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About Time:
Analysis and Conservation of a 17th-Century Table Clock

CNS 695 SPECIALIZATION PROJECT

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I. ABSTRACT

An early table clock in the collections of the Buffalo Museum of Science has been in storage since the 1930's. Research was undertaken to provide the rudiments of a provenance and to authenticate museum records. Examination, digital photographic documentation, and materials analysis using ultraviolet induced visible fluorescence, digital capture X-ray radiography, transmission Fourier transform infrared spectroscopy (FTIR), and X-ray fluorescence spectroscopy (XRF) were undertaken to assess the date of manufacture, characterize materials employed, identify alterations and repairs, and provide information relevant to the study and display of this object. Treatment was undertaken to improve the appearance and stability of the object by reducing dirt, grime, and non-original coatings.

II. PROJECT OBJECTIVES

The purposes of this investigation and treatment are twofold: to document the materials, techniques of manufacture, and inner works of an early spring-driven clock, as well as to present the owner institution with an object and accompanying information suitable for didactic display.

Photographic documentation and the employment of analytical techniques including ultraviolet-induced visible fluorescence, x-ray radiography, transmission Fourier transform infrared spectroscopy, and x-ray fluorescence spectroscopy will add to the technical understanding of materials and mechanisms used in this clock.

Comparison with other known clocks of the time period and those attributed to the same maker will be instrumental in establishing the basics of attribution and provenance.

Identification of previous alterations and repairs using a combination of historical scholarship and technical analysis will further develop the understanding and appreciation of the manufacture and use of this unique object.

Treatment will improve the appearance and cleanliness of the object, such that it will be suitable for exhibition. Additionally, it is anticipated that treatment will result in an appearance more in keeping with the original aesthetics of the object. Though it may be possible to return the clock to going order, this is not a primary goal of treatment.

Figure 1, Buffalo Scheirer clock before treatment Left: oblique view Right: Top view

III. PREVIOUS DOCUMENTATION AND PROVENANCE

i. Overview

Relatively little is known about the provenance of this clock. Likewise, few published examples of surviving clocks have been attributed to the maker Johan Scheirer. In the interest of a comprehensive review, relevant sources are here excerpted at length for reasons of analysis and comparison.

ii. Museum Records

Museum records include the following description of the clock:

> “Table Clock
>
> Brass, metals
>
> 17th century, Germany
>
> Purchased from Clapp & Graham Co., 514 Madison Avenue, New York, NY, 1937.”[1]

Clapp & Graham are listed under “Antiques and Bric-a-Brac” in the 1930 edition of White and Orr’s Classified Business Directory, New York City Section.[2] A review of auction records at Sotheby’s and other houses indicates that Clapp & Graham were dealers specializing in European decorative arts and paintings, active as early as 1916.[3]

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[1] Buffalo Museum of Science, Curatorial Catalog, C12920

[2] *White and Orr’s,* 1930.

[3] Sotheby’s. Sale N07930, Lot 15. 2003.

Other museum records of the same date indicate that this clock was donated as part of a large collection of scientific instruments.

iii. *Hobbies* Magazine

A museum-affiliated publication, *Hobbies*, published the following description of the clock soon after its purchase:

> “The German seventeenth century hexagonal table clock, by Johan Scheirer, possesses a number of features rather surprising in so old a timepiece. The escapement is controlled by a balance wheel, although unfortunately, for purposes of accuracy, no compensating devices are apparent. Adjustments could not be made for temperature. Power is supplied by a spring, with barrel and fusee. It is surprising that this example arose early in such days, for we find a very perfect mechanism, operating just as do those in modern types. The dial for instance occupies the whole of the face, and is marked with the major numerals. Most interesting are these numerals, in the Roman character, using the IIII symbol instead of the IV and possessing wide and narrow strokes of the V and X such as even at the present day are so commonly seen on our large timepieces.”[4]

Though it is possible to view the majority of the works through the side windows of this clock, this description is specific enough that it is possible the works were removed from the case for inspection at this time. If the mechanism were not removed especially for the purposes of this article, it is still likely that the clock was partially or wholly disassembled at the time of sale, as it is customary in the horological world to inspect the inner works before purchase. It may also be possible that some amateur restoration may have occurred this time, such as cleaning, polishing, replacement of screws, or replacement of the window glass.

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[4] Cummings, C. E. 1937. P. 104

iv. *Science on the March* Magazine

A separate publication, from 1965, offers a second description of the clock, this time with an accompanying picture.

Figure 2, Cummings, V. L. 1965. P. 15

> "Johan Schreirer [sic] of Germany is credited with fashioning a hexagonal brass and silvered table clock in the mid-seventeenth century. Glass panels on each five-inch side permit viewing of the chiseled movement which makes use of a spring and balance wheel. There are three legs in the shape of winged cherubs which raises (sic) the piece sufficiently to allow room for an hour and alarm bell below the mechanism. The hours are marked on a large face with finely engraved and filled Roman numerals separated by fleur-de-lis. Arabic numbers on a smaller dial are for the alarm set."[5]

This description is more superficial than that printed in 1937, and may indicate that the clock was not disassembled for this later article. However, inspection of the accompanying picture suggests that the current condition of the clock is similar or

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[5] Cummings, V. L. 1965. P. 15

identical to its condition in 1965. Cracks in the metal, abrasions to the gilding, and losses to the hour numeral inlay appear extremely similar. Interestingly, the hour hand in the 1965 picture reads approximately 7:30, whereas the current position of the hand reads 5:30. The alarm set appears in the same position. This may indicate that the hour train was wound and set to going sometime between 1965 and 2009. As the drive spring for this train was partially wound and under tension when this clock was received (as revealed by x-ray radiography), this is a distinct possibility.

v. *Britten's Old Clocks and Watches and Their Makers*

The maker Johan Scheirer is listed in *Britten's Old Clocks and Watches and Their Makers*, in the appendix 'Former Clock and Watch Makers,' with one attributed clock. Various editions list this hexagonal clock as early as 1620[6] and as late as 1675.[7] The earlier date may be more accurate, as it appears in the latest edition. The second edition of *Britten's Old Clocks and Watches and Their Makers* includes a description and discussion of this clock, with an accompanying engraving. The relevant text is here excerpted at length:

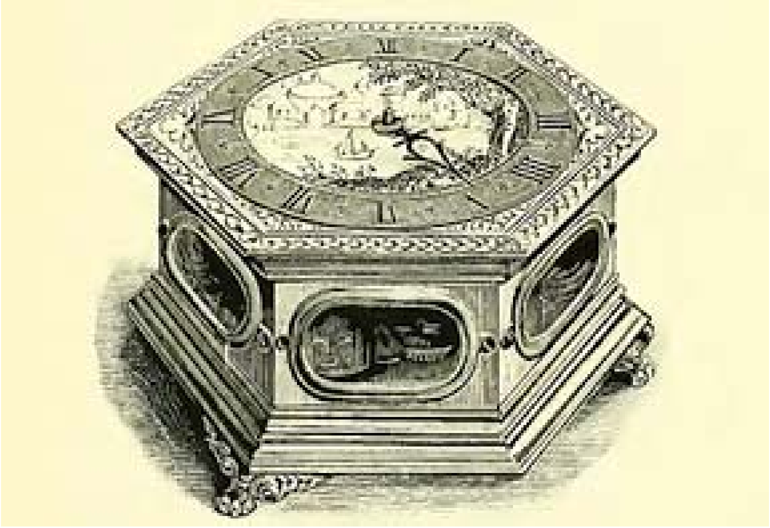

Figure 3, Britten, F. J. 1904. P. 105 Britten's Fig. 100

> "A good examples of early seventeenth century table clocks is shown in Fig. 100. It is in a brass case with silver hour ring, divided into twelve, and a *fleur-de-lis* midway

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[6] Baillie, G. H. 1990. P. 594

[7] Baillie, G. H. 1956. P. 469

> between each hour. The characteristic features which note the departure from the earliest specimens are the glass panels in the side of the case and the bronze feet, which give a better effect than is obtained with the primitive flat hexagonal and octagonal clocks, besides allowing space for the bell to project below the bottom surface of the case. The cocks and hammer are nicely engraved and pierced, and on the plate is the name Johan Scheirer. A balance spring has been applied subsequently to the manufacture of the piece, and as the original balance cock is retained, the spring is much cramped. The balance appears to be the original one, and is weighted with pieces of metal to keep the vibration sufficiently slow after the addition of the spring. A notable peculiarity is that the fly pinion has but four leaves.[8]"

Britten attributes this clock to the Schloss collection. Though the connection is not made explicit, it is believed that this refers to the collection of Adolphe Schloss, the early 20th century French collector of 17th and 18th century European paintings and decorative art. The Schloss collection was seized by the Nazi war machine in 1943, and has featured in several high-profile repatriation lawsuits in the ensuing years.[9] Much of the information published about the Schloss collection has focused on the more than 300 old master paintings that formed the bulk of the collection, and complete lists of the stolen articles are thought to have been destroyed in the final days of World War II. Thus, it cannot be established with certainty if this clock was indeed part of the collection of Adolphe Schloss, or where its present location may be.

As can been seen in the engraving published in the second edition of *Britten's*, this clock bears a number of similarities in style and form to the clock from the Buffalo Museum of Science. It should be noted that the published engraving is not an exact

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[8] Britten, F. J. 1904. P. 104-105

[9] The French government maintains a website dedicated to the location and repatriation of paintings from the Schloss collection, online at: https://pastel.diplomatie.gouv.fr/editorial/archives/dossiers/schloss/sommaire_ang.html

reproduction of the appearance of the original, though it is assumed that it records the salient features. The case is hexagonal, with a horizontal face and glass windows on each side. Though the ornamentation is slightly different, the basic form of the two clocks is strikingly similar. The picture in *Britten's* appears to suggest that the interior works are engraved in a style similar to the floral and foliate patterns on the works of the Buffalo clock. Interestingly, though both clocks have only three feet, the example in *Britten's* shows the feet located at the corners of the clock's base, rather than the centers of the sides, as with the Buffalo example.

The primary difference between the two clocks is their remarkably distinct faces. Both clocks show similar chapter rings, though this style was in common use from the 16th to the 18th century. Within the chapter ring, however, the *Britten's* example appears to show an engraved river scene, whereas the Buffalo clock contains the set dial for the alarm. It appears likely that the alarm dial and mechanism on the Buffalo example are later alterations to the clock. The engraving of the Arabic numbers on the alarm dial is of a somewhat lower quality, lacking in the fine quality of line present in the numerals on the outer chapter ring. However, this in itself does not conclusively prove that the alarm is a later alteration.

The *Britten's* example shows a delicate, pierced hand extending beyond the inner edge of the chapter ring, whereas the Buffalo example has a shorter, stouter hand reaching only to the inside of the alarm dial. It is quite possible that the example published in *Britten's* has a replacement hand from a later period, possibly the 18th century, as earlier clocks generally have shorter, thicker hands, akin to the one retained by the Buffalo example.[10]

vi. Sotheby's "Important Watches, Clocks, and Automata"

The above comparison of the Buffalo and *Britten's* examples is of particular interest in light of a third clock attributed to Johan Scheirer, sold at auction at Sotheby's, New York, on October 20, 2009.[11] It does not appear that this clock is the same as that published by Britten in 1904, as there are significant structural differences. The complete listing and condition report, as they appear in the online auction catalogue, are as follows:

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[10] Basserman-Jordan, E. V. 1964. P. 194-195

[11] Sotheby's. Sale N08578, Lot 12. 2009.

Figure 4, Sotheby's, Sale N08578, Lot 12. 2009. Exterior of clock attributed to Johan Scheirer

"VARIOUS PROPERTIES

JOHAN SCHEIRER, VILNA

A RARE AND LARGE HEXAGONAL SILVERED AND GILT-METAL HOUR AND QUARTER STRIKING TABLE CLOCK LATE 17TH CENTURY

MEASUREMENTS:

Width 7 in (18cm)

DESCRIPTION:

Gilt-brass and steel three train movement, balance cock and bridges finely pierced and engraved, dolphin head engraved hammers striking two bells. The dial possibly replaced silvered chapter ring, centered by an engraved seascape. The gilt case with silvered caryatids, mounted on silvered foliate feet. Movement signed.

CONDITION REPORT:

With Alterations

This has been adapted to a two handed clock; it would have been a single handed clock. The running and striking trains are fully wound. The dial now applied with a crude chapter ring, suggests possible replacement, however the remainder of the clock is of very high quality. Accompanied by a key."[12]

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[12] Sotheby's. Sale N08578, Lot 12. 2009

All three clocks share a number of important similarities, along with some important distinguishing features. The signature of the maker appears in a slightly different style of script on the Sotheby's and Buffalo clocks, but is spelled consistently. Though the basic form and styles of all three clocks are very similar, the Sotheby's clock is nearly half again as large as the Buffalo clock, and has the most elaborate scheme of ornamentation of all three examples.

Figure 5, Signatures on the base plates of the Buffalo Scherier, left, and the Sotheby's Scheirer, right

As the condition report notes, it appears that the rather clumsy chapter ring on the Sotheby's clock's dial is a later replacement. The Sotheby's chapter ring lacks the fluer-de-lis and divisions of the quarter hour seen on the Buffalo and *Britten's* examples. Similarly, the hour and minute hands of the Sotheby's clock, which are known to be later alterations, resemble the hour hand of the *Britten's* clock, suggesting that it, too, is a later alteration. The appearance of the original face of the Sotheby's example is extremely similar, however, to that of the *Britten's* example. These two clocks show nearly identical programs of decoration on the outer edge of the face, as well as very similar scenes engraved on the inside of the chapter ring. Though the Sotheby's catalogue describes this scene as a "seascape," the inclusion of foreground vegetation, swans, and a city suggest that the scene is more likely a depiction of a river.

