OPTICAL FILTERING FOR STAR TRACKERS

Final Report for NASA Grant 10-008-009

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I. INTRODUCTION

In seeking parameters which are well suited to automatic identification of stars, one is naturally led to considerations involving optical filters. Therefore the central problem toward whose solution this grant work has been directed is the optimization of optical filtering for star trackers. Since light gathering power is low for the optics used in most star trackers, it has been common practice to dispense with optical filters so as to use all available light. However, this procedure introduces two further difficulties: 1. the anode current of a tracker now becomes strongly dependent on the spectral response of its particular photocathode* (i.e. no two trackers will respond alike to a sequence of stars having various spectral energy distributions) and, 2. the extensive lists of star magnitudes, published over the years by astronomers, cannot be used since astronomers do not make observations without filters.

When only a few of the very brightest stars in the sky need be tracked, it is possible to identify them by coarse pointing and rough brightness measures, but eventually it may be necessary to track much fainter stars, perhaps down to the fifth magnitude. This is because the first and second magnitude stars are not sufficiently numerous nor uniformly distributed to provide guide stars wherever

*We consider here only trackers which employ photoemissive detectors.

they may be needed. When dealing with these fainter stars, however, it will be necessary to recognize them by accurately measured magnitudes (or possibly even magnitudes and color indices). Thus it appears that optical filters may become necessities as increased performance is demanded of star trackers. Given that optical filters are to be used, we next ask what the optimum specifications are for such filters, recognizing that these specifications may depend to some extent on particular mission requirements. The characteristics of a filter may be approximately described by three quantities: a) the wavelength of maximum transmission, λ_{max}, b) the width of the transmission curve at half transmission, and c) the percent transmission at λ_{max}. Unless we use very narrow filters, c) is not a strong variable and is usually in the range of 80 to 90 percent. For practical purposes, therefore, optimizing filter characteristics reduces to answering the following two questions: A. What is the most favorable effective wavelength for observing the desired guide stars? B. What bandwidth is most desirable at this effective wavelength? Optimization criteria for points A and B will be discussed in the following sections.

In order to become intimately familiar with the operation of a typical star tracker, and to test empirically conclusions reached from mathematical models, an all-electronic tracker utilizing a star-tracking photomultiplier was constructed. This was tested on a simulated second magnitude star, on loan from the Systems Division of Goddard Space Flight Center. This tracker is described in Section IV. Experience with the tracker is described in Section VI.

An additional program involved production of tables of outside atmosphere sky brightness for the use of persons selecting guide stars. A rather large sample of sky is measured unavoidably along with each guide star, and in certain unfavorable cases this sky light might become comparable to that of the star. It is important, therefore, to insure that sky brightness is not objectionably great in the vicinity of each star. Finding the brightness at a particular point on the celestial sphere is complicated, however, by the fact that the Zodiacal light moves with respect to the stars (in particular, with respect to the Milky Way) throughout the year. The computations are further complicated by the multiplicity of coordinate systems in use. Normally the user will want the answer in equatorial coordinates, but the Zodiacal light is given in ecliptic coordinates and the Galactic light in Galactic coordinates. The present tables give the sum of Zodiacal and Galactic light in equatorial coordinates for the beginning of each month. They have been printed separately as Goddard Space Flight Center Publication X-732-69-96 (Convenience Tables of Outside Atmosphere Sky Brightness) and are also printed here as Appendix I.

Time did not permit completion of one project, the computation of an improved spectral energy distribution for integrated Galactic light. However the spectral energy distributions for certain types of galaxies have recently been computed by Grewing, Demoulin and Burbidge (1968), and we recommend use of their tables to replace those by Quasuis and McCanless (1966). The latter authors have grossly overestimated the amount of blue and ultraviolet radiation present

in Galactic light because they have overestimated the abundance of high temperature stars by a large factor. It is possible to compute a spectral energy distribution for Galactic light which is more suitable for tracking problems than those available from Grewing, Demoulin and Burbidge, since their galaxies were of a different type than the Milky Way. However, we recommend their results for present use.

II. FILTER OPTIMIZATION FOR PRE-SELECTED GUIDE STARS

Choice of the effective wavelength and bandwidth for trackers divides naturally into two separate cases. The first case, which we consider in this section, is that in which a set of guide stars has been pre-selected. An example of such a set is the list of 34 guide stars for the Orbiting Astronomical Observatory (OAO), which are given in Table 1. In the second case we are limited only by the availability of stars in the sky. That is, the guide stars are to be selected along with the filters. This problem is considered in Section III.

Two fundamental aspects are common to both of the above mentioned cases. One is the requirement for a compromise between a small bandwidth for reliable stellar magnitude determinations, and a large bandwidth to pass greater signals. The other is the selection of the wavelength at which we have maximum available signal to noise ratio (S/N). When the set of guide stars is pre-determined, this becomes particularly straightforward. That is, we first find the wavelength at which we have maximum S/N for our faintest guide stars, and then choose a filter at this effective wavelength having the narrowest bandwidth which gives sufficient S/N (with, perhaps, a safety factor) to insure reliable operation of the tracker.

In outside atmosphere photometry, we maximize the signal to noise ratio if we maximize the signal. It is well known that Johnson noise (thermal noise from resistive elements) is negligible compared to shot noise (arrival fluctuations for photoelectrons) for photomultiplier detectors. Also atmospheric scintillation noise will be absent and shot noise due to dark current and sky current, even if

not completely negligible, will usually be quite small. Therefore the only important primary source of noise is shot noise in the star current, and since this is proportional to the square root of the signal, S/N will grow as the square root of the signal. Our problem now reduces to maximizing the arriving signal strength or, more specifically, to choosing the wavelength at which the faintest guide star on the list has the maximum signal. The star signal in which we are most directly interested is not the energy flux or even the photon number flux but rather the number flux of cathode photoelectrons. At a fixed wavelength, of course, the number of cathode electrons is directly proportional to the photon flux (their ratio, Q_λ, is the quantum efficiency) but the constant of proportionality changes with wavelength. Obviously, a large quantity of starlight coming at a wavelength to which the detector is not sensitive does not increase our signal, so we want to study the variation of expected cathode electron flux with wavelength for the 34 OAO guide stars. This has been done separately for S-4, S-11, and S-20 cathodes as well as for direct photon fluxes, and the results are shown graphically in Figures 1-3. In these black and white reproductions, the separation of individual stars is somewhat more difficult than in the originals, where stars are differentiated mainly by colors. However separate color prints of the originals will be submitted with the report. The vertical scale requires some explanation. A logarithmic scale of some kind is required to preserve a common form of SED for bright and faint stars. Furthermore, since we are dealing with stars, it seems appropriate to use a stellar magnitude scale.

Therefore, the vertical scale is -2.5 times the common logarithm of the quantity (cathode electron flux for the given star divided by cathode electron flux for α Lyrae at λ5438). That is, all cathode electron fluxes are normalized to that for α Lyrae at λ5438, and we then plot minus 2.5 times the logarithm of this quantity.

Sources for the data of Figures 1-3 were necessarily quite varied, and the original formats and units required considerable processing before direct comparison became possible. With the recent interest in absolute photoelectric spectrophotometry of stars, this situation is rapidly improving, but the present results had to be taken from four different sources (Bahner, 1963; Oke, 1960; Willstrop, 1965; and Barbier and Chalonge, 1941). In general, the units, normalization factors, and tabulation intervals were different in all of these sources, so the preparation of Figures 1-3 was considerably more troublesome than one might suspect. Now that we can compare all 34 stars on a common basis, however, an interesting feature is apparent. If we neglect the star α Tau for the moment, we see that the lower envelope of the SED's for the other 33 stars is very well defined. That is, there is a large density of points just above the envelope, but there are no points below it. Therefore the highest point reached by this lower envelope provides a very satisfactory solution to our problem of maximizing the signal from the faintest OAO guide star. This maximum occurs not far from λ4000, and for an S-20 cathode we see that the faintest OAO stars have about 3.5 times more signal at this wavelength than at

λ5500, which corresponds approximately to visual observations. We also see that the SED of α Tau crosses the lower envelope at about λ4800 and falls far below at shorter wavelengths. Therefore α Tau should be replaced on this list by a bluer star if our filter recommendation (next paragraph) is adopted.

The optimum value of λeff, based on this information, depends somewhat on the bandwidth employed because the envelope falls off much more steeply toward short wavelengths than toward long wavelengths. With a very narrow filter we would prefer a value of λeff just short of λ4000 (perhaps λ3900), but with a broader filter of, say, 1000 Å half-width, λ4200 would be better. At this point it should be mentioned that one further consideration has some importance, as follows. The Balmer discontinuity and the general decline in received signal due to the confluence of the Balmer lines of neutral hydrogen between λ3647 and λ4000 have been shown to have an undesirable effect on magnitude and color transformations. Johnson (1952) has pointed out that it is not always possible to predict magnitudes on one system from magnitudes on another when one or both of these systems have significant response shortward of λ3800. For this reason it would be best to exclude this region from tracker filters, which would probably mean shifting the wavelength of peak transmission to λ4300 or λ4400.

The effective wavelength of the astronomical B system (the blue magnitude of the U, B, V photometric system, Johnson and Morgan, 1953), is about λ4350 to λ4400, so this magnitude system seems especially well suited to the present

problem. A further advantage to using filters similar to those of the B system would be the availability of measured magnitudes for all stars sufficiently bright to be considered as guide stars within the forseeable future.

We now are to choose the most favorable bandwidth for our blue filter. Defining, as usual, the bandwidth of the filter as the full width at half-transmission (commonly called half-width) we find this to be about 950 Å for the standard B filter of U, B, V, against about 2200, 2300, and 2800 Å for S-4, S-11, and S-20 photocathodes, respectively. Persons making tradeoff analyses between wide and narrow bandwidths will now be interested in the loss of signal for various bandwidths. Computations have been carried out to illustrate this, and are given in graphical form in figure 4. Since the B filter appears so well suited to our problem, the computations on which Figure 4 is based have been limited to this particular filter. Some discussion of the B filter is now in order. The nominal specifications for the filter have been published in several places (eg. Johnson, 1955). It consists of Corning 5040 blue glass, standard optical thickness, in combination with 2 millimeters of Schott GG13. "Standard optical thickness" means that the thickness has been adjusted, for a particular melt, to give a filter whose absolute spectral transmission agrees well with the catalog transmission curve for that type of glass, Corning 5040 glass has appreciable transmission below λ3800, the region of difficulty with regard to magnitude transformations, so the Schott GG13 ultraviolet absorbing glass has been added to provide a short wavelength cutoff.

Our present choices are not limited to the extremes, i.e. the standard B filter or no filter at all. We may also choose a filter generally similar to the 5040-GG13 standard combination, but with greater transmission gained by the use of less than standard optical thickness. In our computer calculations we have retained the standard 2 mm of Schott GG13 but varied the thickness of the Corning 5040 to 0.50, 0.75, 1.25, 1.50, and 2.00 times standard. The computations were performed as follows: The percent transmission, T_λ, at a given wavelength, λ, is given by

$$T_\lambda = e^{-k\lambda x} \, T_\lambda (GG13) \, R_\lambda^4 \qquad (1)$$

Here k_λ is the monochromatic absorption coefficient for Corning 5040 glass, X is the thickness of the 5040 glass, T_λ (GG13) is the percent transmission of 2 mm of GG13 glass (given in Table 2), and R_λ^4 is the total reduction by reflection losses at the four surfaces. R_λ^4 was assumed constant with wavelength and equal to 0.815. Equation (1) now reduces to

$$T_\lambda = \text{constant} \; (e^{-k\lambda x}) \qquad (2)$$

If we take standard optical thickness as our unit of length, equation (2) takes the simple form

$$T_\lambda = \text{constant} \; (e^{-k\lambda}) \, , \qquad (3)$$

and since T_λ is provided by the Corning catalog, the computer can solve for k_λ at representative values of λ (here every 100 Å). We can now substitute $X = 0.50, 0.75$, etc. into equation (1) and find the overall absolute transmission of modified B filters of various thicknesses. Thus, if it is not desirable to use a standard B filter with the accompanying signal loss, one can select from Figure 4 a filter thickness to effect a reasonable compromise. Since the computations are rather simple, they have been done for many combinations of filter thickness and cathode response (i.e. S-4, S-11, and S-20).

To use this information, we first decide how many stellar magnitudes can be sacrificed to the filter losses. That is, we find the difference in magnitude between the faintest star that can be tracked without a filter and the faintest star we desire to track. For example, a given system may be capable of tracking stars to magnitude 4.0 but, for a given application, it is only necessary to track stars of magnitude 2.5. We can afford the loss of 1.5 magnitudes, or a factor of about four in signal, in order to recognize stars with greater reliability. Figure 4 now tells us the filter thickness corresponding to $1^m.5$ of filter losses, and this is the narrowest usable filter for our particular mission.

In summary, we have the following recommendations for observing the stars of the OAO list with filtered tracker optics.

1. For maximum S/N, use a filter whose effective wavelength falls in the range λ3900 to λ4500.

2. To eliminate difficulties with the Balmer discontinuity and Balmer lines,

exclude light shortward of λ3800.

3. There should be a compromise between large bandwidth to increase signals and small bandwidth to improve recognition capability, as discussed above.

4. The B filter of the U, B, V system is well suited to this problem on all counts. Figure 4 may be used to adjust the filter characteristics to meet particular requirements.

5. The star α Tau should be replaced by a bluer star or simply eliminated if the present filter recommendations are adopted.

III. FILTER OPTIMIZATION FOR AVAILABILITY LIMITED GUIDE STARS

A problem of more general interest than that of Section II is that of selecting optimum filter specifications when any stars at all may be used as guide stars. As before, choice of the acceptable filter losses will involve a compromise between large bandwidth for small losses and small bandwidth for easy star recognition, but we now have an additional degree of freedom since the optimum effective wavelength may depend to a considerable degree on the particular guide stars selected. To illustrate this point, suppose a different set of 34 stars were on the OAO guide star list, and suppose the lower envelope of their composite SED graph peaked at λ 6000 instead of approximately λ 4000. Obviously our filter recommendations at the end of Section II would have been quite different. Of course we could not really change to a completely different set of OAO guide stars because a sufficient number of bright stars does not exist, but when we deal with fainter stars we have a much greater selection. At first sight it might seem that we could simply repeat the process of Section II for third, fourth, and fifth magnitude stars, but there are two difficulties with this idea. The first is that the number of stars to be graphed becomes almost prohibitive, both from the standpoint of producing and also of using the graphs. Even if we are willing to accept this practical difficulty, however, we see that this approach does not produce a unique answer to the problem, for we would have to decide whether to include stars to the fifth B magnitude, fifth V magnitude, fifth S-4 magnitude, etc. Naturally, when we do have an answer as

to the most desirable wavelength at which to observe, we would not like it to depend on such an arbitrary matter as the choice of a particular system for expressing magnitudes. If we are to specify characteristics so as to optimize a passband for some application, we must begin with a clear idea of what would constitute optimum performance. We cannot simply decide to tailor the filter for maximum signal for a particular kind of star, because we do not know at this stage what kind of star will be tracked. That is, the optimum filter effective wavelength will depend on the SED of the available stars but, even if we can select guide stars from the entire sky, we cannot say which stars will be available until we know the limiting magnitude of the system. Moreover, we would have to express this limiting magnitude on some particular magnitude system which, to be strictly logical, should have the same effective wavelength as the tracker response, but we do not yet know the effective wavelength because that is the quantity we set out to optimize.

This shows that we cannot develop a straightforward scheme to maximize the signal for the faintest guide stars when we do not know in advance which stars are to be tracked. The wavelength of maximum signal depends on which stars are to be tracked, but which stars are to be tracked depends on the wavelength of maximum signal, so we have a circular argument. We can, however, proceed in an entirely straightforward manner if we agree to maximize a different quantity. We shall maximize the number of stars above a specified signal level. This is certainly a reasonable criterion because the

only fundamental limitation we have is the availability of real stars in the sky. Accepting, as before, the time averaged number of cathode photoelectrons as our signal, we proceed by specifying this number and then listing the number of stars which exceed this signal level as a function of wavelength.

In doing this, we encounter several practical difficulties. We would like to do this down to, say, the fifth magnitude, but spectrophotometric observations are lacking for most stars in this brightness range. Also, since the number of stars will be large, data handling problems would be prohibitive even if such spectrophotometry did exist. However, since we do not need extreme accuracy for this problem, a simple alternate approach is provided by the large body of B, V photometry which exists for bright stars. The SED's of most stars can be represented to excellent accuracy, in the visible region of the spectrum, by a Wien approximation. i.e.

$$W_\lambda = \frac{C_1}{\lambda^5 e^{c_2/\lambda T}} \tag{4}$$

or, dividing by hc/λ to find the number flux of photons

$$N_\lambda = \frac{C_1}{hc\lambda^4 e^{c_2/\lambda T}} = \frac{K_1}{\lambda^4 e^{K_2/\lambda}} \tag{5}$$

The observed B and V magnitudes of a star provide two points on its SED, thus giving an exact solution for our two constants, K_1 and K_2. With K_1 and K_2 known, we can use equation (5) to compute the numbers of photons at other wavelengths, and if we multiply these numbers by Q_λ, the quantum efficiency of the cathode, we obtain the number of cathode photoelectrons as a function of wavelength. These calculations are well suited to computer processing, and have been carried out so as to give the number of stars above a fixed signal level as a function of wavelength and for many signal levels. The computations were for S-4, S-11, and S-20 cathodes as well as for direct photon fluxes (i.e. $Q_\lambda \equiv 1$). The faintest stars are about fifth visual magnitude. All known variable and visual binary stars have been edited from our list of prospective guide stars. The results, in tabular form, are given in Appendix II and also in GSFC Publication X-732-70-125. In these tables we see for typical values of the threshold signal, (N_e^{min}) a broad maximum which peaks between λ4000 and λ 4500. For some values of N_e^{min} the curve is still rising at λ4000 but, for the reasons given earlier, we do not recommend use of these wavelengths. The most obvious information provided by these curves is that the choice of wavelength is not critical as long as it is in the blue or blue-green region. As a general rule, the number of available guide stars will be reduced by a factor of two, compared to the peak wavelength, at about λ 5200. It then drops quite rapidly for longer wavelengths.

IV. LABORATORY OPERATIONS

The next and final specification we must make for the optical passband is the half-width. As pointed out earlier, decisions on this parameter depend on the signal-strength requirements of the instrument because, for the trackers we are considering, maximization of the signal will minimize the relative noise. It appears that all-electronic, as opposed to part-mechanical, trackers have the most potential for future applications. Therefore, following a block diagram, including block transfer functions, for a particular all-electronic design supplied by NASA (which we understand is typical of present day designs), we constructed a bench model version of an image dissector type star tracker. This was considered necessary in order to gain general familiarity with the operation of one such device. Our tracker has two-channel operation (pitch and yaw), is constructed largely from integrated circuits, and reproduces, as accurately, as can be discerned, the overall transfer function of the NASA tracker. At the time of expiration of the grant we were at work on the acquisition mode circuitry, and it is a shortcoming of this report that a theory of the effects of noise on the acquisition mode, based on experiments, cannot be given. However we feel that we were fortunate to construct and test the track mode circuitry within the two-year grant period. Of course the partially completed acquisition mode circuits are in storage, and it may prove possible to continue work on this phase in the future. Figure 5 shows the completed instrument, from several views, in the test situation. Figure 6 is a view of the fully constructed and mounted circuit boards.

The basic design of the NASA tracker can be inferred from Figure 7. A 3200 hz multivibrator provides the internal clock signals through which all functions of the tracker are synchronized. This 3200 hz square wave is divided by a series of flip flops to 1600, 800, and 400 hz square waves which are used to construct the driving current for the pitch and yaw deflection coils of the star tracking photomultiplier and for activating switches in the subsequent logic circuits. The Miller integrator provides the triangular waveform which is also needed in forming the coil current.

Figure 7 illustrates only the yaw channel, and a dummy pitch coil, for constant deflection, is shown. However the actual pitch channel is identical in operation to the yaw channel. After amplification, the right-left information in the photomultiplier anode current is converted to plus-minus information by the indicated gates and polarity inverter. It is then smoothed by the low pass filter and averaged over many cycles by the tracking integrator and summer. The mean value is then applied to the (yaw) coil current so as to correct any deviation of the star image from a pre-assigned spot on the photomultiplier cathode. In a complete tracker, this spot would have been assigned by the acquisition mode circuitry.

Figure 8 shows what takes place in the star tracking photomultiplier. In the focal plane for electron star images is a plate perforated with a small hole. Proper initial dc bias currents in the deflection coils bring the electron image of a particular star to the center of this opening. Upon transfer from the

acquisition to the track mode, the scan pattern shown in the figure is begun. The star thus exits to the right, returns, exits to the left, returns, exits at the top, returns, exits at the bottom, and returns, during one complete scan. Each of these excursions is equal to twice the radius of the opening, and the tracker extracts position information by comparing the intervals spent in and out of the aperture on the right swing as opposed to the left swing (or up and down swings in the pitch channel). Below the scan pattern (Figure 8b) is shown the idealized photomultiplier output for a diametral crossing of the aperture. It is not rectangular because the electron image of the star is not sufficiently sharp to produce a rectangular profile, but it is converted to a rectangular profile by the video amplifier and inverter (Figure 7). We shall see that this must be recognized in developing a theory for the dependence of output noise on star brightness (Section V). Figure 8c shows the schematic waveforms produced in this step. Most of the internal waveforms of interest are shown in the timing diagram of Figure 9.

The block diagram of Figure 10 shows the transfer functions of the various logical subunits of the tracker. By adjusting the constants K_1 through K_5 it proved possible to reproduce quite faithfully the response to a step input for the original tracker. The theoretical response is shown in Figure 11 and the response actually realized in Figure 12. Figure 12 also shows the mechanical rig used to produce a step input in the star position. A slide containing a relatively large hole is moved along a track so as to simultaneously cover one pinhole (artificial

star) and uncover another a short distance to the side. The separation of the pinholes is somewhat exaggerated in the diagram. Their actual separation was such that, with one just covered, the other was just uncovered so that a small motion of the slide caused one to appear at essentially the same instant as the other disappeared.

We have found that the track mode operates reliably in the presence of a great deal of noise, and we shall see that this favorable characteristic may be attributed to its general principles of operation. The device will track artificial eighth magnitude stars reliably and ninth magnitude stars marginally using only a two-inch aperture collecting lens. A ninth magnitude star is about one-sixteenth as bright as the faintest stars visible to the naked eye. The photomultiplier anode current for such faint stars shows so much noise that it is entirely impossible to see the bell-shaped profile of Figure 8b when this signal is displayed on an oscilloscope. Figure 13 shows the anode waveform one actually sees for a much brighter star (about first magnitude).

In order to investigate the capability of the tracker for following moving sources, we attached a pinhole light source to the pen movement of a potentiometer strip chart recorder and applied the output error signal from the tracker yaw channel as the input to the recorder. Mechanical motion of the entire recorder then simulated a moving light source. The tracker responded by changing the error output to keep the pen in a constant position regardless of mechanical motions of the recorder casing. We intended to study the angular rates at which

the instrument could track stars of various magnitudes, but unfortunately, time did not permit this. Again, this is a point which could be taken up in the future.

In summary, our bench model star tracker shows that, insofar as the track mode operation is concerned, its design is far more than adequate for applications to rather faint stars. Of course for most uses the limiting magnitude would be set by the acquisition mode, but since it proved impossible to complete work on that part of the tracker within the grant period, we have applied our attention to experimental and mathematical descriptions of the track mode peformance, as described in the following section.

V. DEPENDENCE OF OUTPUT ERRORS ON STAR BRIGHTNESS

Our star tracker is a null device so that, in order to follow the standard procedure of describing its signal to noise ratio, it is necessary to specify some particular input signal. For example, we might specify that the signal to noise ratio should be evaluated at ten seconds of arc from null (the signal). Since in a star tracker the noise is not a strong function of the angular distance from null, we view this as an artificial procedure. We shall, therefore, concern ourselves only with the noise output at null and the way in which this varies with star brightness.

There are two basic internal time constants which concern us in developing an understanding of the operation of the tracker. The first is a short time constant, τ, which is the interval during a particular sweep of the basic cycle within which the tracker smooths the photomultiplier anode current. A lower limit to τ is set by the photomultiplier itself through the internal dispersion in transit time for electrons traversing the tube's dynode structure. The oscilloscope traces in Figure 13 show that τ is sufficiently short so that individual pulses are at least partially separated. The longer time constant, τ', is the number of complete cycles (each of which lasts 0.005 seconds) over which the tracker averages the internal error waveforms. That is, τ' is the overall response time of the tracker. The particular numerical values of τ and τ' for our tracker are not of central interest in the remaining discussion as long as their orders of magnitude are established. To this end we note that τ is of the

order of 10^{-7} to 10^{-8} seconds, while τ' is of the order of 10^{-1} seconds.

In the general transfer equation of the device, using O for the output transform and I for the (noise) input,

$$\frac{O(\omega)}{I(\omega)} = T(\omega) \tag{6}$$

we assume that

$$I(\omega) = I'(\omega)A(m) . \tag{7}$$

That is, the noise input is some function of stellar magnitude times $I'(\omega)$, the noise input for a star of some particular magnitude. We therefore assume that the frequency dependence of the input noise is independent of the brightness of the star, which should certainly be the case since it is due to the shot effect. Thus

$$O(\omega) = T(\omega)\, A(m)\, I'(\omega) \tag{8}$$

and

$$\int_{\omega} O(\omega)\, d\omega = A(m) \int_{\omega} T(\omega)\ I'(\omega)\, d\omega \tag{9}$$

The left side is the noise integrated over all frequencies, which is the quantity we wish to investigate. The integral on the right is a constant for a particular tracker, which we shall not treat further because of the general nature of our

discussion. We now have

$$\text{Total noise} = \text{constant X } A(m) \tag{10}$$

and our problem becomes one of finding the functional form of $A(m)$.

The input angle, θ, is measured by the time integral of $\phi(t)$ which is waveform I of Figure 9. Let us consider $P(t)$, the probability of being in the wrong switching state (i.e. indicating that the electron image of the star is out of the aperture when it is actually in, or vice versa.) $P(t)$ naturally reaches a maximum value of 0.5 at the switching points and falls rapidly to small values at points well away from the switching points. We now divide one cycle of the basic waveform, $\phi(t)$, into bins of length τ. τ may now be interpreted as the time constant for independent decisions or switching. In each bin, occurring at time t (which we understand to be reinitialized to zero at the start of each cycle, and is therefore a phase), $P(t)$ is a function of the number of arriving anode pulses. Assuming Poisson statistics for these anode pulses,

$$P(t) = \sum_{k_{switch}}^{\infty} \frac{\lambda^k}{k!} e^{-\lambda} \tag{11}$$

if we are below the nominal switching point, and

$$P(t) = \sum_{0}^{k_{switch}} \frac{\lambda^k}{k!} e^{-\lambda} \tag{12}$$

if we are above the nominal switching point.

Here λ = np where

n = the number of trials in time interval τ (taken fairly large)

k = the number of successful trials (get a photon)

P = the probability of getting a photon in our small time increment of length τ/n.

Also N(t) = (the number of trials per large time constant, τ') X P(t)

N(t) is thus an average value for the number of times the tracker is in the wrong switching state at phase t per large time constant (τ'). In its normal operation, the tracker repeats this experiment for each time increment, τ'. Of course, N(t) is a smooth function, so we must also consider the values, N'(t), actually realized at each time increment, τ'. N'(t) will then be a statistical quantity, and the distribution of its values in a large number of trials should also be Poisson, i.e.

$$P'(k')_t = \frac{\lambda'^{k'}}{k'!} e^{-\lambda'} \qquad (13)$$

where now k' is the number of times the tracker was in the wrong state and $\lambda' = n'P(t)$ where

n' = the number of repetitions of the basic experiment (stepping in time),

P(t) = N(t) /total number of trials

note: this is therefore the same P(t) used in the previous step (Equations (11) and (12)).

We are interested in the standard deviation of $N'(t)$, which is given by

$$\sigma_t = \sqrt{N'(t)}. \tag{14}$$

Finally we want to find the rms value of σ_t averaged over τ'; i.e. we want

$$\sigma_{total} = \sqrt{\frac{1}{m}\sum \sigma_t^2}. \tag{15}$$

σ_{total} measures the total noise in θ due to photon statistics.

We thus see that the total noise in the output error signal is proportional to the square root of $\Sigma N'(t)$ where the summation is over the time interval τ', and therefore $\Sigma N'(t)$ is the average number of times the tracker is in the wrong switching state per long time constant. $N'(t)$ itself is basically found from the earlier statistical formulas (11) and (12), but it is not obvious that we can use a simple square root law here because $P(t)$ in (11) and (12) is measured by the areas under the tails of a Poisson distribution rather than by the width of the distribution. However we can adopt the working hypothesis that a square root law will be an adequate representation, and consider the consequences. If these theoretical consequences disagree with our experimental findings, the problem can then be looked at more closely. With this assumption, we see that the total noise in the output error signal should decrease with the fourth root of the photon arrival rate because it was proportional to $\sqrt{\Sigma N'(t)}$, but $N'(t)$ is inversely

proportional to the square root of the expected number of photons in time constant τ, through Equations (11) and (12) and the accompanying definitions. Letting

$$A(m) = \text{const.} / \sqrt[4]{F} \tag{16}$$

where F is the photon flux, and remembering that

$$m = -2.5 \log F \tag{17}$$

we have

$$F = 10^{-.4m} \tag{18}$$

and

$$A = \text{const.} / \sqrt[4]{10^{-.4m}} \tag{19}$$

or

$$A(m) = \text{const. } X\ 10^{+.1m} \tag{20}$$

or

$$\log A(m) = 0.1\ m + \text{constant} \tag{21}$$

which we next attempt to verify by experiment.

VI. EXPERIMENTAL NOISE MEASURES

In the interest of rapid and impersonal noise measurement, a noise meter was constructed. This device measures the integrated noise above approximately one hz and was used to find the experimental relation between tracker noise (in the output error signal) and star magnitude. Stars in a range of brightness from about first to about ninth magnitude were simulated by placing a star simulator, on loan from the Systems Division of Goddard Space Flight Center, at two distances corresponding to a magnitude difference of $1.^{m}00$, and interposing various thicknesses of calibrated neutral filters. The results are given in Figure 14. We see that on the log-log scale of Figure 14 the empirical points fall on a curved relation having a "mean slope" about the same as that of the theoretical relation, which is given by the straight line. It is somewhat disturbing that the empirical relation is curved, since one normally expects a linear log-log relation in measurements of this kind. We are unable to specify the direct cause for this curvature, except to say that it must be due to the partial breakdown of one or more assumptions used in our mathematical model. It seems that it cannot be due to improper procedures in the noise measures, as these have been checked thoroughly. However we note that, inasmuch as the general trend of the experimental points is the same as that of the theoretical line, the theory does explain the correct increase of noise over a fairly large range of star brightness. That is, since the theory predicts a fourth root law for the noise vs. star brightness relation, a second magnitude star should produce

five times less noise than a ninth magnitude star ($5 \approx \sqrt[4]{631}$), which we find is just about the case. We conclude that the present analysis may provide a useful intermediary understanding of the dependence of tracker noise on star brightness.

ACKNOWLEDGMENTS

The author wishes to thank Mr. James O. Farmer for carrying out the laboratory phases of this work in unusually capable manner for nearly two years. Also, nearly all of the accompanying figures were drawn or photocopied by Mr. Farmer. Mr. Leslie Mann also worked in the laboratory for several months and was very helpful. Computations were done by Mr. Allen Bender and Mr. Richard Maas. Discussions with Mr. Lawrence Draper of Goddard Space Flight Center and Dr. E. J. Devinney of the University of South Florida were very useful at various stages. Mr. Draper also arranged for the loan of the star simulator, which is normally used in his calibration of star trackers.

