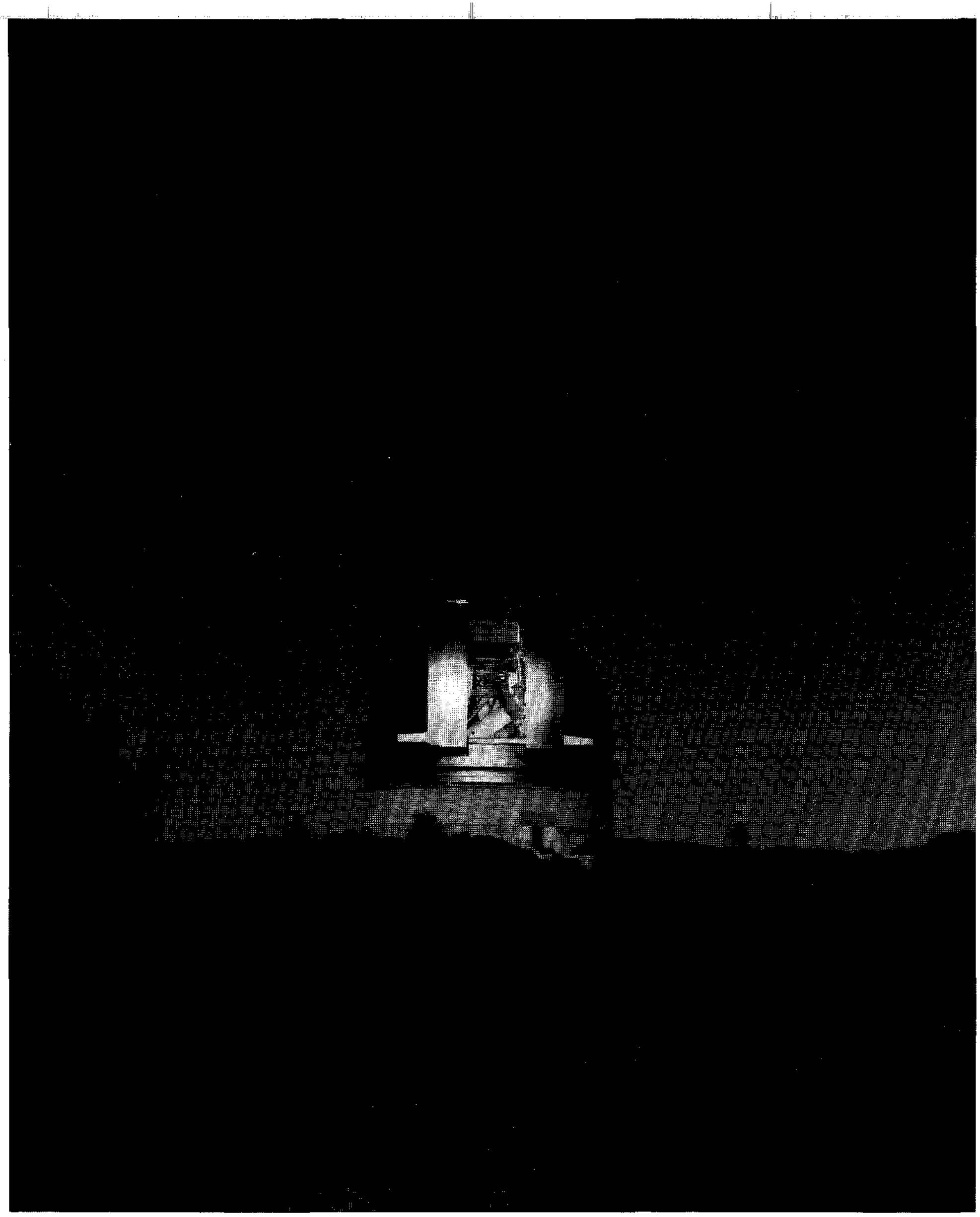

A Giant's Birthday

The Hale Telescope—30 years of distinguished service to science

by Dennis Meredith

This year marks the 30th anniversary of the first use of one of the premier scientific instruments of all time — the giant 200-inch Hale Telescope at Palomar Mountain. Since 1949, at every opportunity, the shutter on the massive dome has opened to the night sky, and the 500-ton telescope has captured and recorded light from stars millions of times fainter than can be seen by the unaided eye. Both technological progress and the brilliant engineering that first went into its construction have kept the instrument one of the most important in astronomy.

Astronomers using the Hale Telescope have contributed enormously to the understanding of the universe, and a

1948: Dedication of the 200-inch Hale Telescope, June 3. Actual use began in the winter of 1949.

complete listing of the advances due to the instrument would be voluminous. Such studies, which could only have been done with the 200-inch telescope, include:

- The determination to great distances of the Hubble constant, which is the measure of the rate at which the universe is expanding,
- Studies of the rate at which that expansion is slowing,
- Studies of star clusters, which made possible an understanding of how stars evolve, and
- Discovery of quasars and the first determinations of their redshift.

