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UBVRI STANDARD STARS IN THE E-REGIONS

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Photometry on the *UBVRI* Kron-Cousins system is presented for 102 stars covering the magnitude range 7 to 16 in the nine Harvard E-regions. These stars, at declination close to $-45°$, are suitable for use as Southern Hemisphere standards in the photometry of faint stars and galaxies. The large magnitude range in most fields makes the sequences useful for the calibration of the Pickering-Racine wedge, a device widely used to extend photometric sequences to fainter limits on photographic plates. Positions accurate to a few arc seconds as well as identification charts are given for each star.

Key words: UBVRI photometry—standard stars

I. Introduction

There is a growing need for faint standard stars on the *UBVRI* system of broad-band photometry. Observers who use large telescopes with photomultipliers of limited dynamic range often find that available standard stars are too bright. In addition, users of photographic plates and of other detectors for direct imagery require a range of photometric standards within a small area for calibration. For Southern Hemisphere observers, the nine Harvard E-regions are particularly suitable locations for standard magnitude sequences. They are spaced evenly around the sky every 2^h40^m in right ascension at declination $-45°$ and there is almost always one region at a convenient location for the direct comparison of stellar magnitudes in other fields of interest. Recognizing these advantages, astronomers at Cape Town, South Africa, chose the E-regions for standardizing the photometry of the Cape Photographic Catalogue. The early Harvard photometry in the E-regions proved inadequate and a long-term program was carried out to obtain accurate magnitudes and colors for standard stars in each region. The history of the project was reviewed briefly by Cousins and Stoy (1962). As a result of this work, carried out over many years, a system of *UBVRI* photometry has been well defined with respect to bright stars in each of the E-regions. It has been possible to tie the E-region *UBV* photometry firmly to the Johnson *UBV* system (Johnson and Morgan 1953). However, a similarly satisfactory transformation is not possible for *R* and *I* and the *R* and *I* system as used at the Cape has become very much a system in its own right. Nevertheless, it is easily reproducible (Bessell 1976) and steps are being taken to facilitate transfer of the system to the Northern Hemisphere (Cousins 1980*a*). Important references to the development and standardization of this *UBVRI* system are Cousins (1973, 1976, 1978, 1980*c*) and Bessell (1976, 1979).

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For the work at Cerro Tololo Inter-American Observatory (CTIO) described in this paper, about ten stars have been chosen in each E-region covering the magnitude range 7–16. The accurate observations of many 6th- and 7th-magnitude stars by the Cape observers provide a strong base on which to set the new measurements. In choosing stars for the magnitude sequences, one aims to satisfy two criteria which in practice are somewhat in conflict. These are: (1) the inclusion of stars covering a wide range in color, and (2) the inclusion of stars with a large magnitude range within a small area of the sky. Although some red and blue stars were specifically included on the observing list, the present emphasis has been on the second criterion. Except for some stars of extreme color, observation has been restricted to the central part of each E-region. The letter-identification scheme of the Harvard work (Pickering 1917) is used as well as the Cape "Q" numbering system (Cousin and Stoy 1962). In recognition of the precise pointing capability of modern telescopes, an effort has been made to obtain a position for each star of sufficient accuracy that a setting can be made from coordinates alone. Identification charts are also provided.

II. The *UBVRI* Filters

The *UBVRI* system is mostly, but not completely, defined by a set of glass filters. The short wavelength

TABLE I
Glass Filter Combinations Used

U:	Corning 9863 + solid $CuSO_4$ cryst
B:	2mm GG385 + 2mm BG12 + 2mm BG18
V:	2mm GG495 + 2mm BG18
R:	2mm OG570 + 2mm KG3
I:	1mm RG780 + 3mm RG715

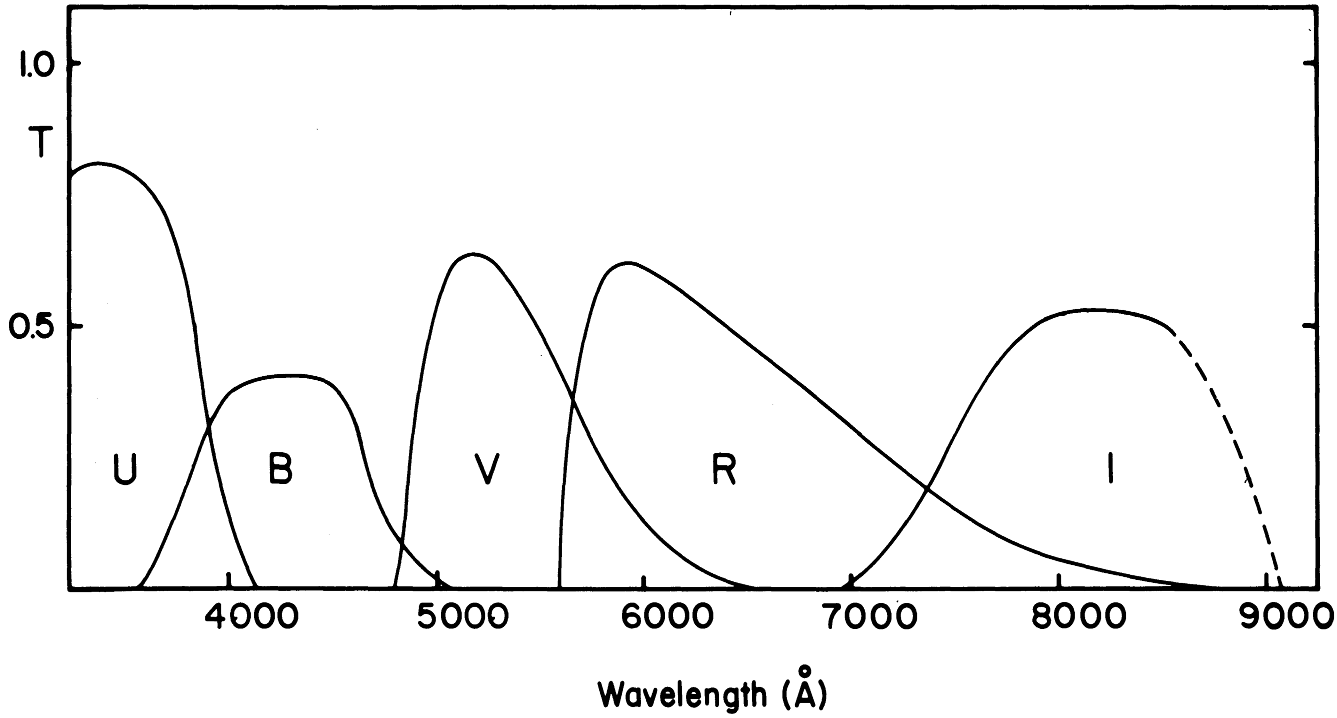

FIG. 1—Transmission curves are shown for the *U, B, V, R, I* filter combinations used in this program. They were measured with the Oriel spectrometer at CTIO. The long wavelength cutoff of a typical RCA 31034 photomultiplier is shown as a dashed curve.

boundary of the *U* band is produced mainly by atmospheric absorption while the long wavelength boundary of the *I* band is determined by the cutoff of the photomultiplier. Several combinations of glass filters have been tried in order to match best the standard system. Table I shows the specification for the filter set which was finally settled upon for the CTIO observations. It is made up of Schott glass filters unless otherwise stated. Figure 1 shows the *measured* transmission curves for these filter combinations. A similar filter specification, differing slightly from that in Table I is recommended by Bessell (1979).

III. Observations and Transformations to the Standard System

The observations were all made with photomultipliers of the RCA 31034 type used in a pulse-counting mode. These detectors with gallium arsenide photocathodes have come into wide use on account of their high sensitivity over the entire ultraviolet-near infrared spectral range. The main disadvantages are a limited dynamic range (bright stars cannot be observed) and the sharp cutoff at 9000 Å which causes difficulty in reproducing *I* colors measured using detectors with a more extended red response (Kunkel and Rydgren 1979). From observations of stars of different known magnitudes with telescopes of various sizes it is found that, as long as bright stars are avoided, the tube has a linear response to within a few thousandths of a magnitude per magnitude. Laboratory tests on a photomultiplier of this type by Walker (1978) confirm that nonlinear effects are unlikely to be significant.

The CTIO 0.4-m, 0.9-m, and 1.5-m telescopes were matched with a single-channel photometer for the observations. The 0.4-m telescope was primarily used to tie the photometry of the 7th- to 9th-magnitude program stars to the brighter standards (Cousins 1973, 1976). On those nights, ten or 15 standard stars were selected from the Cousins list for this purpose. The nights on the 0.9-m and 1.5-m telescopes were used to extend the photometry to fainter stars with the 0.4-m program stars as intermediate standards. To minimize dead time corrections at fast counting rates, the pulse-count rate was rarely allowed to exceed 10^5 sec^{-1}. Typically this corresponds to a star of visual magnitude 6.0–6.5 at the 0.4-m telescope. The integration time for bright stars was 10 sec for each color. For fainter stars, when the total count was lower than 5000, the integration time was increased until this count was exceeded. For the faintest stars, the accuracy of a single observation was limited by the observing time available. Sometimes, particularly in the *U* and *I* bands, the observed precision was 3% to 5%.

