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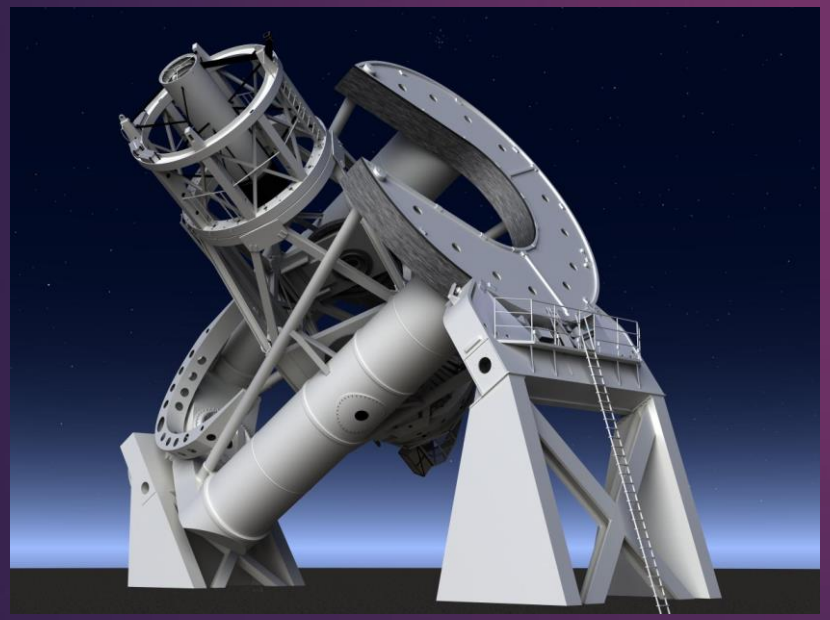
The 200” at 70

70 YEARS OF THE HALE 200” TELESCOPE AT PALOMAR



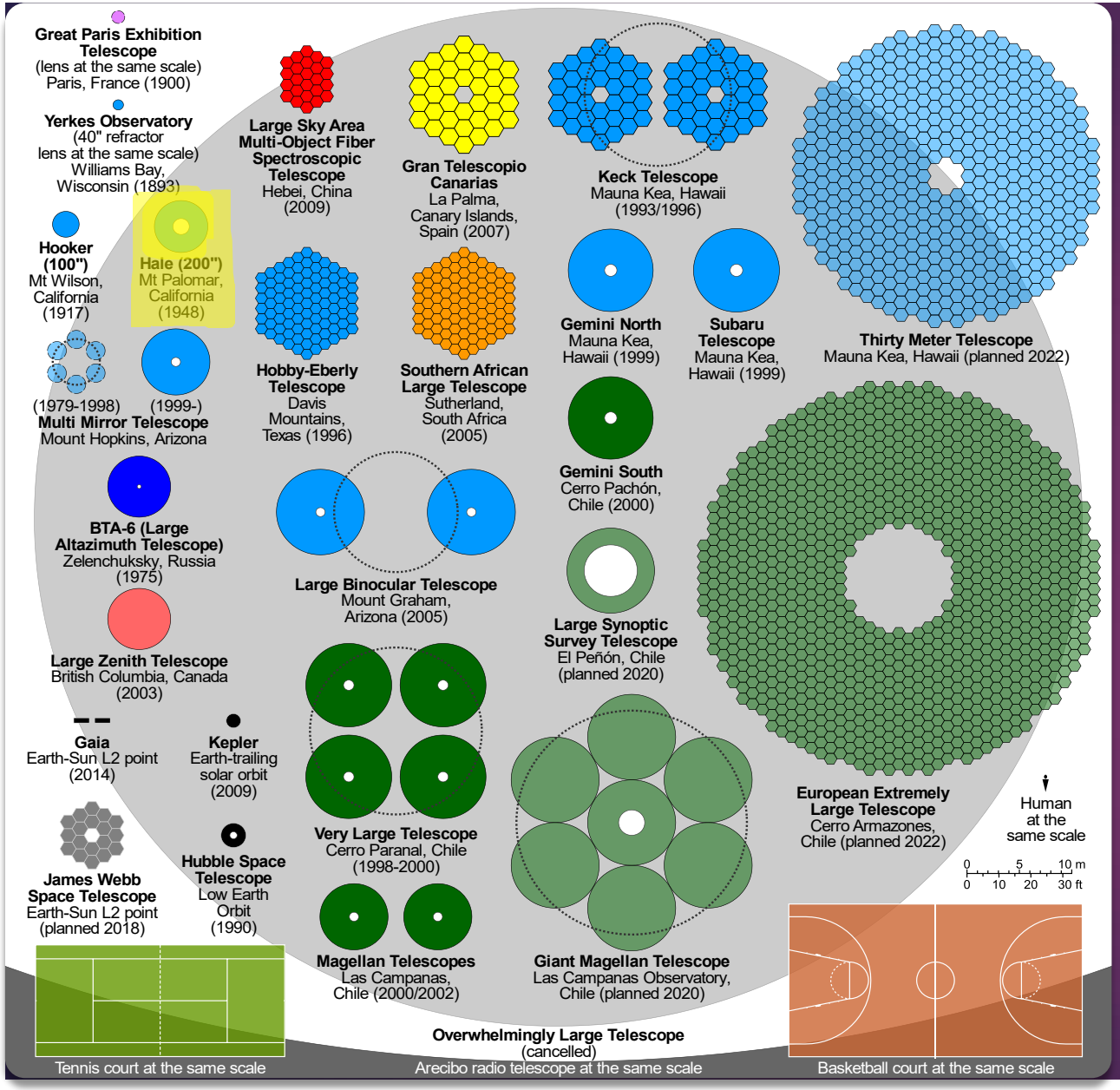
Gord Tulloch,
RASC, Winnipeg Centre
AAVSO:TGR

Stories of the 200”

- How it got built
- What it has discovered
- What it’s used for today
- Telescope techniques
- Go see it for yourself!

What is The Hale Telescope?

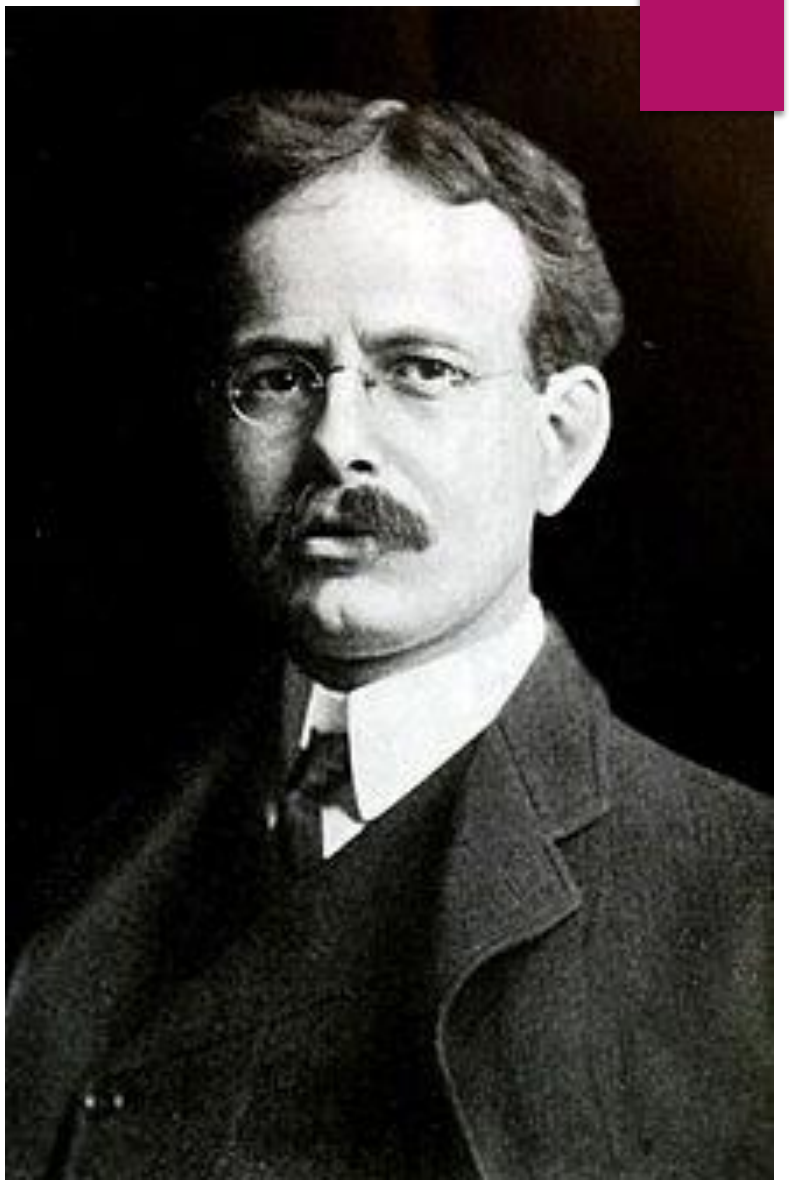
- 200 In (5.1m) f/3.3 reflecting telescope
- Located at Palomar Observatory in on Palomar California
- Named after George Ellery Hale, moving force behind large telescope builds in the early 20th century
- Largest telescope in the world til Russian BTA-6 built in 1976 (and largest that actually worked til Keck in 1993)
- Saw first light January 26, 1949 at 10:06pm PST by Edwin Hubble targeting NGC 2261 (Hubble's Variable Nebula)



How big is big?

