



## 200@70

Dr Steve Barrett

SHA 24 Oct 2020

**Cyclops of Palomar**

ROBERT T. EDGAR

Presenting  
"THE CYCLOPS OF PALOMAR"

A Unique, Non-Technical Lecture-Demonstration of the Wonder of the World, the Great 200-inch Telescope on Mount Palomar, California

The Exciting, Dramatic Story of Man's Greatest Scientific Achievement ... Presented in a Forceful, Dynamic Manner by a Master Story Teller.

Authentic - - - Inspiring - - - Entertaining

Time \_\_\_\_\_  
Place \_\_\_\_\_

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Wonder of the World ...

The Exciting, Dramatic Story of Man's Greatest Scientific Achievement ...

Presented in a Forceful, Dynamic Manner by a Master Story Teller.

" Barometer up and humidity down.  
One of those crystal-clear nights  
when the stars fairly crackle — "

Glass Giant of Palomar

David Woodbury 1939

DAVID G. WOODBURY

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**Horsehead Nebula**

1951

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**Contents**

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<b>George Ellery Hale</b>	• Billionaire–whisperer • 40" → 60" → 100" → 200"
<b>Building the 200"</b>	• Selecting a Site • Making the Mirror • Making the Telescope
<b>Operating the 200"</b>	• 70 Years On
<b>Acknowledgements</b>	

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**George Ellery Hale**

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George Hale (1868-1938) had a remarkable life.

His contributions to solar spectroscopy, such as his invention of the spectrohelioscope that imaged the Sun at different wavelengths, were surpassed by his vision and drive to design and construct the largest telescopes in the world.

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**Largest Telescopes in the World**



40" refractor 1900  
Yerkes Observatory



60" reflector 1908



100" Hooker 1918  
Mount Wilson Observatory

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**Birth of the 200"**

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The 100" Hooker telescope was operational in 1918.

Hale now thought bigger... **More light!**

In 1928 he approached the Rockefeller Foundation and persuaded them to pledge \$6 million to build the 200" telescope and observatory.

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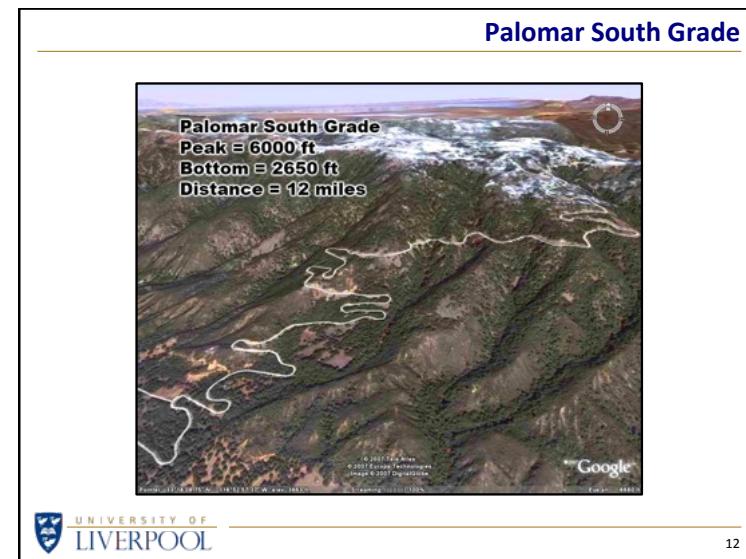
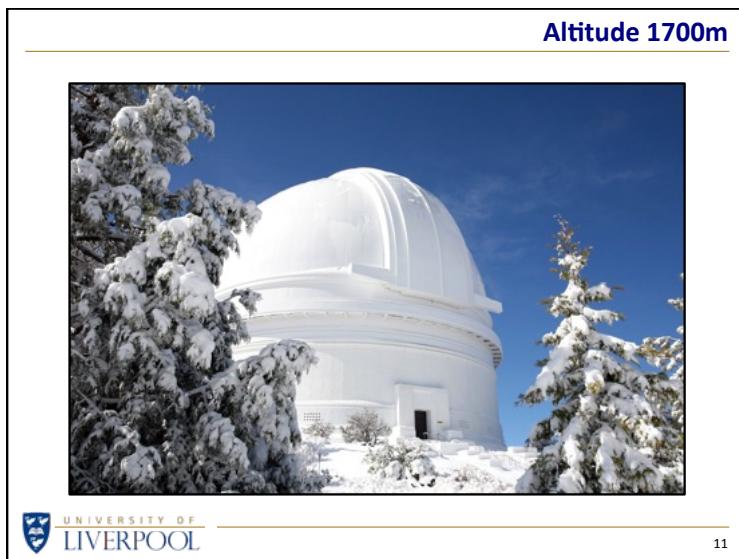
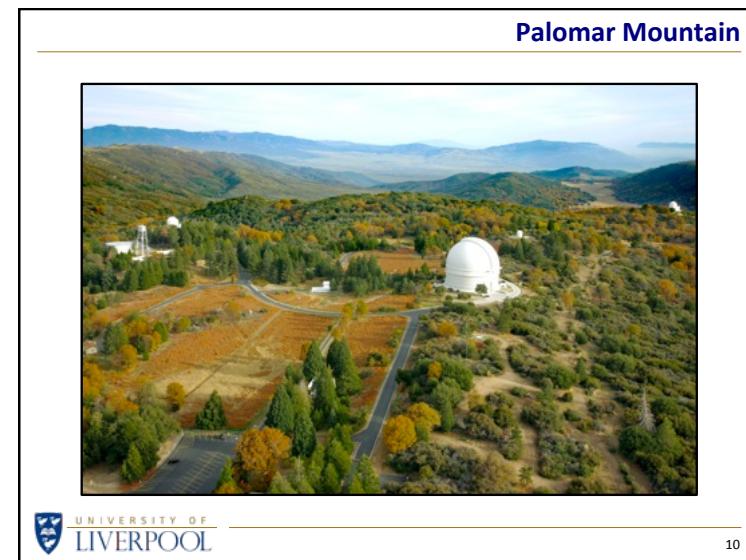
**Selecting a Site for the 200"**

