Figure 2, where the calculated intensities are indicated by filled circles. The synthetic intensity distribution has been calculated for $R = 0.1$ and a central absorption for the stronger Li^7 component of 0.55 per cent. The agreement between the observed and calculated intensity distributions is poor, and there is fairly clear evidence for at least two interloping features of unknown origin in the observed distribution. One is at approximately λ 6707.8 Å and the other at λ 6708.0 Å. The asymmetries of the residual absorption in the two cases might suggest that the assumed lithium line strengths are too high. However, since further refinements would constitute an overinterpretation of the observations, we will adopt the synthetic intensity distribution as representing an upper limit to the lithium absorption in the solar-disk spectrum.

The total equivalent width for the lithium components used in the synthesis is 1.6 mÅ. This value is considered to be an upper limit. Greenstein and Richardson found an equivalent width of 3.7 mÅ. Goldberg, Müller, and Aller (1960) give an equivalent width for Li^7 of 2.6 mÅ, and Dubov (1955) gives an equivalent width of 1.74 mÅ.

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OBSERVATIONS OF EXTREMELY COOL STARS*

As one part of a program of infrared astronomy carried on at the California Institute of Technology, a survey of the sky in two infrared spectral ranges, 0.68–0.92 μ and 2.01–2.41 μ, is being carried out. The motivation for such a survey is to obtain an unbiased census of objects that emit in the 2.0–2.5-μ atmospheric window; this will, of course, include many ordinary stars, but it might also reveal many potentially interesting objects that would not be included in an a priori selection of objects to be measured. In fact, a number of strikingly red stars have already been found. Since most of these "superred" stars occur in the Milky Way, interstellar reddening may be of some consequence; but in at least a few cases the stars seem to be intrinsically extremely red. These preliminary results seem of sufficient interest to merit brief description at this time.

The survey instrument consists essentially of a 62-inch, f/1 aluminized plastic mirror capable of 2′ resolution. The entire mirror is vibrated sinusoidally at 20 c/s so as to move images across a detector system composed of a liquid-nitrogen-cooled, eight-element array of PbS detectors, arranged in a north-south line of four "push-pull" pairs, and a silicon photodetector. Each pair of PbS detectors spans a declination range of 10′ so that 40′ is spanned by the entire array. The Si detector spans a 20′ declination range coinciding with that of the central two pairs of PbS detectors, and is located about 15′ west of the PbS array. The telescope is normally swept in R.A. at 15 or 30 times sidereal rate in a raster pattern one hour of R.A. in "length" with 15′ declination steps. In this way, a strip of sky 3° or 6° wide in declination is covered each night, each point of sky being covered at least twice.

A comparison of PbS signals with the K magnitudes of a number of stars listed by

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Johnson (1962, 1964) and of the Si detector signals with I magnitudes listed by Kron, White, and Gascoigne (1953) shows agreement within about ± 0.2 mag. over a wide range of spectral types. The sensitivity is such that minimum detectable sources have infrared apparent magnitudes of approximately $I \approx 9$ and $K \approx 5$. From results obtained to date, it is estimated that ultimately several thousand objects bright enough at 2.0–2.5 μ to be measured within about ± 0.2 mag. will be detected. Positions can be measured within about 1′ in declination and $0^{m}.1$ in R.A. Although the system is preferentially sensitive to "point" sources, it is calculated that a 450° K black-body radiator with a 10′ radius would give a signal-to-noise ratio of at least 10:1.

To get a preliminary idea of the relative numbers of stars of various colors being detected in the survey, the infrared color indices $I - K$ for about 350 objects in a certain limited part of the sky that includes part of the Milky Way in the Aur-Tau region have been tabulated. The objects were selected to have a K magnitude brighter than about 2 to assure that $I - K$ could be measured sufficiently accurately for all objects. The distribution of measured $I - K$-values shows a steep decline in the relative number of stars per unit magnitude difference beyond $I - K \approx 4$, and it becomes essentially zero at a value $I - K \approx 6$, except for a few stragglers which amount to about 1 per cent of the total.

