These filters were used for the remainder of the program. Graham's (1982) Fig. 1 shows their transmission characteristics.

The program stars observed at the 0.4-m telescope were chosen from two sources. First, stars were taken from those published earlier (Landolt 1973). Their characteristics were a known quantity, and their value as standard stars could be enhanced by adding *RI* color indices to the already known *UBV* information. In addition, further *UBV* measures would double check the constancy of the stars both in brightness and in color. Second, since a shortcoming of those standard stars published earlier was a shortage of stars of a really broad range in color, an attempt was made via a literature search to locate quite blue and red stars.

A total of 147 stars made up the program at the 0.4-m telescope, most stars falling within a degree or two of the celestial equator, and distributed around the sky in right ascension. The data were reduced night by night with the results having been tied into an *UBVRI* photometric system defined by Cousins' (1973, 1976) E-region standard stars. The magnitude and color indices differed slightly for the stars observed in September 1977, Jan-

TABLE III. *UBVRI* glass filters.

V	2 mm GG 495 + 2 mm BG 18
B	2 mm GG 385 + 2 mm BG 18 + 2 mm BG 12
U	Corning 9863 + solid Cu SO_4 crystal
R	2 mm KG 3 + 2 mm OG 570
I	3 mm RG 715 + 1 mm RG 780

uary 1978, and April 1978 due to the filter change after the April 1978 observing run. Transformation relations were derived which permitted the successful combination of all data into one large data set. These relations had slopes of no more than 1.48%, or zero point differences of no more than 0.0117 magnitudes. The average slope was 0.76%, and the average zero point was − 0.0050 magnitude.

A goal of the project was to add Cousins' *RI* indices to the *UBV* standard stars available (Landolt 1973). The steps described, using the filters in Table III, accomplished the goal for the *RI* indices. However, a comparison of the *UBV* results with previously published values showed small differences between *UBV* values derived up to this point herein, which were based on Cousins (1973) *UBV* standard stars, and my published values (Landolt 1973). The delta quantities calculated were the quantities tied into Cousins' E-region standard stars for a given star *minus* the equatorial standard star values for the same stars given by Landolt (1973). Mathematically, these relations take the form, utilizing 63 stars in Landolt (1973) having five or more measures each:

$$(B-V) = +0.00855 + 0.98163(B-V)_{\text{Cousins}} \pm 0.00203 \pm 0.00233,$$

$$(U-B) = -0.01685 + 1.02458(U-B)_{\text{Cousins}} \pm 0.00242 \pm 0.00299,$$

$$V = V_{\text{Cousins}} + 0.00341 - 0.00431(B-V)_{\text{Cousins}} \pm 0.00215 \pm 0.00249.$$

If one had not intercompared the data using regression lines, straight differences in the same sense would have shown $\Delta V = -0.00027 \pm 0.00917$, $\Delta(B-V) = +0.00494 \pm 0.01213$, and $\Delta(U-B) = +0.00457 \pm 0.02191$.

These slight color equation differences between Cousins' (1973) *UBV* system and my equatorial (Landolt 1973) *UBV* system then were applied. The success of the operation is illustrated graphically in Figs. 1–3. The delta quantities plotted on the ordinate in each figure are the quantities obtained with the RCA 31034 after removal of the transformation nonlinearity *minus* the values obtained for the same star given by Landolt (1973) equatorial standard stars. The abscissa values came from Landolt (1973). The *UBV* data then were tied into Landolt (1973) and the *RI* data were tied into Cousins (1976).

Since this was my first experience with an RCA 31034 photomultiplier, and I was not certain how data from it would transfer onto an *UBV* system based upon a 1P21, I measured a subset of the 147 program stars at the CTIO 0.4-m telescope using a 1P21 photomultiplier. Stars of all colors were observed, with special attention being given to the bluest stars. Twelve nights were spent on this aspect of the program. The resulting data were tied thoroughly into the *UBV* system (Landolt 1973).

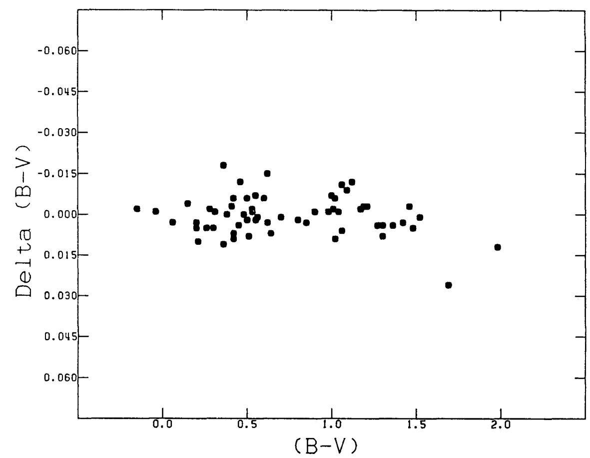

FIG. 2. A comparison of the $(B-V)$ color index tied into Cousins' E-region standard stars as a function of Landolt's (1973) equatorial standard star's $(B-V)$ color index.

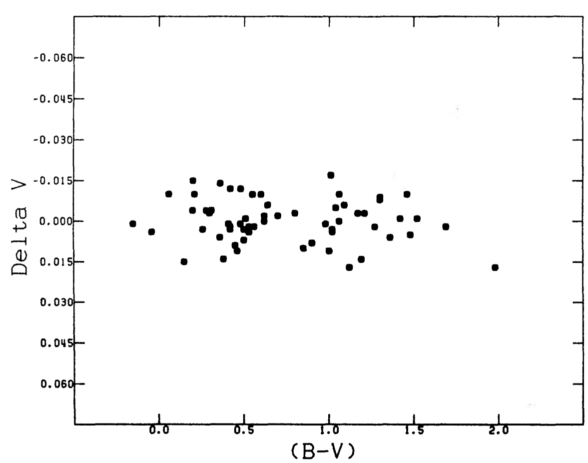

FIG. 1. A comparison of the V magnitude tied into Cousins' E-region standard stars as a function of Landolt's (1973) equatorial standard star's $(B-V)$ color index.

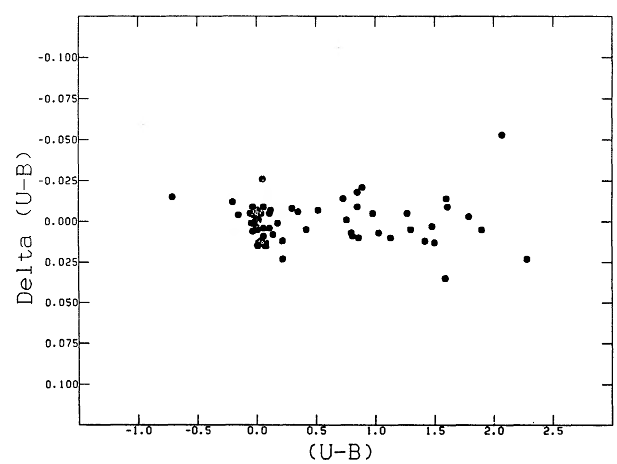

FIG. 3. A comparison of the $(U-B)$ color index tied into Cousins' E-region standard stars as a function of Landolt's (1973) equatorial standard star's $(U-B)$ color index.

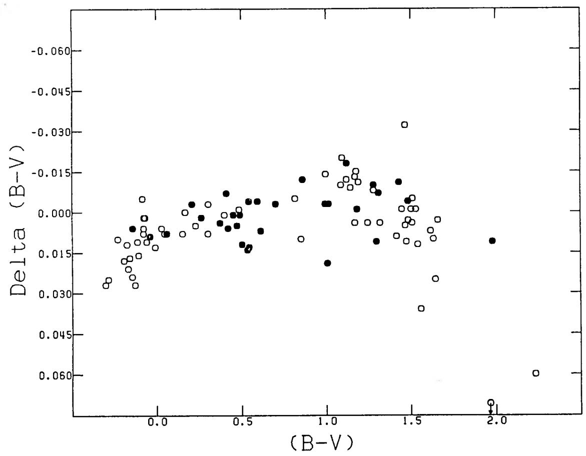

FIG. 4. A comparison of the $(B-V)$ color index obtained with the RCA 31034 as a function of the $(B-V)$ color index observed with a 1P21. Closed circles indicate stars with five or more measures each in Landolt (1973); open circles are for stars with less than five measures each.

Comparison of the 1P21 results with those derived from the RCA 31034, using stars in common, showed that the $(B-V)$ and $(U-B)$ transformations were nonlinear. The situation is illustrated in Figs. 4 and 5. The delta quantities plotted on the ordinate in each figure are the quantities obtained with the RCA 31034 *minus* the values obtained for the same star with a 1P21. It is evident upon inspection of Figs. 4 and 5, that linear relations would intersect at $+0.1$ and -0.2 for $(B-V)$ and $(U-B)$, respectively. Graham (1982) had found that the linear relations met in the region $(B-V)\sim(U-B)\sim+0.4$. Since we used the same equipment, I tested both possibilities. For my data, the nonlinear relations seem to be better taken into account at $(B-V)=+0.1$ and $(U-B)=-0.2$. Stars whose observed $(B-V)$ and $(U-B)$ values were bluer than $+0.1$ and -0.2, respectively, then were corrected by the relations:

$$(B-V)_{\text{corrected}} = -0.00765 + 1.04851(B-V) \pm 0.00217 \pm 0.01729,$$

$$(U-B)_{\text{corrected}} = -0.01317 + 0.94118(U-B) \pm 0.01434 \pm 0.01856.$$

The *UBV* portion of the *UBVRI* data collected with the RCA 31034 photomultiplier, and initially tied into Cousins' (1973) E-region standard stars are now on the *UBV* system defined by Landolt (1973). This exercise was deemed desirable since the vast majority of the *UBV* photometry in recent years used Landolt's standard stars. Therefore, past and future results should be more easily comparable. And, the final *RI* values are on Cousins' (1976) system, descended from the work of Kron *et al.* (1953).

b) The 0.9-m Telescope Observations

The data acquisition and reduction techniques employed at the 0.9-m telescope mimiced those used at the 0.4-m telescope. The standard stars used were those manufactured at the 0.4-m telescope. A diaphragm 16 seconds of arc was used to obtain the majority of the observations. The program stars came from Tables I and II in Landolt (1973). Again small corrections had to be applied to those data obtained in 1977 and early 1978 to transfer those data onto the photometric system defined by the filters in Table III. Once done, a comparison, which used 67 stars from Landolt (1973), each with five or more published measures, was made between the 0.9-m telescope results and the Landolt (1973) values. The situation is illustrated in Figs. 6 and 7. The delta

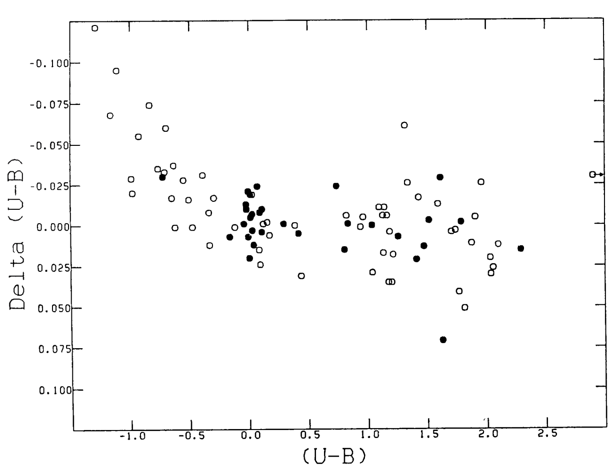

FIG. 5. A comparison of the $(U-B)$ color index obtained with the RCA 31034 as a function of the $(U-B)$ color index observed with a 1P21. The symbols have the same meaning as in Fig. 4.

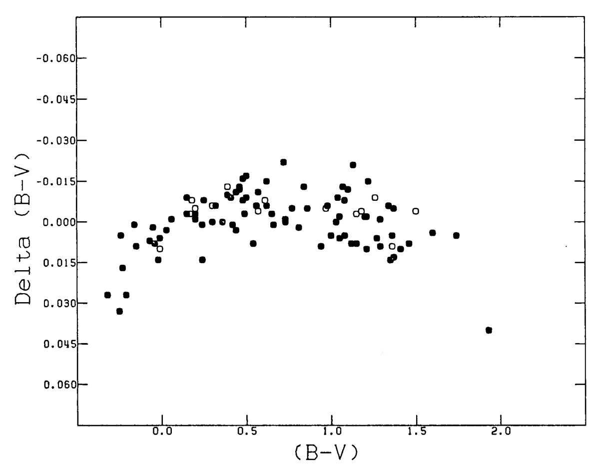

FIG. 6. A comparison of the $(B-V)$ color index observed with the RCA 31034 as a function of Landolt's (1973) equatorial standard star's $(B-V)$ color index. The symbols have the same meaning as in Fig. 4.

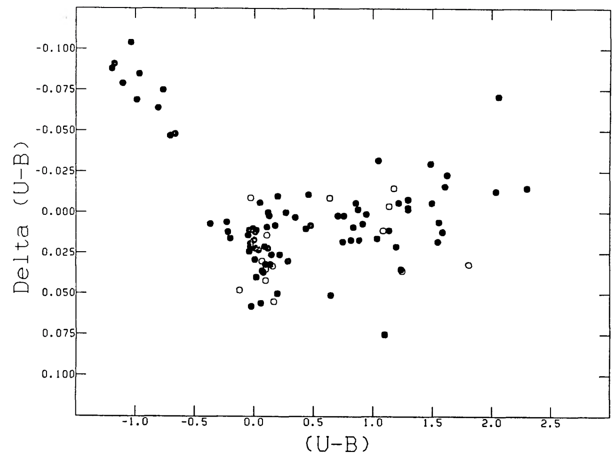

FIG. 7. A comparison of the $(U-B)$ color index observed with the RCA 31034 as a function of Landolt's (1973) equatorial standard star's $(U-B)$ color index. The symbols have the same meaning as in Fig. 4.

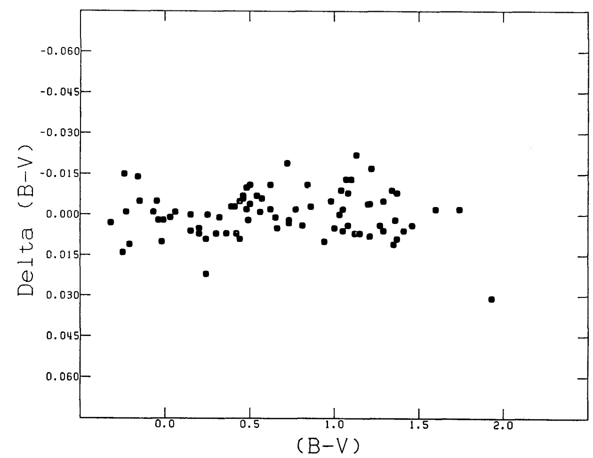

FIG. 8. A comparison of the $(B-V)$ color index observed with the RCA 31034 after removal of the transformation nonlinearity as a function of Landolt's (1973) equatorial standard star's $(B-V)$ color index.

quantities on the ordinate in each figure are the color indices obtained with the RCA 31034 for a star *minus* the corresponding equatorial standard star color indices for that same star given by Landolt (1973). These delta quantities then were plotted as a function of either the $(B-V)$ or $(U-B)$ color index given by Landolt's (1973) equatorial standard stars. Once again there is evidence for nonlinearity of the transformation relations between the RCA 31034 data and the published 1P21 values. Again, upon testing, the nonlinear breakpoints appeared at $(B-V) \sim +0.1$ and $(U-B) \sim -0.2$. Corrections demanded by the nonlinear transformation relations, then, were effected via the equations:

$$(B-V)_{\text{corrected}} =$$
$$-0.00406 + 1.06740(B-V) \qquad (B-V) < +0.1$$
$$\pm 0.00331 \pm 0.02140$$
$$(B-V)_{\text{corrected}} =$$
$$+0.01037 + 0.98992(B-V) \qquad (B-V) > +0.1$$
$$+0.00240 \pm 0.00253$$
$$(U-B)_{\text{corrected}} =$$
$$-0.03066 + 0.89818(U-B) \qquad (U-B) < -0.2$$
$$\pm 0.00697 \pm 0.00757$$
$$(U-B)_{\text{corrected}} =$$
$$-0.02382 + 1.01895(U-B) \qquad (U-B) > -0.2$$
$$\pm 0.00347 \pm 0.00395$$
$$V_{\text{corrected}} =$$
$$V - 0.00189 - 0.00068(B-V)_{\text{corrected}}$$
$$\pm 0.00171 \pm 0.00200.$$

The corrected magnitude and color indices were compared to Landolt's (1973) results once again. The success in effecting the nonlinear transformations is shown in Figs. 8 and 9. The delta quantities plotted on the ordinate in each figure are the quantities obtained with the RCA 31034 after removal of the transformation nonlinearity *minus* the values obtained for the same star given by Landolt (1973) equatorial standard stars. The abscissa values came from Landolt (1973).

A comparison of the magnitude and color indices for 67 stars with at least five measures each in Landolt (1973) with the new 0.9-m data in this paper now show, in the sense RCA 31034 values *minus* Landolt (1973) values: $\Delta V = -0.00121 \pm 0.00941$; $\Delta(B-V) = -0.00022 \pm 0.00869$; and $\Delta(U-B) = -0.00035 \pm 0.01857$. Hence, the data obtained at the 0.9-m tele-

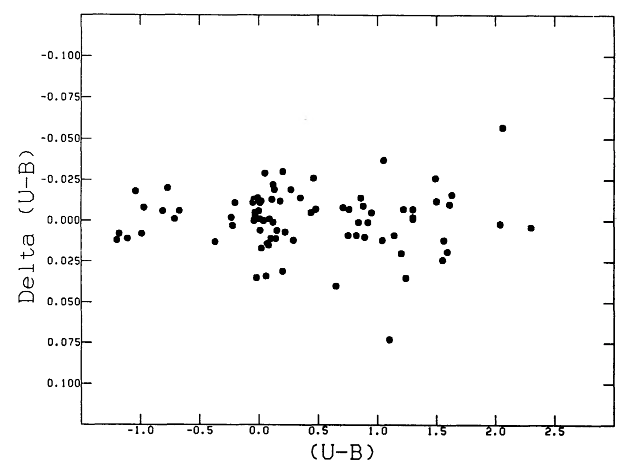

FIG. 9. A comparison of the $(U-B)$ color index observed with the RCA 31034 after removal of the transformation nonlinearity as a function of Landolt's (1973) equatorial standard star's $(U-B)$ color index.

