

MICROCOMPUTERS IN ASTRONOMY

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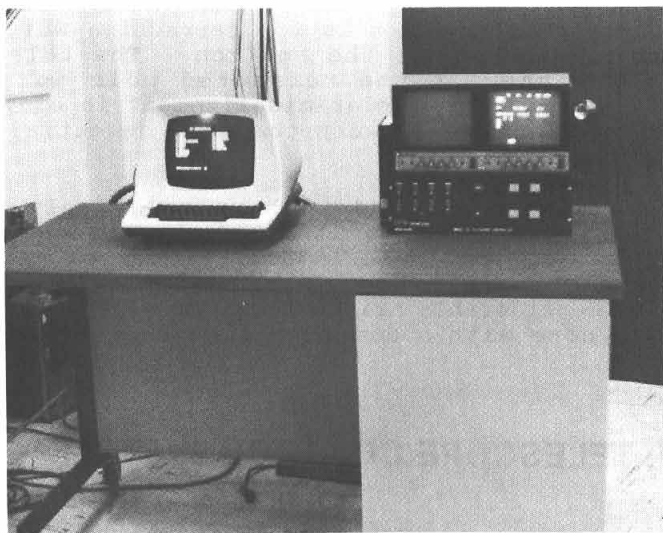


Figure 2-1. DFM Engineering Control System Console used at the Cerro Tololo Interamerican Observatory 1.5-meter telescope.

switching between a terminal at the TCS console or at a terminal located at the telescope. The TCS hardware will be located in a control room a short distance from the telescope where the operators will be warm and comfortable. A front panel is provided which has indicators and switches to enable/disable many of the automatic functions. This has been designed into the system for operator convenience. Some functions are awkward to handle through a terminal (such as EMERGENCY STOP, for example), while other functions are used so seldom that a simple switch is easier for the operator to comprehend.

Switches are provided for EXTERNAL COMPUTER OFF, AUTO DOME OFF, DRIVES OFF, AUTO GUIDER OFF, EMERGENCY STOP, GO. Several extra indicators, switches, and push buttons are provided for future growth.

A standard hand paddle may be plugged into the console for operation of the telescope in the traditional manner. This paddle is in parallel with the

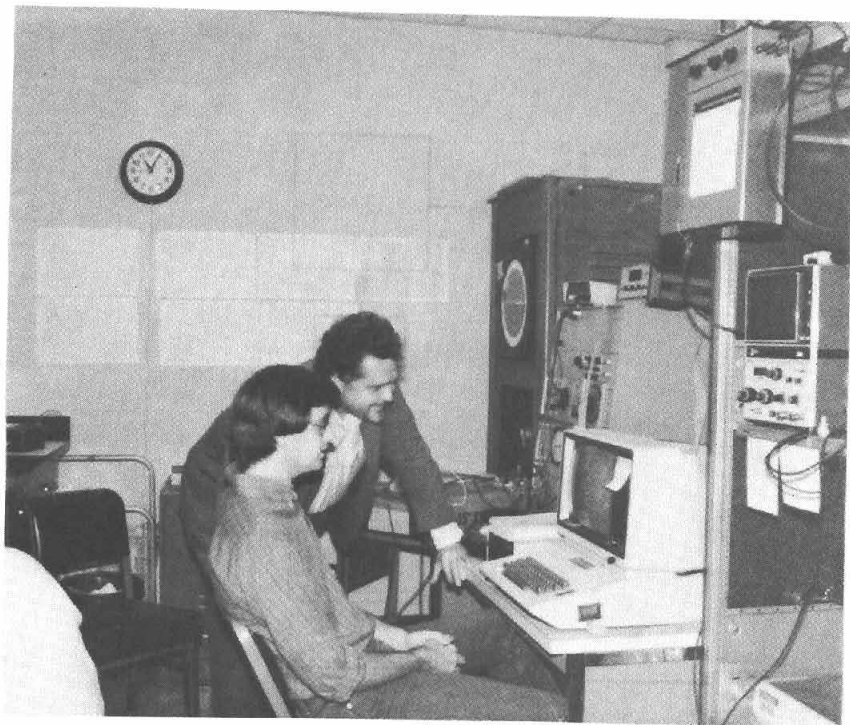


Figure 5-2. The Apple and other control electronics.

