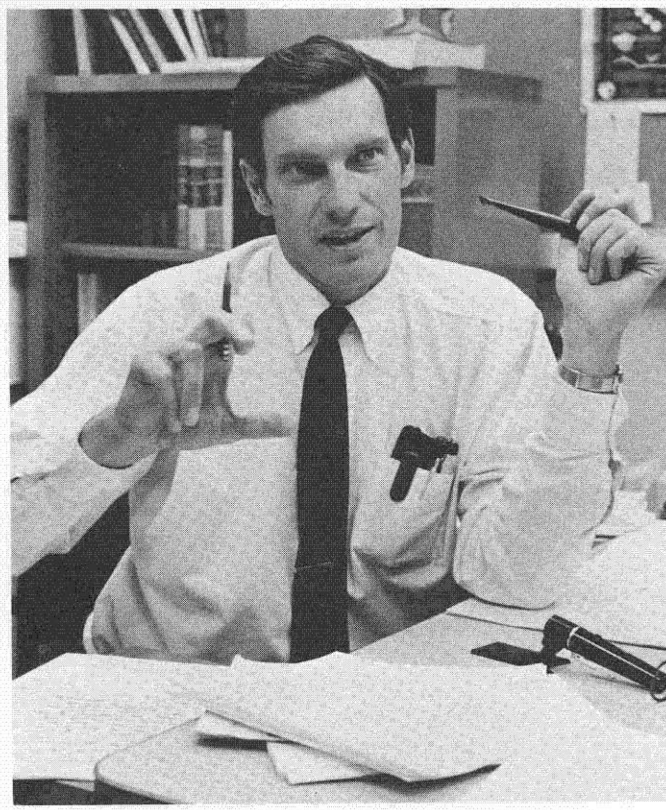
AUTOMATED ASTRONOMY

Computerization Comes to Palomar

by Edwin Dennison



Edwin Dennison—staff member of the Hale Observatories and head of its astroelectronics laboratory.

About two and a half years ago the astroelectronics laboratory of the Hale Observatories began working on a computer system to handle data and to control telescopes at Palomar and Mt. Wilson. Previous experience with photometric observations had shown us that by using an automated system an astronomer could observe many more stars per night than he had been able to observe before. The main boost in efficiency came from automatic recording and instantaneous data display—a major improvement over earlier systems, which required time-consuming manual calculations to convert sensor data into meaningful information.

However, these early automated systems were hard-wired, which is to say the logic reflecting a given control strategy was permanently wired into the basic system hardware. Because of this it was extremely difficult to modify the system to accommodate new observing requirements.

We therefore started developing a computerized data system. This would greatly increase the flexibility of the system, permitting the variety of command functions to be limited only by the availability of sufficient core storage and of computer software written to perform the specific function. Building the system around a digital computer also meant that we could add new observing instruments and data collection devices without having to modify the hardware already constructed. All we would have to do was write the software—the instructions that tell the computer what to do with the data being fed into it.

The first Hale Observatories telescope to be automated was the new 60-inch at Palomar. The system by which it operates is one of the first to include both telescope control and data acquisition functions. We are also building a similar system for the 200-inch Hale telescope, and we hope to start one for the 60-inch at Mt. Wilson soon.

One of the basic ground rules we established before we began the actual design was that the control procedures must be simple and directly related to the observing operation. There are times at night when even the best observer becomes fatigued, and we certainly didn't want to require him to become a skilled computer operator just to operate the system. Further, the number of devices that confront an observer will undoubtedly increase with time, and it could easily develop that no one person could handle all the control functions efficiently.

We looked at a number of possible hardware configurations, including timesharing (sharing a large computer with other users), but we decided on a dedicated computer —one located and set up to operate exclusively with this telescope. This would allow us to avoid depending on a central installation, which of course would not be able to guarantee being operational 24 hours a day. In addition, this approach made it possible for us to avoid the problems of data transmission from a remote site to a central computer.

We finally selected a Raytheon 703 minicomputer—a machine we judged to be ideally suited to our special astronomical applications. This computer has a convenient instruction set, and the manufacturer-supplied software is well developed and complete. Core memory size is 8,000 words—more than adequate to handle our current core storage requirements. Standard peripheral devices include an input keyboard, TV monitors, a teletype printer, and a paper-tape punch. In addition, we developed a generalized input/output expander circuit so we could attach our own special sensors and actuators via a single cable that runs serially through each. We can expand to over 200 such devices, and we can issue up to 256 commands to each one.

