



## Making a reflective telescope



Replica of the first reflective telescope built by Sir Isaac Newton

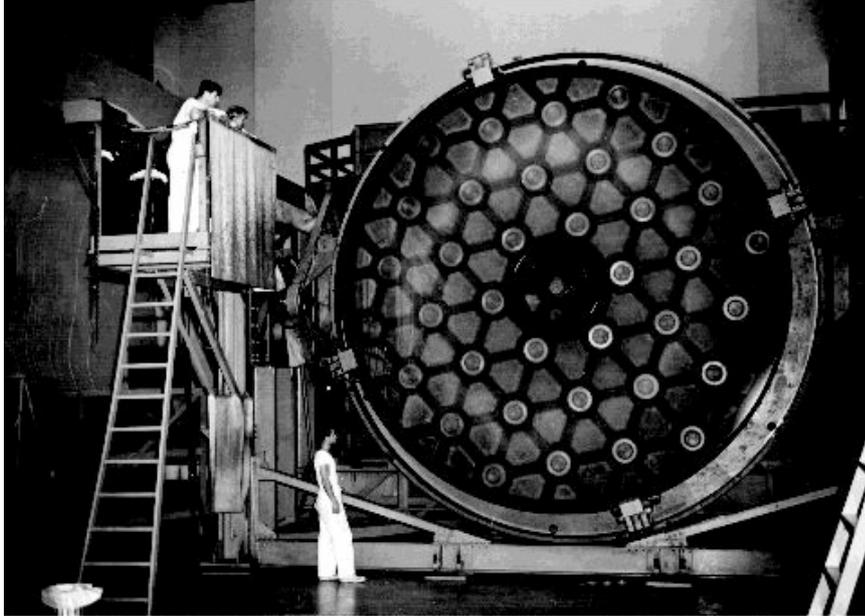
Nowadays, professional astronomers use another type of telescope that is different to the first telescope invented (the refractory telescope.) This other kind of telescope can be over 10m in diameter! It is called a reflective telescope. It was invented by Isaac Newton around 1670.

The main difference is that it uses curved mirrors instead of lenses to collect the light.

Why is the reflective telescope the one most astronomers prefer to use?

The universe is huge and full of stars and galaxies that are so far away they hardly seem to shine, or we can't see them at all. The best way to look at those faraway stars is not to magnify the sky with a refractory telescope, but to gather as much light as possible. If you have ever held a mirror outside in the Sun, you will have noticed that mirrors collect and reflect light very well!

