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THE EARLIEST TELESCOPE PRESERVED IN JAPAN

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Abstract: This paper describes the antique telescope owned by one of Japan's major feudal warlords, Tokugawa Yoshinao. As he died in 1650, this means that this telescope was produced in or before that year. Our recent investigation of the telescope revealed that it is of Schyrlean type, consisting of four convex lenses, so that it gives erect images with a measured magnifying power of 3.9 (± 0.2-0.3). This also implies that Yoshinao's telescope could be one of the earliest Schyrlean telescopes ever. The design, fabrication technique, and the surface decoration of the telescopic tube and caps all suggest that it is not a Western make at all, but was produced probably under the guidance of a Chinese Jesuit missionary or by the Chinese, in Suzhou or Hangzhou in Zhejiang province, China, or in Nagasaki. Following descriptions in the Japanese and Chinese historical literature, we also discuss the possibility that production of Schyrlean-type telescopes started independently in the Far East nearly simultaneously with the publication of *Oculus Enoch et Eliae* by Anton Maria Schyrle in 1645.

Keywords: Antique Schyrlean telescope, Japanese telescope, Tokugawa Yoshinao, cultural transfer

1 INTRODUCTION

Although the invention of the telescope has often been attributed to the Dutch optician Hans Lipperhey in 1608, the fact seems more likely to be that the telescope was not invented by any single particular person (van Helden, 1977). To our knowledge, the first introduction of a telescope into Japan was in 1613. Both Japanese and English sources record without contradiction that the telescope was offered to the first Shogun Tokugawa Ieyasu (1542–1616) by a captain of the British East India Company for establishing a bilateral trading relation, and it had a gold-coated tube with a silver mounting.[1] Considering that it took a few years at that time for a sailing ship to reach Japan from Europe via the Cape of Good Hope, this is a good example of very quick cultural transfer (Sluiter, 1997). The whereabouts of this first telescope are now unknown. After that, a considerable number of European telescopes were brought to Japan by British, Portuguese, Spanish and Dutch traders as flattering gifts for high-ranking Shogunal officers and warlords, responding to their requests (e.g. Shirayama, 1990); unfortunately, none of these seems to have survived.[2]

In 1964, a small antique telescope was displayed for the first time at an exhibition of telescopes held in Tokyo to commemorate the 400th anniversary of the birth of Galileo Galilei (National Science Museum, 1964). It would seem that the telescope did not attract any interest from the organizer or the audience, because neither a photograph nor a mention of it was included in the exhibition catalogue. Only a one-line description appeared, which was included in a mimeographed list of the displayed items, which was distributed to only a limited number of people. This stated that the telescope was originally owned by Tokugawa Yoshinao, but was now in the possession of the Tokugawa Art Museum in Nagoya city.

Thanks to the generosity and kindness of the Museum, in 2003 and 2005 I was given the chance to subject Yoshinao's telescope to detailed examination, in collaboration with staff from the Museum. This paper reports the results of our investigation. Firstly, in Section 2 we investigate the origin and the history of the telescope, and how it came to end up in the Tokugawa Art Museum. Then in Section 3 we describe the apparent structural and optical characteristics of the telescope in terms of surface decoration, fabrication technique, magnifying power, and so on. Finally, in Section 4 we discuss the historical implications of this telescope when viewed against the background and the perspective of the history of the telescope in general.

2 THE AUTHENTICITY OF YOSHINAO'S TELESCOPE

The Tokugawa is the Shogun's family. The original owner of the telescope is believed to have been Tokugawa Yoshinao (1600–1650), who was the ninth Prince of Ieyasu. Yoshinao's officially-recorded death on 5 June 1650 (in the Gregorian Calendar) implies that his telescope was made in or prior to that year. However, in the case of such an old cultural asset, establishing the authenticity of the reputed ownership is very important, in order to validate the conclusions derived from these studies.

Yoshinao was given by his father, Ieyasu, a large and prosperous *han* (clan) in the Owari-Nagoya district (which includes the current city of Nagoya), and he became the first *Hanshu* (feudal Governor) there. Because of his scholastic interests, he also inherited many rare books and curiosities from his father. These treasures have been safely retained by his descendants for more than 380 years without loss or damage from fires or wars, and now comprise the backbone of the prestigious collection stored in the Tokugawa Art Museum.

Yoshinao's telescope is in a catalogue compiled about a century ago which lists the properties that Yoshinao's son, Mitsutomo, inherited from his father. This catalogue is an edited version of the original inventory. Because the original inventory books maintained at the time when Yoshinao died were later reorganized into different classified catalogues to accommodate the growing collection, we lack the original description of the telescope.[3] However, since various records of the family indicate that swords, armour and tea ceremony instruments which make up a major part of the Museum collection have been kept with the original inventory and Yoshinao's telescope has always been stored with them, there is no room for doubting the authenticity of this telescope. Hence,

we conclude that Yoshinao's telescope was certainly made in or before 1650.