Mount Wilson  
Los Angeles  
Palomar  
San Diego

20 miles

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**Telescope Mounts**

The diagram shows three types of telescope mounts: German, Fork, and English (yoke). Below the diagram are three photographs of the 40", 60", and 100" telescopes in their respective mounts.

German

Fork

English

40"

60"

100"

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**100" Hooker**

Hale did not want the 200" telescope to suffer from the same limitations as the 100" Hooker telescope.

The English (yoke) mount meant that no observations could be made within 30° of the north celestial pole.

More importantly, the plate glass mirror expanded and contracted with changing temperatures, distorting the mirror surface.

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**Horseshoe Yoke Mount**

The photograph shows the 200" Hale telescope on its Horseshoe Yoke Mount. The telescope is oriented towards the North, with the South direction indicated.

South

North

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**100" Mirror**

Can the 100" mirror be scaled up to make a 200" mirror?

Using plate glass would result in the same distortions with changing temperature, so Hale decided on the use of low-expansion glass.

To avoid having a mirror 8 times heavier, it would need to be made with innovative glass-pouring techniques.

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**Making a Mirror**

An empty mould results in a slab of glass that is roughly flat on its top and bottom surfaces.



After cooling to room temperature the glass slab can be ground down to make a curved surface and then coated with a thin layer of aluminium.



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**Making a Ribbed Mirror**

If the mould is first filled with 'cores' made of fire bricks then the glass flows around them.

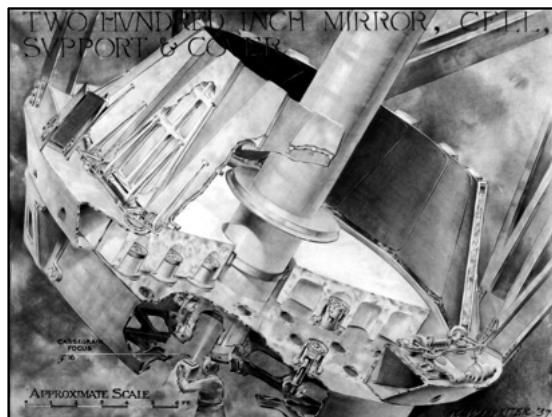


When the mirror has cooled the cores are removed.

The result is mirror with a front surface as before but now with a ribbed back, making it lighter and stronger.



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**Mirror Section**

Russell Porter 1937

19

**Mirror Mould**

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Casting the Mirror



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1934

21

Casting the Mirror

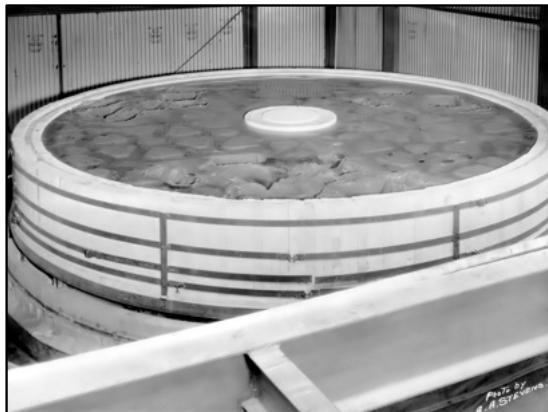


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1934

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First Mirror

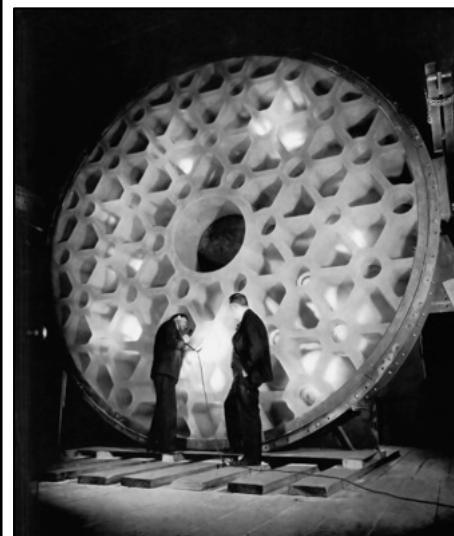


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1934

23

Inspection



The first mirror blank was ruined by pieces of the mould floating to the surface, and by fire bricks falling from the inside wall of the annealing oven onto the mirror surface.