The electronics are straight forward as can be seen in Figure 5-3. The receiver horn feeds directly into a low noise amplifier (LNA) which can detect 11-16 GHz. The LNA has a noise of less than 4.5 dB and a gain of 35 dB. At these frequencies 4.5 dB noise was the best obtainable two years ago without going to cooled electronics or increasing costs by several orders of magnitude.

The LNA is followed by a tunable YIG microwave filter with a 40 MHz band width. Following this is the mixer/IF stage with its local oscillator which down converts the signal to 1-160 MHz. The filter and the LO can be set from the control room. We will eventually have them coupled so as the filter is tuned the LO will follow with an 80 MHz difference. The tunable filter

processors, there is little if any reason to use FORTH or any other lower-level language.

IV. TELESCOPE

The telescope itself is shown in Figure 7-1. The mount is a very sturdy cross-axis type. The primary mirror is 16-inches in diameter, f-3.75, and made of quartz. It was ground by one of us (Genet) with the assistance of Edward Jones. The overall optical and baffle design was done by Frank Melsheimer at DFM Engineering, using a special computer program. The fully illuminated field-of-view at the focal plane is one degree in diameter, which is 5-inches at the scale of 25 arcsec/mm. The effective f-ratio is 18.0, and the effective focal length is 288 inches.

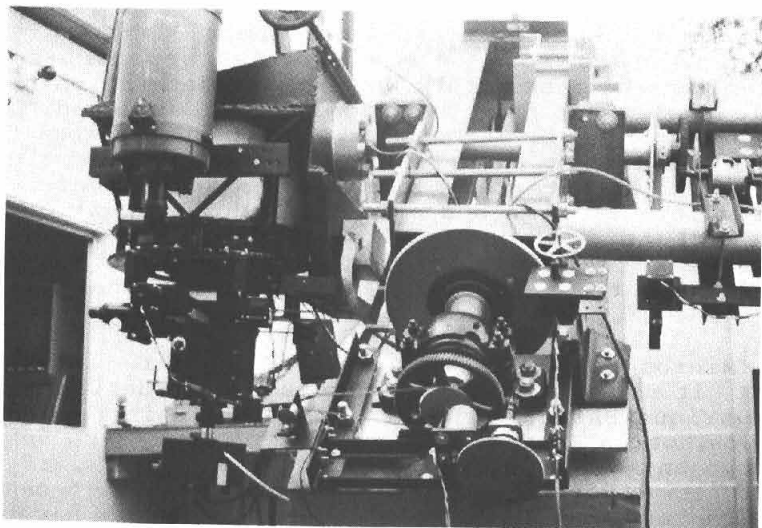


Figure 7-1. The 16-inch Cassegrain telescope at the Fairborn Observatory. This telescope was built primarily out of scrap steel by Genet.

and friction clutch, while in DEC there is a 2-foot tangent arm. These provide fine motions. Slewing is provided by an 8-inch spur gear and electric clutch in each axis.

V. INSTRUMENTATION

There are provisions on the telescope for mounting an on-axis payload such as the EMI Gencom Starlight 1 photometer shown in Figure 7-2, or for mounting two automatic photometers on X-Y stages on each side, providing a dual-channel (two-star) capability. The X-Y stages (with the photometers removed) can be seen in Figure 7-2, along with the linear steppers that move them under microcomputer control.

