Christiaan Huygens and his telescopes

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Louwman Collection of Historic Telescopes, Wassenaar, The Netherlands

As an amateur astronomer myself, I have personally always been very interested in the early development of the telescope in the 17th century. I regard it as a privilege to have been asked to tell you something about Christiaan Huygens and his telescopes.

To me, Christiaan Huygens is a very fascinating person. Christiaan not only designed his telescopes**,** he also built them himself and he also used them.

Christiaan's first involvement with telescopes was in the autumn of 1652, when he was 23 years of age. He started to become interested in the art of lens grinding and he decided to get more information from the well-known instrument maker, Johann Wiesel from Augsburg, southern Germany. The optical instruments Wiesel made, such as spectacles, telescopes and microscopes, were sold throughout many parts of Europe. Even in London his price lists were distributed among potential buyers.

Based on information he got from his correspondence with Wiesel, Christiaan instructed a certain 'Master Paul' in Arnhem to build a telescope for him. This seems not to have been a success, because in the next year Christiaan decided to grind lenses himself, assisted by his older brother Constantijn.

Figure 1: Johann Wiesel (Staats- und Stadts-Bibliothek, Augsburg)

At first the Huygens brothers had to rely on the experience of professional Dutch lens grinders, such as Jan van der Wyck from Delft and Caspar Calthoff from Dordrecht. Especially Calthoff had a fine reputation, but unfortunately for the Huygens brothers, he soon moved to England.

Lens grinding and polishing is very delicate and precise work. It is also very heavy manual work and very time-consuming. To lighten this hard labour for himself, Christiaan designed and built his own lens-grinding and -polishing machines (Figure 2).

One of the greatest problems with lens grinding is to make a suitable lap by utilising metal moulds with a perfect spherical shape. Another problem for the Huygens brothers was to find glass of high quality and homogeneous in structure. However, not only the quality was important: they also needed to acquire glass of suitable dimensions to be able to make a large objective lens for their telescopes.

According to research by Rob van Gent and Anne van Helden[2], the Huygens' brothers bought their glass from various sources, among others in Amsterdam and in London, but later also from the important glass works in the city of 's Hertogenbosch (Bois-le-Duc) in the centre of the Netherlands.

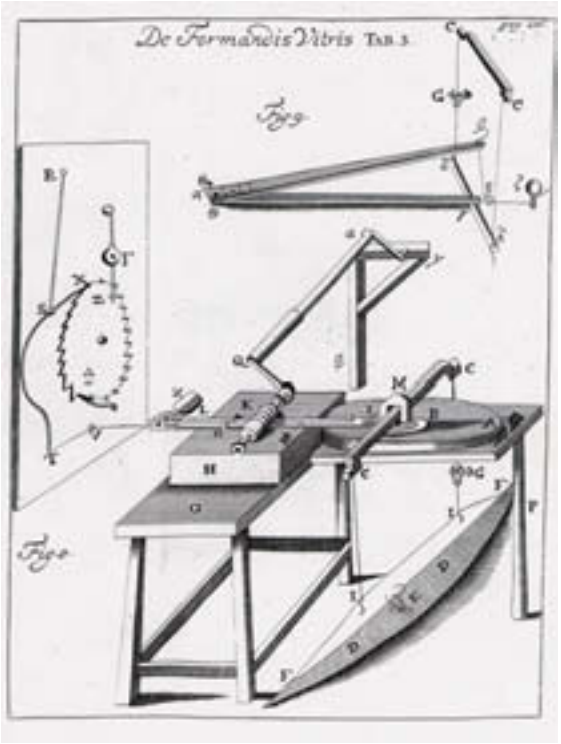

Figure 2: Lens-grinding machine of Christiaan Huygens (From his 'Opuscula Posthuma'*, published posthumously by Janssonio Waesbergios, Amsterdam, 1728)*

What made it very difficult to produce usable lenses, as the Huygens brothers soon found, was that the whole art of lens grinding was surrounded by secrecy. They couldn't benefit much from the experience of professional lens makers, because these lens makers weren't very communicative and they vigorously protected their trade secrets from the competition.

One of the most surprising astronomical discoveries Christiaan Huygens made with one of his first self-made telescopes dates from March 25th, 1655, when he discovered that Saturn has a moon, revolving around the planet in about 16 days. The moon was later named 'Titan'.

Figure 3: Sketches of the position of the newly-discovered moon relative to Saturn, in Christiaan's book Systema Saturnium, *1659 (O.C. Vol 15)*

The telescope he used for his discovery was equipped with an objective lens (also known as an 'object glass') with a focal length of 10 Rhineland feet (about 337 cm). The eyepiece he used was a single-lens of 3 Rhineland inches (79 mm) focal length, resulting in a magnification of about 43x. Christiaan himself writes that he used a telescope of 12 Rhineland feet, but at that time this meant the total length of the telescope tube including the eyepiece, not the focal length of the objective lens.

