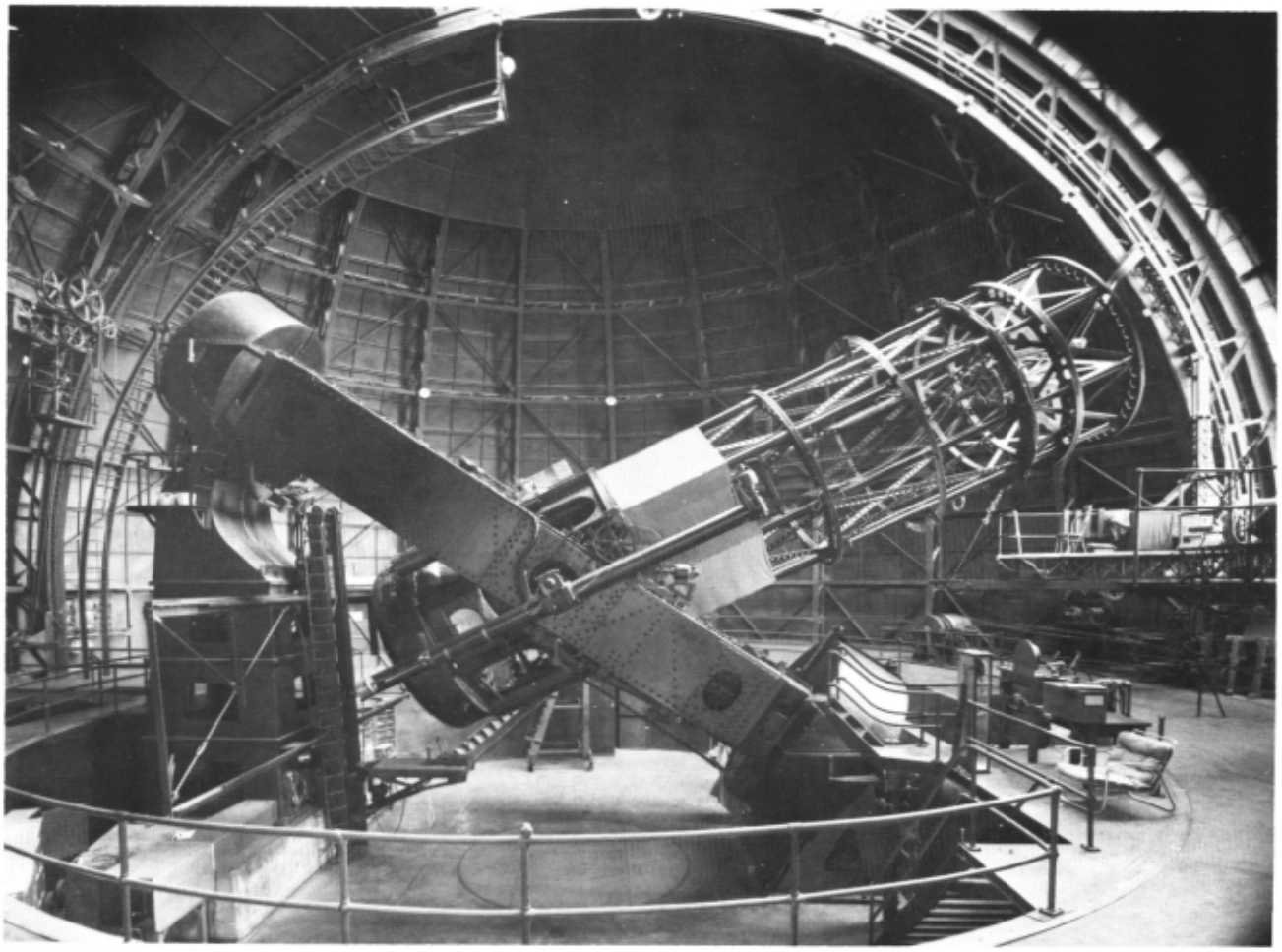


The 100-Inch Telescope of the Mount Wilson Observatory

An International Historical Mechanical Engineering Landmark

The American Society of Mechanical Engineers • June 20, 1981

Mount Wilson Observatory
Mount Wilson, California

The completed facility.