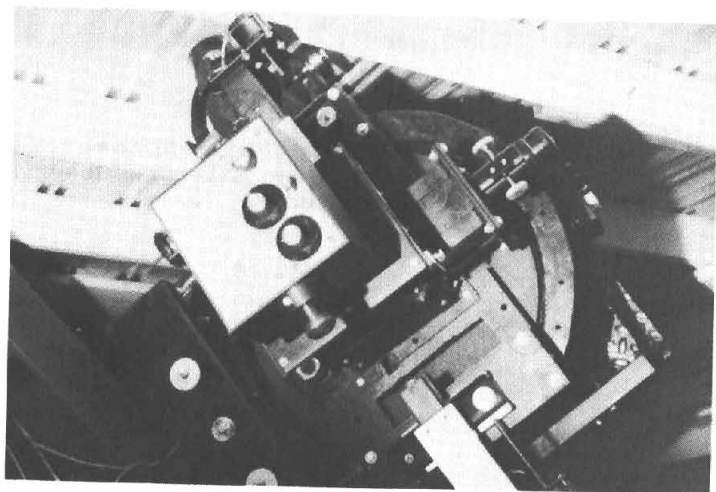


Figure 7-2. The "business end" of the 16-inch telescope. Shown is an on-axis Starlight 1 photometer and two X-Y stages for mounting a dual-channel photometer.

photometer heads with the side panels removed. Stepped steppers are used to control separate diaphragm and filter wheels. The diaphragm wheel can be offset in either direction by any amount to obtain sky readings.

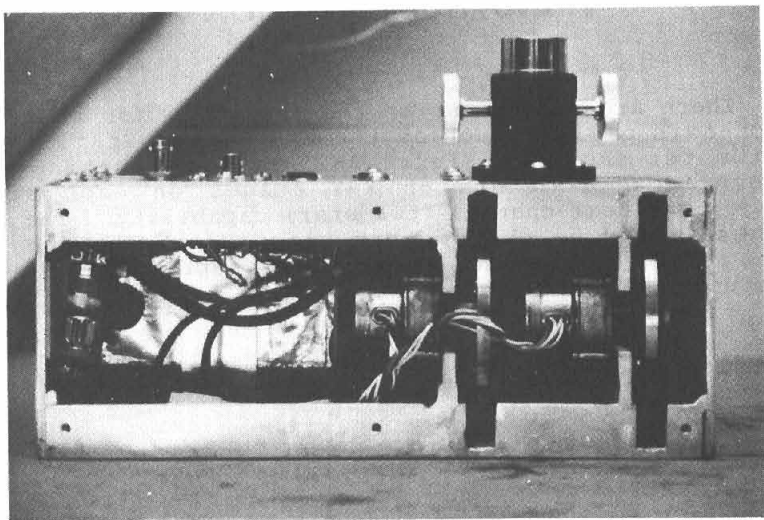


Figure 7-3. One of the two automatic photometers used in the dual-channel system at the Fairborn Observatory. The side panels have been removed.

Each head contains a 30-mm end-on EMI 9924 photomultiplier. A LeCroy MVL-100 chip is used as the amplifier-discriminator, and an ECL-TTL converter chip is also contained in each head.

A block diagram of the STD control system is shown in Figure 7-4. As presently configured, the system consists of 14 different STD cards, including the CPU. Four of the cards, besides the CPU, contain their own microprocessors and programs in PROM and qualify as "smart" STD cards. Each different card will be described briefly.

