Chapter 1 – PREPARATIONS

Setting up an Observing Program

The purpose of this manual is to give you some guidance on how to make variable star observations and submit them for inclusion in the AAVSO International Database. In addition to this manual, you will find other useful information in the new member package and in the "New Observers" section of the AAVSO website (http://www.aavso.org). Please read all materials carefully and feel free to contact the AAVSO at any stage with any questions you might have.

Getting started

Selecting which stars you wish to track, gathering the necessary observing equipment, choosing an observing site, and deciding when and how often you wish to observe are all part of setting up a successful observing program. To obtain the maximum benefits from variable star observing, you should establish an observing program that is suited to your own personal interests, experience, equipment, and observing site conditions. Even if you submit just one observation a month, you will be making an important contribution to the field of variable star astronomy and can take satisfaction in the knowledge that you have done so.

Help is available

Sometimes there is no substitute for hands-on training. To further assist new observers who request help getting started, the AAVSO has a mentorship program which connects new observers with more experienced observers in their geographical area, whenever possible. Information about this program is included with the new member package.

Another resource, available to new and experienced observers alike, is the "AAVSO Discussion" group. This is an email-based forum in which observers can post their questions or make comments and other AAVSO members and observers can respond to their inquiries. Information on how to access this service is also included in the new member package and on the AAVSO website.

Though making variable star observations may sound straightforward as outlined in this manual, the process for the beginner can be very challenging and seemingly impossible at times. THIS IS NORMAL! We state this up front because many have been initially discouraged by the difficulty, believing that things will not get better. We reassure you that things *do* get better. It just takes a little practice.

Some members of "Astronomische Jugenclub", organized by AAVSO observer Peter Reinhard of Austria

Which stars should I observe?

It is highly recommended that new visual observers begin by choosing stars from the "Stars Easy to Observe" list, included with the new member package and posted on the AAVSO website. This list contains stars visible from all parts of the world, at various seasons of the year, so you will have to pare it down to the ones best suited to your location, equipment, and month when you wish to observe. There are separate lists available for binocular and unaided-eye observers. Unless the stars that you are observing are circumpolar, you will need to add more to your program as the seasons progress and the stars that you were observing are no longer above your horizon at night.

Expanding your program

As you gain experience and begin to feel comfortable with your variable star work, you will probably wish to expand the selection of stars you are observing beyond the "Easy to Observe" list. For instance, you could start observing more of the Long Period Variable stars listed in the The *AAVSO Bulletin,* all of which need long-term monitoring. There are often special observing requests outlined in the *Alert Notice* and *MyNewsFlash.* These, along with other more advanced observing projects, will be listed on the "Observing Campaigns" section of the AAVSO website.

Mary Glennon with her 7x50 binoculars

Some factors to consider as you set up, then later expand, your observing program include:

Geographical location – The scale of your observing program will be influenced by the location and terrain of your observing site as well as by how often you can use it.

Sky conditions – The more clear nights you have in your location, the more advisable it is to go after stars that require nightly observations, such as the cataclysmic variables and R Coronae Borealis stars (more information about types of variable stars can be found in Chapter 3 of this manual). If a site has clear weather less than 20% of the time, it is recommended that you observe slowly varying, long period variables, since, for these stars, even one observation per month is meaningful.

Light pollution – The amount of light pollution at your observing site greatly affects your selection of stars to observe. An observer living in a city is advised to concentrate on observing bright stars, while observers with dark skies should be challenged to go after stars as faint as their instruments will allow. Some of the most productive AAVSO observers work under very light-polluted conditions!

Observing Site Conditions

A remote, dark-sky observing site is by no means required for the visual observation of variable stars. The old axiom that the number of observations accrued per month is inversely proportional to the distance traveled from your home to your observing site is still valid. If you can do your observing from your own backyard several nights a week, perhaps under moderately light-polluted skies, it may actually prove more productive and enjoyable than once a month travelling two hours each way to a remote site with dark skies but obtaining only a handful of estimates. Being successful at variable star observing is more a matter of adapting your observing program to your location and instrumentation than any other factor. It is inspiring to note that quite a number of the AAVSO's leading observers currently reside in, and observe from, urban areas.

