JIB vol. 2 (2023)
ISSN: 2785-6569 online
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DOI: 10.57579/2023.5

JIB
JOURNAL OF INTERACTIVE BOOKS

Behind the scenes of movable books: paper engineering wonders in late 19th century volumes

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ABSTRACT

This essay focuses on the restoration carried out on three movable books produced in the latter half of the 19th century between Italy, France, and Germany, that are conserved inside the collection of the Foundation Tancredi di Barolo in Turin: *Cendrillon ou la petite pantoufle de verre*, *Les méfaits de Gaspard* and *Grande serraglio*.

The restoration was quite complex due to the variety of constituent materials (paper, fabric, metal) and the difficulty of restoring the elaborate mechanisms that allow the movement of the mechanical devices. Before the treatment, as usual, bibliographic research was carried out to learn about the processes and production techniques. Then, a series of diagnostic investigations were performed to understand the chemical composition of the constituent materials and the nature and extent of their degradation. An accurate photographic documentation was collected throughout the process.

To be enjoyed, movable books must be actioned. The continuous or incorrect manipulation by readers, often children, has produced in many cases the malfunction of mechanical devices due to the breakage or displacement of one or more elements. In fact, each of the parts that make up the mechanisms has a specific role and the detachment of even the smallest element leads to the loss of functionality of the entire device. The restoration focuses on restoring the functionality of the mechanisms, sometimes hidden between the pages, which, before being disassembled, had to be carefully studied. For this purpose, facsimiles and virtual 3D models were created, thanks to which it was possible to fill the figurative losses of missing parts, place the detached elements back in the correct position and, where necessary, replace small parts to ensure the functionality of the devices. Some of these operations have raised interesting deontological questions, that have been tackled with various experts.

KEYWORDS

Conservation; Scenic book; Pull the tab; Aquarium; Cinderella; Puppets.

CITATION

Guizzo S., "Behind the scenes of movable books: paper engineering wonders in late 19th century volumes". *JIB*, 2 (April 2023): 87-102. DOI: 10.57579/2023.5.

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JIB vol. 2 (2023)
ISSN: 2785-6569 online
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DOI: 10.57579/2023.5

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Introduction

The subject of this essay is the restoration of three movable books: *Cendrillon ou la petite pantoufle de verre* (from now on *Cendrillon*), *Grand théâtre des marionnettes. Les méfaits de Gaspard. Drame comique en six actes et six tableaux* (from now on Les méfaits de Gaspard) and *Grande serraglio*. These volumes were produced in the latter half of 19th century between Italy, France and Germany and are conserved inside the rich collection of Fondazione Tancredi di Barolo in Turin. The treatment was carried out for my degree thesis at the Istituto Centrale per la Patologia degli Archivi e del Libro[1].

To be enjoyed movable books must be actioned and, since they are made of poor-quality materials, their decay is almost inevitable. The continuous or incorrect manipulation by the readers, often children, has produced in many cases the malfunction of mechanical devices due to the breakage or displacement of one or more elements. This was because each of the parts that make up the mechanism has a specific role and the detachment of even the smallest element leads to the loss of functionality of the entire device. The restoration focused on restoring the functionality of the mechanisms, sometimes hidden between the pages, which, before being disassembled, had to be carefully studied.

During the process, some problems and questions of a methodological, conservative, and scientific nature arose. One problem was related to the lack of unambiguous terms for the description of the various elements that make up the mechanism of the mechanical devices. Furthermore, doubts and uncertainties characterize the reconstruction of the production processes of the volumes that appeared on the market around the end of the 19th century. There is no certain information on the places of production and assembly and, only in rare cases, it is possible to establish whether these places coincide with the country in which they are published. The three volumes did not contain any dates, nor any mention of the author or artist who had created the mechanical devices they contained. Dates were presumed from bibliographic research, auction houses websites and from the catalogues of the Ulrico Hoepli publishing house (*Catalogo* 1896).

Finally, the disassembly of the mechanical devices, the filling of the figurative losses and the replacement of some original elements were at the centre of a debate that involved various professional figures (client, restorers and scientific staff of the Chemistry Biology and Technology Laboratories of the Istituto Centrale per la Patologia degli Archivi e del Libro).

* *I would like to thank my supervisor, Professor Maria Luisa Riccardi, for supporting me during this incredible experience, a long journey in the world of movable books. I would also like to thank Professor Gianfranco Crupi and Professor Pompeo Vagliani for giving me the opportunity to work on such beautiful 'objects'.*

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Description of the volumes

Cendrillon is a scenic book published in the second half of the 19th century by the publishing house Magnin et Fils based in Paris. It is the French edition of the book *Cinderella or The little glass slipper* published by Dean & Sons in England in the 1860s, the third issue in the *New Scenic Book* series. The presumed date of publication can be placed between the end of the 1860s and the beginning of the 1870s. The volume, composed by one section of four bifolios, has a half cloth case binding. On the front board there is a chromolithographic print that shows one of the most iconic scenes of this fairy tale, in other words the appearance of the fairy godmother to Cinderella (**Fig. 1**). In this volume there are eight mechanical devices that can be lifted from the pages by pulling a green silk ribbon. This action allows the creation of a multilevel scene in perspective composed by a sequence of three parallel die-cut layers with chromolithographic prints (**Figs. 2 a, b**). Each layer is fixed to the next by a piece of ribbon that is inserted into the circular holes present on the layers and blocked by metal eyelets. The ribbon comes out from the *verso* of the background layer for a portion sufficient to be grabbed and pulled (**Fig. 3**). The black printed text, which is present exclusively on the *recto* of the pages, is visible only when the device is lifted.

