DATA SET CATALOG # 50

Two Micron Sky Survey

CORRMSS 1tape

Table of Contents

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1. INTRODUCTION:

The documentation for this data set was originally on paper, kept in NSSDC's Data Set Catalogs (DSCs). The paper documentation in the Data Set Catalogs have been made into digital images, and then collected into a single PDF file for each Data Set Catalog. The inventory information in these DSCs is current as of July 1, 2004. This inventory information is now no longer maintained in the DSCs, but is now managed in the inventory part of the NSSDC information system. The information existing in the DSCs is now not needed for locating the data files, but we did not remove that inventory information.

The offline tape datasets have now been migrated from the original magnetic tape to Archival Information Packages (AIP’s).

A prior restoration may have been done on data sets, if a requestor of this data set has questions; they should send an inquiry to the request office to see if additional information exists.

2. ERRATA/CHANGE LOG:

NOTE: Changes are made in a text box, and will show up that way when displayed on screen with a PDF reader.

When printing, special settings may be required to make the text box appear on the printed output.

Version	Date	Person	Page	Description of Change
01				
02				

3 LINKS TO RELEVANT INFORMATION IN THE ONLINE NSSDC INFORMATION SYSTEM:

http://nssdc.gsfc.nasa.gov/nmc/

[NOTE: This link will take you to the main page of the NSSDC Master Catalog. There you will be able to perform searches to find additional information]

4. CATALOG MATERIALS:

a. Associated Documents — To find associated documents you will need to know the document ID number and then click here. http://nssdcftp.gsfc.nasa.gov/miscellaneous/documents/

b. Core Catalog Materials

Micron Sky Survey

D-01801
C-01165

The data contained in the Preliminary Catalog of the Two Micron Sky Survey of the California Institute of Technology are also available on IBM punched cards and magnetic tape. The latter contains card images, in BCD form, of the punched cards.

For each zone, the cards are arranged in four sections which contain, in turn, the data of all the Left Hand pages, of all the Right Hand Pages, of the section of Measurements with Chi-square Excesses, and then of the Remarks section. Each of these sections is preceded by a title card which has the zone in columns 1-3 and the appropriate title starting in column 9; these are:

LEFT HAND PAGE

RIGHT HAND PAGE

MEASUREMENTS OF CHI-SQ EXCESS STARS

REMARKS

On the magnetic tape each zone is terminated by an "end of file". The zones are arranged in order of increasing declination. An explanation of the entries is included in the introduction to the catalog. The format of the cards for each of the four sections is described below.

D-1801 C-1165

Card Format - "Left Hand Pages"

Column	Format	Information
1-6	I6 or A3, I3	Catalog number of star
7	I1	1 if there is a remark
		0 otherwise
[illegible]-9	I2	RA hour (1950)
1[illegible]-12	I2	RA minute (1950)
14-15	I2	RA second (1950)
17-19	I3	DEC degree (1950)
21-24	F4.1	DEC minute (1950)
25-27	I3	RA error in seconds
28-3[illegible]	F5.2	RA Chi-square
33-35	F3.1	DEC error in minutes
3[illegible]-[illegible]	F4.1	DEC Chi-square
41-4[illegible]	F5.2	K magnitude (3)
47-5[illegible]	F4.2	K error (3)
51-5[illegible]	F5.2	K Chi-square (3)
57-6[illegible]	F5.2	I magnitude (1), (4)
63-[illegible]	F4.2	I error (1), (2), (4)
6[illegible]-[illegible]	F5.2	I Chi-square (1), (2), (4)
7[illegible]	I1	1 if there is a Q
		0 otherwise
[illegible]	I1	1 if no Chi-sq excess
		2 if I Chi-sq excess
		3 if K Chi-sq excess
		4 if I, K both Chi-sq excess
76	I1	1 if I, K both on scale
		2 if I off scale
		3 if K off scale
		4 if I, K both off scale
77-78	I2	NK
7[illegible]-80	I2	NI

(1) Ignore if I mag is bigger than 14.0

(2) Ignore if Col 73 equals 1

(3) Ignore if Col 76 equals 3 or 4

(4) Ignore if Col 76 equals 2 or 4

Card Format - "Right Hand Pages"