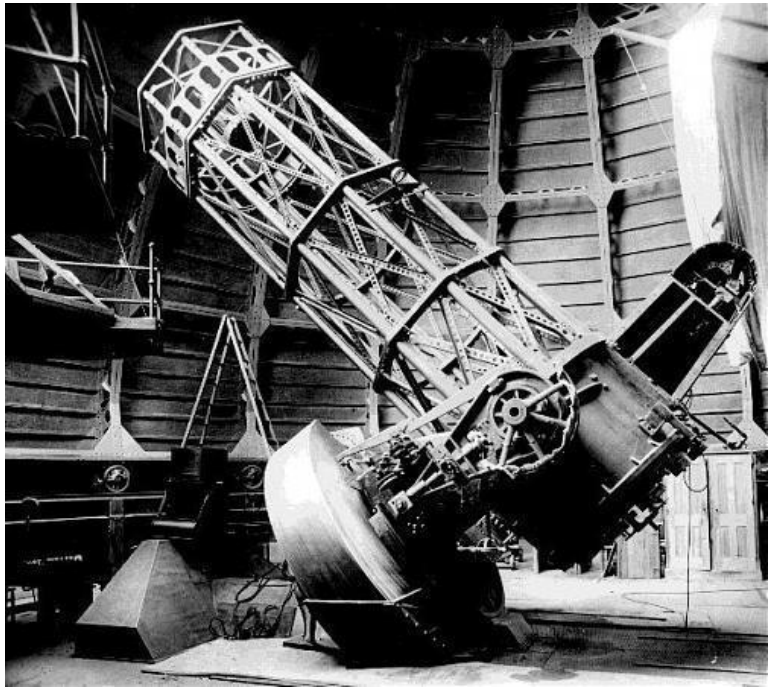
George Ellery Hale

- 1868-1938, son of elevator magnate
- Solar astronomer – discovered magnetic fields in sunspots
- Built world class telescopes
  - 40" refractor at Yerkes
  - 60" Hale reflector at Mount Wilson
  - 100" Hooker reflector at Mount Wilson
  - Solar Laboratory in Pasadena
  - 200" Hale reflector at Palomar
- Instrumental in founding the National Research Council and CalTech

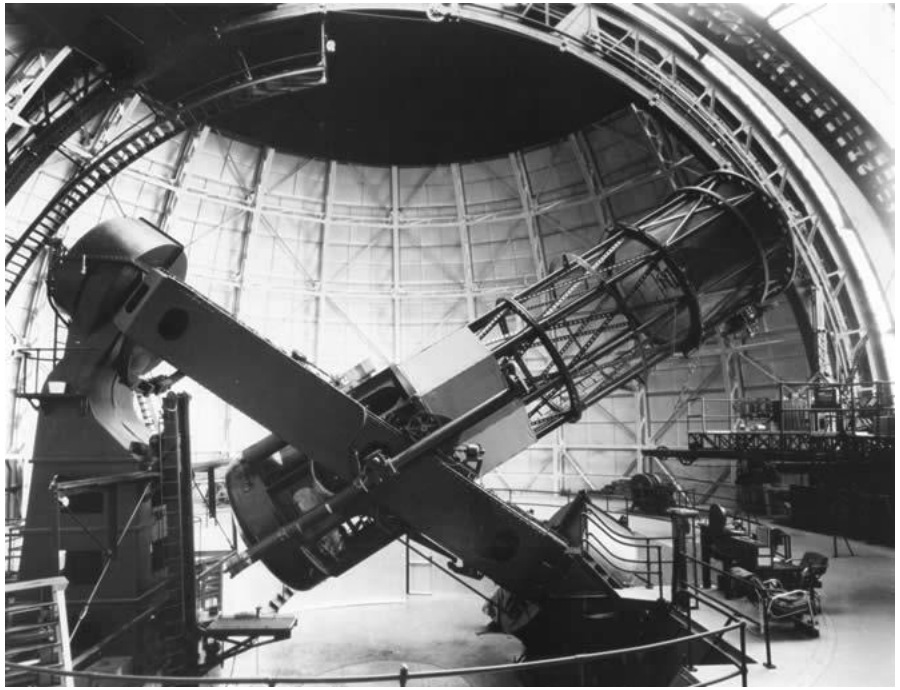


Hale's Masterpieces

1897



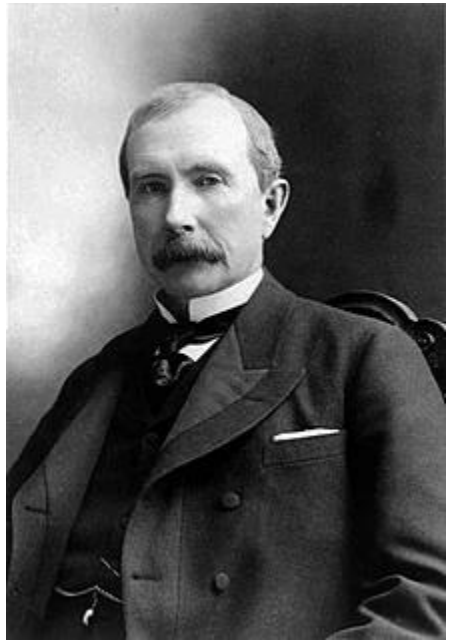
1908



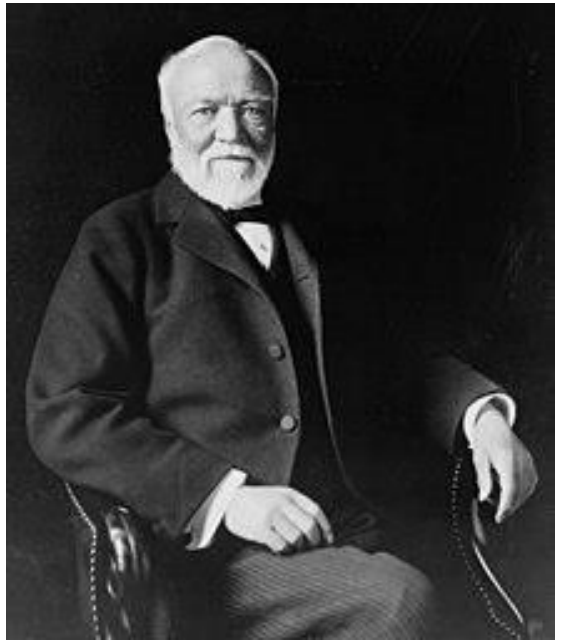
1917

Funding the 200”

- Hale found funding from the Rockefeller Foundation for $6M for the entire telescope, mount, and observatory in 1928
- However the Carnegie Foundation was supporting the Mt. Wilson observatory so there was conflict in who would own and run the observatory, resulting in funding disappearing briefly



John D. Rockefeller
(Standard Oil)



