# THE STEWART STEREOPHOTOMETER

**Robert J. Stewart**
13-33 20th Street
Fair Lawn, NJ 07410

*Presented at the Annual Meeting of the AAVSO, October 25, 1997*

## Abstract

The author describes a unique visual photometer he designed, built, and installed on his 44-cm Dobsonian reflector to assist him in making variable star observations of greater accuracy and with less potential for errors from the usual sources. Details of its operation, observational benefits, and some preliminary results are given.

## 1. Introduction

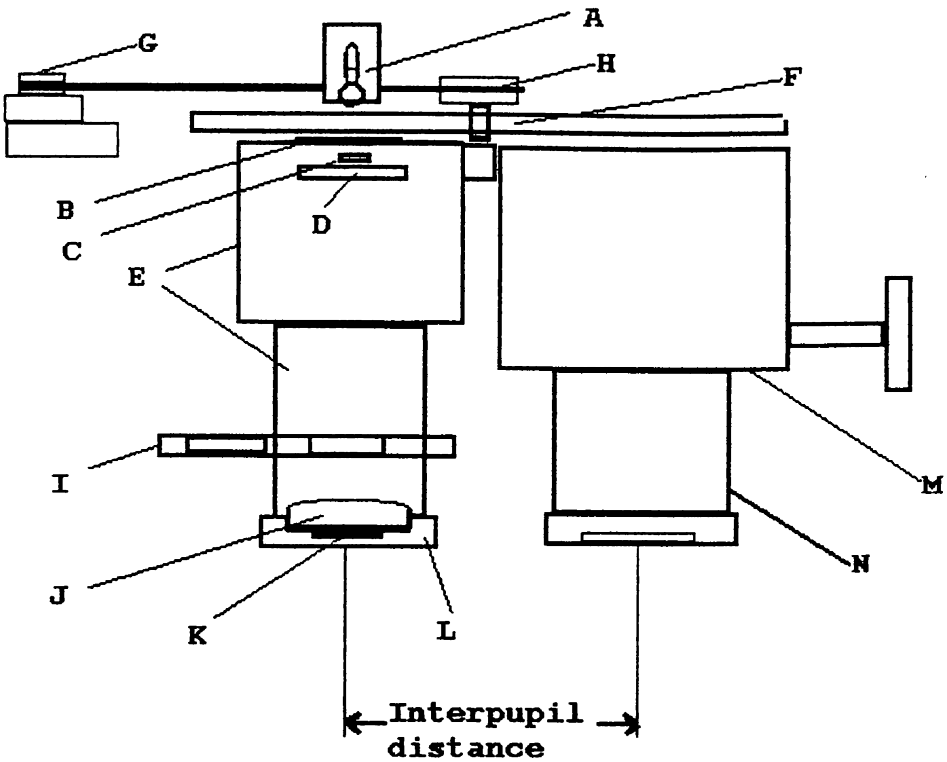
I have long been interested in visual photometers. Several years ago I made an extinction photometer for my 17.5" Dobsonian which operated by varying the telescope aperture until small brightness differences in two seemingly identical stars could be seen. While browsing in some relevant literature, I was intrigued by a flicker photometer described in the *Amateur Astronomer's Handbook* (Sidgewick 1960). Soon thereafter I got the idea to feed the photometer source into my normally idle left eye. This idea seemed to offer benefits, including ease of construction, resulting in the design of the Stewart Stereophotometer, which is in function a differential equalization photometer that can be used with merged flickering or side-by-side comparison techniques.

## 2. How it works; operating modes

Figure 1 shows the optical configuration of the photometer. The left eye sees a realistic simulated star from an incandescent source (6 volt from 110v) passing through a 50-micron precision pinhole. The artificial star has an overall range as seen in the field of view from 6th magnitude down to the detection limit of the telescope, and there are ±2 magnitudes of intensity variation from any starting magnitude. The photometer utilizes two stages of attenuation: first, a polarizing eyepiece is rotated to equalize the source with the first star (the reference); second, a variable-density beamsplitter obtained from Edmund Scientific is adjusted by translation over the source to equalize it with the second star (one of which is always the variable, of course) to obtain the brightness difference between them.