"We have found that those parts of the instrument that one is bound to — the basic structure of the telescope — are really superb," says Maarten Schmidt, director of the Hale Observatories, which is run by Caltech jointly with the Carnegie Institution of Washington. Schmidt is the astronomer responsible for the discovery of the large redshift in the light from quasars, which indicated that they are the most distant objects in the universe. "The 200-inch is as good as telescopes that were built only recently," he says.

A visit to Palomar Mountain reveals how lightly three decades of almost constant use have touched the telescope. The massive gears that allow the giant to track the slow movement of the stars across the sky each night are as unmarred as the day they were installed, and spare gears still hang on the wall where they were placed decades ago. The 1,000-ton dome rotates with a silky smoothness, emitting only a faint hiss and a delicate rumble as it moves.

"The instrument is in excellent shape," says Gary Tuton, superintendent of the five telescopes on Palomar Mountain, which also include 18-, 20-, 48-, and 60-inch telescopes used in various research modes. "The amount of downtime for this mass of equipment is quite minimal, and can only be attributed to the genius of the designers."

Maintenance of the big telescope includes washing the mirror with distilled water and then drying it with soft

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1910: Andrew Carnegie and George Ellery Hale in front of the 60-inch dome on Mt. Wilson.

towels four times a year, and realuminizing the mirror about once every three years.

The battleship-gray telescope looks every bit the modern, efficient scientific device, but there are touches here and there in the dome that remind one of old-time craftsmanship. Doors in the observatory are made of richly polished black walnut, and the electrical power system consists of massive wiring linked solidly to heavy, old-fashioned terminals.

''That electrical system hasn't given us a moment of worry since the day it was built,'' says Tuton, who was a night assistant at Palomar for 17 years before becoming superintendent.

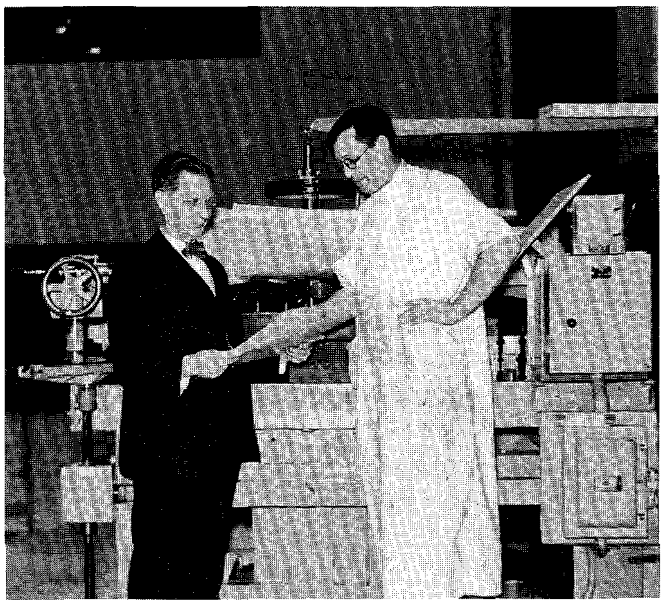
The history of the design and construction of the 200-inch telescope features a plot worthy of an epic thriller — and with characters just as colorful.

The central figure was, of course, George Ellery Hale, the prominent scientist and masterful fundraiser who, despite a chronic and debilitating illness, launched the 200-inch telescope project and saw it safely on its way. He first issued the challenge of building an enormous astronomical instrument in 1928 in an article in *Harper's* magazine:

''Like buried treasure, the outposts of the Universe have beckoned to the adventurous from immemorial times. Princes and potentates, political or industrial, equally with men of science have felt the lure of the uncharted seas of space. If the cost of gathering celestial treasures exceeds that of searching for the buried chests of a Morgan or a Flint, the expectation of rich return is surely greater.

''Starlight is falling on every square mile of the earth's surface, and the best we can do is to gather up and concentrate the rays that strike an area 100 inches in diameter,'' he wrote, proposing a telescope twice the diameter of the Mount Wilson telescope, the giant of that period.

Hale persuaded officials of the Rockefeller Foundation to fund the telescope, and the adventure was on. A fascinating group of scientists, engineers, and technicians participated in the great project, which was that era's version of a major space shot. There was, for example, Francis Pease, the engineer and astronomer who dreamed along with Hale of a gigantic telescope; and there was John A. Anderson, physicist and executive officer who supervised the project from 1930 to World War II. There was also the gifted artist Russell W. Porter, the taciturn New Eng-



1934: Under the supervision of John A. Anderson (left), Marcus H. Brown saw to the grinding of the 200-inch mirror.

lander, brilliant inventor, architect, and Arctic explorer who once made a telescope out of an obsolete automobile.