These problems were fixed for the casting of the second blank.

1935

24

**THE EYE THAT SEES**  
6,000,000,000,000,000,000 MILES

Forraine is now due in the autumn of this year and the first of which astronomers will be able to see through the telescope. It is the first time that Mr. Palomar, in his great scheme, has been able to get the telescope up. Mr. Palomar, as you know, is the man who has been working on the telescope for the last ten years. He has now finished the telescope and the glass for the lenses. Now he is working on the mirror blank. This is the first time that Corning has ever made a mirror blank for a telescope.

IN PYREX WARE AND OTHER CONSUMER, TECHNICAL AND INDUSTRIAL PRODUCTS •

**CORNING**  
PYREX  
Research in Glass

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## Corning Advert

Creating the 200" mirror blank from low-expansion Pyrex glass took years of innovation on the part of Corning.

After overcoming problems with the annealing ovens, dealing with a flood of the nearby river and even an earthquake, they were keen to promote the successful casting of the 200" mirror as their flagship project.

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**The Mirror Arrives at Caltech**

1936

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**21 Men – 11 Years**

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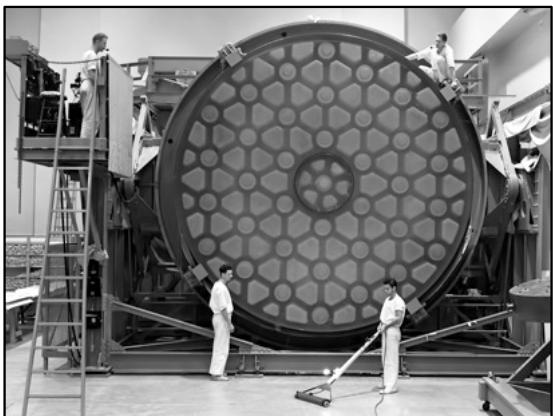
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**Grinding the Mirror Surface**

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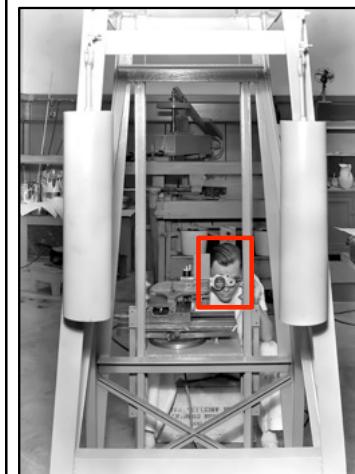
Mirror Vertical For Testing



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Testing the Mirror



As the mirror was slowly ground to  
the correct shape ('figured') it was  
checked using a 'knife-edge' test.



"Resistance is futile"

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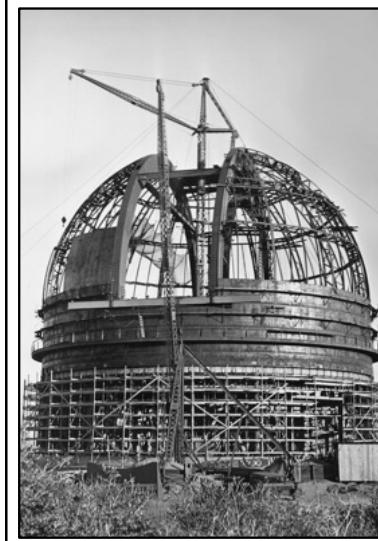
Observatory Building Takes Shape



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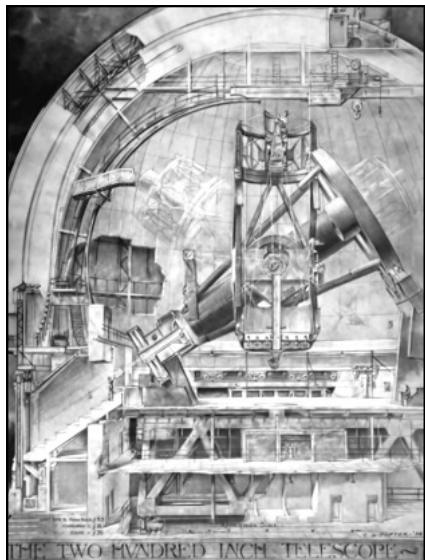
Constructing the Dome



