THE ORGANOLOGY OF THE QUEEN MARY AND LAMONT HARPS

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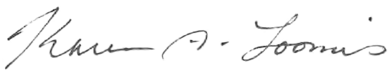

Karen A. Loomis

To the memory of Robert Bruce Armstrong

Abstract

The metal strung harp indigenous to Ireland and Scotland from the Medieval period to the end of the 18th century was widely admired throughout its time period, and is now an important part of the cultural and musical heritage of both of these countries. This type of harp, known as the 'Irish harp', *cláirseach*, or *clàrsach,* currently has 18 known surviving instruments, including two sets of fragments. All of these harps are now too fragile to be played, therefore musicians and audiences wishing to explore the performance practice and repertory associated with them must rely on faithful replicas. The extensive knowledge and understanding of the construction of the surviving harps that is crucial to building these replica instruments is currently very limited, however.

Although harps of this type enjoyed a long period of use dating back to the Medieval period, most surviving instruments post-date the beginning of the 17th century. Two harps belonging to the National Museum of Scotland, the 'Queen Mary' and 'Lamont', generally dated to circa the 15th century, are understood to be two of the oldest extant examples, making a study of their construction of particular interest. This dissertation presents the results of a comprehensive study of the construction of these two harps. A methodology was developed to address the issue of their uniqueness and fragility by combining the techniques used for non- and minimally destructive analysis of archeological artefacts with non-invasive medical diagnostic imaging. This study has utilized CT-scanning to provide three-dimensional radiography of each harp; XRF and SEM-EDX analysis to identify woods, metals, and pigments; photography and microscopy to record the decorative work, visible damage, repairs, and modifications; and a visual examination to assess the current state of each harp and to identify areas of interest for further analysis. The CT scanning was conducted at the Clinical Research Imaging Centre of Queen's Medical Research Institute, and the remainder of the analysis was conducted at the National Museums Scotland Collections Centre. Staff at both centres kindly facilitated the acquisition of the data for this study.

Part I of this dissertation discusses the stringing of the instruments, presenting materials analysis of wire fragments, analysis of the effect of damage to the frames on the length and number of strings, and proposed reconstructions of the 'as-built' string lengths. Possible solutions for the pitch and gamut of each harp are also discussed. The construction of the harps is discussed where it is relevant to understanding the stringing. Part II presents a general discussion of the construction of each harp, including materials, decorative work, modifications, and signs of wear. This section also discusses evidence that may help establish dates of construction and timelines of modifications. Diagrams showing the dimensions of each harp are also presented. The implications of the results of this study for current understanding of these harps are discussed in detail and the methodology employed is discussed in terms of its applicability to future research of other surviving instruments.

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Acknowledgements

This project owes a debt of gratitude to the dedication and expertise of a number of talented individuals and to the institutions whose collaboration made it possible. Foremost, I would like to thank National Museums Scotland for supporting this extensive study of two of their most important cultural artefacts, and for putting their impressive curatorial and conservation staff and facilities at its disposal. I would also like to thank the Clinical Research Imaging Centre of Queen's Medical Research Institute for making their facility available for the groundbreaking CT scans of these two historical harps, and for providing expertise and support during this phase of the project.

I would particularly like to thank Dr. David Caldwell, former Keeper of Scotland and Europe at the National Museum of Scotland, Dr. Edwin van Beek, SINAPSE Chair of Clinical Radiology at the University of Edinburgh, and Director of the Clinical Research Imaging Centre, Dr. Jim Tate, former Head of the Department of Conservation and Analytical Research at National Museums Scotland, and Dr. Ticca Ogilvie, Head of Artefact Conservation at National Museums Scotland for their support of this project from its inception, for the significant contributions of their expertise, and for coauthoring with me the first published paper on the results of this study. I would also like to thank Dr. Darryl Martin for his excellent tuition on stringing analysis, which was the foundation of Part I of this dissertation.

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The staff at the National Museums Scotland Collections Centre deserve particular acknowledgement. Their tireless work and dedication over a number of long days in the laboratory is evident in the extensive analytical data that was acquired for the two harps. Dr. Lore Troalen (Analytical Scientist), Verena Kotonski (former Assistant Artefacts Conservator), Dr. Suzanne Kirk (former Analytical Scientist), and Isabell Wagner (Curatorial Intern), led by Dr. Ticca Ogilvie and formerly Dr. Jim Tate merit special recognition. I would especially like to note the exceptional contributions of the expertise of Dr. Ticca Ogilvie for the sampling and identification of the woods and of Dr. Lore Troalen for conducting the scanning electron microscopy. I would also particularly like to thank my sister, Maripat Goodwin, for volunteering her time and expertise as a professional photographer to conduct the photographic survey of the Lamont harp at the Collections Centre, and for her moral support during this project. Additionally, I would like to thank Dr. Justine Bayley for her expert advice on sample preparation and analysis of the wire fragments found in the Lamont and Queen Mary harps.

The CT scans of the two harps are the cornerstone of this study, and the work of the staff at the Clinical Research Imaging Centre in acquiring these scans was a major contribution to its success. I would like to thank Tessa Smith (former Radiographer), Danielle Bertram (Radiographer), and David Brian (Superintendent Radiographer). I would especially like to thank Dr. Martin Connell of Queen's Medical Research Institute for his expertise in acquiring the scan data, and for his continued support and advice.

A number of dedicated individuals have also contributed to this study. Foremost among these is Keith Sanger, who volunteered his time and expertise researching archival materials related to the history and provenances of these two harps, and who shared his extensive knowledge in a number of particularly informative conversations and emails. I would also like to thank National Records of Scotland for their assistance with Keith Sanger's archival work.

I would like to thank Amanda Munday, Jonathan Letcher, and Mike Parker for bringing the Montgomery tuning pins to my attention, and would also like to thank Amanda Munday for hosting my visit to Montgomery. I would especially like to thank the Old Bell Museum in Montgomery for permission to photograph the tuning pins, and the curators John and Ann Welton, for their assistance.

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During the course of this study, it has been my pleasure to meet and discuss harps with a number of researchers, musicians, and luthiers. I have learned much from these conversations, and I would like to thank the community of people who have a dedicated interest in these instruments for their support and enthusiasm for this study, and for their valuable feedback while it has been in progress. I would particularly like to thank Paul Dooley for sharing his knowledge and insight in a number of enlightening conversations, and for setting the bar quite high in his work with the Trinity College harp, which was the inspiration for Part I of this dissertation. I would also particularly like to thank Simon Chadwick for sharing his extensive knowledge of the harps, for countless lively discussions, and for his support and encouragement.

Lastly, and most importantly, I would like to thank my daughter Vivian for her unwavering patience.

Karen Loomis
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Introduction

Figure 0.1: *The Queen Mary harp (left), and the Lamont harp (right), National Museum of Scotland H.LT1 and H.LT2, respectively. Photograph: Isabell Wagner*

Background

From the Medieval Period to the end of the 18th century, the harp of Ireland and Highland Scotland, known variously as an Irish harp, *cláirseach* (in Irish), or *clàrsach* (in Scottish Gaelic), was a highly regarded musical instrument. During its long period of use, it was enjoyed in the houses of the chieftains in Gaelic society as well as at court in England and on the continent.[1] The substantial construction of its frame, and its metal stringing played by striking with the fingernails, imparted this instrument with a distinctive resonant sound that was greatly admired.[2]

It is not known when this harp first appeared in Ireland and Scotland. Harps are depicted on Pictish stone monuments in Scotland from the 8th – 10th centuries, but these are not identifiably of this type.[3] A possible early depiction appears on the Irish Breac Mhaodóg (the Shrine of St Mogue), which dates to the second half of the 11th century.[4] What may be the earliest written reference to the instrument appears in the 12th-century *Topographia Hibernica* of Giraldus Cambrensis, in which he comments on the *cithara* played in Ireland, pointing out the brass (or bronze) stringing, while remarking on the sound of the instrument and skill of the players.[5] A possible early representation of particular note is a harp depicted in detail in the late 13th-century Angel Choir of Lincoln Cathedral that closely resembles the earliest surviving instruments.[6]

As Rimmer (1963) notes, iconographic depictions of harps with the characteristic form of the 'Irish harp' were in evidence by the end of the 14th century.

> "From the plethora of harps, real, symbolic and imaginary, which appear in medieval iconography, two distinct forms are recognisable by the end of the fourteenth century. One is the European form, which Sachs rather loosely called Romanesque; the other is the Irish harp."[7]

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[1] Ann Buckley, "Music and Musicians in Medieval Irish Society," *Early Music* 28, no. 2 (2000): 165 – 66. Cólm Ó Baoill, "Highland Harpers and their Patrons," in *Defining Strains: The Musical Life of Scots in the Seventeenth Century*, ed. James Porter (Bern: Peter Lang AG, International Academic Publishers, 2007), 181. Peter Holman, "The Harp in Stuart England: New Light on William Lawes's Harp Consorts," *Early Music* 15, no. 2 (1987): 188 – 92.
[2] Joan Rimmer, "Harps in the Baroque Era," *Proceedings of the Royal Musical Association*, 90 (1963 – 64): 61 – 62.
[3] Keith Sanger and Alison Kinnaird, *Tree of Strings: A history of the harp in Scotland* (Temple: Kinmor Music, 1992), 14 – 30.
[4] Buckley, "Music and Musicians," 168.
[5] Christopher Page, *Voices and Instruments of the Middle Ages* (London: J. M. Dent & Sons, Ltd., 1987), 229 – 30.
[6] Jeremy Montagu and Gwen Montagu, *Minstrels & Angels: Carvings of Musicians in Medieval English Churches* (Berkeley: Fallen Leaf Press, 1998), 3, Plate 1. Montagu and Montagu label this instrument an "Irish-type" harp.
[7] Rimmer, "Harps in the Baroque Era," 59.

Spanning their long history of use, there are many historical references to the individuals who played these harps as professional musicians, as noted by a number of authors.[8] It thrived as a musical instrument through the end of the 16th century and into the Stuart era of the early 17th century, until political upheavals in Ireland and Scotland in the 17th and 18th centuries resulted in the decline and loss of the old Gaelic nobility and their patronage of the harpers.[9] This, along with changing musical tastes as well as competition from other instruments, may have contributed to a slow decline in use that continued through the 18th century until the instruments fell out of use altogether. Notably, the last generation of 18th-century harpers was observed and interviewed first-hand by Edward Bunting, whose publications and extensive field notes, including descriptions of performance practice, tuning, and a large body of music transcribed directly from performances by the musicians, are a significant repository of information on the music and performance of this instrument.[10]

The surviving harps are now an important part of the cultural and musical heritage of both Ireland and Scotland. There are currently 18 known extant instruments (including two sets of fragments).[11] All of these are now too fragile to be played, so musicians and audiences wishing to explore the performance practice and repertory associated with them must rely on faithful reproductions. The knowledge and understanding of the materials, construction, and craftsmanship of the original instruments that is crucial to building these reproductions is currently somewhat limited, however. The primary source of information has been Robert Bruce Armstrong's *The Irish and The Highland Harps*, which was published over 100 years ago.[12] More recently, in depth studies have been undertaken for the Downhill, Bunworth, and 'Brian Boru' (a.k.a. the Trinity College) harps, adding to present

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[8] Edward Bunting, *The Ancient Music of Ireland, Arranged for the Piano Forte* (Dublin: Hodges and Smith. 1840), 67 – 82. Robert Bruce Armstrong, *Musical Instruments Part I. The Irish and the Highland Harps* (Edinburgh: David Douglas, 1904), 1 – 23, 139 – 54. Sanger and Kinnaird, *Tree of Strings*, 78 – 152.
[9] Ó Baoill, "Highland Harpers," 183 – 84.
[10] Colette Moloney, *The Irish Music Manuscripts of Edward Bunting (1773 – 1843): An Introduction and Catalogue* (Dublin: Irish Traditional Music Archive, 2000), 3 – 16.
[11] Simon Chadwick, "The Early Irish Harp," *Early Music* 36, no. 4 (2008): 522.
[12] Armstrong, *Irish and the Highland Harps*.

knowledge of these instruments.[13] There is, however, a need for additional extensive and detailed research of all of the surviving harps.

Most of the extant instruments post-date the beginning of the 17th century. Three instruments, the Trinity College harp of Trinity College, Dublin, and the Queen Mary and Lamont harps of the National Museum of Scotland, are generally dated to circa the 15th century, and are understood to be the oldest surviving harps of this type, making a study of them of particular interest.[14] In consideration of the need for more research into the construction of these harps, particularly the earliest examples, this author approached the National Museum of Scotland and the Clinical Research Imaging Centre of Queen's Medical Research Institute in 2010 to propose a study of the Queen Mary and Lamont harps.

The history of these two harps has been extensively researched by Sanger and Kinnaird (1992) and Sanger (2013).[15] Both harps belonged to the Robertson (formerly Tarlochson) family of Lude, in Perthshire, Scotland, and were handed down in that family for a number of generations before eventually being acquired by the National Museum of Antiquities of Scotland (now the National Museum of Scotland).[16] The earliest published information on them comes from Gunn (1807), as related to him by General William Robertson.[17] According to Gunn, the Lamont harp is so named because it is supposed to have been acquired through the marriage of a lady of the Lamont family of Argyll into the house of Lude in Perthshire around

[13] Michael Billinge,"Building a Reproduction of the Downhill Harp (the Harp of Denis Hempson) for the Irish Television Documentary *Banríon an Cheoil*," *Bulletin of the Historical Harp Society* 20 (2010): 6 – 19. David Kortier, "Replicating the Bunworth Harp," accessed 19 November, 2014, http://www.kortier.com/subpages/bunworth.htm. Paul Dooley, "Reconstructing the Medieval Irish Harp," *The Galpin Society Journal* 67 (2014): 107 – 42. The Downhill harp, built in 1702, is owned by Diageo. The Bunworth, built in 1734, is owned by The Museum of Fine Arts, Boston, and the Trinity College harp, usually dated to circa the 15th century, is owned by the Trustees of Trinity College, Dublin.
[14] Chadwick, "Irish Harp," 523.
[15] Sanger and Kinnaird, *Tree of Strings*, 71 – 77. Keith Sanger, "The Robertson Family and Their Harps." last modified 7 June, 2013, http://www.wirestrungharp.com/harps/lude/lude_robertson_tarlochson.html.
[16] Sanger, "The Robertson Family and Their Harps."
[17] John Gunn, *An Historical Inquiry Respecting the Performance on the Harp in the Highlands of Scotland* (Edinburgh: Archibald Constable, 1807), 1 – 17, 73 – 84.

1460.[18] Bell (1880), quoting *Burke's Landed Gentry*, names her as Lilias Lamont, and the year of marriage as 1464.[19] This provenance for the harp is unconfirmed, however. The Queen Mary harp is so named because it is supposed to have been given as a gift to Beatrix Gardyne (the wife of John Tarlochson), by Mary, Queen of Scots (during a hunting expedition in Perthshire in 1563, according to Gunn's somewhat florid account).[20] This provenance is also unconfirmed. It is unknown if these two harps were in continuous use throughout their long working lives, but their last historical player is understood to be John Robertson of Lude, who died in 1731.[21]

Both harps remained in the Robertson family until the death of Colonel James Robertson in 1874, at which point they passed to his close friend John Steuart of Dalguise.[22] Sanger (2013) has surmised that by this time the two harps had already been at the Dalguise estate for a number of years, where they were kept in a storage cupboard in Stewartfield House.[23] The harps eventually passed to a J. N. D. Steuart of Dalguise, and were put up for auction in 1904, after his death.[24] The Queen Mary harp was purchased by the National Museum of Antiquities of Scotland, but as there were insufficient funds for the Lamont harp, this was purchased by the antiquarian Moir Bryce, who bequeathed it to the museum upon his death in 1919.[25]

The two harps were first examined and described by Gunn in 1805, on behalf of the Highland Society, and the earliest engravings of them were published in his 1807 report.[26] They were next examined in 1880 by Charles Bell, on behalf of the Society

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[18] Gunn, *Historical Inquiry*, 1, 73. Sanger and Kinnaird, *Tree of Strings*, 72.
[19] Charles Bell, "Notice of Two Ancient Harps and Targets," *Proceedings of the Society of Antiquaries of Scotland* 15 (13 December, 1880): 28. See also, Sanger and Kinnaird, *Tree of Strings*, 72.
[20] Gunn, *Historical Inquiry*, 77 – 81. See also Sanger and Kinnaird, *Tree of Strings*, 72.
[21] Sanger and Kinnaird, *Tree of Strings*, 150.
[22] Sanger, "The Robertson Family and Their Harps."
[23] ibid.
[24] ibid. A copy of the auction catalog is archived at National Museums Scotland, "Queen Mary harp archive," H.LT1 (National Museums Scotland Library).
[25] Moir Bryce, *Moir Bryce to Scott Moncreiff*, 25 October, 1918. Letter, National Museums Scotland, H. LT2 archive. Sanger, "The Robertson Family and Their Harps." Sanger notes in a footnote that Bryce died on 2 August, 1919, according to the National Archives of Scotland records. His year of death has been misquoted elsewhere as 1918.
[26] Gunn, *Historical Inquiry*, v.

of Antiquaries of Scotland.[27] In his report the harps are described and illustrated in some detail, with particular attention given to the decorative work on the Queen Mary harp.[28] Bell is also fairly critical of Gunn's earlier report, pointing out its inaccuracies and shortcomings.[29] The most comprehensive and detailed examination of them prior to the current study was conducted by Armstrong, and published in his 1904 volume, *The Irish and the Highland Harps*. Armstrong examined, photographed, and measured both harps, and in particular, provided accurate, detailed drawings of the decorative work on all parts of the Queen Mary harp.[30] His work has been the primary source of information on the construction of these two harps, to date.

At the time of Bell's 1880 report the harps were permanently loaned to the Society of Antiquaries, and were placed on display at the National Museum of Antiquities, where they both remained (excluding a brief loan for exhibition) until they were auctioned. The Lamont harp then went to its new owner, Moir Bryce, until it was returned to the museum after his death. Both harps have remained with the museum (now the National Museum of Scotland) to the present day.

Methodology

Due to the age and uniqueness of the Lamont and Queen Mary harps, any study of them must be conducted with minimum physical impact. To address this issue, a methodology was developed to combine non- and minimally invasive materials analyses, as used in conservation and research of museum artefacts, with non-invasive medical imaging, supported by a thorough visual assessment and complete photographic survey of each instrument. The materials analyses and the visual and photographic surveys were conducted at the National Museums Scotland Collections Centre, in collaboration with museum conservation staff. The medical imaging was

[27] Charles Bell, "Notice of Two Ancient Harps and Targets," 10 – 33.
[28] ibid., 13 – 23.
[29] ibid., 16 – 18.
[30] Armstrong, *Irish and Highland Harps*, 158 – 83.

conducted at the Clinical Research Imaging Centre (CRIC) of Queen's Medical Research Institute (QMRI), in collaboration with CRIC staff. Both of these facilities are located in Edinburgh, Scotland.

In June and July of 2010, each harp underwent two days of preliminary examination, materials analysis, and a photographic survey at the Collections Centre, followed by medical imaging at CRIC.[31] The medical imaging was initially used for the author's MMus thesis, "The Queen Mary and Lamont Harps: A Study of Structural Breaks and Repairs," which was concerned specifically with the evidence of damage and repairs to these harps. The current study has significantly expanded upon that work to comprehensively examine their construction.

An extensive examination and analysis of both harps was undertaken at the Collections Centre over a period of two weeks in December 2012. This consisted of a visual examination and survey (both unaided and under magnification), photography of the interiors and exteriors of the instruments, macrophotography of specific areas of interest, photomicroscopy, sampling, and materials analysis. Additional analysis of samples was undertaken in April and July of 2013. The analysis tools used are discussed below.

Materials Analysis

X-ray fluorescence (XRF) spectroscopy was used for non-destructive identification of the elements comprising materials in specific areas of interest. In nearly all instances the analysis was conducted on materials in situ on the harps. The analyser used was an Oxford Instruments ED 2000 with Oxford Instruments software ED 2000SW version 1.31. The operating voltage was 46 kV, with a current up to 1000μA. The beam size was 4mm × 2mm. For analysis of the Lamont harp, the system was

[31]Karen Loomis, "The Queen Mary and Lamont Harps: A Study of Structural Breaks and Repairs" (MMus thesis, University of Edinburgh, 2010).

calibrated for semi-quantitative analysis using the GM8B and B10F blocks of 'Copper Alloys 2008'.[32]

The penetration depth of XRF depends upon the target material and the beam energy, and can range from a few microns to a few millimetres. For the XRF analyses presented here, it should be assumed that the results represent the composition at or near the surface of the material.

Scanning electron microscopy with energy dispersive x-ray spectroscopy (SEM-EDX) was used for high resolution imaging (SEM) of small samples taken from the harps, and for identification of composition (EDX). The instrument used was a CamScan MX2500 SEM in controlled pressure mode. A Noran Vantage EDX system with Vista software was used for identification of elements via spectral analysis.[33] Two imaging modes were used: secondary electron imaging (SEI), which is sensitive to surface topography, and backscattered electron imaging (BSC), which is sensitive to the atomic mass of the elements comprising the material.[34]

Medical Imaging

X-ray computed tomography (CT) was used to scan each harp. The scanner used was a Toshiba Medical Corporation 320-multidetector row Aquilion ONE, operating at 135 kVp for the Lamont harp and 120 kVp for the Queen Mary harp.[35] The output data is in DICOM format, with a bit depth of 16-bits. The full diameter of the scans is 50 cm, and

[32] Jim Tate and Susanna Kirk, "Analytical Research Section Report No. AR 2010/39: XRF analysis of the Queen Mary and Lamont harps." Internal Report. National Museums Scotland, 12 July, 2010, Appendix 1.
[33] ibid.
[34] "SEM Illustrative Example: Secondary Electron and Backscatter Electron Images," last modified 30 October, 2014, http://www.andersonmaterials.com/sem/sem-secondary-backscatter-images.html.
[35] A higher kVp was used for the Lamont harp in order to penetrate the thick metal cheekbands and the metal end cap.

the resolution is 0.5 mm.[36] The scans were rendered and analysed with the OsiriX DICOM viewer software package, version 5.6, 64-bit, on an Apple MacBook Pro running Mac OS 10.7.5. A set of three full scans was taken for each harp.

CT scanning has successfully been used since the early 1980's as a powerful non-invasive analysis tool for the study of musical instrument construction.[37] CT effectively generates a three-dimensional 'x-ray' (referred to as a tomogram) that can be viewed from any angle, or in any cross-section, allowing examination and measurement of all parts of the construction. The specific uses of CT for this project are discussed below in the Intended Research Outcomes section.

Construction of the Instrument

This section provides a brief description of the basic construction of these harps, noting the terms used for the parts of the instruments.

As noted at the beginning of this introduction, the historical harp of this type is referred to variously as an Irish harp, *cláirseach* (in Irish), or *clàrsach* (in Scottish Gaelic). The names all refer to the same instrument, as there is no organological difference between these harps in Ireland and Highland Scotland.[38] The choice of term is left to the discretion of the user, and depends on the context. This dissertation uses the term Irish harp, but only when referring to these instruments as a group, as that is the term

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[36] Karen Loomis et al., The Lamont and Queen Mary Harps," *The Galpin Society Journal* 65 (2012): 114.
[37] Steven Sirr and John Waddle, "CT Analysis of Bowed Stringed Instruments," *Radiology* 203 (1997): 801– 05. Steven Sirr and John Waddle, "Use of CT in Detection of Internal Damage and Repair and Determination of Authenticity in High Quality Bowed Stringed Instruments," *Radiographics* 19, no. 3 (1999): 639 – 46. Arnd Both, "3D-Computed Tomography and Computational Fluid Dynamics: Perspectives in the Non-Contact Organological and Acoustical Research of Ancient Musical Instruments," in *Studies in Music Archaeology: VI: Challenges and Objectives in Music Archaeology*, ed. A. A. Both, et al. (Rahden: Marie Leidorf, 2008), 383 – 88. Terry Boreman and Berend Stoel, "Review of the Uses of Computed Tomography for Analyzing Instruments of the Violin Family with a Focus on the Future," *Journal of the Violin Society of America* 22, no. 1 (2009): 1 – 12.
[38] Joan Rimmer, *The Irish Harp* (Cork: The Mercier Press, 1969), 35.

most often used by historical and modern commentators in this context. Specific instruments are always referred to individually by name.[39]

The frame of the Irish harp is constructed of three members: soundbox, forepillar, and neck. Mortise and tenon joints connect the members of the frame, which is designed to be held together by the tension of the strings. Each frame member is constructed from one piece of wood, including the soundbox, which is made from a single large timber hollowed out from the back, oriented with the wood grain running parallel to its long axis. The opening in the back of the soundbox is enclosed by a separate board. The soundbox has a flat back upon which it rests when the harp is not in use, and a single projecting foot at its base upon which the harp balances while it is in playing position.

The front face of the soundbox has a raised string band with metal reinforcements, referred to as 'string shoes', at the string holes. The raised string band enlarges at the treble end of the soundbox to form a pair of arches, commonly referred to as the 'eyebrows'. The harp is strung with wire strings, and each is held in place at the soundbox by a toggle knotted to the end of the string inside the box. The forepillar is curved and has a reinforcing T-section along its central portion. The sides of the neck are reinforced with metal cheekbands, through which the tuning pins pass. The line of tuning pins on the neck is referred to as the harmonic curve.

The parts of the harp frame are illustrated in the figure below.

[39] When referring specifically to the harps in Scotland, it is most appropriate to use the term *clàrsach*.

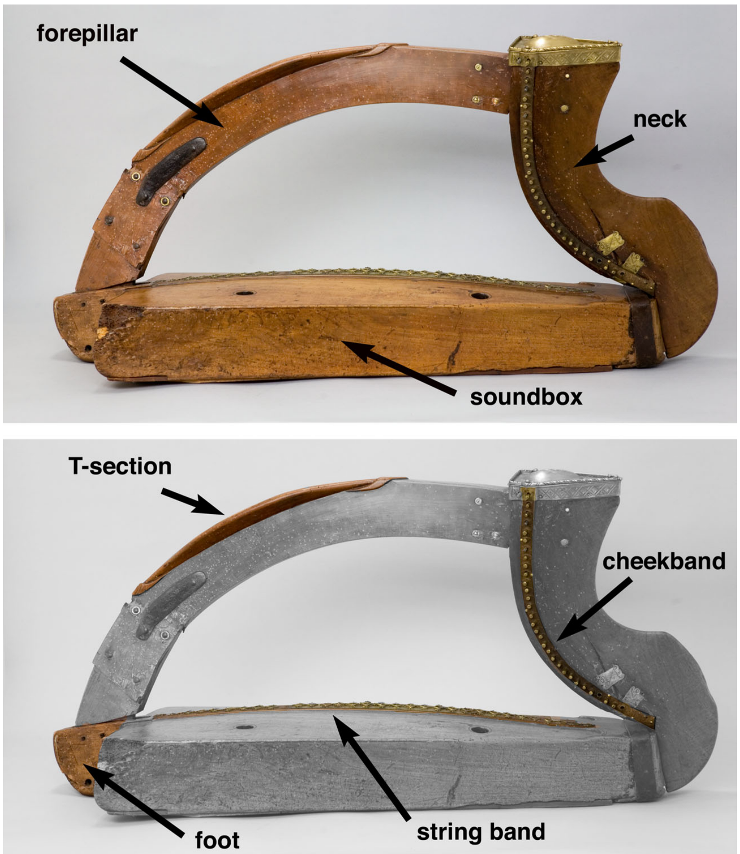

Figure 0.2: *The Lamont harp, illustrating the parts of the frame. Photograph: Maripat Goodwin, edited by the author.*[40]

The Lamont and Queen Mary harps are of the form described as 'low-headed' by Rimmer (1964).[41] The low-headed Irish harp is characterized by a comparatively short string scaling in the bass. When the instrument is in playing position, the bass end of the neck is nearly level with the treble end, hence the designation 'low headed'. An additional distinguishing characteristic of the construction is the forepillar joint at the neck, which has the neck mortised on top of the end of the forepillar. The 'low-headed' Irish harp is understood to be the form of the instrument prior to the mid to late 17th century, as contrasted with the later 'high-headed' Irish harp.[42]

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[40] This figure is adapted from two figures in Loomis, "Structural Breaks and Repairs," 7 – 8.
[41] Joan Rimmer, "The Morphology of the Irish Harp," *The Galpin Society Journal* 17 (1964): 39 – 40. Rimmer further subdivides this group into 'small low-headed' and 'large low-headed'.
[42] Rimmer, "Morphology of the Irish Harp," 44.

In the later 'high-headed' form, the bass strings are proportionately longer, resulting in a neck that sweeps upwards towards the bass end of the frame. When the instrument is in playing position, the bass end of the neck is higher than the treble end, hence the designation 'high headed'. In contrast to the low-headed harp, the end of the neck is joined to the side of the forepillar, with the end of the forepillar extending above the neck.[43]

The convention used for referring to locations on the harps is illustrated below. Left and right are always from the perspective of the player holding the harp. Tuning pins and string holes are numbered from #1 in the treble, increasing towards the bass.

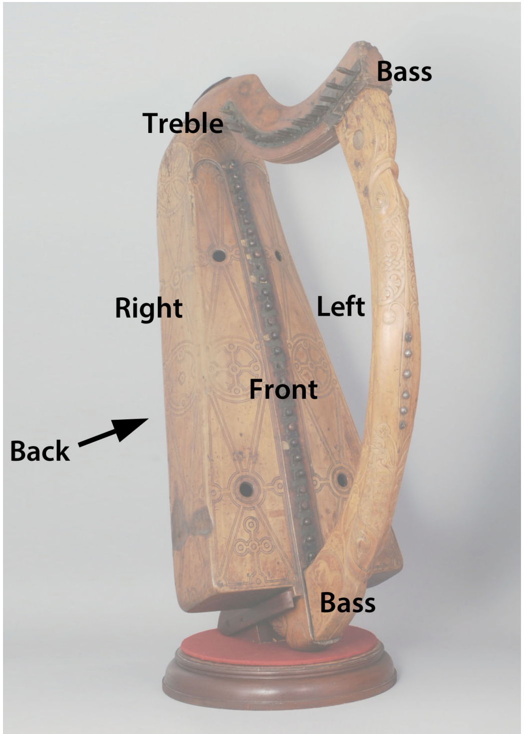

Figure 0.3: *Convention used for referring to locations on the harps*

[43] For comparison, the Bunworth (Museum of Fine Arts, Boston) is an example of a 'high-headed' Irish harp.

Organization of the Dissertation

This dissertation is divided into two parts. Part I discusses the stringing of the instruments, presenting materials analysis of wire fragments, analysis of the effect of damage to the frames on the length and number of strings, and proposed reconstructions of string lengths for the straightened frames. Possible solutions for the pitch and gamut of each harp are also discussed. The construction of the harps is discussed where it is relevant to understanding the stringing. Part II presents a general discussion of the construction of each harp, including materials, decorative work, modifications, and signs of wear. This section also discusses evidence that may help establish dates of construction and timelines of modifications. Diagrams showing the dimensions of each harp are also presented.

List of Abbreviations

BSC	Backscattered electron imaging
CT	X-ray computed tomography
DICOM	Digital imaging and communications in medicine
EDX	Energy dispersive x-ray spectroscopy
f (Hz)	Frequency in hertz
FWHM	full width at half maximum
kgf	kilogram-force
kVp	Peak kilo-volt
SEI	Secondary electron imaging
SEM	Scanning electron microscopy
wt%	percent by weight
XRF	X-ray fluorescence
σ	standard deviation

List of Terms

CT scan	see above, under Methodology: medical imaging
Jeton	a metal token used for counting
Photomicroscopy	imaging with a microscope
Photomicrograph	an image taken through a microscope
Scanning electron microscopy	imaging with a scanning electron microscope
Scanning electron micrograph	an image taken with a scanning electron microscope
Surface rendering	a depiction of the surface of an object in three dimensions (in this study, generated from the CT scans)
Tomogram	an image generated from a CT scan
Volume rendering	a depiction of an object as a solid in three dimensions (in this study, generated from the CT scans)
Voxel	a volume element in a tomogram, three-dimensional analogue of a pixel
X-ray fluorescence	see above, under Methodology: materials analysis

This dissertation uses Helmholtz pitch notation for naming musical notes on the scale: c′ is Middle C.

Intended Research Outcomes

This dissertation is intended to provide a comprehensive survey and analysis of the Queen Mary and Lamont harps, including the knowledge and understanding of the materials, measurements, modifications, and historical construction practices necessary for building faithful reproductions. These reproductions are essential to effective interpretation and reconstruction of the repertory associated with the historical instruments. It has also been the intention of this project to develop a useful methodology for the study and analysis of the other surviving historical harps of this type, none of which has been studied this comprehensively.

This research is for the benefit of present day luthiers, musicians, and other researchers, and consequently the general public who may wish to explore and experience the cultural heritage associated with these harps, either through performance of historical repertory on faithful reproductions, or through enhanced interpretive material for the instruments themselves at the National Museum of Scotland.

The body of data generated by this research project will be archived at the National Museum of Scotland, where it will be accessible to current and future luthiers and other researchers of these and similar harps. This data will include, particularly, the photographic surveys and the complete CT scans. Due to the age and uniqueness of these harps, access to them is necessarily limited. This database addresses the on-going issue of frequent requests by luthiers for access to the instruments by providing the information they require, and by enabling them, via the CT scans, to take accurate measurements themselves without handling the harps.

In the process of this examination and analysis of the Lamont and Queen Mary harps, this study ultimately endeavours to address four fundamental questions that are of importance to scholars, musicians, and luthiers with an interest in these harps. These questions are as follows:

What are the dimensions of these harps?

With regard to the dimensions, although these harps have previously been measured, the internal dimensions of the soundbox and of the joinery have been unknown, as it has not been feasible to fully access these areas.

What are the original string lengths?

Due to shifting and twisting of the frame members, the current string lengths are significantly different from what they would have been when the frames were straight, making it difficult for luthiers to faithfully reproduce these instruments with their intended string lengths and scaling.

What are they made of?

With regard to the materials used to construct the harps, although samples of wood have previously been taken from both harps for microscopic identification, the results have been questioned by a number of researchers and luthiers. No additional materials analysis had been conducted to date on either harp.

How old are they?

The ages of these two harps are not known with any certainty. Even the century to which they belong has been somewhat uncertain. This has made it difficult for researchers studying the development and evolution of the instrument, and for musicians who would like to explore historical repertory that is contemporary with these two harps.

These questions are revisited in the Conclusion to this dissertation, and discussed in the context of how the findings of this study have addressed each of them.

Part I. Stringing

As discussed in the addendum to the author's MMus thesis, there is limited historical information pertaining to the stringing of Irish harps.[44] Several contemporary references do exist, however. These have been discussed, for example in Page (1987), Heymann and Heymann (2003), and in a comprehensive compilation in Chadwick (2004-2009).[45] Historical sources note the use of wire as a point of distinction from other harps. For example, Sir John Pettus, writing in 1683, remarked that

> "most of the choice *Instruments* of *Musick* were and still are either in the whole or in parts composed of *Metals ... viz.* the strings of the *Harp* (which we now call the *Irish Harp* (being strung with wire) in distinction of the *Welsh Harp* strung with *Guts strings*)."[46]

The metal nearly always referred to is a copper alloy, either brass or bronze, with possibly the earliest known reference being Giraldus's 12th-century mention of stringing for the *cithara* in Ireland, as noted in the introduction to this dissertation.[47] Giraldus observed that, "actually, bronze [*aeneis*] strings are used, not strings made of hide."[48] Vincenzo Galilei, Michael Praetorius, and James Talbot all noted brass as the stringing material for the Irish harp, with Galilei also mentioning the use of iron in the treble."[49] Praetorius, writing in the early 17th century, describes the strings of

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[44] Loomis, "Structural Breaks and Repairs," 77 – 79.
[45] Page, *Voices and Instruments*, 218 – 19 and 229 – 30. Ann Heymann and Charlie Heymann, "Strings of Gold", *Journal of the Historical Harp Society* 13 (2003): 9 – 15, revised 2004, http://www/annheymann.com/gold.htm. For a comprehensive list of sources see Simon Chadwick,"Stringing: history," http://www.earlygaelicharp.info/stringing/history.htm.
[46] Sir John Pettus, "Essays on Metallick Words" in Lazarus Ercker, *Fleta minor the laws of art and nature, in knowing, judging, assaying, fining, refining and inlarging the bodies of confin'd metals",* trans. Sir John Pettus, 2nd edition (London: Thomas Dawks, 1685).
[47] Page, *Voices and Instruments*, 230.
[48] ibid. The Latin in square brackets has been added. The version of the Latin text quoted in Page reads "*AEneis quoque utuntur chordis, non de corio factis*". The Latin word *aeneis* can be translated as copper, bronze, or brass.
[49] "They commonly have strings of brass with some steel in the higher pitches in the manner of the harpsichord [*gravicembalo*]." Vincenzo Galilei (1581), *Dialogue on Ancient and Modern Music,* trans. Claude V. Palisca (New Haven: Yale University Press, 2003), 357. The original Italian text reads "*hanno comunemente le corde d'ottone, & alcune poche*

the "*Harpa Irlandica*" as "*grobe dicke Messings*" (coarse thick brass), which could suggest that the gauges used were thick in comparison to other wire strung instruments of the time.[50] Some of these historical commentators mention compass and tuning as well. Interestingly, the tuning Praetorius gives appears to be partially chromatic, whereas writing later in the same century, James Talbot describes a tuning that is diatonic with a pair of unison strings.[51]

In addition to the use of copper alloy and iron as stringing materials, silver is also mentioned, historically. A harp string of silver appears in the late 12th-century *Acallam na Sénorach* (Tales of the Elders) from the Fenian Cycle. The reference is to a harp with three strings, each of a different metal: "A string of iron, a string of noble bronze, and a string of entire silver."[52] Given the literary context, however, it is possible that these metals have simply been chosen to make a point within the text, and therefore do not necessarily reflect actual stringing used at the time. A more straightforward reference to silver stringing appears much later, in the early 17th century. Writing in 1625, Philip O'Sullivan Beare states that the strings of the harp are "never of iron, but are of brass and silver" (in contrast to Galilei's earlier mention of iron stringing).[53] Recent research by Chadwick (2013) has uncovered further

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d'acciaio nella parte acuta à guisa del Gravicembalo." (Fiorenza: Giorgio Marescotti 1581), 143.

50 Michael Praetorius, *Syntagma musicum*, facsimile reprint, ed. A. Forchert (Kassel: Barenreiter-Verlag Karl Votterle GmbH & Co. KG, 2001), 54, and Plate XVIII. Praetorius also provides a tuning that appears to be partially chromatic.

51 Praetorius, *Syntagma musicum*, 54 and Plate XVIII. Joan Rimmer, "James Talbot's Manuscript (Christ Church Library Music MS 1187): VI. Harps," *The Galpin Society Journal* 16 (1963): 67.

52 Eugene O'Curry, *On the Manners and Customs of the Ancient Irish, Vol. III* (London: Williams and Norgate, 1873), 223. The original Middle Irish reads "*téad diarann, teud duṁa an, an ceadna darccod iomlean*." The term used for the musical instrument in the poem is "*cruit*", which can mean either a lyre or a triangular frame harp. Buckley (2005) notes, however, that the use of this term to refer to a lyre was superseded in the late 10th – 11th century with its use to refer to a triangular frame harp. See Ann Buckley, "Music in Ireland to c. 1500," in *A New History of Ireland, Volume 1: Prehistoric and Early Ireland*, ed. Dáibhí Ó Cróinín (Oxford: Oxford University Press, 2005), 750.

53 Philip O'Sullivan Beare (c. 1625), *Zoilomastix,* quoted in Simon Chadwick, "Stringing history: 16th-17th century," last modified May, 2006, http://www.earlygaelicharp.info/stringing/history2.htm. The original Latin reads "*nunquam ferreas, sed aeneas, vel argentas lyrae*." O'Sullivan Beare's remark was written as a rebuttal to statements made by Richard Stanihurst in *De Rebus in Hibernia Gestis*. See Alan J.

evidence of the possible use of silver strings in an early transcription of a late 18th-century letter written by Ralph Ouseley, owner at the time of the Trinity College harp. Ouseley states in his letter that this harp had silver strings on it when it was acquired by the previous owner, Matthew MacNamara, in the mid 18th century.[54] Heymann and Heymann (2003) have hypothesized that silver and gold strings could have been used historically to compensate for the characteristically short scaling in the basses of the low-headed Irish harps, and have carried out experiments with silver and gold strings on harps modeled after the surviving historical instruments.[55] Although to date no direct physical or historical evidence has been found, many modern reproductions of the historical low-headed Irish harps now employ silver and/or gold strings in the bass.[56]

Beyond what has been noted above, there is little additional historical information pertaining to the stringing of low-headed Irish harps. There are a few additional references to number of strings and stringing material for the later, high-headed harps, however.[57] Among these is a letter from James MacDonnell to Edward Bunting giving the number of strings for Charles Fanning's harp, and noting the number in the treble that are iron.[58] He does not indicate the string gauges, though, and because this harp has not survived, the string lengths are also not known. In his 1840 volume of *The Ancient Music of Ireland,* Bunting gives the compass and tuning for Dennis

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Fletcher, *Drama and the Performing Arts in Pre-Cromwellian Ireland: Sources and documents from the earliest times until c. 1642* (Cambridge: D. S. Brewer, 2001), 519.