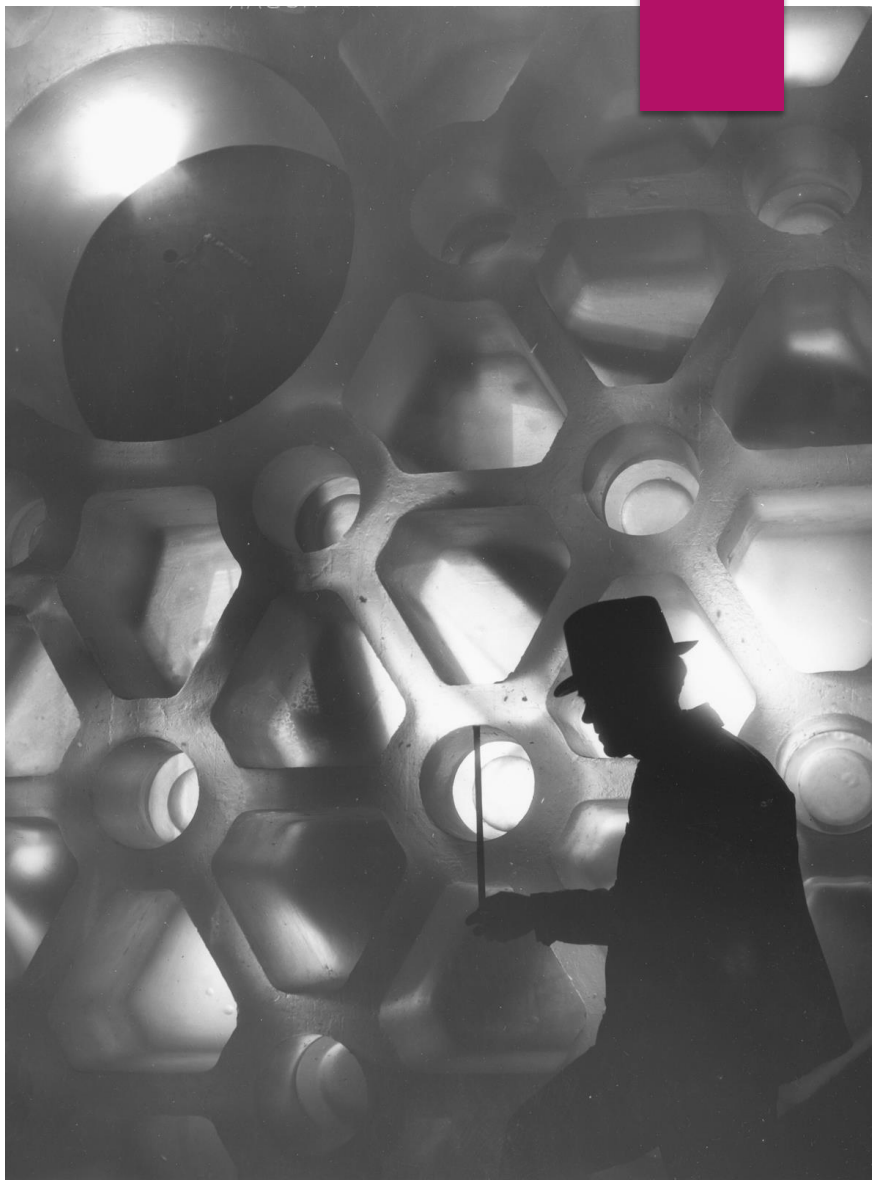
Andrew Carnegie
(US Steel)

The 200” Mirror – first attempts

- George Ellery Hale was an avid follower of new advances in optical substrates
- Contracted Elihu Thomson, a scientist, engineer and businessman who founded the Thomson-Houston Electric Company which later merged with Edison General Electric to become General Electric
- Eventually used spraying process to create blanks

200” Mirror – the Corning Adventure

- After costs at GE topped $600k and no disk in sight, GE Hale moved on to Corning, which produced PYREX low thermal expansion borosilicate glass
- George V. McCauley, a Corning physicist and engineer, was given the task of casting a successive series of disks culminating in the 200”
- Watch https://www.youtube.com/watch?v=66qYjl5c6TE



Pouring the 200” Mirror

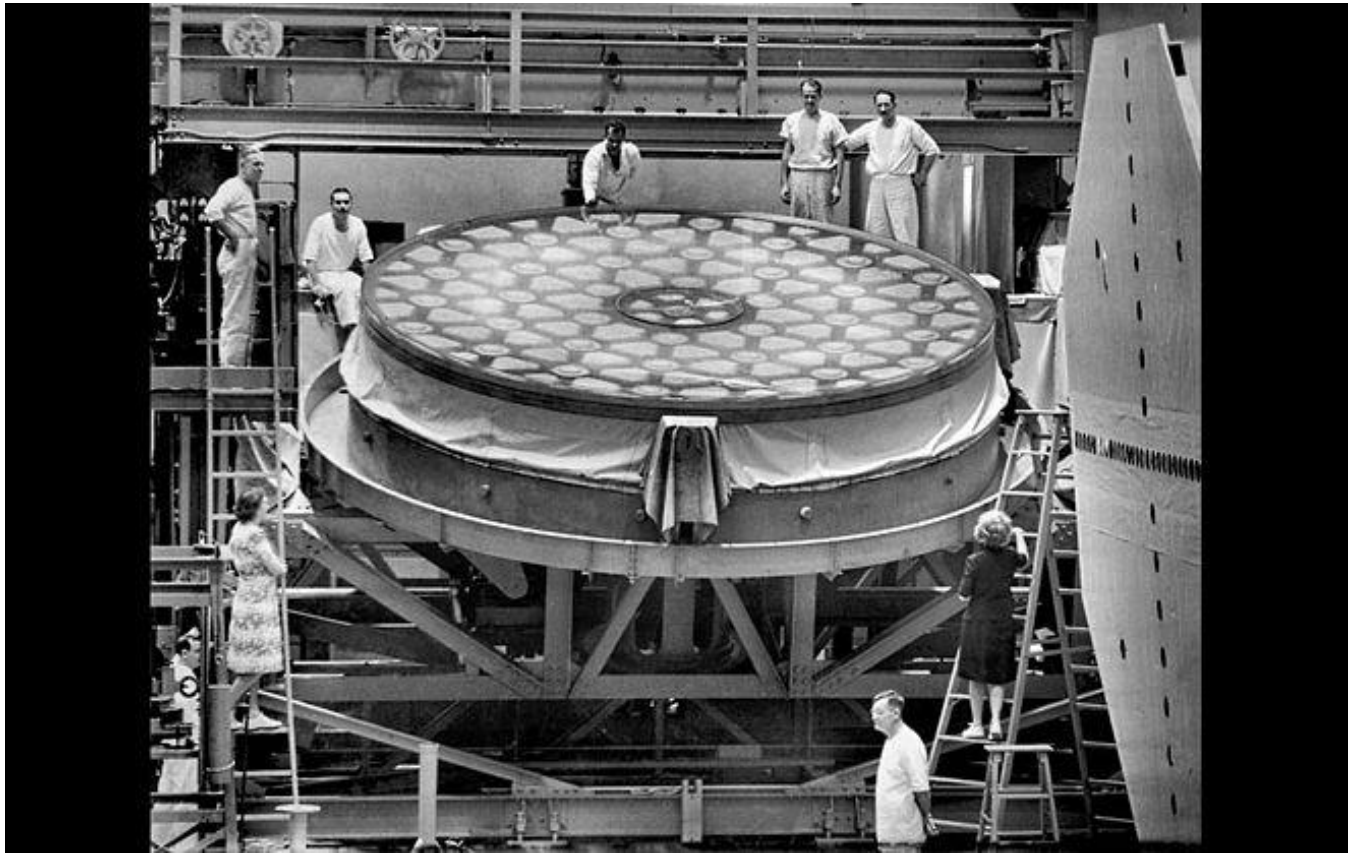
In this excerpt from “Journey to Palomar” we see the process of pouring the 200” disk

The 200” Train

Once annealed, the disk traveled upright on a padded railroad car for more than two weeks. The train traveled only by daylight and at speeds not exceeding 25 miles per hour. It made numerous stops along the way, with much fanfare in each city where it stopped.

