

Chapter 2

Herschel's Telescopes

Early Instruments

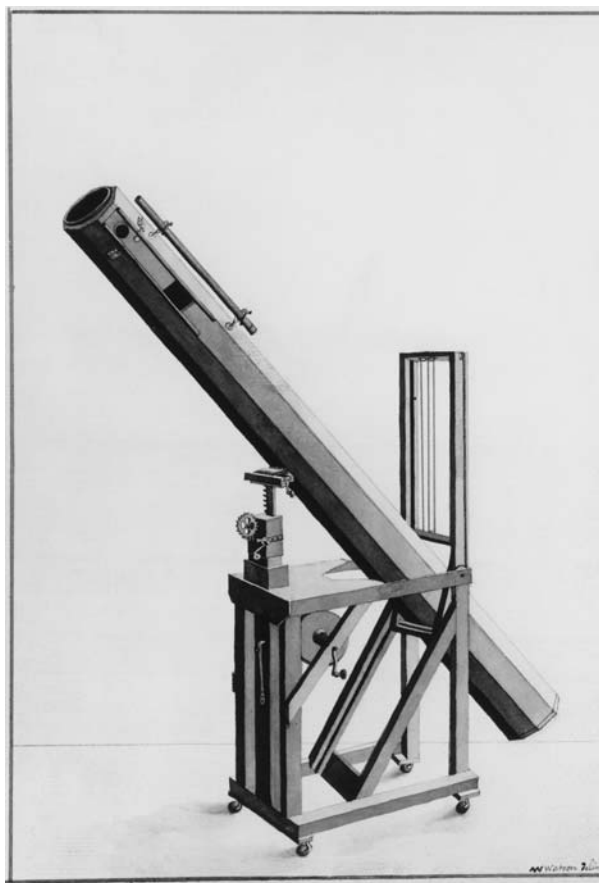
William Herschel began his telescope-making career in 1773 by experimenting with relatively small refractors (small in aperture, but certainly not in length – one of them being 30 feet long!). As these were then still optically primitive compared to today's instruments, he soon turned his attention toward reflectors. These could be made in larger sizes and without concern for the quality of optical glass, for they used mirrors instead of lenses. But these were not the familiar telescope mirrors of today, as silver-on-glass optics did not appear until long after Herschel's death. Instead, they were made of speculum metal – a brittle and hard casting composed mainly of copper and tin. He first made several mirrors for a 5.5-foot Gregorian reflector, but then turned to the simpler Newtonian form. All of his telescopes from that point on were long-focus Newtonians of ever-increasing size, culminating in the great 40-foot reflector (see below).

He soon produced a 7-foot telescope (as previously mentioned, telescopes in Herschel's day were specified by their length rather than by the size of their optics), probably of around 6-in. aperture. He also made several 9-inch mirrors for a 10-foot reflector (and much later a 10-foot reflector with a 24-inch mirror), followed by 20-foot models having 12- and 18.7-inch mirrors as described below. But his favorite early reflector was another 7-foot which contained “a most capital speculum” as he described it of 6.2-inch aperture. This is the telescope that he used for his first “review” of the heavens and the one with which he discovered the planet Uranus (Fig. 2.1).

A Telescope-Making Business

Herschel's telescopes far surpassed in both quality and size any other telescope in the world at that time. After comparison trials at a number of observatories in England including Greenwich, he stated with confidence “I can now say that I absolutely have the best telescopes that were ever made.” His fame as a telescope-maker spread rapidly and soon he was flooded with requests from both other observers and observatories to make instruments for them. While he was not in the telescope-making business as such, his allowance from the King – while freeing him from his musical duties – did not entirely meet his expenses, and so he began to make and sell telescopes privately. In addition to at least 60 complete instruments (most of them 7- and 10-feet in size), he also made several hundred mirrors upon order in addition to those for his own telescopes!

Fig. 2.1. The 6.2-in. “7-foot” reflector with which William Herschel discovered the planet Uranus on the night of March 13, 1781. Like all of his telescopes, it employed a speculum-metal mirror that was ground, polished, and figured with his own hands. Courtesy of the Royal Astronomical Society/ Science Photo Library, London.