3 CHARACTERISTICS OF THE TELESCOPE

3.1 Outer Appearance

Figure 1 shows the fully extended tube, the inner tube, the eyepiece and two caps of Yoshinao's telescope, along with the wooden box in which it was stored. The surface of the box reads "Oyuzuri To-onmegane" in golden Chinese letters, meaning "The inherited telescope". In spite of the telescope's apparent antiquity, it gives us an impression of having been preserved in good condition, without any parts going missing.

The telescope consists of five-stage draw-tubes, including the ocular part. The contracted and extended lengths of the telescope are respectively 41cm and 119cm, while the outer tube diameter is 50mm. Figure 2a shows the objective lens, and we can infer that it is about 40mm diameter since the inner diameter of the first-stage draw-tube was 41mm (unfortunately, we were not allowed to separate the lens from the tube and measure it). Directly in front of the lens there is an aperture stop, which is made of a brown-color mottled tortoiseshell and is attached to the tube with a copper ring. The diameter of the aperture measures 24mm. Although in Europe Galileo was already familiar with the optical effects of aperture stops to suppress chromatic aberration (Dupré, 2003), we imagine that the use of a tortoiseshell aperture stop in Yoshinao's telescope was simply intended as special decoration that would appeal to high-ranking people rather than for optical purposes since tortoiseshell was very expensive imported material at that time. It is noted that some Japanese telescopes produced by Mori Nizaemon during the 1720s also adopted this tortoiseshell decoration, suggesting that they were possibly influenced by Yoshinao's telescope. Figure 2b shows the eyepiece section of the telescope. The effective diameter of the eyepiece lens was 11mm, and the white eye-ring is probably made of ivory (which was also an expensive material).

Figure 3a shows part of the decoration on the surface of the telescope tube. The tube itself is made of paper, which is painted with semi-transparent *urushi*-lacquer. This is very traditional in Chinese and Japanese handicrafts, although the *urushi* work on later Japanese telescopes looks like non-transparent Western lacquer and appears quite different from that on Yoshinao's telescope. In Figure 3a, along the circumference of the tube, we see contiguous silver patterns symbolizing perhaps shrimps or scorpions, which were probably made by pressing with a kind of stencil. Such a symbol is not so common, but is seen on some of later telescopes (such as Iwahashi's telescope).

Figure 3b shows the inside of the tube. One can see plenty of fine wooden annular rings running parallel to the axis of the telescope (and the small piece attached at the lower left could have been for adjusting a loose movement of the tube). It was not hard for a skilled Japanese carpenter to cut out such material thinner than a piece of paper with a sharp plane. The tube of the telescope is fabricated by multiple layering of paper sheets on the wooden surface with strong natural glue. This technique is the same as that adopted in later Japanese telescopes made before the 1860s and is known as *Ikkan-bari*, which is Chinese in origin. It was considered that the oily resin coming out from the wooden surface would have kept the draw-tubes of the telescope moving smoothly for an extended period of time. The *Ikkan-bari* technique is referred to again in Section 4.

Figure 1: Overall view of Tokugawa Yoshinao's telescope preserved at the Tokugawa Art Museum in Nagoya city, Japan.

Figure 2a (above): The objective lens with a tortoiseshell aperture stop.

Figure 2b (right): The ocular part whose ring is made of ivory.

Figure 3a (left): The surface decoration of the telescopic tube.
Figure 3b (above): The inside view of the tube made of thin wooden sheets.

Figure 4a (left): The outside view of the telescope cap.
Figure 4b (above): The inside of the telescope cap with colored water-marble decoration.

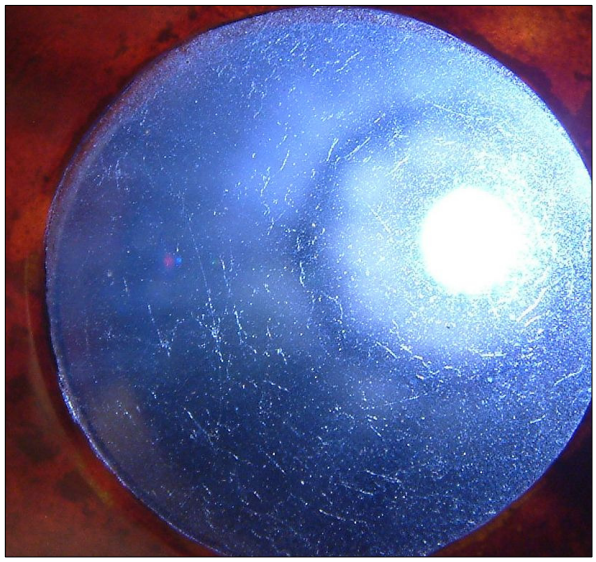

Figure 5a (above): Glass material of the objective lens seen through a back-illuminated light.