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Table 1

OAO-A2 Guide Star List

Star No.	Name	B.S. No.	V	Star No.	Name	B.S. No.	V
1	α CMa	2491	-1.45	18	β Tau	1791	1.66
2	α Car	2326	-0.71	19	β CMa	2294	1.98
3	α Lyr	7001	0	20	α Cru	4730/1	0.81
4	β Ori	1713	0.15	21	β Car	3685	1.67
5	α Eri	472	0.49	22	η UMa	5191	1.86
6	β Cen	5267	0.61	23	γ Vel	3207	1.82
7	α Cen	5459/6	-0.26	24	ϵ Sgr	6879	1.84
8	α Aur	1708	0.06	25	α Pav	7790	1.93
9	α Vir	5056	0.96	26	κ Ori	2004	2.06
10	α CMi	2943	0.35	27	γ Gem	2421	1.91
11	α Aql	7557	0.74	28	σ Sgr	7121	2.09
12	α Leo	3982	1.35	29	α Gru	8425	1.73
13	ϵ CMa	2618	1.50	30	α And	15	2.06
14	α Cyg	7924	1.25	31	α Boo	5340	-0.06
15	γ Ori	1790	1.63	32	α Psa	8728	1.15
16	α Gem	2890/1	1.58	33	β Cru	4853	1.24
17	ϵ UMa	4905	1.78	34	α Tau	1457	0.86

Table 2

Transmission of 2 mm Schott GG13 UV-absorbing Glass

λ	T_λ
3500 Å	0.000
3600 Å	0.001
3700 Å	0.04
3800 Å	0.27
3900 Å	0.60
4000 Å	0.80
4100 Å	0.90
4200 Å	0.93
4300 Å	0.955
4400 Å	0.966
4500 Å	0.973
4600 Å	0.977
4700 Å	0.980
4800 Å	0.980

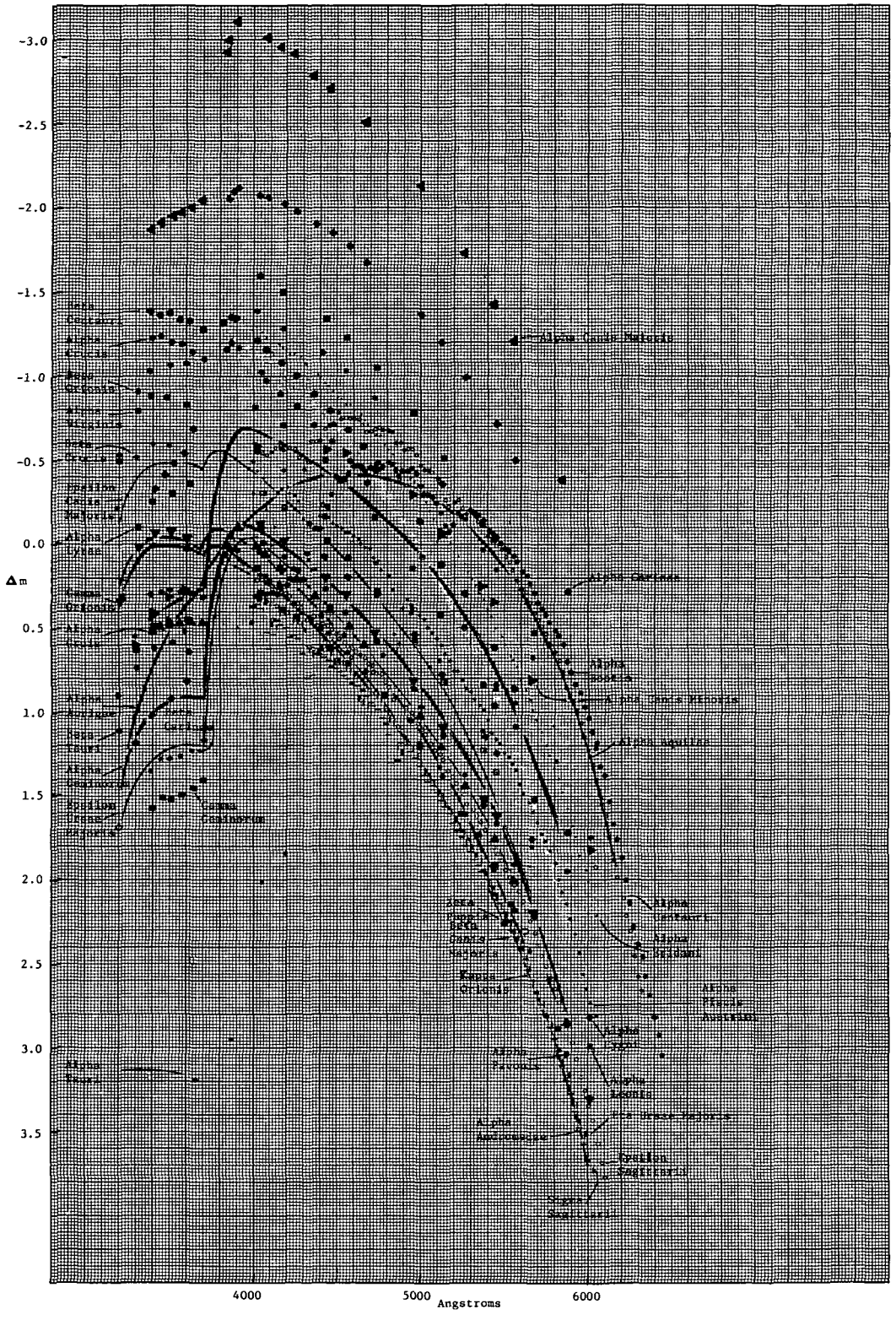


Figure 1. S-4 Star Radiation X Response Curves

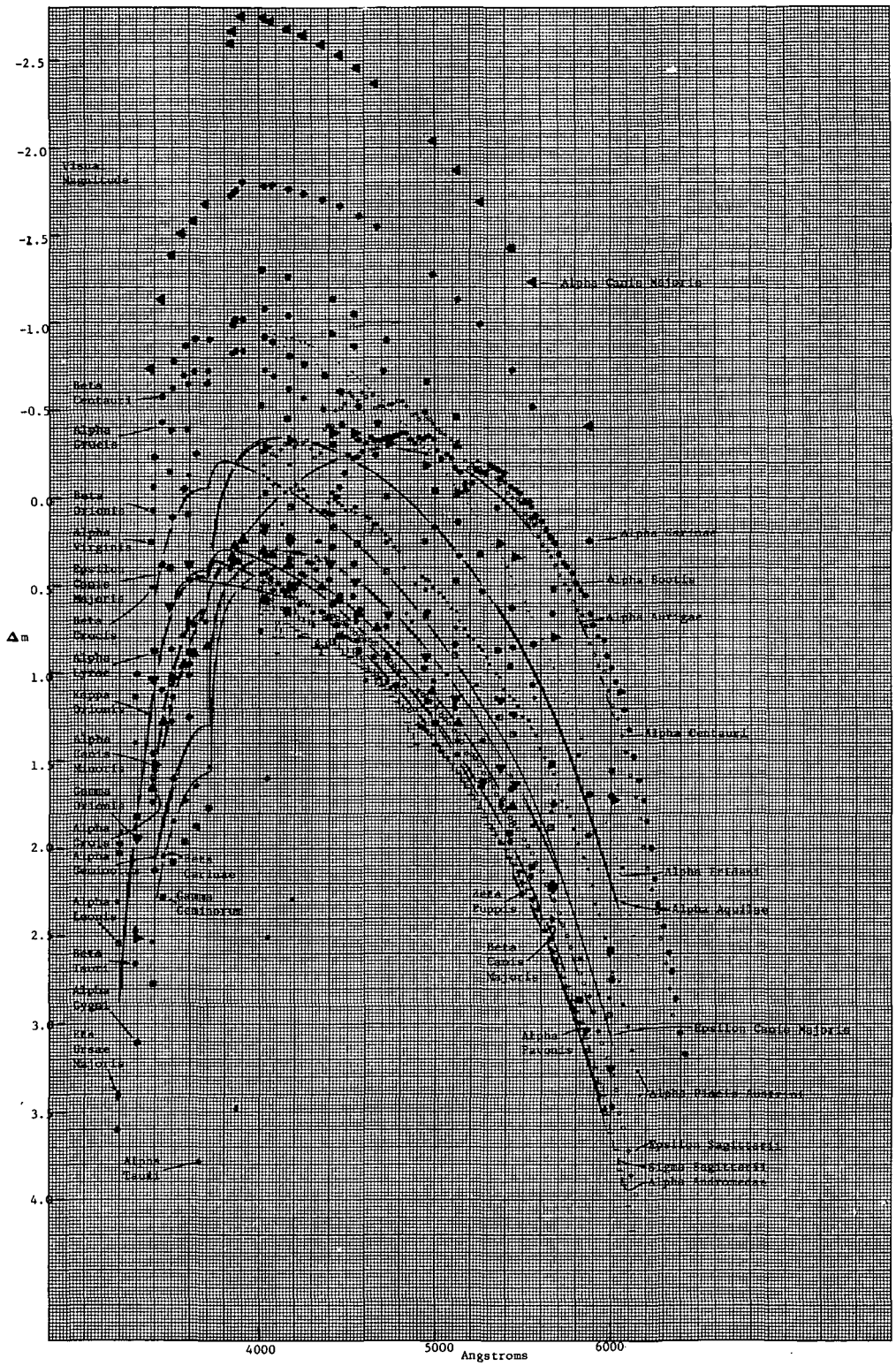


Figure 2. S-11 Star Radiation X Response Curves

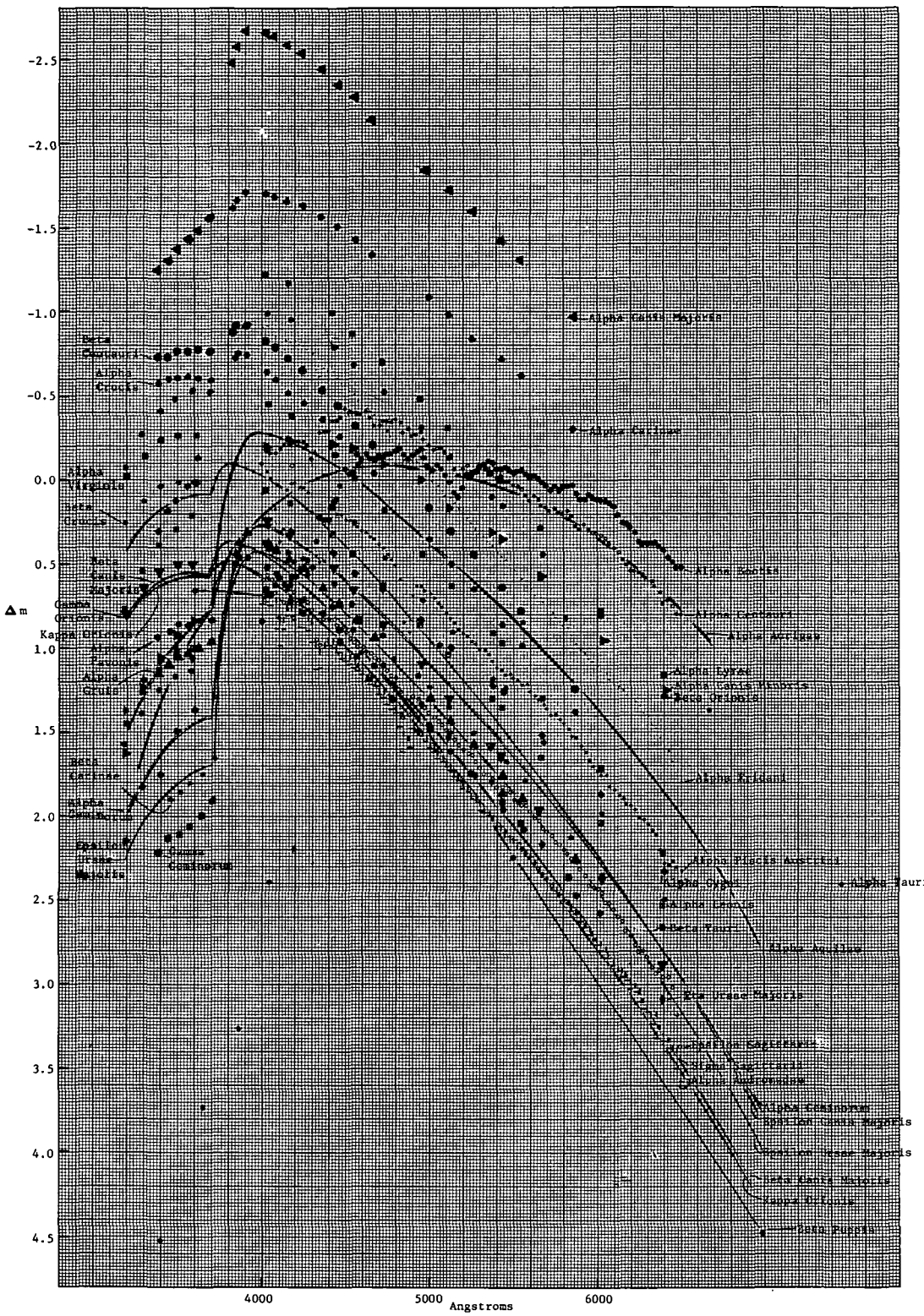


Figure 3. S-20 Star Radiation X Response Curves

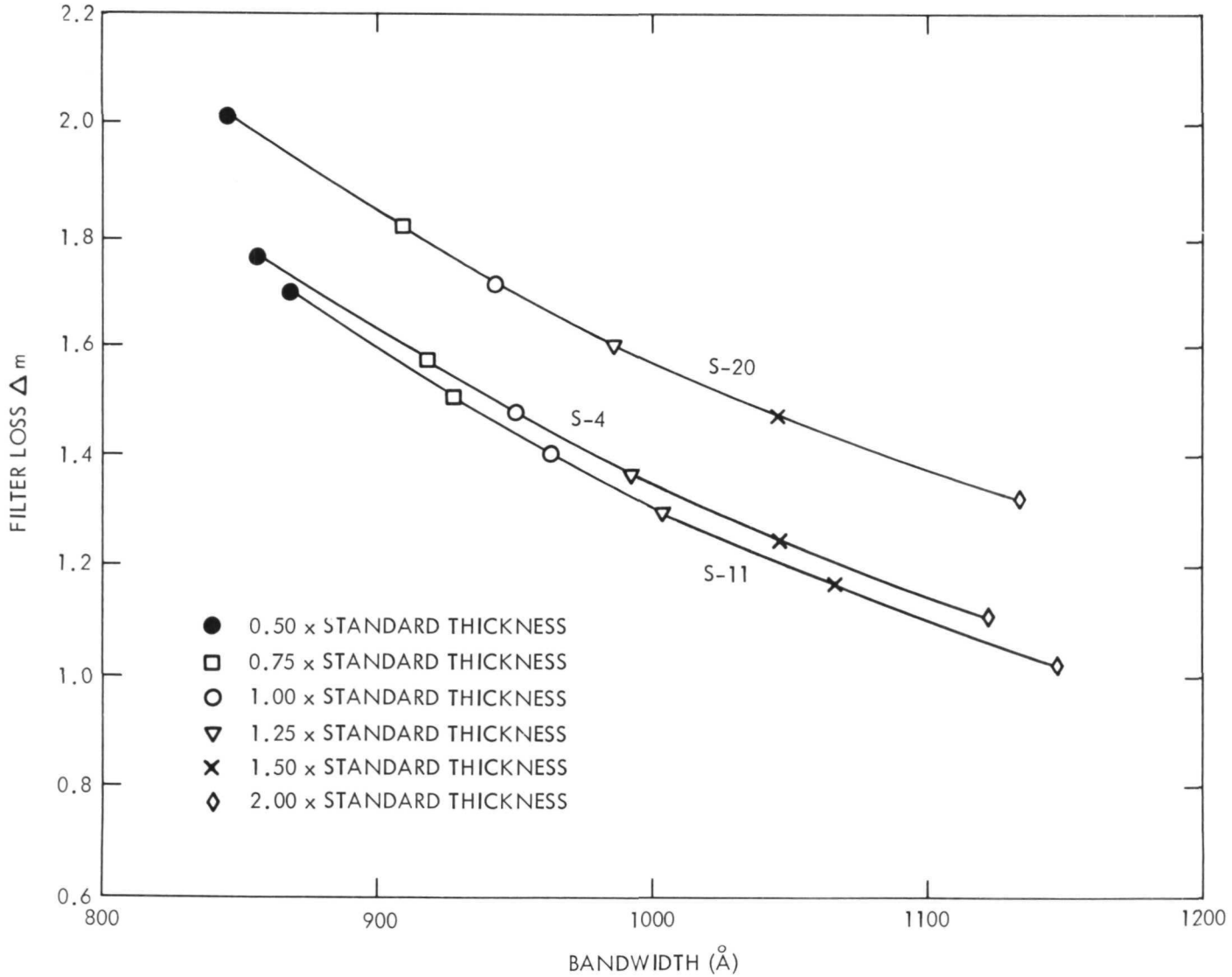
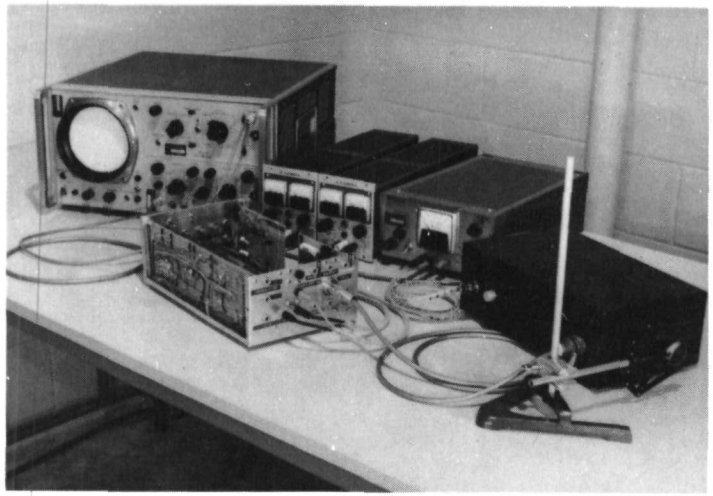
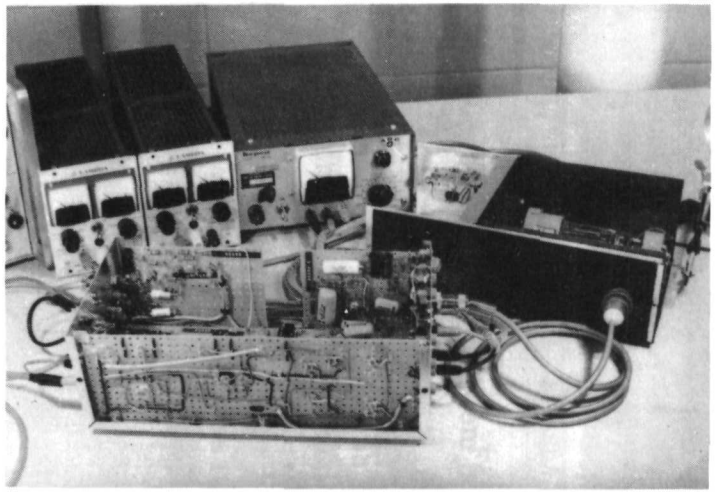
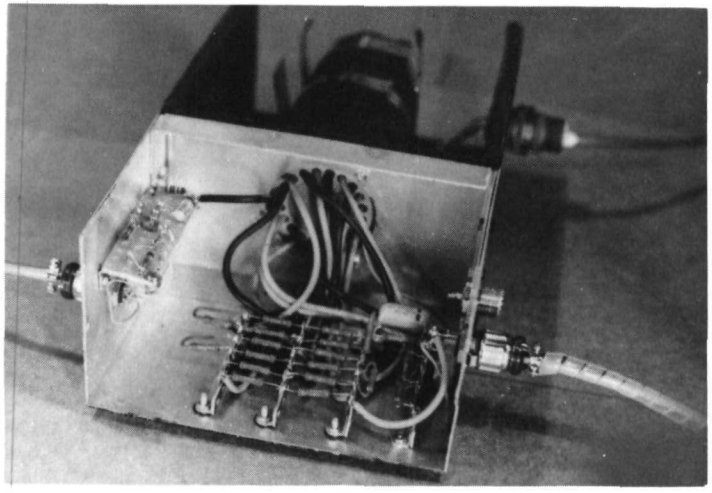


Figure 4. Tradeoff of Filter Losses vs. Bandwidth







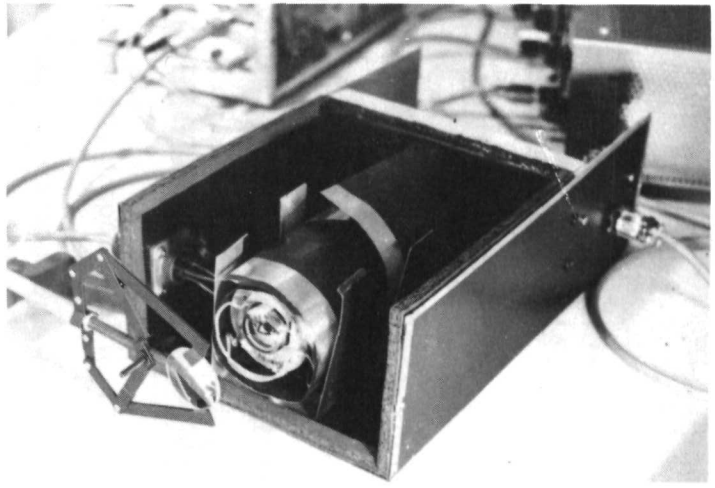


Figure 5

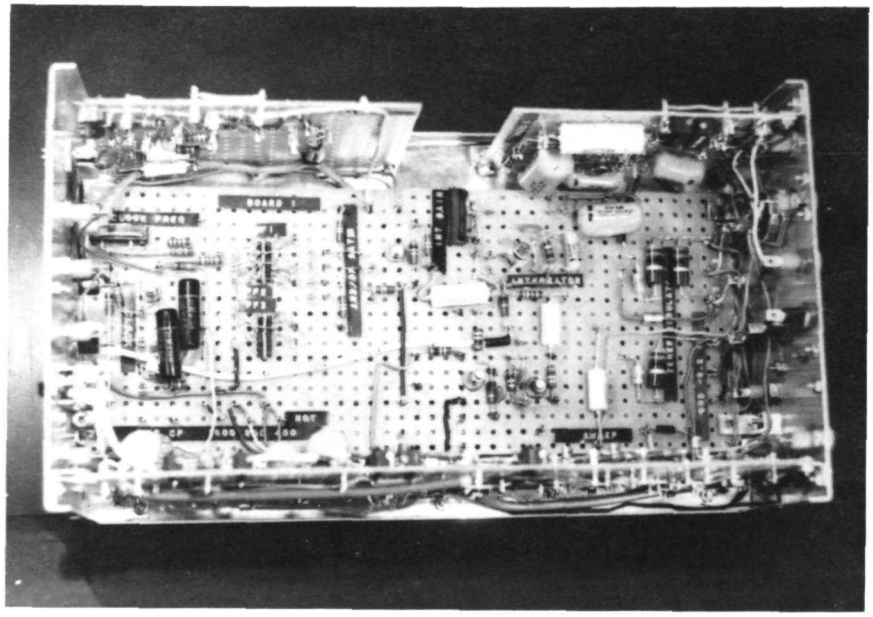


Figure 6

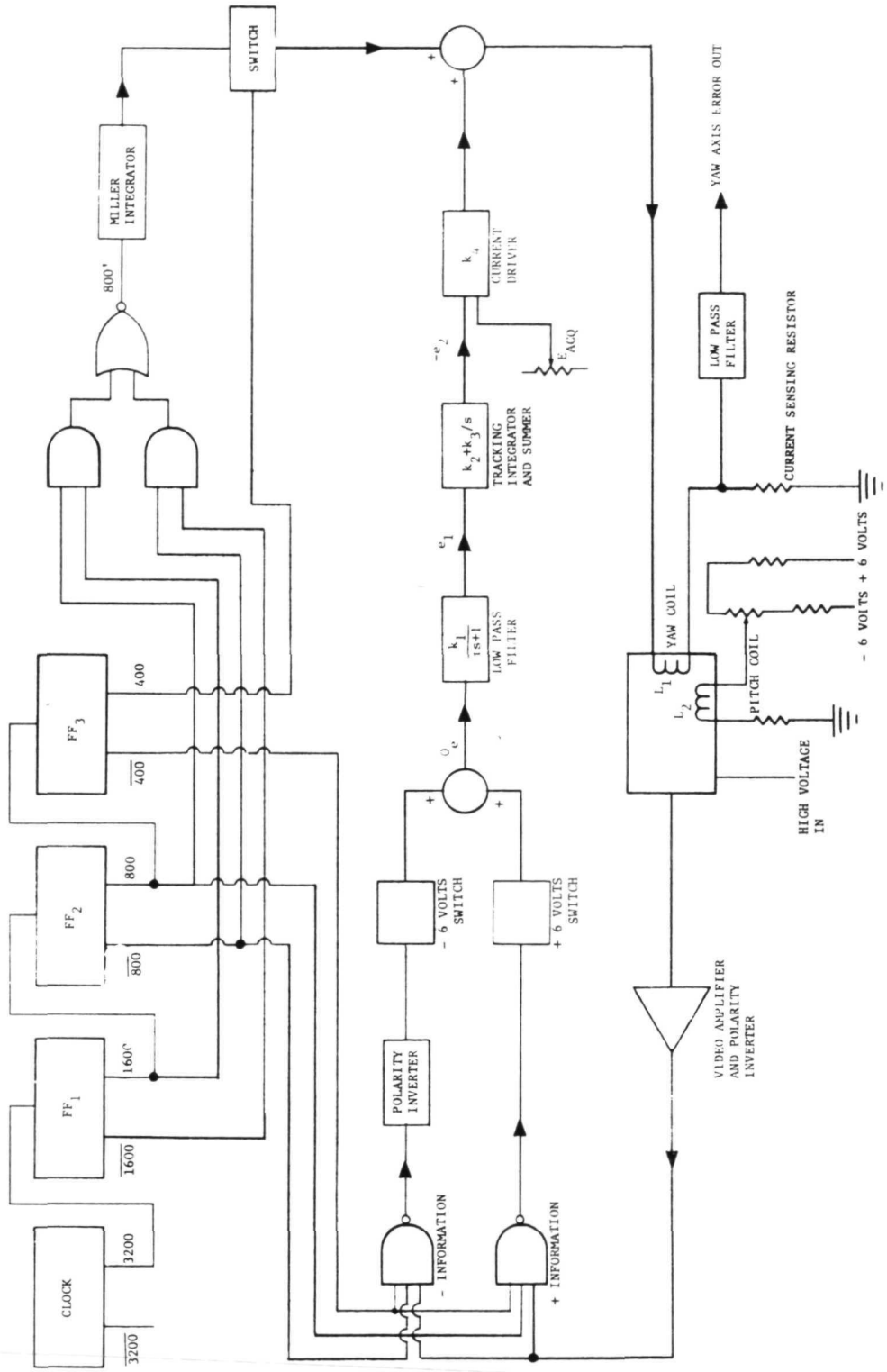
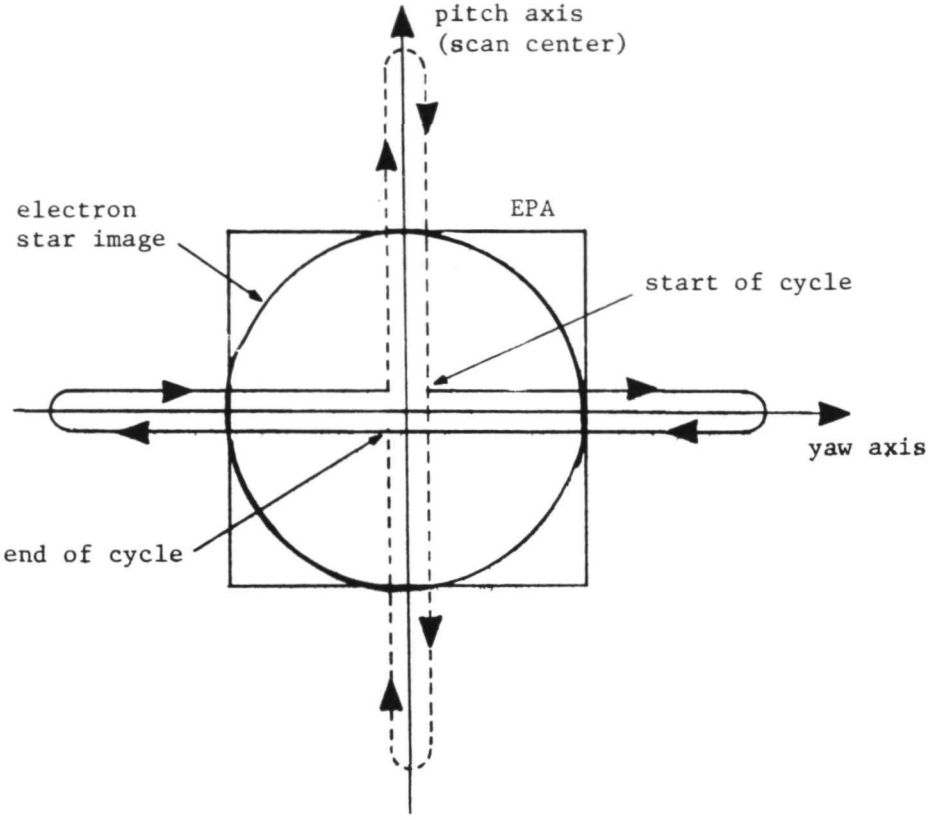
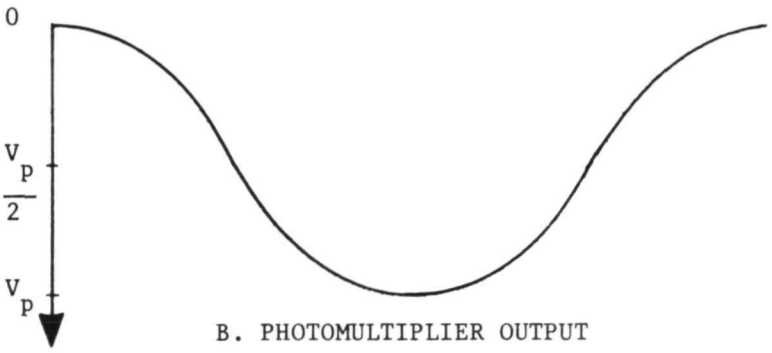


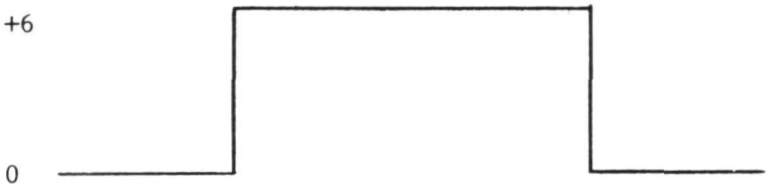
Figure 7. Star Tracker Logic Diagram



A. DEFLECTION PATH



B. PHOTOMULTIPLIER OUTPUT



C. VIDEO AMPLIFIER OUTPUT

Figure 8. Video Information

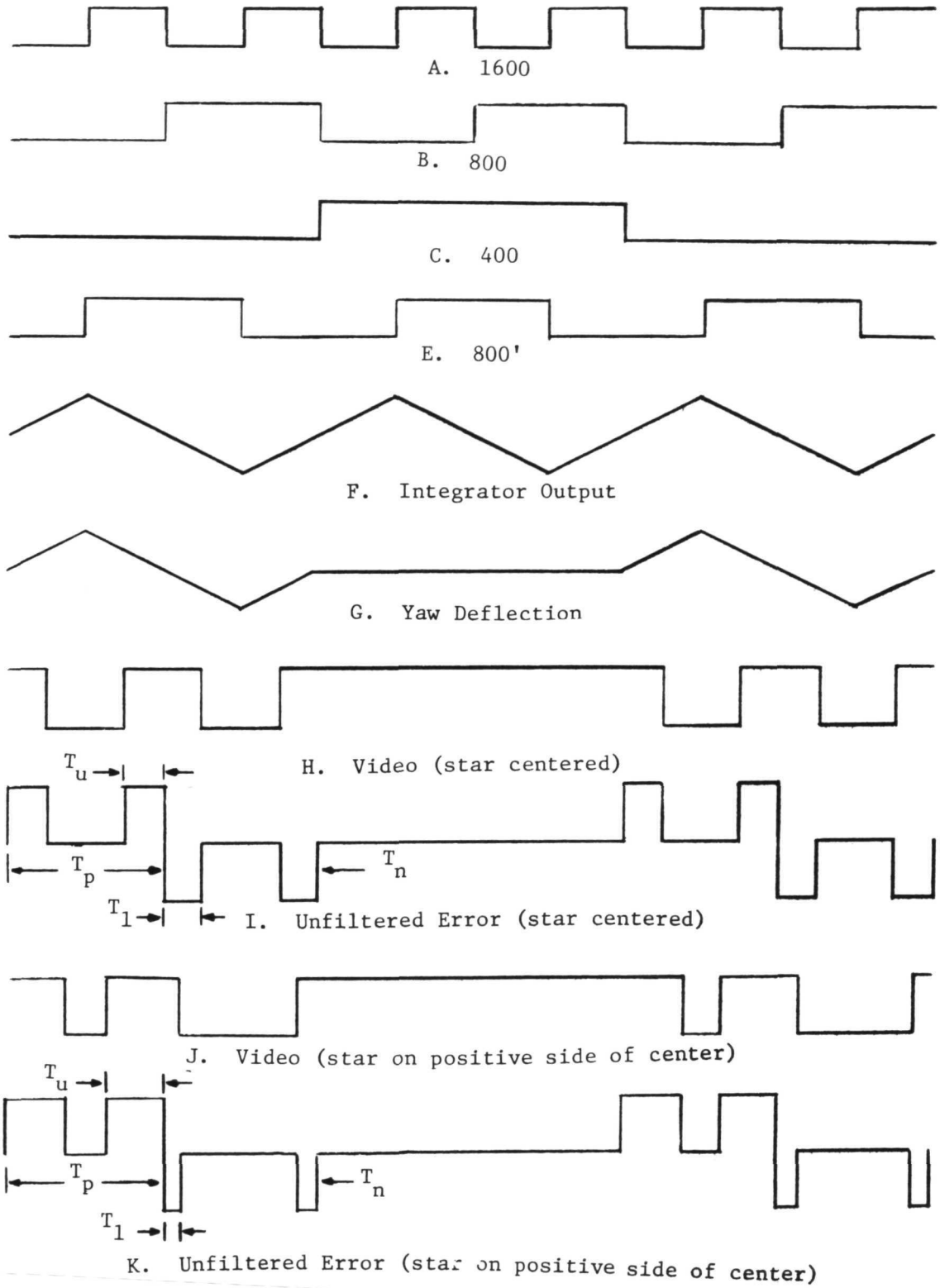
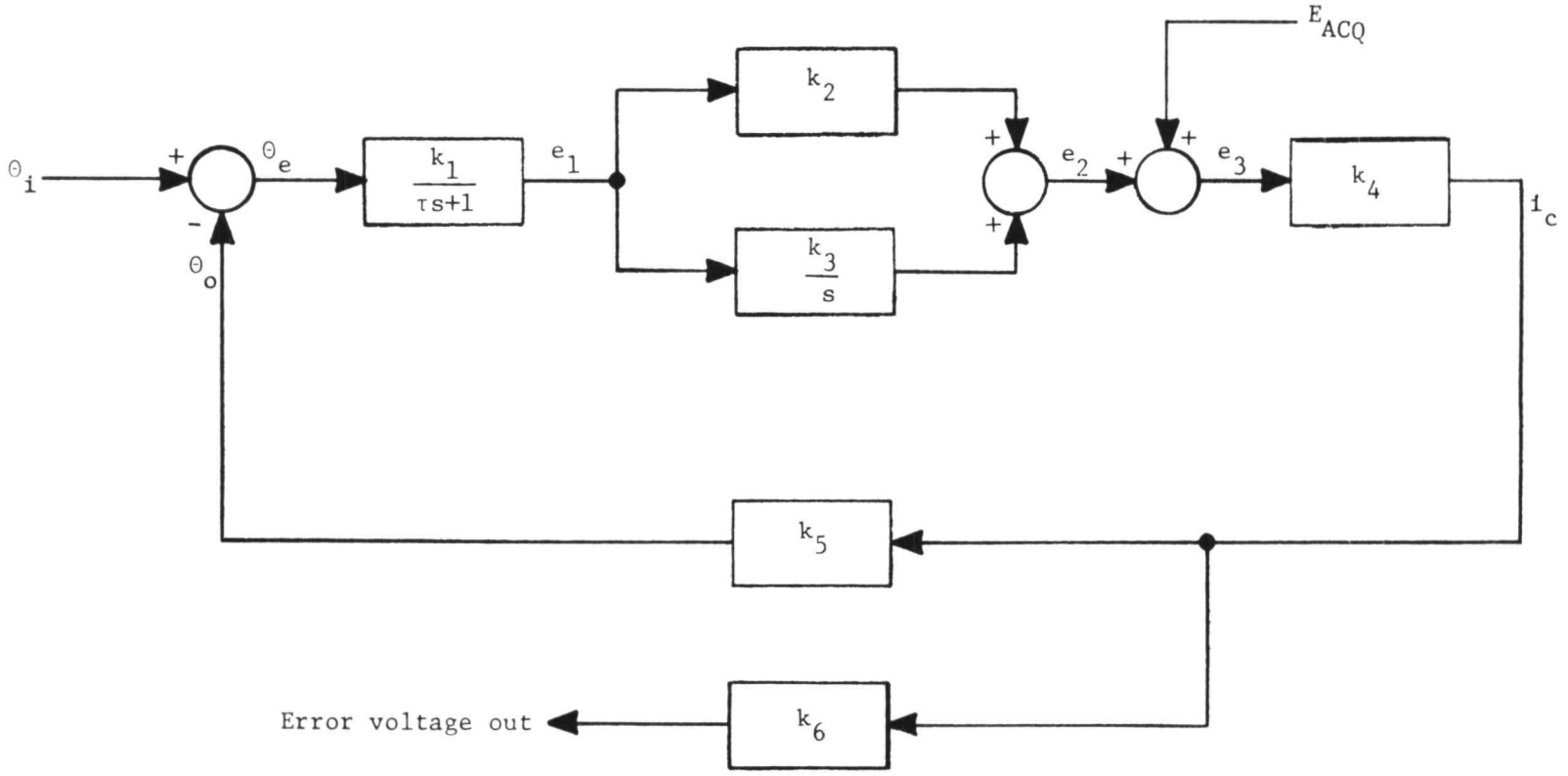