The photometer was originally constructed with motorized filter translation measured with a 2-inch travel dial indicator, but this has been modified to a simpler thumb-wheel for translation and a scale on the photometer housing, graduated in 0.1-magnitude increments with a zero-adjustable pointer (Figure 2). The LED-illuminated scale is much easier to read than the dial indicator. The brightness change per unit of travel of the variable-density beamsplitter was determined to be a constant 0.1 magnitude per 0.038"±.003 by repeated measurements of the 9.06 magnitude and 10.06 magnitude stars in the North Polar Sequence, as well as through the averaging of measures taken of many comparison star pairs on AAVSO charts.

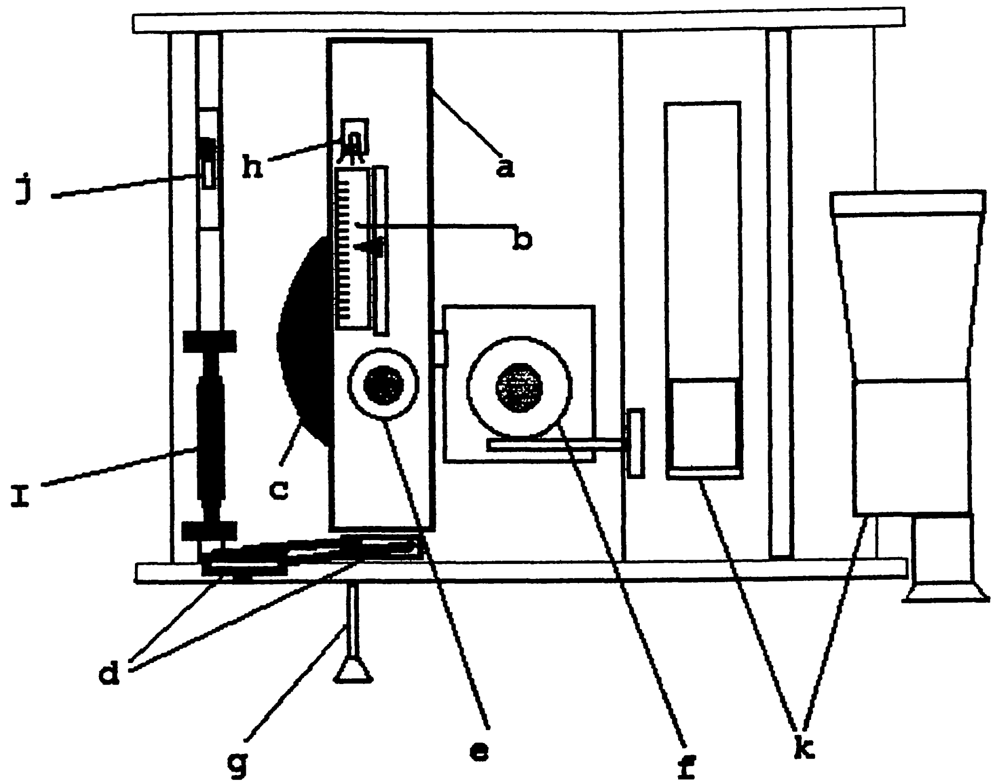
There are two distinct modes of operation: (1) For stars brighter than about 8th magnitude, the real and simulated stars are defocused and superimposed as a rotating shutter alternates the images between eyes in rapid succession, which causes any brightness difference to show as flicker. This potentially very sensitive technique is




Key to Figure 1

A. Light source, condensing lens, housing
B. Polarizing filter
C. 50-micron pinhole
D. Variable-density beamsplitter
E. Photometer housing
F. Rotating shutter (inside tube)
G. 300-RPM motor
H. Shutter bearing, belt
I. Lenses for focus/defocus
J. Pinhole imaging lens
K. 2nd polarizing filter
L. Rotating polarizer cell
M. Telescope focuser
N. Drawtube, eyepiece

Figure 1. Diagram of overall set-up of the Stewart Stereophotometer.