With more experience

Experienced observers may wish to make observations that can only be made during the morning or evening twilight. Observations made at these times are particularly valuable. This is because the difficulty of observing during twilight leads to a scarcity of observations as a star is entering or emerging from the seasonal gap. The seasonal gap is the period of up to several months when the star is above the horizon only during daylight hours. Observations made between midnight and dawn for stars in the eastern sky also have special value because most observers are active before midnight, when these stars have not yet risen.

Haldun Menali observing in the city

Equipment Needed

Optical Equipment

Successful variable star observing requires interest, perseverance, and the proper optical tools. A good pair of binoculars or even the unaided eye is sufficient for bright stars, while for fainter stars you need a telescope which can be either portable or permanently mounted. Much information on optical equipment is available from magazines and on the web (see Appendix 3 for more resource information).

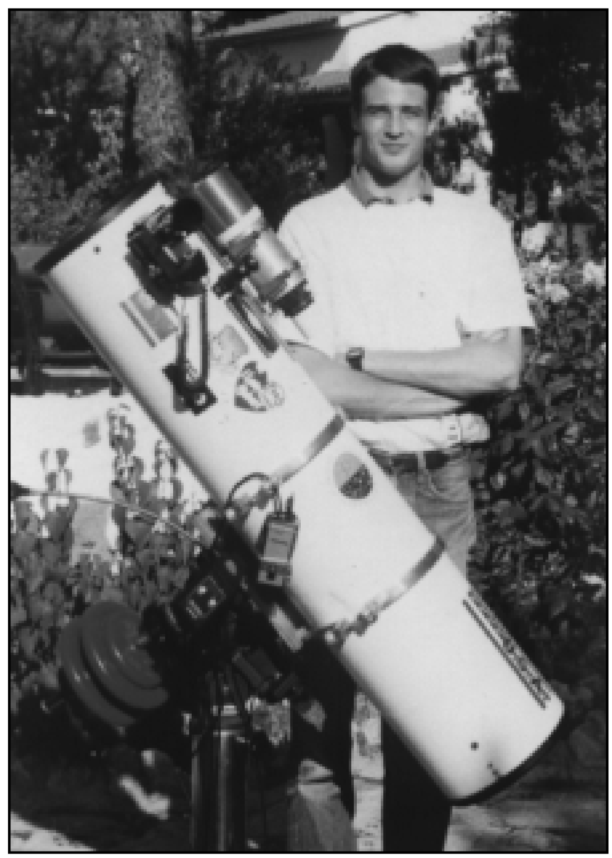
Binoculars – For beginning and experienced observers alike, binoculars are an excellent variable star observing tool. They are portable, easy to use, and provide a relatively large field of view, making it easier to locate the variable star field. Much can be done with a pair of good quality binoculars. Handheld 7x50's or 10x50's are the most generally useful for variable star observing. Higher magnification binoculars also work fine, but will usually require a mount.

Telescope – There is no "ideal" telescope for variable star observing; each has its own special advantage. Variable star observers can use just about every make, model, and type of telescope available. Your own telescope *is* the best scope! The most popular type of telescope among variable star observers is the short focus (f/4–f/8) Newtonian reflector with an aperture of 6 inches (15cm) or more. They are usually far less expensive than other designs and relatively easy to build. In recent years, the Schmidt-Cassegrain and Maksutov telescopes, with their compact designs, have gained considerable popularity among new and experienced observers alike.

Finder – It is paramount that your telescope be equipped with a good tool for finding the general region of the sky in which the variable is located. Standard finder scopes, setting circles (regular or digital), or 1X aiming devices can all be used in variable star observing. Preference varies among observers, so it is suggested that if you are already utilizing one of these systems, you should stick with it, at least in the short term.