A study of the latter objects plus a few similar ones that have been found in other areas of the sky has indicated the stragglers have the following properties:

a) They are not just a little redder than the main group, but seem instead to be well separated in $I - K$ from the rest. In fact, there is a suggestion of homogeneity in this group, the value $I - K \approx 7.5$ being a typical color index. Approximately ten such extremely red objects have been observed so far. Of these only one, TX Cam, has been found listed in a catalogue of stars or variable stars.

b) They appear to occur mostly near the plane of the Galaxy, but one has also been found near the north galactic pole.

c) The objects observed so far have K apparent magnitudes between 0 and 2; the latter limit is set by the minimum detectable 0.8-μ signal. Those few objects bright enough to appear on the red plates of the 48-inch Schmidt survey have been identified with faint stellar images—generally fainter than about magnitude 16. Only the brightest of them has yet been seen visually, and it is a difficult visual object even at the 200-inch telescope.

d) An estimate of the temperature of the extremely red objects can be obtained if one assumes the data are representative of a Planck black-body distribution. The color index $I - K = 7.5$ corresponds roughly to the distribution of radiation emitted by a 1000° K black body. Near-infrared spectra of two of the brightest objects, as well as photometry in the 2.0–2.5- and 3.2–4.1-μ spectral ranges, confirm that a black-body radiation temperature on the order of 1000° K is appropriate (J. D. Scargle, private communication; E. E. Becklin, private communication).

e) On the assumption that a star radiates as a black body, one can estimate its angular diameter from its apparent magnitude. A 1000° K black body of apparent magnitude $K = 0.0$ should have an angular radius of approximately $0''.04$, or about 10 $R_{\odot}$ per parsec distance. If the apparent tendency toward occurrence near the plane of the Galaxy is real, this would imply large distances and huge sizes for these objects.

The approximate positions and preliminary magnitude estimates for two of the brightest of the infrared objects are as follows:

