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WAS HEVELIUS' FAMOUS GIANT REFRACTING TELESCOPE EVER BUILT?

Maciej R. Nowacki
Gdańsk Museum of Science, Profesorska 3, 80-856 Gdańsk, Poland
E-mail: man@oldscope.pl

Abstract: Undoubtedly, the most recognizable Baroque refracting telescope is Johannes Hevelius' 'Telescopio maximo', measuring over 40 meters in length. It was described in detail and illustrated in the *Machinae Coelestis Pars Prior*, a book issued by Hevelius in 1673. However, no published observations made with this telescope are known, nor are there any mentions of them in Hevelius' own correspondence. This prompted the author to conduct an in-depth analysis of the available data on this instrument to determine whether it was ever built and used. There are several reasons to conclude that it was never assembled as a functioning telescope due to problems with both its optics and mechanics.

Keywords: Hevelius' non-achromatic refractor; Baroque telescope.

1 INTRODUCTION

If one keys the phrase 'Hevelius telescope' into an Internet browser, the engraving from Johannes Hevelius' *Machinae Coelestis Pars Prior* will immediately appear (Figure 1). It is hard to imagine anyone not having seen it. It can be found in every encyclopedia, every monograph on telescopes, and even on puzzles and cushions offered by home decoration and furnishing manufacturers. Information about the size of this gigantic telescope is widely reproduced—given as more than 40 meters in length—as is the year of its construction, said to be about 1670. Indeed, all this is based on information from Hevelius himself.

