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Published version:

DOI:10.1080/00393630.2018.1563348

A Japanned Telescope from Cavour Castle in Santena: Study and Conservation Treatment of an 18th-century Scientific Instrument

Sara Aveni[a,*], Maria Beatrice Failla[b], Alessandro Gatti[b], Loredana Mannina[b] and Tommaso Poli[c]

[a] *Università degli Studi di Torino, Via XX Settembre 18, 10078 Venaria Reale (Turin), Italy;* [b]*Historical Studies Department, Università degli Studi di Torino, Via XX Settembre 18, 10078 Venaria Reale (Turin), Italy;* [c] *Chemistry Department, Università degli Studi di Torino, Via P.Giuria 7, 10125 Turin, Italy*

+393275612740; aveni.sara@gmail.com

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Abstract

The conservation treatment of a telescope belonging to the collections of Cavour Castle in Santena form the topic of this paper. The artefact is valuable both as a material testimony of the diffusion of scientific progress and as a rare example of a japanned telescope, attesting the circulation of this decorative style in Piedmont between the 17th and the 18th century. A historical research was necessary to solve some questions regarding the manufacture and dating of the telescope. Comparison of the data and information collected with those of similar scientific instruments allowed to date the artefact in the 18th century and to situate its manufacturing in northern Italy. The pigments and binder of the artefact were identified, confirming the Western origin of the red lacquer that embellishes the outer tube of the telescope. The lacquer was applied on a leather support. Three-dimensional mock-ups were used to carry out tests aimed at defining the right methodology and products to be applied for the main operations of the conservation treatment, such as the adhesion of the lacquer lifted from leather and the infilling of losses in the japanned layer. The treatment aimed at resolving specific conservation issues while at the same time preserving the traces left on the instrument by time and events.

Keywords: japanning; telescope; lacquer on leather; adhesives; retouching.

Introduction

The article presents the results of the study and conservation treatment of a japanned telescope belonging to the collections of Cavour Castle in Santena (Ballaira 1992; Manchinu and Traversi 2005), a small town in the province of Turin in Italy. The research required the adoption of a multi-disciplinary approach and was structured in several stages. The first steps concerned the historical contextualization of the artefact, the analysis of its optical system and the characterization of its numerous material components, followed by the identification of all the deterioration phenomena and their possible causes. The information gathered was essential in the methodological planning of the conservation treatment, that took into consideration the co-existence in the artefact of a scientific and artistic significance linked respectively to its functionality and its japanned decoration.

Description of the artefact

The object of this study is composed of several elements, playing different roles in its use and functionality: the telescope, the base, the tripod and the wooden case in which they were all stored (Figure 1). The telescope is made of one main tube and five drawtubes having decreasing diameters, reaching an overall length of 3.80 m. Given the extension of the instrument it had to be used on a stand, consisting of a demi-octagonal concave base mounted on a tripod. The tripod was originally composed of a central element with a triangular section and three legs. However, one of the legs is missing, but the archival research did not lead to any document attesting the exact moment of its loss.

The artefact is of outstanding value both as a material testimony of the diffusion of scientific progress and as a rare example of an instrument decorated in Oriental style. While the drawtubes present a common plain green coating, the outer tube of the telescope is embellished with a red lacquer and golden motifs. The motifs form a coherent composition of two flowered branches and birds of different species, derived from a typical Asian iconography denominated ‘birds and flowers’ (Griseri 2005, 122–129; Caterina 2005, 62). The base and the tripod are also decorated, but differ from that of the main tube of the telescope in the colour of the background lacquer, which is black, and in the arrangement of the golden motifs not forming a composition. These motifs include not only animals and flowers but also some Asian figures.

Historical context

A detailed historical research was necessary to solve some questions left unanswered by the absence of archival data regarding the manufacture and dating of the telescope. In the first place, the functionality of the instrument was examined to establish the date of the invention as a *terminus post quem* for its manufacture.