BACKGROUND

THE MOUNT WILSON OBSERVATORY was founded in 1904 by the CARNEGIE INSTITUTION OF WASHINGTON, a private foundation for scientific research supported largely from endowments provided by Andrew Carnegie.

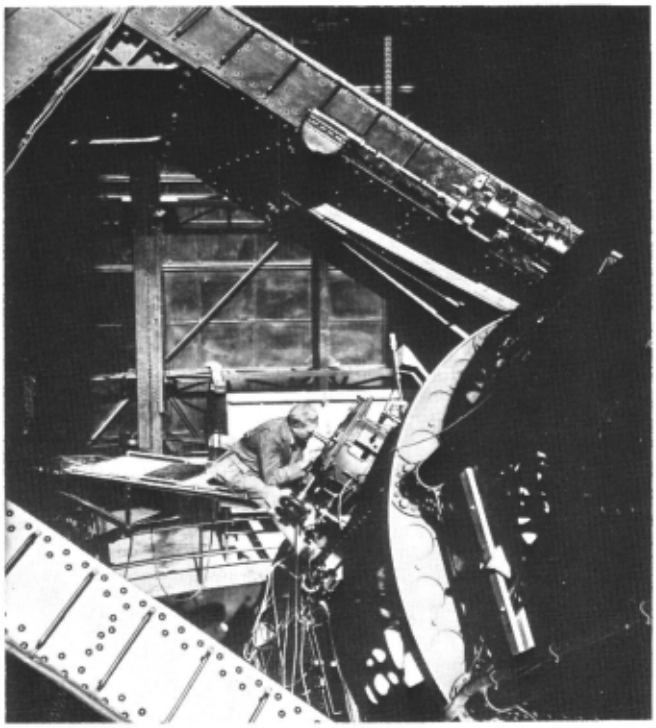
Within a few years, the Observatory became the world center of research in the new science of astrophysics, which is the application of principles of physics to astronomical objects beyond the earth. These include the sun, the planets of our solar system, the stars in our galaxy, and the system of galaxies that reaches to the limits of the visible universe.

SCIENTIFIC ACHIEVEMENTS

The Mount Wilson 100-inch reflector dominated discoveries in astronomy from its beginning in 1918 until the dedication of the Palomar 200-inch reflector in 1948. (Both telescopes are primarily the result of the lifework of one man — George Ellery Hale.) Many of the foundations of modern astrophysics were set down by work with this telescope.

One of the most important results was the discovery that the intrinsic luminosities (total light output) of the stars could be found by inspection of the record made when starlight is dispersed into a spectrum by a prism or a grating. These so-called spectroscopic absolute luminosities, discovered at Mount Wilson and developed for over forty years, opened the way to an understanding of the evolution of the stars and eventually to their ages.

Perhaps the most important scientific discovery of the 20th century is that we live in an expanding Universe. The observed velocities of galaxies increase progressively with ever-increasing distances. It was this finding, made in 1930 with the Hooker reflector, together with the earlier discovery in 1924, also made with the Hooker reflector, that galaxies are stellar systems, that solved the most basic question of cosmology — namely, what is the nature of the large scale structure of the Universe.



Francis G. Pease at the Cassegrain focus of the 100-inch telescope.