The telescope itself doesn't exist anymore, but its objective lens, which is by far the most important part of a telescope, has been preserved. Researchers are fully convinced that Christiaan used this lens for discovering Titan, because he scratched with a diamond, in his own handwriting, not only his name and the date of manufacture of the lens (February 3, 1655) along the rim of the lens, but he also scratched on it in Latin "*Admovere oculis distantia sidera nostris*" ("they brought the distant stars closer to our eyes").

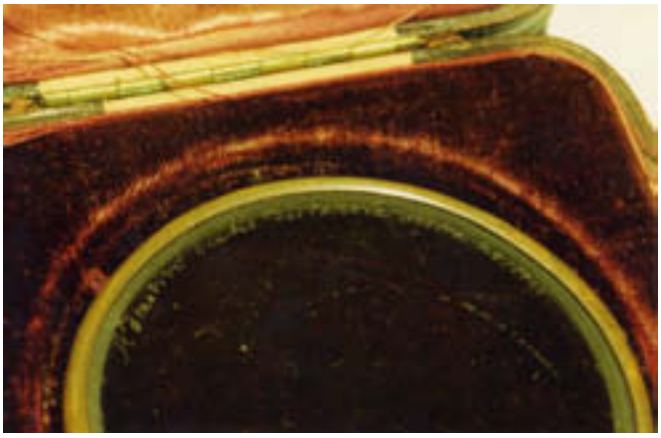

*Figure 4: The '*Admovere*' lens in a protective casing. Along the rim is visible "*Admovere oculis distantia sidera nostris*" that has been scratched on the glass with a diamond by Christiaan Huygens (Universiteits Museum Utrecht, photo by author)*

On June 13th 1655 Christiaan wrote a letter to Prof. J. Wallis in Oxford telling him that he had made 'a discovery' with his new 12-foot telescope. However, he didn't tell him exactly what his discovery was, but, as was the custom in those years, he re-wrote the sentence explaining his discovery into the following anagram:

> *Admovere oculis distantia sidera nostris*, v, v, v, v, v, v, v, c, c, c, r, r, h, n, b, q, x

On March 15, 1656 Christiaan disclosed the solution to the anagram by writing to Prof. J. Wallis that the letters of his anagram should be rearranged into the following sequence:

> *Saturno luna sua circunducitur diebus sexdecim horis quatuor*

It is therefore convincing that this lens (in literature it is often nicknamed the '*Admovere*') was used in Christiaan's 12-foot telescope when he discovered Titan. Normally the '*Admovere*' is safely kept in a well-protected vault at the University Museum of Utrecht, but for the occasion of the commemoration of Huygens' 375th birthday, it is now temporarily on display for the public in a showcase at Museum Boerhaave in Leiden.

It is very lucky that we can nowadays see and admire the '*Admovere*' lens, because it once was nearly lost! The lens is referred to in an auction catalogue dated 1722, and two years later it was mentioned by the Dutch

physicist 's Gravenzande in his foreword to his publication about Christiaan Huygens' life and works '*Opera Varia*'. But after that, the lens was never again mentioned, nor seen. It seemed that nobody was really concerned. Then, in 1867 it was fortunately discovered by Professor Harting in a little old box, containing some old lenses, in the Physical Laboratory of Utrecht.

Figure 5: Here we see an objective lens made by Christiaan, similar to the one he used to discover Saturn's moon 'Titan'. Along the rim Christiaan signed: "Chr. Hugenius A° 1656". On the opposite side of the lens "PED II" tells us the focal length is 11 feet. (Lens from the Louwman Collection of Historic Telescopes; photo by author; also Figure 6)

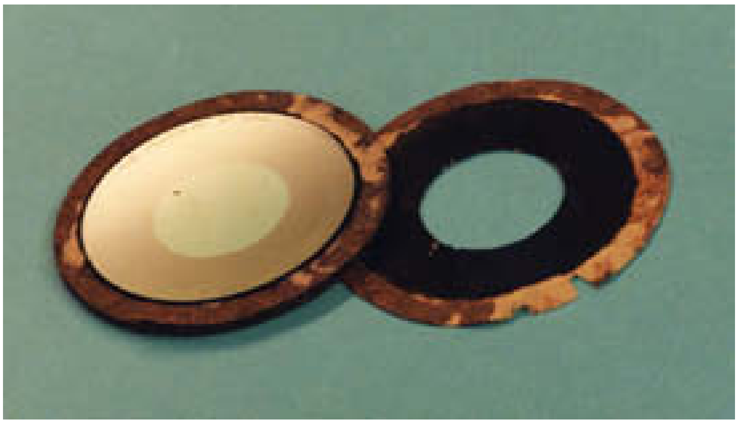

Figure 6: The same lens as left in its original protection fittings made of cardboard. The total diameter of this objective lens is 63 mm, but Christiaan stopped down the open aperture to 35 mm. He did this by covering the outer parts of the lens with a diaphragm (the black ring with the hole in the middle). As with most 17th century lenses, only the middle part of the lens has an optically perfect form. By installing the diaphragm only light rays passing through the middle of the lens are used to create an image. Light rays that would have passed through the outer parts of the lens are blocked by the diaphragm

