

History of Telescopes

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Brief History

Since before the dawn of civilization the night sky has intrigued humans. Any child today can still point out the same constellations that the great sailors once used to navigate the northern hemisphere hundreds of years ago. We have studied the heavens, mapped its beauty and wonder, and even done a bit of exploring our heavenly neighbors, the Moon and Mars. We have sent men to the moon, satellites into orbit, and probes beyond the reaches of our solar system. The drive of human curiosity has allowed us to examine our universe in ways that were inconceivable, even just a century ago. But at the root of all our great space endeavors, is the tool that was first used to show us how imperfect, vast and beautiful our universe really is, the telescope.

The roots of the telescope can be traced back to the Dutch, who at the time were excelling in the manufacture of lenses for spectacles. Research into the matter turns out many stories and this researcher doubts that any one man could be given the honor of this discovery, due to a lack of documentation. The most common story that was run upon was that of Hans Lipperchey, who is often credited with popularizing the device. The story goes that in 1608, Lipperchey just happened to hold two lenses in line with each other and noticed that a church steeple in the distance appeared closer. Lipperchey, evidently enthused, pursued his development by mounting a lens at each end of an adjustable tube. With some adjustments he had effectively made a telescope or spyglass. According to records kept by the States-General of Holland, Lippershey apparently presented his instrument to the government, around October of 1608 asking for what was basically a patent for his design and the ability to exclusively manufacture them for the government. The government responded with an inquiry as to making the scope into a

binocular, and asking what it would take to satisfy Lippershey monetarily (King, pg: 30-1; 1955). So it would appear that Galileo was not the first to capitalize on the monetary possibilities of military interests in such a device. Once again, the story becomes fuzzy, because we do not firmly know how the idea of the telescope came to the hands of Galileo. Stories vary but usually include a trip by Galileo to the Netherlands, or a trip by one of his peers who brought information about the device back with him, and usually center around the middle of 1609. The stories vary from source to source, rarely with anything that could be defined as consistency.

Upon hearing the news of this 'new' device, the telescope, Greek for "far-seeing," Galileo set his skills as a craftsman at work and created one for his own experimentation, based on his knowledge of optics and refraction. He quickly improved the telescope's resolving power to 9. In August of 1609, it is said that he brought a demonstration model to Venice, and showed the tool's military applications, earning him a lifetime professorship and double his current salary (Friedman, 1998). Galileo immediately went home and set went back to work, quickly devising a mounting system and then quadrupling the resolving power to 36. It is only after this that he supposedly began exploring the heavens, starting with our beloved Moon and the gas-giant Jupiter.

On January 7, 1610 he observed Jupiter with a forth and even better telescope of 30 magnification, having ground the lenses himself and spared 'neither labour nor expense.' (King, pg 36; 1955)

According to Galileo's records, he saw three of Jupiter's moons, not knowing at the time they were moons. Repeated observations over the next three months caused him to declare them satellites of the planet. This powerful telescope also allowed him to view

the moon in all its imperfection. He described his findings in his book, *The Starry Messenger*, published in 1610. In the case of the moon, he said it was:

"...rough and uneven, covered everywhere just like the earth's surface with huge prominences, deep valleys and chasms." (Friedman, 1998)

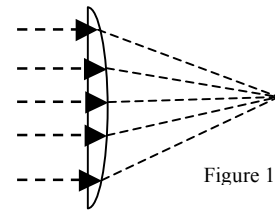
The next major revolution in telescopes did not come until the mid-1600s, during the era of Isaac Newton. Many would hastily give credit to Newton for the discovery of the reflecting telescope, but in 1663, five years prior to Newton's first publicized reflection telescope, John or James Gregory (depending on the source) designed a unit similar to what Newton would release in 1668. However, Newton's telescope was more widely known about, and more practical, so it is with his name with associate the reflecting, or Newtonian, telescope (De Pree, 2001, King, 1955). This telescope used a mirror, instead of a curved lens, to collect light, and therefore was not subject to the flaws and imperfections that defined the glass lenses of the era. Even with current technology perfect lenses cannot be created, and due to their impracticality and expense, the largest known is the 40 inch refractor in the Yerkes Observatory in Wisconsin, operated by the University of Chicago (Arny, pg 124). Further refinements would come four years later in 1672 by Guillaume Cassegrain, a Frenchman who moved the focus of Newton's telescope. In a Cassegrain-Focus telescope, the focus is at the bottom of the barrel, resembling a refracting telescope since the view piece is at the bottom of the tube rather than side near the top as in a Newtonian-Focus. The Cassegrain's idea of using a convex mirror with a concave mirror lessens the aberrations visible, as defined later. Newton denounced the Cassegrain focus, both to his own misunderstandings and on the grounds that Cassegrain's idea was similar (and he thought based on) Gregory's design. Plus the

fact that he was French...I would say that with the 'special relationship' the British have with the French had as much bearing on Newton's opinions as did his scientific objections. Cassegrain faded out of view until his design was later resurrected and paired with new technology that alleviated the problems Newton said such a design would have and is now widely used in both professional and amateur telescopes.