α (1965)	δ (1965)	I	K
$3^{h}51^{m}.5$	+11°18′	7	0
20 45 2	+39 59	8	1

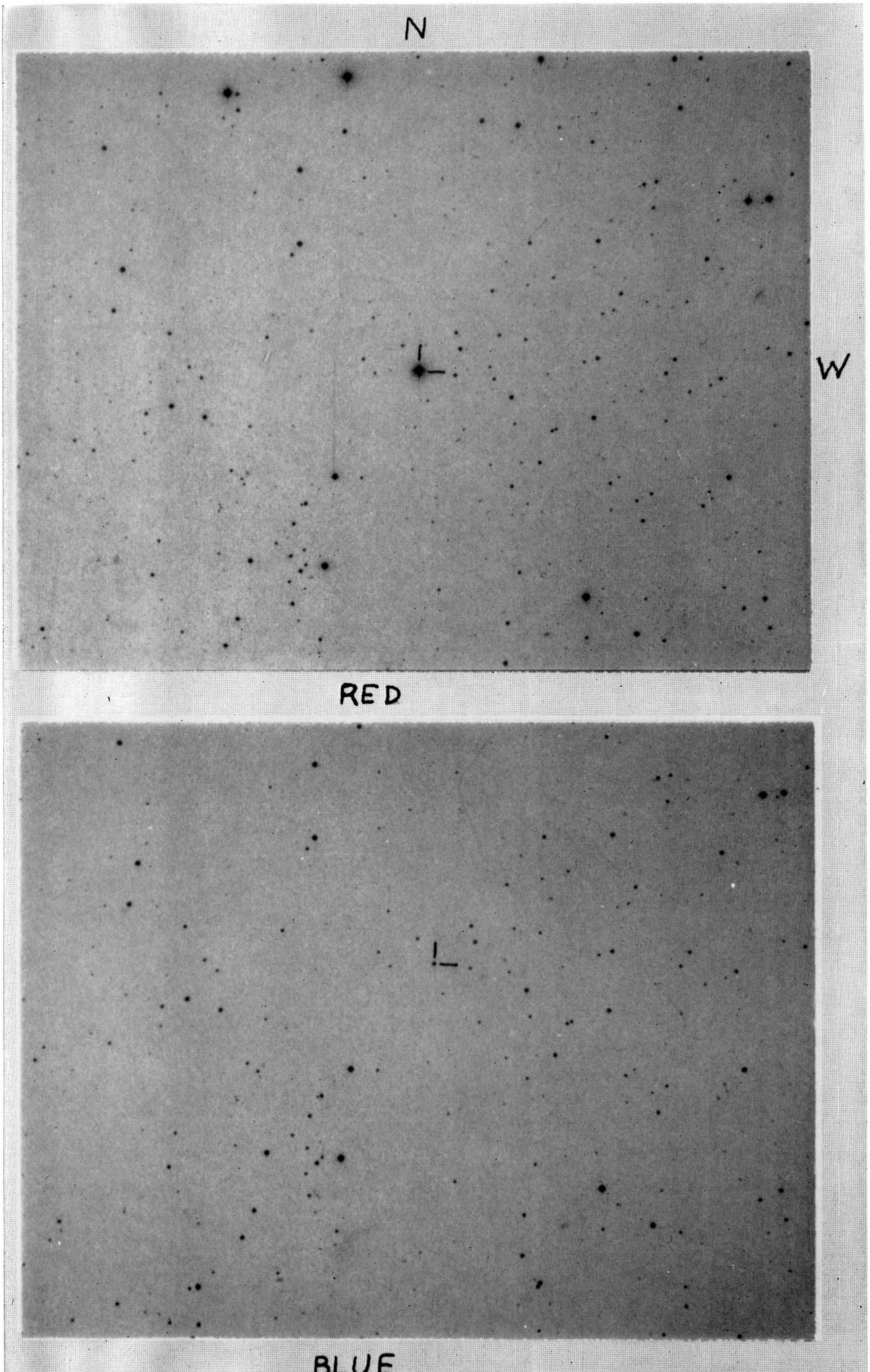

FIG. 1.—Taurus source

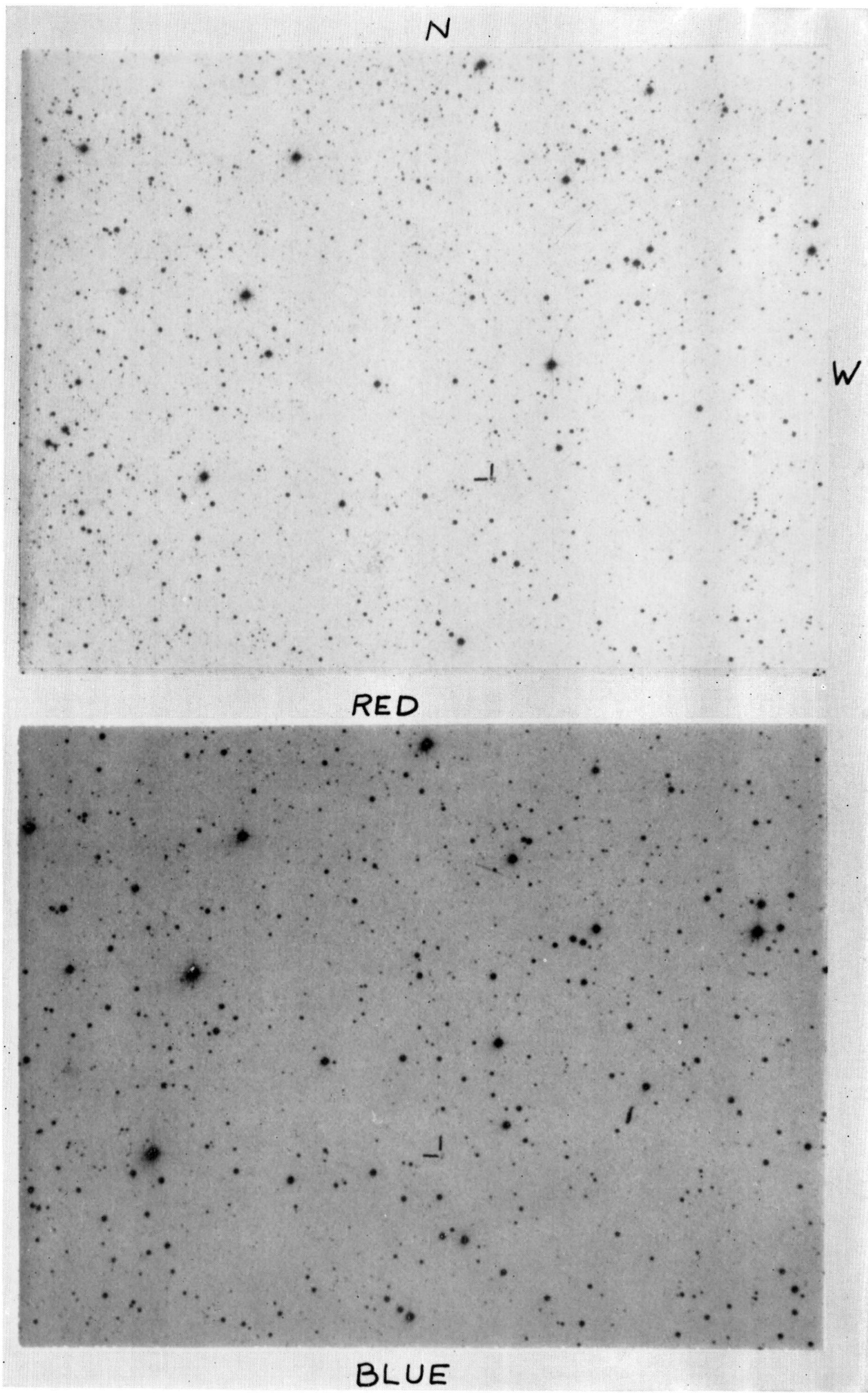

FIG. 2.—Cygnus source

Portions of the red and blue plates of the 48-Schmidt camera survey showing the sources in Taurus and Cygnus are given in Figures 1 and 2.

Further information concerning the numbers, positions, and other properties of these infrared stars will be published as it becomes available in the course of the reduction of the sky-survey data now under way.

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THE SPECTRA OF TWO EXTREMELY RED OBJECTS

The unknown nature of the objects discovered by Neugebauer, Martz, and Leighton (1965), as described in the preceding letter, has prompted us to attempt a preliminary study of their spectra. On October 1, 1964, a photographic spectrum of the object in Taurus (R.A. = 3^h51^m5, $\delta = +11°18'$) was obtained with the prime-focus spectrograph of the 200-inch telescope, using a IV-N ammoniated emulsion and a linear dispersion of 370 Å/mm. The spectrum exhibits the characteristics of a very advanced spectral type, the most prominent features being the VO band systems around λλ 7400 and 7900 Å. The band heads of TiO appear less pronounced than in the M6 giant standard HD 196610 and through the region λλ 6700–8900 Å also show a steeper density gradient than the M6 standard. The lack of standards for later types does not allow us to assign a precise spectral type, but from the definitions of the classification system established by Sharpless (1956) we can say that the spectral type is not earlier than M8, and also that it probably is not a main-sequence object.

Measures of the energy flux in the Taurus object and also the Cygnus object (R.A. = 20^h45^m2, $\delta = +39°59'$) were made on September 29 and 30, 1964, with the Cassegrain spectrum scanner of the 60-inch Mount Wilson reflector, using an RCA 7102 photomultiplier as detector. The spectral range longward of 8000 Å was measured first with a pass band of 50 Å, and later smaller wavelength intervals were searched with band widths as small as 2 Å. Using α Lyrae as a standard and following the procedures developed by Oke (1964) to reduce the data to absolute units, we find that the fluxes from the two objects, reduced to zero air mass, at those wavelengths where band absorption is not prominent, are as given below.

λ (μ)	1/λ (μ^{-1})	Taurus Object	Cygnus Object
0 8805	1 125	2 1×10^{-18} W/cm² Å	…
1 025	0 975	15	0 79×10^{-18} W/cm² Å
1 080	0 925	26	