Figure 9. Timing Diagram



Θ_i: Angular position of the star with respect to the boresight axis

Θ_o: Angular position of the scan center

Θ_e: Position of the star image with respect to the scan center

Figure 10. Control System Block Diagram

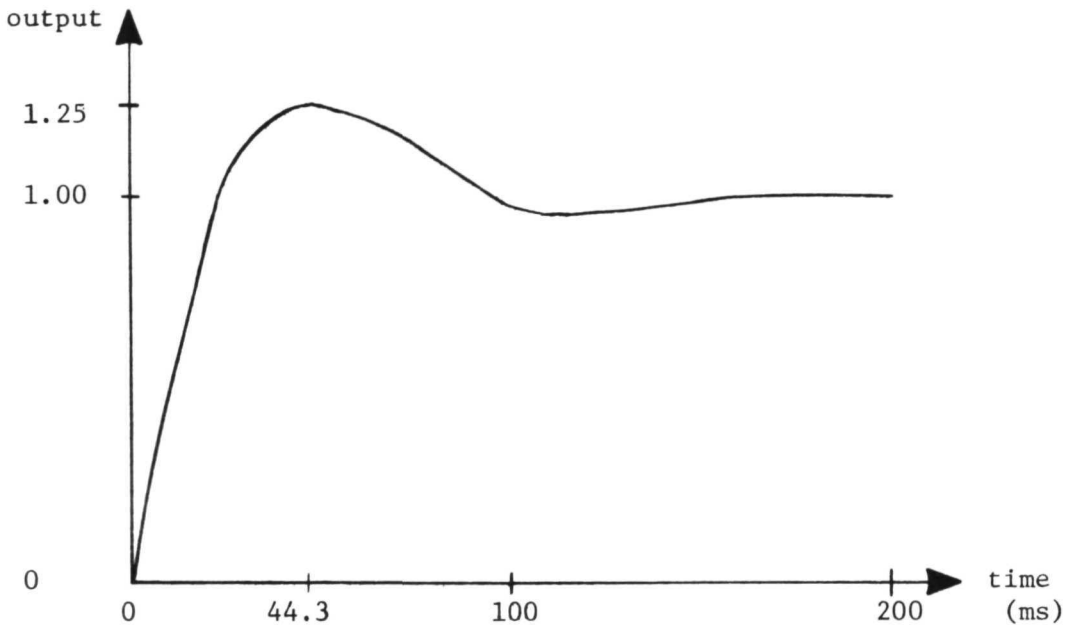
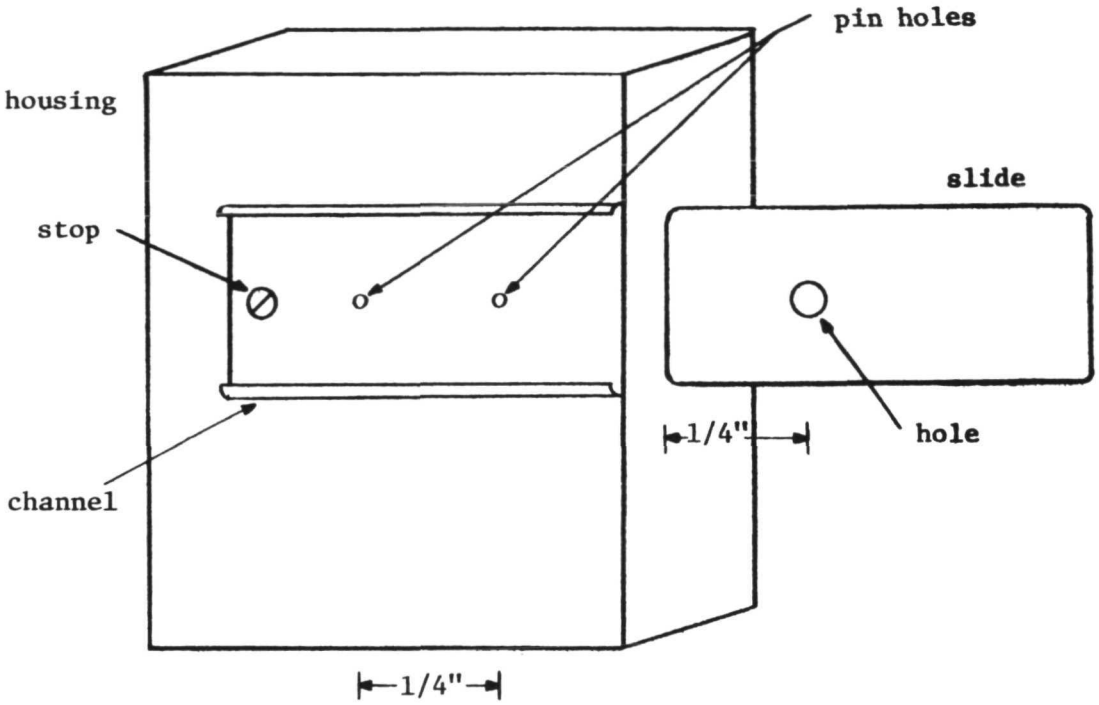
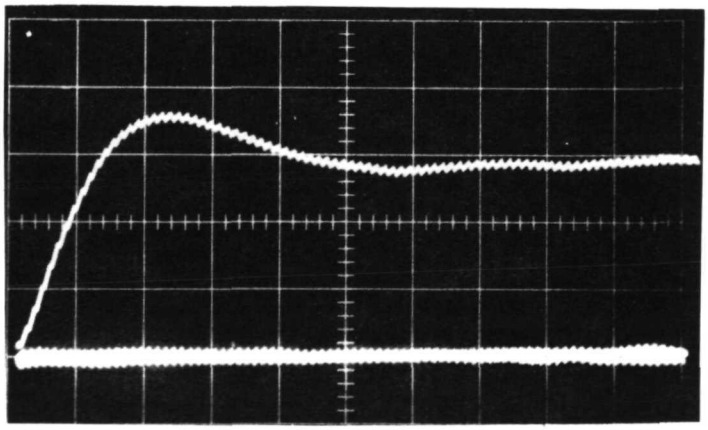


Figure 11. Response to Step Input (Theoretical)



Device For Producing Step Input



Scale: 20 milliseconds per centimeter

Figure 12. System Response to Step Input

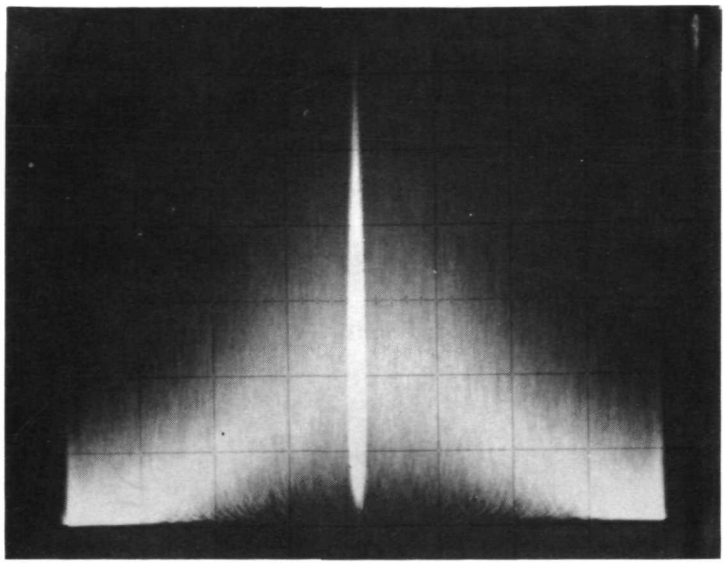


Figure 13

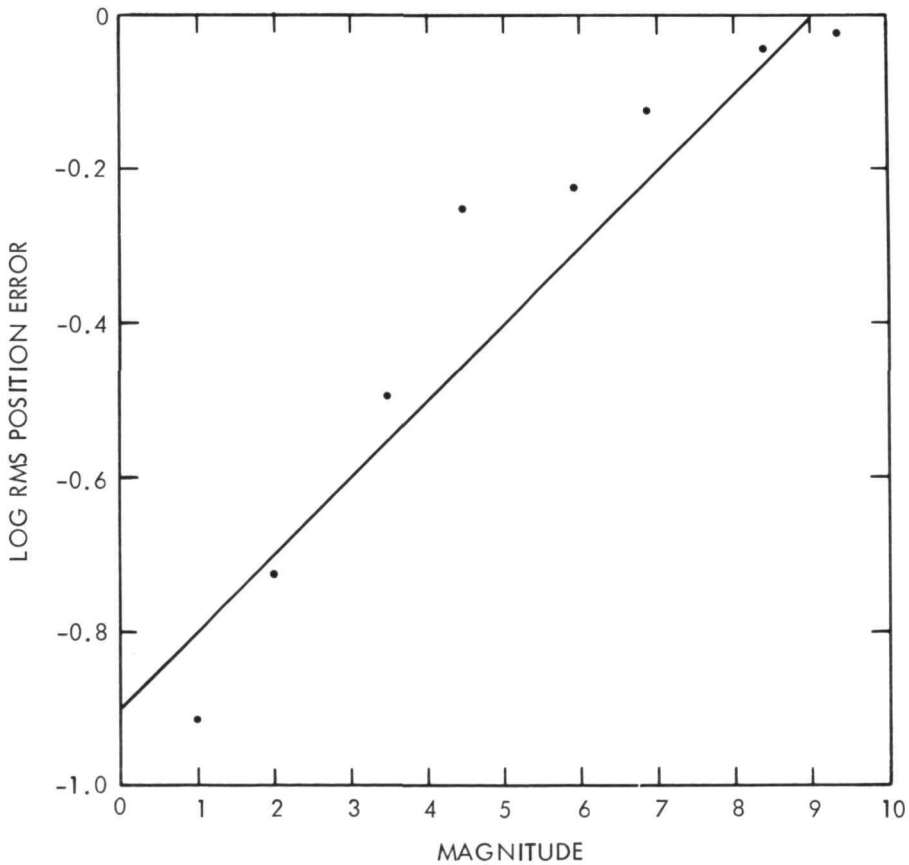


Figure 14. Comparison of Theoretical and Experimental Output Noise

APPENDIX I

CONVENIENCE TABLES OF OUTSIDE ATMOSPHERE SKY BRIGHTNESS

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These tables give the sum of Zodiacal light and Galactic background light over the entire sky at intervals of five degrees in declination and twenty minutes in right ascension. The epoch for the equatorial coordinates is 1967.0. Since the Zodiacal light moves with the sun, the tables are given for twelve dates throughout the year; specifically the first day of each month. They are primarily intended for the convenience of persons selecting navigational stars for celestial tracking systems. For Zodiacal light the source of observations was "The Absolute Photometry of the Zodiacal Light" (Smith, Roach, and Owen, 1965) while for Galactic light it was "Integrated Starlight over the Sky" (Roach and Megill, 1961). In this latter source, stars brighter than magnitude 6 have been excluded. The empirical correction factor of 1.26, recommended by Roach and Smith (1964), has been applied to the Roach and Megill observations. The Zodiacal light observations have been smoothed somewhat by the use of approximation formulas of the form:

$$D = a + bx^{\frac{1}{2}} + cx + dx^{3/2}$$

where B is brightness, $x = \exp.\ [0.02277(90-\beta)]$ and a, b, c, and d are constants adjusted by least squares for each elongation. β, of course, is celestial latitude. The unit of brightness is the number of 10th visual magnitude stars per square degree, which is the same unit used in Smith, Roach, and Owen, and in Roach and Megill. The sky brightness in the immediate vicinity of the sun is large, but is not accurately known. For this and other reasons it is not likely that stars near the sun would be selected as guide stars, so the vicinity of the sun is marked by zeros wherever it occurs in the tables.

This work was done as part of NASA grant NGR 10-008-009. The computations were performed on the U.S.F. IBM 1410 Computer.

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BRIGHTNESS OF THE SKY AT JANUARY 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA / DEC	0H	20M	40M	1H	20M	40M	2H	20M	40M	3H	20M	40M	4H	20M	40M	5H	20M	40M
0	336	305	280	259	245	236	228	223	220	215	213	213	216	220	229	243	259	280
5	309	297	288	271	254	245	236	230	226	221	219	219	220	225	232	246	261	278
10	285	276	269	262	258	253	243	236	232	227	224	224	225	230	236	250	264	291
15	268	260	256	253	252	248	243	239	236	231	229	228	231	235	242	257	273	325
20	256	252	250	249	248	245	243	238	235	233	232	234	238	243	254	270	306	393
25	254	251	250	249	248	245	242	238	235	233	232	234	240	251	266	292	339	481
30	260	257	255	253	249	247	242	239	235	234	234	238	250	263	282	320	428	453
35	275	268	265	260	256	253	247	241	238	236	245	253	266	281	311	385	422	372
40	291	285	278	271	267	260	253	252	255	259	264	275	289	309	364	387	344	311
45	317	307	299	292	287	282	280	277	278	281	287	297	314	357	349	309	281	271
50	331	322	315	309	303	299	297	297	297	301	308	328	330	307	277	256	250	249
55	346	336	327	322	318	315	312	313	319	325	313	294	270	243	236	233	235	240
60	393	376	361	353	347	335	318	305	288	272	253	232	228	225	222	227	233	233
65	302	298	289	283	275	265	251	237	228	226	222	218	216	219	224	228	227	225
70	240	237	234	230	228	225	221	218	214	215	216	218	221	224	223	221	220	218
75	219	219	218	218	218	218	218	218	218	219	218	217	217	217	215	214	212	209
80	211	210	211	211	211	211	211	211	211	211	211	210	209	208	206	204	204	202
85	201	202	201	201	202	202	202	202	201	201	200	199	199	199	198	197	197	196
90	190																	

BRIGHTNESS OF THE SKY AT JANUARY 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	6H	20M	40M	7H	20M	40M	8H	20M	40M	9H	20M	40M	10H	20M	40M	11H	20M	40M
DEC																		
0	301	373	530	451	377	337	310	282	261	241	233	226	223	225	228	234	241	252
5	326	464	517	422	359	323	293	270	250	237	230	223	222	222	227	232	240	245
10	364	538	484	399	341	306	281	261	242	236	227	223	220	221	223	225	230	232
15	474	516	449	372	318	291	273	254	240	233	227	221	217	216	216	218	220	221
20	533	477	414	350	308	283	269	250	237	227	221	215	211	209	209	209	211	211
25	473	421	369	320	291	270	254	240	228	217	214	209	206	204	202	201	201	202
30	398	358	325	295	272	257	242	230	219	211	207	202	201	199	197	195	194	195
35	338	310	290	274	258	245	232	221	212	205	201	197	194	193	191	191	189	188
40	289	279	271	259	247	234	225	215	205	199	196	193	191	188	187	186	187	185
45	264	259	255	246	235	226	217	209	200	196	192	189	188	185	185	184	182	181
50	250	246	242	236	226	218	210	203	196	192	189	186	185	184	182	181	179	177
55	239	236	231	227	218	210	204	198	192	188	186	184	183	182	180	178	177	176
60	230	227	222	218	211	204	199	194	191	186	183	182	181	179	179	178	176	174
65	222	218	214	210	205	200	195	192	189	185	183	182	180	179	178	177	176	174
70	214	210	208	203	200	196	194	191	188	186	183	181	180	178	178	177	176	175
75	207	204	202	199	195	193	191	190	187	186	184	182	180	179	179	177	177	176
80	200	198	197	195	193	191	189	188	187	186	185	184	183	182	181	180	179	179
85	195	194	193	193	192	191	190	189	188	188	187	186	186	186	185	185	185	184
90	190																	

BRIGHTNESS OF THE SKY AT JANUARY 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	12H	20M	40M	13H	20M	40M	14H	20M	40M	15H	20M	40M	16H	20M	40M	17H	20M	40M
DEC																		
0	265	272	280	289	301	316	332	347	359	374	394	417	449	507	0	0	0	0
5	249	250	256	262	273	284	296	307	317	327	338	352	371	407	0	0	0	0
10	234	234	235	239	247	256	266	274	284	291	298	310	322	344	0	0	0	0
15	222	221	220	222	227	234	240	247	255	264	271	279	290	305	320	330	359	392
20	212	209	208	207	211	214	217	223	230	241	250	257	268	280	292	309	334	361
25	199	201	199	198	197	199	201	204	210	221	232	241	253	265	275	295	314	341
30	195	193	192	190	188	187	188	190	193	202	217	228	240	256	266	282	299	325
35	188	186	185	183	180	180	180	180	182	187	201	215	228	243	256	268	286	308
40	183	181	179	178	177	175	174	174	175	177	186	201	215	231	245	256	274	291
45	179	177	175	174	172	172	172	172	173	174	177	188	203	218	232	245	259	273
50	176	174	172	171	170	169	169	170	172	174	176	181	192	205	217	229	243	256
55	174	172	171	170	168	168	168	168	170	173	177	181	186	196	202	213	222	237
60	173	172	171	170	169	168	168	168	170	170	173	179	186	192	201	201	203	214
65	173	173	172	172	171	170	170	171	172	172	173	175	177	179	183	193	185	190
70	174	174	173	173	172	172	172	173	174	174	175	177	177	179	181	183	183	185
75	176	175	175	175	174	174	174	174	175	175	176	178	180	182	183	186	188	189
80	179	178	178	178	178	178	179	180	180	181	181	182	182	183	185	186	187	188
85	184	184	184	183	183	183	183	184	185	185	185	185	186	186	187	188	188	188
90	190																	

BRIGHTNESS OF THE SKY AT JANUARY 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	18H	20M	40M	19H	20M	40M	20H	20M	40M	21H	20M	40M	22H	20M	40M	23H	20M	40M
DEC																		
0	C	0	0	0	0	0	C	0	0	617	551	514	481	453	427	405	382	356
5	C	0	0	0	0	0	C	C	0	485	445	424	404	387	372	357	341	323
10	C	0	0	0	0	0	0	0	450	410	383	367	356	344	336	325	311	296
15	416	433	439	478	579	534	C	C	414	371	353	336	325	319	309	299	288	278
20	387	409	391	404	509	584	507	458	415	370	338	325	313	302	291	282	272	262
25	371	397	386	387	444	580	568	492	442	394	352	325	312	296	281	272	267	261
30	353	377	392	377	410	515	632	555	492	431	387	350	316	298	286	277	270	262
35	336	365	386	384	397	444	578	674	547	481	426	383	346	314	298	291	285	278
40	316	340	361	378	382	417	485	619	679	545	472	411	376	351	331	317	303	297
45	296	318	334	350	361	372	426	495	604	647	545	457	408	374	359	347	338	327
50	275	293	305	315	325	340	361	401	451	533	596	561	467	416	388	365	348	339
55	252	266	274	278	283	294	308	322	357	384	436	486	517	506	453	405	376	359
60	229	238	240	236	250	256	263	276	286	306	328	344	373	396	412	419	409	401
65	193	199	204	235	235	237	239	241	246	253	259	269	281	288	291	291	299	303
70	188	192	199	206	208	212	214	218	221	224	227	227	227	225	225	231	236	238
75	193	193	194	193	196	198	201	203	206	208	211	217	222	228	230	228	225	223
80	189	191	192	193	195	196	196	198	199	200	202	203	205	206	208	209	209	210
85	189	190	192	193	194	194	195	196	196	197	198	198	199	199	200	200	200	201
90	190																	

BRIGHTNESS OF THE SKY AT JANUARY 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	0H	20M	40M	1H	20M	40M	2H	20M	40M	3H	20M	40M	4H	20M	40M	5H	20M	40M
DEC																		
-5	328	296	269	249	236	227	221	215	213	208	207	208	212	217	225	241	260	283
-10	318	285	259	240	227	218	213	208	207	202	201	203	206	213	221	236	258	285
-15	305	274	250	232	219	210	205	201	198	197	196	199	203	209	219	231	254	282
-20	290	262	241	225	211	203	198	196	193	191	191	194	199	204	214	225	246	275
-25	275	250	231	216	205	198	192	189	187	186	187	189	193	199	208	220	236	264
-30	260	239	222	208	198	192	187	184	184	182	183	184	190	196	203	215	227	253
-35	250	230	213	201	194	188	183	182	180	178	178	181	186	192	198	209	220	241
-40	240	226	210	197	188	184	180	179	178	177	177	178	183	188	194	204	213	228
-45	235	223	210	195	185	180	179	177	177	176	175	175	179	184	190	197	207	217
-50	233	224	212	200	188	179	176	175	176	175	174	175	176	182	186	193	200	209
-55	233	226	216	208	197	187	178	175	175	176	176	175	176	178	183	189	194	203
-60	239	230	222	214	206	198	190	183	180	178	180	183	182	180	182	187	192	195
-65	240	235	230	222	216	209	202	197	192	189	189	191	193	195	199	202	186	191
-70	238	233	230	228	225	221	216	212	207	204	200	198	195	194	190	185	199	190
-75	241	239	236	233	230	227	224	221	219	217	217	217	218	218	220	223	224	226
-80	246	244	243	241	240	239	238	237	238	237	236	236	235	236	237	239	239	239
-85	251	250	250	250	249	248	249	249	248	248	248	249	249	248	249	249	250	250
-90	259																	

BRIGHTNESS OF THE SKY AT JANUARY 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	6H	20M	40M	7H	20M	40M	8H	20M	40M	9H	20M	40M	10H	20M	40M	11H	20M	40M
DEC																		
-5	301	353	477	499	393	344	326	298	274	251	236	229	225	227	231	233	240	250
-10	311	339	415	534	444	365	334	315	284	262	244	233	230	230	232	233	241	248
-15	315	346	405	514	526	391	348	325	299	273	253	239	233	233	233	234	241	247
-20	308	353	399	479	599	500	389	339	312	283	261	248	238	235	235	238	241	247
-25	295	348	399	473	587	644	481	391	336	297	272	254	244	240	239	242	246	252
-30	282	325	389	457	556	719	672	483	401	337	290	264	250	246	246	248	252	257
-35	268	297	363	435	525	638	835	714	507	425	350	299	268	257	253	255	259	267
-40	253	276	326	400	485	589	736	923	785	571	472	383	334	289	275	270	271	279
-45	238	260	284	353	427	508	630	807	1003	885	686	553	470	400	364	331	307	312
-50	226	244	262	304	364	440	517	629	775	1049	1031	846	685	591	529	475	439	426
-55	215	231	246	258	310	361	424	486	587	680	883	1041	1031	903	784	687	628	600
-60	208	220	229	243	263	305	342	392	435	502	577	644	790	936	990	1006	952	897
-65	196	207	216	229	238	260	293	322	355	384	409	452	503	548	586	632	712	773
-70	194	202	216	229	241	249	259	280	259	316	336	356	374	389	401	430	458	480
-75	228	231	233	235	233	239	248	255	264	279	292	304	314	326	338	351	361	369
-80	241	245	246	247	250	252	255	258	261	265	268	272	276	283	290	296	301	305
-85	252	253	255	257	259	260	260	262	263	264	265	267	268	270	271	272	273	274
-90	259																	

BRIGHTNESS OF THE SKY AT JANUARY 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	12H	20M	40M	13H	20M	40M	14H	20M	40M	15H	20M	40M	16H	20M	40M	17H	20M	40M
DEC																		
-5	263	281	303	318	334	352	375	394	415	441	474	513	564	660	0	0	0	0
-10	259	277	299	325	357	397	429	460	495	539	594	658	735	0	0	0	0	0
-15	258	274	295	321	353	396	449	524	613	685	773	873	1009	0	0	0	0	0
-20	257	273	293	318	348	384	427	488	577	706	891	1137	1405	0	0	0	0	0
-25	261	275	294	318	345	376	413	460	526	628	766	944	1231	0	0	0	0	0
-30	267	280	298	320	344	370	402	447	504	579	675	806	1038	0	0	0	0	0
-35	277	291	310	331	358	386	415	451	494	551	632	741	0	0	0	0	0	0
-40	290	308	328	351	380	406	432	471	512	561	623	713	0	0	0	0	0	0
-45	323	341	363	391	420	452	480	514	549	584	637	727	0	0	0	0	0	0
-50	422	430	446	468	491	516	539	567	604	645	699	0	0	0	0	0	0	0
-55	582	579	584	592	605	621	641	672	738	818	914	0	0	0	0	0	0	0
-60	857	832	819	820	831	853	884	929	928	918	832	740	688	642	594	562	526	487
-65	815	835	840	835	818	788	745	693	649	622	593	559	521	499	475	444	418	389
-70	497	507	513	519	519	513	501	481	459	454	448	436	420	400	384	364	342	326
-75	376	380	383	385	385	384	382	380	377	369	362	354	345	335	321	309	305	301
-80	308	311	313	315	317	317	316	314	311	307	301	298	297	294	291	288	286	283
-85	275	276	277	277	278	278	279	279	279	279	279	278	277	277	275	274	272	271
-90	259																	

BRIGHTNESS OF THE SKY AT JANUARY 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	18H	20M	40M	19H	20M	40M	20H	20M	40M	21H	20M	40M	22H	20M	40M	23H	20M	40M
DEC																		
-5	C	0	0	0	0	0	C	C	0	832	714	653	600	549	507	470	424	368
-10	C	0	0	0	0	0	0	0	0	0	970	870	784	703	570	469	404	356
-15	C	0	0	0	C	0	C	0	0	0	1377	1073	820	636	512	431	378	339
-20	0	0	0	0	0	0	0	0	0	0	1216	884	691	554	459	396	352	319
-25	C	0	0	0	0	0	C	C	0	0	0	742	587	484	412	362	326	300
-30	C	0	0	0	0	0	0	0	0	0	0	631	501	422	370	332	303	281
-35	C	0	0	0	0	0	C	C	0	0	0	535	433	374	335	306	283	266
-40	C	0	0	0	0	0	0	0	0	0	0	0	385	336	306	286	269	254
-45	C	0	0	0	0	0	0	C	0	0	C	0	346	312	289	272	258	246
-50	C	0	0	0	0	0	C	C	0	0	0	0	301	291	277	264	253	242
-55	C	0	0	0	0	0	C	C	355	329	310	294	282	273	265	259	251	242
-60	446	429	426	414	393	368	345	329	318	304	293	283	274	267	257	250	249	245
-65	362	359	354	343	330	318	307	297	289	283	277	273	268	262	257	251	243	242
-70	321	317	311	301	293	286	283	278	273	269	266	263	261	258	254	251	247	244
-75	296	291	286	280	274	268	266	265	263	261	259	256	255	253	251	249	247	244
-80	280	276	273	269	265	262	259	258	256	255	255	254	253	251	250	249	248	246
-85	269	268	266	264	262	261	260	258	256	256	255	254	254	253	253	252	251	251
-90	259																	

BRIGHTNESS OF THE SKY AT FEBRUARY 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	0H	20M	40M	1H	20M	40M	2H	20M	40M	3H	20M	40M	4H	20M	40M	5H	20M	40M
DEC																		
0	855	648	516	431	377	337	304	278	258	242	233	230	230	233	243	255	271	287
5	639	587	542	465	401	355	320	292	272	254	244	240	238	241	248	259	273	285
10	503	476	451	425	401	367	334	307	285	267	255	249	245	248	254	263	274	297
15	416	403	392	379	363	344	328	314	300	280	266	257	253	254	259	270	281	328
20	365	359	353	345	333	319	307	295	285	277	271	267	261	260	270	280	310	394
25	338	334	328	320	312	300	289	279	271	266	262	260	260	269	282	301	342	480
30	325	320	312	305	296	286	275	268	261	258	257	258	268	281	297	331	434	454
35	326	313	305	296	286	278	269	261	257	255	263	270	283	298	326	397	430	376
40	327	314	304	294	286	276	268	266	269	273	278	288	304	324	377	399	353	316
45	338	324	314	305	298	292	290	287	288	293	298	309	327	369	361	321	290	277
50	340	331	323	316	310	306	304	304	305	310	317	338	341	318	288	267	259	255
55	350	341	332	327	323	320	318	319	325	332	320	302	279	252	245	243	243	247
60	396	379	364	356	351	338	322	309	294	277	258	238	235	232	230	235	240	240
65	305	301	293	286	278	268	255	241	232	229	226	223	222	226	230	235	234	231
70	243	239	235	232	230	227	223	220	216	217	220	223	225	229	229	227	226	223
75	220	220	220	219	219	219	219	220	220	222	221	221	221	221	219	219	216	214
80	211	211	212	213	213	214	214	213	213	214	213	213	212	211	209	208	207	205
85	202	203	202	202	203	203	204	203	203	203	202	202	201	201	201	200	199	198
90	191																	

BRIGHTNESS OF THE SKY AT FEBRUARY 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	6H	20M	40M	7H	20M	40M	8H	20M	40M	9H	20M	40M	10H	20M	40M	11H	20M	40M
DEC																		
0	305	371	521	446	373	338	316	292	274	246	231	219	212	211	210	215	217	219
5	328	459	503	413	353	324	299	282	269	248	233	220	215	211	211	215	218	216
10	363	529	466	386	334	306	288	275	265	254	237	226	219	216	210	207	211	210
15	471	504	425	353	309	289	278	270	267	260	246	229	216	210	203	201	202	203
20	526	459	384	325	294	280	272	265	264	257	238	222	210	202	197	194	194	195
25	464	401	339	293	276	266	256	249	246	242	230	215	204	197	191	188	187	187
30	393	344	302	273	259	251	242	237	231	228	221	208	200	193	187	183	182	182
35	337	301	273	257	247	238	231	225	220	216	214	202	194	188	183	180	178	178
40	290	275	259	246	238	229	223	217	210	206	204	198	191	184	180	178	177	176
45	267	258	248	237	229	222	214	210	203	199	197	194	188	182	179	177	174	173
50	254	247	238	230	222	215	208	203	198	194	191	189	186	182	177	175	172	171
55	244	239	231	223	216	208	202	197	192	189	187	185	183	180	177	174	172	170
60	235	230	224	217	210	203	199	194	190	186	184	182	180	178	177	175	172	170
65	227	222	217	212	205	200	195	193	189	185	183	181	179	178	176	175	173	172
70	218	214	211	206	202	197	194	192	189	187	183	181	179	177	177	176	175	173
75	211	207	205	202	198	194	193	191	188	187	185	183	180	179	178	177	176	175
80	203	201	199	197	195	193	191	190	188	187	186	185	184	183	182	180	180	180
85	197	196	195	195	193	192	191	190	189	189	188	187	187	187	186	185	185	185
90	191																	