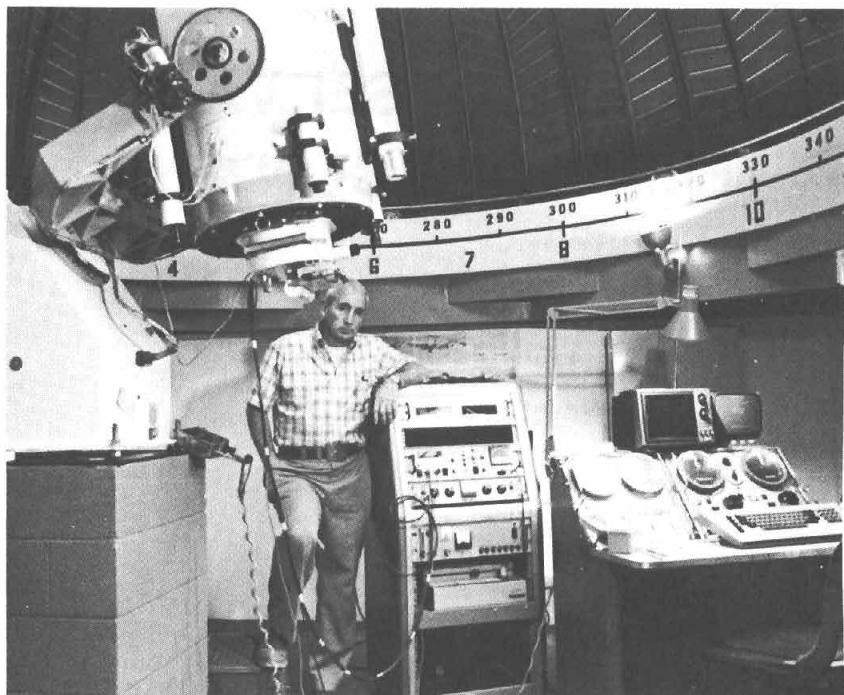


Figure 8-1. The 16-inch Cassegrain telescope and some of the electronics at the Braeside Observatory. Next to the telescope room is an insulated control room that contains the Apple II computer.

These limitations include:

- 1) The need for frequent adjustment.
- 2) Relatively large backlash accumulation.
- 3) Limited reliability due to the large number of interacting mechanical components necessary to provide all required operating motions.
- 4) Low resolution electro-mechanical position encoders.
- 5) Declining overall performance due to its heavy use and advanced age of some 18 years.

that the clock interrupted. In that instance the RA counter is incremented.

If it was an RA interrupt, the high bit of the data word is read, simultaneously clearing the interrupt and obtaining the direction of the pulse from the shaft encoder. RA is either incremented or decremented depending on the direction. DEC is handled similarly.

If the scope is moving, the changed counter is compared to either the switchpoint (if in slew) or the new location (if in set). If these destinations have been reached, the proper relay word to effect the downshift or stop is sent out.

When either side stops, it checks the other side to see if it, too, is stopped. If this is the case, the "moving" flag is cleared, and the move is over.

In all cases, whether a change in relay status has occurred or not, the ISR executes an RTI and returns to the main program.

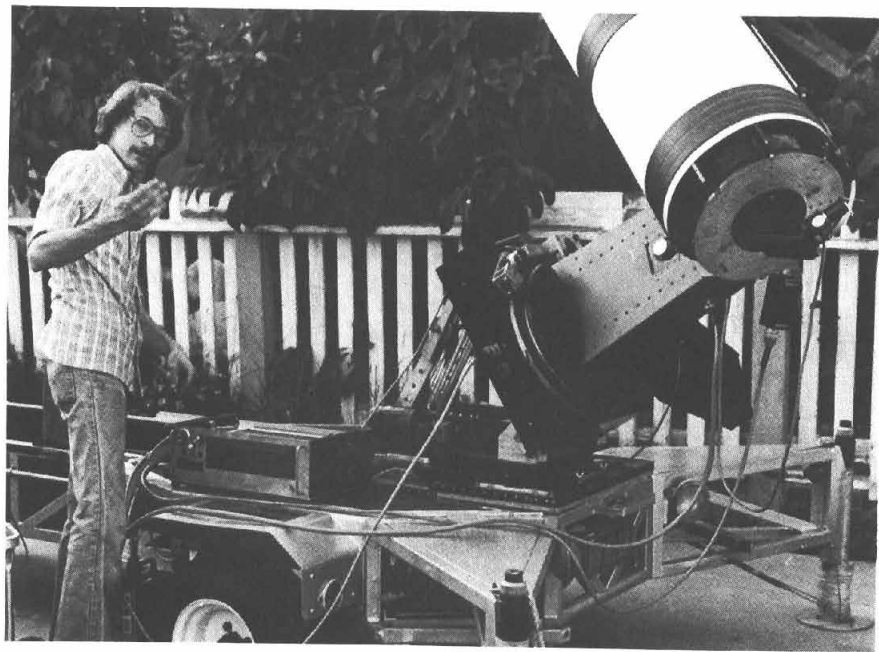


Figure 10-3. The mobile computer-operated telescope.