SYSTEMA SATURNIUM. 47

ex quam dixi annuli inclinatione, omnes mirabiles Saturni facies sicut mox demonstrabitur, eo referri posse inveni. Et haec ea ipsa hypothesis est quam anno 1656 die 25 Martii permixtis literis una cum observatione Saturniae Lunae edidimus.

Erant enim Literae aaaaaaa ccccc d eeeee g h iiiiiii llll mm nnnnnnnnn oooo pp q rr s ttttt uuuuu; quae suis locis repositae hoc significant, *Annulo cingitur, tenui, plano, nusquam cohaerente, ad eclipticam inclinato.* Latitudinem vero spatii inter annulum globumque Saturni interjecti, aequare ipsius annuli latitudinem vel excedere etiam, figura Saturni ab aliis observata, certiusque deinde quae mihi ipsi conspecta fuit, edocuit: maximamque item annuli diametrum eam circiter rationem habere ad diametrum Saturni quae est 9 ad 4. Ut vera proinde forma sit ejusmodi qualem apposito schemate adumbravimus.

Caeterum obiter hic in respondendum censeo, quibus novum nimis ac fortasse absonum videbitur, quod non tantum alicui caelestium corporum figuram ejusmodi tribuam, cui similis in nullo hactenus eorum deprehensa est, cum contra pro certo creditum fuerit, ac veluti naturali ratione constitutum, solam in iis sphaericam convenire, sed & quod annulum

Figure 7: Christiaan announced his discovery of the rings of Saturn in System Saturnium *in 1659*

At about the same time Christiaan made with this same telescope (though he may also have used his new 23-foot telescope) another most impressive discovery: he discovered the true nature of the puzzling appearance of the mysterious two 'attachments' (ears) of the planet Saturn. Actually, he didn't owe this discovery to his visual observations only: it was also the result of his deductive reasoning. Christiaan came to the right solution of the puzzle by examining old telescopic observations made by other astronomers during the first half of the 17th century. These astronomers didn't yet have telescopes with sufficient resolving power, as Christiaan had. They therefore never exactly understood what they were seeing through their telescopes. To make the mystery even more complex for these astronomers, the attachments (or 'appendages') regularly disappeared for a short time, then reappeared for several years.

Christiaan, with his genius and his remarkable sense of intuition, immediately grasped what he was seeing through his telescope. It was a three-dimensional view of a flat ring, floating in space around the planet.

With his discovery he was at the same time able to explain why the appendages regularly disappeared and reappeared. Really a marvellous, great discovery, which brought him much fame.

Another important astronomical discovery Christiaan Huygens made with his telescopes was determining the rotation period of the planet Mars. By observing spots on its surface for many weeks, Christiaan came to the correct conclusion that Mars rotates. He found that it takes Mars about 24½ hours to complete one rotation, so a little longer than the Earth.

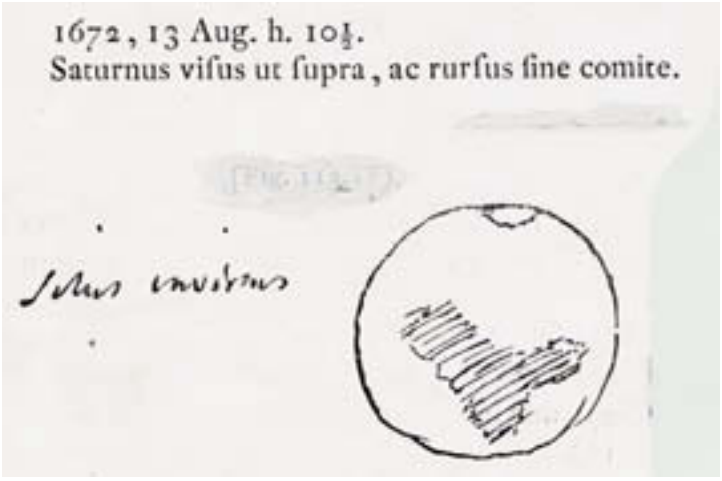

Figure 8: Sketch of Mars drawn by Christiaan on August 13th, 1672 (O.C. Vol 15 p113)

Figure 9: Modern photograph of the same part of Mars by the Dutch amateur astronomer John Sussenbach. Compare the white polar cap and the triangular shaped region called 'Syrtis Major' with those in Christiaan's drawing

At this time, in about 1659, both Christiaan and Constantijn Huygens temporarily stopped making lenses and telescopes, although they didn't lose their interest in them. Only after 1681, so more than 20 years later, did they resume making lenses and telescopes.