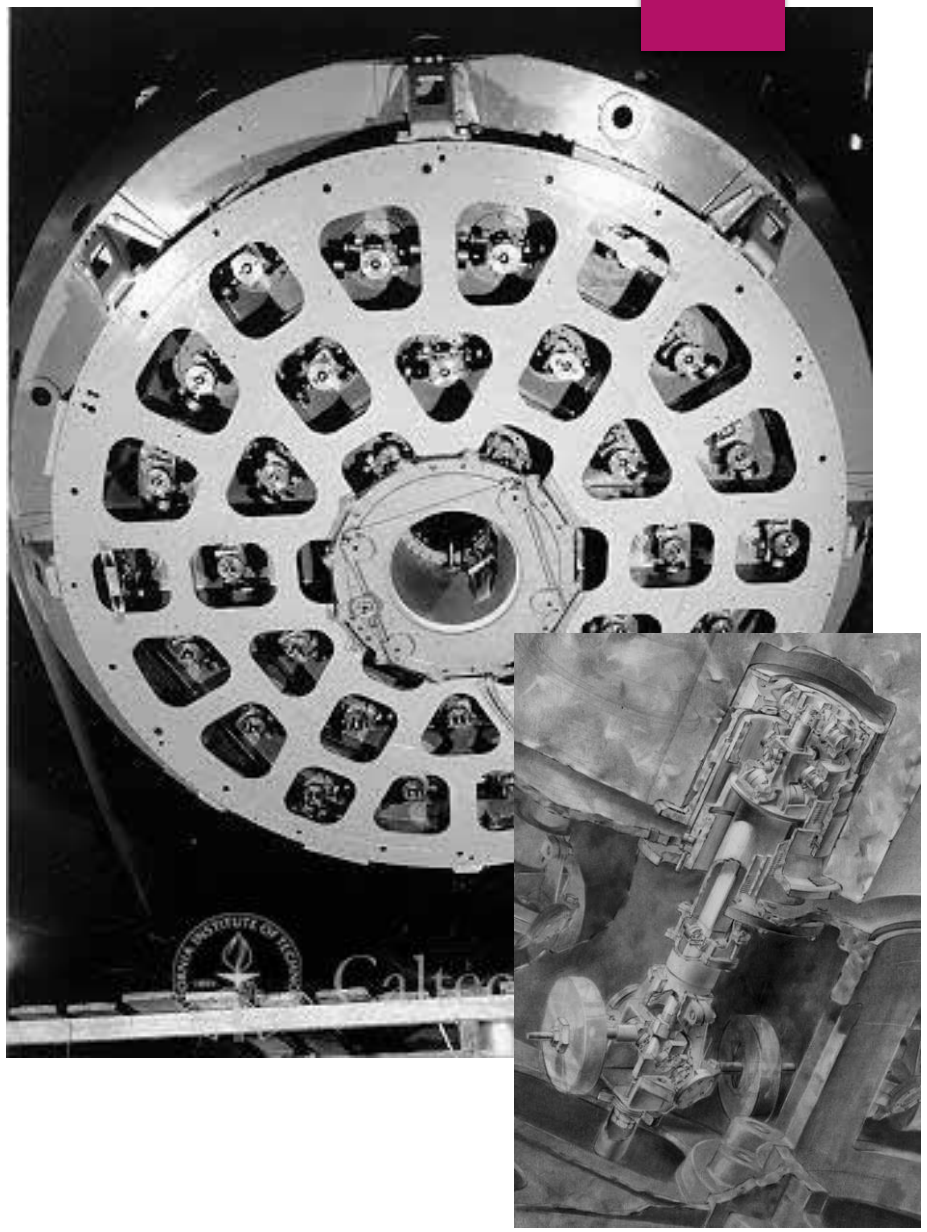
Grinding and Polishing

- The mirror finally arrived in Pasadena at the Optical Ship at Caltech in 1934
- A special 240 in (6.1 m) 25,000 lb (11 t) mirror cell jig was constructed which could employ five different motions when the mirror was ground and polished.
- Under the direction of John A. Anderson and Marcus H. Brown at Caltech, the mirror disk was ground and figured into the proper shape. It began as a 20-ton (18-tonne) disk and finished at 14.5 tons (13 tonnes)
- Including delays for WWII the disk was in the shop for 11 ½ years



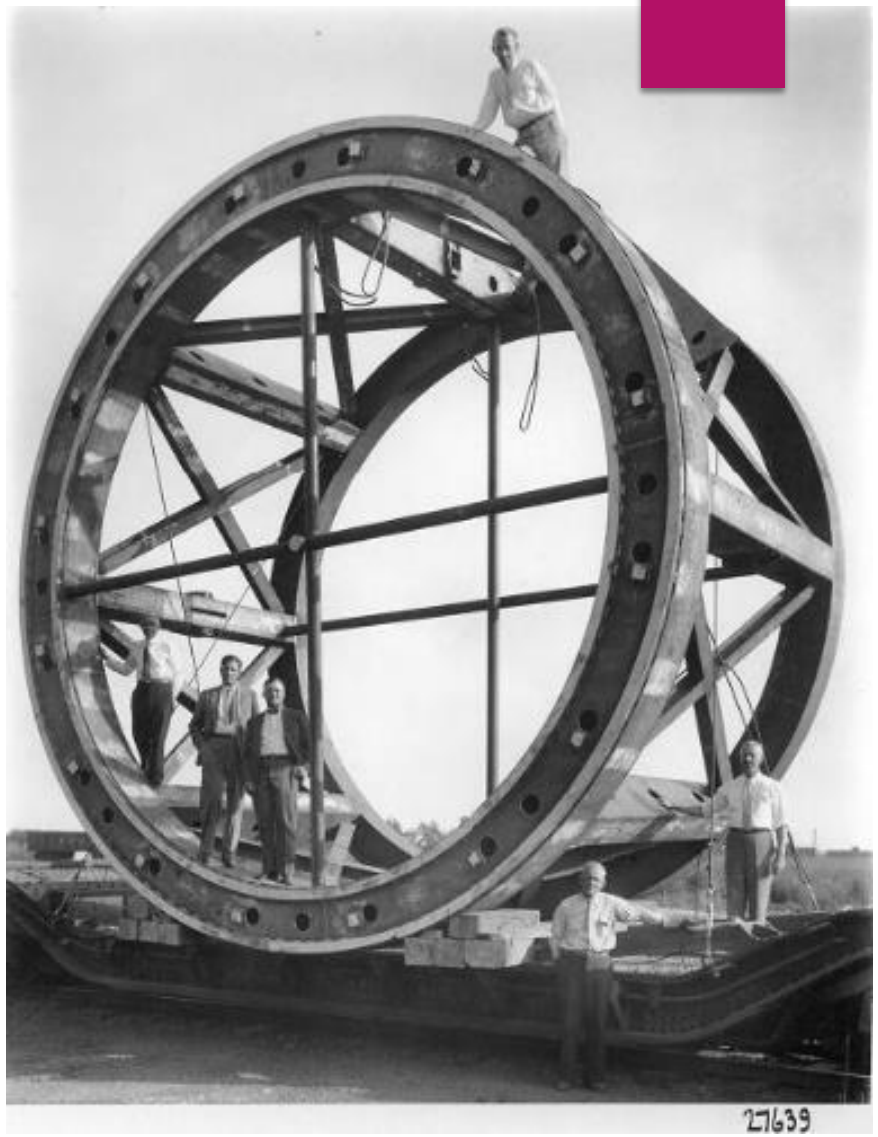
Mirror Cell

- All mirrors have a lot of issues with flexure changing the figure
- This was a somewhat extreme problem with the 200" despite efforts to keep the mirror light
- A completely 36 point mechanical mirror cell was able to keep the figure of the mirror within 200 millionths of an inch (50nm)
- No computer controls here!