The observation of the inside of the tubes led to the discovery of a lens that allowed to place the telescope from Santena into the category of refracting telescopes having an optical system composed of lenses. This category can be further divided into two subcategories: astronomical and terrestrial telescopes. Astronomical telescopes only present two lenses, the objective and the ocular, located at the two extremities of the instrument, and produce an upside-down image. Terrestrial telescopes have two additional lenses which are called "erector group" having the function of producing an upright image (King 1955, 34–46). The investigation of the inside of the telescope tubes with X-radiography was crucial in determining not only the position of the only lens left, which is placed inside the smaller tube, but also the presence of the mounting of a second lens in the same tube (Figure 2). The objective and the ocular, which were originally placed at the ends of the telescope, were missing. It was possible to assume that the telescope from Santena originally had four lenses in total and was therefore a terrestrial telescope. The optical system of terrestrial telescopes was theorized for the first time in 1645 by Antonius Maria Von Schyrle in his treaty *Oculus Enoch et Eliae* (Bedini and Bennet 1955, 103–126).

Due to the diffusion of terrestrial telescopes throughout Europe and Asia the analysis of the functionality of the telescope from Santena was not sufficient in determining the exact context of manufacture which, according to the literature concerning this type of instrument, can be determined by its decoration (Louwman and

Zuidervaart 2013, 72; Turner 1966). The main stylistic features of the telescope studied were therefore compared to the ones of other similar instruments, starting with the use of the colours red and green for the outer tube and the drawtubes respectively. This resulted to be a common characteristic of many French and Italian telescopes of the 18th century, just like the use of non-abstract motifs to decorate the outer tube. However, the feature that most characterizes the telescope from Santena is the use of oriental motifs and techniques, shared by only few other instruments produced, in particular by a constructor named Pietro Patroni who worked in Milan at the beginning of the 18th century (Lualdi 1955, 671–689). Two main similarities with our case emerged from the research conducted on Patroni's work, which were the use of lacquers and golden 'birds and flowers' motifs to decorate the outer tube of some of his telescopes, and the analogous construction technique of the tripod of a binocular telescope attributed to him. Given the stylistic similarities found between the telescope from Santena and many other Italian telescopes, the current assumption therefore is that it was manufactured and decorated in Italy in the first half of the 18th century.

Materials and methods

Vermillion, Beva Artist Gesso-P, isopropanol and ethanol were supplied by: Kremer Pigmente GmbH & Co. KG, Hauptstr. 41 – 47, DE 88317 Aichstetten, Germany.

Klucel G, Beva 37, Agarart, Tween 20, Cicloesano, were supplied by CTS Srl - Via Piave 20/22 - 36077 Altavilla Vicentina (VI), Italy.

The radiographic device is constituted of an X-ray source X General Electric Eresco 42 MF4, with an anodic tension from 5 to 200 kV, max current 10 mA (max power 900 W), focal spot 3 mm, emission cone 40° (V) x 60° (O), 0.8 mm beryllium window and an aluminium filter of 2 mm; linear detector Hamamatsu C9750-20TCN, with 2560 squared pixel, 4096 grey levels (12 bit) with a gadolinium scintillator.

X-Ray Fluorescence (XRF) analyses have been carried out with a μ-EDXRF Bruker ARTAX 200 working in the energy range from 0 to 50 keV at a maximum current of 1500 μA. The detector has an energy resolution lower than 150 eV (FWHM) for Kα of Mn (5,9 keV).

Fourier transform infrared (FT-IR) transmission spectra (64 scans) have been recorded using a diamond anvil cell by High Pressure Diamond Optics Inc. on a Bruker Vertex 70 spectrophotometer coupled with a Bruker Hyperion 3000 IR microscope equipped with an Infrared Associates Inc. MCT detector in the spectral range from 6000 to 600 cm^{-1} with an average spectral resolution of 4 cm^{-1}.

Gas chromatographic analyses have been carried out on GC6890N Network GC System (Agilent Technologies, U.S.A,) equipped with a capillary column HP-5MS cross-linked 5% phenyl-methyl polysiloxane (30 meters). The mass spectrometer is a 5973 Network MASS Selective Detector (Agilent Technologies, U.S.A.). The pyrolizer is a CDS Pyroprobe 1000 (Analytical Inc., USA) with a 1500 Valved interface.

Polished cross sections have been observed by means of minero-petrographic microscope OLYMPUS BX51 equipped with an OLYMPUS DP71 digital camera. Software: analySIS Five. Polished cross-sections have been prepared using an epoxy resin (Epofix). Mounted samples have been cut with Struers Secotom-10 micrometer cutter and the obtained surface has been polished with a Struers Labopol-5 using plane polishing discs with SiC powder abrasive, in successively finer steps from 500 to 4000 grit.