BRIGHTNESS OF THE SKY AT FEBRUARY 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	12H	20M	40M	13H	20M	40M	14H	20M	40M	15H	20M	40M	16H	20M	40M	17H	20M	40M
DEC																		
0	221	223	226	229	232	236	239	243	247	256	269	285	305	327	348	369	394	429
5	216	215	217	218	223	223	226	228	231	236	247	259	277	298	321	341	365	391
10	209	208	208	209	212	213	215	216	217	221	227	239	252	272	298	320	343	369
15	202	202	200	201	203	206	205	206	206	208	212	220	233	249	276	302	328	357
20	196	194	193	193	196	196	195	196	197	198	201	206	215	230	256	283	312	345
25	187	189	188	187	186	187	188	188	189	190	192	196	203	214	238	268	296	332
30	184	183	183	182	181	181	181	181	182	184	187	189	195	205	223	254	280	317
35	179	178	178	177	175	175	176	176	177	179	182	185	190	197	210	239	264	298
40	175	175	174	172	173	171	171	171	173	174	177	181	186	193	202	225	250	277
45	172	172	172	170	169	169	169	169	170	171	174	177	184	191	197	214	236	257
50	170	169	169	169	168	167	167	167	168	170	172	175	180	189	196	207	222	239
55	169	168	167	167	167	166	166	167	168	169	171	174	177	182	193	204	215	221
60	168	168	168	168	166	166	167	167	169	170	172	174	178	180	184	193	211	210
65	170	170	169	169	169	168	169	170	170	170	172	174	176	179	182	186	185	190
70	173	172	172	171	171	171	172	172	174	174	176	177	178	181	184	186	190	185
75	175	175	175	174	174	174	174	175	176	177	178	180	181	183	184	186	187	184
80	179	179	178	178	178	178	179	180	180	180	181	182	182	183	184	184	184	186
85	184	184	184	183	183	183	183	184	184	184	184	185	185	185	186	187	187	188
90	191																	

BRIGHTNESS OF THE SKY AT FEBRUARY 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	18H	20M	40M	19H	20M	40M	20H	20M	40M	21H	20M	40M	22H	20M	40M	23H	20M	40M
DEC																		
0	470	548	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1019	936
5	415	460	0	0	0	0	0	0	0	0	0	0	0	0	0	819	733	687
10	394	405	0	0	0	0	0	0	0	0	0	0	0	0	0	592	554	528
15	384	386	385	450	573	556	0	0	0	0	0	0	0	0	489	455	441	430
20	376	388	374	398	508	593	544	508	464	425	0	0	0	0	396	383	377	369
25	370	391	385	390	443	582	579	514	460	421	384	357	0	362	351	345	344	342
30	364	376	397	380	409	511	632	560	498	447	409	376	352	351	343	337	333	328
35	356	364	389	385	394	439	579	672	551	496	448	412	385	365	351	345	339	331
40	311	335	361	378	381	416	486	620	690	565	499	443	424	403	390	364	349	338
45	285	309	331	352	365	378	421	510	623	673	576	503	459	421	402	386	372	356
50	258	281	301	320	336	352	375	420	476	564	639	608	509	454	422	393	370	353
55	230	256	277	290	302	312	328	345	386	420	474	520	547	533	474	420	385	364
60	203	236	249	260	265	271	277	293	309	328	349	363	390	410	420	423	411	403
65	193	199	204	211	226	237	244	249	257	265	271	280	288	292	294	294	302	306
70	188	192	203	219	223	226	228	230	231	233	235	234	234	230	229	235	240	242
75	191	192	195	197	197	198	201	203	207	209	213	218	223	229	231	228	226	224
80	188	190	191	193	194	197	199	200	201	202	204	205	206	207	208	209	210	210
85	189	190	192	193	194	194	195	196	196	197	198	198	199	200	201	201	201	202
90	191																	

BRIGHTNESS OF THE SKY AT FEBRUARY 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA / DEC	0H	20M	40M	1H	20M	40M	2H	20M	40M	3H	20M	40M	4H	20M	40M	5H	20M	40M
-5	741	574	464	394	351	317	288	263	245	230	223	221	224	227	237	252	271	291
-10	635	505	418	363	326	297	272	251	233	220	214	213	216	222	231	246	268	292
-15	546	444	377	334	303	279	255	237	221	211	205	207	210	216	226	238	262	289
-20	469	390	342	309	283	263	243	225	211	202	198	200	204	209	218	230	253	281
-25	418	349	311	286	268	251	233	214	202	195	192	193	197	203	212	224	241	270
-30	369	315	287	268	254	241	226	209	196	188	187	188	193	199	206	218	231	257
-35	0	291	270	255	246	235	223	209	193	183	181	184	189	194	200	211	223	244
-40	269	267	257	249	239	230	220	209	195	183	179	181	186	190	195	204	215	230
-45	261	251	242	241	236	228	220	210	200	188	179	178	183	187	191	198	209	218
-50	254	247	240	231	232	229	222	213	204	194	186	180	182	187	188	193	201	210
-55	246	243	238	235	227	225	222	217	208	200	193	188	187	187	190	189	196	202
-60	240	238	236	233	229	225	220	216	212	207	202	197	192	194	199	200	192	199
-65	238	236	234	231	229	226	222	219	215	211	208	201	194	191	194	195	186	191
-70	238	237	235	233	232	230	228	227	225	222	218	216	214	213	213	212	209	190
-75	241	240	239	237	236	235	233	232	231	230	229	228	227	225	224	221	217	213
-80	245	244	242	241	240	239	238	237	236	234	232	231	230	228	227	226	224	221
-85	246	244	244	243	242	241	241	240	239	238	237	238	237	237	236	236	236	236
-90	250																	

BRIGHTNESS OF THE SKY AT FEBRUARY 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	6H	20M	40M	7H	20M	40M	8H	20M	40M	9H	20M	40M	10H	20M	40M	11H	20M	40M
DEC																		
-5	305	353	471	495	391	346	330	305	280	251	231	220	213	212	213	215	218	220
-10	316	340	412	532	442	367	337	320	286	259	237	222	218	215	216	217	220	223
-15	319	348	405	513	525	392	350	328	297	267	245	229	222	220	219	220	223	226
-20	312	356	399	479	599	500	390	338	309	277	253	239	228	223	224	225	227	230
-25	299	351	400	474	587	644	481	388	332	290	264	246	236	232	230	232	234	237
-30	285	328	390	458	556	718	670	480	395	331	283	258	244	240	238	240	242	245
-35	271	299	364	436	524	637	833	710	502	420	345	295	264	251	248	249	252	257
-40	254	277	327	400	484	587	734	919	782	567	469	380	331	285	271	266	265	271
-45	239	260	284	353	426	507	628	804	1001	882	685	551	468	398	360	327	303	306
-50	226	242	262	304	364	440	516	628	773	1048	1030	845	683	588	526	472	435	420
-55	213	230	246	260	311	361	424	484	587	679	882	1039	1028	900	781	685	625	594
-60	205	219	233	245	264	302	341	392	435	500	573	640	786	933	987	1003	945	883
-65	196	207	216	229	238	257	287	315	347	376	402	446	498	541	577	619	695	750
-70	194	202	210	227	228	232	242	264	285	302	323	343	359	372	382	408	431	449
-75	203	215	220	228	237	240	242	245	251	263	274	283	290	299	307	317	324	329
-80	220	224	227	230	232	234	236	238	240	243	245	248	251	256	262	267	271	275
-85	237	238	240	240	242	243	244	245	246	247	248	249	250	251	252	254	255	256
-90	250																	

BRIGHTNESS OF THE SKY AT FEBRUARY 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	12H	20M	40M	13H	20M	40M	14H	20M	40M	15H	20M	40M	16H	20M	40M	17H	20M	40M
DEC																		
-5	225	229	235	238	244	250	255	259	268	280	294	315	338	360	382	408	445	496
-10	227	232	238	245	255	267	273	282	292	306	325	349	375	402	430	468	526	606
-15	230	236	242	249	258	270	284	303	322	338	359	385	421	454	495	556	649	767
-20	234	239	246	251	260	269	283	302	325	351	384	428	478	525	591	691	829	1023
-25	241	246	251	258	266	275	288	304	325	357	392	432	480	542	638	769	942	1244
-30	249	255	260	267	275	283	297	319	346	374	405	444	492	555	639	756	970	1196
-35	263	269	276	285	297	310	327	349	371	399	439	477	525	588	672	842	1047	1047
-40	278	288	300	310	325	340	357	387	417	450	486	522	578	647	802	983	984	893
-45	313	324	337	352	370	394	416	445	473	500	539	594	664	818	967	948	836	767
-50	413	413	418	430	445	464	483	508	542	579	624	747	884	958	880	779	711	650
-55	570	558	553	553	560	572	589	618	683	763	859	917	884	776	711	646	588	534
-60	836	804	784	779	786	804	833	877	878	873	794	709	661	612	561	524	482	441
-65	786	802	801	792	770	738	694	644	608	589	564	533	497	476	452	422	397	370
-70	461	467	469	471	470	465	456	445	429	426	421	413	399	382	368	353	334	321
-75	334	337	339	343	347	350	352	351	349	344	340	335	329	321	311	303	303	301
-80	279	282	284	287	290	291	291	291	290	288	285	284	284	284	285	285	284	283
-85	257	258	259	260	262	263	264	265	266	267	267	268	268	269	269	269	267	267
-90	250																	

BRIGHTNESS OF THE SKY AT FEBRUARY 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	18H	20M	40M	19H	20M	40M	20H	20M	40M	21H	20M	40M	22H	20M	40M	23H	20M	40M
DEC																		
-5	564	719	C	C	C	0	C	C	0	0	0	0	0	0	0	0	1382	981
-10	712	953	0	0	0	0	C	C	0	0	0	0	0	0	0	0	1175	823
-15	965	1256	0	0	0	0	C	C	0	0	0	0	0	0	0	0	0	719
-20	1305	1537	0	0	0	0	0	C	0	0	0	0	0	0	0	0	0	617
-25	1490	1662	0	0	0	0	C	C	0	0	0	0	0	0	0	0	0	0
-30	1206	1319	0	0	0	0	C	C	0	0	0	0	0	0	0	0	0	0
-35	1014	1060	0	0	0	0	C	C	0	0	0	0	0	0	0	0	0	0
-40	859	859	0	0	0	0	C	C	0	0	0	0	0	0	0	0	0	0
-45	717	688	0	0	0	0	C	C	0	0	0	0	0	0	0	329	297	275
-50	593	552	0	0	0	0	C	C	0	0	0	0	386	353	315	291	276	263
-55	487	443	0	0	0	0	0	C	363	349	343	339	324	305	288	270	258	250
-60	402	375	366	348	332	324	323	320	315	307	298	293	286	275	265	257	250	245
-65	344	336	326	316	307	301	297	295	290	283	276	270	266	260	254	248	244	242
-70	317	311	301	293	289	285	283	279	276	272	267	262	258	254	250	246	243	241
-75	297	292	285	277	274	272	271	270	268	265	262	259	256	253	250	248	246	244
-80	280	277	273	268	263	261	261	260	259	258	257	256	254	252	250	249	247	245
-85	266	265	263	261	259	257	255	253	251	251	251	250	250	249	249	248	247	247
-90	250																	

BRIGHTNESS OF THE SKY AT MARCH 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA / DEC	0H	20M	40M	1H	20M	40M	2H	20M	40M	3H	20M	40M	4H	20M	40M	5H	20M	40M
0	C	0	0	0	849	641	514	430	376	340	313	292	275	264	263	270	283	299
5	C	0	0	1429	997	759	593	485	416	370	338	312	291	279	274	279	289	300
10	C	0	0	1148	1026	900	688	550	461	403	363	332	307	293	287	289	295	316
15	C	0	907	801	753	697	637	579	509	437	388	349	326	309	302	303	308	352
20	C	0	653	604	577	545	511	477	448	420	390	366	343	328	323	323	345	423
25	C	528	494	478	467	450	431	413	395	379	358	341	330	329	332	345	378	511
30	C	428	414	406	400	391	379	370	359	346	332	322	322	325	335	363	462	479
35	389	379	374	369	364	358	350	341	332	322	320	319	322	330	353	421	453	396
40	373	366	360	354	348	341	333	327	324	322	320	324	332	346	397	417	370	332
45	383	373	364	357	351	345	341	332	327	326	327	333	346	385	375	334	303	289
50	388	378	370	362	355	348	340	334	330	331	336	353	353	329	298	277	269	265
55	396	384	373	365	357	348	339	336	340	344	331	311	286	260	253	250	251	254
60	434	414	396	383	372	353	334	318	301	284	264	244	240	238	236	241	246	245
65	331	323	310	298	287	273	259	244	235	233	230	227	226	230	235	240	238	235
70	254	247	241	235	232	229	225	223	219	220	223	226	229	233	232	230	229	226
75	223	223	222	221	221	222	222	223	223	225	224	224	223	223	222	221	218	216
80	216	216	216	217	217	217	217	216	216	216	215	215	214	212	211	209	209	207
85	204	204	204	204	205	204	204	204	204	204	203	203	202	202	202	201	200	199
90	191																	

BRIGHTNESS OF THE SKY AT MARCH 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA / DEC	6H	20M	40M	7H	20M	40M	8H	20M	40M	9H	20M	40M	10H	20M	40M	11H	20M	40M
0	315	383	533	456	383	344	316	284	259	236	227	222	223	231	233	228	223	219
5	341	473	516	425	363	329	299	273	249	233	225	220	224	232	243	239	229	218
10	379	545	480	398	343	311	286	265	242	232	224	222	225	236	240	234	223	212
15	489	520	440	366	317	293	275	258	241	230	226	222	219	222	225	226	215	206
20	547	475	399	337	300	281	268	252	240	225	217	213	209	209	211	213	207	199
25	487	417	354	305	283	269	256	243	231	217	210	204	201	200	200	200	200	191
30	413	361	317	287	269	258	245	235	223	211	204	197	195	193	192	191	192	187
35	353	318	288	271	258	248	237	227	217	207	199	192	187	187	185	185	184	183
40	304	289	273	259	250	239	231	222	211	202	196	190	185	181	180	179	180	180
45	279	270	260	248	240	232	224	216	207	200	194	187	183	179	178	177	175	175
50	263	258	248	240	232	224	217	211	203	197	192	187	183	180	176	174	173	171
55	251	247	239	231	224	216	211	205	199	193	190	186	183	179	176	173	172	170
60	241	236	230	223	217	210	206	201	197	191	188	186	183	179	177	175	172	170
65	231	226	221	216	210	205	201	199	195	191	187	185	183	181	178	176	174	172
70	221	217	213	209	205	201	199	196	194	191	188	185	183	181	180	178	176	175
75	213	209	206	204	200	197	196	194	192	190	189	186	184	182	181	179	178	177
80	204	202	200	198	196	194	193	192	190	190	188	187	186	185	184	182	181	181
85	198	197	195	195	194	193	192	191	190	190	189	189	189	189	188	187	187	186
90	191																	

BRIGHTNESS OF THE SKY AT MARCH 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	12H	20M	40M	13H	20M	40M	14H	20M	40M	15H	20M	40M	16H	20M	40M	17H	20M	40M
DEC																		
0	221	214	212	214	215	216	217	221	223	228	234	240	249	260	272	290	310	340
5	213	206	204	203	207	208	210	211	214	218	223	228	236	247	261	277	299	325
10	205	199	196	195	198	200	202	203	205	208	211	217	225	236	249	266	288	314
15	199	193	189	189	191	194	195	196	197	199	202	207	215	224	239	256	278	307
20	194	187	183	182	186	187	187	189	190	191	195	198	205	214	229	244	267	297
25	185	183	179	178	177	180	181	182	184	185	188	191	198	207	220	236	254	286
30	183	179	176	173	173	174	176	177	179	180	183	186	192	202	212	229	243	272
35	179	175	172	170	168	169	171	173	174	176	179	182	187	195	204	220	233	257
40	177	173	169	167	166	166	167	169	171	172	175	178	183	190	198	212	227	243
45	173	171	168	166	164	165	165	166	169	170	173	175	180	186	192	205	220	231
50	170	168	167	166	164	163	164	165	166	169	171	174	179	184	188	197	212	224
55	169	168	166	165	165	164	164	164	167	168	169	173	177	182	186	192	201	218
60	168	168	167	167	165	165	167	166	168	169	171	174	176	179	183	189	194	209
65	171	170	169	169	169	168	168	169	171	172	174	176	178	181	183	185	185	190
70	174	173	172	172	172	171	172	172	174	174	176	178	179	181	184	185	186	185
75	177	176	175	175	174	174	174	174	175	175	176	177	178	180	182	184	186	188
80	181	180	180	179	179	179	180	180	180	180	181	182	182	183	185	186	187	187
85	186	185	185	185	185	185	185	186	186	186	186	187	187	187	187	188	188	189
90	191																	

BRIGHTNESS OF THE SKY AT MARCH 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	18H	20M	40M	19H	20M	40M	20H	20M	40M	21H	20M	40M	22H	20M	40M	23H	20M	40M
DEC																		
0	367	404	509	556	539	556	605	0	0	0	0	0	0	0	0	0	0	0
5	344	371	435	540	516	508	541	0	0	0	0	0	0	0	0	0	0	0
10	340	350	375	475	532	501	500	0	0	0	0	0	0	0	0	0	0	0
15	338	350	362	422	535	513	0	0	0	0	0	0	0	0	0	0	0	0
20	332	362	353	379	491	573	504	461	434	423	0	0	0	0	0	0	0	0
25	326	368	366	377	439	573	567	500	456	422	408	421	0	0	0	0	0	0
30	311	353	378	372	408	507	635	561	498	447	422	406	392	385	395	0	0	0
35	295	339	371	379	395	441	584	676	551	493	449	421	399	382	375	372	366	0
40	275	311	344	372	377	418	489	621	688	560	495	448	426	410	397	385	371	373
45	258	287	316	342	358	376	431	510	621	670	578	501	460	432	419	407	397	391
50	243	263	286	307	327	349	375	422	479	569	641	611	520	471	444	416	403	397
55	232	243	255	277	296	314	335	355	395	429	484	535	567	556	500	458	430	411
60	226	219	239	259	272	284	292	311	323	345	368	386	416	444	461	467	454	445
65	193	199	204	237	244	251	258	265	276	286	295	308	322	328	329	328	334	335
70	188	192	219	213	218	225	231	237	243	248	252	253	252	249	248	253	256	256
75	191	191	200	209	211	213	216	218	220	222	224	229	234	238	239	236	232	227
80	188	190	191	194	197	201	204	207	209	210	212	212	213	214	215	215	215	216
85	190	191	192	193	194	194	196	197	197	198	199	199	201	202	203	202	203	204
90	191																	

BRIGHTNESS OF THE SKY AT MARCH 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA / DEC	0H	20M	40M	1H	20M	40M	2H	20M	4CM	3H	20M	40M	4H	20M	40M	5H	20M	40M
-5	C	0	0	0	725	541	443	381	339	311	291	272	260	252	251	263	281	301
-10	C	0	0	0	0	462	385	340	310	287	272	255	244	240	242	254	275	300
-15	C	0	0	C	0	407	341	307	284	269	255	242	232	228	234	244	267	294
-20	C	0	0	0	0	356	307	282	266	254	244	232	222	218	224	234	257	285
-25	C	0	0	0	0	0	282	263	252	242	234	224	212	209	215	227	245	273
-30	C	0	0	0	285	265	260	251	244	234	227	218	208	203	208	221	234	259
-35	C	0	317	288	270	255	245	239	238	230	222	215	206	199	201	214	226	245
-40	347	312	279	265	254	246	240	232	231	229	221	213	206	198	198	209	218	231
-45	293	274	258	246	239	237	235	232	224	227	222	212	206	200	196	203	213	218
-50	261	250	241	235	231	229	229	228	225	220	219	214	207	202	199	201	209	210
-55	244	239	233	230	228	227	225	224	222	219	215	211	208	202	198	204	208	205
-60	240	236	232	229	227	226	225	223	222	219	217	213	208	200	197	198	213	210
-65	241	237	234	231	229	227	226	225	224	222	221	218	216	211	208	204	186	191
-70	241	238	235	232	230	229	228	227	225	223	220	219	216	215	213	210	204	190
-75	236	234	233	231	229	227	224	222	220	218	217	215	213	208	200	201	204	206
-80	236	234	233	231	229	227	224	222	221	219	217	216	214	212	211	210	210	211
-85	225	224	224	223	222	221	221	220	219	218	217	217	216	215	215	214	215	216
-90	219																	

BRIGHTNESS OF THE SKY AT MARCH 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	6H	20M	40M	7H	20M	40M	8H	20M	40M	9H	20M	40M	10H	20M	40M	11H	20M	40M
DEC																		
-5	314	362	481	505	400	351	331	299	271	245	229	224	223	229	227	221	217	216
-10	323	347	420	540	451	372	338	315	280	255	237	227	227	228	222	217	216	215
-15	324	353	411	521	532	397	351	324	294	266	246	233	230	226	220	216	216	216
-20	316	359	404	486	605	505	391	337	307	276	254	242	233	224	221	219	217	219
-25	302	353	405	479	592	647	482	388	331	290	265	248	237	229	225	224	224	227
-30	287	330	393	462	560	721	671	480	365	331	284	259	242	236	232	231	233	236
-35	272	300	366	439	527	639	834	711	502	420	345	293	260	246	241	241	244	249
-40	255	279	329	402	486	589	735	919	781	566	468	377	327	279	265	259	260	265
-45	239	262	285	354	427	508	628	804	1000	881	682	548	463	393	356	323	299	301
-50	226	244	262	303	364	440	515	627	773	1047	1027	842	680	585	523	470	433	417
-55	214	230	245	258	310	361	424	485	586	678	880	1037	1026	898	780	683	623	591
-60	205	218	228	245	264	305	343	392	435	499	572	638	785	932	986	1002	944	881
-65	196	207	216	232	240	258	287	312	344	375	402	445	497	540	576	618	692	747
-70	194	202	212	221	226	232	242	264	285	301	321	340	356	369	378	403	427	445
-75	218	221	222	221	220	224	229	233	240	254	265	275	283	293	303	313	320	326
-80	215	218	219	221	224	226	228	229	230	232	234	237	240	245	251	256	260	263
-85	217	217	218	218	220	220	221	223	224	224	225	226	228	228	229	230	230	231
-90	219																	

BRIGHTNESS OF THE SKY AT MARCH 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	12H	20M	40M	13H	20M	40M	14H	20M	40M	15H	20M	40M	16H	20M	40M	17H	20M	40M
DEC																		
-5	218	218	221	223	223	224	226	229	234	240	244	254	263	274	287	305	331	367
-10	216	218	223	227	230	233	236	240	245	251	259	270	279	292	307	330	364	413
-15	218	221	226	231	234	239	244	251	258	266	277	287	301	315	334	364	414	477
-20	221	225	230	234	238	243	250	259	267	277	292	312	329	348	375	421	485	580
-25	229	233	238	243	248	254	261	268	276	291	309	324	344	373	422	483	556	730
-30	240	244	249	254	260	265	274	289	303	317	330	348	375	415	470	543	699	848
-35	255	260	268	275	285	296	309	324	334	350	373	395	427	474	541	686	857	815
-40	272	282	292	302	315	329	342	365	385	408	430	453	497	555	699	867	851	738
-45	308	319	331	345	363	385	404	426	447	465	492	536	595	744	886	860	741	663
-50	410	409	414	424	439	457	472	492	521	550	585	697	827	895	814	710	639	576
-55	567	554	549	549	550	566	581	606	666	739	826	874	834	723	655	588	531	477
-60	833	801	781	776	783	800	827	868	863	851	763	670	616	564	511	473	431	391
-65	783	759	758	790	768	735	689	634	592	566	533	496	456	432	406	374	349	323
-70	458	465	467	469	467	459	447	430	409	399	389	377	360	340	323	306	286	275
-75	330	333	333	336	337	337	334	329	323	314	307	298	289	279	266	257	256	255
-80	266	268	268	269	270	268	266	263	260	255	249	246	244	242	241	239	239	239
-85	231	231	231	231	232	231	232	231	231	230	230	229	228	229	228	229	228	228
-90	219																	

BRIGHTNESS OF THE SKY AT MARCH 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	18H	20M	40M	19H	20M	40M	20H	20M	40M	21H	20M	40M	22H	20M	40M	23H	20M	40M
DEC																		
-5	406	489	601	578	584	630	697	0	0	0	0	0	0	0	0	0	0	0
-10	468	596	633	628	665	725	819	0	0	0	0	0	0	0	0	0	0	0
-15	591	719	679	698	767	852	989	1272	0	0	0	0	0	0	0	0	0	0
-20	743	749	748	799	886	1017	1212	1491	0	0	0	0	0	0	0	0	0	0
-25	835	771	771	809	840	898	966	1075	0	0	0	0	0	0	0	0	0	0
-30	767	722	703	693	688	710	737	787	887	0	0	0	0	0	0	0	0	0
-35	725	671	635	593	576	574	574	598	652	0	0	0	0	0	0	0	0	0
-40	672	612	554	502	489	477	470	479	497	0	0	0	0	0	0	0	0	0
-45	596	535	475	442	427	409	401	399	400	411	0	0	0	0	0	331	316	309
-50	511	457	404	391	376	359	353	349	345	344	0	0	302	300	296	288	277	267
-55	428	382	361	351	338	324	320	317	312	308	302	291	282	278	273	267	258	250
-60	354	331	326	318	309	300	297	294	292	287	283	275	270	267	262	258	253	246
-65	306	299	297	292	286	280	279	278	277	275	272	268	261	256	256	253	250	246
-70	273	274	273	270	267	264	265	264	263	264	264	262	260	254	248	246	245	244
-75	253	254	254	253	252	250	250	251	252	251	252	251	252	251	249	247	244	240
-80	238	238	239	238	238	237	237	238	238	238	239	239	239	238	238	238	237	236
-85	227	228	228	227	227	227	227	227	226	226	227	227	227	227	227	226	226	226
-90	219																	

BRIGHTNESS OF THE SKY AT APRIL 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA / DEC	0H	20M	40M	1H	20M	40M	2H	20M	40M	3H	20M	40M	4H	20M	40M	5H	20M	40M
0	C	0	0	0	0	0	0	0	0	0	553	447	394	364	350	347	346	347
5	C	0	0	0	0	0	0	0	0	0	668	533	456	410	383	373	368	362
10	C	0	0	0	0	0	0	0	0	0	804	642	535	466	425	405	392	392
15	C	0	0	0	0	0	0	0	0	1364	992	782	635	536	476	445	425	444
20	C	0	0	0	0	0	0	C	0	1209	1042	921	758	625	544	494	483	530
25	C	0	0	0	0	0	C	0	0	861	774	701	633	580	540	516	521	623
30	C	0	0	0	0	0	C	0	718	637	593	557	529	506	492	500	580	575
35	C	0	0	0	0	0	C	C	541	503	488	475	466	463	474	530	547	475
40	425	0	0	0	0	0	0	466	445	437	433	434	437	447	492	503	445	395
45	405	407	402	396	0	0	C	415	407	406	409	415	427	464	450	401	361	338
50	399	398	394	388	382	386	393	393	392	395	401	419	418	392	357	328	313	301
55	408	402	394	390	386	386	387	389	394	399	386	366	341	310	298	288	282	279
60	452	436	422	411	406	398	383	369	352	333	313	291	285	278	270	267	267	262
65	358	351	341	338	334	323	309	293	282	278	272	267	261	260	258	257	251	245
70	290	289	287	284	281	275	269	264	259	257	257	256	255	253	247	241	236	232
75	265	264	262	260	259	257	256	255	253	252	248	245	240	235	230	227	222	219
80	242	241	241	241	240	239	238	236	234	232	229	226	222	219	216	212	211	209
85	217	217	216	215	216	215	214	213	212	211	209	208	206	206	205	204	203	201
90	196																	

BRIGHTNESS OF THE SKY AT APRIL 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	6H	20M	40M	7H	20M	40M	8H	20M	40M	9H	20M	40M	10H	20M	40M	11H	20M	40M
DEC																		
0	351	407	551	472	397	357	330	299	273	248	235	224	217	214	210	211	216	219
5	398	506	541	445	382	347	314	290	264	245	233	223	218	215	212	213	217	216
10	439	590	515	426	368	333	305	283	259	245	231	224	219	217	212	207	207	207
15	563	578	486	403	349	321	299	277	258	243	231	223	216	212	207	201	199	198
20	636	548	459	387	343	317	297	272	256	240	227	218	212	206	201	196	193	191
25	581	496	418	358	325	303	283	264	249	234	224	214	207	202	197	192	187	184
30	492	425	369	329	303	286	269	254	241	228	218	209	204	199	194	188	184	181
35	419	369	329	303	285	270	257	244	233	223	213	204	198	194	190	186	182	178
40	356	329	305	284	270	257	247	236	224	216	209	202	196	190	187	184	182	179
45	319	301	284	267	255	246	236	228	217	211	205	197	193	189	186	183	179	177
50	292	280	266	253	244	235	227	220	212	206	201	195	191	188	184	181	178	175
55	272	263	251	241	233	224	218	212	206	200	197	192	189	186	182	180	178	175
60	254	247	238	230	223	216	212	206	202	197	193	190	187	184	182	180	177	175
65	239	233	227	221	215	210	206	203	199	195	191	188	185	184	181	179	178	176
70	226	221	217	212	209	205	202	200	197	194	191	188	185	182	181	179	178	177
75	215	212	209	206	203	200	199	197	195	192	190	188	185	184	183	181	179	178
80	206	205	203	201	199	197	196	195	193	193	191	190	188	186	185	183	182	182
85	200	199	198	199	198	197	196	195	194	194	193	193	193	193	192	191	191	190
90	196																	

BRIGHTNESS OF THE SKY AT APRIL 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	12H	20M	40M	13H	20M	40M	14H	20M	40M	15H	20M	40M	16H	20M	40M	17H	20M	40M
DEC																		
0	229	236	240	233	222	215	211	209	209	212	219	225	233	243	254	266	277	295
5	217	219	223	223	214	207	203	200	201	204	210	216	224	235	248	260	275	292
10	206	206	209	212	206	200	196	193	194	196	200	208	216	227	240	255	272	292
15	197	197	197	199	199	194	190	188	187	189	193	200	208	218	232	248	268	292
20	190	188	188	188	193	187	183	182	181	183	187	193	200	209	224	240	261	288
25	181	182	181	181	181	181	178	176	176	178	182	187	194	203	216	232	251	281
30	179	177	176	175	175	175	173	173	172	174	178	182	190	199	210	226	240	270
35	176	173	172	171	168	169	170	169	169	171	175	179	186	193	202	217	230	255
40	175	172	169	167	166	166	166	166	167	168	172	175	181	189	197	209	223	239
45	174	171	168	166	164	164	164	165	166	168	170	174	179	185	192	203	215	226
50	173	170	168	166	165	163	164	164	165	168	170	173	178	182	188	197	207	215
55	173	171	168	167	166	165	164	164	166	167	169	173	177	182	184	192	199	206
60	173	171	170	169	167	166	167	167	168	169	171	175	178	181	185	188	193	199
65	174	174	172	171	170	169	169	169	170	171	173	175	177	181	184	188	185	190
70	176	175	174	173	173	173	173	173	174	174	175	176	177	179	181	183	187	185
75	177	176	176	176	176	176	176	176	177	178	178	180	180	182	183	184	189	199
80	182	181	180	180	180	179	180	181	181	181	181	182	183	186	190	194	196	199
85	190	190	189	189	189	189	189	191	191	192	192	193	193	194	195	196	196	196
90	196																	

BRIGHTNESS OF THE SKY AT APRIL 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	18H	20M	40M	19H	20M	40M	20H	20M	40M	21H	20M	40M	22H	20M	40M	23H	20M	40M
DEC																		
0	308	332	427	465	436	429	420	406	411	431	484	571	726	0	0	0	0	0
5	299	312	369	468	438	418	413	394	387	399	428	493	622	0	0	0	0	0
10	306	302	319	416	469	434	415	394	370	374	388	433	0	0	0	0	0	0
15	313	311	313	369	481	459	434	407	377	358	368	396	0	0	0	0	0	0
20	314	328	310	330	440	530	473	434	398	368	355	373	0	0	0	0	0	0
25	313	339	326	329	389	537	541	479	434	397	369	353	0	0	0	0	0	0
30	300	327	341	325	361	479	612	544	489	439	400	374	358	368	393	0	0	0
35	285	317	337	334	352	413	564	665	550	491	444	415	394	380	381	401	440	0
40	266	291	313	329	343	393	473	616	689	558	500	450	428	410	400	405	411	423
45	247	271	289	309	330	355	419	506	618	673	582	504	459	429	418	412	413	411
50	230	252	267	286	306	333	364	415	476	570	641	611	517	467	439	419	407	402
55	215	238	253	261	280	296	323	347	391	428	484	535	565	554	502	456	429	415
60	204	232	231	239	253	272	286	309	326	349	374	391	422	447	463	471	463	458
65	193	199	204	235	247	258	269	278	289	299	307	319	332	339	342	344	354	358
70	188	192	199	221	231	240	247	253	259	265	270	272	273	271	272	279	285	286
75	208	212	207	209	212	214	220	225	232	238	244	252	260	267	272	271	270	268
80	200	204	206	208	209	212	214	218	221	224	228	231	233	236	238	239	240	241
85	198	199	200	202	203	204	206	208	208	210	211	212	213	214	215	215	216	216
90	196																	