While most of the objects Herschel discovered in his first review of the heavens with his prized 7-footer were double and multiple stars, he also found a number of his early clusters and nebulae with it. (It should be mentioned here that in his day and long thereafter, galaxies were not yet recognized as such, being simply lumped under the category of “nebulae.”) It is frequently stated that a modern 6- to 8-inch telescope will show a large percentage of the objects in the Herschel catalog (including many of his faint and very faint nebulae), and that a good 12-inch telescope should reveal every one of them even though most were found using his two 20-foot instruments. This is largely possible, of course, due to the much higher reflectivity of today’s coated-glass telescope mirrors – and to a lesser extent to modern eyepieces as well. (Herschel primarily used single-lens oculars,* multiple-element

*As a fascinating aside, Herschel often mentioned using very high magnifications for his solar system and double star studies employing these simple eyepieces – in some cases in excess of 6,000×! While many in his time doubted these claims, modern optical tests on his eyepieces prove that he did, indeed, achieve such remarkable powers. One of his surviving oculars actually has a focal length of just 0.0111 in.! But no one was more aware of the limitations of high powers than he, and most of his observing (even with his large instruments) was conducted at magnifications under 300×.

designs and antireflection coatings laying far in the future.) The author fully agrees with this assessment based on years of viewing these wonders with telescopes ranging from 2- to 14-inches (and on occasion up to 30-inches!) in aperture.

The Small and Large 20-Foot

Herschel's two "workhorse" telescopes – those used for all his later various reviews of the heavens – were his 20-foot reflectors. The earlier and smaller of these in terms of aperture (referred to as the "Small 20-Foot") used 12-inch mirrors, while the larger and later instrument (called the "Large 20-Foot") used 18.7-inch mirrors. Note that "mirrors" is plural, since several were needed for each telescope – the one currently in use, and at least one in the process of being repolished and refigured due to the rapidity with which speculum-metal tarnished (Fig 2.2)!

The one with 18.7-inch mirrors became his most useful telescope and in later years he even preferred it to the massive 40-foot one, for it was both much easier to use and the mirrors performed better (not to mention that they were also vastly easier to make and keep ready). It was in constant use on clear nights from dusk to dawn, revealing over 2,000 previously unknown star clusters and nebulae. Due to the huge light-loss at each reflected surface, Herschel eventually decided to dispense with the secondary mirror in the Newtonian form. Instead, he tilted the primary mirror so that its focus could be examined off-axis directly at the front of the tube – a form he referred to as the "front-view." This concept is still used in some amateur-made as well as commercial telescopes today, but instead of being called the "front-view" form it is now known as the "Herschelian" in honor of its inventor. And while loss of reflectivity is not the concern today it was in his time, moving the secondary mirror and its support out of the optical path essentially gives

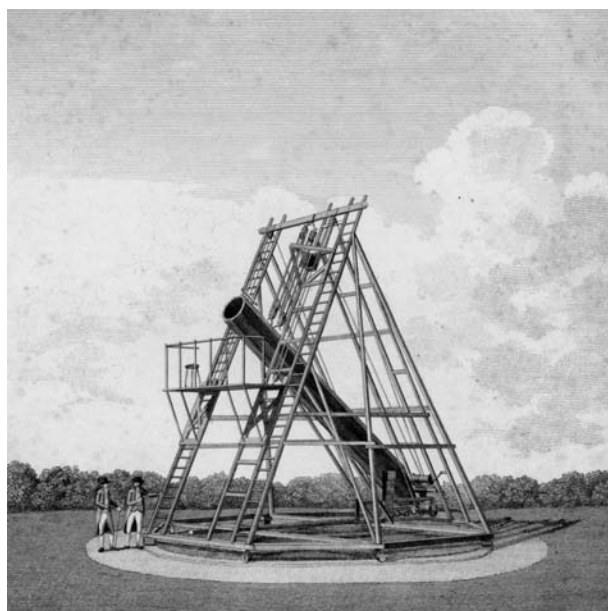


Fig. 2.2. The "Large 20-foot" reflector had an aperture of 18.7 inches. This was Sir William's most useful instrument and the one with which he discovered most of his clusters, nebulae, and galaxies. (He called it "large" to distinguish it from another earlier 20-foot reflector that used a 12-inch mirror.) Courtesy of the Royal Astronomical Society/Science Photo Library, London.

the unobstructed performance of a refractor combined with total freedom from the color aberrations inherent in lenses.