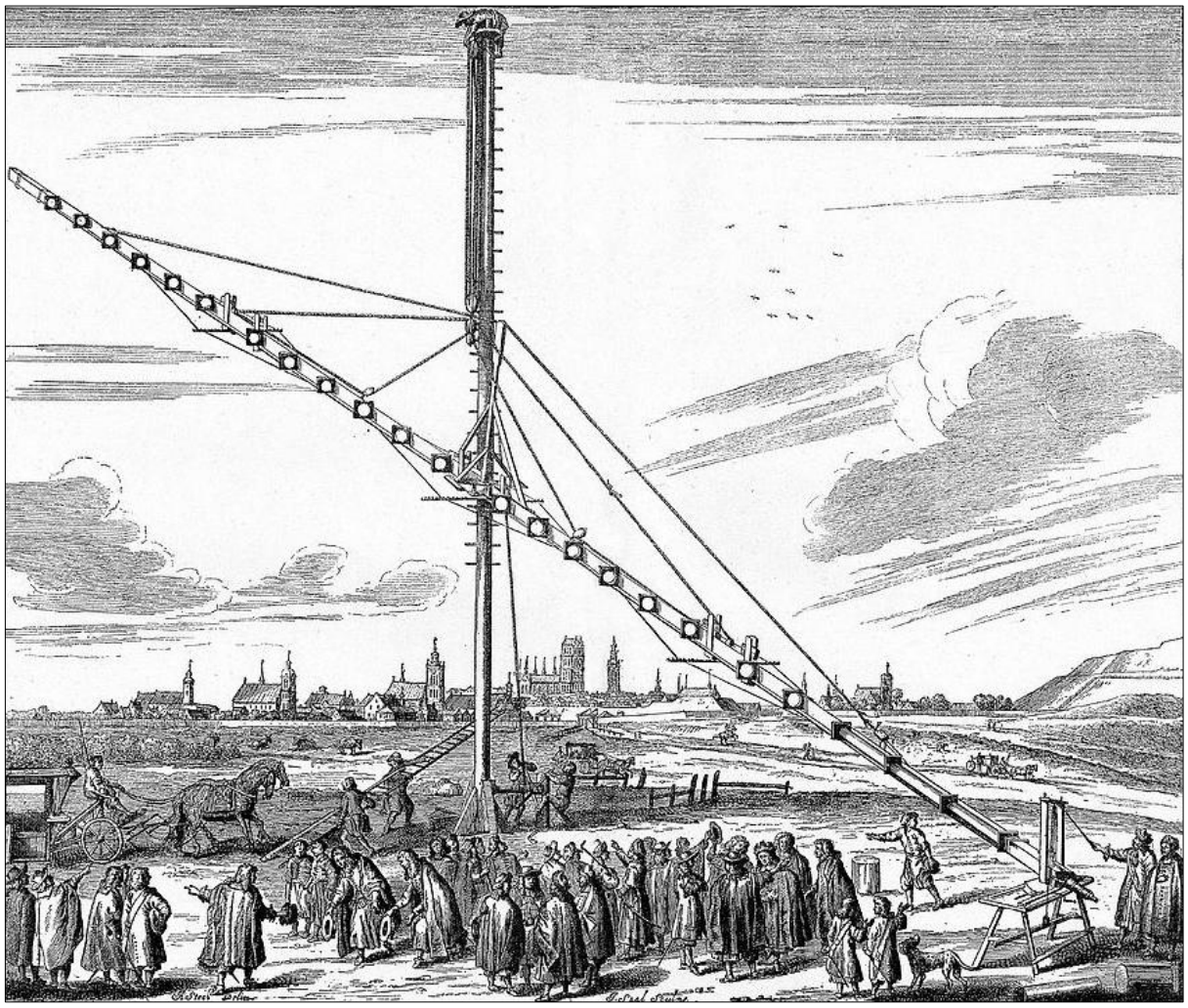


Figure 1: Hevelius' famous giant 'open-tube telescope' (after Hevelius, 1673: 410).

However, when we look beyond *Machinae Coelestis* … for confirmation of what would surely be a great achievement by the Danzig scholar and critically analyze what he himself wrote, some doubts emerge. This paper offers an analysis of the data contained in Hevelius' work, as well as other—intriguingly sparse—material on the massive refractor.

2 THE DESCRIPTION IN *MACHINAE COELESTIS PARS PRIOR*

The giant instrument is described and illustrated in detail in Chapter XXI under the title *De Telescopio nostro maximo*, i.e., "Of our great telescope" (Hevelius, 1673); German and English translations are currently available, the former with extensive and insightful comments (Lühning, 2023; Prince, 1882).

2.1 The Descriptions

In several places, Hevelius meticulously writes how he built a semi-open rectangular tube with a length of ... well, it is not exactly certain what length he specifies. The account jumps every now and then between lengths of 140 and 150 Danzig feet, which is between 39.8 and 42.7 meters.[1] Lühning (2023) writes that the instrument was assembled from four pieces of 50 Danzig feet each, and he speculates that to get enough overlap of the pieces, the length of 140 feet (~40 m) is more likely. However, the overlap size is not provided. Had the telescope actually been completed and used, one suspects that Hevelius would have known its length with greater accuracy. Other dimensions are also given only approximately in the text, and some are missing altogether (Lühning, 2023: Chapters XIX–XXII).

What Hevelius describes is a semi-open tube, consisting of one horizontal and one vertical plank. In profile they form an inverted, asymmetrical 'T', to which baffles have been perpendicularly attached. Hevelius gives the dimensions of the component parts as follows (in Danzig feet and inches, recalculated to metric units by Lühning, 2008):

- Vertical side board, length 40 ft = ca. 11.4 m; cross-section 10″–11″ × 1¼″ = ca. 250 mm × 30 mm.[2]
- Horizontal base board; cross-section 8″–9″ × ¾″ = ca. 200 mm × 18 mm; upright height 12′ = ca. 3400 mm.
- Clamping winch, rack length 3′ = ca. 850 mm.
- Rest tensioning bar, length 4′ = 1140 mm; cross-section 1½″ × 1″ = 36 mm × 24 mm.
- Supporting mast, length 90′ = ca. 25.6 m (not clear what part of it was buried in the ground).
- Baffle spacing 3′–4′ = average ca. 995 mm.
- Lens box length 10′ = ca. 2.85 m.