TABLE IV. *UBVRI* standard stars.

Star	α (1985)	δ	V	B−V	U−B	V−R	R−I	V−I	n	m	Mean Errors of the Mean V	B−V	U−B	V−R	R−I	V−I	Notes
315	0:06:59	− 2 37 52	6.440	−0.145	−0.497	−0.037	−0.064	−0.101	4	3	0.0065	0.0070	0.0035	0.0040	0.0055	0.0065	1
2892	0:31:26	+ 1 06 13	9.366	+1.321	+1.409	+0.692	+0.625	+1.319	15	10	0.0044	0.0036	0.0046	0.0021	0.0031	0.0021	1
−15 115	0:37:36	−15 04 51	10.881	−0.190	−0.860	−0.095	−0.103	−0.198	11	8	0.0063	0.0042	0.0057	0.0033	0.0084	0.0084	1
−12 134	0:46:19	−11 57 32	11.775	−0.294	−1.329	−0.088	−0.078	−0.161	12	8	0.0049	0.0040	0.0089	0.0043	0.0098	0.0072	1,2
−11 162	0:51:30	−10 44 49	11.190	−0.081	−1.138	+0.050	+0.095	+0.144	10	7	0.0079	0.0054	0.0063	0.0047	0.0032	0.0057	1
92 336	0:54:16	+ 0 42 36	8.046	+0.985	+0.815	+0.518	+0.465	+0.984	16	10	0.0017	0.0022	0.0033	0.0012	0.0045	0.0047	
92 342	0:54:24	+ 0 38 22	11.616	+0.435	−0.040	+0.264	+0.272	+0.536	22	12	0.0019	0.0023	0.0041	0.0017	0.0021	0.0023	
92 263	0:54:54	+ 0 31 26	11.784	+1.048	+0.846	+0.564	+0.520	+1.085	23	12	0.0054	0.0027	0.0058	0.0023	0.0019	0.0031	3
5505	0:56:05	+ 1 36 00	9.001	+1.078	+0.955	+0.553	+0.502	+1.056	12	8	0.0032	0.0038	0.0055	0.0012	0.0032	0.0032	1
92 288	0:56:31	+ 0 31 55	11.631	+0.857	+0.473	+0.489	+0.441	+0.931	23	12	0.0027	0.0035	0.0044	0.0027	0.0017	0.0023	
F 11	1:03:30	+ 4 09 15	12.061	−0.236	−0.978	−0.119	−0.141	−0.260	24	12	0.0018	0.0020	0.0035	0.0020	0.0039	0.0037	
93 103	1:52:35	+ 0 18 50	8.831	+1.161	+1.157	+0.585	+0.518	+1.104	18	11	0.0028	0.0031	0.0049	0.0026	0.0024	0.0031	
F 16	1:53:51	− 6 50 42	12.405	−0.010	+0.015	−0.009	+0.004	−0.001	25	13	0.0018	0.0022	0.0084	0.0054	0.0036	0.0038	
93 317	1:53:52	+ 0 38 36	11.547	+0.489	−0.053	+0.293	+0.296	+0.589	20	11	0.0011	0.0022	0.0027	0.0016	0.0013	0.0013	
93 326	1:54:04	+ 0 42 40	9.569	+0.454	−0.039	+0.263	+0.265	+0.528	24	14	0.0020	0.0033	0.0041	0.0029	0.0035	0.0031	
93 332	1:54:17	+ 0 35 48	9.789	+0.518	−0.024	+0.296	+0.306	+0.602	18	11	0.0040	0.0035	0.0052	0.0026	0.0024	0.0026	
93 333	1:54:19	+ 0 41 20	12.006	+0.829	+0.434	+0.469	+0.421	+0.891	20	10	0.0022	0.0029	0.0042	0.0018	0.0018	0.0029	
93 241	1:54:33	+ 0 32 08	9.400	+0.853	+0.425	+0.463	+0.453	+0.916	24	14	0.0022	0.0029	0.0053	0.0014	0.0018	0.0018	
93 424	1:54:40	+ 0 52 19	11.620	+1.084	+0.945	+0.553	+0.504	+1.059	20	10	0.0016	0.0036	0.0060	0.0013	0.0016	0.0013	
11983	1:56:47	− 7 36 11	8.192	+1.512	+1.884	+0.807	+0.746	+1.554	22	14	0.0049	0.0055	0.0096	0.0060	0.0028	0.0053	1
12021	1:57:10	− 2 10 37	8.874	−0.082	−0.404	−0.042	−0.056	−0.098	22	14	0.0023	0.0036	0.0026	0.0021	0.0026	0.0028	1
F 22	2:29:32	+ 5 12 19	12.798	−0.055	−0.816	−0.105	−0.101	−0.201	26	16	0.0033	0.0037	0.0065	0.0037	0.0053	0.0055	
F 24	2:34:19	+ 3 40 10	12.409	−0.199	−1.172	+0.092	+0.362	+0.450	26	16	0.0035	0.0022	0.0076	0.0033	0.0037	0.0047	
16581	2:38:46	+ 1 17 26	8.195	−0.057	−0.305	−0.025	−0.038	−0.063	21	15	0.0039	0.0044	0.0035	0.0022	0.0017	0.0033	1
−0 454	2:55:09	+ 0 27 24	8.895	+1.426	+1.579	+0.758	+0.686	+1.445	20	12	0.0027	0.0034	0.0076	0.0016	0.0018	0.0025	1
94 305	2:55:10	+ 0 27 20	8.889	+1.423	+1.586	+0.757	+0.685	+1.443	17	10	0.0046	0.0049	0.0073	0.0034	0.0015	0.0041	
94 308	2:55:28	+ 0 27 41	8.743	+0.494	−0.004	+0.290	+0.287	+0.576	22	15	0.0019	0.0021	0.0041	0.0017	0.0023	0.0021	
94 242	2:56:36	+ 0 15 02	11.730	+0.307	+0.095	+0.177	+0.186	+0.362	19	12	0.0021	0.0023	0.0032	0.0023	0.0023	0.0025	
−2 524	2:56:54	− 2 03 26	10.307	−0.104	−0.641	−0.050	−0.062	−0.111	24	16	0.0029	0.0037	0.0041	0.0018	0.0031	0.0039	1
94 251	2:57:01	+ 0 12 28	11.203	+1.218	+1.275	+0.656	+0.586	+1.243	19	12	0.0018	0.0021	0.0050	0.0016	0.0014	0.0021	
94 702	2:57:27	+ 1 07 18	11.595	+1.416	+1.614	+0.758	+0.672	+1.431	19	12	0.0018	0.0030	0.0083	0.0018	0.0016	0.0018	
94 342	2:57:43	+ 0 22 39	9.041	+0.993	+0.716	+0.527	+0.488	+1.015	18	12	0.0021	0.0031	0.0054	0.0019	0.0014	0.0021	
21197	3:24:18	− 5 23 14	7.866	+1.150	+1.141	+0.686	+0.558	+1.246	24	15	0.0047	0.0047	0.0031	0.0020	0.0018	0.0031	1
95 301	3:51:55	+ 0 28 39	11.219	+1.285	+1.298	+0.692	+0.622	+1.313	21	14	0.0044	0.0024	0.0059	0.0033	0.0013	0.0031	
95 96	3:52:08	− 0 02 21	10.014	+0.147	+0.068	+0.079	+0.093	+0.172	45	31	0.0031	0.0024	0.0037	0.0013	0.0024	0.0024	
95 52	3:53:28	− 0 10 58	9.574	+0.529	+0.069	+0.307	+0.304	+0.611	23	14	0.0027	0.0029	0.0033	0.0017	0.0019	0.0021	
95 206	3:53:30	+ 0 14 44	8.737	+0.502	+0.015	+0.290	+0.285	+0.575	21	13	0.0022	0.0017	0.0041	0.0017	0.0013	0.0024	
95 132	3:54:05	+ 0 02 44	12.062	+0.449	+0.302	+0.259	+0.289	+0.546	19	13	0.0030	0.0030	0.0087	0.0021	0.0028	0.0034	
95 74	3:54:45	− 0 11 49	11.529	+1.127	+0.702	+0.598	+0.566	+1.163	17	12	0.0024	0.0024	0.0073	0.0017	0.0017	0.0017	
95 236	3:55:27	+ 0 06 08	11.492	+0.735	+0.169	+0.421	+0.412	+0.832	16	12	0.0012	0.0030	0.0060	0.0017	0.0012	0.0020	

TABLE IV. (continued)

Star	α (1985)	δ	V	B−V	U−B	V−R	R−I	V−I	n	m	Mean Errors of the Mean V	B−V	U−B	V−R	R−I	V−I	Notes
96 180	4:50:55	− 0 06 44	8.930	+1.049	+0.841	+0.548	+0.504	+1.051	20	12	0.0029	0.0013	0.0051	0.0011	0.0018	0.0018	
96 36	4:50:57	− 0 11 41	10.589	+0.250	+0.111	+0.133	+0.137	+0.270	19	10	0.0023	0.0016	0.0053	0.0014	0.0014	0.0021	
96 393	4:51:44	+ 0 00 39	9.652	+0.598	+0.042	+0.345	+0.343	+0.687	18	11	0.0021	0.0028	0.0047	0.0016	0.0026	0.0028	
96 737	4:51:49	+ 0 21 01	11.718	+1.331	+1.173	+0.736	+0.698	+1.433	19	10	0.0028	0.0030	0.0094	0.0023	0.0014	0.0021	
96 406	4:52:04	+ 0 05 36	9.300	+0.220	+0.148	+0.116	+0.121	+0.237	20	12	0.0018	0.0022	0.0054	0.0018	0.0018	0.0025	
96 83	4:52:13	− 0 16 11	11.721	+0.181	+0.197	+0.090	+0.100	+0.189	24	13	0.0020	0.0018	0.0067	0.0031	0.0029	0.0037	
96 235	4:52:33	− 0 06 31	11.139	+1.072	+0.900	+0.558	+0.510	+1.068	19	10	0.0023	0.0023	0.0048	0.0016	0.0011	0.0014	
36395	5:30:43	− 3 41 39	7.960	+1.474	+1.231	+0.985	+1.095	+2.076	28	18	0.0045	0.0055	0.0047	0.0025	0.0015	0.0032	1
GD 71	5:51:34	+15 53 11	13.027	−0.255	−1.099	−0.141	−0.168	−0.305	24	13	0.0033	0.0047	0.0078	0.0043	0.0076	0.0073	
97 249	5:56:22	+ 0 01 07	11.735	+0.651	+0.098	+0.366	+0.353	+0.719	13	7	0.0044	0.0031	0.0069	0.0011	0.0011	0.0019	
97 346	5:56:41	+ 0 13 17	9.260	+0.594	+0.114	+0.338	+0.324	+0.662	29	18	0.0024	0.0024	0.0030	0.0020	0.0015	0.0026	
97 351	5:56:51	+ 0 13 38	9.783	+0.205	+0.084	+0.124	+0.142	+0.264	44	27	0.0021	0.0014	0.0048	0.0012	0.0011	0.0017	
97 284	5:57:39	+ 0 05 09	10.787	+1.366	+1.098	+0.778	+0.726	+1.504	14	7	0.0024	0.0037	0.0061	0.0016	0.0011	0.0019	
46056	6:30:33	+ 4 50 58	8.230	+0.192	−0.762	+0.135	+0.149	+0.283	3	2	0.0098	0.0035	0.0029	0.0029	0.0035	0.0064	1,4
47761	6:39:17	− 4 41 00	8.724	+0.159	−0.602	+0.138	+0.141	+0.279	21	13	0.0118	0.0024	0.0070	0.0035	0.0046	0.0074	1,5
98 978	6:50:48	− 0 10 22	10.576	+0.606	+0.103	+0.351	+0.321	+0.671	18	11	0.0028	0.0016	0.0031	0.0009	0.0012	0.0016	
98 185	6:51:16	− 0 26 14	10.537	+0.203	+0.114	+0.112	+0.126	+0.237	18	11	0.0038	0.0012	0.0054	0.0016	0.0019	0.0031	
50167	6:51:17	+ 1 16 41	7.861	+1.535	+1.744	+0.826	+0.757	+1.583	23	14	0.0035	0.0031	0.0050	0.0023	0.0017	0.0025	1
98 193	6:51:18	− 0 26 10	10.027	+1.175	+1.163	+0.616	+0.537	+1.154	17	9	0.0029	0.0024	0.0034	0.0012	0.0010	0.0019	
98 653	6:51:19	− 0 17 11	9.538	−0.004	−0.097	+0.007	+0.008	+0.014	43	30	0.0018	0.0005	0.0009	0.0009	0.0009	0.0014	
98 667	6:51:25	− 0 16 34	8.378	+0.028	−0.336	+0.071	+0.078	+0.149	20	13	0.0045	0.0018	0.0051	0.0020	0.0020	0.0025	
98 320	6:52:02	− 0 35 26	9.180	+1.143	+1.136	+0.596	+0.520	+1.116	37	25	0.0020	0.0021	0.0025	0.0013	0.0007	0.0015	
52533	7:00:42	− 3 05 28	7.702	−0.088	−0.958	−0.011	−0.030	−0.038	23	13	0.0048	0.0021	0.0048	0.0017	0.0046	0.0035	1
57884	7:22:22	− 4 11 30	9.135	+2.299	+3.864	+1.264	+1.019	+2.287	27	14	0.0139	0.0089	0.1640	0.0060	0.0031	0.0083	1,5
+5 1668	7:26:36	+ 5 16 16	9.843	+1.557	+1.213	+1.206	+1.514	+2.714	24	13	0.0047	0.0055	0.0137	0.0067	0.0041	0.0067	1
60826	7:35:42	+ 2 06 22	8.983	+2.741	+5.118	+1.495	+1.178	+2.677	24	13	0.0465	0.0135	0.2188	0.0133	0.0061	0.0190	1,5
99 6	7:52:48	− 0 47 12	11.054	+1.249	+1.287	+0.652	+0.577	+1.229	22	11	0.0023	0.0034	0.0041	0.0017	0.0006	0.0015	
99 358	7:53:12	− 0 19 45	9.605	+0.776	+0.509	+0.432	+0.405	+0.838	21	12	0.0041	0.0028	0.0039	0.0026	0.0033	0.0035	
99 367	7:53:26	− 0 23 13	11.149	+1.005	+0.829	+0.531	+0.477	+1.009	20	10	0.0022	0.0031	0.0034	0.0016	0.0011	0.0016	
99 296	7:54:01	− 0 27 12	8.454	+1.187	+1.265	+0.600	+0.523	+1.123	15	9	0.0039	0.0044	0.0034	0.0018	0.0023	0.0023	
99 185	7:54:07	− 0 43 00	8.344	+1.081	+0.975	+0.563	+0.507	+1.071	17	10	0.0041	0.0032	0.0036	0.0022	0.0019	0.0010	
99 408	7:54:27	− 0 23 08	9.807	+0.407	+0.043	+0.253	+0.247	+0.499	27	16	0.0023	0.0021	0.0021	0.0012	0.0012	0.0013	
99 418	7:54:41	− 0 15 07	9.474	−0.041	−0.154	−0.003	−0.013	−0.016	17	10	0.0051	0.0044	0.0085	0.0032	0.0032	0.0036	
99 438	7:55:08	− 0 14 26	9.399	−0.155	−0.719	−0.060	−0.082	−0.143	48	31	0.0027	0.0017	0.0025	0.0012	0.0010	0.0012	
99 447	7:55:21	− 0 18 18	9.415	−0.071	−0.217	−0.031	−0.041	−0.074	22	11	0.0021	0.0019	0.0053	0.0013	0.0013	0.0015	
65079	7:56:19	+ 3 00 09	7.832	−0.182	−0.786	−0.055	−0.075	−0.130	18	11	0.0052	0.0052	0.0049	0.0024	0.0040	0.0059	1
72055	8:29:50	− 7 06 14	8.113	−0.137	−0.460	−0.031	−0.056	−0.086	17	10	0.0039	0.0044	0.0070	0.0029	0.0029	0.0032	1
100 241	8:51:49	− 0 36 23	10.140	+0.156	+0.102	+0.077	+0.087	+0.164	20	12	0.0020	0.0022	0.0074	0.0011	0.0013	0.0016	
100 606	8:52:12	− 0 06 04	8.641	+0.052	+0.125	+0.026	+0.022	+0.048	15	7	0.0021	0.0044	0.0114	0.0018	0.0023	0.0023	
100 162	8:52:29	− 0 40 03	9.148	+1.274	+1.501	+0.648	+0.553	+1.204	37	20	0.0018	0.0020	0.0038	0.0015	0.0010	0.0016	

TABLE IV. (continued)