The observer communicates with the computer primarily through the keyboard and TV monitors. Commands—e.g., data acquisition time or telescope tracking rates—are entered via the keyboard and verified by alphanumeric displays on the monitors. Data acquired by the telescope and received by the computer are also displayed on the monitors as well as recorded in storage or printed out.

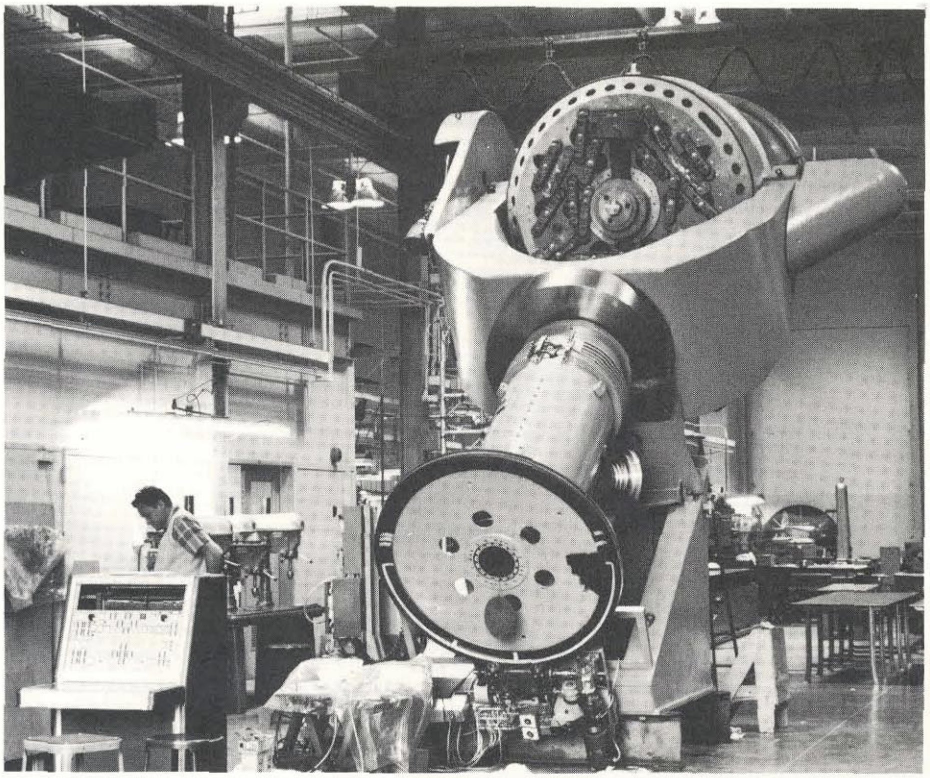
The system is controlled through panels at the observer's and night assistant's stations. One panel enables the night assistant to select the various control program options that are available. A second panel contains buttons to start, stop, or suspend the data collection process. It also permits the recording cycle to be suppressed when the data is considered to be of no value.

Because accurate time is fundamental for most astronomical observations, the system includes a clock which operates as an independent unit. It has an independent display and separate power source that remain on when the rest of the system is turned off. It can also be run from standby batteries if power interruptions prove to be frequent. The computer consults the clock to read sidereal time (which is time based on the earth's rotation with respect to the stars) and civil time (which is time based on the earth's rotation with respect to the sun).

Merely by automating the data recording and display functions, we have improved by a factor of two the speed with which an observer can make photometric observations. The significance of improvements such as this in telescope utilization efficiency becomes immediate and obvious when we remind ourselves of the magnitude of investment represented by these instruments: Total construction and installation costs on the 60-inch telescope came to some $1 million.

Another major step will come when we have preprogrammed stellar coordinate corrections, which will free the observer from the traditional, time-consuming methods of calculating coordinates to locate an object in the sky. I expect this improvement to produce an additional 10 percent saving in observation time. This saving alone will pay for the entire computing system, which cost a little over $100,000.

But even beyond the dollar savings, we have really only begun to scratch the surface in providing astronomers with the enormous flexibility of the modern digital computer. Right now, observers are still getting acquainted with the possibilities of the system. As they become more familiar with its capabilities, they will identify new observation requirements—to which we will respond by developing new control devices, data gathering devices, and computer software.



In early 1969 the telescope was assembled, without optics and data acquisition devices, in the central engineering shops on the Caltech campus. After completion of the control system tests, it was disassembled and shipped to Palomar.