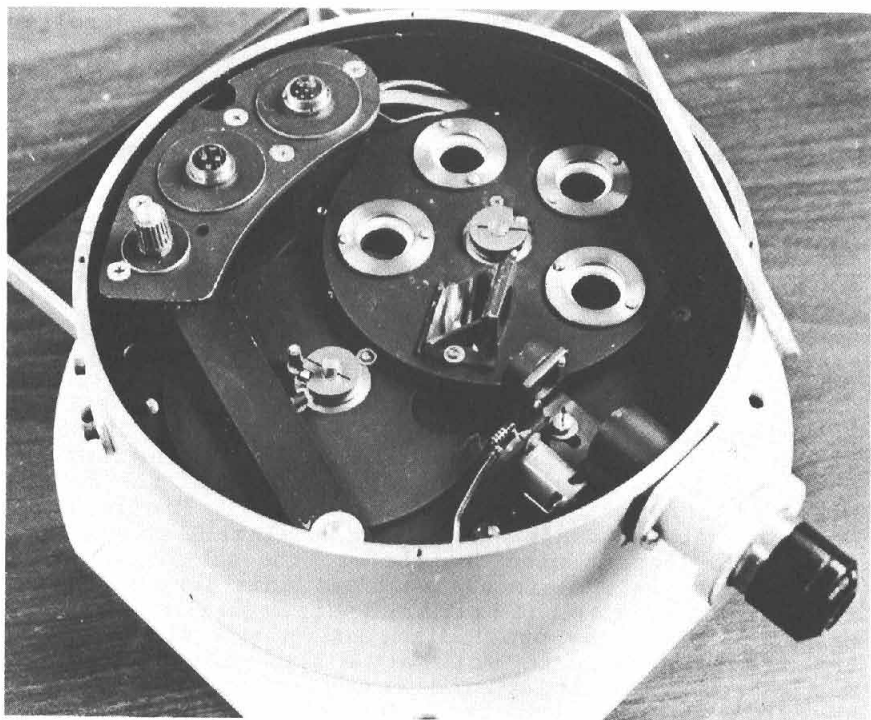


Figure 12-1. GORT-I photometer on the bench with its rear plate removed (taking with it the PMT housing). Note the electrical connectors (power and control) remain in place and merely protude through light-baffled clearance holes when the rear plate is in place. Wheel rotation limit detection switches were not installed when this photograph was made.

Of course some sort of manual interaction is unavoidable for selecting diaphragms to match seeing while viewing the star and aperture together. The computer's keyboard can be used for this purpose or if located too far away, a simple momentary switch near the photometer monitored by some program inputs will serve as well. In operation, such a switch is momentarily actuated, resulting in a change to the next adjacent diaphragm.