Column	Format	Information
1-6	I6 or A3, I3	Catalog number of star
7	I1	1 if there is a remark
		0 otherwise
8-17	I10	Observational time-table for the 3-1/4 years in the format of the catalog
19	I1	1 if spectral type and V mag are given
		0 otherwise
21-25	F5.2	V mag(1)
27-29	A3	Spectral type(1)
31	I1	1 if luminosity class is given
		0 otherwise
33	I1	2 = Luminosity class I and II(2)
		3 = Luminosity class III(2)
		4 = Luminosity class IV(2)
		5 = Luminosity class V(2)
		6 = Luminosity class c(2)
		7 = Luminosity class g(2)
		8 = Luminosity class d(2)
35-38	I4	HD/BS number if identified in Yale Catalog of Bright Stars
		0 implies no identification
40-44	I5	GC number if identified in General Catalog of 33342 Stars for the Epoch 1950
		0 implies no identification
46-54	A3, I6	DM number if identified in S.A.O. Star Catalog
		0 in col 54 implies no identification
56-63	A6, A2	Star name if identified in General Catalog of Variable Stars
		000000 in col 56-61 implies no identification
65	I1	1 if there is an identification with RA and DEC differences.
		0 otherwise
67-69	I3	RA difference in seconds(3)

Column	Format	Information
70-74	F4.1	DEC difference in minutes (3)

(1) Ignore if Col 19 equals 0.

(2) Ignore if Col 31 equals 0.

(3) Ignore if Col 65 equals 0. These are the infrared catalog S.A.O. Star Catalog positions or, if no S.A.O. identification, the variable star positions.

Card Format - Measurements of Chi-sq Excess Stars

Column	Format	Information
1-6	I6 or A3, I3	Catalog number of star
7-8	I2	Number of observations; i.e. number of successive entries under this star
10-14	F5.2	K magnitude
15-18	F4.2	K error
19-23	F5.2	I magnitude (1)
24-27	F4.2	I error (2)
28	I1	1 if I mag questionable 0 otherwise
29-32	I4	Julian day (should read 243XXXX)
35-56 59-80	repeats the format for columns 9-32 for more observations, if there are any.	

(1) Ignore if I > 14.

(2) Ignore if I > 14 or col 28 equals 1

Card Format - Remarks

Column	Format	Information
1-6	I6 or A3, I3	Catalog number of star
9-80	A72	Remark

NASA SP-3047

TWO-MICRON SKY SURVEY

A Preliminary Catalog

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

OCT 8 1969

FOREWORD

This catalog, giving sources of emission in the 2.2μ region for over 5000 stars, represents a systematic survey of the Northern Hemisphere for stars brighter than third magnitude. It is a prominent step forward for researchers in this rapidly advancing field and will be of great assistance to astronomers throughout the world.

The National Aeronautics and Space Administration is interested in extending observations to spectral regions available only above the atmosphere and at the same time encouraging the extension of ground-based observations in new spectral regions to the extent that useful results can be obtained below the atmosphere. We, therefore, take pleasure in coordinating with observers using telescopes on the ground and in assisting with the publication of this catalog.

John E. Naugle
Associate Administrator for
Space Science and Applications

December 1968

ACKNOWLEDGMENTS

A great many people contributed to the survey at one time or another. It would be impossible to fully acknowledge each person's contribution. The telescope was constructed largely with the assistance of David L. Vail. More than one-half of the data was taken by Gordon S. Forrester. Among the Caltech undergraduate students who helped in the construction, operations, and analysis were: Harvey R. Butcher, Gary O. Fitzpatrick, Edward J. Groth, Kenneth S. Hultman, Joseph D. Kinkade, Dan McCammon, Andrew D. McKay, Jerry E. Nelson, Douglas D. Osheroff, Ronald S. Remmel, B. Thomas Soiffer, Craig Spencer, and Henry S. Tye. Graduate students who worked on the survey were Eric E. Becklin, Theodore Hilgeman, and especially Evan E. Hughes; the statistical analyses of the data of the survey form a portion of Hughes' Ph.D. thesis. Research fellows Dowell E. Martz and James A. Westphal made important initial contributions to the instrumentation of the survey; Bruce T. Ulrich initiated the analysis procedure. The strip chart recordings were digitized by Annamaria Dienes, Linda Schofield, and Jantina Wesseling, and the data handling was done in turn by Patricia S. Kuhi, Ann C. Gee, Patricia A. Longworth, and Judith D. Bennett. Mary L. Edwards and Linda K. Murphy provided secretarial help. It is a great pleasure to thank all of these people for their help in this survey. We especially thank Mr. Edward J. Groth who undertook a major portion of the responsibility for the reduction of the survey data to its final form.

