George Ellery Hale and the Mount Wilson Observatory

Dr. Peter R. Young
NASA Goddard Space Flight Center

"…one of the most eminent men of science this country ever produced."
- New York Times obituary, 1938

Timeline

1865: US Civil War ends.

1868: Hale born in Chicago.

1897: Director of Yerkes Observatory.

1904: Mount Wilson Observatory founded; Hale the first Director.

1908: Hale measures magnetic field in sunspot.

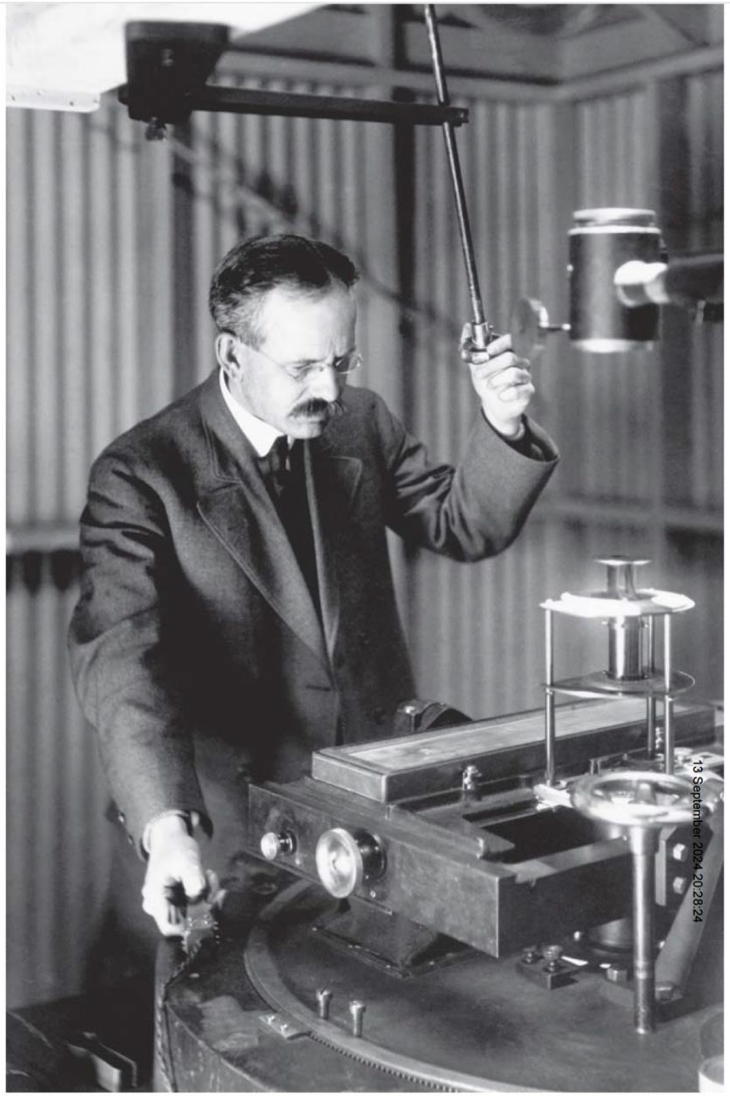
1914: First World War begins.

1917: Mt. Wilson 100in telescope completed.

1928: Advocates for 200in telescope.

1938: Hale dies.

1948: The 200in Hale telescope (Mt. Palomar) is dedicated.



The New Astronomy: Astrophysics

1814: Fraunhofer makes the first spectroscope grating and finds absorption lines in the solar spectrum.

1859: Kirchoff & Bunsen lab experiments lead to identification of some of the Fraunhofer lines.

1863: Secchi obtains first spectra of stars other than the Sun.

1868: Huggins makes first radial velocity measurements of a star through Doppler shifts.

1868: Lockyer names helium for unidentified Fraunhofer line seen in eclipse spectra.

1882: The 13-year-old Hale builds his first spectroscope.

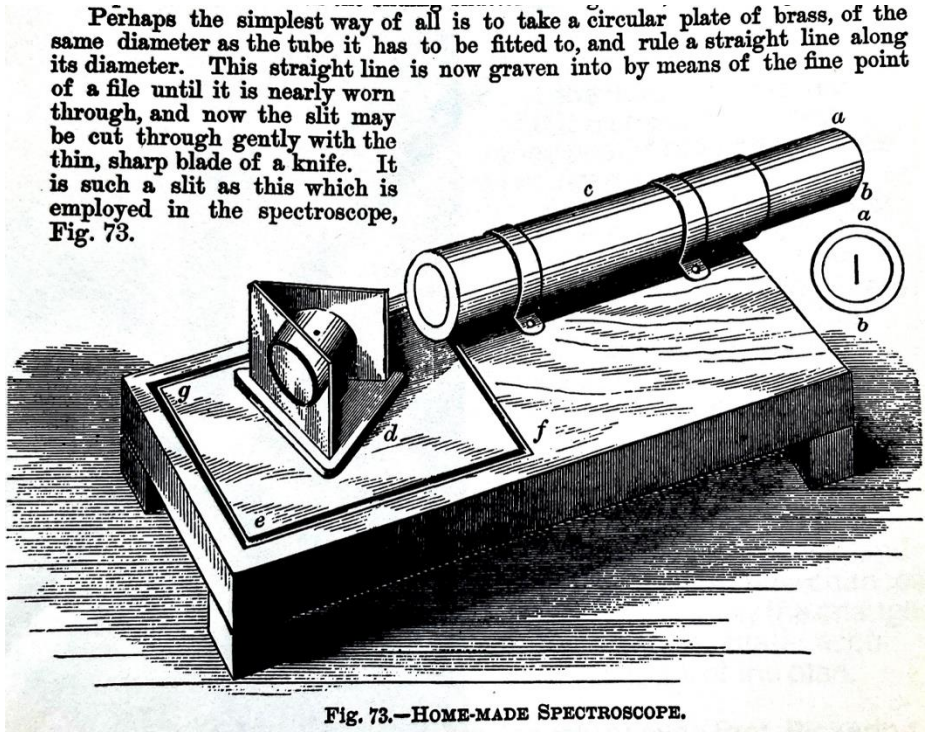
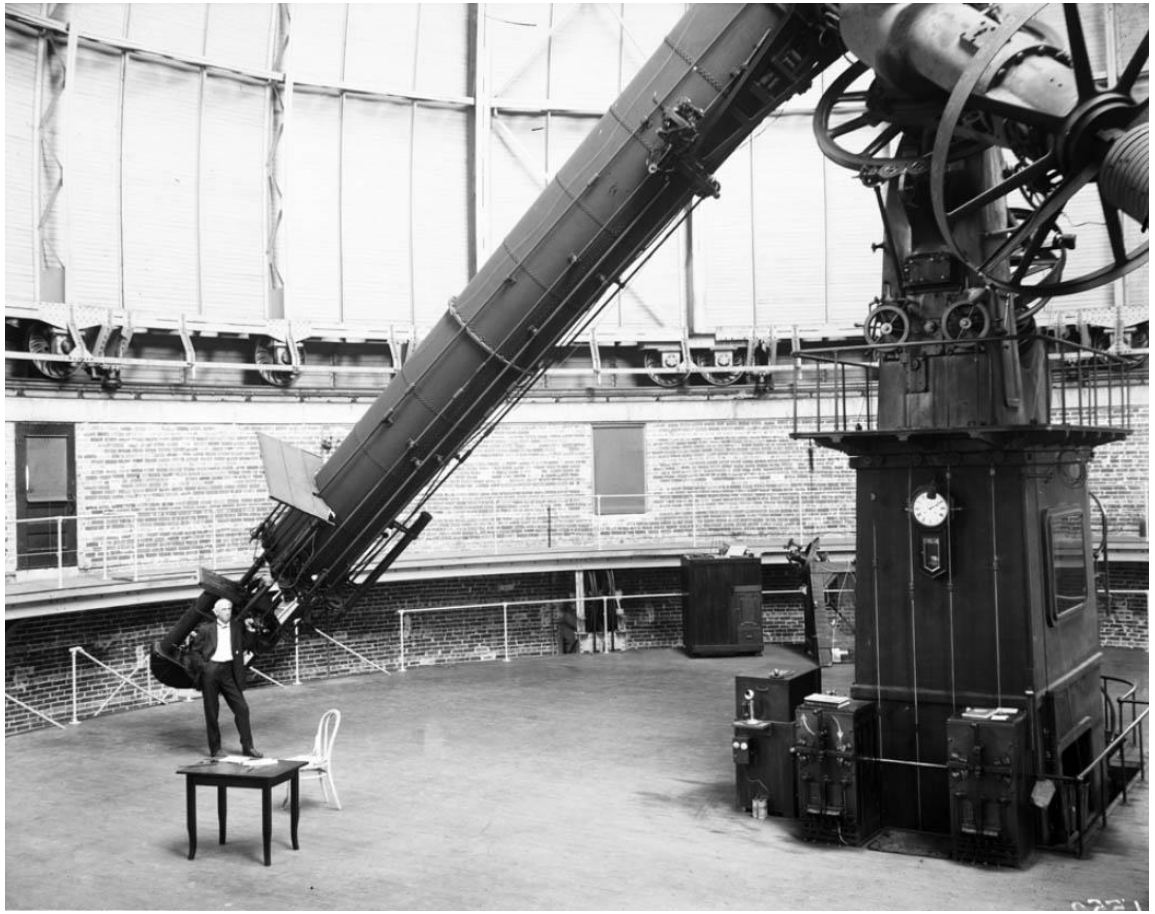