Fig. 1 | *Cendrillon.* front board.

Figs. 2 a, b | *Cendrillon.* Third device closed (a) and lifted (b)

Fig. 3 | *Cendrillon.* Ribbon and eyelet.

Fig. 4 | *Les méfaits de Gaspard.* Front board

Les méfaits de Gaspard is a pull the tab book published in the second half of 19th century by the publisher Alexandre Capendu (1880-1920), successor of Guérin-Müller et Cie. (1850-1880), based in Paris. The volume is the French adaptation of the first movable book published in 1864 by the German publishing house Schreiber-Verlag entitled *Schreiber's Großes Puppentheater* (Geisenheyn 2014, 24-25). The illustrations in both volumes were realised by Carl von Häberlin (1832-1911), a German painter and illustrator. Certainly 1880 can be indicated as a *post quem* date since the publication of the volume took place after the acquisition of Guérin-Müller et Cie. by Alexandre Capendu, as shown in the cover illustration. This volume, composed by two sections, has a half cloth case binding and on the front board there is a chromolithographic print (**Fig. 4**).

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In the first section there are the frontispiece and the table of the scenes with the list of the characters and the settings. In the second section there are the mechanical devices on the *recto* and the play script of the following act on the *verso*.
The mechanism of the six mechanical devices is hidden by being embedded between two sheets of paper, from which comes out a single tab used to produce the movement (**Figs. 5 a, b, c**). The front sheet of paper has a chromolithographic print on which there are a series of slots and holes. The inner mechanism is made up of a central tab in cardboard and a series of levers. These levers are connected to the central tab with adhesive or fixed with a small spiral-shaped metal rivet. The other end is glued on the *verso* of the cut-out characters (**Fig. 6**). The characters are inserted into the slots present in the front sheet of paper and blocked by inserting the rivets in the corresponding holes. The central tab is inserted in a guide created with four carboard squares, placed two on the top and two on the bottom of the *verso* of the front sheet.

Fig. 5 a, b, c | *Les méfaits de Gaspard.* Second device: front sheet of paper (a, b) and inner mechanism (c)

A locking system make up by two strips of paper glued on the top of the squares guarantee the correct vertical movement of the central tab (**Figs. 7 a, b**).

Fig. 6 | *Les méfaits de Gaspard.* Levers and spiral-shaped rivets.

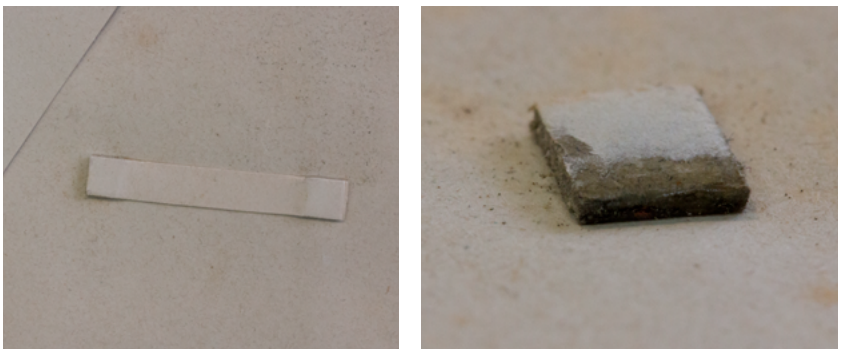

Fig. 7 a, b | *Les méfaits de Gaspard.* Lock mechanism

Grande serraglio is a scenic book published between 1883 and 1884 by the Ulrico Hoepli publishing house. This volume could derive from a German edition published by Schreiber in 1882 entitled *Großes Menagerie* (Ibid., 23-24) which has the same graphic apparatus and the same mechanical devices. No direct

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ISSN: 2785-6569 online
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reference to that edition or editor were found in the volume. *Grande serraglio* has a half cloth case binding and on the front board there is a chromolithographic print that shows the entrance to the menagerie (**Fig. 8**). The textblock is made up of a single section composed of an individual leaf and three bifolios. On the individual leaf are shown the advertising poster of the show and the preliminary speech of the tamer Miss Aïssa. The blue printed text is present in the three bifolios only on the *recto* and is bordered with a geometric frame of the same colour. As in *Cendrillon,* the six mechanical devices that made up this volume obscure the text when folded down. Reading is made possible by lifting a chromolithographic print which creates a three-dimensional structure composed of die-cut layers in sequence at regular distances and kept in an upright position by a cardboard tab placed obliquely (**Figs. 9 a, b, c**). To allow the opening and closing of the device, one end of the tab is left free to slide inside an air pocket between the background of the scene and the chromolithographic print.

Fig. 8 | *Grande serraglio.* Front board.

Fig. 9 a, b, c | *Grande serraglio.* Sixth device: chromolithographic print (a), three-dimensional scene (b, c).