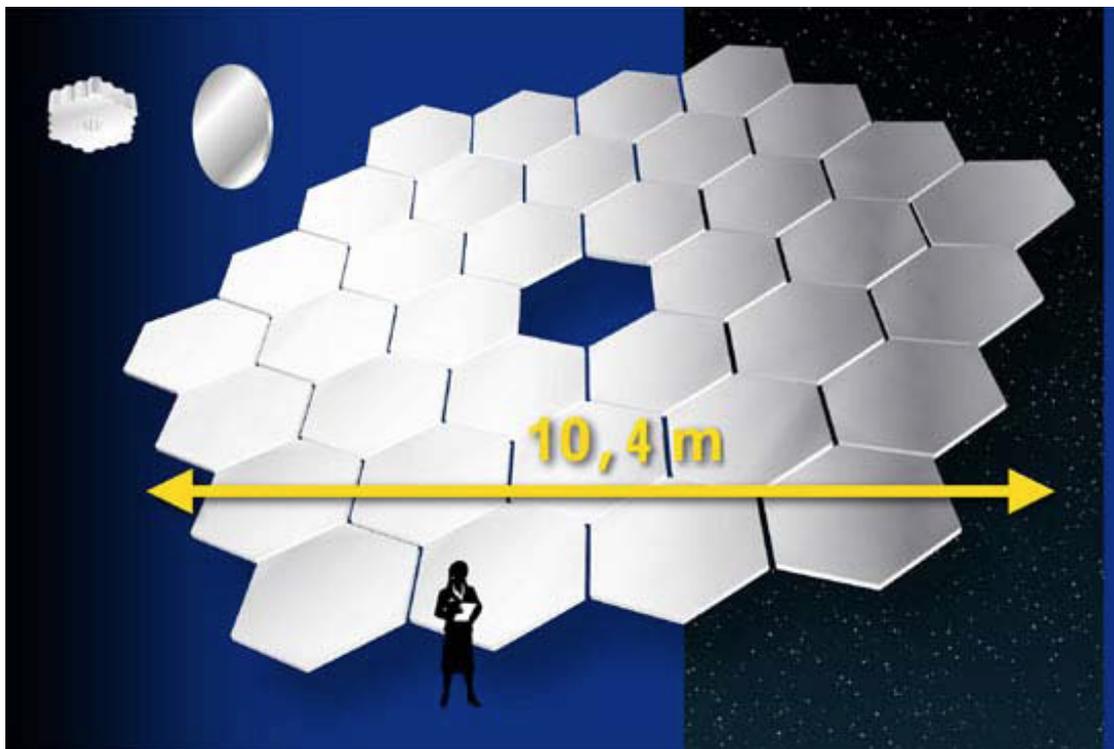




(Source: Caltech archives)

Building the 5 m mirror for the Palomar Observatory, Pasadena

Mirrors have other advantages too. Unlike lenses, the light just has to reflect off one side and not shine through them. This means that they don't have to be supported just around the edges (like a pair of glasses). They can be made really big and still remain steady.



The mirror at the Gran Telescopio Canarias, Observatorio Roque de los Muchachos,



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★ GOAL: To build a simple reflective telescope and note its use of mirrors. To imagine how a professional telescope works.

★ MATERIALS: a concave mirror (with some magnification), like the ones you have in the bathroom.

- a small magnifying glass like the ones used by stamp collectors.
- a thick cardboard tube, equal to the focal length of the mirror
- 2 smaller tubes about 10 cm in length and 2 to 3cm in diameter.
- a 2 cm x 2 cm flat mirror
- a thin wooden dowel (not rounded!) or chopstick with edges
- a tape-measure
- double-sided tape
- gaffa tape ( strong)
- masking tape (easy to use on cardboard)
- scissors
- cardboard cutter



★ AGE GROUP: Supervised, indoor/outdoor demonstration and group activity for 7 years and up.





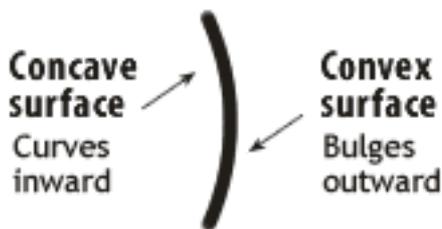
(source: Caltech archives)

Polishing the 5 m mirror destined for Paloma Observatory. Opticians removed over 4,500 kilos of glass before they achieved the perfect form.

*\*A quick word about mirrors*

The quality of reflective telescopes depends a lot on the perfection of the mirror surface.

Technicians spend hours and hours of precise and painstaking work grinding and polishing the mirrors to achieve the 'concave' 'curve that they need.



(A concave mirror has a shallow dip on one side causing light rays to meet or merge.)

Since the ordinary type of concave mirrors that we are going to use (the ones you have in the bathroom) are not of good quality, the resulting telescope is not going to resemble the ones used by research astronomers. But you will get the idea of how they work!

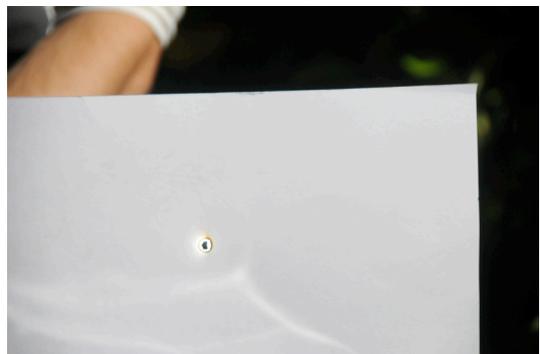


WHAT TO DO:

- First we need to know the 'focal length' or 'focal distance' of the concave mirror. Go outside on a sunny day and find a spot with the Sun in front of you. Face a wall.



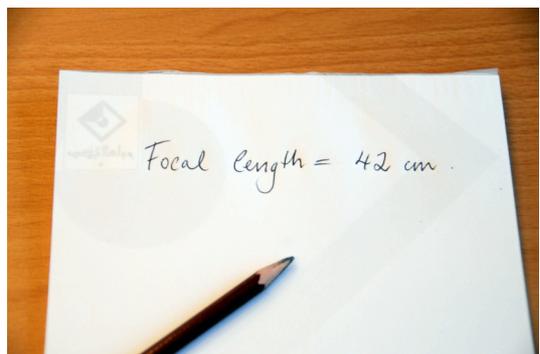
- Watching the wall ONLY, raise your hand and hold your mirror until it catches the light. If you use a piece of paper for your 'wall' you will notice how the reflected heat of the Sun can actually burn a hole in the paper. This is why we NEVER look at the Sun.