Eyepieces – A low-power, wide-field, eyepiece is an important aid in locating variable stars, and it allows the observer to include as many of the comparison stars in the field as possible. High magnification is not necessary unless you are observing faint stars (nearer to the limit of your telescope) or crowded fields. The exact size and power of eyepieces you will need depends on the size and type of telescope you use. It is recommended that you have 2 or 3 eyepieces. One of these should be of low power (20X–70X) for use in finding and making observations of the brighter variables. Other eyepieces should be of higher power for viewing fainter stars. Higher quality eyepieces (especially at higher power) afford better star images, which translate into fainter star visibility. A good quality, achromatic, two- or three-power Barlow lens may also be a valuable aid. (See next page for more about eyepieces.)

Mount – Either equatorial or alt-azimuth mounts can be used successfully in variable star observing. Stability is important to prevent jittery star images, and smooth movements help in star-hopping. A drive system can be helpful when high magnification is used, but many observers make do without one.



Nicholas Oliva with Newtonian reflector

A Few Words on Eyepieces by Carl Feehrer, AAVSO Member/Observer

A basic understanding of certain eyepiece parameters helps significantly in choosing chart scales, setting expectations concerning what you will see, and deriving maximum benefit from your equipment. Brief discussions of the more important of these are presented below.

Eye Relief—This refers to the distance that necessarily exists between the eye and the eyepiece at the point where the whole field is visible and in focus. In general, the higher the magnification of the eyepiece, the smaller the exit "hole" through which you look will need to be, and the closer you will have to place your eye to the lens. The need to get very close with some eyepiece designs/magnifications can present a problem for eyeglass wearers in particular, and it may result in discomfort for observers whose eyelashes actually must touch the eyepiece in order to achieve a satisfactory view. "Long" eye relief exists when you are able to place your eye several (e.g. 8–20) millimeters from the eyepiece and still maintain an in-focus, full field view. Fortunately, there are several eyepiece designs that aid in meeting this goal.

Field of View—There are actually two concepts here: True Field (TF), and Apparent Field (AF). TF refers to the angular subtence of sky that you are able to see through your instrument, and it depends upon the amount of magnification provided by the eyepiece. The angle seen by the unaided (i.e.1x power) eye is an example of True Field. AF refers to the angular subtense of the eyepiece alone, and it is dependent upon the diameter of the eyepiece lenses. The fixed frame of a TV monitor provides an example of Apparent Field.

A common empirical method for estimating TF that is based on the time taken for a star to transit the field is given in the section on "Additional Observing Tips" (page 11). If you already know the Apparent Field of View (AFOV) and Magnification (M) of your eyepiece, it can also be estimated from the following relationship:

$$TF = AF/M$$

Thus, a 40-power eyepiece with an AF of 50 deg. will display a true angular subtense of sky equal to 1.25 deg., which is approximately equal to 2.5 times the diameter of the full moon.

Exit Pupil—The exit pupil is the name given to the "hole" through which you look. The response of the eye itself sets practical limits to the size of the exit pupil: If it is greater than about 7mm in diameter, some of the transmitted light is "wasted" because that value is approximately the maximum diameter of the diaphragm of the fully dark-adapted eye of a young, healthy person; if it is less than about 2mm, so little light enters the eye that the brightness of a star that is initially not very bright, may not be able to be judged at all.

If you know the focal length (FL) of your eyepiece and the focal ratio (FR) of your telescope, the exit pupil (EP) can be estimated from the following relationship:

$$EP = FL/FR$$

Thus, an eyepiece with a focal length of 25mm, fitted to a telescope with a focal ratio of 10, has an exit pupil equal to 2.5mm. Note that if you do not know the FR, it can be determined by dividing the focal length of the telescope (in mm.) by the aperture (in mm.)

Contrast Enhancement via Magnification—As the magnifying power of an eyepiece increases, the amount of light reaching the eye decreases. However, a modest increase in magnification is often found to enhance the contrast between stars and the surrounding sky, and this effect can sometimes be exploited when making estimates of relative magnitude in moderately light polluted skies. It is frequently found, for example, that 10x–50mm binoculars are preferable to 7x–50mm binoculars in less than totally dark skies. The same holds true for a telescope, and you may find that an increase from a low power to a medium power eyepiece, say, from 20x to 40x, will provide a more favorable viewing situation under marginal conditions.