Condition

In general, the decay of the binding and the textblock of the three volumes was similar. There were: dust and dirt, abrasions, tears, losses, and stains (**Fig. 10**). In addition to this, there were tears of the cloth on the headcaps, the breaking of the sewing, and the split of some bifolios at the spine fold (**Fig. 11**). The boards were deformed due to the smaller size of the mechanical devices compared to the textblock. There was also a chemical decay such as a widespread paper oxidation and foxing (only in *Les méfaits de Gaspard*) (**Fig. 12**). In addition to this, both in *Cendrillon* and in *Les méfaits de Gaspard*, there were signs of biological decay.

The greatest damages, however, were those present on the mechanical devices. The devices of *Cendrillon* had damages to the lifting ribbons which compromised their functionality and figurative losses which

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Fig. 10 | *Grande serraglio.* Tear.

Fig. 11 | *Cendrillon.* Broken seam.

Fig. 12 | *Grande serraglio.* Foxing.

compromised their readability, as well as minor detachment and breaking. The green silk ribbon that connected the various layers of the mechanical devices was torn, mainly due to the sharp edges of the metal eyelets and to the stress experienced when lifting the devices (**Fig. 13**). The portion of ribbon which was used to lift the device was often brittle, with oxidation and discoloration of the fabric. In the third device the ribbon was broken near the metal eyelet. In some cases (devices 2, 4, 5 and 6), they were badly repaired with a yellow synthetic ribbon, thicker and brighter than the original or with a blue narrower one (device 8). This reinforcing ribbon had been fixed to the original one with adhesive, without removing the metal eyelets from the holes. Sometimes, a thin strip of paper was used to block it on the *verso* of the device (devices 2, 5 and 6 - **Fig. 14**). This did not allow the correct functioning of the mechanical devices. In addition to this, in the first device there was the figurative loss of the background layer (**Fig. 15**). This led to the loss of the depth of the scene as the perspective references, such as the ceiling and the floor, were missing. In the second device the head of one of Cinderella's two stepsisters was missing (**Fig. 16**).

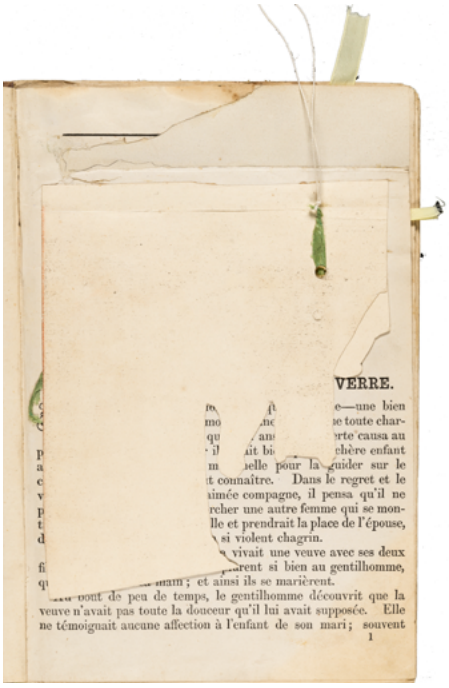

Fig. 15 | *Cendrillon.* Loss of the background layer in the first device.

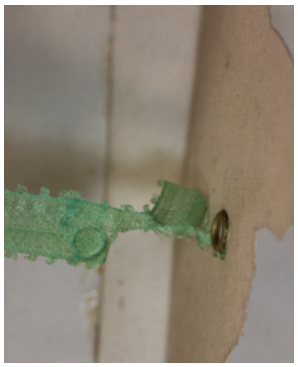

Fig. 13 | *Cendrillon.* Torn ribbon.

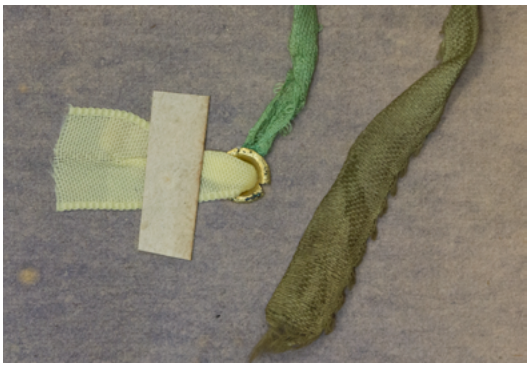

Fig. 14 | *Cendrillon.* Discoloration of the ribbon fabric. Yellow ribbon blocked by a thin strip of paper.

Fig. 16 | *Cendrillon.* Loss of Cinderella's stepsister head in the second device.

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In the volume *Les méfaits de Gaspard*, the movement of most of the devices was compromised by damage to the metal spirals and to the lock mechanisms of the central tab. In some cases, there were the detachment of the characters and the loss of the mobile elements. The fifth device was the only one that worked properly. All the central tabs were no longer inserted in the guides due to the detachment of the paper strip and sometimes of one of the cardboard squares (**Fig. 17**). Consequently, most of the metal spirals had come out of the holes due to the possibility of lateral and oblique movement of the central tab (**Fig. 18**). The characters were no longer in the correct position and excessive movement of the central tab in one direction, or another could lead to these coming out of the slots. Furthermore, one of the characters of the sixth device did not make any movement when the central tab was pulled, as it was detached from the lever that connected it to this one (**Fig. 19**). At last, there was also the figurative loss of one of the ears of the hare in the first device as evidenced by the presence of a hole and a slot (**Figs. 20 a, b, c**). As we found out from the comparison with other copies, the ear originally must have been present, connected with a lever to the central tab and fixed with a spiral in the corresponding hole.