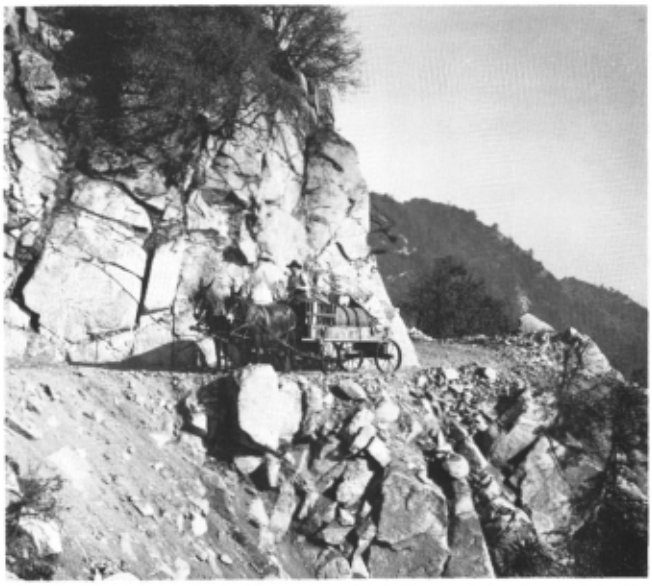
1910 – 1918. DESIGN AND CONSTRUCTION OF THE MOUNT WILSON 100-INCH HOOKER TELESCOPE

In 1902, George Ellery Hale, builder and first director of the University of Chicago's Yerkes Observatory, proposed and persuaded the Institution that an observatory be started in the California wilderness above Pasadena to study the sun and stars from a mountain site. Soon after, Hale assembled the nucleus of a group of astronomers, engineers, and technicians who designed and constructed the Mount Wilson telescopes to new standards of excellence and performance. The first facilities to be built were the 60-foot and 150-foot solar towers and the 60-inch reflector.

Hale began planning the 100-inch telescope project as early as 1906. In that year a gift of $45,000 from Mr. John Hooker of Los Angeles permitted placing the order for the 4½-ton glass disk for the mirror with the Plate Glass Company of St. Gobain in France. After initial failures a successful casting produced the largest glass blank then in existence. The disk was received in Pasadena in 1908.

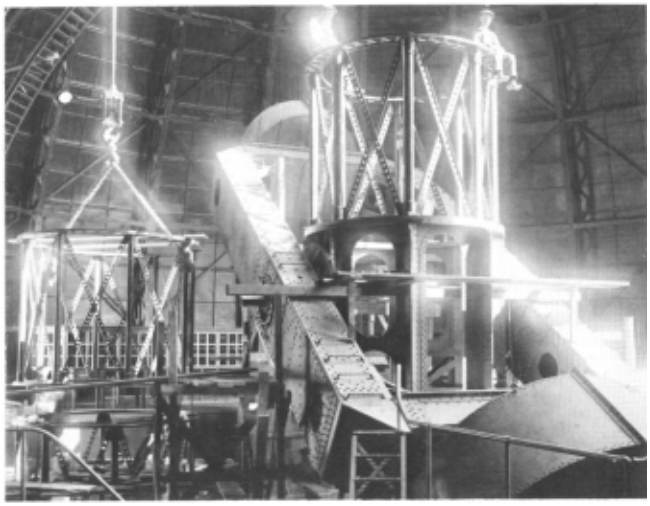
Design and construction of the 100-inch telescope took place during the years 1910-1918. Francis G. Pease (see photo) was the chief designer and a trained mechanical engineer. He was responsible for mechanical engineering, design calculations, material selection, and performance specifications of the 100-inch telescope. Major engineering problems had to be solved. One was that of supporting the massive mirror with no final stress that would distort its surface in all positions of gravity loading, as the telescope moves to follow the stars. Another was the compensation for flexure of the tube that carries the secondary mirrors and photographic equipment so that the axis of the optical train remains nearly stationary relative to the tube. As the structure is very large, these problems of support were of great concern. While the massive and intricate support and mounting mechanisms were being designed, the mirror itself was being ground to a precise figure in the Observatory's optical shop, under the direction of G.W. Ritchey. The new techniques of optical engineering invented here were later used in all other telescopes built after 1920.

The larger and heavier parts of the telescope were constructed at the Fore River Shipyards in Quincy, MA, where Professor Peter Schwamb of M.I.T. was resident representative of the Observatory. The dome was designed by D. H. Burnham & Co. of Chicago; it was erected by the Morava Construction Co.



The road over which the telescope and dome structures were hauled to Mount Wilson.