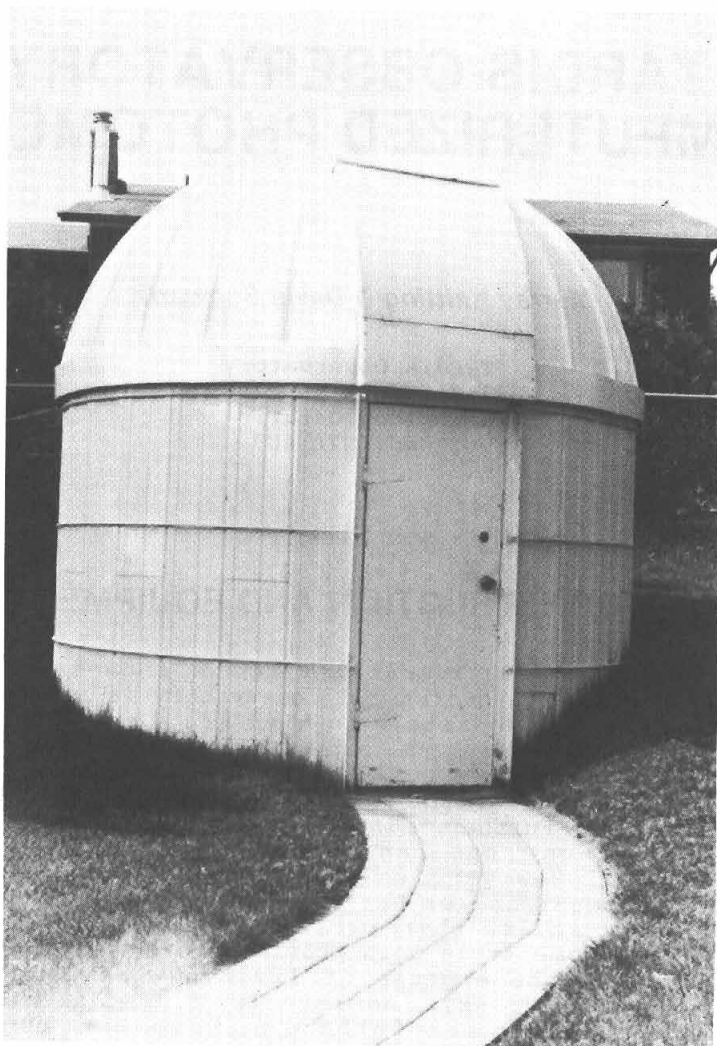


Figure 15-1. Exterior view of the Tardis Observatory. The walls are made from interlocking silo blocks that went together in just a few hours.

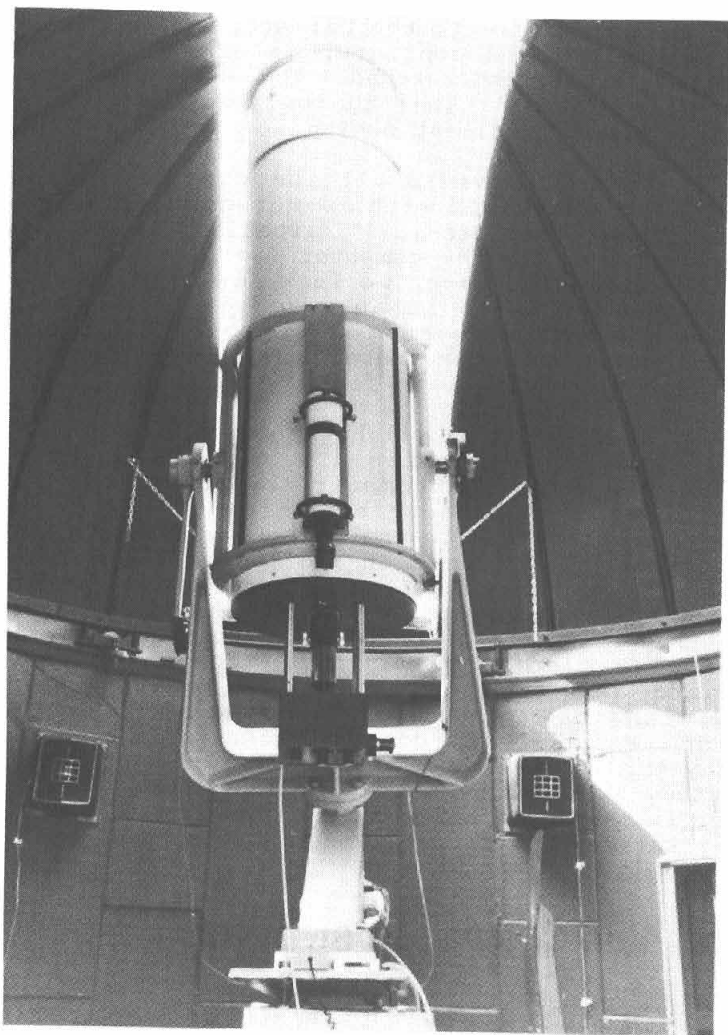


Figure 15-2. The 36.2-cm F/16 Cassegrain equipped with a Starlight-1 photometer. The telescope is mounted on an Astro-Works fork mount.

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Figure 28-2. The Maria Mitchell Observatory on Nantucket Island.