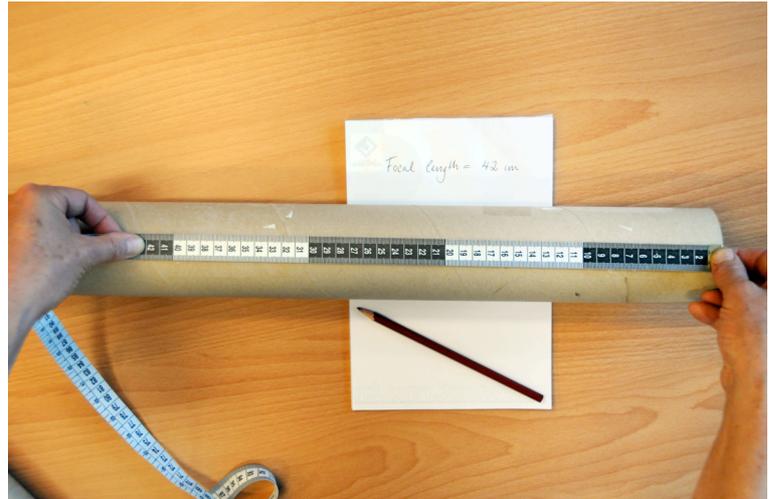
- Focus the mirror onto the wall, and adjust it back and forth until you can see the Sun like a very fine point. The distance between the mirror and the wall is the 'focal length'.



- Ask a friend to measure it with a metric tape. Write down the focal length, this is VERY important!



- Find a cardboard tube with a diameter similar to that of the concave mirror. It must also be at least as long as the focal length you have just measured.



- Fix the concave mirror in one of the tube ends, with its surface turned inwards.



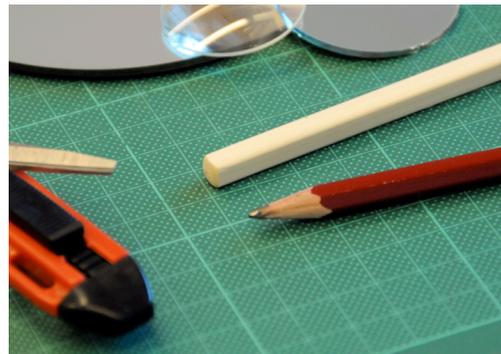
- From the position of the mirror, make a mark on the tube that measures 10 cm BEFORE that of the entire focal length. Make a hole at the 10 cm mark with a diameter equal to the small cardboard tube. This will be where you place the 'ocular' or eyepiece.



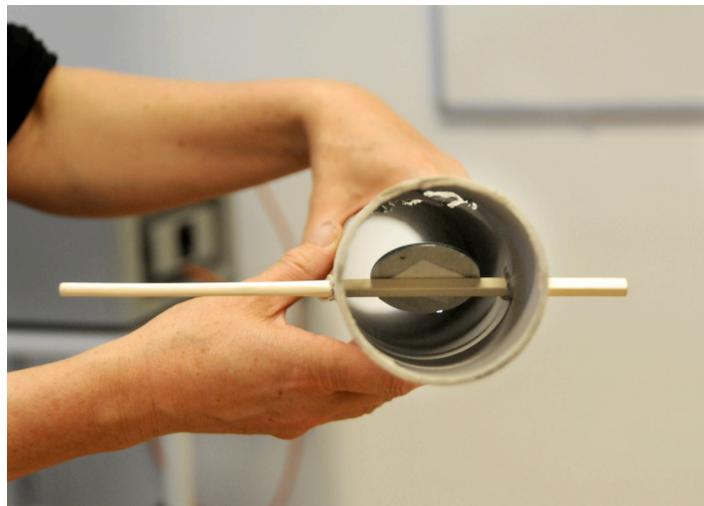
- From the top of the ocular hole, trace a line 90 degrees downwards and mark the point. Do the same on the other side.



- Make 2 small holes at these points and poke the thin piece of wood all the way through. It is important that the rod not be smooth but have an edge.



- Put some double-sided tape on the back of the flat mirror and introduce it through the ocular hole. Attach it to the chopstick or dowel so that it forms an angle of 45 degrees with the diameter of the big tube. This way it will deflect the rays coming from the mirror, introducing the rays in the small ocular.