The lead sulfide cells, which remained operational throughout the survey, were purchased from the Santa Barbara Research Center. A preliminary, edited version of the *Smithsonian Astrophysical Observatory Star Catalog* was generously provided by Messrs. Russell G. Walker and Anthony P. D'Agati of A.F.C.R.L. Dr. Harold L. Johnson kindly provided us with a card listing of his measurements. The cooperation of the Mount Wilson Observatory through its director, Dr. Horace W. Babcock, and the mountain superintendent, Mr. Benjamin Traxler, is gratefully acknowledged.

The survey was funded by National Aeronautics and Space Administration Grant NGL-05-002-007.

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CONTENTS

TWO-MICRON SKY SURVEY

In 1965 an infrared sky survey was initiated by the California Institute of Technology. The purpose of the survey was to obtain an unbiased sample of celestial objects that emit in the infrared region and to study their characteristics. Such properties as apparent intensities, colors, variability, and spatial distributions were of primary interest. In addition, it was expected that objects having extreme redness might be found and, if so, would be of great interest.

This catalog contains a complete listing of all objects detected on the survey that had a flux density at 2.2μ exceeding approximately 4×10^{-25} W m^{-2} Hz^{-1}.

GENERAL DESCRIPTION

The survey was carried out with a telescope at Mount Wilson, Calif. having a 62-inch diameter and an f/1 aluminized epoxy mirror mounted equatorially. Radiation at an effective wavelength of 2.2μ was detected by lead sulfide photoconductive cells cooled by liquid nitrogen and located at the prime focus of the mirror. Eight lead sulfide cells, each subtending about 10′ north-south by 3′ east-west, were arranged in an array whose overall dimensions were 40′ north-south and 6.5′ east-west (fig. 1). The effects of terrestrial background radiation were minimized by vibrating the mirror at 20 hertz so that an image of a point source oscillated in the east-west direction and fell alternately on one or the other of two adjacent cells. Only the alternating signal was amplified, thus eliminating the

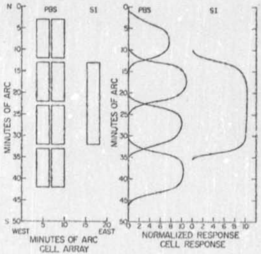

Figure 1.–The geometry of the cell array and the normalized cell response as measured at the telescope are shown. The latter was measured bidaily to monitor possible variations in the cell sensitivity.

nonvarying background. It should be noted that this method of chopping effectively measures the second derivative of the source intensity and thus discriminates against smoothly varying extended sources.

In addition to the 2.2μ detector array, radiation at an effective wavelength of 0.84μ was detected by a single silicon photovoltaic cell which subtended a rectangular area of the sky 20′ north-south by 3′ east-west, centered 10′ to the east of the central two pairs of lead sulfide cells (fig. 1).

The signals from the four pairs of lead sulfide cells and from the silicon cell were amplified, synchronously detected, and displayed on separate tracks of a strip chart recorder, along with marker pulses indicating the right ascension of the telescope at the time of observation (fig. 2). The amplifier gains were maintained at such a value that a full-scale deflection corresponded to a signal approximately 40 times the system noise level. This 40-to-1 range was increased by a factor of 10 by displaying the sum of all five signals attenuated by a factor of 10 on a sixth recorder channel.

During survey operations, the telescope automatically scanned a raster pattern made up of right ascension sweeps, at 18 times sidereal rate, between hour angles of -30^m to $+30^m$. After each sweep the telescope was advanced northward 15′ in declination and then reversed in sweep direction. Alternating sweeps were continued for approximately 50 minutes until a net declination change of 3°30′ was reached. After either two or three calibration stars were recorded to check the sensitivity of the system, the telescope was reset manually to the starting declination. Thus, in a full night, a band of sky covering a range of 8^h to 12^h in right ascension and 3°30′ in declination was surveyed. For declinations north of +56°, the sweep rate was raised to 36 times sidereal rate and a band 6°30′ in declination was scanned.

