Bone telescopes from Amsterdam

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Abstract

In Amsterdam five bone telescopes or spyglasses were found in excavations. These were ‘Dutch’ or ‘Galilean’ telescopes with an optical system consisting of a convex objective and a concave ocular. They are dated to the 18th century. The telescopes were for personal use. The tubes of the telescopes were made from bovine metatarsals. Different specialized artisans were involved in the manufacturing process. In the Dutch Republic, a society where merchants had a lot of influence, it is probable that merchants from Amsterdam played an important role in the manufacture and distribution of these little telescopes (fig. 1).

Key words: Telescopes, bone, 18th century, Amsterdam

1 Introduction

In the past 35 years the Office for Monuments & Archaeology (Bureau Monumenten & Archeologie; BMA) has found over 2000 objects made from hard animal tissues. These objects are found in excavations from all over Amsterdam and are dated between the 12th and the 19th centuries. The materials that were identified are bone, antler, ivory, horn, tortoise shell, baleen and hoof. These materials were used to manufacture objects with different functions, such as toys, combs, toothbrushes, beads, buttons, needles and many more (Rijkelijkhuizen 2004). The finds of five bone telescopes are unique in Dutch archaeology.

2 The invention of the telescope

It was not until the beginning of the 17th century that the telescope, an instrument for seeing faraway things as though they were nearby, was invented. This invention is often attributed to one of two Dutchmen, Sacharias Janssen and Hans Lipperhey, both spectacle makers from Middelburg. The question of who the first inventor of the telescope was has occupied researchers for decades, even centuries without a positive result (Van Helden 1977; Ernst 1985; Degenaar 1988; Van Berkel 2002). The two Dutchmen from Middelburg and a Dutchman from Alkmaar, Jacob Metius saw the potential of such a magnifying instrument and they played a big role in the distribution and popularity of the telescope (Van Helden 1977: 24-25).
The first person to apply for a patent was Hans Lipperhey in 1608, followed by Jacob Metius. However, the son of Sacharias Janssen, Johannes Sachariassen, later said that his father was the first to make a telescope in The Netherlands after an Italian example. Neither Hans Lipperhey nor Jacob Metius received a patent because the manufacture of a telescope appeared to be a simple procedure and could be copied very quickly. It could not be kept a secret (Van Helden 1977: 20-21). Lipperhey’s demonstration of the telescope to Prince Maurice of Nassau and the States General in The Hague and his attempt to claim a patent received wide notice in newsletters and diplomatic correspondence, and the instrument itself reached the major European cities within a year (Van Helden 1977: 24-25). Soon they were made and sold all over Europe (Willach 2001: 381). Therefore 1608 is considered the year of the invention of the telescope.

3 Optical systems

Refracting telescopes use a lens, while reflecting telescopes use a mirror as the primary receptor. The first telescopes were refractors. Although various ideas about using mirrors in a tele-
scope circulated as early as the 16th century, a working version was not built until 1668 by Isaac Newton (Zuidervaart 2004: 409; Hall & Simpson 1996: 2-3). The reflecting telescope did not become common until the 18th century (Zuidervaart 2004). The advantages of reflecting telescopes over the earlier refracting telescopes were that they are shorter and there is no chromatic aberration. Chromatic aberration occurs in refracting telescopes because the lenses cannot focus all the different colours of a ray of white light at one point when refracted (Pedrotti & Pedrotti 1993: 102). This problem with refracting telescopes was not solved until the 18th century.

4 Refracting telescopes

Refracting telescopes can have different optical systems. The first telescope that was developed had an optical system that was called the Dutch system (because of its origin) or the Galilean system (after the man who made the instrument famous). In 1611 the German astronomer Johannes Kepler developed another system, the Keplerian system, described in his book Dioptrice. This system did not come into use until several decades later (Allen 1943: 303, Van Helden 1976, Degenaar 1988: 60) and was preferred from that time onward by astronomers over the Dutch system. This instrument was therefore also called the astronomical telescope. Looking at both systems we can understand why they preferred the Keplerian system.

In order to understand the two different optical systems, we must keep in mind the difference between convex and concave lenses. Convex lenses are thicker in the middle. The image seen through a convex lens is magnified but indistinct. These lenses were used to aid far sighted people and were available from the 13th century onwards (Van Helden 1977: 10, 17). Concave lenses are thinner in the middle. The image seen through a concave lens is reduced but sharp. These lenses were used to aid near sighted people but were not common in northern Europe until the 16th century (Van Helden 1977: 10-11, 17).