- Make your ocular or eye-piece in the following way.  
( this is exactly the same way as you make the eye-piece in a refractory telescope).

- Cut along the entire length of one of the tubes.  
This is Tube #1.



- Hold the tube directly over the magnifying glass.



- Grip the tube tightly to make it smaller in diameter (make the cut edges overlap) so that the lens is held securely in place.



- Attach the lens from the magnifying glass securely to the end of Tube # 1. This will be your 'eyepiece' the part which you will use to observe with.



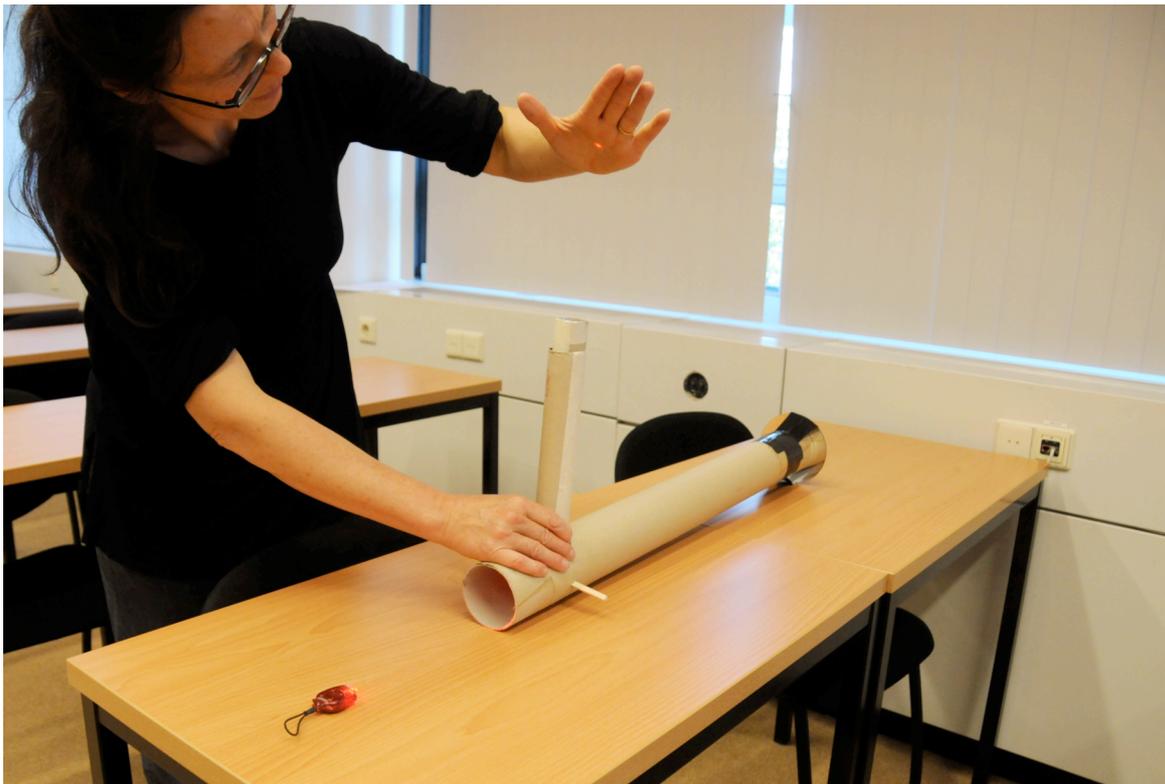
- Put Tube #1 inside the second tube and check to see that it slides easily up and down. Once you are sure that the lens in Tube #1 is secure, and that the tube can move snugly inside the second tube ( the tube which is not cut), tape all along the cut border.



- The small tube must be able to slide in and out neatly in order to focus the final image.



- Direct the telescope towards an object and observe it by using the small tube. Move the ocular back and forth until you see the object focused. In the picture below, imagine that the small red lamp is a star or a planet! Its light is collected by the concave mirror which reflects it back onto the flat mirror which in turn reflects it onto the hand through the ocular.



Source: Ricardo Moreno, UNAWE en español

UNAWE is an international programme to inspire young underprivileged children with the beauty and scale of the universe. Universe Awareness illustrates the multicultural origins of modern astronomy in an effort to broaden children's minds, awaken their curiosity in science and stimulate global citizenship and tolerance.

Universe Awareness is imagination, excitement and fun in the universe for the very young.