Parfocal Eyepieces—Eyepieces that are of similar design and produced by the same manufacturer can often be interchanged without the need to refocus, making them very convenient to use. It is sometimes possible to create a "parfocal" set from a mixed set by slipping O-rings or spacers cut from plastic tubing over the eyepiece barrels.

Eyepiece Designs—Eyepieces come in a wide variety of designs. The older varieties contain as few as two lenses, while newer ones contain as many as eight. Some perform best at low to intermediate powers, while others cover the full range from low to high. Choosing the "right" ones depends upon what you plan to observe, your needs in terms of magnification, resolution, field of view, and how much money you are willing to spend. Rough comparisons of common types with respect to eye relief, apparent field, and cost are presented below.

	Eye Relief re: Kellner	Apparent Field (deg)	Cost re: Kellner
Kellner	(short)	36-45	(low)
Orthoscopic	moderate	40-50	moderate
Plossl	moderate	48-52	moderate
Erfle	long	60-70	moderate
"Ultrawide"	long	52-85	very high

Atlas

A star atlas or small scale sky chart will help greatly with learning the constellations and finding the general region of the sky in which a variable can be found. The *AAVSO Variable Star Atlas* is specially designed for locating variable stars. In addition, there are several other atlases to choose from, based on your own needs and preferences. Many of these are listed in Appendix 3 under "Reading Materials."

AAVSO Star Charts

Once you find the region of the sky in which the variable is located, you will need AAVSO Star Charts of various scales to identify the variable and make an estimate of its brightness. The next two pages of this manual contain a detailed description of a typical AAVSO Variable Star Chart along with a sample of one. Charts can be downloaded from the AAVSO website or paper copies can be sent to you from AAVSO Headquarters for a small fee.

Clock or Watch

Your timepiece should be readable in near darkness and accurate to within a few minutes for most kinds of stars. Accuracy to within seconds is needed for observations of special types of stars such as eclipsing binaries, flare stars, or RR Lyrae stars. Radio time signals available in North America include:

CHU Ottawa, Ontario, Canada
3.330, 7.335, 14.670 MHZ

WWV Fort Collins, Colorado, USA
2.5, 5, 10, 15, 20 MHZ

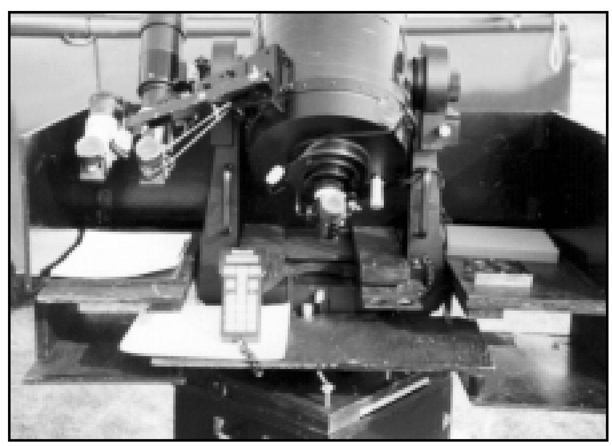
Record-Keeping System

An efficient record-keeping system is a necessity, and observers have devised many different kinds. Some enter all the observations for the night in a logbook and later copy them on to data sheets for individual stars. Others keep a record sheet for each star at the telescope. Still others enter their observations directly into their computers. No matter what system is adopted, one must not be influenced by previous estimates and should carefully check all records for accuracy.

Observing Stand

Most observers use a desk or table to hold charts, record sheets, and other equipment. Many have also constructed a shelter or cover over it to keep things from blowing away in the wind and free of dew. A shielded red light, which does not effect night-vision, is useful for illuminating the charts. Over the years, AAVSO observers have devised many creative solutions to this problem as seen in the photos below.