Star	α (1985)	δ	V	B−V	U−B	V−R	R−I	V−I	n	m	Mean Errors of the Mean V	B−V	U−B	V−R	R−I	V−I	Notes
100 280	8:52:50	− 0 33 15	11.802	+0.496	+0.009	+0.295	+0.296	+0.591	20	12	0.0027	0.0034	0.0029	0.0020	0.0025	0.0027	
76082	8:53:13	− 0 33 20	8.409	+1.118	+1.090	+0.585	+0.516	+1.101	15	9	0.0031	0.0059	0.0059	0.0015	0.0013	0.0021	1
100 95	8:54:08	− 0 54 40	8.915	+0.814	+0.391	+0.453	+0.431	+0.884	15	8	0.0021	0.0021	0.0062	0.0021	0.0021	0.0021	
79097	9:11:07	− 6 54 45	7.601	+1.628	+1.933	+0.990	+1.100	+2.087	19	11	0.0073	0.0023	0.0069	0.0044	0.0030	0.0062	1,6
84971	9:47:59	− 2 38 29	8.636	−0.159	−0.770	−0.063	−0.089	−0.152	19	11	0.0037	0.0032	0.0028	0.0025	0.0028	0.0041	1
101 389	9:53:34	− 0 10 50	9.962	+0.427	−0.001	+0.256	+0.248	+0.503	16	10	0.0012	0.0015	0.0025	0.0017	0.0015	0.0022	
101 311	9:53:49	− 0 20 01	8.233	+0.265	+0.003	+0.159	+0.164	+0.322	19	11	0.0018	0.0016	0.0046	0.0018	0.0018	0.0016	
101 24	9:54:50	− 1 03 10	7.997	+1.108	+1.037	+0.575	+0.515	+1.091	16	9	0.0042	0.0038	0.0038	0.0017	0.0015	0.0027	
101 324	9:55:11	− 0 18 56	9.743	+1.157	+1.149	+0.591	+0.520	+1.111	20	13	0.0027	0.0029	0.0031	0.0013	0.0009	0.0016	
101 333	9:55:53	− 0 23 22	7.835	+1.485	+1.787	+0.795	+0.728	+1.524	19	11	0.0037	0.0025	0.0060	0.0025	0.0018	0.0032	
101 282	9:56:19	− 0 25 42	10.002	+0.429	+0.010	+0.260	+0.260	+0.520	17	9	0.0034	0.0032	0.0032	0.0027	0.0029	0.0024	
101 281	9:56:19	− 0 27 20	11.579	+0.814	+0.435	+0.455	+0.410	+0.866	21	12	0.0022	0.0020	0.0048	0.0013	0.0013	0.0022	
101 363	9:57:33	− 0 21 16	9.871	+0.262	+0.121	+0.145	+0.151	+0.296	19	13	0.0023	0.0016	0.0060	0.0014	0.0014	0.0021	
+1 2447	10:28:10	+ 0 56 31	9.652	+1.509	+1.238	+1.044	+1.226	+2.266	19	9	0.0034	0.0064	0.0131	0.0041	0.0023	0.0041	1
G162 66	10:32:59	−11 37 02	13.015	−0.174	−0.982	−0.126	−0.136	−0.262	26	14	0.0029	0.0025	0.0049	0.0025	0.0057	0.0057	
102 276	10:52:26	− 0 57 56	9.910	+0.492	−0.024	+0.291	+0.285	+0.575	18	10	0.0014	0.0014	0.0031	0.0012	0.0035	0.0033	
102 466	10:53:52	− 0 50 40	9.246	+1.056	+0.921	+0.563	+0.506	+1.069	16	10	0.0017	0.0025	0.0033	0.0017	0.0017	0.0022	
102 472	10:54:04	− 0 50 15	8.754	+1.014	+0.819	+0.528	+0.483	+1.011	16	7	0.0040	0.0017	0.0035	0.0017	0.0017	0.0022	
102 620	10:54:20	− 0 43 31	10.067	+1.087	+1.013	+0.642	+0.523	+1.167	18	11	0.0024	0.0021	0.0026	0.0021	0.0016	0.0021	
102 58	10:54:32	− 1 20 38	9.380	+0.060	+0.021	+0.044	+0.015	+0.060	35	18	0.0015	0.0027	0.0057	0.0014	0.0012	0.0014	
102 625	10:54:39	− 0 43 57	8.890	+0.552	+0.035	+0.312	+0.308	+0.621	16	8	0.0047	0.0022	0.0030	0.0025	0.0022	0.0030	
102 381	10:55:55	− 1 05 18	7.916	+0.309	+0.095	+0.173	+0.173	+0.346	16	7	0.0038	0.0012	0.0050	0.0017	0.0015	0.0030	
102 1081	10:56:19	− 0 08 21	9.904	+0.665	+0.251	+0.367	+0.332	+0.698	18	11	0.0033	0.0019	0.0038	0.0014	0.0014	0.0016	
G163 50	11:07:14	− 5 04 16	13.057	+0.031	−0.676	−0.089	−0.072	−0.163	23	11	0.0042	0.0040	0.0052	0.0035	0.0046	0.0052	
97503	11:12:29	+ 4 33 32	8.702	+1.178	+1.121	+0.720	+0.596	+1.317	16	9	0.0045	0.0035	0.0047	0.0017	0.0020	0.0025	1
+5 2468	11:14:46	+ 5 02 20	9.348	−0.116	−0.560	−0.038	−0.054	−0.092	17	10	0.0049	0.0029	0.0044	0.0017	0.0024	0.0024	1
100340	11:32:03	+ 5 21 40	10.117	−0.242	−0.975	−0.101	−0.137	−0.238	18	10	0.0047	0.0049	0.0066	0.0026	0.0033	0.0033	1
+5 2529	11:41:03	+ 5 13 04	9.581	+1.250	+1.188	+0.781	+0.668	+1.450	18	10	0.0054	0.0061	0.0082	0.0021	0.0024	0.0024	1
103 462	11:53:13	− 0 26 48	10.111	+0.564	+0.089	+0.324	+0.306	+0.630	15	10	0.0026	0.0023	0.0034	0.0013	0.0015	0.0015	
103 483	11:54:15	− 0 28 21	8.353	+0.427	+0.093	+0.245	+0.235	+0.480	20	11	0.0027	0.0018	0.0025	0.0013	0.0016	0.0018	
103 302	11:55:20	− 0 42 54	9.862	+0.369	−0.058	+0.230	+0.237	+0.467	32	20	0.0025	0.0018	0.0021	0.0014	0.0028	0.0028	
103 526	11:56:08	− 0 25 13	10.903	+1.089	+0.941	+0.563	+0.509	+1.073	17	11	0.0034	0.0039	0.0041	0.0015	0.0015	0.0015	
104 306	12:40:18	− 0 32 15	9.361	+1.583	+1.662	+0.833	+0.763	+1.588	44	28	0.0098	0.0045	0.0069	0.0032	0.0050	0.0042	5
104 337	12:41:42	− 0 29 21	11.207	+0.768	+0.336	+0.434	+0.399	+0.832	22	14	0.0019	0.0017	0.0045	0.0015	0.0017	0.0019	
104 461	12:42:21	− 0 27 26	9.706	+0.478	−0.029	+0.290	+0.289	+0.580	47	29	0.0016	0.0016	0.0019	0.0009	0.0010	0.0007	
104 598	12:44:31	− 0 11 42	11.476	+1.108	+1.052	+0.663	+0.546	+1.211	21	14	0.0033	0.0024	0.0059	0.0026	0.0017	0.0026	
118246	13:34:56	− 6 04 55	8.089	−0.141	−0.636	−0.034	−0.047	−0.081	19	10	0.0071	0.0021	0.0053	0.0025	0.0025	0.0037	1,7
105 205	13:35:07	− 0 53 16	8.798	+1.363	+1.616	+0.744	+0.675	+1.419	34	21	0.0027	0.0019	0.0039	0.0012	0.0010	0.0012	
105 405	13:35:14	− 0 30 00	8.309	+1.521	+1.905	+0.832	+0.784	+1.617	27	14	0.0037	0.0012	0.0065	0.0013	0.0017	0.0015	
105 214	13:35:30	− 0 51 10	7.062	+0.528	−0.010	+0.313	+0.311	+0.624	17	8	0.0027	0.0024	0.0041	0.0019	0.0017	0.0029	

TABLE IV. (continued)

Star	α (1985)	δ	V	B−V	U−B	V−R	R−I	V−I	n	m	Mean Errors of the Mean V	B−V	U−B	V−R	R−I	V−I	Notes
105 28	13:35:58	− 1 11 04	8.345	+1.039	+0.870	+0.533	+0.485	+1.018	19	10	0.0034	0.0030	0.0037	0.0016	0.0016	0.0021	
105 663	13:36:44	− 0 08 41	8.760	+0.342	+0.033	+0.211	+0.217	+0.429	18	10	0.0049	0.0019	0.0031	0.0016	0.0019	0.0016	
105 448	13:37:02	− 0 32 57	9.176	+0.249	+0.037	+0.149	+0.162	+0.311	20	13	0.0020	0.0011	0.0042	0.0011	0.0009	0.0018	
105 66	13:38:49	− 1 08 53	9.426	+0.977	+0.756	+0.522	+0.481	+1.003	31	19	0.0022	0.0018	0.0032	0.0013	0.0009	0.0013	
105 815	13:39:18	+ 0 02 23	11.456	+0.387	−0.232	+0.270	+0.294	+0.563	18	12	0.0019	0.0040	0.0038	0.0014	0.0016	0.0016	
+2 2711	13:41:35	+ 1 34 48	10.367	−0.162	−0.708	−0.070	−0.094	−0.165	25	13	0.0044	0.0040	0.0042	0.0028	0.0032	0.0026	1
121968	13:58:04	− 2 50 54	10.256	−0.179	−0.935	−0.069	−0.095	−0.164	15	8	0.0034	0.0028	0.0059	0.0031	0.0026	0.0036	1
106 834	14:38:43	− 0 11 00	9.088	+0.701	+0.292	+0.379	+0.357	+0.736	15	8	0.0034	0.0023	0.0054	0.0049	0.0044	0.0028	
106 1024	14:39:21	+ 0 05 36	11.594	+0.332	+0.085	+0.195	+0.196	+0.391	19	12	0.0076	0.0034	0.0055	0.0028	0.0023	0.0044	8
106 700	14:40:06	− 0 19 47	9.787	+1.361	+1.574	+0.728	+0.642	+1.372	19	12	0.0025	0.0025	0.0041	0.0014	0.0014	0.0021	
106 1250	14:40:41	+ 0 10 06	8.123	+1.029	+0.832	+0.532	+0.494	+1.026	15	8	0.0039	0.0021	0.0039	0.0013	0.0013	0.0018	
106 575	14:40:53	− 0 22 12	9.341	+1.308	+1.483	+0.672	+0.592	+1.265	18	9	0.0049	0.0031	0.0080	0.0042	0.0019	0.0035	
106 485	14:43:28	− 0 33 20	9.484	+0.380	−0.039	+0.232	+0.232	+0.463	19	10	0.0050	0.0021	0.0046	0.0018	0.0021	0.0028	
129975	14:44:51	− 0 17 23	8.373	+1.504	+1.899	+0.829	+0.776	+1.605	17	9	0.0029	0.0027	0.0068	0.0017	0.0015	0.0017	1
107 544	15:36:03	− 0 12 14	9.037	+0.401	+0.156	+0.233	+0.226	+0.457	37	22	0.0018	0.0013	0.0021	0.0013	0.0010	0.0013	
107 684	15:36:31	− 0 06 51	8.433	+0.619	+0.072	+0.356	+0.353	+0.708	14	7	0.0032	0.0037	0.0051	0.0019	0.0019	0.0021	
107 970	15:36:40	+ 0 21 30	10.910	+1.604	+1.788	+1.144	+1.426	+2.567	20	11	0.0123	0.0031	0.0123	0.0042	0.0072	0.0063	5
107 35	15:36:42	− 0 50 10	7.779	+1.275	+1.309	+0.663	+0.585	+1.249	14	9	0.0029	0.0032	0.0043	0.0027	0.0019	0.0024	
107 1006	15:37:48	+ 0 17 16	11.715	+0.764	+0.285	+0.440	+0.420	+0.861	16	10	0.0025	0.0022	0.0045	0.0022	0.0020	0.0025	
107 347	15:37:50	− 0 33 01	9.443	+1.296	+1.299	+0.713	+0.653	+1.367	17	10	0.0027	0.0015	0.0019	0.0015	0.0015	0.0019	
107 595	15:38:17	− 0 15 40	7.500	+0.543	+0.051	+0.312	+0.297	+0.608	16	9	0.0030	0.0027	0.0047	0.0022	0.0017	0.0022	
107 131	15:39:38	− 0 51 49	8.073	+1.118	+0.948	+0.598	+0.548	+1.147	12	6	0.0020	0.0017	0.0035	0.0017	0.0009	0.0014	
140850	15:45:11	− 1 23 50	8.816	+1.670	+2.078	+0.948	+0.947	+1.895	25	14	0.0022	0.0020	0.0072	0.0024	0.0016	0.0028	1
148817	16:29:55	− 0 06 49	8.341	+1.485	+1.805	+0.804	+0.737	+1.542	24	12	0.0047	0.0016	0.0047	0.0010	0.0018	0.0022	1
149382	16:33:36	− 3 58 59	8.944	−0.281	−1.167	−0.126	−0.138	−0.264	16	8	0.0025	0.0052	0.0107	0.0025	0.0030	0.0020	1
108 1332	16:34:35	− 0 02 18	9.199	+0.384	+0.087	+0.228	+0.228	+0.454	33	19	0.0017	0.0014	0.0017	0.0012	0.0012	0.0016	
108 702	16:35:12	− 0 22 57	8.208	+0.559	+0.021	+0.319	+0.309	+0.628	32	20	0.0016	0.0012	0.0016	0.0009	0.0009	0.0012	
108 475	16:36:14	− 0 32 53	11.308	+1.379	+1.464	+0.741	+0.665	+1.408	21	12	0.0024	0.0031	0.0057	0.0015	0.0017	0.0017	
108 1491	16:36:28	− 0 00 54	9.059	+0.965	+0.620	+0.524	+0.498	+1.022	38	24	0.0011	0.0011	0.0021	0.0011	0.0010	0.0013	
108 827	16:36:36	− 0 22 54	7.964	+1.303	+1.413	+0.682	+0.589	+1.269	21	11	0.0009	0.0013	0.0004	0.0009	0.0015	0.0011	
108 551	16:37:01	− 0 31 19	10.705	+0.175	+0.180	+0.097	+0.109	+0.204	51	31	0.0017	0.0010	0.0053	0.0014	0.0018	0.0025	
108 1911	16:37:01	+ 0 04 33	8.050	+0.758	+0.390	+0.417	+0.366	+0.784	13	7	0.0014	0.0019	0.0055	0.0025	0.0019	0.0019	
157881	17:25:05	+ 2 10 12	7.540	+1.356	+1.276	+0.854	+0.768	+1.622	20	11	0.0054	0.0074	0.0016	0.0016	0.0020	0.0018	1
160233	17:37:56	+ 4 21 19	9.095	−0.054	−0.846	−0.003	−0.023	−0.026	16	9	0.0040	0.0027	0.0082	0.0017	0.0025	0.0030	1
109 71	17:43:20	− 0 24 38	11.491	+0.321	+0.156	+0.188	+0.223	+0.410	19	12	0.0018	0.0021	0.0057	0.0016	0.0014	0.0016	
109 381	17:43:26	− 0 20 12	11.728	+0.701	+0.231	+0.426	+0.437	+0.863	19	11	0.0025	0.0044	0.0034	0.0021	0.0014	0.0023	
109 747	17:44:05	− 0 07 45	8.477	+0.305	+0.243	+0.187	+0.210	+0.396	26	14	0.0022	0.0024	0.0043	0.0012	0.0016	0.0014	
109 231	17:44:34	− 0 25 31	9.331	+1.462	+1.600	+0.786	+0.705	+1.492	50	27	0.0016	0.0018	0.0038	0.0008	0.0008	0.0013	
109 1082	17:44:43	+ 0 04 38	9.017	+0.802	+0.344	+0.455	+0.423	+0.878	16	9	0.0050	0.0042	0.0090	0.0025	0.0020	0.0033	
109 537	17:44:56	− 0 21 15	10.358	+0.608	+0.229	+0.377	+0.393	+0.769	42	24	0.0037	0.0023	0.0031	0.0012	0.0014	0.0020	

TABLE IV. (continued)