Figure 6, Buffalo Scheirer clock before treatment Left: Bottom, bell plate closed Right: Base plate, bell plate opened

The feet of the Sotheby's example are nearly identical to those of the *Britten's* example, but differ substantially from those of the Buffalo clock. The Sotheby's example includes six feet, rather than the three found on the other two clocks,[13] but this may be a result of the increased weight due to the large size of the clock. It is worth noting that the cherubim feet on the Buffalo example appear to be drawn from the same stylistic repertoire as the caryatids of the Sotheby's clock. The silvered ornamentation on all three clocks is very similar not only in style but in the method and location of attachment using small screws.

The style of decoration on the base plates of the Buffalo and Sotheby's clocks appear quite similar, with the important difference that the Sotheby's clock has an added striking train for the quarter hours. It should be noted that comparison of the decoration on balance cocks and bridges is almost never a conclusive method for the identification of particular clockmakers. Almost all balance cocks incorporated into timepieces before the 19th century were produced as piece-work, in a process separate and removed from the manufacture of the clock's works.[14] Furthermore, the decoration of the hammers of

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[13] Three feet are most common for hexagonal clocks of this period. See Baillie, G. H. et. al. *Old Clocks and Watches and Their Makers*. 9th ed. Bloomsbury Books, London. (1990) p. 28
[14] Basserman-Jordan, E. V. 1964. P. 202-203

table clocks with anthropomorphic or grotesque heads is quite common, and not indicative of a particular location.[15] Other works visible on the base plate of the Buffalo clock show signs of alteration or repair, including the bushing, drilling, and filing of pivots, the cutting and addition of part of a cock, and the addition of a cork raiser.

Figure 7, Sotheby's, Sale N08578, Lot 12. 2009. Base plate of clock attributed to Johan Scheirer

Sotheby's location of Scheirer in Vilna is an assertion that has not been independently confirmed. Vilna is an archaic name for the present-day city of Vilnius, capital of modern Lithuania. Though most table clocks of the seventeenth century are associated with Augsburg, it is worth noting that the devastating effects of the Thirty Years War (ending in 1648) are known to have prompted a number of clockmakers to emigrate from southern Germany to the Baltic countries.[16] German-speaking territories that remained relatively unaffected included the Grand Duchy of Lithuania and its neighbor, Ducal Prussia. A number of extremely similar clocks are known to have been made in Konigsburg, capital of Ducal Prussia, indicating that the clockmaking tradition was alive and well in the Baltic states during the second half of the seventeenth century.

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[15] Baillie, G. H. 1990. P. 28

[16] Bedini, S. A. 1980. P. 21

vii. Conclusions

Analysis and comparison of the various written and visual records of clocks attributed to Johan Scheirer suggests several important conclusions in relation to the example in the collection of the Buffalo Museum of Science. It is very likely that this clock was indeed manufactured by Johan Scheirer, as it bears numerous significant similarities to other published examples. It is likely that the chapter ring and perhaps the hour hand are original to the clock. The chapter ring was almost certainly silvered, as are the other Scheirer examples, and as was customary in the 17th century.[17] The alarm mechanism is unique to the Buffalo clock, and may be a later addition, as evidenced by modifications and additions to the works. The silvered feet and window frames appear different from those on other Scheirer clocks, though at present, there is no indication that they are not original. It is not known precisely when or where this clock was made, though it corresponds to other hexagonal clocks made in the middle of the 17th century in German-speaking territories. Unfortunately, it has not been possible to conclusively link Johan Scheirer to the city of Vilna (Vilnius).

It appears that this clock has been in stable condition since at least 1965. Photographic and x-radiographic evidence suggests that at least one drive spring has been under tension since at least that date. Based on museum records, it is possible to infer that the last time the clock was likely disassembled or cleaned occurred at the time of sale, in 1937. No diagram or complete description of the clock's works is known to exist. The clock is missing the winding keys. The originals would likely have been pierced and engraved, with pointed ends used for the correction of the strike.[18] Unfortunately, photographs of the Sotheby's clock's keys are not included in the catalogue.

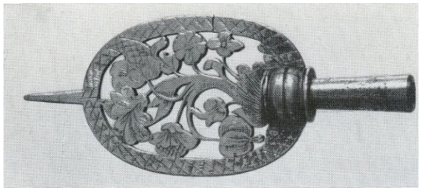

Figure 8, Bassermann Jordan, E. V. 1964. P. 263. Seventeenth -century winding key, of German manufacture

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[17] Baillie, G. H. 1990. P. 28

[18] Basserman-Jordan, E. V. 1964. P. 196, 263

IV. EXAMINATION AND ANALYSIS:

i. Overview of Analytical Techniques

a. Ultraviolet-Induced Visible Fluorescence/False-Color Ultraviolet Images

Ultraviolet visible fluorescence has been used for many years for the non-invasive examination of materials and objects. Surfaces of interest are irradiated with ultraviolet radiation, a form of electromagnetic radiation more energetic than visible light. Ultraviolet radiation includes wavelengths of radiation from 10nm to 400nm. Certain molecules, when exposed to ultraviolet radiation, form excited states of higher energy. As these excited states lose energy, they emit longer wavelength radiation in the visible spectrum. This characteristic emission of visible light of different wavelengths allows for the identification of materials, particularly organic dyes and resins.[19]

Ultraviolet-induced visible fluorescence does not always identify materials with absolute certainty, however, it serves as a useful tool to identify materials of interest for further analysis. The creation of false-color ultraviolet photographic images can aid in this process by serving as a visual record of visible fluorescence. To create a false color image using digital photography, ultraviolet visible fluorescence information is substituted for the blue channel, blue for the green, and green for the red. The result is an image of whose blue tones record visible fluorescence under ultraviolet irradiation.

b. X-ray Radiography

X-ray radiography is a non-destructive technique of analysis that employs electromagnetic radiation of higher energy than ultraviolet radiation. Objects to be examined are exposed to x-rays of a given energy, and their transmission is recorded by film or sensitized plates placed opposite the X-ray tube. Materials of higher atomic weight transmit fewer X-rays and correspondingly appear white on the X-ray film. Materials of lower atomic weight transmit more X-rays, appearing dark on the X-ray film. X-ray radiography can be employed to distinguish among materials based upon their atomic weights and resulting densities. It may also be used to examine interior

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[19] Stuart, B. 2007. P. 75

structures that are not otherwise visible, and is commonly used to examine metal objects.[20] This information can be of use when deciding among treatment options.

c. Transmission Fourier Transform Infrared Spectroscopy

Fourier transform infrared spectroscopy is a technique of analysis that relies upon the characteristic absorption of energy by molecules exposed to a known wavelength of infrared radiation. Absorption, as indicated by changes in vibrational energy, is measured by the spectrometer, producing spectra with peaks indicative of particular chemical bonds or functional groups.[21] To aid in identifying unknown materials, these spectra may be compared to those of other known materials.

Fourier transform infrared spectroscopy is best suited to the identification of organic materials and other substances that absorb in the range of 2500nm to 10,000 nm. Materials of similar chemical composition produce very similar spectra, and are therefore sometimes difficult to distinguish.

This technique of analysis is nondestructive, however, given the limitations of the instrumentation, a microscopic sample of material must be removed from the object of interest. Care must be taken in removing and preparing the sample, as any contamination may result in inaccurate or misleading results.

d. X-Ray Fluorescence Spectroscopy

X-ray fluorescence spectroscopy is a noninvasive and nondestructive technique of analysis that is widely used in the conservation field. An object of interest is irradiated with X-rays. The individual atoms of the irradiated material then emit characteristic lower energy X-rays that are recorded by the spectrometer and displayed as spectra. The characteristic peaks of individual atoms allows for the identification of the elemental composition of the material, yielding insight into the composition and structure of the object.[22] This technique is largely qualitative, though it can yield semi-quantitative results when employed in a standardized fashion. Elements of lower molecular weight than sodium are not reliably identified, and some characteristic elemental peaks overlap, making identification difficult in some instances. The technique is not limited to the

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[20] Stuart, B. 2007. P. 78
[21] Stuart, B. 2007. P. 10
[22] Stuart, B. 2007. P.234

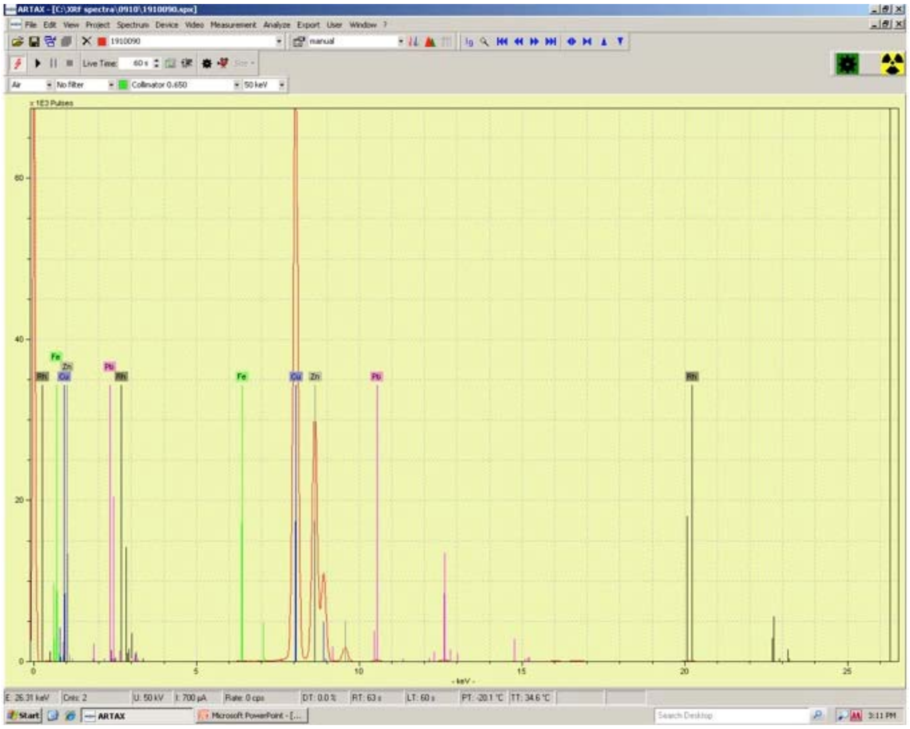
surfaces of objects, and will provide information about substrate material.

ii. Materials Analysis

a. Brass Base Metal

The substrate metal for all of the major components, including works, case, and ornamentation, is brass. Brass is a versatile metal alloy of zinc and copper which may be cast or worked and which can be plated with silver or gold. When polished, brass has an attractive yellow luster, which can imitate gold. Brass is also reasonably resistant to corrosion, especially in comparison to iron, which it replaced during the sixteenth and seventeenth centuries as the primary metal employed in the manufacture of clocks. These material and aesthetic characteristics lend this alloy to use in clocks.

X-ray fluorescence analysis was undertaken to confirm the materials used in the manufacture of this clock (see Appendix XIV i a: X-Ray Fluorescence). Though this type of analysis is not a quantitative technique, it is possible to compare relative readings of different elements recorded using the same instrumental settings. This allows for the relative comparison of alloy compositions, making it theoretically possible to identify different brass alloys.



ARTAX - [C:\XRf spectra\0910\1910090.spx]

1910090

manual

Live Time: 60 s

Air | No filter | Collimator 0.650 | 50 keV

E: 26.31 keV | Cnts: 2 | U: 50 kV | I: 700 µA | Rate: 0 cps | DT: 0.0 % | RT: 63 s | LT: 60 s | PT: -20.1 °C | TT: 34.6 °C

Figure 9, Composite XRF spectra for three sampled areas on brass base metal of alarm set dial, showing peaks for iron, copper, zinc, lead, and ruthenium (from the source tube)

XRF Analysis of Base Metals (Brass)

Sample_Area_&_Number	Fe	Cu	Zn	Ag	Au	Pb
Foot Base Metal (0910074)	t	M	M			t
Frame Base Metal (0910076)	t	M	M	t		t
Chapter Ring, Base Metal (0910078)		M	M			t
Bell Plate (0910086)	t	M	m	t		t
Alarm Dial Face, Base Metal (0910088)	t	M	M		t	t
Alarm Dial Engraving, Base Metal (0910090)	t	M	M			t
Case Base Metal, Underside (0910092)	t	M	M		m	t
Case Base Metal, Side (0910093)	t	M	M		m	t
Balance Cock, Base Metal (0910095)	t	M	m			t
Heel Cock Base Metal (0910097)	t	M	m			t
Alarm Hammer "Cock" Base Metal (0910099)	t	M	m			t

Note: M= major constituent, m= minor constituent, t= trace

Table 1, XRF analysis of brass components, showing major, minor, and trace elements

In all samples analyzed, copper was the major constituent of the alloy, which also included significant amounts of zinc. Traces of lead were present in all brass areas analyzed. Small amounts of lead are often added to brass to improve its ductility and lower melting temperature, both desirable qualities when working or casting. Traces of iron were also present in nearly all samples. This may be due to dirt accumulations, as the surfaces were not aggressive stripped and cleaned before analysis, or they may indicate the presence of trace iron impurities in the constituent metals of the alloy.