A telescope with a Dutch or Galilean system has a convex objective and a concave ocular (eye-lens). The stronger ocular is placed within the focal distance of the objective. A telescope with a Keplerian or astronomical system has a convex objective and a stronger convex ocular. The focal distances cross each other. (fig. 2) The Keplerian system therefore requires a somewhat longer tube than the Dutch system. The tube of the Keplerian telescope is as long as the focal length of the objective plus the focal length of the ocular (fo + fe). The length of a Dutch telescope is the focal length of the objective plus the (negative) focal length of the ocular (fo + fe, where fe is negative) (Pedrotti & Pedrotti 1993: 139-142). To increase the magnification of the telescope, the objective should be made weaker and/or the ocular stronger. In practice this meant that telescopes became longer and longer in the 17th century.

The advantage of the Dutch system is that it gives an erect image, in contrast with the Keplerian telescope, which gives an inverted image. The advantages of the Keplerian telescope over the Dutch telescope are that the image is brighter and that the field of view is larger (Pedrotti & Pedrotti 1993: 141). Because of these advantages, astronomers preferred the Keplerian telescope to the Dutch telescope. For astronomers an inverted image is not a problem. The image of a Keplerian telescope could also be made erect by putting in an extra convex lens, a so-called erector lens (Willach 2001: 382). This, however, also affects the quality of the image by increasing the chromatic aberration (Allen 1943: 303; Willach 2001: 383). It also lengthens the telescope (Pedrotti & Pedrotti 1993: 141; Willach 2001: 382).
5 Bone telescopes from Amsterdam

5.1 The bone telescopes

Three almost complete telescopes (fig. 2, 4, and 7) and two fragments of telescopes were found in excavations in Amsterdam. The fragments found in Amsterdam could be identified as telescopes by comparing them with the nearly complete bone telescopes (Rijkelijkhuizen 2004). Four of the telescopes consist of a single part. The length of these four telescopes is between 79.7 and 89.6 mm. The largest diameter measures approximately 24 mm. The fifth telescope is made from two parts, which are fixed together with a screw-thread. The total length of this telescope is 138.7 mm; the lengths of the individual parts are 68.9 and 76.7 mm. The largest diameter of the bone tube is about 25.5 mm.

Figure 2 Bone telescope with view of the lens (VIN9-1). Collection: Bureau Monumenten & Archeologie (BMA), Photo: Wiard Krook, BMA.

Figure 3 The Dutch/Galilean and the Keplerian/astronomical system.
Figure 4 Bone telescope (A-448). Collection: BMA, Photo: Wiard Krook, BMA.

Figure 5 Marrow cavity is visible on one of the telescopes. Collection: BMA, Photo: Marloes Rijkeliokuizen.

Figure 6 Cross-section of a bone telescope.
Two of the telescopes were recovered from cesspits and could be dated to the 18th century. One was found in a cesspit in the Vinkenstraat and is dated between 1725 and 1775 (VIN9-1); the other was excavated in the Korte Houtstraat, near the Waterlooplein, and is dated between 1725 and 1750 (WLO-179-12). The other three have no clear context (A-448, SIN1-4, VARA-6-3), but the similarity in their appearance suggests that these also date to the 18th century.

5.2 Raw material and manufacture

The telescopes were made from cattle metatarsals. Cattle metatarsals are especially suitable because they are quite round and have a thick *compacta*. The length of the telescopes is about 8 to 9 cm, this is about the limit for making telescopes because the marrow cavity becomes more oval towards the epiphyses. After the removal of the epiphyses, the outer side of the diaphysis was modified on a lathe. The marrow cavity was only modified on each end to create a platform for the lenses to rest on. On both ends screw-thread was formed on the outer side for the lens caps. When the bone tube of the telescope was finished, the lenses were put in place with metal rings (Peter Louwman, pers.comm.).