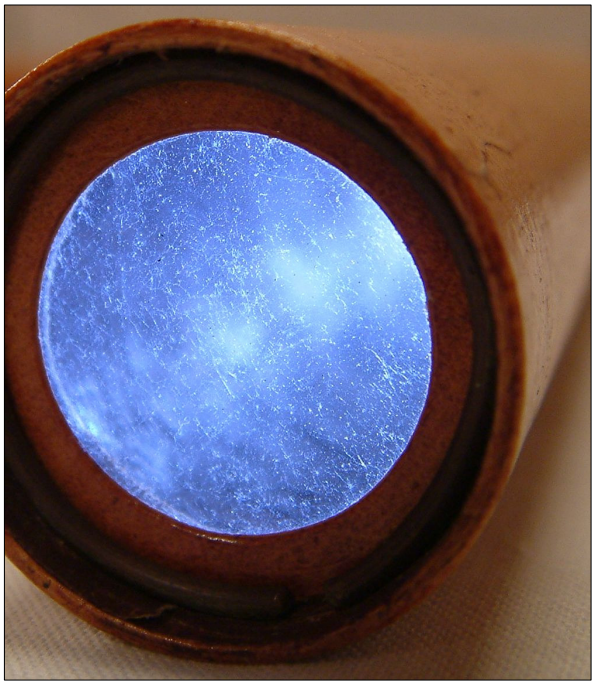

Figure 5b (right): Glass material of an ocular lens seen through a back-illuminated light.

Figure 4a and 4b are the outside and inside views of the telescope caps. As mentioned later, *Ikkan-bari* used to be basically a method to make a cap of a small vessel. The bottom of the inside of the cap (Figure 4b) is decorated with a red, blue and white-colored water-marble pattern. An historical description of colored Japanese water-marble first appeared in *Kiyu Shoran* (Kitamura 1830),[4] although monochromatic charcoal water-marbles in Japan date back to around the tenth century (Kawakami, 1987). Recognizing that Yoshinao's telescope is more than 350 years old, the three-colored water-marble of the telescope may be a sign of the use of a non-Japanese art tradition. Therefore, all the characteristics thus far explained about this telescope seem to indicate that it is surely neither a Western product nor of purely Japanese manufacture.

3.2 Measurements of the Magnifying Power

Since we could not obtain permission to attach a camera to the telescope in order to measure the magnification out in the open air, we had to measure the magnifying power in the narrow storage room at the Museum. Textbooks on optics (e.g. see Kingslake, 1983) teach us that the magnifying power of a telescope is equal to the ratio of the effective diameter of the objective lens (the entrance pupil) to the size of the Ramsden's circle (the exit pupil) observed at the eyepiece lens. With the telescope fully extended for distant viewing, a light plate for the inspection of slides was placed directly in front of the objective lens and the size of the exit pupil (namely, the image of the illuminated objective lens focused by the lenses) was measured using a magnifying glass of power 20 with a scale of 50-micron divisions. Using this technique, the magnifying power of Yoshinao's telescope was calculated to be 3.9, from the measured sizes of the entrance and exit pupils being 24.0mm and 6.2mm, respectively. We confirmed this magnification by viewing different items in the storage room through the telescope, which had a field of view of about 2.5° and showed erect images. We also checked the measuring error of this method by applying it to some modern telescopes and binoculars whose magnifying powers (from 5× to 15×) were precisely known, and found errors of ±0.2-0.3 for them. Hence we expect a similar error to apply to Yoshinao's telescope.

3.3 Lens Defects and Image Quality

In order to check production and erosion conditions of the lens material, we carefully examined the objective and some ocular lenses by back-illuminating them with white LED lights. This revealed plenty of fine cracks and bubbles. Some of these could be lens-surface scratches produced during the polishing process, while others were internal inclusions (see Figure 5a and 5b). We also noticed a ragged circumference (left) of the objective lens (Figure 5a), and a small fracture on the upper right edge (Figure 5b). Everything seemed to reinforce the impression that Yoshinao's telescope was really an old one.

In order to check the image quality seen through the telescope, we hung a calendar on the wall about 5m away in the storage room and photographed the numbers on it through the eyepiece (see Figure 6). Probably because of the low magnifying power of the eyepiece, we did not notice any particular image defects.