Star	α (1985)	δ	V	B-V	U-B	V-R	R-I	V-I	n	m	Mean Errors of the Mean V	B-V	U-B	V-R	R-I	V-I	Notes
+4 3508	17:46:49	+ 4 50 24	9.326	+1.753	+2.077	+0.974	+0.900	+1.874	14	8	0.0053	0.0043	0.0150	0.0019	0.0013	0.0027	1
161961	17:47:50	− 2 11 27	7.782	+0.224	−0.747	+0.143	+0.158	+0.306	20	11	0.0029	0.0045	0.0094	0.0022	0.0022	0.0020	1
+4 3561	17:57:03	+ 4 38 00	9.553	+1.737	+1.264	+1.228	+1.553	+2.779	7	3	0.0049	0.0045	0.0234	0.0045	0.0036	0.0053	1
170493	18:29:05	− 1 49 38	8.037	+1.076	+1.068	+0.634	+0.509	+1.145	14	8	0.0024	0.0027	0.0037	0.0019	0.0013	0.0013	1
110 471	18:40:42	+ 0 33 01	7.474	+1.449	+1.710	+0.767	+0.681	+1.448	15	8	0.0028	0.0023	0.0070	0.0015	0.0013	0.0023	
110 340	18:40:43	+ 0 14 28	10.023	+0.301	+0.123	+0.169	+0.180	+0.349	35	22	0.0017	0.0014	0.0037	0.0010	0.0017	0.0020	
110 353	18:41:31	+ 0 08 24	8.447	+2.002	+2.292	+1.186	+1.120	+2.306	25	14	0.0026	0.0026	0.0070	0.0028	0.0030	0.0042	
110 441	18:42:48	+ 0 18 44	11.124	+0.553	+0.111	+0.325	+0.337	+0.663	17	10	0.0034	0.0044	0.0041	0.0017	0.0017	0.0034	
110 450	18:43:06	+ 0 22 01	11.585	+0.950	+0.690	+0.552	+0.631	+1.181	17	10	0.0053	0.0068	0.0053	0.0022	0.0022	0.0029	
173637	18:45:50	− 7 56 56	9.375	+0.236	−0.729	+0.168	+0.187	+0.354	15	9	0.0039	0.0036	0.0036	0.0021	0.0021	0.0023	1
175544	18:55:02	+ 0 14 49	7.395	+0.107	−0.671	+0.074	+0.077	+0.151	19	11	0.0021	0.0028	0.0076	0.0018	0.0021	0.0023	1
184914	19:35:58	− 4 19 26	8.170	+1.180	+0.940	+0.636	+0.604	+1.241	20	12	0.0013	0.0022	0.0038	0.0013	0.0011	0.0018	1
111 717	19:36:09	+ 0 05 29	8.529	+0.425	+0.224	+0.236	+0.247	+0.483	15	8	0.0028	0.0026	0.0052	0.0015	0.0023	0.0023	
111 2522	19:36:19	+ 0 35 31	9.706	+0.164	−0.409	+0.121	+0.140	+0.267	21	11	0.0050	0.0033	0.0037	0.0048	0.0022	0.0024	
111 773	19:36:30	+ 0 08 56	8.963	+0.206	−0.211	+0.118	+0.144	+0.261	38	22	0.0015	0.0018	0.0019	0.0010	0.0011	0.0010	
111 775	19:36:30	+ 0 10 02	10.747	+1.738	+2.042	+0.965	+0.897	+1.864	20	11	0.0029	0.0038	0.0170	0.0022	0.0013	0.0022	
111 1969	19:36:58	+ 0 23 44	10.384	+1.961	+2.304	+1.181	+1.223	+2.405	20	11	0.0038	0.0031	0.0103	0.0031	0.0020	0.0031	
111 2009	19:37:09	+ 0 24 24	10.608	+0.889	+0.513	+0.509	+0.460	+0.969	13	7	0.0039	0.0042	0.0069	0.0033	0.0022	0.0033	
111 1496	19:37:36	+ 0 18 39	7.216	+0.278	+0.113	+0.154	+0.166	+0.319	13	7	0.0014	0.0019	0.0058	0.0014	0.0019	0.0019	
111 2864	19:38:02	+ 0 34 16	8.292	+1.716	+2.017	+0.933	+0.853	+1.786	20	11	0.0027	0.0027	0.0092	0.0018	0.0016	0.0016	
188934	19:56:52	+ 0 11 51	9.351	+2.040	+2.102	+0.942	+0.787	+1.731	20	10	0.0127	0.0206	0.0311	0.0027	0.0016	0.0031	1,5
191639	20:10:22	− 8 53 10	6.223	−0.087	−1.031	+0.014	+0.014	+0.027	14	9	0.0505	0.0136	0.0069	0.0118	0.0171	0.0289	1,5
196395	20:36:21	− 0 33 12	8.711	+1.662	+2.059	+0.933	+0.926	+1.859	18	11	0.0024	0.0024	0.0054	0.0024	0.0016	0.0033	1
196573	20:37:31	+ 0 57 40	7.885	+1.641	+2.043	+0.931	+0.955	+1.884	10	6	0.0054	0.0028	0.0035	0.0028	0.0022	0.0032	1
112 595	20:40:32	+ 0 13 14	11.349	+1.598	+2.003	+0.899	+0.901	+1.800	19	10	0.0039	0.0034	0.0179	0.0021	0.0023	0.0028	
112 636	20:40:49	+ 0 13 18	9.853	+0.688	+0.132	+0.402	+0.396	+0.799	14	8	0.0053	0.0027	0.0080	0.0040	0.0032	0.0037	
112 223	20:41:29	+ 0 05 46	11.421	+0.454	+0.008	+0.273	+0.273	+0.546	17	10	0.0019	0.0024	0.0027	0.0024	0.0027	0.0032	
112 1242	20:41:38	+ 0 23 29	9.088	+0.414	+0.019	+0.251	+0.250	+0.501	16	9	0.0025	0.0033	0.0030	0.0012	0.0020	0.0017	
112 275	20:41:50	+ 0 04 05	9.905	+1.206	+1.298	+0.647	+0.570	+1.217	38	23	0.0016	0.0016	0.0036	0.0010	0.0011	0.0011	
112 805	20:42:00	+ 0 12 52	12.090	+0.150	+0.151	+0.063	+0.075	+0.138	20	11	0.0031	0.0022	0.0042	0.0034	0.0034	0.0045	
112 822	20:42:09	+ 0 11 48	11.550	+1.031	+0.871	+0.558	+0.505	+1.064	18	10	0.0016	0.0038	0.0071	0.0012	0.0024	0.0024	
199280	20:55:31	− 3 37 10	6.566	−0.076	−0.306	−0.034	−0.043	−0.078	12	7	0.0020	0.0017	0.0026	0.0014	0.0012	0.0012	1
200340	21:02:14	− 0 59 44	6.498	−0.099	−0.496	−0.037	−0.045	−0.083	10	6	0.0032	0.0022	0.0019	0.0016	0.0019	0.0022	1
205556	21:35:11	+ 5 25 11	8.301	−0.054	−0.395	−0.021	−0.032	−0.053	18	10	0.0042	0.0026	0.0031	0.0019	0.0016	0.0019	1
113 442	21:39:54	+ 0 40 37	9.650	+1.163	+1.251	+0.605	+0.517	+1.123	12	7	0.0026	0.0026	0.0058	0.0026	0.0029	0.0026	
113 466	21:40:42	+ 0 36 06	10.007	+0.452	−0.001	+0.282	+0.282	+0.565	32	19	0.0016	0.0012	0.0018	0.0012	0.0014	0.0016	
113 259	21:40:58	+ 0 13 30	11.743	+1.196	+1.213	+0.622	+0.545	+1.168	21	12	0.0024	0.0035	0.0076	0.0017	0.0017	0.0022	
113 475	21:41:05	+ 0 35 11	10.306	+1.057	+0.841	+0.569	+0.526	+1.096	21	12	0.0020	0.0024	0.0037	0.0013	0.0020	0.0020	
113 267	21:41:10	+ 0 16 37	7.653	+0.488	+0.013	+0.291	+0.291	+0.582	10	5	0.0038	0.0028	0.0047	0.0022	0.0016	0.0013	
113 269	21:41:15	+ 0 13 35	9.482	+1.112	+1.054	+0.572	+0.520	+1.092	10	5	0.0028	0.0028	0.0120	0.0025	0.0028	0.0032	

TABLE IV. (continued)

Star	α (1985)	δ	V	B−V	U−B	V−R	R−I	V−I	n	m	Mean Errors of the Mean V	B−V	U−B	V−R	R−I	V−I	Notes
113 276	21:41:41	+ 0 22 14	9.074	+0.647	+0.181	+0.357	+0.336	+0.692	12	6	0.0038	0.0026	0.0069	0.0029	0.0017	0.0029	
113 274	21:41:41	+ 0 22 38	8.831	+0.480	+0.004	+0.284	+0.271	+0.555	13	7	0.0028	0.0031	0.0028	0.0017	0.0028	0.0028	
G93 48	21:51:39	+ 2 19 17	12.736	−0.008	−0.790	−0.099	−0.096	−0.194	27	14	0.0033	0.0037	0.0035	0.0029	0.0058	0.0056	
209796	22:05:16	+ 1 18 36	8.933	+1.187	+1.173	+0.621	+0.557	+1.178	19	11	0.0034	0.0021	0.0064	0.0016	0.0016	0.0021	1
210894	22:12:50	− 4 38 19	9.167	+1.315	+1.462	+0.697	+0.605	+1.304	17	10	0.0029	0.0032	0.0073	0.0017	0.0022	0.0029	1
114 531	22:39:51	+ 0 47 14	12.094	+0.732	+0.170	+0.422	+0.405	+0.827	18	10	0.0014	0.0033	0.0049	0.0014	0.0016	0.0021	
114 548	22:40:51	+ 0 54 24	11.600	+1.362	+1.572	+0.732	+0.652	+1.385	19	11	0.0046	0.0030	0.0094	0.0023	0.0014	0.0025	
114 750	22:40:59	+ 1 07 54	11.913	−0.038	−0.357	+0.030	−0.017	+0.013	23	15	0.0025	0.0025	0.0031	0.0019	0.0035	0.0042	
114 755	22:41:22	+ 1 12 06	10.908	+0.571	−0.064	+0.311	+0.310	+0.621	16	11	0.0015	0.0017	0.0022	0.0017	0.0012	0.0017	
114 670	22:41:24	+ 1 05 34	11.106	+1.203	+1.220	+0.645	+0.578	+1.224	13	8	0.0014	0.0022	0.0061	0.0019	0.0019	0.0022	
114 473	22:41:38	+ 0 41 32	8.503	+1.008	+0.807	+0.532	+0.483	+1.015	11	6	0.0018	0.0039	0.0063	0.0018	0.0027	0.0030	
114 172	22:42:03	+ 0 09 10	6.969	+0.311	+0.105	+0.187	+0.189	+0.376	15	9	0.0026	0.0015	0.0057	0.0010	0.0018	0.0015	
114 272	22:42:11	+ 0 19 37	7.737	+0.864	+0.473	+0.480	+0.462	+0.941	9	5	0.0020	0.0027	0.0077	0.0017	0.0033	0.0023	
114 176	22:42:24	+ 0 16 32	9.242	+1.490	+1.854	+0.804	+0.719	+1.524	40	26	0.0017	0.0019	0.0036	0.0009	0.0009	0.0011	
216135	22:49:41	−13 23 12	10.112	−0.115	−0.630	−0.052	−0.069	−0.121	16	9	0.0027	0.0022	0.0027	0.0017	0.0030	0.0015	1
GD 246	23:11:35	+10 42 08	13.090	−0.317	−1.188	−0.149	−0.185	−0.333	31	16	0.0031	0.0038	0.0032	0.0036	0.0066	0.0075	
F 108	23:15:24	− 1 55 32	12.966	−0.231	−1.058	−0.104	−0.138	−0.241	30	16	0.0042	0.0026	0.0035	0.0024	0.0075	0.0069	
115 420	23:41:50	+ 1 00 58	11.162	+0.470	−0.033	+0.287	+0.295	+0.581	16	10	0.0025	0.0025	0.0033	0.0017	0.0022	0.0025	
115 271	23:41:55	+ 0 40 10	9.695	+0.619	+0.099	+0.352	+0.350	+0.700	47	28	0.0013	0.0016	0.0016	0.0012	0.0009	0.0015	
115 427	23:42:28	+ 1 01 46	8.857	+1.168	+1.140	+0.618	+0.551	+1.169	15	8	0.0028	0.0026	0.0080	0.0018	0.0023	0.0021	
115 349	23:42:29	+ 0 49 15	8.600	+1.066	+0.869	+0.557	+0.507	+1.066	11	6	0.0033	0.0018	0.0039	0.0015	0.0021	0.0015	
115 516	23:43:29	+ 1 09 13	10.433	+1.030	+0.759	+0.563	+0.535	+1.099	20	12	0.0020	0.0016	0.0025	0.0013	0.0011	0.0018	
+1 4774	23:48:24	+ 2 18 34	9.003	+1.434	+1.128	+0.971	+1.075	+2.043	14	9	0.0021	0.0069	0.0184	0.0016	0.0013	0.0019	1

1. Additional information for this star appears in Appendix I.
2. BD −15°115 is the planetary nebula NGC 246 (118 −74°1). W. Liller reminded me that if indeed this object is usable as a standard, an observer should use the same size diaphragm that I used, namely a 27 arc sec diameter.
3. Although the mean error in V is at the 2σ level, the V, B−V, and U−B almost precisely reproduce earlier measures (Landolt 1973), including mean errors. It is usable as a standard.
4. HD 46056 has a companion at θ ~ 340°, ρ ~ 9″; V = 11.468, B−V = +1.040, U−B = −0.070, V−R = +0.105, R−I = +0.252, V−I = +0.359.
5. Variable.
6. HD 79097 is a possible variable; the mean error of a single observation in V indicates a 3.3σ variation.
7. HD 118246 is a possible variable; the mean error of a single observation in V indicates a 3.1σ variation.
8. SA 106 1024 is a possible variable; the mean error of a single observation in V indicates a 3.5σ variation.

scope are tied properly into the *UBV* system defined by the Landolt (1973) stars.

III. DISCUSSION

Many of the program stars observed at the 0.4-m telescope were used as standard stars at the 0.9-m telescope. Some of the former stars were observed as program stars at the 0.9-m telescope, too, thereby ensuring a more complete tie-in of results from both telescopes. The final magnitudes and color indices from the two telescopes were merged, as were the mean errors of a single observation of each quantity. The magnitude and color index values obtained at each telescope were weighted by the number of observations and the mean error of a single observation obtained at that telescope (Barford 1967):

$$\text{Weighted result} = \left[\frac{w_1 X_1/s_1^2 + w_2 X_2/s_2^2}{w_1/s_1^2 + w_2/s_2^2} \right],$$

$$\text{Weighted error} = \left[\frac{w_1 + w_2}{w_1/s_1^2 + w_2/s_2^2} \right]^{1/2},$$

where w_i is the number of nights, X_i is the magnitude or color index, and s_i is the mean error of a single observation.

Table IV contains the final magnitude and color indices for the 223 celestial equatorial stars that were observed at the 0.4-m and 0.9-m telescopes. Each star was observed an average of 20.7 times on 12.2 different nights. The star identifications have been taken from the Henry Draper Catalogue, the Bonner Durchmusterung, Feige (1958, 1959) lists of blue stars, Giclas stars in various Lowell Observatory Bulletins (Landolt 1973),

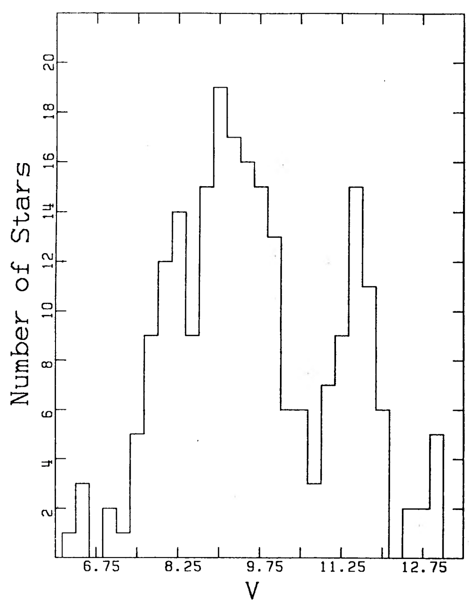

FIG. 10. The number of program stars observed in intervals of 0.25 V magnitude.

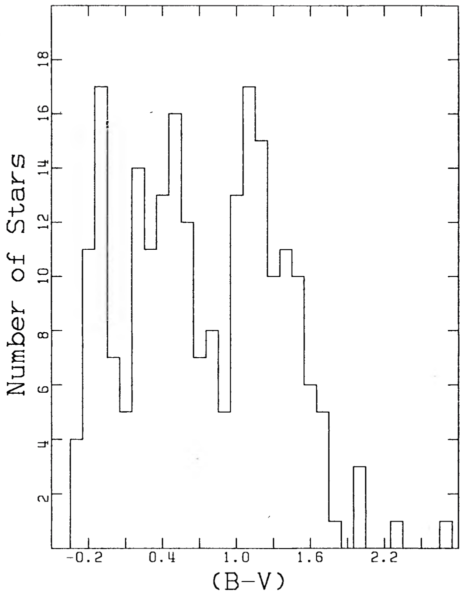

FIG. 11. The number of program stars observed in intervals of 0^{m}1 in the $(B-V)$ color index.

and from Harvard Annals, Vol. 101 (Durchmusterung of Selected Areas).

The coordinates for the stars in Table IV have been precessed to the 1985.0 equinox for ease of use. The original coordinates were taken from the sources cited above. Note that the stars in Table IV are ordered by right ascension. Finding charts for the Selected Areas, Feige, and Giclas stars may be found in Landolt (1973). Proper motions have been taken into account in computing the coordinates for the half dozen largest proper motion stars.

Columns 4–9 give the weighted magnitude and weighted color indices on the *UBVRI* photometric system as defined by stars in Landolt (1973) and Cousins (1976). Column 10 indicates the number of times, n, that each star was observed. Column 11 gives the number of different nights, m, that each star was observed. Since the numbers in cols. 4–9 are mean values, I decided to tabulate the mean error of the mean magnitude or color index in cols. 12–17. This kind of error is defined by $[\Sigma(x_i - x)^2/n(n-1)]^{1/2}$, where x_i is an individual observation, x is the average value, and n is the number of observations. If anyone needs the mean error for a single observation of any quantity in cols. 4–9, they need only multiply the appropriate number on the same line in cols. 12–17 by $(n)^{1/2}$ where n is given in column 10. The mean error of a single observation is defined by $[\Sigma(x_i - x)^2/(n-1)]^{1/2}$. The numbers in column 18 refer to footnotes at the end of Table IV.

Figure 10 illustrates the number of program stars in intervals of 0.25-V magnitudes. Figure 11 shows the number of program stars observed in intervals of 0.1 mag in the $(B-V)$ color index.

Perusal of Table IV indicates that several of the stars obviously are variable in light: HD 47761, HD 57884,

TABLE V. Error analysis.