Transport of the telescope and dome structures from Pasadena to the mountaintop was itself a challenge. The 9-mile road previously carved out of the rugged slopes of the San Gabriel mountains had to be widened. A special truck was constructed; in the end, mules had to help.



Assembly of the telescope in its dome.

NOTEWORTHY DESIGN FEATURES

Among the noteworthy features is the use of *mercury flotation* for reduction of friction. (This was earlier used for the first time on the Mount Wilson 60-inch telescope.) The polar axle of the telescope, on which the 87-ton instrument must turn smoothly to counteract the rotation of the earth, is defined by self-aligning journal bearings, but the bulk of the load is carried by two steel drums that float in mercury. The resulting friction is so low that the whole telescope may be rotated by the force exerted by one hand at the end of the main tube.

To rotate the telescope at the sidereal rate, a large worm gear, 18 feet in diameter, is mounted on the south end of the polar axle. The gear, of cast iron with hollow spokes, was made in two halves, bolted together along a diameter. It meshes with a tool-steel worm that is rotated by a mechanical driving clock at one turn per minute. Because tracking errors greater than one-tenth arc-second cannot be tolerated, great precision was required in cutting the teeth of the large worm gear. This operation was done by the Italian instrument maker, C. Jacomini, with the gear in place on the telescope. Using a microscope and a diamond scriber, he first divided the gear into 1440 equal segments, one for each tooth, scribing the marks on an inserted brass ring near the edge of the gear. Later he gashed the teeth individually. The gear and worm were "run in" with rouge and oil. The worm is driven by a governor-controlled, weight-driven mechanical clock that was constructed in the Observatory's shop.

The *rotating dome* placed over the telescope (which weighs 500 tons) was also of innovative design in its mechanical structure and electric control. The dome, supported by railroad trucks on a precision-ground double, circular railroad track, must rotate smoothly to keep the open dome slit in the telescope's direction. The mechanism, under control of the astronomer, must respond quickly to his command no matter at which of the possible observing stations he may be working.

Grinding the rails for the moving dome.

Gashing of one of the 1440 teeth in the 18-foot diameter gear.

PLAQUE WORDING

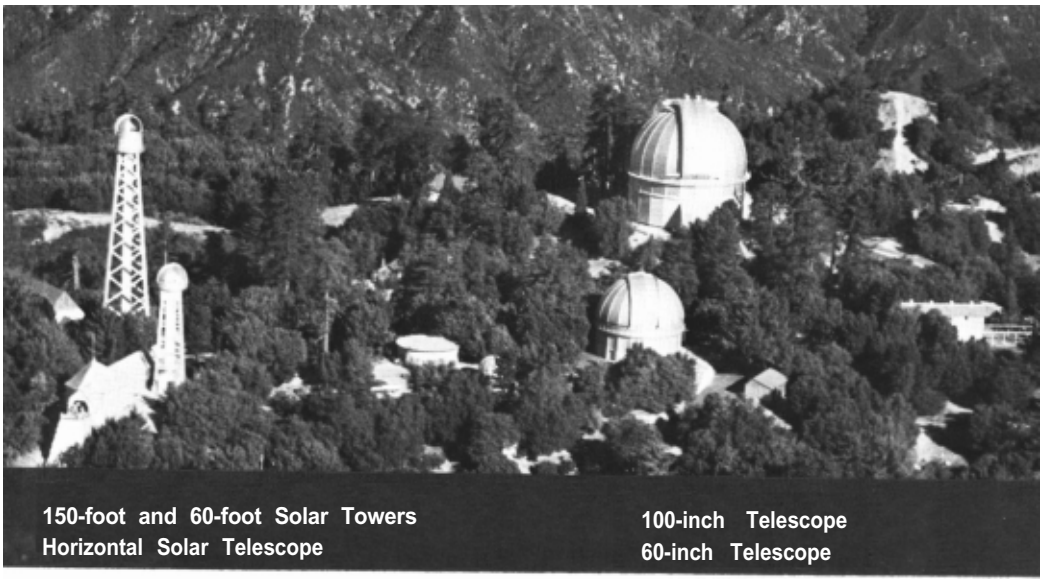
INTERNATIONAL HISTORIC MECHANICAL ENGINEERING LANDMARK
The Mount Wilson 100-inch Telescope — 1918

The increased light-grasp of this telescope made possible many notable advances in structural cosmology between 1924 and 1930. They have revised our ideas about the universe in which we live.