The measured magnitudes and colors were corrected for atmospheric extinction to "outside atmosphere" values. Except for the $(B-V)$ extinction coefficient, no account was taken of changes in effective bandpasses with

TABLE II

E1 - Region

Star	HD/CPD	α (1980.0) h m s	δ ° ' "
41-C	8681	01 23 49.9	-44 37 55
35-R	8362	01 21 10.1	-44 31 49
20-Q	8501	01 22 24.3	-44 46 32
44-S	-45°155	01 23 19.8	-44 33 16
49-V		01 24 05.9	-44 44 37
a		01 24 27.6	-44 33 16
h		01 23 47.6	-44 40 10
i		01 23 56.3	-44 44 46
p		01 23 12.5	-44 29 57

	V	U-B	B-V	V-R	R-I	n	Sp
41-C	6.270(03)	1.084(06)	1.146(02)	0.577(01)	0.517(04)	5	K1 II
35-R	9.471(07)	1.679(08)	1.427(05)	0.777(05)	0.722(05)	6	K3 (III)
20-Q	9.855(08)	0.275(09)	0.736(08)	0.402(04)	0.387(05)	5	G8 IV/V
44-S	10.885(13)	0.146(14)	0.620(12)	0.359(05)	0.334(14)	4	
49-V	11.640(17)	0.019(09)	0.564(13)	0.332(10)	0.327(14)	4	
a	12.666(10)	0.020(12)	0.615(07)	0.341(05)	0.335(05)	4	
h	13.828(10)	0.235(10)	0.722(11)	0.375(11)	0.373(14)	4	
i	13.759(08)	0.614(17)	0.916(05)	0.514(07)	0.446(13)	4	
p	14.778(09)	0.383(17)	0.799(06)	0.475(06)	0.461(12)	4	

spectral type. Extinction coefficients were routinely measured on all nights of observation with the 0.4-m telescope. Typical coefficients were: k_v: $0\overset{m}{.}170$, k_{b-v}: $0\overset{m}{.}115$ $-0.015\,(b-v)$, k_{u-b}: $0\overset{m}{.}280$, k_{v-r}: $0\overset{m}{.}045$, k_{r-i}: $0\overset{m}{.}050$ ($(b-v)$, $(u-b)$, $(v-r)$, and $(r-i)$ are the observed instrumental colors). At the 0.9-m and 1.5-m telescopes mean extinction coefficients were used and observation restricted to times when specific E-regions were within two hours of the meridian (air mass less than 1.3).

During the course of the program, it was necessary to use several photomultipliers and each gave slightly different transformation relations to the standard *UBVRI* system. It was not possible to reach the ideal of completely linear relations to the Cousins system over the whole range of observed colors. Single linear transformations sufficed for $(V-R)$ and $(R-I)$ colors over the color range observed although a slight nonlinearity is to be expected for the reddest stars. Usually two linear relations were necessary for each of $(U-B)$ and $(B-V)$. These met in the region $(B-V) \approx (U-B) \approx 0\overset{m}{.}4$. The slopes of the linear relations were within 10% of unity. For the *V* magnitudes a color-term correction of about $-0\overset{m}{.}03\,(B-V)$ was found. Although there appeared to be no loss in accuracy for the stars observed in this program, it is likely that a color term in $(V-I) = ((V-R) + (R-I))$ might be less dependent on the highly structured energy distribution of very red stars and would give more satisfactory results for these objects.

Tables II to X and Figures 2 to 10 give positions, photometry, spectral types, and identification charts for the program stars. The positions, precessed to 1980.0, come from the Smithsonian Catalogue for the brighter stars. These positions were used in turn to compute the positions for the fainter stars by using the x,y coordinates published in Harvard Annals 71 (Pickering 1917). All positions are expected to be accurate to within 5 arc sec.

As a cross-check to provide unambiguous identification, finding charts are presented for the stars in each field. For the central part of each region these are made from short-exposure red or yellow photographs taken with the 4-m, 1.5-m, and 1-m telescopes at CTIO. The scale and orientation are marked on each chart. For out-

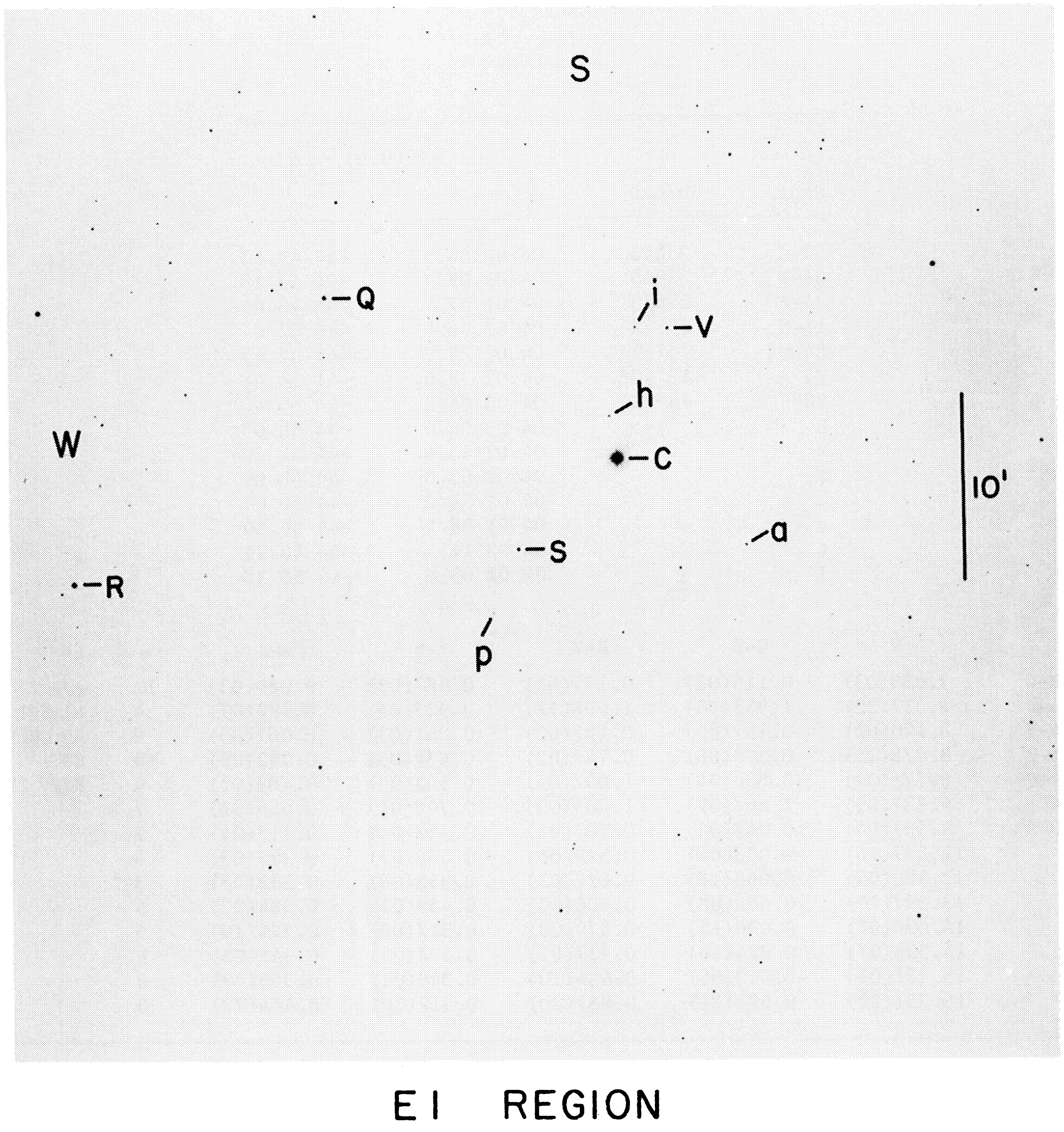

FIG. 2—Finding chart for stars in the E1 region.

lying stars, chosen for their extreme colors, the identification charts are 5X enlargements from the *True Visual Magnitude Photographic Star Atlas* (Papadopoulos 1979). Each chart is 15 arc min square and has the same orientation as the larger chart for the region. I am grateful to Mr. Papadopoulos for permission to reproduce for this purpose, the relevant parts of this very useful atlas.

Photometry for each star is listed as *V* magnitude and $(U-B)$, $(B-V)$, $(V-R)$, and $(R-I)$ color indices. Numbers in parentheses after each mean value indicate the calculated internal standard errors of these means in units of $0^{m}.001$. The column headed *n* shows the number

TABLE III

E2 - Region

Star	HD/CPD	α (1980.0) h m s	δ ° ' "
2-C	25843	04 03 06.5	-44 47 13
36-P	25966	04 04 09.2	-44 43 18
4-F	25653	04 01 37.7	-44 43 04
18-N	25842	04 03 06.8	-44 32 04
34-Q	25762	04 02 25.7	-44 38 45
74	-42°408	04 07 39.0	-41 54 48
20-S	-44°427	04 03 06.2	-44 30 46
b		04 03 06.0	-44 50 03
ℓ		04 02 43.6	-44 48 20
m		04 02 03.0	-44 48 09
o		04 01 54.0	-44 50 09
s		04 01 58.5	-44 50 56
t		04 02 11.5	-44 48 24
I		04 02 05.8	-44 50 33

	V	U-B	B-V	V-R	R-I	n	Sp
2-C	7.638(03)	0.115(02)	0.177(03)	0.087(03)	0.089(03)	12	A/m
36-P	8.032(22)	1.952(15)	1.608(12)	0.923(04)	0.992(07)	4	M1 III
4-F	8.190(05)	0.157(05)	0.127(02)	0.061(03)	0.067(03)	9	A3 IV/V
18-N	8.478(05)	0.209(08)	0.727(03)	0.409(03)	0.392(06)	10	G5 V
34-Q	8.771(07)	0.834(04)	1.007(05)	0.543(03)	0.488(03)	9	K1/2 III
74	9.337(09)	1.661(09)	1.405(03)	0.748(01)	0.656(02)	7	
20-S	9.502(04)	0.087(05)	0.587(03)	0.328(04)	0.313(04)	9	
b	11.577(16)	0.023(06)	0.529(06)	0.306(07)	0.297(03)	3	
ℓ	12.980(04)	0.066(18)	0.627(03)	0.353(08)	0.358(05)	3	
m	13.097(10)	0.485(08)	0.806(03)	0.439(03)	0.384(07)	5	
o	14.090(08)	0.038(15)	0.570(08)	0.312(08)	0.326(10)	5	
s	14.596(07)	0.324(10)	0.727(07)	0.372(08)	0.341(05)	4	
t	15.171(09)	-0.013(05)	0.634(10)	0.349(02)	0.355(02)	3	
I	15.751(22)	0.602(29)	0.887(20)	0.512(20)	0.446(22)	3	

of nights on which each star was observed. The spectral types in the tables are from the Michigan Spectral Catalogue (Houk 1978).