BRIGHTNESS OF THE SKY AT APRIL 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	0H	20M	40M	1H	20M	40M	2H	20M	40M	3H	20M	40M	4H	20M	40M	5H	20M	40M
DEC																		
-5	0	0	0	0	0	0	0	0	0	0	460	382	347	330	322	325	330	337
-10	0	0	0	0	0	0	0	0	0	0	0	336	312	304	301	306	315	326
-15	0	0	0	0	0	0	0	0	0	0	0	302	289	284	286	289	299	312
-20	0	0	0	0	0	0	0	0	0	288	272	275	272	269	271	275	284	298
-25	0	0	0	0	0	0	0	307	285	268	259	254	259	259	260	264	268	281
-30	0	0	0	0	352	332	301	271	259	252	248	245	247	253	252	255	255	266
-35	0	0	306	296	287	279	263	250	241	238	239	240	237	246	245	246	245	252
-40	272	272	270	264	254	249	240	234	231	230	232	234	234	238	240	238	237	239
-45	257	253	251	247	239	234	231	226	225	226	227	227	230	229	232	231	229	229
-50	245	243	241	239	235	229	227	225	224	224	225	226	224	224	222	223	222	224
-55	243	237	233	235	232	229	225	224	223	223	224	223	224	219	216	210	214	216
-60	239	237	233	227	226	226	224	221	221	221	221	222	222	219	218	211	195	207
-65	229	229	229	227	225	221	218	216	215	214	214	213	214	213	213	211	186	191
-70	218	217	217	216	216	215	213	212	209	205	201	198	194	191	189	193	197	190
-75	205	205	205	204	204	204	202	201	200	198	198	199	199	202	206	207	207	202
-80	198	197	197	197	197	197	197	197	198	198	199	200	201	201	202	203	200	199
-85	204	203	204	203	203	202	203	203	203	203	202	203	203	202	202	202	203	203
-90	209																	

BRIGHTNESS OF THE SKY AT APRIL 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	6H	20M	40M	7H	20M	40M	8H	20M	40M	9H	20M	40M	10H	20M	40M	11H	20M	40M
DEC																		
-5	340	379	494	516	411	362	342	311	283	256	236	226	218	213	211	210	214	220
-10	340	359	429	549	459	380	348	325	291	265	243	229	222	215	212	211	215	221
-15	336	361	417	527	539	403	359	332	303	274	252	234	224	218	214	213	218	223
-20	323	364	409	490	610	510	397	344	315	283	259	243	228	220	218	218	221	226
-25	306	356	408	482	595	651	486	394	338	296	269	249	235	227	224	225	228	233
-30	289	332	396	464	562	723	675	485	401	336	287	259	241	235	232	233	236	241
-35	274	303	369	440	528	641	837	715	507	424	347	293	260	246	241	242	246	252
-40	258	283	331	403	486	591	737	923	784	569	469	378	327	279	265	260	260	264
-45	245	267	287	354	428	509	630	806	1002	882	683	548	463	392	355	322	297	298
-50	235	251	262	304	366	441	516	628	773	1048	1028	842	679	584	521	467	430	413
-55	228	236	245	260	310	361	423	484	587	678	880	1037	1025	896	778	680	619	586
-60	224	217	232	243	262	303	343	392	435	499	571	637	784	930	984	998	940	878
-65	196	207	216	231	241	259	288	315	346	376	402	445	496	538	574	616	690	745
-70	194	202	209	218	227	233	243	265	285	301	321	340	356	367	376	402	426	444
-75	198	203	210	214	218	224	228	233	240	253	265	275	283	292	302	312	319	325
-80	200	203	206	210	213	217	220	223	225	228	230	233	237	242	248	253	257	260
-85	204	205	208	209	211	212	213	216	217	218	219	220	221	222	223	224	225	226
-90	209																	

BRIGHTNESS OF THE SKY AT APRIL 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	12H	20M	40M	13H	20M	40M	14H	20M	40M	15H	20M	40M	16H	20M	40M	17H	20M	40M
DEC.																		
-5	230	243	254	244	231	223	220	217	218	222	227	235	243	252	260	272	285	308
-10	230	242	245	241	236	233	231	228	228	233	239	246	253	262	271	284	305	338
-15	231	242	239	236	234	235	237	237	242	247	251	256	266	274	285	305	340	381
-20	233	237	236	234	234	235	238	243	250	256	263	273	282	294	311	345	394	471
-25	240	238	238	239	240	242	247	251	258	271	282	292	303	322	358	404	461	614
-30	243	243	245	247	250	253	260	273	287	298	308	322	343	374	418	478	617	748
-35	254	257	261	266	274	284	295	309	320	333	355	374	402	442	499	632	788	731
-40	268	277	284	292	305	318	330	353	373	394	415	436	476	529	666	823	794	670
-45	303	312	323	337	354	376	394	417	437	454	481	523	580	724	860	826	696	609
-50	404	402	407	417	432	450	465	485	513	541	576	687	815	880	794	683	605	535
-55	562	549	544	544	551	562	576	600	660	732	818	866	825	712	641	569	506	446
-60	830	797	778	773	780	796	822	864	858	846	758	664	610	556	501	460	414	370
-65	781	797	797	788	765	732	686	631	589	562	529	492	451	426	399	365	338	307
-70	457	463	466	467	465	457	444	427	405	396	386	373	356	336	319	301	279	264
-75	329	331	332	334	334	334	331	326	320	311	304	295	287	277	264	253	251	247
-80	262	264	265	266	266	265	263	260	257	252	247	244	242	240	238	236	234	231
-85	226	227	227	227	228	228	228	227	227	227	227	226	225	225	223	223	221	220
-90	209																	

BRIGHTNESS OF THE SKY AT APRIL 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	18H	20M	40M	19H	20M	40M	20H	20M	40M	21H	20M	40M	22H	20M	40M	23H	20M	40M
DEC																		
-5	332	400	499	460	441	447	434	431	440	478	551	667	847	1189	0	0	0	0
-10	374	485	503	472	466	462	454	457	476	534	632	791	1022	1414	0	0	0	0
-15	476	582	513	490	491	477	475	485	522	598	726	847	931	1019	0	0	0	0
-20	604	581	536	519	505	489	492	502	526	555	595	640	687	731	815	0	0	0
-25	687	590	547	527	488	465	452	449	455	465	485	507	529	549	583	0	0	0
-30	643	577	533	491	447	427	408	405	405	405	411	417	425	430	439	465	0	0
-35	624	554	504	445	409	387	367	366	362	361	359	358	359	357	358	362	0	0
-40	591	519	452	391	370	349	335	333	327	325	322	318	315	311	307	306	305	0
-45	531	460	394	356	338	318	308	304	299	299	296	292	289	285	280	276	273	266
-50	462	398	339	322	306	288	283	280	276	274	276	273	270	267	263	260	257	253
-55	391	336	309	295	280	266	262	259	256	254	255	256	256	253	251	249	247	246
-60	326	295	283	271	259	248	245	242	239	237	238	240	242	242	241	240	238	239
-65	279	271	263	253	243	235	232	229	226	224	223	224	227	229	229	230	229	230
-70	258	253	246	238	231	225	223	220	217	215	214	212	213	213	215	217	218	219
-75	242	237	234	228	223	218	216	215	212	210	208	206	205	203	204	203	204	205
-80	229	225	223	220	217	214	212	210	208	207	207	205	204	202	201	200	199	198
-85	218	217	216	214	213	211	211	209	208	207	207	206	206	205	206	205	204	204
-90	209																	

BRIGHTNESS OF THE SKY AT MAY 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA / DEC	0H	20M	40M	1H	20M	40M	2H	20M	40M	3H	20M	40M	4H	20M	40M	5H	20M	40M
0	1225	1420	0	0	0	0	0	0	0	0	0	0	0	0	0	0	468	443
5	1068	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	551	502
10	915	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	667	602
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1064	837	759
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1377	1091	999
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1402	1183	1158
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1079	1017	931
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	898	831	710
40	390	0	0	0	0	0	0	0	0	0	0	0	0	0	0	731	627	551
45	400	407	417	450	0	0	0	0	0	0	0	0	0	0	0	540	479	443
50	399	399	409	423	440	452	454	0	0	0	0	0	0	0	457	415	392	377
55	406	402	400	404	410	413	412	420	432	436	422	0	0	0	359	348	342	339
60	448	432	419	416	414	404	393	384	372	356	336	315	312	315	314	316	318	314
65	353	350	343	338	333	324	315	305	298	296	293	290	287	291	299	303	300	295
70	292	290	287	284	284	283	281	280	277	278	280	281	281	288	290	288	286	280
75	272	272	272	273	273	274	275	276	277	277	274	273	275	278	276	275	271	265
80	261	262	263	263	264	264	264	263	261	263	264	266	265	263	261	259	256	252
85	246	247	247	248	249	250	250	250	250	250	249	249	248	247	246	244	242	239
90	226																	

BRIGHTNESS OF THE SKY AT MAY 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	6H	20M	40M	7H	20M	40M	8H	20M	40M	9H	20M	40M	10H	20M	40M	11H	20M	40M
DEC																		
0	438	488	627	540	455	403	365	326	295	267	254	242	234	230	225	222	220	219
5	508	612	637	532	457	408	364	328	295	273	258	246	238	231	228	224	220	217
10	609	731	638	536	463	411	370	335	303	282	265	255	244	235	227	220	217	213
15	809	773	648	542	468	419	380	345	317	295	277	260	244	232	223	217	211	207
20	991	822	676	564	491	436	396	357	324	293	267	250	237	225	218	212	207	202
25	990	808	657	544	475	421	375	338	306	277	257	240	229	219	212	206	200	196
30	776	652	552	479	429	389	351	318	289	264	245	230	221	214	206	202	196	192
35	615	533	469	424	390	358	328	299	274	253	235	222	213	207	201	197	192	188
40	493	450	413	382	356	330	306	282	259	241	226	216	208	201	196	192	190	186
45	417	392	369	346	327	306	285	266	246	231	219	208	202	197	193	190	185	183
50	367	352	335	319	303	284	267	250	235	222	212	203	199	194	190	186	183	179
55	332	322	309	296	282	266	250	237	223	213	206	199	194	191	187	184	182	178
60	307	299	288	278	266	252	239	226	216	206	200	195	191	187	185	183	180	177
65	288	281	272	264	253	242	231	220	211	202	196	192	189	187	184	182	181	178
70	273	266	260	252	244	235	228	218	209	202	195	191	187	185	184	182	181	180
75	260	254	249	243	236	230	225	219	212	205	199	194	189	186	185	183	182	181
80	248	244	240	236	232	227	223	220	215	212	207	204	200	196	193	191	189	188
85	237	235	233	232	229	227	225	222	220	218	217	215	214	212	211	209	208	207
90	226																	

BRIGHTNESS OF THE SKY AT MAY 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	12H	20M	40M	13H	20M	40M	14H	20M	40M	15H	20M	40M	16H	20M	40M	17H	20M	40M
DEC																		
0	220	218	212	210	210	212	215	219	224	224	221	221	225	232	242	253	265	283
5	215	210	206	202	202	202	204	207	211	215	212	212	216	225	237	250	265	282
10	209	204	200	195	194	193	195	196	200	204	202	205	208	217	231	247	265	285
15	204	200	195	191	189	188	188	189	191	194	195	196	202	210	225	242	263	287
20	199	194	190	186	185	183	180	182	183	185	189	190	195	203	217	235	257	284
25	192	190	186	183	179	178	176	176	177	179	182	184	190	197	211	228	248	278
30	189	186	183	179	176	174	172	172	172	174	178	181	186	194	205	222	239	268
35	186	182	179	176	172	171	170	169	169	171	174	177	183	190	199	214	229	254
40	182	179	176	173	171	169	168	167	168	168	171	174	179	187	194	207	221	238
45	179	176	174	172	169	168	167	167	167	169	170	173	178	184	190	202	213	225
50	176	174	172	171	169	167	167	166	166	168	171	173	177	183	188	196	205	214
55	175	173	171	170	168	167	167	166	167	168	170	173	177	182	186	193	200	203
60	175	173	171	170	169	168	168	168	169	170	171	173	176	181	185	190	196	197
65	176	175	174	172	171	170	169	171	172	172	173	175	176	179	181	183	185	190
70	179	178	176	175	174	173	173	173	174	174	175	177	177	179	181	183	195	185
75	181	181	181	181	181	181	181	181	183	184	186	189	191	195	198	203	202	198
80	187	186	185	185	186	186	188	188	190	191	193	195	197	197	199	200	203	206
85	206	205	204	204	203	203	203	205	205	206	206	207	208	210	211	213	214	216
90	226																	

BRIGHTNESS OF THE SKY AT MAY 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	18H	20M	40M	19H	20M	40M	20H	20M	40M	21H	20M	40M	22H	20M	40M	23H	20M	40M
DEC																		
0	296	318	410	439	397	375	348	319	308	305	318	338	365	402	458	551	695	915
5	290	302	356	448	408	375	354	321	304	301	306	324	345	374	419	492	606	778
10	299	295	310	401	447	399	365	332	301	298	298	310	329	350	387	442	526	660
15	308	305	307	359	465	432	391	354	319	296	298	303	316	334	360	400	467	583
20	310	324	305	324	429	506	435	386	346	314	299	308	314	323	342	371	420	516
25	310	335	323	326	381	516	505	434	385	348	325	317	321	325	333	354	395	0
30	298	324	338	323	353	457	577	500	440	394	370	351	333	336	341	353	379	0
35	284	314	334	332	343	390	529	620	502	454	419	394	375	360	356	361	366	0
40	265	288	309	326	331	369	437	570	646	532	477	435	417	404	389	379	372	376
45	246	267	284	301	316	331	383	465	588	649	565	495	459	429	411	407	403	400
50	229	245	258	274	292	308	333	386	452	552	632	609	518	465	444	423	409	403
55	215	227	237	254	268	281	301	327	375	417	478	530	564	558	506	460	431	415
60	204	213	230	245	250	257	270	292	312	339	366	387	421	447	464	471	461	455
65	193	199	204	215	222	240	255	265	279	292	303	318	332	339	342	343	351	354
70	188	192	219	229	237	245	252	258	265	271	276	278	279	276	277	283	288	290
75	202	198	213	221	227	234	241	245	250	254	258	265	271	278	281	279	278	275
80	209	211	212	217	223	229	232	236	239	242	246	249	251	253	256	258	259	260
85	218	220	222	225	227	228	230	232	232	235	237	238	239	241	243	243	244	245
90	226																	

BRIGHTNESS OF THE SKY AT MAY 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA / DEC	0H	20M	40M	1H	20M	40M	2H	20M	40M	3H	20M	40M	4H	20M	40M	5H	20M	40M
-5	882	982	0	0	0	0	0	0	0	0	0	0	0	0	0	0	413	407
-10	648	685	0	0	0	0	0	0	0	0	0	0	0	0	0	0	372	382
-15	495	509	546	0	0	0	0	0	0	0	0	0	0	322	315	319	342	363
-20	398	400	411	0	0	0	0	0	0	357	342	315	297	292	293	299	319	346
-25	335	332	333	340	0	0	0	298	291	290	284	275	266	269	277	287	299	329
-30	293	290	288	288	284	265	265	263	259	253	252	248	250	254	265	277	283	313
-35	266	263	261	260	259	251	248	246	242	236	235	234	239	246	255	266	272	295
-40	245	246	246	246	245	239	237	237	235	231	230	229	234	240	247	257	263	276
-45	230	231	232	233	235	235	228	230	230	229	227	227	231	236	242	246	252	257
-50	216	219	220	222	224	227	228	222	223	224	224	226	228	233	235	238	240	240
-55	199	205	208	212	214	215	217	219	217	216	217	218	224	225	228	230	229	225
-60	190	192	194	198	201	203	205	206	208	208	208	210	210	214	219	220	221	215
-65	188	186	185	185	187	189	191	193	194	195	197	197	195	190	190	199	186	191
-70	191	189	187	185	184	184	184	185	187	189	191	194	196	200	204	207	206	190
-75	192	191	190	189	189	189	188	188	189	189	190	190	190	189	188	190	193	195
-80	194	193	192	191	190	190	189	189	190	189	189	190	191	191	193	195	195	196
-85	196	198	198	198	197	197	198	197	197	197	197	198	198	198	199	200	201	202
-90	208																	

BRIGHTNESS OF THE SKY AT MAY 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	6H	20M	40M	7H	20M	40M	8H	20M	40M	9H	20M	40M	10H	20M	40M	11H	20M	40M
DEC																		
-5	407	445	556	570	453	395	367	329	299	271	251	240	233	228	225	221	220	219
-10	397	414	480	589	488	402	363	337	302	276	255	240	235	228	225	221	221	220
-15	387	409	459	556	557	416	368	340	311	283	261	245	235	230	226	222	222	222
-20	371	408	443	510	620	517	403	350	321	290	266	252	238	230	228	226	225	223
-25	352	395	436	495	600	655	490	399	343	301	275	255	243	236	232	231	230	230
-30	333	366	418	472	565	726	678	489	404	339	291	264	248	243	239	238	238	237
-35	314	332	386	445	530	644	840	717	509	426	350	298	267	253	247	246	246	248
-40	293	305	343	406	490	594	739	925	766	570	472	382	332	284	269	262	259	262
-45	272	283	297	359	433	513	631	807	1003	885	686	552	468	396	358	323	297	297
-50	251	260	274	312	371	441	517	628	776	1049	1031	845	682	586	523	468	430	413
-55	231	244	259	268	311	361	424	486	587	680	881	1038	1026	897	778	681	619	586
-60	212	240	243	243	263	305	342	392	435	499	571	638	785	931	984	998	940	877
-65	196	207	216	229	238	256	285	312	346	376	402	445	496	538	573	615	689	744
-70	194	202	214	222	228	234	243	265	285	301	321	340	355	367	376	401	425	442
-75	198	203	206	214	219	225	230	234	241	254	265	275	283	292	301	310	317	323
-80	206	203	206	209	211	214	217	221	224	227	230	233	236	241	247	252	256	259
-85	204	205	207	208	210	212	213	215	216	218	219	220	221	222	223	223	224	225
-90	208																	

BRIGHTNESS OF THE SKY AT MAY 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	12H	20M	40M	13H	20M	40M	14H	20M	40M	15H	20M	40M	16H	20M	40M	17H	20M	40M
DEC																		
-5	221	221	219	219	222	222	228	233	240	235	230	231	234	240	247	257	272	293
-10	220	220	220	225	230	236	244	252	256	247	243	242	245	250	256	268	288	318
-15	221	220	222	226	232	241	254	268	271	263	256	254	260	262	269	288	320	357
-20	223	223	225	229	235	243	256	270	271	267	267	274	278	282	296	328	372	441
-25	229	229	231	237	243	252	264	272	270	276	281	288	295	309	342	387	437	582
-30	237	238	242	248	255	262	275	286	292	298	303	314	332	360	402	460	596	721
-35	250	254	260	268	279	292	307	314	320	330	348	363	389	427	483	615	771	709
-40	267	276	285	295	309	325	335	354	370	389	406	425	464	516	651	809	780	653
-45	303	312	324	339	357	380	394	414	432	446	471	512	568	712	848	814	684	596
-50	404	402	408	418	433	449	463	481	506	533	567	677	805	870	784	674	596	524
-55	562	549	544	544	549	558	571	594	653	724	810	858	817	704	633	561	498	438
-60	829	796	776	771	776	792	817	857	852	839	751	658	604	551	495	454	408	363
-65	779	795	794	784	762	727	681	626	583	556	524	487	447	422	394	361	334	303
-70	455	461	463	464	461	453	440	423	401	392	383	370	354	333	316	298	276	261
-75	327	329	330	332	332	331	329	323	317	309	302	294	285	274	261	251	248	244
-80	261	263	263	264	264	263	261	259	256	251	246	242	241	239	237	235	232	230
-85	226	226	226	226	227	227	227	227	227	226	226	225	224	224	222	222	220	219
-90	208																	

BRIGHTNESS OF THE SKY AT MAY 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	18H	20M	40M	19H	20M	40M	20H	20M	40M	21H	20M	40M	22H	20M	40M	23H	20M	40M
DEC																		
-5	315	381	475	426	392	382	348	326	313	316	329	351	386	429	499	613	749	821
-10	353	461	471	429	407	385	353	332	320	327	340	365	404	459	500	537	577	615
-15	448	549	472	436	421	388	359	338	332	337	351	367	385	405	422	440	459	480
-20	569	538	483	453	424	389	362	337	331	326	328	335	345	358	367	376	385	392
-25	648	543	491	461	411	374	343	319	309	302	303	306	313	320	326	331	332	334
-30	613	542	490	440	385	353	321	302	290	282	281	281	285	289	292	295	295	295
-35	600	527	472	407	362	329	299	286	273	266	262	260	260	262	264	265	267	267
-40	573	499	428	363	336	306	284	272	259	251	246	242	241	240	240	241	244	245
-45	517	445	377	336	314	286	271	260	249	242	235	230	228	226	223	223	224	227
-50	451	387	327	309	290	268	258	250	241	233	229	222	218	215	212	209	209	210
-55	383	327	300	286	269	253	246	241	234	228	222	217	213	208	205	201	198	198
-60	320	289	277	265	252	240	236	231	227	222	218	214	209	205	201	198	194	192
-65	275	267	258	248	238	230	226	224	220	217	213	210	207	204	200	197	194	192
-70	255	249	242	235	228	222	220	217	214	212	210	207	205	202	200	197	195	193
-75	240	235	231	225	220	215	213	211	210	208	206	204	203	201	199	196	195	194
-80	227	224	221	217	214	211	209	207	205	204	203	202	201	199	198	197	196	194
-85	217	216	214	212	210	209	208	206	205	204	204	203	203	201	201	200	199	199
-90	208																	

BRIGHTNESS OF THE SKY AT JUNE 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA / DEC	0H	20M	40M	1H	20M	40M	2H	20M	40M	3H	20M	40M	4H	20M	40M	5H	20M	40M
0	417	443	474	506	543	579	617	691	0	0	0	0	0	0	0	0	0	0
5	400	463	563	645	707	772	835	973	0	0	0	0	0	0	0	0	0	0
10	378	432	514	641	834	1066	1201	0	0	0	0	0	0	0	0	0	0	0
15	360	402	469	568	718	929	1291	0	0	0	0	0	0	0	0	0	0	0
20	344	379	432	509	621	788	0	0	0	0	0	0	0	0	0	0	0	0
25	337	363	401	457	542	686	0	0	0	0	0	0	0	0	0	0	0	0
30	335	354	380	419	481	596	0	0	0	0	0	0	0	0	0	0	0	0
35	343	352	369	396	445	0	0	0	0	0	0	0	0	0	0	0	0	0
40	354	359	367	384	416	0	0	0	0	0	0	0	0	0	0	0	0	0
45	376	375	378	386	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50	390	387	384	383	381	390	404	0	0	0	0	0	0	0	0	0	0	0
55	405	394	388	390	391	394	402	416	437	456	476	0	0	0	0	0	0	0
60	445	433	422	416	413	405	392	384	375	371	367	359	364	365	357	355	361	356
65	358	355	348	342	335	325	314	302	298	302	303	304	307	312	315	319	318	315
70	294	292	288	285	283	280	277	276	273	275	278	284	289	293	293	292	291	290
75	272	272	271	271	271	271	271	271	271	274	274	275	275	276	275	275	274	273
80	264	263	264	264	264	265	265	265	265	266	265	266	265	264	263	262	262	261
85	254	254	254	254	255	255	255	255	255	255	255	254	254	254	254	253	252	251
90	240																	

BRIGHTNESS OF THE SKY AT JUNE 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	6H	20M	40M	7H	20M	40M	8H	20M	40M	9H	20M	40M	10H	20M	40M	11H	20M	40M
DEC																		
0	0	0	0	696	575	511	469	425	390	355	331	308	290	277	266	259	254	250
5	0	0	0	790	645	569	509	460	418	386	359	332	312	295	284	275	264	250
10	0	0	0	952	761	660	584	520	466	428	394	363	337	318	294	271	254	241
15	0	0	0	0	942	809	706	617	545	488	442	389	342	309	281	260	243	231
20	0	0	0	0	1236	1041	895	739	595	491	420	370	328	295	270	249	233	222
25	0	0	0	0	1226	960	775	628	520	441	388	347	312	283	258	238	223	212
30	0	0	0	0	964	767	636	534	456	398	357	323	296	270	248	229	215	206
35	0	0	0	0	763	618	526	458	404	361	329	302	277	256	237	221	208	199
40	0	0	0	0	610	506	446	399	359	328	305	284	264	243	227	213	204	196
45	0	0	0	0	494	430	385	352	325	303	285	268	253	235	220	208	197	190
50	0	0	0	0	0	371	340	317	298	283	269	257	244	230	214	202	193	186
55	0	0	0	0	0	326	307	292	278	267	257	247	238	227	213	200	191	183
60	343	331	317	304	299	293	285	275	267	256	248	241	233	225	215	205	193	185
65	310	303	294	287	279	271	267	265	258	252	244	238	231	225	218	210	202	194
70	288	283	278	273	268	261	254	254	253	250	245	239	232	226	222	216	211	205
75	272	268	266	263	259	255	250	246	244	244	244	240	236	232	228	223	219	215
80	260	258	256	254	252	250	247	245	242	239	236	237	235	234	233	230	228	227
85	250	249	248	248	247	246	244	243	241	241	239	238	238	237	235	234	233	232
90	240																	

BRIGHTNESS OF THE SKY AT JUNE 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	12H	20M	40M	13H	20M	40M	14H	20M	40M	15H	20M	40M	16H	20M	40M	17H	20M	40M
DEC																		
0	244	234	229	223	219	217	215	214	211	210	213	218	228	239	252	258	263	276
5	239	229	222	216	214	210	209	207	204	204	205	209	217	229	244	253	263	276
10	231	222	217	210	207	204	203	200	198	197	197	201	209	220	235	248	261	278
15	224	216	209	205	201	199	197	194	193	192	191	194	202	211	226	242	259	281
20	216	208	202	198	196	193	190	189	187	186	187	188	194	203	218	234	254	278
25	205	202	196	192	188	186	184	183	182	182	183	184	190	197	210	227	245	273
30	200	195	191	186	184	181	179	179	178	178	180	181	187	194	205	221	236	264
35	194	189	186	182	177	176	175	175	175	175	178	179	183	190	198	213	227	251
40	189	185	181	178	175	172	171	171	172	173	174	176	181	187	194	207	220	237
45	185	181	178	176	172	171	169	169	170	171	173	175	179	185	190	202	213	224
50	181	177	176	174	171	169	168	167	168	170	172	174	178	182	188	196	206	215
55	179	176	173	173	171	169	168	167	168	169	171	174	177	181	184	193	200	207
60	178	175	173	173	172	171	171	170	170	170	172	175	178	180	183	186	195	201
65	185	181	176	175	174	174	175	176	177	176	176	175	177	179	182	187	185	190
70	199	194	189	185	183	181	180	181	183	184	186	189	191	196	201	206	197	185
75	211	208	205	202	199	197	195	194	194	194	194	196	197	198	197	195	199	209
80	225	223	220	218	217	215	215	214	213	211	210	210	210	212	216	217	219	222
85	231	230	229	229	228	227	227	228	227	227	227	228	228	229	230	231	231	232
90	240																	

BRIGHTNESS OF THE SKY AT JUNE 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	18H	20M	40M	19H	20M	40M	20H	20M	40M	21H	20M	40M	22H	20M	40M	23H	20M	40M
DEC																		
0	285	306	397	426	384	361	332	299	279	262	257	255	257	266	281	302	329	364
5	280	292	345	438	398	363	342	305	281	264	253	251	252	260	273	293	319	353
10	290	286	301	393	439	391	355	320	282	267	254	248	249	254	269	288	310	340
15	300	297	300	353	459	425	384	344	304	271	260	249	247	255	265	281	304	329
20	303	318	301	319	424	502	429	379	335	295	267	259	254	256	265	281	298	318
25	305	331	320	322	378	512	501	429	376	332	295	273	268	266	270	282	300	319
30	294	321	337	320	351	454	574	497	434	379	339	308	284	283	286	295	308	320
35	281	312	333	330	341	387	526	618	496	436	388	353	328	310	307	317	327	333
40	263	286	308	325	329	366	434	568	636	510	443	392	369	355	349	349	347	350
45	246	265	283	300	313	326	380	459	572	622	528	450	410	387	384	383	382	379
50	229	243	258	272	286	302	325	373	431	521	591	563	478	438	419	403	393	391
55	215	225	237	247	257	268	289	310	350	383	441	498	537	535	488	448	425	414
60	205	212	221	228	237	251	259	275	290	313	342	365	402	433	455	468	462	455
65	193	199	204	234	238	238	242	248	261	275	288	304	321	332	338	340	348	355
70	188	192	216	219	221	225	231	239	248	256	263	267	270	269	272	281	288	292
75	217	222	227	231	233	236	241	243	246	249	254	261	268	275	279	278	277	275
80	225	230	233	235	238	242	245	248	249	251	253	255	257	258	260	261	262	263
85	233	236	238	240	243	243	244	245	245	247	248	248	250	251	252	252	253	253
90	240																	

BRIGHTNESS OF THE SKY AT JUNE 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	0H	20M	40M	1H	20M	40M	2H	20M	40M	3H	20M	40M	4H	20M	40M	5H	20M	40M
DEC																		
-5	368	385	399	415	434	452	471	503	0	0	0	0	0	0	0	0	0	0
-10	330	339	346	354	362	370	377	390	419	0	0	0	0	0	0	0	0	0
-15	297	303	307	312	315	317	319	323	334	0	0	0	0	343	372	379	381	396
-20	268	272	277	281	281	281	282	283	286	285	274	283	293	296	312	321	336	358
-25	243	245	249	254	257	258	257	257	260	258	257	261	266	268	278	288	305	331
-30	222	223	226	230	236	239	239	240	245	245	242	248	252	254	261	272	285	312
-35	207	206	207	209	217	223	226	228	233	235	232	239	244	247	252	262	275	297
-40	195	195	195	196	198	206	212	217	221	228	231	229	237	241	247	256	267	282
-45	190	188	186	185	185	189	198	205	210	217	223	224	228	234	241	249	260	268
-50	188	185	182	181	179	179	183	190	198	204	210	216	218	224	230	241	250	256
-55	186	185	182	181	179	177	175	178	184	190	196	202	207	210	216	226	236	241
-60	187	184	182	181	179	178	177	176	177	180	186	190	193	198	196	207	218	223
-65	186	184	182	180	178	177	177	178	179	181	184	186	191	196	201	198	186	191
-70	187	185	183	181	180	179	178	177	177	177	177	178	178	181	184	187	192	190
-75	189	188	187	185	185	184	183	182	182	182	183	184	185	187	188	190	190	193
-80	193	192	191	190	190	189	189	188	189	189	189	190	190	190	191	192	194	197
-85	197	197	197	196	196	195	196	196	195	195	195	197	197	198	199	199	201	202
-90	207																	

BRIGHTNESS OF THE SKY AT JUNE 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	6H	20M	40M	7H	20M	40M	8H	20M	40M	9H	20M	40M	10H	20M	40M	11H	20M	40M
DEC																		
-5	0	0	0	664	534	473	445	406	373	337	308	288	272	261	254	248	245	243
-10	0	0	0	650	549	464	426	399	359	325	295	274	262	251	245	241	241	238
-15	416	435	491	603	610	471	421	391	354	316	287	266	252	245	240	238	238	237
-20	389	429	470	554	671	566	449	389	349	310	282	264	249	241	239	238	236	237
-25	365	416	462	540	650	700	529	428	360	313	284	263	251	244	241	240	241	242
-30	344	388	445	518	611	765	709	507	413	345	296	269	254	249	246	245	246	247
-35	326	354	416	491	571	676	861	726	512	429	354	302	271	257	252	252	254	257
-40	306	328	376	448	523	617	752	928	787	573	475	385	335	288	273	267	265	270
-45	286	305	326	390	455	527	638	810	1006	888	689	554	470	399	361	327	302	304
-50	267	280	292	330	383	452	522	634	779	1052	1032	846	683	588	526	472	435	419
-55	247	255	264	275	325	371	432	490	589	680	882	1039	1028	900	781	685	623	591
-60	227	218	241	262	276	311	344	392	435	500	573	640	786	933	987	1002	943	880
-65	196	207	216	229	239	258	288	315	346	376	402	446	497	540	575	617	691	745
-70	194	202	212	217	224	231	241	264	284	300	320	339	355	367	376	402	425	443
-75	199	205	211	216	220	225	230	234	241	253	265	275	283	292	301	311	318	323
-80	200	204	207	211	214	217	220	223	225	228	230	233	236	241	247	251	255	258
-85	204	205	207	208	210	211	213	215	216	217	218	219	221	221	222	223	224	224
-90	207																	