Hevelius writes nothing about the weight of the telescope, but Lühning (2023) estimates it as at least 300 kg without rigging, and as a whole it could easily have reached 400 kg (especially in the humid air of Gdańsk). Hevelius does not specify the thickness of the ropes that were used. Instead, he boasts that there is not a single iron part in the entire construction(!), only wedges, clips and wooden nails, and that, despite its monstrous length, it is easy to compensate for flexure by controlling the tension of the rigging. Considering the main material for the boards forming the two long perpendicular walls of the telescope—fir planks only 18 and 30 mm thick—it is hard to imagine getting all that thin construction truly straight. The largest functional replica of the seventeenth-century refractor, built in 2008 at Japan's Makiba Astronomical Observatory (Catalin, 2020), is half the presumed length of the Hevelius telescope (21 meters), uses much stiffer modern materials, has more reinforcements (e.g., as many as 33 baffles) and plenty of metal hardware, yet still requires tension adjustments every ten minutes or so in order to at least roughly maintain its axis. Even a 16-meter telescope, built in the manner of the seventeenth century, poses a huge challenge in terms of alignment, as the author of this paper has experienced.

Hevelius, however, insists that he completed the telescope and that it proved to be usable (Hevelius, 1673, Lühning, 2023). How can this be?

2.2 The Engravings

In the *Machinae Coelestis Pars Prior*, Hevelius (1673: 406 and 410) devotes two two-sided drawings to the giant telescope—an honor that he did not grant any of his other instruments. That is not surprising, because it was one of the longest telescopes of its time, and therefore a prestigious item. Surely Hevelius wanted to impress his contemporary European astronomers, in particular Hooke, Auzout and Flamsteed, who had questioned his positional observations performed with the naked eye. In fact, the first part of *Machinae …* served mostly this purpose (see Kampa, 2018; Vertesi, 2010).

The draftsman Andreas Stech, who sketched Hevelius' instruments is commonly regarded as being very careful in his renderings. When we look at the famous engraving by Isaac Saal (Figure 1) based on Stech's drawing of the telescope and make relevant measurements, taking into account perspective foreshortening,

we arrive at some interesting conclusions (Figure 2).

First, the perspective of the engraving is inconsistent—as if after sketching the back of the tube, Stech (or Saal) realized that the telescope looked too short and changed the perspective of the section of the tube behind the mast.

Second, the engraving depicts the baffles both as enlarged and more widely spaced in comparison to Hevelius' description. Simple geometric analysis shows that instead of the distance 3.5 feet (the "… 3 to 4 feet …", as Hevelius wrote, or the 995 mm given by Lühning (2008; 2023) we have 1.25–1.40 m. Nevertheless, if the telescope is shown in proper proportion to the figures, and if these are ca. 1.7 m tall, then the telescope is at most ca. 30 m in length. If, however, we assume the distance between the baffles to be one meter, adding, of course, some extra space near the 'spreaders', where there are no baffles, we get a length less than 28 m, as there are no more than 26 inter-baffle spaces (Figure 3).

Third, on the engraving of the construction (Figure 4) of a giant telescope, the background tube lying on the ground seems huge, especially in relation to its supports and the human figure at its left end. The distance between adjacent baffles in this figure would then be at least 5 Danzig feet, so we see here a construction about 140 feet in length, much longer than in