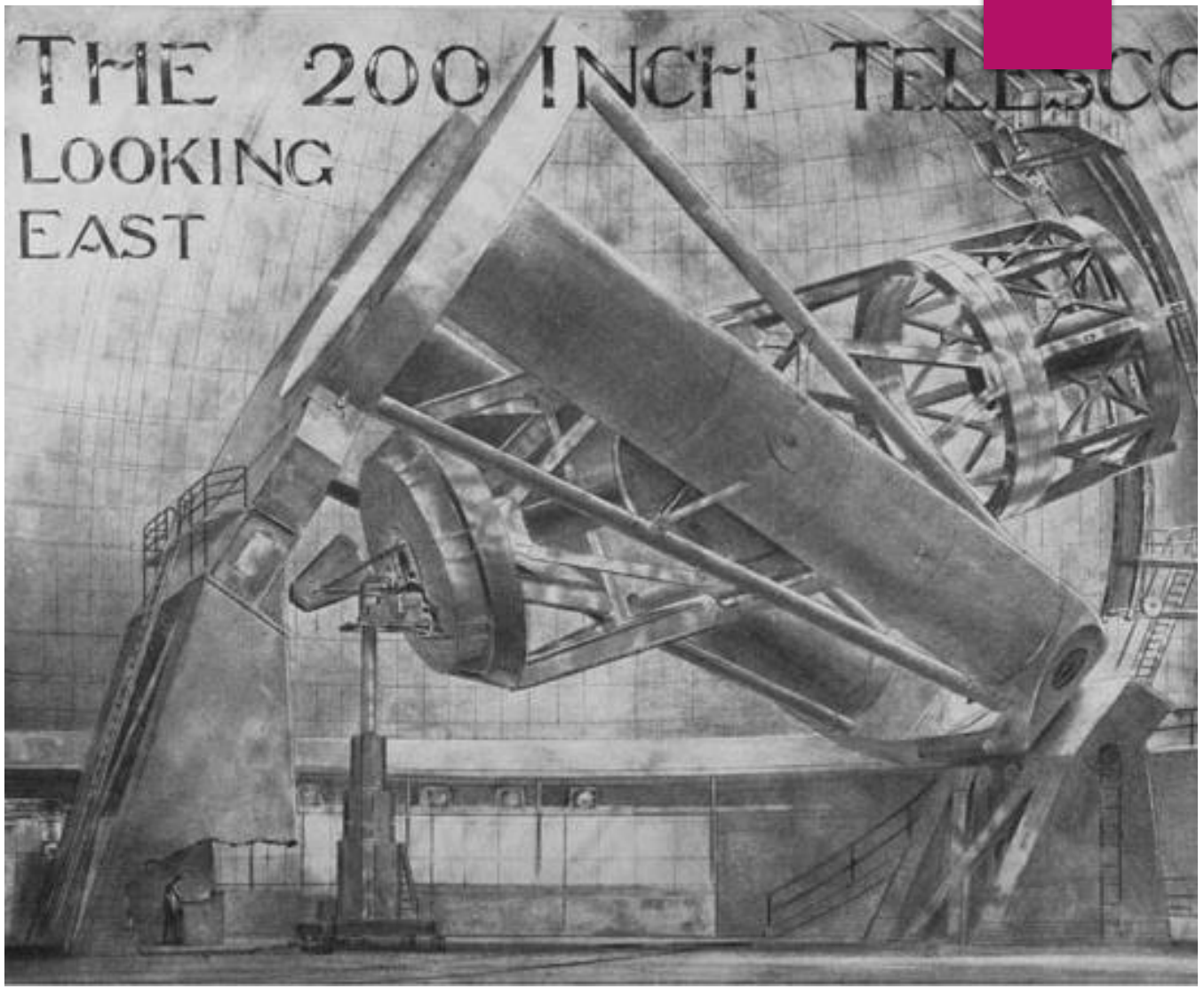
The 200” Mount

- Horseshow mount allows access to the northern sky unlike the yoke on the 100”
- The overall design of the 200-inch Hale Telescope is attributed to Porter and Francis Pease, while engineering of its various aspects to Mark Serrurier, Sinclair Smith, Bruce Rule and others at Caltech, and Rein Kroon of the Westinghouse Electric and Manufacturing Company.
- The construction of the telescope began in 1936. Its components were fabricated primarily at the Westinghouse South Philadelphia plant and then shipped by boat through the Panama Canal to San Diego and trucked to Palomar Mountain for assembly inside the dome.
- The first telescope parts arrived at Palomar in 1938 and construction was finished in 1939.



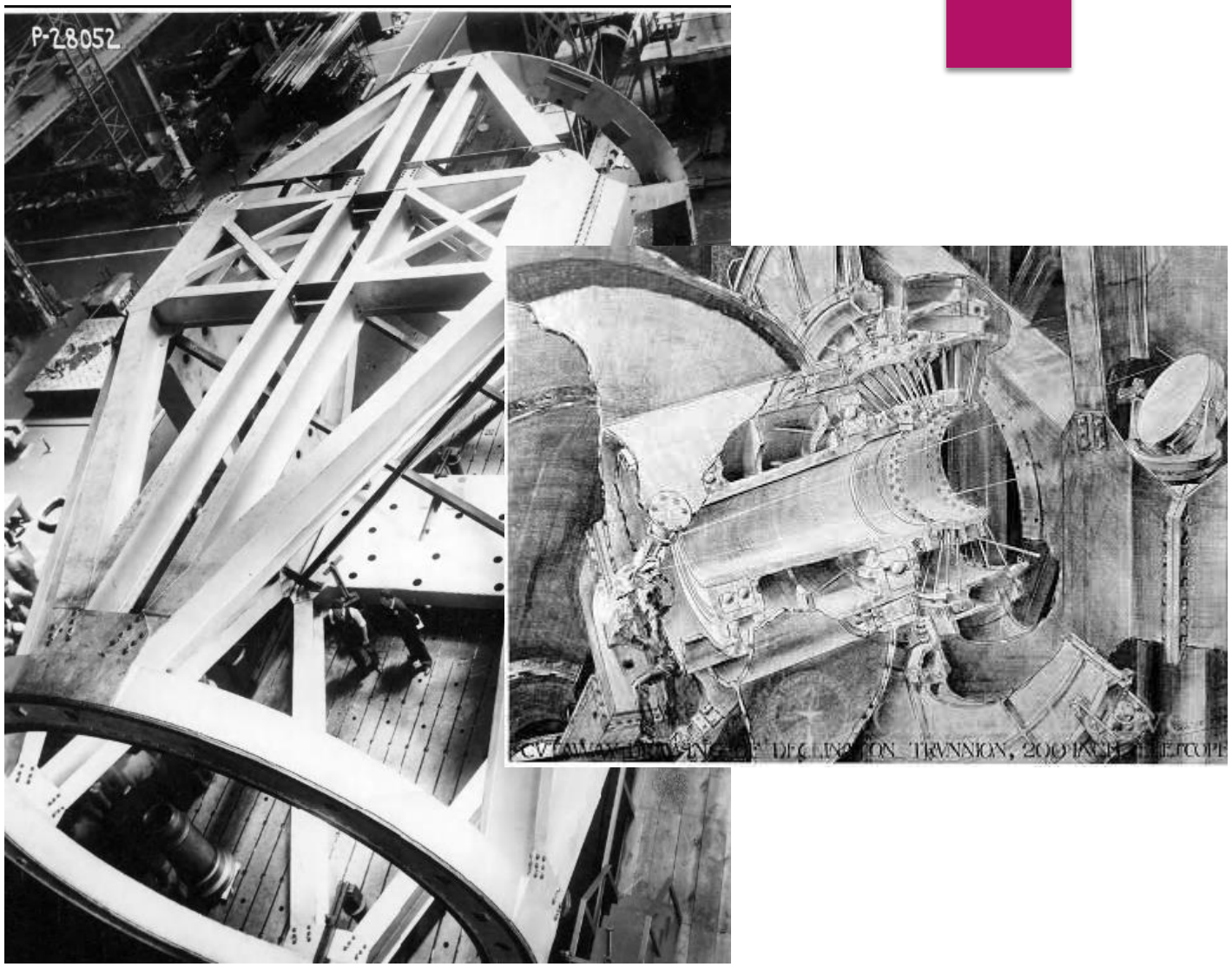
200” Mount

- 530 tons (481-tonne)
- For slewing it uses two small motors: a 3-hp motor for right ascension and a 1-hp motor for declination.
- For tracking it is moved by a 1-hp step motor—this replaced the original 1/12-hp tracking motor after almost 65 years of continual use.
- Pressurized oil bearings
- The telescope is rebalanced every time equipment is changed