BRIGHTNESS OF THE SKY AT JUNE 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	12H	20M	40M	13H	20M	40M	14H	20M	40M	15H	20M	40M	16H	20M	40M	17H	20M	40M
DEC																		
-5	240	236	233	228	226	224	223	221	218	219	222	229	239	250	262	264	271	287
-10	238	236	234	232	231	232	232	231	228	229	235	243	253	265	277	278	289	313
-15	237	236	235	234	234	237	239	240	240	244	250	257	271	283	295	301	324	353
-20	237	236	237	237	238	239	242	243	247	254	263	278	294	310	325	345	378	440
-25	241	241	242	244	246	247	250	251	254	267	280	294	312	336	369	403	444	582
-30	248	249	251	254	256	257	261	271	282	293	304	322	347	383	421	470	598	718
-35	260	263	268	273	280	287	295	305	314	327	350	371	402	446	496	620	770	704
-40	275	283	291	299	309	319	329	349	366	388	409	432	474	530	659	810	777	646
-45	310	318	329	341	356	376	391	411	431	447	474	518	576	720	851	813	679	588
-50	410	407	411	420	432	447	461	479	506	534	569	681	810	874	784	671	590	516
-55	566	552	546	544	549	558	571	594	653	725	812	860	820	704	630	557	492	430
-60	832	798	777	771	776	792	817	858	852	840	752	659	604	549	491	449	401	356
-65	781	796	795	785	762	727	681	625	583	557	524	486	445	419	390	356	328	296
-70	456	462	463	464	461	453	440	423	401	391	381	368	351	330	312	293	271	255
-75	327	329	329	331	331	330	328	322	316	307	300	291	282	271	258	247	244	240
-80	261	262	262	263	263	261	260	257	254	249	243	240	238	236	234	231	229	227
-85	225	225	225	225	226	226	226	225	225	224	224	223	222	221	220	219	217	216
-90	207																	

BRIGHTNESS OF THE SKY AT JUNE 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	18H	20M	40M	19H	20M	40M	20H	20M	40M	21H	20M	40M	22H	20M	40M	23H	20M	40M
DEC																		
-5	305	369	461	411	377	364	328	300	278	266	260	260	265	274	291	312	332	348
-10	343	448	456	413	389	363	327	299	277	269	263	266	271	283	290	297	306	317
-15	440	537	456	419	401	362	327	297	280	269	265	267	266	265	267	272	280	288
-20	565	527	467	437	402	359	324	290	277	264	258	254	252	250	249	252	257	262
-25	646	533	476	445	390	348	311	284	269	256	250	244	241	237	235	236	236	240
-30	606	530	475	423	367	332	296	276	262	249	243	236	231	227	224	222	220	221
-35	591	515	457	390	345	312	279	266	252	243	236	229	223	218	215	211	208	207
-40	562	486	415	348	321	292	269	257	244	235	228	222	216	211	207	204	201	197
-45	507	434	364	324	301	275	259	248	237	230	223	217	213	208	203	200	196	192
-50	441	377	317	298	279	258	248	241	232	225	220	214	209	205	201	197	193	190
-55	373	318	291	277	261	245	239	234	227	221	216	211	208	203	199	195	192	189
-60	312	280	269	258	246	235	230	226	222	217	213	209	205	202	198	194	191	189
-65	268	260	251	242	233	226	222	220	217	213	210	207	204	200	197	194	191	189
-70	249	244	237	230	223	219	217	214	212	210	208	205	203	200	197	194	192	190
-75	235	231	227	221	217	212	211	210	208	206	204	202	201	199	197	195	194	192
-80	224	221	218	214	211	208	206	205	204	203	202	201	200	198	197	196	195	193
-85	215	214	212	210	209	207	206	204	203	202	202	201	200	199	200	199	198	198
-90	207																	

BRIGHTNESS OF THE SKY AT JULY 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	0H	20M	40M	1H	20M	40M	2H	20M	40M	3H	20M	40M	4H	20M	40M	5H	20M	40M
DEC																		
0	267	272	280	289	302	317	339	346	359	373	391	413	445	511	0	0	0	0
5	260	278	302	319	334	355	377	396	417	443	475	513	568	0	0	0	0	0
10	254	272	295	322	356	401	432	465	503	548	602	667	764	0	0	0	0	0
15	252	268	291	318	351	394	447	528	624	700	790	890	1055	0	0	0	0	0
20	252	268	289	314	344	379	423	484	575	711	907	1161	1472	0	0	0	0	0
25	259	272	289	311	337	364	397	444	513	614	750	932	1257	0	0	0	0	0
30	265	279	293	310	329	350	373	409	459	530	628	776	0	0	0	0	0	0
35	285	289	300	312	327	342	359	382	416	463	541	663	0	0	0	0	0	0
40	302	304	311	320	330	338	348	368	396	433	486	580	0	0	0	0	0	0
45	327	326	330	339	345	352	361	373	391	418	459	522	0	0	0	0	0	0
50	342	344	350	354	357	362	368	378	390	410	442	0	0	0	0	0	0	0
55	363	365	364	368	370	373	377	385	399	415	415	0	0	0	0	0	0	0
60	420	410	401	398	398	391	381	372	360	346	331	313	316	322	329	344	360	364
65	336	336	333	331	328	322	312	300	290	290	291	291	293	301	309	317	319	318
70	281	282	283	283	283	282	277	272	272	277	281	286	289	295	294	292	291	289
75	267	269	269	269	268	269	272	275	277	279	279	279	279	279	277	275	273	271
80	258	259	261	263	265	266	267	267	267	268	268	268	266	265	263	261	261	259
85	252	252	252	253	254	255	255	255	255	255	255	255	254	254	253	252	251	250
90	242																	

BRIGHTNESS OF THE SKY AT JULY 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	6H	20M	40M	7H	20M	40M	8H	20M	40M	9H	20M	40M	10H	20M	40M	11H	20M	40M
DEC																		
0	0	0	0	0	0	0	0	0	0	578	525	488	458	433	410	392	371	348
5	0	0	0	0	0	0	0	0	0	771	674	615	565	519	482	447	407	355
10	0	0	0	0	0	0	0	0	0	1064	897	811	725	651	533	444	387	343
15	0	0	0	0	0	0	0	0	0	0	1251	998	761	595	483	410	361	325
20	0	0	0	0	0	0	0	0	0	0	1111	826	647	520	433	374	336	305
25	0	0	0	0	0	0	0	0	0	0	918	680	547	455	390	343	311	285
30	0	0	0	0	0	0	0	0	0	0	0	577	469	400	352	316	290	270
35	0	0	0	0	0	0	0	0	0	0	0	493	404	352	318	293	273	256
40	0	0	0	0	0	0	0	0	0	0	0	422	358	318	292	274	261	247
45	0	0	0	0	0	0	0	0	0	0	0	0	323	293	275	261	249	238
50	0	0	0	0	0	0	0	0	0	0	0	0	289	275	262	251	241	232
55	0	0	0	0	0	0	0	0	322	300	285	271	264	257	250	245	239	231
60	370	381	379	372	357	334	313	302	291	278	269	261	254	247	240	238	237	232
65	318	320	316	311	302	293	281	273	267	261	257	253	248	245	241	234	229	229
70	287	284	281	275	270	266	262	257	253	250	246	245	243	240	239	236	233	229
75	268	265	262	258	253	251	249	248	245	244	242	240	238	237	236	234	232	231
80	257	255	252	250	248	245	243	243	242	241	240	239	238	237	236	235	234	234
85	249	248	247	247	246	245	244	243	242	242	241	240	241	240	240	239	239	238
90	242																	

BRIGHTNESS OF THE SKY AT JULY 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	12H	20M	40M	13H	20M	40M	14H	20M	40M	15H	20M	40M	16H	20M	40M	17H	20M	40M
DEC																		
0	331	303	280	261	247	240	233	230	225	223	224	226	231	237	242	250	259	276
5	326	290	267	248	237	230	224	221	218	216	216	218	222	230	239	247	259	276
10	307	278	255	237	226	220	216	211	210	208	207	211	215	223	233	245	259	278
15	293	266	243	227	217	212	208	203	202	200	200	203	209	215	227	240	258	281
20	279	253	233	217	209	203	199	196	194	193	194	196	201	208	220	234	253	278
25	261	242	223	209	199	194	191	189	187	187	188	190	196	202	214	228	245	273
30	250	230	214	201	192	187	185	184	182	182	183	186	191	199	208	223	237	264
35	240	221	206	194	185	181	179	178	178	177	179	182	187	194	201	215	228	251
40	233	217	200	187	180	176	174	174	174	175	176	178	183	190	196	208	221	237
45	227	215	200	187	177	173	172	172	173	173	174	175	181	186	192	202	213	225
50	223	214	203	190	179	171	170	170	172	173	173	175	178	184	188	196	205	215
55	223	215	206	197	187	177	171	170	172	174	175	175	177	182	186	192	197	206
60	225	218	211	205	197	190	184	178	176	176	179	183	183	180	184	189	193	196
65	228	225	220	214	208	202	196	192	189	187	188	190	192	195	198	199	185	190
70	225	223	222	220	217	213	210	206	203	200	198	197	194	193	189	183	193	185
75	229	227	225	223	221	219	217	215	214	212	211	211	211	213	214	218	218	218
80	233	232	231	230	229	228	228	228	228	228	228	227	226	227	229	230	230	230
85	238	237	237	237	236	236	236	237	237	237	237	237	237	237	237	238	237	238
90	242																	

BRIGHTNESS OF THE SKY AT JULY 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	18H	20M	40M	19H	20M	40M	20H	20M	40M	21H	20M	40M	22H	20M	40M	23H	20M	40M
DEC																		
0	290	314	405	427	380	352	321	286	265	247	240	234	232	233	234	238	244	254
5	284	297	349	436	392	354	331	294	268	252	239	235	231	231	233	234	240	247
10	293	289	302	390	432	382	346	311	272	257	242	234	232	231	233	235	238	242
15	301	299	299	349	452	417	376	337	296	263	251	239	234	235	233	234	237	243
20	304	318	299	315	418	495	423	374	329	289	260	251	243	238	238	239	239	242
25	305	330	317	318	372	507	497	425	372	327	289	266	259	251	247	245	248	252
30	294	320	334	317	347	450	571	494	431	375	335	303	277	271	266	262	261	261
35	281	310	330	327	338	384	525	616	493	433	384	349	323	300	288	285	282	281
40	263	285	307	323	327	364	433	567	635	507	440	390	366	346	328	316	304	301
45	245	265	282	299	311	325	379	458	569	619	526	448	406	374	359	347	339	332
50	230	245	258	272	284	302	325	370	427	517	589	559	467	417	388	365	349	344
55	216	228	238	245	257	268	286	304	344	378	433	485	517	506	452	405	378	367
60	207	215	218	227	234	242	248	265	279	302	327	344	374	398	414	423	418	419
65	193	199	204	213	217	226	235	242	251	258	264	275	287	296	303	308	322	331
70	188	192	204	213	221	227	230	233	236	239	242	244	246	246	250	260	269	275
75	221	221	219	218	214	213	220	225	230	234	239	247	254	262	267	268	269	268
80	230	231	232	231	232	234	234	236	237	239	242	244	247	249	251	253	254	256
85	238	238	240	241	242	243	243	244	243	244	245	245	246	247	249	249	250	251
90	242																	

BRIGHTNESS OF THE SKY AT JULY 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA / DEC	0H	20M	40M	1H	20M	40M	2H	20M	40M	3H	20M	40M	4H	20M	40M	5H	20M	40M
-5	251	253	257	264	275	285	297	307	316	323	335	347	368	405	0	0	0	0
-10	239	237	238	244	250	257	266	275	284	288	296	304	317	340	0	0	0	0
-15	229	225	224	226	230	235	240	247	256	263	269	277	287	300	310	323	357	395
-20	218	215	214	214	214	216	219	225	233	242	249	257	267	277	286	301	328	358
-25	209	206	205	203	202	203	203	205	212	224	233	241	252	263	268	287	306	331
-30	201	198	197	195	194	193	191	192	197	206	219	228	240	254	259	277	289	313
-35	195	191	190	188	189	187	184	184	185	190	204	216	229	243	252	264	278	297
-40	188	187	186	186	184	183	180	179	178	180	190	203	217	231	243	253	266	282
-45	185	183	182	181	180	179	179	177	176	176	180	190	204	217	231	241	254	266
-50	184	182	179	178	177	176	175	176	176	176	177	182	192	204	215	226	238	251
-55	183	181	179	178	176	175	173	173	173	175	178	180	186	193	200	209	221	234
-60	185	182	180	178	176	174	172	172	172	171	175	180	185	191	200	198	200	215
-65	185	183	181	179	177	175	174	174	173	173	174	175	177	178	185	196	186	191
-70	186	184	182	180	180	179	177	177	177	177	177	178	179	181	184	187	187	190
-75	188	186	185	183	183	182	180	180	180	180	181	182	185	187	189	192	194	197
-80	192	191	190	189	189	188	188	188	189	189	189	191	191	192	193	195	196	197
-85	197	196	197	196	196	196	196	196	196	196	196	197	197	198	199	199	201	202
-90	207																	

BRIGHTNESS OF THE SKY AT JULY 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	6H	20M	40M	7H	20M	40M	8H	20M	40M	9H	20M	40M	10H	20M	40M	11H	20M	40M
DEC																		
-5	0	0	0	0	0	0	0	0	536	468	430	409	389	375	364	350	335	321
-10	0	0	0	0	0	0	0	0	452	409	379	361	350	339	330	320	309	298
-15	435	482	543	636	650	505	0	0	412	377	352	334	322	314	305	295	287	280
-20	393	444	491	567	689	588	471	425	397	363	338	321	305	294	285	278	271	265
-25	362	415	468	542	659	717	552	460	406	362	333	311	295	281	271	266	263	260
-30	340	382	447	517	621	784	732	546	461	392	339	308	285	271	264	260	259	258
-35	324	351	418	492	584	698	888	771	559	471	390	330	288	269	261	260	261	264
-40	307	330	381	455	539	641	789	974	828	607	501	400	343	293	278	272	271	275
-45	290	313	336	403	475	555	676	847	1036	910	702	560	472	401	364	331	306	308
-50	272	292	309	347	405	478	552	657	797	1063	1037	848	686	591	529	475	438	422
-55	252	269	281	290	335	387	446	502	599	685	885	1043	1031	902	784	686	626	593
-60	230	243	250	252	278	319	357	403	443	507	578	643	789	934	988	1003	944	882
-65	196	207	216	252	255	271	297	321	350	378	403	446	498	541	576	617	692	747
-70	194	202	211	221	227	233	242	264	285	301	321	341	356	369	378	403	427	445
-75	200	205	209	212	217	224	228	233	240	253	265	275	283	293	302	312	319	325
-80	200	204	207	210	213	216	218	221	223	226	229	232	235	241	246	251	255	258
-85	204	205	207	208	210	211	213	215	216	217	219	220	221	222	223	223	224	225
-90	207																	

BRIGHTNESS OF THE SKY AT JULY 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	12H	20M	40M	13H	20M	40M	14H	20M	40M	15H	20M	40M	16H	20M	40M	17H	20M	40M
DEC																		
-5	309	298	289	273	259	250	242	237	234	232	231	235	240	244	247	253	265	287
-10	288	280	274	269	266	260	251	246	242	240	242	245	249	253	256	264	283	315
-15	273	267	263	262	260	258	255	254	252	251	253	255	262	264	269	284	317	355
-20	260	258	258	258	257	257	258	258	258	259	263	272	280	284	295	326	371	443
-25	257	257	258	260	261	263	265	265	266	274	282	290	298	310	340	385	437	585
-30	259	260	264	266	269	272	275	284	293	301	307	319	335	360	399	456	593	721
-35	268	272	278	282	291	299	307	317	324	335	353	369	392	427	480	610	766	707
-40	281	290	298	307	319	329	339	359	376	395	412	431	466	515	648	803	774	648
-45	315	324	335	348	364	384	400	420	439	453	477	517	570	710	843	807	678	590
-50	413	411	416	425	438	455	469	487	513	539	572	681	805	868	779	667	589	518
-55	568	555	550	549	555	564	578	601	659	730	814	860	817	700	628	555	492	431
-60	833	801	781	776	781	798	823	863	856	843	753	658	602	547	490	448	401	357
-65	783	799	798	789	767	732	685	629	587	559	525	486	444	418	390	356	328	296
-70	458	464	466	467	465	456	443	426	403	393	382	368	351	330	312	293	271	255
-75	329	331	331	333	333	333	330	324	317	308	300	292	283	271	258	247	244	240
-80	261	263	263	264	264	263	261	258	255	250	244	241	239	236	233	231	229	226
-85	225	226	226	226	227	226	226	225	225	224	224	223	222	221	220	219	217	216
-90	207																	

BRIGHTNESS OF THE SKY AT JULY 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	18H	20M	40M	19H	20M	40M	20H	20M	40M	21H	20M	40M	22H	20M	40M	23H	20M	40M
DEC																		
-5	312	380	473	415	375	356	317	286	263	250	242	235	234	234	236	240	245	250
-10	352	463	473	420	389	358	318	287	262	253	242	238	235	235	235	236	238	239
-15	451	557	480	432	405	359	321	286	265	255	244	238	233	229	228	228	229	229
-20	577	552	497	456	410	359	323	283	264	249	240	232	226	223	221	221	222	219
-25	658	560	509	466	399	349	308	275	256	241	234	226	222	217	215	214	213	212
-30	617	551	502	440	374	331	291	266	249	235	228	221	216	212	209	207	204	204
-35	600	531	479	403	350	310	273	256	240	230	222	216	211	207	203	200	197	196
-40	570	498	431	358	324	290	263	247	233	223	217	210	206	201	198	196	193	190
-45	513	442	376	331	302	272	253	240	227	220	213	208	204	201	196	193	190	187
-50	445	382	324	303	280	255	243	234	223	216	212	206	202	199	195	192	189	186
-55	376	321	295	280	260	242	234	227	219	213	208	205	202	198	194	191	188	186
-60	314	282	271	259	245	232	226	221	216	210	207	203	200	197	195	192	189	187
-65	269	261	252	243	232	223	219	215	211	208	204	202	199	196	194	192	190	188
-70	249	244	237	229	222	217	214	211	208	205	203	201	199	196	194	192	190	188
-75	235	230	226	220	215	210	208	207	205	203	201	199	198	196	194	193	191	190
-80	223	220	217	213	210	207	205	203	202	201	200	199	198	196	195	194	193	192
-85	214	213	212	210	208	206	205	204	202	201	201	200	200	199	199	198	197	198
-90	207																	

BRIGHTNESS OF THE SKY AT AUGUST 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA / DEC	0H	20M	40M	1H	20M	40M	2H	20M	40M	3H	20M	40M	4H	20M	40M	5H	20M	40M
0	221	222	225	227	231	234	236	240	247	256	267	283	300	321	344	373	408	450
5	221	225	231	237	243	248	252	258	268	279	294	312	331	354	381	419	464	517
10	221	226	233	240	252	264	272	281	292	305	322	345	368	397	433	483	544	632
15	224	229	235	242	252	263	278	299	318	333	354	381	414	453	505	577	666	812
20	228	233	238	245	252	261	275	292	313	340	372	422	471	529	609	712	860	1088
25	239	241	243	248	254	261	271	287	306	331	361	400	448	522	622	760	953	1272
30	252	251	253	254	257	262	269	283	299	321	348	381	427	483	560	675	878	1018
35	270	265	265	263	263	267	272	281	295	313	343	375	413	460	529	653	751	774
40	289	284	280	276	274	273	276	286	304	324	347	378	411	454	535	590	583	595
45	316	308	301	297	294	295	300	307	319	337	358	384	416	474	484	464	456	473
50	331	324	319	313	310	310	314	322	332	348	369	402	415	404	385	376	382	397
55	348	340	331	327	325	324	327	334	349	366	366	357	342	323	324	329	338	352
60	396	379	364	357	352	343	330	324	317	311	300	288	291	294	297	307	317	323
65	305	300	292	286	280	273	265	259	258	264	267	269	272	281	290	299	301	301
70	243	240	237	236	237	239	241	245	247	253	260	267	273	281	284	286	287	286
75	227	229	231	234	238	241	246	251	254	259	262	265	267	271	273	274	273	272
80	233	234	237	240	242	244	247	249	251	254	255	258	260	261	261	261	261	260
85	237	238	239	240	242	243	244	245	246	247	248	248	248	249	249	249	249	247
90	234																	

BRIGHTNESS OF THE SKY AT AUGUST 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	6H	20M	40M	7H	20M	40M	8H	20M	40M	9H	20M	40M	10H	20M	40M	11H	20M	40M
DEC																		
0	514	0	0	0	0	0	0	0	0	0	0	0	0	0	0	983	887	820
5	632	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1418	1144	855
10	807	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	977	728
15	1111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	837	616
20	1435	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	529
25	1508	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	462
30	1126	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	849	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	643	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45	509	0	0	0	0	0	0	0	0	0	0	0	0	0	0	305	281	264
50	421	0	0	0	0	0	0	0	0	0	0	0	363	321	295	278	263	252
55	363	0	0	0	0	0	0	0	338	336	336	322	305	287	267	255	247	242
60	324	324	312	306	305	303	302	299	293	284	281	276	267	257	250	242	236	232
65	299	294	289	286	282	279	276	273	267	261	255	252	247	242	237	234	231	229
70	281	274	273	271	269	265	263	260	256	251	246	242	239	236	234	231	229	228
75	268	262	260	260	259	256	254	252	249	247	244	240	237	236	234	232	231	230
80	256	253	250	250	250	249	247	247	245	244	242	241	239	237	236	235	234	234
85	246	245	243	243	242	241	241	240	239	240	239	238	239	238	237	236	236	235
90	234																	

BRIGHTNESS OF THE SKY AT AUGUST 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	12H	20M	40M	13H	20M	40M	14H	20M	40M	15H	20M	40M	16H	20M	40M	17H	20M	40M
DEC																		
0	745	578	473	406	360	324	295	274	255	245	242	241	244	251	254	261	269	282
5	651	516	430	375	338	306	280	259	243	233	230	230	233	241	249	257	269	282
10	569	462	391	345	314	287	265	244	231	222	218	221	223	232	242	254	268	284
15	492	410	354	318	294	271	250	232	219	211	208	210	215	222	234	248	266	287
20	429	365	323	294	275	255	235	219	208	201	200	201	206	212	225	239	260	284
25	374	327	297	274	257	242	223	208	198	194	192	195	200	206	217	232	250	278
30	337	299	275	258	244	231	216	201	190	187	187	189	194	201	210	226	240	268
35	306	277	259	246	233	223	212	197	185	180	182	185	189	196	202	217	230	254
40	272	260	248	238	228	219	209	197	184	177	178	181	186	191	197	209	222	239
45	251	243	238	234	225	218	209	200	189	180	176	179	184	188	193	203	215	226
50	244	237	228	227	226	219	211	203	195	187	181	179	185	189	189	197	207	215
55	238	233	229	223	220	220	216	208	201	194	188	186	186	191	191	192	200	205
60	230	229	227	225	221	216	215	213	209	203	198	194	192	196	198	200	193	200
65	227	227	226	224	223	220	217	215	212	208	203	198	194	194	193	194	185	190
70	227	227	226	225	225	224	223	221	219	216	214	212	210	209	209	208	206	185
75	229	229	228	228	228	227	227	226	226	225	224	224	222	221	218	218	213	208
80	233	232	231	230	230	229	230	229	229	228	227	225	223	221	221	219	217	216
85	234	234	233	232	231	231	230	230	229	229	228	227	227	226	226	226	225	225
90	234																	

BRIGHTNESS OF THE SKY AT AUGUST 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	18H	20M	40M	19H	20M	40M	20H	20M	40M	21H	20M	40M	22H	20M	40M	23H	20M	40M
DEC																		
0	291	309	396	421	378	355	329	299	273	248	236	226	220	218	218	219	219	219
5	286	294	344	433	391	357	337	303	271	249	232	224	219	216	216	216	216	217
10	296	288	299	388	432	384	350	315	271	252	233	223	220	217	218	218	217	217
15	305	299	298	348	452	419	378	337	292	257	242	228	222	222	221	220	220	222
20	308	320	298	315	418	496	424	371	324	281	251	242	234	228	228	227	226	225
25	308	332	317	318	372	507	496	421	367	320	282	259	252	244	238	236	237	238
30	297	322	334	317	346	449	568	490	425	369	329	298	272	265	259	255	252	249
35	283	312	331	327	338	383	522	612	489	429	380	346	319	296	283	279	275	271
40	264	286	307	323	327	362	431	563	631	504	438	387	363	342	324	311	299	293
45	246	265	283	299	311	324	377	455	567	617	524	446	403	371	355	343	335	325
50	229	244	258	272	285	301	324	369	426	516	588	558	464	414	385	362	346	338
55	214	227	238	247	258	268	284	302	344	377	433	483	514	503	450	404	376	360
60	203	215	223	230	235	239	248	264	278	299	323	339	370	395	411	419	410	404
65	193	199	204	212	217	223	229	233	241	250	258	269	281	288	292	294	303	306
70	186	192	220	217	213	214	216	220	223	227	231	231	232	229	229	235	240	242
75	200	200	206	208	213	215	216	216	217	218	220	225	229	234	236	233	231	229
80	212	211	212	215	216	217	217	218	218	219	221	221	223	224	226	228	229	231
85	225	225	225	226	227	227	228	229	229	230	231	231	232	233	234	234	235	236
90	234																	

BRIGHTNESS OF THE SKY AT AUGUST 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	0H	20M	40M	1H	20M	40M	2H	20M	40M	3H	20M	40M	4H	20M	40M	5H	20M	40M
DEC																		
-5	217	217	217	219	221	222	224	225	229	235	245	258	274	294	314	341	373	409
-10	214	211	210	212	213	212	213	214	216	218	226	237	251	271	292	317	348	382
-15	209	206	204	205	206	204	204	204	204	206	211	220	232	250	275	296	327	362
-20	203	200	200	199	198	197	196	196	196	197	200	206	217	232	257	279	309	345
-25	198	195	194	193	192	192	189	189	189	190	192	195	203	217	241	265	291	328
-30	191	189	189	188	186	186	184	183	184	184	186	188	194	205	226	253	274	311
-35	186	184	184	183	184	182	180	179	180	179	181	184	189	196	213	239	261	293
-40	181	181	181	181	180	179	177	176	176	177	179	181	186	191	203	226	247	273
-45	179	179	178	178	177	176	176	174	173	175	175	177	183	188	196	213	234	253
-50	178	178	176	176	175	174	174	173	173	172	173	175	179	188	193	206	219	236
-55	178	178	176	176	175	173	172	172	171	171	172	173	176	181	191	201	210	219
-60	180	179	177	175	174	173	172	171	171	171	173	175	176	179	182	196	211	207
-65	182	180	178	176	176	174	172	172	172	172	174	175	176	178	183	188	186	191
-70	184	182	180	179	178	178	177	176	177	177	177	178	179	182	185	189	193	190
-75	187	186	185	183	183	182	181	181	181	182	183	185	186	188	190	192	193	192
-80	192	191	190	189	189	188	188	188	189	189	189	191	191	191	193	194	193	194
-85	198	197	197	197	196	196	196	196	196	196	196	196	196	197	197	198	200	201
-90	207																	

BRIGHTNESS OF THE SKY AT AUGUST 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	6H	20M	40M	7H	20M	40M	8H	20M	40M	9H	20M	40M	10H	20M	40M	11H	20M	40M
DEC																		
-5	451	0	0	0	0	0	0	0	0	0	0	0	0	0	784	692	655	617
-10	422	0	0	0	0	0	0	0	0	0	0	0	0	0	573	530	510	490
-15	401	430	497	621	653	543	0	0	0	0	0	0	0	0	440	425	419	410
-20	380	425	476	565	691	607	513	470	435	412	0	0	0	383	371	366	364	360
-25	359	413	468	544	658	722	564	476	423	387	360	337	0	339	334	334	334	334
-30	341	386	451	519	617	780	735	548	468	409	361	335	325	322	318	318	318	319
-35	322	354	421	492	580	692	890	770	567	488	413	358	333	319	312	311	311	312
-40	302	328	380	455	538	642	789	977	842	629	526	440	391	341	324	315	311	309
-45	280	306	333	405	480	561	683	859	1057	936	738	607	519	444	403	365	334	328
-50	257	282	308	353	416	490	565	677	822	1098	1080	890	724	624	557	497	451	430
-55	232	262	285	303	354	402	465	526	628	721	919	1072	1057	923	798	695	629	596
-60	208	242	260	276	292	332	367	420	463	526	596	658	801	942	992	1005	946	884
-65	196	207	216	229	250	271	302	329	361	390	413	454	503	544	579	621	695	750
-70	194	202	211	230	241	247	255	276	295	310	329	347	362	374	382	407	430	447
-75	197	203	209	215	219	224	229	233	241	254	265	276	284	293	303	313	320	326
-80	199	203	206	210	213	216	219	223	225	228	230	233	237	242	248	252	257	260
-85	203	205	207	208	210	212	213	215	217	218	219	220	222	223	224	224	225	226
-90	207																	

BRIGHTNESS OF THE SKY AT AUGUST 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA / DEC	12H	20M	40M	13H	20M	40M	14H	20M	40M	15H	20M	40M	16H	20M	40M	17H	20M	40M
-5	577	536	497	435	381	341	312	288	271	259	253	254	255	259	261	265	275	292
-10	468	447	426	406	381	357	328	306	287	274	269	267	267	269	270	276	291	318
-15	401	391	381	368	352	338	326	317	305	292	285	280	281	280	283	295	323	356
-20	357	353	348	339	328	318	310	305	300	295	296	298	296	299	307	333	373	440
-25	333	330	325	320	313	307	303	299	296	302	308	311	315	326	352	391	438	581
-30	318	314	312	309	306	302	301	307	315	322	327	336	352	376	412	465	597	720
-35	310	309	310	310	315	319	325	334	341	352	369	384	408	442	493	620	772	708
-40	308	313	318	324	333	342	351	371	389	407	425	444	480	528	660	813	781	651
-45	329	336	346	358	373	393	409	430	449	463	488	528	581	722	854	818	685	594
-50	420	417	422	431	444	461	476	495	520	547	581	690	815	878	789	677	597	522
-55	571	559	553	553	560	569	583	606	665	736	821	867	825	709	637	564	499	436
-60	836	804	784	779	785	801	827	867	861	848	759	665	609	555	498	456	408	362
-65	786	802	801	791	769	735	688	632	590	563	530	492	450	425	397	362	333	301
-70	460	466	468	469	466	458	445	427	406	397	386	373	356	335	318	298	276	259
-75	330	332	332	334	334	334	331	326	320	311	304	296	287	276	262	251	248	243
-80	263	264	265	266	266	265	263	260	257	252	247	243	242	239	237	234	232	229
-85	226	227	227	227	228	228	228	227	227	227	226	225	224	223	222	221	219	218
-90	207																	

BRIGHTNESS OF THE SKY AT AUGUST 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	18H	20M	40M	19H	20M	40M	20H	20M	40M	21H	20M	40M	22H	20M	40M	23H	20M	40M
DEC																		
-5	311	371	460	407	372	360	327	303	277	255	241	230	225	221	220	223	220	218
-10	348	450	455	409	385	360	329	306	284	265	246	237	232	225	220	220	218	216
-15	444	540	456	416	398	361	332	309	296	275	255	240	230	220	214	212	212	211
-20	566	530	467	434	402	360	332	307	296	272	251	234	222	214	208	206	206	205
-25	646	536	476	442	390	347	315	292	280	262	244	228	217	207	203	201	199	199
-30	609	533	475	421	363	329	295	278	266	254	237	222	212	203	198	195	192	192
-35	596	518	458	388	341	307	276	264	251	245	231	217	208	199	193	189	187	187
-40	568	490	415	346	316	286	263	252	240	233	225	212	203	196	190	186	184	182
-45	513	438	365	322	296	268	253	242	232	226	220	210	202	196	190	185	182	179
-50	447	381	318	297	275	252	242	235	226	219	215	209	201	195	190	185	182	180
-55	379	322	293	276	258	239	233	227	220	215	210	206	201	195	191	186	183	180
-60	317	285	271	257	243	230	225	220	216	210	207	204	200	196	192	188	185	183
-65	272	264	254	243	232	223	218	215	211	208	204	201	199	196	192	190	187	185
-70	253	247	240	231	223	217	214	211	208	205	203	200	198	195	193	190	188	187
-75	238	233	229	222	217	211	209	208	206	204	202	199	197	196	194	192	191	189
-80	226	222	220	215	212	208	206	204	203	201	201	200	199	197	196	195	193	192
-85	216	215	213	211	210	208	207	205	203	202	202	201	201	200	200	199	198	198
-90	207																	

BRIGHTNESS OF THE SKY AT SEPTEMBER 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	0H	20M	40M	1H	20M	40M	2H	20M	40M	3H	20M	40M	4H	20M	40M	5H	20M	40M
DEC																		
0	217	210	209	210	211	211	212	215	218	221	222	228	234	244	261	287	316	349
5	211	211	217	217	216	218	220	222	227	229	232	239	244	257	276	303	334	366
10	208	210	216	218	221	224	227	231	235	239	243	250	257	272	293	321	353	399
15	209	212	217	221	224	228	232	237	243	248	256	262	274	290	314	345	380	454
20	214	218	222	225	228	231	236	239	245	253	265	277	292	313	341	374	431	547
25	226	228	230	231	234	236	238	242	246	252	260	271	289	319	354	400	470	645
30	241	240	241	241	241	241	241	245	246	251	258	270	293	322	358	415	544	593
35	262	257	255	252	250	250	249	248	248	252	266	281	303	332	377	468	523	491
40	282	277	272	267	263	259	257	258	264	273	282	298	321	352	420	457	429	409
45	311	302	295	290	285	283	283	283	287	293	303	317	341	393	395	367	350	350
50	327	320	314	308	304	301	300	302	305	311	322	345	352	337	315	303	305	312
55	345	336	327	323	319	317	316	319	326	334	324	308	288	267	265	270	278	290
60	393	376	361	353	348	337	322	310	295	280	262	243	243	243	245	254	265	272
65	302	297	290	284	277	267	255	242	234	233	230	228	227	233	240	248	252	254
70	241	238	235	232	230	228	225	223	219	220	223	226	230	234	235	236	239	241
75	220	220	221	221	222	222	223	223	223	225	224	224	223	224	224	226	226	227
80	216	216	216	217	217	217	217	216	216	216	215	216	215	214	214	215	217	218
85	207	207	206	206	207	207	207	207	207	207	207	207	207	209	209	209	210	210
90	204																	