The strip chart recordings were digitized for processing with the IBM 7094 computer of the Caltech computing facility. Each night's data were processed to combine the signal "peaks" observed on the various cells (fig. 2) into individual "stars," to compute the magnitude of each star, and, by comparison with stars in the *Smithsonian Astrophysical Observatory Star Catalog*, to evaluate and correct for telescope misalinement and missetting. Although the blur circle of the telescope was approximately 3′ and the detector dimension exceeded 3′, coordinates could be determined to better than 1′ by combining the several sightings of a star as it passed over the cell array (fig. 1). For the rest of this introduction, the result of the above processing will be called as a single measurement of any individual source.

The data of each night were subsequently combined with those of all other nights into a single catalog. In this process the results of each measurement were treated as independent data.

The wavelength response at 2.2μ was defined by the use of an interference filter with half-transmission points at 2.0 and 2.4μ. The resultant response defines a system that is in close agreement with the K-magnitude system established by Johnson (1962, 1964). The survey magnitude scale was established by comparison with observations published by Johnson (1964); no color correction has been applied.

The minimum detectable 2.2μ signal observable under survey conditions has a K magnitude between 4.0 and 4.5. The maximum signal that could be recorded has a nominal K magnitude between -1.5 and -2.0. This maximum measurable signal varied partly because of seasonal variations in the responsivity of the detection system and partly because of interference between bright 0.84μ signals and bright 2.2μ signals when both were observed on the 10-time attenuated output.

The wavelength response of the 0.84μ system was defined by a Kodak No. 70 Wratten filter, which passed energy of wavelengths greater than 0.7μ, and by the long wavelength cutoff of the silicon cell at 1.0μ. The resultant system is in agreement with that used by Kron, White, and Gascoigne (1953). The latter system was used to set the survey I magnitude scale although comparisons could be made only over a fairly restricted range of spectral classes. The I magnitudes which could be measured range from 2 to 10.

Because the stars tabulated by Kron et al. (1953) and Johnson (1964) cover a large magnitude range and are not uniformly distributed over the sky, a uniformly distributed network of 450 secondary standards whose magnitudes were within the survey magnitude range was established. For these stars typically $0.8 < K < 2.0$ and $2.5 < I < 3.8$. Eighty percent of the standards have colors corresponding to a color index I-K between 1.3 and 2.6. At monthly intervals during the time of operation, an entire night would be devoted to measuring all accessible secondary standards as well as the stars of Johnson (1964) and Kron et al. (1953) to insure the constancy of the secondary standards. As a further check, the spectral response of the detector system was measured with a laboratory double-prism monochromator on a bimonthly basis throughout the survey.

During each hour of survey, at least two of these secondary standards located near the area being surveyed were observed and were used to calculate the instrumental sensitivity for that night. Nights for which the derived sensitivity showed fluctuations whose standard deviation exceeded

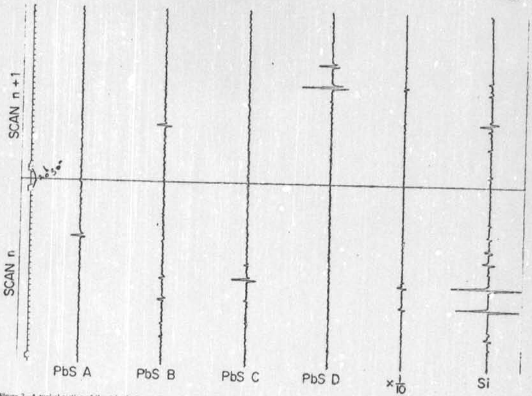

Figure 2.–A typical section of the strip-chart recording is shown. The marks to the left designate each minute of right ascension. The peaks on the lead sulfide cells resemble, because of the chopping mode, the second derivative of a spike function; peaks on the silicon cell resemble the first derivative of a spike. A star is seen on lead sulfide A 10^m before the end of scan n and then again 10^m after the start of scan n+1 on lead sulfide B. The 0.84μ signal for this star appears offset by approximately 1^m on scan n+1 on the silicon channel. The latter signal is also seen, attenuated by a factor of 10, on the X 1/10 channel.

approximately 7 percent were rejected from the data. The average standard deviation for nights which were accepted was approximately 3 percent.