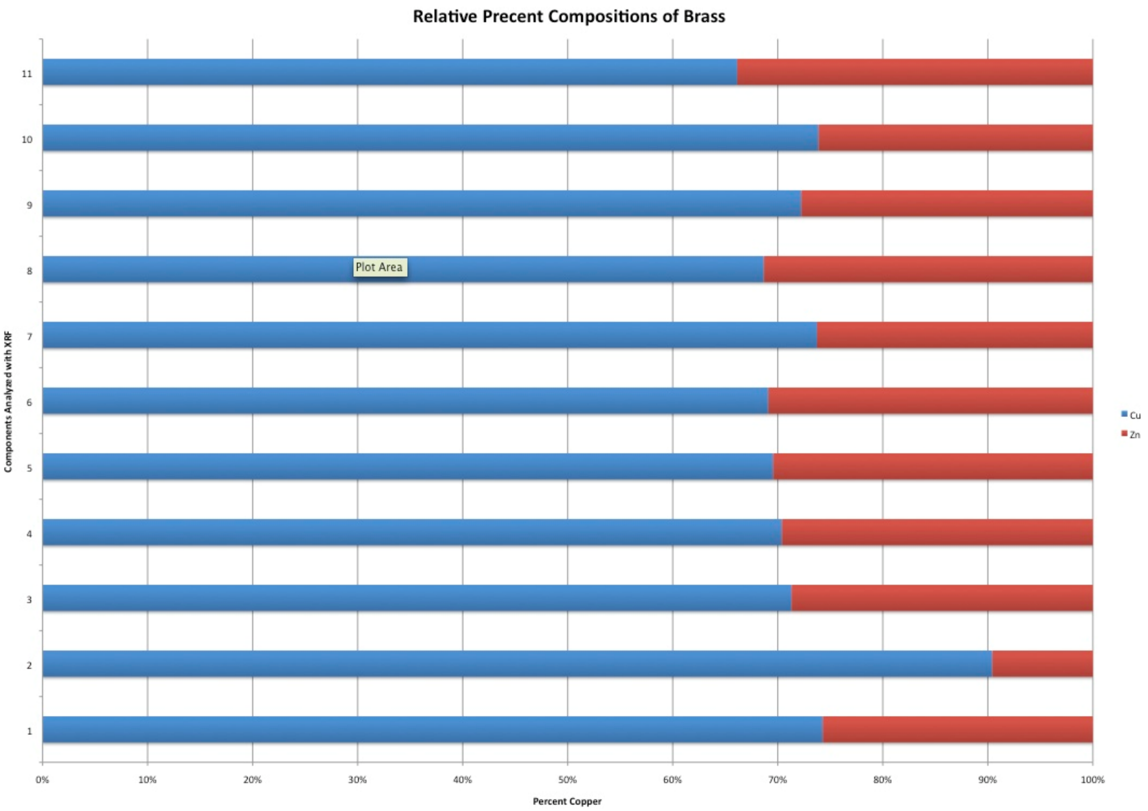


Figure 10, Chart showing relative percent compositions of brass analyzed with XRF. Note: components 1-11 correspond to sample numbers 0910074-0910099, as in above table

All of the brass alloys analyzed were extremely similar. Several areas of analysis of metal underlying or adjacent to gilding or silvering layers (specifically those on the frame, bell plate, and case; components 2, 4, and 7 in the above chart) contained silver or gold. The silver or gold was likely present as a thin surface layer that consequently attenuated the signals of copper, zinc, and other metals underneath. These XRF spectra exhibited lower peaks for zinc and copper because of this attenuation, but the proportions between the two appear elements appear consistent with the other brass spectra.

Tin was identified as a significant component of the bell metal (a high tin bronze), but was not identified anywhere else. This suggests that the brass employed in this clock was of a high quality, and not recycled from scrap, which would likely include bronze or other alloys.

The XRF data suggest that all of the brass components of the clock analyzed are very similar in composition. Brass has been used for millennia, so this information is not particularly relevant to dating of the clock, however, it does suggest that all components analyzed are either original to the clock or are replacements manufactured from similar materials.

b. Silvered Surfaces

Visual examination under magnification suggests that the silvered feet and frames were cast and silvered via the same or similar processes. Both sets of components appear to have been cast from single templates, then plated with silver. The chapter ring on the face of the clock retains evidence of silvering underneath losses to the fills in the Roman numerals. It is unclear whether the chapter ring was manufactured using these same techniques.

In order to better characterize the silvering layer on these components, X-ray fluorescence (XRF) was employed (see Appendix XIV i a: X-Ray Fluorescence).

XRF Analysis of Silvered Components

Sample_Area_&_Number	Fe	Cu	Zn	Ag	Hg	Pb
Foot Base Metal (0910074)	t	M	M			t
Foot Silver (0910075) 1	t	M	m	m	t	t
Foot Silver (0910075) 2	t	M	m	m	t	t
Foot Silver (0910075) 3	t	M	m	m	t	t
Frame Base Metal (0910076)	t	M	M	t		t
Frame Silver (0910077) 1		M	m	m	t	t
Frame Silver (0910077) 2		M	m	m	t	t
Frame Silver (0910077) 3		M	m	m	t	t
Chapter Ring, Base Metal (0910078)		M	M			t
Chapter Ring, Silver (0910079) 1	t	M	m	t		t
Chapter Ring, Silver (0910079) 2	t	M	m	t		t
Chapter Ring, Silver (0910079) 3	t	M	m	t		t

Note: M= major constituent, m= minor constituent, t= trace

Table 2, XRF analysis of silvered components, showing major, minor, and trace elements

Chapter ring silvering is approximately 30.405 microns thick

Frame silvering is approximately 4.64 microns thick

Foot silvering is approximately 59.11 microns thick[23]

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[23] For a complete explanation of theory and formula employed in this calculation, see: Hubbell, J. H., Seltzer, S. M. 1996. Tables of X-ray mass attenuation coefficients and mass energy-absorption coefficients. National Institute of Standards and Technology. Available online at: http://www.nist.gov/physlab/data/xraycoef/index.cfm

XRF analysis of the silvered surfaces of the foot and frame at 6 o'clock identified silver and trace amounts of mercury. Mercury was traditionally employed in a silvering process known as fire gilding/silvering, and is frequently found on sculptural elements or ornamentation. An amalgam of mercury and silver is brushed onto the surface to be silvered, and then the object is heated to drive off the mercury as vapor. The silver remains behind as a solid, metallic decorative layer. This process inevitably leaves some mercury trapped between the silver surface and the metal substrate. [24] It is very likely that the feet and frames of this clock were silvered in this manner, and that the mercury evident in XRF analysis is a remnant of this process.

XRF analysis of the remaining silvered surfaces underneath losses to the numeral fills in the chapter ring detected silver and very low levels of mercury, suggesting that it was silvered via the same amalgam process.

Calculation of the thickness of silver layers suggested that the extant chapter ring silvering is approximately 30 microns thick, silvering on the frame is approximately 5 microns thick, and that silvering on the foot is approximately 59 microns thick. This data may be inaccurately for several reasons. Firstly, it is calculated based on the average x-ray attenuation of the copper K- alpha peak (located at 8.046 enegery/KeV) of three spectra from silvered areas in comparison to single spectra from un-silvered areas. The 6'oclock frame lacked an area of completely exposed base metal, meaning that some silver was present in the initial reading. Consequently, the attenuation of the copper K-alpha peak is artificially lower, resulting in a low value for the calculated thickness of the silvering layer. It is therefore likely the silvering is in fact thicker than 5 microns.

c. Gilded Surfaces

The gilded surfaces on this clock include the wheel works, the case, the alarm set dial, and the cocks. The wheelworks and case are gilded not only for aesthetic reasons, but also to prevent corrosion of the brass substrate metal. XRF analysis was undertaken to better characterize the gilding on these several parts.

XRF analysis identified trace or minute quantities of mercury in all areas of gilding, suggesting that fire gilding was employed on all surfaces. This finding concurs with the analysis of the silvered surfaces. Fire gilding was the most common European

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[24] Bayley, J., Russel, A. 2008. P. 38

method of creating gold-plated surfaces before the introduction of electro-plating in the nineteenth century.[25]

Calculation of gilding thickness based on x-ray attenuation of the copper k-alpha peak identifies the gilded engraving on the alarm dial as approximately 40 microns thick and the gilded numeral face on the alarm dial as approximately 16.8 microns thick. The original gilding layer on the engraving is much thicker than the re-used and re-gilded alarm set face. The frugal use and re-use of materials appears to be characteristic of the later repairs and alterations made to this clock.

XRF Analysis of Alarm Dial

Sample_Area_&_Number	Fe	Cu	Zn	Au	Hg	Pb
Alarm Dial Face, Base Metal (0910088)	t	M	M	t		t
Alarm Dial Engraving, Gilding (0910089) 1		M	m	M	t	
Alarm Dial Engraving, Gilding (0910089) 2		M	m	M	t	
Alarm Dial Engraving, Gilding (0910089) 3		M	m	M	t	
Alarm Dial Engraving, Base Metal (0910090)	t	M	M			t
Alarm Dial Face, Gilding (0910091) 1	t	M	M	m		t
Alarm Dial Face, Gilding (0910091) 2	m	M	M	t		t
Alarm Dial Face, Gilding (0910091) 3	t	M	M	m		t

Note: M= major constituent, m= minor constituent, t= trace

Table 3, XRF analysis of alarm dial brass and gilding, showing major, minor, and trace element

Original gilding is approximately 39.94 microns thick
New gilding is approximately 16.8 microns thick[26]

The case gilding is calculated to be approximately 11 microns thick, though this number is likely lower than the actual thickness. As with the silvered frame, no exposed substrate metal was completely free of gold, resulting in artificially low attenuation and a correspondingly smaller calculated value for the thickness of the gilding layer. It is likely that the case gilding is somewhat thicker than this value.

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[25] Bayley, J., Russel, A. 2008. P. 38
[26] Hubbell, J. H., Seltzer, S. M. 1996.

XRF Analysis of Case

Sample_Area_&_Number	Fe	Cu	Zn	Au	Hg	Pb
Case Base Metal, Underside (0910092)	t	M	M	m		t
Case Base Metal, Side (0910093)	t	M	M	m		t
Case Gilding, Side (0910094) 1	t	M	m	M	m	t
Case Gilding, Side (0910094) 2	t	M	m	M	m	t
Case Gilding, Side (0910094) 3	t	M	m	M	t	t

Note: M= major constituent, m= minor constituent, t= trace

Table 4, XRF analysis of clock case brass and gilding, showing major, minor, and trace elements

Case gilding on sides is approximately 10.95 microns thick[27]

The calculated thicknesses of the gilding on the cocks are significantly lower, ranging from approximately 6 to 2.5 microns. The cocks, unlike the case, dial, and wheel works, are purely decorative; their gilding does not have to withstand constant wear. Furthermore, these components were likely manufactured separately and purchased by the clockmaker to include in the finished clock. It appears that the craftsmen responsible for the cocks did not impart thick gilding layers where they were not needed.

XRF Analysis of Cocks

Sample_Area_&_Number	Fe	Cu	Zn	Au	Hg	Pb
Balance Cock, Base Metal (0910095)	t	M	m			t
Balance Cock Gilding (0910096) 1		M	m	M	m	
Balance Cock Gilding (0910096) 2		M	m	M	m	
Balance Cock Gilding (0910096) 3		M	m	M	m	
Heel Cock Base Metal (0910097)	t	M	m			t
Heel Cock Gilding (0910098) 1		M	m	M	m	
Heel Cock Gilding (0910098) 2		m	m	M	m	
Heel Cock Gilding (0910098) 3		M	m	M	m	
Alarm Hammer “Cock” Base Metal (0910099)	t	M	m			t
Alarm Hammer “Cock” Gilding (0910100) 1	t	M	m	m	t	
Alarm Hammer “Cock” Gilding (0910100) 2	t	M	m	M	t	
Alarm Hammer “Cock” Gilding (0910100) 3	t	M	m	M	t	

Note: M= major constituent, m= minor constituent, t= trace

Table 5, XRF analysis of cocks’ brass and gilding, showing major, minor, and trace elements

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[27] Hubbell, J. H., Seltzer, S. M. 1996.

Alarm cock gilding is approximately 5.861 microns thick
Balance cock gilding is approximately 4.474 microns thick
Heel cock gilding is approximately 2.511 microns thick[28]

d. Glass

Initial examination of the glass in the six side windows of the clock suggested that at least two types of glass were present. Examination under visible light identified the glass at 2 o'clock and 4 o'clock as slightly thicker and possessing a faint blue/green tint. All other glass windows appeared thinner and colorless.

Additional examination under long wave and short wave ultraviolet radiation (UVA and UVC) suggested that perhaps three or more types of glass were present. The glass at 4 o'clock appeared to fluoresce very faintly under UVA, while none of the other glass did so. The glass at 2 o'clock did not fluoresce under UVC, whereas all of the other glass did fluoresce to varying degrees.

Visible and ultraviolet examination suggest that the glass windows at 2 and 4 o'clock may be two distinct types of glass, and all other glass windows may be largely similar in composition.

After the glass windows were removed from the clock and cleaned, visible and ultraviolet examination were again performed. With the glass windows removed from their frames, it was possible to better judge the thickness, color, and method of shaping for each window. The glass windows at 2 and 4 o'clock exhibit conchoidal fractures around their perimeters, which suggests that they were been grozed (a process of controlled, small breaks) to achieve their final oval shape. All other glass windows have clean, smoothed edges, and appear to have been cut to their final shape.

To clarify the significance of the ultraviolet data, each of the glass samples was subjected to X-ray fluorescence analysis (see Appendix XIV i a: X-Ray Fluorescence Data).

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[28] Hubbell, J. H., Seltzer, S. M. 1996.