3.4 Optical Structure

In terms of the magnifying power mentioned in the previous Section, Yoshinao's telescope may look like no more than an opera-glass of Galilean type on sale at a toyshop. However, as shown schematically in Figure 7, this telescope was actually found to be of a more advanced form, namely a Schyrlean type consisting of four convex lenses (one objective and three eyepiece lenses).

It is well known that Anton Maria Schyrle (1597–1660) of Rheita, Bohemia, a friar of the Capuchins (a sect of the Franciscans), first invented practical tele-

scopes with three- or four-lens configurations at Augsburg, assisted by two opticians, and publicized the fact in his book *Oculus Enoch et Eliae* in 1645 (Court and von Rohr, 1929). After Johann Zahn cited Schyrle's telescopic achievements in his book which was published in 1685 and included illustrations (see Figure 8), the fame of Schyrlean-type telescopes, with their erect and wide-field images, spread throughout Europe. Regarding this, Court and von Rohr (1929) present a story that Sir Charles Cavendish from Britain, hearing the rumor of the new telescope in 1644, went all the way to Augsburg to meet Schyrle and order one of his telescopes. Whether or not Cavendish actually succeeded in obtaining a telescope is not clear, but this anecdote does tell us that around 1645 it was still hard to acquire a Schyrlean telescope in Europe. According to Court and von Rohr (ibid.) and van Helden (1999), telescopes definitely attributable to Schyrle (or more precisely his artisan, Johann Wiesel) do not seem to have been widely known at this time.[5]

From what has been mentioned above, we conclude that Yoshinao's telescope is of the Schyrlean type. This means that a Schyrlean telescope was already in the Far East just a few years after the publication of Schyrle's book in 1645. If Yoshinao's telescope was a result of information on the Schyrlean telescope brought from the West, this represents a case of very swift cultural transmission. In regard to this hypothesis, another possibility is discussed below in Section 4.

4 IMPLICATIONS OF YOSHINAO'S TELESCOPE AND HISTORICAL BACKGROUND

Here we discuss what the existence of Yoshinao's telescope implies in the context of the historical development of the telescope. In the case of Galilean-type telescopes, it is likely that eyeglass polishing artisans without backgrounds in lens-making science could devise a telescope consisting of a convex lens and a concave lens by trial and error, if they were taught the concept of the Galilean telescope. In fact, Lipperhey is also believed to have invented his telescope through such a process (e.g. see King 1955; van Helden, 1977). Therefore, it is likely that in each country the early development of telescopes was intimately connected with the activities of eyeglass workers, whose history extends back about two centuries earlier than that of telescopes.

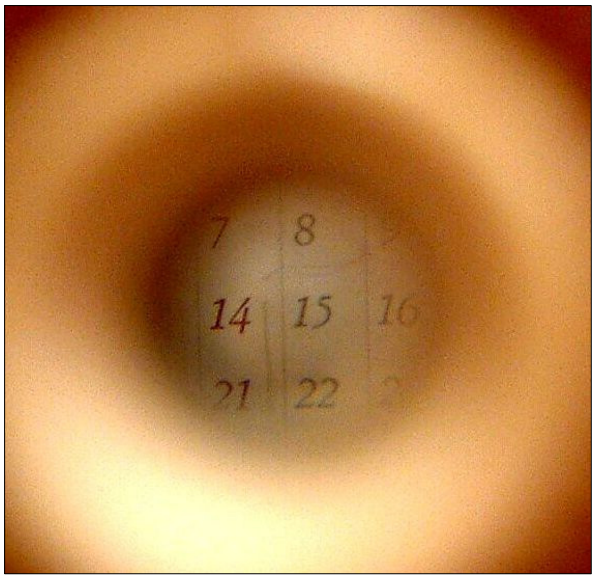

Figure 6: Day numbers of a calendar seen through Yoshinao's telescope. The defocused circular part is the ivory eyepiece ring.

4.1 The Japanese Background

First of all, let us consider the origin of eyeglass-making in Japan. In relation to this, there are a few legend-like anecdotes that date back to the 1620s and 1630s. The first story is recorded in *Nagasaki Yawaso* (*Night Stories of Nagasaki*), which Nishikawa Masayoshi, an astronomer at Nagasaki, published in 1720 after collecting the stories he heard from his father Joken, the highly-respected astronomer and geographer. It says:

> Hamada Yahyoye, the Nagasaki dweller, who used to sail to foreign countries during his peak-activity time, learnt there how to polish eyeglasses, and taught it to his disciple Ikushima Toshichi. This is the origin of lens-making in Japan, and thereafter Nagasaki became well known for its eyeglass production. The place where handiwork-skilled Hamada and his brother learnt lens-polishing was located in an adult country, to the east and south of Japan.