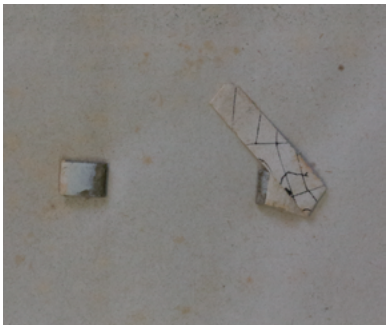

Fig. 17 *Les méfaits de Gaspard.* Detachment of the paper strip.

Fig. 18 *Les méfaits de Gaspard.* Spiral that comes out of the hole.

Fig. 19 *Les méfaits de Gaspard.* Detachment of a character in the sixth device.

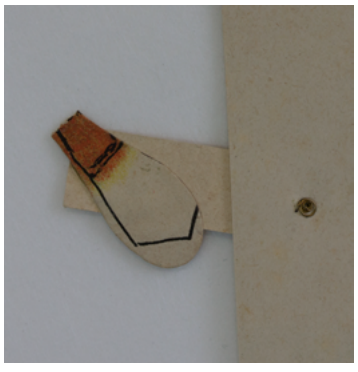

Fig. 20 a, b, c *Les méfaits de Gaspard.* Loss of one ear of the hare in the first device.

In the volume *Grande serraglio*, the main problems were related to the lifting of all the devices. The lifting of the mechanical devices created creases and deformation on the pages in correspondence of the bottom

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ISSN: 2785-6569 online
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of the three-dimensional scenes because the cardboard tabs that supported the structure could not always slide correctly in the air pocket. This led to tears and partial detachment of one end of the tabs from the bottom of the scenes (**Fig. 21**). In addition to this, in the second device entitled *L'aquario*, the transparent film which was used to imitate the glass of the aquarium had large tears that could come from a little trauma **(Fig. 22)**. Furthermore, it was yellowed and covered with a matt white patina. All this compromised not only the stability of the fish adhering to it on the *verso*, but also the readability of the other layers.

Fig. 21 *Grande serraglio.* Loss of Cinderella's stepsister head in the second device.

Fig. 22 *Grande serraglio.* Tears and yellowing of the transparent film in the second device loss of Cinderella's stepsister head in the second device.

Conservation treatment

The conservation treatment was quite complex due to the variety of constituent materials (paper, cloth, silk, metal) and the difficulty of restoring the elaborate mechanisms that allow the movement of the mechanical devices. Before the treatment, as usual, bibliographic research was carried out. Then, a series of scientific investigations were performed, and an accurate photographic documentation was collected. Before disassembling the devices, facsimiles and virtual 3D models were created to understand the functionality of the mechanisms. Some of these operations have raised interesting deontological questions, that have been tackled with various experts, including Pompeo Vagliani, Gianfranco Crupi, and the scientific staff of the Chemistry, Biology and Technology Laboratories[1] of the Istituto Centrale per la Patologia degli Archivi e del Libro. The information exchange with Jess Ortegon, a restorer of the University of Delaware which had performed a treatment on a movable book (*The aquarium* 1880) with a fake glass in it like the one in *L'aquario* was also very useful.

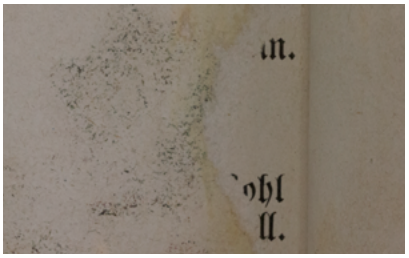

Fig. 23 *Les méfaits de Gaspard.* Fragment of paper printed in gothic inside the fourth device.

Bibliographic search

As usual, before proceeding with the restoration of the volumes, research was carried out on the history of movable books, on the production processes and techniques, and on the publishers of these volumes. In the literature it is reported that it was a known practice to reuse chromolithographic illustrations in different volume due to the complexity of their production process. Indeed, during the restoration of the fourth device, a fragment of a paper printed in Gothic character was found adhered to the *verso* of the front sheet of paper (**Fig. 23**). This would support the hypothesis that the

[1] Paola Biocca (Chemistry Laboratory), Maria Carla Sclocchi and Matteo Montanari (Biology Laboratory) and Daniele Ruggiero (Technology Laboratory).

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mechanical devices and the illustrations of the volume *Les méfaits de Gaspard* were printed in Germany. Furthermore, bibliographic search allows to define the production period of the volumes and to find important information for understanding the functioning of mechanical devices in order to plan the correct conservation treatment methodology.

Photographic documentation

In general, before proceeding with restoration, it is always necessary to carry out accurate photographic documentation of the condition and all the constituent elements of the volumes on which the treatment will be carried out. The photographic documentation must be produced also during the restoration and at the end of it. This is necessary to leave visual evidence of the treatment and evaluate its effectiveness by comparing the before and after.
For the volume *Cendrillon*, it was not easy to perform the photographic documentation of these kinds of volumes due to the presence of three-dimensional devices which are not conceived to self-stand.

