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Twenty years of conservation of plated brass instruments at the Musée de la musique in Paris

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ABSTRACT

The Musée de la musique in Paris conserves an important collection of brass instruments, which is often displayed, loaned out or played. The manufacturing techniques used to create these instruments, in particular their plating, are not well known and are rarely documented. Using specialized observational techniques, the authors have revealed several types of data that will help to identify the manufacturing techniques used for this type of instrument in the future. These instruments need regular conservation or restoration. For this reason, the authors compared several different protocols that have been used. The results are discussed with respect to the current state of the instruments and the conservation-restoration treatment formerly chosen. An evaluation grid is proposed to help conservators and restorers choose among potential conservation treatments for brass instruments. Finally, specific maintenance protocols are identified that respect the instruments' playing mechanics, the specific features of the corpus and the ethics and standards of conservation-restoration deontology.

INTRODUCTION

The Musée de la musique in Paris conserves an important collection of brass instruments, which is often displayed, loaned out or played. In particular, a group of Adolphe Sax's brass instruments, including unique prototypes, that has been studied at the Conservation and Research Laboratory of the museum on many occasions, including during a restoration campaign for the museum's opening (1992–97), during the refurbishment of the main exhibition in 2009, and during day-to-day conservation monitoring. The authors will discuss the evolution of the protocols adopted for different types of interventions on these instruments: from the study of manufacturing techniques to different conservation-restoration treatments and protocols for maintenance after instruments are played.

HISTORICAL CONTEXT

On Thursday, November 17, 1864, the Musée de la musique (then named the Instrument Museum of the Paris Conservatory) opened its doors to unveil a collection of musical instruments to the public for the first time (Getreau 1996). This national collection now numbers over 7,000 objects and includes musical instruments, paintings, and sculptures tracing musical history from antiquity to the modern day. Today, the Musée is part of the Philharmonie de Paris. Wind instruments, particularly brass instruments, are well represented, comprising instruments made of a copper alloy, most often brass. The collection contains an important group of instruments that includes trombones, trumpets, and saxophones, many invented or developed by the well-known instrument maker Adolphe Sax. Antoine Joseph Sax, known as Adolphe Sax, was born in Dinant, Belgium in 1841 and died in Paris in 1894. He perfectly embodied the entrepreneurial spirit of the 19th century, tirelessly seeking to perfect his musical instruments, and revolutionized the world of wind instruments in particular by improving their precision, sound quality, and ease of playing (he held 33 patents) (SAX200 Exhibition Catalogue 2015). His sons continued to operate the factory for some time, but it would eventually be purchased by the Selmer company.

The museum holds nearly 120 of Sax's instruments. The Research and Conservation team at the museum has carried out work on these instruments at several points: during the period leading up to the opening of the museum's

current building (1992–97); during its renovation in 2009; in preparation for significant loans, such as those to the SAX200 exhibition (co-organized by the Musée) and to the Museum of Musical Instruments, Brussels (mim) in 2014; and for museum recording projects (Figure 1).



Figure 1. The showcase for Sax's instruments at the Musée de la musique

MANUFACTURING TECHNIQUES FOR BRASS INSTRUMENTS

As will be seen, these projects considerably enriched the documentary files on these instruments, both regarding their constituent materials and manufacturing techniques, as well as their state of conservation and the impact of restoration work on their current condition.

Manufacturing techniques for brass instruments in the 19th century are rarely well documented, particularly with regard to plating and other surface treatments. Most often, these amounted to nothing more than a polishing or shining. In some cases, finishing the surface consisted of applying a fine layer of a white or golden metal. This could be silver, gold, or nickel, and served an aesthetic purpose, but also had a protective function. These plating techniques are difficult to identify with the naked eye because finishing techniques such as polishing reduce or erase the tell-tale signs of plating processes. Varied plating techniques were used and understanding them often explains the deterioration observed on the instruments. Gold and silver plating can be done in three ways:

- Leafing: a leaf of gold or silver is placed on a perfectly scoured surface and then polished and buffed.
- Mercury amalgam: a liquid amalgam is applied to a completely acid-stripped surface (silver and gold being both soluble in mercury). The object is then heated, evaporating the mercury and leaving only the metal, which coats the tiniest details of the surface.
- Electroplating: the objects to be treated are perfectly cleaned, including solvent degreasing and polishing. They are then immersed in an electrolyte