Technique and material components

Each object composing the instrument is made of several different materials. The structure of the telescope is made of layers of paper, rolled up and glued together to obtain a cylindrical shape. The choice of paper to make the tubes became popular in the second half of the 17th century when telescopes started to reach greater lengths and the use of a light material proved to be necessary (Bedini and Bennet 1955, 103–126). Due to the sensitivity of paper to the humidity of the environment, all the tubes are coated. Leather, probably produced with a process of vegetable tanning, is the coating material of the outer tube, visible only where the red lacquer applied to it was missing. The drawtubes, instead, have been coated using parchment dyed with a copper-based green (Figure 3). Moreover, by comparing the follicles pattern with that of samples of known animal species, it was possible to deduce that the parchment was made from goat skin. While the material used for the tubes had to be light, the structure of the base and the tripod was made of wood for stability reasons. On the two ends of these objects the wood is covered with brass laminas.

As already stated, the outer tube of the telescope, the base and the tripod present the same type of decoration made of a lacquer background and golden motifs. The components of these pictorial layers have been identified with the aid of non-invasive and micro-invasive analytical techniques. In the first place, X-ray Fluorescence allowed to characterize brass as the metal of the golden powders used to make the decorations, and mercury sulphide (known as cinnabar or vermillion) as the pigment of the red lacquer decorating the main tube of the telescope (Dei Negri 2005). The black pigment present in the lacquer of the base and the tripod is probably bone black, as the XRF analysis showed the presence of calcium allowing to distinguish it from lamp black. Samples were taken from each object to examine the composition of the lacquer. Initially they were analysed using Fourier Transform Infrared Spectroscopy (FT-IR) showing to be a mixture of natural resins. The same samples were then investigated using Pyrolysis Gas Chromatography Mass Spectrometry (Py-GC/MS) to identify the exact types of resins. This analysis was crucial for establishing that the lacquer is made of a spirit varnish composed of sandarac, shellac and colophony, which are all resins that have been commonly used in Europe to imitate Asian lacquer (Webb 2000, 99–111). The sequence of pictorial layers was then investigated by taking a cross-section sample of the lacquer of the outer tube of the telescope (Figure 4). The observation of the sample under the microscope showed that the mixture of resins and vermillion was applied directly on the leather. On the pigmented lacquer there is a layer of varnish and finally the brass powders of the decoration. The assumption is that the decorations were made imitating the Oriental techniques: the outline of the figures was applied using a transparent lacquer, or in the case of the base and the tripod a lacquer mixed with a pigment of a different colour from that of the background; brass powder was then applied all over the fresh lacquer (Bianchi, Negri and Lucarelli 2005, 357–361). Inner details were obtained by engraving, creating a contrast between the color of the metallic powders and that of the underlying lacquer.

State of conservation

After having identified the material components and the techniques used to make and decorate the instrument, all related conservation issues were examined. It was immediately noticeable by a naked eye inspection that the outer tube of the telescope presented a worse state of conservation compared to that of the rest of the instrument. Dirt deposits were present over the entire surface including the japanned layers, inhibiting their natural glossy appearance. The leather of the outer tube of the telescope showed, in the areas where it was left exposed by the losses in the lacquer layer, a general problem of cohesion. Moreover, in some areas the external layer of the skin, called grain, was lifted. The most serious issue, however, was the loss of adhesion between the lacquer and the leather, which over time had led to the formation of numerous losses evenly distributed and of small dimensions (Figure 5). This phenomenon could be related to the incompatibility of the lacquer and the leather, which increases with ageing. In fact, while the leather tends to respond to changes in temperature and humidity of the environment by expanding and contracting, the lacquer, instead, tends to become more rigid and less flexible with time. The lacquered layers of the base and the tripod did not show the same problem, as they only presented a few losses attributed to scratches.