5.3 The optical system

One of the lenses is still present in one of the telescopes (fig. 2). Both lenses are preserved in this telescope that consists of two parts (fig. 7). The telescopes were therefore refracting telescopes. But which optical system was used, the Dutch/Galilean or the Keplerian/astronomical system? Whether the lenses in the telescopes are convex or concave lenses cannot be seen. The small telescopes found in Amsterdam probably had a low magnification. Following the rapid development of the telescope soon after its invention, larger and better telescopes were available in the 18th century. These small telescopes were probably personal items for terrestrial use. A Dutch system is more convenient for telescopes for terrestrial use because of the upright view. Keplerian telescopes could also have an upright view when an extra third lens was installed in the telescope. The telescopes found in Amsterdam only have two lenses. It can therefore be concluded that the telescopes used the Dutch system.

Simple lenses can suffer from spherical aberration, caused by the light passing through the edges and the centre of the lens coming to focus at different points. The size of the objective lens limits the amount of light that comes into the telescope (Pedrotti & Pedrotti 1993: 109-110). The diameter of the lens could be reduced to lessen spherical aberration (Allen 1943: 304). The effective aperture of the lens is already limited by the size of the opening against which it is
fixed. It is also possible to further reduce the aperture of the lens by means of a lens cap with a small opening. It is unknown whether the lens caps were for protection of the lenses only or also to reduce the effective size of the lens.

Another influence on the amount of light could be the inside of the bone tube; because the marrow cavity is not enlarged, the thicker bone around the middle of the tube might block the outer rays of light (Fig. 6). In the case of the telescope made from two parts, the marrow cavity is reduced further by putting in a bone insertion with a small opening (Fig. 7). This functions as an aperture stop (Van Helden, pers. comm.). It blocks the outer rays of light, which results in a sharper view by reducing the spherical aberration.

6 Other finds of small telescopes

No other bone telescopes are known in archaeological collections in the Netherlands. One reason for this could be that if no lenses are present and the object is incomplete, fragments are not recognized as fragments of telescopes. Only a few similar finds, made of wood, are known. These wooden telescopes were found in shipwrecks and can be precisely dated.

One telescope was found in the shipwreck of the Amsterdam, a Dutch East India Company (VOC) ship that ran ashore in 1749 in Hastings, England. Excavations provided plenty of information on this ship and its contents (Gawronski 1994). One of the many finds was a small ebony telescope with copper lens caps. It is approximately 17 cm long and probably consisted of two parts and had two lenses (Jansma 1986). A copper lens cap was found in another Dutch East India ship, the Hollandia. This ship was wrecked on the Scilly Islands in 1743. It is unknown what kind of telescope this lens cap belonged to (Gawronski 1994: 275). Another wooden telescope was found in a Swedish ship, the Kronan. This ship was wrecked in 1676 on the east coast of the island Öland (see www.kalmarlansmuseum.se). The telescope has a length of circa 13.5 cm and is probably made of wood from the Guayak-tree (Lignum vitae) or ebony (Lars Einarsson, pers. comm.).

7 Artisans, merchants and the use of small telescopes

For what purpose were these small telescopes manufactured? Two bone telescopes were found in cesspits in Amsterdam. Two wooden telescopes were found on board of ships. Because of the low magnification, the telescopes were probably not for astronomical but for terrestrial use. They were, however, not used for navigation; in navigation a different type of telescope with a higher magnification was used. This indicates that the small telescopes were a kind of pocket telescopes for personal use. They could, for example, be used as opera-glasses or for personal use on ships.

Little is known about the manufacturers of such telescopes. The manufacture of a bone tube and the grinding of lenses are different crafts and it is possible that the bone tubes and the lenses were made by different artisans. People with a scientific education, such as the famous Dutchmen Spinoza or Huygens, knew how to make lenses. But in the 17th and 18th centuries merchants in the Dutch Republic had the influence and money to require knowledge about optics, and some of them even made scientific instruments themselves (Zuidervaart 2004). In the Kalverstraat in Amsterdam telescopes could be bought, for example, at the knife-shop of Coenraad Metz. He sold all sorts of optical instruments (Gawronski 1994: 274-275).
Although the development of the telescope rapidly spread throughout Europe, the pocket telescope was still a luxury item. It is not surprising that these bone telescopes were found in Amsterdam. Amsterdam was an important trading town and a centre of craft. Telescopes were also manufactured in this city. Perhaps more undiscovered telescopes are yet to be found in museum and archaeological collections. Further research, both archaeological and historical, must be done to reveal more about the artisans and merchants and also about the use of these small telescopes.

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