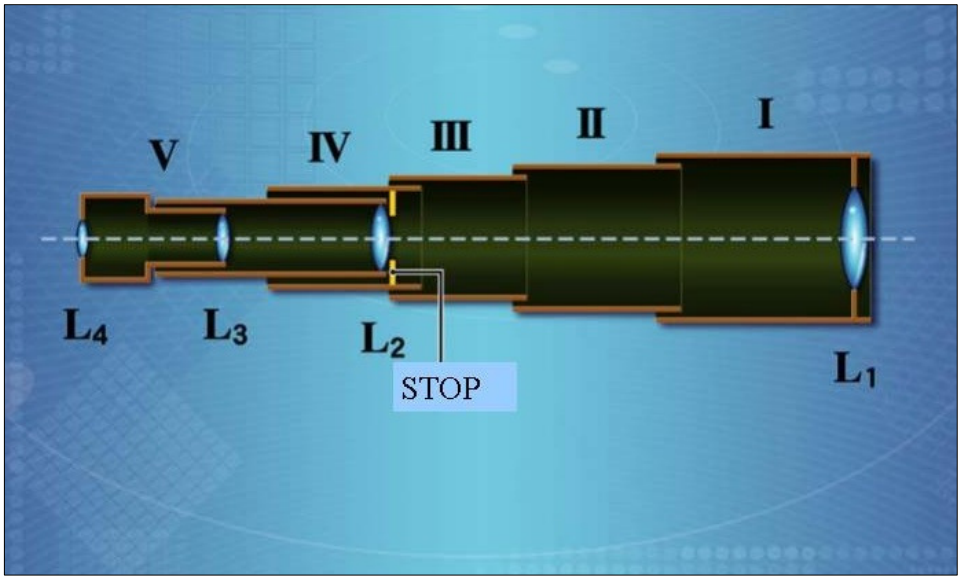

Figure 7: Schematic lens configuration of Yoshinao's telescope. The lengths of draw-tubes I, II, III, and IV are respectively about 400mm, 242mm, 246mm, and 200mm. The tube (267mm) connecting the eyepiece part and the IV-th draw-tube has a stop at the front end.