Perhaps the simplest way of all is to take a circular plate of brass, of the same diameter as the tube it has to be fitted to, and rule a straight line along its diameter. This straight line is now graven into by means of the fine point of a file until it is nearly worn through, and now the slit may be cut through gently with the thin, sharp blade of a knife. It is such a slit as this which is employed in the spectroscope, Fig. 73.

Fig. 73.—Home-made Spectroscope.

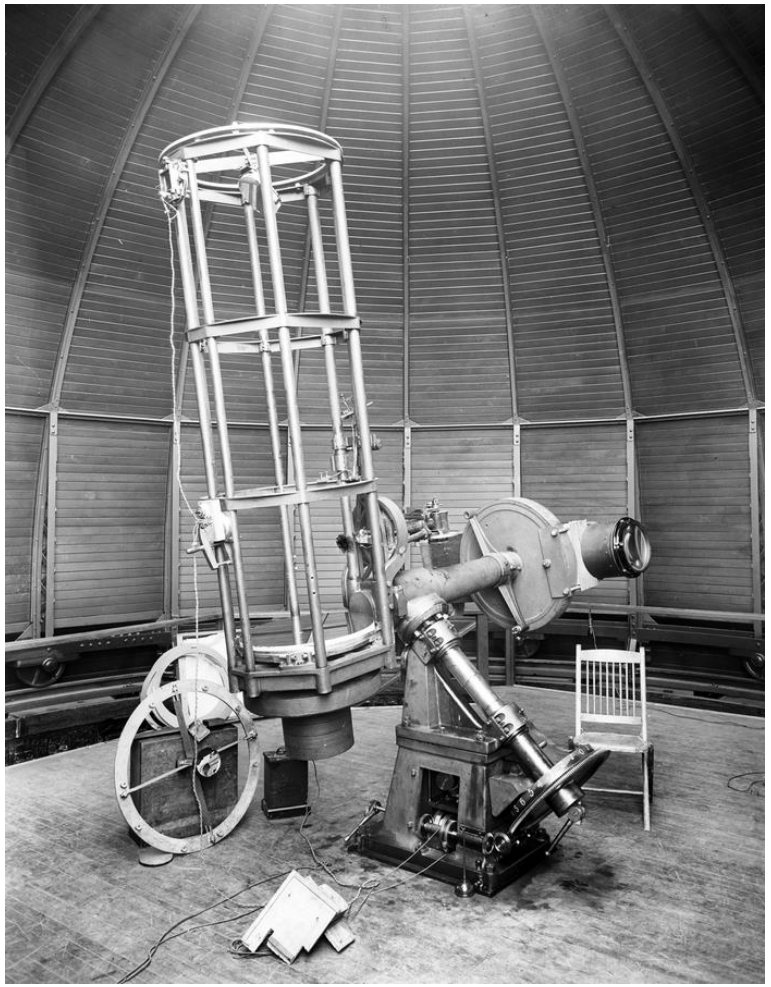
A Moment in Time: 25 June 1903

- Hale visits Mount Wilson for the first time.
- He is 34 years old.
- He is a member of the National Academy of Science.
- He is a professor at the University of Chicago.
- He is the director and founder of Yerkes Observatory (Wisconsin).