1937

Now it starts to *look*  
like an observatory

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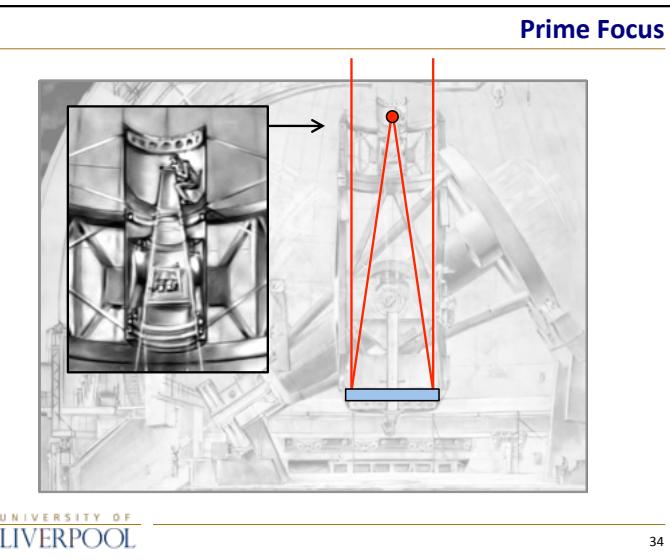
## Palomar Observatory

Cutaway drawing of the 200" telescope and its observatory building by Russell Porter.

In this talk this drawing will be used as a guide to locate some parts of the telescope or mount or observatory.

Russell Porter 1938

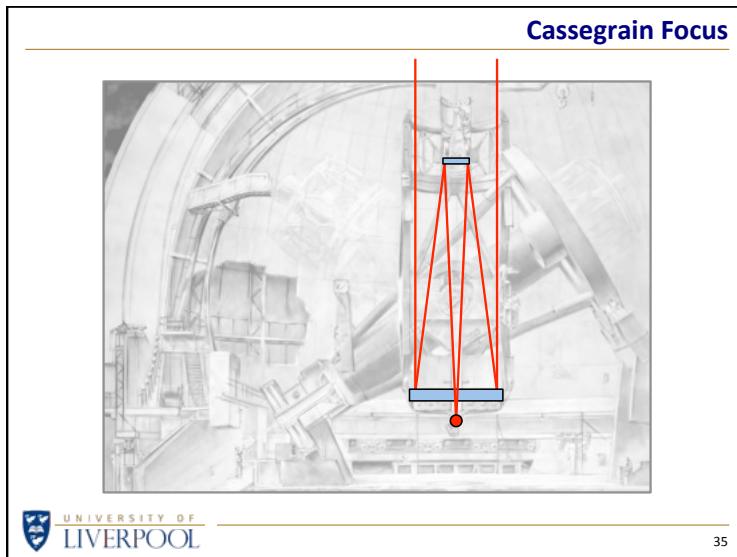
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## Prime Focus

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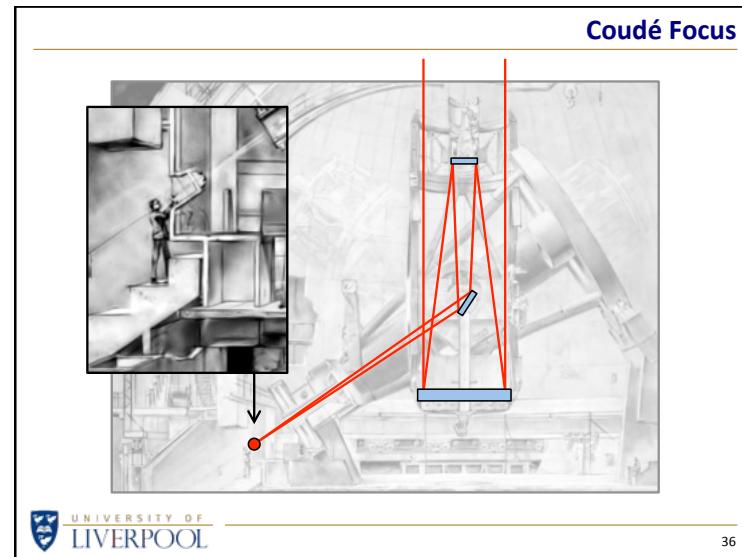
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## Cassegrain Focus

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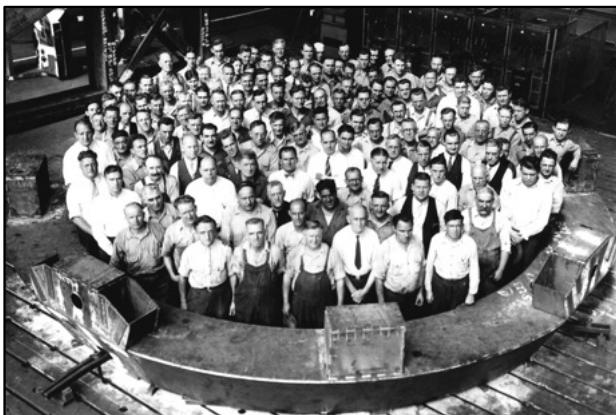