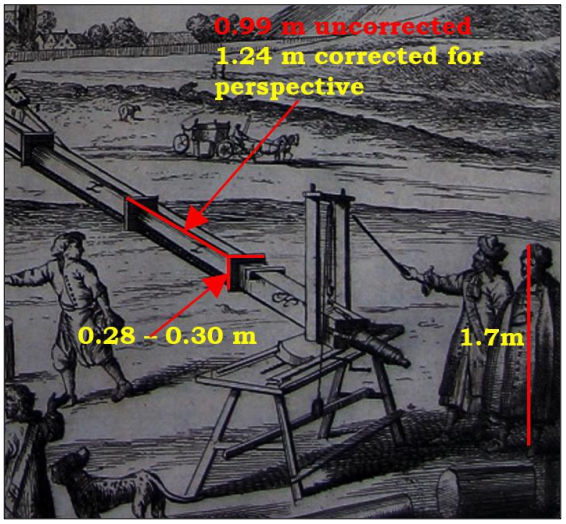


Figure 2: An enlargement of the eyepiece end of the giant telescope in Figure 1 showing baffle spacing. A correction for perspective was made by dividing the line length by cos 36.7°. This is the approximate angle of view between the horizontal line, perpendicular to the tube, and the line of vision. It was estimated from the shape of the small table, though it may be only approximate. But even if we take 45° (to be on the safe side), it makes the distances even longer, at 1.40 m (based on Hevelius, 1673: 410).

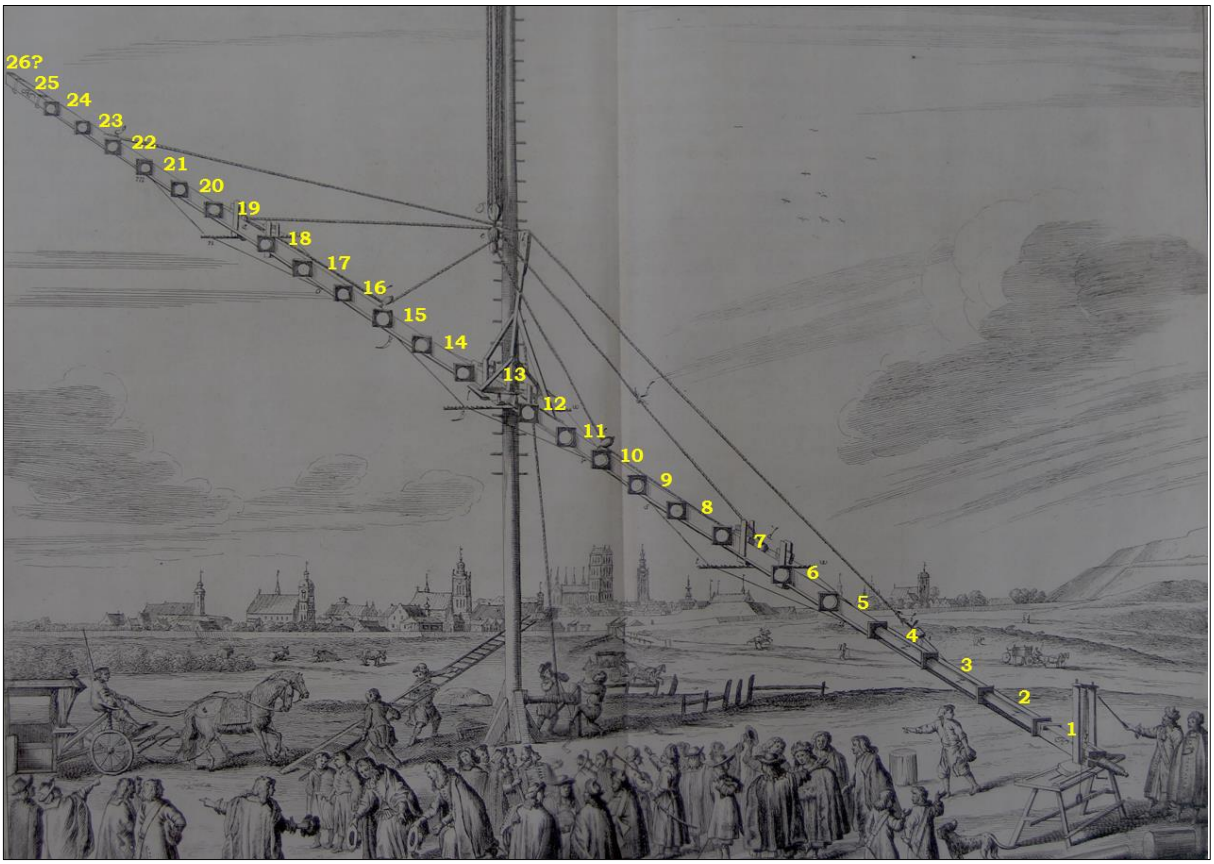


Figure 3: A modified version of Figure 1 with the individual inter-baffle spaces numbered (base image after Hevelius, 1673: 410).