A New Telescope

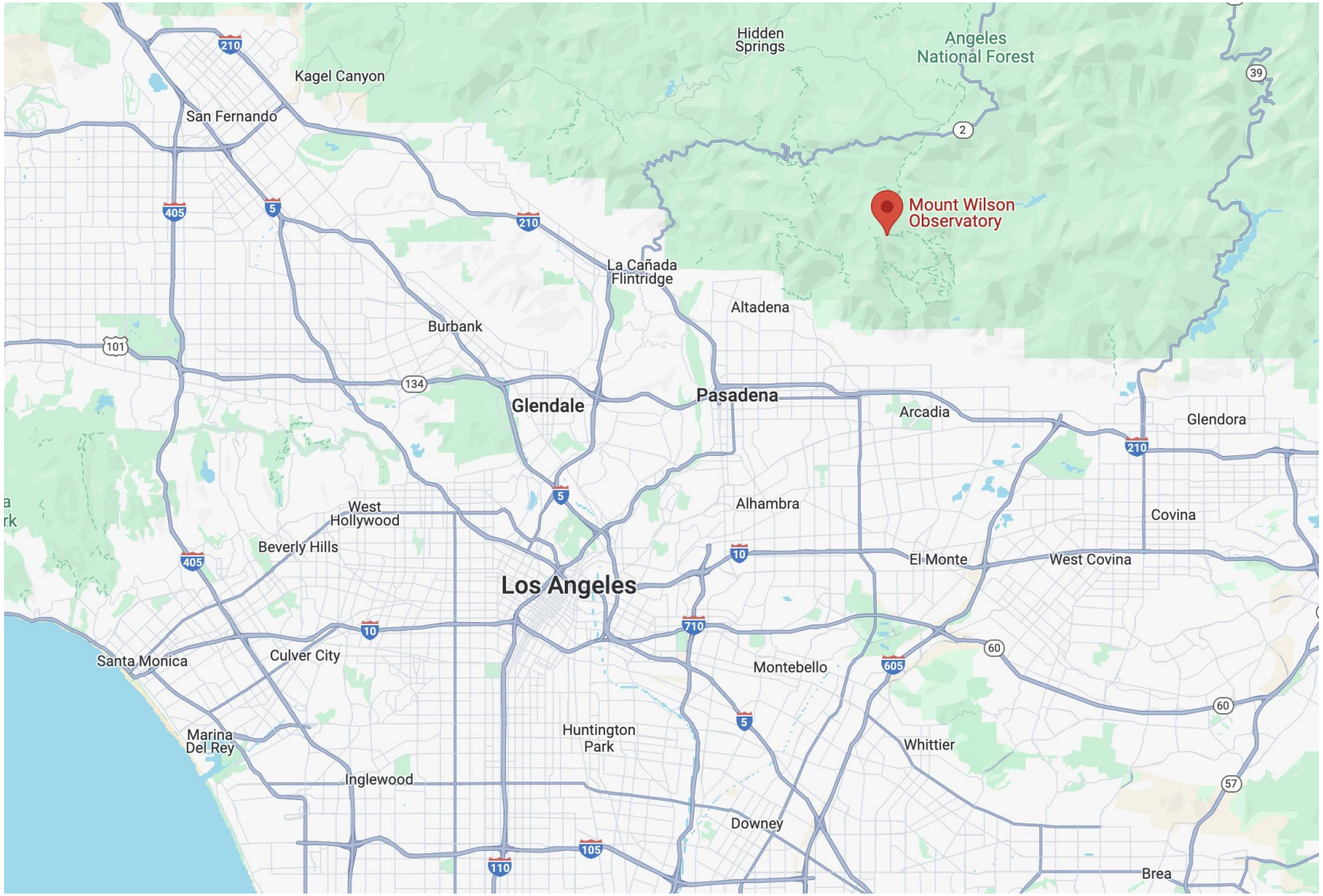


Yerkes 40” refracting telescope



Yerkes 24” reflecting telescope

Location of Mt. Wilson Observatory

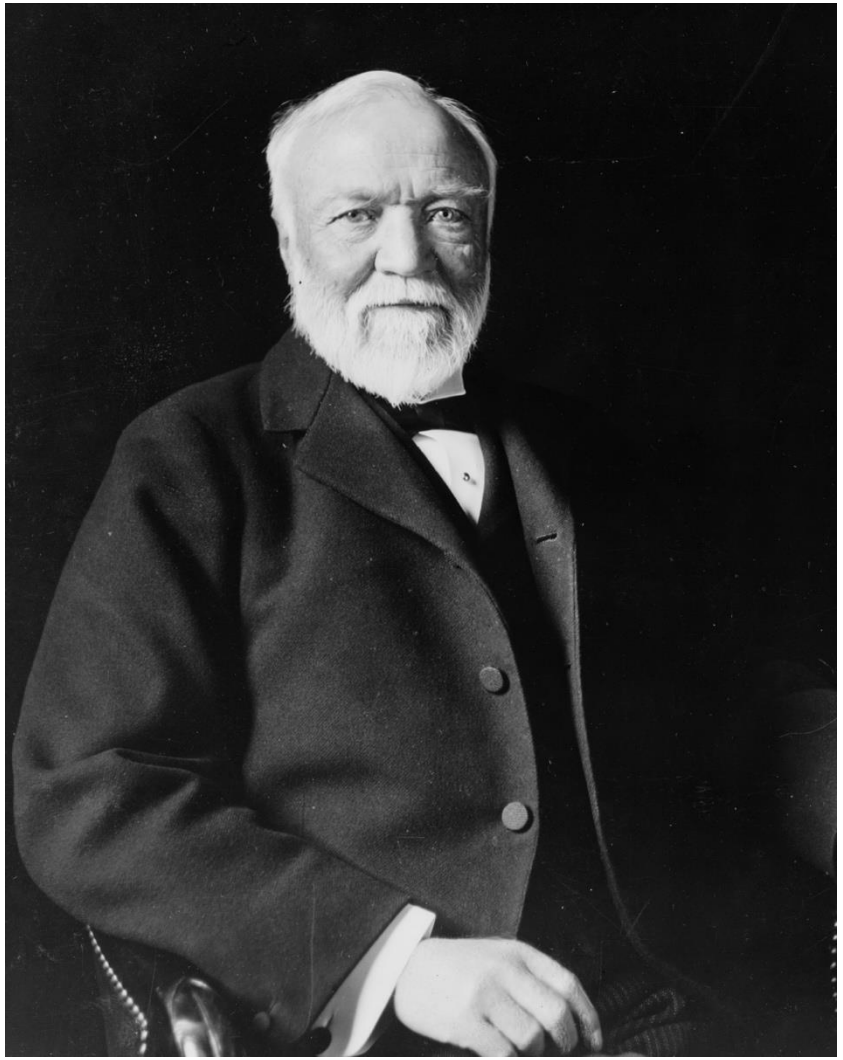


Populations (1900)

Pasadena: 9000

Los Angeles City: 100,000

Andrew Carnegie (1835-1919)



Scottish-American industrialist (mainly steel)

Set up Carnegie Institution in 1902
Provided $300,000 for Mt. Wilson Observatory in Dec. 1904

Pioneers

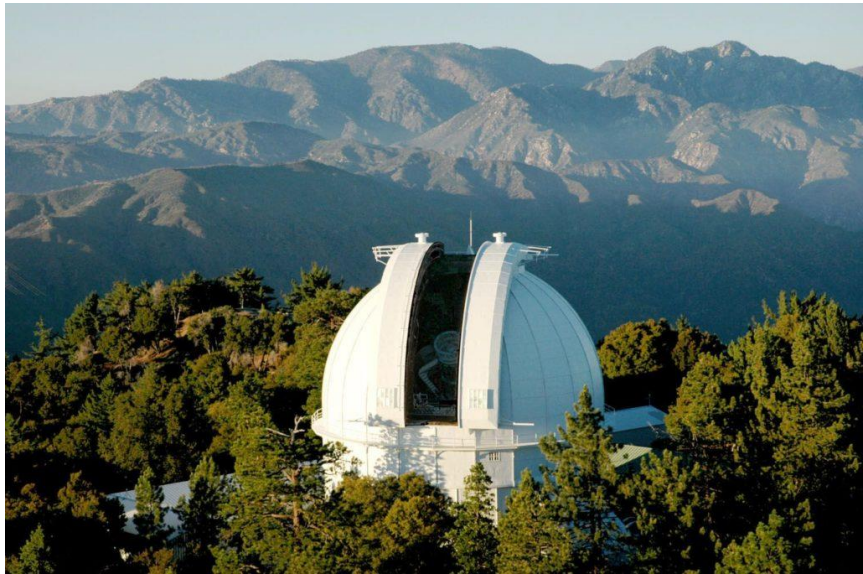
"*Hale was never so happy as when, like a boy on vacation, he could pack a knapsack and start on the eight-mile climb over the old trail to the summit*." Walter Adams

The Astronomical Telescopes on Mt. Wilson

1. The 60-inch telescope (1908)
2. The 100-inch Hooker telescope (1917)

Achievements

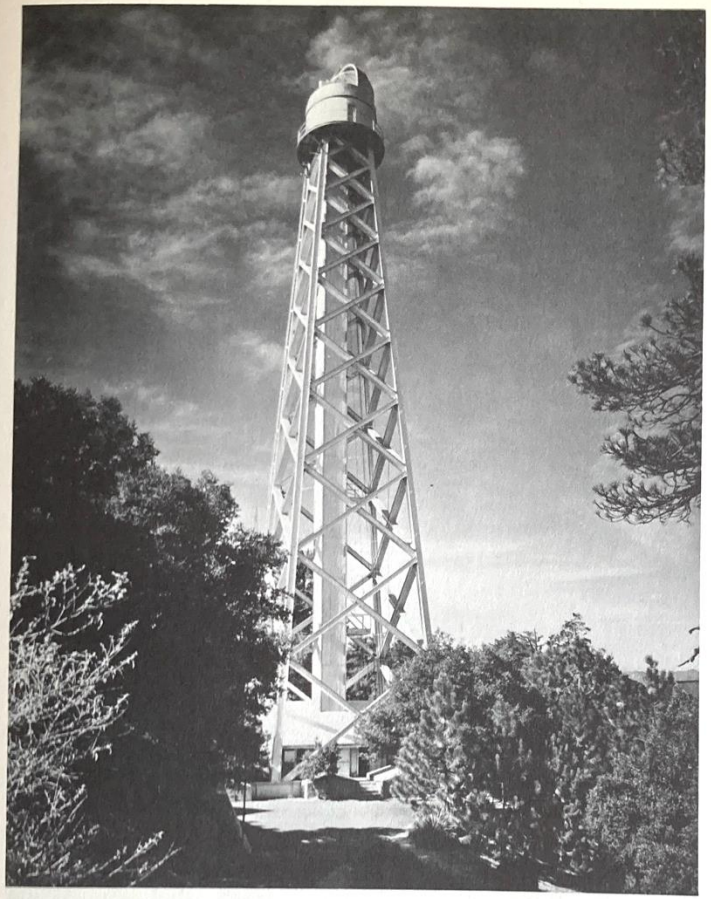
- Diameter of Betelgeuse (0.047’’) through interferometry (Michelson).
- Distance to globular clusters (Shapley).
- Distance to Andromeda Galaxy (Hubble).
- Expansion of the universe (Hubble).