Conservation treatment

The information needed for the correct planning of the conservation treatment derived from different sources such as direct observation of the artefact, research into specific literature, scientific analyses and tests conducted on mock-ups. In fact, due to the peculiar technique of japanning on leather combined with its poor state of conservation, it was considered that the best course of action would be to test methodologies and products on mock-ups before applying them on the real artwork. Tests on mock-ups were focused on three different operations: leather consolidation, re-adhesion of the lacquer to the leather and infilling of the japanning losses. A rectangular piece of vegetable tanned leather was used for the first part of the experimentation. For the second and third series of tests, the whole sequence of layers of the outer tube of the telescope was reproduced. In this case, vegetable tanned leather was glued to cylindrical sections of a cardboard tube using wheat starch paste and the red lacquer was applied onto the leather surface using a brush. Data collected from the analyses were cross-checked with the ones gathered through the reading of historical treaties reporting the recipes used by European craftsmen to imitate Asian lacquer. The combination of these data allowed the fair reproduction of the lacquer used for the decoration of the telescope. A recipe in particular seemed to match the results of the analyses, indicating the same pigment and the same natural resins dissolved in ethanol to make the lacquer. This recipe, found in Watin's treaty *L'art du peintre, doreur, vernisseur* (1728) and titled '*pour employer le Vermillon sur les trains d'équipages*', therefore, was used to make the red lacquer on the mock-ups. They were then exposed to accelerated ageing to reproduce similar issues to the ones present on the telescope (Chaine and Rottier 1997; Florian 2006; Larsen 2000). This process consisted of substantial and frequent variations of temperature and relative humidity for100 days, resulting in the discoloration of the leather and in the crazing and lifting of the lacquer from the leather surface (Figure 6). The first operation tested on mock-ups was the adhesion of the lifted grain. Lifted areas were reproduced on the mock-up using a scalpel, the adhesives to test were applied with a brush under the lifted surface, and a weight was put onto the treated area to facilitate re-adhesion. Klucel G (hydroxypropylcellulose) was chosen for its binding properties and compatibility with leather (Kite, Thomson and Angus 2006, 128). It was tested by varying its concentration (2%, 3%, 4%) in two different solvents, ethanol and isopropanol. The tests conducted on the mock-up were then evaluated and it was decided to use Klucel G at 3% in isopropanol as it induced no chromatic changes in the leather and was effective in the adhesion of the lifted grain. The same adhesive was used in a lower concentration (2%) in the areas in which the leather showed a problem of cohesion.

The following step was the choice of the product to be used for the re-adhesion of the japanning layer detached from the leather. The first level of selection was based on the exclusion of all the products that were not considered compatible with the original materials of the artefact, such as water-based adhesives causing alterations in the leather like discolouration, deformation and stiffness, as well as all products soluble in polar solvents that could damage the lacquer. The selected products were then tested on the mock-ups in different concentrations, to assess whether the viscosity of the solution allowed the application by injection. The final choice of the product was based on the results of peeling tests carried out using paper tape, which was evenly applied to the surface of the mock-ups and then removed delicately to evaluate the amount of lacquer detached from the leather. The peeling test of the mock-up after artificial ageing showed how this process was successful in recreating the phenomenon of loss of adhesion and offered a starting point to compare the efficacy of the different adhesive solutions. Beva 371 in cyclohexane (1:4 ratio v/v) was the solution showing the best efficacy, with only 0.001% of lacquer present on the tape after the peeling test, and it was therefore selected to be used on the telescope (Figure 7). This solution was applied with a syringe on the edges of the losses and by brush on the crazed surface, paying particular attention to the presence of residues on the lacquered surface which were promptly removed using a non-polar solvent. After waiting the time required for the volatile part of the adhesive to evaporate, Beva 371 was activated with heat (65°C) using a hot spatula (Borgioli and Cremonesi 2005; Horie 2010). Immediately after, the area was put under a weight to allow adhesion.

Having obtained the re-adhesion of the lacquer to the leather, it was possible to proceed with the removal of deposits of soil from the japanned surfaces. In this case, tests were carried out directly on the artefact, after having verified that the use of water did not imply the risk of blooming effects or removal of original material. The pH value of the japanned surface was also measured in order to bring the buffer solutions used for the test to the right value. In this case, water at pH 6.0 was tested in three ways: in the form of a gel with Agar Agar (3%), applied liquid without any additive, and applied liquid with 2% of non-ionic surfactant Tween 20. After observing the results, it was decided to use the aqueous solution at pH 6.0 without surfactant, which allowed removing the deposits without leaving any residue. The japanned surface of the base and the tripod was cleaned using a different method as the absence of lacunae causing surface irregularities made it possible to test more solutions with minor risk of leaving residues. A water-in-oil emulsion was used to limit the penetration of water and therefore its contact with the wood underneath the japanned layer. It was made using demineralized water, White Spirit and Brij L4 as surfactant. The choice of the surfactant was based on its lipophilic properties that make it easily removable from the artefact surface using a non-polar solvent. The emulsion was applied with a brush and residues were first removed with a cotton swab and then with the non-polar solvent White Spirit.