IV. Comparison with Cape Results

Plotted against $(V-I)$ $(= (V-R) + (R-I))$ in Figure 11 are the residual differences in V, $(U-B)$, $(B-V)$, $(V-R)$, $(R-I)$ between the CTIO values and the Cousins 1973 and 1976 lists. No overall systematic differences are expected but the absence of large fluctuations with color indicates that the transformation procedures are generally satisfactory for $(V-I) < 1^{m}\!.5$. There are indications, however, that the CTIO $(U-B)$ measures may be $0^{m}\!.01$ or $0^{m}\!.02$ less than the Cape values at $(V-I) = -0^{m}\!.1$ and for $(V-I) > 0^{m}\!.5$. Figure 12 shows similar plots for the fainter stars in common between Tables II-X of this paper and the Cape observations by Menzies and Laing (1980) and Cousins (1973, 1976, 1978, 1980*b*). The few stars with $(V-I) > 1^{m}\!.5$ have not been included in this comparison. The larger scatter in Figure 12 as compared with Figure 11 is due to the fainter stars involved but here too a systematic difference in $(U-B)$ is noticeable.

Observers may wish to apply corrections to the $(U-B)$ values in Tables II–X based on the differences shown in Figures 11 and 12. The aim of the present

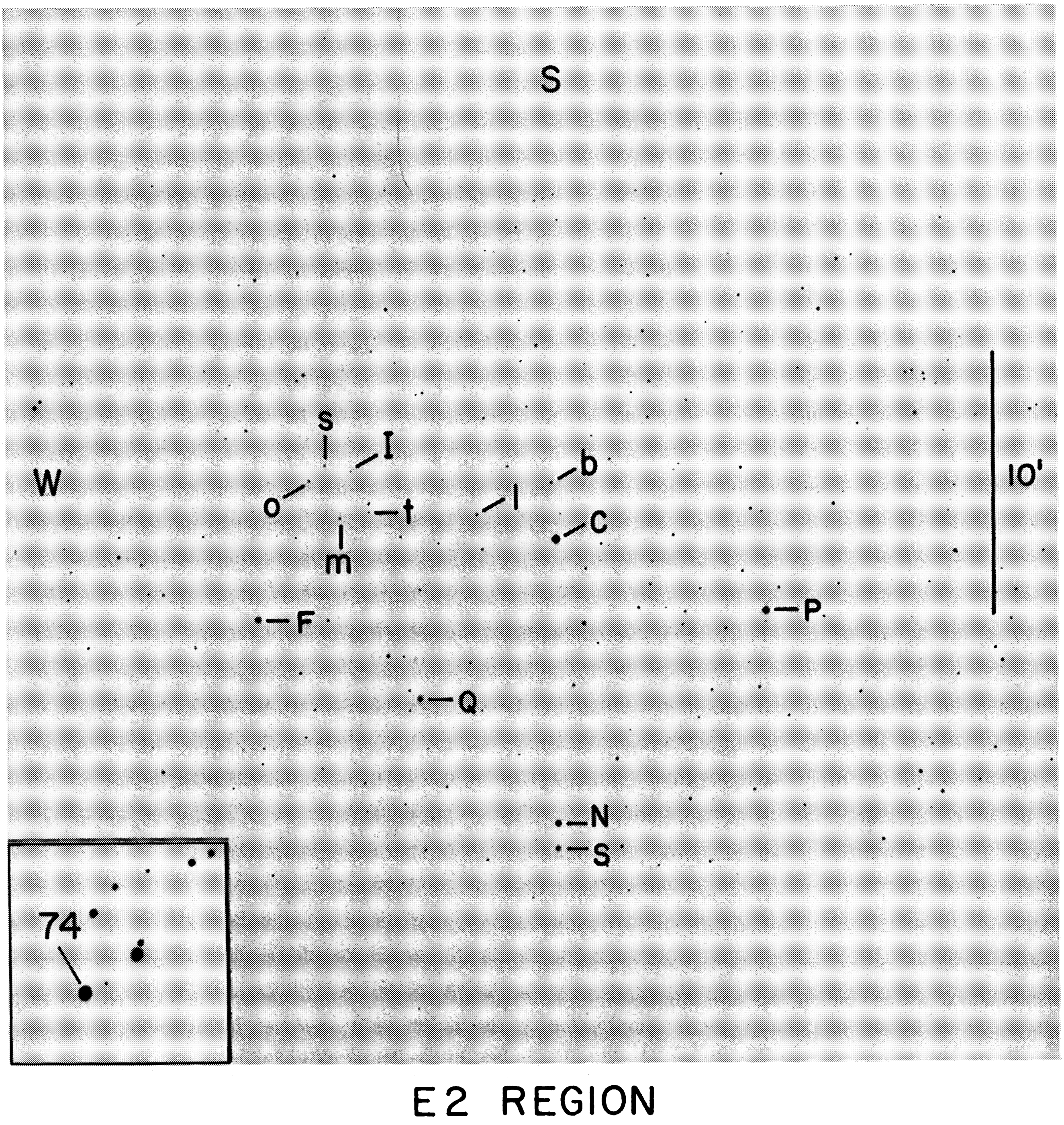

FIG. 3—Finding chart for stars in the E2 region. The insert for E2-74 is a 5X enlargement from the Papadopoulos Atlas and covers an area 15′ × 15′ with south to the top and east to the right.

work has been to reproduce the *UBVRI* system as used at the Cape and certainly no claim can be made here that the values given in this paper are closer to the original Johnson system. However, caution should be observed. We note, for example, that, even allowing for the increased scatter, the $(U-B)$ differences for the fainter stars in Figure 12 are larger than in Figure 11 suggesting that there may be some small systematic differences among the Cape observations themselves. The $(U-B)$ index is known to be difficult to produce and there is more of a question as to whether it is *possible* to obtain observatory-to-observatory repeatability better than a few

TABLE IV

E3 - Region

Star	HD/CPD	α (1980.0) h m s	δ ° ' "
	49798	06 47 28.7	-44 17 35
19-I	48464	06 40 43.7	-45 15 19
26-N	48730	06 41 56.4	-45 20 06
34-S	-44°1030	06 39 36.2	-45 04 52
33-T	-45°1002	06 41 50.3	-45 08 00
55-R	48855	06 42 39.2	-45 13 17
59-X	-45°1014	06 42 45.4	-45 11 44
58-W	-45°994	06 40 47.0	-45 19 46
e		06 42 01.4	-45 07 56
k		06 42 19.2	-45 07 24
o		06 42 11.2	-45 09 36
t		06 41 59.9	-45 04 12
v		06 42 15.0	-45 08 55

	V	U-B	B-V	V-R	R-I	n	Sp
49798	8.279(07)	-1.169(14)	-0.289(06)	-0.115(02)	-0.147(04)	7	05/7p
19-I	8.990(11)	0.063(04)	0.251(07)	0.140(05)	0.139(02)	6	F0 V
26-N	9.530(04)	0.108(04)	0.469(05)	0.260(02)	0.258(03)	8	F3/5 IV
34-S	9.713(04)	0.633(12)	0.955(04)	0.493(02)	0.469(03)	6	
33-T	10.053(03)	1.116(08)	1.158(06)	0.580(05)	0.520(04)	7	
55-R	10.659(04)	0.003(09)	0.058(06)	0.014(05)	0.025(01)	6	B9 V
59-X	11.345(08)	-0.090(26)	0.409(10)	0.271(04)	0.275(06)	6	
58-W	11.570(07)	0.092(12)	0.129(09)	0.051(05)	0.060(02)	6	
e	12.867(22)	0.018(09)	0.585(05)	0.353(09)	0.340(05)	4	
k	14.078(06)	-0.012(09)	0.584(09)	0.328(11)	0.332(09)	5	
o	14.804(08)	-0.069(16)	0.552(07)	0.314(13)	0.348(05)	5	
t	15.514(18)	0.167(31)	0.733(13)	0.428(14)	0.420(15)	4	
v	16.254(25)	-0.033(33)	0.509(14)	0.312(31)	0.347(30)	5	

hundredths of a magnitude in this case. Atmospheric extinction corrections, for example, are complicated (Gutiérrez-Moreno, Moreno, and Cortés 1981) and one problem in the present series may have been the neglect of a color or spectral-type term in the $(U-B)$ extinction coefficient.