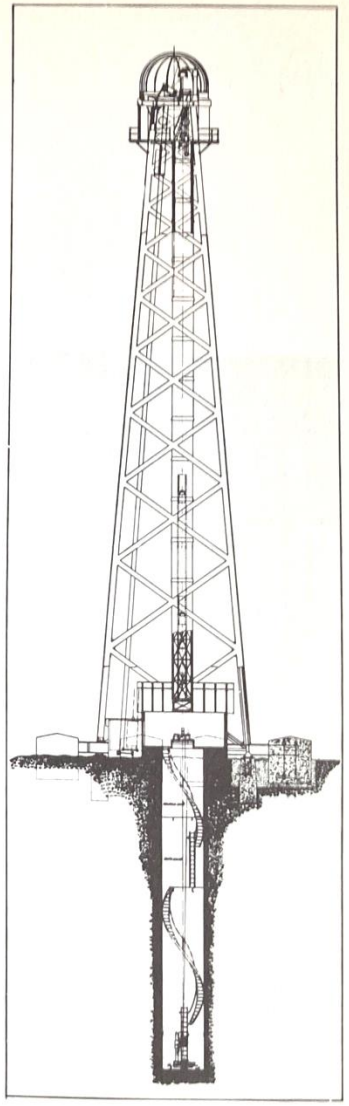
The Mt. Wilson Solar Telescopes

1. The Snow horizontal telescope (1904)
2. The 60 ft tower telescope (1908)
3. The 150 ft tower telescope (1912)

The Snow horizontal telescope

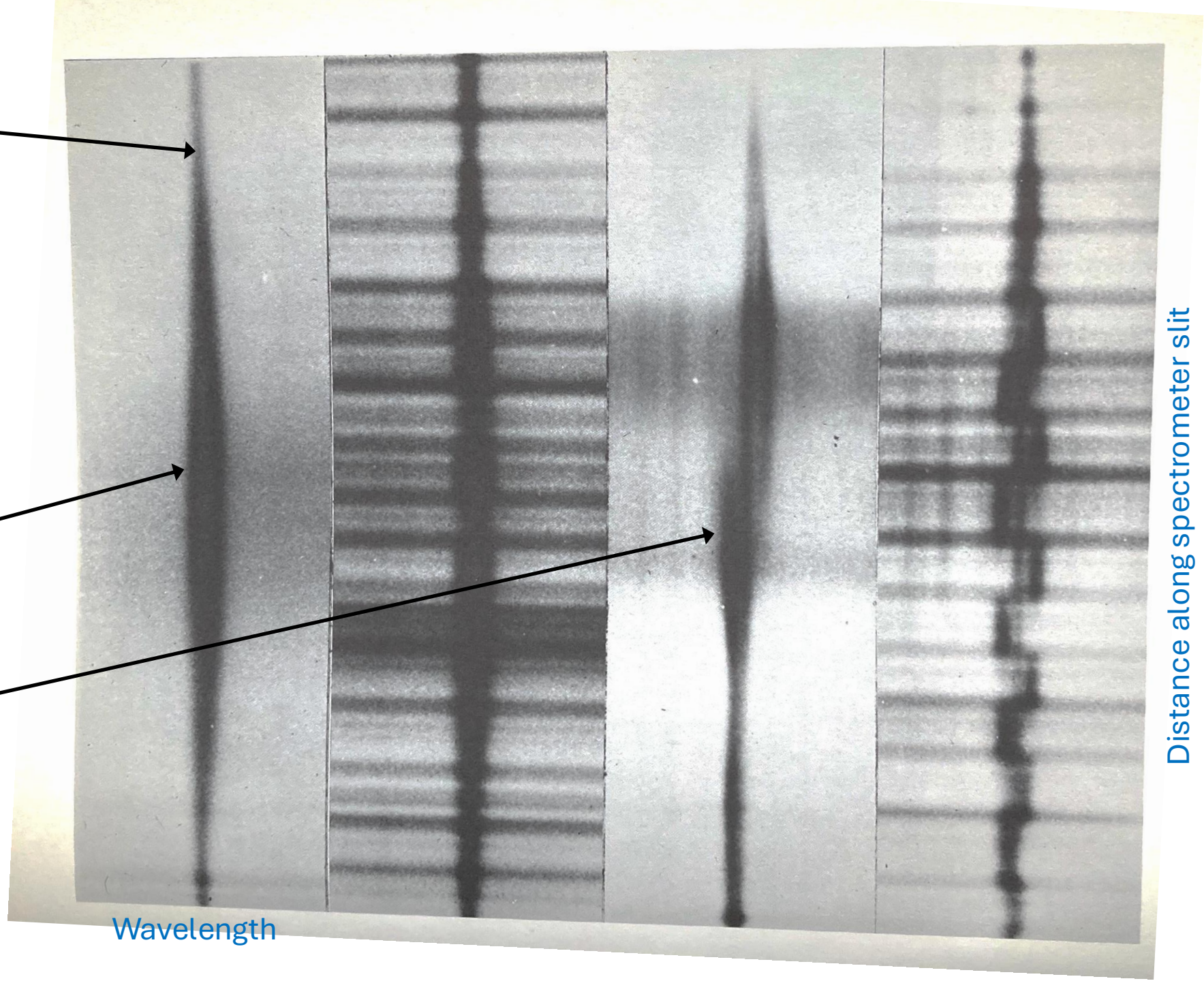


The 150-foot tower telescope on Mount Wilson.
The Hale Observatories.



Cutaway view of the 150-foot solar tower.
The Hale Observatories.

The 150-foot tower telescope


Absorption line
Line broader in sunspot due to magnetic field
Isolating Zeeman components to estimate field strength
Wavelength
Distance along spectrometer slit

ON THE PROBABLE EXISTENCE OF A MAGNETIC FIELD IN SUN-SPOTS[1]

By GEORGE E. HALE

1908, ApJ, 28, 315
468 citations, including 13 in 2025!

"…the greatest result of any that recent years have afforded astronomy." Arthur Eddington (1909).

"You are opening up a new field and nobody can tell at present to what unexpected and far-reaching results it may lead…" J.C. Kapteyn (1908).

"After balancing the evidence for and against the probable existence of magnetic fields in sun spots…I very decidedly come to a favourable opinion." P. Zeeman (1908).

Nobel Prize winner?