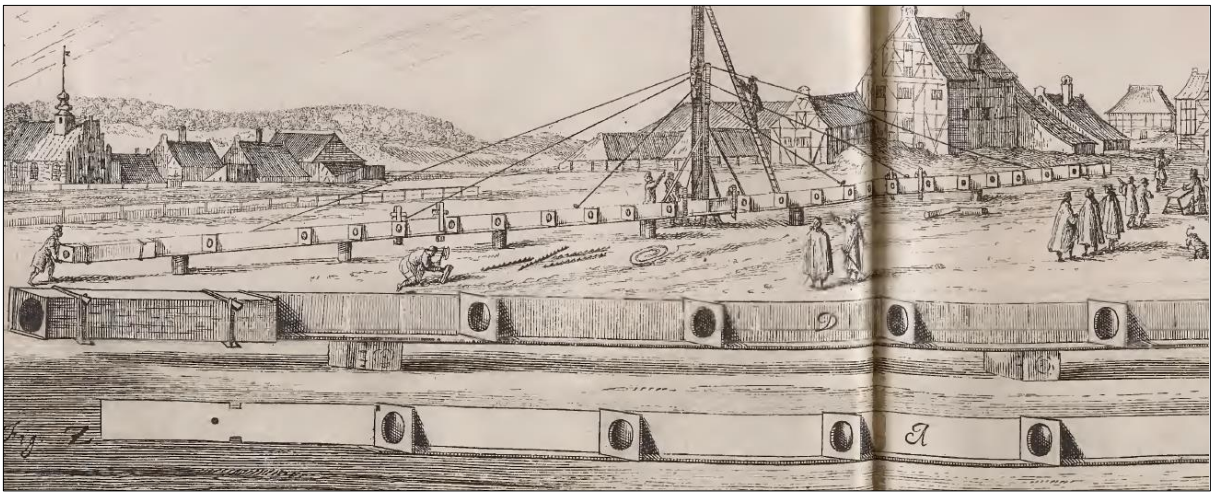


Figure 4: A giant telescope under construction (after Hevelius, 1673: 406).

Figure 1, even though Hevelius would have us believe that the two engravings show the same instrument.

Where do these discrepancies come from? Hevelius apparently gave license to Andreas Stech, who made illustrations for the *Machinae* … to enlarge the size of some of the instruments depicted. The long telescope is not the only example. On page 184 of *Machinae Coelestis Pars Prior* we have an engraving representing Hevelius, standing beside the great quadrant which he says has a radius of 4½ cubits. By contrast, Hevelius is depicted there with the (relative) size of a child (Lühning, 2011). Hevelius' own tendency to exaggeration is also recorded in correspondence with Oldenburg, where his telescopes of 20 and 50 feet long grow to become 30 and 60 feet (Kampa, 2018). Moreover, Lühning (2008; 2011) showed that Hevelius' observation platform on the roof of his three tenements in Danzig at Pfefferstadt No. 47–49 had a size not of 50 × 25 ft, as claimed, but only of 40 × 20 ft. This was also far too small to allow operating a 60-foot telescope (Kampa, 2018).