	Mean errors of a single observation	Mean errors of the mean
V	0.0134 ± 0.0056	0.0029 ± 0.0012
$B-V$	0.0124 ± 0.0050	0.0027 ± 0.0011
$U-B$	0.0228 ± 0.0119	0.0050 ± 0.0026
$V-R$	0.0090 ± 0.0042	0.0020 ± 0.0009
$R-I$	0.0095 ± 0.0058	0.0021 ± 0.0013
$V-I$	0.0116 ± 0.0060	0.0025 ± 0.0013

HD 60826, SA 104 306, SA 107 970, HD 188934, and HD 191639. The average weighted mean error of a single observation of the V magnitude, excluding the aforementioned seven obvious variable stars, was found to be 0.0134 ± 0.0056 magnitudes. Therefore, a two-sigma error would be 0.025 mag. Any star whose weighted mean error of a single observation was greater than 0.025 mag has been noted in the footnotes to Table IV as being a possible variable star.

The numerical size of the average weighted mean error of a single observation of a V magnitude or a color index is given in the second column in Table V. The third column shows the average weighted mean error of the mean observed magnitude or color index. Since there were an average of 20.7 measures per star, the third column numbers are $(20.7)^{1/2}$ smaller than those given in the second column.

Figures 12–18 have been plotted using data from Table IV, and are self-explanatory. Note, though, that in each figure, the ordinate is the weighted mean error *of a single observation*. Figures 19 and 20 illustrate the $(U-B)$, $(B-V)$, and $(V-R)$, $(R-I)$ color-color plots, respectively, for these new standard stars, thereby showing the range of colors in these color indices possessed by the standard stars.

Kunkel and Rydgren (1979) observed a subset of Landolt's (1973) equatorial standard stars on Johnson's *BVRI* photometric system (Johnson *et al.* 1966). Recall that in particular, the I band is quite different from Cousins'. Their results, transformed to Johnson *et al.* (1966), are tabulated as $(V-R)$ and $(V-I)$ in their Table II. They also published color indices labelled $(V-r)$ and $(V-i)$ in their Table II, which they left on the RCA 31034A natural system. These latter values may be compared to data in Table IV in this paper. One finds $\Delta(V-r) = +0.0002 \pm 0.0172$ and $\Delta(V-i) = -0.0302 \pm 0.0094$ in the sense Kunkel Rydgren *minus* Landolt. These data are illustrated graphically in Figs. 21 and 22. The regression relations are:

$$(V-R)_{\text{this paper}} = \underset{\pm 0.00328}{+0.02026} + \underset{\pm 0.00734}{0.94498}\,(V-r)_{KR},$$

and

$$(V-I)_{\text{this paper}} = \underset{\pm 0.00280}{+0.02198} + \underset{\pm 0.00328}{1.01187}\,(V-i)_{KR}.$$

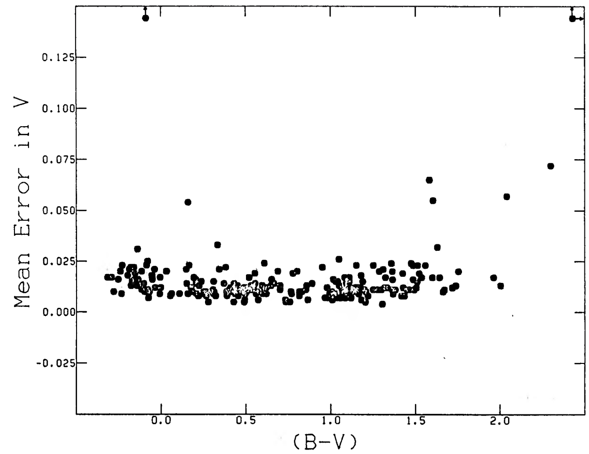

FIG. 13. The weighted mean error of a single observation in V as a function of $(B-V)$.

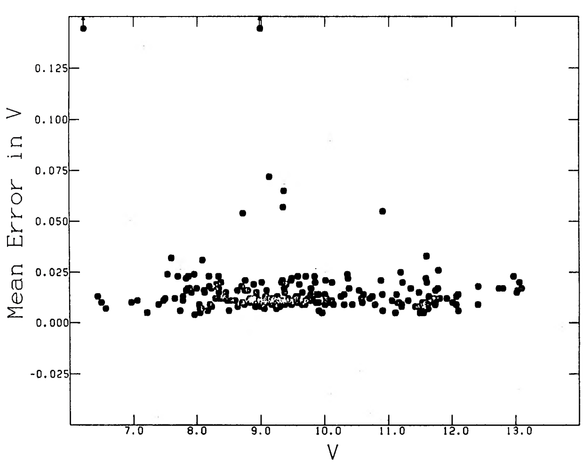

FIG. 12. The weighted mean error of a single observation in V as a function of V.

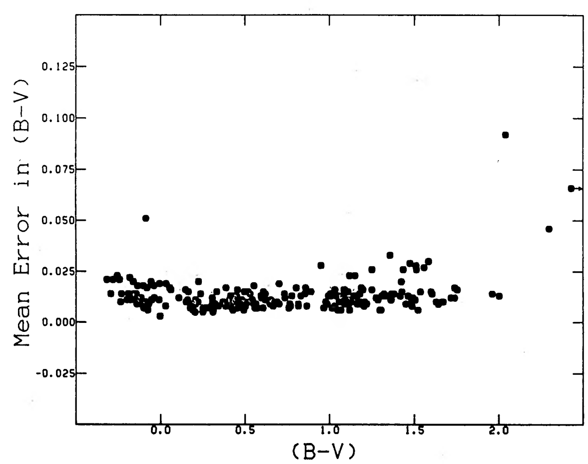

FIG. 14. The weighted mean error of a single observation in $(B-V)$ as a function of $(B-V)$.

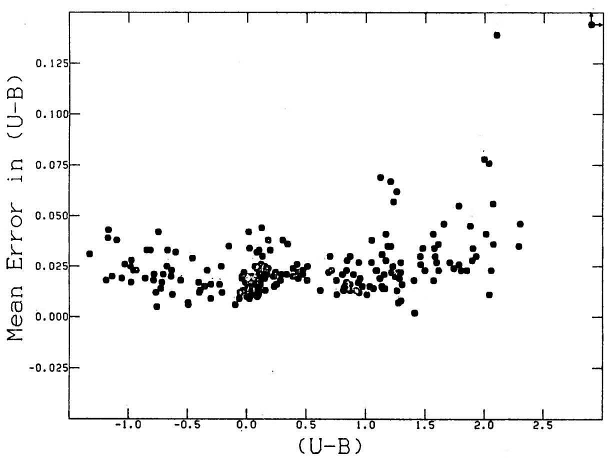

FIG. 15. The weighted mean error of a single observation in $(U-B)$ as a function of $(U-B)$.

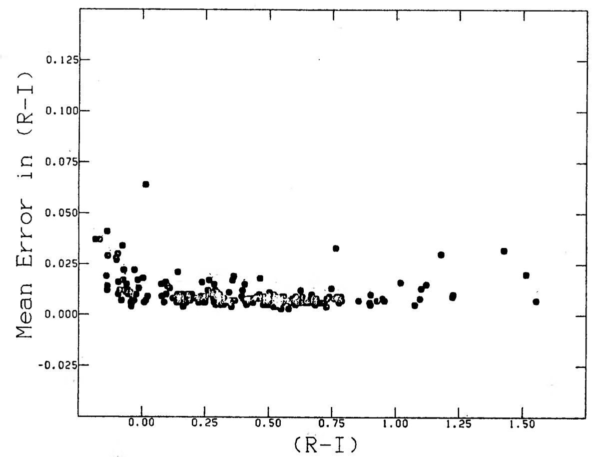

FIG. 17. The weighted mean error of a single observation in $(R-I)$ as a function of $(R-I)$.

Moffett and Barnes (1979) observed 189 of Landolt's (1973) equatorial standard stars. These measurements also were tied into Johnson *et al.* (1966) *BVRI* photometric system. A comparison of their results with Table IV herein gives $\Delta V = +0.0026 \pm 0.0095$, $\Delta(B-V) = +0.0009 \pm 0.0117$, $\Delta(V-R) = +0.2052 \pm 0.0959$, and $\Delta(R-I) = +0.0060 \pm 0.0330$, in the sense Moffett Barnes *minus* Landolt. One should recall that the *RI* differences result from a comparison of data taken at different effective wavelengths. These relations are illustrated further in Figs. 23–27. The regression relations are:

$$(B-V)_{\text{this paper}} = -0.00058 + 0.99958\,(B-V)_{MB},$$
$$\pm 0.00224 \pm 0.00257$$

$$V_{\text{this paper}} = V_{MB}$$
$$-0.00398 + 0.00188\ (B-V)_{\text{this paper}},$$
$$\pm 0.00181 \pm 0.00208$$

$$(V-R)_{\text{this paper}} = -0.03206 + 0.71652\,(V-R)_{MB},$$
$$\pm 0.00207 \pm 0.00440$$

and

$$(R-I)_{\text{this paper}} = +0.04245 + 0.87342\,(R-I)_{MB}$$
$$\pm 0.00246 \pm 0.00568.$$

I observed 52 of Graham's (1982) stars. Since our observations were obtained with nearly the same equipment at the same site, our results ought to agree. The comparison is not quite fair, though, since, although I observed these 52 stars an average of two times each, half of them were observed only once. Given that caveat, intercomparison of Graham's (1982) data with those in Table IV herein show $\Delta V = +0.0038 \pm 0.0096$, $\Delta(B-V) = +0.0024 \pm 0.0111$, $\Delta(U-B) = -0.0148 \pm 0.0343$, $\Delta(V-R) = -0.0039 \pm 0.0098$, and $\Delta(R-I) = +0.0031 \pm 0.0113$ in the

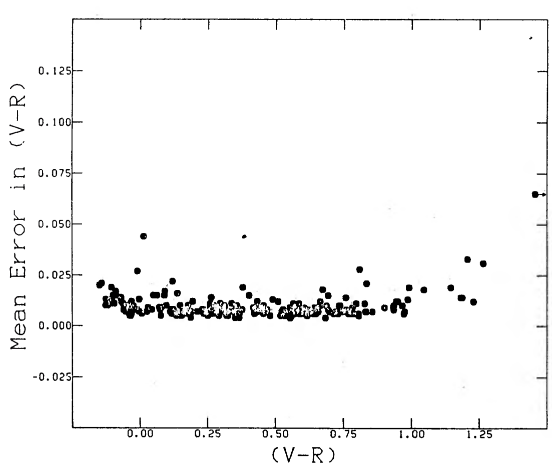

FIG. 16. The weighted mean error of a single observation in $(V-R)$ as a function of $(V-R)$.

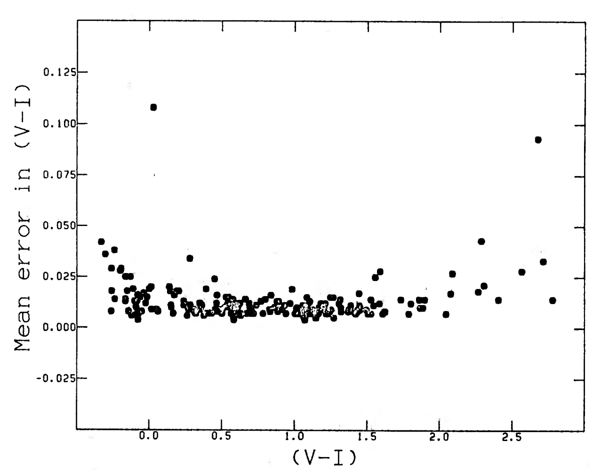

FIG. 18. The weighted mean error of a single observation in $(V-I)$ as a function of $(V-I)$.

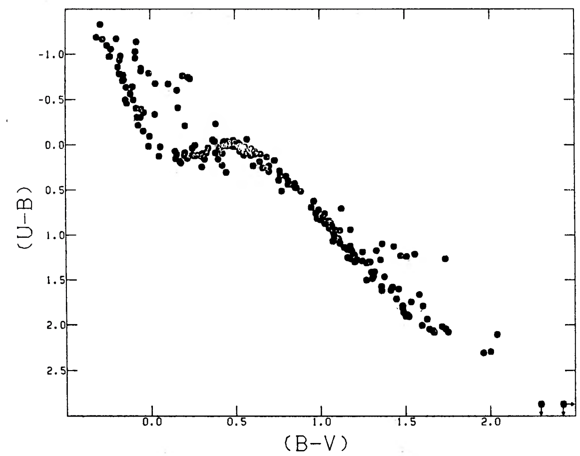

FIG. 19. The $(U-B)$, $(B-V)$ color-color plot for the new standard stars.

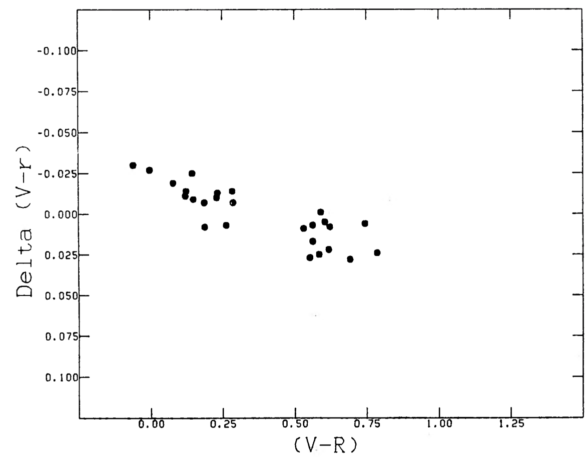

FIG. 21. A comparison of Kunkel-Rydgren's $(V-r)$ with $(V-R)$ in Table IV in this paper.

sense Graham *minus* Landolt. These results are illustrated graphically in Figs. 28–33. The regression relations are:

$$(B-V)_{\text{this paper}} = +0.00241 + 0.99304\,(B-V)_{JG},$$
$$\pm 0.00244 \pm 0.00284$$

$$V_{\text{this paper}} = V_{JG}$$
$$-0.00084 - 0.00467\ (B-V)_{\text{this paper}},$$
$$\pm 0.00216 \pm 0.00252$$

$$(U-B)_{\text{this paper}} = +0.00143 + 1.02615\,(U-B)_{JG},$$
$$\pm 0.00518 \pm 0.00597$$

$$(V-R)_{\text{this paper}} = +0.00560 + 0.99590\,(V-R)_{JG},$$
$$\pm 0.00226 \pm 0.00470$$

and

$$(R-I)_{\text{this paper}} = -0.00598 + 1.00740\,(R-I)_{JG}.$$
$$\pm 0.00249 \pm 0.00536$$

Many, many individuals have helped ensure the success of this work. Foremost are my wife, Eunice, for her support and Dr. John A. Graham for his cheerful and helpful discussions over the years. It is a pleasure to thank the staff and Directors V. M. Blanco and P. S. Osmer of the Cerro Tololo Inter-American Observatory for their hospitality and assistance.

I acknowledge with thanks aid from the ever helpful superb CTIO staff including L. Alday, E. Cosgrove, C. Czuia, A. Gomez, R. Gonzalez, G. Martin, D. Maturana, M. Naverrete, C. Poblette, J. Rios, O. Saa, P. Ugarte, and R. Venegas.

The data reductions and computer graphics would have taken much longer without the able assistance of Linda Johnston. Linda Gauthier did her usual excellent job of typing. Jennifer Landolt assisted with the data entry at the computer terminal.

Helpful thoughts arose from conversations with J. Barnes, W. P. Bidelman, V. M. Blanco, R. Canterna, O.

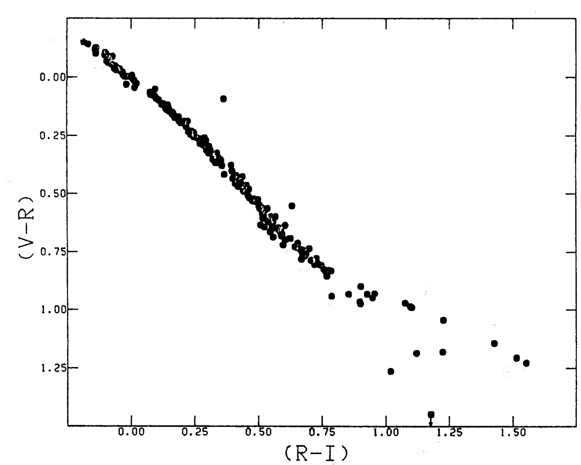

FIG. 20. The $(V-R)$, $(R-I)$ color-color plot for the new standard stars.

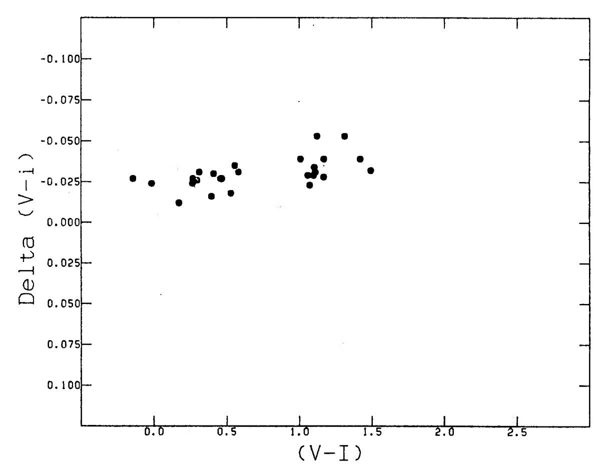

FIG. 22. A comparison of Kunkel-Rydgren's $(V-i)$ with $(V-I)$ in Table IV in this paper.