The Great 40-Foot

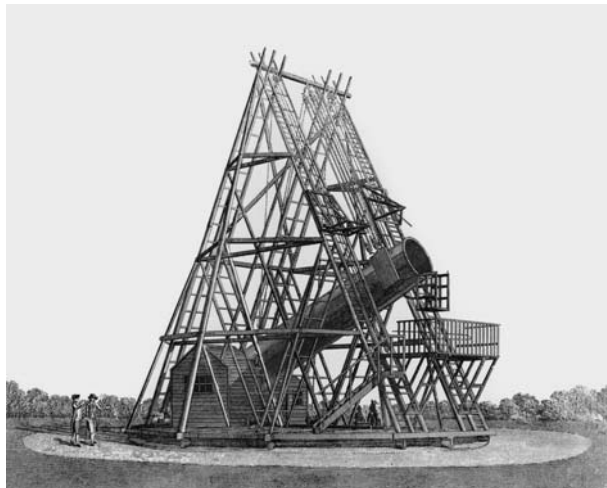
Herschel's most ambitious telescope-making project – indeed, the most ambitious in history up to that time – was the construction of his great “40-Foot” reflector with its 48-inch (or 4-foot) diameter mirror (resulting in a focal ratio of $f/10$). He received financial support for this massive undertaking from the King, as well as an annual allowance for upkeeping the telescope once it was completed. Herschel actually made several mirrors for it before he finally was able to get one that would take an acceptable polish and figure (Fig 2.3). (Interestingly, Herschel had much earlier tried to make a mirror for a proposed 30-ft telescope, but gave up on the idea after several near-disastrous events that occurred during attempts at casting it.)

In 1787, Herschel climbed into the mouth of the huge tube and searched for the focus using one of his first mirrors. His target was the Orion Nebula, which he described as “extremely bright” but the figure was far from perfect. On later attempts he used Saturn as his test object, discovering several new satellites while at it. Some idea of the light-grasp of this instrument can be had from this famous description by Sir William of the star Sirius as seen through it:

... the appearance of Sirius announced itself, ... and came on by degrees, increasing in brightness, till this brilliant star at last entered the field of view of the telescope, with all the splendour of the rising sun, and forced me to take the eye from that beautiful sight.

Regular work with the telescope finally began in 1789. But Herschel was never pleased with the telescope's performance. Perhaps this is best summed up in the following lines from telescope historian Henry King's definitive work, *The History of the Telescope*:

Fig. 2.3. Herschel's great 40-foot reflector which housed a 48-inch diameter mirror. This wonder of the ages attracted royalty, dignitaries, and other visitors from far and wide. Even today, this famous image remains a lasting icon to a bygone era of visual observational astronomy. Courtesy of the Royal Astronomical Society/ Science Photo Library, London.



The paucity and irregularity of Herschel's observations with the 40-foot leave little doubt that the great telescope failed to meet its maker's expectations. In the first place, the weather was seldom good enough to allow full use of its aperture and, when conditions were favorable, Herschel preferred the smaller and more manageable 20-foot. He found there were few objects visible in the 40-foot which he could not see in its smaller counterpart.

That very few of the objects contained in the Herschel catalog were actually discovered with the 40-foot certainly confirms the above statement. How very sad for Herschel after all his labors over this great instrument! But while it was a disappointment for him, it was certainly not for the many sightseers who came to gawk at this wonder of the ages, including royalty and dignitaries of all levels and noted scientists from the world over. One famous early event from this period involves the day the King came to inspect the telescope while still under construction, bringing with him the Archbishop of Canterbury. As they were about to enter the open mouth of the tube (which at this point still lay on the ground), the King said "Come, my Lord Bishop, I will show you the way to Heaven!" Even today, the image of Herschel's mammoth 40-foot telescope remains one of the great – if not *the* greatest – icons of astronomical history.

In closing, two very important points need mention. First, all of Herschel's many telescopes were mounted as simple altazimuths, being moved about the sky and tracked manually. And secondly, they were all mounted outside of his various residences in the open night air. For all his fame and discoveries, Sir William never had an observatory!

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