BRIGHTNESS OF THE SKY AT SEPTEMBER 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA / DEC	6H	20M	40M	7H	20M	40M	8H	20M	40M	9H	20M	40M	10H	20M	40M	11H	20M	40M
0	385	469	639	587	545	555	626	0	0	0	0	0	0	0	0	0	0	0
5	429	582	652	595	583	619	721	0	0	0	0	0	0	0	0	0	0	0
10	490	683	655	624	641	708	854	0	0	0	0	0	0	0	0	0	0	0
15	627	696	667	665	717	833	1026	0	0	0	0	0	0	0	0	0	0	0
20	718	699	693	731	834	1006	1244	1604	0	0	0	0	0	0	0	0	0	0
25	672	659	663	698	775	872	973	1145	0	0	0	0	0	0	0	0	0	0
30	563	548	548	569	613	670	729	824	0	0	0	0	0	0	0	0	0	0
35	474	462	461	475	501	529	560	605	0	0	0	0	0	0	0	0	0	0
40	401	402	403	410	422	434	447	462	499	0	0	0	0	0	0	0	0	0
45	355	359	360	362	366	370	372	379	391	0	0	0	0	0	0	323	317	307
50	322	327	327	327	327	326	324	325	325	328	0	0	291	290	287	279	268	262
55	298	302	302	300	298	295	293	291	288	285	280	269	266	264	260	254	247	241
60	277	281	280	279	277	274	272	270	269	265	259	254	253	250	247	244	239	233
65	259	262	262	263	260	258	257	257	256	254	251	246	241	242	241	239	236	233
70	243	246	247	247	247	246	246	246	247	247	245	244	240	234	233	233	233	232
75	230	232	234	235	235	235	236	236	236	237	237	237	236	235	234	231	228	226
80	219	221	222	223	224	224	224	225	225	226	226	227	227	227	226	226	226	226
85	211	212	212	214	214	214	214	214	214	215	215	215	216	216	216	216	215	215
90	204																	

BRIGHTNESS OF THE SKY AT SEPTEMBER 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	12H	20M	40M	13H	20M	40M	14H	20M	40M	15H	20M	40M	16H	20M	40M	17H	20M	40M
DEC																		
0	0	0	0	1099	779	608	494	420	371	341	318	299	285	277	273	276	282	294
5	0	0	0	0	666	518	431	375	338	314	294	278	266	262	263	268	279	291
10	0	0	0	0	570	443	377	336	309	289	272	259	249	248	252	262	275	292
15	0	0	0	0	0	387	335	304	285	270	256	242	235	234	241	254	271	293
20	0	0	0	0	0	344	302	279	265	253	243	229	220	220	230	244	264	288
25	0	0	0	0	0	0	277	261	250	241	232	220	211	211	220	236	253	282
30	0	0	0	0	274	263	256	249	240	232	226	216	205	204	213	228	243	271
35	0	0	310	278	258	247	239	238	234	227	221	212	203	198	204	220	233	256
40	339	298	272	256	246	238	233	225	230	225	218	210	203	197	200	213	226	240
45	288	268	249	239	233	231	228	225	221	224	218	210	205	199	197	208	218	226
50	253	242	235	229	225	223	223	222	220	217	218	213	207	202	200	204	213	215
55	235	230	224	222	221	220	220	219	219	216	214	211	208	204	201	207	211	207
60	228	226	223	222	219	220	220	220	221	217	215	212	209	199	199	200	214	209
65	229	227	225	224	223	222	222	223	223	221	219	217	215	211	206	202	185	190
70	230	228	226	224	224	224	223	222	221	220	219	218	215	213	211	207	201	185
75	225	224	224	223	221	220	219	217	216	215	213	211	209	206	196	195	198	198
80	225	223	222	220	219	217	216	215	213	211	210	208	207	205	204	203	201	202
85	215	214	213	213	212	211	210	210	209	209	208	207	206	205	204	204	203	203
90	204																	

BRIGHTNESS OF THE SKY AT SEPTEMBER 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	18H	20M	40M	19H	20M	40M	20H	20M	40M	21H	20M	40M	22H	20M	40M	23H	20M	40M
DEC																		
0	303	321	408	432	386	358	326	286	262	241	235	232	234	240	235	228	221	218
5	296	304	354	443	399	361	335	293	264	245	233	231	231	233	225	218	213	211
10	303	296	308	397	439	388	349	309	267	250	235	229	231	226	221	216	210	207
15	311	306	305	356	458	422	377	334	290	257	244	233	231	225	219	214	211	210
20	312	324	304	321	423	499	423	370	323	282	253	246	237	227	223	219	215	212
25	311	335	322	324	376	510	496	421	366	321	283	261	251	240	232	227	226	226
30	299	324	338	321	350	451	569	491	425	369	329	297	268	260	252	246	243	239
35	284	314	334	331	340	385	523	613	488	428	379	343	314	289	276	271	268	263
40	265	288	309	325	328	363	432	563	631	502	436	384	358	337	318	305	293	287
45	246	267	284	300	311	325	377	455	566	615	522	443	399	366	351	339	331	321
50	229	245	258	271	285	302	323	369	425	515	585	555	461	410	383	360	343	335
55	215	227	237	245	258	268	285	303	343	376	431	481	512	502	448	402	373	357
60	205	212	219	230	236	242	249	264	278	298	321	338	369	394	410	417	408	401
65	193	199	204	215	218	223	226	231	240	249	257	269	280	287	290	291	299	303
70	188	192	199	206	208	211	214	217	221	224	227	227	228	225	225	231	236	238
75	208	210	209	205	200	198	201	203	206	208	211	217	222	228	230	228	226	224
80	203	205	205	205	205	207	207	208	208	208	209	209	210	211	212	214	214	215
85	204	204	204	204	204	203	204	204	204	204	205	204	205	206	206	206	206	207
90	204																	

BRIGHTNESS OF THE SKY AT SEPTEMBER 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	0H	20M	40M	1H	20M	40M	2H	20M	40M	3H	20M	40M	4H	20M	40M	5H	20M	40M
DEC																		
-5	212	205	201	203	204	204	205	207	209	211	214	218	225	234	248	273	303	337
-10	208	200	196	197	198	198	199	200	202	202	206	210	216	226	238	259	290	325
-15	203	195	192	191	192	192	193	193	194	196	199	203	210	218	231	247	275	311
-20	198	191	189	188	187	187	187	188	189	190	192	196	204	210	222	235	261	295
-25	194	187	184	183	183	184	182	182	184	185	187	190	196	204	214	227	246	278
-30	188	183	180	179	178	179	178	178	180	180	183	185	191	199	208	221	233	262
-35	185	179	177	175	177	176	176	176	177	177	178	181	186	194	201	214	226	247
-40	181	178	176	175	173	174	173	174	174	175	176	178	182	188	195	208	219	234
-45	180	176	174	173	171	171	172	172	172	173	174	175	180	184	190	201	214	224
-50	178	176	174	172	171	170	170	170	170	171	172	174	176	182	186	193	208	219
-55	178	177	174	173	172	171	169	170	170	169	171	173	176	178	183	189	199	215
-60	180	178	176	174	172	171	170	170	170	170	173	173	174	178	182	187	192	210
-65	182	180	178	176	175	174	172	172	172	173	174	176	178	179	184	185	186	191
-70	185	183	181	180	179	178	176	176	177	177	177	179	180	183	186	189	191	190
-75	188	187	185	183	183	182	181	181	181	181	182	182	183	184	188	189	192	195
-80	193	192	191	190	189	189	188	188	189	189	189	190	191	191	193	195	196	197
-85	199	198	198	198	197	197	197	197	197	197	197	198	199	199	199	200	201	202
-90	208																	

BRIGHTNESS OF THE SKY AT SEPTEMBER 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	6H	20M	40M	7H	20M	40M	8H	20M	40M	9H	20M	40M	10H	20M	40M	11H	20M	40M
DEC																		
-5	368	432	566	606	522	508	C	C	0	0	0	0	0	0	0	0	0	0
-10	365	404	490	622	546	492	C	C	0	0	0	0	0	0	0	0	0	0
-15	357	401	470	589	611	490	0	0	0	0	0	0	0	0	0	0	0	0
-20	341	400	456	546	674	579	470	431	422	419	0	0	0	0	0	0	0	0
-25	322	389	451	534	655	709	553	468	422	393	398	412	0	0	0	0	0	0
-30	303	362	435	515	618	779	737	550	468	411	378	366	359	360	367	0	0	0
-35	286	329	406	490	580	697	895	772	565	486	415	371	343	338	338	339	338	0
-40	268	304	366	450	534	644	791	976	838	623	527	441	394	354	343	338	339	351
-45	252	284	320	396	474	560	683	859	1055	936	738	606	526	459	423	390	365	373
-50	240	264	291	341	408	488	567	681	827	1101	1083	899	739	645	582	526	495	479
-55	230	247	263	292	351	407	474	536	638	731	933	1092	1081	950	833	740	679	643
-60	224	222	251	276	301	346	386	437	479	545	618	685	833	982	1036	1049	988	923
-65	196	207	216	253	264	285	317	345	380	410	439	484	536	578	612	652	724	776
-70	194	202	235	229	237	246	258	283	306	324	345	364	379	391	399	423	444	459
-75	199	203	212	225	232	238	243	247	254	266	277	287	293	302	310	318	324	329
-80	200	203	206	210	214	219	224	229	232	235	237	240	243	248	254	258	262	265
-85	204	205	207	209	211	212	214	216	217	218	220	221	222	223	224	225	226	227
-90	208																	

BRIGHTNESS OF THE SKY AT SEPTEMBER 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	12H	20M	40M	13H	20M	40M	14H	20M	40M	15H	20M	40M	16H	20M	40M	17H	20M	40M
DEC																		
-5	0	0	0	1297	938	719	570	472	411	372	342	321	305	293	285	284	292	307
-10	0	0	1192	1037	959	839	653	532	454	405	371	345	325	312	302	301	313	336
-15	0	0	841	763	716	664	609	558	499	440	397	367	349	333	324	327	350	378
-20	0	0	610	582	559	532	505	479	455	431	405	392	376	363	358	373	407	467
-25	0	506	482	472	463	452	441	429	416	409	398	388	380	382	401	431	473	609
-30	424	414	411	411	411	407	405	408	408	405	398	396	402	418	447	496	625	743
-35	375	377	381	387	394	400	406	411	412	414	422	429	444	473	519	643	794	727
-40	359	368	377	386	397	407	415	429	441	453	463	475	506	550	679	831	798	667
-45	379	387	398	411	426	444	456	470	485	494	514	549	599	738	869	831	699	606
-50	469	465	468	476	487	499	507	521	543	567	597	704	827	889	800	687	607	532
-55	616	600	592	589	590	593	602	621	678	747	831	876	833	717	644	572	507	444
-60	872	836	812	802	801	813	835	875	868	854	765	670	615	560	504	462	414	368
-65	809	821	815	801	775	739	692	636	594	567	533	496	455	429	401	367	338	306
-70	469	472	471	471	468	460	447	431	409	399	390	377	359	338	321	302	279	262
-75	333	334	335	337	337	337	334	329	323	314	307	298	289	278	265	254	250	245
-80	267	269	269	269	269	268	266	263	259	254	248	245	243	241	239	236	233	230
-85	227	228	228	228	229	228	229	228	228	228	227	226	225	225	223	222	220	219
-90	208																	

BRIGHTNESS OF THE SKY AT SEPTEMBER 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	18H	20M	40M	19H	20M	40M	20H	20M	40M	21H	20M	40M	22H	20M	40M	23H	20M	40M
DEC																		
-5	325	386	473	418	380	362	322	288	261	245	237	234	239	246	248	241	229	218
-10	365	466	470	420	392	362	323	289	261	249	240	238	242	253	254	240	226	215
-15	463	556	471	426	404	362	324	290	265	251	245	239	237	238	239	232	220	211
-20	586	546	482	443	404	359	322	287	265	246	238	230	226	225	225	226	214	205
-25	666	551	491	452	393	348	310	279	258	239	230	222	218	214	214	215	208	200
-30	628	550	491	433	371	333	295	271	252	234	224	215	210	206	204	203	201	194
-35	613	535	473	401	351	314	279	262	244	230	220	210	204	200	197	194	192	190
-40	583	505	429	359	327	295	269	254	238	225	215	206	199	195	191	189	187	185
-45	526	451	378	334	307	278	260	246	233	223	214	205	199	194	190	186	184	181
-50	457	392	329	307	285	262	250	240	229	220	213	206	199	194	190	185	182	180
-55	387	331	301	285	267	248	241	234	225	218	212	206	201	195	190	186	183	180
-60	323	291	278	265	251	238	232	227	222	215	211	206	201	196	192	188	185	183
-65	277	268	259	248	238	229	225	221	217	213	208	205	202	198	194	190	188	186
-70	256	250	243	235	227	222	219	216	213	210	207	204	201	198	195	192	190	188
-75	240	235	231	225	220	215	213	212	209	207	205	203	201	198	196	194	193	191
-80	227	223	221	217	214	211	209	207	205	204	203	202	201	199	198	197	195	194
-85	217	215	214	212	210	209	208	206	205	204	204	203	202	201	201	200	199	199
-90	208																	

BRIGHTNESS OF THE SKY AT OCTOBER 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	0H	20M	40M	1H	20M	40M	2H	20M	40M	3H	20M	40M	4H	20M	40M	5H	20M	40M
DEC																		
0	235	239	235	222	213	206	202	202	203	206	208	213	219	227	242	260	279	300
5	231	243	241	230	219	214	211	209	211	213	215	219	224	234	248	266	284	302
10	228	234	230	224	221	223	218	216	219	220	221	225	230	240	255	272	289	318
15	228	227	224	222	221	221	221	222	229	227	228	230	237	247	262	281	301	356
20	228	224	223	221	221	220	222	223	227	229	232	237	243	255	273	295	336	428
25	232	228	226	224	224	224	223	226	228	231	233	238	247	266	286	317	370	518
30	241	237	235	231	230	229	227	229	230	232	235	243	259	279	303	345	457	485
35	259	251	247	242	239	238	236	234	235	236	247	260	276	298	332	409	450	401
40	278	270	263	257	253	249	246	247	253	259	267	281	300	325	383	409	369	336
45	305	295	287	282	277	275	275	274	277	283	291	304	325	372	366	329	303	292
50	321	314	307	301	297	295	293	295	297	303	313	335	340	321	292	274	269	267
55	340	331	322	318	315	312	311	313	320	328	317	301	279	254	249	248	251	256
60	390	373	358	351	345	333	318	305	291	275	257	238	236	234	233	240	246	247
65	301	296	288	281	275	265	252	239	230	229	226	223	223	227	233	239	239	236
70	240	237	234	230	229	226	222	220	216	217	220	223	226	231	231	230	229	227
75	219	219	219	219	219	219	220	220	220	222	221	222	221	222	221	221	219	217
80	212	212	212	213	213	213	213	213	213	214	214	214	213	212	211	210	209	208
85	203	203	202	203	204	204	204	204	204	204	203	203	202	203	202	201	201	200
90	193																	

BRIGHTNESS OF THE SKY AT OCTOBER 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	6H	20M	40M	7H	20M	40M	8H	20M	40M	9H	20M	40M	10H	20M	40M	11H	20M	40M
DEC																		
0	322	396	558	497	443	424	421	415	425	451	514	621	841	0	0	0	0	0
5	350	491	549	476	437	427	424	431	453	505	596	738	1005	0	0	0	0	0
10	392	569	522	461	431	427	435	455	494	572	696	886	1189	0	0	0	0	0
15	507	553	492	441	420	428	451	484	544	647	811	957	1045	1216	0	0	0	0
20	571	518	463	426	418	434	470	507	546	592	648	707	761	847	0	0	0	0
25	513	464	420	393	394	405	423	439	459	481	511	539	567	599	661	0	0	0
30	432	395	368	356	358	368	378	387	395	404	416	428	440	454	482	0	0	0
35	368	342	326	324	328	334	340	345	348	350	354	357	360	363	369	383	0	0
40	315	306	300	299	302	305	309	311	311	311	312	311	311	308	308	311	0	0
45	287	282	279	277	278	280	281	282	283	283	283	280	279	276	275	273	270	259
50	269	266	261	259	258	257	257	257	258	260	260	259	258	257	254	253	251	244
55	256	253	247	244	241	237	237	236	236	238	242	243	243	242	240	240	240	238
60	244	241	235	231	227	223	221	219	220	220	224	227	229	229	230	230	230	231
65	234	230	225	221	216	212	209	209	207	207	209	213	216	218	219	220	220	221
70	224	220	217	212	209	205	203	201	199	198	198	199	201	204	207	208	210	211
75	215	212	209	207	203	200	198	197	194	193	192	190	190	191	193	194	196	197
80	206	205	203	202	200	198	196	195	193	192	191	190	189	188	187	186	186	187
85	200	199	198	199	198	197	196	195	194	194	193	193	193	193	192	192	191	191
90	193																	

BRIGHTNESS OF THE SKY AT OCTOBER 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	12H	20M	40M	13H	20M	40M	14H	20M	40M	15H	20M	40M	16H	20M	40M	17H	20M	40M
DEC																		
0	C	0	0	0	0	0	C	C	0	638	497	428	390	367	353	344	335	333
5	C	0	0	0	C	0	C	C	0	0	424	371	346	334	329	324	320	320
10	C	0	0	0	0	0	C	C	0	0	365	330	313	308	308	308	307	312
15	C	0	0	0	0	0	C	0	0	0	319	297	289	286	290	293	295	306
20	C	0	0	0	0	0	C	C	0	281	280	274	271	269	274	278	282	296
25	C	0	0	0	0	0	C	305	279	264	257	256	259	258	262	266	268	286
30	C	0	0	0	356	325	289	268	257	251	248	241	251	252	252	257	256	273
35	C	0	311	294	289	273	258	244	238	239	240	237	242	246	243	247	246	258
40	275	273	268	257	250	243	234	230	228	229	232	233	232	240	237	238	239	244
45	253	250	247	239	231	228	223	221	222	224	226	228	229	231	232	232	232	234
50	239	238	235	232	226	221	220	218	219	222	224	225	226	225	223	224	224	228
55	231	228	229	227	224	221	220	219	220	221	222	223	223	222	218	213	216	222
60	229	226	221	222	222	221	220	219	221	219	221	223	223	220	216	211	198	209
65	222	224	223	222	218	216	215	215	215	214	214	215	216	214	212	209	185	190
70	211	212	212	213	213	213	211	209	207	204	202	200	196	191	186	185	193	185
75	198	199	200	200	200	199	199	198	198	197	196	195	194	196	199	203	202	199
80	188	188	188	189	189	189	191	191	191	191	192	192	193	193	195	196	195	193
85	191	191	191	191	191	191	191	192	192	192	192	193	193	193	193	193	192	192
90	193																	

BRIGHTNESS OF THE SKY AT OCTOBER 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	18H	20M	40M	19H	20M	40M	20H	20M	40M	21H	20M	40M	22H	20M	40M	23H	20M	40M
DEC																		
0	331	340	423	445	399	370	340	300	274	251	240	231	224	218	215	216	218	224
5	315	317	365	453	409	371	346	305	275	255	238	230	221	216	212	211	214	219
10	317	305	316	404	447	396	358	319	277	259	240	228	221	214	213	213	214	218
15	319	312	311	362	464	429	385	343	299	264	248	232	222	218	214	214	216	221
20	317	329	309	326	428	503	429	377	331	288	256	244	232	223	221	221	221	222
25	314	338	326	327	379	513	501	427	373	325	286	259	248	238	231	229	231	235
30	301	327	341	324	352	454	573	496	431	373	331	296	267	259	253	248	247	244
35	287	317	336	332	341	387	526	617	492	432	380	343	314	290	277	273	270	263
40	269	292	310	326	329	365	434	566	633	504	436	384	358	337	319	305	292	284
45	252	271	284	300	313	326	379	457	568	616	522	443	399	366	350	337	328	316
50	239	249	258	272	285	302	324	369	425	515	585	554	461	409	381	357	339	330
55	228	229	237	247	257	267	284	303	343	376	430	480	511	500	446	398	369	352
60	222	212	221	227	232	242	248	264	278	298	321	338	368	392	407	414	405	398
65	193	199	204	215	219	224	229	233	241	250	257	268	279	286	289	290	297	301
70	188	192	199	202	207	212	215	218	221	225	227	226	226	223	223	230	235	238
75	193	192	194	197	197	198	201	203	206	208	211	217	222	227	230	227	225	223
80	190	190	191	193	194	197	198	200	202	202	204	205	206	208	209	210	210	211
85	192	192	192	193	194	194	196	197	197	198	199	199	199	200	201	201	201	202
90	193																	

BRIGHTNESS OF THE SKY AT OCTOBER 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA / DEC	0H	20M	40M	1H	20M	40M	2H	20M	40M	3H	20M	40M	4H	20M	40M	5H	20M	40M
-5	223	225	227	215	207	200	196	195	196	198	202	207	214	222	235	255	277	301
-10	213	213	214	210	201	195	191	189	191	191	196	201	207	218	229	248	272	300
-15	205	203	203	204	196	190	186	183	184	187	190	196	203	212	225	239	264	294
-20	198	195	195	196	191	185	182	180	180	182	186	191	199	206	217	231	254	285
-25	191	188	188	188	188	182	178	176	176	178	182	186	193	200	211	224	242	273
-30	184	183	182	181	181	179	175	173	174	175	178	182	188	196	205	218	231	259
-35	182	178	177	176	178	177	173	172	171	172	174	179	185	192	199	211	223	245
-40	178	177	176	175	174	174	172	171	170	171	173	176	181	187	194	205	214	231
-45	179	176	174	173	171	171	171	170	170	170	171	173	178	183	190	198	208	218
-50	180	177	174	173	171	170	170	169	169	170	171	173	176	180	185	193	202	210
-55	181	179	176	174	173	171	169	169	169	169	171	172	176	179	180	188	196	202
-60	184	181	179	176	174	172	171	170	170	170	173	174	176	180	183	184	192	199
-65	185	183	181	178	176	174	172	172	172	173	174	176	178	180	185	190	186	191
-70	187	185	183	181	180	179	177	177	176	176	176	177	178	180	184	186	190	190
-75	189	188	187	185	185	184	182	182	182	182	183	185	186	187	188	190	192	203
-80	194	193	192	191	190	189	189	189	189	189	190	191	191	192	195	199	203	207
-85	202	201	201	201	200	200	201	201	201	201	202	203	204	205	206	207	209	210
-90	213																	

BRIGHTNESS OF THE SKY AT OCTOBER 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA / DEC	6H	20M	40M	7H	20M	40M	8H	20M	40M	9H	20M	40M	10H	20M	40M	11H	20M	40M
-5	315	371	500	536	447	418	418	407	406	416	452	543	0	0	0	0	0	0
-10	327	354	434	563	487	426	411	406	350	391	410	477	0	0	0	0	0	0
-15	327	358	421	537	560	443	414	401	386	375	384	0	0	0	0	0	0	0
-20	319	363	411	497	627	545	446	404	386	369	366	0	0	0	0	0	0	0
-25	304	356	409	486	610	683	532	449	403	371	354	336	0	0	0	0	0	0
-30	289	332	396	467	577	755	718	538	462	401	357	339	336	353	377	0	0	0
-35	274	303	369	444	546	673	875	767	566	480	414	366	342	338	349	386	424	0
-40	257	283	332	410	507	623	780	975	837	627	532	444	395	353	351	361	377	391
-45	241	267	291	366	450	543	675	855	1054	939	742	607	524	456	423	397	380	386
-50	228	252	272	319	389	475	558	674	825	1101	1084	898	735	640	580	530	496	484
-55	216	243	262	276	334	391	463	530	636	731	934	1091	1079	951	834	739	680	652
-60	208	239	241	252	287	337	382	438	484	551	625	691	838	985	1040	1056	1000	939
-65	196	207	216	253	269	293	328	359	353	424	452	497	548	591	627	671	746	801
-70	194	202	221	233	248	259	273	299	322	341	363	383	400	414	424	450	474	494
-75	214	223	224	226	233	241	248	255	266	282	296	309	320	331	343	354	361	366
-80	211	215	219	224	228	231	234	238	242	247	251	255	260	266	273	278	282	285
-85	212	213	215	216	219	220	222	224	226	228	229	231	232	233	234	235	236	236
-90	213																	

BRIGHTNESS OF THE SKY AT OCTOBER 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	12H	20M	40M	13H	20M	40M	14H	20M	40M	15H	20M	40M	16H	20M	40M	17H	20M	40M
DEC																		
-5	C	0	0	0	0	0	0	0	0	778	598	505	446	408	383	368	359	358
-10	C	0	0	0	0	0	0	C	0	944	730	602	515	459	423	402	395	400
-15	C	0	0	0	0	0	C	0	1589	1139	893	717	601	522	473	449	447	455
-20	C	0	0	0	0	0	0	0	1206	1039	937	831	703	602	540	518	520	558
-25	C	0	0	0	0	0	C	0	872	794	738	679	625	585	571	576	588	704
-30	C	0	0	0	0	0	0	736	673	644	616	592	574	570	582	613	722	823
-35	C	0	0	0	0	0	0	599	573	564	566	563	570	589	625	738	873	793
-40	403	0	0	0	0	0	534	536	543	553	564	573	601	641	763	906	861	719
-45	402	417	430	442	0	0	526	541	555	568	589	625	674	809	934	888	747	646
-50	482	484	490	500	519	544	559	576	601	627	659	765	887	946	849	730	642	561
-55	631	619	615	614	622	636	650	672	730	800	883	927	882	761	680	602	531	464
-60	892	860	837	833	844	860	885	923	916	901	810	713	653	592	528	481	430	380
-65	835	850	854	846	823	787	738	681	636	607	571	529	482	450	417	378	347	313
-70	509	516	518	517	512	502	487	468	443	431	417	399	377	351	330	307	284	266
-75	370	371	371	371	370	368	363	356	347	335	324	311	298	284	268	256	252	248
-80	288	289	289	289	288	285	281	277	271	264	256	251	248	243	241	238	235	232
-85	236	236	236	236	236	235	235	233	232	231	230	229	228	227	225	224	223	222
-90	213																	

BRIGHTNESS OF THE SKY AT OCTOBER 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	18H	20M	40M	19H	20M	40M	20H	20M	40M	21H	20M	40M	22H	20M	40M	23H	20M	40M
DEC																		
-5	362	412	494	436	397	377	338	303	274	255	243	234	229	223	219	221	222	220
-10	413	502	498	444	414	381	340	305	275	259	244	237	232	229	220	216	215	213
-15	523	604	509	458	432	386	343	306	280	260	246	238	231	224	215	210	208	206
-20	660	607	532	486	440	389	345	301	280	258	244	234	225	218	211	205	202	198
-25	746	619	546	497	429	378	331	296	274	253	240	229	221	213	207	202	197	193
-30	694	603	534	467	400	358	315	288	268	249	236	225	217	209	203	197	192	188
-35	666	576	506	428	374	334	296	277	259	244	232	221	213	206	200	194	188	185
-40	624	537	455	380	345	311	283	267	251	238	227	217	209	202	196	192	187	182
-45	557	475	397	350	321	291	272	257	244	234	224	215	208	203	196	191	187	182
-50	480	409	342	319	296	271	260	249	238	229	222	214	207	202	197	191	187	183
-55	403	343	311	294	275	256	248	241	231	225	218	212	207	201	197	192	188	184
-60	334	299	285	271	257	244	238	233	226	219	215	210	206	201	197	193	190	187
-65	283	274	263	253	242	234	229	225	221	216	211	208	204	201	197	194	191	189
-70	260	254	246	238	231	225	222	219	216	213	210	206	203	200	197	194	192	190
-75	243	238	234	228	223	218	216	214	212	209	207	204	203	200	198	195	193	191
-80	230	226	224	220	217	214	211	210	208	206	205	204	202	200	199	198	196	195
-85	220	219	218	216	214	213	212	210	208	208	207	206	206	205	204	203	202	202
-90	213																	

BRIGHTNESS OF THE SKY AT NOVEMBER 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA / DEC	0H	20M	40M	1H	20M	40M	2H	20M	40M	3H	20M	40M	4H	20M	40M	5H	20M	40M
0	218	213	208	206	207	207	210	215	221	213	207	207	208	215	229	247	267	287
5	215	212	213	216	215	218	223	228	231	221	215	213	213	220	233	251	269	285
10	211	210	212	216	221	230	238	244	241	230	222	219	219	226	238	255	271	297
15	211	210	213	217	223	232	245	256	251	237	229	225	227	232	244	262	278	329
20	214	214	216	220	226	233	244	248	243	236	232	235	234	240	257	273	307	394
25	224	222	223	226	231	236	243	241	235	232	229	231	235	249	270	295	339	481
30	237	234	234	234	236	239	242	237	232	229	228	232	245	262	286	325	432	455
35	256	250	248	246	245	247	243	236	232	230	237	247	262	281	315	391	428	377
40	276	270	265	260	258	255	247	245	248	251	256	269	286	310	368	394	351	317
45	305	295	289	283	280	276	273	270	270	274	280	293	313	359	354	316	289	278
50	321	314	308	302	297	292	289	289	290	294	303	325	329	310	282	263	258	256
55	340	330	322	317	312	308	305	306	312	319	309	292	271	246	241	240	243	247
60	389	371	356	347	341	328	312	299	284	268	250	231	230	228	227	233	240	240
65	298	294	285	278	270	260	247	233	225	224	221	219	219	223	228	234	234	232
70	237	234	230	227	225	222	219	216	212	214	217	221	223	227	227	226	226	224
75	217	217	217	216	216	216	217	217	218	220	220	220	219	220	219	219	216	214
80	210	210	210	211	211	212	212	212	212	213	212	212	212	211	209	208	207	206
85	202	202	202	202	203	203	203	203	203	202	202	202	201	202	201	200	199	198
90	191																	

BRIGHTNESS OF THE SKY AT NOVEMBER 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	6H	20M	40M	7H	20M	40M	8H	20M	40M	9H	20M	40M	10H	20M	40M	11H	20M	40M
DEC																		
0	308	379	535	463	395	360	340	319	310	306	319	339	367	410	477	586	753	997
5	332	468	519	433	377	349	326	314	307	312	328	352	389	440	525	657	812	888
10	367	539	482	408	360	334	319	311	308	319	335	365	408	469	518	562	610	654
15	475	513	442	376	336	321	313	310	314	325	343	363	387	409	431	454	477	500
20	530	467	400	347	322	314	312	309	311	312	318	330	344	357	368	378	389	399
25	468	409	354	315	303	298	291	287	286	286	292	298	307	316	323	327	331	334
30	397	353	317	295	283	280	273	269	265	264	267	270	278	284	288	291	291	292
35	341	310	287	277	269	264	258	252	247	245	246	247	251	255	258	263	264	264
40	294	283	271	264	258	251	246	240	233	230	229	229	231	232	234	238	244	245
45	271	265	258	252	246	240	235	230	223	219	216	214	214	214	216	218	222	226
50	257	253	247	242	236	230	225	220	215	211	207	204	203	202	201	201	203	208
55	247	243	237	232	227	220	216	212	207	203	201	197	196	193	191	190	190	191
60	238	234	228	224	218	212	209	206	202	198	195	193	190	188	186	184	182	180
65	229	225	220	216	211	207	203	201	198	195	192	191	188	187	184	182	180	178
70	220	216	213	209	205	202	199	197	195	194	191	188	186	185	184	183	181	180
75	212	208	206	204	200	197	195	194	192	191	190	188	185	184	183	182	181	181
80	204	202	200	199	197	195	193	192	190	189	188	187	186	185	184	183	182	182
85	197	196	195	195	194	193	192	191	190	190	190	189	189	188	188	187	186	186
90	191																	

BRIGHTNESS OF THE SKY AT NOVEMBER 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	12H	20M	40M	13H	20M	40M	14H	20M	40M	15H	20M	40M	16H	20M	40M	17H	20M	40M
DEC																		
0	1395	0	0	0	0	0	0	0	0	0	0	0	0	0	0	508	449	430
5	953	1089	0	0	0	0	0	0	0	0	0	0	0	0	0	429	400	392
10	692	759	0	0	0	0	0	0	0	0	0	0	0	0	0	0	367	371
15	518	541	0	0	0	0	0	0	0	0	0	0	0	323	318	331	345	359
20	407	413	434	0	0	0	0	0	0	364	341	309	299	294	298	307	327	347
25	335	336	340	0	0	0	0	305	293	296	285	274	268	273	282	293	310	337
30	292	290	289	289	274	264	266	264	258	256	252	250	251	258	270	283	295	323
35	264	261	259	258	251	245	245	244	239	236	236	235	241	248	258	272	281	305
40	244	242	241	240	238	231	234	233	231	228	228	229	234	242	250	261	269	285
45	228	228	228	229	229	227	222	227	226	226	226	227	232	238	243	251	257	264
50	212	214	216	218	220	222	221	217	221	222	223	226	230	235	237	240	244	244
55	196	200	204	207	209	212	215	215	214	215	217	219	225	229	231	234	232	225
60	182	185	190	194	197	200	203	205	209	207	208	211	213	216	220	222	222	214
65	177	177	179	181	185	187	190	192	195	196	198	197	194	191	194	201	185	190
70	179	178	177	177	177	178	180	183	186	188	190	192	194	198	202	205	204	185
75	181	181	181	181	181	181	182	182	184	185	186	188	187	186	183	184	186	188
80	182	181	180	180	180	180	180	181	181	181	181	182	182	183	185	186	187	187
85	185	185	185	184	184	184	184	185	186	186	186	187	187	187	187	188	188	189
90	191																	