[54] Simon Chadwick, "Silver Strings on the Trinity College Harp," http://earlyclarsach.blogspot.co.uk/2013_09_01_archive.html. Precious metal stringing of historical instruments has been discussed by other authors, most recently in Patrizio Barbieri, "Gold- and Silver-Stringed Musical Instruments: Modern Physics vs. Aristotelianism in the Scientific Revolution," *Journal of the American Musical Instrument Society* 36 (2010): 118 – 154. For the medieval psaltery, Page notes that the 13th-century writer Bartholomaeus Anglicus mentions silver strings in addition to copper alloy, and that the 15th-century writer Jean de Gerson mentions silver, as well as brass and gold strings. Page, *Voices and Instruments*, 217.

[55] Ann Heymann and Charlie Heymann, "Strings of Gold," *Journal of the Historical Harp Society* 13 (2003): 9-15, revised 2004, http://www/annheymann.com/gold.htm.

[56] Barbieri, "Gold- and Silver-Stringed Musical Instruments,"147.

[57] Simon Chadwick, "Stringing history: 18th-19th century," last modified January, 2009, http://www.earlygaelicharp.info/stringing/history3.htm.

[58] James MacDonnell, undated letter to Edward Bunting, quoted in Charlotte Milligan Fox, *Annals of the Irish Harpers* (London: Smith, Elder, & Co., 1911), 281.

O'Hampsey's harp (now known as the 'Downhill' harp), which includes a pair of unison strings and a gapped bass.[59] It is notable that the tuning is known for this instrument, because it has survived intact, and although there is some ambiguity due to the presence of two extra string holes in the soundbox, a complete set of string lengths is known.

Because only limited information regarding stringing practices has been available, present day builders of harps modeled after the historical instruments have had to decide how to string their instruments without knowing the gauge or alloy of the wire used historically, and often without knowing the tuning and compass. This has been further complicated by having to estimate 'as-built' string lengths from the distorted and damaged frames of the surviving historical instruments.

An important piece of physical evidence for the stringing of the low-headed harps came to light in the 1990's with the discovery by Robert Evans of a wire fragment adhered to a tuning pin belonging to the surviving metalwork of the Ballinderry harp.[60] This wire fragment was analysed and found to be a 0.7mm diameter wire of copper alloy containing 10% zinc.[61] Until the commencement of the current study of the Lamont and Queen Mary harps, this was the only known wire fragment associated with a low-headed Irish harp. As noted in Loomis (2010), a second fragment of wire has been discovered embedded in a string hole in the soundbox of the Lamont harp.[62] Two additional small wire fragments have since been discovered in the Queen Mary harp. The analysis of these three fragments is discussed in Chapter 1. Chapter 2 proposes reconstructed string lengths for 'straightened' frames, and discusses possible tuning regimes based on the string scaling.

[59] Bunting, *Ancient Music of Ireland*, 23.
[60] Robert Evans, "A Copy of the Downhill Harp," *The Galpin Society Journal* 50 (1997): 124. The Ballinderry harp (National Museum of Ireland, Antiquities Ref: WK.372) consists of the metal fittings for a 36 string low-headed harp, found in the 19th c. in the crannog of Ballinderry, Co. Westmeath, Ireland.
[61] Evans, "Downhill Harp,"124.
[62] Loomis, "Structural Breaks and Repairs," 77 – 90.

Chapter 1. Wire Fragments

Queen Mary Harp Fragments

Examination of the CT scans of the Queen Mary harp revealed the presence of two small metal fragments in the soundbox. Their location in the area of the string holes suggested that they might be fragments of wire strings.[63]

The position of both fragments as they appear on a tomographic cross-section of the harp is shown in figure 1.1, below.

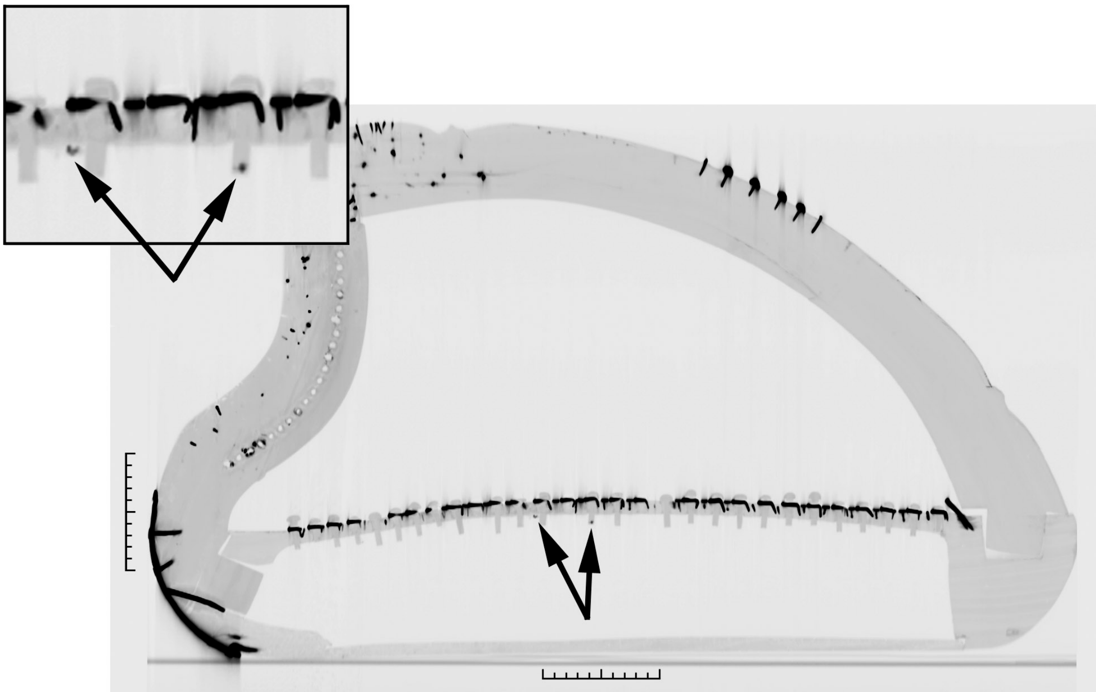

Figure 1.1: *tomogram of the Queen Mary harp in cross-section showing the location of two metal fragments in the soundbox. The fragments are near the string band (arrowed and inset, arrowed). Scale 1 tick : 1cm.*

[63] The image of one fragment, apparently lodged in the end of a wooden string hole peg, was noticed by the author (figure 1.1 inset, right-hand side). A second, larger fragment was subsequently observed by Simon Chadwick (figure 1.1, inset, left-hand side).

In December 2012, the open soundbox was visually examined for the presence of these metal fragments, and both were located. One, a small fragment approximately 3 mm in length, was found embedded in the end of the wooden peg in string hole #15. The other, an approximately 5 mm long c-shaped fragment of wire, was found wrapped around a wad of textile adhered to one side of string hole #13. The location of both fragments is shown in the photograph in figure 1.2. A detail of the interior of the soundbox showing the fragments in situ is shown in figure 1.3.

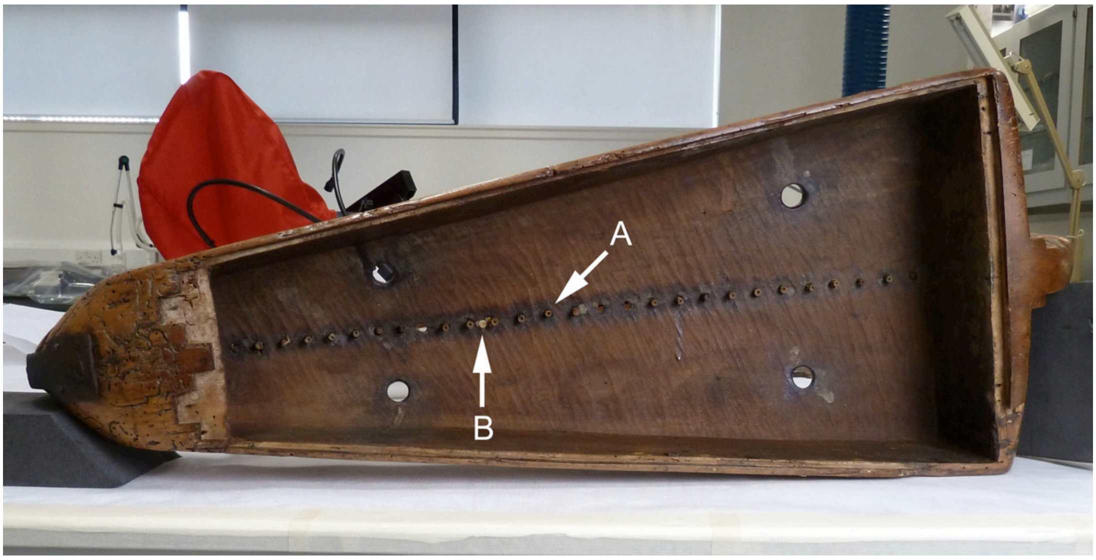

Figure 1.2: *location of two wire fragments in the soundbox of the Queen Mary harp. A ~3 mm fragment ('A', arrowed) was found embedded in the end of the wooden peg in string hole #15, and a ~5 mm fragment was found wrapped around a wad of textile to one side of string hole #13.*

Figure 1.3: *detail of the interior of the Queen Mary harp soundbox showing the two wire fragments. Fragment A is embedded in the end of a wooden string hole peg, and fragment B is wrapped around a wad of textile. The treble end of the soundbox is towards the left of the photo.*

Fragment 'A'

As noted above, the smaller of the two metal fragments (labeled 'A' in figures 1.2 and 1.3) was found embedded in the end of a wooden string hole peg located in string hole #15. As discussed below, these wooden pegs probably date to a restringing of the harp in 1805.[64] Gunn (1807) reported that the harp was initially restrung with brass wire, as per the wishes of the Highland Society of Scotland, before being restrung again with gut at the suggestion of the Swiss harpist John Elouis, who was resident in Edinburgh at the time.[65] Elouis subsequently played the instrument strung with gut for members of the Society, and fragments of gut string found attached to three of the wooden pegs may date from this time (see figure 1.4).[66]

[64] Sanger and Kinnaird, *Tree of Strings*, 58.
[65] Keith Sanger, "John Elouis," WireStrungharp.com, accessed 29 April, 2014. http://www.wirestrungharp.com/harps/harpers/elouis/elouis_john.html#_ednref2.
[66] Gunn, 18 – 20.

Figure 1.4: *a wooden peg from string hole #8, of the Queen Mary harp soundbox. A fragment of gut string is knotted around the shaft.*

Prior to Elouis's involvement, Gunn had consulted with Andrew Wood of Muir, Wood and Company, a prominent Edinburgh musical instrument manufacturer, for advice on tuning and stringing the harp in brass wire.[67] Gunn describes Wood as "an ingenious and experienced mechanic, and a manufacturer of the Harp, and other musical instruments".[68] According to Cranmer (2003), Wood "directed manufacture, tuning and repairs" at the company, which primarily made square pianos but also made other instruments, including pedal harps.[69] The wooden soundbox pegs currently in the soundbox of the Queen Mary harp are, notably, of the style used on pedal harps. Microscopic examination of some of the pegs by Ticca Ogilvie at the National Museums Scotland Collections Centre revealed that they were made from tropical woods, and it is probable that they were supplied by either Wood or Elouis in 1805. As noted above, the metal fragment was found lodged in the end of one of these pegs. Some of the pegs have a channel cut into the end of the shaft, and one of the remaining gut string fragments was found pressed cross-wise into one of these as

[67] Gunn, 18. For Muir, Wood and Co., see John Cranmer, "Muir, Wood and Company," in *The Piano: An Encyclopedia*, ed. Robert Palmieri (New York: Routledge, 2003), 243.
[68] Gunn, *Historical Inquiry*, 18.
[69] Cranmer, "Muir, Wood and Company," 243.

shown in figure 1.5. It is possible that these pegs were used in a similar manner when the harp was strung with wire.

Figure 1.5: *the end of the wooden peg in hole #4, as viewed from the interior of the soundbox. The peg has a channel cut across the end of the shaft, with a fragment of gut string in it.*

Figure 1.6 shows the end of the wooden peg for string hole #15. In the top right-hand photo, the metal fragment is just visible embedded in the end of the peg. A photomicrograph of the fragment (bottom, centre) reveals the characteristic balloon shaped corrosion that identifies this metal as iron.

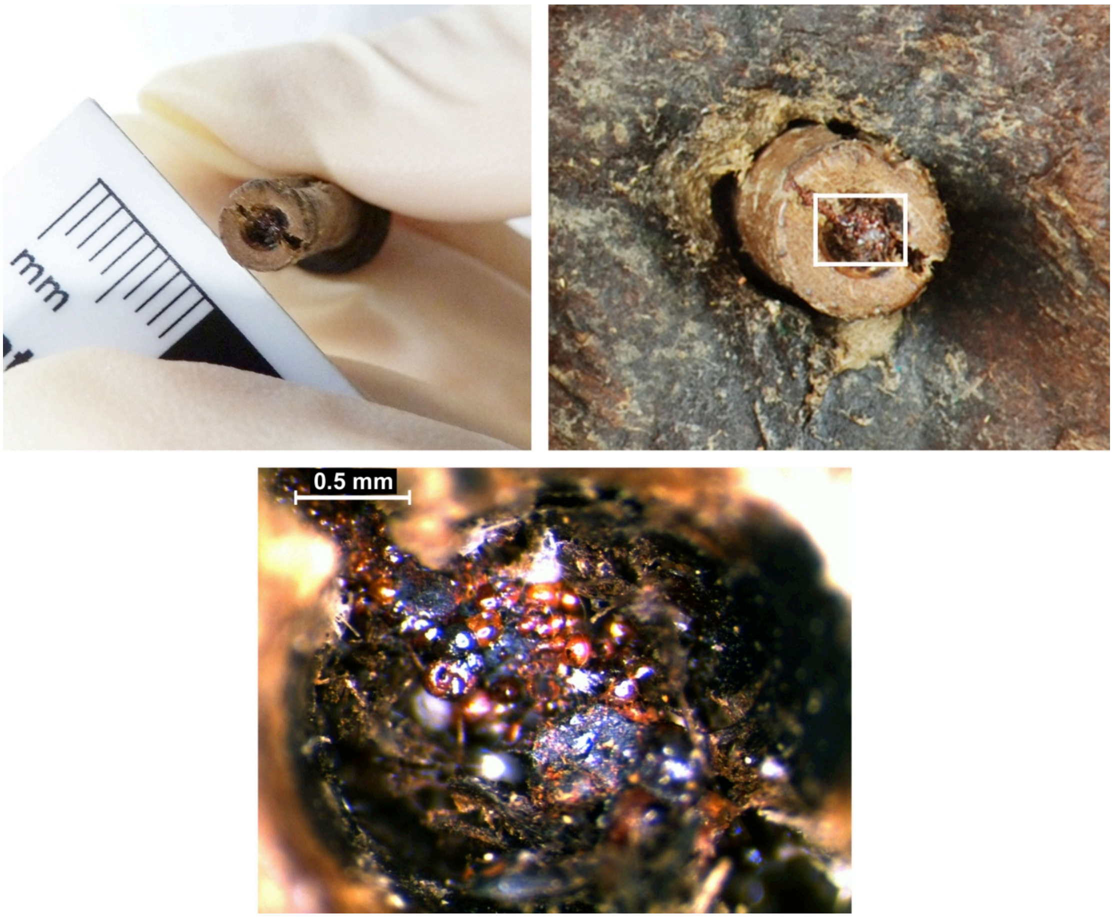

Figure 1.6: *the end of the wooden peg for string hole #15 of the Queen Mary harp soundbox. In the photo at top right, the peg is shown in place in the soundbox. A fragment of metal is just visible embedded in the end. At bottom centre is a photomicrograph of the metal fragment. The area of this image is indicated by the white box in the photo at top right. The photomicrograph shows the characteristic 'balloon shaped' corrosion that identifies this metal as iron.*

The photomicrograph in figure 1.7 shows one end of the fragment visible from the side of the peg. Viewed in cross-section, the fragment appears to be a thin wire. Due to the degree of corrosion, it was not possible to ascertain the original diameter. The current diameter is approximately 0.5 mm. As discussed, the pegs were probably put on the harp for the restringing in 1805. It is likely that this iron wire fragment dates to this time, and therefore does not date to the historical period of this instrument. Although Gunn doesn't mention using iron wire to restring the Queen Mary harp, it is plausible that iron would be tried in the treble with brass in the bass. The location of this soundbox peg in the middle of the compass doesn't preclude this as all of the pegs are loose and can easily be moved around.

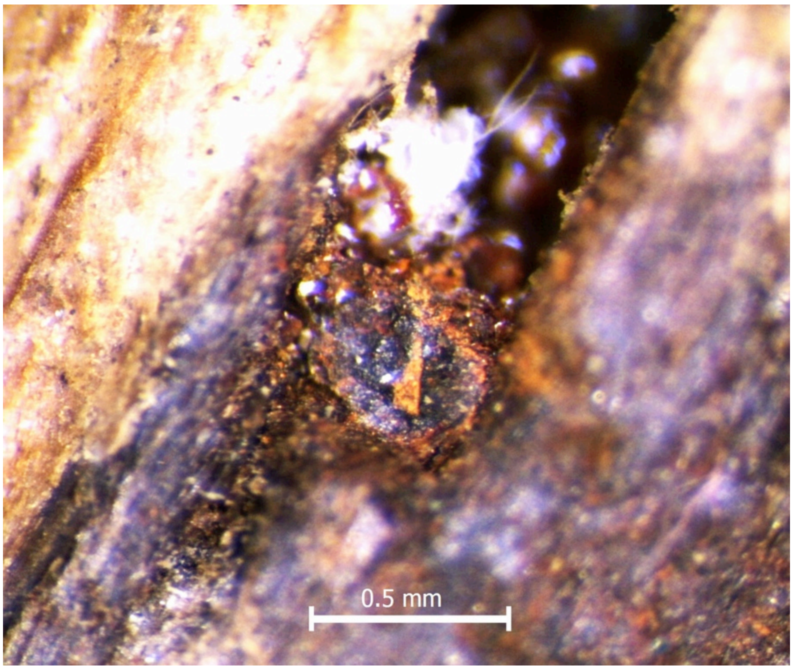

Figure 1.7: *photomicrograph of the side of the wooden soundbox peg for string hole #15 of the Queen Mary harp soundbox. This image shows the end of the iron fragment (at centre), which appears in cross-section to be a thin wire.*

Fragment 'B'

The larger of the two metal fragments was found attached to a wad of textile adhered to one side of string hole #13, as discussed above (see figures 1.2 and 1.3). This fragment is a curved piece of wire approximately 5 mm in length. It is green in colour, indicating that it is probably a copper alloy. Stains on the textile suggest it was originally wrapped all the way around it. The textile would have been too flexible to serve as a string toggle, so this wire fragment was probably not part of a string.

The textile was found adhered to a layer of varnish that had dripped into the string hole from the exterior of the soundbox. This varnish was apparently applied to the exterior of the soundbox with the pegs in place, as it had run into several of the string holes and down some of the peg shafts. It therefore postdates their addition to the harp. When the interior of the soundbox was examined, the textile was found pushed inward, with one end still adhered to the string hole. This presumably happened at some point when the peg was removed and reinserted.

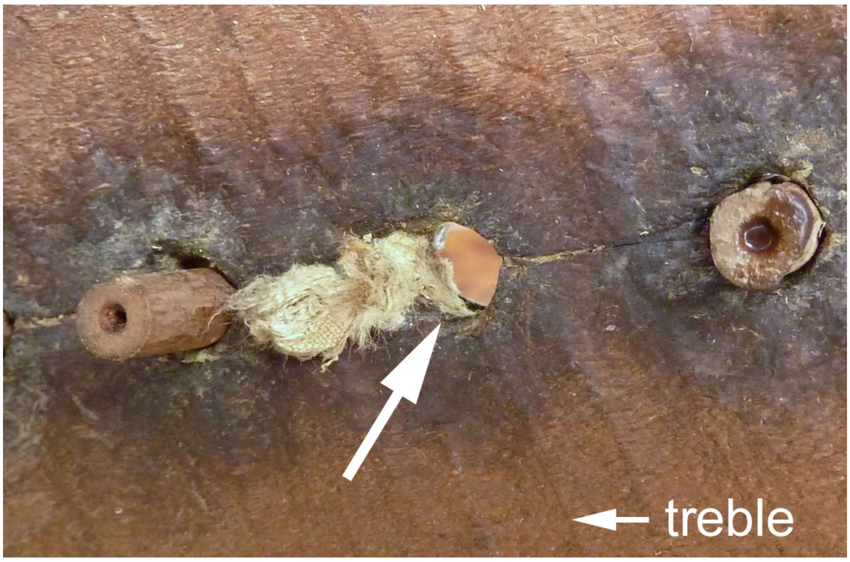

Figure 1.8: *the textile found adhered to string hole #13 of the Queen Mary harp, as viewed from inside the soundbox. The treble end of the soundbox is towards the left of the photo, as indicated.*

The textile with attached wire fragment was removed from the harp by Ticca Ogilvie for analysis. Figure 1.9 shows them together, after they were removed from the harp. As shown in figure 1.10, the string hole is enlarged on one side where the textile had been located. This enlargement is on the treble side of the string hole, and is aligned with an area of deep wear on the string shoe. The textile wad was apparently an attempt to fill this space.

Figure 1.9: *the textile with wire fragment after removal from the soundbox of the Queen Mary harp.*

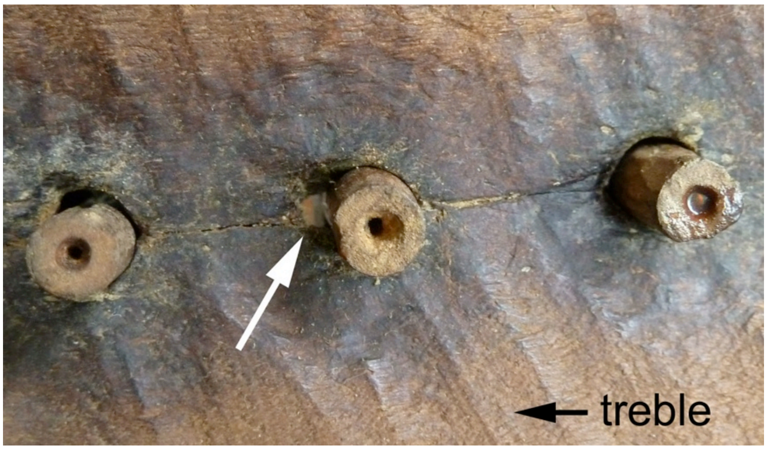

Figure 1.10 *string hole #13, showing enlargement on the treble side where the textile was located (arrowed), as viewed from the inside of the soundbox. The treble end of the soundbox is towards the left of the photo, as indicated.*

After removal from the harp, the textile and wire fragment were examined microscopically and imaged with SEM. The textile is constructed of a coarse over-under natural weave, with a z-twist in both the warp and the weft fibres.[70] A photomicrograph is shown in figure 1.11.

Figure 1.11: *a photomicrograph of the Queen Mary harp textile and wire fragment. The textile is a natural fibre, with a coarse over-under weave. The green corrosion on the wire suggests it is a copper alloy. Corrosion stains on the textile indicate that the wire was probably wrapped entirely around it. Photomicrograph: Jim Tate and Lore Troalen.*

Under examination with SEM, the distinctive nodes characteristic of flax were visible on the textile fibres, identifying it as linen, as shown in figure 1.12.

[70] Observed by Ticca Ogilvie under microscopic examination.

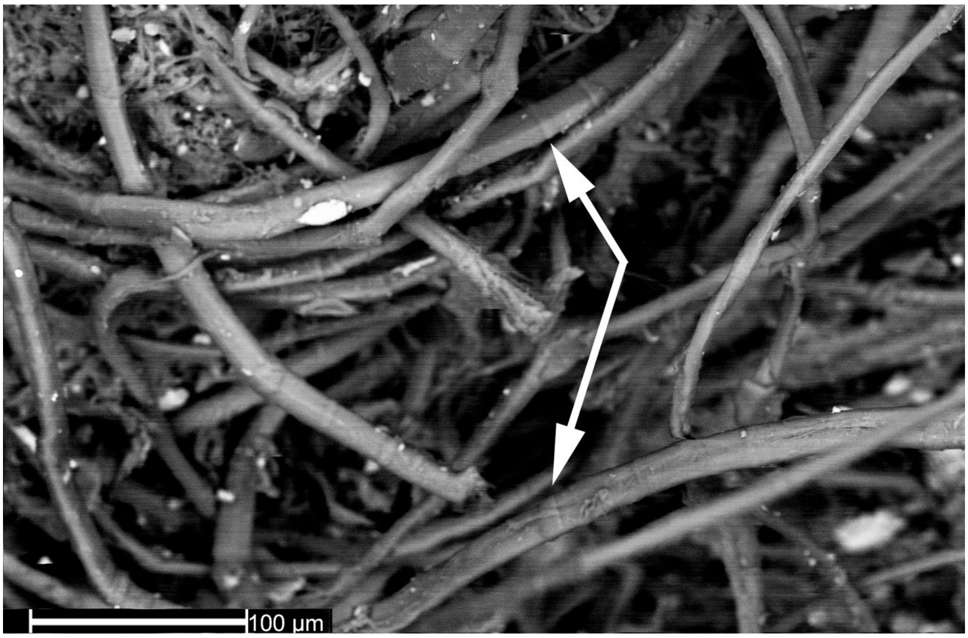

Figure 1.12: *a back-scattering scanning electron micrograph of fibres in the Queen Mary harp textile. Nodes characteristic of flax (arrowed), identify this textile as linen.*

Imagery of the wire revealed that the corrosion, although copper based, is of an unusual form that may involve an organic, possibly bacterial, process.[71] The textile and wire were probably exposed to damp conditions for a number of years when the harp was in storage in Stewartfield House at Dalguise during the 19th century, and this may have been a contributing factor. A photomicrograph and scanning electron micrograph (SEM image) of the corrosion are shown in figure 1.13.

[71] Flavia Pinzari, Agricultural Research Council, Research Centre for Soil-Plant System Studies, Rome, Italy, e-mail message to Lore Troalen, National Museums Scotland (forwarded to author), 8 December, 2012.

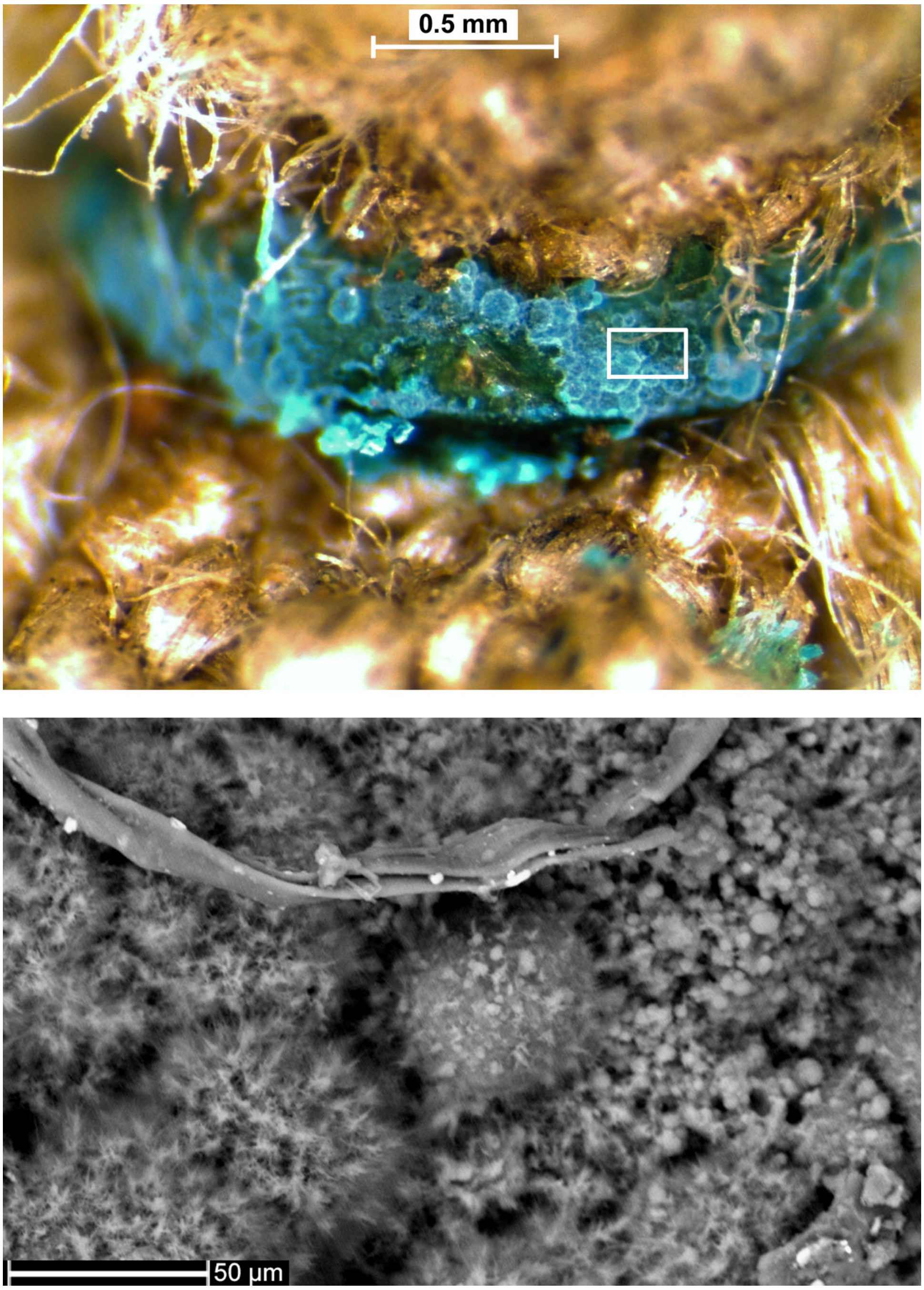

Figure 1.13: *photomicrograph (top) and back-scattering scanning electron micrograph (bottom) of the wire fragment (B) from the Queen Mary harp. The white box in the photomicrograph indicates the area imaged in the scanning electron micrograph. The corrosion is of an unusual form that may involve a bacterial process.*

The composition of the corrosion on the surface of the wire was analysed with SEM-EDX and found to contain a significant amount of carbon, suggesting an organic process.[72] Copper was also present, as were traces of silicon, sulfur, chlorine, potassium, calcium, and zinc.[73] This result may provide a clue as to the conditions to which this fragment has been exposed. Notably, it highlights the importance of preparing a clean cross-section of the wire for compositional analysis. While every effort was made to employ non-destructive analysis for the study of these harps, for this wire fragment and the wire fragment from the Lamont harp (discussed later in this chapter), it was necessary to take and prepare samples in order to avoid analyzing the surface corrosion instead of the wire. On old wire, it is difficult to judge the depth of corrosion from visual examination of the surface alone. Additionally, the process of corrosion changes the composition of the alloy near the surface by depleting some elements more than others, so simply removing the powdery outer layer of corrosion is not sufficient preparation for measuring the composition of the interior of the wire.[74]

The wire fragment was prepared for SEM-EDX analysis by cleaning the surface and embedding a sample in an epoxy resin plug, which was then polished to expose a cross-section of the wire.[75] Due to the small size of the fragment, it was necessary to use most of it for the sample. A back-scattering scanning electron micrograph of the polished, exposed cross-section of the wire is shown in figure 1.14. In this image, brightness is proportional to atomic number of the elements in the sample. Areas of corrosion, which include lighter elements, are visible on the lower right-hand side of the cross-sectional surface as darker patches. For the analysis of the composition three areas 0.1 mm in diameter and 0.1 mm from the outer edge of the cross-section were sampled non-destructively with energy dispersive x-ray spectroscopy (EDX). Each area underwent three iterations of measurement. The composition, in percent by weight (wt%), and the measured diameter of the wire are given in table 1.1, below.[76] For each element, the value given in the table is the average for the three areas

[72] Lore Troalen, "Queen Mary harp EDX analysis, 10th-13th December, 2012," (internal report, National Museums Scotland, 2012).
[73] Troalen, "Queen Mary harp EDX analysis."
[74] Justine Bayley, e-mail message to author, 22 November, 2012.
[75] The samples were prepared by Lore Troalen using the procedure recommended by Justine Bayley. Bayley, e-mail message to author, 22 Novemeber, 2012.
[76] EDX analysis courtesy of Lore Troalen, National Museums Scotland.

analysed. The uncertainty is given as the average of each of the standard deviations for these three areas. In every case this was larger than the standard deviation of the three values from which the average wt% was computed.

For this analysis, the minimum detectable level for an element is defined as twice the measurement uncertainty (2σ), after Mitchiner et al (1987).[77] Those elements whose measurements fall below this threshold are signified by a bar in the table. Aluminium was also detected at a level of 1.0 wt% (with the exception of a fourth measurement with a detection at 3.1 wt%). The presence of this aluminium is believed to be due to contamination from the epoxy resin or from the polishing process.[78] It is not included in the tabulated composition. If taken into account it does slightly affect the proportions of the other elements, however.[79] All other elements had no measurable presence.

[77] M. B. Mitchiner, C. Mortimer, and A. M. Pollard, "Nuremberg and its Jetons, c. 1475 to 1888: Chemical Compositions of the Alloys," *The Numismatic Chronicle* 147 (1987): 123.
[78] Hannes Vereecke et al. also encountered aluminum contamination in their SEM analysis of historical brass. See Hannes W. Vereecke, Bernadette Frümann, and Manfred Schreiner, "The Chemical Composition of Brass in Nuremberg Trombones of the Sixteenth Century," *Historic Brass Society Journal* 24 (2012): 70.
[79] With the inclusion of aluminium, the average wt% of the detected elements are as follows: Cu 70.68%, Zn 27.18%, Al 1.05%, Ni 0.25%, Fe 0.15%.

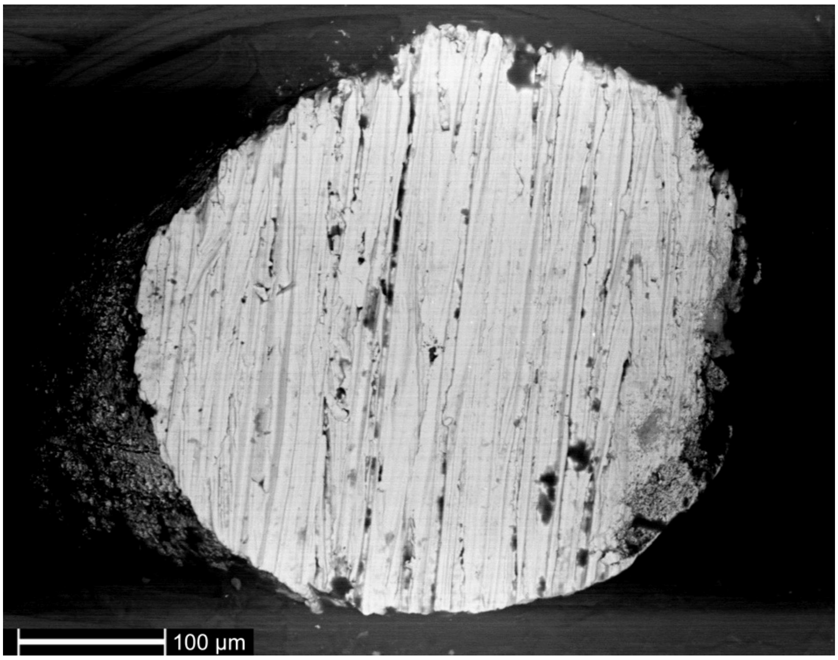

Figure 1.14: *back-scattering scanning electron micrograph of a cross-section of the wire fragment (B) from the Queen Mary harp. The vertical ridges on the face of the cross-section are due to the polishing. The darker areas near the lower right-hand edge of the cross-section are corrosion in the wire.*

Table 1.1.

Composition of Queen Mary harp wire fragment (B)

element	**average wt%**	**average σ**
Cu	71.60	0.62
Zn	27.71	0.61
Ni	0.31	0.12
Fe	0.17	0.07
Pb	-	-
Sn	-	-

(note: remainder is trace elements detected at levels < 2 σ)

diameter: 0.40 mm
density: 8.39 g/cm^3 (calculated from the composition)

Based on the results of the analysis, this wire is a 28% zinc brass with traces of nickel and iron. The composition of this brass is discussed in the context of known historical brasses along with the results of the analysis of the wire from the Lamont harp later in this chapter.

<u>Lamont Harp Fragment</u>

As reported in Loomis (2010) and Loomis et al. (2012), a fragment of wire was discovered inside string hole #14 of the Lamont harp soundbox. A photograph of the fragment in the string hole is shown in figure 1.15. The verdigris coloured corrosion on its surface suggests a copper alloy wire, which would be consistent with historical information for the stringing of Irish harps. One end of the wire appeared to be embedded in the wood, and upon initial observation it had not been determined if it could be extracted without causing damage to either the wood or the wire.

Tomograms from the CT scans of the harp were used to determine the overall shape of the wire, as well as its position in the hole and the surrounding wood, as shown in the cross-section in figure 1.16 and in the three-dimensional rendering in figure 1.17. In a second photograph, taken in December 2012, one end of the wire can be seen embedded in the wood just below the point at which a crack in the soundbox intersects with the string hole (see figure 1.18). The other end of the wire can be seen resting against the inside of the string hole.