XRF Analysis of Glass Windows

Sample_Area_&_Number	Si	K	Ca	Mn	Fe	Zn	As	Sr
Glass, 12 O'clock (0910080)	M	t	M		t		m	
Glass, 2 O'clock (0910081)	M	M	m	t	m			
Glass, 4 O'clock (0910082)	M	M	M	t	m			t
Glass, 6 O'clock (0910083)	M	m	M		t		M	
Glass, 8 O'clock (0910084)	M	m	M		t	m	t	
Glass, 10 O'clock (0910085)	M	m	M		t		M	

Note: M= major constituent, m= minor constituent, t= trace

Table 6, XRF analysis of glass windows, showing major, minor, and trace elements

The glass windows at 2 and 4 o'clock appear very similar in elemental composition. Potassium was identified as the primary flux agent, with substantial amounts of calcium likely present as a network stabilizer. Small but significant amounts of iron and manganese were found to be present in both glass windows. Iron is present as an impurity in most glass, imparting a green/brown color. Manganese has traditionally been used as a "clarifying agent" to counteract the color of iron by imparting a pink/purple color. This ancient method of producing transparent glass often results in a faint blue/green color, which is observed on both of these examples.[29] The presence of trace amounts of a metal such as strontium in the glass at 4 o'clock may account for its faint fluorescence under UVA and UVC.[30]

The glass windows at 12, 6, 8, and 10 o'clock have little potassium, but significant amounts of calcium present. Only trace amounts of iron are present in each of these glass windows. All contain arsenic in varying amounts, which has been used commercially to raise the refractive index of glass, in a manner similar to lead,[31] thus increasing the clarity. Nevertheless, all of these window glasses show substantial similarities in elemental composition, which supports conclusions drawn from visual and ultraviolet examination. These four glass windows appear to be of later manufacture than the glass windows at 2 and 4 o'clock.

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[29] Bamford, C. R. 1977. P. 142

[30] Bamford, C. R. 1977. P. 173

[31] Bamford, C. R. 1977. P. 142

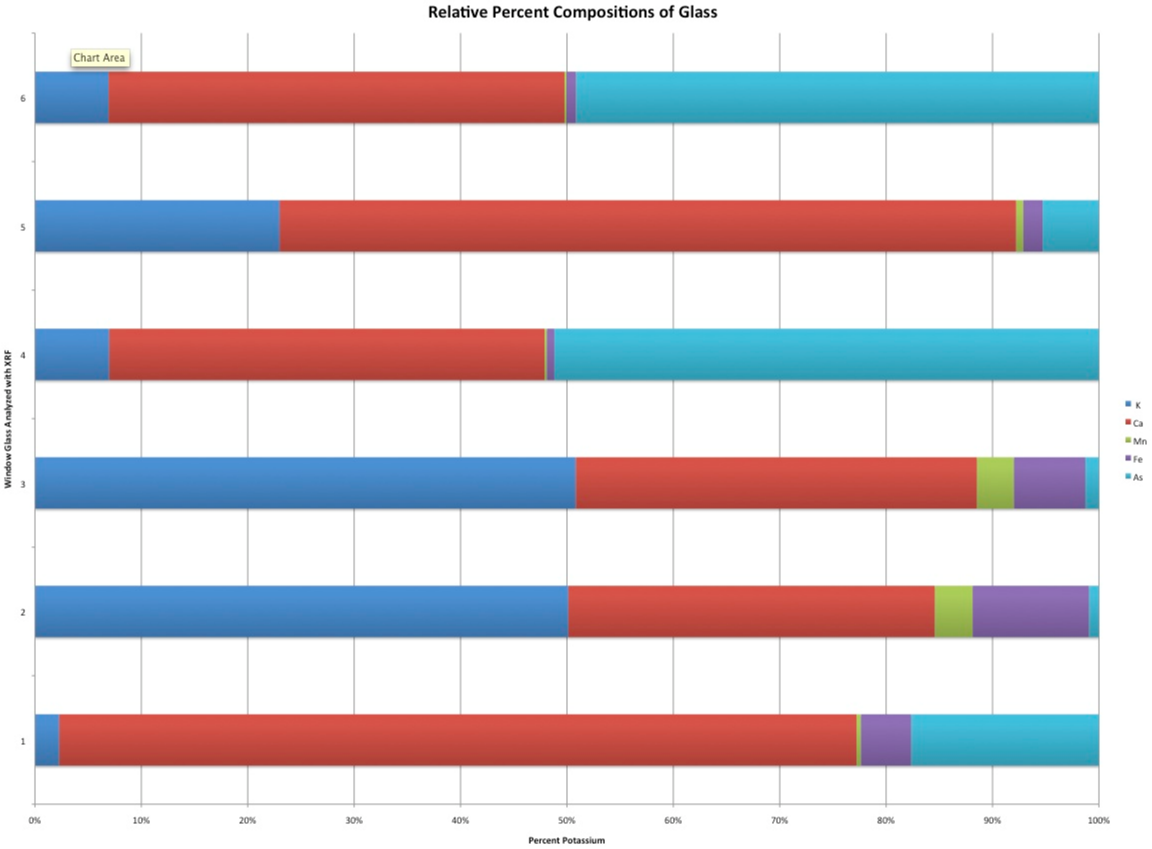

Figure 11, chart showing relative percent composition of glass windows analyzed with XRF. Note: components 1-6 correspond to window glasses 12 o'clock to 10 o'clock.

Interestingly, the XRF spectrum for the window glass at 8 o'clock exhibits a strong peak for zinc, which is not typically employed in the manufacture of glass. This may indicate a surface deposit of zinc-containing material, or may indicate the presence of a complex glass corrosion product.

Scott notes that dezincification is favored in stagnant or slow moving environments, and is most common in environments rich in chloride ions, though may be facilitated by highly alkaline environments.[32] The area behind the silver frames would certainly qualify as stagnant, and chlorides may be present as residues from silver polishes composed of "common salt, cream of tartar, and cold water," which were traditionally employed in the restoration of clocks,[33] though no chlorides were detected using Odegaard's test for chloride ions using sulfuric acid.[34] More pertinently, a highly

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[32] Scott, D. A. 2002. P. 27
[33] Wills, P. B. 1995. P. 50
[34] Odegaard, N. 2005. P 104

alkaline environment can result from the leaching of calcium and potassium ions during glass corrosion. It is possible that corrosion of this glass facilitated the dezincification of the brass with which it was in contact, in turn forming a complex glass corrosion product.

Microscopic examination of the glass surface, however, does not show the microscopic network of fissures that typifies glass corrosion. Instead, the surface appears to be covered in what resemble drying spots. This suggests that the zinc peak observed with XRF may in fact be due to a material applied to the surface purposefully or accidentally.

The zinc-containing material on this window was not identified conclusively, but it was not deemed essential to the treatment of the clock as a whole.

e. Fills in Numerals

The material used to fill the engraved Roman numerals on the chapter ring of the clock appears dark, cracked, and is brittle when probed. The fill material fluoresces in the visible range under long wave ultraviolet radiation, suggesting that it is organic in nature. To better characterize this material, transmission Fourier Transform Infrared Microscopy (FTIR) was undertaken (See Appendix XIV i b: FTIR).

Figure 12, False color UVA image showing visible fluorescence of fill material

Analysis with FTIR suggests that the material used to fill the numerals is a softwood resin or pitch, though the similarity to other natural resins, such as that of the lac insect, makes it difficult to identify the material with absolute certainty. Pine pitch or rosin is a traditional material that has historically been widely used as a fill material.[35] Pitch or rosin has been widely available for millennia, and may have been chosen for this application because it is easily applied as a fill, and its dark color would have contrasted with the original bright silver of the chapter ring, enhancing the legibility of the numbers.

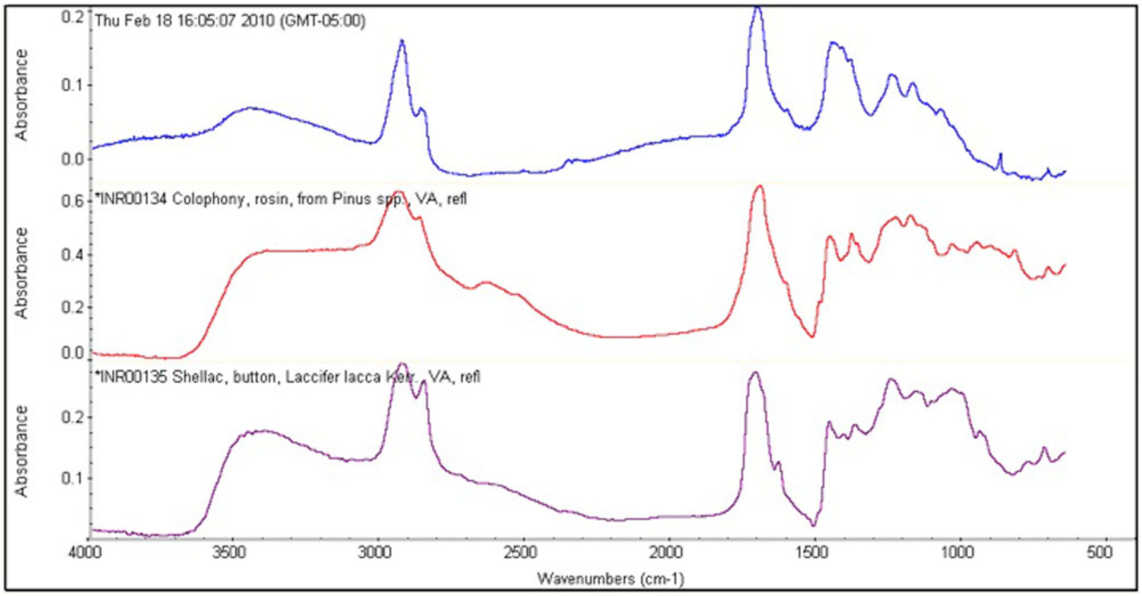

Figure 13, FTIR spectra for unknown fill material (top, blue), known sample of rosin (center, red), and known sample of shellac (bottom, purple).

f. Solders

Solder is present on the bell bridge and the alarm set dial. It appears to have been used as a repair to the bell bridge, and as an attachment for the mounts on the alarm set dial that anchor it to the hour hand arbor. Both solders appear dull grey.

In an effort to better characterize these solders, analysis using x-ray fluorescence was undertaken. As noted above, XRF is not a surface technique, and will identify underlying substances. The relatively thin applications of solder make it difficult to conclusively identify their elemental compositions, as peaks from the underlying metals will also appear in spectra taken in areas of soldering. The solder on the bell bridge is applied over an iron bar on a brass plate. It is therefore not surprising that iron and copper are present in the spectrum for this solder. The solder on the alarm set dial is very thin and applied over gilded brass. The spectrum for this solder accordingly shows peaks for gold and copper.

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[35] Thornton, J. 1998

XRF Analysis of Solders

Sample_Area_&_Number	Fe	Cu	Zn	Sn	Au	Pb
Bell Bridge Solder (0910101)	t	t	m	m		M
Alarm Set Dial Solder (0910102)		M	m	t	M	M

Note: M= major constituent, m= minor constituent, t= trace

Table 7, XRF analysis of solders, showing major, minor, and trace elements

The spectra for these two solders do contain relevant information, however. Major peaks for lead and small but significant amounts of tin identify the solder as a lead-tin solder, which has been in common use since antiquity. Elevated levels of zinc suggest that the flux used for soldering may be zinc chloride, a commonly used historical flux.

Though this information does not assist in dating the repairs or differentiating among the solders, it does confirm that the repairs are likely historical in nature and not contemporary. Most modern solders no longer employ lead, and other fluxes have become common.

g. Oil Residue:

Oxidized oil residue is visible on the base plate and bell plate under far ultraviolet (UVC) irradiation. Identifying the type of oil is of interest because it may indicative of the last time the clock was cleaned and oiled.

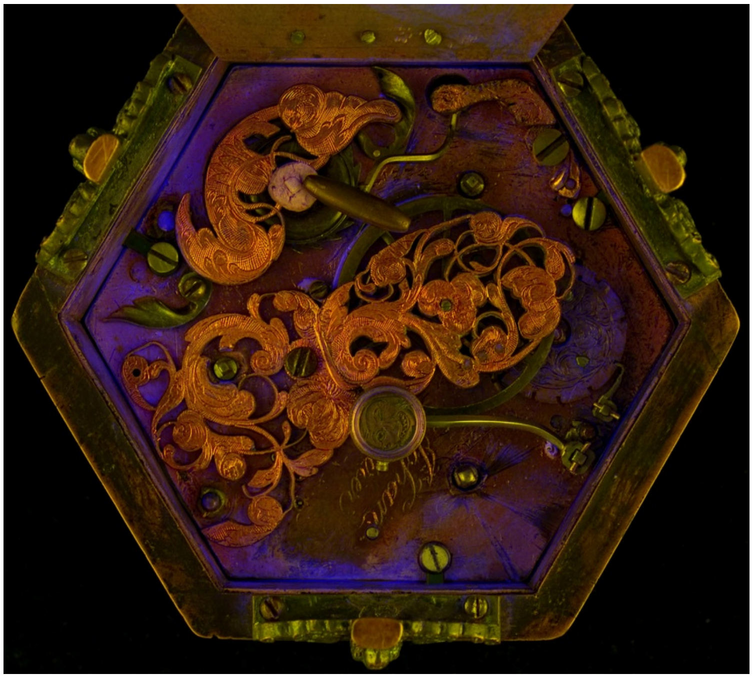

Figure 14, False color, far ultraviolet (UVC) induced visible fluorescence image, showing oil residue on base plate, in purple

Fourier-Transform Infrared Spectroscopy was used to analyze a sample of this material. Solvent testing was applied to the residue on the base plate, and it was found that the petroleum benzine was an appropriate solvent. Residue removed with petroleum benzine on a swab was transferred to a glass slide, and left for several minutes to permit the solvent to evaporate. Analysis of this residue identified traces of sperm oil and possibly linseed oil. Modern petroleum-based oil lubricants do not appear to be present. Conclusive identification for all peaks was not realized. It may be that the residue is a combination of oils, complicating analysis. However, it should also be noted that the sample analyzed may have been contaminated with cotton fiber, producing extraneous peaks.