In 1666 Christiaan was invited by the wealthy and influential King Louis 14th to come to Paris and to become a prominent member of the French *Académie des Sciences*. He stayed here 15 years (1666 to 1681) and worked together with famous astronomers, such as Cassini (from Italy) and Römer (from Denmark).

During his stay in Paris, he several times visited the important telescope maker Philippe-Claude Lebas. Lebas seemed to have found a superior method of polishing. But despite all Christiaan's efforts, he was never able to discover exactly how this new method worked. When Lebas died, Christiaan tried to persuade Lebas' widow to kindly disclose the method, but in vain, because she, too, protected her husband's secret.

We now know that the Huygens brothers used paper as one of the main elements for polishing their lenses on a lap.

Also in Paris, in 1662 Christiaan Huygens greatly improved a special eyepiece for telescopes, which is now commonly known as the '*Huygens eyepiece*'. This eyepiece consists of two positive lenses with different focal lengths, separated from each other by a certain distance. It gives an improved and wider field of view and it fully removes lateral colour aberration.

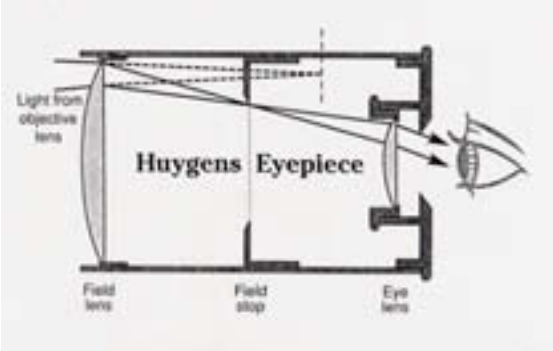

Figure 10: The Huygens eyepiece

Christian Huygens kept his fascination for telescopes all his life. This can be illustrated by a remarkable incident, when during one of his trips to England in 1661 he visited the shop of the telescope maker Richard Reeves at Longacre in London. On the day of his visit the coronation of King Charles II was taking place in London, but Christiaan preferred not to go and view all the festivities. No, he took his chance to observe with Reeves' telescopes the very rare 'transit of Mercury', which was on the very same day. Together with the astronomer Thomas Streete and Richard Reeves he observed to his delight the passage of the planet Mercury across the sun's disc[i].

When Christiaan returned home from Paris in 1681, he found that during his absence from Holland several lens makers had greatly improved the art of lens grinding, also in his hometown of The Hague. Telescopes and microscopes were in high demand by wealthy customers, who bought them to, more-or-less, play with them. However, despite the increased interest from the public, the Huygens brothers couldn't find lens makers who were able to deliver them lenses as good as they could make them themselves.

So, the Huygens brothers decided to continue making both their objective lenses and their eyepiece lenses themselves. As we know from correspondence, both brothers seemed to enjoy doing this highly specialised work together. To ease their share of the work, Christiaan and Constantijn limited themselves to polishing lenses. They were convinced nobody could

[i] Mercury revolves around the Sun in an orbit between the Earth's orbit and the Sun. When the Sun, Mercury and the Earth are exactly aligned in a straight line, a 'transit of Mercury' takes place. With a telescope we can then see Mercury as a tiny little black disc slowly crossing the solar disc. This, however, doesn't happen every time Mercury moves between the Sun and the Earth: because Mercury's orbit around the Sun is slightly inclined to the Earth's orbit, Mercury mostly 'misses' the disc of the Sun, as viewed from the Earth. A transit of Mercury occurs very rarely; only 9 were visible from the Netherlands in the last 100 years, and of these only 5 were visible from the beginning of the passage of Mercury across the solar disc till the end.

do this delicate work of polishing as well as they could. So, the Huygens brothers reserved for themselves the immensely important 'finishing touch'.

However, the grinding of lenses they farmed out to craftsmen, who were better capable of doing this heavy and time-consuming task. It is interesting in this respect to note that the Huygens brothers often enlisted Master Dirck, nicknamed by them 'the chimney sweep'. Dirck lived in '*het Achterom*', just around the corner from their home (in Het Plein) in the centre of The Hague. Of course, it was the Huygens brothers who selected and supplied the necessary glass to Master Dirck.

