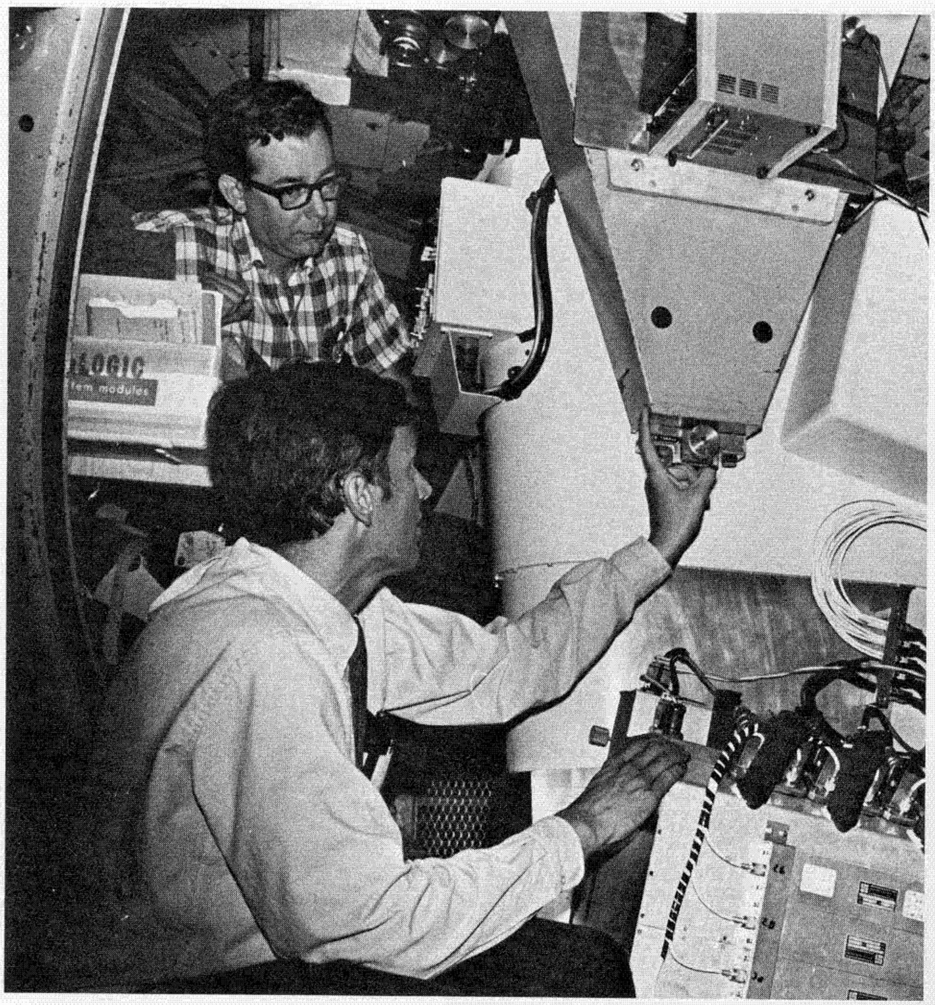
Electronic Revolution at Palomar



The 32-channel spectrometer on the 200-inch Hale telescope at Palomar is one of several new systems for increasing the observational efficiency of the instrument. Edwin Dennison, director of the Astro-Electronics Laboratory, and J. Beverley Oke, professor of astronomy and associate director of the Hale Observatories, make a few adjustments in preparation for the night's observations.

Gone forever are the daring, adventurous—and chilly—nights of observing on Palomar Mountain. No longer will the astronomer don an electrically heated flying suit, climb into the observing cage of the 200-inch Hale telescope 75 feet above the observatory floor, and crouch there all night.

With the aid of an impressive array of modern electronic devices—television, computers, image intensifiers, photomultipliers, and data processors—the astronomer now has complete control of the 500-ton instrument from the warmth of the Palomar Observatory's data room. With his night assistant he can look at a television screen, locate the stellar object he wants to observe, and wait for the automatic instruments to start feeding data to him.

These improvements make life much more comfortable for the astronomer, but the main benefits are in his ability to find cosmic objects more quickly and obtain information in a shorter time. And, with observation time on the 200-inch booked ahead for more than a year, this is a tremendous asset.

Most of this sophisticated new equipment has been designed, installed, and maintained over the last nine years by a group headed by Edwin Dennison, director of the Astro-Electronics Laboratory of the Hale Observatories. The efforts of the group have been concentrated in two areas—extending the observational limits of the telescopes, and improving their operating efficiency.