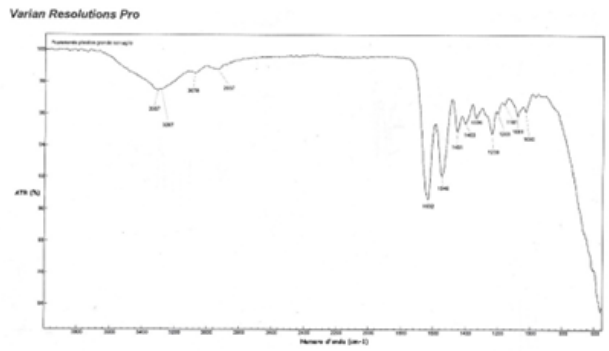

Fig. 24 || *Grande Serraglio.* FTIR spectrum of the transparent film.

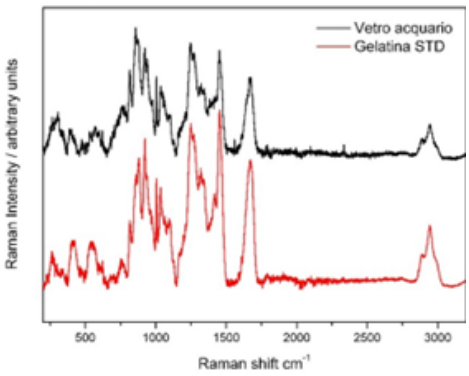

Fig. 25 || *Grande Serraglio.* µ-Raman spectrum of the transparent film.

Scientific investigations

Before proceeding with the restoration of the volumes some scientific investigations were carried out on the constituent material, including the transparent film of the *Grande serraglio*. Scientific investigations represent a moment of great knowledge of the work of art as they allow the characterization of the constituent materials and the analysis of the decay phenomena.
Thanks to the observation of the transparent film under the stereomicroscope and optical microscope, and to the investigation carried out using FTIR and µ-Raman spectroscopy and XRF spectrometry, it was in fact possible to establish the chemical composition of this material and the nature of its decay (**Figs. 24-25**). The sheet used to create the fake glass is made up of collagen, specifically animal gelatin as evidenced by the spectra obtained (Brown et al. 1972). The use of a photographic collagen films obtained by mixing inorganic salts used in photography as cross-linking agents for very diluted solutions could explain the extreme flexibility, as well as the transparency of the sheet of gelatin. The XRF investigation reveal the presence in traces of elements

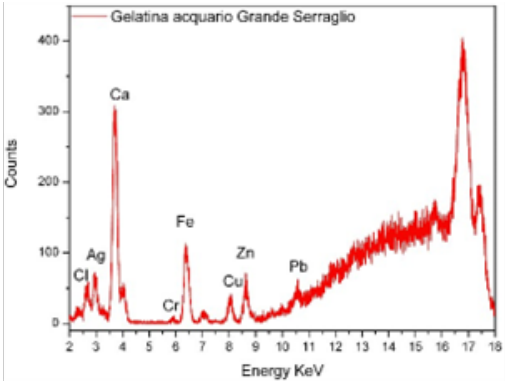

Fig. 26 || *Grande Serraglio.* XRF spectrum of the transparent film.

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referable to the manufacture of gelatin sheets for photographic use such as Silver (Ag) and Chlorine (Cl) commonly used as halide in the development process and also Chromium (Cr) which could indicate the presence of a Chromium Sulphate used as a hardening agent during the manufacture of gelatin sheets (Edward and Kenneth 1942) (**Fig. 26**).
The biological analysis revealed also that the loss of transparency of the film was due to a widespread microbiological infestation on the entire surface, both on the *recto* and the *verso*, with growth of crystals all along the hyphae (**Figs. 27 a, b, c**).

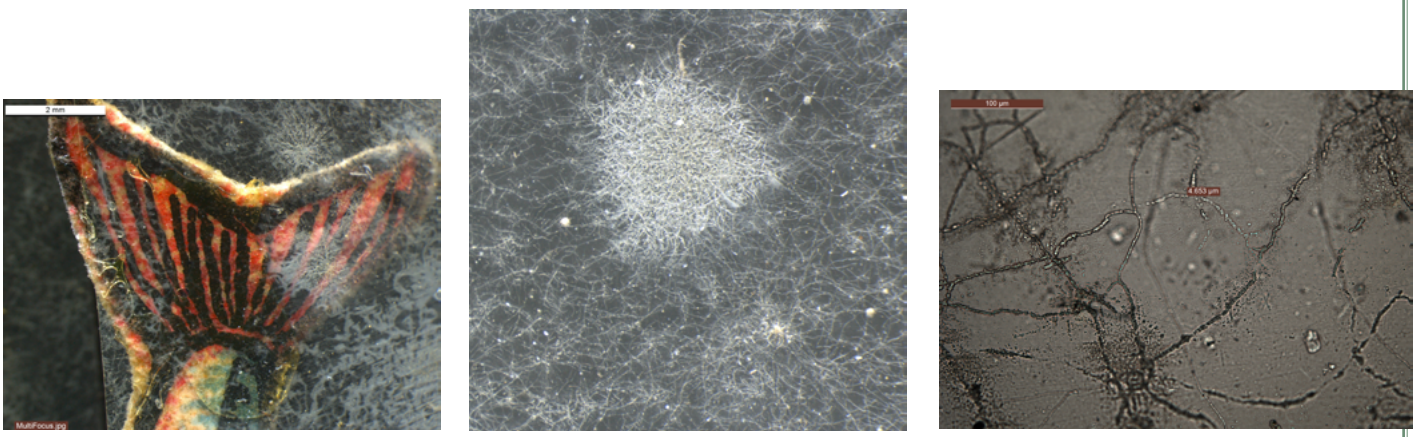

Fig. 27 a, b, c | *Grande Serraglio* biological decay of the transparent film

Considering the information obtained from scientific investigations it was decided, in agreement with the client, the replacement of the gelatin sheet as the biological infestation would have jeopardize the conservation of the volume.