It is possible that the drawing upon which Figure 1 was based originally was intended to show trials with a telescope of only 70 feet (about 20 m) long. Indeed, a lens suitable for this focal length was made by Burattini[3] before the giant telescope's construction was said to have started—if it ever did (*ibid.*). Most probably Hevelius was not successful with this 70-foot instrument, because no telescope of this size appears in his published descriptions, observations, or correspondence. The present author's suspicion is that Stech redrew his sketch, and Hevelius then gave a false description of a much larger instrument. In turn, Figure 4 represents a possibly authentic construction of a 140-foot tube which, however, probably did not go beyond the phase of laying the basic structure on the supports.

In this regard it is curious to note that two lenses by Burattini with a stated focal length of 140 feet (as well as lenses for the eyepiece) reached Hevelius only in June 1672, at a time when the *Machinae Coelestis Pars Prior* was already in print! There is no chance that a functioning telescope using these lenses was finished by the time of publication. Moreover, a few years later, in August 1675, Burattini asked Des Noyers (a dignitary at the Polish Royal Court who often served as an intermediary in dealings with Hevelius) to ask Hevelius whether the lenses with focal length of 140 feet had already been tested. Hevelius wrote back that, in his opinion, the tube that he had built turned out to be too short for the lenses. Burattini suggested re-grinding the lenses. But Hevelius, apparently disappointed with the performance of Burattini's lenses, did not respond to this suggestion. He also did not admit this failure to Oldenburg, with whom he corresponded until his death in 1677, albeit on several occasions he promised him that he would report back on observations with a giant telescope (Kampa, 2018).

In summary, it seems very doubtful that Hevelius described and pictured an existing instrument.

3 THE MAST LOCATION IN DANZIG (GDAŃSK)

Of course, no telescope of this size could be installed in the observatory at Pfefferstadt, and Hevelius chose a site for it just over one kilometer away. This was most likely in the vicinity of the present-day railway station at Al. Zwycięstwa (= Victory Alley), close to the tank monument (Figure 5). It is the former location of a brick factory, owned by Hevelius, and the