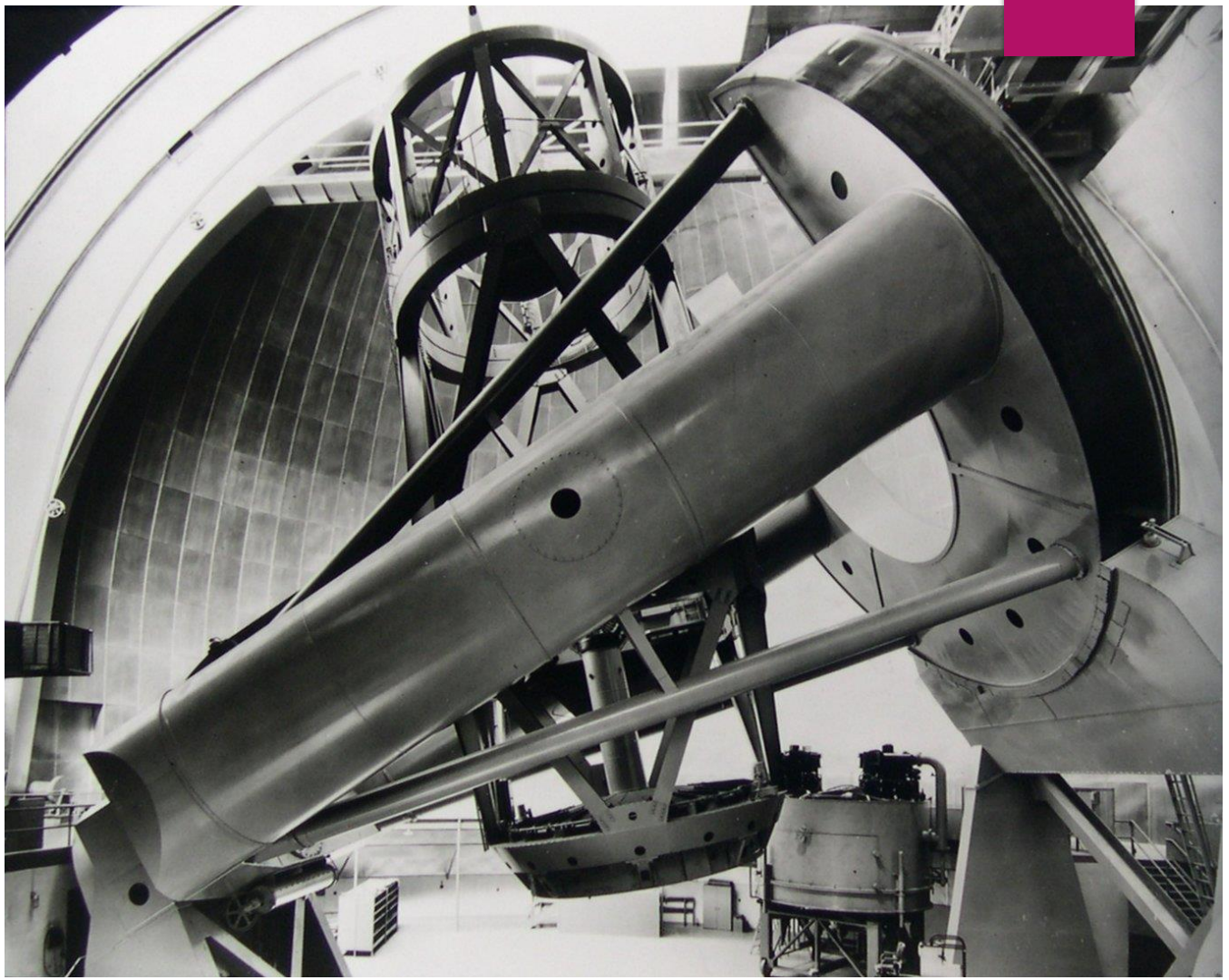
200” OTA

- Some remarkable engineering challenges were addressed with very limited technology
- Serrurier truss
- Spoke Declination Axis



Final Mount Installation

- The first telescope parts arrived at Palomar in 1938 and construction was finished in 1939.
- While not quite completed, the 200-inch was dedicated as the Hale Telescope on June 3, 1948. The telescope was designed for photographic work, all of which was initially done on glass photographic plates.
- The first "official" photos were taken by Edwin Hubble on January 26, 1949. It was not until November 1949—21 years into the project—that astronomers were finally able to begin research.



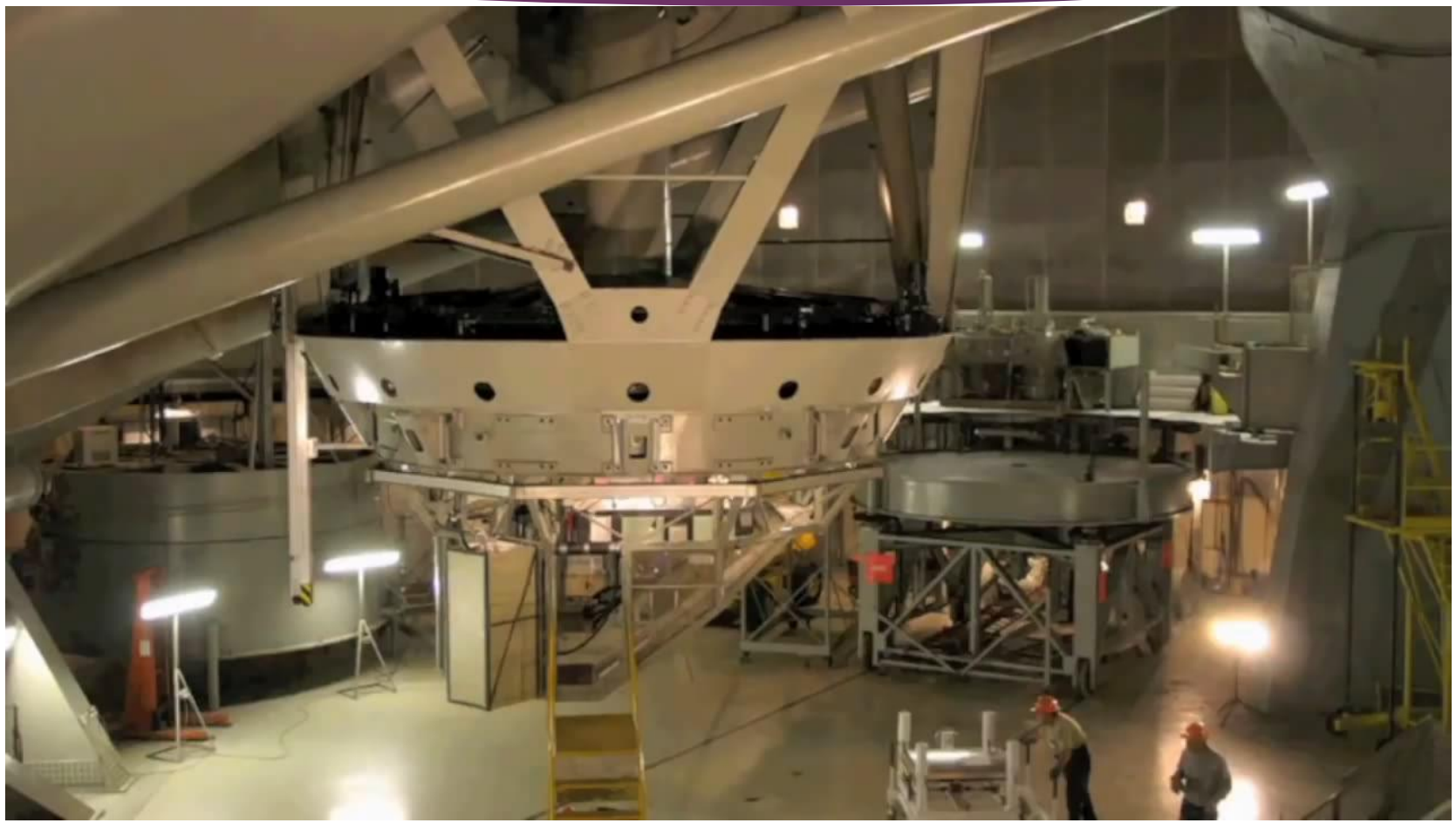
200” Dome

- The piers for the Hale Telescope are anchored to the bedrock 22 feet (6.7 meters) below, while the dome supports go about 7 feet (2.1 meters) into the overlying granite.
- The dome is 135 feet (41 meters) tall and 137 feet (42 meters) in diameter.
- The rotating part of the dome weighs approximately 1,000 tons (900 tonnes), with a plate steel exterior and aluminum panel interior, separated by four feet (1.2 meters) to allow for an insulating layer of air.
- Two 125-ton (113-tonne) shutters cover the opening and slide open at night to allow light through the slit and into the telescope. The top section of the dome rotates on two circular rails, riding on 32 carriages each with four wheels. One rotation takes about 4 minutes. Rotation of the dome is driven by four 7.5 horsepower motors (30 hp total).