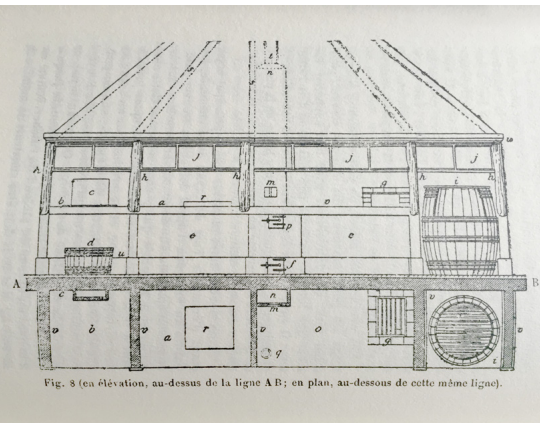


Figure 2. Furnace for plating: mercury amalgam technique (Maigne and Mathey 1980, 28) for gold and silver plating



Figure 3. Sax's workshop (*Le Monde Illustré*, 3 January 1863, p. 13)

bath of metal salts, to which a weak electric current is applied. The anode is a plate of pure metal and the cathode consists of the pieces to be plated.

It is essential to identify these techniques accurately in order to properly conserve these objects today. It is probable that these plating operations were not carried out in the instrument maker's workshop, but rather in the foundry by gilders, goldbeaters, or "platers and makers of rolled gold and silver." These artisans formed corporations and can easily be identified from lists of Paris merchants published by the Bureau of the Almanac of Commerce beginning in 1820. Among these, it is worth mentioning Maison Thomaire (from the beginning of the 19th century), Picard, La Maison Christofle, or H. Fontaine (from the end of the 19th century).

The products used in these techniques are often dangerous – mercury, cyanide, concentrated sulfuric or nitric acids – and the processes require specialized equipment, including hutches and ventilation. Passing the objects through an acid bath during the stripping process (which releases toxic vapors), as well as the heating stages (up to 350°C) needed to evaporate the mercury during the amalgam technique, are technical steps that require equipment similar to that seen in the Roret Encyclopedia or the practical guide of A. Roseleur. By comparison, in Sax's instrument-making workshop in 1848, there is only a single furnace to the side, used for the soldering or braising involved in assembling the different parts of the instruments, and none of the trays and other fixtures required for plating (Figures 2 and 3).

Visual observations of several instruments from the collection were confirmed and supplemented by analysis with an EDS electron probe microanalyzer (EPMA). These observations were led by Marc Voisot, a restorer of watches and scientific instruments, on several instruments from the museum's collections.

Screws and other removable parts of the instruments were partially included in the resin in order to allow the observed section to be sufficiently polished. The polished areas were first viewed with an optical microscope in order to characterize their structure, and then analyzed with a scanning optical microscope with an EDS electron probe microanalyzer in order to determine the quantitative composition. Together, this information allowed the authors to compile a list of markers for each technique, which now allows the chosen manufacturing techniques to be better identified. Table 1 shows some characteristic examples of each technique.

Other research projects involving analysis by x-ray fluorescence (XRF) provided important data for several instruments from the collection. To complement the qualitative studies carried out with the XRF equipment,¹ a quantitative study was implemented, using calibration curves from known standards of bronze and brass.²

The analysis of Adolphe Sax's bell in E (inventory no. E.974.11.22) is a good example (Figure 4). This bell is part of a group of 24 instruments previously conserved at the Paris Opera and transferred to the Musée.

METALS

**TWENTY YEARS OF CONSERVATION OF
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Figure 4. Sax's bell (E.974.11.22)

Table 1. Analysis and observations on plated saxophones

Denomination	Image	EDS and metallographic analysis	Visual observation	Details
Saxophone alto E.715		Thick and rather irregular plating (around 60 µm). Silver plating with mercury amalgam	Degradation of the silver plating in the form of irregular "œil de bouillon" halos. Marks from the brass brush used to apply the mercury amalgam.	
Bass saxophone E.995.20.1		Thin and very regular silver plating. Electrolytic silvering	Holes due to hydrogen bubbles occurred during electrolytic deposition. This may be because the area underneath was irregular (brazing).	

It is made of a hammered copper alloy, in the shape of a truncated cone with four horizontal bands. On one of them, the engraved word "mi" (E) is readable, indicating the tone of the bell. The area where the sheets are joined is visible in the form of a darker line, surrounded by an area where the alloy is more reddish in color. The analyses and results are summarized in Table 2. It was possible, therefore, to precisely identify the alloy as well as the assembly process for soldering the metal sheets.

Along with the records of previous conservation treatments and condition reports for the instruments, these tools allow us to enrich our knowledge of the collection and to better understand the deterioration seen on each instrument.