Figure 1.15: *photograph of the wire fragment embedded in string hole #14 of the Lamont harp soundbox. The view is from the interior of the soundbox, and the treble end of the harp is towards the right.*

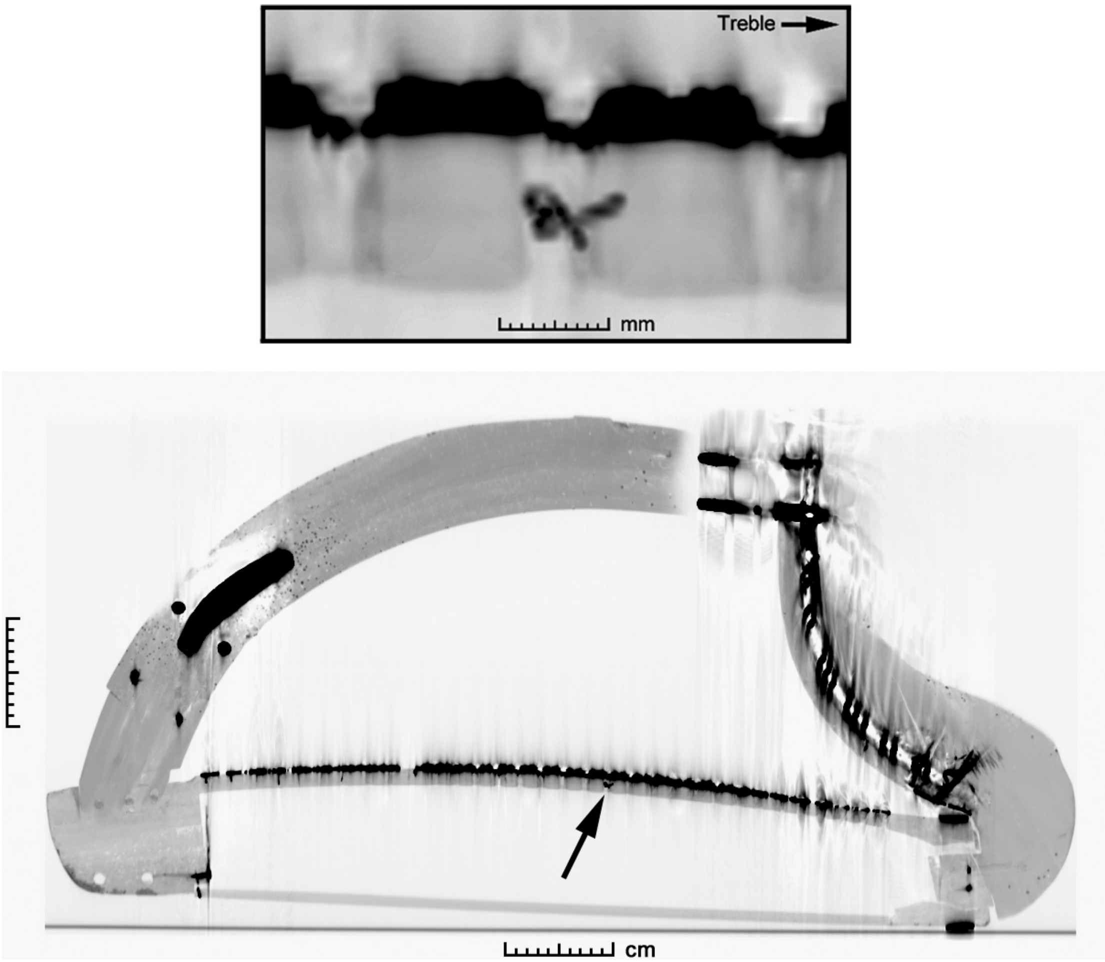

Figure 1.16: *tomogram of the Lamont harp in cross-section showing the location of the wire fragment in the soundbox (bottom, arrowed). A close-up of the wire in the string hole (top) shows its shape and the extent to which it is embedded in the wood.*

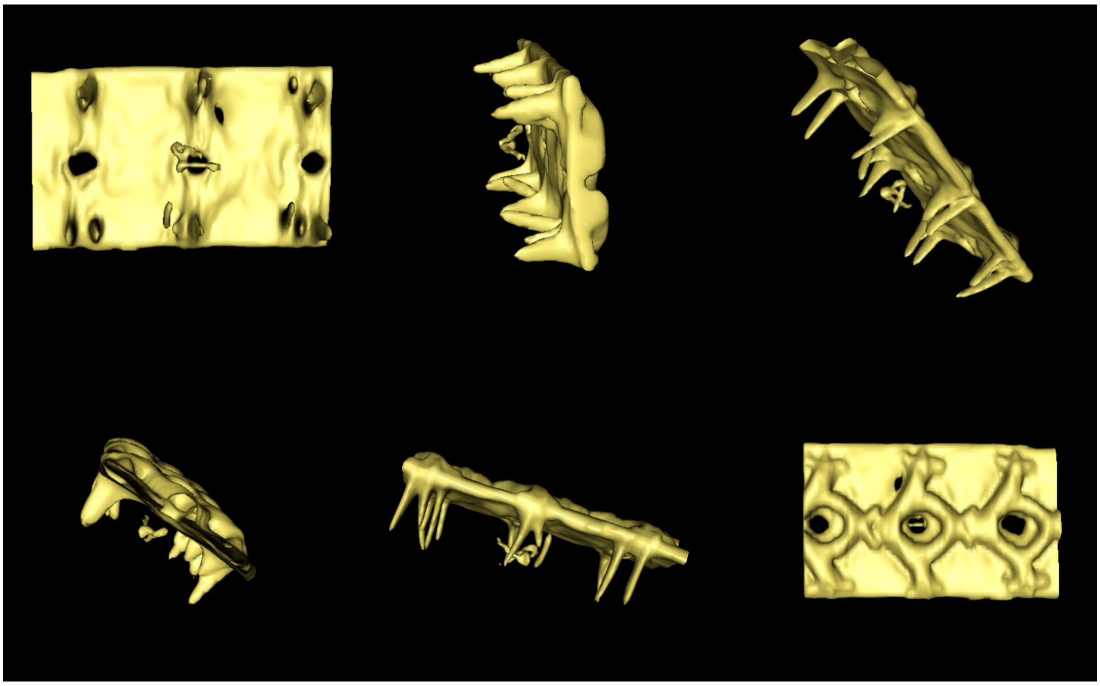

Figure 1.17*: snapshots from a surface rendering video of a section of the string band of the Lamont harp soundbox at the location of string holes #13 – 15. At upper left the wire fragment is in roughly the same orientation as the photograph in figure 1.18, below. The fragment is shown from different angles, revealing its shape and position. For clarity, the wood has been rendered invisible.*

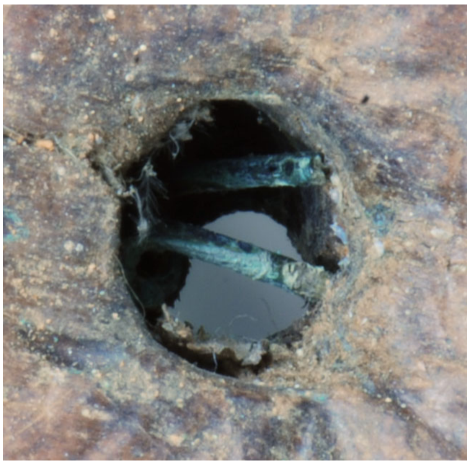

Figure 1.18: *photograph of the wire fragment in string hole #14, taken from a slightly different angle to the photograph in figure 1.15 (see above). One end of the wire is embedded in the wood just below a crack. The other end is not embedded, and can be seen resting against the inside of the string hole. The treble end of the harp is to the right in this photograph.*

By consulting the tomograms and examining the wire in the string hole, it was determined that, with care, it would be possible to safely remove it from the harp. This task was undertaken by Ticca Ogilvie in December 2012, at the National Museums Scotland Collections Centre. It was important to accomplish this without damaging the surrounding wood, but also preserving the twisted shape of the wire fragment, as it might be part of an historical toggle knot. The form of the knot used is not recorded in any contemporary sources, so the shape of this fragment is therefore of interest.[80]

Current replicas of historical Irish harps often use a toggle knot of the form shown in figure 1.19, based on the knot described in Heymann (1988).[81] A few of the surviving 18th-century harps have toggled wires on them, some of which could date to the historical period for these instruments (although this needs to be established). Figure 1.20 shows some of these toggles inside the soundbox of the Sirr harp, a mid 18th-century instrument at the National Museum of Ireland. Here the wire is simply looped once around the toggle and back over itself, with the end left under the toggle. The Sirr harp and the Lamont harp were made in different centuries, and are of different design, though, so the style of knot used may have been different as well (and may have changed over the working life of the harp).

[80] Talbot describes the knotted toggle as "a noose drawn over a bit of wood". Rimmer, "James Talbot's Manuscript," 67.
[81] Ann Heymann, *Secrets of the Gaelic Harp* (Minneapolis: Clairseach Productions, 1988) 123 – 24.

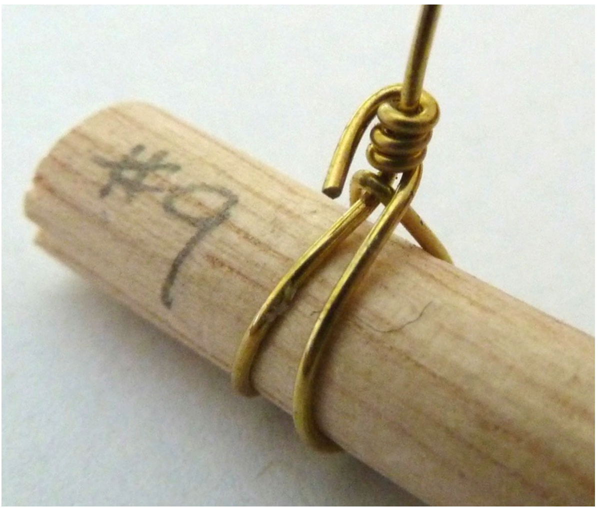

Figure 1.19: *a modern toggle knot made by the author, based on Heymann (1988). Photograph reproduced from Loomis (2010).*[82]

Figure 1.20: *string toggles inside the soundbox of the 18th-century Sirr harp (National Museum of Ireland). The wire is fastened by a single loop over and under the toggle. It has not been ascertained whether these toggles date to the historical period of this instrument. Image reproduced with the kind permission of the National Museum of Ireland.*

[82] Loomis, "Structural Breaks and Repairs," 89.

Figure 1.21 shows two photographs of the wire after it was extracted from the Lamont harp. These were taken at two different orientations to further illustrate the overall shape of the fragment.

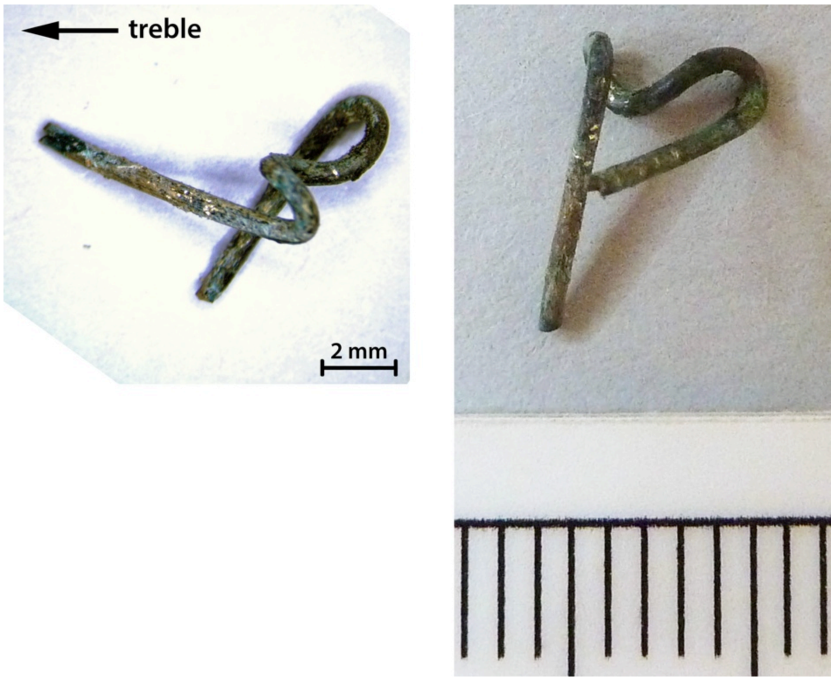

Figure 1.21: *Two views of the Lamont harp wire fragment after extraction from the soundbox. The left-hand image is a photomicrograph in the same orientation as the fragment in the string hole (see figure 1.16). The right hand image was taken with a handheld camera. Both images are shown at the same scale. The scale shown in the right hand image is in mm.*

The left-hand image in figure 1.21 shows the fragment in the orientation in which it was found in the string hole. The end pointing towards the left in both images is the end that was embedded in the wood. The shape of the fragment is consistent with it having been coiled around a thin rod, not more than ~1.5 mm in diameter, which could have been the toggle. A wooden toggle this thin would break under the tension of the string, however a metal toggle would be sufficiently strong, and metal toggles are sometimes used in modern built harps modeled after the historical instruments.[83] Figure 1.22 illustrates this with a mock-up of the fragment.

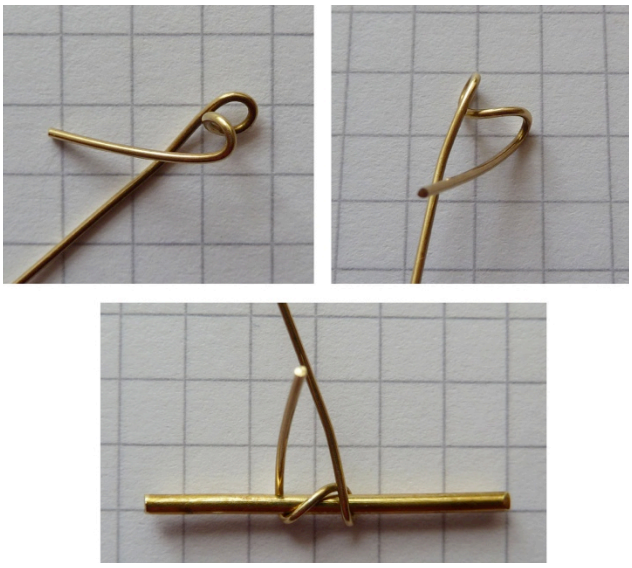

Figure 1.22: *A mock-up of the wire fragment, demonstrating the width of toggle that would fit through the coils. The scale is 1 square: 5 mm.*

If the shape of this wire fragment is due to its having been coiled around a toggle, the question remains as to how this coil came to be lodged inside its string hole with one end of the wire embedded sideways in the wood and the other pointing down into the soundbox. The string toggle normally rests against the inside surface of the soundbox and prevents the end of the wire from pulling up into the string hole. When wires break, they usually do so either at the tuning pin or at the string shoe. If a wire breaks at the string shoe, the length of wire left attached to the toggle will be equal to the depth of the string hole. Neither end of this fragment is long enough to span this distance, however. So, if this section of wire was wrapped around a toggle, the toggle was up inside the string hole when the wire broke. The toggle could have been pulled into the string hole if it had been bent, or broken, or the wire had slid to one end of it. This could also explain the position of the embedded end of the wire. The free end of the wire would have found the crack adjacent to the string hole (an easy entry point), and would have been forced inward as the rest of the wire was pulled upwards. The

[83] The use of metal versus wooden toggles is discussed further in Chapter 3, page 264.

end of this wire fragment is deeply embedded in the wood and would have been difficult to dislodge. The other end of the wire, which would have been left pointing outwards when the string broke, could have been forced inward in the process of trying to dislodge the wire from the string hole, leaving it pointing into the soundbox in the position in which it was found.

After the wire fragment was examined and photographed, an approximately 1.5 mm sample was taken from the end for analysis. The sample was embedded in resin and polished to expose the wire in cross-section. The sampling and preparation were conducted by Ticca Ogilvie and Lore Troalen, at the National Museums Scotland Collections Centre. The prepared sample and the remainder of the fragment were both imaged and analysed with SEM-EDX to examine the condition and diameter of the wire, and to determine its composition. Figure 1.23 shows a scanning electron micrograph of a portion of the wire fragment. This is a secondary electron image (SEI), which highlights the topography of the surface. The large irregular patches are corrosion. The thin parallel lines running the length of the surface are the result of the wire having been drawn, and can be seen following its twist. Of particular note is what appears to be a cleft in the surface of the wire. This is a defect that runs the length of the fragment. It is more easily visible in the scanning electron micrograph in figure 1.24. This is a backscattering image (BSC), which is sensitive to the atomic number of the elements that make up the material. Figure 1.25 shows a close up of the end of the wire that was cut for analysis. Here, in cross-section, the cleft is visible as a crack that extends deep into the interior of the wire.

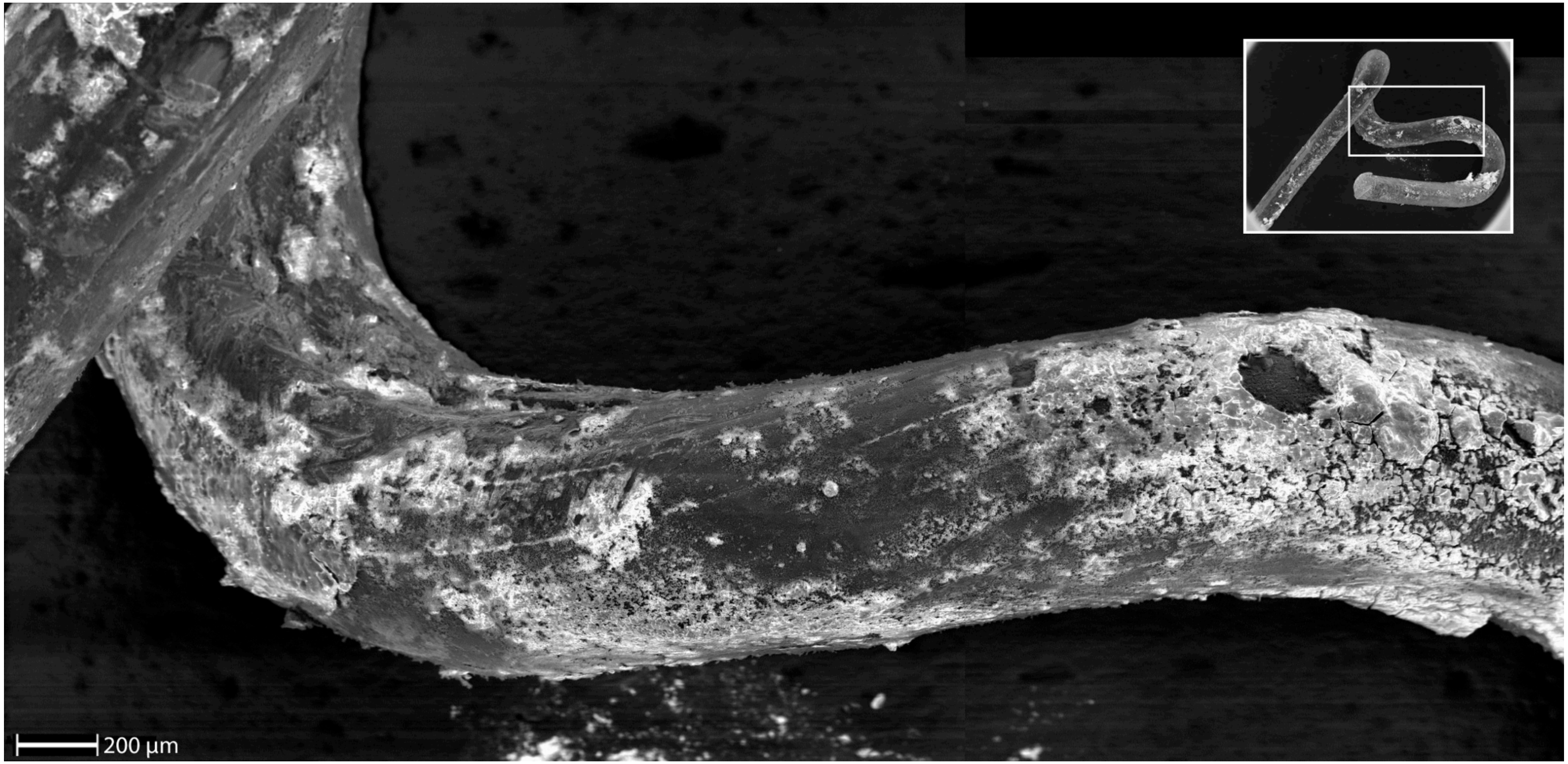

Figure 1.23: *SEI scanning electron micrograph of a detail of the Lamont harp wire fragment. The area imaged is shown in the box in the inset. This image highlights the surface topography. Surface corrosion is visible as large irregular patches. Thin parallel lines left by the drawing of the wire are also visible. A cleft on the inside curve of the bend is a defect in the wire.*

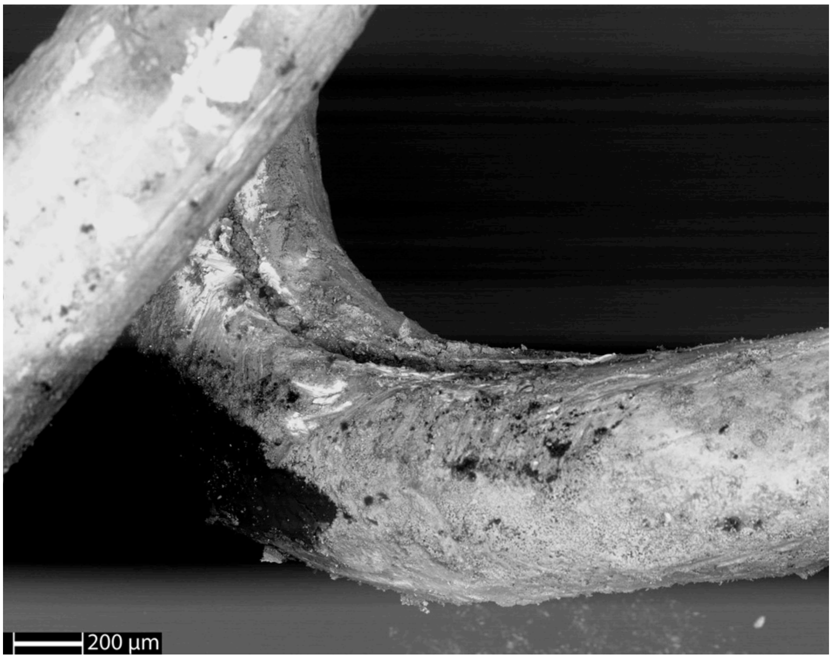

Figure 1.24: *BSC scanning electron micrograph of a detail of the Lamont harp wire fragment. In this image, the defect in the wire is easily visible in the surface of the fragment at the bend.*

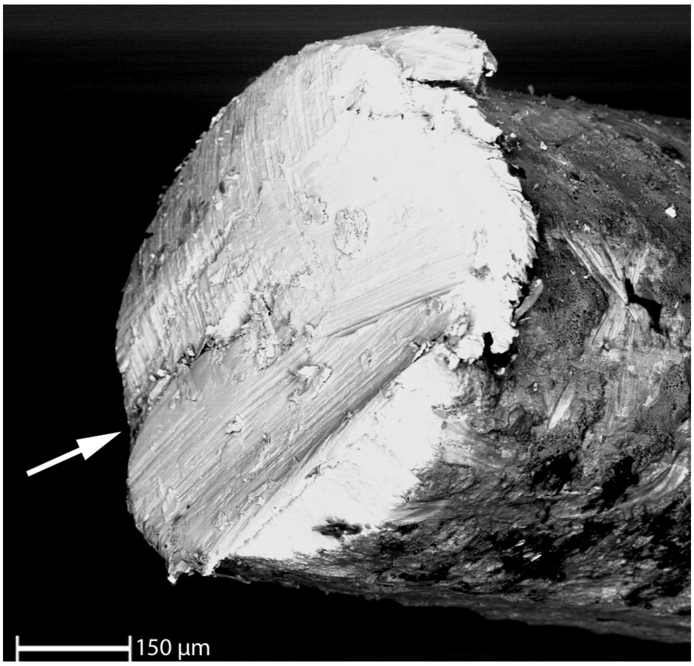

Figure 1.25: *BSC scanning electron micrograph of the end of the wire after cutting for analysis. Viewed in cross-section, the defect (arrowed) can be seen extending deep into the interior of the wire.*

As discussed above, the sample taken from the wire was embedded in an epoxy resin plug and polished to reveal the wire cross-section for analysis. Figure 1.26 shows the cross-section in both SEI and BSC electron micrographs. A portion of the surface is eclipsed by an air pocket in the resin, which indicates that some resin remains on at least part of the polished surface. This is an issue for the analysis of the composition due to possible contamination from aluminium in the resin, as discussed above for the wire fragment from the Queen Mary harp.

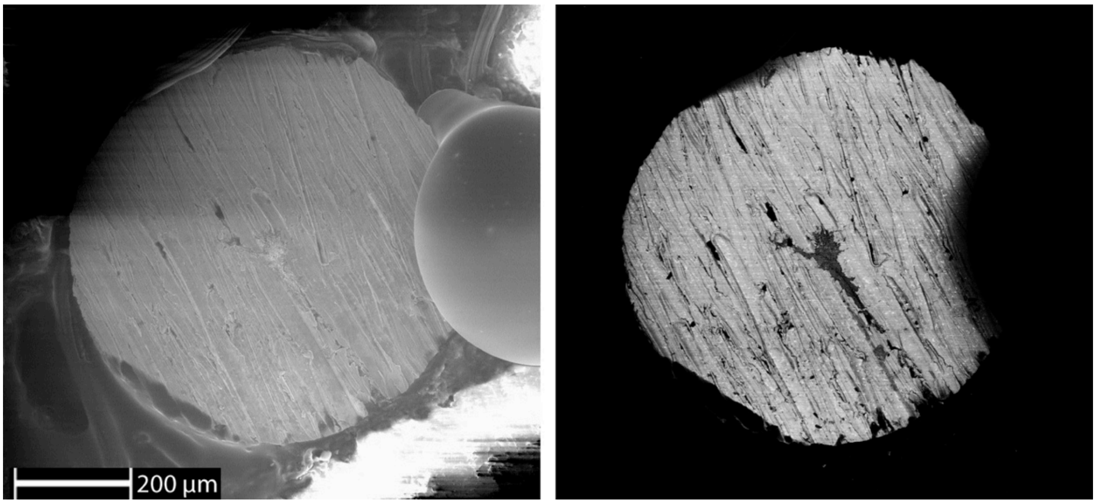

Figure 1.26: *SEM images of a sample cross-section of the wire fragment found in the Lamont harp. The sample has been embedded in resin and polished to expose the end of the wire. An air bubble in the resin is overlapping the edge of the end of the sample on the right-hand side. The SEI image, sensitive to topography, is shown on the left; the BSC image, sensitive to atomic number, is shown on the right. The defect in the wire is visible in this image as a darker, less dense feature extending to the centre of the wire.*

The composition of the exposed cross-section of the wire sample was analysed with EDX at four points, each at a distance of 0.08 – 0.10 mm in from the outer edge of the cross-sectional surface to avoid analyzing possible areas of corrosion. Aluminium was detected in all of the analysed areas, at an average level of 3.0 ± 0.1 wt% in three instances, with a high value of 8.3 wt% in the fourth analysed area. The data from this last area has been excluded.[84]

As with the Queen Mary harp wire sample, the detected aluminium is suspected to be due to contamination from the epoxy resin or the polishing process. Before excluding it from the analysis, however, it is important to check independently if there is any aluminium present in the wire. Prior to the analysis of the sample, semi-quantitative EDX analysis was performed on the exposed end of the wire from which the sample was cut. A spectrogram of the composition is shown in figure 1.27.[85] The height of the peaks is indicative of the quantity of the element present, as is evident in the strong peaks for copper and zinc. Aluminium was detected, but at a level only marginally above the system noise. It is therefore not present in the wire in a measurably significant amount, which indicates that the aluminium detected in the analysis of the sample does not come from the wire itself.[86] It would, however, be advisable to re-polish and re-analyse the embedded sample to confirm the analysis presented here.

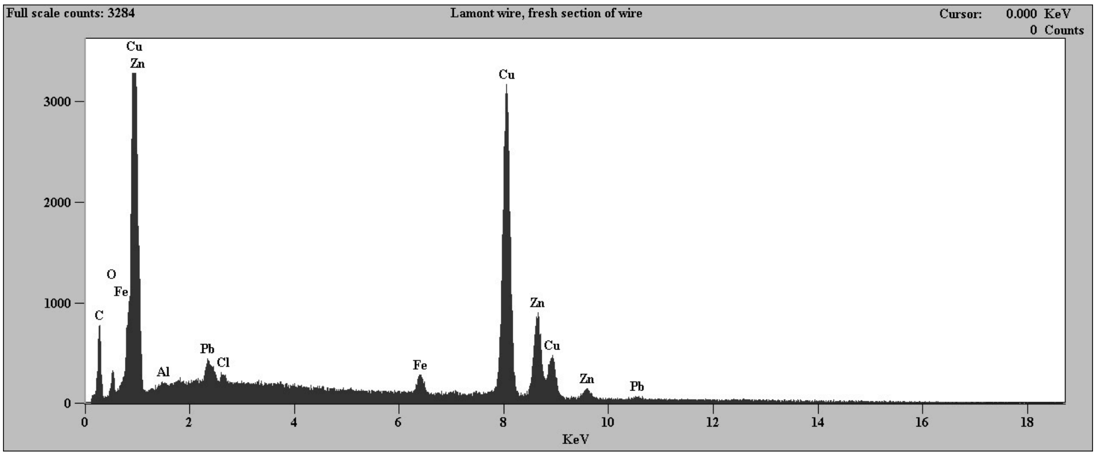

Figure 1.27: *semi-quantitative compositional analysis of the exposed end of the wire after sampling. Spectrogram: Lore Troalen*

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[84] A high percentage of carbon was also detected in the analysed area with the highest percentage of aluminum.

[85] This is a plot of the energies of x-ray photons ('x-rays') emitted by the material as a result of excitation by an x-ray beam. Each chemical element emits photons at a unique set of multiple energies.

[86] The carbon and oxygen detected are due to surface contamination.

The average composition derived from the three sampled areas, excluding aluminium, is given in table 1.2, below.[87] The same criteria used for the presentation of the results for the wire from the Queen Mary harp are also used here.

Table 1.2.
Composition of Lamont harp wire fragment sample

element	wt%	average σ
Cu	74.30	0.65
Zn	23.03	0.58
Pb	2.07	0.20
Ni	0.32	0.13
Fe	0.18	0.08
Sn	-	-
Bi	-	-

diameter: 0.69 mm
density: 8.55 g/cm^3 (calculated from the composition)

Based on the results of the analysis, this wire is a 23% zinc brass with 2% lead and traces of nickel and iron. The composition of this brass is discussed in detail below. The diameter of the wire was also measured on an SEM image of the sample, and found to be 0.69 mm. For comparison, the wire fragment found on the Ballinderry harp was a 10% zinc brass with a diameter of 0.7 mm.[88] This wire fragment was found corroded to a tuning pin, which had been underground in a crannog with the rest of the Ballinderry harp until it was discovered in the 19th century, so the

[87] With the inclusion of aluminium, the average wt% of the detected elements are as follows: Cu 71.46%, Zn 22.15%, Al 3.03%, Pb 2.12%, Ni 0.30%, Fe 0.18%.
[88] Evans, " Downhill Harp," 124.

composition and diameter may have been affected by the conditions to which it was exposed.[89]

The defect in the Lamont harp wire fragment was also analysed. This defect is visible in figure 1.26 as the darker grey linear feature extending to the centre of the wire. It was found to be composed of 72.6% copper, 25.4% zinc, 1.2% iron, and 0.44% lead. The percentage of iron in the defect is six times higher than in the rest of the wire. This is most likely the result of incompletely melted iron contaminating the brass during the alloying process.[90] This defect would have seriously weakened the wire and may have caused it to break. Furthermore, the wire is split along this defect. So, in addition to being weak, this wire would have sounded false.

Analysis Discussion

Historically, brass has been produced with a range of percentages of zinc and trace elements across different time periods, as well as within a single time period.[91] It is therefore not possible to say anything conclusive about the dates of these two wire fragments based on their compositions. Some compositions were more common than others within a particular time period, however, so it is worth discussing the wire fragments in terms of this information. Even if a date of manufacture cannot be established from this, we can at least know when similar brass was most likely to be in use. The studies by Mitchiner et al. (1987) and Pollard and Heron (2008) present comprehensive analyses and discussions of a large body of data on the composition of brass in Europe from the medieval era through the industrial revolution.[92] These

[89] The discovery of the Ballinderry harp fragments in a crannog is discussed in W. G. Wood-Martin, *The Lake Dwellings of Ireland: Or Ancient Lacustrine Habitations of Erin, Commonly Called Crannogs* (Dublin: Hodges, Figgis, & Co., 1886), 125 – 26.
[90] Iron melts at a higher temperature than both copper and zinc.
[91] Mitchiner et al., "Nuremberg and its Jetons," 114 – 55. See also e.g. Jean-Marie Welter, "The Zinc Content of Brass: a chronological indicator?" *Techné* 18 (2003): 32 – 33; and Vereecke et al., 67 – 68.
[92] Mitchiner et al., "Nuremberg and its Jetons," 114 – 55. Mark Pollard and Carl Heron, "The Chemical Study of Metals – the Medieval and Later Brass Industry in Europe," in *Archeological Chemistry* (Cambridge: The Royal Society of Chemistry, 2008), 193 – 234.

studies show definite groupings and trends in composition over time that also correlate with the historical information on brass production and trade in Europe. It should be noted that the results are largely based on the analysis of brass jetons. While their composition may be representative of brass in common use, different formulations of brass may have also been produced for other purposes.[93]

Zinc:

As shown in table 1.2, the wire fragment from the Lamont harp is a 23% zinc brass. Brass artefacts with approximately this percentage of zinc were produced over a long time period, from at least the early 15th century to the end of the 18th century.[94] It is a composition particularly typical of brass produced in the 17th century, as well as some late 15th-century brass.[95] Brass produced in the 16th century had less zinc on average, around 19%, while brass with less than 25% zinc was uncommon after 1700.[96]

The wire fragment from the Queen Mary harp is composed of a brass with 27 – 28% zinc (see table 1.1). While brass containing 28% zinc was being produced in Europe as early as the mid 15th century, it was more common from the late 17th century onwards.[97] After the mid 18th century, high zinc brass (> 33% zinc) begins to come into common use as well, and predominates after the mid 19th century.[98]

Trace elements:

Each of the two wire fragments also contains trace elements. The studies mentioned above have shown some correlations between the presence and quantity of trace

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[93] Pollard and Heron also present the results of analysis of brass scientific instruments and of clock mechanisms. Pollard and Heron, "Medieval and Later Brass Industry," 215 – 25.
[94] Pollard and Heron, "Medieval and Later Brass Industry," 212.
[95] Mitchiner et al., "Nuremberg and its Jetons," 141 and 130 – 31; and Pollard and Heron, 210 – 12. The percentage of zinc increased from ~20% to ~23% in brass jetons produced by the younger members of the Lauffer family of Nuremberg after 1612.
[96] Mitchiner et al., "Nuremberg and its Jetons," 132 – 36, and 143 – 44. Mitchiner et al., attribute the rise in percentage of zinc after 1700 to the widespread adoption of the use of granulated copper in the alloying process. See also Pollard and Heron, 228.
[97] Pollard and Heron, "Medieval and Later Brass Industry," 210 – 13. Mitchiner et al., "Nuremberg and its Jetons," 141 – 43.
[98] Mitchiner et al., "Nuremberg and its Jetons," 151 and 155.

elements and the location and time period of manufacture.[99] This is a complex topic, however. A number of factors influence the presence of trace elements, including the use of recycled material, so it is only possible to make some general (but potentially important) observations.

Nickel:

Both wire fragments contain 0.3% nickel. The proportion of nickel present in historical brass primarily falls into two distinct groups. These are the 'high nickel' brasses, with typically 0.1% – 0.5% nickel, and the 'low nickel' brasses, with less than 0.05% nickel.[100] This is understood to be due to the source of the copper used in the brass.[101] From circa 1200 – 1450, the primary source of copper for brass production in Europe was the non-nickel bearing ore from the Falun mine in Sweden, and 'low nickel' brass is predominant in artefacts from this time period.[102] In the mid 15th century, the primary source of copper shifted to nickel bearing copper ore from mines in present day Austria and Hungary as well as the Harz in northern Germany, after which time 'high nickel' brass predominated (although 'low nickel' copper continued to be supplied from Sweden).[103] Over the course of the 18th and 19th centuries, production of 'low nickel' brass increased again as output from the nickel bearing copper mines decreased and was replaced with copper from non-nickel bearing ores. These were mined in the Harz and in Mansfield in the Halle district of present-day northern Germany, as well as in Cornwall in England.[104]

[99] See e.g. Pollard and Heron, "Medieval and Later Brass Industry," and Mitchiner et al., "Nuremberg and its Jetons."

[100] Mitchiner et al., "Nuremberg and its Jetons," 126 – 27. Pollard and Heron, "Medieval and Later Brass Industry," 210 – 13.

[101] Pollard and Heron, "Medieval and Later Brass Industry," 210 – 14.

[102] ibid., and Mitchiner et al., "Nuremberg and its Jetons," 126 – 27.

[103] Mitchiner et al., "Nuremberg and its Jetons," 127, and Pollard and Heron, "Medieval and Later Brass Industry," 213.

[104] Pollard and Heron, "Medieval and Later Brass Industry," 212 – 13, and Mitchiner et al., "Nuremberg and its Jetons," 126 – 27. There is also an observed spike in numbers of 'low nickel' brass artefacts from the 17th century England corresponding to a brief period of domestic production and an embargo of imported brass. See Pollard and Heron, "Medieval and Later Brass Industry," 203.

Lead:

The Lamont harp wire fragment contains 2% lead whereas the Queen Mary harp wire fragment does not contain any measurable traces of lead. Prior to circa 1450, brass produced in Europe typically contained 1 – 2% lead.[105] A lead content of less than 1% is typical of later brass.[106] The reduction in lead is part of an overall change in the composition of brass that occurred at this time, which includes a corresponding drop in tin and the previously mentioned rises in nickel and zinc.[107] There is a further reduction in lead content in the 19th century, which correlates with a shift in the manufacturing process for brass from the cementation of copper with zinc bearing calamine ore to alloying directly with metallic zinc.[108]

Iron:

Both wire fragments contain essentially the same percentage of iron. The iron content of the Lamont brass wire was measured at 0.18% and the iron content of the Queen Mary brass wire was measured at 0.17%. The amount of iron in brass remained fairly constant from the 13th century through the mid 18th century, with percentages typically ranging between 0.1 – 0.4%.[109] Brass with less than 0.1% iron begins to become common after circa 1750 and is increasingly common in the 19th century, although higher iron content is still seen.[110] The lower percentages of iron are more commonly seen in 'high zinc' brasses. As with the 19th-century reduction in lead mentioned above, this may be a result of the shift from the use of calamine ore to direct alloying with metallic zinc.

Silver and Tin:

The above are all of the trace metals that were detected in the two brass wire fragments at measurable levels. Two other metals worth mentioning are silver and tin, which are notable by their absence. As discussed by Mitchiner et al. (1987), if the copper used came from a silver bearing ore, the resulting brass will contain traces of

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105 Pollard and Heron, "Medieval and Later Brass Industry," 212.
106 ibid.
107 ibid.
108 Mitchiner et al., "Nuremberg and its Jetons," 124.
109 ibid., 130 – 55.
110 ibid.

silver, even if the ore has been refined to recover it.[111] Based on their analysis, de-silvered copper can be expected to have retained 0.1 – 0.15% silver, historically.[112] Pollard and Heron (2008) note the presence of silver at 0.1 – 0.2% in pre-1450 brass, which is likely to be due to the silver bearing copper ore of the Falun mines in Sweden.[113] Mitchiner et al. note that the presence of silver in brass in the late 15th century followed by a drop in the occurrence of silver bearing brass thereafter may be due to a shift at that time in the predominant source of copper from the silver bearing copper ore of the Harz mines to the non-silver bearing ore of the Austro-Hungarian mines.[114]

The significant change in overall composition of brass that occurred in the mid 15th century, as noted above for nickel, lead and silver, also affected the percentage of tin present. Both Mitchiner et al. (1987) and Heron and Pollard (2008) note that brass made before the mid to late 15th century contained significant traces of tin, primarily above 2%.[115] Pollard and Heron report 3.7% tin, on average, from the analysis of pre-1450 brass jetons.[116] Later brass jetons were found to have, on average, less than 0.2% tin. Pollard and Heron propose that the drop in average levels of tin may have been due to eliminating the practice of using scrap bronze in the manufacturing process.[117]

Summary

Taking into consideration the information on all of the elements discussed above, some comparisons can be made with regard to the composition of the wire fragments

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[111] ibid., 124 – 25.
[112] ibid.
[113] Pollard and Heron, "Medieval and Later Brass Industry," 212. See also Mitchiner et al., "Nuremberg and its Jetons," 125. Copper ore from the Falun mines was being refined to recover the silver.
[114] Mitchiner et al., "Nuremberg and its Jetons," 125.
[115] ibid., 115, Pollard and Heron, "Medieval and Later Brass Industry," 210. Mitchiner et al. date the change to the 1480s. Pollard and Heron date it to circa 1450.
[116] Pollard and Heron, "Medieval and Later Brass Industry," 210.
[117] ibid., 213.

from the two harps. These are only general comparisons, however, and not definitive determinations of the age of the wire. Similarities to brass common to a particular time period do not necessarily mean the wire was made in that time period.
For the Lamont wire fragment, the observed percentages of nickel and iron and the absence of any measurable tin and silver are typical of brass made at any time from the late 15th century to the beginning of the 19th century. The percentage of zinc present is most typical of brass made in the 17th century. The percentage of lead is high, however, and suggests the possibility that this brass may include recycled material from a cast object.[118] As discussed previously, the location of this wire fragment in the string hole strongly suggests that it was part of a wire string for the harp. Since it is unlikely that this harp was used after the death of John Robertson in 1731, it is plausible that this wire dates to the 17th century. The possibility that the brass may have been made with recycled material, as suggested by the high lead content as well as the large iron defect, is interesting in this context. In the British Isles, brass was scarce during the English Civil War, a circumstance that was exacerbated by the floundering domestic brass industry in 17th century England.[119] One could easily imagine a scenario in which scrap cast brass was being melted down to be repurposed (or sold), for example as rods for wire drawing.

The Queen Mary wire fragment contains more zinc than the Lamont wire fragment, and no measurable lead. The percentage of zinc is typical of brass made from the late 17th century onwards. The absence of lead is more common for brass made after the beginning of the 19th century, although the presence of appreciable iron and especially nickel were more common before the 19th century. It is plausible, therefore, that this wire dates to no earlier than the late 17th century, but the composition is not clearly suggestive of either a pre- or post- 19th-century date. The most convincing evidence for dating this wire is the circumstance of its location in the string hole. In order to be held in place, the textile wad it was wrapped around had to have been wedged between one of the wooden soundbox pegs and the side of the string hole. The only other thing preventing the textile from falling out of the

[118] Lead is added to brass for casting to improve the flow. See Mitchiner et al., "Nuremberg and its Jetons," 124.
[119] Pollard and Heron, "Medieval and Later Brass Industry," 203.

string hole was the varnish it had adhered to, which was applied sometime after the wooden soundbox pegs were added to the harp. The connection with the wooden soundbox pegs strongly suggests 1805 as the date for the use of this wire, which means it was likely to have been made within a few years prior to that date.

Chapter 2. Stringing Regimes

Little is known about the pitch and compass of the surviving low-headed Irish harps. Based on extant historical information, we can surmise that they were tuned diatonically, possibly with a single pair of strings tuned to a unison.[120] More detailed information survives for the 18th-century instruments, as recorded by Edward Bunting.[121] As discussed in the introduction, these later Irish harps are of the design referred to as high-headed by Rimmer (1964).[122] Their frames are of a different design to the earlier form of the instrument, and in particular they have a longer string scaling in the bass. Historical information regarding their pitch and compass may therefore not be applicable to the earlier, low-headed Irish harps.

Investigations of the pitch and compass of the low-headed harps, and attempts to faithfully reproduce their stringing regimes, have been hampered by the state of the frames of the surviving instruments. Distortions due to twisting and shifting of the members, cracks and deterioration, as well as repairs and modifications, have combined to alter the original string lengths. In order to study the stringing of any of these harps, it is necessary to reconstruct the original geometry of the frame. It is also necessary to examine surviving evidence on the frame related to the stringing in order to understand how the harp was strung and any changes that may have been made to the stringing arrangement.

