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21831

Real-Time Control With the TRS-80®

Russell Genet

BLACKSBURG CONTINUING EDUCATION SERIES™
edited by Larsen, Titus & Titus

gear and clutch can be seen to the left of the telescope in Fig. 10-1. Motion about this "polar" axis is measured in hours of Right Ascension (RA).

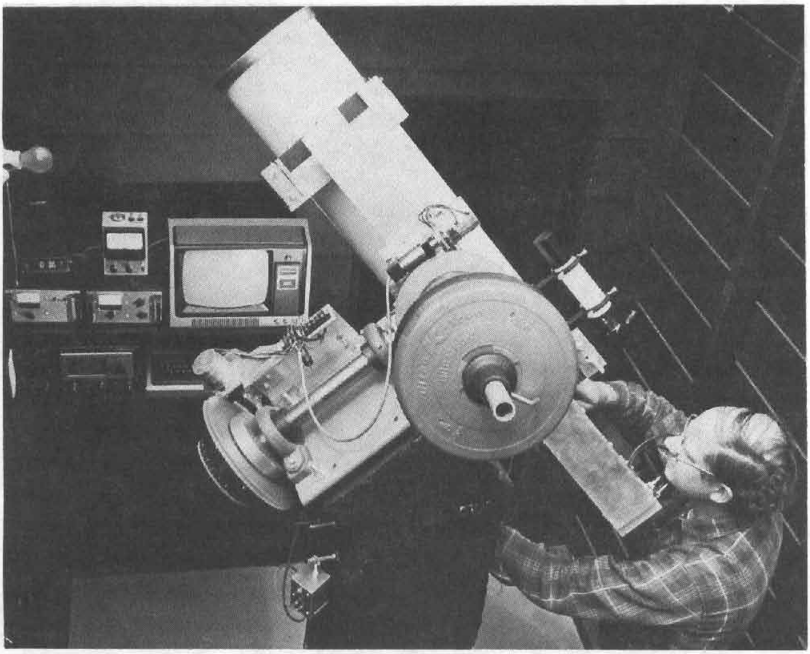

Fig. 10-1. Mark I system—the telescope is mounted on pier.

The second axis, known as the Declination (Dec) axis is perpendicular to the polar axis. On this particular type of mount, the telescope is on one end of the Declination axis, with counterweights on the other end as can be seen in Fig. 10-2. A smaller worm gear and clutch can be seen in Fig. 10-2 just to the left of the pier center along the Declination axis.

The telescope, itself, is an 8-inch f/15 Cassegrain. As diagrammed in Fig. 10-3, the light enters the top of the tube (A), reflects off of the primary mirror at the bottom of the tube (B), travels back up the tube and reflects again off of a smaller secondary mirror (C), travels back down through the tube and passes through a hole in the middle of the primary mirror (D) into the photometer head (E).

The photometer head can be seen more clearly in Fig. 10-4, and is shown diagrammatically in Fig. 10-5. As shown in Fig. 10-5, light