## Coudé Focus

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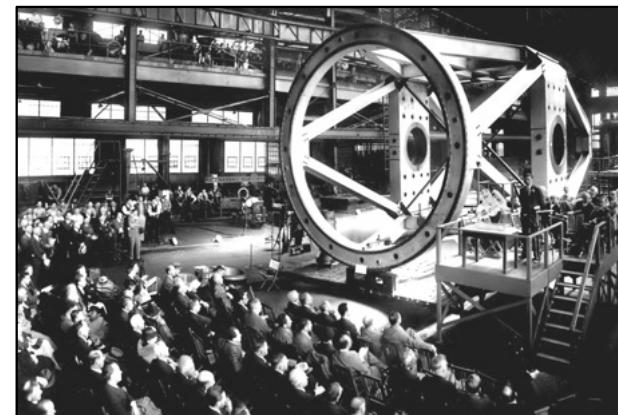
Westinghouse Construction Crew



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Construction at Westinghouse



1937

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Horseshoe Horn

Note the thickness of the curved steel plates forming the inside and outside surfaces.

The 4.5" thick plates were bent to shape in a 12000-ton forge press.

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Checking the Horseshoe



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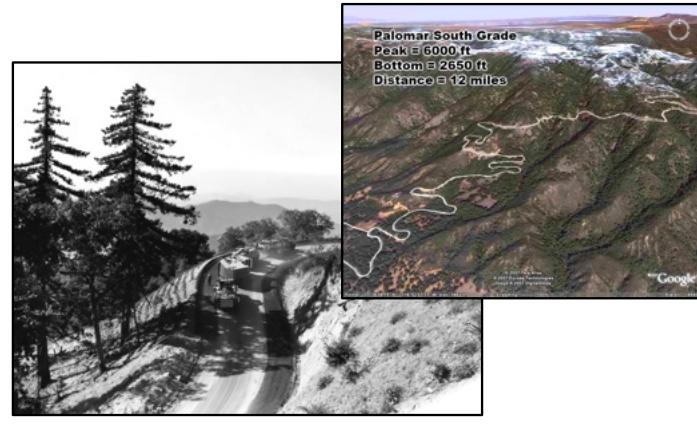


### South Yoke

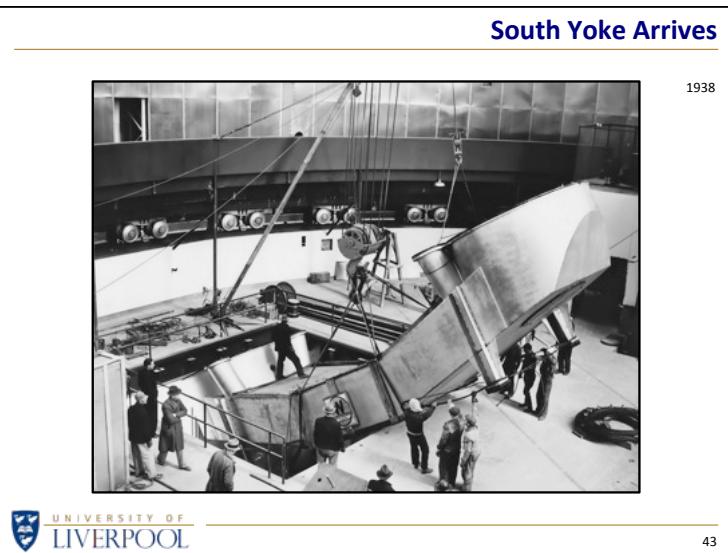
Looking like a huge telephone handset, the south end of the yoke is a bar with a hole for the south polar bearing in the centre.