Creation of facsimiles and 3D-models

To fully understand the functioning of the devices and to place each element back in the correct position at the end of the restoration, facsimiles and, subsequently, virtual 3D-models of the mechanisms present in the volumes were created (**Figs. 28 a, b, c**). For the creation of the facsimiles, it was necessary an in-depth study of the mechanisms and of all the parts which make them up. The facsimiles were particularly useful for *Les méfaits de Gaspard* where it was necessary to place back some characters and detached elements in the correct position. In fact, gluing an element in the wrong position would compromise the functioning

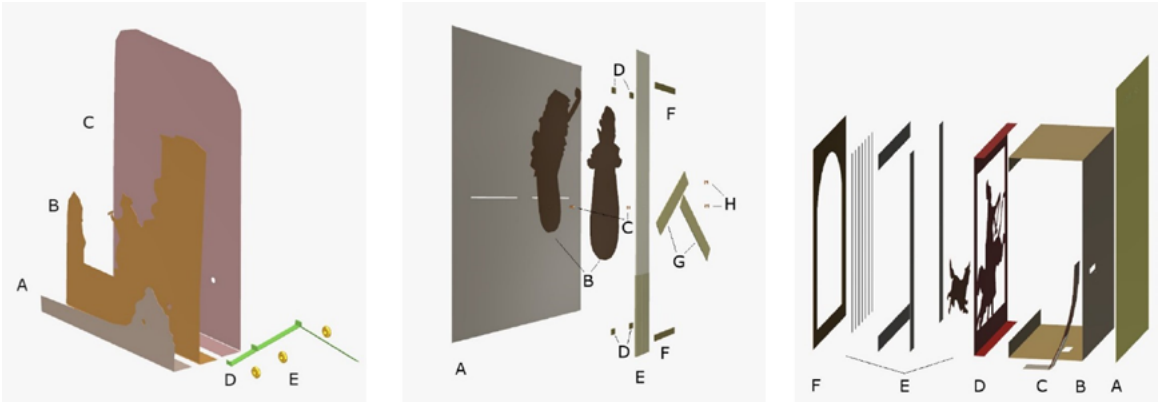

Fig. 28 a, b, c | Exploded view: third device of *Cendrillon* (a), third device of *Les méfaits de Gaspard* (b) and first device of *Grande seraglio* (c).

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of the entire device so this operation was carried out first on the facsimile and, only after having found the correct position, on the original.

Restoration

The treatment that was performed on the textblock and on the binding was similar for all three volumes. After a preliminary dry cleaning, it was decided to release the volumes from the cover to mend bifolios that were split at the spine fold, as the sewing was already broken. Repairing of the tears and filling of the losses were than carried out. At the end of the restoration of the binding and the mechanical devices, the textblock was sewed following the holes of the original sewing. Then the volumes were reassembled.
As previously underlined, however, the main purpose of the treatment was the restoration of the functionality of the mechanical devices. This operation was carried out preserving all the original characteristics of the volumes in accordance with the fundamental principles of restoration such as minimum intervention, reversibility, recognizability of the treatment and chemical and physical compatibility of materials used for the restoration. Movable books have a high aesthetic value, so it is important to fill the figurative losses of missing parts to restore their potential unity. It is therefore necessary to balance the need to re-establish the potential unity of the work of art with that of not creating a fake. In the literature there are essays relating to the restoration of movable books with mechanical devices that had figurative losses. Some restorers have filled them with high-definition printed reproductions of the missing part faithfully copied from other volumes. In agreement with Pompeo Vagliani, this rather unusual intervention methodology was excluded, as it was judged too imitative.
It was decided to carry out a recognizable filling of the figurative losses, having found the images online from other copies of the volumes and therefore having the exact position and the shape of the missing parts. The images were printed to scale to obtain the exact dimensions. The shape was then recreated on acid-free conservation paper of suitable weight and neutral colour, creating only the lines which defines the volumes leaving out the details. The chromolithographic effect was obtained with watercolour pencils through shades of colour. To make the restoration easily recognizable, the filling was carried out by varying the execution technique and using a colour undertone. The treatment was adapted to the characteristics of each volume. In *Cendrillon*'s first device the background layer was created on the cardboard by drawing the lines defining the volumes with graphite. To restore the lost depth, the ceiling was drawn in perspective, accentuating the shadows (**Fig. 29**). The stepsister's missing head was, instead, drawn on acid-free cardboard which was previously dyed in light rose with Winsor & Newton® watercolours to match the colour of the flesh (**Fig. 30 a**). In *Les méfaits de Gaspard* the figurative loss of the hare's ear in the first device was filled by taking up the basic colours of the scene and using a cross-hatching in the shaded areas like the original (**Fig. 30 b**). In *Grande serraglio*'s second device there was only the caudal fin of the dogfish. This has been recreated by reproducing the original colour using an undertone (**Fig. 30 c**).