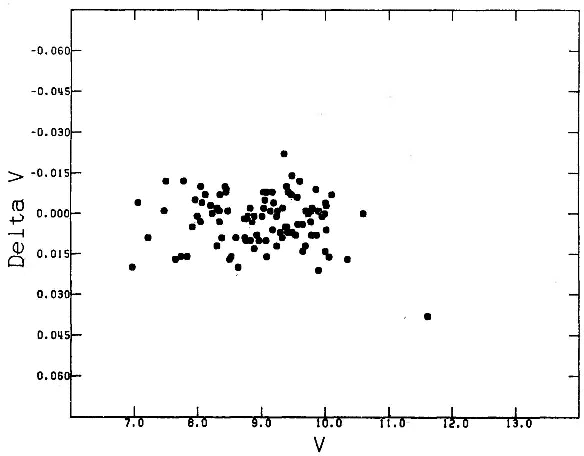

FIG. 23. A comparison of Moffett-Barnes V magnitude with the V magnitude in Table IV in this paper.

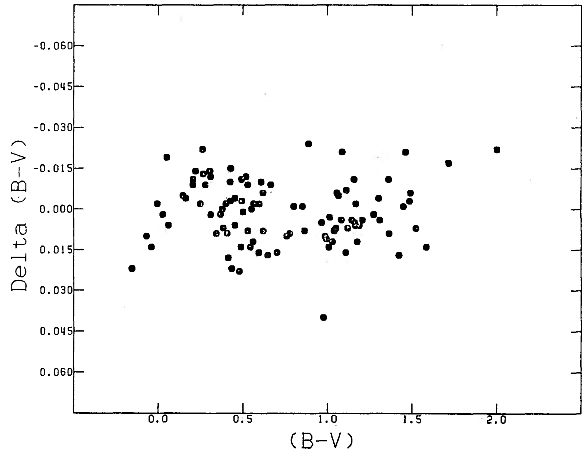

FIG. 25. A comparison of Moffett-Barnes $(B - V)$ color index with the $(B - V)$ color index in Table IV in this paper.

J. Eggen, J. H. Elias, J. D. Fernie, A. D. Grauer, J. B. Irwin, R. E. Luck, J. McClintock, E. C. Olson, C. L. Perry, G. Tammann, J. Tohline, and H. Weaver.

This project has been supported by Grants 77-3218 and 82-0192 from the Air Force Office of Scientific Research.

APPENDIX I

The literature has been searched for additional information for the BD and HD stars in Table IV. Similar information for the Selected Area stars has been listed in Appendices I and II (Landolt 1973). MK spectral types for the Selected Area stars may be found in Drilling and Landolt (1979). Abbreviations used in this Appendix include: abs. π = absolute trigonometric parallax; BD = *Bonner Durchmusterung*; C = *Cincinnati Obs. Publ.* No. 18; comp. = companion; dbl. = double; em. = emission; F = Feige; G = Giclas *et al.* nos. in *Lowell Obs. Bulletin* proper motion lists; GC = Boss' *General Catalogue of 33, 342 Stars for the Epoch* 1950; GCRV = *General Catalogue of Radial Velocities*; HD = *Henry Draper Catalogue*; LFT = Luyten (1955); LTT = Luyten (1957); M = absolute magnitude; MWC = Mt. Wilson Catalogue of Be and Ae Stars (Merrill and Burwell, 1933); PC = Jenkin's *Parallax Catalogue* (Yale); pe. ptm. = photoelectric photometry; R = distance; rel. π = relative trigonometric parallax; r.v. = radial velocity; SA = Selected Areas; sp. bin. = spectroscopic binary; sp. cl. = spectroscopic classification; sp. π = spectroscopic parallax; T = tangential velocity; Y = Barney (1949); μ = proper motion; π = trigonometric parallax.

The star names which follow appear in order of increasing right ascension.

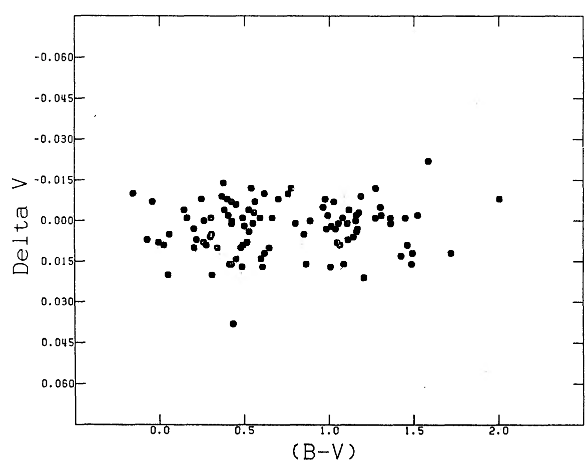

FIG. 24. A comparison of Moffett-Barnes V magnitude with the $(B - V)$ color index in Table IV in this paper.

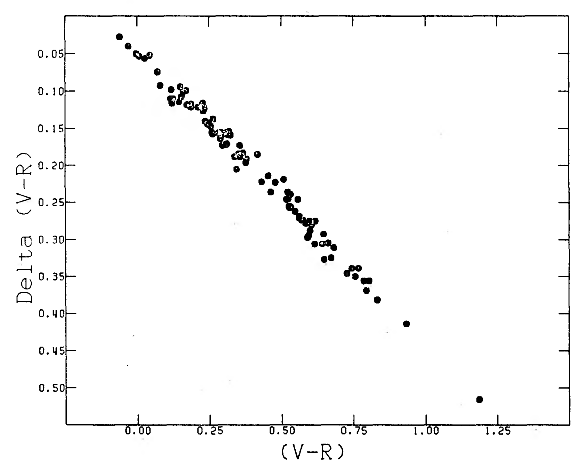

FIG. 26. A comparison of Moffett-Barnes $(V - R)$ color index with the $(V - R)$ color index in Table IV in this paper.

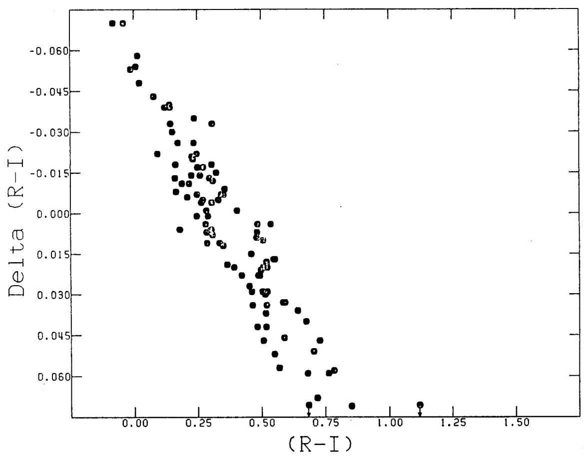

FIG. 27. A comparison of Moffett-Barnes $(R - I)$ color index with the $(R - I)$ color index in Table IV in this paper.

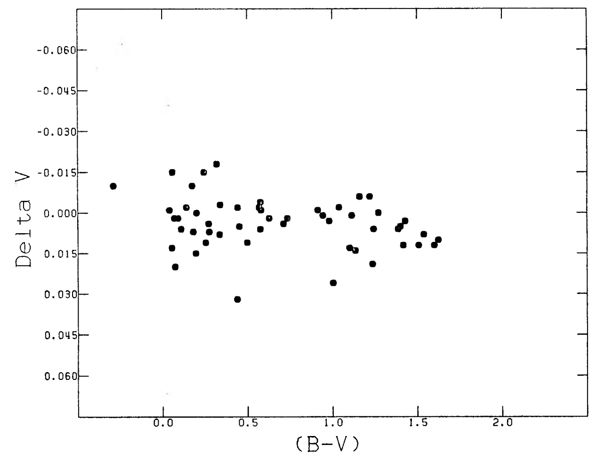

FIG. 29. A comparison of Graham's (1982) V magnitude with my $(B - V)$ color indices for his stars.

HD 315 = 4 Ceti = HR 11 = GC 114 = BD $-$ 3°2 = GCRV 57; GC gives $\mu_\alpha = +0^{s}.0014$; $\mu_\delta = 0''.003$; GCRV gives $V_r = +13.2$ km/s, apparently from Christie and Wilson (1938); Abt (1970) lists additional r.v. measures; sp. cl. B8p Si from Cowley (1968), and B8IIIp Si quoted by Hoffleit (1982); pe. ptm. by Cousins (1962): $V = 6.42$, $(B - V) = -0.15$, $(U - B) = -0.46$; by Crawford (1963): $(B - V) = -0.15$, $(U - B) = -0.46$; $\beta = +2.707$; and by Golson (1970): $V = 6.45$, $(B - V) = -0.136$, $(U - B) = -0.457$.

HD 2892 = BD + 0°71; star 40-0-no. 6 in Sanders (1966): pe. ptm. $V = 9.31$, $(B - V) = +1.35$, $(U - B) = +1.39$; HD sp. cl. = K5.

BD $-$ 15°115; Cowley (1958) discovered object to be blue, with sp. cl. B5, $\mu_\delta = +0''.032$, $\mu_\delta = +0''.006$; Klemola (1962) found sp. cl. B2, $\mu_\alpha \cos\delta = +0''.004$, $\mu_\delta = +0''.022$, $V = 10.88$:, $(B - V) = -0.23$, $(U - B) = -0.79$.

BD $-$ 12°134 = NGC 246 = 118 $-$ 74°1; (Perek and Kohoutek 1967), object discovered by Herschel in 1785; called a planetary nebula by Curtis (1918), his Fig. 2; van Maanen (1929) measured motions: $\mu_\alpha = -0''.041$, $\mu_\delta = 0''.014$, abs. $\pi = +0''.009$; van Maanen apparently was the first to mention the existence of a comp. ~4" distant; Minkowski (1955) indicated a double stellar nucleus, probably hot sd + G; Cowley (1958) rediscovered it as a blue object; Minkowski (1960), more on companion. Klemola (1962) found sp. cl. = Op; pe. ptm.: $V = 11.76$, $(B - V) = -0.33$, $(U - B) = -1.24$; $\mu_\alpha \cos\delta = -0''.030$, $\mu_\delta = -0''.006$; O'Dell (1963) gave parameters for the planetary; Greenstein and Minkowski (1964) gave sp. cl. = sdOfe, with $M_v = +3$.

BD $-$ 11°162 = No. 352.14 in *Second McCormick Catalogue of Proper Motions*; Vyssotsky (1953) discovered blue nature of star with motions $\mu_\alpha = -0''.032$, $\mu_\delta = -0''.028$; Osvalds and Osvalds

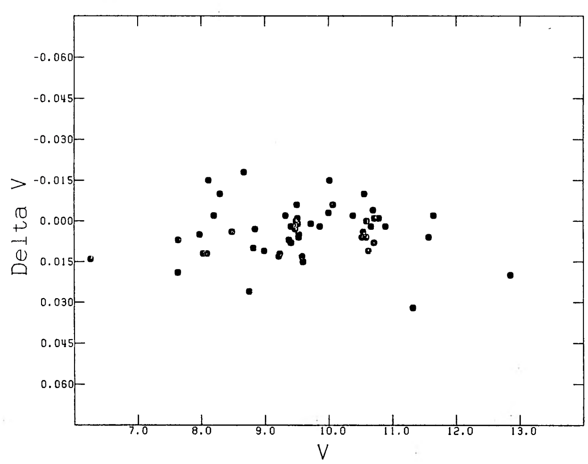

FIG. 28. A comparison of Graham's (1982) V magnitude with my V magnitudes for his stars.

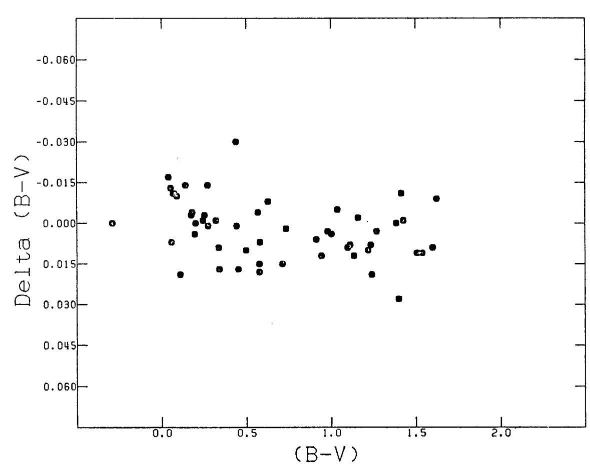

FIG. 30. A comparison of Graham's (1982) $(B - V)$ color index with my $(B - V)$ color indices for his stars.

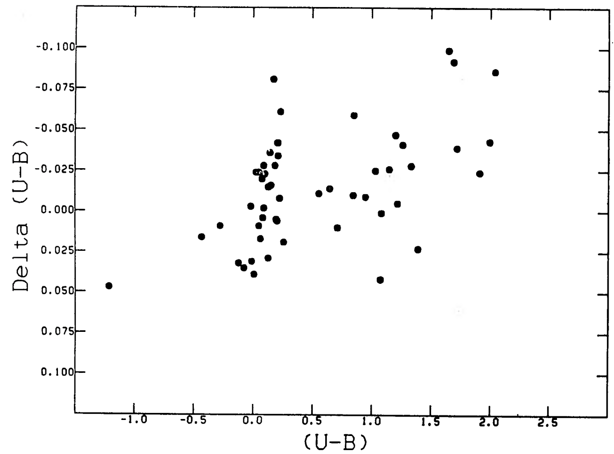

FIG. 31. A comparison of Graham's (1982) $(U-B)$ color index with my $(U-B)$ color indices for his stars.

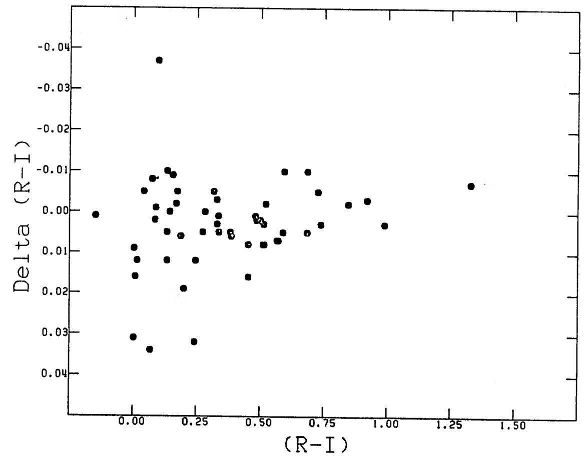

FIG. 33. A comparison of Graham's (1982) $(R-I)$ color index with my $(R-I)$ color indices for his stars.

found rel. $\pi = -0''.021$, with sp. cl. = B2, concluded object not a white dwarf; Klemola (1962) found sp. cl. = Op with pe. ptm.: $V = 11.23$, $(B-V) = -0.10$, $(U-B) = -1.10$; motions: $\mu_\alpha \cos\delta = -0''.029$, $\mu_\delta = -0''.032$.

HD 5505 = BD + 0°146; pe. ptm. from Priser (1966): $V = 8.99$, $(B-V) = +1.09$, $(U-B) = +0.96$; HD sp. cl. = K5.

HD 11983 = BD − 8°349; star 200-10-no. 2 in Sanders (1966): pe. ptm.: $V = 8.15$, $(B-V) = +1.52$, $(U-B) = +1.82$: HD sp. cl. = K0.

HD 12021 = BD − 2°329; Cowley (1958) found object to be a blue star with sp. cl. = B8p and $\mu_\alpha = -0''.009$, $\mu_\delta = -0''.006$; Klemola (1962) found sp. cl. = B7; pe. ptm: $V = 8.86$:, $(B-V) = -0.10$, $(U-B) = -0.40$; motions: $\mu_\alpha \cos\delta = -0''.011$, $\mu_\delta = -0''.007$.

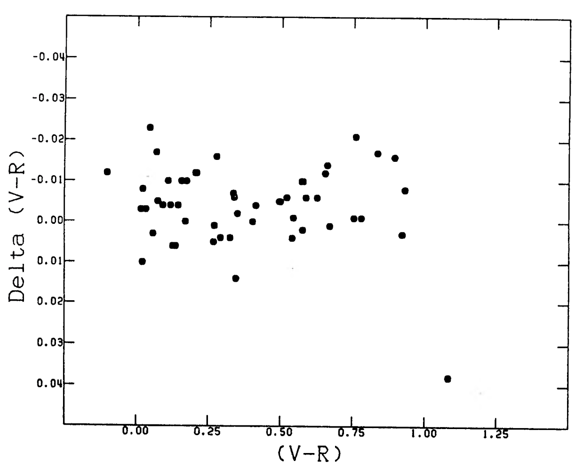

FIG. 32. A comparison of Graham's (1982) $(V-R)$ color index with my $(V-R)$ color indices for his stars.

HD 16581 = BD + 0°442; Golson (1970) pe. ptm.: $V = 8.19$, $(B-V) = -0.065$, $(U-B) = -0.269$; Crawford, Golson, and Landolt (1971) pe. ptm: $V = 8.192$, $(B-V) = -0.062$, $(U-B) = -0.278$; HD sp. cl. = B9.

BD − 0°454 = SA 94 305; Buscombe (1980) quotes pe. ptm: $V = 8.89$, $(B-V) = +1.42$, $(U-B) = +1.60$, and sp. cl. = K5 III.

BD − 2°524 = F 29; Feige (1958) found star to be blue with sp. cl. = B3 III and r.v. = + 2 km/s; chart in Feige (1959); Klemola (1962) found sp. cl. = B4; pe. ptm.: $V = 10.27$:, $(B-V) = -0.11$, $(U-B) = -0.63$; motions: $\mu_\alpha \cos\delta = +0''.011$, $\mu_\delta = +0''.005$; Berger (1963) gave r.v. = − 9km/s and sp. cl. = B3–B5 IV.