With their renewed enthusiasm for telescope making, the Huygens brothers started, from 1681 onwards, making more powerful telescopes and especially much longer ones.

During his Paris period, Christiaan had seen and used the telescopes that the astronomer Cassini used at the Paris Royal Observatory. These had objective lenses with very long focal lengths, from 17 feet up to 100 and even 140 feet. They were made by the famous Italian lens maker Giuseppe Campani. The longest of the Cassini telescopes were tubeless and consisted only of two components: an objective lens fixed on top of the wooden Marly Tower and an eyepiece, which had to be held in the hand. The Marly Tower was originally built to lift water for the Versailles reservoirs and fountains.

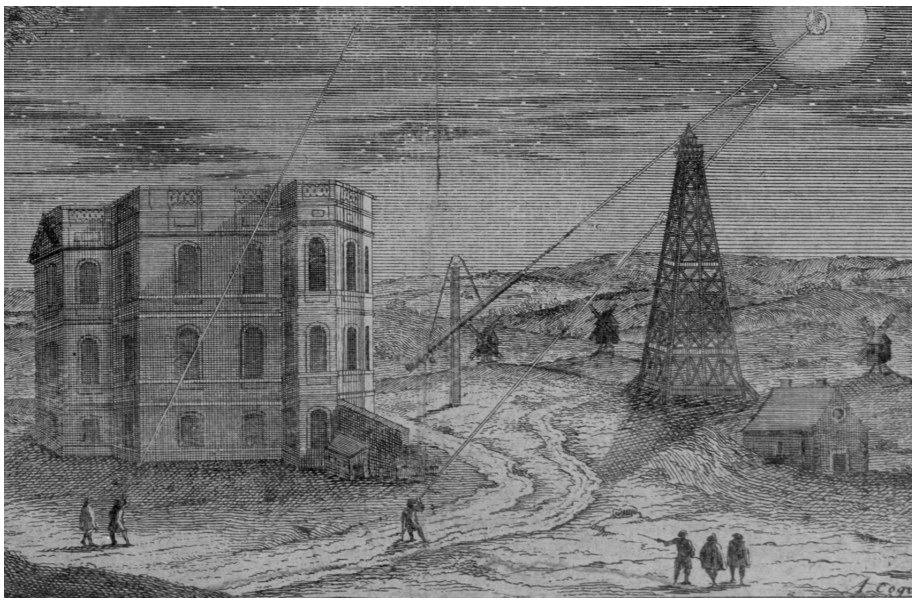

Figure 11: Ultra-long focus tubeless telescope used by Cassini at the Royal Observatory in Paris (©Bibliothèque Observatoire de Paris)

In The Hague, the Huygens brothers constructed similar long tubeless telescopes of which Christiaan made a technical drawing and published it in his booklet *Astroscopia Compendiaria* in 1684 (Figure 12).

At the top of the pole the objective lens is attached to a ball and socket mechanism and kept upright by a counterweight. The ball and socket is fixed to a platform, which is adjustable in height by a cable and which is also balanced by the counterweight hanging next to the pole. Christiaan used the lantern on the ground during his observations to locate the exact position of the objective lens (not so easy in the dark!). By picking up the lantern and holding it next to his ear and directing the light rays in the direction of the

objective lens, Christiaan could see a reflection in the lens, and by doing so was able to do two things: he could find the objective lens through which he wanted to observe, *and* he could direct his telescope in the direction of the object in the sky to be observed.