The last operations conducted on the outer tube of the telescope were infilling and inpainting. Also, in this case different products were tested on the mock-ups to find a filler which could satisfy the criteria of being elastic, stable and inert with respect to the original materials. Different ground inert materials were combined with different binders. After assessing the results of the experimentation, it was decided to use BEVA© Artist Gesso-P, a ready-to use filler that was applied in a thin layer. Once dry, it was heated with a hot spatula using Melinex to obtain a totally flat and translucent surface. The white surface of the fillings was then retouched using a technique called *puntinato* consisting of juxtaposed small dots of pure colours that at a distance blend together so as to resemble the original hue of the lacquer, but at the same time making the inpainted areas recognizable from a close point of view. Inpainting was done in three phases: first with *gouache* colours, then a thin layer of varnish (Laropal A81) was applied and finally it was completed using varnish colours (Figure 8).

Conclusion

The conservation treatment of the telescope from Santena was a precious occasion to study a complex object. The results of this research led, in the first place, to the formulation of a valid hypothesis about the manufacture of the instrument, that considered both its functional and artistic aspects linked to specific historical moments. The examination of the materials the instrument is made of was essential to identify another peculiarity, which is the use of leather as the substrate for japanning, not reflected in many other case-studies. This is probably due to their low diffusion and to the incompatibility of the two materials leading to rapid deterioration (Webb 2000). The use of mock-ups tailored to the characteristics of the artefact was useful to achieve further understanding about the technique and causes of the deterioration, and in outlying the conservation treatment.

Acknowledgements

The authors would like to thank Maria Rosaria Severino (Soprintendenza Archeologia, Belle Arti e Paesaggio per la Città Metropolitana di Torino) and Caterina Thellung (Comune di Torino) for giving us the opportunity to study the artefact. Our graditude also goes to Roberta Bianchi (Polo Museale del Piemonte) for her precious support.

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Figure 1. The telescope belonging to the collections of Cavour Castle in Santena with its base, tripod and wooden case. © Centro Conservazione e Restauro La Venaria Reale

Figure 2. X-radiography of the telescope showing: 1. the original position of the objective lens (missing); 2. the mounting of the first lens of the erector group (missing); 3. the second lens of the erector group still in place; 4. the diaphragm; 5. the original position of the ocular lens (missing). © Centro Conservazione e Restauro La Venaria Reale

Figure 3. Above: the structure of the tubes made of rolled sheets of paper. Below: two photographs taken with a stereomicroscope showing the leather coating of the outer tube (on the left) and the green-dyed parchment of the drawtubes (on the right). © Centro Conservazione e Restauro La Venaria Reale

Figure 4. Stratigraphic sample of the red lacquer applied on the outer tube of the telescope, in visible light (above) and in UV light (below). © Centro Conservazione e Restauro La Venaria Reale

Figure 5. The main conservation issues of the outer tube of the telescope: lifting of the upper layer of the leather coating (above) and crazing and lifting of the red lacquer causing the formation of lacunae (below). © Centro Conservazione e Restauro La Venaria Reale

Figure 6. A. The mock-ups before artificial ageing; B. the mock-ups after artificial ageing. © Centro Conservazione e Restauro La Venaria Reale

Figure 7. On the left the execution of the peel-test on a mock-up. On the right the results of the peel-test of: A. the mock-up before ageing; B. the mock-up after artificial ageing; C. the mock up treated with different concentrations of Beva 371 in cyclohexane. © Centro Conservazione e Restauro La Venaria Reale

Figure 8. On the left the outer tube of the telescope before, during and after the operations of infilling and inpainting of the japanned decoration. On the right a detail of the *puntinato* technique. © Centro Conservazione e Restauro La Venaria Reale