A correction of 0.1 magnitude/air mass was applied to each star to account for the extinction in the Earth's atmosphere. The dependence of extinction on air mass could not be determined using the 62-inch survey telescope because the range of hour angles for which observations could be made was too small. Thus, the form of the extinction law was found by a comparison with those stars measured by Johnson, Mitchell, Iriarte, and Wisniewski (1966). An independent check of the average extinction law was made with the 24-inch telescope on Mount Wilson using detectors filtered to have wavelength responses similar to those of the survey detectors.

After the catalog was completed, a comparison of the survey K and I magnitudes and those of Johnson et al. (1966) and Kron et al. (1953) was made. These comparisons are shown in figures 3 to 8.

THE SURVEY

The data represented in the present catalog were obtained from January 30, 1965, through April 7, 1968. Because of limitations in the telescope mounting, the northern limit of the survey was set at +81°. The southern limit of -33° was set to include the region of the galactic center at -30°. Objects at -33° are observed through an air mass of 2.58; the extinction effects on observations further to the south become prohibitive.

Within the limits described above, the areal coverage obtained was as follows:

	Percent
Fraction not covered	0.0
Fraction covered 1 time	0.6
Fraction covered 2 times	28.1
Fraction covered 3 times	35.2
Fraction covered 4 times	21.3
Fraction covered 5 or more times	14.7

The completeness of the catalog covering these areas was maintained by including in it only sources whose K magnitude was less than 3.0. Thus, under the worst conditions, the minimum signal exceeded the noise level by a factor of at leas ? A further check of the completeness was obtained in those cases when the area was surveyed more than once, because the scans during 1967 and 1968 were offset in declination by 7.5' from the previous scans. This offset was such that the zones of maximum sensitivity during the second coverage fell where the minimum sensitivity occured during the first set of scans. Furthermore, as part of the routine processing, a check was made for the sources that appeared either fewer or more times than the area had been surveyed. Finally, about one-fifth of these sources that appeared variable were reprocessed during compilation of the catalog.

Approximately 20 000 sources were detected in the survey. Of these, 5562 were brighter than K=3.0. In addition, 50 sources were included whose average brightness was fainter than K=3.0 but which, according to criteria discussed below, were potentially variable and were observed on one or more nights to be brighter than K=3.0. Of the total of 5612 stars observed more than one 2.2μ measurement was obtained for all but 53 objects. On 361 stars only single measurements were obtained at 0.84μ.

THE CATALOG

The catalog is divided into 12 subcatalogs each of which contains those objects that meet the brightness requirements stated above and lie within a zone 10° wide in declination, centered on integral multiples of 10°. The catalog for each zone has three sections: a main data section, a section for stars with chi-square excesses, and a section for remarks. These will be discussed in turn below.

As a general rule, each observed quantity is listed together with an estimate of its error and of χ^2 for the measurements. The measure of χ^2 was taken to be

$$\chi^2 = \sum_i (x_i - \bar{x})^2/\epsilon_i^2$$

where x is the observed mean of the individual measures x_i and ϵ_i is the assigned a priori error expected for the ith measurement.

For the purposes of this catalog, the estimate of χ^2 for measurements of brightness was used as an indicator of potential variability. Any star was considered potentially variable if χ^2 exceeded that value which would be exceeded only 10 percent of the time if the true errors were normally distributed and consistent with the assumed a priori errors.

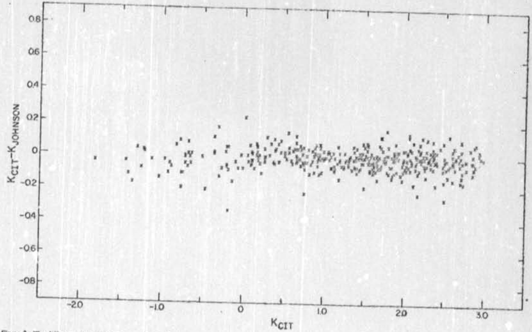

Figure 7.–The difference between the survey K magnitude and that of Johnson et al. (1966) is shown as a function of the survey K magnitude for the 407 stars observed in common. The standard deviation is 0.07 mag and the average value is -0.02 mag. Stars that show potential variability in K are excluded.