Ed Halbach's observing cart



Jack Nordby's "rotating workstation"

AAVSO Variable Star Charts

Locating a variable star is a learned skill. To aid the observer, finding charts have been prepared with well-determined, visual-magnitude sequences of comparison stars. We urge our observers to use these charts in order to avoid the conflict that can arise when magnitudes for the same comparison star are derived from different sets of charts. This could result in two different values of variation being recorded for the same star on the same night.

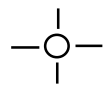
The standard AAVSO charts are 8-1/2 x 11 inches in size, and range in scale from 5 arcminutes per millimeter (“a” charts) to 2.5 arcseconds (“g” charts), a 120-times difference. The scales needed for your observing program will depend on the observing equipment you are using. Table 1.1 below summarizes this information:

Table 1.1 - *Chart Scales*

	arc / mm	area	good for
a	5 minutes	15 degrees	binoculars / finder
ab	2.5 minutes	7.5 degrees	binoculars / finder
b	1 minute	3 degrees	small telescope
c	40 seconds	2 degrees	3–4” telescope
d	20 seconds	1 degree	≥ 4” telescope
e	10 seconds	30 minutes	large telescope
f	5 seconds	15 minutes	large telescope
g	2.5 seconds	7.5 minutes	large telescope

Figure 1.1 on the facing page shows a typical AAVSO star chart with its features labeled. The heading of each chart contains quite a bit of information including the designation of the variable (see pages 17-18 for a description of this term), a letter identifying the scale of the chart, and the name of the star. Below the variable’s designation are: the range of variation in magnitude; period of variation; class of variable; and spectral type of the star. The position of the variable for the epoch 2000 (sometimes also with the epoch for 1900 or 1950) is listed below the star’s name. The coordinates for right ascension are in hours, minutes, and seconds, and those for declination are in degrees, minutes, and tenths of minutes. The latest revision date for the chart is shown in the upper right hand corner of the chart along with the scale of the chart in seconds or minutes of arc per millimeter. Many older style charts may give this information in a different format or be incomplete. The stars on an AAVSO chart are shown as black dots on a white background. The sizes of the dots—particularly for comparison stars—indicate relative brightness. Through a telescope, of course, the stars will appear as points.

Except on the “a” and “b” charts, the position of the variable is generally in the center of the field and is indicated by this symbol:

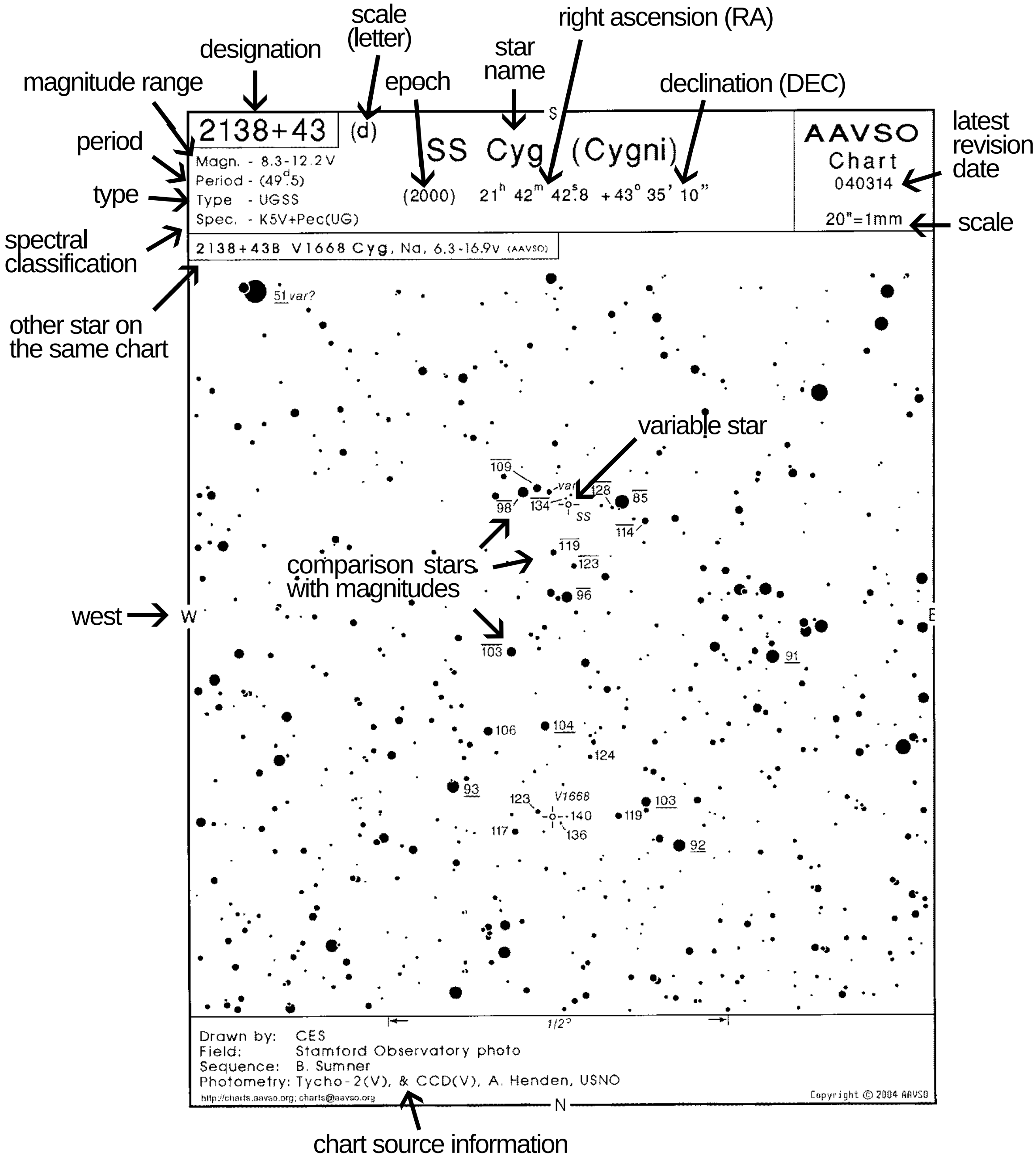


On some of the older charts, the variable is indicated by a simple open circle, sometimes with a dot in the middle. In most cases, when more than one variable in the AAVSO program occurs on the chart, an additional heading is provided for each.

Surrounding the variable star(s) are stars of known constant magnitude called comparison stars. These are used to estimate the brightness of a variable. The comparison stars are recognizable by the fact that they have magnitudes associated with them. These magnitudes are determined to the nearest tenth of a magnitude, the decimal point being omitted to avoid possible confusion with star disks. For example, “8.6” would appear on the chart as “86”. The numbers are placed to the right of the disk spot of the star wherever convenient, otherwise a short line connects disk and number.

In addition to the standard AAVSO charts, there are available: charts which have been *reversed* west to east for use with telescopes with an odd number of reflections (such as Schmidt-Cassagrains or refractors with diagonal mirrors); 4" x 5" *finder* charts which show a large area of the sky; and special purpose charts such as those used for observing eclipsing binary or RR Lyrae stars or by observers with photoelectric photometry or CCD equipment.

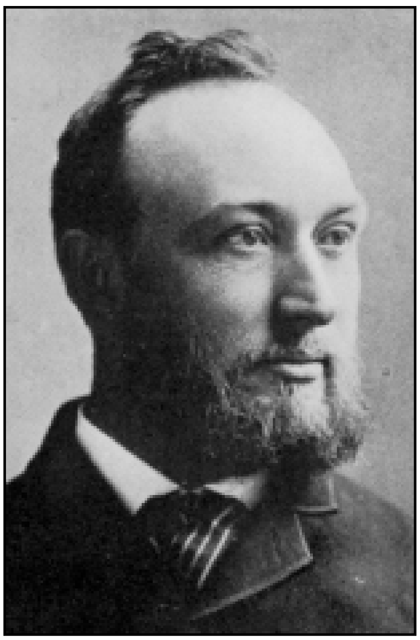
Figure 1.1 – *Sample AAVSO star chart*



All AAVSO charts are available through use of the on-line Chart Search Engine (http://www.aavso.org/observing/charts/). Paper copies may be obtained from AAVSO Headquarters upon request.