Key to Figure 2

a. Photometer housing
b. Magnitude difference scale
c. Rotating shutter
d. Manual translation assembly
e. Photometer eyepiece with rotating eyepiece and sliding lens
f. Telescope eyepiece
g. Pointer zero-adjustment rod
h. LED scale illuminator
I. Upper tube handle
j. Shutter on/off switch
k. Telrad and monocular

Figure 2. Diagram of Stewart Stereophotometer showing details of magnitude difference scale and manual translation assembly.

tricky—especially on a Dobsonian, which must be tracked manually. (2) For all stars fainter than ~8 magnitude, the real and simulated stars are placed close together, side by side, where the relative equalization points are measured.

## 3. Observing procedure

Two comparison stars are selected: One brighter (C+), and the other fainter (C-) than the variable appears, ideally about one magnitude apart. I make and record a careful estimate using C+ and C-. Next, I place either of the comparison stars (carefully noting which) to the immediate right of the simulated star. (I have noted that positioning the source on the right side results in the eyes crossing in an attempt to move it back to the side of the eye receiving the source.) I then use the photometer's rotating polarizer eyepiece to precisely equalize the simulated star to the comparison star. At this point I slide the scale pointer rod so that the scale reads zero (or, I preset the scale prior to starting). The variable is now positioned next to the "calibrated" artificial star, which is brightened or dimmed by rotating the wheel which translates the variable-density beamsplitter until exact equalization is achieved with the variable star. The magnitude difference in tenths of a magnitude is then read directly from the scale. I average the value obtained in my estimate with that of the measurement, usually favoring the latter, which I believe results in the most reliable overall observation. Fortunately, quite often the two values are the same or are extremely close, but discrepancies clearly increase as the comparison-star-to-variable brightness differences increase. The same is true with the comparison-star-to-variable distances.

## 4. Advantages and disadvantages of use

4.1. Advantages

a. All comparisons are made at the center of the telescopic field of view, avoiding drop-off in illumination of the field off-axis.

b. Because each eye is seeing only one source, the position-angle effect is eliminated.

c. In the flickering mode only, effects of color difference are greatly diminished, as is the Purkinje effect, due to the merging and flickering of the defocused stellar images.

d. Equalization is inherently more accurate than interpolation.

e. The binocular observing process is very comfortable and allows both eyes to contribute to the determination of the equalization points.

f. An accurate observation can be obtained on stars with only one available comparison star, and when the nearest one is a magnitude or more brighter or fainter.

4.2. Disadvantages

a. Any change in the sky conditions that occur during a measurement will disturb the measurement by causing the real stars to change relative to the constant photometer source. For this reason, observations must not take too long to perform. I am considering a modification which would use real stars for the photometer source, thus nullifying this effect.

b. The simulated and natural star must have the same appearance, which, depending on the seeing conditions, will require the right combination of defocus and magnification of both real and simulated stars.

c. The telescope focus setting must not change during an observation.

d. Working too close to the detection limit will compromise accuracy. My working limit is about magnitude 13.5, but I don't like to exceed 13th magnitude in my harsh observing conditions (in terms of light pollution).

e. Changes in the dark-adaptation level may affect real and simulated stars differently. I have not yet conducted any experiments to determine if such effects exist.

## 5. Conclusion

My motivation for making this photometer was simply the desire to make all of my observations as accurate as possible. This instrument helps me to accomplish this by providing a means of countering the serious and usually unavoidable error sources inherent to the physiology of the eye, to optical systems in the form of aberrations, and in fields where large sequence gaps exist. The Stewart Stereophotometer also gives me the ability to see somewhat smaller variations than are possible by observing by eye alone. The project continues to evolve, and I look forward to many interesting experiments and observing projects.

I would be happy to furnish details of construction to anyone further interested in this project.

## References

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