Gregorian Telescopes

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The Gregorian telescope was invented by the Scottish mathematician and astronomer **James Gregory** in 1663, when he published the design in his work ***Optica Promota*** (Figure 1).

James Gregory was a contemporary of Isaac Newton, and both often worked simultaneously on similar projects. Gregory's design was published in 1663 and pre-dates the first practical reflecting telescope, the Newtonian telescope, built by Sir Isaac Newton in 1668.

Gregory's design was only a theoretical description, and he never actually constructed the telescope. It was not successfully built until five years after Newton's first reflecting telescope[1].

James Gregory (1638–1675) was one of the early pioneers of modern optics. Born in Drumoak, Aberdeenshire, he showed exceptional mathematical talent from a young age. After studying at Marischal College in Aberdeen, he travelled to London and then to Italy, where he worked with leading scientists of the time.

In 1663, at just 24 years old, he published *Optica Promota*[2], the book in which he introduced the design of the Gregorian reflecting telescope. Although Gregory never built the telescope himself, his design was later successfully constructed by Robert Hooke, proving its practicality.

Gregory[3] made significant contributions to mathematics as well, including early work on calculus, infinite series, and trigonometric functions. He later became a professor at the University of St. Andrews and then at the University of Edinburgh.

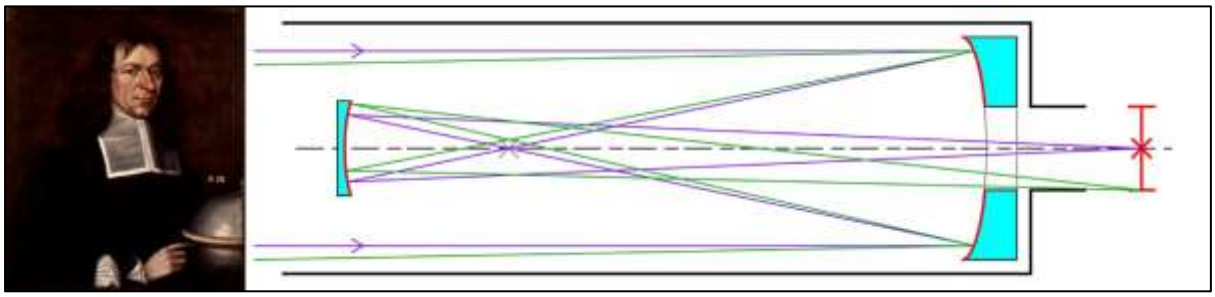

Figure 1 - James Gregory (1638–1675) and the Gregorian Telescope.

[1] Although Gregory conceived the idea, he never built one himself; the first working model was constructed later by Robert Hooke in 1673.
[2] *Optica Promota* ("The Advance of Optics") is a scientific work published in 1663 by the Scottish mathematician and astronomer James Gregory. It's historically important because it introduced: (i) The Gregorian reflecting telescope; (ii) Early ideas related to diffraction, refraction, and optical theory; (iii) Mathematical treatments of lenses and mirrors that were ahead of their time.
[3] His life was short, he died in 1675 at the age of 36, but his influence on optics and mathematics has been long-lasting.

What is a Gregorian Telescope

A **Gregorian telescope** is a design created in 1663 by **James Gregory**, a Scottish mathematician and astronomer. It was first successfully built later by **Robert Hooke** in 1673.

How It Works

It uses **two concave mirrors**:

- **Primary mirror**: a concave paraboloid that gathers light and brings it to a focus.
- **Secondary mirror**: a concave ellipsoid placed beyond the primary focus. It reflects the light back through a hole in the primary mirror.

This arrangement produces an **erect (upright) image**, which makes the design useful not only for astronomy but also for **terrestrial viewing**.

Key Advantages

- **Erect image** without needing prisms
- **Observer stands behind the primary mirror**, making viewing more comfortable
- **Good for solar telescopes** because a field stop can be placed at the primary focus to reduce heat load
- **Easier for amateur telescope makers** than a Cassegrain, since both mirrors are concave and testable

Modern Use

While largely replaced by the Cassegrain design for many applications, Gregorian optics are still used in:

- Some **spotting scopes**
- Large research telescopes like the **Magellan telescopes**, **Large Binocular Telescope**, and **Daniel K. Inouye Solar Telescope** [4]

The Gregorian design solved the problem of viewing the image in a reflector by allowing the observer to stand behind the primary mirror. This type of telescope produces an erect image, making it useful for terrestrial observations. It also functions as a telephoto lens, with a tube much shorter than the system's actual focal length.

In the Gregorian design, the primary mirror forms a real image before the secondary mirror. This allows a field stop to be placed at that location, preventing light from outside the field of view from reaching the secondary mirror. This is a major advantage for solar telescopes, where a field stop (a

[4] https://nso.edu/telescopes/inouye-solar-telescope/ The Daniel K. Inouye Solar Telescope on Maui, Hawaii , is the world's largest solar telescope, designed to advance understanding of the Sun's dynamic behaviour. Its off-axis optical system and advanced polarimetry enable the first continuous measurements of magnetic fields in the solar corona. The four-meter primary mirror and high-resolution instrument suite capture unprecedented images of the solar surface and lower atmosphere, revealing features three times smaller than previously observable. Alongside its imaging power, the telescope's spectroscopic capabilities allow detailed study of atomic and ionic signatures across the solar atmosphere, offering new insights into the processes driving solar activity.

"Gregorian stop") can reduce the amount of heat reaching the secondary mirror and subsequent optical components. The Solar Optical Telescope on the Hinode satellite is one example of this design.

For amateur telescope makers, the Gregorian can be less difficult to fabricate than a Cassegrain because its concave secondary mirror is Foucault-testable like the primary, unlike the Cassegrain's convex secondary.

The first working Gregorian telescope was constructed by Robert Hooke in 1673. Hooke's craftsmanship finally proved that Gregory's design was practical.

After Hooke, many opticians and instrument makers produced Gregorian telescopes (Figure 2 and 3), especially in the 18th century, including:

- John Hadley (1682/1744)– improved mirror-making techniques
- James Short (1719/1768)– famous for extremely high-quality Gregorian reflectors
- Dollond family[5] – major optical instrument makers in London

These makers helped the Gregorian design become widely used for astronomy and terrestrial viewing.

Figure 2 - Pocket brass Gregorian reflecting telescope, speculum mirror, in leather case, unsigned, English, 1740-1800. Science Museum Collection, London.

[5] The Dollond family firm was established in 1750 when a small optical workshop was opened in Spitalfields. The growing demand for high quality optical apparatus necessitated several moves in the eighteenth and nineteenth centuries. The business became a limited company in 1907 and amalgamated with the firm of Aitchison in 1927.

Figure 3 - Gregorian reflecting telescopes. Science Museum Collection, London.

Figure 4- Gregorian Telescope (*circa* 1800). Personal collection Pedro Ré.

Figure 5- Gregorian Telescope (*circa* 1800), speculum mirror. Personal collection Pedro Ré.

Figure 5- Gregorian Telescope (*circa* 1800), eyepiece. Personal collection Pedro Ré.

Figure 6- Pocket Gregorian Telescope (*circa* 1800). Personal collection Pedro Ré.

Figure 7- Pocket Gregorian Telescope, speculum mirror & eyepiece (*circa* 1800). Personal collection Pedro Ré.

Figure 8- Pocket Gregorian Telescope, speculum mirror & eyepiece (*circa* 1800). Personal collection Pedro Ré.

Figure 9- Pocket Gregorian Telescope (*circa* 1800). Personal collection Pedro Ré.