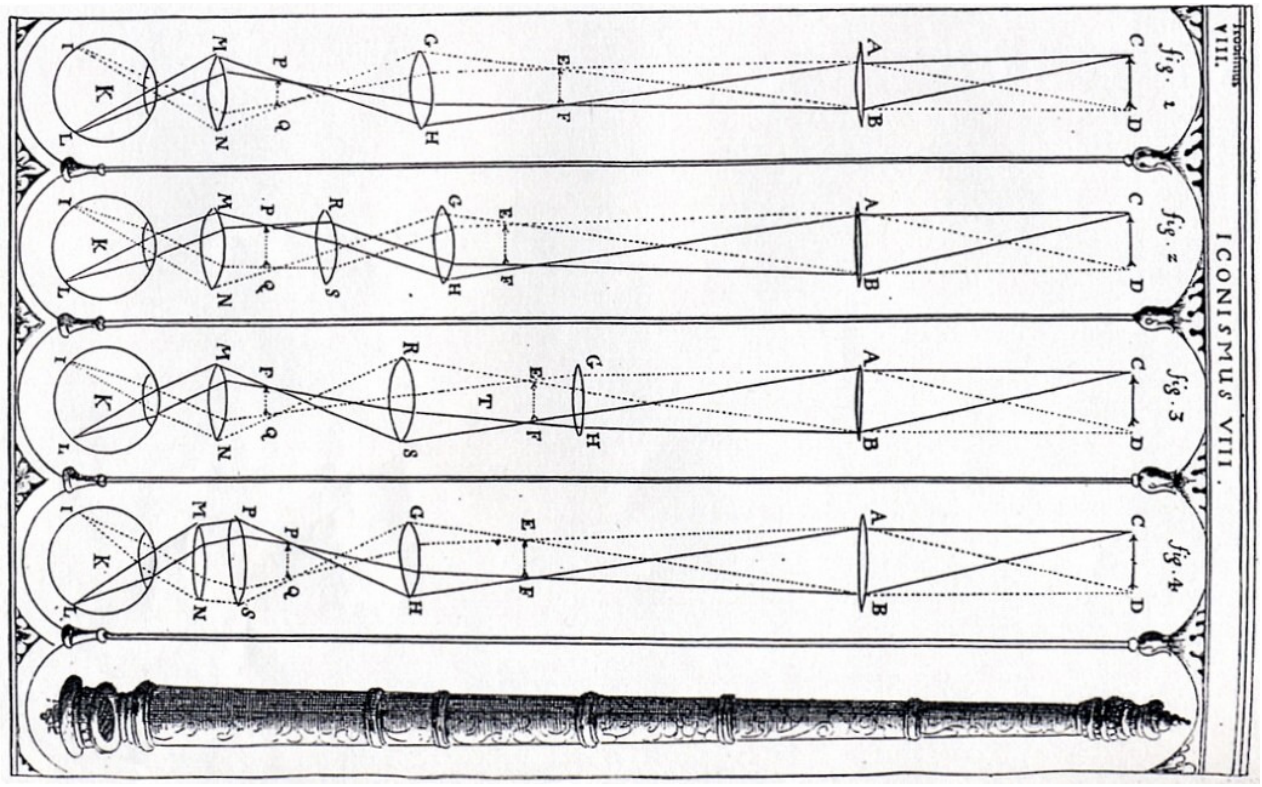

Figure 8: Johann Zahn's plate for optical configurations of Schyrlean telescopes (after Court and von Rohr, 1929).

Hamada Yahyoye was the captain of the *Shuin-sen* (a Government-licensed ship for foreign trade) based at the port of Nagasaki. No one knows for certain where the "adult country" actually was ("adult" usually meaning "civilized" at this time), but because Hamada's ship often went to Taiwan and Vietnam, and he and his crew came into conflict with the Dutch colonists in 1628 at a town in southern Taiwan, it would seem most likely to have been the southern coastal area of continental China. If this is the case, Hamada may have had a good chance to learn lens production there, possibly from Chinese experts.

Figure 9. *Natsume* (a small vessel for keeping tea-leaf) used in Japanese traditional tea ceremony.

There is another record relating to the origin of lens-polishing at Nagasaki. In 1632, a Chinese monk called Mokusu Nyojo (the Japanese pronunciation) from Jiangxi province came to Nagasaki, as an escapee from the political turmoil that followed the decline of the Ming Dynasty, and was nominated to be the chief priest of the Kohukuji Temple. He is famous for his construction of the first stone arch bridges in Japan. It is also said that, upon arriving in Nagasaki, he took some gemstone- and lens-polishers with him and taught the technique to people in Nagasaki.[6] Nyojo's alleged achievements are very likely to have been true, even though the relevant primary sources were stored at the Kohukuji Temple and were totally destroyed by the atomic bombing of Nagasaki in 1945.

In Section 3.1 we mentioned that the tube and caps of Yoshinao's telescope were produced using the *Ikkan-bari* technique, and that subsequent Japanese telescopes followed the same method. A cap skillfully made by *Ikkan-bari* fits the telescope tube very closely and smoothly. Here we should point out that the tube- and cap-making associated with Japanese traditional telescopes—including Yoshinao's—shows good resemblance to the technique used to produce *natsume* (Figure 9), a small tea-leaf vessel with a cap for protection from humidity, which has long been used in the Japanese tea ceremony.

During the period from 1624 into the 1630s, at about the same time that Nyojo came to Japan, a man called Hirai Ikkan (the Japanese pronunciation, his Chinese name is unknown) from the city Hangzhou in Zhejiang Province, China, arrived in Nagasaki and later became a naturalized Japanese (Ikeda, 1987; Sawada, 1966). His profession was to make various small containers by multiple layering of paper on a wooden base with glue and *urushi* lacquer. This

technique was so favored by Sen Sotan, who was then the top master of the tea ceremony, that Ikkan was eventually appointed to be one of the ten important artisans to support the tea ceremonial world, and was given the honor of living in the capital, Kyoto, near the master. Japanese people at that time praised his technique by calling it the *Ikkan-bari*, but he kept his methods secret and never taught them to the Japanese during his lifetime (i.e. 1598–1657).

Since the *Ikkan-bari* technique had been used in the manufacture of Yoshinao's telescope in or before 1650 —while Ikkan was still alive—this suggests that the telescope probably was not produced by Japanese artisans. If Yoshinao's telescope was in fact fabricated in Nagasaki by a Chinese immigrant, it is likely that the maker of the telescope collaborated with Ikkan, because most Chinese were forced by the Shogunal Government to live in the small Chinese colonial district of Nagasaki. Or, it may be more likely that the *Ikkan-bari* technique had already existed in China before Ikkan's arrival in Japan, and that he merely applied it to *natsume*, while the maker of Yoshinao's telescope independently utilized the same method.