The identification of sperm oil, a product of whaling, is not surprising. This non-gumming oil has been used for centuries to oil clocks. Linseed oil, however, is unusual in clocks and mechanical movements, as it tends to oxidize and become sticky.

Analysis using FTIR did not conclusively identify the lubricant residue, though it appears that modern oils are not present. Sperm oil remains prized for its lubricating properties in clocks, and was used throughout the twentieth century. It is therefore unclear when this clock was last disassembled, cleaned, and oiled.

h. Residue on Case/Frames:

A hazy white residue is present on the exterior of the clock case, in the area underneath the frames, and appears to correspond closely to the edges of the frames. This residue is insoluble in water, but soluble in acetone. No white residue is observed on the reverse of the silvered frames, however, a very thick and discolored surface layer is present on the silvered surfaces. This discolored layer is also partially soluble in acetone.

Figure 15, Case of the Buffalo Scheirer, 4 o'clock side, showing white residue, at top left

To better characterize the residue and identify any potential coating on the silvered surfaces, FTIR analysis was performed on a sample of the hazy white residue from the exterior of the clock case at 4 o'clock. The spectrum for the sample was an extremely close match to white shellac, a form of processed shellac from which nearly all of the red lac dye has been removed. This shellac was likely applied as a protective coating to the silvered frames after they were polished at some time in the past two hundred years. Shellac was not in common use in Europe in the seventeenth century, and the coating is therefore unlikely to be original.

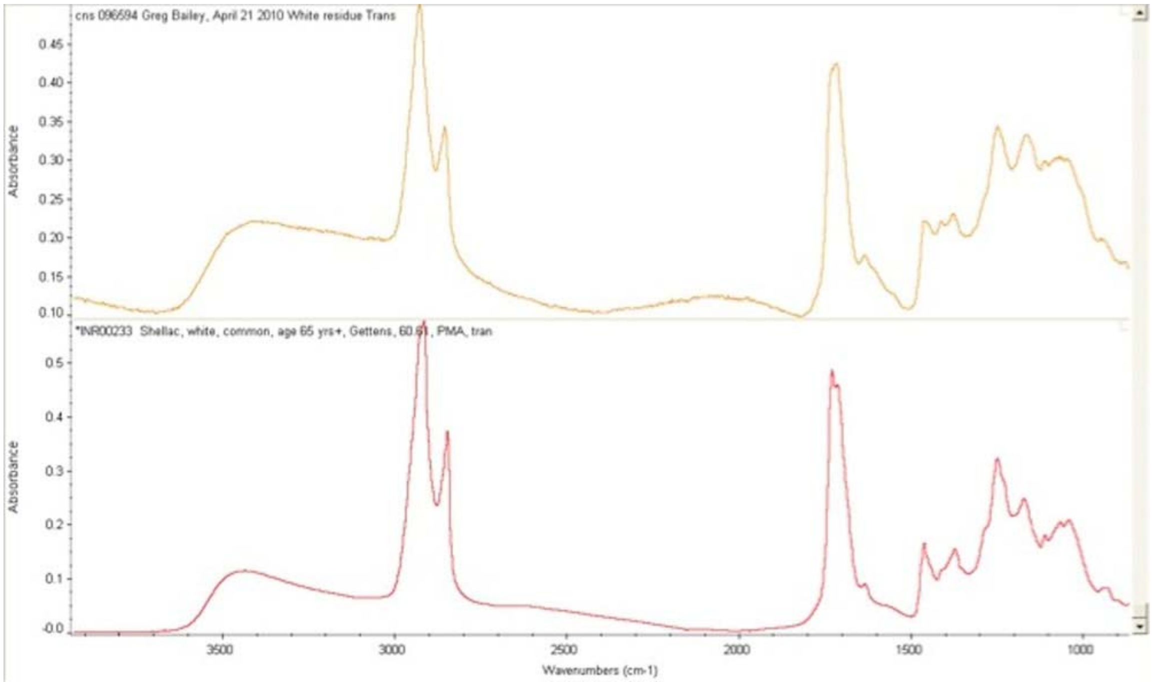

Figure 16, FTIR spectra for unknown residue (top, yellow), and known sample of aged white shellac (bottom, red)

This finding may explain why FTIR analysis of fill material from the Roman numerals suggested the presence of shellac. The hour chapter ring was originally silvered, and may have been polished and shellacked at the same time as the other silvered elements. Though the silver and the shellac have been removed, it is possible that traces of shellac remain in the fill material.

Analysis with FTIR clearly identified the presence of a deteriorated protective coating. Accordingly, appropriate solvents were used during cleaning and polishing to facilitate the removal of the degraded shellac.

i. Springs

The three drive springs employed in this clock are all made of steel. Hand-made, tempered steel springs are typical of seventeenth-century clocks, though many originals were replaced with more reliable springs of later manufacture. X-ray radiography before treatment showed that each of the springs was intact and all were wound to greater or lesser degrees. The springs were not removed from their barrels, so further characterization was not undertaken. It was not established if the springs were original to the clock.

It is not advisable to maintain historic steel springs under constant tension for prolonged periods of time, as stress cracking may result in failure. Information from X-ray radiography allowed for each of the springs to be let down safely, reducing tension and the risk of cracking.

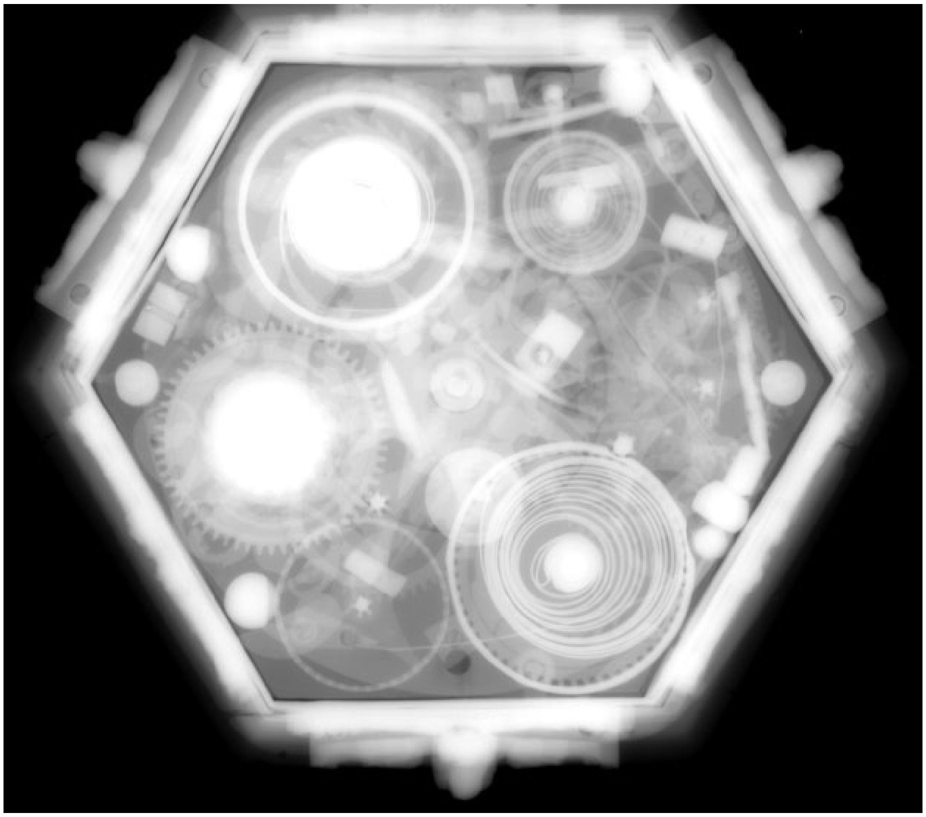

Figure 17, X-radiograph of clock works, showing springs under tension.

Hour train spring is at top left, alarm strike spring is at top right, hour strike spring is at bottom right.

iii. Conclusions

Visual, ultraviolet visible fluorescence, X-ray fluorescence, and X-radiographic examination all assisted in identifying structures and materials of interest. FTIR was utilized to identify the fills in the numerals as likely consisting of pitch or rosin, and the oil lubricant residue as sperm oil and possibly linseed oil. Shellac coatings on silvered surfaces were also identified using FTIR. X-ray fluorescence and X-ray attenuation were employed to analyze the structural metals and metallic surface layers employed. Brass was identified as the primary substrate metal. Silvered and gilded areas were likely produced via amalgam or fire gilding/silvering, an important historical technique employing mercury. The solders employed in repairs and alterations appear to be lead-tin alloys with zinc fluxes. Two types of glass, iron/manganese and arsenical glass, were identified with XRF, confirming UV examination. X-ray radiography showed that the steel springs were intact and partially wound before treatment.

V. TECHNOLOGICAL AND STYLISTIC CONSIDERATIONS

i. Overview

Though this clock lacks a secure provenance, it is possible to provide an approximate date of manufacture based on the technology employed, the materials used, and the style of ornamentation. The seventeenth century was particularly fruitful in respect to the development of the clockmaker's craft, and a number of important innovations serve as historical milestones. Technical examination of this clock suggests that is dates from sometime around 1660-1680. As this proposed date has a strong influence on the significance of this clock, a further discussion follows.

ii. Form and External Appearance

The overall form of this clock is known to have been fairly common in the sixteenth and seventeenth centuries, with a number of examples still produced in the early eighteenth. Hexagonal gilt-brass clocks with side windows, positioned on feet with bells suspended beneath the case are usually associated with German clock makers during this time period, such as those of Wolf Heinrich Gauer of Konigsburg (c. 1660,[36] see Figure 15; and c. 1675,[37] see Figure 16) and Wilhalm Köberlin (c. 1725,[38] see figure 15).

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[36] Baillie, G. H. 1956. List of old clock and watch makers.

[37] Christie's. Sale 7764, Lot 232. 2009.

Lot Description

"A PRUSSIAN GILT-BRASS GRANDE SONNERIE HEXAGONAL TABLE CLOCK WITH DOUBLE HOUR STRIKE WOLF HEINRICH GAUER, KÖNIGSBERG. THIRD QUARTER 17TH CENTURY AND LATER CASE: framed glass side panels, on winged lion feet to all corners, hinged base plate with turn catch and set with hour and quarter bells; regilded DIAL: engraved winged cherub spandrels, replaced silvered chapter ring with foliate engraved centre, replaced blued steel hands MOVEMENT: with six ringed tapering pillars, single chain fusee for the going and three engraved fixed barrels for the strike trains, later verge and balance escapement with replaced pierced and engraved balance cock, signed 'Wolf Heinrich Gauer Königsberg', pierced and engraved cock to blued steel set up ratchet, the hammers with engraved zoomorphic heads; restorations, adaptations to trains and under dial work 4 in. (10 cm.) high; 6½ in. (16.5 cm.) wide **Lot Notes**

Wolf Heinrïch Gauer is recorded working in Königsberg, Germany *circa* 1675. A quarter striking hexagonal table clock, by the Danzig maker Johann Eichstedt, in a case of closely related design to the present clock and supported on similar lion feet sold, Christie's Amsterdam, *The P.C. Spaans Collection of Important Clocks*, 19 December 2007, lot 411."

The hexagonal form was very popular not only for small table clocks such as these, but also for a variety of other types of clocks. The widespread use of the hexagon

Figure 18, Left: Baillie, G. H. ed. 1956. P. 28. Hexagonal table clock by W. H. Gauer of Konigsburg, circa 1660 (C. A. Ilbert Collection) Right: Basserman-Jordan, E. V. 1964. P. 134. Miniature hexagonal travel clock, signed Wilhalm Koberlin, with original key, circa 1725

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[38] Britten's 9th, "Koberle/Koberlin/Coeberle, Wilhelm/Wilhelmus (1680-1715); Eichstatt" This maker is known to have made traveling hexagonal clocks with striking mechanisms in gilt brass cases, with pierced and engraved ornamentation. Note: Eichstaett is located between Nurnberg and Augsburg.

for the shape of early clocks likely relates to the historical relationship between timekeeping and astronomy. Early mechanical models associated with the astrolabe and the motions of the planets gave rise to the development of mechanical timepieces in the thirteenth century.[39] Astronomical models often made use of the hexagon, as the shape made direct reference to the six planets known in the ancient and medieval worlds. This association between the six celestial bodies and the passage of time persisted in early clocks and watches.

In at least one important instance, the production of hexagonal clocks was mandatory. The guild requirements for the certification of master clockmakers in Augsburg, one of the most important historic clock making centers, specifically require the production of hexagonal clocks. The masterpieces required of potential masters between 1577 and 1732 included, "a hexagonal clock…strikes hours and quarters, also alarm, and shows the astrolabe, the length of the day, and the planets."[40] Interestingly, the same list of masterpieces required production of, "a clock of the sort called 'mirror' which shall show all things and strike."[41] The use of the word "mirror" ("Spiegel" in the original) is somewhat ambiguous, as almost no early clocks with mirrors are known to survive. "A clock of the sort called 'mirror'" may instead refer to clocks with windows, as this was an extremely popular form and a great many are known to exist. The basic hexagonal form with side windows that can be observed in the Scheirer clock may be a reflection of the taste for "masterpiece" clocks that resembled those made by masters in the clock making centers of Augsburg and Nurnberg between the late sixteenth and early eighteenth centuries.

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[39] Haber, F. C. 1980. P. 10-11

[40] Groiss, E. 1980. P. 67

[41] Groiss, E. 1980. P. 67

Figure 19, Christie's, Sale 7764, Lot 232. 2009. Clock attributed to Wolf Heinrich Gauer circa 1650-1675.