There was Marcus H. Brown, who had worked his way from chicken farmer and truck driver to become one of the most obsessively perfectionist opticians in the world. As chief optician, under Anderson's supervision, he saw to the grinding of the 200-inch mirror. There was Sinclair Smith, the astronomer and engineer who, while dying of cancer, designed the precise control system for the telescope. After Smith's death, the control system was perfected by Ed Poitras.

The construction of the telescope, which one science magazine described later as "a kind of overachievement for its time, an astronomical tour de force," was fraught with adventure and peril. The huge mirror was to be made from Pyrex, after experiments with fused quartz failed. The blank was successfully poured on the second try, after the first attempt failed when weight-reducing cores broke loose and bobbed to the surface of the molten glass. After its pouring, the disk was menaced, not once but twice, by rising floodwaters of the Chemung River, which ran beside the Corning Glass Works in Pennsylvania where it was formed. At one point, workmen pulled the disk clear only hours before the river inundated the spot where it had rested.

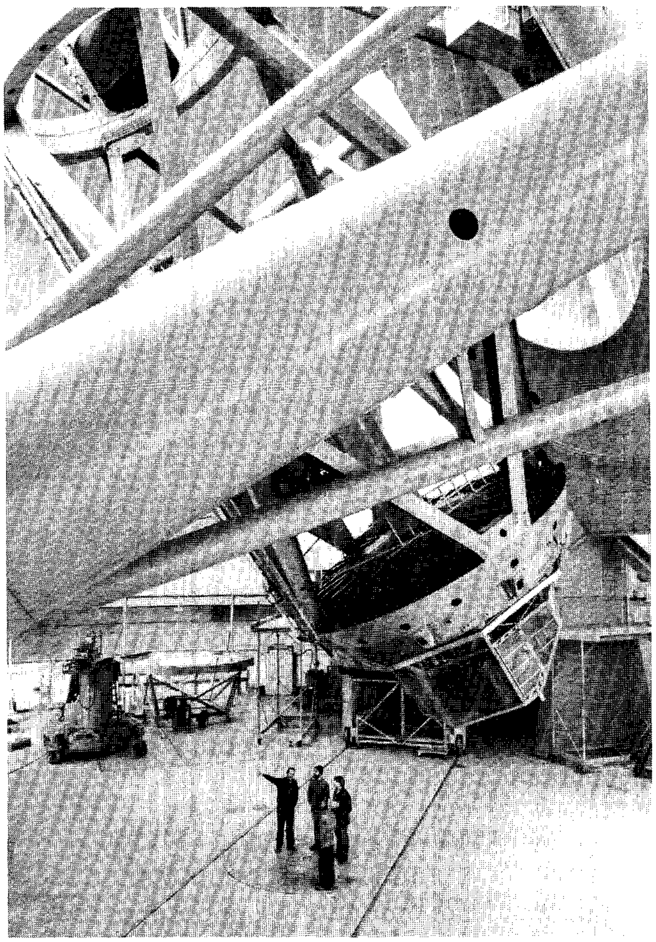
Once safely in the workshop at Caltech in Pasadena, the disk was ground by a team of technicians who, over four years, removed 5¼ tons of glass from the 20-ton blank, bit by laborious bit.

The construction of the telescope was also a harrowing ordeal, with each huge piece of structural steel having to be hauled up the side of Palomar Mountain.

Many new engineering concepts had to be developed for the telescope. The oil-film bearing, in which the weight of the telescope rode on a thin film of oil pumped between the sliding surfaces, was one such innovation. Another was the Serrurier truss, a structural concept that insured that, as the telescope swung, the optical axis remained in alignment, despite unavoidable sag in the structure. These and other features have been adapted for practically all more recent telescopes.

Active construction began at Palomar in 1935, was interrupted by World War II in 1941, and continued upon the end of hostilities to completion in 1948. The first pictures were taken throughout the winter of 1949. Unfortunately Hale, Pease, and Smith died in 1938, more than a decade before completion of the telescope, and never lived to see their dream realized.

Besides its immense scientific contributions, the 200-inch Hale Telescope has served over the years as an inspiration for later telescopes. "I believe the fact that one could build a successful 200-inch telescope made it possible for other groups to plan large telescopes without hesitation," says Maarten Schmidt.