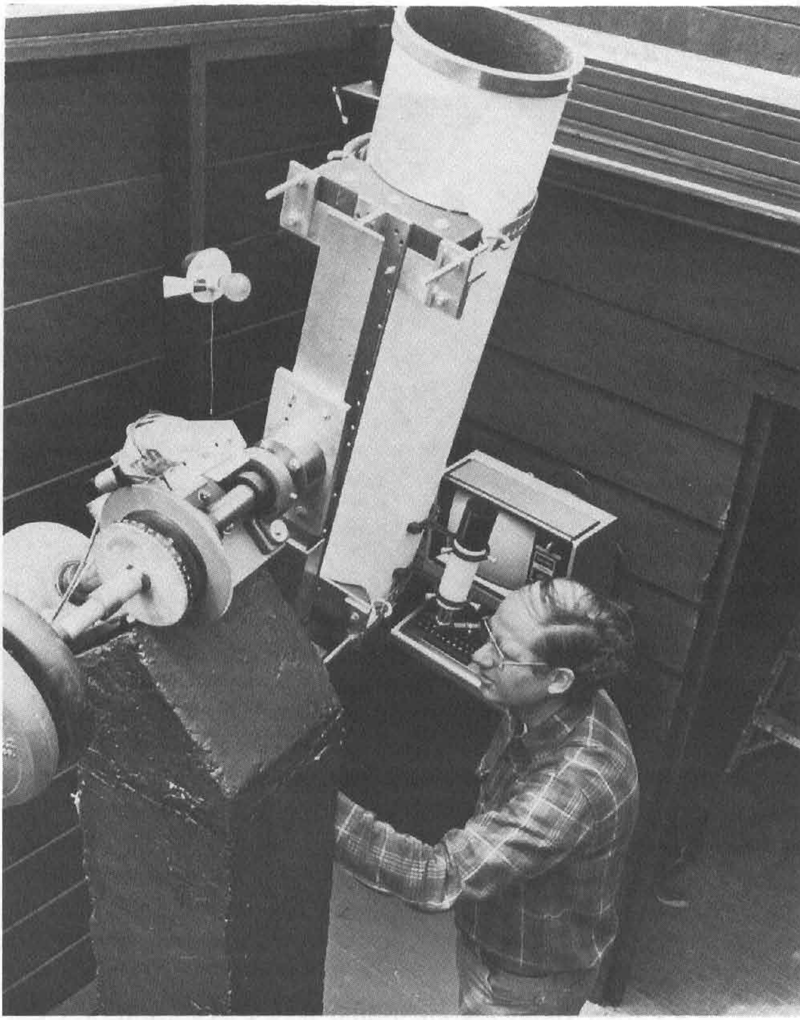

Fig. 10-2. Detail on the declination axis.

from the telescope enters the previewer section first (A). With the first flip mirror moved to the dotted position (B), the light is reflected to the eyepiece on the right (C). This wide-angle, low power eyepiece is used to roughly center the star on illuminated crosshairs within the eyepiece. Once the star is roughly centered, the first flip mirror is moved out of the light path by rotating it to the

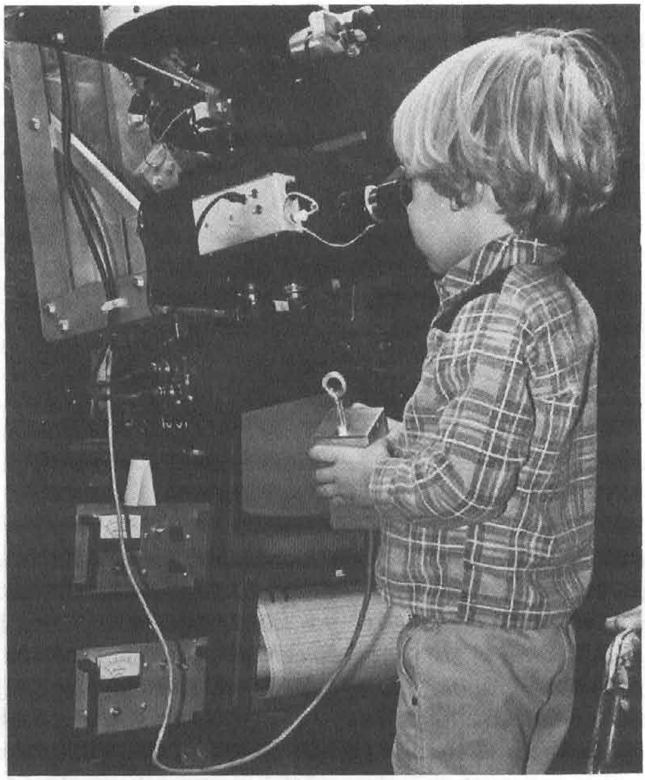

Fig. 10-4. The photometer head and electronics.

filters collectively. By isolating different portions of the spectrum, the photometric system can be used to determine effective stellar temperatures.