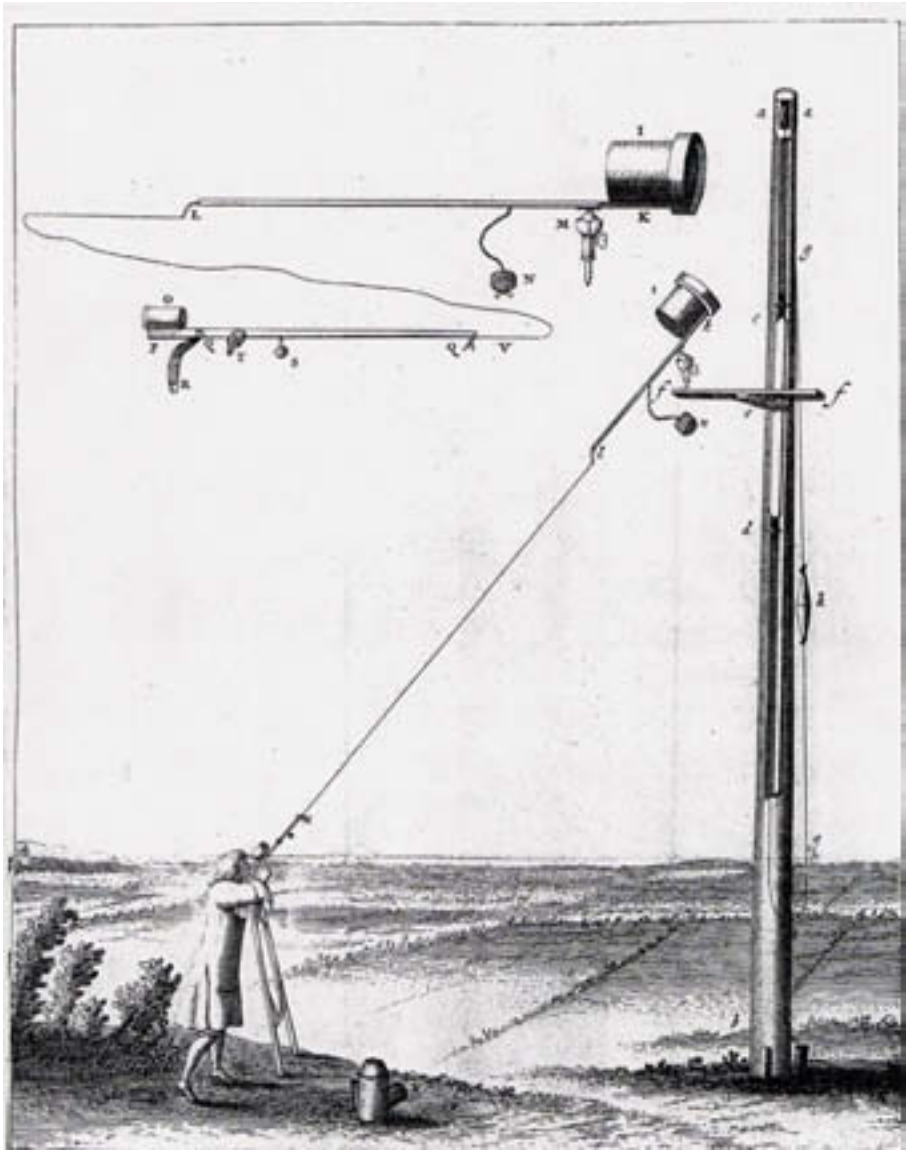

Figure 12: The tubeless telescope used by Christiaan in The Hague. From Astroscopia Compendiaria, *1684*

This very same illustration of Huygens' 'tubeless telescope' has become very well known and can be found reproduced in many popular astronomical books and magazines. It has even been used as a logo on the front cover of the "*Journal for the History of Astronomy*" ever since its first issues appeared in 1972.

Huygens' tubeless telescopes had some clever technical improvements compared with the telescopes used at the Royal Observatory in Paris. Christiaan erected his tubeless telescopes next to his home in the centre of The Hague, and possibly also one at his summer residence 'Hofwyck' in nearby Voorburg. In The Hague he had the problem that his tubeless telescope was so long that its upright supporting pole had to be placed in the

garden of his neighbour. A notarial act has been found that tells us that Christiaan had negotiated with his neighbour for permission to set up the telescope-pole in his neighbour's garden. The act claims that Christiaan was legally permitted, when necessary, to enter his neighbour's garden through a specially-made gate in the stone wall separating the two gardens.