From what has been discussed thus far, no matter where Yoshinao's telescope was made, it seems clear that its outer appearance, design and production technique all point to a Chinese origin. At the same time, in the history of the Japanese telescope, one can see that Yoshinao's telescope is very important in the sense that its existence substantiates the above-mentioned anecdotes regarding Hamada Yahyoye, Mokusu Nyojo, and Hirai Ikkan, which have long been regarded only as legendary stories.

4.2 The Chinese Background

Given the importance of Yoshinao's telescope, a discussion of the history of telescopes in China would seem in order. Among the Japanese sources on astronomy written in the eighteenth century, some explain that the method of telescope-making in Japan was transferred from Europe, via China. For example, the book *Tenkei Wakumon Chukai Zukan* (*Annotated Illustrations of Tianjing Huowen*),[7] published by Irie Shukei in 1750, states that "… the telescope was invented in Holland in the Middle Ages and that instrument was brought to China and then to Japan."

Another example is in the book *Shusei Horyaku Kojutsu Genreki* (*Revised Compendium of the Horyaku Calendar*) written by the Shogunal astronomer Sasaki Nagahide in 1769. After confirming that he saw the same telescopic views of planets and stars as described by Yang Manuo, Sasaki says: "Both the splendid gadget due to Manuo and the one produced by the people of Qing Dynasty were certainly the instruments that made use of glasses for distant-viewing." There is no doubt that Sasaki is referring to the telescope. Here, Yang Manuo is the Chinese name of Emmanuel Diaz (1574–1659), the Portuguese Jesuit priest who came to China in 1610 and served the Qing Dynasty as an astronomer. He wrote the book *Tianwenlue* (*Concise Dialogue on Astronomy*) in 1615; the main part of the telescopic description in Sasaki's book is in fact no more than an abbreviated version of Yang's *Tianwenlue*. Sasaki's words seem to suggest that some Japanese understood that the telescope had been produced by the Chinese from a fairly early time.

Tianwenlue was actually the earliest book published in Chinese that introduced telescopic observations of celestial bodies. On the other hand, the first Chinese book that described the structure of the telescope and how it was made was *Yuanjingshuo* (*Explanations of the Telescope*), which was published in 1626 by the famous Jesuit astronomer Tang Ruowang (Johann Adam Schall von Bell, 1591–1666). The part of the book dealing with the making and use of the telescope simply states that telescope production can be achieved by combining a front convex lens and a rear concave one. However, even with such an elementary description, an eyeglass polisher with knowledge of the strength of the lenses and perhaps advice from a Missionary priest could have easily assembled a simple telescope of the Galilean type.

Bo Jue is the person whose name first appears in Chinese history as a telescope maker. He was a civil scholar from the city Suzhou, and was famous for his production of copper artillery. Bo owned his own workshop where he carried out experiments and manufactured various instruments. He also studied varied disciplines, including Yinyang divination, astronomy, iron manufacturing, military technology, agricultural irrigation, and so on. Bo began making telescopes in 1635 or a few years earlier, and even attached a telescope to an artillery gun for aiming purposes (Chen, 2003; Wang et al., 1997). According to Wang et al. (op. cit.), in the 1930s and later, in the 1950s, a certain professor examined one of Bo's telescopes and found that it gave *inverted* images, meaning that it was of a Keplerian type. If this is the case, it seems highly likely that Bo independently invented the two convex-lens telescope, since in Europe Christopher Scheiner produced the first Keplerian telescope in 1630 (King, 1955). But it is equally possible that Bo or some of the artisans who assisted him by trial and error came up with the idea of adding one or two lenses to obtain an erect image, since just such a process led Schyrle to succeed in inventing the Schyrlean telescope.

Incidentally, it is interesting to note that Bo worked as an independent scholar and had no contact with the Jesuit missionaries (Wang et al., 1997). A few decades later, an engineer from the city Suzhou named Sun Yunqiu (ca.1629–ca.1662) was engaged to produce various optical instruments, including telescopes which were said to have been almost the same shape, structure, and size as those made by Bo (Wang et al., 1997).

Given the foregoing accounts, it is natural to consider that telescopes themselves and their method of production were quickly transmitted to Japan, because in spite of Japan's strict national seclusion policy—which commenced in the 1620s—the Chinese visited Japan much more frequently and freely than the Europeans did. In this context, it is worth noting that Sun and Hirai Ikkan both came from Zhejiang Province.

5 SUMMARY AND DISCUSSION

In this paper we show that Tokugawa Yoshinao's telescope, which is preserved in the Tokugawa Art Museum, is of Schyrlean type (i.e. consisting of four convex lenses) and was made in or before 1650. In light of the anecdote by Sir Charles Cavendish men-

tioned in Section 3.4 (cited in Court and von Rohr, 1929) and the fact that Schyrle's *Oculus Enoch et Eliae* was only published in 1645, Yoshinao's telescope must be one of the oldest Schyrlean telescopes in existence.