The photomultiplier (K) not only converts the light into electricity, but it amplifies it about 1,000,000 times. The photomultiplier used in the Mark I system is an RCA 1P21. Besides the photocathode, it has nine dynodes and an anode. Approximately 1000 volts dc is applied across the tube such that there is about a 100 volt drop between each of the elements. When a photon of light strikes the photocathode, a single electron will be released. The electron is accelerated to the first dynode and on hitting it knocks out about four electrons which are accelerated to the second dynode, where about 16 electrons are released. This continues until there are about 1,000,000 electrons collected by the anode.

Fig. 11-2. Mark II observatory equipment.

Fig. 11-3. Mark II computer equipment.

and lights are turned off in the office, and the door is latched to preclude unauthorized access by junior members of the staff.

On arriving in the observatory the "Main Menu" is displayed on the remote monitor. The time cube is activated and set on a post outside the observatory to avoid the considerable interference from the computer that travels along the control lines. Option 1, "Synchronization of the Clock," is selected from the menu. For "slow" variables close synchronization of the local clock with WWV is not required and any three-digit delay may be keyed in. For somewhat faster variables the WWV "tick" and local clock "tick" may be synchronized by ear to within one-tenth of a second. More precise alignment, such as required for occultations, requires an oscilloscope to observe the WWV tick crossover.

Once the WWV and local clock seconds ticks are aligned satisfactorily for the type of observation, the clock is set by asking for menu Option 2. The computer asks for the hours and minutes of the next "at the tone." These are entered on the keypad and, when the tone is heard, full synchronization will be maintained if any key is pressed within a second. The time is then displayed in the upper right hand corner of the screen. It may be checked at any later time by asking for menu Option 7 which displays the time.

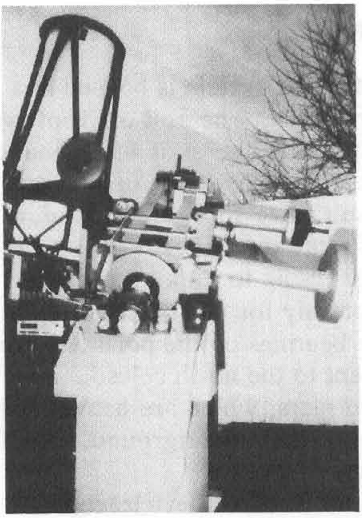

Fig. 12-1. Overview of the observatory (16-inch).

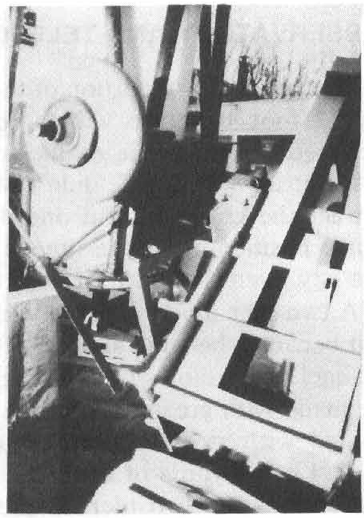

Fig. 12-2. The telescope in more detail.

PHOTOMETER HEAD

The photometer head is perhaps the most critical portion of the photometer system. For the Mark III system, the author helped Robert C. Wolpert and the staff at EMI Gencom, Inc., design a research grade pulse counting stellar photometer that has been named the Starlight-1. A close-up picture of this photometer mounted on the 16-inch Cassegrain telescope is shown in Fig. 12-3.

We wanted to design the Starlight-1 so that the detector would not be the limiting factor in measurement accuracy. This required a photomultiplier tube which had the following characteristics:

1. Greater than 30% quantum efficiency at peak wavelength
2. Extremely low background noise
3. A gain sufficient for single photoelectron detection
4. Small dimensions
5. UBV capability without requiring cooling
6. Interchangeability with mechanically identical PMT's but with different spectral sensitivities
7. Operate at less than 1000 V dc
8. Low in cost

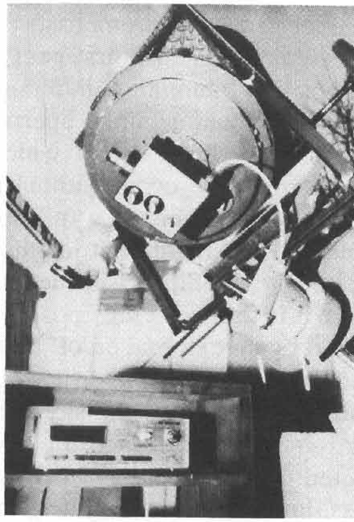

Fig. 12-3. Close-up of the Starlight-1 mounted on the 16-inch telescope.