"The latter would appear to be of lesser importance," says Dennison. "But it is in fact more significant, since the principal gain achieved by telescopes larger than 20 inches in aperture is a gain in operational efficiency; that is, the amount of astronomical information that can be collected per hour. A technique that doubles the number of observations per hour can be viewed as giving the same result as a telescope with twice the collecting area."

This concept is very helpful when the dollar value of a new electronic instrument is being analyzed. A 60-inch telescope costs about $2 million and a 200-inch about $20 million. That means it is worth $2 million to double the effectiveness of the 60-inch or to increase it by 10 percent for the 200-inch. The $150,000 computer system installed on the 200-inch telescope a year ago has more than paid for itself by substantially increasing the operating efficiency.

The system provides a comprehensive, coordinated method of acquiring astronomical data and recording it on magnetic tape, punch cards, and print-outs, while at the same time controlling the telescope automatically. Information about the telescope and the observing instruments is displayed on a desk monitor while the observation takes place, which allows the astronomer to evaluate the data almost as soon as it is collected by the mirror. The observer has more control over the data-collecting process and receives more information about the observations as they are being made. For example, if the astronomer spots something particularly interesting in the raw data being received that demands a change in his plans, he can make alterations immediately. Before, he would have to study the information he collected for months. If he wanted more information, he would have to wait more months before he got a chance to use the telescope again.

The system has proved so useful on the 200-inch telescope that it is now being installed on the 60-inch telescopes at both Palomar and Mt. Wilson. By next spring it will also be installed on the 150-foot solar tower telescope at Mt. Wilson.

Complementing the computer system on the 200-inch is a $50,000 television setup to aid astronomers in sighting on their targets. Observers formerly used "blind offsetting"—locating with respect to the nearest visible bright objects the exact position in the sky of other objects too faint to be seen by the eye. With computer control there was still a certain amount of error, for although the computer system is very accurate—to within 10 seconds of an arc—most stellar objects cover much less than a second of arc.

The television view-finding system reduces this error by letting the astronomer see fainter objects than he would if he just looked through the telescope eyepiece. The television camera looks through the telescope and amplifies the image several hundred times before projecting it on a conventional television screen. A series of still pictures results. This system has the advantage over visual sighting because, like the photographic plate, it can accumulate images from faint objects over a long period of time. And it does not lose its ability to detect small details on dim objects as does the eye.

Through the 200-inch the human eye can see about 18½-magnitude stars. By contrast, as a standard television camera, the view-finding system can see 15th-magnitude stars. With a 6-second time exposure it can see 21st-magnitude stars, which is near the photographic limit of the 200-inch and 2.5 million times fainter than can be seen by the unaided eye without a telescope. So, in many cases, the system permits the astronomer to actually sight on what he wants to record.

Much of this effort to improve operational efficiency would be useless if there were not some means of extending the observational efficiency of the telescope—its ability to collect light. And modern astronomy is greatly concerned with objects at the very edge of the 200-inch telescope's photographic limit.

One new device is the photomultiplier tube, which converts optical signals into electric signals and amplifies them. It is 10 times more sensitive than the traditional photographic plate. However, the photomultiplier has the disadvantage that it can only observe one point on an optical image at any one time. And for observations involving many points, such as spectroscopic analysis, it has been more efficient to use the photographic plate. But, by using several photomultipliers simultaneously, it is possible to gather information on several points at once. One such system is a spectrometer on the 200-inch that has 32 photomultipliers operating together. This, in effect, improves the telescope's observational efficiency 32 times.

For many years astronomers have dreamed of the possibility of an image intensifier with a large number of picture elements, each having the same characteristics as a single photomultiplier tube. Ideally, such a device should have as many picture elements as are contained on a photographic plate—roughly 40 to 50 million. But a system that could handle even 60,000 to a million such picture elements would be suitable for many exciting astronomical problems.

Dennison and his group are working with a new system, an ultra-high-gain television camera, that reaches this lower limit. It collects light from a source and stores it as an electron image on a target. A microscopic beam scans the image, extracts the information, and stores it on a magnetic tape. Such a system will be used on the 200-inch telescope to measure 65,000 picture elements simultaneously.

Desirable as such observational improvements are, they also increase the pressure on Dennison and his co-workers to continue to improve the operational efficiency of the telescope. "It's a vicious circle," he says. "As reaching out to greater distances and detecting fainter objects combine to make telescope observing more complex, the need for simple, manageable observation systems becomes more important."