Year	Favorite(s)	Votes (%)	Winner(s)	Votes (%)
1914	Max Planck	29	Max von Laue	5
1915	William Henry Bragg / George Ellery Hale	21	William Henry Bragg	21
			William Lawrence Bragg	11
1916	Johannes Stark	16	[none awarded]	N/A
1917*	George Ellery Hale	18	Charles Barkla	2
1918*	Max Planck / Albert Einstein	21	Max Planck	20
1919	Max Planck / Robert Millikan	20	Johannes Stark	3
1920	Albert Einstein	29	Charles Guillaume	4
1921*	Albert Einstein	45	Albert Einstein	40
1922	Albert Einstein	36	Niels Bohr	23
1923	George Ellery Hale / Friedrich Paschen	19	Robert Millikan	6

Phys. Today, 2017

Hale's law of sunspot polarities

- In 1912, routine monitoring of sunspot polarities began with the 150ft telescope

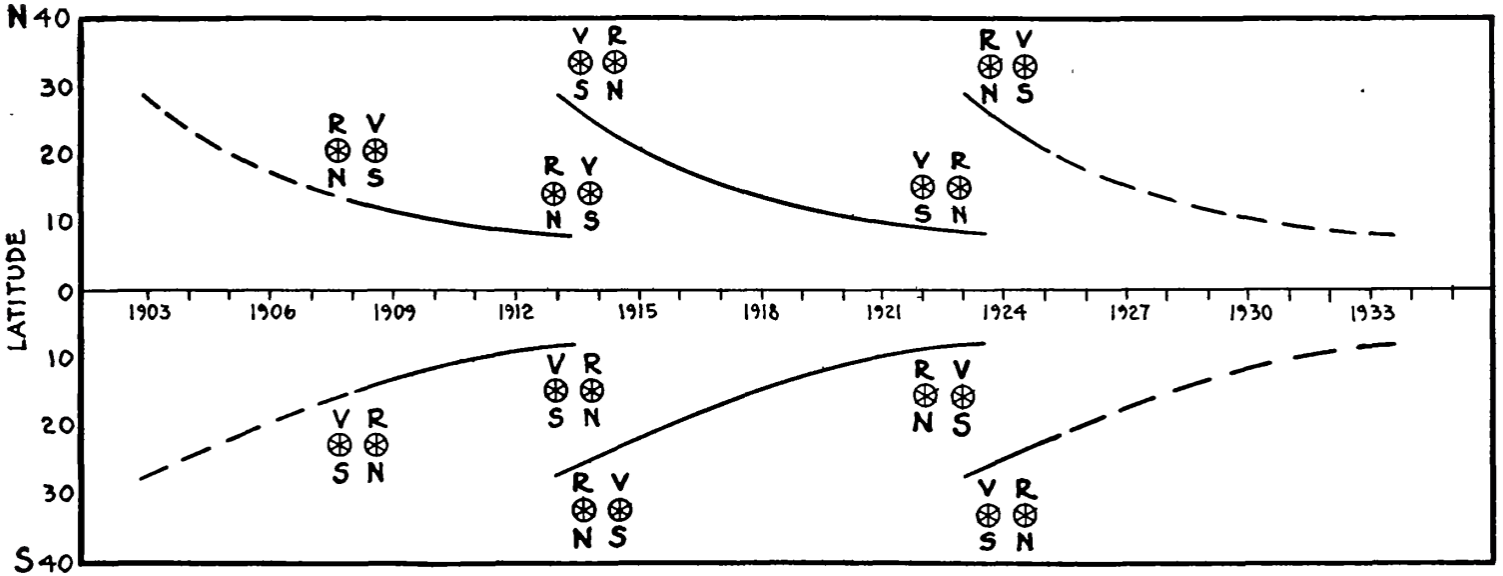


FIG. 18.—The law of sun-spot polarity. The curves represent the approximate variation in mean latitude and the corresponding magnetic polarities of spot groups observed at Mount Wilson from June 1908 to January 1925. The preceding spot is shown on the right.

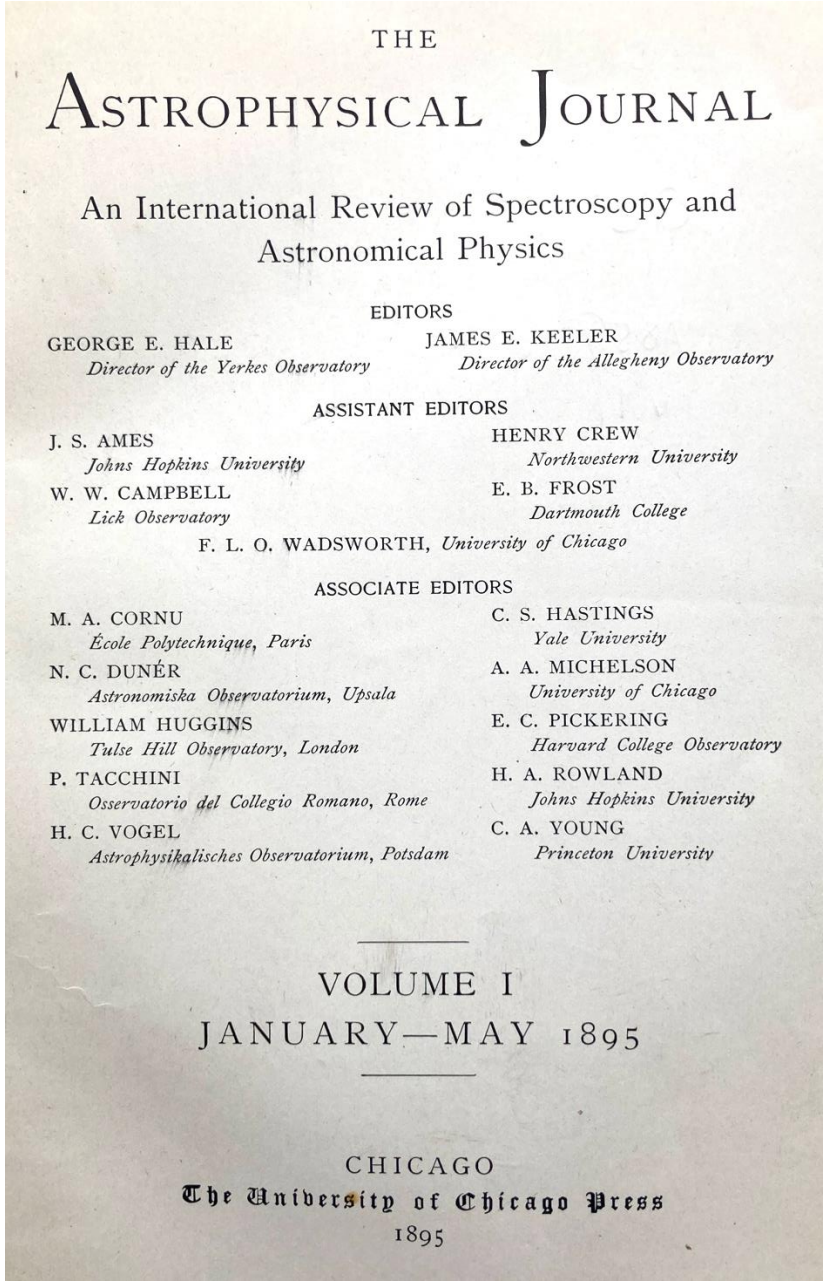
Hale & Nicholson, 1925
ApJ, 62, 270.

"I got a very curious new result yesterday…the new sun-spot vortices are whirling in the opposite direction"
1914, Hale (letter to wife)

The Astrophysical Journal

- Hale was the founder and first editor.
- First issue published in 1895

"...it was felt from the first that unless the journal were made truly international in character it could not be a success." Hale, 1895.



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VOLUME I
JANUARY—MAY 1895

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The American Astronomical Society

- The idea for the AAS is generally credited to Simon Newcomb.
- Hale is considered the driving force in founding the society in 1899.
- He served as vice-president, but never president.
- Hale insisted the society be named the American Astronomical and *Astrophysical* Society.
- The present name was adopted in 1914.