Fig. 29 | *Cendrillon*. Filling of the figurative loss of the background layer in the first device.

As already mentioned, mechanical devices have often a very complex mechanism made up of lots of parts, and it is very important that each of this element is placed in the correct position to guarantee the

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ISSN: 2785-6569 online
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Fig. 30 a, b, c

Filling of figurative losses: the head of Cinderella's stepsister in the second device of ***Cendrillon*** (a), the ear of the hare in the first device of ***Les méfaits de Gaspard*** (b) and the dogfish in the second device of ***Grande serraglio*** (c).

functionality of the devices. For these reasons it was decided to dismount the devices only when strictly necessary as in the case of *Cendrillon* where there was the risk of a complete detachment of the silk ribbon when lifting the device as it was already torn and brittle and needed to be reinforced. In fact, a total break of the ribbon would have definitively compromised the possibility of lifting the devices, an action already limited, in some cases, by the paper strips on the *verso* of the background layer. For this reason, both the ribbons and the eyelets have been detached (**Figs. 31 a, b**). It was decided also to remove the portions of ribbon used for the repairs. The original fragments of ribbon were moistened with a cotton swab soaked in deionized water to bring them back to their original shape (**Fig. 32**). To provide a more solid support during the lifting of the devices, the ribbons were reinforced with a silk ribbon of a similar colour, texture, and thickness. The adhesive Beva 371® Original Formula Film 63.5 µm was the ideal solution, in fact it provided the proper flexibility to the reinforcing ribbon and ensured perfect adhesion with the original one.

Fig. 31 a, b

Cendrillon. Detaching of the ribbon and the eyelets.

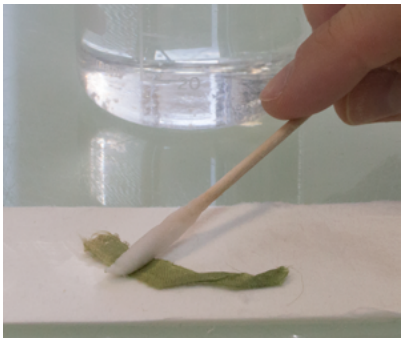

Fig. 32

Cendrillon. Moistening of the original ribbon.

JIB vol. 2 (2023)
ISSN: 2785-6569 online
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DOI: 10.57579/2023.5

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Some problems arose during the reassembly of the devices as it was important to keep a portion of ribbon between one layer and another which guaranteed the proper distance between the layers when lifting the device. The assembly was carried out following the holes and marks on the original ribbon. The ribbon and the metal eyelets were then inserted into the corresponding holes one layer at a time and fixed using eyelet pliers.

In the case of *Les méfaits de Gaspard* it was necessary to partially disassemble the devices to restore the hidden inner mechanism and, therefore, the correct movement. In some cases, however, it was possible to carry out the treatment without disassembly, working carefully on the original mounted mechanisms.

The spirals, in most cases, had to be placed back in the holes and the central tab had to be reinserted into the guides so that only a vertical movement could be performed. To do that it was essential to detach one of the two sides of the front sheet of paper. This operation was tricky due to the strong adhesive[2] that was used to assemble the device. Some tests were carried out to choose the product that was able to soften the thick layer of gelatin by releasing low humidity to avoid stains and discoloration of the graphic media. The choice fell on Nanorestore Gel loaded with a 40:60 hydroalcoholic solution, a product with low humidity release which did not cause significant discoloration nor damage to the paper surface (**Fig. 33**). Once the front sheet of paper was detached, it was possible to remove the inner mechanism, which in some cases was in poor condition, to reinforce the brittle areas with folds and to reposition the detached characters (**Fig. 34**).

Fig. 33 *Les méfaits de Gaspard.*
Detaching of the front sheet of paper.

Fig. 34 *Les méfaits de Gaspard.*
Repositioning of the detached character in the sixth device.

Where the spiral was lost or broken[3], it was necessary to create a new one (**Fig. 35**). We decide to use a copper wire of the same diameter as the original but more ductile and flexible protected with 2% Paraloid B72 in Acetone (**Fig. 36**). The difference in colour made the new spiral recognizable compared to the original one. With the disassembly of the devices, it was also possible to restore the front sheet of paper by repairing the tears and closing the holes of the spirals. Then, the restoration of the guide and the lock mechanism was performed by creating small new squares with acid-free cardboard and strips of paper where necessary. At the end of the restoration, the characters were inserted again into the slots and the spirals into the holes with the help of a steel spatula and tweezers. The central tab has been positioned inside the guides and the paper strip of the lock mechanism has been glued on the cardboard squares with EVA ART (**Fig. 37**).

[2] Gelatin as evinced from the FTIR spectrum.
[3] The hare's ear and a character in the fourth device.

JIB vol. 2 (2023)
ISSN: 2785-6569 online
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DOI: 10.57579/2023.5

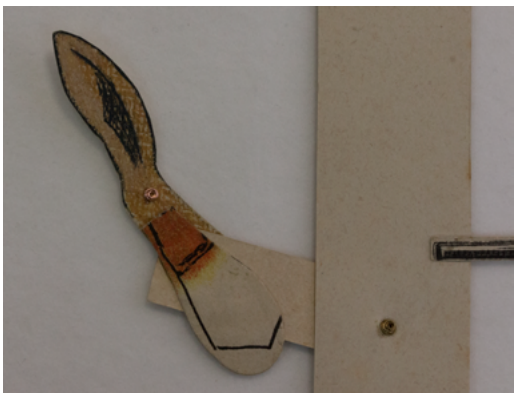

Fig. 35 *Les méfaits de Gaspard.* New spiral for the ear of the hare in the first device.