V. Application to the Pickering-Racine Wedge Calibration

The principal use of the lists of standard-star values given in this paper is for calibrating *UBVRI* photometry of stars and galaxies. It is worth pointing out that many of the sequences have the characteristic of a large magnitude range and thus are suitable for checking the performance of various two-dimensional detectors. One example is in the use of the Pickering-Racine wedge (Pickering 1891; Racine 1969; Couch and Newell 1980). This technique is employed for extending photometric magnitude sequences to fainter limits on photographic plates. A small nondispersing but slightly deviating glass wedge is placed in the entrance beam of the telescope and thus produces secondary images which are fainter by a fixed magnitude difference than the primary images of relatively bright stars. If this magnitude difference is known, the secondary images can be compared directly with the primary images of fainter stars, making it possible to extend an established photometric sequence as far as the limiting magnitude on the photographic plate. It has been found in practice that the method works well if the optical adjustment of the telescope is sufficiently good to produce similar structure in the primary and secondary images. However, a calibration of the magni-

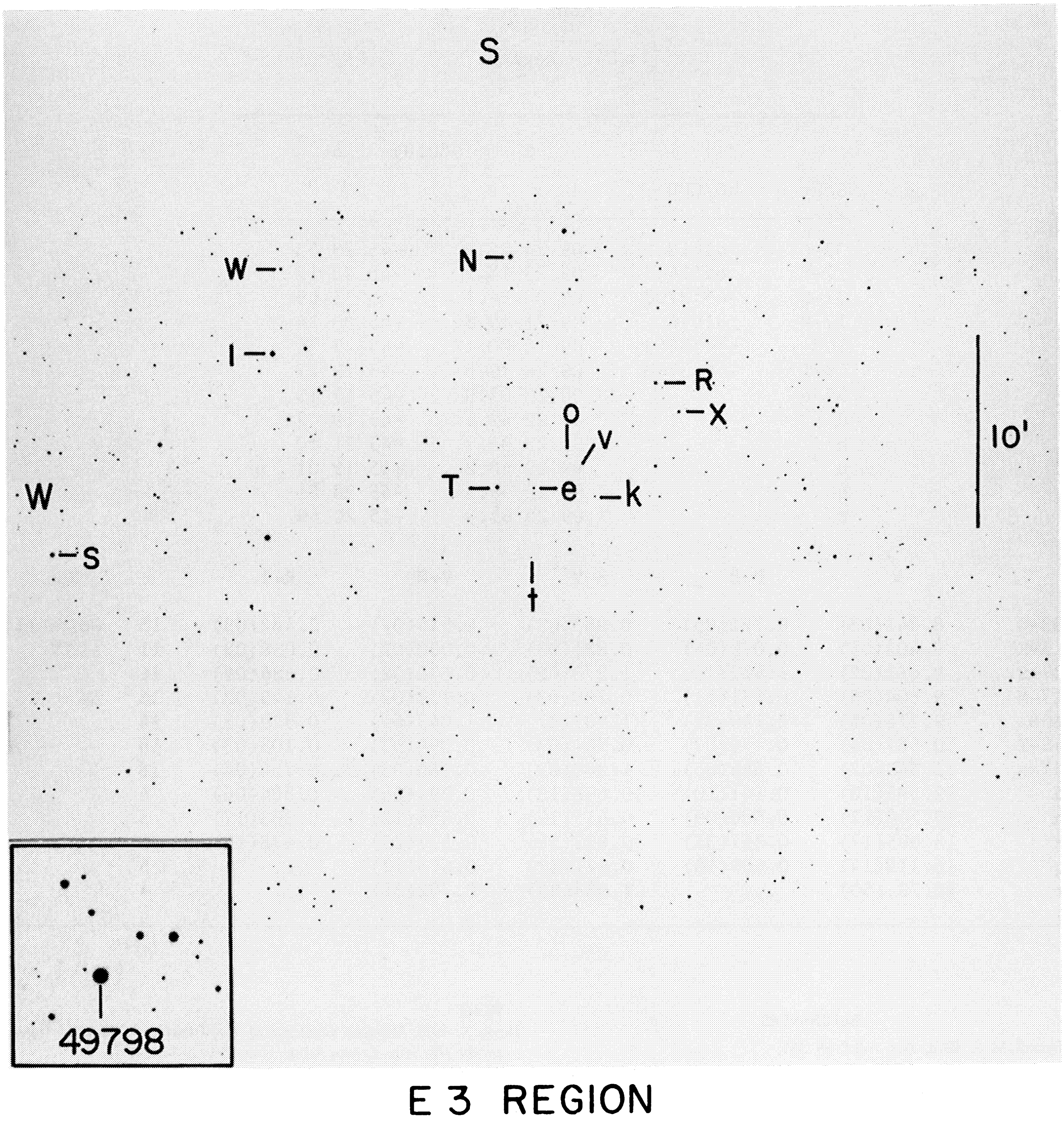

FIG. 4—Finding chart for stars in the E3 region. The insert is a chart for the nearby blue star HD 49798 and is a 5X enlargement from the Papadopoulos Atlas. It covers an area 15′ × 15′ with south to the top and east to the right.

tude difference should be carried out on each night of observation. Short exposures of magnitude sequences such as these published here are very suitable for the task.

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TABLE V

E4 - Region

Star	HD/CPD	α (1980.0) h m s	δ ° ' "
33-0	81610	09 24 28.8	-45 23 53
7-K	81414	09 23 18.2	-45 23 12
37-S	-45°3708	09 22 24.1	-45 35 09
17-M	81076	09 21 19.8	-45 33 24
108	-44°3663	09 18 00.1	-45 22 34
48-T	-44°3763	09 24 19.5	-45 12 27
57-a		09 23 07.0	-45 17 15
d		09 22 42.1	-45 19 42
h		09 23 05.7	-45 21 10
n		09 22 40.2	-45 19 01
q		09 22 59.5	-45 20 51
r		09 23 01.3	-45 20 49

	V	U-B	B-V	V-R	R-I	n	Sp
33-0	8.841(03)	0.721(05)	0.983(03)	0.514(02)	0.482(03)	15	G8/K0 III
7-K	9.405(05)	0.079(04)	0.081(03)	0.030(02)	0.038(03)	11	A1 IV
37-S	9.482(02)	1.412(10)	1.273(02)	0.670(02)	0.584(02)	16	
17-M	9.604(06)	0.171(11)	0.200(03)	0.132(02)	0.145(02)	15	Ap
108	9.776(05)	2.149(22)	1.907(07)	1.043(04)	0.929(02)	14	
48-T	10.587(04)	0.170(07)	0.201(03)	0.099(03)	0.103(03)	18	
57-a	11.343(07)	0.844(05)	1.288(09)	0.760(03)	0.754(04)	18	
d	12.595(10)	0.141(10)	0.638(13)	0.394(04)	0.384(06)	4	
h	13.760(12)	0.086(09)	0.615(12)	0.384(12)	0.383(17)	5	
n	15.005(17)	0.357(35)	0.823(16)	0.517(25)	0.478(18)	4	
q	16.118(14)	0.609(10)	0.971(32)	0.613(12)	...	5	
r	16.73 (50)	...	1.088(33)	0.702(31)	...	4	

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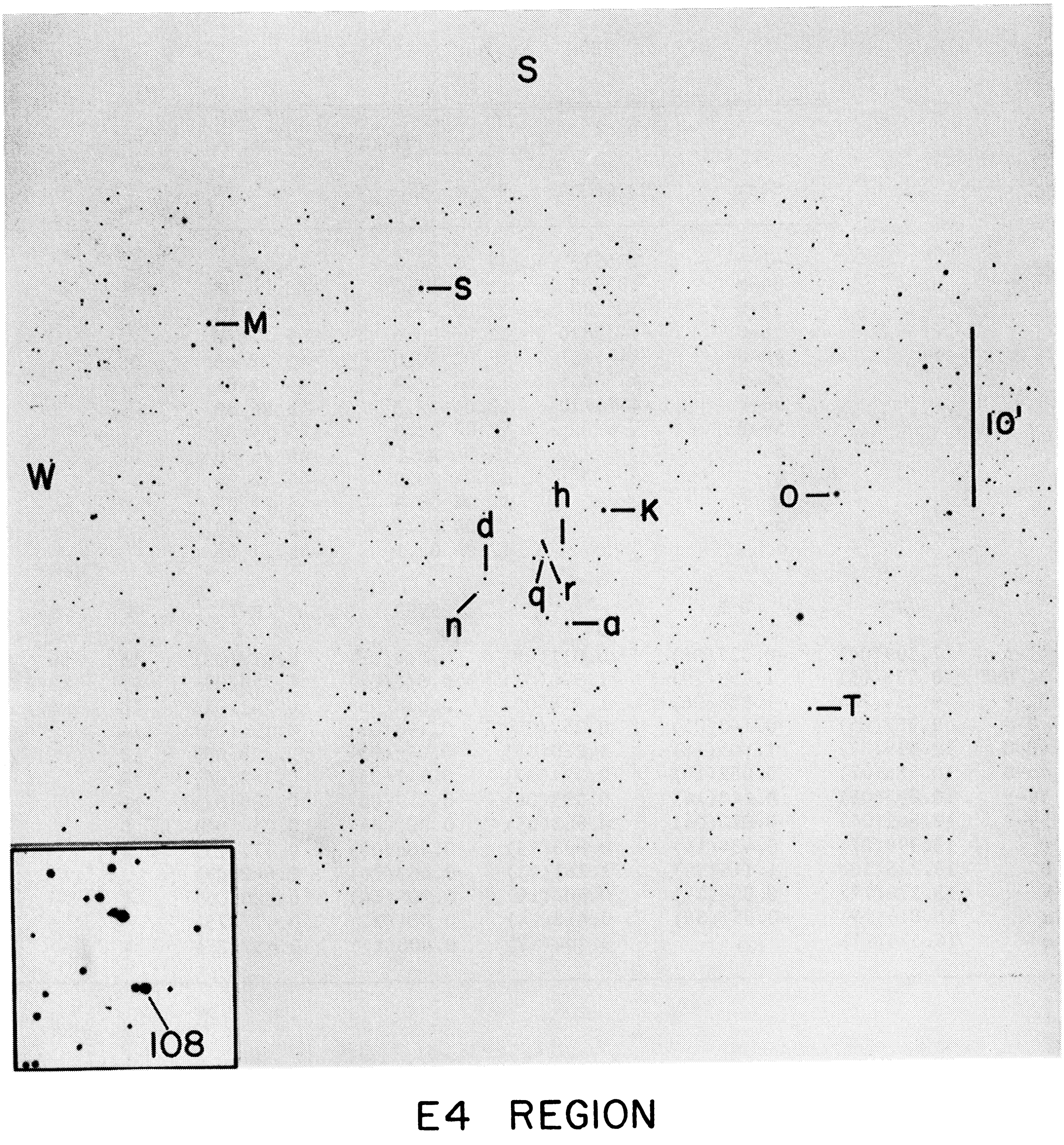

FIG. 5—Finding chart for stars in the E4 region. The insert for E4-108 is a 5X enlargement from the Papadopoulos Atlas and covers an area 15′ × 15′ with south to the top and east to the right.