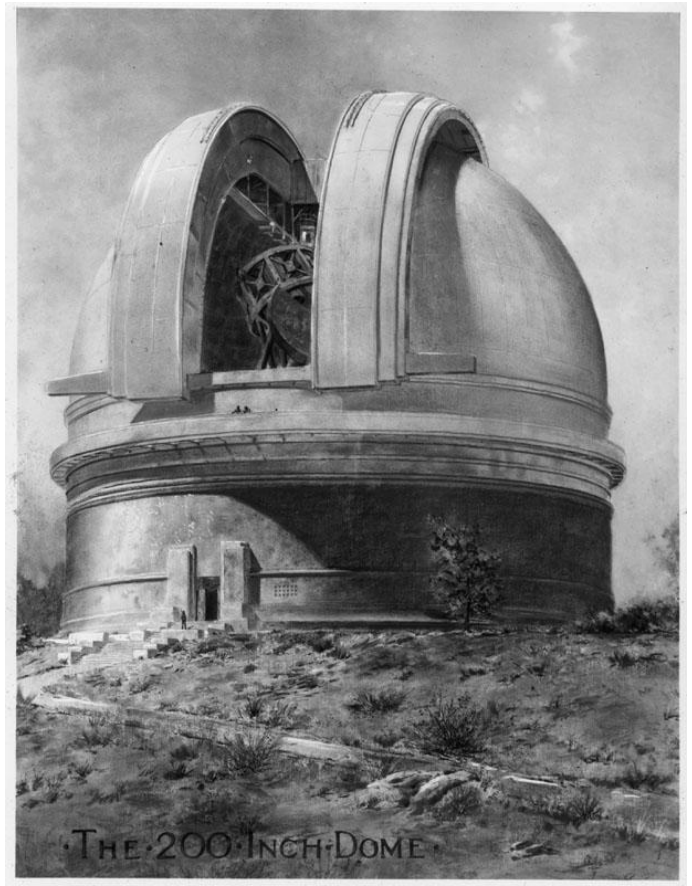
48” Schmidt Telescope

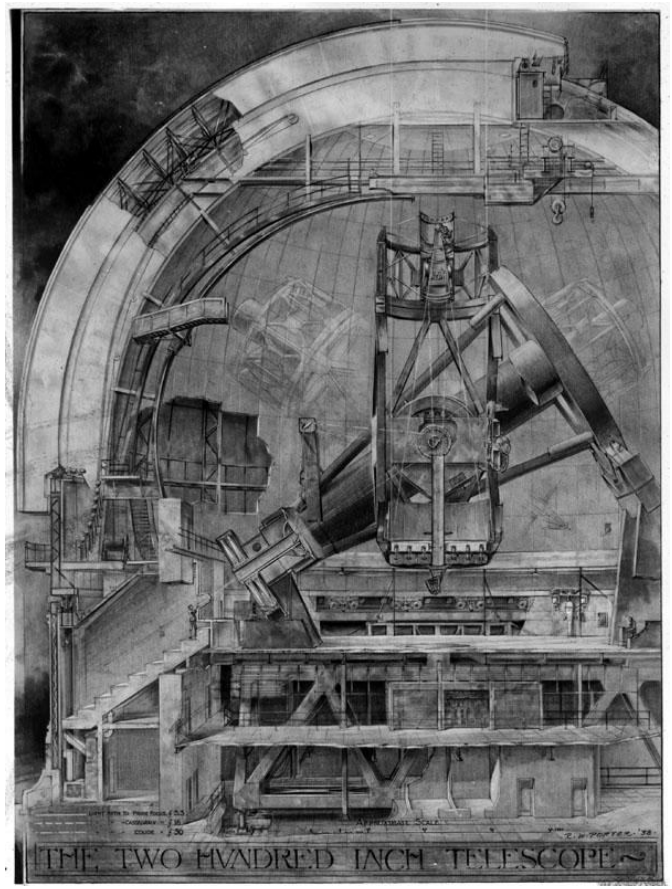
- The Schmidt telescope was invented in 1930 by optician Bernhard Schmidt at the Hamburg Observatory, Germany.
- Palomar was one of the first observatories in the world to utilize this new technology, which enabled astronomers to survey the sky. Given the success of the 18-inch (0.46-meter) Schmidt telescope during the 1930s, resources for building the larger 48-inch Schmidt were committed in 1937 with funds from the 200” project.
- Very prolific in sky surveys that provided targets for 200”

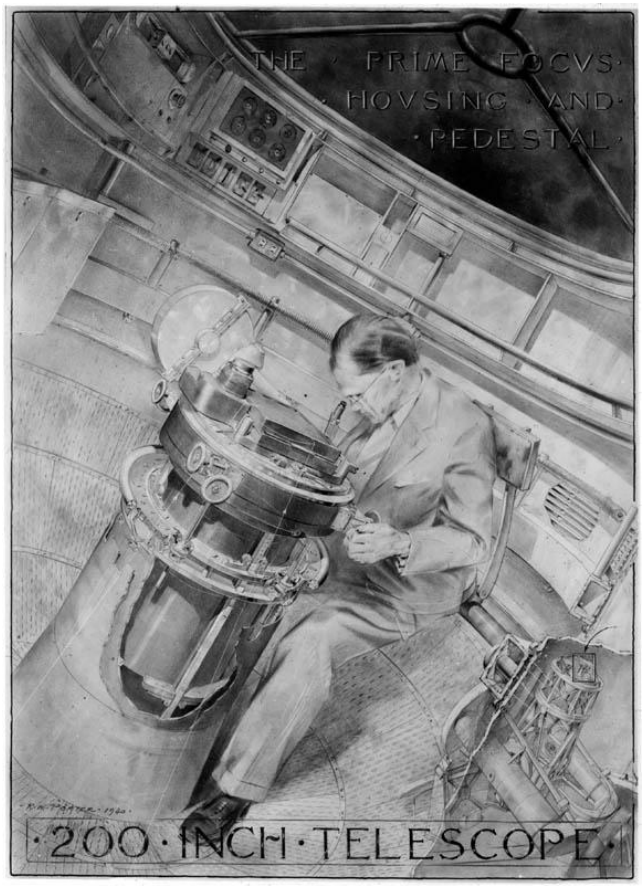
Aluminizing the 200”



Russell Porter



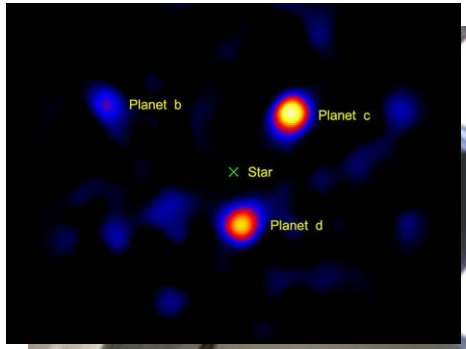




https://stellafane.org/history/early/index.html

Discoveries

- Extragalactic distance measurements by Hubble Sandage and Baade
- Ground-breaking work by Baade, Jesse Greenstein, Rudolph Minkowski, and others led to the identification of distinct stellar populations of different age and elemental composition, which resulted in a new understanding of galaxy formation and stellar evolution.
- Instrumental in the discovery and analysis of quasars and active galactic nuclei in the 60s and 70s
- 1993 Imaged Shoemaker Levi-9 impacts on Jupiter in infrared
- 1994 discovered first brown dwarf
- First adaptive optics system operational around 2000
- 2003 Discovered minor planet Sedna
- In 2009 a red dwarf companion to Alcor was discovered using the 200”
- In 2010 the 200” was able to image three exoplanets using adaptive optics and a coronagraph

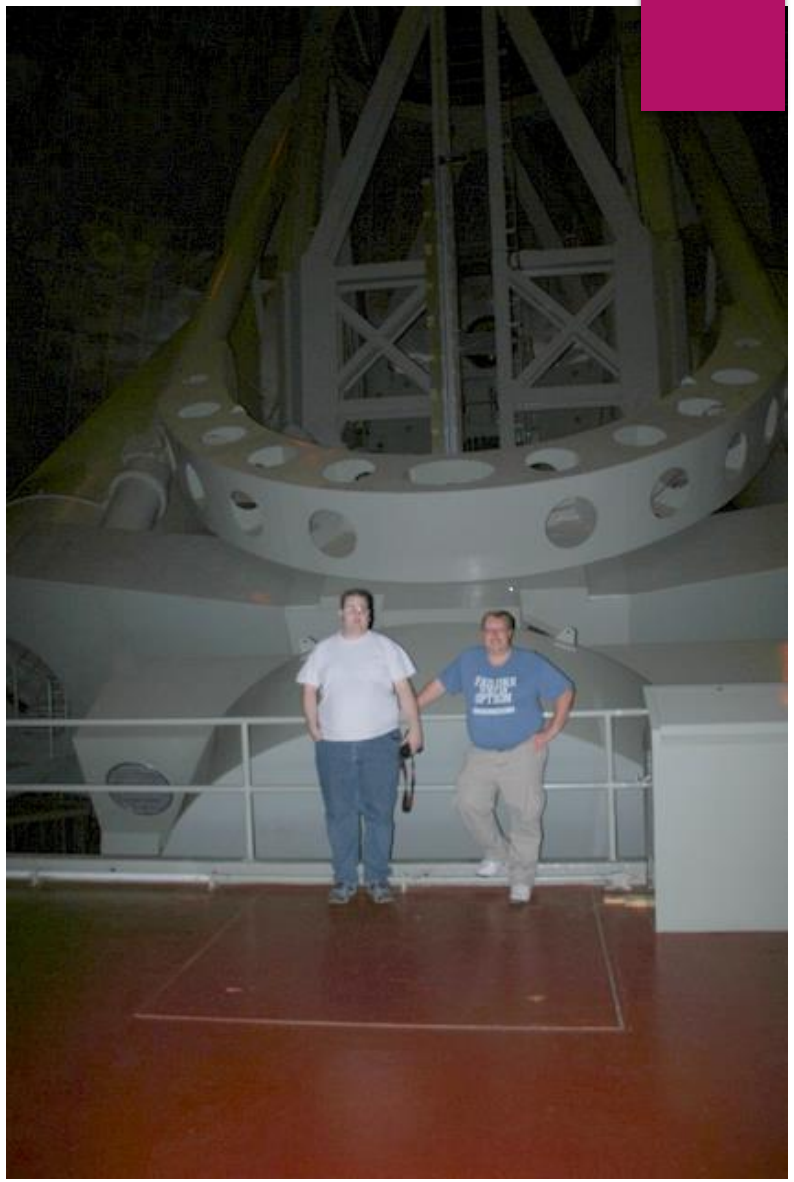


Observing today

- The 200" still an active instrument for scientific research
- Stay at the "Monastery" or remote
- 200" 60" and 48" Samuel Oschin Telescope (Schmidt)
- Details on instruments available on the public web site at Prime or Cassegrain foci
- Prime Focus - Large format camera, Wide field IR camera, Wafer-scale Imager
- Cass - Double spectrograph, Cosmic Web Imager, TripleSpec, PALM-3000, PHARO