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[120] Rimmer, "Talbot's Manuscript," 67. See also Bunting, *Ancient Music of Ireland*, 23. The tuning Bunting describes is for a high-headed Irish harp, however. Notably, the surviving fragments of the Cloyne (a.k.a. Dalway), a low-headed Irish harp dated 1621, include a second rank of seven tuning pins, suggesting that it may have been partially chromatic. For a discussion of this see Michael Billinge and Bonnie Shaljean, "The Dalway or Fitzgerald Harp (1621)," *Early Music* 15, no. 2 (1987): 175 – 187. For a discussion of the unison strings see Simon Chadwick, "Sister Strings, or na Comhluighe," last modified, February, 2014, http://www.earlygaelicharp.info/tradition/sisters.htm.

[121] Bunting, *Ancient Music of Ireland,* 23, and Bunting, *MS 29*, 81, 150, 156.

[122] Rimmer, "Morphology," 44. Rimmer's term is derived from the name *cinnard cruit* (meaning 'high-headed harp') used by the 18th-century Irish harpers. Bunting, *Ancient Music of Ireland*, 20.

The frame of the Lamont harp

Number and arrangement of strings

The frame of the Lamont harp poses some interesting problems with regard to reconstruction of its stringing. In addition to some severe damage and movement of the members there are questions regarding the tuning pins, such as how many were originally on the neck, how many were in use at different stages of the instrument's working life, and which string holes they were strung to in the soundbox. This harp has 32 string holes in its soundbox but only 31 holes for tuning pins in the cheekbands on its neck. A 32nd hole for a tuning pin is located below the cheekbands at the bass end of the neck, directly underneath the position for the 31st tuning pin, as shown in figure 2.1.

Figure 2.1: *detail of the left side of the neck of the Lamont harp. A single tuning pin hole is located below the cheekband at the bass end (arrowed). This tuning pin hole and the one directly above it in the cheekband are located under the sleeve of the end cap, which also covers the ends of the cheekbands on both sides of the neck. Photograph: Maripat Goodwin*

This tuning-pin hole appears to be a later addition to the neck. A plausible explanation is that the neck and cheekbands had been shortened, resulting in the loss of the 32nd tuning-pin hole at the end. This "lost" hole would have then been relocated below the cheekbands, under the 31st hole. This explanation is supported by the crude alteration that had been made to the sleeve of the metal end cap to make it fit the end of the neck, as shown in figure 2.2.

Figure 2.2: *a view of the Lamont harp end cap showing the section of the sleeve that has been cut and bent back to fit the end of the neck (arrowed). Photograph: Maripat Goodwin*

Direct examination of the end of the neck could answer the questions about the 32nd tuning pin hole, however this is hidden from view by the end cap, which is nailed to the neck and not removable without risking damage to both the neck and the cap. It is, however, possible to see under the end cap in the tomograms from the CT scans. Three tomograms of the end of the neck are shown in figure 2.3, below. Although interference from the metal obscures some of the detail, it is possible to see the hidden ends of the cheekbands as well as the cross sections of the tuning pin holes.

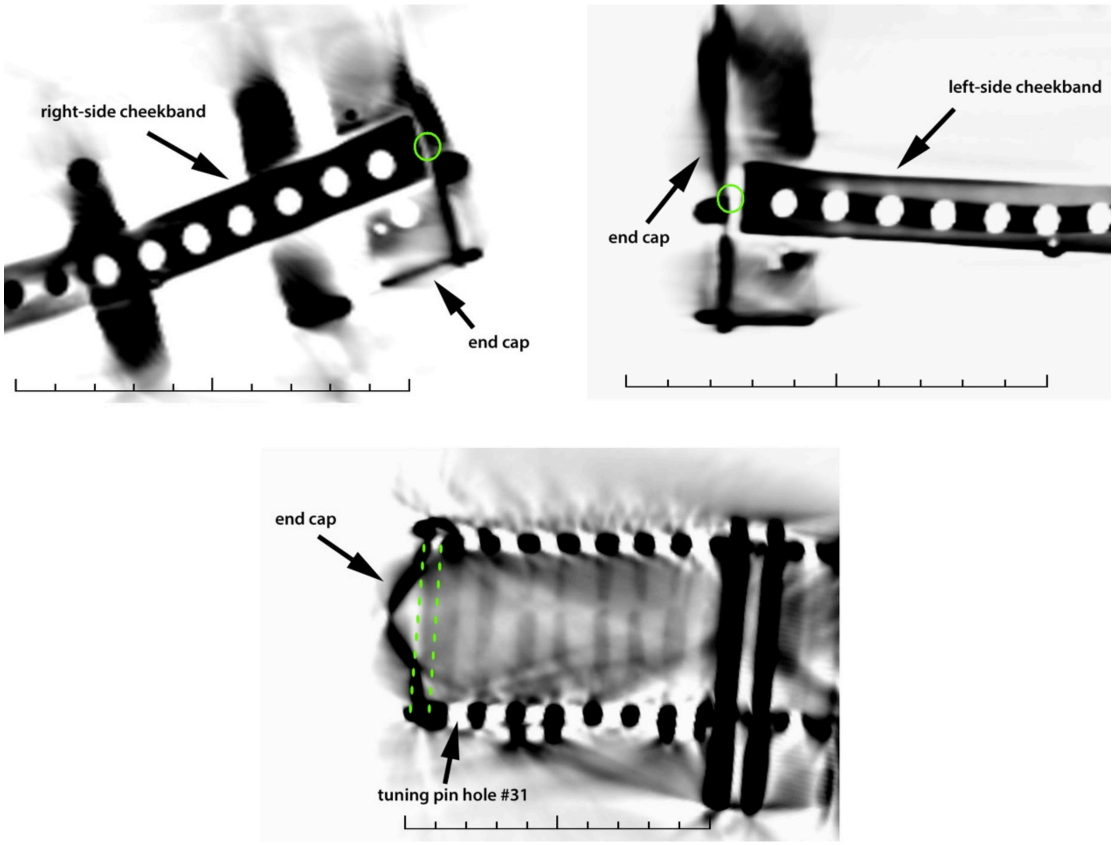

Figure 2.3: *tomograms of the end of the Lamont harp neck. Clockwise from top left: cross sections of the right side cheekband, of the left side cheekband, and across the neck through the tuning pin holes. The ends of the cheekbands, which are under the sleeve of the end cap, are visible in the upper two tomograms. All but two of the tuning pins were removed for this scan. The unoccupied tuning pin holes appear as white circles in the cheekbands. In the lower tomogram, these tuning pin holes appear as lighter grey bands through the neck, while the wood between them appears as darker grey bands. The two remaining tuning pins are visible on the right-hand side in this tomogram. The position that would be occupied by a 32nd tuning pin hole in the cheekbands is indicated by the green circles in the upper two tomograms and by the green dashed lines in the lower tomogram. The scale is 1 tick : 1 cm.*

Given the spacing of the tuning pin holes, if the cheekbands had originally included a 32nd hole, part of this hole should still be present and visible at the end of the neck. The position this hole would occupy is indicated in figure 2.3. For the left-hand cheekband, a 32nd tuning pin hole would have been located just at the edge of the current end of the band. It is not possible to tell from this cheekband if a 32nd hole has been cut away. On the right-hand cheekband, however, the tuning pin holes are larger, so the gap between them is narrower. A 32nd tuning pin hole (if it were present) would overlap the end of the cheekband and should therefore still be visible as a small cut-out at the end of the band, as indicated in the upper left tomogram in figure 2.3. There is no corresponding cut-out at the end of this cheekband, however, suggesting that it has not been shortened.[123] The overlap is not large, though, 2 – 3 mm at most. The cross section through the neck shown in the lower tomogram in figure 2.3 is more convincing. In this cross-section it is evident that the distance from the last hole to the end of the neck is noticeably larger than the space between the tuning-pin holes. Although not shown here, the cheekbands also end a few millimetres short of the end of the neck. Based on the spacing of the tuning-pin holes, part of a 32nd hole would still be visible as a channel in the wood at the end of the neck. Examination of the cross section through the neck as shown in figure 2.3, and of additional cross sections parallel to the neck end, have shown that no channel is present in this location. The conclusion is that the neck of the Lamont harp was originally made for 31 tuning pins, not 32.

Although the neck was made for 31 tuning pins, the soundbox of this harp has 32 string holes. The location of the 32nd string hole on the string band can be seen in the right hand photograph in figure 2.4. The spacing of this string hole with respect to the others suggests that it is part of the original layout and was not added at a later date.

[123] This is also discussed in Loomis et al., "Lamont and Queen Mary Harps," 121.

Figure 2.4: *detail of the soundbox of the Lamont harp showing the treble (left) and bass (right) ends of the string band. The bottom most string hole in the bass is #32. The spacing with respect to the other string holes suggests that it was not added at a later date. Photographs: Maripat Goodwin*

If there were originally 31 tuning-pin holes on the neck and 32 string holes on the soundbox, which tuning pin was strung to which string hole, and why doesn't the number of tuning pins in the neck match the number of string holes in the soundbox?[124] Clues to a possible explanation may be found in the stringing marks in the interior of the soundbox. Originally observed by Hobrough (1979), they consist of numerous linear indentations around the string holes, as shown in figure 2.5.[125]

[124] The Lamont is not the only surviving Irish harp for which the number of tuning pin holes does not match the number of string holes. The Downhill harp has 30 tuning pin holes in its cheekbands and 32 string holes in its soundbox. See Armstrong, *Irish and Highland Harps*, 89.
[125] Tim Hobrough, "Notes on European Harps," *FOMHRI Quarterly,* 14 (1979): 49; and *Tim Hobrough to R. B. K. Stevenson, Keeper, National Museum of Antiquities of Scotland,* 23 January, 1979, letter, National Museums Scotland, *H. LT2 archive*. The author would like to thank Simon Chadwick for pointing out the *FOMHRI* reference.

Figure 2.5: *the interior of the Lamont harp soundbox (top) and detail (bottom) showing marks around the string holes. The red box in the upper photo indicates the area shown in detail in the lower photo. The size, shape, location, and distribution of the marks are consistent with their having been made by string toggles and wires pressing against the wood.*

The size, shape, location, and distribution of the marks around the string holes are consistent with their having been made by string toggles and wires pressing against the wood.[126] For comparison, similar marks present around some of the string holes in the author's harp, built by Guy Flockhart after the Lamont, are shown in figure 2.6. The marks observed in the Flockhart harp were made by the string toggles.

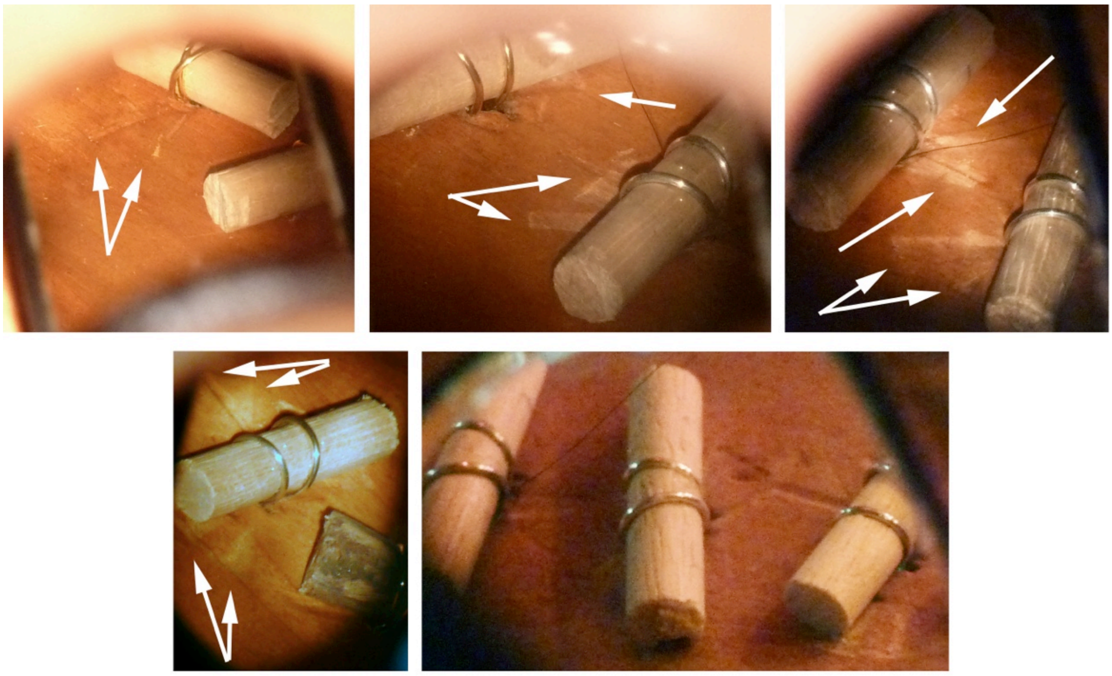

Figure 2.6: *toggles and toggle marks (arrowed) around the string holes in the harp built by Guy Flockhart in 1996, after the Lamont. The string holes shown are (clockwise from top left): #19, #20 – 21, #21 – 22, #23, and # 21 – 23. The photographs were taken with an inspection mirror inserted into a soundhole.*

Each time a string is brought up to tension, the toggle presses against the wood, often leaving an impression.[127] With the string under tension the toggle will stay in place and not rotate or shift until the string is loosened again. Each mark in the wood,

[126] Loomis, "Structural Breaks and Repairs," 88. Loomis et al., "Lamont and Queen Mary Harps,"117.

[127] The form of the toggle may affect the impression it leaves in the wood. In the case of the Flockhart harp, most of the current toggles are made from round wooden dowel, but its original toggles were hand-whittled bits of wood (part of one of these is visible in the lower left photo in figure 2.6). These were irregular in profile, and may have left impressions in the wood more readily. A thin metal toggle would also more readily leave an impression.

therefore, effectively represents a string replacement. For the Flockhart harp, the handful of observed toggle marks is consistent with the number of times these strings have been replaced. This harp was 17 years old at the time the photographs in figure 2.6 were taken. The strings at holes #19 – 23 have been replaced 2 – 3 times by the author, over a 7-year period, and may have been replaced a comparable number of times by the harp's original owner over the previous 10 years. The number of toggle marks around these string holes can be compared to the marks visible around string holes #18 – 20 in the Lamont harp soundbox, as shown in the photograph in figure 2.7.

Figure 2.7: *Toggle marks around string holes #20 – 18 (l. – r.) in the soundbox of the Lamont harp.*

At the string holes shown in figure 2.7 numerous toggle marks are present to the point of saturation.[128] This is the case for nearly all of the string holes, although the number of toggle marks tapers off slightly towards both ends of the string band. The

[128] The toggle marks can be used to estimate the number of years the harp was in use. This is discussed in Part II of this dissertation.

exceptions are the string holes at each end of the string band: holes #1 and #32. The string holes were extensively examined under magnification. String hole #32 was found to be devoid of any signs of use, in contrast to all of the other string holes, which have marks from the string toggles as well as indentations, scratches, and some verdigris stains from the wire strings. String hole #1 was found to have only minimal signs of use in the form of a small number of string indentations at the edge of the hole and a few light scratches radiating from the hole. One toggle mark was also found at this hole. This is in contrast to string hole #2, which has significantly more signs of use in the form of numerous toggle marks, scratches, and wire indentations. The comparative differences can be seen in the photographs of the string holes in figure 2.8 and figure 2.9. A close-up of string hole #1 in figure 2.10 shows the signs of use visible at this hole.

Figure 2.8: *String holes #32, 31, and 30 (l. - r.) in the soundbox of the Lamont harp. There are numerous toggle and string marks around holes #31 and 30, but no marks around hole #32. Examination under magnification did not reveal any marks or scratches in or around string hole #32, in contrast to the two adjacent holes.*

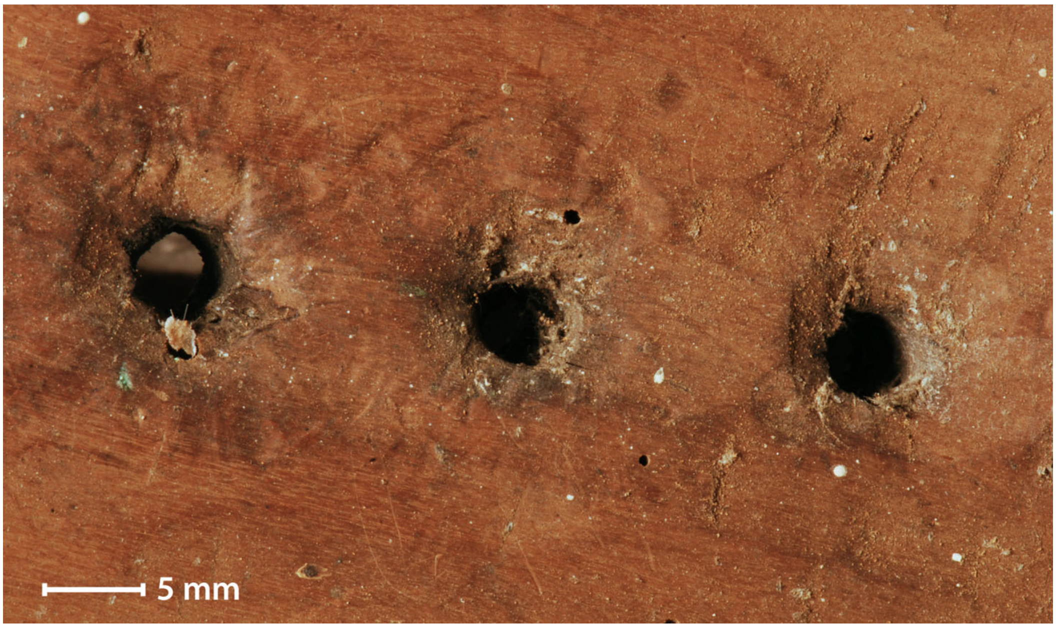

Figure 2.9: *String holes #3, 2, and 1 in the soundbox of the Lamont harp. The lighting in this photograph is less optimal than for the photograph in figure 2.8, however numerous toggle marks are visible around string holes #2 and #3, as well as a few verdigris stains, and a number of fine scratches radiating from the holes. In contrast, string hole #1 has minimal signs of use.*

Figure 2.10: *close-up of string hole #1 in the soundbox of the Lamont harp, showing fine scratches radiating from the hole, string indentations at the hole edge, and a toggle mark (arrowed). The location of the toggle mark is indicated by the top arrow. The string hole is approximately 5 mm in diameter. The treble end of the soundbox is toward the right.*

The absence of marks at the #32 string hole is an indication that this hole was left unused, and the comparatively small number of marks at string hole #1 is an indication that this hole was minimally used. This suggests some possible stringing solutions when considered in conjunction with the evidence on the neck. The harp may have been originally strung with 31 strings, starting from tuning pin #1 and string hole #1, leaving string hole #32 unused. When Armstrong examined this harp, however, he noted that the large crack in the neck passes through the position of the first and second tuning pins, and commented that the first and probably the second tuning pin positions would not have been usable after the crack formed (see figures 2.13 and 2.15, below).[129] Examination of the inside of the neck on the CT scans shows that the first and second tuning pin holes have indeed been compromised by the crack to the point of being unusable, with the #1 hole most extensively damaged. Repairs associated with this crack suggest that the harp continued to be used after the crack formed.[130] Based on this and the evidence of the toggle marks, it is possible that the #1 tuning pin hole ceased to be usable relatively early in the working life of the instrument. Taking this into consideration, one solution for the stringing is for the top string to be strung directly from string hole #2 to tuning pin #2 and the remaining string positions strung likewise down to string hole #31 which would be strung to tuning pin #31, the last position in the cheek band. This avoids the first tuning pin, and presents a harp with 30 strings, the same number as the Queen Mary harp (including its additional string in the bass), and the Trinity College harp (including its additional string in the bass).[131]

While the solution just described explains how the first tuning pin could be avoided after it became unusable, there is still the question of the purpose of the 32nd tuning pin hole, and the question of the second tuning pin hole, which was also compromised by the neck crack. Both of the first two tuning pin holes can be avoided by stringing from string hole #2 to tuning pin #3, and continuing likewise to string

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[129] Armstrong, *Irish and Highland Harps*, 164.
[130] For a discussion of the neck crack and repairs see Loomis, "Structural Breaks and Repairs," 28 – 34, and Loomis, et al., 121.
[131] Paul Dooley, "Reconstructing the Medieval Irish Harp," *The Galpin Society Journal* 67 (2014): 113.

hole #30, strung to tuning pin #31. With the addition of the 32nd tuning pin hole below the cheekband, the bottom string can be strung from the 31st string hole to this additional tuning pin position. Offsetting the stringing in this manner avoids the two unusable tuning pin holes, while allowing the harp to retain 30 strings.

Although a string could have simply been strung directly from the 32nd string hole to the added 32nd tuning pin, with the rest of the stringing following suit up to the third string hole and tuning pin, there is a disadvantage to stringing the harp this way. In addition to the problem of the compromised tuning pin holes, there is the issue of alignment of the tuning pins and string holes. The string tension has caused the neck of this harp to shift in a direction that has moved the cheekband towards the treble relative to the position of the string holes in the soundbox. This has the effect of lowering the angle of the strings to the string band on the soundbox and reducing the string spacing, which could present problems for the player. As will be seen in the reconstruction of the straightened frame, offsetting the stringing as described above (e.g. string hole #2 to tuning pin #3) has the advantage of compensating for the backwards shift of the cheekband.

In the following discussion, the stringing schemes described above are used to determine proposed string lengths for the frame of the harp in its current state, and a reconstructed straightened frame with the distortions due to twisting and shifting of the frame members removed.

String lengths for the Lamont harp

Amongst the surviving Irish harps, the Lamont has probably suffered the most extreme twisting of its frame, as evident in the photographs in figure 2.11.

Figure 2.11: *the Lamont harp viewed from the front, top, and bottom (clockwise, from left), showing the distortion of the frame. Right hand photographs: National Museums Scotland H.LT2 archive.*

To reconstruct the string lengths for this harp with a straight frame, it is important to understand how and why the frame came to be in its current state. The Lamont harp is very old and, as with other old musical instruments, there have been multiple episodes of damage, repair, and modification. These, however, provide clues to the original state of this harp.

As discussed in Loomis (2010) and Loomis et al. (2012), the string tension has caused the frame members to rotate, shift, bend, and crack.[132] The overall distortion to the shape of the frame is complex, but by individually addressing each component of the total movement the geometry of a "straightened" frame can be reconstructed

[132] Loomis, "Structural Breaks and Repairs," 9 – 10; Loomis et al., "Lamont and Queen Mary Harps,"115 – 22.

and string lengths can be calculated for this frame. The directions in which the neck and soundbox have moved are shown in figure 2.12, below. It is the movement and distortion of these two frame members that has affected the relative positions of the tuning pins and string holes, and therefore the string lengths.

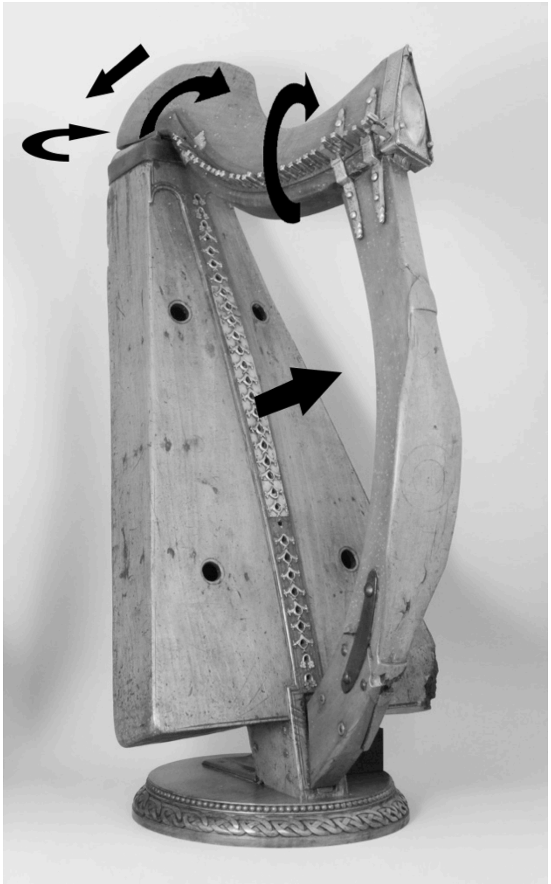

Figure 2.12: *direction of movement of the neck and string band of the Lamont harp. The neck has rotated about its long axis towards the left side of the instrument, and pivoted forwards out of its joint with the soundbox. It has also rotated in this joint towards the left side of the instrument and shifted backwards, towards the back of the soundbox. The soundbox has risen along the string band to form a 'belly'. Photograph: Isabell Wagner; annotations by the author.*

As illustrated in figure 2.12, the neck has rotated about its long axis, pivoted forward (towards the forepillar), rotated sideways in the soundbox joint, and shifted backwards in this joint towards the back of the soundbox. Most of these motions will have altered the string lengths. Although the sideways rotation of the neck in the soundbox joint has caused the top end of the forepillar to pivot dramatically towards the left side of the instrument, this motion has primarily only resulted in the string plane pivoting in the same direction, and has not had a significant effect on the string lengths. The other components of the motion of the neck have, however. These are described in more detail below.

The forward rotation and backwards shift of the neck can be seen more clearly in the cross-sectional tomogram of the neck/soundbox joint shown in figure 2.13. The neck has rotated forwards 5.9°, pivoting against the top end of the soundbox, and has also shifted 10 mm backwards towards the back of the soundbox.[133] This combined motion has reduced the distance between the tuning pins and string holes, and has shifted the cheekbands towards the treble end of the harp relative to the string band. It has also caused the back of the soundbox to be pushed outward by the tenon, which has, in turn, resulted in the tenon being sheared off, necessitating the repairs to both the tenon and the soundbox.[134]

[133] A small wooden shim can be seen in between the neck and soundbox, just below and to the left of pivot 1 in Figure 2.13. It has probably been inserted to create some space where the neck would otherwise pinch against the soundbox in its current position.

[134] The damage and repairs to the neck joint are discussed in detail in Loomis, "Structural Breaks and Repairs," 35 – 42. The rotation of the neck towards the left side of the harp has also contributed to the damage to the tenon.

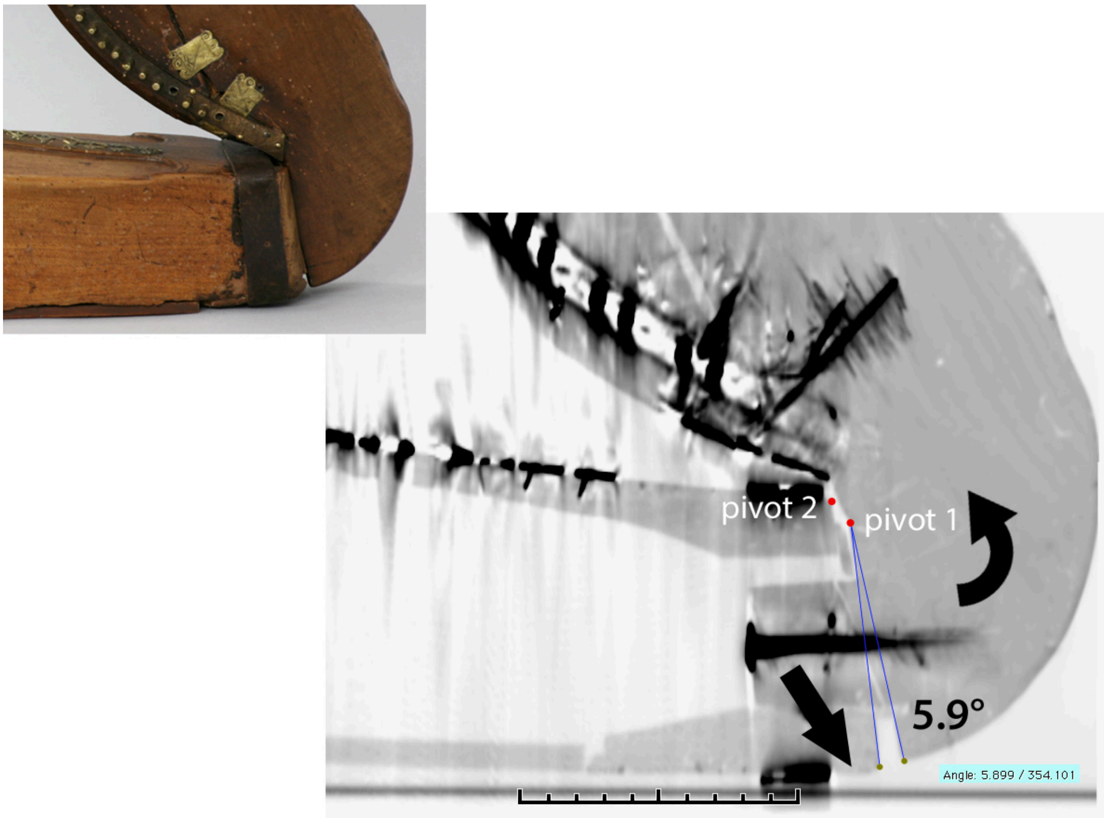

Figure 2.13: *tomogram of the Lamont harp neck/soundbox joint, and photograph of the same area (inset). The points labeled 'pivot 1' and 'pivot 2' were originally adjacent. As a result of the string tension, the neck has shifted backwards and has pushed the back of the soundbox outwards in the direction indicated by the straight arrow. The neck has also pivoted forwards, causing the joint to open by 5.9°, as indicated by the curved arrow. Photograph: Maripat Goodwin. The scale in the tomogram is 1 tick : 1 cm.*

The rotation of the neck around its long axis, towards the left side of the harp has contributed to the change in relative position of the tuning pins and string holes by causing the tuning pins to rotate downwards on the left side of the neck, bringing the string ends of the pins closer to the soundbox. The measured rotation about this axis is 20.5°, as shown in figure 2.14.

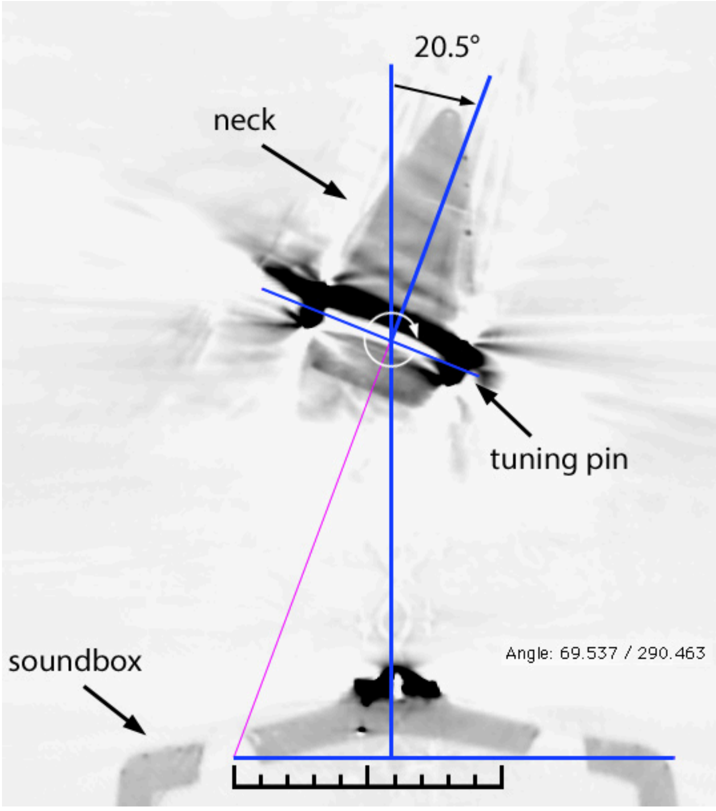

Figure 2.14: *tomographic cross-section of the Lamont harp neck showing the angle of rotation about its long axis. The scale is 1 tick : 1 cm*

The large crack on the left side of the neck has contributed to this rotation by acting as a hinge, with the portion of the neck below the crack, including the tuning pins, having rotated slightly more than the rest of the neck. The crack passes through the first and second tuning-pin holes, rendering them unusable, as discussed above. The remainder of the tuning-pin holes lie below this crack. Nail fragments above the current position of the end of the left-hand cheekband (see figure 2.15) indicate that the end of the cheekband probably had to be re-affixed down and forward as a result of the crack opening up. The presence of more than one nail fragment suggests that the end of the cheekband may have been repositioned more than once. This could have been due to the crack continuing to open up over time, which would agree with the proposed scenario of the first tuning pin hole becoming unusable, followed later by the second tuning pin hole.

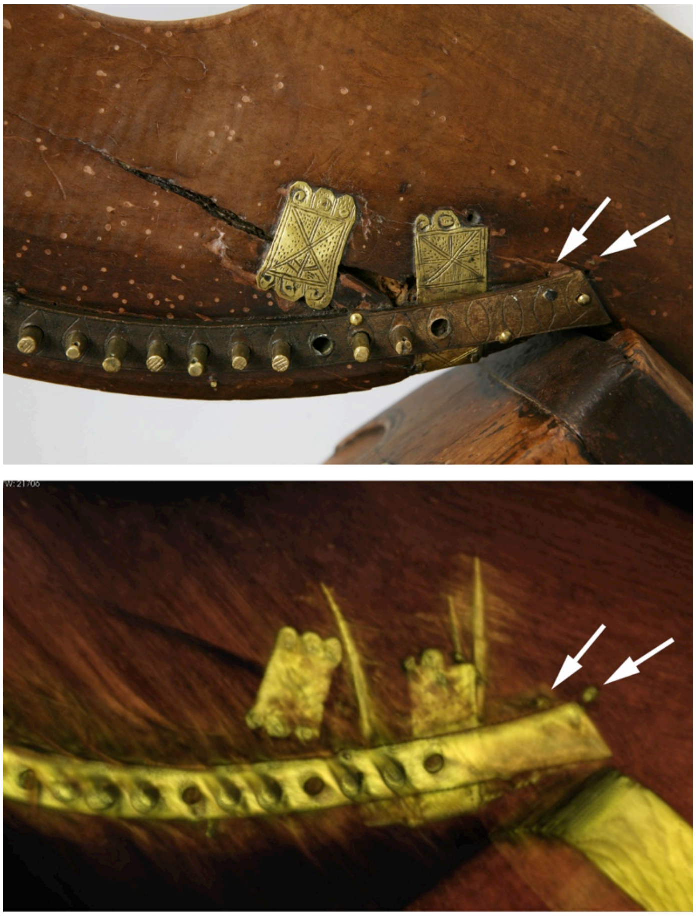

Figure 2.15: *Photograph (top) and tomographic volume rendering (bottom) of a large crack in the neck of the Lamont harp, viewed from the left side of the instrument. The wood is rendered semi-transparent in the tomogram to make embedded metal more visible. Nail fragments near the end of the cheekband (arrowed) suggest that it needed to be re-attached to the neck as the crack opened up. Photograph: Maripat Goodwin.*

In addition to the changes to the shape and orientation of the neck, the string tension has pulled the soundbox front upwards, forming a 'belly', which has moved the string holes up towards the tuning pins. There has long been speculation as to whether the soundbox arch or 'belly' of Irish harps was carved to shape, pulled up by the string tension, or a combination of both of these. It is currently generally accepted that the string tension at least contributes to the shape of the soundbox belly.[135] The evidence for this is discussed in Loomis (2010), and Loomis et al. (2012).[136] The question has

[135] Armstrong, *Irish and Highland Harps*, 56.
[136] Loomis, "Structural Breaks and Repairs," 11 – 12, 46; Loomis et al., "Lamont and Queen Mary Harps," 122 – 23. The author gratefully acknowledges Simon Chadwick for bringing to

remained, however, as to whether the belly is entirely the result of the string tension or whether it was initially carved to shape and then pulled further up by the strings. The answer can be found by examining the string hole cross-sections on tomograms of the soundbox. The holes at the extreme treble and bass ends of the string band, where there is no appreciable belly, have straight sides in cross-section, whereas the string holes nearer the highest point of the belly have sides that are angled towards each other, as shown in the top two tomograms in figure 2.16. The top cross-section in this figure is through string hole #31, which is located near the extreme bass end of the string band, where the front face of the soundbox is nearly flat. The middle cross-section is through string hole #23, which is located on a section of the string band where there is an appreciable belly in the front face of the soundbox.[137] In the cross-section of string hole #31, the walls of the string hole are parallel, whereas in the cross-section of string hole #23 they are angled upwards. This could be due to the tool used to make the hole, but it's unlikely that the builder would have chosen to use a different tool just for the string holes on the belly, so the angling of the sides of the string hole located on the belly must be due to the front of the soundbox being pulled up by the string tension. The question remains as to whether some of the observed belly was carved, however. This can be answered by rotating the two sides of the image of the cross-section of string hole #23 to recreate a 'flat' fronted soundbox. If this string hole was made in a soundbox with a flat front, the two sides of the wall in the 'flattened' cross-section should be parallel. If, however, this string hole was made in a soundbox with a carved belly, the sides of the wall should angle downward. The two sides of the string hole wall in the 'flattened' cross-section (figure 2.16, bottom) are parallel. Just as for string hole #31, this string hole was made through a flat soundbox face. The belly of the Lamont harp is, therefore, entirely the result of the string tension pulling up the wood.

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her attention the pulled in sides of soundboxes as evidence of the front having been pulled up by the string tension.

[137] These two string holes were also chosen because they had the least amount of interference on the tomograms due to nearby metal parts.

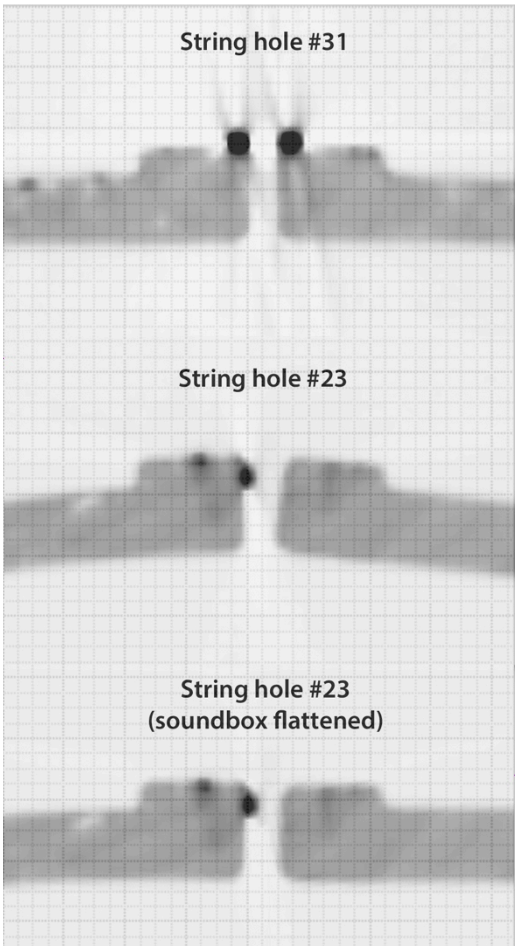


Figure 2.16: *tomographic cross-sections of string holes in the Lamont harp soundbox. Top: string hole #31, located where the front of the soundbox is nearly flat; middle: string hole #23, located on the 'belly' of the soundbox; bottom: string hole #23 with the two 'sides' rotated down to recreate a flat soundbox face. Note the angle of the walls of the string holes. In string hole #31 (top) they are parallel; in #23 (middle) they are angled upwards; in #23 for the 'flattened' soundbox (bottom) they are again parallel, indicating that the face of the soundbox was flat when this hole was made. The grid scale is 1 box : 2.5 mm*

Having established that the Lamont harp soundbox was made with a flat front, this can be taken into account when reconstructing the 'as-built' string lengths for this harp by making a correction for the shift in position of the string holes due to the rise of the belly. It should be noted, however, that for present day wire strung harps constructed in the manner of the historical instruments, the belly develops over a fairly short time period (several months). The belly of the Lamont harp soundbox will have probably developed over a similarly short time period, so this should be taken into account when considering the actual working string lengths for the harp.

The discussion that follows derives proposed string lengths for the Lamont harp in its current state (which represents a 'late' working state), its 'as built' state, and an 'early' working state with a developed soundbox belly. This was accomplished by measuring the current positions of the tuning pins and string holes on the tomograms and utilizing trigonometry and geometry to derive string lengths for a 'straightened' frame with the neck and soundbox restored to their estimated 'as built' configuration.

Reconstruction of string lengths for the frame in its current state

This reconstruction begins by determining the string lengths for the frame of the harp with the frame members in their current positions. Although the frame has suffered significant twisting and damage to its members, there is evidence that it was used in this state during at least part of its working life.[138]

The string lengths for the harp in its current state can be calculated from the CT scan data by measuring the (x, y, z) coordinates of each tuning pin and string hole at the point of contact of the string and applying the distance formula to calculate the distance from string hole to tuning pin:

$$d(P_1, P_2) = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2} \ .$$

With this formula, the coordinates can be used to derive string lengths for any tuning-pin to string hole combination. This has the advantage of making it possible to easily explore any number of different stringing arrangements. As discussed above, there is some ambiguity as to which string hole was strung to which tuning-pin for this harp, and it is probable that different stringing arrangements were used at different times during the working life of the instrument. The string lengths for two

[138] Loomis, "Structural Breaks and Repairs," 24 – 25.

possible stringing schemes described earlier have been calculated: (1) direct stringing, starting from string hole #2 (i.e. string hole #2 – pin #2 : string hole #31 – pin #31); and (2) offset stringing (i.e. string hole #2 – pin #3 : string hole #31 – pin #32). Due to the crack in the neck, however, it is unlikely that a string would have been strung to tuning pin #2 late in the instrument's working life. The string length for that position is included in the direct stringing scheme for the purpose of comparison to the string lengths for the offset stringing scheme. The calculated string lengths for both stringing arrangements are given in table 2.1 on page 91, and a measured diagram of the harp frame in its current state with the offset stringing scheme is shown in figure 2.19.