BRIGHTNESS OF THE SKY AT NOVEMBER 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	18H	20M	40M	19H	20M	40M	20H	20M	40M	21H	20M	40M	22H	20M	40M	23H	20M	40M
DEC																		
0	415	422	498	510	451	412	370	324	295	270	259	248	242	235	228	224	220	218
5	385	384	425	502	447	399	367	322	290	269	253	244	237	231	224	219	216	214
10	375	361	364	440	473	415	372	331	288	270	251	241	235	228	224	220	216	212
15	371	359	350	386	480	440	394	351	307	273	257	243	234	230	225	220	217	215
20	364	370	339	342	437	510	435	383	337	295	264	253	242	234	230	226	221	216
25	359	375	349	337	384	517	505	432	378	331	292	267	257	247	239	233	231	228
30	342	358	358	328	354	457	577	499	434	377	336	303	275	267	258	251	246	239
35	324	343	349	334	344	390	529	619	495	434	384	348	321	296	281	275	268	261
40	300	312	320	329	333	369	436	568	635	507	440	389	363	341	322	306	291	283
45	277	286	294	305	318	328	380	458	569	619	525	447	402	369	352	338	328	316
50	253	260	269	281	289	303	325	370	427	517	588	557	463	411	382	357	339	330
55	232	242	250	254	257	268	286	304	344	377	432	482	512	501	447	399	369	352
60	212	234	230	228	235	242	248	264	277	298	321	338	368	393	407	414	404	397
65	193	199	204	212	217	220	226	232	241	250	257	268	279	285	288	289	296	299
70	188	192	202	207	209	213	215	218	221	225	227	226	226	223	223	229	234	236
75	191	191	191	194	198	199	202	204	207	208	211	216	221	227	229	226	224	221
80	188	190	191	193	194	195	196	198	199	201	203	204	205	207	208	209	209	209
85	190	191	192	193	194	194	195	196	196	197	198	198	199	200	200	200	201	201
90	191																	

BRIGHTNESS OF THE SKY AT NOVEMBER 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA / DEC	0H	20M	40M	1H	20M	40M	2H	20M	4CM	3H	20M	40M	4H	20M	40M	5H	20M	40M
+5	214	209	202	199	199	199	201	203	207	204	201	201	204	211	224	244	267	291
+10	212	205	198	195	193	191	193	194	197	197	195	195	199	208	219	239	264	292
+15	208	202	196	192	188	185	186	186	188	191	189	191	196	203	217	233	259	289
+20	204	198	194	190	185	181	180	181	182	184	185	187	192	198	211	226	250	281
+25	200	194	190	187	183	180	176	176	177	178	181	183	187	194	205	220	239	270
+30	195	190	187	184	181	178	174	173	174	175	177	179	184	192	201	215	229	257
+35	191	186	184	180	181	177	173	172	171	171	174	177	182	188	196	209	222	244
+40	187	185	183	181	178	177	173	172	171	171	172	174	179	185	192	203	214	229
+45	185	182	180	178	176	174	174	171	171	171	171	172	177	182	188	197	207	217
+50	184	182	179	177	176	174	172	171	170	170	171	172	175	180	185	193	200	209
+55	184	182	179	178	176	174	172	171	170	169	171	173	176	179	183	189	196	201
+60	186	183	180	178	176	174	173	171	171	170	172	173	176	179	184	188	194	195
+65	187	185	182	179	177	175	174	174	173	173	174	175	176	178	181	184	186	191
+70	190	187	184	182	181	180	178	177	177	177	177	178	179	181	184	187	196	190
+75	193	192	191	190	189	188	187	186	187	187	189	192	195	199	203	208	210	205
+80	198	197	196	196	196	196	196	196	198	199	200	203	205	206	207	209	210	214
+85	216	215	215	214	214	213	214	214	214	215	215	217	218	219	221	223	225	228
+90	240																	

BRIGHTNESS OF THE SKY AT NOVEMBER 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	18H	20M	40M	19H	20M	40M	21H	20M	40M	21H	20M	40M	22H	20M	40M	23H	20M	40M
DEC																		
0	415	422	498	510	451	412	370	324	295	270	259	248	242	235	228	224	220	218
5	385	384	425	502	447	399	367	322	290	269	253	244	237	231	224	219	216	214
10	375	361	364	440	473	415	372	331	288	270	251	241	235	228	224	220	216	212
15	371	359	350	386	480	440	394	351	307	273	257	243	234	230	225	220	217	215
20	364	370	339	342	437	510	435	383	337	295	264	253	242	234	230	226	221	216
25	359	375	349	337	384	517	505	432	378	331	292	267	257	247	239	233	231	228
30	342	358	358	328	354	457	577	499	434	377	336	303	275	267	258	251	246	239
35	324	343	349	334	344	390	529	619	495	434	384	348	321	296	281	275	268	261
40	300	312	320	329	333	369	436	568	635	507	440	389	363	341	322	306	291	283
45	277	286	294	305	318	328	380	458	569	619	525	447	402	369	352	338	328	316
50	253	260	269	281	289	303	325	370	427	517	588	557	463	411	382	357	339	330
55	232	242	250	254	257	268	286	304	344	377	432	482	512	501	447	399	369	352
60	212	234	230	228	235	242	248	264	277	298	321	338	368	393	407	414	404	397
65	193	199	204	212	217	220	226	232	241	250	257	268	279	285	288	289	296	299
70	188	192	202	207	209	213	215	218	221	225	227	226	226	223	223	229	234	236
75	191	191	191	194	198	199	202	204	207	208	211	216	221	227	229	226	224	221
80	188	190	191	193	194	195	196	198	199	201	203	204	205	207	208	209	209	209
85	190	191	192	193	194	194	195	196	196	197	198	198	199	200	200	200	201	201
90	191																	

BRIGHTNESS OF THE SKY AT NOVEMBER 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	12H	20M	40M	13H	20M	40M	14H	20M	40M	15H	20M	40M	16H	20M	40M	17H	20M	40M
DEC																		
-5	1197	0	0	0	0	0	C	C	0	0	0	0	0	0	0	619	529	494
-10	C	0	0	0	0	0	C	C	0	0	0	0	0	0	0	776	651	600
-15	C	0	0	0	0	0	C	C	0	0	0	0	0	0	0	992	829	749
-20	C	0	0	0	0	0	C	C	0	0	0	0	0	0	0	1292	1081	985
-25	C	0	0	0	0	0	C	C	0	0	0	0	0	0	0	1348	1198	1189
-30	C	0	0	0	0	0	C	C	0	0	0	0	0	0	0	1113	1125	1152
-35	0	0	0	0	0	0	0	C	0	0	0	0	0	0	1042	1053	1135	1014
-40	385	0	0	0	0	0	C	C	0	0	0	0	0	0	1020	1102	1031	869
-45	400	425	461	517	0	0	0	C	0	0	0	0	0	0	1089	1014	859	751
-50	482	491	514	542	573	602	614	C	0	0	0	0	0	0	944	814	721	639
-55	628	621	622	631	645	658	676	707	767	836	918	0	0	824	744	664	593	527
-60	887	856	840	839	848	868	897	942	938	925	835	740	689	637	579	535	484	435
-65	834	851	853	845	824	792	750	697	655	629	596	556	514	492	465	429	398	364
-70	510	517	520	522	522	515	504	487	466	457	444	428	414	396	378	358	333	314
-75	382	384	386	388	389	389	387	382	374	363	355	350	343	332	318	306	300	293
-80	311	314	314	315	315	313	311	309	307	303	299	296	294	291	287	283	278	273
-85	270	271	272	272	273	273	274	273	273	273	272	270	268	267	264	262	259	257
-90	240																	

BRIGHTNESS OF THE SKY AT NOVEMBER 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	18H	20M	40M	19H	20M	40M	20H	20M	40M	21H	20M	40M	22H	20M	40M	23H	20M	40M
DEC																		
-5	480	517	589	519	466	434	381	338	303	281	267	255	248	240	233	228	222	218
-10	576	640	618	549	502	454	399	354	316	294	276	266	254	244	236	228	222	217
-15	753	789	663	590	543	476	419	370	335	309	288	273	256	242	232	225	219	214
-20	986	859	733	651	577	498	438	381	343	307	282	264	248	237	228	221	215	209
-25	1118	902	764	669	567	484	418	365	327	294	272	254	242	230	224	217	210	205
-30	957	813	705	609	519	453	391	347	312	282	262	245	235	224	217	211	204	199
-35	852	733	640	544	473	416	361	327	296	272	253	238	228	219	211	205	198	195
-40	758	655	560	475	427	379	338	309	281	260	244	230	221	213	206	200	196	190
-45	655	566	481	427	388	347	316	292	269	252	237	226	218	211	204	198	193	188
-50	556	481	411	383	351	316	295	276	258	243	232	222	214	208	203	197	192	187
-55	465	403	369	347	321	293	276	262	247	236	226	218	213	207	201	197	192	187
-60	387	351	335	316	296	275	261	249	238	228	221	215	210	205	201	197	193	190
-65	332	321	307	293	277	262	249	239	230	222	216	211	208	204	200	197	194	191
-70	305	297	286	275	263	252	243	233	225	218	213	209	206	202	200	197	195	193
-75	285	278	271	262	253	244	238	232	225	218	213	208	205	202	200	198	196	195
-80	268	263	258	252	246	241	235	231	227	222	219	215	211	207	205	203	201	198
-85	254	251	249	246	243	240	237	234	231	229	228	225	224	222	221	219	218	217
-90	240																	

BRIGHTNESS OF THE SKY AT DECEMBER 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	0H	20M	40M	1H	20M	40M	2H	20M	40M	3H	20M	40M	4H	20M	40M	5H	20M	40M
DEC																		
0	239	229	223	217	214	211	208	206	203	201	201	206	213	223	240	249	263	279
5	232	228	226	221	218	216	215	212	209	208	209	214	220	232	246	255	266	277
10	228	226	223	221	221	222	222	218	216	216	217	222	230	243	255	261	269	290
15	227	224	224	223	224	224	225	222	224	225	227	231	242	256	265	271	278	323
20	228	227	226	226	226	225	225	221	223	228	232	243	257	272	281	286	311	392
25	236	234	232	231	231	228	224	223	223	227	231	240	256	279	292	307	343	480
30	247	244	242	239	236	231	226	225	224	227	232	242	264	287	300	331	432	450
35	266	259	255	249	244	239	233	229	227	230	242	257	277	299	324	393	426	370
40	285	277	270	262	256	248	242	241	245	253	261	277	298	321	372	393	346	309
45	312	301	292	285	278	272	270	267	270	276	285	299	322	364	354	313	283	268
50	326	318	311	302	296	291	288	288	290	296	306	329	335	312	281	259	251	247
55	343	334	323	317	312	307	305	306	313	321	310	295	272	245	238	235	236	239
60	391	373	357	348	341	328	312	299	284	268	251	232	228	225	223	228	233	232
65	299	294	286	278	270	259	247	233	225	223	221	217	216	219	224	229	227	225
70	238	234	230	226	224	221	218	215	211	212	214	218	220	224	223	221	220	218
75	217	217	216	216	216	215	216	216	216	218	217	217	216	216	215	214	212	210
80	210	209	209	210	210	210	211	210	210	210	210	210	209	207	206	205	204	203
85	201	201	200	200	201	201	201	201	201	200	200	199	199	199	199	198	197	196
90	190																	

BRIGHTNESS OF THE SKY AT DECEMBER 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	6H	20M	40M	7H	20M	40M	8H	20M	40M	9H	20M	40M	10H	20M	40M	11H	20M	40M
DEC																		
0	297	367	523	451	382	345	323	296	278	257	252	248	252	264	282	307	338	379
5	320	455	504	418	361	330	304	285	267	255	251	250	256	269	289	313	339	357
10	356	525	466	391	341	311	291	275	260	254	251	255	261	275	285	294	308	321
15	465	499	425	358	314	293	279	266	257	250	251	254	254	257	262	269	278	288
20	523	454	384	330	297	280	270	257	252	244	241	240	240	239	241	245	252	260
25	462	396	338	298	279	268	258	249	242	236	233	229	228	226	225	227	230	234
30	388	339	301	277	264	256	247	240	233	227	224	219	218	216	214	213	213	216
35	330	296	271	260	252	246	238	231	225	220	216	211	208	207	204	203	201	202
40	283	269	257	248	243	236	231	224	217	212	209	206	202	199	197	196	195	193
45	260	253	245	238	233	229	223	218	211	207	203	199	197	194	193	191	189	187
50	247	242	236	231	226	220	216	211	206	202	198	195	193	191	188	186	184	182
55	237	234	228	223	219	212	209	205	200	196	194	191	190	187	184	182	181	179
60	229	226	221	217	212	207	204	200	197	193	191	188	186	184	182	181	179	177
65	222	218	214	211	206	202	199	197	194	191	189	187	185	184	181	179	178	176
70	214	211	208	204	202	199	197	194	192	191	188	186	184	182	181	180	178	177
75	208	205	202	200	197	195	194	193	190	189	188	186	184	183	182	180	179	178
80	201	199	198	196	194	192	191	190	189	189	187	186	185	184	183	182	181	181
85	196	195	194	194	193	192	191	189	188	188	188	187	187	187	186	186	185	185
90	190																	

BRIGHTNESS OF THE SKY AT DECEMBER 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA / DEC	12H	20M	40M	13H	20M	40M	14H	20M	40M	15H	20M	40M	16H	20M	40M	17H	20M	40M
0	438	469	502	538	576	615	657	752	0	0	0	0	0	0	0	0	0	0
5	381	397	414	433	455	475	498	545	0	0	0	0	0	0	0	0	0	0
10	335	346	355	363	374	383	393	411	0	0	0	0	0	0	0	0	0	0
15	299	307	312	315	321	325	328	333	348	0	0	0	0	359	383	386	378	393
20	268	272	277	280	285	286	286	288	293	283	280	289	297	302	320	330	340	361
25	239	245	249	254	256	258	258	260	262	260	259	264	268	272	285	297	313	340
30	219	222	225	230	234	237	239	242	245	244	245	249	254	257	266	279	295	324
35	203	203	205	208	213	219	224	227	233	236	232	240	245	248	255	268	282	307
40	192	191	190	190	195	203	210	215	221	227	229	230	237	243	249	261	275	291
45	184	182	181	180	180	187	195	203	209	216	223	223	230	236	244	254	266	276
50	180	177	176	174	173	174	180	188	196	204	211	217	221	228	234	244	255	261
55	177	176	174	172	171	170	170	175	183	190	197	204	209	215	221	232	240	244
60	175	174	174	173	172	172	172	172	175	180	186	191	196	200	197	210	221	224
65	175	175	174	173	173	173	174	176	178	180	183	187	192	198	198	195	185	190
70	176	175	174	173	173	173	173	173	174	174	176	177	178	179	181	184	188	185
75	177	177	177	176	176	176	176	176	177	177	178	180	181	182	182	184	185	185
80	181	180	180	179	179	179	180	180	180	180	181	181	182	182	183	183	185	187
85	185	184	184	184	183	183	183	184	184	184	184	184	185	185	186	188	188	189
90	196																	

BRIGHTNESS OF THE SKY AT DECEMBER 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	18H	20M	40M	19H	20M	40M	20H	20M	40M	21H	20M	40M	22H	20M	40M	23H	20M	40M
DEC																		
0	C	0	0	650	565	518	471	420	386	353	331	309	292	278	266	258	252	246
5	C	0	0	589	525	477	444	397	361	331	306	288	273	261	251	244	241	236
10	C	0	0	501	534	477	434	391	341	314	288	271	259	248	244	240	235	230
15	400	385	387	437	534	494	446	399	345	302	281	262	249	244	239	236	232	230
20	384	393	369	389	487	558	480	420	362	313	279	265	253	244	241	238	233	230
25	374	398	378	384	432	560	541	456	392	341	300	274	264	255	247	243	242	240
30	357	382	391	377	399	494	604	513	441	382	341	308	280	273	265	259	255	249
35	338	368	385	382	382	420	547	626	498	437	388	352	325	300	286	281	276	269
40	316	337	356	369	363	389	446	570	637	510	443	392	366	345	326	312	298	290
45	293	309	324	335	338	341	385	460	573	622	528	449	405	372	355	343	334	323
50	276	280	288	297	302	312	330	375	431	519	589	558	464	413	385	361	345	335
55	247	249	256	261	271	277	293	307	345	378	433	482	514	503	450	403	373	356
60	225	213	231	246	247	247	248	265	278	299	323	339	370	395	410	417	407	400
65	193	199	204	213	218	223	229	233	241	250	258	269	280	287	290	290	298	301
70	188	192	200	202	204	209	213	216	220	223	226	226	226	223	223	229	235	236
75	192	194	196	198	198	199	202	204	206	208	211	216	221	227	229	226	224	221
80	188	191	192	194	195	197	198	200	201	202	203	204	205	206	207	208	208	209
85	190	190	192	193	194	194	195	196	196	197	198	197	198	199	200	199	200	200
90	190																	

BRIGHTNESS OF THE SKY AT DECEMBER 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA / DEC	0H	20M	40M	1H	20M	40M	2H	20M	40M	3H	20M	40M	4H	20M	40M	5H	20M	40M
-5	236	227	219	213	209	206	203	200	197	195	195	199	207	216	231	245	263	283
-10	233	222	215	210	205	201	198	196	194	190	190	193	200	211	223	239	260	285
-15	228	217	211	205	200	196	193	191	188	187	186	189	196	205	219	232	254	282
-20	220	211	207	202	196	192	189	187	185	184	184	186	192	199	211	224	246	275
-25	214	206	200	197	192	189	185	183	181	181	181	182	187	194	205	218	236	264
-30	205	200	195	191	188	185	182	179	179	178	179	180	185	191	200	213	226	253
-35	200	194	191	186	186	182	179	178	177	175	176	178	182	188	195	207	220	240
-40	193	190	188	185	182	180	177	176	175	175	175	176	180	185	192	202	213	227
-45	190	187	184	182	179	177	176	174	173	174	173	174	178	183	188	197	207	216
-50	189	185	182	180	178	176	174	172	173	172	173	174	175	180	185	193	201	210
-55	187	185	182	181	178	176	173	172	171	171	172	173	176	177	181	189	197	203
-60	189	185	182	181	179	177	175	172	172	171	173	175	176	179	182	184	194	201
-65	194	188	184	181	181	180	179	179	177	176	175	175	177	179	184	188	186	191
-70	208	201	195	191	188	186	184	184	185	186	187	190	192	196	202	209	203	190
-75	221	217	213	209	206	203	200	199	198	198	198	199	201	203	204	201	202	215
-80	236	233	230	227	225	223	222	221	220	219	218	218	217	218	222	225	227	230
-85	243	242	242	241	240	239	239	239	238	238	238	239	239	239	241	242	244	245
-90	257																	

BRIGHTNESS OF THE SKY AT DECEMBER 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	6H	20M	40M	7H	20M	40M	8H	20M	40M	9H	20M	40M	10H	20M	40M	11H	20M	40M
DEC																		
-5	298	349	473	501	399	354	337	310	288	265	251	247	249	260	278	300	330	369
-10	310	337	414	537	450	375	344	326	295	274	256	248	250	258	274	295	322	356
-15	314	345	407	518	533	400	357	334	307	282	263	251	249	257	270	289	314	343
-20	308	354	401	484	605	507	396	346	319	290	269	258	251	255	268	285	306	330
-25	296	349	403	478	593	650	486	395	342	302	278	261	255	257	267	283	304	324
-30	282	327	391	461	561	723	675	486	404	341	294	270	258	261	269	285	304	321
-35	269	298	365	439	528	641	837	716	510	429	354	303	275	268	275	292	307	323
-40	253	277	328	402	486	591	737	924	788	574	475	386	339	301	300	307	317	331
-45	239	260	285	354	428	509	631	808	1006	888	688	556	478	418	393	369	352	362
-50	226	242	262	304	365	441	517	632	780	1053	1034	853	700	615	562	516	485	477
-55	214	228	245	260	310	361	429	492	593	686	892	1057	1054	933	822	732	678	650
-60	206	217	232	243	267	315	353	403	448	516	594	667	820	973	1034	1054	998	934
-65	196	207	216	252	258	271	301	331	368	403	434	483	539	586	623	666	742	801
-70	194	202	229	236	242	249	262	289	314	335	359	381	399	414	426	454	479	498
-75	224	234	241	249	255	261	269	274	282	296	309	321	331	342	353	364	372	377
-80	235	242	248	252	256	261	266	270	273	277	280	284	288	293	299	304	309	312
-85	247	249	252	254	258	260	262	264	266	267	269	270	271	273	274	275	276	277
-90	257																	

BRIGHTNESS OF THE SKY AT DECEMBER 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	12H	20M	40M	13H	20M	40M	14H	20M	40M	15H	20M	40M	16H	20M	40M	17H	20M	40M
DEC																		
-5	419	491	604	697	766	833	928	0	0	0	0	0	0	0	0	0	0	0
-10	398	457	547	690	904	1153	1334	C	0	0	0	0	0	0	0	0	0	0
-15	377	427	501	612	775	1014	C	0	0	0	0	0	0	0	0	0	0	0
-20	358	397	456	541	666	877	C	C	0	0	0	0	0	0	0	0	0	0
-25	347	377	422	485	580	757	0	C	0	0	0	0	0	0	0	0	0	0
-30	339	363	397	447	531	0	C	C	0	0	0	0	0	0	0	0	0	0
-35	340	360	387	427	499	0	0	C	0	0	0	0	0	0	0	0	0	0
-40	346	367	392	428	0	0	C	C	0	0	0	0	0	0	0	0	0	0
-45	376	394	416	444	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-50	473	476	484	499	520	549	582	C	0	0	0	0	0	0	0	0	0	0
-55	626	611	613	617	629	647	670	708	778	871	989	0	0	0	0	0	0	0
-60	887	860	843	840	849	868	897	943	946	947	870	787	737	682	617	575	527	473
-65	839	856	857	848	826	792	748	696	658	635	607	573	535	509	479	446	418	385
-70	512	518	520	521	519	512	499	483	462	454	446	435	419	398	382	363	343	328
-75	382	384	384	386	386	385	383	377	372	364	357	350	341	331	318	308	307	304
-80	315	316	316	317	317	316	314	312	309	304	299	296	295	293	291	289	288	285
-85	278	278	278	279	280	280	280	279	279	279	279	278	277	276	275	274	272	271
-90	257																	

BRIGHTNESS OF THE SKY AT DECEMBER 1
UNITS--THE NUMBER OF TENTH VISUAL MAGNITUDE STARS PER SQUARE DEGREE

RA	18H	20M	40M	19H	20M	40M	20H	20M	40M	21H	20M	40M	22H	20M	40M	23H	20M	40M
DEC																		
-5	0	0	0	747	641	587	520	465	421	388	361	335	316	299	286	276	263	249
-10	0	0	0	918	779	687	600	528	470	432	396	366	342	323	298	275	257	244
-15	0	0	0	1171	975	836	717	618	543	486	441	390	348	314	286	265	248	237
-20	0	0	0	1539	1240	1051	885	724	589	491	426	374	333	302	275	255	239	228
-25	0	0	0	1622	1219	979	781	631	526	449	397	354	319	288	265	246	231	221
-30	0	0	0	0	985	801	655	549	470	410	369	333	304	276	254	236	221	212
-35	0	0	0	0	800	657	549	478	419	377	344	314	288	264	243	227	213	205
-40	0	0	0	0	652	544	470	421	379	347	320	296	273	252	234	220	208	199
-45	0	0	0	0	540	460	411	377	347	323	302	283	264	245	227	214	204	195
-50	0	0	0	0	451	397	367	343	322	304	289	273	257	240	224	210	200	193
-55	0	0	0	0	385	353	334	318	303	290	277	265	253	239	223	210	199	192
-60	422	382	362	346	336	320	310	300	290	278	269	260	250	239	228	214	203	195
-65	355	343	331	318	305	295	291	287	280	272	263	256	249	240	231	222	213	203
-70	322	316	307	299	288	279	277	276	272	268	262	255	249	242	235	228	222	215
-75	299	295	290	284	279	270	265	264	264	263	260	256	252	246	241	236	231	226
-80	283	279	277	273	269	266	262	258	255	253	253	252	251	249	246	244	241	238
-85	270	268	267	265	263	261	260	257	255	254	253	251	250	248	248	246	245	244
-90	257																	

APPENDIX II
TABLES OF AVAILABLE GUIDE STARS

Use of the Tables to Select Optimum Filter Characteristics

1. The numbers of cathode electrons per second (N_e - Column 2) pertain to a telescope aperture of $1\,cm^2$, a peak filter transmission of 100 percent, and an optical bandwidth of 1 micron (10,000 A). Find the multiplying factor which will convert these to the optical system in question. For example, for an objective lens of 10 square centimeters area, peak filter transmission of 80 percent, and an optical bandbwidth of 2000 A (between the half-response points) we would multiply these numbers by (10) (0.8) (0.2) = 1.6. For a simple photometer with a one-second time constant, S/N will be given by the square roots of these numbers* (i.e., for the above example $\sqrt{1.6\ N_e}$), neglecting dynode multiplication noise. For a star tracker, the relation between these numbers and noise in the error signal output will in general be more complicated, but in most cases should be proportional to the square root of the number of cathode electrons, with the constant of proportionality being determined by experiment for each tracker.

2. Determine, from experiment, the smallest cathode electron flow for which the tracker will perform satisfactorily. If desired, a safety margin may be added. By comparing this with column 2, as modified in step 1, we may now relate this to a particular row of the appropriate Table (S-4, S-11, or S-20).

3. Scanning along this row, we find the wavelength at which the largest number of potential guide stars is available. This is the optimum effective wavelength for a filter with the bandwidth and peak transmission specified in Step 1.

References

Hoffleit, D., 1964, Yale Catalog of Bright Stars (3rd Edition).

Johnson, H. L., 1965, The Absolute Calibration of the Arizona Photometry, Comm. Lunar and Planetary Lab. No. 53.

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*For a two-second time constant, S/N is given by the square root of twice this number, etc.

TABLE 1
S-4

B	N_e	4000	4100	4200	4300	4400	4500	4600	4700	4800	4900	5000	5100	5200	5300	5400	5500	5600	5700	5800	5900	6000	6100	6200	6300	6400	6500
.00	1.83×10^6	6	5	4	4	2	2	2	2	2	2	2	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
.25	1.45×10^6	6	6	6	5	4	4	4	2	2	2	2	2	1	1	1	1	1	0	0	0	0	0	0	0	0	0
.50	1.15×10^6	6	6	6	6	6	6	5	4	4	2	2	2	2	2	1	1	1	1	0	0	0	0	0	0	0	0
.75	9.16×10^5	8	8	7	7	7	6	6	6	5	4	4	2	2	2	2	1	1	1	0	0	0	0	0	0	0	0
1.00	7.27×10^5	12	11	9	9	8	7	7	7	7	6	4	4	3	2	2	2	2	1	1	0	0	0	0	0	0	0
1.25	5.78×10^5	18	16	15	12	10	10	10	9	8	8	8	6	4	4	2	2	2	2	1	1	0	0	0	0	0	0
1.50	4.59×10^5	24	23	21	19	16	15	12	11	10	9	8	8	8	5	5	2	2	2	2	1	1	0	0	0	0	0
1.75	3.65×10^5	32	29	27	24	24	20	18	15	13	11	9	9	8	8	6	5	3	2	2	1	1	0	0	0	0	0
2.00	2.90×10^5	38	36	35	32	30	25	24	22	18	14	13	11	9	9	8	7	5	3	2	2	1	1	0	0	0	0
2.25	2.20×10^5	60	54	47	43	39	34	32	31	26	24	20	16	14	11	10	8	7	6	3	2	2	1	0	0	0	0
2.50	1.83×10^5	74	68	64	62	55	48	43	41	35	31	26	23	17	16	12	11	11	7	6	3	2	1	1	0	0	0
2.75	1.45×10^5	92	89	84	77	73	69	62	53	48	41	34	29	24	20	16	14	11	11	8	5	3	2	1	0	0	0
3.00	1.15×10^5	114	111	104	97	93	89	79	72	66	57	49	41	36	27	22	17	15	12	11	8	4	3	1	1	0	0
3.25	9.16×10^4	140	137	127	123	119	106	101	97	87	80	70	60	50	40	34	24	18	15	12	10	7	3	2	1	0	0
3.50	7.27×10^4	186	177	167	160	150	139	132	120	113	105	91	82	65	57	47	38	27	18	14	12	9	6	3	1	1	0
3.75	5.78×10^4	239	228	217	204	196	178	171	156	144	131	118	107	90	78	65	52	42	29	17	14	11	8	3	2	1	0
4.00	4.59×10^4	320	306	288	267	246	240	220	202	190	169	153	131	120	104	84	70	54	44	32	17	12	9	6	3	1	1
4.25	3.65×10^4	423	395	381	362	344	324	292	276	249	223	197	172	155	135	120	94	72	55	43	29	15	12	8	3	2	1
4.50	2.90×10^4	544	529	506	477	449	424	392	364	328	299	266	232	204	174	150	133	103	77	58	42	22	14	9	6	3	1
4.75	2.20×10^4	661	660	651	627	603	567	529	497	451	401	351	311	270	230	200	166	141	107	77	58	39	19	13	8	4	2
5.00	1.83×10^4	707	713	730	741	748	732	688	644	588	537	478	413	362	316	267	216	177	147	108	76	51	29	14	9	6	3

TABLE 2
S-11

B	N_e	4000	4100	4200	4300	4400	4500	4600	4700	4800	4900	5000	5100	5200	5300	5400	5500	5600	5700	5800	5900	6000	6100	6200	6300	6400	6500
.00	2.25×10^6	4	4	4	4	2	2	2	2	2	2	2	2	1	1	1	1	0	0	0	0	0	0	0	0	0	0
.25	1.78×10^6	6	6	6	5	4	4	4	2	2	2	2	2	2	2	1	1	1	0	0	0	0	0	0	0	0	0
.50	1.42×10^6	6	6	6	6	6	6	5	4	4	4	2	2	2	2	2	1	1	1	0	0	0	0	0	0	0	0
.75	1.13×10^6	7	6	7	7	7	6	6	6	5	4	4	4	2	2	2	2	1	1	1	0	0	0	0	0	0	0
1.00	8.94×10^5	9	9	9	9	8	7	7	7	7	7	5	4	4	3	2	2	2	1	1	1	0	0	0	0	0	0
1.25	7.10×10^5	15	14	13	12	10	10	10	9	9	8	8	8	7	5	4	2	2	2	1	1	1	0	0	0	0	0
1.50	5.64×10^5	22	20	20	19	16	16	14	11	10	9	9	8	8	8	6	5	2	2	2	1	1	0	0	0	0	0
1.75	4.48×10^5	28	26	25	24	24	22	18	16	14	13	11	9	9	9	8	6	5	3	2	2	1	1	0	0	0	0
2.00	3.56×10^5	36	34	32	31	30	28	24	22	21	16	14	13	11	9	9	8	6	5	3	2	2	1	0	0	0	0
2.25	2.83×10^5	46	44	43	41	39	35	32	31	28	25	23	19	17	15	11	11	9	6	5	3	2	1	1	0	0	0
2.50	2.25×10^5	65	64	63	60	55	48	48	43	39	33	28	25	22	17	14	13	11	10	7	5	3	2	1	0	0	0
2.75	1.78×10^5	86	81	81	76	73	70	66	57	51	45	40	35	29	24	20	16	13	11	11	7	3	3	1	0	0	0
3.00	1.42×10^5	106	101	96	95	93	89	81	80	76	64	59	47	42	37	29	22	16	13	12	10	7	3	2	1	0	0
3.25	1.13×10^5	130	123	122	119	119	109	107	99	96	85	80	67	60	53	44	34	24	17	13	12	9	6	3	1	0	0
3.50	8.94×10^4	165	161	157	152	150	139	138	129	118	109	104	92	83	69	59	47	39	27	17	13	11	8	3	2	0	0
3.75	7.10×10^4	212	213	210	200	196	184	176	163	152	141	127	118	108	93	79	67	51	40	29	17	12	9	5	3	1	0
4.00	5.64×10^4	292	276	265	259	246	243	227	213	200	185	167	158	139	126	112	88	69	54	43	26	15	12	8	3	1	0
4.25	4.48×10^4	371	370	357	352	344	329	308	287	275	244	225	201	176	163	140	121	93	72	57	40	22	13	9	4	2	1
4.50	3.56×10^4	490	487	472	463	449	432	411	381	351	319	302	267	239	214	183	154	130	100	75	57	38	18	12	8	3	1
4.75	2.83×10^4	613	622	619	609	603	580	553	521	486	442	401	358	326	282	244	203	166	139	102	73	49	26	13	8	4	2
5.00	2.25×10^4	686	700	714	736	748	742	711	667	624	573	527	473	422	378	328	274	214	174	144	101	62	41	19	12	5	3