HD 21197 = GC 4076 = BD − 5°642 = GCRV 1886 = PC 712 = LFT 282 = C 453; Adams and Joy (1923) give r.v. = − 11.3 km/s; Abt (1970) lists individual r.v.: PC gives $\pi = 0''.061$, and uses GC motions: $\mu_\alpha = -0''.243$, $\mu_\delta = 0''.773$; GCRV gives r.v. = − 11.8 km/s; Roman (1955) finds sp. cl. = K5 V; sp. $\pi = +0''.100$, pe. ptm: $V = 7.85$, $(B-V) = +1.16$, $(U-B) = +1.16$; Wilson (1962) finds sp. cl. = K4 V, and $M_v = +6.7$; Stoy (1963) pe. ptm: $V = 7.86$, $(B-V) = +1.16$, $(U-B)_c = +2.26$; also, Stoy (1965) pe. ptm: $V = 7.84$, $(B-V) = +1.17$, $(U-B)_c = +2.28$; and, Cowley, Hiltner, and Witt (1967) found pe. ptm: $V = 7.88$, $(B-V) = +1.16$, $(U-B) = +1.11$ with $M_v = 6.80$ and $T = 62$ km/s.

HD 36395 = GC 6836 = BD − 3°1123 = GCRV 3349 = PC 1255 = C 683 = G99 − 15; Adams and Joy (1923) find r.v. = + 11.4 km/s; Abt (1970) lists individual r.v.: PC gives $\pi = 0''.163$, and uses GC motions: $\mu_\alpha = +0''.771$, $\mu_\delta = -2''.098$; GCRV quotes r.v. = + 10.9 km/s; Wilson (1967) gives r.v. = + 10.0 km/s; an *UBV* standard star Johnson and Harris (1954) with pe. ptm.: $V = 7.97$, $(B-V) = +1.47$, $(U-B) = +1.21$, and sp. cl. = M1 V; many, many pe. measures (Blanco *et al.* 1968); Eggen (1979) pe. ptm.: $V = 7.98$, $(B-V) = +1.47$, $(U-B) = +1.21$, $R = 6.85$, $(R-I)_E = +0.85$; Buscombe (1977) quotes sp. cl. = M1.5 Ve.

HD 46056 = BD + 4°1291 = BAL 2666 = MWC 808 = GCRV 4169; see p. 190 in *Index Catalogue of Double Stars*, Lick Observatory Publications, Vol. 21: BAL 2666 from R. Baillaud's work; GCRV gives r.v. = + 18 km/s, notes star is sp. binary with $\mu = 0''017$; Abt and Biggs (1972) list extensive r.v. values; Johnson (1955) pe. ptm. $V = 8.19$, $(B-V) = +0.18$, $(U-B) = -0.76$; sp. cl. = O8; Hiltner (1956) pe. ptm.: $V = 8.15$, $(B-V) = +0.19$, $(U-B) = -0.74$; $M = -5.1$; $m - M = 11.8$; also polarization measures; Mendoza (1958) lists object as a Be star: see Table 2, p. 216; Conti and Alschuler (1971) say star in Mon 2 assoc., with sp. cl. = O8 *V*, $M_v = -4.1$, in NGC 2244. Buscombe (1977) quotes pe. ptm.: $V = 8.17$, $(B-V) = +0.19$, $(U-B) = -0.75$, and sp. cl. = B2 III.

HD 47761 = BD − 4°1607 = GCRV 4321; Neubauer (1943) gives sp. cl. = B0ek, average r.v. = + 29.0 km/s, with variable velocity range of 70 km/s; GCRV quotes r.v. = + 29.0 km/s, and $\mu = 0''019$; Hiltner (1956) found pe. ptm.: $V = 8.63$, $(B-V) = +0.17$, $(U-B) = -0.62$; $M = -2.0$; sp. cl. = B2 V:pe; also has polarization measures; Mendoza (1958) found pe. ptm.: $V = 8.62$, $(B-V) = +0.20$, $(U-B) = -0.67$; $r = 1.51$ kpc; lists object as a Be star; Buscombe (1977) quotes sp. cl. = B2 Vpe, and pe. ptm.: $V = 8.71$, $(B-V) = +0.12$, $(U-B) = -0.61$.

HD 50167 = BD + 1°1561; Golson (1970) pe. ptm.: $V = 7.85$; $(B-V) = +1.546$; $(U-B) = +1.72$; Crawford, Golson, and Landolt (1971) pe. ptm.: $V = 7.861$, $(B-V) = +1.534$, $(U-B) = +1.721$; HD sp. cl. = K5.

HD 52533 = GC 9248 = BD − 2°1885 = GCRV 4611 = ADS 5705; GC gives $\mu_\alpha = -0''003$, $\mu_\delta = 0''007$; GCRV gives r.v. = + 5.5 km/s; Neubauer (1943) found r.v. = + 5.5 km/s; Hiltner and Johnson (1956) found pe. ptm.: $V = 7.70$, $(B-V) = -0.09$, $(U-B) = -0.95$, and sp. cl. = O9 V; Stoy (1963) pe ptm.: $V = 7.68$, $(B-V) = -0.07$, $(U-B)_c = +1.16$, and quotes sp. cl. = B6; same pe. ptm. values given by Cousins, Lake, and Stoy (1966); Conti and Alschuler (1971) say sp. cl. = O8.5 V.

HD 57884 = BD − 3°1873 = GCRV 4904; GCRV gives r.v. = + 55 km/s, presumably from Sanford (1944); Vandervort (1958) pe. ptm.: $V = 8.40$, $(B-V) = +2.19$; sp. cl. = R8; motions: $\mu_\alpha = +0''004$, $\mu_\delta = +0''010$; Buscombe (1977) quotes pe. ptm.: $V = 9.4$ with sp. cl. = C4 +, 3; also $V = 8.40$, $(B-V) = +2.19$, with sp. cl. = C5, 4; HD sp. cl. = *N*.

BD + 5°1668 = GCRV 4954 = PC 1755 = GL 273 = LFT 527 = G89-19; PC gives $\pi = 0''263$, $\mu_\alpha = +0''59$, $\mu_\delta = -3''71$; Large motion announced by Luyten and Ebbighausen (1935); GCRV gives r.v. = + 26 km/s; Popper (1942) finds r.v. = + 22 km/s; Kuiper (1942) quotes same r.v.; Joy (1947) finds r.v. = + 28 km/s; Eggen (1979) pe. ptm.: $V = 9.80$, $(B-V) = +1.55$, $(U-B) = +1.12$; $R = 8.41$, $(R-I)_E = +1.21$; and *UBV* standard star (Johnson and Harris, 1954), pe. ptm.: $V = 9.82$, $(B-V) = +1.56$, and $(U-B) = +1.12$; Buscombe (1977) quotes sp. cl. = M5 V; Buscombe (1980) quotes pe. ptm. $V = 9.75$.

HD 60826 = BD + 2°1715 = GCRV 5071 = CVS 1089; Sanford (1935) says r.v. = + 40 km/s; Sanford (1944) gives r.v. = + 44 km/s; GCRV quotes r.v. = + 44 km/s, and $\mu = 0''08$, HD sp. cl. = Na, and notes star to be variable with an irregular period; Keenan and Morgan (1941) say sp. cl. = $C5_5$; Vandervort (1958) pe. ptm.: $V = 8.65$, $(B-V) = +2.46$; sp. cl. = R8; r.v. = + 44 km/s; $\mu_\alpha = 0''075$, $\mu_\delta = -0''040$; Buscombe (1977) quotes sp. cl. = C5, 4.

HD 65079 = BD + 3°1848 = MWC 188 = GCRV 5276; GCRV gives r.v. = − 11 km/s; calls a sp. bin.; quotes $\mu = 0''021$; Heard (1951) r.v. = + 2.6 km/s; Petrie and Pearce (1961) r.v. = + 2 km/s; Mendoza (1958) pe. ptm.: $V = 7.83$, $(B-V) = -0.14$, $(U-B) = -0.76$; sp. cl. = B2e; he calls object a Be star; $r = 1.74$ kpc; Stoy (1963) pe. ptm.: $V = 7.83$, $(B-V) = -0.20$, $(U-B)_c = +1.24$; sp. cl. = B3ne; Cousins, Lake, and Stoy (1966) pe. ptm.: $V = 7.83$, $(B-V) = -0.20$, $(U-B) = -0.76$; Guetter (1968) sp. cl. = B2: Vne; Walborn (1971) sp. cl. = B2V (*n*)(*e*?), $M_v = -2.5$.

HD 72055 = BD − 6°2620; Sanders' (1966) star 820-5-no. 13 with pe. ptm.: $V = 8.15$, $(B-V) = -0.13$, $(U-B) = -0.44$; Buscombe (1980) quotes sp. cl. = B8p Si.

HD 76082 = BD − 0°2087 = GCRV 5854 = PC 2125; GCRV gives r.v. = + 58.2 km/s and $\mu = 0''016$; PC gives $\pi = +0''009$ and $\mu_\alpha = -0''01$, $\mu_\delta = +0''04$; Wilson and Joy (1952) find r.v. = + 58.7 km/s; Abt (1970) lists individual Mt. Wilson r.v. values; Cousins and Stoy (1962) pe. ptm.: $V = 8.40$, $(B-V) = +1.13$, $(U-B)_c = +2.20$; quote sp. cl. = *g* K1; Priser (1966) pe. ptm.: $V = 8.41$, $(B-V) = +1.14$, $(U-B) = +1.13$; Buscombe (1980) quotes sp. cl. = K0 III.

HD 79097 = GC 12691 = BD − 6°2839 = GCRV 6015; GC gives $\mu_\alpha = +0''007$, $\mu_\delta = +0''002$; GCRV gives r.v. = + 6.7 km/s; $\mu = 0''007$; Wilson and Joy (1952) find r.v. = + 7.2 km/s; Abt (1970) lists individual Mt. Wilson r.v.; Cousins and Stoy (1962) pe. ptm.: $V = 7.61$, $(B-V) = +1.63$, $(U-B)_c = +2.52$; quote sp.cl. = gM2.

HD 84971 = BD − 2°2986; Guetter (1968) sp. cl. = B2V; Kennedy and Buscombe (1974) quote sp. cl. = B3 V; Golson (1970) pe. ptm. $V = 8.65$,

$(B-V) = -0.167$, $(U-B) = -0.756$; Crawford, Golson, and Landolt (1971) pe. ptm.: $V = 8.633$, $(B-V) = -0.158$, $(U-B) = -0.751$.

BD + 1°2447 = PC 2456 = GCRV 6576 = Ci 20,580 = CC 580; PC gives $\pi = 0''.128$; $\mu_\alpha = -0''.60$, $\mu_\delta = 0''.75$; GCRV gives r.v. = + 11 km/s; Abt (1970) r.v. = + 18.3 km/s; Buscombe (1977) quotes $V = 9.63$, $(B-V) = +1.52$, $(U-B) = +1.19$, sp. cl. = M2.5 V; Eggen (1980) finds pe. ptm.: $V = 9.65$; $(B-V) = +1.50$, $(U-V) = +1.28$, $R_E = 8.50$, $(R-I)_E = +0.96$.

HD 97503 = GC 15419 = BD + 5°2463; GC gives $\mu_\alpha = -0''.305$, $\mu_\delta = -0''.034$, Roman (1955) finds sp. $\pi = +0''.066$; $\mu_\alpha = -0''.293$; $\mu_\delta = -0''.030$; pe. ptm.: $V = 8.73$, $(B-V) = +1.17$, $(U-B) = +1.09$; sp. cl. = K5 V.

BD + 5°2468; Cowley (1958) found object to be a blue star, $\mu_\alpha = -0''.043$, $\mu_\delta = +0''.012$; sp. cl. = B8; Klemola (1962) found $\mu_\alpha \cos\delta = -0''.067$, $\mu_\delta = -0''.025$; sp. cl. = B6; pe. ptm.: $V = 9.42$, $(B-V) = -0.14$, $(U-B) = -0.54$.

HD 100340 = BD + 6°2461; Cowley (1958) discovered object to be a blue star, $\mu_\alpha = -0''.001$, $\mu_\delta = +0''.008$; Klemola (1962) found $\mu_\alpha \cos\delta = -0''.035$, $\mu_\delta = +0''.01$; pe. ptm.: $V = 10.19$:, $(B-V) = -0.24$, $(U-B) = -0.94$; Klemola notes that the BD right ascension is one hour earlier than value given by Cowley; Buscombe (1980) quotes $V = 10.13$, and sp. cl. = B1 IV–V.

BD + 5°2529 = PC Suppl. 2703.1 = LTT 13212; PC Suppl. gives $\pi = +0''.043$, $\mu_\alpha = +0''.20$; $\mu_\delta = -0''.46$; Mumford (1956) sp.cl. = K8; pe. ptm.: $V = 9.60$, $(B-V) = +1.19$; $M = 8.0$; Wilson (1967) r.v. = + 18.7 km/s, and pe. ptm.: $(R-I)_c = +0.52$. Buscombe (1977) quotes $V = 9.59$, $(B-V) = +1.24$, $(U-B) = +1.18$, sp. cl. = K8 V.

HD 118246 = BD − 5°3730; Golson (1970) pe. ptm.: $V = 8.07$, $(B-V) = -0.16$, $(U-B) = -0.628$; Crawford, Golson, and Landolt (1971) pe. ptm.: $V = 8.062$, $(B-V) = -0.158$, $(U-B) = -0.629$; Buscombe (1980) quotes $V = 8.0$, $(B-V) = -0.15$, $(U-B) = -0.61$; sp. cl. = B5e; calls it a variable.

BD + 2°2711; Cowley (1958) discovered object to be blue; sp. cl. = B8; Klemola (1962) found sp. cl. = B4, $\mu_\alpha \cos\delta = -0''.003$, $\mu_\delta = -0''.006$; pe. ptm.: $V = 10.41$, $(B-V) = -0.17$, $(U-B) = -0.69$.

HD 121968 = BD − 2°3766; Cowley (1958) discovered object to be blue, sp. cl. = B8, $\mu_\alpha = +0''.006$, $\mu_\delta = +0''.037$; Klemola (1962) found sp. cl. = B0; $\mu_\alpha \cos\delta = +0''.004$, $\mu_\delta = +0''.049$; pe. ptm.: $V = 10.31$, $(B-V) = -0.19$, $(U-B) = -0.89$.

HD 129975 = BD + 0°3234; Golson (1970) pe. ptm.: $V = 8.37$, $(B-V) = +1.496$, $(U-B) = +1.856$; Crawford, Golson, and Landolt (1971) pe. ptm.: $V = 8.363$, $(B-V) = +1.501$, $(U-B) = +1.845$; Buscombe (1980) quotes sp. cl. = K3 III.

HD 140850 = BD − 0°3005; Golson (1970) pe. ptm.: $V = 8.80$, $(B-V) = +1.661$, $(U-B) = +2.02$; Crawford, Golson, and Landolt (1971) pe. ptm.: $V = 8.813$, $(B-V) = +1.660$, $(U-B) = +2.004$; Upgren and Staron (1970) sp. cl. = K2 III; note object is in Selected Area 107; however, the star is not catalogued in HA Vol. 101.

HD 148817 = BD + 0°3536; Priser (1966) pe. ptm.: $V = 8.32$, $(B-V) = +1.48$, $(U-B) = +1.78$; HD sp. cl. = K2.

HD 149382 = BD − 3°3967 = GCRV 9530; GCRV r.v. = + 3 km/s, $\mu = 0''.017$; Neubauer (1943) r.v. = + 3.3 km/s; notes r.v. var.?; sp. cl. = B5n.

HD 157881 = GC 23592 = BD + 2°3312 = GCRV 10069 = PC 3955 = LFT 1348 = G19-24; GC gives $\mu_\alpha = -0''.588$, $\mu_\delta = -1''.196$; PC gives $\pi = 0''.125$, $\mu_\alpha = -0''.587$; $\mu_\delta = -1''.196$; GCRV gives r.v. = − 28.3 km/s; Adams (1915) r.v. = − 27.8 km/s; Wilson (1967) r.v. = − 21.4 km/s; Wilson (1962) $\pi = 0''.125$, and $M_v = +8.1$; Cowley, Hiltner, and Witt (1967) sp. cl. = K7 V; Johnson and Harris (1954), an *UBV* std. star whose pe. ptm.: $V = 7.54$, $(B-V) = +1.36$, $(U-B) = +1.26$; many, many references in Blanco *et al.* (1968). Eggen (1979) pe. ptm.: $V = 7.60$, $(B-V) = +1.36$; $(U-B) = +1.25$; $R_E = 6.68$, $(R-I)_E = +0.60$; Cousins and Stoy (1963) pe. ptm.: $V = 7.52$, $(B-V) = +1.37$; $(U-B) = +1.26$.

HD 160233 = BD + 4°3467 = GCRV 10191; GCRV r.v. = + 3 km/s; noted to be SB; $\mu = 0''.023$; list magn. as 8.6; Neubauer (1943) r.v. = − 24.3 km/s; Petrie and Pearce (1961) note var. r.v., and give ave. r.v. = + 28 km/s; Morgan, Code, and Whitford (1955) sp. cl. = B1 V. My photometry indicates a constant V magn. over 28 months; does the quoted GCRV magn. indicate a possible eclipsing system?

BD + 4°3508; Hogg and Kron (1955), their star no. 91; pe. ptm.: $V = 9.33$, $(B-V) = +1.736$, $(U-B) = +2.10$; quote sp. cl. = K3.

HD 161961 = BD − 2°4458 = GCRV 10302; GCRV r.v. = − 11 km/s; $\mu = 0''.032$; Sanford and Merrill (1938) r.v. = − 3 km/s; Neubauer (1943) r.v. = − 13.0 km/s, and sp. cl. = Blsk; Wilson, and Joy (1950) r.v. = − 6.0 km/s; Guetter (1964) pe. ptm.: $V = 7.89$, $(B-V) = +0.23$, $(U-B) = -0.67$; $r = 2.47$ kpc; sp. cl. = B0.5 III.