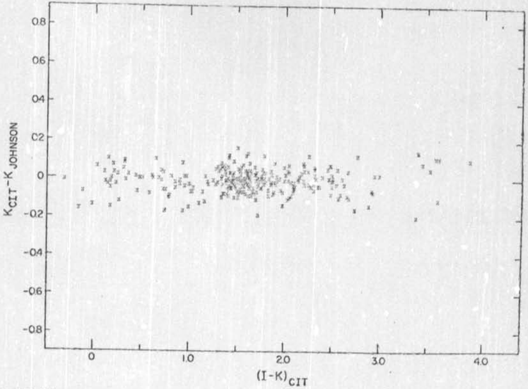

Figure 4.- The difference between the survey K magnitude and that of Johnson et al. (1966) is shown as a function of the color index I-K measured on the survey for 431 stars. Stars which showed potential variability in K or I were excluded.

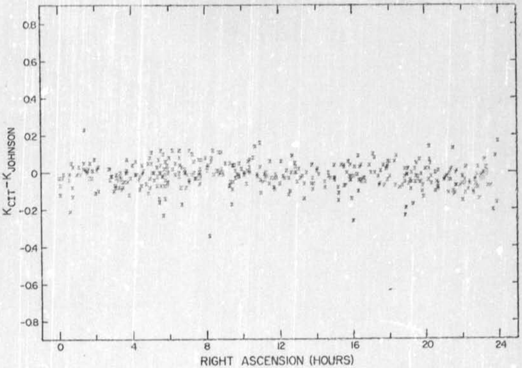

Figure 5.–The difference between the survey K magnitude and that of Johnson et al. (1966) is shown as a function of right ascension. The same standards clearly could not be observed over the entire 24^h range; thus, the lack of systematic variation indicates the consistency of the standards network.

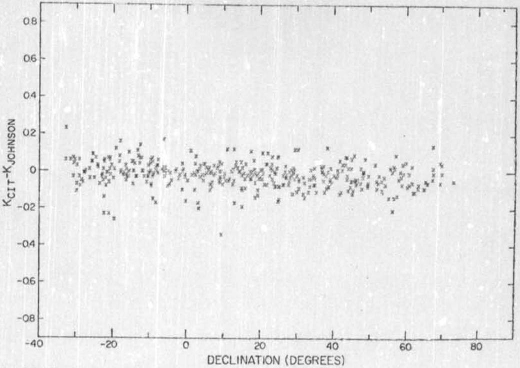

Figure 6.—The difference between the survey K magnitude and that of Johnson et al. (1966) is shown as a function of declination. The systematic drift is probably caused by an error in the air-mass-extinction correction, which was based on the secondary standard stars, rather than on the data shown here.

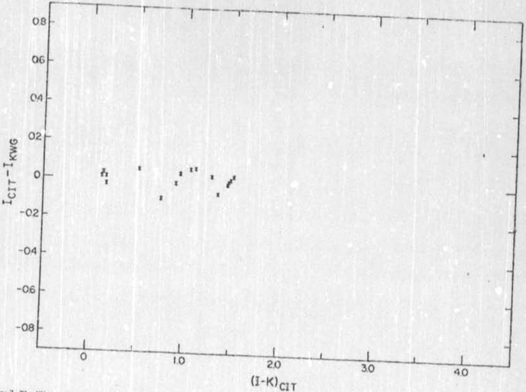

Figure 7.–The difference between the survey I magnitude and that of Kron et al. (1953) is shown for 16 stars observed in common. The zero point of the survey I magnitude scale was actually set using about twice the number of stars shown, but some of these were either offscale at 0.84μ as measured during survey operations or were accompanied by too faint at 2.2μ signal to be included in the catalog.

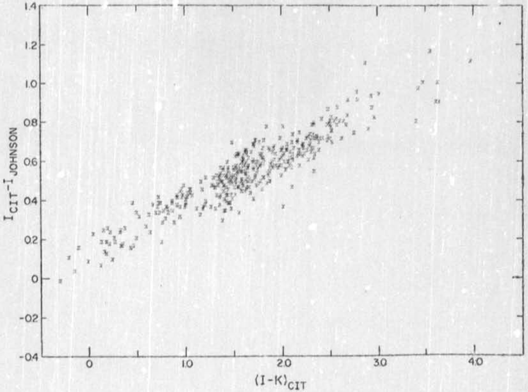

Figure 8.–The difference between the survey I magnitude and that of Johnson et al. (1966) is shown for 431 stars as a function of the color index I-K found on the survey. It is seen that the I magnitude systems differ both in color and the zero point.