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### Up To the Observatory



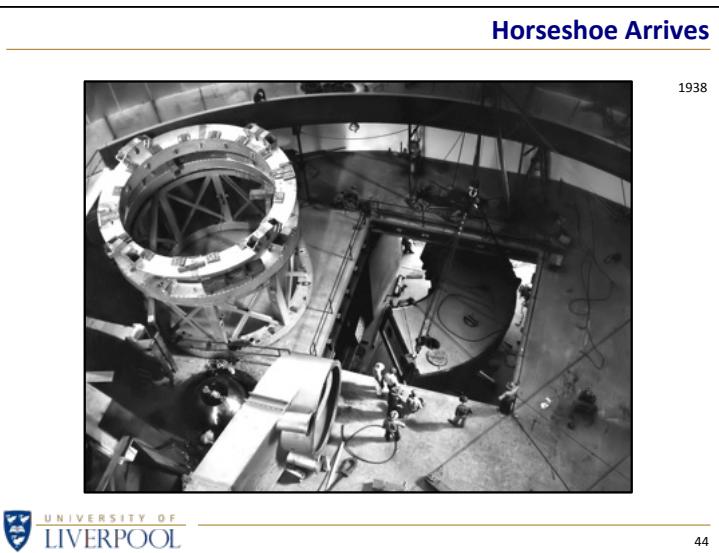
42



### South Yoke Arrives

1938

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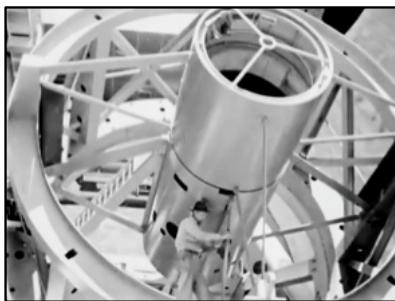


### Horseshoe Arrives

1938

44

Working on the Telescope Tube



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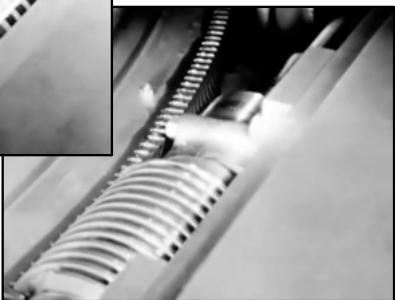
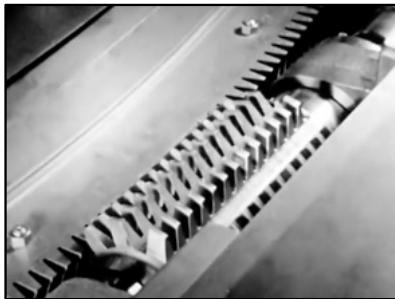
RA Gear Wheel



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Cutting the Gear Teeth



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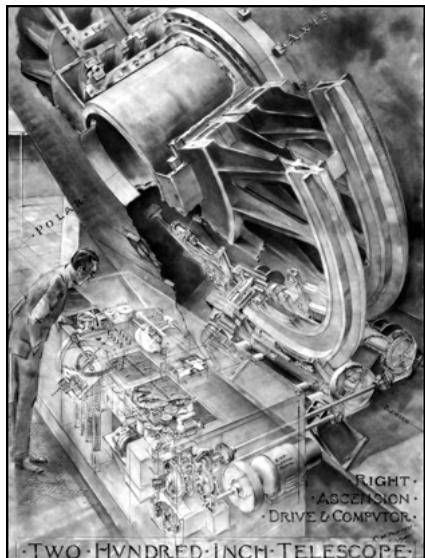
Russell Porter



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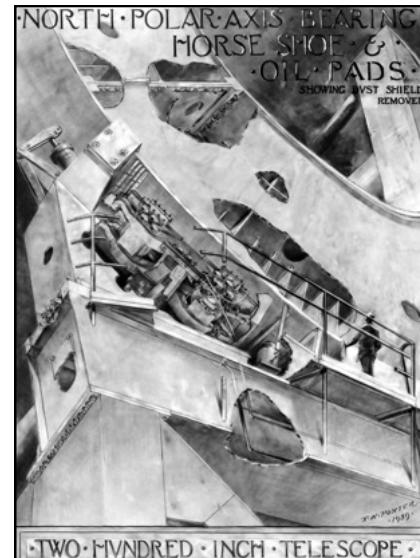
The highly detailed drawings made by Russell Porter between 1937 and 1940 (some of which are shown in the next eight slides) give a unique insight into the design and construction of the 200" telescope.

**RA Drive**

Right Ascension Drive and "Computer", an analogue computer comprising gears and cams that was designed to vary the drive speed automatically to account for very small variations in the apparent positions of the stars, such as those produced by refraction of starlight through the Earth's atmosphere.

Russell Porter 1940

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**Polar Axis Horseshoe**

The massive horseshoe bearing floats on four oil pads so that the friction is reduced to a thousand times less than would be the case for ball bearings or roller bearings.