These hexagonal window clocks typically had silvered dials[42] and after 1650, almost always had silvered feet and mounts on their sides.[43] Clocks with horizontal faces manufactured before the seventeenth century generally did not have feet, as they lacked striking mechanisms. The appearance of feet beneath the cases of table clocks such as these was occasioned by the placement of the bell and striking mechanism under the base plate of the works, rather than its suspension over the face of the clock in a dome or tower. These clocks, called miniature tower or tabernacle clocks, declined in popularity during the first half of the seventeenth century, when smaller clocks with horizontal faces began to predominate.[44] The structure and use of silver embellishment on the Buffalo Scheirer clock place it securely within the seventeenth century.

iii. Decoration of the Movement

The predominance of engraving as a primary means of ornamenting the case and works is another important characteristic to consider. Extant records of clockmakers from Augsburg in the sixteenth and seventeenth centuries record that the single largest

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[42] Bassermann-Jordan, E. V. 1964. P. 193

[43] Himmelheber, G. 1980. P. 122. Also, Baille, G. H. 1990. P.28

[44] Baille, G. H. 1990. P.30

expense in the manufacture of a clock, apart from the master's fee, was the cost of engraving.[45] At that time, it was common practice for engraving and gilding to be performed by an independent or affiliated craftsman, and not by the clockmaker himself.[46] The clock under consideration is engraved elaborately on the prominent surfaces, including the barrel of the striking spring, the stop plate of the striking mechanism, the count wheel, and the surfaces of the original face.

All of the hexagonal clocks discussed here have engraved center scenes, a common feature of table clocks. The Scheirer clock appears to exhibit a somewhat unusual scene, however. Whereas almost all other table clocks present landscapes or floral motifs, this clock appears to show a sleeping child at the foot of a mausoleum, with a church steeple rising in the background.

Figure 20, Alarm set dial Left: Original engraving on underside Right: Present appearance of set dial

Though this scene may appear unusual by comparison, it is not without precedent. Sleep, death, and the eternal life of the church were commonly interpreted as allegories of time, and religiously inflected memento mori were routinely incorporated into public clocks as early as the thirteenth century.[47] The existence of a central scene on the original clock is typical of the seventeenth century, but its subject seems to refer back to an older visual tradition associated with the marking of time. The variation in subject matter of engravings on clocks by a single maker may be explained in part by the caprices of an independent engraver or the differing work of several engravers.

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[45] Groiss, E. 1980. P. 68
[46] Bedini, S. A. 1980. P. 20
[47] Haber, F. C. 1980. P. 9

The cocks that secure and protect the foliots and pawls of table clocks were also manufactured independently, and purchased by the clockmaker to include in the finished timepiece.[48] Pierced and gilded cocks became increasingly elaborate during the seventeenth century, with arabesques of “strawberries, Dutch flower designs, narcissi, tulips, and anemones”[49] predominating. Cocks of the mid seventeenth century were oval in shape and large enough to cover and protect the foliot.[50] Toward the close of the century, it was common for the heel cock covering the pawl to be ornamented on either side with symmetrical scrolls or acanthus leaves.[51] This clock appears to retain the original cocks, as no extra holes are present which might correspond to their removal or replacement. The cocks exhibit the floral motifs of tulips and anemones common in the second half of the seventeenth century and known from published books of models by Jacques Vauquer and others.[52] Additionally, the style of the heel cock, with its symmetrical blued steel acanthus leaves, suggests that the clock dates from sometime during the second half of the seventeenth century.

Figure 21, Balance cock of the Buffalo Scheirer

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[48] Bassermann-Jordan, E. V. 1964. P. 202
[49] Bassermann-Jordan, E. V. 1964. P. 199
[50] Cardinal, C. 1989. P. 155
[51] Cardinal, C. 1989. P. 167
[52] Cardinal, C. 1989. P. 134

Additionally, the vogue for grotesque human or animal heads engraved on striking hammers ended sometime near the close of the seventeenth century.[53] The Gauer and Koberlin clocks described above, as well as the other known examples of Scheirer's work all include anthropomorphic or zoomorphic striking hammers. The hour strike hammer of the Buffalo Scheirer discussed here is ornamented with a grotesque face, further suggesting that the movement was created and decorated sometime during the second half of the seventeenth century.

iv. Materials and Mechanisms Employed in the Movement

Note: For a more comprehensive review of the movements in this clock, see Appendix i: Examination Report

The motive power for the three different trains of wheelworks in this clock is supplied by wound steel springs. Springs are known to have been in use in small clocks of this sort since sometime in the middle of the fifteenth century,[54] though there is some debate about whether the first springs were made of steel or brass.[55] The use of steel springs in the Buffalo clock is not necessarily indicative of a particular time period, as they are still employed in handmade watches today.

Of greater interest is the method of controlling the spring drive. A wound spring initially supplies more power, as a greater length of coiled spring is acting upon the drive train. As the spring winds down, progressively less force is applied to the movement. This tendency of springs is problematic when applied to timekeeping, as it means that a clock will initially run fast, then gradually slow to a stop, never quite keeping accurate time. Anyone who has played with simple clockwork toys will recognize that an unregulated spring will not supply consistent force over a given period of time.

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[53] Baillie, G. H. 1990. P. 28

[54] Cardinal, C. 1989. P. 14

[55] Baillie, G. H. 1956. P. 15

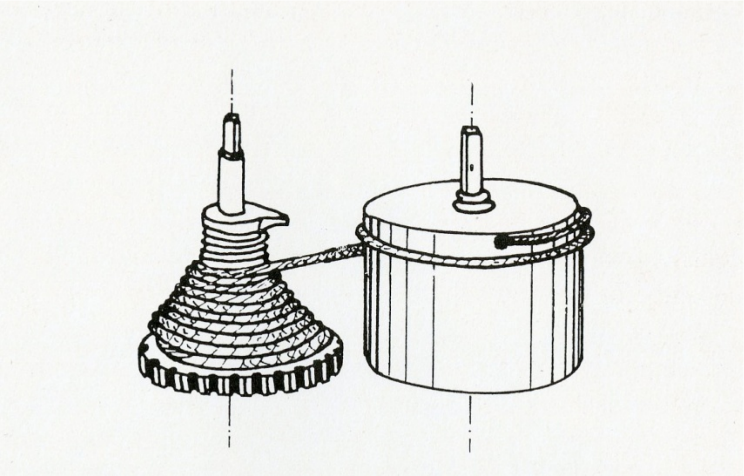

Figure 22, Cardinal, C. 1989, P. 71. Barrel and fusee mechanism

The problem of translating a spring into a mechanism of consistent drive was solved by employing a fusee, or spiral (from the French *fusée*, “a spindle of yarn”; from the Latin, *fusus*, “spindle”).[56] A cord wound around the spiral fusee is gradually drawn around the fixed diameter of the barrel as the drive spring unwinds. The cord initially turns the smallest portion of the spiral fusee, when the spring is driving the barrel the fastest. When the spring is driving the barrel the slowest, the cord turns the largest portion of the spiral fusee. By carefully relating the conical shape of the fusee to the diameter of the barrel and the length of the spring, it is possible to maintain a relatively consistent driving force around the central axis of the fusee. The changing forces at work in the barrel and fussee mechanism are analogous to those in a system of levers. A force of twice as much applied to a lever (or radius) half as short, is equal to force of half as much applied to a lever (or radius) twice as long.[57]

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[56] Merriam-Webster

[57] For a more complete explanation of the mathematics involved in the development and manufacture of fusee mechanisms, see Honig, P. S. 1980. *History and Mathematical Analysis of the Fusee*.

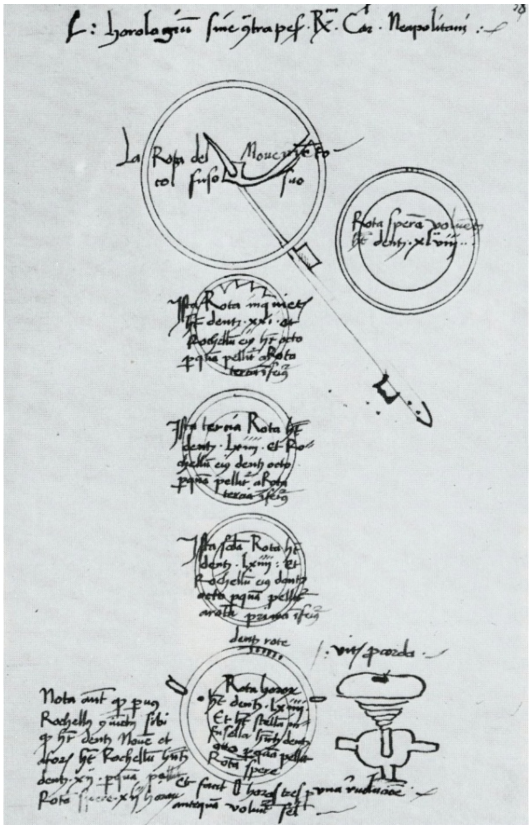

Figure 23, Smith, A., ed. 1996. P. 275. Page from the Almanus manuscript, 2nd cod., 209 folio 38.

Schematic diagram of a spring driven clock owned by the bishop of Naples, about 1480.

The employment of a fusee is standard in virtually all spring driven timepieces manufactured before the early eighteenth century. The first recorded instances of fusees coincide with the first records of spring drives, sometime near the middle of the fifteenth century.[58] These early fusees were carved from wood and employed gut cords.[59] About the middle of the sixteenth century, however, the wooden fusee was replaced with the cut brass fusee and the gut cord with the steel chain, such as are seen in the Buffalo Scheirer.[60] Between 1600 and about 1650, German clock works, which had previously been made of iron or steel, came to be made primarily of brass, usually gilded to prevent corrosion.[61] Brass plates were also in general use by the middle of the seventeenth century, and steel screws had come to replace pins for most of the smaller points of

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[58] Cardinal, C. 1989. P. 14.
[59] Honig, P. S. 1980. P. 114-115
[60] Cardinal, C. 1989. P. 69
[61] Baillie, G. H. 1956. P. 64

attachment, excluding the plates and pillars.[62] The Buffalo Scheirer employs all of these mid-seventeenth century improvements. The inclusion of these materials and technological advances strongly suggests that the Scheirer clock was made sometime after 1650.

This clock employs a verge escapement, consisting of two parts. A wheel with angled teeth, set perpendicular to the plane of all the other wheels, is driven by the train of gears running back to the fusee. This wheel is known as the crown wheel because of its distinctive shape. The crown wheel is governed by the verge, which allows the wheel to advance one tooth at a time. The verge is a rotating brass arbor, or axis, parallel to the crown wheel, with two paddles known as flags, protruding at right angles. When one flag engages with the teeth on the upper part of the crown wheel, the lower flag rotates away from the wheel. When the upper flag swings free of the wheel’s teeth, the lower flag engages, thereby allowing only one tooth to advance per oscillation of the verge. The periodic clicking sound of this escapement gives rise to the “tick-tick” sound that is typical of mechanical clocks.

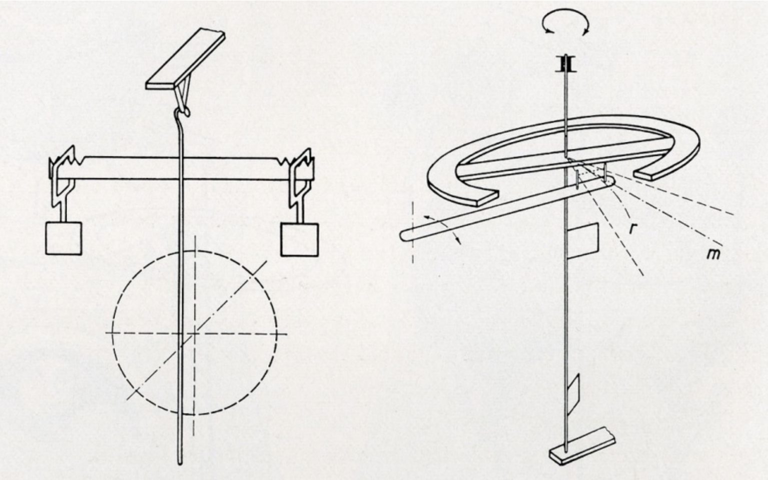

Figure 24, Basserman-Jordan, E. V. 1964. P. 190.

Foliot balances. Left: foliot governed by weights. Right: Foliot governed by pins or “hog bristles.”

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[62] Cardinal, C. 1989. P. 69

During the first three quarters of the seventeenth century, foliots, or small weighted balances, were used to govern the oscillations of the verge.[63] Foliots, which could be straight bars or small wheels, were mounted at the top of the verge arbor, and acted much like the weight on a spindle in making sure that the verge swung swiftly and consistently in and out of engagement with the teeth of the crown wheel. The length of their oscillation, and thus the speed of the escapement, could be regulated by fixing pins or "bristles" to limit their movement, or else by repositioning small weights. This type of mechanism, also known as "recoil" because it must come to a full stop at every oscillation, produced significant stress on the parts of the escapement and was only precise if very skillfully machined and mounted.

A later development, known as the spring-regulated balance wheel, introduced by Christiaan Huygens in 1675, greatly improved the accuracy of the verge escapement.[64] In place of a foliot at the top of the verge arbor, a symmetrical disk or wheel is mounted. A small spring, with one end attached to the arbor and the other to a stationary point, is wound by each advancing tooth of the crown wheel. As one flag of the verge slips out of engagement, the unwinding of the spring propels the other flag to engage, starting the process over gain. The combination of spring and balance wheel ensures that the verge will oscillate much more precisely, while also reducing stress and inertia acting on the clock's drive mechanism.

This clock shows aspects of both of these escapement regulation methods. Since the likely date of manufacture of this clock is very near 1675, it is possible that the balance is either original or that it is an alteration made soon after production. Further discussion is included below in Section VI: Previous Alterations and Repairs.