One of these advances was that the spiral nebulae are galactic units like our own; another was the idea of an expanding universe.

The telescope's mirror support and the use of mercury flotation to reduce the friction are among its outstanding engineering features.

The American Society of Mechanical Engineers — 1981

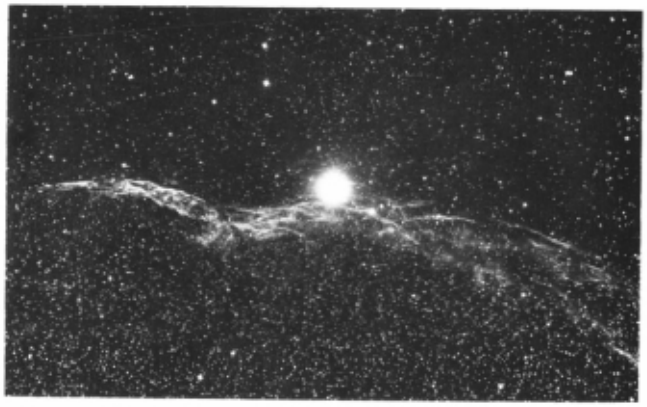


Aerial view of the Mount Wilson Observatory

AN ACCOLADE

The Mount Wilson 100-inch reflector telescope is an engineering marvel whose role in the development of astronomy is unique among scientific instruments. Its past achievements are legend, and, given its age, it is even more remarkable that it is still in regular nighttime operation, serving still another generation of staff and guest observers.

1918-1981, 63 years of
constant service



The western loop of Veil Nebula in Cygnus (taken with the 100-inch telescope).

ACKNOWLEDGEMENTS

The Los Angeles Section of the American Society of Mechanical Engineers acknowledges the efforts of those members who organized the landmark dedication program. The Los Angeles Section also recognizes the efforts and cooperation of the Carnegie Institution of Washington and the Mount Wilson Observatory.

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NATIONAL HISTORIC MECHANICAL ENGINEERING LANDMARK PROGRAM

In September 1971, the ASME Council reactivated the Society's History and Heritage program with the formation of a National History and Heritage Committee. The overall objective of the committee is to promote a general awareness of our technical heritage among both engineers and the general public. A charge given the committee is to gather data on all works and artifacts with a mechanical engineering connection which are historically significant to the profession — an ambitious goal, and one achieved largely through the volunteer efforts of the Sections and Divisions History and Heritage Committees and interested ASME members.

Accordingly, two major programs are carried out by the Sections and Divisions under the direction of the National Committee: 1) a listing of industrial operations and related mechanical engineering artifacts in local Historic Engineering Records; and 2) a National Historic Mechanical Engineering Landmark program. The former is a record of detailed studies of sites in each local area; the latter is a demarcation of local sites which are of national significance — people or events which have contributed to the general development of civilization.

In addition, the Society cooperates with the Smithsonian Institution in a joint project which provides contributions of historical material to the National Museum of History and Technology in Washington, D.C. The Institution's permanent exhibition of mechanical engineering memorabilia is under the direction of a curator, who also serves as an ex-officio member of the ASME National History and Heritage Committee.

The Mount Wilson 100-inch Telescope is the fifty-ninth landmark and fourth international landmark to be designated since the program began in 1973.

For a complete list of the Society's landmarks, please contact the Public Information Department, ASME Headquarters, 345 E. 47th Street, New York, N.Y. 10017 212/644-7740.

The Mount Wilson Observatory is located in the mountains northeast of Pasadena, CA. Offices, shops, laboratories, and research facilities are at 813 Santa Barbara St., Pasadena, CA 91101, 213/577-1122. The observatory is one of five research departments operated by the CARNEGIE INSTITUTION OF WASHINGTON.

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