Conference of Astronomers and Astrophysicists at the dedication of Yerkes Observatory, 1897

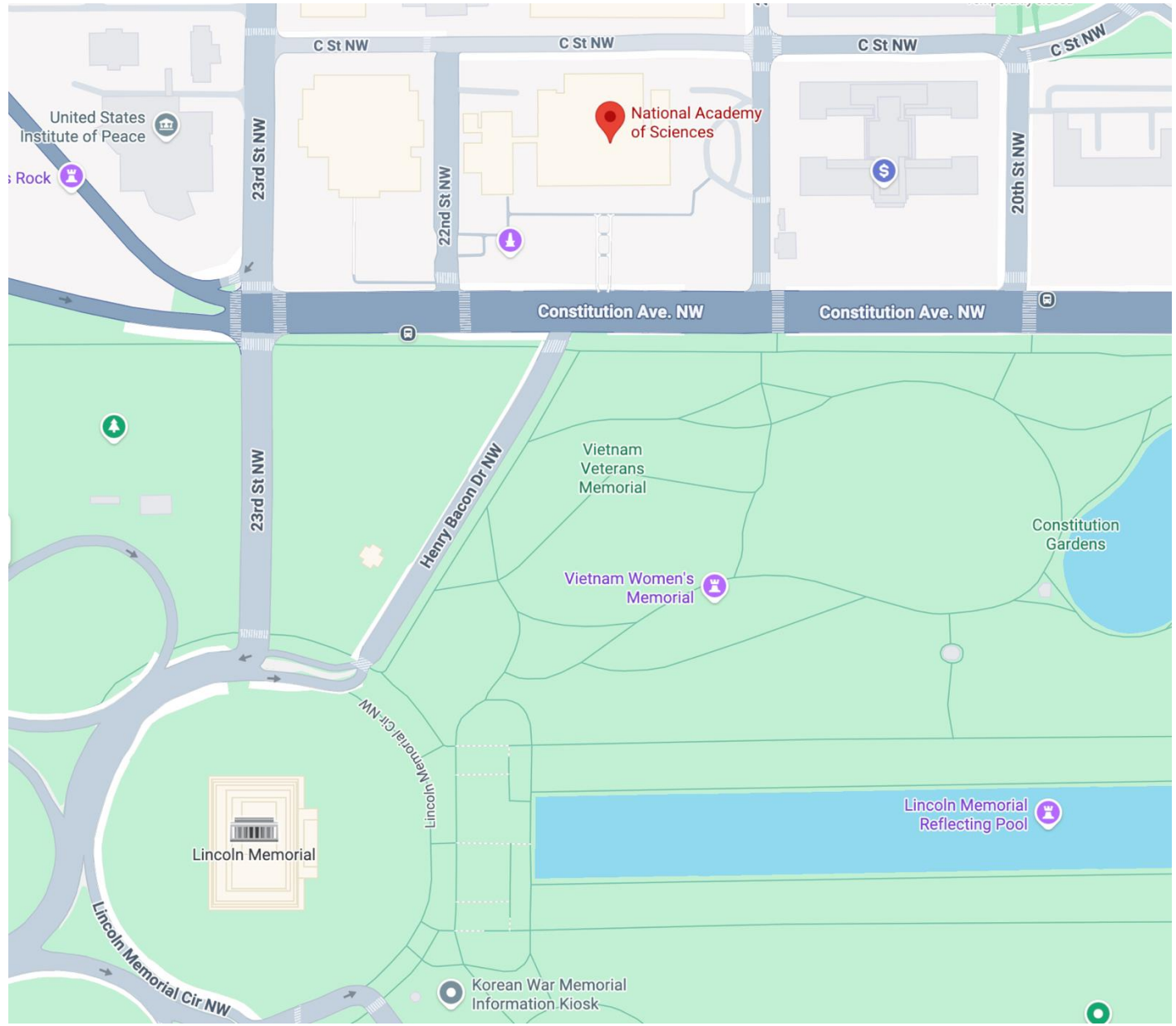
An International Community

- Hale formed the International Union for Cooperation in Solar Research (“Solar Union”) in 1904.
- In 1910 this was expanded to all of astronomy, the forerunner to the IAU.
- In 1918 he proposed an international union of scientists.
- The International Research Council was formed in 1918; the IAU is a subsidiary.
- Hale was the president of the IRC for 1931-34.

Solar Union meeting, Mt. Wilson, 1910.

National Academy of Sciences

- The Academy was founded in 1863 during the Civil War.
- Hale was elected a member in 1902 (age 33).
- He began “an ardent campaign to rouse [the Academy] from its lethargy and widen its influence.” (Wright 1966)
- His achievements:
  - A prominent headquarters in Washington DC.
  - Founded the journal *Proceedings of the National Academy of Sciences* (PNAS).
  - Strengthened connection with government (NRC).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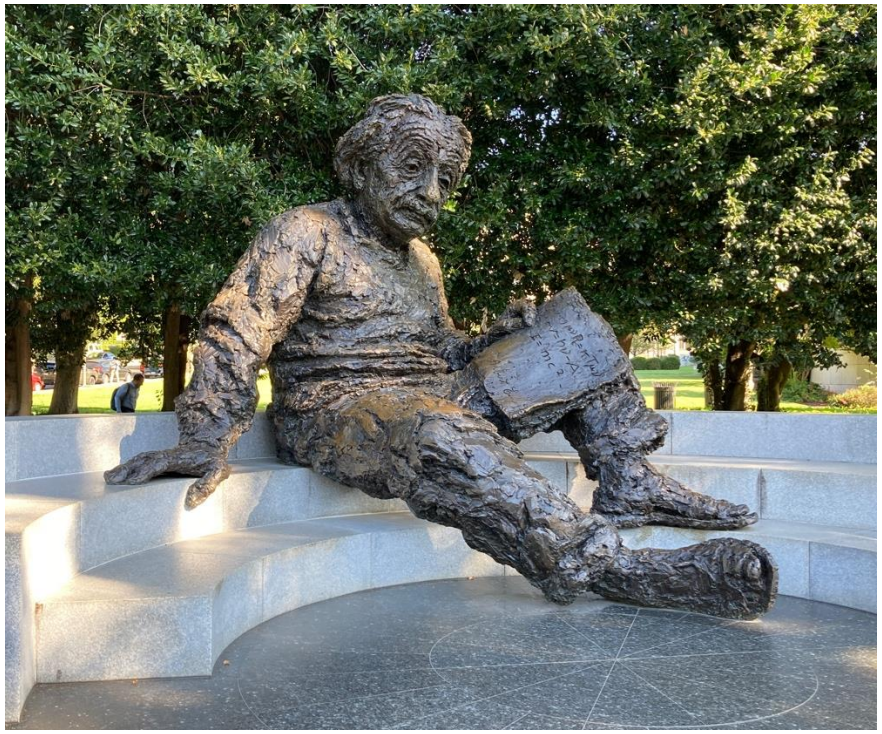
National Academy of Sciences
23rd St NW
22nd St NW
20th St NW
Constitution Ave. NW
Constitution Ave. NW
23rd St NW
Henry Bacon Dr NW
Vietnam Veterans Memorial
Constitution Gardens
Vietnam Women's Memorial
Lincoln Memorial Cir NW
Lincoln Memorial
Lincoln Memorial Reflecting Pool
Lincoln Memorial Cir NW
Korean War Memorial Information Kiosk