TABLE VI

E5 - Region

Star	HD/CPD	α (1980.0) h m s	δ ° ' "
41-A	105313	12 06 30.2	-45 28 11
34-M	103729	11 55 37.5	-45 26 08
32-P	104720	12 02 27.4	-46 03 01
8-0	-44°5820	12 05 30.6	-45 20 30
48-U	-44°5801	12 02 50.0	-45 22 46
46-S	-44°5804	12 03 27.9	-45 22 01
56-V	-45°5770	12 04 39.3	-45 48 30
59-Y		12 04 22.0	-45 24 52
c		12 04 25.6	-45 25 50
h		12 04 20.0	-45 30 00
k		12 04 08.9	-45 27 07
m		12 04 01.7	-45 27 30
o		12 04 02.1	-45 27 03

	V	U-B	B-V	V-R	R-I	n	Sp
41-A	7.309(04)	-0.057(08)	0.011(03)	0.018(03)	0.018(03)	15	B9 V
34-M	8.532(05)	1.853(19)	1.530(07)	0.818(02)	0.750(03)	11	K3/4 III
32-P	9.236(22)	1.886(06)	1.518(05)	0.816(06)	0.741(02)	10	K4/5 II
8-0	9.987(06)	0.165(05)	0.357(05)	0.192(02)	0.194(08)	14	
48-U	10.519(07)	1.305(18)	1.260(05)	0.646(03)	0.578(03)	12	
46-S	10.586(07)	0.089(10)	0.594(07)	0.347(03)	0.342(06)	10	
56-V	10.865(05)	0.643(14)	0.983(06)	0.517(03)	0.509(07)	12	
59-Y	12.869(04)	-0.020(04)	0.063(05)	0.021(04)	0.034(05)	6	
c	13.399(07)	0.434(16)	0.893(13)	0.485(08)	0.477(15)	4	
h	14.225(10)	1.116(39)	1.261(13)	0.663(06)	0.642(08)	3	
k	15.376(17)	0.036(47)	0.502(19)	0.303(14)	0.326(06)	4	
m	15.814(25)	-0.057(38)	0.612(14)	0.381(35)	0.417(25)	4	
o	16.525(17)	...	0.704(17)	0.400(17)	0.407(25)	4	

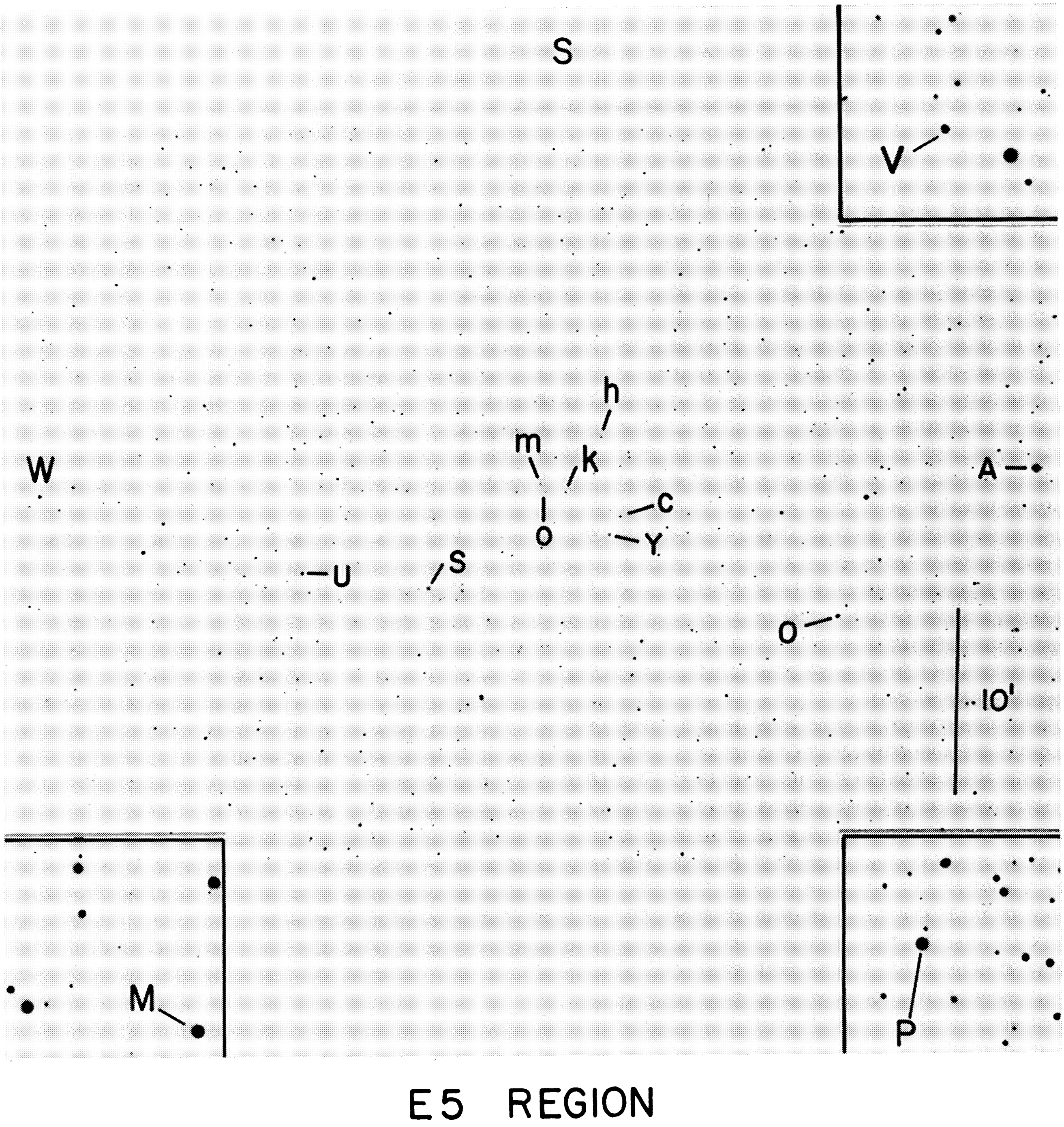

FIG. 6—Finding chart for stars in the E5 region. The inserts for E5-M, E5-P, and E5-V are 5X enlargements from the Papadopoulos Atlas. Each chart covers an area 15′ × 15′ with south to the top and east to the right.

TABLE VII

E6 - Region

Star	HD/CPD	α (1980.0) h m s	δ ° ' "
98	129474	14 42 50.5	-47 10 14
8-M	129688	14 44 07.5	-45 34 55
16-P	129660	14 43 55.5	-45 20 30
48-X	129857	14 45 06.0	-45 41 00
49-W	-44°6958	14 46 24.5	-45 11 13
50-Z	-44°6945	14 44 32.3	-45 10 37
g		14 45 03.5	-45 30 16
ℓ		14 45 05.8	-45 23 48
n		14 45 15.6	-45 19 15
r		14 44 55.8	-45 20 04

	V	U-B	B-V	V-R	R-I	n	Sp
98	8.820(07)	1.953(25)	1.614(08)	0.887(04)	0.844(02)	10	K4 (III)
8-M	9.219(03)	0.027(03)	0.041(03)	0.013(02)	0.013(02)	15	A0/1 V
16-P	9.378(04)	0.177(08)	0.276(04)	0.163(02)	0.168(03)	14	A7 V
48-X	9.584(08)	0.939(06)	1.108(04)	0.562(03)	0.523(02)	15	K0 III
49-W	10.538(08)	0.137(09)	0.258(06)	0.145(07)	0.146(06)	12	
50-Z	10.709(10)	0.057(07)	0.345(07)	0.196(03)	0.219(08)	10	
g	12.177(06)	0.093(26)	0.558(10)	0.341(09)	0.337(06)	3	
ℓ	12.336(09)	1.340(16)	1.319(13)	0.702(13)	0.624(20)	3	
n	12.820(15)	0.713(21)	1.060(04)	0.563(06)	0.546(09)	2	
r	14.171(10)	0.547(41)	0.987(15)	0.541(10)	0.548(01)	2	