For the striking of the hours, the Buffalo clock employs a count wheel or locking-plate mechanism. This striking mechanism was in common use from the Gothic era to the end of the seventeenth century, when it was largely replaced by the rack and snail mechanism, invented by English clockmakers.[65] As the Buffalo Scheirer clock retains the original count wheel striking mechanism, complete with a grimacing, winking face

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[63] Tyler, E. J. 1973. P. 55
[64] Bassermann-Jordan, E. V. 1964. P.168-169
[65] Bassermann-Jordan, E. V. 1964. P. 210

engraved on the hammer, it was likely manufactured before 1700.

Additionally, the short steel hour hand with relatively long tail that is present on the Scheirer clock appears to correspond closely to other hour hands dated to the mid-seventeenth century. Beginning in the eighteenth century, hands became more slender, and the tail was considerably shortened.[66]

v. Conclusions

The accumulated evidence of technical examination on the grounds of materials, technology, and style of ornamentation employed in the manufacture of this clock suggests that it was produced sometime after the middle of the seventeenth century but before the dawn of the eighteenth. The alarm mechanism and the spring balance do not appear to be original to the clock, however, and their examination suggests an earlier terminus ante quem of around 1675. A further discussion of this dating is to be found in the next section, Previous Alterations and Repairs.

VI. Previous Alterations and Repairs

i. Spring Balance Wheel

As discussed above, verge escapements are typical of clocks manufactured in the seventeenth century. Prior to 1675, the oscillation of the escapement, and thus the speed of the clock, was regulated by foliots, which were either straight bars or small disks, mounted to the top of the verge arbor with a pivot in the center of a cock.

In the spring of 1675, the Dutch scientist Christiaan Huygens published a letter in the *Journal de Sçavans* describing his invention to more accurately regulate the action of a verge escapement.[67] The regulation of clock's escapements had been a topic of hot debate among the Royal Society of London, and Robert Hooke proposed a similar mechanism around the same date.[68] Though there were a number of patent disputes, history has accorded Huygens the honor of inventor of the balance spring, likely due to his swiftness in publication.

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[66] Bassermann-Jordan, E. V. 1964. P. 194
[67] Cardinal, C. 1989. P. 78
[68] Bassermann-Jordan, E. V. 1964. P. 168

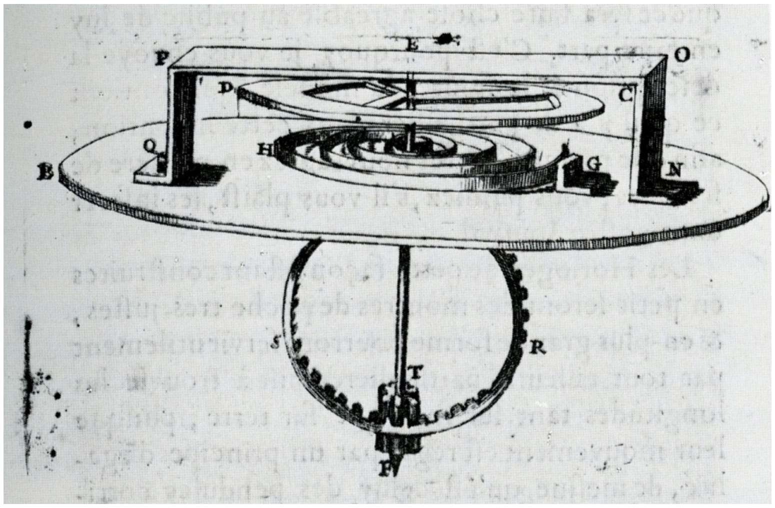

Figure 25, Cardinal, C. 1989. P. 79. Spring balance invented by Christiaan Huygens, published in *Journal des Sçavans, 1675*

The new escapement was considerably more accurate. It has been reported that early balance spring escapements permit an error of approximately 1 ½ minutes in 24 hours, a major advance over the finicky recoil foliot escapements, which might lose or gain considerably more over the same period.[69] The obvious advantages of the balance spring escapement led to its almost immediate adoption by clockmakers, as well as a demand for updates and conversions from clock owners.

The Buffalo Scheirer currently has a spring balance escapement, but preserves characteristics of the older recoil foliot escapement. To better gauge whether this balance is original, and thus estimate the likely date of the clock's manufacture, it is instructive to compare the Buffalo clock's escapement with that of a timepiece known to have been manufactured with a spring balance after 1675.

For purposes of comparison, a late seventeenth century watch from the study collection of the Art Conservation Department of Buffalo State College was chosen (See Appendix ii: Watch with Spring Balance, DuFresne, Paris, c. 1698). This watch appears to be in original condition, without significant alteration or repair of the movement. The fusee and verge escapement for the hour and minute hands are nearly identical to the hour movement of the Buffalo clock. The balance wheel and cock of the DuFresne watch, however, are significantly different than those found in the Buffalo clock.

The Dufresne watch, which dates to c. 1698, was produced after Huygens's

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[69] Tyler, E. J. 1973. P. 55

invention of the spring balance wheel. This watch has a double-footed cock that entirely covers and protects the balance wheel. The balance wheel is made of brass, as is the verge escapement and the rest of the movement. The spring is integrated into the guard, and no secondary guide is present. The spring is rather long, and coiled several times around the arbor of the escapement. No holes, fills, or scratches are present on the base plate, suggesting that no structural alterations have been made and that the extant movement is original.

Figure 26, DuFresne, Paris, 1698. Original late-seventeenth-century spring balance

The Buffalo clock, which likely dates to sometime between 1660 and 1700, as discussed above, retains the oval shaped balance cock typical of foliot or hog bristle balances.[70] Furthermore, the clock retains the numbers 1-5 and 1-4 engraved in the base plate at the top and bottom of the balance cock. These numbers would have served as a simple scale for positioning hog bristles or weights on a foliot to speed or retard the escapement. Nevertheless, a balance wheel and spring are present, in the manner of the spring balance published by Huygens in 1675. The balance wheel is extremely cramped in the original cock and is not fully protected. The verge arbor pivot in the center of the

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[70] Cardinal, C. 1989. P. 155

cock has been filled and replaced with a steel anchor for the arbor of the balance wheel, and the foot of the cock has been filed down so that the wheel just fits. The spring for the balance is relatively short and held in place by a peg and guide that have been inserted into the original guard. The balance wheel, pin, new anchor, and guide are steel, though the remaining portions of the original escapement are brass. Furthermore, the quality of workmanship evident in the spring balance wheel is decidedly poorer than that of the original movement; edges are left unfinished, mechanical elements are not symmetrical, and the base plate gilding is scratched by file marks. Finally, the balance wheel partially covers the signature of the maker. It seems unlikely that the maker would have intentionally chosen to obscure his identity. All of these reasons suggest that the spring balance wheel is a later addition, and not original to the clock.

Figure 27, Buffalo Scheirer clock. Spring balance adapted from foliot during the late seventeenth or early eighteenth century

It is known that many early clocks were modernized with spring balance wheels shortly after Huygen's publication, as the new method of regulating the escapement was significantly more precise than the various types of foliots that had been in use until the last quarter of the 17th century.[71] Indeed, the escapements of the Scheierer clock known from the *Britten's* engraving as well as the Chritsie's Gauer clock were both updated with spring balance wheels.

Early conversions employed relatively short, stiff springs held in place with circular, tapered pins in round holes, whereas later spring balance wheel escapements typically had longer, more flexible springs secured by square pegs in square holes (to avoid distorting the flat spring).[72] Clocks and watches manufactured with balance wheels regulated by springs (after 1675) almost always have circular cocks, designed to cover and protect the delicate balance wheel.[73] Comparison of the Buffalo and Dufresne timepieces bears out these distinctions between converted and manufactured spring regulated balance wheels. The Dufresne watch appears to have employed the new spring balance wheel technology in its manufacture, likely sometime around the year 1700. The Buffalo clock, on the other hand, appears to be a mid-17th century clock that was converted to a spring balance wheel escapement sometime in the last quarter of the century. Combined with the information gleaned from technical examination and analysis, it is reasonable to surmise that this clock dates to sometime between 1660 and 1680.

ii. Alarm Train

Alarm trains of the sort present in the Buffalo clock are known to date from the seventeenth century. Though the technology is not inconsistent with the probable date of manufacture, a number of other factors suggest that this entire drive train is a later addition to the clock, not the least of which is the fact that no other clocks attributed to this maker are known to have alarms.

The barrel, wheels, arbors, and escapement of this drive train are all made of steel. This by itself does not necessarily indicate that the movement is an addition, however, it is manufactured of a different material than the elements of the other two drive trains, and of a similar material to the known alterations made to the hour escapement. It should be noted that the alarm train of the DuFresne watch, which is believed to be original, is also

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[71] Tyler, E. J. 1973. P. 23
[72] Tyler, E. J. 1973. P. 61
[73] Cardinal, C. 1989. P. 155

made entirely of steel, in contrast to the remainder of the movement, which is made of brass. Because alarm strikes are subject to considerable stress due to unregulated recoil,[74] steel may have been employed because it is less likely to deform.

As with the spring balance, the quality of workmanship is considerably lower for all elements of the alarm train. A number of makeshift measures suggest that the alarm train was fitted in at the cost of other elements of the mechanism. The hour strike train appears cramped, and several of the arbors may have been moved to accommodate the additional alarm train, as a number of extraneous pivot holes exist in the base plate. An extremely large hole has been cut for the verge arbor through the base plate, very much in contrast to the snugly fitted pivot of the hour strike hammer. The alarm verge arbor is anchored by a piece of a cock that has been cut down for the purpose and mounted to the base plate with a steel screw. The alarm hammer itself is rather large for the movement. The winding post of the main hour spring has been cut down and fitted with a small piece of wood or cork to prevent the alarm hammer from striking it on the recoil. The alarm hammer itself is a tapered brass oblong, considerably different in size and style than the hour strike hammer. In another clock with original twin striking trains attributed to this maker (see Figure 7, Sotheby's clock, above) the hammers are both grotesque heads of similar style and execution (in the style of dolphins).

The alarm set dial in the center of the face of the clock appears to be a re-use of the underside of the original center engraving. The original gilded engraving was evidently turned over, hammered out into a convex shape to accommodate the soldered mounts for the hour hand arbor, and then engraved with numerals and gilded on the reverse. X-ray fluorescence analysis of the solder used to secure the mounts has tentatively identified it as a lead-tin alloy that may include zinc as a flux. The engraving of the numerals on the set dial is rougher and shows a hesitancy of line lacking in the engraving of the numerals in the hour chapter ring. Furthermore, the gilding is much thinner, even in areas of little wear.

The ad-hoc nature of the alarm train, the use of distinct materials, the re-use of original materials, and the uniqueness of this alarm among the known work of this maker make it likely that the alarm train is a later addition. Small table clocks such as these

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[74] Tyler, E. J. 1973. P. 55

were among the first portable clocks, and were often provided with wood and leather cases for traveling.[75] It is therefore not surprising to think that this clock may have been modified with an alarm to fit the needs of a later traveler.

iii. Glass

At least two distinct types of glass appear to be present, suggesting that at least one campaign of replacement has occurred (see above, under Technical Analysis: Glass, as well as Appendix i. a., X-Ray Fluorescence Data). The glass windows, as some of the most fragile parts of this clock, are particularly susceptible to damage and therefore replacement.

The thickness, color, and grozing of the windows at 2 and 4 o'clock all suggest that they are older elements. The thinness, uniformity, clarity, and cut edges of all other window glasses suggest that they are more recent elements.

iv. Re-bushing of Pivots

In addition to the modifications discussed above, all of the pivot holes for the arbors of the works have been re-bushed at some point. As pivots wear, they gradually enlarge the holes in which they turn. As a consequence, the arbors will begin to wobble, the wheels will not mesh properly, and the movement of the clock suffers. Re-bushing involves removing worn holes and replacing them with trued pivot holes to ensure smooth operation of the works.[76] The cutting and filing involved in this process of re-bushing can leave significant evidence of the process, as in the case of the Buffalo Scheirer clock.

It appears that the re-bushed pivot holes were cut from the base plate and inserted where they were needed. This parsimonious re-use of original materials is in keeping with the re-use of the center engraving as the alarm set dial, and suggests that these are both older repairs.

v. Bell Bridge

An iron bridge on the bell plate supports the bell against which the hour and alarm hammers strike (hour from the inside, alarm from the outside). This bridge appears to have two campaigns of repairs: a small, riveted brass plate holding one end of the bridge

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[75] Cardinal, C. 1989. P. 15

[76] Wills, P. B. 1995. P. 38

in place, and an adjacent area of solder that also appears to be securing the bridge to the bell plate.

The materials and craftsmanship employed in the two repairs suggest that the small brass plate was the first of the campaigns. This repair is farther from the center of the bell plate, and employs traditional techniques and materials. The solder repair is closer to the bell, suggesting a secondary point of failure. This second repair uses comparatively more modern materials that have not been brought to a high degree of finish.

X-ray fluorescence analysis identified this solder as a lead-tin alloy that may contain zinc chloride as a flux. This composition is consistent with historical solder formulations. Given the limitations of this analytical technique, it is uncertain whether this solder repair utilizes the same solder that was employed to attach the mounts to the alarm set dial.

vi. Screws

Though the posts, hammer arms, detents, and hour hand are pinned, most attachments are secured with screws, a feature of mid seventeenth century clocks, as noted above. A mixture of hand- and machine-cut brass and steel screws in a variety of sizes and shapes are currently present on the clock. Early screws, such as those employed in the seventeenth century are known to have pronounced, rounded heads, and often uneven or incomplete threads. Later screws characteristically had flatter heads and more threads per inch. Machine screws are uniform in size and shape, usually with flat heads and even, sharply-incised threads.

The steel screws securing the heel cock and the foliot guard have pronounced, rounded heads and uneven threads. These screws are associated with pieces that are believed to be original. They correspond in form and manufacture to screws dating to the time of manufacture of the clock. Additionally, the undersides of the screws’ heads show traces of bluing, a decorative and anti-corrosion surface treatment that has also been identified on all original steel elements of the clock.