National Academy of Sciences

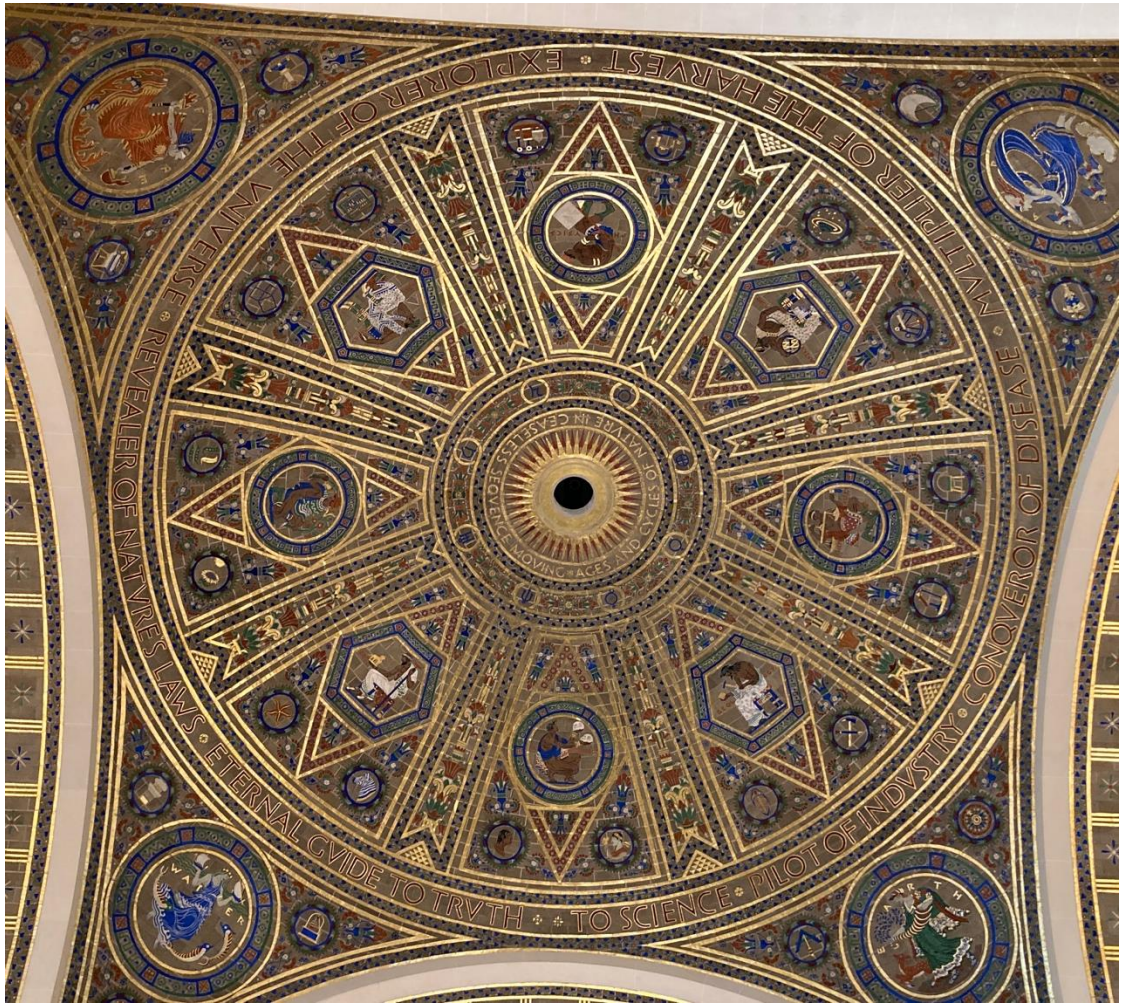
Building on Constitution Ave, DC
Completed in 1924
“extreme simplicity and refinement”



The Einstein memorial – Robert Berks

Entrance Door

Great Dome Inscription



Science, Pilot of Industry, Conqueror of Disease, Multiplier of the Harvest, Explorer of the Universe, Revealer of Nature's Laws, Eternal Guide to Truth.

"If there should be removed from our fair project…the part it owes to the gifted vision and tireless devotion of George Ellery Hale, our temple could not stand."
- Gano Dunn at dedication of the "temple".

National Research Council (NRC)

- During World War I, Hale felt the NAS should play a role in helping the war effort.
- He successfully lobbied President Wilson for the formation of the NRC.

THE NATIONAL RESEARCH COUNCIL.

How It Proposes to Mobilize the Nation's Science for Industrial Progress and Military Efficiency.

By GEORGE ELLERY HALE,
Chairman of the Organizing Co[illegible]

Madison, Conn., July 26, 1916.

To the Editor of The New York Times:

At its annual meeting in April the National Academy of Sciences volunteered to organize the scientific resources of educational and research institutions in the interest of national preparedness. This offer, which was immediately accepted by President Wilson, has led to the establishment of the National Research Council.

Public welfare and national security depend upon industrial progress and military efficiency; and these, in turn, result from practical applications of scientific knowledge. A superstructure, no matter how perfect, must have firm foundations, and thus the development of our industries must go hand in hand with the advancement of knowledge through research.

[illegible]

sus to be prepared in harmony with any general plan adopted by the proposed Government Council of National Defense.

(2) The preparation of reports by special committees, suggesting important research problems and favorable opportunities for research in various departments of science.

(3) The promotion of co-operation in research, with the object of securing increased efficiency; but with careful avoidance of any hampering control or interference with individual freedom and initiative.

(4) Co-operation with educational institutions, by supporting their efforts to secure larger funds and more favorable conditions for the pursuit of research and the training of students in the methods and spirit of investigation.

(5) Co-operation with research foun-

New York Times, 29 July 1916.

Pasadena

- When Hale moved to Pasadena, it had Throop Polytechnic Institute – a small vocational school.
- Hale envisioned a much grander institution for the town: an MIT for the west coast.
- The institution was renamed the California Institute of Technology (CalTech) in 1920.

“I want to see institutions like Throop turn out perhaps ninety-nine of every hundred students as men who are to do given pieces of industrial work better than any one else can do them; […] and the one-hundredth man I want to see with the kind of cultural scientific training that will make him and his fellows the matrix out of which you can occasionally develop a man like your great astronomer, George Ellery Hale.”

- former President Theodore Roosevelt, address at inauguration of new campus, 1911

Robert H. Goddard

"They all jumped at the first shot. Then Hale shook hands and said he would send a good, strong report to Washington."
Goddard, after testing his first rocket at Mt. Wilson.

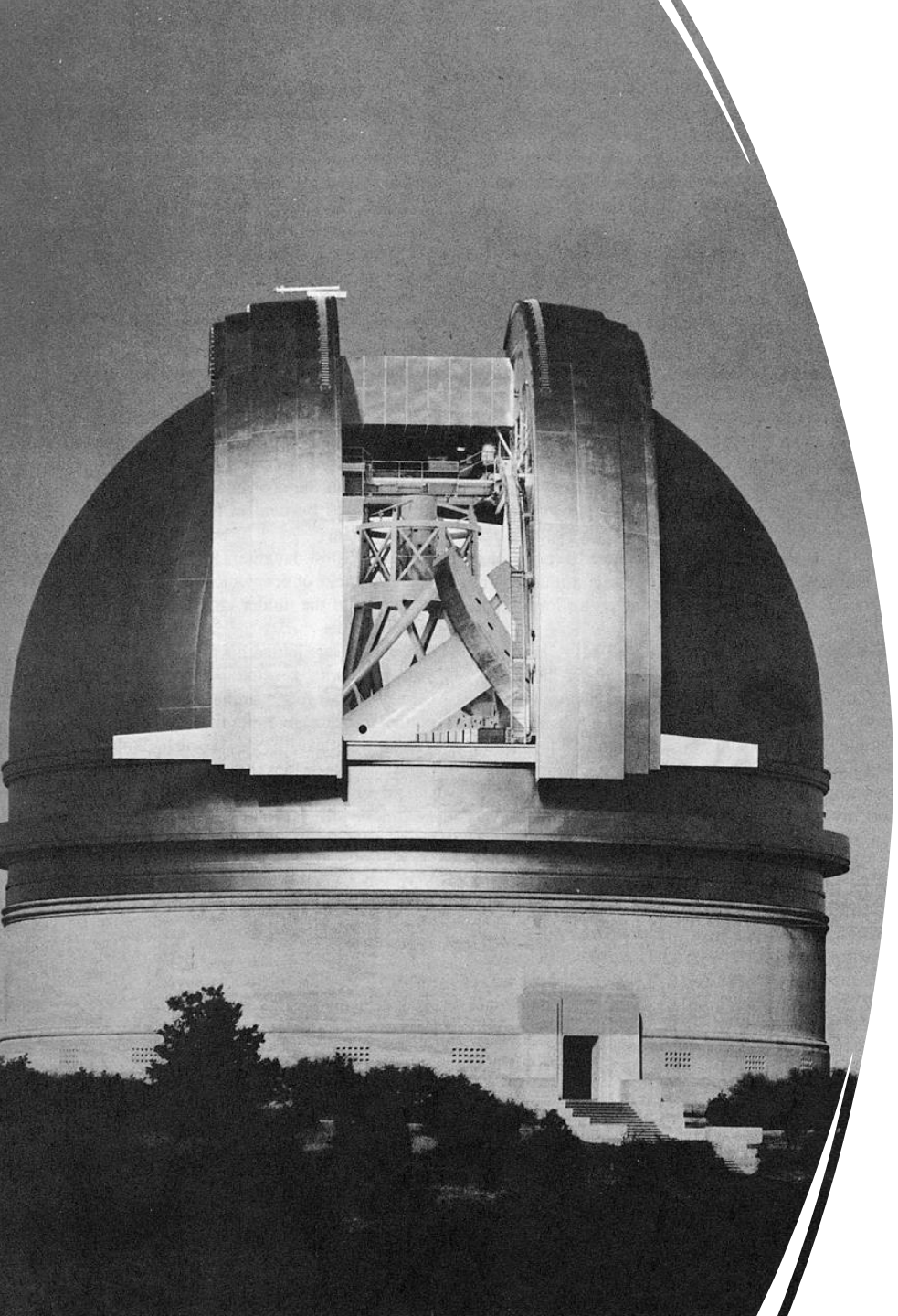
A grant of $5,000 from the Hodgkins Fund, Smithsonian Institution, under which work is being done at present, was advanced toward the development of a reloading, or multiple-charge rocket, herein explained in principle, and this work was begun at the Worcester Polytechnic Institute in 1917, and was later undertaken as a war proposition. It was continued, from June, 1918, up to very nearly the time of signing of the armistice, at the Mt. Wilson Observatory of the Carnegie Institution of Washington, where most of the experimental results were obtained.