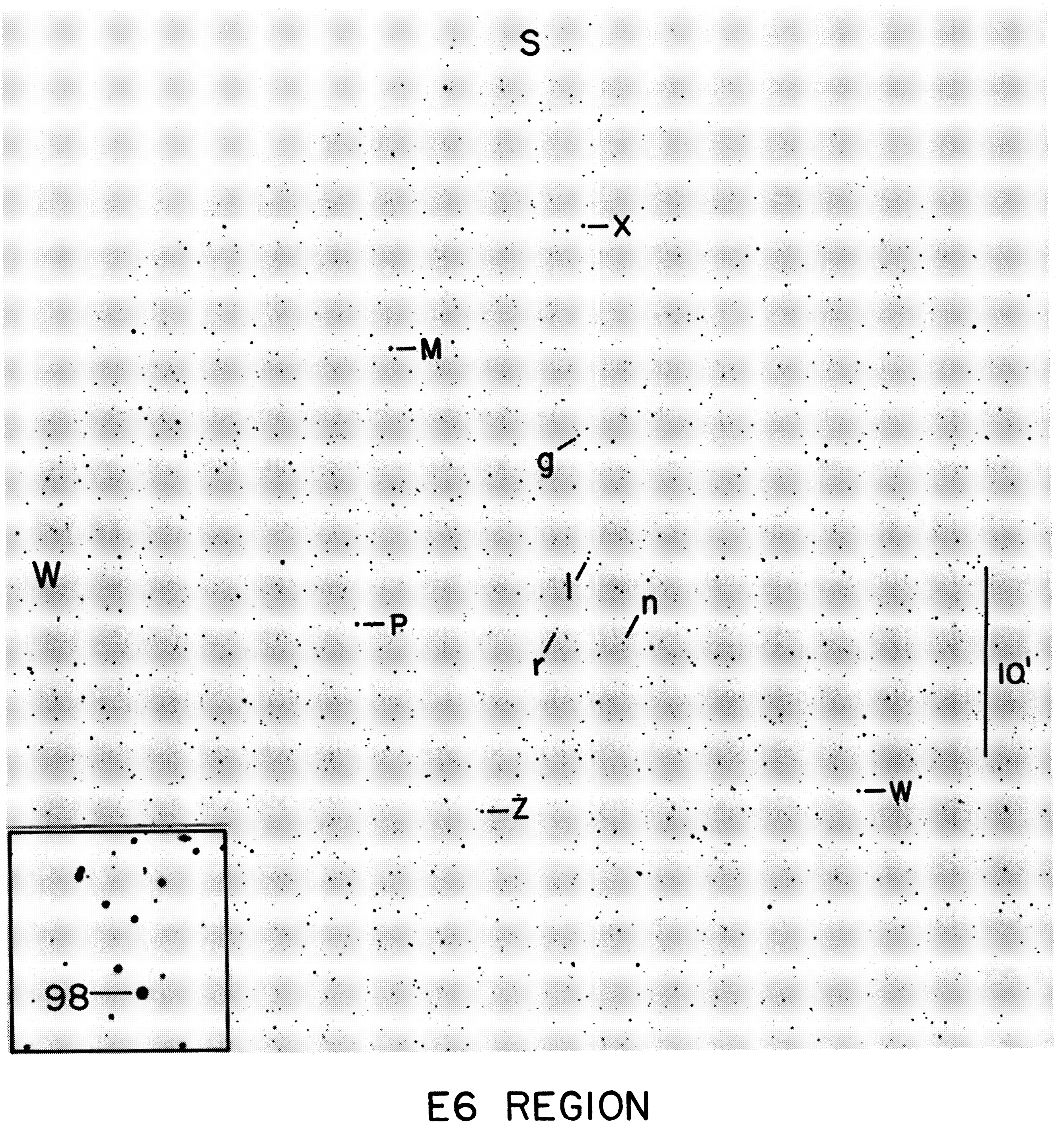

FIG. 7—Finding chart for stars in the E6 region. The insert for E6-98 is a 5X enlargement from the Papadopoulos Atlas and covers an area 15′ × 15′ with south to the top and east to the right.

TABLE VIII

E7 - Region

Star	HD/CPD	α (1980.0) h m s	δ ° ′ ″
32-K	157487	17 24 13.1	-44 45 47
16-H	157477	17 24 13.4	-45 15 00
11-M	157870	17 26 30.5	-44 42 21
64	-46°8664	17 27 09.9	-46 53 14
7-S	157697	17 25 25.7	-44 41 11
8-W	-45°8570	17 24 47.9	-45 09 30
52-X	-44°8508	17 25 58.0	-44 54 17
b	-44°8506	17 25 56.3	-45 04 41
m		17 25 53.8	-45 00 34
s		17 25 56.0	-45 01 01
u		17 25 46.4	-45 01 53

	V	U-B	B-V	V-R	R-I	n	Sp
32-K	7.645(09)	1.122(07)	1.243(04)	0.619(02)	0.572(03)	9	G8 III (CN)
16-H	8.093(03)	0.216(05)	0.243(02)	0.142(02)	0.147(03)	10	A5 V
11-M	8.644(03)	0.199(04)	0.319(02)	0.170(02)	0.169(03)	9	A3 II (m)
64	9.411(04)	1.220(12)	1.549(09)	1.120(09)	1.321(04)	8	
7-S	9.992(05)	-0.269(07)	0.065(06)	0.069(04)	0.089(06)	11	B9 II/III
8-W	10.543(09)	0.058(08)	0.172(04)	0.114(02)	0.124(11)	8	
52-X	10.777(03)	-0.417(06)	0.024(06)	0.031(04)	0.028(08)	9	
b	10.956(05)	0.388(05)	0.612(06)	0.413(02)	0.424(03)	3	
m	12.498(09)	1.322(46)	1.316(05)	0.690(02)	0.605(02)	3	
s	14.225(33)	0.223(05)	0.664(08)	0.389(08)	0.379(03)	4	
u	15.013(21)	0.118(12)	0.572(09)	0.341(44)	...	3	

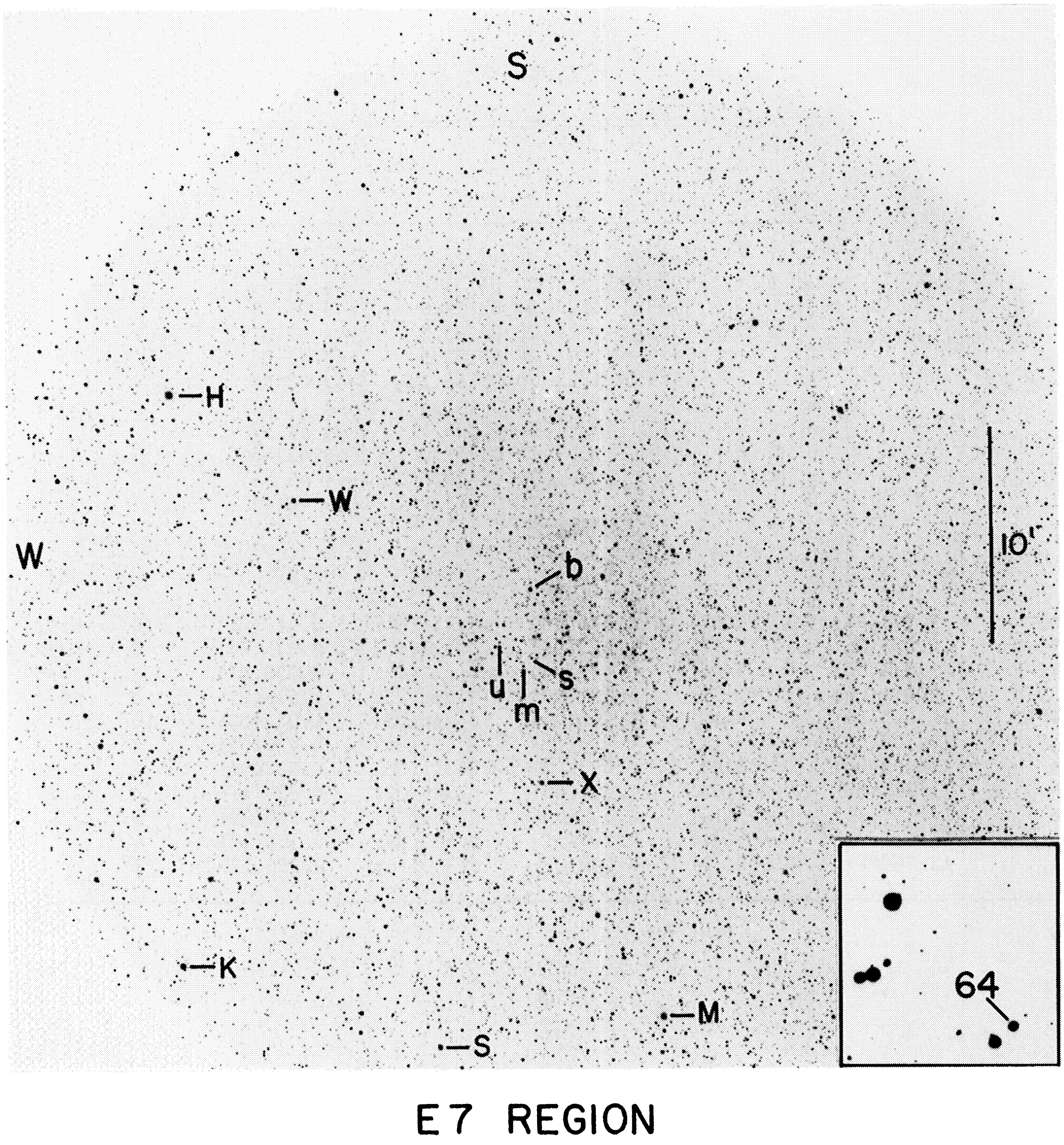

FIG. 8—Finding chart for stars in the E7 region. The insert for E7-64 is a 5X enlargement from the Papadopoulos Atlas and covers an area 15′ × 15′ with south to the top and east to the right.