Reconstruction of string lengths for the 'straightened' frame

As discussed above, string lengths for a 'straightened' frame can be determined by correcting for the relative movement of the tuning pins and string holes that has occurred due to the shifting and bending of the frame members. This can be done by applying some basic rules of geometry and trigonometry to the current positions of the tuning-pins and string holes to derive their positions for a 'straightened' frame, with the neck and soundbox restored to their estimated 'as built' configuration. The method used is described in detail in appendix A, and is briefly summarized here. The 'straight frame' string lengths were determined in three steps. First, the string lengths were adjusted for the forward tilt and backwards shift of the neck such that revised string lengths were derived for the harp with the neck tenon completely seated in the joint with the soundbox. Next, the string lengths were adjusted for the rotation of the neck around its long axis, resulting in string lengths for the harp with the neck upright and the tuning pins parallel to the front face of the soundbox. Lastly, the string lengths were adjusted for the rise of the soundbox belly to derive string lengths for a soundbox with a flat front. The revised (x, y, z) coordinates of the tuning pins and string holes at the points of contact of the strings were also derived from the revised geometry of the frame. The string lengths derived are for the 'straight' stringing scheme (i.e. from string hole #1 - tuning pin #1, to string hole #31

– tuning pin #31), for the frame with and without a soundbox belly. These are given in table 2.1, along with the string lengths for the frame in its current state. Diagrams of the straightened harp frame with the direct stringing scheme are shown in figures 2.20 and 2.21.

The diagrams in figures 2.19 – 2.21 were generated by plotting the coordinates of the tuning pins and string holes and overlaying a tomographic cross-section of the harp, which is shown just in outline for clarity. For the reconstruction of the straightened frame, a separate cross-section taken through the neck (aligned with its center-line) was overlaid on the plotted tuning pin positions. With the neck oriented upright and positioned in its joint with the soundbox, the positions of the pins and of the left-hand cheekband on this cross-section agree with the plotted positions to within the precision of the plotting program. This demonstrates that the values derived analytically for the tuning pin and string hole positions, and for the string lengths, are realistic for this reconstruction of the straightened frame.

Figure 2.19 shows the harp frame in its current state, with 30 strings. These are shown strung starting from string hole #2 – pin #3 down to string hole #31 – pin #32, which is the most plausible stringing scheme for the harp frame in this state, given the evidence discussed earlier. Figure 2.20 shows the harp frame with the neck upright and repositioned, but with the soundbox belly retained. The frame is shown with 31 strings, strung from string hole #1 to tuning pin #1 down to string hole #31 to tuning pin #31. Note that tuning pin #32 is not included in this diagram, as it was likely a later addition. Figure 2.21 shows the frame with the neck repositioned as in figure 2.20, but with the soundbox belly flattened. For this diagram, the positions of the string holes were re-plotted using the coordinates that were derived for a flat fronted soundbox. The harp frame is shown with 31 strings, strung in the same manner as the frame depicted in figure 2.20. The outline of the forepillar in figures 2.20 and 2.21, shown as a dashed line, is speculative and is only included for the purpose of showing the complete frame.

An additional change was made to the reconstruction of the straight frame as depicted in figures 2.20 and 2.21. This has to do with the orientation of the foot of the harp, which does not affect the string lengths in any significant way, but does relate to the 'as built' shape of the soundbox. In its current state, the foot of the soundbox slopes backwards (towards the back of the soundbox). This was observed by Armstrong (1904).[139] At the time he remarked that the angle of the foot follows the slope of the soundbox belly and wondered if it had been carved to this shape. Figure 2.17 shows three tomographic cross-sections of the bass end of the soundbox. The tilt of the foot towards the back of the instrument can be seen in the top two cross-sections. The top one is taken through the centerline of the soundbox and runs through the string holes. The holes nearest the foot (arrowed, at the bass end of the instrument) are angled in the direction of the tilt of the foot, and judging from the rest of the string holes and the shape of the soundbox front, the soundbox itself appears to be arched along its long axis. The lengthwise arch seen in the cross-sections in figure 2.17 appears to involve the entire length of the soundbox, including the foot, which as a consequence is tilted backwards. The foot was not made with this tilt. The evidence for this can be seen in the middle cross-section, which shows the wood grain pattern mirroring the backwards tilt of the foot. The bottom cross-section in figure 2.17 is taken just to one side of the foot, and shows the bottom wall of the soundbox, which is tilted by 6° from the vertical (relative to the back of the box) at this location. This is the same degree of tilt as the neck in the soundbox joint. The pivoting forward of the neck out of that joint has caused it to press down on the forepillar, which in turn has pressed down on the foot at the joint with the soundbox. This, in combination with the strings pulling the front of the soundbox upwards along the string band (which has caused the soundbox to arch along its long axis), has resulted in the observed tilt of the foot. In its 'as built' state, the foot of the soundbox would have been in line with the long axis of the box. Rotating it back by 6° re-aligns it with this axis, and this is how it is shown in the two diagrams illustrating the straightened harp frame.

[139] Armstrong, *Irish and Highland Harps*, 159.

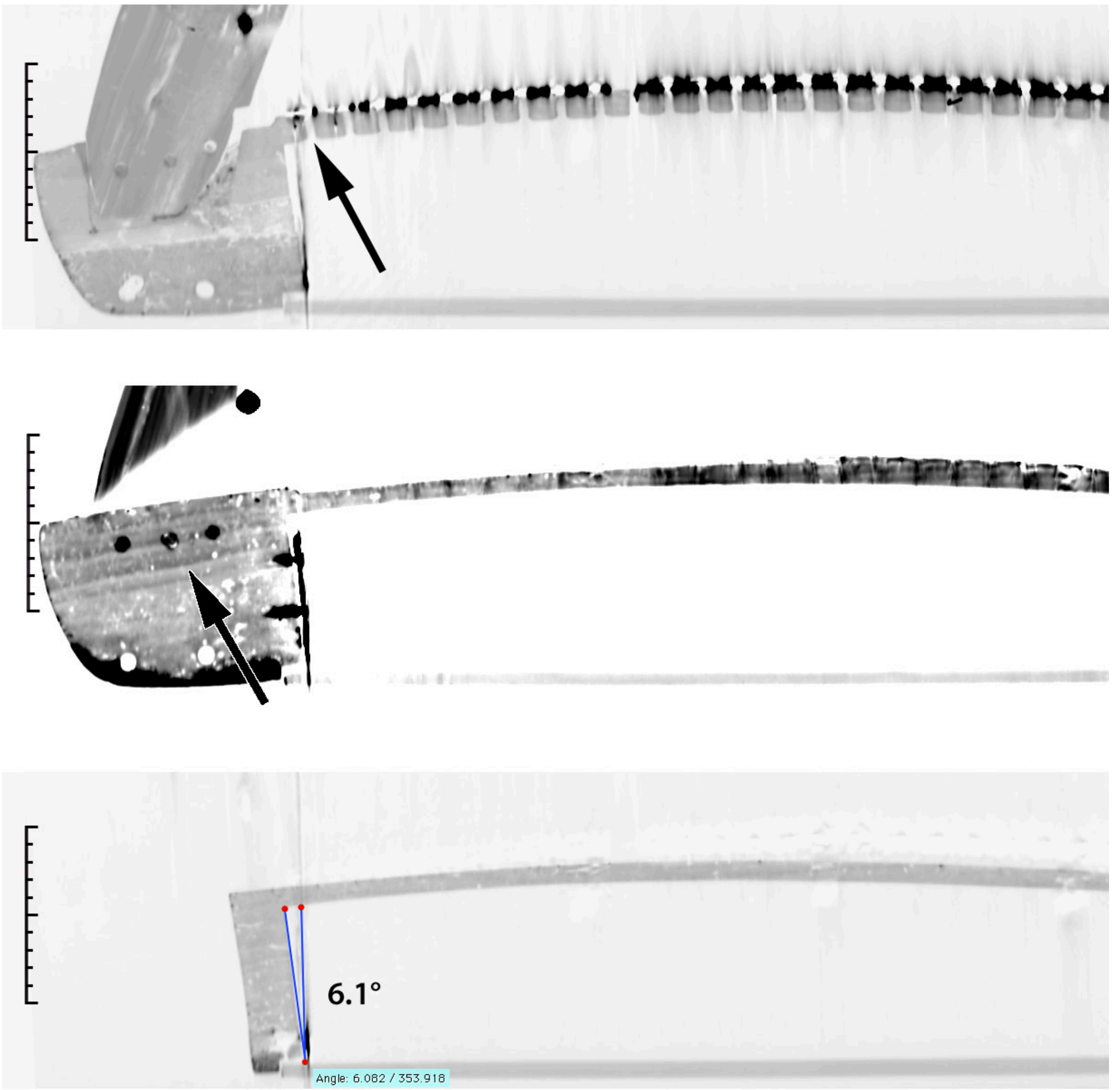


Figure 2.17: *tomographic cross-sections of the Lamont harp soundbox showing the backwards tilt of the foot. The top cross-section passes through the string band. The string holes nearest the foot (arrowed) are angled in the direction of the tilt of the foot. The middle cross section shows the wood grain pattern in the foot (arrowed), which follows the tilt of the foot. The bottom cross-section is located just to the right of the foot, and shows the tilt of the bottom end of the soundbox at this location.*

The backwards tilt of the wall of the soundbox, shown in the bottom cross-section in figure 2.17, can also be seen in the cross-section of the soundbox in figure 2.18. This cross-section, located just above the back cover and back wall of the soundbox, shows the distortion the tilt of the foot has caused at the bass end of the box. The back of the soundbox has been pushed several millimetres in the direction of the treble end of the instrument. This shift becomes noticeable at the treble end of the back of the soundbox when the neck is restored to its original position in the soundbox joint. With the shift, the back of the soundbox would overlap the back of the neck by several millimetres at the treble end of the box. In the diagrams of the straightened frame in figures 2.20 and 2.21, the back of the soundbox is shown terminating at the base of the neck.

A final adjustment to the shape of the soundbox has to do with the neck tenon having pushed the back of the box outwards, as discussed earlier. This is evident from the current position of the tenon as shown in figure 2.13 and from the outline of the back of the soundbox shown in figure 2.19. For the straightened frame in figures 2.20 and 2.21 the back of the box has been drawn as a straight line from the bass end of the box, above the foot, to the base of the neck at the soundbox joint.

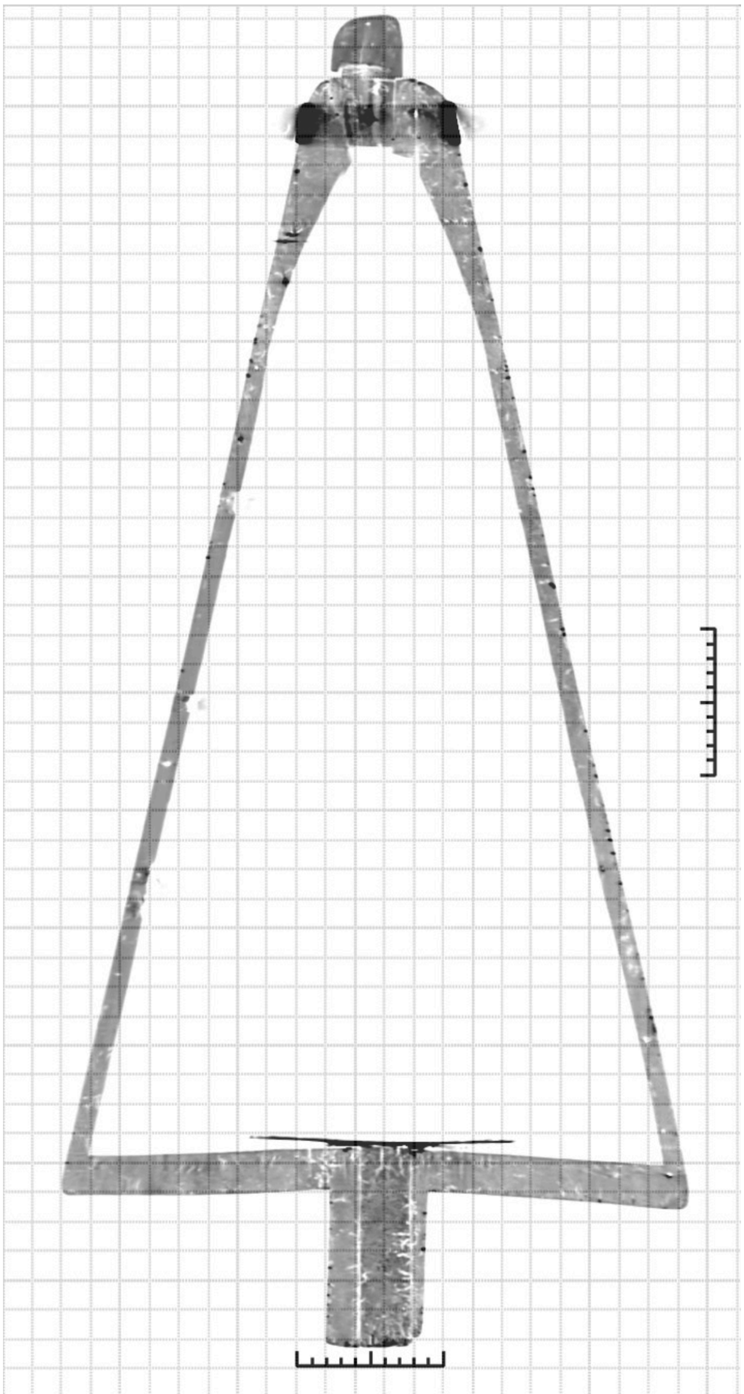


Figure 2.18: *tomographic cross-section of the Lamont harp soundbox. This cross-section is located 2 cm above the back of the box, so does not show the back cover and back wall of the soundbox. The 'upwards' bend in the bass end of the box can be seen against the overlaid grid lines. Grid 1 box : 2 cm; scale 1 tick : 1 cm.*

It is important to note that, as a consequence of the design of the instrument, **the strings do not lie in a plane**, even for the straightened frame. The diagrams of the harp frame in figures 2.19 – 2.21 depict the strings as projected onto a plane. Therefore, the string lengths are foreshortened as depicted in the diagrams**,** particularly at the treble end of the instrument. **Measurements of string length should not be taken off the diagrams**. For the actual calculated string lengths, see table 2.1. Also note that **the points plotted at the ends of the strings are the points of contact only. They are not the centre points of the tuning pin holes and string holes.**

Figure 2.19 (overleaf): *the frame of the Lamont harp in its current state. This outline has been taken from a tomogram, and shows the shape of the frame and the strings as projected onto a plane. Because the neck and forepillar actually project out of the plane, towards the viewer, they appear foreshortened. The black circles and blue squares are the points of contact of the strings at the string shoes and tuning pins, respectively, plotted from the measured coordinates taken from the CT data. The frame is shown strung with 30 strings, starting with string hole #2 – tuning pin #3, in the treble. String holes #1 and #32 are shown unstrung. Scale: 1 box : 2 cm.*

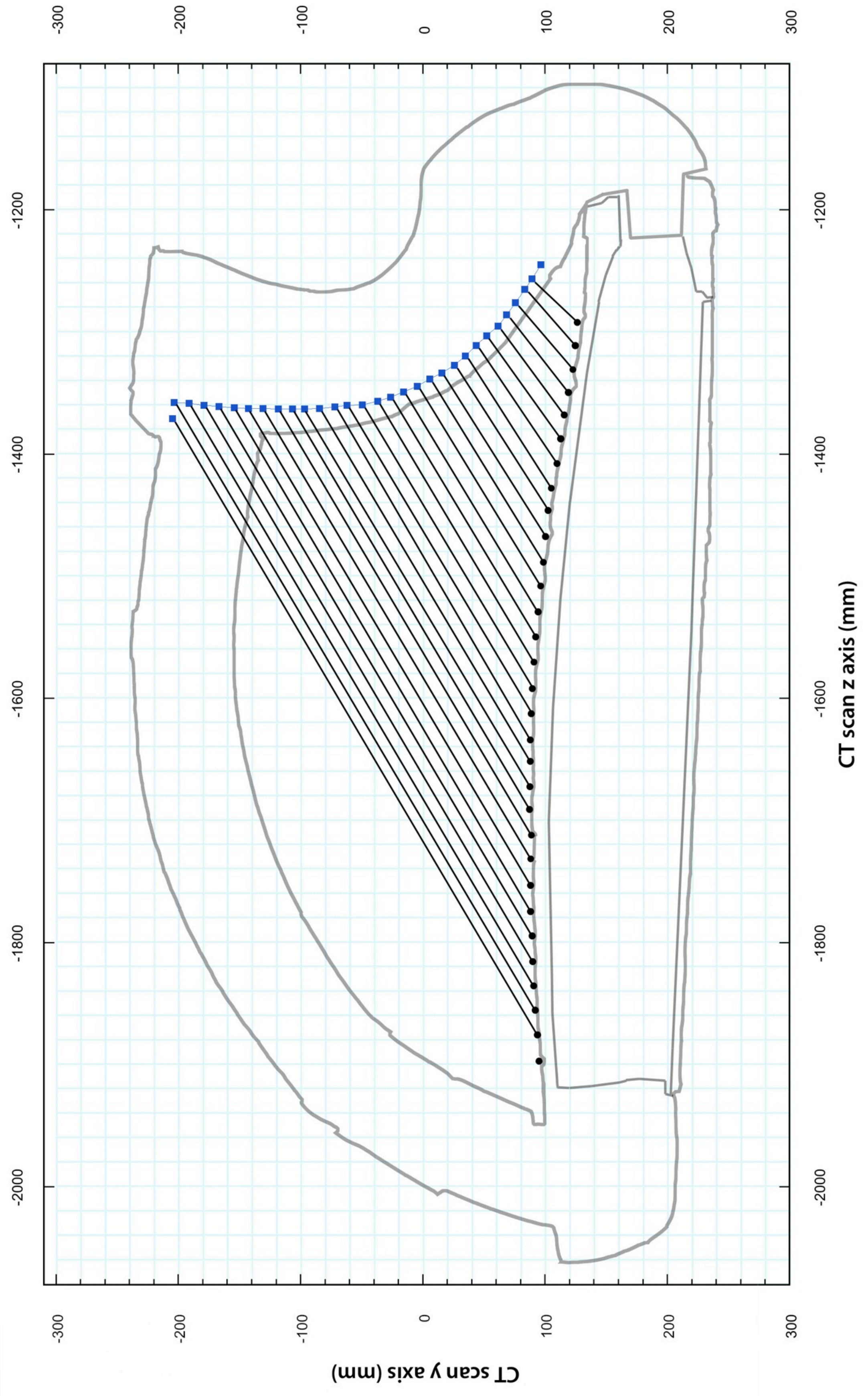

CT scan z axis (mm)
CT scan y axis (mm)
-1200
-1400
-1600
-1800
-2000
-300
-200
-100
0
100
200
300

Figure 2.20 (overleaf): *the frame of the Lamont harp, corrected for the rotation and shift of the neck. The black circles are the points of contact of the strings at the string shoes, plotted from the measured coordinates taken from the CT data. The red circles are the calculated points of contact of the strings at the tuning pins, corrected for the repositioning of the neck. The outline of the neck has been taken from a tomographic cross-section through its centre. This has been positioned with the neck tenon completely seated in the soundbox joint. The back of the soundbox has been redrawn to remove the bulge at the treble end (compare with figure 2.19). This bulge appears to have been caused by the rotation and backwards shift of the neck, which has caused the tenon to push the back of the soundbox outwards. The frame is shown strung with 31 strings, starting with string hole #1 – tuning pin #1, in the treble. As for figure 2.19, string hole #32 is shown unstrung. Tuning pin #32 is not shown, as it appears to be a later addition. The outline of the forepillar, shown as a dashed line, is speculative and is only included to show the complete frame. Scale: 1 box : 2 cm.*

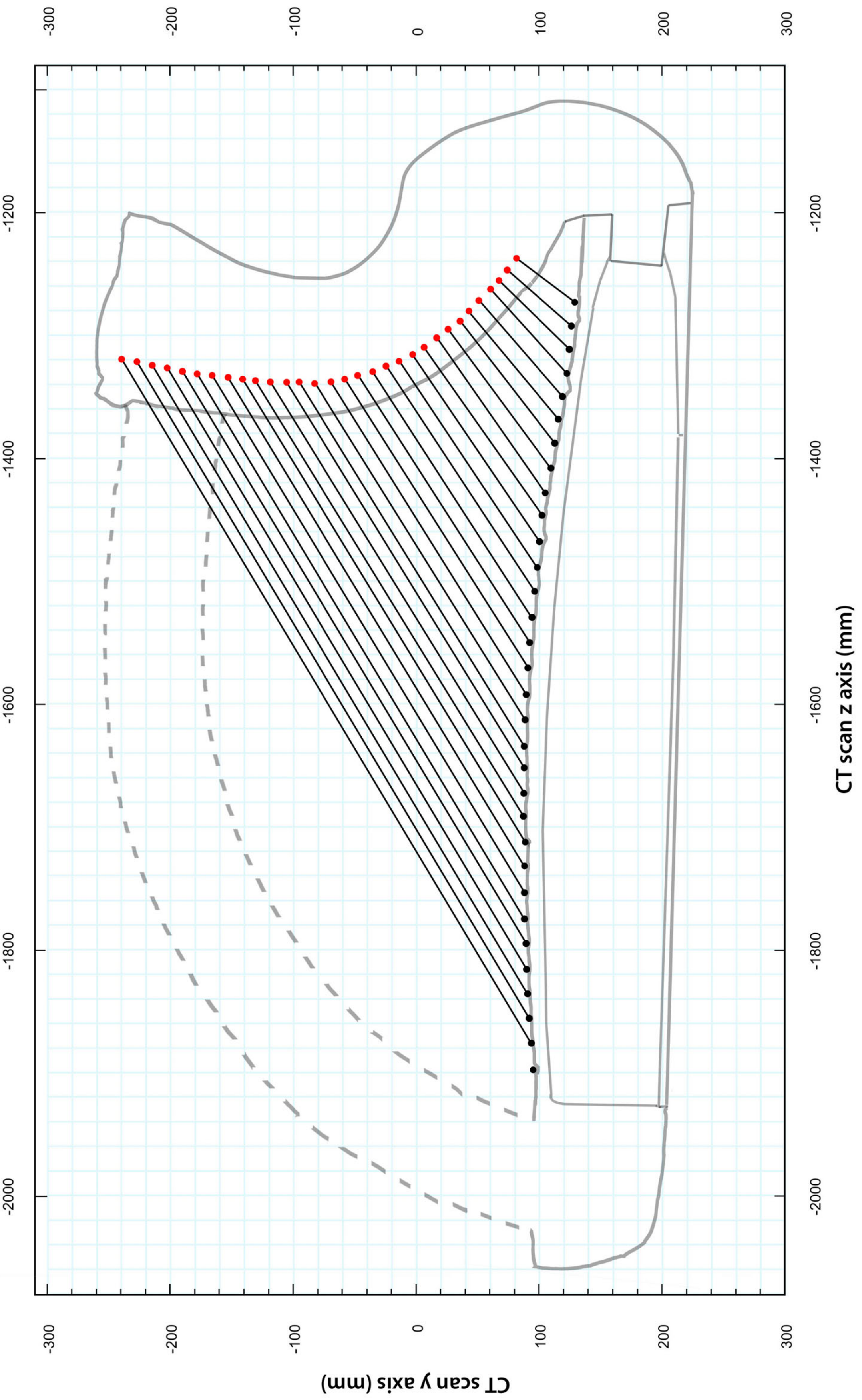
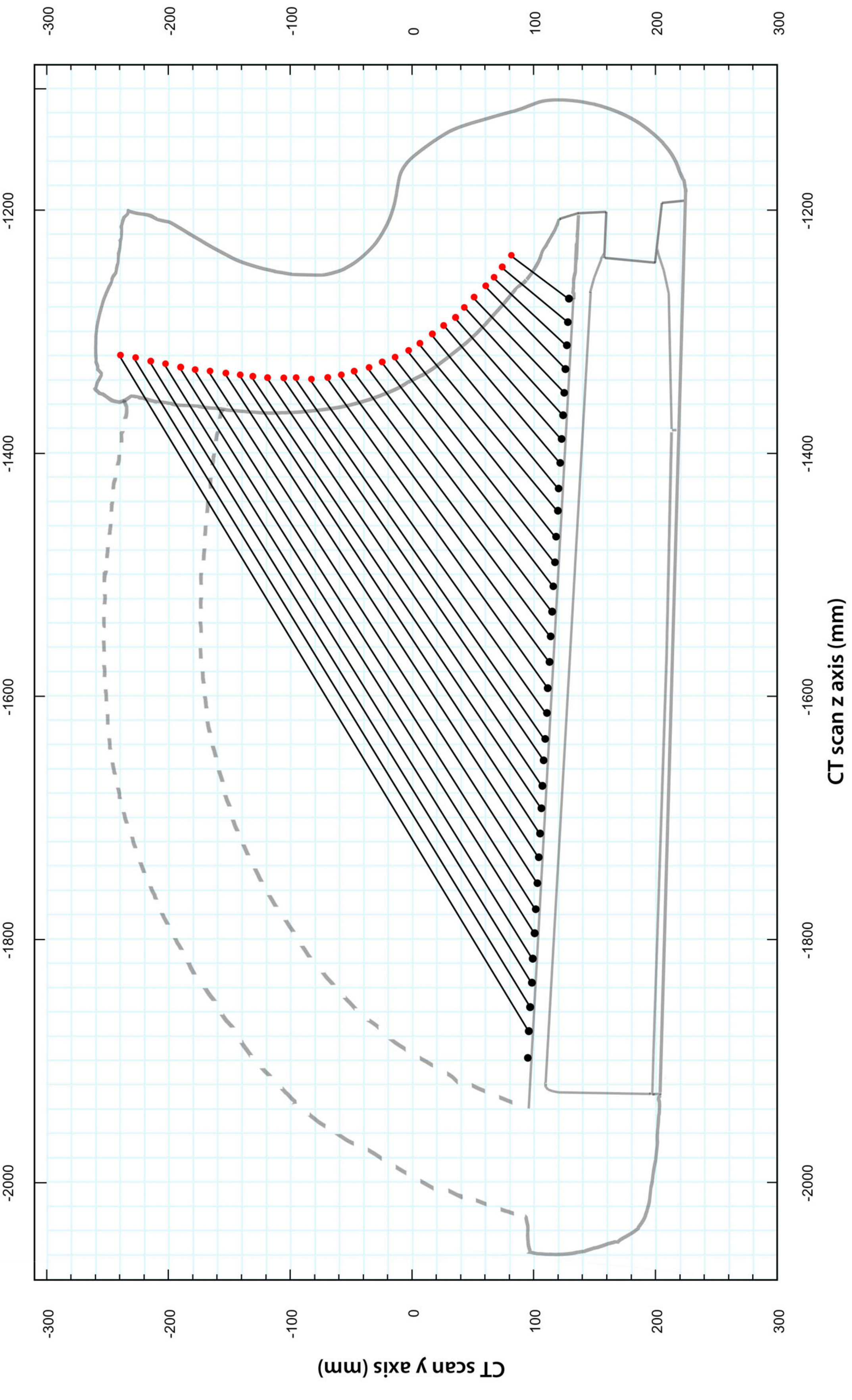

CT scan z axis (mm)
CT scan y axis (mm)
-1200
-1400
-1600
-1800
-2000
-300
-200
-100
0
100
200
300

Figure 2.21 (overleaf): *the frame of the Lamont harp, corrected for the rotation and shift of the neck, and the rise of the soundbox belly. The black circles are the points of contact of the strings at the string shoes, plotted from the calculated positions for a flat fronted soundbox. The remainder of the diagram is the same as shown in figure 2.20. Scale: 1 box : 2 cm.*



CT scan z axis (mm)
CT scan y axis (mm)
-2000
-1800
-1600
-1400
-1200
-300
-200
-100
0
100
200
300

Table 2.1.

Lamont harp string lengths

	offset stringing		direct stringing			
string #	**hole – pin**	**current frame (mm)**	**hole – pin**	**current frame (mm)**	**straight frame (mm)**	**straight frame no belly (mm)**
1	2 – 3	57	1 – 1	(53)	67	67
2	3 – 4	66	2 – 2	(61)	76	77
3	4 – 5	77	3 – 3	70	85	87
4	5 – 6	86	4 – 4	81	97	99
5	6 – 7	96	5 – 5	90	108	111
6	7 – 8	108	6 – 6	99	118	123
7	8 – 9	121	7 – 7	110	129	135
8	9 – 10	133	8 – 8	123	143	151
9	10 – 11	145	9 – 9	135	157	166
10	11 – 12	162	10 – 10	147	170	180
11	12 – 13	180	11 – 11	162	186	197
12	13 – 14	196	12 – 12	179	204	215
13	14 – 15	215	13 – 13	195	222	233
14	15 – 16	233	14 – 14	213	240	252
15	16 – 17	253	15 – 15	231	260	272
16	17 – 18	275	16 – 16	250	280	293
17	18 – 19	298	17 – 17	271	302	314
18	19 – 20	321	18 – 18	292	324	337
19	20 – 21	341	19 – 19	317	350	362
20	21 – 22	365	20 – 20	335	370	381
21	22 – 23	386	21 – 21	359	395	405
22	23 – 24	411	22 – 22	381	417	428
23	24 – 25	435	23 – 23	405	442	451
24	25 – 26	459	24 – 24	428	466	475
25	26 – 27	485	25 – 25	453	493	500
26	27 – 28	510	26 – 26	478	518	526
27	28 – 29	535	27 – 27	502	544	550
28	29 – 30	561	28 – 28	528	571	576
29	30 – 31	586	29 – 29	553	597	601
30	31 – 32	594	30 – 30	579	623	626
31	–	–	31 – 31	603	649	651

Note: the uncertainty in the string lengths is +/- 1 mm for both the measured and reconstructed string lengths. This, however, just represents uncertainty in measurements taken from the tomograms.

Stringing regimes for the Lamont harp

The states of the harp frame discussed in detail above present a picture of the instrument in the early, middle, and late stages of its working life. As also discussed, the string lengths and the arrangement of the stringing would have changed as a result of the changes to the shape of the frame and the damage to the tuning-pin holes. This section discusses the string scaling of the instrument in these different states and proposes some possible solutions for the stringing regimes.

The Lamont harp string lengths given in table 2.1 are plotted together in figure 2.22, showing the comparative differences between them for the different states of the harp frame.

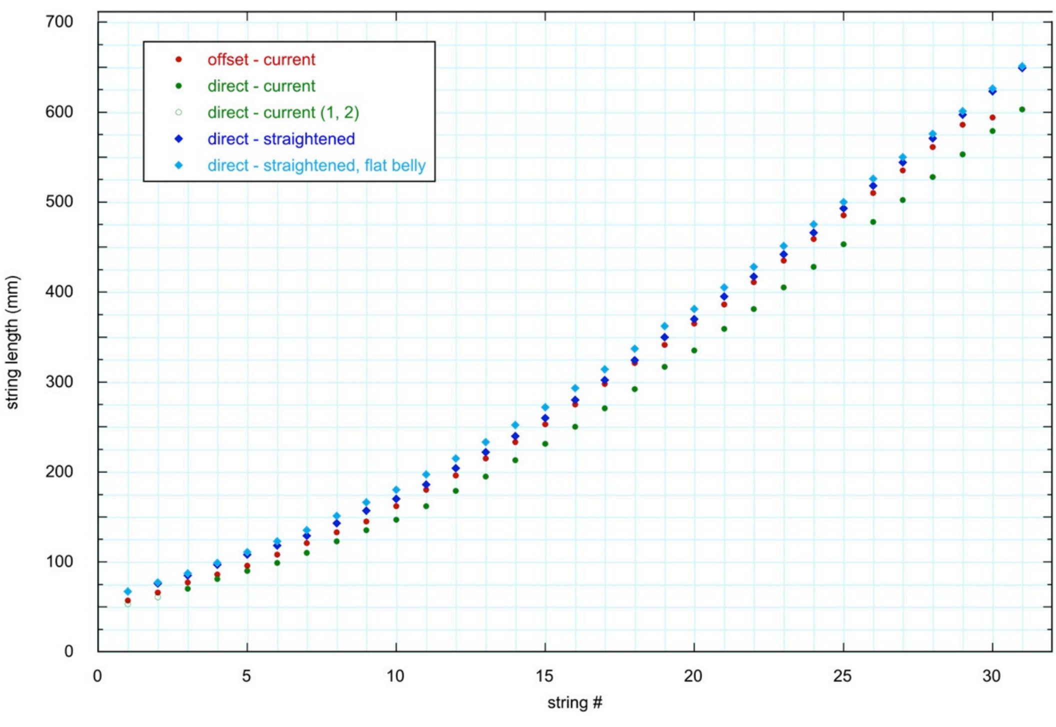


Figure 2.22: *string length versus string number for the Lamont harp. The stringing schemes shown are for the frame in its current state (offset stringing (red), and direct stringing (green)), and the straightened frame with direct stringing (with developed soundbox belly (dark blue), and with a flat soundbox (light blue)). The first two points of the plot of the direct stringing for the frame in its current state are shown as open circles, as it would not be possible to string to the #1 and #2 tuning-pins due to the damage to the neck.*

The graph in figure 2.22 illustrates the effect the twisting of the frame has had on the string lengths. The frame in its current state, with direct hole to pin stringing, has the shortest string lengths overall. The lowest string in the bass is nearly 50 mm shorter than the same string for the reconstruction of the straight frame. This is a difference of 7% of the total length of the string, and although the difference in length is comparatively smaller towards the treble end of the harp, as a percentage of the total length it increases to about 15% in the midrange of the instrument, and up to 20% in the treble. For the frame in its current state, the offset stringing described earlier appears to be a better option. The effect on the string lengths of offsetting the stringing (starting in the treble with string hole #2 strung to tuning pin #3) can be seen in the graph. The advantage of this stringing scheme is evident in that the string lengths are much closer to those for the straightened frame. With this scheme the difference in length as compared to the reconstructed straight frame is reduced to 2.5% in the bass, about 7.5% in the mid-range, and 15% in the treble. The exception is the bottom string. Strung from hole #31 to the added 32nd tuning-pin, this string is comparatively short. This is a consequence of the placement of the 32nd tuning pin below the cheekbands. Stringing to this additional tuning pin, however, makes up for the loss of one of the top two tuning pin holes. As noted earlier, another advantage of this offset stringing scheme is that it compensates for the reduction of the angle of the strings to the soundboard caused by the shift in position of the neck. Note that all of this is accomplished without changing the frame; only the manner in which it is strung has been changed. This stringing scheme, if used, would have been a resourceful solution to the issues caused by the shifting of the frame members and the loss of the top two tuning pin positions.[140]

The reconstruction of the straightened frame has the longest string lengths overall. These are plotted in figure 2.22 with and without the soundbox belly. The effect of the belly on the string lengths in the mid-range of the compass is apparent. This does raise the pitch of the instrument slightly. As discussed below, however, the change is

[140]Ann and Charlie Heymann have suggested that offset stringing may have been employed historically on some Irish harps to change the overall string lengths, particularly in instances where the number of string holes differs from the number of tuning-pin holes. The idea for using an offset stringing scheme on the Lamont harp frame originates from this concept.

small because the highest stressed strings are in the treble, where the difference in string length due to the belly is less than it is in the mid-range.

In order to see the scaling of the instrument, the string lengths are plotted logarithmically in the graph in figure 2.23. Pythagorean scaling would generate a straight line in this plot. The decreasing 'slope' towards the bass indicates the short scaling at this end of the compass, as would be expected. Note that the scaling is different for the different stringing schemes. The effect this has on the overall pitch of the instrument is discussed below along with some possible solutions for the pitch of this harp for each of the states of the frame.

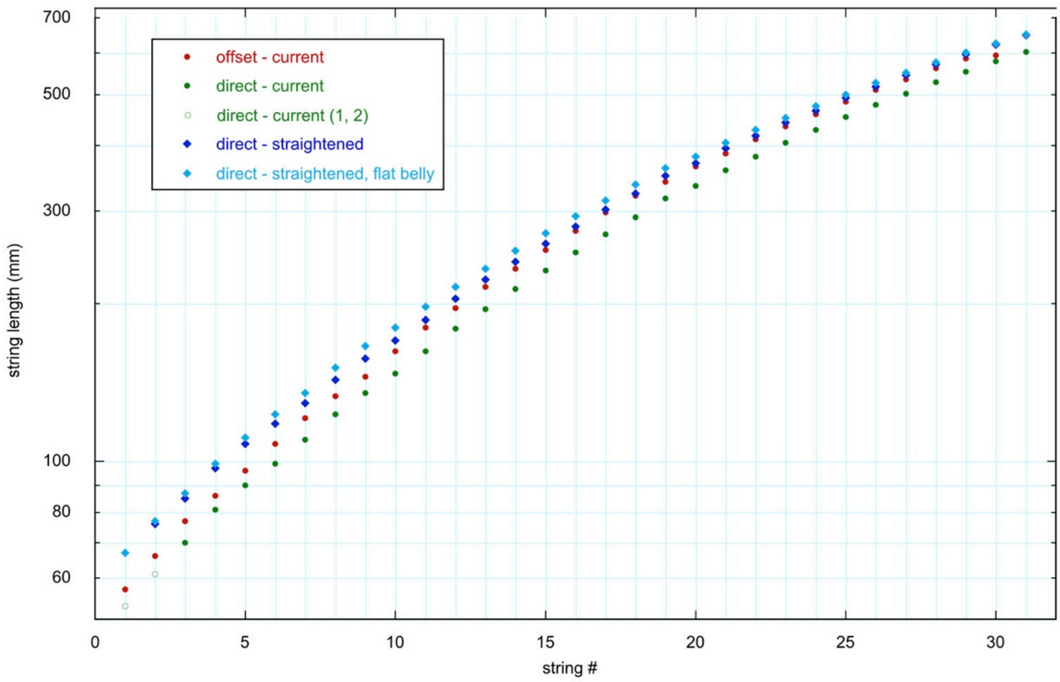


Figure 2.23: *string length versus string number for the Lamont harp, plotted on a logarithmic scale to show the scaling. A decreasing slope towards the bass indicates a 'short scaling' in this region of the compass (i.e. the string lengths are shorter than for Pythagorean scaling).*

The designated pitch of the instrument (i.e. the pitch of the note A above Middle C) depends on the assignment of note names to the strings as well as the string scaling. The note names are not known for this harp, however. The earliest information on the compass of Irish harps comes from Vincenzo Galilei (1581), Michael Praetorius (1619), and James Talbot (late 17th century).[141] Writing at the end of the 18th century, as mentioned earlier, Edward Bunting also provides the tuning for the Downhill harp, which was constructed in 1702.[142] The information these writers provide is summarized in table 2.2, below.

Table 2.2.
Some early historical references to number of strings and compass

Author	**Date of writing**	**Date of harp**	**# of strings**	**lowest note**	**highest note**	**# of octaves**	**position of unison strings**
Galilei	1581	–	58 (Italian harp)	C	d‴	4 (+1 note)	–
Praetorius	1619	–	43	C	e‴	4 (+2 notes)	–
Talbot	circa 1695	–	36 also 40, 43	GG	g‴	5	middle of compass "C (if not g)"
Bunting	1792 ff., 1840	1702 'Downhill'	30	C	d‴	4 (+1 note)	19, 20 g

The information from Galilei is actually for the Italian double harp. Galilei draws a comparison between this type of harp and information he has for an Irish harp, however, stating that the arrangement of stringing for the Irish harp is the same as the Italian harp, and proceeds to describe a 58-string Italian double harp with a compass of "four octaves plus one tone", from C to d‴.[143] It isn't clear from his text what notes were assigned to the strings of Irish harps, for which he only states, "the strings

[141] Galilei, *Ancient and Modern Music*, 358; Praetorius, *Syntagma musicum II*, 54; Rimmer, "James Talbot's Manuscript," 66 – 67.
[142] Bunting, *Ancient Music of Ireland*, 23. See also, Edward Bunting, *MS 29*, manuscript, Queen's University Belfast Library, Special Collections, *Bunting Manuscript Collection*, folio 77 r., 156.
[143] Galilei, *Ancient and Modern Music*, 357 – 58.

number fifty-four, fifty-six, or as many as sixty".[144] Praetorius describes a 43-string Irish harp with a compass of four octaves plus two notes, from C to e‴.[145] Talbot describes a 36-string Irish harp with a compass of five octaves, from GG to g‴.[146] He also notes that Irish harps can have 40 – 43 strings, adding that, "some lately made in England have 35 strings."[147] According to Bunting's notes, the harp played by Denis O'Hampsey (later known as the 'Downhill harp') was strung with 30 strings, from C to d‴, with a compass of four octaves plus one note.[148] His diagram of the gamut of the harp in staff notation indicates the position of the unison strings at g below c′.