The first variable star charts...

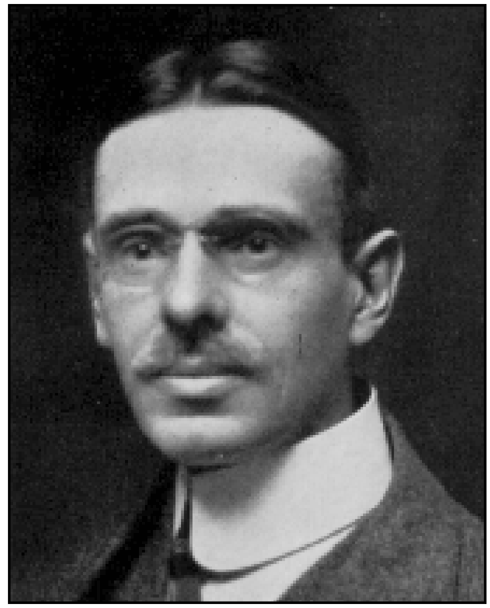
By the mid-1890s, Harvard College Observatory Director, Edward C. Pickering saw that the key to involving many more amateurs in variable star observing—while ensuring the quality and consistency of measurements—would be to provide standard sequences of comparison stars that have assigned magnitudes. For the novice observer, this would make variable star measurement a much simpler activity than having to follow the cumbersome step method (invented by William Herschel and promoted and refined by Argelander), and it would do away with the laborious reductions needed to derive a light curve.



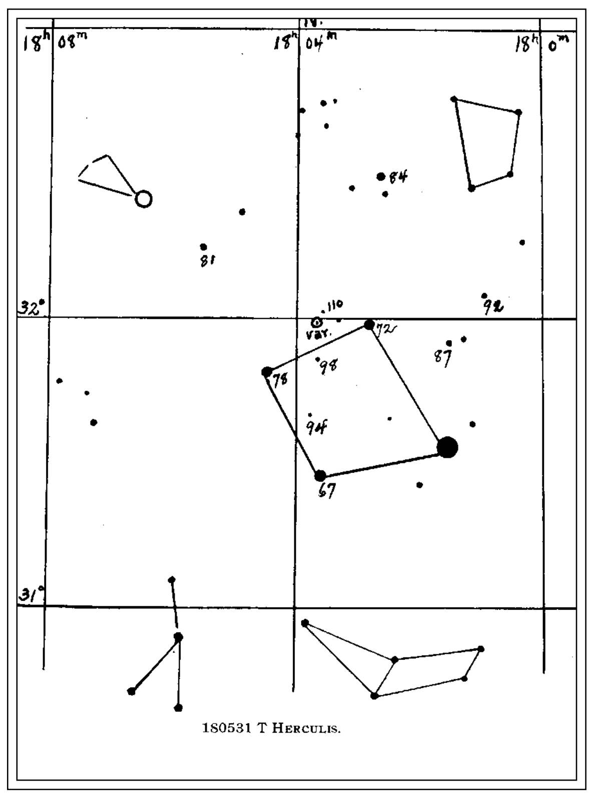
Edward C. Pickering

Pickering (and later AAVSO Co-founder William Tyler Olcott) began providing variable star observers with sets of charts which had the variable star and its comparison stars marked directly on them. The charts were traced from the German star atlas, the *Bonner Durchmusterung*, and the comparison stars were marked with letter-names (a, b, etc.).

In 1906, Pickering made an important change to his chart format, which went hand-in-hand with the way that variable star estimates were to be made. He now entered the photovisual magnitudes of a sequence of comparison stars directly onto photographically reproduced charts. The observation is made by comparing the variable directly with a brighter and a fainter comparison star, and matching or interpolating the variable's magnitude from the given comparison star values. It is a method commonly in use today.



William Tyler Olcott



One of the early variable star charts provided by E. C. Pickering, which W.T. Olcott used in his 1911 Popular Astronomy article, "Variable Star Work for the Amateur with Small Telescopes".