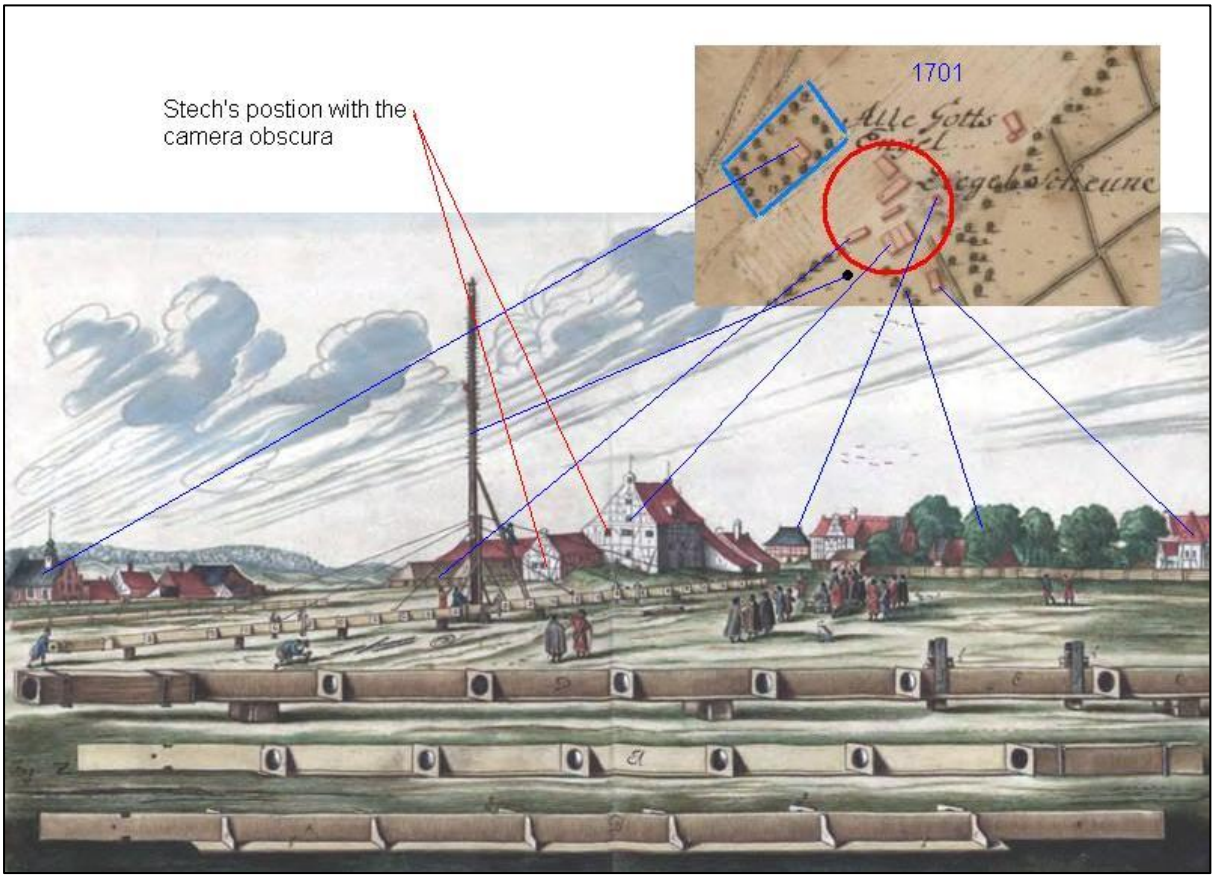


Figure 5: Proposed location (54° 22' 03.3" N, 18° 38' 12.4" E) of the giant telescope, after analysis of the engraving of Figure 4. Two potential positions for the draftsman Stech are shown (Szychliński, 2014).

Church of All God's Angels, neither of which exists any more (Szychliński, 2014).

The whole project had to be expensive, as it required a horse cart to transport telescope elements, rigging, blocks, and weights—though probably only from nearby brickworks—and the assistance of about five people (this is how many can be seen in Figure 1). Among them, at least one (a seaman?) must have had no fear of heights, because he had to climb the mast. Hevelius also realized that the telescope could only be used in very calm weather (Kampa, 2018), which indeed was rare for Gdańsk.

4 THE OPTICS

Unfortunately, though lenses made by Burattini for such a giant telescope did survive until the twentieth century, they were eventually lost, supposedly during World War II. A paper that sheds some light on this point was published in *Physikalische Blätter* (Anonymous, 1960), and the anonymous author tells an interesting story. On the 150th anniversary of the founding of the *Naturforschende Gesellschaft in Danzig* (the Gdańsk Natural Research Society), at the Jubilee Meeting on 2 January 1893, the main speaker, Dr. Kayser, showed the audience two lenses that he said had focal lengths 102 feet and 158 feet, which he claimed had belonged to Hevelius. A Society member, C. Ramsauer, was given the task of determining their exact focal lengths. The editor of the *Physikalische Blätter* from the 1960s, which is the source of this information, notes that he remembers seeing them in 1925. They were

> … carefully polished, almost flat plates, made from yellowish, not very transparent glass 1–2 cm thick and approx. 20 cm in diameter … [and gave] surprisingly sharp images of light bulbs.

These and some other lenses, attributed to Hevelius, were described in more detail in an earlier meeting report from 1887 (Momber, 1888).

One can presume that these were two lenses made by Burattini, neither of which attained its desired focal length, so that Hevelius could not get a sharp image with them. If Kayser's values were correct, perhaps Hevelius did not realize that one lens' focal length was too long and the other too short. Any attempts by Hevelius with these lenses, done in a horizontal position, watching distant objects during the day with the open tube, would not have been easy. Imaging the Sun would require a flat mirror of good quality, which apparently Hevelius did not possess. He wrote that the lenses "…

wanted to show something" … (Kampa, 2018), which perhaps indicated an unfocused image.