In Sections 3 and 4 we demonstrated that it is likely that Yoshinao's telescope was produced in or near Zhejiang Province by Chinese artisans, or possibly in Nagasaki by a Chinese immigrant, without direct European influence. Having said that, however, one still cannot exclude the possibility that Jesuit missionaries in China taught the local Chinese how to produce the Schyrlean telescope, with its four convex lenses. The basis for this speculation is the fact that optical problems were widely studied by various Jesuit missionaries, as represented for example by the activities of Father C. Scheiner (see Shea, 1975).

In relation to this, Court and von Rohr (1929) emphasized the key role that the European Jesuit community played in the development of the telescope by including an interesting illustration (Figure 10), taken directly from Scheiner's *Rosa Ursina sive Sol* (1626-1630). Meanwhile, Baxandall (1922-1923) and King (1955) wrote that Scheiner added a second convex lens to the simple Keplerian telescope in order to get an erect image. Since Scheiner's invention and the telescopes made by Schyrle are both a natural development of Kepler's basic proposal consisting of two convex lenses, it is no surprise that the idea of the four-convex-lens telescope came to the minds of the Chinese-based Jesuits and to Schyrle quite independently. Then the concept was quickly communicated by the missionaries to Chinese artisans, eventually resulting in the manufacture of Yoshinao's telescope.

In any case, we emphasize the importance of Yoshinao's telescope in the history of the telescope, and we stress how vital it is for this telescope to be compared and contrasted with those made by Bo Jue and Sun Yunqiu (if they still exist), and with old telescopes preserved in such places as the Gugong Palace Museum (see Liu Lu, 1999).

Figure 10: Experimental activities in optics by the Jesuit fathers around 1630 (after *Rosa Ursina sive Sol* (1626–1630) by C. Scheiner).

6 NOTES

1. The original Japanese reference to Ieyasu's telescope is in *Sunpu-ki* (*Sunpu chronicle*), which describes Ieyasu's chronicle recorded by one of his vassals. The telescope was offered to Ieyasu on 17 September 1613 at Sunpu city by Captain John Saris who came to Japan in the ship *Clove* (Satow, 1900).
2. Regarding the history of Japanese telescopes, *Nihon Sokuryo-shi no Kenkyu* (*Studies on the History of Land-surveying in Japan*) by Y. Mikami and *Kinsei Nihon Tenmongaku-shi* (*Pre-modern History of Astronomy in Japan*), Volume 2, by T. Watanabe, give elaborate reviews and include bibliographical details and references. Also, Peter Abrahams, a past-President of the Antique Telescope Society, has produced an excellent and detailed chronology written in English, which is available at the following URL: http://home.europa. com/~telscope/ tsjapan.txt. Although it contains some unclear and/or incorrect descriptions, these are not Abrahams' fault as they were inherited from the original Japanese sources that he cites.
3. According to the Tokugawa Art Museum, the original inventory of the articles inherited from Yoshinao was called *Keian 4-nen Odogucho* (*The Articles Catalogue of 1651*).
4. *Kiyu Shoran* by I. Kitamura is now reproduced (2004) as one of Iwanami Bunko series, from Iwanami Shoten Ltd.
5. Willach (2002) reports two Schyrlean telescopes whose credit goes to J. Wiesel, which are preserved in Sweden, although both are in an incomplete state (i.e. some lenses are missing). These telescopes are characterized by five lenses, many-stage draw tubes, and a telescopic tube inversely tapered towards the objective lens. On the other hand, as discussed in Section 3, none of these is a characteristic of Yoshinao's telescope. Hence, if the telescopes preserved in Sweden are typical of those attributable to Schyrle and Wiesel, then we can conclude that European Schyrlean telescopes did not directly influence Yoshinao's telescope. According to Keil (2000: 375), Wiesel's new telescopes were sold from 1649 onward in many European countries.
6. *Encyclopedia of Nagasaki* (Nagasaki, 1984). This book includes an article about the Chinese priest Mokusu Nyujo, based on the *Nagasaki Shishi* (*Chronicle of City Nagasaki*) which was published by Nagasaki city in 1923-1925. Shirayama (1990) also mentions the connection between Nyojo and lens-polishing, but without supplying any references.
7. *Tianjing Huowen* (*Dialogue on Astronomy*, in Chinese), written by You Ziliu, was published in 1675. This book was imported into Japan soon after its publication and for a long time was very much welcomed as an introductory text on Western astronomy.

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