TABLE IX

E8 - Region

Star	HD/CPD	α (1980.0) h m s	δ ° ' "
61	191849	20 12 26.0	-45 13 27
40-0	190480	20 05 31.6	-44 21 44
18-P	189933	20 02 59.9	-45 05 29
39-S	190777	20 07 05.3	-44 42 37
47-V	-45°9862	20 03 53.9	-44 47 05
48-W	-45°9856	20 02 58.1	-45 02 06
a		20 06 12.5	-44 47 20
h		20 06 08.5	-44 44 57
n		20 05 57.0	-44 43 43
p		20 05 40.7	-44 45 53
u		20 06 15.0	-44 46 15

	V	U-B	B-V	V-R	R-I	n	Sp
61	7.971(05)	1.213(08)	1.428(06)	0.921(04)	0.917(02)	10	M1/2 V
40-0	8.093(06)	1.550(17)	1.405(06)	0.752(05)	0.675(04)	8	K3/4 III
18-P	9.314(03)	-0.043(08)	0.443(04)	0.272(02)	0.279(02)	8	F3/5 V
39-S	9.511(04)	1.007(09)	1.121(04)	0.566(02)	0.518(04)	8	K0
47-V	10.625(04)	0.079(10)	0.508(05)	0.295(03)	0.284(03)	10	
48-W	10.708(06)	0.545(11)	0.919(08)	0.489(09)	0.460(05)	8	
a	12.098(08)	0.100(03)	0.603(02)	0.351(06)	0.337(01)	4	
h	13.308(08)	-0.001(02)	0.591(05)	0.349(02)	0.349(11)	5	
n	14.459(04)	0.045(14)	0.590(06)	0.341(07)	0.328(09)	5	
p	14.716(07)	0.406(04)	0.764(11)	0.430(09)	0.368(18)	4	
u	15.909(14)	-0.002(22)	0.600(09)	0.332(16)	0.355(12)	4	

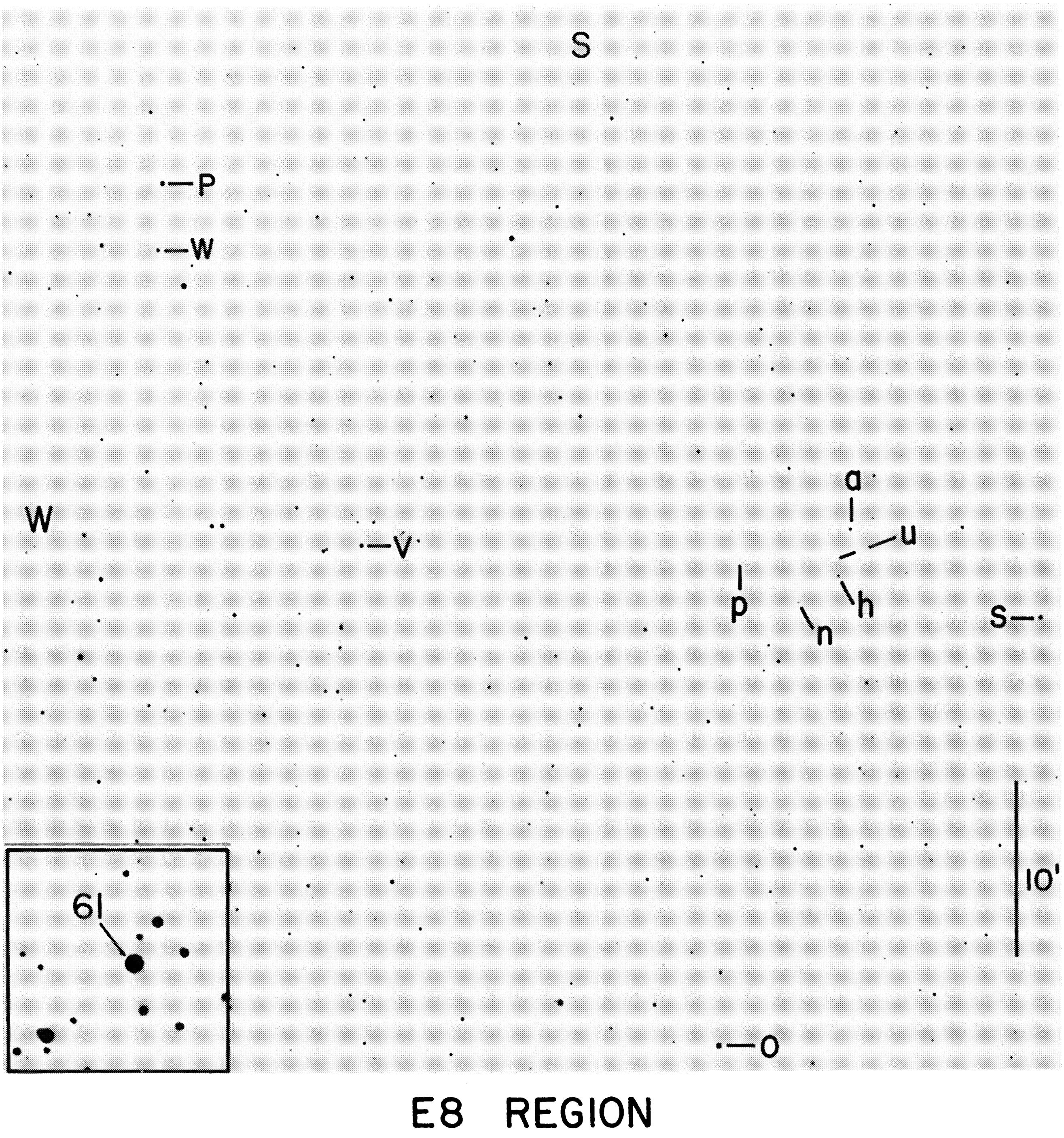

FIG. 9—Finding chart for stars in the E8 region. The insert for E8-61 is a 5X enlargement from the Papadopoulos Atlas and covers an area 15′ × 15′ with south to the top and east to the right.

TABLE X

E9 - Region

Star	HD/CPD	α (1980.0) h m s	δ ° ' "
27-R	215105	22 42 21.8	-44 40 18
38-S	215756	22 46 56.7	-44 21 43
28-V	-45°10328	22 43 26.4	-44 42 55
47-U	217172	22 43 55.7	-44 45 08
g		22 44 22.7	-44 23 53
k		22 44 34.4	-44 36 40
n		22 44 20.9	-44 36 03
q		22 44 15.7	-44 34 05
s		22 44 32.1	-44 31 03

	V	U-B	B-V	V-R	R-I	n	Sp
27-R	9.489(04)	1.154(14)	1.229(14)	0.641(06)	0.594(07)	6	K2 III
38-S	9.526(09)	1.597(25)	1.386(09)	0.737(06)	0.689(09)	6	K3 III
28-V	10.372(07)	0.790(16)	1.033(05)	0.542(05)	0.502(06)	4	
47-U	10.685(08)	0.047(10)	0.591(06)	0.328(05)	0.337(07)	8	A3 V
g	12.698(11)	0.680(24)	0.894(16)	0.509(16)	0.424(07)	3	
k	13.959(13)	-0.067(07)	0.539(07)	0.308(15)	0.321(07)	3	
n	14.713(06)	-0.066(10)	0.563(03)	0.340(08)	0.343(11)	5	
q	15.201(05)	0.193(05)	0.691(04)	0.376(07)	0.351(12)	4	
s	15.573(15)	-0.089(24)	0.523(12)	0.342(15)	0.364(06)	3	