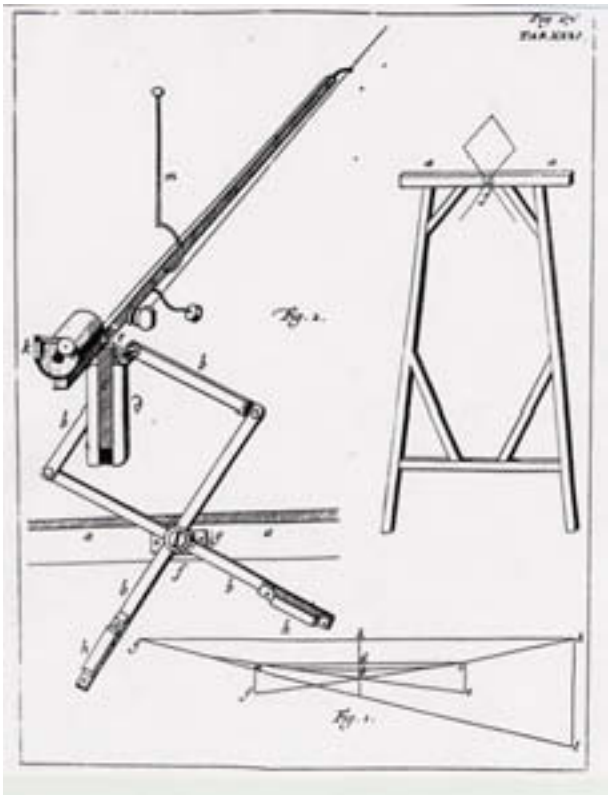

Figure 13: A close-up of the stand that Christiaan leaned against when using the eyepiece to observe through his tubeless telescope. The tube (k) at the left contains the eyepiece consisting of two lenses. Christiaan had to constantly keep the silk line, attached between the eyepiece and the ball and socket mechanism (on which the objective lens was mounted), straight and taut to ensure that the eyepiece remained perfectly aligned with the objective lens, AND to keep their mutual distance constant. Both conditions were necessary to obtain worthwhile and satisfactory images for his observations.
(From 'A Compleat System of Opticks', by Robert Smith, 1738)

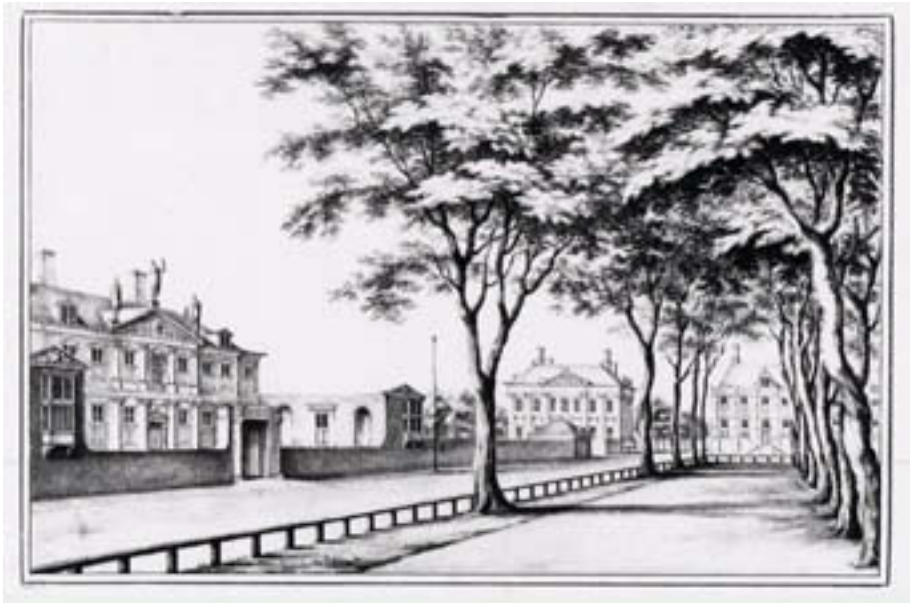

Figure 14: On the left the Huygens' home in the centre of The Hague, which was very unfortunately replaced by a modern building in 1876. In the distance, to the right of the tree in the middle, is 'Het Mauritshuis', now a museum. Christiaan's tubeless telescope was erected somewhere between these two buildings and behind the garden wall.
(Jan van Call, Collectie Haags Gemeentearchief)

Wielding his extremely long tubeless telescopes must have been very difficult. Of course, Christiaan had acquired much experience in the skill of doing this, but trying to share his astronomical observations with other

people must have been nearly impossible. Using the tubeless telescope required a lot of patience too.

In a letter dated 1 September 1693, Christiaan proudly wrote to his brother Constantijn, who was on a military campaign in the south of the Netherlands, that a few days ago he had finished making a beautiful telescope with a square wooden tube for his 45-foot objective lens. He added that he had made it "especially for pleasing gentlemen of higher standing who ask me to show them the Moon and planets and who have too much trouble with the tubeless telescope, which I prefer". This last claim, that Christiaan preferred his tubeless telescope, is interesting. Because the Huygens brothers had a very close relationship, Christiaan's claim that he preferred using the tubeless telescope to a smaller, handier one, must be taken seriously.

Have any of Christiaan's telescopes survived?

Yes, but only one, as far as we know. It is on display at Museum Boerhaave (Figure 16) and it dates from 1683. This telescope was called by Christiaan Huygens the 'Campanine', because of the optical design of its eyepiece (Figure 15), which he had learned from Giuseppe Campani in Italy and whom I already mentioned before. This telescope has 5 metal drawtubes. Its total length, when focused, is about 5 metres and its magnification is 49x. It gives an upright image, so it was designed for terrestrial observations, not astronomical.