The obvious choice was the end-window EMI 9924A. It has a RbCs photocathode with superb UBV sensitivity, a dark current of less than 50 picoamps, an excellent plateau curve at less than 200 Hz, it is only 1⅛ inches in diameter, it has many spectral response variants which are mechanically identical, and (last but not least) it is low in cost. This photomultiplier tube, when coupled to a fast, high gain, differential amplifier/discriminator, will provide single photoelectron detection capability. In addition to the EMI 9924 PMT, the detector assembly consists of a 500–1600 volt dc-dc power supply and a 2 by 4 inch circuit board which contains the PMT voltage divider network, a LeCroy MVL 100 amp/disk and a gain control pot.

The photomultiplier tube is housed in a foamed chamber with rfi and magnetic shielding. This foamed chamber has been designed to be easily replaced (at a later date) by a self-contained, thermoelectric, liquid-cooled chamber. The chamber is also designed to allow easy replacement of the photomultiplier tube.

All of the above items comprise about 40 percent of the available volume in the 6.5 by 4.5 by 7.2 inch photometer head. The remainder of the available space is completely filled by a complex optical assembly.

The optical assembly was the most difficult part of the Starlight-1 to design. Twice the design had to be scrapped as it neared completion in order to incorporate some newly suggested feature. The

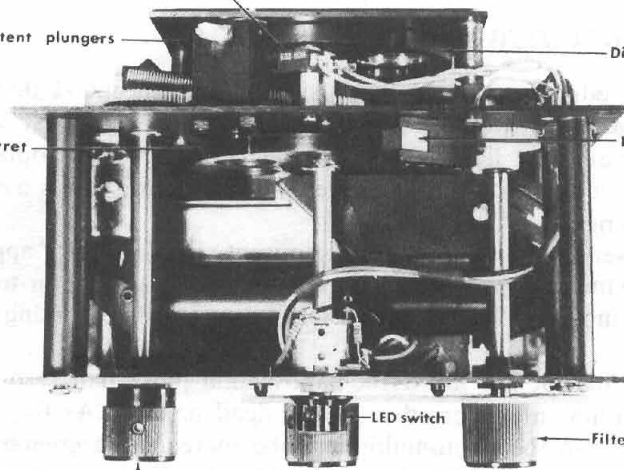

Fig. 12-4. Top view of the photometer head. (Courtesy EMI Gencom.)

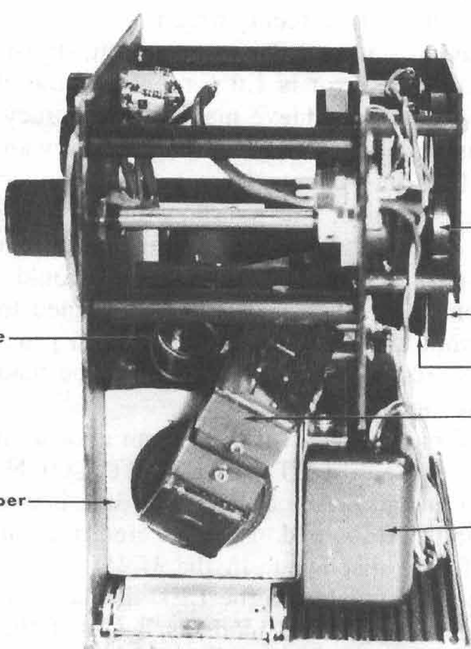

Fig. 12-5. Side view of the photometer head. (Courtesy EMI Gencom.)