It seems that Burattini was not able to properly grind and polish very long-focal-length lenses. There is one big (154 mm diameter) lens of his, with a very bad figure, stored in the Deutsches Museum (Wissner, 1953). Burattini's four failed lenses, made for Hevelius (30 ft, 70 ft and two of 140 feet focal length) must have damaged Hevelius' confidence in Burattini, because after 1670 until the fire which ruined his observatory in 1679, he ordered nothing more from him (Kampa, 2018).

5 THE OBSERVATIONS

Observational data from the 140-foot telescope in *Machinae Coelestis Pars Posterior* and *Annus Climactericus* are missing (Hevelius, 1679; 1685). There is also no mention of them in the known Hevelius correspondence (Kampa, 2018).

Hevelius did not contribute substantially to our knowledge of planets. Despite writing proudly about his several big telescopes, he was unable to provide drawings of the planets at his epoque standards, easily met by Huygens, Cassini or Hooke. This topic will be discussed in detail in a separate paper.

6 CONCLUDING REMARKS

Available data and their analysis suggest that Hevelius' giant telescope was most likely never built and remained only as a project. In short:

- the construction, due to its design, was very fragile, prone to bending and warping, as well as very sensitive to the wind;
- the engravings presented by Hevelius in *Machinae Coelestis Pars Prior* are inconsistent with details (dimensions) given in the text;
- the perspective and relative sizes of the details on giant telescope depictions are unrealistic;
- the claim that the telescope was completed and operable before *Machinae Coelestis Pars Prior* was published, remains in conflict with the fact that Burattini delivered the optics after the printing was done;
- there is no report on giant telescope performance, so eagerly awaited by Oldenburg;
- there are no known data from observations with a 140-foot telescope;
- the lenses made by Burattini for the giant telescope survived at least till 1925, but they had incorrect focal lengths for a 140-foot long tube.
- Hevelius was not a planetary discoverer, and his achievements are by far less impressive than those of Huygens, Hooke or Cassini.

All this is quite perplexing because Hevelius' giant telescope is often cited as a canonical example of huge Baroque refractors with single-lens objectives. Refractors made by G. Campani and used by G.D. Cassini and his contemporaries, proved to be much more productive. Perhaps it was a matter of their location: Hevelius built his observatory in the worst possible place in terms of seeing. This is also to be discussed in another paper.

7 NOTES

1. See, for example, Hevelius (1673: 382 and 386). This is commented on by Lühning (2023: n. 253). Note that according to Lühning (2008; 2023) one Danzig foot = 0.2845 m.
2. Ranges such as 10″–11″ are given by Hevelius himself.
3. Tito Livio Burattini (1617–1681), an Italian nobleman who was an inventor, scientist, instrument-maker and lens-grinder, engineer, architect, traveller, and Egyptologist, worked for most of his life in Poland and Lithuania. He encouraged Hevelius to start the project of a giant telescope and provided the optics (Hevelius, 1673).

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Dr. Maciej R. Nowacki (b. 1964) is a consultant for Hevelius' instruments at the Gdańsk Museum of Science. He has a PhD in Medical Microbiology and works as a Medical Advisor in the pharmaceutical industry.



He has a long-standing interest in antique optical instruments, both microscopes and telescopes, with focus on the seventeenth century, i.e. the 'pre-achromat era'. Maciej collaborates with several major European collections—including the Mathematisch-Physikalischer Salon in Dresden, the Astronomisch-Physikalisches Kabinett in Kassel, the Deutsches Museum in Munich, and the Kunstgewerbemuseum in Berlin—in testing the optics and actual performance of historical telescopes and microscopes.

He has built several functional replicas of Baroque instruments, including Hevelius' favorite 20-foot closed-tube telescope and a 16-meter focal length aerial telescope.

Maciej is a co-author of a two-part article on Hevelius' telescopes in the Polish journal *Urania*. An active amateur astronomer, he also uses modern telescopes of different types up to a 10-inch Newtonian. He lives in Jeżewo, near Gdańsk.