The information from these writers may, or may not, be applicable to the Lamont harp. The harps referred to are not all from the same time period as each other, and it is possible that none is contemporary with the construction of the Lamont harp. The number of strings is also significantly different than the number on the Lamont, with the exception of the Downhill harp. The Downhill, however, is of the later 'high-headed' form of the instrument. As such, it has a somewhat different construction and longer scaling in the bass as compared to the Lamont harp. The Irish harps Galilei and Praetorius refer to are notably different from the Lamont in that they appear to be chromatic, not diatonic, instruments (the note names Praetorius lists for the compass of the Irish harp includes chromatics, and the number of strings quoted by Galilei is too large for a diatonic scale of the given compass).[149] The harps these two writers refer to can, however, be compared to the Cloyne, an Irish harp constructed in 1621, which was designed for 52 strings, with seven in a second, possibly chromatic, rank.[150]

An additional issue is the question of the accuracy of the historical information, in particular the information from Galilei and Praetorius. It is apparent that Talbot and

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144 ibid.
145 Praetorius, *Syntagma musicum II*, 54.
146 Rimmer, "James Talbot's Manuscript," 66 – 67.
147 ibid., 67.
148 Bunting *MS 29*, f. 74 v. (numbered 153). Denis O'Hampsey's name is Anglicized by Bunting as "Dennis Hempson".
149 Galilei, *Ancient and Modern Music*, 358; Praetorius, *Syntagma musicum II*, 54.
150 Billinge and Shaljean, "Dalway or Fitzgerald Harp," 176.

Bunting examined Irish harps first hand. Galilei, however, appears to have acquired his information on the Irish harp second hand and, although he states that the stringing arrangement is the same as for the Italian harp, he does not elaborate on this point so it is not clear how closely or in what manner the stringing of the Irish harp actually corresponds to that of the Italian harp. Praetorius provides a complete list of notes for the strings of the Irish harp, but the order of the chromatics he includes is curious, raising the question as to whether or not all of his information is correct.[151]

With the understanding that the information provided by these writers may not be entirely accurate or applicable, in the absence of better information it is used here as a starting point for assigning notes to the strings of the Lamont harp. The resulting solutions for the stringing regimes presented here are, as a consequence, only provisional.

Galilei, Praetorius, and Bunting agree on C as the lowest note of the instrument, so C is chosen here, initially, as the lowest note for the stringing regimes derived for the Lamont harp. The octave to which this C belongs will be evident from the string lengths. A stringing regime starting on F is also presented (the justification for this, and its relationship to the stringing from C will be described).

It is evident from the scaling of the Lamont harp that the tuning is essentially diatonic, however the possibility of the presence of unison strings, and of a gap in the bass tuning should also be considered. Historical information on the stringing of Irish harps does indicate the presence of a pair of strings tuned to a unison located near, or somewhat below, the middle of the range of these instruments. Although Galilei and Praetorius do not mention unison strings for the Irish harp, they are specifically noted by Bunting and Talbot as well as other writers.[152] This pair of strings was usually referred to as "ne cawlee" (with variant spellings) or as "the sisters".[153] A survey of

[151] Praetorius, *Syntagma musicum II*, 54.
[152] Chadwick, "Sister Strings."
[153] ibid. "Ne cawlee" is a phonetic English spelling of the Irish and Scottish Gaelic term. The translation from Irish of this term is not fully clear. In Bunting (1840) it is spelled as *caomhluighe* but also as *combh luighe*, and translated as 'lying together' and 'equally

the historical evidence for its inclusion and location in the gamut of Irish harps is discussed in Chadwick (2009).[154] The presence of this pair of strings is noted in 17th – 19th-century texts, with a possible early reference dating to the 14th century as well as a possible 12th-century reference, although this last is somewhat uncertain.[155] Possible additional evidence is contained in the tunings diagramed in the "Robert ap Huw" manuscript (BL MS Add. 14905), which include a tuning for the Welsh single rank harp labeled *y lleddf gywair y gwyddil* ("the Irishman's re-tuning"), that includes two pairs of unison strings in each octave.[156]

For the Downhill harp, Bunting places the pair of 'ne cawlee' strings at the g below c′. Talbot places them at the "middle" of the harp. Referring to them as a "Wolf", he states,

> "The Instrument tun'd gradually from the highest Treble to the middle insert then a Unison those two call'd a Wolf the rest arrived gradually thus supposing that in 36 strings the 1st is ggg the last ΓΓ which includes 5 octaves the Wolf shall be C (if not g)."[157]

Of the unison strings, Bunting shows in his manuscript notes that the strings from the upper unison to the treble end of the instrument were intended to be played by the left hand, and the strings from the lower unison to the bass end of the instrument by the right hand.[158] He also writes that the unison string pair "nearly divided the instrument into bass and treble."[159] Judging from Bunting's observations, this pair of strings can be thought of as dividing the instrument into a bass and a treble voice,

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stretched', respectively. The Irish word *comhluigh* is equivalent to "co-lie" in English, and *comhluí* translates as 'lying together'. The same term is translated as "the companions" in John Bell's notes taken down from the harper Patrick Byrne. This may derive from *na céilí* which means 'the companions' in both Irish and Scottish Gaelic. See Bunting, *Ancient Music of Ireland*, 21, 32; Henry George Farmer, "Some Notes on the Irish Harp," *Music & Letters*, 24, no. 2 (1943): 102.

154 Chadwick, "Sister Strings."

155 ibid.

156 Henry Lewis, ed. *Musica: B. M. Additional MS. 14905* (Cardiff: University of Wales Press Board, 1936), 108 – 09; Robert Evans, "Robert ap Huw's Harp Tunings", *Welsh Music History*, 3 (1999): 337. The 'Robert ap Huw' manuscript (BL Addl. 14905) dates to the early 17th century, but appears to have been copied from earlier manuscripts.

157 Rimmer, "James Talbot's Manuscript" 67.

158 Bunting *MS 29*, f 38v. (numbered 81).

159 Bunting, *Ancient Music of Ireland*, 21.

where the highest note of the bass voice is tuned to the same pitch as the lowest note of the treble voice. Based on the historical information, a pair of unison strings is therefore included in the tuning proposed here for the Lamont harp.

Bunting also noted the presence of a gap in the bass tuning, stating that, "the Irish harp had no string for F sharp, between E and G in the bass."[160] This gap is included in the scale he diagrams for the Downhill harp. The gap, as described by Bunting, occurred at E/F in the bass, whereby the string directly below G could be tuned to either E or F, depending on the tuning of the rest of the instrument. According to Bunting's description, when the F-strings on the harp were tuned to F-sharp, this string would be tuned to E, whereas when the F-strings were tuned to F-natural, this string would be tuned up to F-natural.[161] Bunting further notes that when tuned to E, this string was referred to as *tead leagtha,* meaning the "fallen string" (*leagtha* = knocked, thrown, or put down), and when tuned to F-natural it was referred to as *tead leaguidh* the "falling string" (possibly *leagaidh* ≈ of putting down).[162] So, for the tuning with F-sharps, the first four bass strings were tuned to C, D, E, G, and for the tuning with F-naturals, these strings were tuned to C, D, F, G. It is not known if the earlier Irish harps had a similar gap in the bass. As a comparison, however, the repertory of the Robert ap Huw manuscript, which happens to also have C as its lowest note, has no E in the bass.[163] So, the implied first four notes of the bass scale in this case are also C, D, F, G. The tuning scheme proposed here for the Lamont harp includes the gap in the bass, as described by Bunting for the Downhill harp, with the understanding that this is only one possible solution. The solutions for the scaling and pitch, discussed below, would be the same for the instrument if both the unison string and the gap in the bass were omitted. The inclusion of the unison string

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[160] Bunting, *Ancient Music of Ireland*, 23.
[161] ibid.
[162] Colm Ó Baoill notes that the genitive of *leag* is *leagtha* in Irish, but is *leagaidh* in Scottish Gaelic. Colm Ó Baoill, "Tead leagaidh - Falling string Tead leagtha - The string fallen" ed. Simon Chadwick, 2002, last modified 2008, http://www.earlygaelicharp.info/Irish_Terms/22.htm. Dennis O'Hampsey was from Magilligan in Co. Derry, on the north coast of Ireland, so perhaps this form of the word was in his dialect.
[163] Sally Harper, *Music in Welsh Culture Before 1650: A Study of the Principle Sources* (Aldershot: Ashgate, 2007), 144.

shifts the note names down towards the bass by one string, and the inclusion of the gap in the bass shifts the note names up towards the treble by one string. So, in terms of the compass of the instrument, these two alterations to the diatonic scale cancel each other out.

A proposed tuning scheme for the Lamont harp for both the 'as built' and current states of the frame is shown in table 2.3. Note that the stringing used for the current frame is the offset stringing described earlier. The string lengths from table 2.1 are reproduced here for reference. As noted earlier, the string lengths for the current frame are actual measurements taken from the frame of the harp, whereas the string lengths for the straightened frame are reconstructions.

Table 2.3.

Proposed compasses for the Lamont harp, from c in the bass

	straightened frame (no belly) direct stringing		current frame offset stringing	
string #	length (mm)	note	length (mm)	note
1	67	e''''	57	d''''
2	77	d''''	66	c''''
3	87	c''''	77	b'''
4	99	b'''	86	a'''
5	111	a'''	96	g'''
6	123	g'''	108	f♯'''/f'''
7	135	f♯'''/f'''	121	e'''
8	151	e'''	133	d'''
9	166	d'''	145	c'''
10	180	c'''	162	b''
11	197	b''	180	a''
12	215	a''	196	g''
13	233	g''	215	f♯''/f''
14	252	f♯''/f''	233	e''
15	272	e''	253	d''
16	293	d''	275	c''
17	314	c''	298	b'
18	337	b'	321	a'
19	362	a'	341	g'
20	381	g'	365	g'
21	405	g'	386	f♯'/f'
22	428	f♯'/f'	411	e'
23	451	e'	435	d'
24	475	d'	459	c'
25	500	c'	485	b
26	526	b	510	a
27	550	a	535	g
28	576	g	561	e/f
29	601	e/f	586	d
30	626	d	594	c
31	651	c	-	-

For the straightened frame, the compass of the instrument is 4 octaves plus 2 notes, from c to e'''', with the pair of unison strings located at strings #20 and #21, and for the current frame the compass is c to d''''.

The overall pitch of the instrument for this proposed compass depends on the length of the highest stressed strings. These were identified by scaling the string lengths to the equivalent length of the string designated as c''. The scaled lengths for these proposed compasses for the straightened frame and the current frame are shown in figure 2.24.

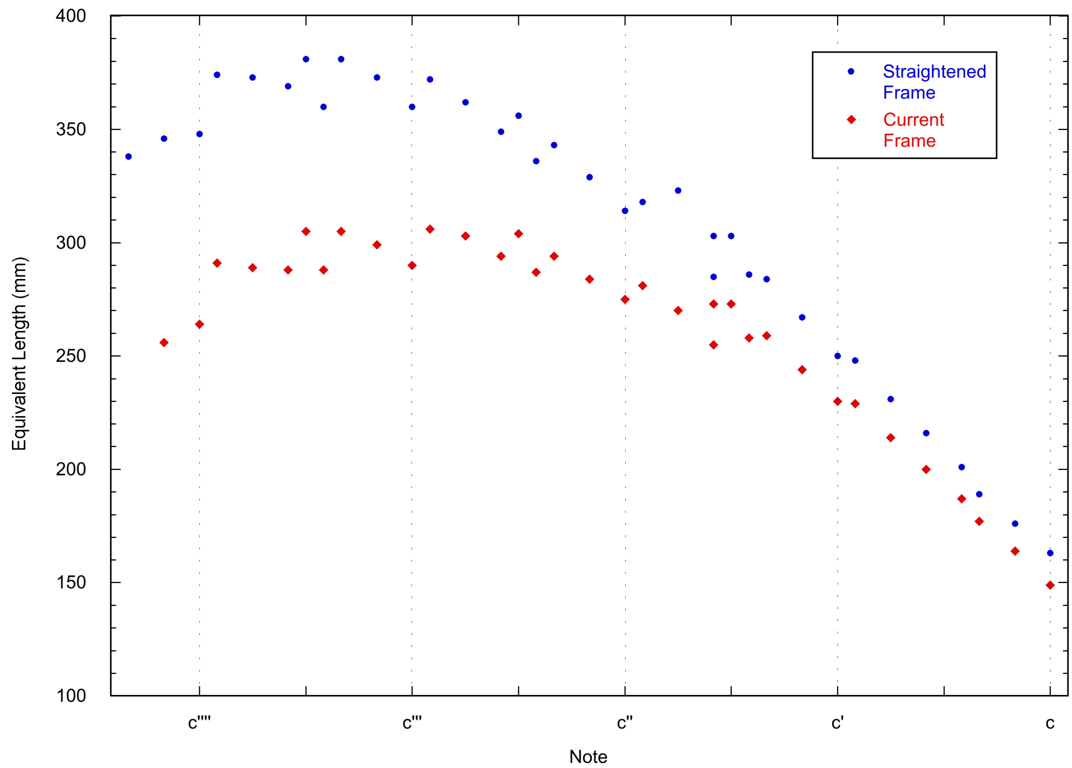

Figure 2.24: *stress curves for the stringing of the Lamont harp, based on a proposed compass of c - e'''' for the straightened frame and c - d'''' for the frame in its current state (see table 2.3). The string lengths have been scaled to the equivalent length of the c'' string for each version of the frame. The equivalent string lengths are represented as blue dots for the straightened frame and as red diamonds for the current frame. The highest stressed strings are identified as those with the longest equivalent length.*

For the straightened frame, the scaling for this compass is 381 +/- 3 mm, based on the equivalent length of the highest stressed strings. For the frame in its current state, with offset stringing, the scaling for the proposed compass is 306 mm +/- 2 mm.[164]

Assuming a yellow brass scaling of 270 mm for c″ at A440, this places the pitch of the instrument at around 310 – 314 Hz for the straightened frame, and at around 386 – 391 Hz for the current frame.[165] These may be considered as optimal pitch for the instrument with this proposed compass and stringing material.[166]

These solutions for the pitch of the instrument, particularly for the straightened frame, which is a reconstruction of the instrument 'as built', are quite low, but are plausible when considered in the context of what is currently known about historical pitches. Haynes (2002) discusses the pitch systems known as "Organ-pitch" and "Quire-pitch", which were in use in the 16th and 17th centuries. These two systems are related by a transposition of a 5th up the scale (or a 4th down). In "Organ-pitch", the bottom note of the organ is a C, and this is understood to have been the lowest note of the compass used when the organist was performing solo. When accompanying a choir, however, the note names were shifted so that the bottom C was renamed F, effectively transposing the pitch of the organ to what is referred to as "Quire-pitch".[167] Haynes quotes Nathanial Tomkins (writing in 1665) describing the "10-foot" pipe of the Worcester Cathedral organ as "double F fa ut of the quire pitch & according to Guido Aretines scale (or as some term it double C fa ut according to y[e]

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[164] The uncertainty is based on an uncertainty of +/- 1 mm in the string length, carried through the calculation for scaling the length to c″.

[165] This result is determined from the relation for change in pitch for a given change in string length: $[log(l_1/l_2)] \times k = \Delta\, cents$, where $k = 1/\left[log\left(\sqrt[100]{\sqrt[12]{2}}\right)\right]$, and $f_1/f_2 = l_2/l_1$, where *f* and *l* are the frequencies and string lengths. For the scaling of yellow brass, see Murray Campbell, Clive Greated, and Arnold Myers, *Musical Instruments: History, Technology, & Performance of Instruments of Western Music* (Oxford: Oxford University Press, 2004), 308.

[166] This pitch assumes the wire is tuned a whole tone below its snapping pitch. The instrument could be pitched lower, probably by as much as a whole tone, and still retain a useable quality of tone, however if pitched more than a semitone higher there is a risk of snapping the highest stressed strings.

[167] Bruce Haynes, *A History of Performing Pitch: The Story of "A"* (Oxford: The Scarecrow Press, 2002), 88 – 89. See also Darryl Martin, "The English Virginal," (PhD diss., University of Edinburgh), 72.

keys & musiks)".[168] Based on measurements of surviving unaltered English organ pipes, Haynes places "Quire-pitch" in England at about A473 and "Organ-pitch" at about A317 (or A634, an octave higher, depending on octave assignment).[169] There are also surviving instruments pitched at multiples of a semitone below "Organ-pitch" or "Quire-pitch", specifically 1, 2, and 3 semitones lower. Martin (2003) has established that 17th-century English virginals were constructed for Quire pitch, and for the intervals of 1, 2, and 3 semitones below, with the instruments constructed at "Quire-pitch" predominating.[170] With regard to the absolute pitch of "Quire-pitch", he notes that A474 (essentially the same pitch that Haynes gives) was most common in the 17th century (based on Gwynn, 1985).[171]

At 310 – 314 Hz, the pitch derived for the straightened frame of the Lamont harp, with a compass starting on C as the lowest note, happens to be close to Haynes's "Organ-pitch" of 317 Hz. If the note names are shifted to start on F, in the manner of the transposing organs, the scaling of the harp converts to 252 – 256 mm, which translates as a pitch of 464 – 471 Hz, corresponding closely with "Quire-pitch" as described above. This also coincides with a common pitch standard in use in Europe in the late 16th and early 17th centuries, referred to as *mezzo punto* or *cornet-ton*.[172] According to Haynes, this was the "normal" pitch for Venetian woodwinds, which were exported throughout Europe and in wide use in the 16th and 17th centuries.[173] Based on surviving cornets, this pitch averaged around 466 Hz, with slightly more than half of these instruments falling within the range of 460 – 471 Hz.[174]

The pitch for the harp in its current state (for the proposed compass, starting on C in the bass), 386 – 391 Hz, should not be expected to agree with any particular pitch standard, as it is a consequence of damage to the harp frame. The frame of the

[168] Haynes, *Performing Pitch*, 88.
[169] ibid., 88 – 89.
[170] The other pitches are multiples of a semitone below this pitch (1, 2, and 3 semitones) in concurrence with the pitch groupings for organs of this period. Martin, "The English Virginal," 75.
[171] ibid.
[172] Haynes, *Performing Pitch*, 58 – 60, and 78 – 79.
[173] ibid., 97.
[174] ibid., 60.

Lamont harp would have been in this state late in its working life, probably from sometime in the 17th century until the death of John Robertson of Lude in 1731.

The C and F bass tuning schemes for the Lamont harp are shown together in table 2.4. Note that for the C bass scheme the unison strings are placed at g′, whereas for the F bass scheme the same strings occur at c′. This could provide a possible explanation for Talbot's remark that the unison strings "shall be C (if not g)."[175]

[175] Rimmer, "James Talbot's Manuscript," 67.

Table 2.4.

Proposed compasses for the Lamont harp
from c and F in the bass
(**reconstructed string lengths for the straightened frame with no soundbox belly**)

string #	**length (mm)**	**note (A – 6)**	**note (A + 1)**
1	67	e''''	a'''
2	77	d''''	g'''
3	87	c''''	f'''
4	99	b'''	e'''
5	111	a'''	d'''
6	123	g'''	c'''
7	135	f♯'''/f'''	b''/b♭''
8	151	e'''	a''
9	166	d'''	g''
10	180	c'''	f''
11	197	b''	e''
12	215	a''	d''
13	233	g''	c''
14	252	f♯''/f''	b'/b♭'
15	272	e''	a'
16	293	d''	g'
17	314	c''	f'
18	337	b'	e'
19	362	a'	d'
20	381	g'	c'
21	405	g'	c'
22	428	f♯'/f'	b/b♭
23	451	e'	a
24	475	d'	g
25	500	c'	f
26	526	b	e
27	550	a	d
28	576	g	c
29	601	e/f	A/B♭
30	626	d	G
31	651	c	F

Note: A – 6 is pitched six semitones below A440; A + 1 is pitched one semitone above A440.

The string lengths for the notes in the F bass tuning scheme are plotted in the graph in figure 2.25.[176] The scaling for yellow brass and red brass (adjusted to A467, the midpoint of the range A464 – 471 Hz) is indicated by the dashed lines.[177] The points at which the string lengths intersect the scaling for these string materials indicates where metal transitions may take place in the stringing. For this tuning scheme, the transition from yellow brass to red brass could take place at the unison strings, a convenient point given that it marks the division between the treble and bass voices of the instrument. The longer of the two unison strings would have to be strung with yellow brass, however, and the b/b-flat string directly below this would be in danger of snapping if tuned up to b-natural. It would be safer in this instance to make the transition a string lower, or to lower the pitch of the instrument by a semitone, which would place it at about A440. This could be accomplished by simply omitting the gap in the bass.

As is typical of low-headed Irish harps, the scaling is quite short in the bass, and the tone of the lowest three or four strings might be improved by the use of a denser stringing material than red brass. As discussed earlier, the use of precious metal stringing in the bass has been theorized, and there is some historical evidence that points to the possible use of silver strings on some of these harps.[178] Whether silver strings were ever used on this harp is unknown.

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[176] Strings that have two possible tunings (i.e. the A/B-flat string in the bass, and the b/b-flat strings in the other octaves) are represented by pairs of points connected by a horizontal line.
[177] Scaling for yellow brass from Campbell, Greated, and Myers, *Musical Instruments*, 308. Scaled from 270 mm for c '' at A440. Scaling for red brass from Grant O'Brien, *Ruckers: A Harpsichord and Virginal Building Tradition* (Cambridge: Cambridge University Press, 2008), 61. Scaled from 211 mm for c'' at A415; silver scaling estimated by the author, based on silver wire hand drawn by Daniel Tokar, scaled from 167 mm for c'' at A440.
[178] Heymann and Heymann, "Strings of Gold." Barbieri, "Gold- and Silver-Stringed Musical Instruments," 147.

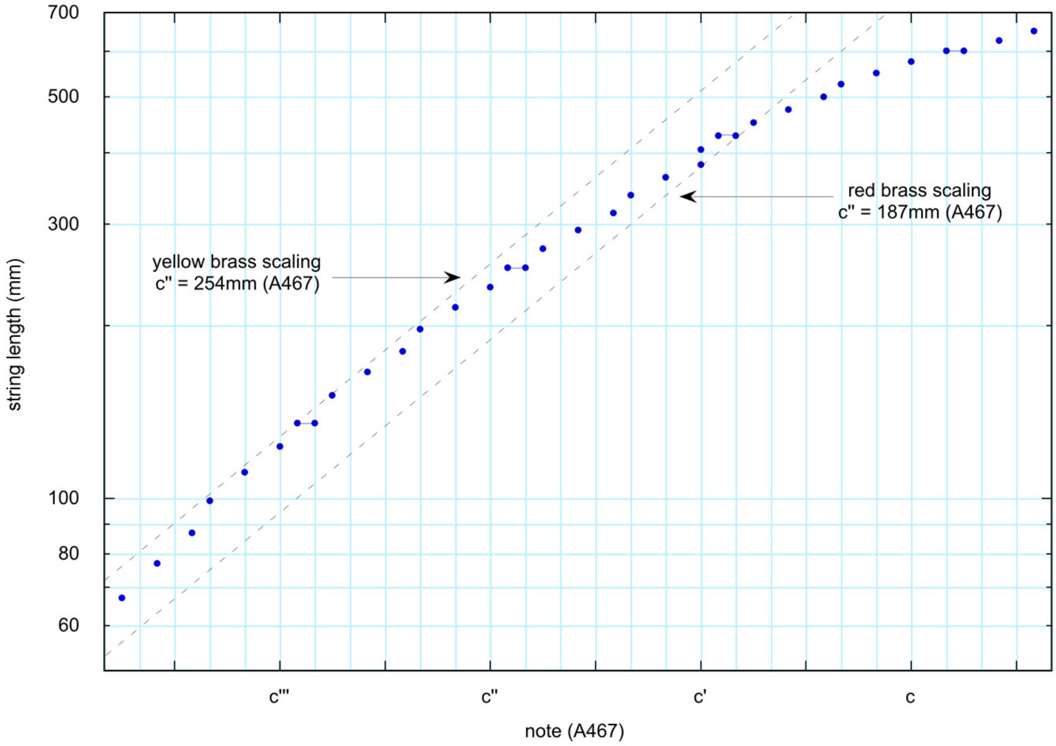

Figure 2.25: *scaling of the Lamont harp for the straightened frame with no soundbox belly for the compass from F in the bass. Strings that have two possible tunings are represented as pairs of points connected by a line. For this scaling, the instrument is pitched at A467. The dashed lines indicate the scaling for yellow brass and red brass (as labeled), adjusted to the pitch of A467. In order to avoid snapping, strings need to be shorter than the scaled length for the chosen material (i.e. they should lie below the dashed lines indicated on the graph).*

With the exception of the wire fragment found in string hole #14, string gauges for the Lamont harp are currently not known. It may be possible to measure string gauges from the wire impressions left in the wood around the string holes (and possibly on the string shoes). By measuring the width and depth of an impression, the gauge of the wire that made it can be calculated from the following formula, which is derived from the theorem for intersecting chords on a circle:

$$D = \frac{\left(\frac{w}{2}\right)^2 + d^2}{d} \ ,$$

where '*w*' is the width of the impression, '*d*' is the depth, and '*D*' is the diameter (or gauge) of the wire. This would require very precise measurements, but may be possible with a high-resolution laser scan.

Using the information derived for string length, pitch, density, and diameter, the tension can be calculated for the string associated with the wire fragment in string hole #14 (which corresponds to string #13 for both the direct and offset stringing discussed above), using the formula

$$T = \frac{f^2 l^2 \rho \pi D^2}{g} ,$$

where 'f' is pitch in hertz, 'l' is string length in meters, 'ρ' is density in kg/m^3, 'D' is diameter in meters, 'g' is the acceleration of gravity in m/s^2, and 'T' is tension in kgf. The measured values for the density and diameter are 8550 kg/m^3 and 6.9x10^{-4} m, respectively (see Chapter 1). For the 'straightened' frame, the reconstructed length of string #13 is 0.233 +/- 0.001 m, the note assigned to this string for the proposed compass starting at F in the bass is c″. With the harp pitched in the range of A464 – 471 Hz, the pitch of this string would be 552 – 560 Hz. The tension on this string would therefore, be 21.9 +/- 0.5 kgf. For the current frame (with offset stringing), the measured length of string #13 is 0.215 +/- 0.001 m, the note is f#″/f″, with the harp pitched in the range of A386 – 391 Hz, so the pitch of this string would be 613 – 621 Hz, for f″ and 649 – 658 Hz for f#″. In this instance the tension on this string would range from 22.9 +/- 0.5 kgf to 25.8 +/- 0.5 kgf.

It is interesting to compare these values to current stringing practices for some modern instruments modeled after the Lamont harp, as summarized in table 2.5, below.[179] A Trinity College harp replica is also included for comparison.

[179] The author would like to thank Simon Chadwick for supplying the stringing specifications for harps B and C.

Table 2.5.

Comparison of derived string tension for the Lamont wire fragment to comparable strings on some harps modeled after the historical instruments

harp	string #	note	f (Hz)	length (m)	gauge (m)	density (kg/m^3)	tension (kgf)
Lamont 'straightened, no soundbox belly'	13	c″ A464 – 471	552-560	0.233	6.9E-04	8550	21.9 +/- 0.5
Lamont 'current'	13	f♯″ f″ A386 – 391	649-658 613-621	0.215	6.9E-04	8550	25.8 22.9 +/- 0.5
harp A, after the Lamont (1996 - 2006 stringing)	13	c″ A440	523	0.245 (1996)	7.0E-04	8536	22.0
harp A, after the Lamont (current stringing)	13	c″ A392	466	0.230 (2008)	5.6E-04	8536	9.85
harp B, after the Lamont	12	b″ A440	493	0.228	6.0E-04	8536	12.6
harp C, after the Trinity College harp	12	b″ A440	493	0.225	5.6E-04	8536	10.6

The first two rows in table 2.5 contain the data for the actual Lamont harp, for both the reconstruction of the straightened frame and for the frame in its current state. As discussed, the tension is derived from the proposed pitch of the string corresponding to the string-hole in which the fragment was located, using the density and diameter of the fragment, from Chapter 1. The comparable strings on the modern replicas are 30% zinc yellow brass wire. Note that the string tension derived for the Lamont harp is double the tension of the comparable strings on the modern replicas. The one exception is the tension derived from the earlier stringing regime for Lamont replica A, which had a pitch and gauge similar to the actual Lamont. This harp, which currently belongs to the author, is an interesting example, as the frame shows clear signs of twisting in the same manner as the original Lamont harp. In particular, the neck has also rotated and shifted backwards towards the back of the soundbox. The damage that this caused to the soundbox necessitated the addition of a metal band in the same location as a similar band at the top end of the soundbox of the Lamont harp. Considering the degree of observed motion of the neck in the soundbox joint of this replica, it is probable that the tenon also has a crack in it, again similar to the actual Lamont harp. After 2006, the author lowered the tension on this instrument by reducing the overall string gauges.[180]

The information in table 2.5 suggests that string tensions for the Lamont harp may have been much higher, at least at some point during its working life, than current practice on instruments modeled after this and other surviving low-headed Irish harps. Given the considerable damage to the frame, which can be directly linked to string tension, it is possible, however, that the Lamont harp may not have been originally intended to be strung at the tension indicated by the wire fragment. There is some interesting related evidence to consider with regard to this, not only for this harp, but also for other low-headed Irish harps.

As mentioned above, the Lamont harp has an iron band around the top of the soundbox that appears to have been added at some point to reinforce and prevent further damage to that part of the box as a result of the string tension causing the neck to rotate forwards, forcing its tenon against the back of the soundbox. It also has a pair of brass straps reinforcing the joint between the neck and forepillar against the pull of the strings towards the left side of the harp. These straps may also be a later addition, as discussed below.

The Lamont harp is not unique in having these reinforcements on its frame. Other low-headed Irish harps were equipped with similar bands and straps. As shown in figure 2.26, the Irish harp depicted in the *Syntagma Musicum* of Praetorius has straps

[180] This was done out of some concern for the frame and concern over the effect of the higher tension on the acoustics. The overall pitch of the instrument was later reduced to accommodate repositioning the unison strings within the constraints of the current stringing.

across the neck/forepillar joint, and appears to have also had a band around the top end of the soundbox, similar to the reinforcements on the Lamont harp.[181]

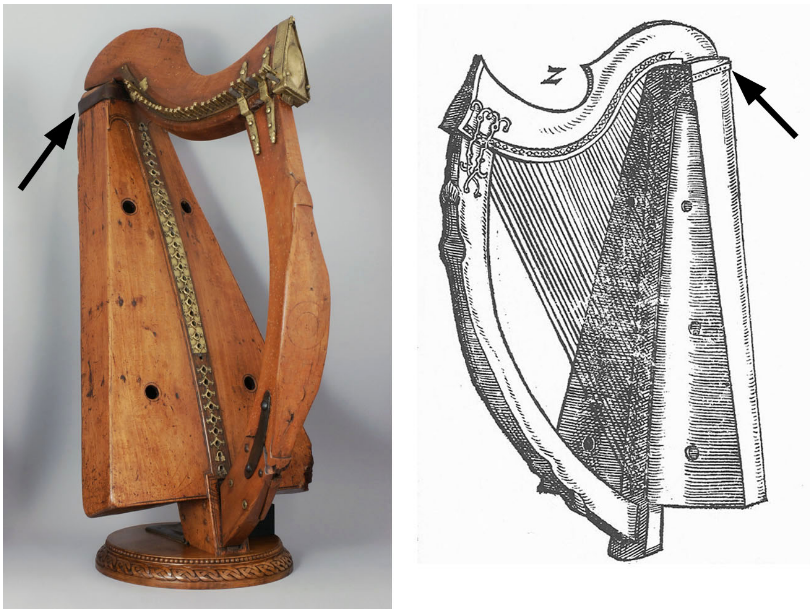

Figure 2.26: *a photograph of the Lamont harp (left) compared with the engraving of an Irish harp in the Syntagma musicum of Praetorius.*[182] *Both harps have straps across the neck/forepillar joint, and both have a strap around the top end of the soundbox where it joins with the neck (arrowed).* Photograph (left): Isabelle Wagner.

The Ballinderry harp fragments include a strap intended to be affixed across the neck/forepillar joint, and both the Queen Mary harp and the Cloyne fragments show signs of having had straps across this joint, as shown in figure 2.27.[183]

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[181] Praetorius, *Syntagma musicum*, 54.

[182] Praetorius, *Syntagma musicum*, detail of plate XVIII, 2. "Irlendisch harff mit Messinges Saiten." Praetorius's engraving appears to be flipped left - right with respect to the normal orientation of these harps.

[183] The 'Cloyne' (a.k.a. 'Dalway') harp, National Museum of Ireland, DF: 1886.2. The 'Ballinderry' harp fragments, National Museum of Ireland, WK.372. Armstrong, *Irish and Highland Harps*, see Plate facing 62. The wooden frame for the Ballinderry harp fragments is a modern reconstruction. The author gratefully acknowledges Simon Chadwick for suggesting the nail marks indicated on the Queen Mary harp may have been associated with straps across the joint.

Figure 2.27: *photographs of the area of the neck/forepillar joint of four low-headed Irish harps. Clockwise from top left: the Lamont, the Ballinderry, the Cloyne, and the Queen Mary.*[184] *The Lamont harp and Ballinderry fragments both have straps across the joint, and the Queen Mary and Cloyne show evidence of having had straps in the same location (arrowed).*

Prior to its conservation in 1961, the Trinity College harp had an iron band around the treble end of the soundbox at the neck joint, the same location as the band on the Lamont harp.[185] This can be seen in photographs of the harp pre-dating the conservation work, and it is referred to in the conservation report.[186] Early 19th-

[184] Photographs: (top left) Maripat Goodwin; (top right) Armstrong, *Irish and Highland Harps*, detail of plate facing 62, "Brass mountings for a harp found at Ballinderry, King's County. Right side"; (lower left) Karen Loomis; (lower right) Karen Loomis, used with the kind permission of the National Museum of Ireland.
[185] British Museum conservation Report, "15th c. Irish harp formerly known as the Brian Boru harp & now known as the TCD harp," file 2231 (Department of Conservation and Scientific Research) 7, 9 – 10. See also, Dooley, "Medieval Irish Harp," 119 – 20.
[186] ibid.

century depictions of this harp show it with a pair of straps across the joint between the neck and forepillar in addition to the band.[187] The band and straps can be seen in an engraving of the harp published in Rees's *Cyclopædia*.[188] A detail of this engraving is shown in figure 2.28, which also shows a photograph, dated 1898, in which the metal band can be seen on the soundbox at the neck joint.[189]

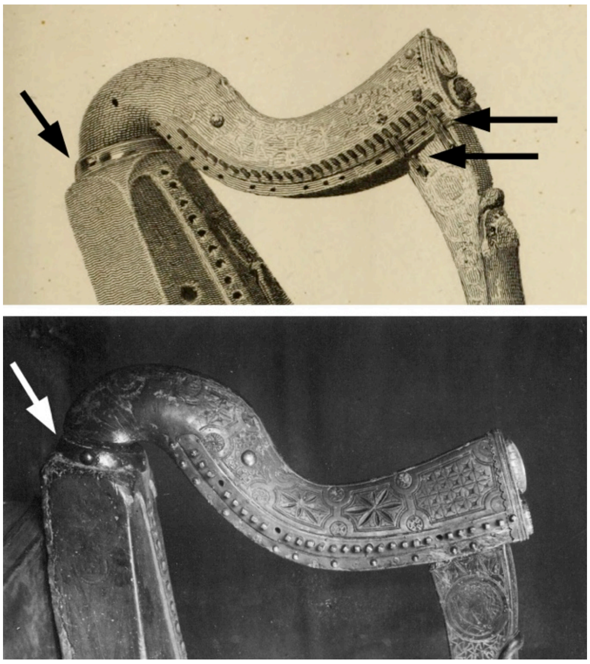

Figure 2.28: *(top) detail of an engraving of the Trinity College harp dated 1808, depicting the instrument with a band around the treble end of the soundbox at the neck joint, and a pair of straps across the neck/forepillar joint (arrowed); and (bottom) detail of a photograph dated 1898, showing the band around the treble end of the soundbox (arrowed).*[190]

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[187] Simon Chadwick, "The Trinity College Harp: Damage," last modified August, 2014, http://www.earlygaelicharp.info/harps/trinitydamage.htm.

[188] Abraham Rees, *The Cyclopædia, or Universal Dictionary of Arts, Sciences, and Literature, Vol. III: Plates* (London: Longman, Hurst, Rees, Orme, & Brown, 1820), Plate X. The author gratefully acknowledges Simon Chadwick for bringing this engraving to her attention.

[189] Benjamin Stone, photograph of the Trinity College harp, dated 1898, *Sir Benjamin Stone Collection* (Birmingham: Birmingham Central Library, Archives & Heritage), box 302, print 38. Reproduced with the permission of the Library of Birmingham. The author gratefully acknowledges Simon Chadwick for bringing this photograph to her attention.

[190] ibid. Arrows added by the author. At the time of Stone's photograph, the harp did not have straps across the neck/forepillar joint. Under magnification, scratches in the wood of the neck are visible in the photograph at the locations of the straps indicated in the engraving.

For some of the surviving harps, these reinforcements appear to be later additions to the frame of the instrument. The nail fragments across the neck/forepillar joint on the Queen Mary harp cross the decorative work in a manner that suggests they were not part of the original construction of the harp, and the engraving of the 'Brian Boru' harp similarly shows the straps covering the decorative work on the forepillar of that harp, also suggesting they were a later addition. This may not be the case for the strap for the neck/forepillar joint of the Ballinderry harp fragments, however. In this instance, it looks like it could be part of the original construction of that harp, based on the similarity of the decorative work to that on the cheekbands. It's not clear if the straps indicated by the marks on the neck of the Cloyne harp were part of the original construction of that harp or added later, although their location does coincide with two natural gaps in the inscription on the neck.[191] Although it isn't possible tell if the straps and the band in the Praetorius engraving were original to the construction of the harp depicted, their inclusion suggests they may have been typical for Irish harps at the time.

Judging from the gap that has opened up at the back of the forepillar/neck joint on the Lamont harp, the forepillar had already been compressed by the string tension when the straps were placed across that joint, so they are a later addition to the harp. As discussed earlier, the band around the top of the Lamont harp soundbox appears to have been added after the box began to develop cracks at that end, so it is also not part of the original design.

It possible that it was necessary to add these reinforcements to the frame as the joinery shifted under normal use. It is, however, also possible that the harps that had these reinforcements added to them, e.g. the Queen Mary, Trinity College, and Lamont, were intended for a string tension that did not require metal reinforcement of the joint between the neck and forepillar, or of the mortise at the neck joint with the soundbox. If so, this could be an indication that stringing practices changed over

[191] These observations are based on the author's examination of the Cloyne harp fragments in September 2012.

the lifetimes of these harps towards significantly higher tension than that for which their frames were originally constructed. For the Lamont harp, it is possible that the string fragment, the added reinforcing straps, and some of the damage to the frame, date to a period of increased string tension for this instrument. As discussed earlier, the composition of the wire fragment is consistent with brass available in the British Isles in the 17th century. While an earlier or later date for the wire cannot be ruled out, it may point to the 17th century as a period during which this harp was strung to a higher tension than that for which it was originally constructed. It would be worth further investigation to try to determine if this is indeed the case, not only for this harp, but for the others as well.

The frame of the Queen Mary harp

Number and arrangement of strings

Before discussing the frame of the Queen Mary harp, and subsequently the string lengths, it is necessary to understand the stringing arrangement. As was the case for the Lamont harp, this can be understood through examination of the tuning-pin holes in the neck and the string holes in the soundbox.

The stringing arrangement for the frame of the Queen Mary harp appears to have been more straightforward than that encountered on the Lamont harp. On the neck of the Queen Mary harp there are 29 holes for tuning pins in the cheekbands plus an additional hole located below the cheekbands, which is slightly larger than the other tuning pin holes. Given its location and mismatched size, this 30th hole appears to be a later addition.[192] In the soundbox, there are 29 holes in the string band. There is also an iron loop at the bass end of the soundbox, which appears to have been added to

[192] Armstrong, *Irish and the Highland Harps*, 171.

accommodate an additional string.[193] The 30th tuning-pin hole and the iron loop are shown in figure 2.29.

Figure 2.29: *left side view of the Queen Mary harp indicating the location of the tuning pin hole below the cheekbands, and the iron loop at the bass end of the string band (arrowed, top photo). The loop and tuning pin hole are shown in close-up in the lower left and lower right photographs, respectively. Photograph (lower right): Isabell Wagner.*

The tuning pin for the additional hole, now missing, is noted by Armstrong as being of a different style compared to the other tuning pins on this harp. He describes it as being made of iron, with a thicker, shorter shaft, a slotted string end, and a square

[193] ibid. 177. A string could have been attached to the soundbox by being strung through the 29th string hole and then through the loop. This allows the string to have good acoustic coupling with the soundbox. This method has been employed by Simon Chadwick on his Queen Mary replica, as suggested to him by Ann Heymann.

drive head, which he observed was "much worn".[194] The ends of this pin are shown in the archival photographs in figure 2.30.