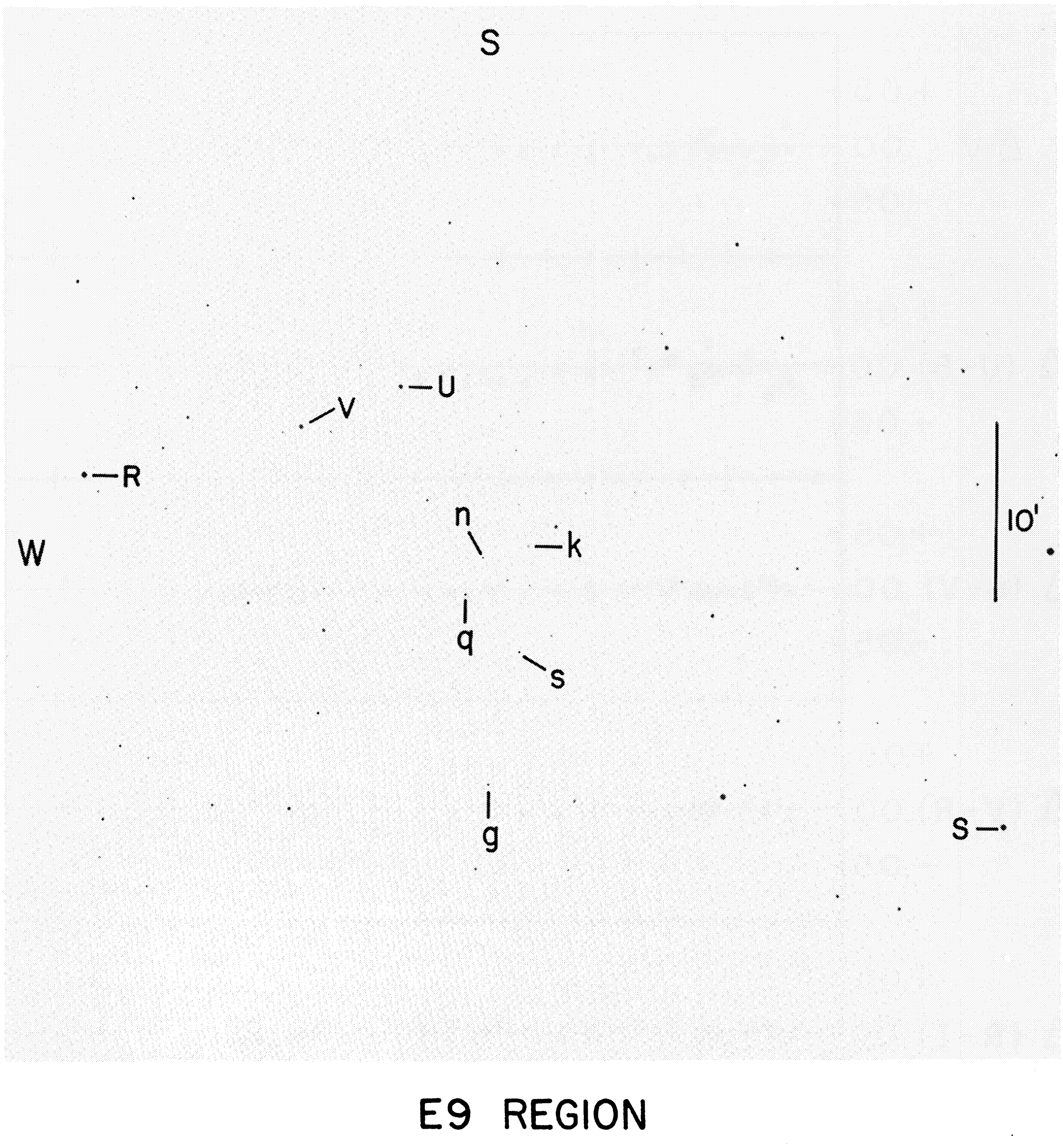

FIG. 10—Finding chart for stars in the E9 region.

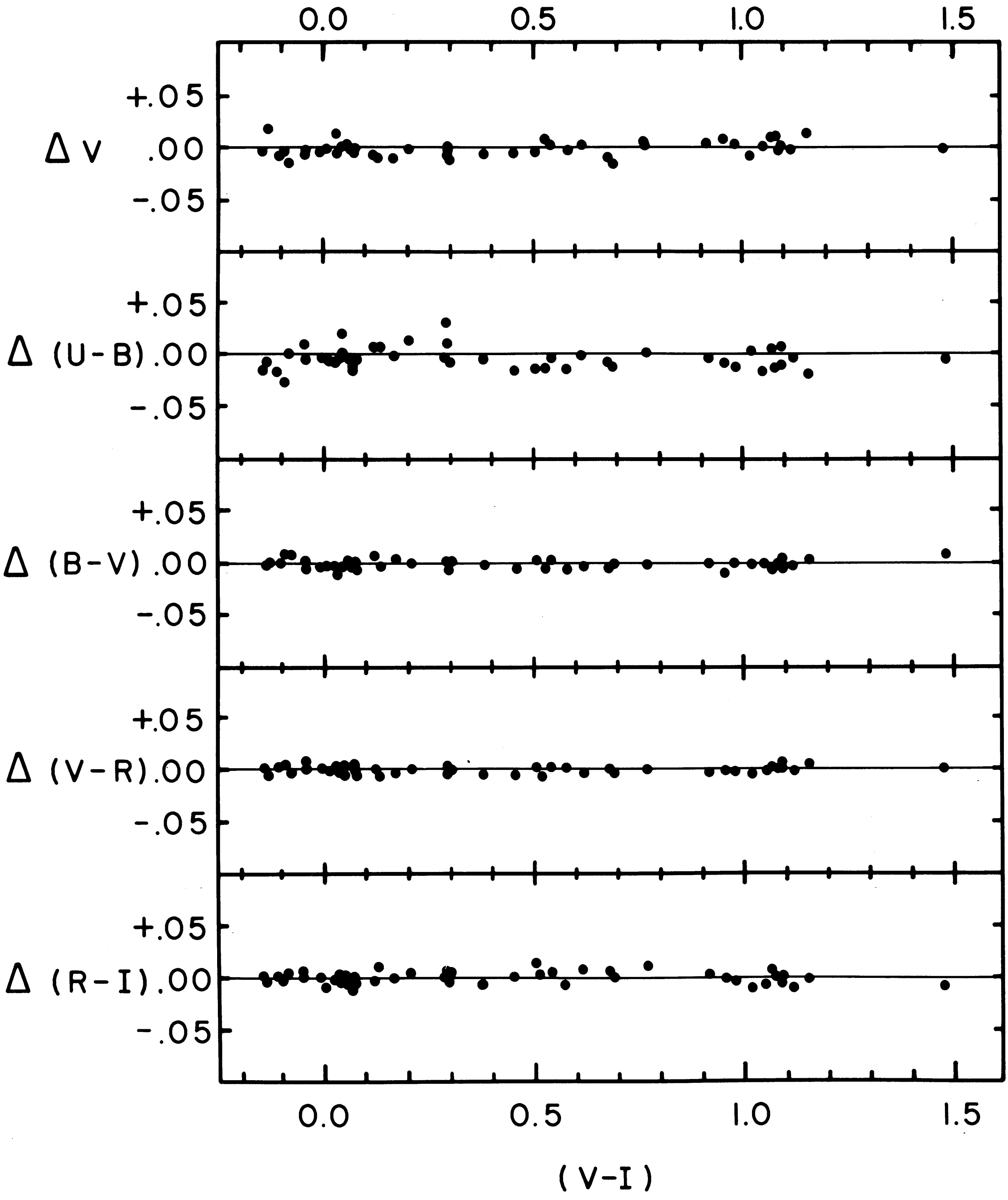

FIG. 11—Differences, in the sense CTIO – Cape, are plotted against $(V-I)$ $(= (V-R) + (R-I))$ for the standard stars observed in the program.

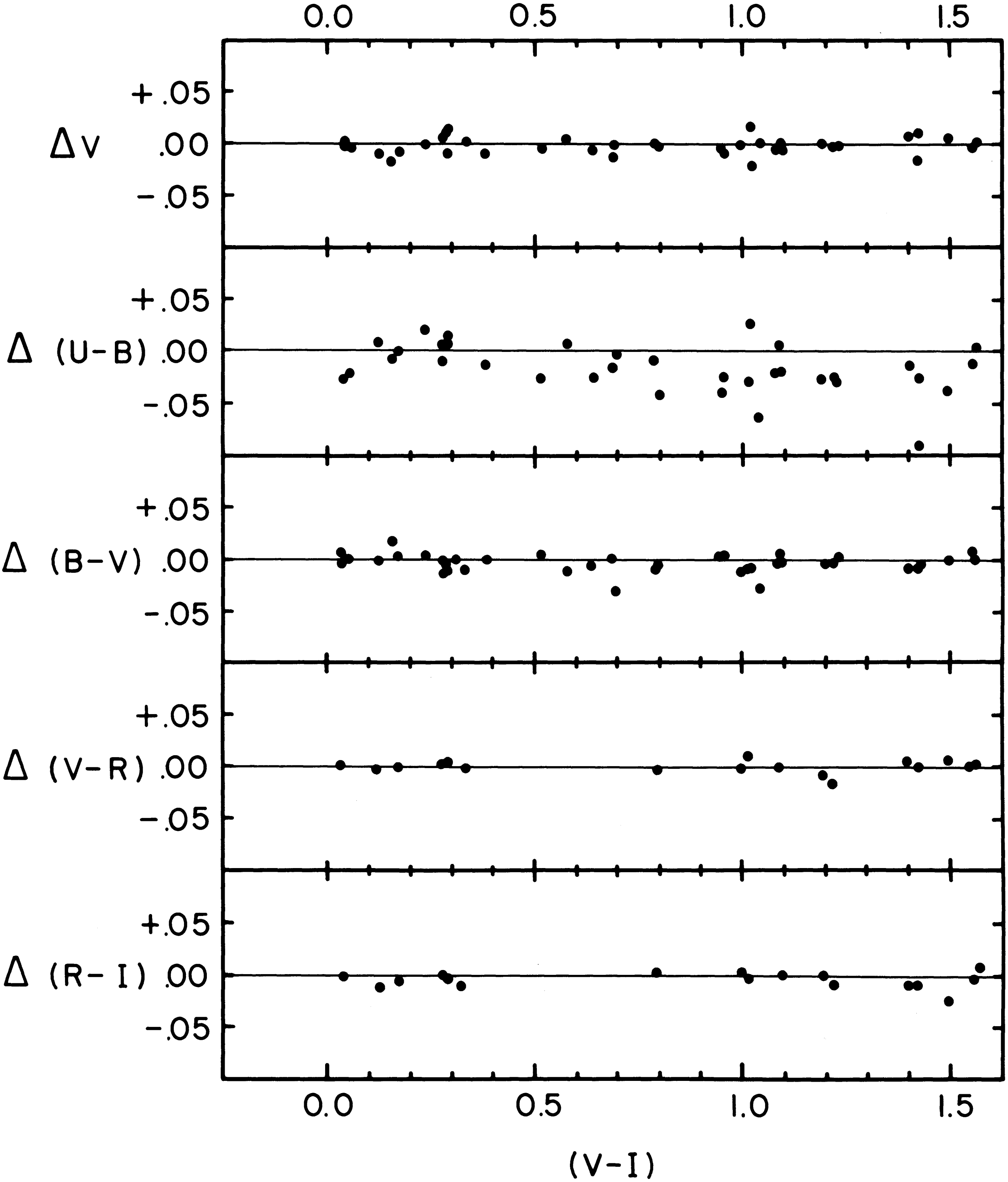

FIG. 12—Differences, in the sense CTIO – Cape, are plotted against $(V-I)$ $(= (V-R) + (R-I))$ for the program stars in common. The few stars with $(V-I) > 1^m.5$ are not included.