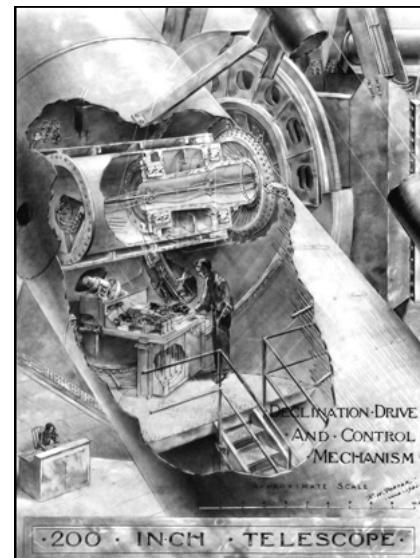
Russell Porter 1939

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**South Polar Bearing**

Russell Porter 1937

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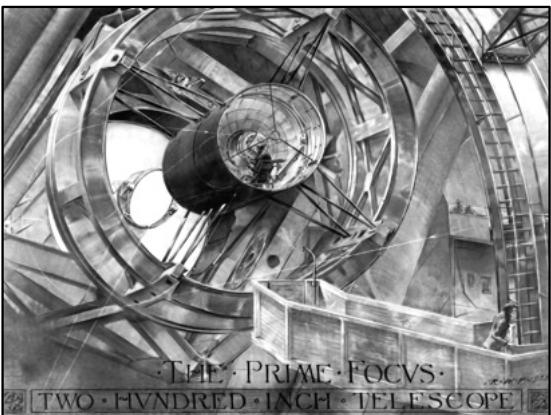
**Declination Drive**

The tubes of the yoke mount are hollow and one of them contains the declination drive motor.

Russell Porter 1940

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**Prime Focus Cage**



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Russell Porter 1938

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**Prime Focus Pedestal**

The pedestal is in the top half of the prime focus cage where the astronomer sits to take photographs.

For long exposures it may be necessary to guide the telescope by watching a guide star and making small manual adjustments to the drive motors.

Russell Porter 1940

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**Prime Focus Mirrors**

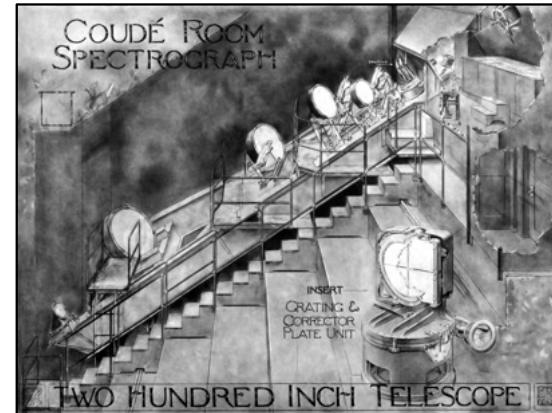
The bottom half of the prime focus cage contains mirrors that fold down into the light path when the astronomer wants to use the Cassegrain or the coudé focus.



Russell Porter 1938

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**Coudé Room**



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### Almost Complete?

Everybody thinks that the telescope is just months from being finished.

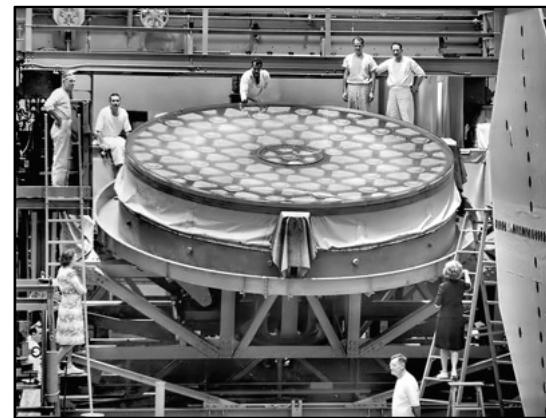
The telescope tube and mount are complete. The mirror has been ground to within a few millionths of an inch of the correct figure.

But ... it is 1941. The USA is about to be dragged into World War II.

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### Mirror Grinding Resumes

1945



58

### Mirror Travels To Observatory

1947



59

### Dedication Ceremony

1948



60

**Final Corrections**



1949

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**Operating the 200"**



Edwin Hubble in the prime focus cage

LIFE

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**In the Prime Focus Cage**



New Comfort in the Strato-Cold

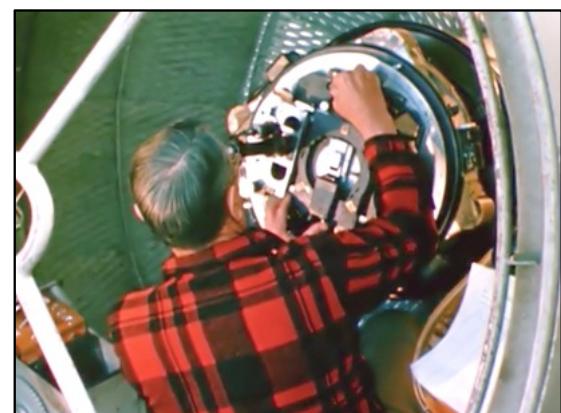
F3-A THE ELECTRICALLY HEATED FLYING SUIT ARMY AIR FORCE TYPE F3-A

A night in the prime focus cage could be a very cold experience

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Herein are some rules and suggestions on the use and care of the AAF Type F-3A electrically-heated flying suit, gathered from the experience of flying men who have worn for you by the LORFIN MANUFACTURING CORP., the suit which has furnished this suit. (See the label on each part of the suit.) For detailed technical data, see the Official Technical Order No. 14-116.