A Personal Pilgrimage

- In 2005 Gord and Paul Trudel from Winnipeg Centre were invited to visit California due to work on the 100 Hours of Astronomy web site
- In addition to JPL, star parties (met Al Nagler), Telescope shows (met astronaut Rusty Schweickart), attended a TWAN showing, we also visited Palomar



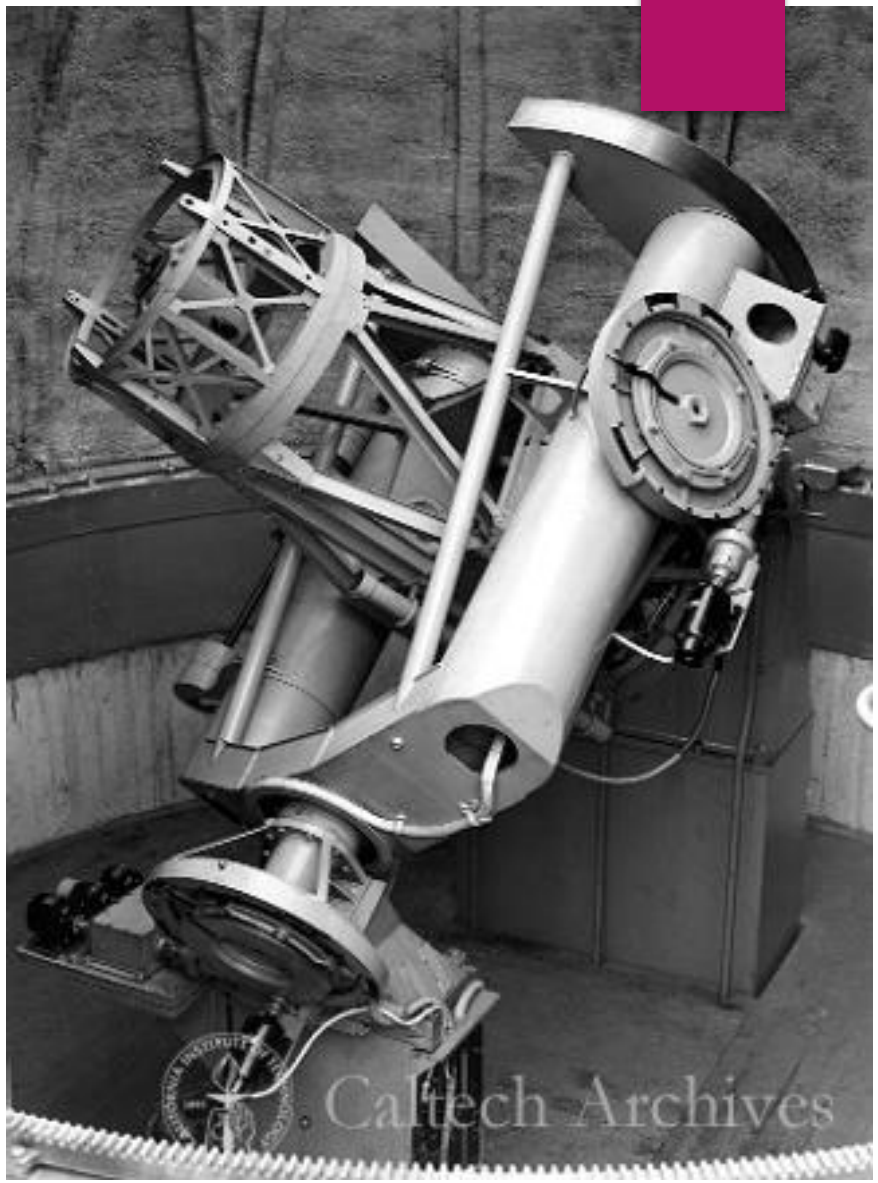

PALOMAR OBSERVATORY
STOP

The World At Night (TWAN)

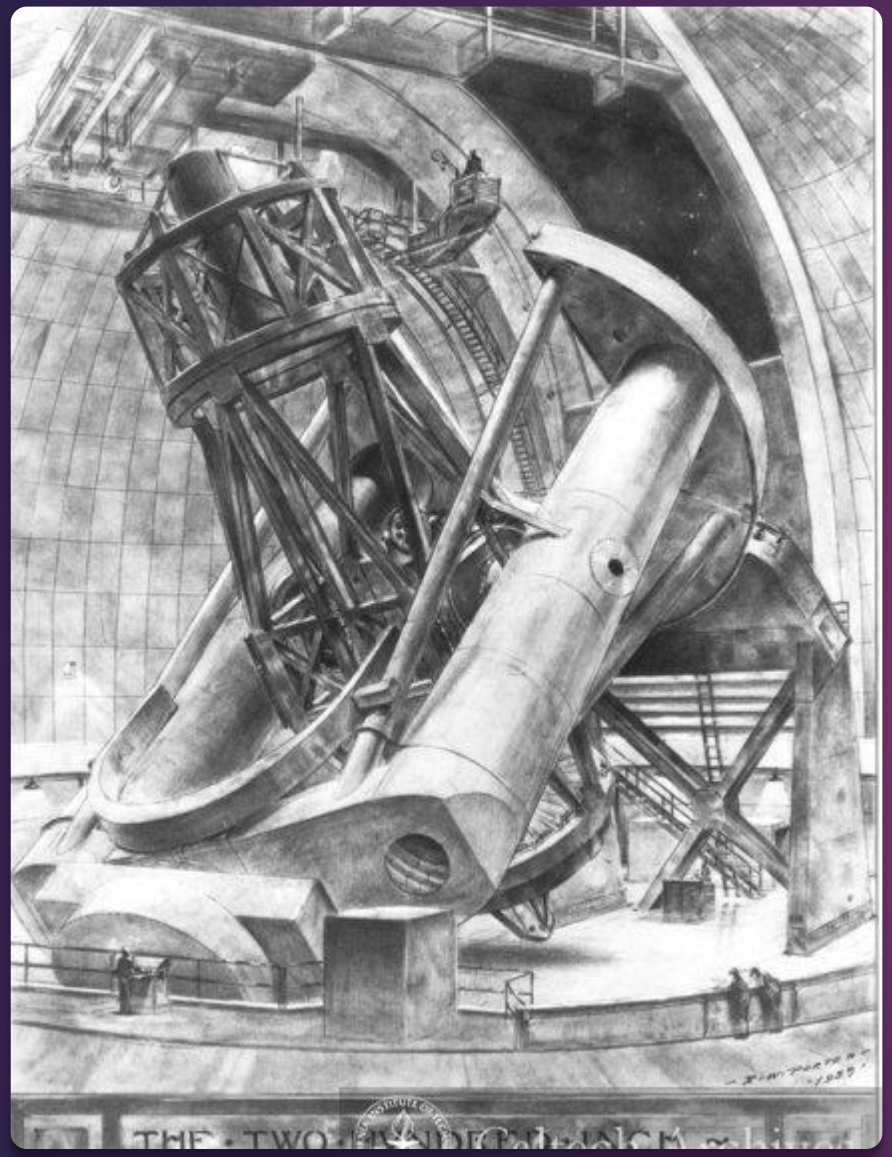
- During our time in Pasadena we met Wally Pacholka at at gallery opening for his astroimages.
- If you haven't seen Wally's work or that of any of the other artists in TWAN, check out: http://twanight.org

Hale Prototype

- A 20” prototype of the Hale telescope was built during the engineering of the full size telescope
- Used by students for many decades in a dome atop the Robinson Astrophysics Building on the Caltech campus
- Now resides in Corning NY at the Corning Community College at the Eileen Collins Observatory



Snowy Plains Astrophysical Observatory 20” Telescope (in develop-ment)



Questions?

http://www.gordtulloch.com
http://www.astro.caltech.edu/palomar
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