Main Data Section— Left-Hand Pages

of various intensities, and were expressed for each observed peak as a combination of a constant error corresponding to K ~ 4 (i.e., the "noise" level) plus an appropriate fractional

Main Data Section — Left-Hand Pages

Columns 1 and 23: Catalog Number

The stars are arranged in order of right ascension within each 10° declination zone. The catalog star number contains a sign and five digits. The sign and first two digits give the central declination, while the last three digits give the number of the star within the zone. An "R" after the catalog number in column 1 indicates that a remark on that star has been included in the "Remarks" section.

Columns 2 to 10: Coordinates

These columns give the measured coordinates corrected for precession to the epoch 1950. No attempt has been made to obtain, or take into account, proper motions. The estimate of the right ascension error is in seconds of time, the estimate of the declination error in minutes of arc.

The errors estimated for each measurement of a star were assigned on the basis of the "peaks" as recorded on the strip chart (fig. 2). A right ascension of $5^s/\cos\delta$ was assigned to each "peak"; the assigned declination error depended on the peak size, peak location within the cell intensity pattern, and the number of peaks observed to make up the star. In a few cases these a priori error estimates were increased because of special conditions prevailing at the telescope. The errors listed in columns 7 and 9 were derived from the estimated errors assigned to each measurement by assuming each measurement of a star to be independent; the number of such independent observations is NK (column 21), the same as the number of K-magnitude measurements.

Fifteen stars were offscale each time they were observed and for these it was impossible to make any coordinate determination. The coordinates of these stars, which were all unambiguously identified, were therefore taken from the *Smithsonian Astrophysical Observatory Star Catalog* and the errors arbitrarily set equal to 0.0.

Columns 11 to 13: K Magnitude

The value of K, the magnitude of 2.2μ, is derived from the average of the observed 2.2μ intensity measurements weighted inversely according to the square of the assigned a priori intensity error. The adopted a priori errors were based upon the performance of the system in recording objects of various intensities, and were expressed for each observed peak as a combination of a constant error corresponding to $K \sim 4$ (i.e., the "noise" level) plus an appropriate fractional error which varied with conditions but was typically 6 percent of the peak height. The number of measurements contributing to the K magnitude is listed as NK in column 21. It should be noted that if the individual measurements differ appreciably, the weighting procedure often biases the result strongly towards the fainter measurements whose absolute errors are small.

An asterisk indicates that all measurements of the source at 2.2μ were offscale, that is, the K intensity exceeded a nominal limit of $K \sim -1.5$. As mentioned above, this limit is not well defined but is a function of the responsivity of the system and the intensity of the 0.84μ signal which, for signals bright enough to require the 10-time attenuator, could obscure or contaminate the recording of the 2.2μ signal. There are 15 cases of offscale 2.2μ measurements.

In order to assess a minimum limit on the extent of contamination of the 2.2μ signal by background stars, a comparison was made of the *S.A.O. Star Catalog* with a preliminary version of the infrared catalog. From those infrared stars that could be identified with stars in the *S.A.O. Star Catalog*, a relationship between spectral class and both V-I and V-K was established. The K magnitude was then predicted for each star that could, on the basis of its location, contribute to the measured 2.2μ flux but that was not identified as the sole source of that flux. If the predicted flux of the extra source exceeded 10 percent of the measured flux an appropriate remark to that effect was entered in the "Remarks" section; 100 stars were found to be contaminated in this way.

Columns 14 to 17: I Magnitude

The value of I, the magnitude at 0.84μ, is derived from the average of the observed 0.84μ intensity measurements weighted inversely according to the square of the assigned a priori intensity error. The a priori errors were assigned by the same procedure as used in 2.2μ. The number of measurements contributing to the I magnitude is listed as NI in column 22. For 119 stars, all measurements at 0.84μ were offscale, and an asterisk is listed instead of an I magnitude.

The measurements of the I magnitude listed in the catalog are more strongly affected by confusion with other stars than are the K magnitudes. There are two main reasons for this: The 0.84μ detector consisted of a single cell spanning an arc of 20′, while the 2.2μ detector was made up of