The Moving Part...Light

Refractors

A refracting telescope gathers light by bending the light towards a point, called the focus, as shown in figure 1*. The distance between the lens and the point at which the gathered light meets is called the focal length. In order to view this



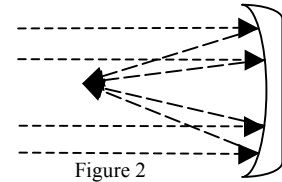
focused light in a refracting telescope, the light must be passed through another lens, which is typically many times smaller than the initial, or objective, lens. This second lens is usually called the eyepiece. Its main purpose is the magnification of the image focused by the objective lens.

There are two types of lens that can be used in telescopes, concave and convex. Concave lenses are shaped like a shallow bowl. Most eyeglasses are concave lenses. Convex lenses are like that illustrated in figure 1. They are rounded on one or both sides, depending on use, and can be found in telescopes and magnifying glasses, just as a pair of examples. Galileo used a convex lens as his objective and a concave lens as his eyepiece in his original telescope (King, pg. 34).

Reflectors

* Images were created using Microsoft Word's drawing tools, and illustrations can be redrawn offhand to verify originality upon request. They were not copied or scanned in any manner.

A reflecting telescope gathers light by using a parabolic mirror to reflect it towards a common point, rather than bending it as a refracting telescope does. Most reflectors use an aluminum coated piece of glass that is polished to a mirror finish. Since light is reflected off of this polished coating (as shown in figure 2) it never passes



through the glass, therefore is not subject to spherical or chromatic aberration. The mirrors used in reflectors can almost be supported from behind, which is a great advantage compared to refracting lenses, which can only be supported on the ends, and large heavy lenses will sag under their own weight causing unwanted image distortion. Reflecting telescopes still use eyepieces to magnify the image presented at the focus, just like refracting telescopes.

The Project

While brainstorming ideas for how to complete this paper, I determined that a companion model coming with the paper would do more to garner a good grade than simply rambling on and trying to stretch my ideas out to the required length. Looking at my choices, between a refracting and reflecting, and weighing the possibilities, I determined that a refracting telescope would make more sense on several grounds. One, a concave mirror isn't something sold at every corner General Store, and grinding my own, coating it with aluminum, then polishing it to a high-mirror shine just did not seem feasible. With a reflecting telescope eliminated, I set out looking for the parts necessary to make a refracting telescope. If Galileo could do it in a day, surely it wouldn't take me more than a couple of months... My initial idea was to use a convex lens from a magnifying glass I had around my room as my objective lens, and the find a smaller lens

suitable for an eyepiece. As it turns out, the quality of the lens in the magnifying glass was less than standard...I'd assume they had better lenses in the 17th century.

Seeking alternative optics I turn to scouring the internet and hobby stores, managing to acquire a children's telescope with a moderate quality objective lens and a trio of eyepieces, which I immediately cannibalized and made a prototype model using cardboard tubes. At the time I intended to manufacture the entire assembly from the tubes, but as my mind churned over the thoughts and my ideas refined themselves, I managed to concoct what you can see now.

While the contraption that comes attached to this paper doesn't really hold true to Galileo's initial design, it does contain some of the same basic characteristics. A convex objective lens, an adjustable tube for focusing are some of the similarities, but my scope also uses convex eyepieces and more modern materials (I'm willing to wager that Galileo would have found many uses for duct tape...).

Using PVC and CPVC piping and adapters, and a touch of duct tape for a snugger fit, I managed to construct a simple, yet durable and functional telescope body, which allows for the interchange of eyepieces, and complete disassembly for cleaning. In viewing through the scope at objects in the distance, it takes some getting used to, as everything is inverted and backwards (figure 3). I have found the best way to aim is to pin the objective end

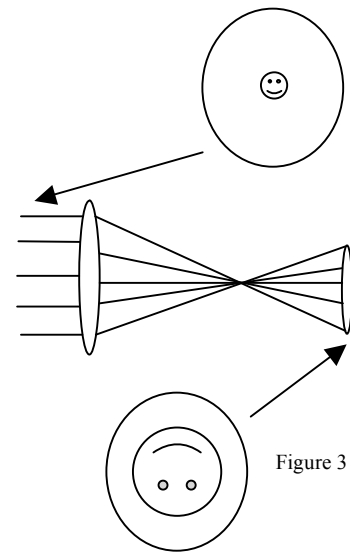


Figure 3

of the scope against a stable surface (wall, doorframe, etc) and move the eyepiece-end of the scope in the direction you need, this allows a somewhat easier method of locating and viewing objects. Another set of lenses or maybe a single, complicated lens could correct

the reversal, causing everything to appear normally, but I was not able to achieve said normality by passing the light through my now spare convex magnifying lens, at any focal point. The telescope is also difficult to use with corrective eyewear on, and usually removing any eyeglasses and using the telescope's focusing is suitable for viewing objects and correcting vision both, but my hypothesis is that if your eyes are really bad a longer or shorter focal length than my scope is designed to provide may be required.

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