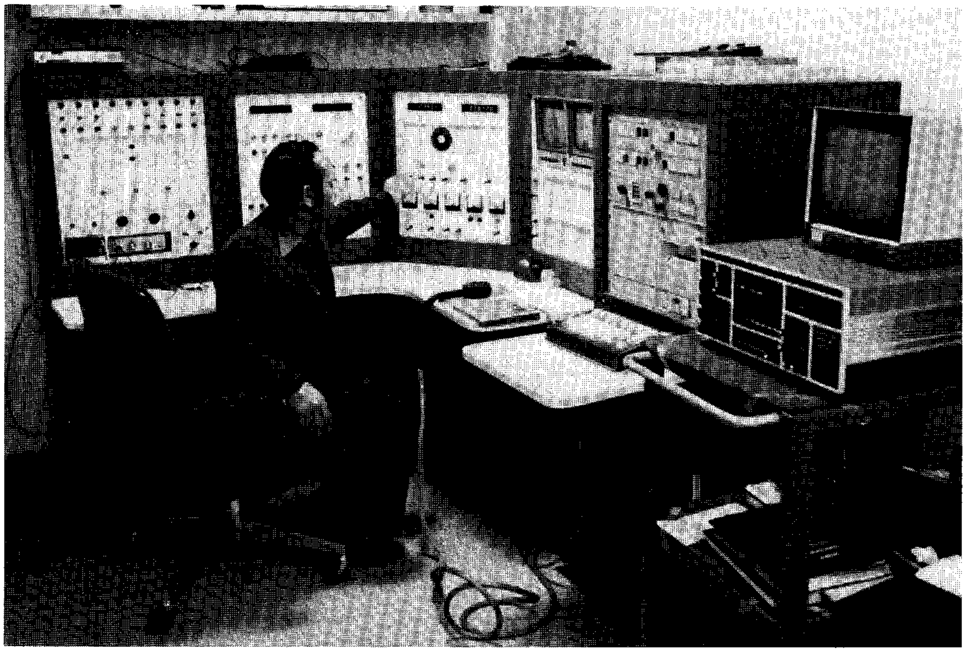


1979: The 200-inch telescope today.

The 200-inch has even produced nationalistic envy — as evidenced by the Soviet 234-inch telescope. "This telescope, which has not proved to be a particularly successful scientific instrument, was exclusively a matter of national pride," Schmidt says. "The Soviets use the metric system, and one cannot help but notice that their 234-inch (or six-meter) telescope is precisely one meter larger than our 200-inch (that is, approximately five-meter) Hale Telescope."

The 200-inch telescope's place in astronomy today is as solid as its construction, one reason being its continuing modernization. When the telescope was built, photographic plates were the predominant data-recording method. Photographic plates can record enormous amounts

Palomar Superintendent Gary Tuton adjusts the controls of the Hale Telescope. These are not the original controls but updated ones that were installed in 1976.



of data, but they have their drawbacks. Hundreds of photons of light are required to activate a single grain on a photographic plate, so that, for very faint objects, exposure times can range up to several nights. However, even if long exposures can be accomplished, photographic plates are nonlinear in their response; twice the exposure does not result in twice the number of grains being activated. Also, the plates become saturated after too long an exposure.

Since the mid-1960s, scientists at Hale Observatories and Caltech have applied numerous sophisticated electronic devices to overcome those limitations. Electronic detectors can record far more sensitively, so that objects which formerly required hours of exposure, now require only minutes. Whereas photographic plates are only about 2 percent efficient in terms of the translation of photons of light into a signal, most current electronic detectors can reach about 25 percent efficiency, and increases to 80 percent have been achieved with new imaging systems based on charge-coupled devices.

Such electronic devices can perform some neat tricks to make an astronomer's life far easier. For example, the electronic target-acquisition system now installed on the telescope allows it to be accurately pointed at objects too faint to be seen by the human eye even through the 200-inch. Light from such an object is collected over a long period, and the integrated signal is displayed to allow the telescope to be centered on the object. Another photoelectric system allows the airglow from the night sky to be subtracted from observations, and still other detectors make possible sophisticated observations at infrared wavelengths.

Another factor in the continuing success of the 200-inch telescope is the management philosophy that allows its use in long-term studies. "Members of the Hale Observatories staff have little hesitation about embarking on projects that will last many years, because they can be assured of observing time to carry them out," says Schmidt. "The national observatories have similar large telescopes, but their style is one of allowing only short observing runs, say a few nights, which does not permit astronomers to address any problems very deeply."

Even with the enormous advances in astronomy over the last three decades, Hale Observatories astronomers expect the Hale Telescope to continue as an important scientific instrument.

"Astronomy is data-limited," says Schmidt, "which means that if you doubled the number of telescopes of 100 inches or so, I think the output of astronomy would almost double, because there is so much to be asked of the universe."

Technology will no doubt continue to advance the science of astronomy, but the giant telescope at Palomar will remain a preeminent scientific instrument. And perhaps just as importantly, it will continue as a reminder of what daring scientist-entrepreneurs like George Ellery Hale and his team of gifted colleagues can do for science. □