In connection with the present publication, I take pleasure in thanking Dr. A. G. Webster for the facilities of the shop and laboratory at Clark University, used in the preliminary experiments herein described. I also take this opportunity of expressing my gratitude to the Smithsonian Institution, for its support and encouragement in the later work.

ROBERT H. GODDARD.

CLARK COLLEGE,
WORCESTER, MASSACHUSETTS,
May 26, 1919.

Preface to "A method of reaching extreme altitudes"

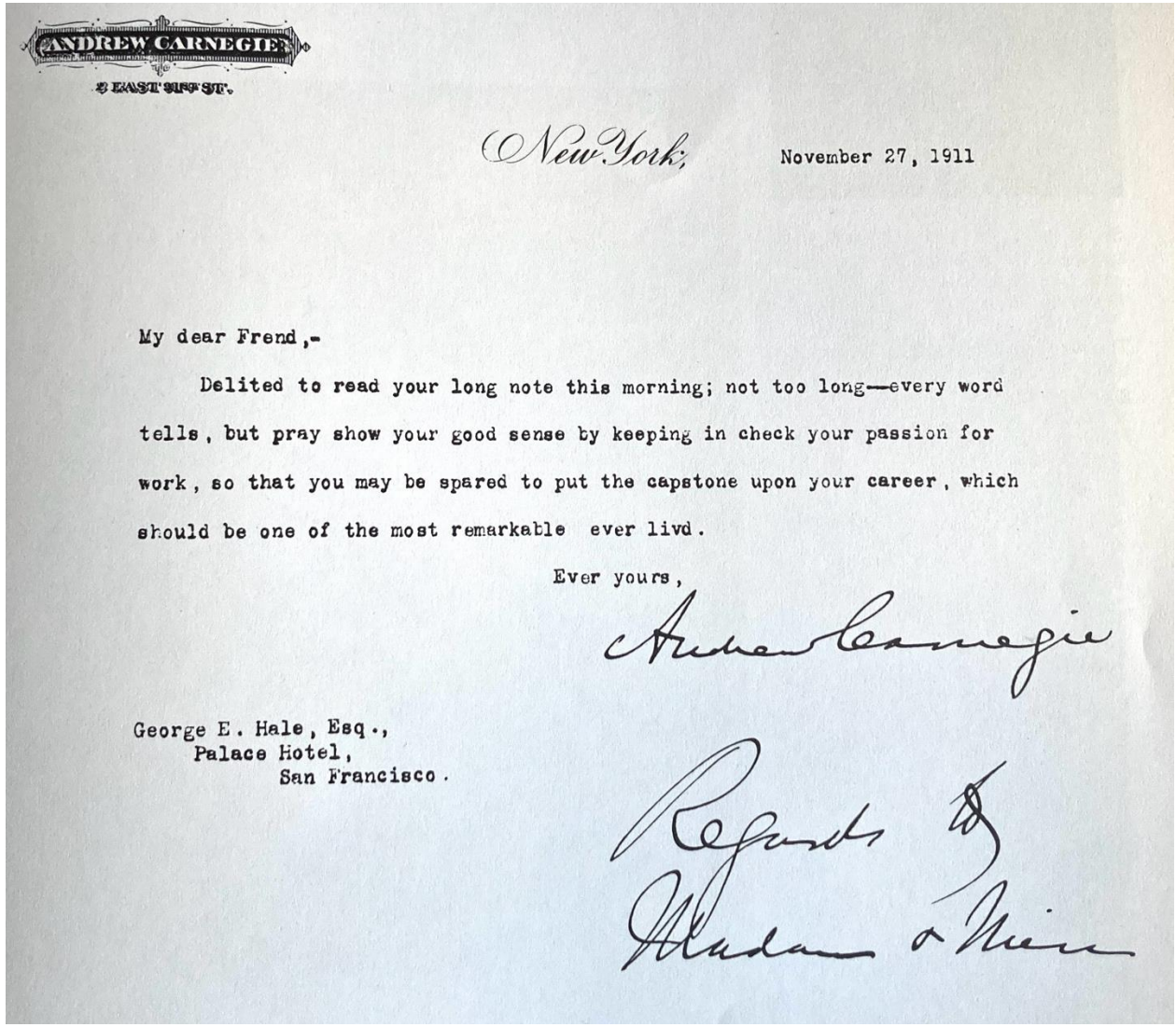


The 200-inch Telescope

- Hale began advocating for an even larger telescope in 1928.
- He secured $6 million from the Rockefeller Foundation and selected a site on Mount Palomar in California.
- The telescope was completed 10 years after Hale died and was named after him.
- It remained the largest telescope in the world until 1976.

Health concerns

- Hale suffered from mental health problems from 1908 onwards.
- He resigned as Mt. Wilson director in 1922.
- He was often recommended to take long holidays and visit sanatoriums by his doctors.
- Probably manic depression (Sheehan & Osterbrock, 2000).



ANDREW CARNEGIE
2 EAST 91ST ST.

New York, November 27, 1911

My dear Frend,-

Delited to read your long note this morning; not too long—every word tells, but pray show your good sense by keeping in check your passion for work, so that you may be spared to put the capstone upon your career, which should be one of the most remarkable ever livd.

Ever yours,

Andrew Carnegie

George E. Hale, Esq.,
Palace Hotel,
San Francisco.

Regards to
Mr. & Mrs.

Inspiration for today's times

- Hale's projects were completed without any government money.
- He carefully negotiated with wealthy benefactors, taking advantage of his many contacts in science and society.
- His passion for science, coupled with persistence and energy were critical.
- He never lost his love of solar spectroscopy and was able to find time for research in all periods of his career.
- He cultivated strong relationships with colleagues in the US and Europe through letters and visits. He won their respect through scientific achievement.

References & further reading

- Sam Hale's AAS lecture: https://aas.org/meeting-videos (244th Meeting)
- Helen Wright biography (1966): *Explorer of the Universe*
- Wright et al. (1972): *The Legacy of George Ellery Hale*
- Zirin (Solar Physics, 5, 435,1968)
- Health issues: Sheehan & Osterbrock (JHA, 31, 93, 2000)
- Internationalism: DeVorkin (IAU Symp. 349, 153, 2019)
- Mt. Wilson website: https://mtwilson.edu