A number of the steel screws securing the silver window frames closely resemble the foliot and heel cock screws, and appear to be original. One of the screws securing the window frame at 6 o’clock is brass, and shares some similarities with these screws.

Half of the screws securing the feet to the case of the clock, and two of those securing the base plate hinges, are made of brass, with the characteristics of seventeenth century manufacture. These may be original, and it is interesting to note that brass seems to have been used for screws securing sliver elements, whereas blued steel was used for steel and gold elements. This choice in materials may reflect aesthetic decisions.

The flat head screws securing the balance cock and the bell show traces of bluing, and though they lack the round heads of early screws, they may be original. The flat heads of these screws may be a functional consideration, as they secure flat attachments.

At least two campaigns of screw replacements seem to have been carried out, though it is likely that many screws were replaced piecemeal during the course of routine cleaning and repair. Larger screws are presumed to be evidence of drilling and tapping new threads, and at least three distinct sizes of screws are present, suggesting two campaigns of replacement after the original.

VII. Treatment

The clock works and case were partially disassembled for purposes of analysis and documentation. Minimal intervention in the functioning of the works was deemed appropriate, and accordingly, treatment was largely restricted to cleaning, polishing, and lacquering.

Figure 28, Pulling the works from the case

All metal surfaces were cleaned initially with acetone rolled on cotton swabs to reduce dirt and grime. Glass was cleaned using a 50%-50% mixture of deionized water and ethanol rolled on cotton swabs.

Discolored oil residue on the base plate and wheel works was removed using petroleum benzine rolled on swabs.

The silvered surfaces of the feet and window frames were further cleaned under magnification with a 1% solution of aqueous triammonium citrate rolled on cotton swabs to reduce significant accumulations of grime. Shellac residue was reduced and the silver polished using precipitated calcium carbonate in deionized water or ethanol rolled on cotton swabs. Surfaces were then cleared with acetone.

After cleaning and polishing, silvered surfaces were lacquered with Agateen, a cellulose-nitrate lacquer. Silvered objects were dipped in a thinned solution of Agateen, and hung to dry.

All screws were cleaned under magnification using a combination of dental picks, bamboo skewers, steel wool, and acetone.

The clock was then reassembled. The cork raiser present at the beginning of treatment had cracked and suffered some loss during removal. The cork pieces were reassembled using dilute fish glue, a new piece of cork was inserted into the loss, and toned Japanese paper was adhered over break edges with wheat starch paste to provide additional reinforcement. All pieces, including pins and screws, were returned to their original positions.

Fills were made to losses in the numerals in the hour chapter ring. Only the visually distracting losses showing the underlying silver were filled. Microcrystalline wax pigmented with ivory black and titanium white was applied and textured using metal spatulas and bamboo skewers.

VIII. Discussion of Treatment Decisions

Clocks, like many functional objects, often have complex histories of use and repair. Historical repairs are of interest as they can serve as documents of the technology and craft current during a particular time and place. For clocks and other artifacts, however, more recent restorations have tended to obliterate or obscure the evidence of previous repairs, alterations, and treatments. In the interests of maintaining the integrity of this clock’s current state, along with surviving evidence of previous campaigns of repair, a minimal intervention was deemed most appropriate.

Though it would be possible to return this clock to going order, it was decided that this was not an acceptable goal of treatment for several reasons. Complete disassembly and mechanical intervention would necessarily remove evidence of previous repair and treatment. Furthermore, because of the ad-hoc nature of the alterations and repairs made to this clock, disassembly would require cutting or removing parts of the original, which is not considered compatible with professional conservation ethics.

Cleaning to reduce surface dirt and grime was undertaken. Cleaning not only improves the aesthetic appearance of the object, but minimizes the likelihood of further metal and glass corrosion by reducing the presence of microclimates and potentially reactive material. Screws were cleaned to ensure that they function smoothly, and are not damaged when removed and replaced in the future.

Figure 29, Silvered foot at 6 o'clock Left: Before treatment Right: After cleaning, polishing, and lacquering

The decision was made to clean and polish the silver. This step was deemed appropriate as the surface coating of shellac was likley to continue to degrade. Furthermore, the darkened silver surfaces did not accurately reflect the original bright and luxurious appearance of the clock case. The Buffalo Museum of Science, to which the clock will be returned, is located in an historic building directly adjacent to a highway, and the likelihood of future tarnishing was considered high. Consequently, the polished silvered surfaces were lacquered. Though this is considered a temporary protective coating that ought to be removed and replaced within 20 to 50 years, this is considered acceptable, as continual re-polishing of an un-lacquered surface will eventually remove the original silvering.

The brass surfaces of the dials were cleaned but not polished. The original silver finish of the hour ring is no longer present, likely as a result of polishing. Re-silvering of hour rings is possible, but it requires the removal of the original pitch fills to the numerals. For this clock, it would also require cutting original rivets. The hour ring was therefore not re-silvered. The brass was not polished, as this would not reflect the original appearance of the clock. The current state after cleaning was deemed acceptable as evidence of the clock's use and maintenance.

The surface of the alarm set dial is similarly abraded, and only traces of the 'original' gilding of this re-used element remain. Though it would be possible to compensate for losses in gilding via several different techniques, it would be practically impossible to avoid obscuring or altering the original surface. Polishing the brass would not accurately represent the original appearance, and would be very likely to further abrade the remaining gilding. For these reasons, the current, cleaned state was accepted as satisfactory.

The alarm set dial was returned to its position at the time treatment was begun. However, the underside of the dial, which likely represents the original face of the clock, was photographed in what may have been the original position. This record will serve to record the unique re-use of this original piece. It should be noted that during treatment of the works, the hour and alarm trains were advanced by approximately half an hour. This change has been recorded in photographic documentation.

Figure 30, Detail of pigmented wax fills

Fills to the losses in the numerals were made to consolidate the remaining original material as well as visually compensate for losses. The original material is brittle and susceptible to flaking out of the engraved numeral. Pigmented wax fills help to prevent further breaks and loss by serving as a gap filling material and partial adhesive. Fills to the numerals also visually reintegrate the areas of loss with the original material, enhancing the legibility of the hour ring and better reflecting the appearance of the original. Wax was deemed an appropriate fill material because it has a solubility distinct from that of the original material, aged pine pitch/rosin, and thus could be removed or reduced in the future.

The fragmented and partially disintegrated cork raiser was reassembled with the addition of some new cork. This decision was made in the interest of preserving as much of the original material and character as possible.

The clock was not wound after treatment. The hour strike and hour hand trains are out of synchronization, and would have to be adjusted to mark time in tandem. The springs are currently under as little tension as possible, which may help to ensure their longevity. This reduces the likelihood of stress cracking and consequent failure of the springs. No keys have been provided for this clock, and this further reduces the likelihood that the clock will be set to going or the springs put under tension at any point in the future. It should be noted that none of these measures preclude a more complete restoration of this clock at any point in the future. It is hoped that the information included in this report will enable the owner institution to make informed decisions about storage, exhibition, and care of this object.

Figure 31, Buffalo Scheirer clock. Left: Before treatment Right: After treatment

IX. Results and Conclusions

Preliminary research into the provenance of this clock indicates that it was most likely manufactured by the maker Johan Scheirer, whose signature appears on the base plate. The similarities in form, design, materials, and mechanics among all three known clocks attributed to Scheirer appear to represent a cohesive oeuvre. The possibility that Scheirer was located in Vilnius, as suggested by the Sotheby's catalogue, appears reasonable, based on other similar clocks produced in the same geographical region during the same period of time. How the clock arrived in New York City in the 1930's is not known.

Examination of the stylistic and technological aspects of this clock strongly suggests that it was manufactured sometime between 1660 and 1680. Comparison with published examples of clocks from this time period, as well as correlation with the accepted history of horological developments, bears out this proposed date. Examination also suggests that the spring balance is a late-seventeenth century alteration, made to improve the accuracy of the clock. The alarm train also appears to be an addition to the original clock, perhaps made in the late seventeenth or early eighteenth centuries. The components of the alarm train appear to have been appropriated from another, slightly larger clock (or clocks). The current alarm set dial appears to be a re-use of the original central engraving. The craftsmanship evident in these alterations and additions is of a considerably lower quality. The re-use of materials similarly suggests that by the time of the alterations, this clock had already passed from being a prestigious luxury item to an object of more functional use.

Materials analysis using ultraviolet induced visible fluorescence, X-ray radiography, Fourier transform infrared spectroscopy, and X-ray fluorescence adds further information about the manufacture, maintenance, and repair of this clock. The consistency and relative purity of the brass alloy used in the manufacture of this clock suggests that its components were cast or hammered from a single source of high-quality brass of approximately 70% copper and 30% zinc, sometimes referred to as “yellow” or “cartridge” brass for its bright golden appearance. Re-bushing of the pivots appears to have employed parts of the original base plate, as the brass is of similar composition, and a number of extraneous holes exist.

The feet, frames, and dial were silvered via the amalgam process, identifiable via XRF detection of the mercury present on these surfaces. XRF and visual analysis confirmed that the hour chapter ring was originally silvered. FTIR identified an aged white shellac coating on silvered components. Significant wear to the original silver was observed underneath the shellac layer, indicating that it had been applied only after the silver surfaces had been polished over the course of many years. The shellac coating was therefore identified as unoriginal, and removed. Polishing and lacquering of the silvered surfaces will help to preserve the original appearance and material.

The gilded surfaces of this clock are likewise the result of amalgam gilding, as identified by XRF detection of mercury in gilding layers. The gilding on the case and original engraving was found to be significantly thicker than gilding on the cocks. This suggests that the gilding on the case and works was intended to serve as a protective layer, and not merely as decoration, as it does on the cocks. Detection of mercury in the gilding of the alarm set dial suggests that it was gilded sometime prior to the middle of the 19th century, when electroplating of gold largely replaced amalgam gilding.

At least two types of glass windows are present. Ultraviolet induced visible fluorescence and XRF analysis indicate that iron/manganese and arsenical glasses are present. It is likely that the arsenical glasses at 6, 8, 10, and 12 o'clock are later replacements. It is unknown if the iron/manganese glasses at 2 and 4 o'clock are original.

The fills in the Roman numeral hours were identified using FTIR as likely composed of a softwood resin or pitch. This material is consistent with fillers known to have been used in the seventeenth century. Solders were identified as lead/tin with zinc chloride flux, a type of solder that has been in use for centuries, making it difficult to pinpoint the time of its application to this object. The clock appears to have been oiled using sperm oil, as suggested by FTIR analysis. This lubricant has also been used at least since the eighteenth century, making it difficult to assess when the clock was last cleaned and oiled.

The springs and the wheel works of the movement are all present and intact, and when tested, all three drive trains proved to be functional. The fusee chain has been wound back, and were the hour and strike springs to be wound, the clock would be set going. The clock has not been thoroughly cleaned or re-lubricated, and several of the arbors were observed to wobble in their pivots. Additionally, the alarm strike is given to slipping, though there is evidence that the verge arbor has been repositioned several times, suggesting this is not a recent problem. It is not advisable to run this clock for any considerable amount of time. In an effort to discourage the winding and running of this clock, no keys have been made.

Cleaning and polishing of this clock have improved the appearance and cleanliness of the object. Though this clock has not been restored to its presumed original state, its current state is representative of its history of use, repair, and alteration. Information gathered during examination and analysis now allows for a more thorough appreciation and understanding of the life of this clock. It is hoped that this fascinating object will be returned to public display sometime in the future.

X. Acknowledgements

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XII. Sources of Materials

- TRIAMMONIUM CITRATE (for dirt and grime removal) percent solution of citric acid in de- ionized water conditioned to pH 7.0 with concentrated ammonium hydroxide
- PRECIPITATED CALCIUM CARBONATE Talas 20 West 20th Street, 5th floor, New York, NY 10011. 212-219-0770
- AGATEEN (cellulose nitrate lacquer) Agate Lacquer Mfg. Co. Inc., 11-13 43rd Rd. Long Island City, NY 11101 (212) 784-0660
- FISH GLUE (high tack) Lee Valley Tools Ltd., P.O. Box 1780, Ogdensburg, NY 13669-6780

- CORK (natural cork stoppers) source unknown
- TONED JAPANESE PAPER vintage kozo paper, light brown, source unknown
- AYTEX-P, precipitated wheat starch, General Mills, dist. by TALAS, New York, NY
- DRY PIGMENTS available from Conservator's Emporium 100 Standing Rock Circle, Reno, NV 89511; (702) 852-0404
- BE SQUARE 195, WHITE (microcrystalline wax) Conservation Support Systems, P.O. Box 91746, Santa Barbara, CA 93190. (805) 682-9843. [manufactured by Bareco division of Petrolite Corp., P.O. Box 384, Wayne, PA 19087]
- BEESWAX (natural) Conservation Support Systems, P.O. Box 91746, Santa Barbara, CA 93190. (805) 682-9843. [manufactured by honeybees]

XIII. Autobiographical Statement

Gregory Bailey received a dual BA in Journalism and Spanish and a BS in Education from the University of Connecticut in 2006. From 2001 to 2007 he worked in the conservation department of the University of Connecticut Libraries. In the Buffalo State College Art Conservation Department, Greg has specialized in the conservation of objects. He has completed summer internships for the Maine Historical Society, in Portland, Maine, and the Skagafjordur Archeological Settlement Survey, a series of excavations in Skagafjordur, Iceland, led by the Univeristy of Massachusetts at Boston. This summer he will be interning at the Henry Ford Museum in Dearborn, Michigan. Greg's third-year internship will be at the Sherman Fairchild Center for Objects Conservation at the Metropolitan Museum of Art, in New York City.