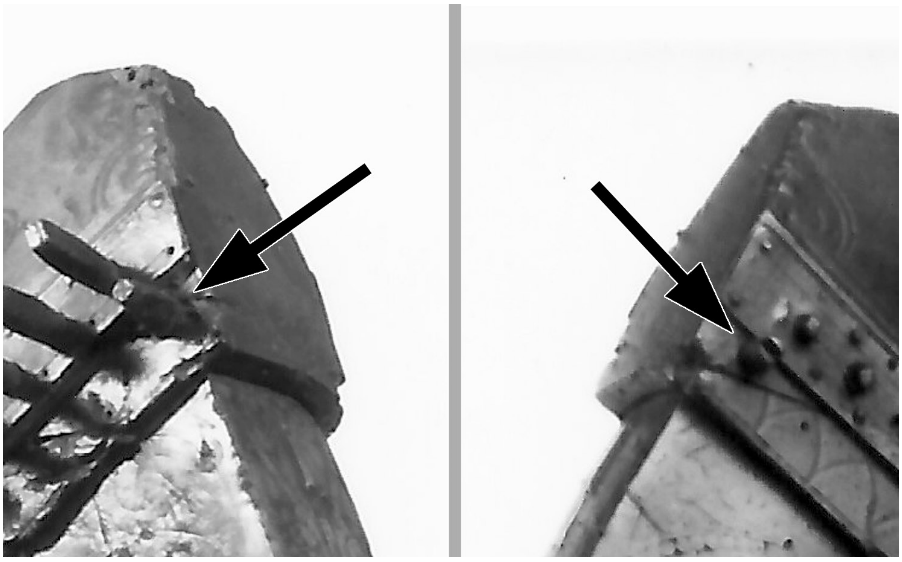

Figure 2.30: *details of archival photographs of the Queen Mary harp showing the ends of the tuning pin in the hole added to the neck for a 30th string. The photograph on the left shows the drive end of the pin, and the photograph on the right shows the string end (undated photographs, National Museums Scotland H.LT1 archive; arrows added by the author).*

With regard to the position of the iron loop in the soundbox, it is evident from its position inside the recess for the mortise in the joint for the forepillar that it was added after the forepillar had shifted in this joint, as can be seen in figure 2.31. Due to the string tension, the forepillar has compressed, causing its tenon to lift up out of the joint at the end facing the string band. The string tension has also caused it to shift forwards in the mortise towards the foot of the harp. This has created the gap in which the loop has been placed.

[194] ibid., 171.

Figure 2.31: *a photograph of the iron loop at the bass end of the soundbox of the Queen Mary harp. It is located beyond the end of the string band inside the recess for the mortise at the forepillar joint. The recess has been exposed due to the forepillar shifting in the joint as a result of the string tension.*

The loop, which is actually a staple, was hammered in at an angle to the front of the soundbox. It was not hammered in vertically and bent forward, therefore it could have been added with the forepillar in place. Its shape and orientation in the wood can be seen in the composite image in figure 2.32.

Figure 2.32: *(left) composite image of a photograph and tomogram of the base end of the Queen Mary harp soundbox showing the orientation of the iron loop in the wood. The loop, which is actually a staple, has been hammered in at an angle to the front of the soundbox. The shape of the loop is shown in cross-section in the inset (right). Scale 1 tick : 1 cm.*

Upon examination of the inside of the soundbox of the Queen Mary harp, numerous indentations and scratches, as well as some verdigris stains, were observed around the string holes. These are similar to the markings observed inside the soundbox of the Lamont harp, and as already discussed for that harp, they are consistent with their having been made by string toggles and wire strings. Figure 2.33 shows the marks around the string holes as they appear from the interior of the soundbox of the Queen Mary harp.

Figure 2.33: *The interior of the Queen Mary harp soundbox, showing marks around the string holes. The size, shape, location, and distribution of the marks are consistent with their having been made by string toggles and wires pressing against the wood. The string holes shown are 7 – 12 (top) and 12 – 16 (bottom). Photograph: (bottom) Isabell Wagner.*

Figure 2.34 shows the marks around string holes #1 and #29. Toggle marks and verdigris stains were observed around both, although they were fewer in number than around the string holes in the middle of the compass.[195]

[195] This was the case for both the Lamont and Queen Mary harps. The string holes in the middle 3/4 of the compass were surrounded by the most marks. This is likely a direct indication of the relative number of string replacements at these locations, and therefore may also be an indication of which strings were most used.

Figure 2.34: *string holes #1 (top) and #29 (bottom) as viewed from the inside of the Queen Mary harp soundbox. Signs of use in the form of verdigris stains and indentations are visible around both string holes (arrowed). Photographs: (top) Karen Loomis, (bottom) Isabell Wagner.*

It is evident from the observed marks that all 29 string holes were used. Although tomograms of the neck show evidence of internal damage to some of the tuning pin holes, none are damaged to the extent of not being useable. It does not, therefore, appear that the tuning pin hole below the cheekbands was added to take the place of another, as appears to be the case for the Lamont harp. The iron loop at the bass end of the string band indicates the addition of a string to the full complement, so this harp therefore appears to have been originally constructed for 29 strings, with one added later to bring the total number up to 30. This concurs with Armstrong's assessment upon examination of the harp, and with the generally accepted opinion on the stringing of this instrument.[196] Upon examination of the CT scans and of the harp itself, nothing was observed that suggests otherwise. The analysis of the stringing therefore assumes this was the case.

String lengths for the Queen Mary harp

The Queen Mary harp frame has distorted as a result of the string tension acting on it, although the twisting and damage is not as severe as it is for the Lamont harp. The geometry of the frame has changed enough to have affected the string lengths, however, so the process of reconstructing the 'as-built' shape of the frame in order to determine the original string lengths is undertaken here for the Queen Mary harp using the same method described for the Lamont harp.

As discussed in the introductory section on the construction of this harp, the frame is made of three members joined by mortise and tenon. Much of the distortion to its shape is due to shifting at these joints, and additional distortion is due to twisting or bending of the frame members themselves. Although not obvious upon casual observation, the shifting and twisting of the frame members of the Queen Mary harp is evident upon close inspection. As discussed for the Lamont harp, it is the movement and distortion of the neck and the soundbox that have affected the relative positions of the tuning pins and string holes, and therefore the string lengths. This analysis therefore focuses on the motion of these two frame members. The directions in which they have moved are illustrated in Figure 2.35, below.

[196] Armstrong, *Irish and the Highland Harps*, 171.

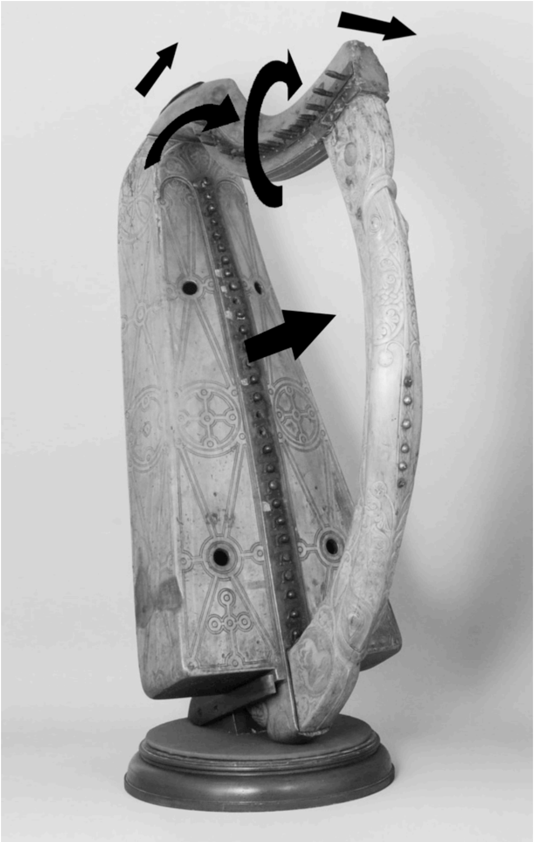

Figure 2.35: *direction of movement of the neck and string band of the Queen Mary harp. The neck has twisted about its long axis towards the left side of the instrument, and pivoted forwards out of its joint with the soundbox. It has also shifted upwards slightly out of this joint. The end of the neck over the forepillar has turned towards the left side of the harp, and the soundbox has risen along the string band. Photograph: Isabell Wagner; annotations by the author.*

The neck of the Queen Mary harp has pivoted forwards slightly out of its joint with the soundbox. It has also shifted upwards a few millimetres out of this joint. Figure 2.36 shows a tomographic cross-section in which the movement of the neck in the joint is indicated.

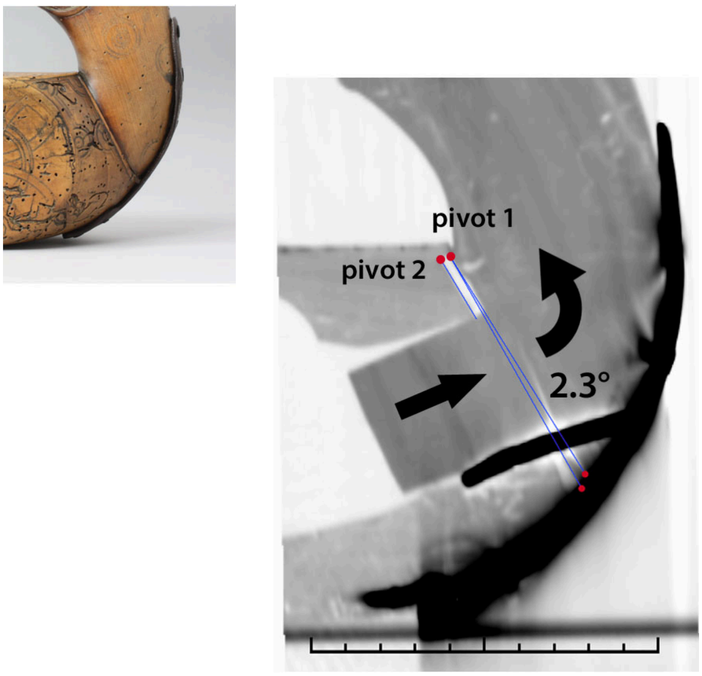

Figure 2.36: *tomogram of the Queen Mary harp neck/soundbox joint, and photograph of the same area (inset). The points labeled 'pivot 1' and 'pivot 2' were originally adjacent. As a result of the string tension, the neck has shifted upwards out of the joint by 2 mm in the direction indicated by the straight arrow. The neck has also pivoted forwards, causing the joint to open by 2.3°, as indicated by the curved arrow and the angle lines. The scale in the tomogram is 1 tick : 1 cm.*

As shown in figure 2.36, the neck of the Queen Mary harp has pivoted forward by 2.3°, and has shifted upward out of the joint by 2 mm, in the direction indicated by the straight arrow in the figure. Figure 2.36 can be compared to figure 2.13 for the Lamont harp. The necks of both harps have pivoted forward and shifted upward out of the joint, however the neck of the Lamont harp has also shifted backward forcing the tenon into the back of the soundbox, causing significant damage to the box and the tenon. The difference in behaviour of this joint in the Queen Mary harp is due in part to the iron strap across the back of the joint, which would have stopped the neck pivoting forward.[197] The location of this strap across the joint is shown in the

[197] The Lamont harp also had a metal strap across the neck-soundbox joint, similar to the strap on the Queen Mary harp. This was noticed by Michael Billinge on an early 20th-century archival photograph of the harp (Keith Sanger, personal communication, 14 April, 2013). Unfortunately, the strap was removed at some point during the 20th century, so it is not possible to make a direct comparison of it to the one presently on the Queen Mary harp.

photograph in figure 2.37. Based on its placement over worn decorative work, it was evidently added after the harp had been in use for some time. It was also apparently added after the neck had already pivoted forward in the joint, as its placement would have prevented further motion.

Figure 2.37: *two views of the iron strap across the neck/soundbox joint of the Queen Mary harp. Its placement over decorative work that is worn (arrowed) indicates that the harp was in use for some time before it was added.*

Although the strap may have prevented some damage of the sort observed in the same joint on the Lamont harp, some of the observed difference in damage may be due to the difference in construction of this joint on the two harps. This is illustrated in the diagrams shown in figure 2.38.

Given the observed damage to the joint, the strap would have been added after the Lamont neck tenon had already pushed the back of the soundbox outwards.

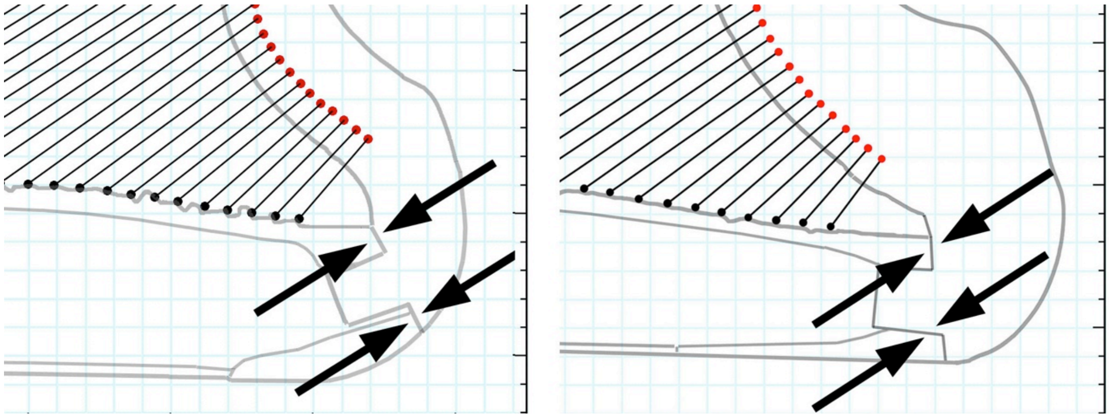

Figure 2.38: *diagrams of the neck/soundbox joint of the Queen Mary harp (left) and the Lamont harp (right). Both joints are shown in their original state, not their current state. The arrows indicate the direction of force of the neck on the soundbox, and vice-versa. Both harps are drawn to the same scale. Scale: 1 tick : 2 cm.*

The differences between the two joints are apparent when viewed in cross-section. Both are shown as they would have been originally, with the tenons seated, and the joints reconstructed to their pre-damaged state.[198] The neck-soundbox joint on the Queen Mary harp has an angled mortise, whereas the same joint on the Lamont harp has an in-line mortise, aligned with the long axis of the soundbox. The arrows on the diagram indicate the approximate direction of force of the neck pushing down on the soundbox, and of the opposite force of the soundbox pushing up on the neck, assuming the forepillar is sufficiently rigid to withstand the force on it at the bass end of the neck. The direction of force is aligned with the angle of the majority of the strings, with a slight adjustment to account for the change in angle of the treble strings (which also contribute less to the total force). Note that on the Queen Mary harp the shoulders of the mortise are angled such that the force is nearly perpendicular to the face of the shoulder on the soundbox and the neck, whereas on the Lamont harp it is at an angle to it. Note also that on the Queen Mary harp the force is roughly parallel to the sides of the tenon, so there is minimal torque on the tenon in this configuration. On the Lamont harp, however, the force is at an angle to the tenon. Consequently, even before the neck began to pivot forward the tenon was

[198] This is particularly relevant to the Lamont harp, as its mortise has been enlarged by the tenon pushing the back of the soundbox outwards, so the soundbox of that harp was originally narrower at this location than it is currently.

already at some risk of shearing off, as it is cut across the wood grain and therefore vulnerable to a force applied to its side. Additionally, because the force of the neck pushing down on the soundbox is not perpendicular to the mortise shoulders on the Lamont harp, a component of the force is directed into the back wall of the mortise. This could have contributed to the damage to the back of the soundbox of this harp even before the neck had begun to pivot forward. This is not the case for the joint on the Queen Mary harp, where the force is not directed into the back wall of the mortise; it is directed onto the shoulder.

On both harps, however, the neck began to pivot out of the joint as a consequence of the forepillar compressing, and this has caused both neck tenons to push into the back of the soundbox. As already discussed, this motion has damaged the soundbox of the Lamont harp and necessitated the addition of the metal strap around the top of the soundbox. On the Queen Mary harp, however, the mortise has a significantly thicker wall on the side that faces the back of the soundbox, which would have strengthened the back of the soundbox. There was still the risk of shearing off the tenon of the Queen Mary harp (which is also cut across the grain), and the tenons of both harps have cracked, although the damage to the Lamont harp tenon is greater.

Although this joint is damaged on both harps, there is considerably less damage overall to the joint on the Queen Mary harp, and while there are other factors that may have contributed to the greater degree of damage to the Lamont harp joint (perhaps higher string tension), as a consequence of its construction, the neck-soundbox joint of the Queen Mary harp appears to be stronger than the same joint on the Lamont harp.

Regarding other movement of the neck, in addition to pivoting forward out of the soundbox joint, it has rotated along its long axis towards the left side of the harp. This has caused the neck/soundbox joint to open up on the right side of the harp, and at some point prior to the addition of the iron strap a wooden wedge was inserted into the gap in the joint on this side of the harp.[199] Some parts of the neck have rotated more than others, however. The degree of twisting is greatest at the treble end of the neck, where it is 8°, and gradually decreases to about 2.6° at pin #22, then increases again, rising to between 4° and 6° for the last three pins. This indicates that for a period of time the neck was being held more rigidly upright at the forepillar than at the soundbox, resulting in the greater twist at the soundbox end. This would have occurred before the iron strap was added across the neck-soundbox joint. After the addition of the strap, the neck would have been held more rigidly in place at the soundbox and any additional twisting would have occurred at the forepillar end. This would have been exacerbated by internal cracks at the bass end of the neck, which have caused it to turn sideways towards the left side of the harp. This can be seen in the photograph in figure 2.39, which shows the alignment of the tuning pins as viewed from above the neck. The orientation of the pins shifts abruptly at tuning pin hole #25 (at the location of the third tuning pin from the top in this photograph), which is just to the bass side of a metal patch that covers a break in the right-hand cheekband.[200] The cheekband on the opposite side is slightly bowed out, and has been carefully cut and spliced at tuning pin hole #19.[201]

[199] Armstrong, *Irish and the Highland Harps*, 179.
[200] The cheekband break is shown and discussed in detail in Loomis "Structural Breaks and Repairs," 59 – 62, and Loomis et al. "Lamont and Queen Mary Harps," 125 – 26.
[201] Armstrong, *Irish and Highland Harps*, 178.

Figure 2.39: *the bass end of the Queen Mary harp neck, viewed from above, showing the alignment of the tuning pins (and therefore the tuning pin holes). Red lines have been superimposed to highlight their orientation. The gaps are due to missing tuning pins. The uppermost tuning pin hole in this photograph is #29. Note that the alignment of the pins shifts at the third from the top, #25, which is located just to the bass side of a metal patch that covers a break in the right-hand cheekband. On the opposite side of the neck, the cheekband is visibly bowed out.*

Internally, the neck has several cracks at the bass end, aligned along the wood grain, one of which passes through tuning-pin hole #25, as shown in figure 2.40, below.[202]

[202] Loomis et al. "Lamont and Queen Mary Harps," 126.

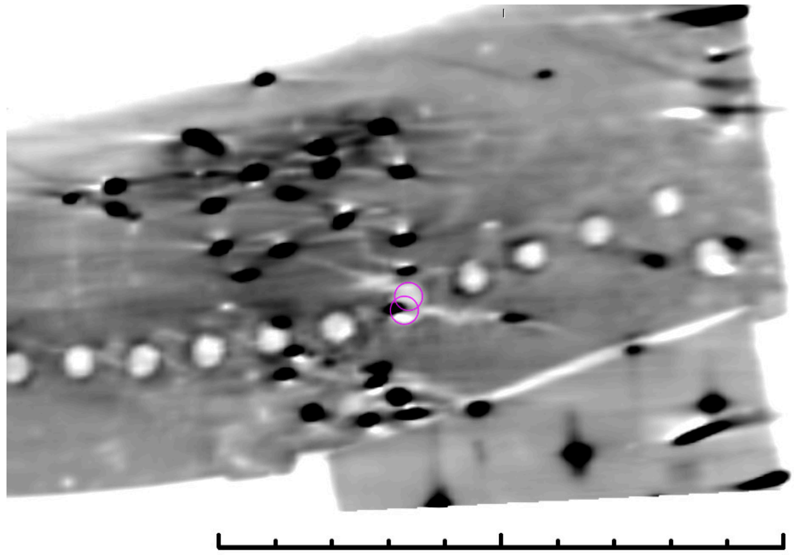

Figure 2.40: *tomogram of the bass end of the neck of the Queen Mary harp showing the tuning pin holes. This cross-section, located a few millimetres inside the neck on the right-hand side, shows a sudden shift in the line of tuning pin holes occurring at a crack that passes through hole #25 (outlined in pink). The position of this hole has shifted by 2.9 mm where the crack has opened up on the right hand side of the neck. The scale is 1 tick : 1 cm.*

These cracks, which appear to be the result of the bass end of the neck being forced down onto the forepillar (as discussed in Loomis (2010)) have allowed the end of the neck to turn towards the left side of the harp, resulting in the observed shift in alignment of the tuning pin holes, as well as the damage to both cheekbands.[203]

The final change in shape of the frame to be addressed is the rise of the belly of the soundbox. The front of the soundbox has been pulled up by the string tension. As discussed in Loomis (2010) and Loomis et al. (2012), this is evident from the observed 'pulling in' of the sides of the soundbox as the front has risen.[204] Earlier in this dissertation, the question of whether the front of the soundbox was originally flat was addressed for the Lamont harp by examining the cross-sections of the string holes. The same method is used here to try to answer this question for the Queen Mary harp.

[203] Loomis, "Structural Breaks and Repairs," 61 – 64.

[204] Loomis, "Structural Breaks and Repairs," 46. Loomis et al. "Lamont and Queen Mary Harps," 122 – 23. The author gratefully acknowledges Simon Chadwick for pointing out that pulled in soundbox sides are evidence of a belly that has been pulled up by the string tension.

Figure 2.41 shows cross-sections of two string holes in the soundbox of the Queen Mary harp: #28, near the bass end, where there is no appreciable belly, and #14 which is located on the belly. These two string holes were chosen because they provided the clearest views of the sides of the string hole and of the string band. Unfortunately, the wooden peg inserted in string hole #28 (and most of the other string holes) makes it difficult to see the sides of the hole. There is, at least, a clear view of the string band, which is flat, along with the front of the soundbox. The sides of string hole #28 are either parallel or angled slightly outward. The sides of string hole #14 are clearly angled outward, and the string band is either flat or curved slightly upwards. If the harp was carved with a flat soundbox front, then rotating the two halves of the cross-section at string hole #14 down to 'flatten' the front of the box (as was done for the cross-sections of the Lamont harp soundbox) should recreate a string hole and string band that resembles the cross-section of hole #28. This has been done for string hole #14 in the 3rd cross-section from the top in figure 2.41. Note that the sides of the string hole are now angled inward, and the string band is angled in on itself. This does not resemble the cross-section of string hole #28. In the bottom cross-section in figure 2.41, the two halves of the cross-section have been rotated down just enough to flatten the string band. Note that the sides of string hole #14 are now parallel, but the front of the soundbox is not flat. This suggests that the soundbox of the Queen Mary harp may not have been made flat, but instead may have been carved with a belly that has subsequently been pulled up further by the string tension, such that the current belly is the result of both string tension and carving.

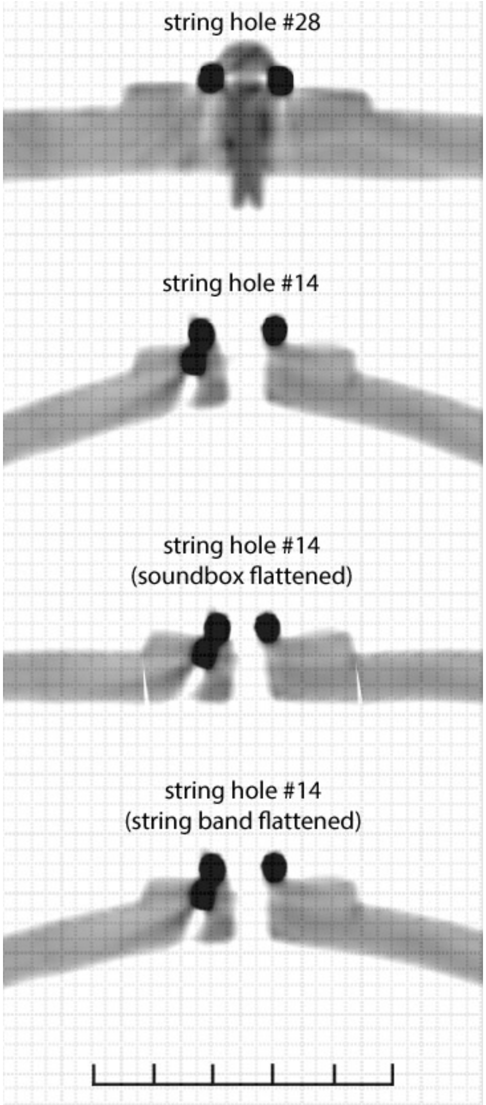

Figure 2.41: *tomographic cross-sections of string holes in the Queen Mary harp soundbox. Top: string hole #28, located where the front of the soundbox is nearly flat; 2nd from top: string hole #14, located on the 'belly' of the soundbox; 3rd from top: string hole #14 with the front of the soundbox 'flattened'; and bottom: string hole #14 with the string band 'flattened'. Note the angle of the walls of the string holes and the front face of the string band. In string hole #28 (top) the sides of the string hole are either parallel or angled outward, and the string band is flat. In #14 (2nd from top) they are angled outward. In #14 for the 'flattened' soundbox (3rd from top) the sides of the string hole are angled inward and the string band is not flat, it is angled downward. In #14 for the 'flattened' string band (bottom), the sides of the string hole are parallel, and the front of the soundbox has a belly. Scale: 1 tick : 1 cm; grid scale 1 box : 2.5 mm.*

There are other possible interpretations of these string hole cross-sections. Tapered wooden pegs, like the one in hole #28, had been inserted into all of the string holes in the early 19th century, and could have altered the profile of the holes. If a peg had less taper than the string hole into which it was inserted it would push the sides of the hole outward. This could explain the sides of the hole consequently angling inward in the 'flattened' cross-section shown in figure 2.41. This doesn't explain the observed profile of the string band, though. At string hole #28, which is not on the belly, the interior and exterior surfaces of the string band are parallel. This is not the case at string hole #14, which is on the belly. Another possibility is that the string toggles have compressed the wood around the string hole to the extent that the inside surface of the string band has been effectively 'pushed up' and is no longer parallel to the outside surface. If this were the case, then it would also be observed on the string hole in the bass, were the string tension is higher and the angle of the string is nearly the same, but it isn't. Furthermore, this effect is it not observed at all on the Lamont harp.

Although the string hole cross-sections suggest the soundbox was not constructed with a flat front, in the event that this interpretation is incorrect, the reconstruction of the 'as-built' string lengths and the string scaling analysis includes solutions for the harp both with and without a belly. It was not possible to estimate the height of the presumed carved belly, so the current belly is used, with the understanding that it would have been lower than this prior to the string tension pulling up the front of the soundbox.

The following section presents the string lengths for the Queen Mary harp frame in its current state, including the 30th string, as well as for a straightened frame with 29 strings and a flat fronted soundbox, and a straightened frame with 29 strings and a belly (although this is the current full height belly). All of the derived string lengths assume direct string hole to tuning pin stringing.

Current and reconstructed string lengths

The method used to calculate the current and reconstructed string lengths for the Queen Mary harp is the same as that used for the frame of the Lamont harp (see Appendix A). The string lengths were derived from the current coordinates of the string holes (and iron string loop) and the tuning pins at the point of contact of each string, as well as the positions of the 'pivot points' and 2.3° forward tilt of the neck (as shown in figure 2.36), and the twist of the neck along its long axis. These quantities were measured in three dimensions on one of the CT scans of the harp. Since the tuning-pins were not in the harp when it was scanned, the tuning-pin positions were measured just outside the cheekband on the leading edge of the tuning-pin hole. This is closer to the string band than a string would be wound in practice, particularly at the extreme treble end of the compass, but provided consistent measurements. This does, however, result in a slight shortening of the calculated string lengths for the top few strings.

In order to take into account the twist in the neck, its sideways rotation was measured at each tuning pin hole. The calculated string lengths for the three versions of the frame are given in table 2.6, and diagrams of the harp frame in its current state and with a reconstructed straightened frame are shown in figures 2.42 – 2.44.

The diagrams of the Queen Mary harp frame in figures 2.42 – 2.44 depict the strings as projected onto a plane. The string lengths are therefore depicted foreshortened, particularly at the treble end of the instrument. **Measurements of string length should not be taken off the diagrams.** For the calculated string lengths, see table 2.6. Also note that **the points plotted at the ends of the strings are the points of contact only. They are not the centre points of the tuning pin holes and string holes.**

Figure 2.42 (overleaf): *the frame of the Queen Mary harp in its current state. This outline is based on a tomogram of the harp, and shows the strings and frame as projected onto a plane. The outline of the interior of the soundbox and the neck-soundbox joint are also shown. The black circles and blue squares are the points of contact of the strings at the string shoes and tuning pins, respectively, plotted from the measured coordinates taken from the CT data. The frame is shown with 30 strings, strung directly from string hole to corresponding tuning pin. The 30th string is strung from the iron loop as discussed above. Scale: 1 box : 2 cm.*

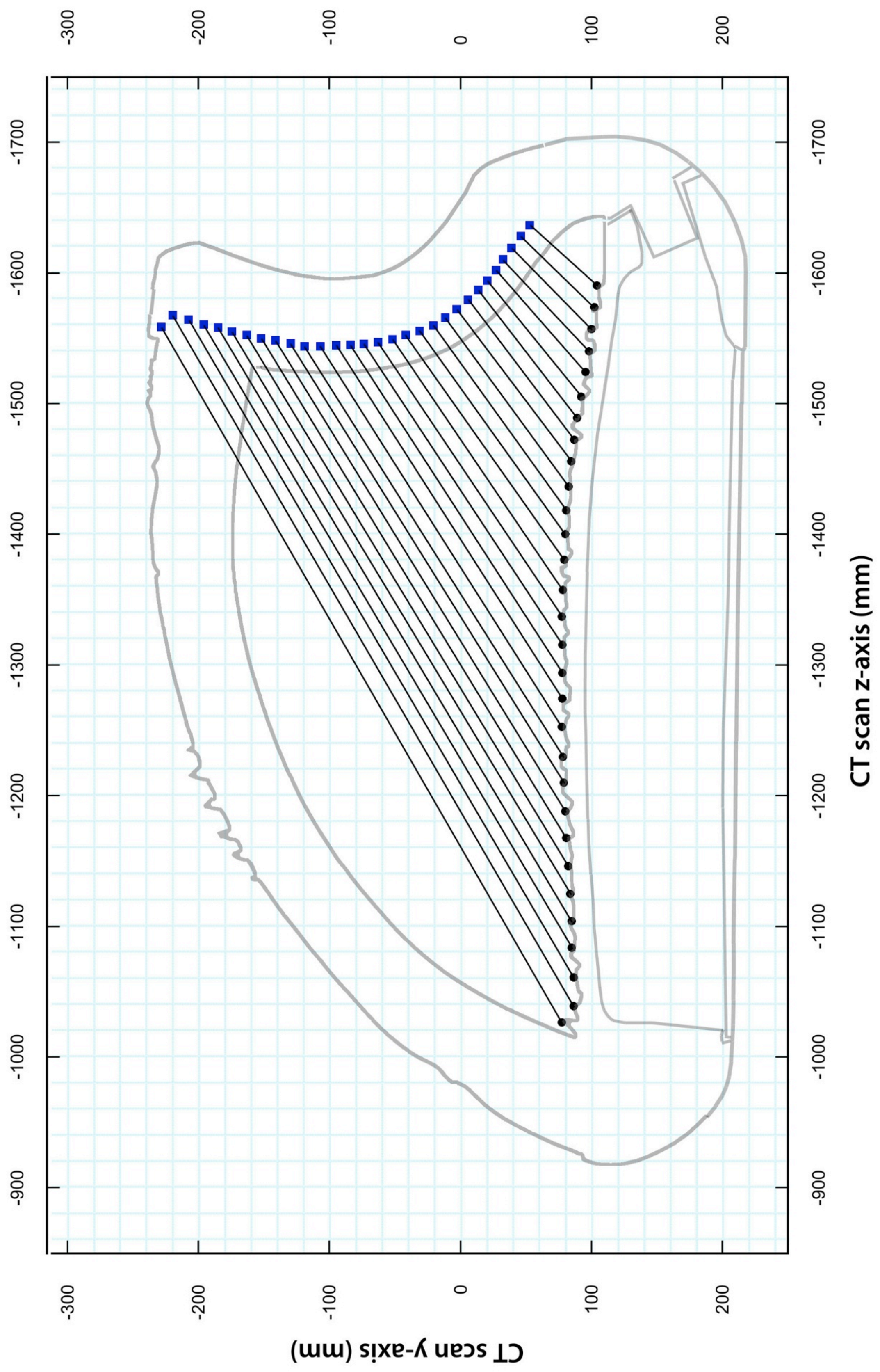
CT scan z-axis (mm)
CT scan y-axis (mm)
-1700
-1600
-1500
-1400
-1300
-1200
-1100
-1000
-900
-300
-200
-100
0
100
200

Figure 2.43 (overleaf): *the frame of the Queen Mary harp, corrected for the rotation, twisting, and shift of the neck. The black circles are the points of contact of the strings at the string shoes, plotted from the measured coordinates taken from the CT data. The red circles are the calculated points of contact of the strings at the tuning pins, corrected for the repositioning of the neck. The outline of the neck has been taken from a tomographic cross-section through its centre, repositioned with the tenon completely seated in the soundbox mortise. The outline of the back of the soundbox at the neck joint has been slightly redrawn to remove the change in shape that will have occurred due to the tenon pushing against it as the neck rotated forwards. A gap between the back of the tenon and the mortise where a metal rod is currently located has been left in, as it is not known if there was originally a gap at this location. The frame is shown with 29 strings, strung directly from string hole to corresponding tuning pin. The 30th tuning pin and the iron loop are not shown, as they were later additions. The outline of the forepillar, shown as a dashed line, is speculative and is only included to show the complete frame. Scale: 1 box : 2 cm.*

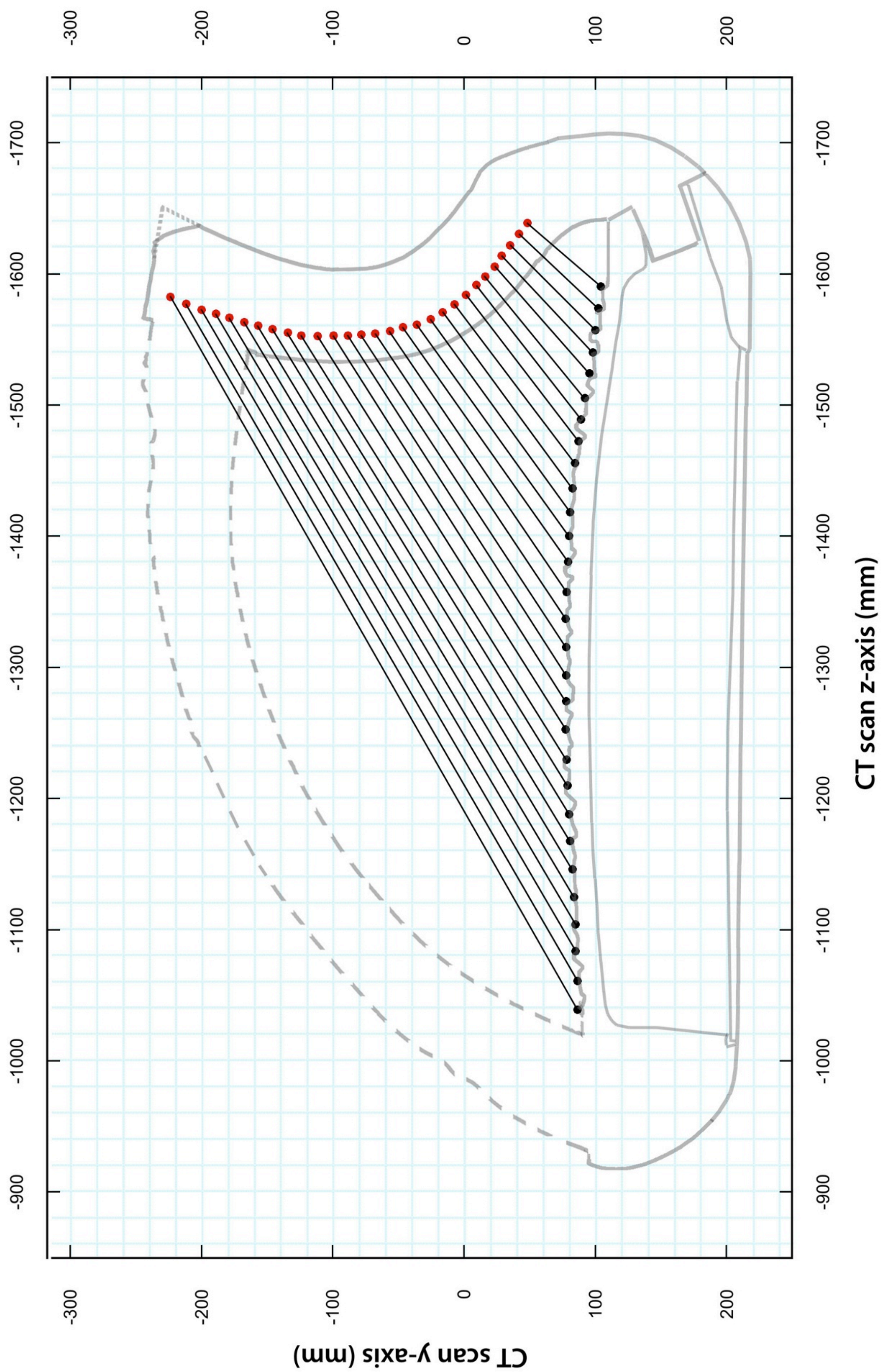
CT scan z-axis (mm)
CT scan y-axis (mm)
-1700
-1600
-1500
-1400
-1300
-1200
-1100
-1000
-900
-300
-200
-100
0
100
200

Figure 2.44 (overleaf): *the frame of the Queen Mary harp, corrected for the motion and distortion of the neck as shown in figure 2.43, and also adjusted to flatten the soundbox belly. The black circles are the points of contact of the strings at the string shoes, plotted from the calculated positions for a flat fronted soundbox. The remainder of the diagram is the same as shown in figure 2.43. Scale: 1 box : 2 cm.*

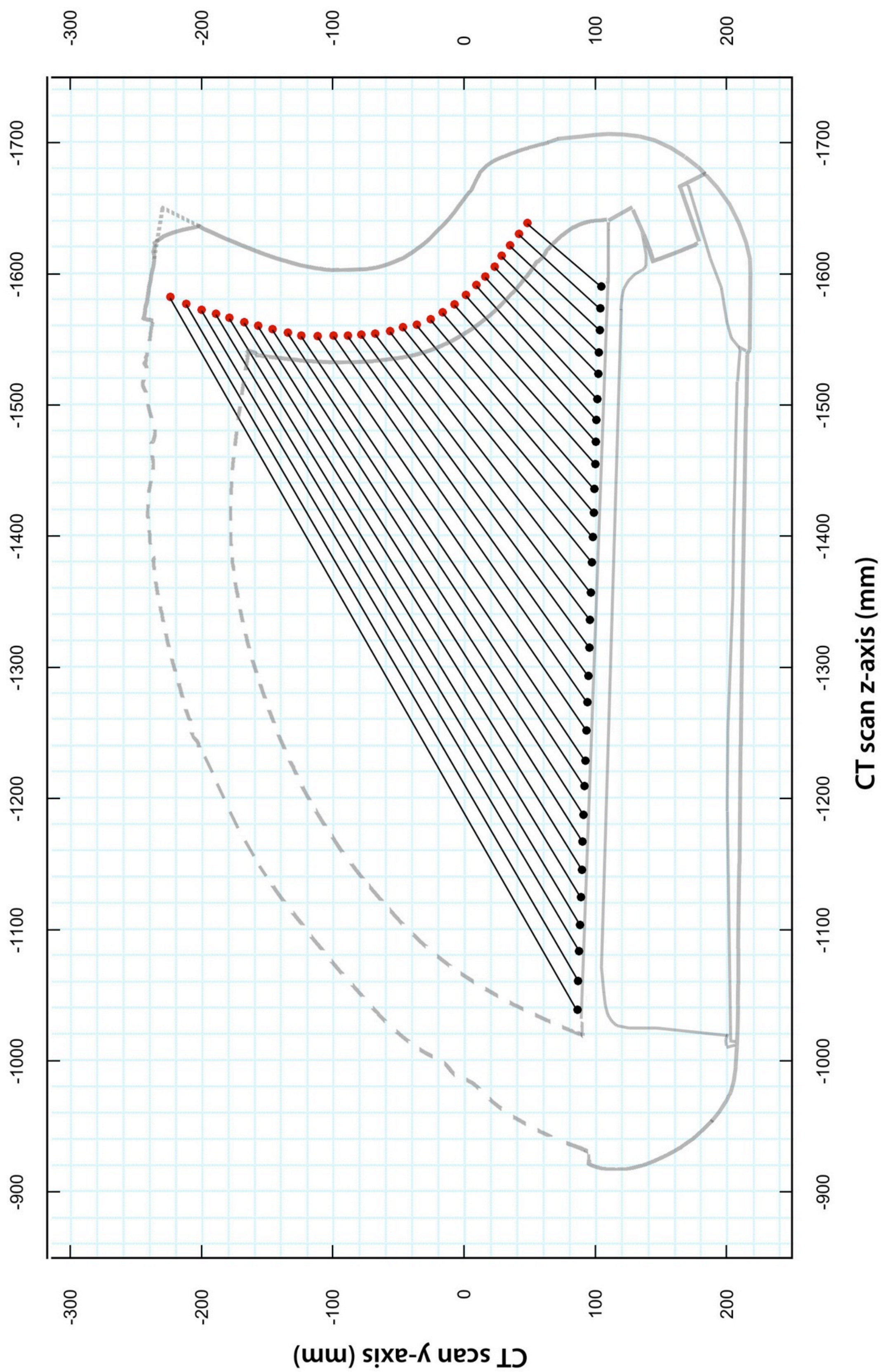
CT scan z-axis (mm)
CT scan y-axis (mm)
-1700
-1600
-1500
-1400
-1300
-1200
-1100
-1000
-900
-300
-200
-100
0
100
200

Table 2.6.