Fig. 36 *Les méfaits de Gaspard.* Protection of the spiral with Paraloid B72.

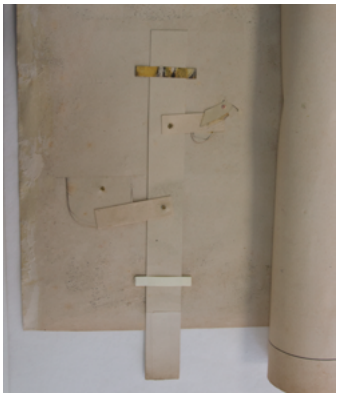

Fig. 37 *Les méfaits de Gaspard.* First device after the restoration of the lock mechanism.

In the *Grande serraglio* the restoration was carried out without disassembly the devices, working vertically thanks to the use of magnets (**Fig. 38**). Only in two devices (devices 2 and 5) the first layer was dismounted to perform scientific investigations, replace the transparent film, and reposition the detached elements.
As evidenced by the biological analysis, on the surface of the transparent film of the aquarium there was a widespread presence of molds. As it was impossible to treat them without damaging the support, we decided to replace the gelatin film for conservation reasons. The first layer was detached using Nanorestore Gel loaded with a 40:60 hydroalcoholic solution. Magnets were used to keep the hydrogel in contact with the paper since it was not possible to work on a flat surface or use weights. On the *verso*, a glass was placed in contact with the Nanorestore Gel to shield it from the magnet and ensure uniform pressure. On the *recto* the magnet was placed on absorbent paper to avoid direct contact with the paper layer (**Fig. 39**).

Fig. 38 *Grande serraglio.* Use of magnet in mounted device.

Fig. 39 *Grande serraglio.* Detaching of the first layer of the fifth device.

The fish that was glued on the *verso* of the transparent film had to be detached and repositioned on the new one. Before proceeding with the detachment, a mapping of the surface was carried out where the exact point of the fish was indicated.
The removal of the transparent film was more complex than expected due to the extreme brittleness of the surface. It was not easy to detach it without producing further creases and tears. Furthermore, the film was glued to the paper using gelatin so any solvent or gel that was able to solubilize or swell the adhesive would have had the same effect on the transparent film. The operation was then carried out without humidity with a steel spatula. In accordance with what was described in in University of Delaware's Department of Art Conservation 2021 we decided to replace the gelatin film with a sheet of polyethylene terephthalate (Mylar) which restores the lost readability thanks to the high degree of transparency. A facsimile was then created to test the flexibility and resistance of this material once assembled and to choose the proper adhesive. It was decided not to glue the fish to the Mylar film. It was anchored at the top of the *verso* of the first layer by two thin strips of Mylar (**Fig. 40**). The first layer was then reassembled with the aid of magnets (**Fig. 41 a, b**).

JIB vol. 2 (2023)
ISSN: 2785-6569 online
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DOI: 10.57579/2023.5

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Fig. 40 *Grande serraglio.* Repositioning of the fish in the second device.

Fig. 41 a, b *Grande serraglio.* Second device: before (a) and after (b) the restoration.

JIB vol. 2 (2023)
ISSN: 2785-6569 online
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DOI: 10.57579/2023.5

Guidelines for safe handling

Since the continuous and incorrect manipulation has been one of the main causes of decay of these volumes, at the end of the restoration we have drawn up some guidelines for safe handling.
In *Cendrillon* as the three-dimensional devices are not conceived to self-stand, the ribbon is continuously in stress and risks being damaged by the sharp edges of the metal eyelets. It is suggested to handle it carefully so as not to cause tears or creases.
In *Les méfaits de Gaspard*, to ensure the correct functioning of mobile devices, it is necessary to keep the central tab inside the guides. We therefore suggest that the tab should only be pulled vertically, avoiding lifting it.
Finally, in the *Grande serraglio*, the biggest problem is the sliding of the tab in the air pocket when lifting the device. To avoid the creation of creases on the page and the detachment of the tab from the bottom of the scene, we suggested to place one hand lightly on the page to keep it still and slowly lift the device accompanying the movement.

Conclusions

The restoration of these volumes represented for us a great opportunity to get to know the world of movable books for children which are often relegated to the rank of minor and ephemeral literature.
The restoration always represents a moment of great knowledge of the volume, its history, and the materials it is made of. There is still a lot to discover about the production processes of this kind of volumes, about the publisher, as well as about the complex solutions adopted by various paper engineering over the centuries. Thanks to scientific investigations it was possible to characterize the constituent materials and find out that the gelatin used as a binder in photographic processes could also be produced in transparent and flexible sheets, used for different purposes.
In general, the conservation treatment was complex, but necessary to restore the correct functioning of the mechanical devices. In fact, the volumes can be read, opened, and actioned again to create that feeling of wonder desired by those who created these fascinating books.

JIB vol. 2 (2023)
ISSN: 2785-6569 online
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DOI: 10.57579/2023.5

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