Table 2. XRF analysis of Sax's bell

Localization of XRF analysis	Analysis	Details
	<p>Estimated alloy calibrations: brass with $30.67 \pm 1.4\%$ mass of zinc</p> <p>Join between sheets: welding (no other metal detected and no variation in the % of zinc)</p> <p>In the reddish area: lower zinc content due to the migration of copper in the alloy when the sheet was heated</p>	

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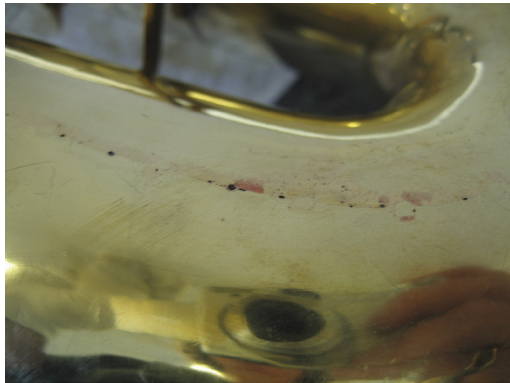


Figure 5. Reddish area on Saxophone E.996.18.1 due to the acidic action of EDTA

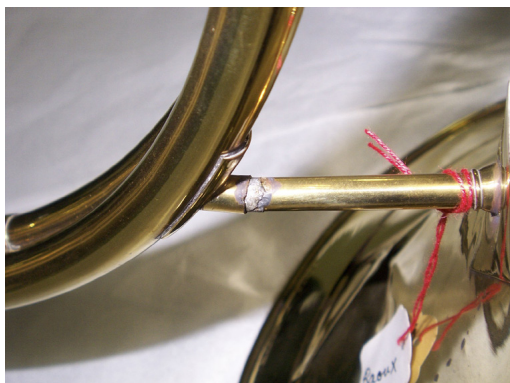


Figure 6. Unsuccessful re-soldering

DIAGNOSTIC AND COMPARATIVE STUDY OF CONSERVATION AND RESTORATION TREATMENTS

These instruments were examined many times, both when the museum was opened and renovated, and when the instruments were loaned out for temporary exhibitions. In addition to these examinations, an assessment of the condition of the entirety of the collections was carried out in 2007. The recurring changes observed are a reaction to the instruments' direct environment, including during manufacturing, handling, use, maintenance, and restoration. Dents and creases on bells were the result of past impacts, and trace fingerprints were due to being handled without gloves in the museum. Remnants of abrasive dust were present in the creases and joints of the pieces. Many instruments showed localized reddish areas on the surface of the brass, and others oily deposits on the surface. Finally, instruments with silver plating were strongly sulfurized.

By comparing these changes with the records of previous treatments carried out, and with the indications of these techniques seen on the instruments, it was possible to modify the protocols for intervention.

Many brass instruments showed a localized reddening on the surface, often near areas of soldering. After reviewing the archival documentation, the instruments were cleaned with a solution of disodium EDTA at 0.1 M in demineralized water. The solution has an acidic pH at this concentration (around 4) which, in this case, produces an acidic reaction attacking the surface, rather than a complexation reaction attacking the copper in the alloy. For the last stage of cleaning, therefore, either buffered disodium EDTA at a neutral pH or buffered DTPA³ at a neutral pH are recommended. The latter complexant has five active sites and, at a neutral pH, at least three are usable. For local cleaning, this complexant in a gel is now preferred (Wolbers 2005) (Figure 5).

Oily areas were present on many of the brass instruments. The archival documentation indicated that they had been polished in the final stage of cleaning with rottenstone (also known as tripoli) in an oil solution. It is very likely that this solution was insufficiently removed afterwards. In the future, therefore, it is advised that the instruments be rinsed with alkane solvents to eliminate any trace of oil from previous treatments.

Many brass instruments with silver electroplating showed small local perforations that were interpreted as being linked to hydrogen bubbling during the manufacture of the plating. They had been cleaned in 1992 by electrolysis in collaboration with the Valectra laboratory with technological and scientific sponsorship from ED. The instruments were cleaned by reducing silver sulfides by immersion in a simple electrolytic cell with a solution of sodium sesquicarbonate. The cathode potential was fixed at -1.3V/ESS. However, the presence of these fragile areas led to the discarding of this cleaning technique for this type of instrument in the future in favor of a technique based on abrasives, rather than chemical products such as complexants (Storme 2011) (Figure 6).