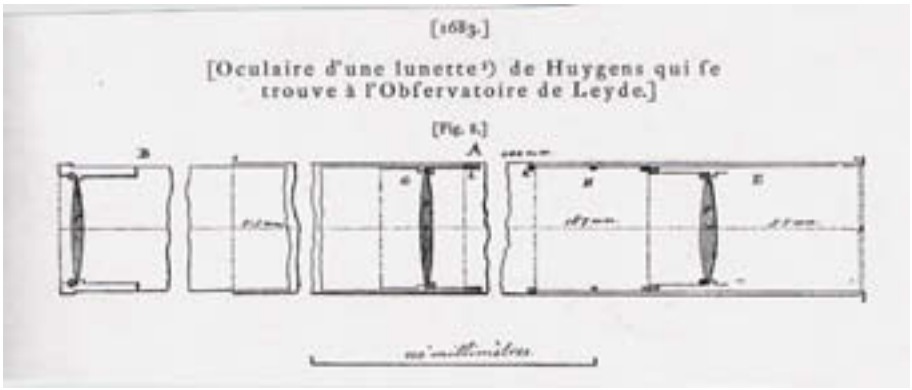

Figure 15: Here Christiaan sketched the eyepiece he constructed for his 'Campanine' telescope. It consists of three lenses. (O.C. Vol 13, p607)

Museum Boerhaave has in total 19 objective lenses made by the Huygens brothers, including the one mounted inside the Campanine telescope. In another showcase, Boerhaave exhibits five objective lenses all made by Constantijn.

Figure 16: The 'Campanine' telescope displayed standing vertically. The 5 metal drawtubes of the telescope are pushed in.

At the left we see six large objective lenses mounted vertically in the showcase. Three of the lenses are signed by Christiaan, and have focal lengths from 10 to 34 feet. The largest has a diameter of 13 cm. Two other lenses were made by Constantijn. One of them has a focal length of no less than 122 feet! The sixth lens is not a Huygens lens, but made by Nicolaas Hartsoeker. Finally, we also see, partly hidden behind the 'Campanine' telescope, two tubular metal housings. One contains an eyepiece, the other an objective lens. It is very plausible that they have always belonged together and that they were once part of a complete telescope.

(Museum Boerhaave, Leiden, photo by author)

In total, there are another nine lenses signed by the Huygens brothers preserved in other collections:

- Two at the University of Utrecht, of which one (the '*Admovere*') is now temporarily in Museum Boerhaave, Leiden
- Three at the Royal Observatory at Brussels (Figure 17)
- Three at the Royal Society in London
- One in a private Dutch collection

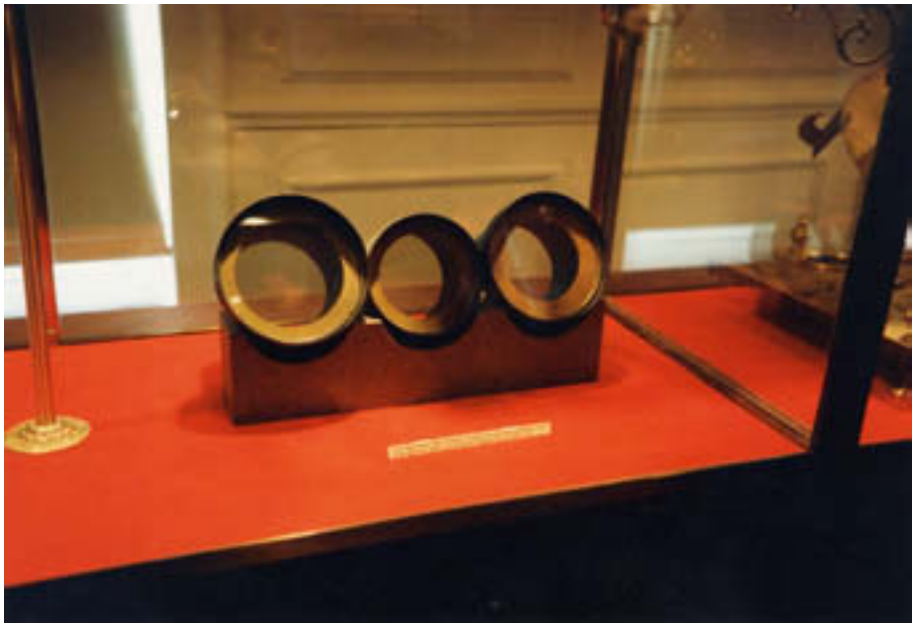

Figure 17: The three objective lenses in their original metal lens mounts at the Royal Observatory in Brussels, Belgium. One of them is made by Christiaan, the other two by Constantijn (photo by author)

More information about the objective lenses and eyepieces that Christiaan Huygens used for his telescopes can be found in "The Huygens Collection" by van Helden and van Gent[1].

References

[1] "The Huygens Collection", by Anne C. van Helden and Rob H. van Gent, a Museum Boerhaave publication, 1995. ISBN 90-6292-107-8

[2] "The Lens Production by Christiaan and Constantijn Huygens", Annals of Science, 56 (1999), pages 69-79.