**In the Prime Focus Cage**



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In the Coudé Room



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Main Control Desk



The control desk operated by the  
Night Assistant (in communication with  
the astronomer at the telescope)



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Horsehead Nebula



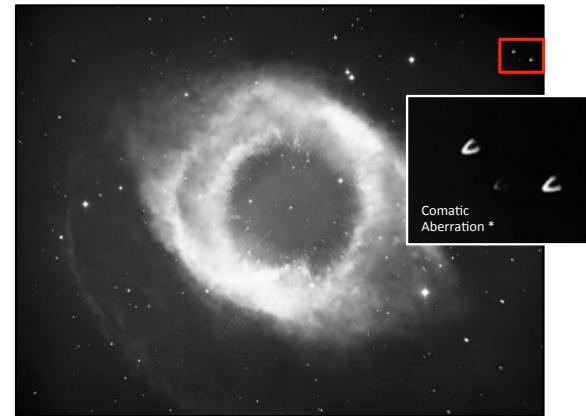
1951



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Helix Nebula



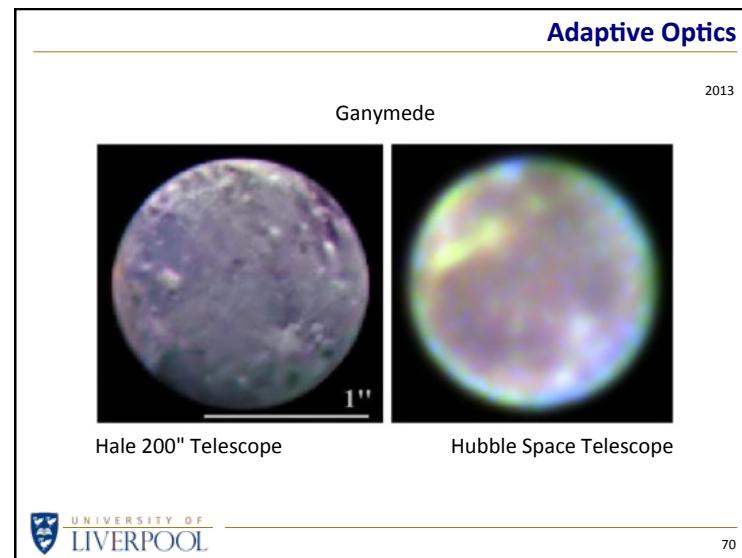
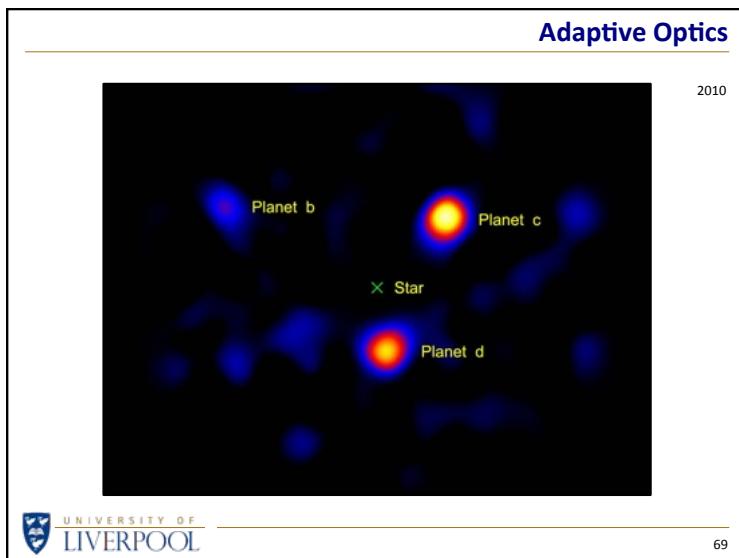
1952



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\* See "Fiat Lux II"

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### Hale Telescope Today



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### Acknowledgements

Caltech archives

[archives.caltech.edu](http://archives.caltech.edu)

[archive.org/details/caltech](http://archive.org/details/caltech)

'Palomar Skies' by Scott Kardel (Public Affairs Coordinator)

[palomarskies.blogspot.co.uk](http://palomarskies.blogspot.co.uk)

Corning Museum of Glass

[www.cmog.org/article/glass-giant](http://www.cmog.org/article/glass-giant)

[www.cmog.org/article/hale-reflecting-telescope-palomar](http://www.cmog.org/article/hale-reflecting-telescope-palomar)

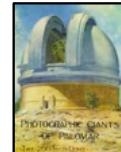


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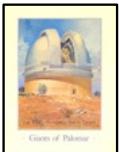
### Acknowledgements



*The Glass Giant of Palomar*  
David Woodbury 1939



*Photographic Giants of Palomar*  
James Fassero and Russell Porter 1952



*Giants of Palomar*  
Russell Porter 1983



*The Perfect Machine*  
Ronald Florence 1995



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