Finally, soldering on parts of several instruments had disintegrated. Most had been subject to re-soldering, but much of this had not bonded. In order

to limit the invasive and irreversible character of this type of intervention, it was decided to join the pieces with an adhesive, using reinforcing blocks as needed to limit the tensions present in the assembly.

MAINTENANCE PROTOCOL FOR INSTRUMENTS IN PLAYING CONDITION

A complete evaluation of the corpus, and of the tools available to best conserve it, allowed a protocol for the maintenance of instruments before and after being played to be developed.

Occasionally, the museum receives a request to allow one of the instruments in the collection to be played, whether as part of a recording project, in order to preserve a sonic record, or for a concert (Barclay 2004). Most frequently, metal instruments are used, since the variations in relative humidity while being played can be more easily regulated with a metal instrument than a wooden one. However, exceptionally, other instruments from the museum are played, such as violins, pianos, or harpsichords. Finally, in some cases where it is deemed essential to play an instrument but the one conserved at the museum cannot withstand the rigors of performance, the decision is made to create a facsimile. For instruments from the brass family, bringing a piece up to playing condition involves a very specific protocol,⁴ whose objectives are: a) to describe and evaluate the current conservation condition of the object; and b) to serve as a baseline for evaluation of the effort to bring the object back into playing condition.

For this specific issue, the highlighted criteria involve the mechanical coherence of the instrument, good sound reproduction, and maintenance of the instrument's integrity after having been played. As a result, the following must be considered:

- Mechanical fragility (which could interfere with intensive handling of the item during playing). Examples could include faults in the soldering, or cracks in the metal plates. For example, a network of microfissures on the bell of a French horn (E.1531) prevented its being restored to playing condition.
- The presence of a varnish on the surface, the conservation of which would be endangered by cleaning of the instrument after playing.

At the same time, before the instrument is played, a maintenance protocol is drafted (Loeper-Attia 2007).

Different types of exogenous materials can be transferred from the musician to the instrument during playing or handling. These can include saliva, oils, or other products on the fingers of the musician. The majority belong to the following chemical families:

- waxes
- oils and aged oils
- natural resins, and
- proteins and polysaccharides.

Using a Teas solubility graph,⁵ it was possible to choose the most appropriate solvent based on solubility parameters and the solubility windows for the solid materials to be eliminated.

The following protocol for inspection after playing was therefore proposed:

1. complete disassembly of the instrument;
2. immersion in a solution of demineralized water with an active neutral surfactant (Dehypon LS54 at 1%), and brushing with a soft brush;
3. rinsing with demineralized water;
4. rinsing with ethanol;
5. rinsing with cyclohexane;
6. rinsing with acetone; and
7. drying in room-temperature air and warm air (using a hair dryer), and wiping with a soft cloth.

The conservation condition of the instrument is then compared with that observed during the initial review. To date, a dozen instruments have been played and inspected in this manner.

CONCLUSION

With the help of these various studies, knowledge on this corpus has been broadened in several aspects:

- the instruments' manufacturing techniques and maintenance, by establishing specific indicators that help us expand our knowledge of the history of the instruments in the corpus;
- the comparison of different conservation-restoration techniques and their effects on the instrument in the long term; and
- the maintenance protocols that could be safely adopted with these instruments for temporary recording projects or concerts.

All this information will be shared with the public through temporary exhibitions, our website, an instrument database and publications.

ACKNOWLEDGEMENTS

None of this work could have been achieved without the conservation team at the Musée de la Musique, or without the participation of external conservators and scientists such as Marc Voisot, Virginia Costa, and Sylvie Gomes. We would like to thank you all.

NOTES:

¹ ARTAX prototype II x-ray fluorescence spectrometer (Intax GmbH).

² Work completed by Sylvie Gomes during a Ministry of Culture and Communication residency at the museum in 2013.

³ DTPA: Pentetic or diethylenetriaminepentaacetic acid (DTPA) with 5 pKa values of 1.8, 2.6, 4.4, 8.8, and 10.5. The 4 pKa values for the EDTA (ethylenediaminetetraacetic acid) were 2, 2.7, 6.2, and 10.2.

⁴ “Horns and natural trumpets: Condition findings”, an internal study completed by V. Costa and M.-A. Loeper-Attia, June 2006.

⁵ See iscr.beniculturali.it/flash/progetti/TriSolv/dati/FR/TriSolv_FR.pdf.

MATERIALS LIST

Dehypon® LS54
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DTPA
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Thermo Fisher (Kandel) GmbH
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www.alfa.com/chemicals

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