BD + 4°3561 = Barnard's star = PC 4098 = CC 1069 = Ci20, 1069 = LFT 1385 = GL 699 = G140-24; PC gives $\pi = +0''.545$ and $\mu_\alpha = -0''.72$, $\mu_\delta = +10''.27$; Adams and Joy (1923) r.v. = − 107 km/s; Munch (1944) r.v. = − 111 km/s; Wilson (1967) r.v. = − 106.6 km/s; Johnson and Morgan (1953) sp. cl. = M5 V; an *UBV* std. star, pe. ptm.: $V = 9.54$, $(B-V) = +1.74$, $(U-B) = +1.29$; Eggen (1979) pe. ptm.: $V = 9.54$, $(B-V) = +1.57$ (5 and 7 transposed?), $(U-B) = +1.30$, $R_E = 8.09$, $(R-I)_E = +1.26$.

HD 170493 = BD − 1°3500 = PC 4254 = GCRV 10958 = C 2425 = Ci 18, 2425; PC gives $\pi = +0''.051$ and $\mu_\alpha = +0''.14$, $\mu_\delta = -0''.21$; GCRV gives r.v. = − 53.3 km/s; Wilson and Joy (1950) r.v. = − 52.8 km/s; Johnson and Knuckles (1957) pe. ptm.: $V = 8.05$, $(B-V) = +1.10$, $(U-B) = +1.06$; sp. cl. = K5; Nikonov *et al.* (1957) pe. ptm.: $V = 8.05$, $(B-V) = +1.09$; sp. cl. = dK4; Buscombe (1977) quotes sp. cl. = K5 V.

HD 173637 = BD − 8°4702 = GCRV 11220; GCRV r.v. = − 46 km/s; and $\mu = 0''.022$; Neubauer (1943) r.v. = − 46 km/s; sp. cl. = B0e, note says "almost continuous" spectrum; Morgan, Code, and Whitford (1955) sp. cl. = B1 IV; Hiltner and Iriate (1955) pe. ptm.: $V = 9.35$, $(B-V) = +0.28$, $(U-B) = -0.66$; $M = -3.2$; $(m-M) = 10.9$.

HD 175544 = BD + 0°4055 = GCRV 11377; GCRV gives r.v. = − 4 km/s, and notes that star is a dbl. line SB; $\mu = 0''.036$; Neubauer (1943) r.v. = − 4.1 km/s; Petrie and Pearce (1961) ave. r.v. = − 16 km/s; Thackeray and Tatum (1966) ave. r.v. = − 12.9 km/s, with orbital solution, $P = 1^d.98575$; Hiltner (1956) sp. cl. = B3 V; pt. ptm. $V = 7.35$, $(B-V) = +0.10$, $(U-B) = -0.64$; $M = -1.5$; $(m-M) = 8.0$; also gave polarization measures.

HD 184914 = BD − 4°4855; Golson (1970) pe. ptm. $V = 8.16$, $(B-V) = +1.197$, $(U-B) = +0.927$; HD sp. cl. = K5; Crawford, Golson, and Landolt (1971) pe. ptm.: $V = 8.168$, $(B-V) = +1.194$, $(U-B) = +0.935$.

HD 188934 = − 0°3883 = GCRV 12300; GCRV r.v. = + 57 km/s; Sanford (1924, 1935, 1944) r.v. = + 56.6, + 56, + 57 km/s, respectively; sp. cl. = R3 in (1924) and R4 in (1944); Vandervort (1958) r.v. = + 57 km/s; $\mu_\alpha = -0''.008$, $\mu_\delta = -0''.013$; sp. cl. = R8; pe. ptm.: $V = 9.31$, $(B-V) = +2.06$; Mendoza and Johnson (1965) pe. ptm.: $V = 9.37$, $(B-V) = +2.01$, $(U-B) = +2.10$, $(U-V) = +4.11$, $(V-R) = +1.40$, $(V-I) = +2.37$, $(V-J) = +3.16$, $(V-K) = +4.22$, $(V-L) = +4.11$; sp. cl. = R8; B.C. = − 1.54, $T_e = 3390$ K; diameter = $0''.0007$; recall that the just quoted colors are Johnson colors, not Cousin-Kron as in Table IV in this paper.

HD 191639 = HR 7709 = GC 27998 = BD − 9°5382 = GCRV 12530; GC gives $\mu_\alpha = +0''.003$, $\mu_\delta = 0''.000$; GCRV gives r.v. = − 7 km/s; Plaskett and Pearce (1931) r.v. = − 7.2 km/s; Morgan, Code, and Whitford (1955) sp. cl. = B1 V; Cousins (1964) pe. ptm.: $V = 6.48$, $(B-V) = -0.16$, $(U-B) = -0.92$; Lesh (1968), distance = 863 pc; Hoffleit (1982): notes on p. 434 say star is var., with amplitude 0.3V, 0.09U, 16.82 day period; magnetic variable.

HD 196395 = BD − 1°4014; Golson (1970) pe. ptm.: $V = 8.72$, $(B-V) = +1.659$, $(U-B) = +2.043$; Crawford, Golson, and Landolt (1971) pe. ptm.: $V = 8.722$, $(B-V) = +1.653$, and $(U-B) = +2.043$.

HD 196573 = BD + 0°4558; Priser (1966) pe. ptm.: $V = 7.87$, $(B-V) = +1.65$, $(U-B) = +1.99$; HD sp. cl. = K5.

HD 199280 = HR 8014 = GC29212 = BD − 4°5307; GC gives $\mu_\alpha = +0''.022$, $\mu_\delta = +0''.020$; r.v. = − 29.2 km/s; Cowley *et al.* (1969) sp. cl. = B8 Vn; Cousins (1962) pe. ptm.: $V = 6.56$, $(B-V) = -0.10$, $(U-B) = -0.28$; Crawford (1963) pe. ptm.: $(B-V) = -0.08$, $(U-B) = -0.33$; H$\beta = +2.787$; also see Hoffleit (1982), where some quoted values differ slightly.

HD 200340 = HR 8054 = GC 29377 = BD − 1°4095; GC gives $\mu_\alpha = +0''.003$, $\mu_\alpha = 0''.000$; r.v. = − 11.8 km/s, var. vel.; Kennedy and Buscombe (1974) quote sp. cl. = B6 V from Cowley *et al.* (1969), but I could not verify; Crawford (1963) pe. ptm.: $(B-V) = -0.10$, $(U-B) = -0.47$, H$\beta = +2.700$; Cousins (1964) pe. ptm.: $V = 6.49$, $(B-V) = -0.10$, $(U-B) = -0.48$; also see Hoffleit (1982), where some quoted values differ slightly.

HD 205556 = BD + 4°4703; Golson (1970) pe. ptm.: $V = 8.32$, $(B-V) = -0.058$, $(U-B) = -0.354$; HD sp. cl. = B9; Crawford, Golson, and Landolt (1971) pe. ptm.: $V = 8.318$, $(B-V) = -0.057$, $(U-B) = -0.362$.

HD 209796 = BD + 0°4820; Golson (1970) pe. ptm.: $V = 8.94$, $(B-V) = +1.206$, $(U-B) = +1.169$; HD sp. cl. = K2; Crawford, Golson, and Landolt (1971) pe. ptm.: $V = 8.934$, $(B-V) = +1.208$, $(U-B) = +1.161$.

HD 210894 = BD − 5°5735; Sanders (1966) star 2220-5, no. 6; pe. ptm.: $V = 9.14$, $(B-V) = +1.35$, $(U-B) = +1.41$; HD sp. cl. = K2.

HD 216135 = BD − 14°6357 = F 107; Cowley (1958) discovered star to be blue, sp. cl. = B8; Feige (1958) also found blue nature of star, and provided chart (Feige, 1959); Klemola (1962) found $\mu_\alpha \cos\delta = -0''.020$, $\mu_\delta = -0''.016$; sp. cl. = B3; pe. ptm.: $V = 10.13$, $(B-V) = -0.13$, $(U-B) = -0.59$.

BD + 1°4774 = GC 33053 = PC 5763 = Ci 18, 3124 = GL 908 = G29-68 = LFT 1828 = Y 20 − 8164 = Ci 20 − 1454 +; GC gives $\mu_\alpha = +0''.980$, $\mu_\delta = -0''.962$; PC gives $\pi = +0''.160$; Johnson and Morgan (1953): an *UBV* std. star; sp. cl. = M2 V; pe. ptm.: $V = 8.98$, $(B-V) = +1.48$ $(U-B) = +1.09$; Wilson (1967) r.v. = − 65.3 km/s; Buscombe (1977) quotes sp. cl. = M2 V e; Eggen (1979) pe. ptm.: $V = 8.98$, $(B-V) = +1.50$, $(U-B) = +1.08$, $R_E = 7.94$, $(R-I)_E = +0.865$.

REFERENCES

Abt, H. A. (1970). Astrophys. J. Suppl. Ser. **19**, 387.

Abt, H. A., and Biggs, E. S. (1972). *Bibliography of Stellar Radial Velocities* (Kitt Peak National Observatory, Tucson, Arizona).

Adams, W. S. (1915). Astrophys. J. **42**, 172.

Adams, W. S., and Joy, A. H. (1923). Astrophys. J. **57**, 149.
Barford, N. C. (1967). In *Experimental Measurements: Precision, Error, and Truth* (Addison-Wesley, London), p. 62.
Barney, I. (1949). Trans. Astron. Obs. Yale Univ. **20**.
Berger, J. (1963). Publ. Astron. Soc. Pac. **75**, 393.
Bessell, M. S. (1976). Publ. Astron. Soc. Pac. **88**, 557.
Bessell, M. S. (1979). Publ. Astron. Soc. Pac. **91**, 589.
Blanco, V. M., Demers, S., Douglass, G. G., and FitzGerald, M. P. (1968). *Publ. U. S. Naval Observatory, Second Series*, **21**, p. 196.
Buscombe, W. (1977). *General Catalogue of MK Spectral Classifications*, 3rd ed.
Buscombe, W. (1980). *General Catalogue of MK Spectral Classifications*, 4th ed.
Christie, W. H., and Wilson, O. C. (1938). Astrophys. J. **88**, 34.
Conti, P. S., and Alschuler, W. R. (1971). Astrophys. J. **170**, 325.
Cousins, A. W. J. (1962). Mon. Not. Astron. Soc. S. Africa, **21**, 20.
Cousins, A. W. J. (1963). Mon. Not. Astron. Soc. S. Africa, **22**, 12.
Cousins, A. W. J. (1964). Mon. Not. Astron. Soc. S. Africa, **23**, 10.
Cousins, A. W. J. (1973). *Mem. R. Astron. Soc.* **77**, 223.
Cousins, A. W. J. (1976). *Mem. R. Astron. Soc.* **81**, 25.
Cousins, A. W. J., Lake, R., and Stoy, R. H. (1966). R. Obs. Bull., No. 121.
Cousins, A. W. J., and Stoy, R. H. (1962). R. Obs. Bull. No. 64.
Cowley, A. P. (1968). Publ. Astron. Soc. Pac. **80**, 453.
Cowley, A. P., Cowley, C. R., Jaschek, M., and Jaschek, C. (1969). Astron. J. **74**, 375.
Cowley, A. P., Hiltner, W. A., and Witt, A. N. (1967). Astron. J. **72**, 1334.
Cowley, C. R. (1958). Astron. J. **63**, 484.
Crawford, D. L. (1963). Astrophys. J. **137**, 530.
Crawford, D. L., Golson, J. C., and Landolt, A. U. (1971). Publ. Astron. Soc. Pac. **83**, 652.
Curtis, H. D. (1918). Publ. Lick Obs. **13**, 58.
Drilling, J. S., and Landolt, A. U. (1979). Astron. J., **84**, 783.
Eggen, O. J. (1979). Astrophys. J. Suppl. Ser. **39**. 89.
Eggen, O. J. (1980). Astrophys. J. Suppl. Ser. **43**, 457.
Feige, J. (1958). Astrophys. J. **128**, 267.
Feige, J. (1959). Astrophys. J. **129**, 600.
Golson, J. C. (1970). Unpublished.
Graham, J. A. (1982). Publ. Astron. Soc. Pac. **94**, 244.
Guetter, H. H. (1964). Publ. D. D. O., **2**, 403 (No. 13).
Guetter, H. H. (1968). Publ. Astron. Soc. Pac. **80**, 197.
Heard, J. F. (1951). Publ. D. D. O. **1**, 523.
Hiltner, W. A. (1956). Astrophys. J. Suppl. Ser. **2**, 389.
Hiltner, W. A., and Iriarte, B. (1955). Astrophys. J. **122**, 185.
Hiltner, W. A., and Johnson, H. L. (1956). Astrophys. J. **124**, 367.
Hoffleit, D. (1982). *Yale Catalogue of Bright Stars*, 4th ed.
Hogg, A. R., and Kron, G. E. (1955). Astron. J. **60**, 365.
Johnson, H. L. (1955). Ann. Astrophys. **18**, 292.
Johnson, H. L., and Harris, D. L. III (1954). Astrophys. J. **120**, 196.
Johnson, H. L., and Knuckles, C. F. (1957). Astrophys. J. **126**, 113.
Johnson, H. L., Mitchell, R. I., Iriarte, B., and Wisniewski, W. Z. (1966). Comm. Lunar Planet. Lab. **4**, 99 (No. 63).
Johnson, H. L., and Morgan, W. W. (1953). Astrophys. J. **117**, 113.
Keenan, P. C., and Morgan, W. W. (1941). Astrophys. J. **94**, 501.
Kennedy, P. M., and Buscombe, W. (1974). *MK Spectral Classifications.* Published since Jaschek's *La Plata Catalogue.*
Klemola, A. R. (1962). Astron. J. **67**, 740.
Kron, G. E., White, H. S., and Gascoigne, S. C. B. (1953). Astrophys. J. **118**, 502.
Kuiper, G. P. (1942). Astrophys. J. **95**, 201.
Kunkel, W. E., and Rydgren, A. E. (1979). Astron. J. **84**, 633.
Landolt, A. U. (1973). Astron. J. **78**, 959.
Landolt, A. U. (1983). In preparation.
Lesh, J. R. (1968). Astrophys. J. Suppl. Ser. **17**, 371.
Luyten, W. J. (1955). *A Catalogue of 1849 Stars with Proper Motions Exceeding 0″.5 Annually* (Lund Press, Minneapolis, Minnesota).
Luyten, W. J. (1957). *A Catalogue of 9867 Stars in the Southern Hemisphere with Proper Motions Exceeding 0″.2 Annually* (Lund Press, Minneapolis, Minnesota).
Luyten, W. J., and Ebbinghausen, E. G. (1935). Harvard College Observatory Bulletin, No. 900.
Mendoza V, E. E. (1958). Astrophys. J. **128**, 207.
Mendoza V, E. E. and Johnson, H. L. (1965). Astrophys. J. **141**, 161.
Merrill, P. W., and Burwell, C. G. (1933). Astrophys. J. **78**, 87.
Minkowski, R. (1955). In *Gas Dynamics of Cosmic Clouds*, edited by J. M. Burgers and H. C. van de Hulst (North Holland, Amsterdam), p. 106.
Minkowski, R. (1960). *Mt. Wilson and Palomar Observatories Annual Report*, 1959–60, p. 18.
Morgan, W. W., Code, A. D., and Whitford, A. E. (1955). Astrophys. J. Suppl. Ser. **2**, 41.
Mumford, G. S. III (1956). Astron J. **61**, 213.
Münch, G. (1944). Astrophys. J. **99**, 271.
Neubauer, F. J. (1943). Astrophys. J. **97**, 300.
Nikonov, V. B., Nekrasona, S. V., Polosuhina, N. S., Rachkovsky, D. N., Chuvajev, K. K. (1957). Izv. Krymsk. Ap. Obs. **17**, 42.
O'Dell, C. R. (1963). Astrophys. J. **138**, 67.
Perek, L., and Kohoutek, L. (1967). *Catalogue of Galactic Planetary Nebulae* (Prague).
Petrie, R. M., and Pearce, J. A. (1961). Publ. D. A. O. **12**, 1.
Plaskett, J. S., and Pearce, J. A. (1931). Publ. D. A. O. **5**, 1.
Popper, D. M. (1942). Astrophys. J. **95**, 307.
Priser, J. B. (1966). Publ. Astron. Soc. Pac. **78**, 474.
Roman, N. G. (1955). Astrophys. J. Suppl. Ser. **2**, 195.
Sanders, W. L. (1966). Astron. J. **71**, 719.
Sanford, R. F. (1924). Astrophys. J. **59**, 339.
Sanford, R. N. (1935). Astrophys. J. **82**, 202.
Sanford, R. N. (1944) Astrophys. J. **99**, 145.
Sanford, R. F., and Merrill, P. W. (1938). Astrophys. J. **87**, 517.
Schulte, D., and Crawford, D. (1961). Kitt Peak National Observatory Cont. No. 10.
Stoy, R. H. (1963). Mon. Not. Astron. Soc. S. Africa **22**, 157.
Stoy, R. H. (1965). Mon. Not. Astron. Soc. S. Africa **24**, 29.
Thackeray, A. D., and Tatum, J. B. (1966). Publ. D. A. O. **13**, 19.
Upgren, A. R., and Staron, R. T. (1970). Astrophys. J. Suppl. Ser. **19**, 367.
Vandervort, G. L. (1958). Astron. J. **63**, 477.
van Maanen, A. (1929). Publ. Astron. Soc. Pac. **41**, 181.
Vyssotsky, A. N. (1953). Publ. Astron. Soc. Pac. **65**, 48.
Walborn, N. R. (1971). Astrophys. J. Suppl. Ser. **23**, 257.
Wilson, O. C. (1962). Astrophys. J. **136**, 793.
Wilson, O. C. (1967). Astron. J. **72**, 905.
Wilson, R. E., and Joy, A. H. (1950). Astrophys. J. **111**, 221.
Wilson, R. E., and Joy, A. H. (1952). Astrophys. J. **115**, 157.