Queen Mary harp string lengths

string #	current frame (mm)	straight frame (mm)	straight frame no belly (mm)
1	74	77	77
2	82	86	88
3	90	95	97
4	99	104	107
5	106	112	115
6	117	122	127
7	126	132	138
8	136	142	150
9	147	154	163
10	161	168	178
11	175	183	193
12	192	200	211
13	212	220	230
14	233	241	252
15	254	262	273
16	277	286	295
17	300	309	318
18	322	331	340
19	346	356	364
20	372	382	389
21	397	407	413
22	424	434	439
23	449	460	464
24	476	487	490
25	503	514	516
26	530	541	542
27	555	567	567
28	584	597	596
29	613	626	626
loop - 30	615	(628)	(628)

Note: the uncertainty in the string lengths is +/- 1, based on the measurement uncertainty carried through the calculations.

Stringing regimes for the Queen Mary harp

The versions of the Queen Mary harp frame presented above represent the harp as it may have been when it was built, and later in its working life. Although it did not suffer the extreme damage and twisting of the Lamont harp frame, it has distorted enough from its original shape to alter the string lengths. This section discusses the string scaling of the Queen Mary harp for the current and straightened states of the frame, based on the reconstructed and measured string lengths, respectively.

The string lengths derived for the straightened harp frame with no belly, and with a full height belly, and for the frame in its current state are shown plotted together in figure 2.45 for comparison.

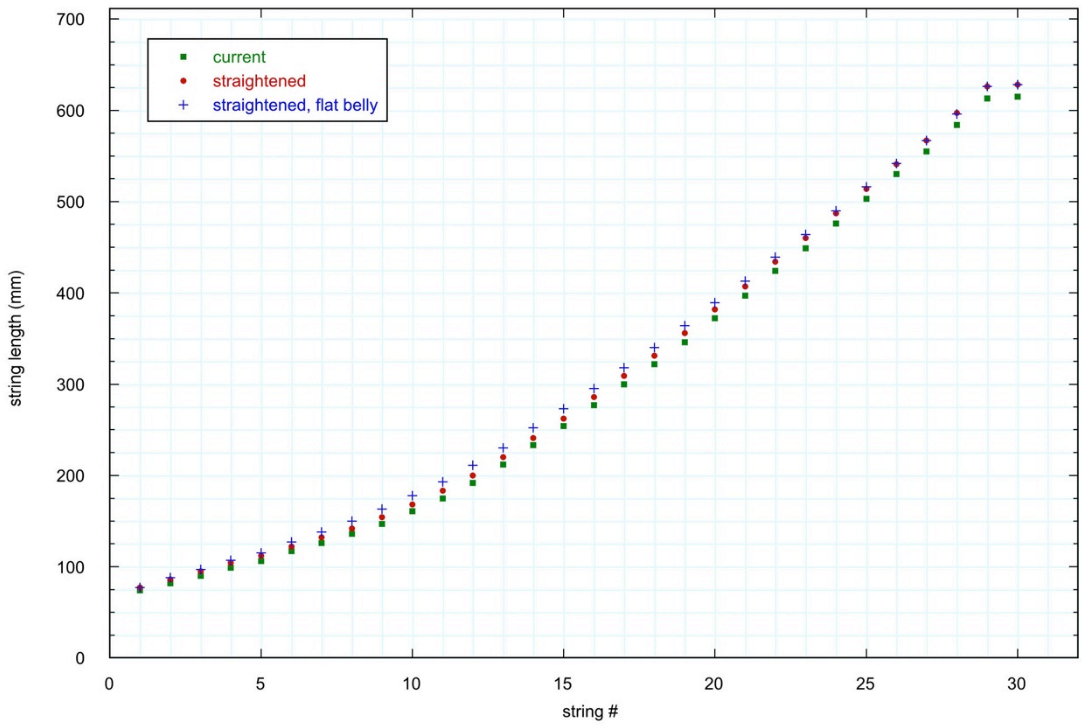

Figure 2.45: *string length versus string number for the Queen Mary harp. The string lengths shown are for the frame in its current state (green squares), the straightened frame with a fully developed soundbox belly (red circles), and the straightened frame with no soundbox belly (blue crosses). All of the string lengths shown are for direct string hole to tuning pin stringing.*

For the frame in its current state, the string lengths fall increasingly short of the straightened frame string lengths towards the bass end of the harp. If the straightened frame is representative of the harp 'as built', string #29 has shortened by an estimated 13 mm from its original length. This represents a change of 2% of the total length of the string. At the treble end of the instrument, string #1 has shortened by an estimated 4 mm (representing a change of 5% of the total length). Not surprisingly, the difference between the current string lengths and those derived for the straightened frame is significantly less than it is for the Lamont harp.

It is worth comparing the current and reconstructed string lengths for both the Queen Mary and Lamont harps to see where they are similar and where they diverge. These are plotted together on the graphs in figures 2.46 and 2.47. Their relative differences are pertinent to the discussion of possible solutions for the compass and pitch of the Queen Mary harp.

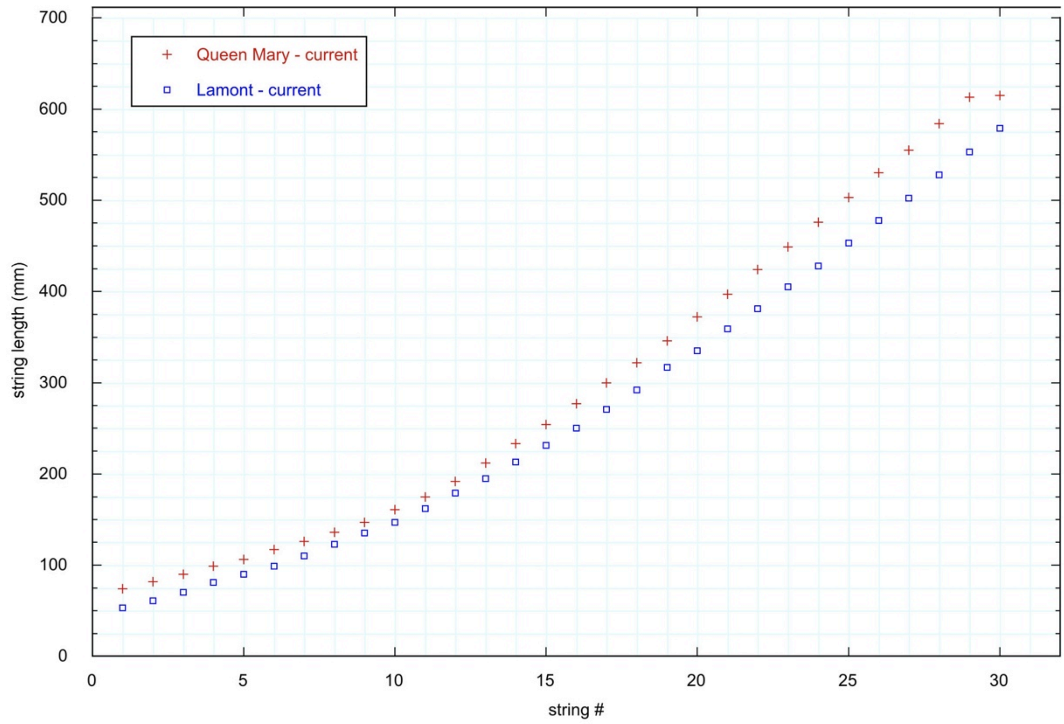

Figure 2.46: *comparison of string lengths for the Queen Mary and Lamont harp frames in their current state. Both sets of string lengths are for direct string hole to tuning-pin stringing. Note that the string lengths at the treble and bass ends of the compass are proportionately longer for the Queen Mary harp.*

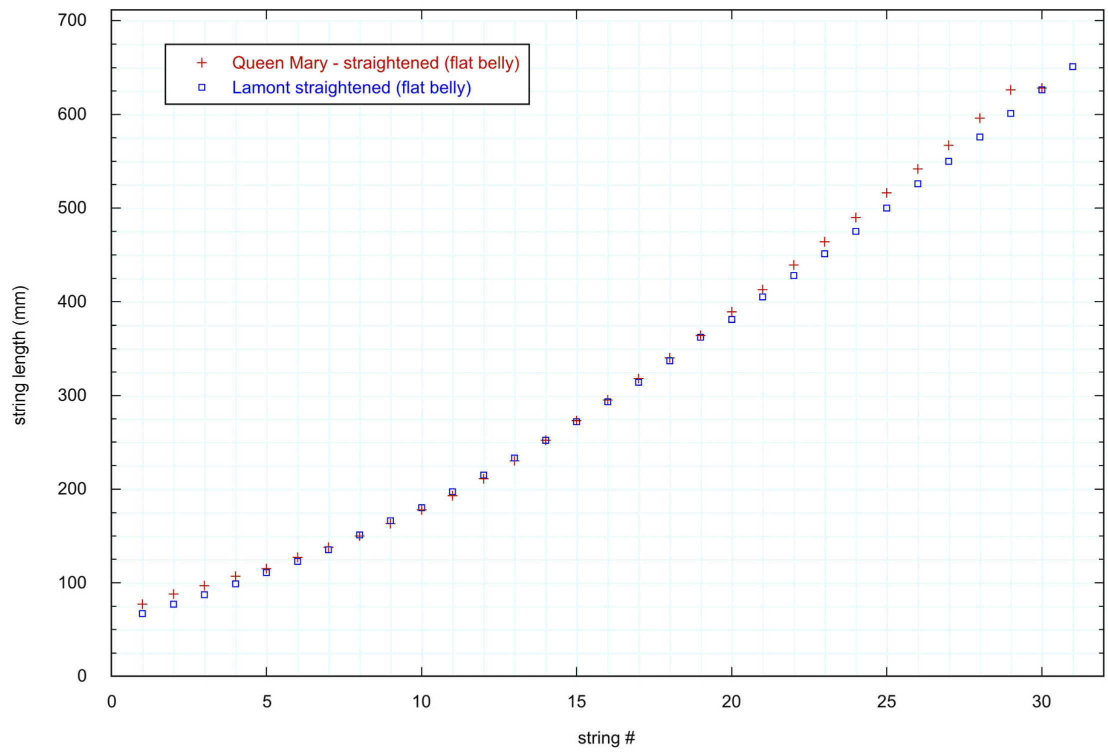

Figure 2.47: *comparison of reconstructed string lengths for the straightened Queen Mary and Lamont harp frames, with no soundbox belly. As for figure 2.46, both sets of string lengths are for direct string hole to tuning pin stringing. Note that the string lengths for both harps are nearly the same in the mid-range of the compass, but the Queen Mary harp string lengths are longer in the treble and the bass.*

The string lengths plotted in figures 2.46 and 2.47 are for direct string hole to tuning pin stringing for both harps, so that a direct comparison can be made. Figure 2.46 shows the current string lengths, and figure 2.47 shows the reconstructed string lengths for the straightened 'as-built' frames. Although the two harp frames are noticeably different in overall size (the Lamont is generally regarded as a 'bigger' harp than the Queen Mary), their string lengths are similar. Actually, the Queen Mary harp currently has entirely longer string lengths than the Lamont harp, due to the extreme distortion of the frame of the latter harp. For the straightened frames the string lengths for the two harps are nearly the same for much of the compass. What is notable, however, is that the string lengths for the Queen Mary harp are proportionately longer in the treble and bass than those for the Lamont harp. This is the case for both the current and the reconstructed 'straightened' frame string lengths, so this difference is not likely to be simply due to underestimating the reconstructed

Lamont harp string lengths. As will be apparent in the discussion that follows, the strings in the treble of the Queen Mary harp are disproportionately long in terms of the scaling of the compass, and this has implications for possible solutions for the stringing and pitch of this harp.

Figure 2.48 shows the string lengths for the Queen Mary harp plotted logarithmically to show the overall scaling of the instrument. As discussed for the Lamont harp, the decreasing 'slope' towards the bass indicates short scaling at that end of the compass. The effect of the belly on string length is also apparent in the mid-treble portion of the compass.

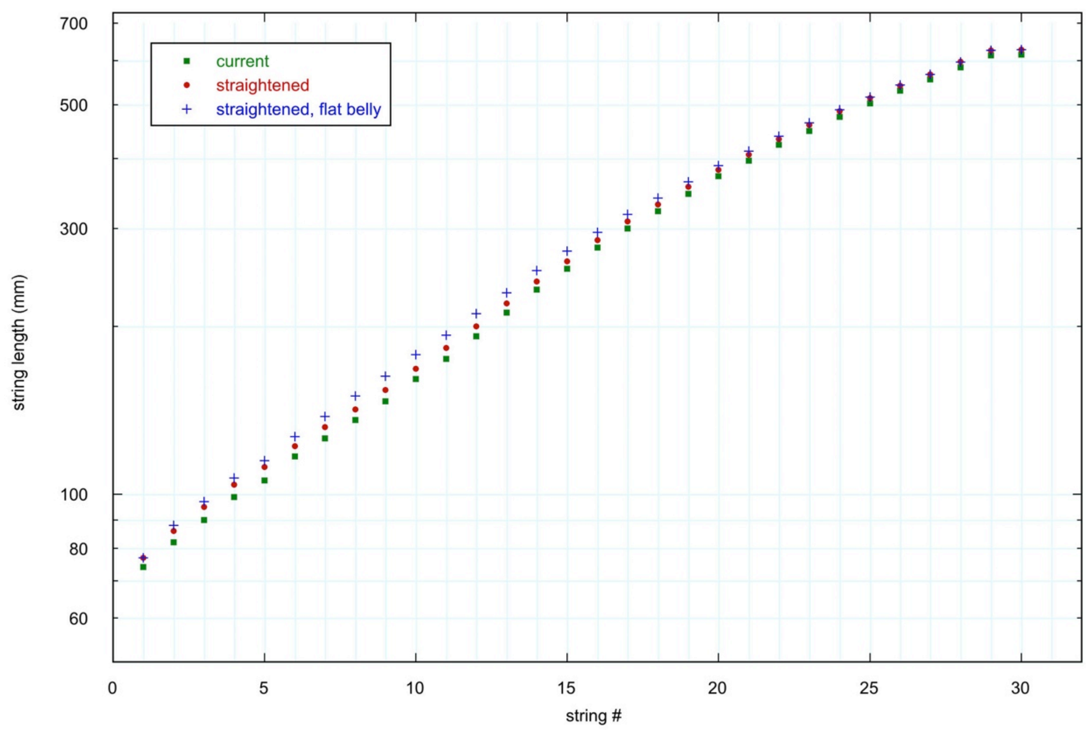

Figure 2.48: *string length versus string number for the Queen Mary harp, plotted on a logarithmic scale. The string lengths plotted are the same as in figure 2.45. This plot shows the expected short scaling in the bass.*

Possible solutions for the compass and pitch of this harp can be explored by scaling the string lengths and identifying the highest stressed string, as discussed for the Lamont harp. Although there are identifying letters, apparently cut out of printed text, pasted onto the soundbox next to several of the strings, these may date to the post-historical restringing of the harp in the early 19th century, and are discussed separately in relation to that.[205] As discussed in detail for the Lamont harp, historical information on the compass of these instruments is limited and there are numerous possibilities. A number of these are explored for the Queen Mary harp. Examining the scaling of this harp has also raised an interesting point, as discussed below.

Using the same method as for the Lamont harp, solutions for the pitch were explored by assigning a proposed compass to the strings and scaling the lengths to determine the pitch based on the highest stressed strings. This was done for a number of possible compasses. Figure 2.49 shows a sample set of stress curves for a diatonic tuning from c in the bass to c‴ in the treble, scaled to c″. These have been calculated for the harp frame in its current state, the straightened frame with a fully developed soundbox belly, and the straightened frame with no soundbox belly. For the two versions of the straightened frame the compass includes a pair of unison strings (at g′) and a gap in the bass (at e / f), as discussed for the Lamont harp. For the frame in its current state, the compass is purely diatonic with no gap and no unison strings (the reason for this choice is discussed later in this section).

[205] For a discussion of the letters pasted onto the soundbox, see also Simon Chadwick, "The Queen Mary Harp: Inscriptions," last modified March, 2014, http://www.earlygaelicharp.info/harps/QMinscription.htm.

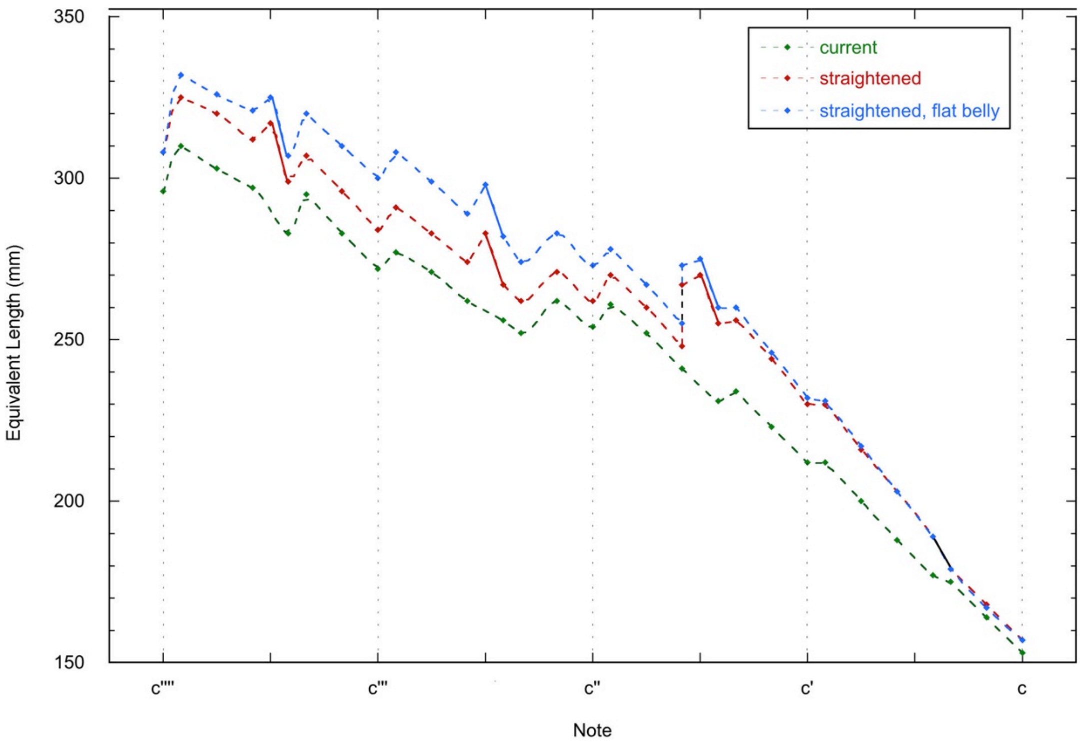

Figure 2.49: *stress curves for the stringing of the Queen Mary harp, based on a proposed compass of c – c'''', with 29 strings, scaled to c''. The three curves shown are for the frame in its current state (green), the 'straightened' frame with a fully developed soundbox belly (red), and the 'straightened' frame with a flat soundbox belly (blue). For clarity, the data points belonging to each are connected by dashed lines. For the two versions of the 'straightened' frame, the compass shown includes a pair of unison strings at g', and a gap at e/f in the bass. The equivalent lengths of re-tunable strings are connected by a solid line. For this stringing, these occur at e/f in the bass, and at f/f# for the rest of the compass. The compass shown for the current frame is purely diatonic, with no gap in the bass, no unison strings, and no re-tunable strings.*

The shape of the stress curves, which is a function of the scaling and is therefore essentially the same regardless of choice of compass, can be compared to the stress curves shown in figure 2.24 for the Lamont harp. The curve for the Lamont harp falls off towards the treble, past the mid-point of the compass, whereas the stress curves for the Queen Mary harp continue to rise almost to the top string. This means the highest stressed strings of the Queen Mary harp are at the extreme treble end of the compass. The instrument cannot be pitched higher than the snapping pitch of these strings, and the implication of this is that using a stringing material of the same strength for both the treble and the mid-range of the compass would result in the strings in the middle of the compass being tuned below their optimal pitch. The stringing marks on the inside of the soundbox suggest the strings in the middle of the compass received a lot of use, historically, as would be expected, so it seems unlikely that they would be strung sub-optimally. It is therefore possible that the Queen Mary harp was intended to be strung with stronger strings in the treble than in the mid-range of the compass. This is discussed further below.

While it is beyond the scope of this dissertation to explore all plausible compasses for this harp, solutions for the pitch of the instrument were calculated for compasses beginning on c and F in the bass (with their variants). This also includes compasses starting on G in the bass for the harp with 29-strings, as that is equivalent to a 30-string compass starting on F. Compasses were considered for the instrument with either 29 or 30 strings, for the string lengths derived for the straightened frame, both with and without a soundbox belly. The calculated values for the pitch of the instrument are for yellow brass stringing with a scale length of 270 mm for c″ at an instrumental pitch of A440 Hz. These solutions can be found in table A.1 in Appendix B.

Considering first the solutions that assume no change to a stronger stringing material for the treble, in several cases the resulting instrumental pitch was found to be either implausibly low or high, making these compasses less likely to have been used. Haynes (2002) lists very few instruments pitched below A380 Hz or above A500 Hz, so solutions that yield a pitch outside of this range may be considered as unlikely. From the data compiled in table A.1, this eliminates nearly all of the solutions for a compass beginning on F in the bass for the instrument with either 29 or 30 strings. The transpositions from c to F, in the context of "Organ-pitch" and "Quire-pitch" as discussed for the Lamont harp, yielded pitches for the compasses on F that were too high to be plausible. This also means that compasses beginning on G in the bass for the instrument with 29 strings also yielded an instrumental pitch that is implausibly high. The one exception is a compass on F, with 30 strings, that is either purely diatonic, or has unison strings plus the gap in the bass. Assuming yellow brass wire with a scaling of 270 mm for c″ at A440 Hz, the pitch of the instrument with this compass would be between about A480 – 500 Hz, depending on the height of the soundbox belly. If the lengths of the top strings are adjusted for the position of the winding on the tuning pins (as discussed earlier), this pitch could be as low as A 470 – 490 Hz. All except one of the compasses starting on c in the bass result in a pitch that is implausibly low. The one exception is a compass starting on c with 29 strings that includes the pair of unison strings, but no gap in the bass. Stringing with yellow brass with a scaling of 270 mm for c″ at A440 Hz, would yield an instrumental pitch between about A 397 – 408 Hz. These two compasses are summarized in table 2.7 (see below).

The two compasses (29 strings, from c, pitched at A 397 – 408 Hz; and 30 strings on F, pitched at A 481 – 502 Hz) result in plausible pitches for the instrument, and it is interesting to think about the harp with the original 29 strings having a compass from c in the bass, followed later (after the addition of the iron loop) with a 30 string compass from F in the bass. It is possible that these two compasses were indeed used. There is, however, the issue of the scaling of the string lengths in the treble. As discussed earlier, the scaling appears to favour using stronger strings there. On describing the Irish harp, Galilei (1581) remarked that, "they commonly have strings made of brass with some steel in the higher pitches in the manner of the harpsichord [*gravicembalo*]".[206] Table A.1 includes a set of solutions for stringing with iron on the top eight strings in the treble. Other sufficiently strong wire could be used in place of iron. Based on the string scaling for this harp, the wire used in the treble would need a scale length at least 1.12 – 1.16 times longer than that for the wire used lower down in the compass.[207] There would not be a significant advantage to having more than eight iron strings, also based on the string scaling. Additionally, setting the number at eight conveniently places the stringing change at the top octave of the compass. Putting iron stringing in the treble allows the strings farther down the

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[206] Galilei, *Ancient and Modern Music*, 357.

[207] This is calculated as follows: $\frac{S_1}{e.l._1} = \frac{S_2}{e.l._2}$, where S_1, $e.l._1$, and S_2, $e.l._2$ are the scale lengths of the wire used and equivalent lengths of the highest stressed strings for each of the two portions of the compass, respectively. At 330 mm, the scale length of iron for c″ at A440 is 1.22 times longer than the scale length of yellow brass at 270 mm for c″ at A440.

compass to be tuned up closer to their optimal pitch, raising the overall pitch of the instrument. Placing iron stringing in the treble results in the instrument being pitched implausibly high for all of the proposed compasses starting on F in the bass, however (as well as those starting on G for the instrument with 29 strings). Most of the compasses starting on c in the bass, which were primarily pitched too low before, though, now result in a plausible range of pitches for the instrument. These are shown in table 2.7, along with the two most plausible solutions discussed above for brass stringing in the treble.

Table 2.7.

Possible compass and pitch for the Queen Mary harp

# of strings	compass	unison strings?	stringing	instrumental pitch (Hz)
29 strings	c – b‴	yes	brass	A397 – 408
30 strings	F – g‴	no *or* unison + bass gap	brass	A481 – 502
29 strings	c – c⁗	no *or* unison + bass gap	brass + iron	A383 – 411
29 strings	c – b‴	yes	brass + iron	A430 – 462
30 strings	c – d⁗	yes	brass + iron	A383 – 411

Note: the pitch is derived for yellow brass with a scale length of 270 mm for c" at A 440 Hz, and is based on the scaled length of the highest stressed strings. For the stringing with iron in the treble this is the highest stressed string below the top eight strings in the treble. ***The pitch ranges include the solutions for both flat and bellied soundboxes*** *and also reflect an uncertainty in the un-scaled string lengths of +/- 1 mm. Taking into account the underestimate of string length at the upper end of the treble would result in slightly lower pitch ranges for the harp with brass only stringing.*

As an example, figure 2.50 shows the scaling of the harp with a straightened frame and a fully developed soundbox belly, for the 29-string compass from c in the bass, with unison strings at g′ and no gap in the bass, and with iron stringing in the treble (see table 2.7, second line from bottom). The scale lengths of iron, yellow brass, and red brass wire are plotted on the graph for c″ at A459 Hz (the average of the pitch range for this solution, with a soundbox belly).

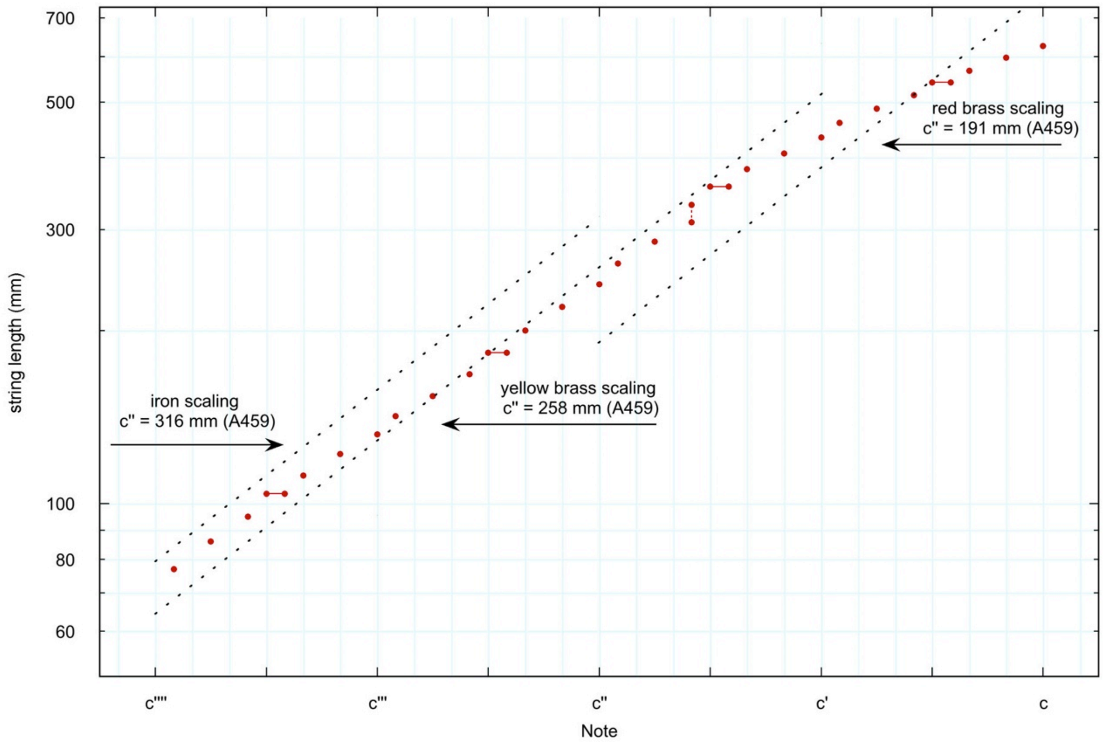

Figure 2.50: *Queen Mary harp string scaling for a proposed compass of 29 strings from c – c⁗ with a pair of unison strings at g′, and brass stringing with eight iron strings in the treble. The scaling for red brass, yellow brass, and iron at the proposed instrumental pitch of A459 Hz is shown as dotted lines.*[208] *Strings that might be retuned are represented by data points connected by a horizontal bar. For this compass, these are the F – F# strings. A vertical dashed line is shown connecting the data points for the two unison strings. The string lengths are for the straightened frame with a fully developed soundbox belly.*

The string lengths plotted in figure 2.50 indicate possible metal transitions where the data points cross the scaling lines for iron, yellow brass, and red brass. The transition from iron to yellow brass could occur at a‴ (string #9), and from yellow brass to red

[208] The scale lengths for yellow brass and iron are based on scalings of 270 mm and 330 mm for c″ at A440 Hz from Campbell, Myers, and Greated, *Musical Instruments*, 308. The scale length for red brass is based on a scaling of 211 mm for c″ at A415 Hz from O'Brien *Ruckers*, 61.

brass at g (string #25). This would result in the instrument being strung in red brass from c to g, in yellow brass from a to a″, and in iron from b″ to b‴. The iron stringing is more than sufficiently strong for the treble strings, as indicated by the position of the plotted string lengths below the line for iron scaling, however the actual lengths for these strings may be 2 – 3 mm longer. Nevertheless, as discussed earlier, a stringing material that is not as strong as iron (with the scale length used here) would also suffice. A significant point illustrated by figure 2.50 is that with this stringing there is no requirement for precious metal strings in the bass of this harp.

There are a number of possible solutions for the historical compass and pitch of the Queen Mary harp, some of which have been presented here. It is not possible with the available information to single out one solution that is most likely to have been what was originally used. We do know from Gunn (1807) that this harp was restrung in brass in the early 19th century for exhibition performances by the harpist John (or Joseph) Elouis.[209] As mentioned earlier in this section, there are several letters pasted onto the string band of the Queen Mary harp, adjacent the string holes. These letters, which appear to be for the purpose of labelling the strings with notes of the scale, are shown in the photographs in figure 2.51.

[209] Keith Sanger, "John Elouis," WireStrungharp.com, accessed 29 April, 2014, http://www.wirestrungharp.com/harps/harpers/elouis/elouis_john.html#_ednref2.

Figure 2.51: *letters pasted onto the string band of the Queen Mary harp. The letters, which appear to have been cut out of printed text, label six strings with notes of the scale. The letters are oriented on the soundbox so that they appear right side up to the player looking down onto them.*[210] *A photograph of each letter is shown on the right, in the order that they appear on the harp. The photographs have been rotated to orient the letters right side up (note the direction of the string shoes). Photograph (left): Isabell Wagner.*

The letters, cut out of printed text, read from bass to treble: C, C, G, B, c, (c). The letter at the top end of the scale has been partially eaten away by insect damage and is not legible, but may be a lower-case c. Gunn (1807) mentions the harp first being restrung in brass and then later gut, and discusses the compass chosen for the stringing as follows:

> The shortest string, or highest note, of Queen Mary's Harp, we found to be the upper C, or highest note of the modern piano forte, with additional keys; and proceeding by the descending scale, it has exactly a compass of four complete octaves, terminating in C, the

[210] Chadwick, "The Queen Mary Harp: Inscriptions."

> notation of which, in our music, is placed on the second space of the bass stave.[211]

This compass matches the positions of the letters pasted onto the string band. It is likely that it did not include unison strings or a gap in the bass. Although Gunn was aware of Edward Bunting's work, and quotes from his 1796 volume, Bunting's discussion of the scale of the Irish harp with unison strings and bass gap was not published until 1840, so it would not have occurred to Gunn, Elouis, or Wood to include these modifications to the scale.[212]

It appears from Gunn's account that this description refers to the gut stringing, however this compass could also work for brass stringing with string lengths for the frame in its current state. Using the same method discussed for the string lengths derived for the 'straightened' versions of the harp frame, the instrumental pitch can be determined by scaling the string lengths and identifying the highest stressed strings. If they had strung the harp entirely in brass through the treble, the instrument would have to be pitched about a whole tone below A440 Hz (at around 380 – 388 Hz, for yellow brass with a scaling of 270 mm at c″), and the strings in the middle of the compass would be below their optimal pitch.

As discussed in Chapter 1, a fragment of iron wire was found embedded in the end of one of the wooden string-hole pegs. As also discussed, these pegs most likely date to the early 19th-century restringing of the harp, and were either supplied by Wood or Elouis. Since Wood was in charge of the stringing and tuning of instruments manufactured by Muir, Wood, and Co., including pedal harps, he is a likely source, and it is very possible that the iron wire fragment is evidence that iron stringing was used in the treble when the harp was re-strung in brass. It is interesting to note that, although Gunn doesn't mention iron, he quotes from the same passage in Galilei that mentions iron stringing, so he would have been aware of Galilei's remark about iron strings in the treble. If Wood and Gunn had strung the harp with iron in the treble, the pitch of the instrument would rise to about A426 – 430 Hz (using yellow brass,

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211 Gunn, *Historical Inquiry*, 22.
212 Bunting, *Ancient Music of Ireland*, 23.

scaled as before). This happens to be close to the prevailing pitches in London, Vienna, and Paris at the time (A430 – 440 Hz), which might have encouraged them to settle upon this particular compass.[213]

Comparison with the Trinity College harp

It is worth comparing the reconstructed string lengths for the straightened frames of the Lamont and Queen Mary harps to the string lengths for the Trinity College harp. As for the Queen Mary and Lamont harps, the frame the Trinity College harp has distorted over time, altering the string lengths. Paul Dooley has undertaken the task of reconstructing the dimensions of the Trinity College harp with a straightened frame.[214] Thanks to this work, it is possible to make a direct comparison of the reconstructed string lengths for the Queen Mary and Lamont harps to Dooley's reconstructed string lengths for the Trinity College harp.[215] It is of particular interest to compare the Trinity College and Queen Mary harps, due to their similarity.[216]

Figure 2.52 shows the string lengths of the three harps plotted together. The lengths are for direct string shoe to tuning pin stringing for all three harps. For the Lamont and Queen Mary harps, these are the reconstructed lengths for the straightened frame with their current soundbox bellies. For the Trinity College harp, these are the reconstructed string lengths published in Dooley (2014), for that harp with a straightened frame and an adjusted soundbox belly with a height of 12.7 mm.[217] The current bellies of the Queen Mary and Lamont harps have maximum heights of 18 and 22 mm, respectively, as calculated from measurements taken from the CT scans.

[213] Haynes, *History of Performing Pitch*, 329 – 30, 333.
[214] Paul Dooley, "Medieval Irish Harp," 107 – 42.
[215] ibid., 124.
[216] Compare, for example, the photograph of the Trinity College harp in Dooley, "Medieval Irish Harp," 48 to the photograph of the Queen Mary harp in figure 2.51. See also Armstrong *Irish and Highland Harps*, 55 – 62, and 168 – 83.
[217] Dooley, "Medieval Irish Harp,"124.

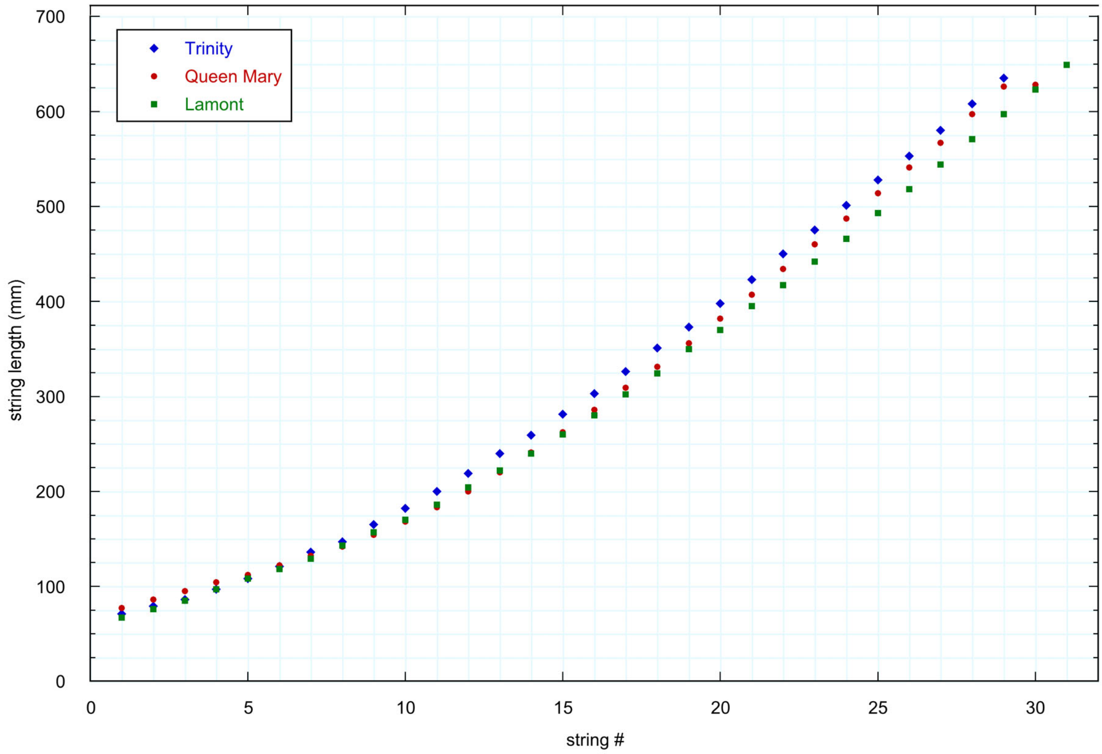

***Figure 2.52:** a comparison of reconstructed string lengths for the Trinity College, Queen Mary, and Lamont harps with straightened frames. The string lengths for the Trinity College harp are from Dooley (2014).*[218]

Aside from the treble end of the compass, where the string lengths of the Queen Mary harp are comparatively long, the reconstructed string lengths for this harp fall short of those for the Trinity College harp by as much as 20 mm in the middle of the compass. Part of the difference in length is due to the different soundbox belly heights. Even taking this into consideration, however, the string lengths for the Queen Mary harp would still be shorter than those for the Trinity College harp in this part of the compass. As a comparison, if the Trinity College harp had a compass from c – b‴ (with unison strings) and stringing as discussed above for the Queen Mary harp (although without iron in the treble), it would have a pitch of about A418 – 423 Hz (assuming a measurement uncertainty of +/- 1 mm for the string lengths).[219] The Queen Mary harp, with its current soundbox belly, (and with iron in the treble) would have a pitch of A 455 – 462 Hz. This is a difference of about 1½ semitones. If

[218] Dooley, "Medieval Irish Harp," 124.
[219] This is for yellow brass stringing with a scaling of 270 mm at c″ (A440).

the difference in height of the soundbox bellies is taken into account, the difference in pitch between the two harps would be 1 semitone.

In comparing the string lengths of the Lamont harp to the Trinity College harp, the string lengths of the Lamont fall increasingly short if each is compared starting from the first string in the treble, as plotted in figure 2.52. If the string lengths are compared starting from string #2 for the Lamont harp instead (shifting the Lamont harp string lengths up by one), the lengths for these two harps are, in fact, very similar, as shown in figure 2.53, below.

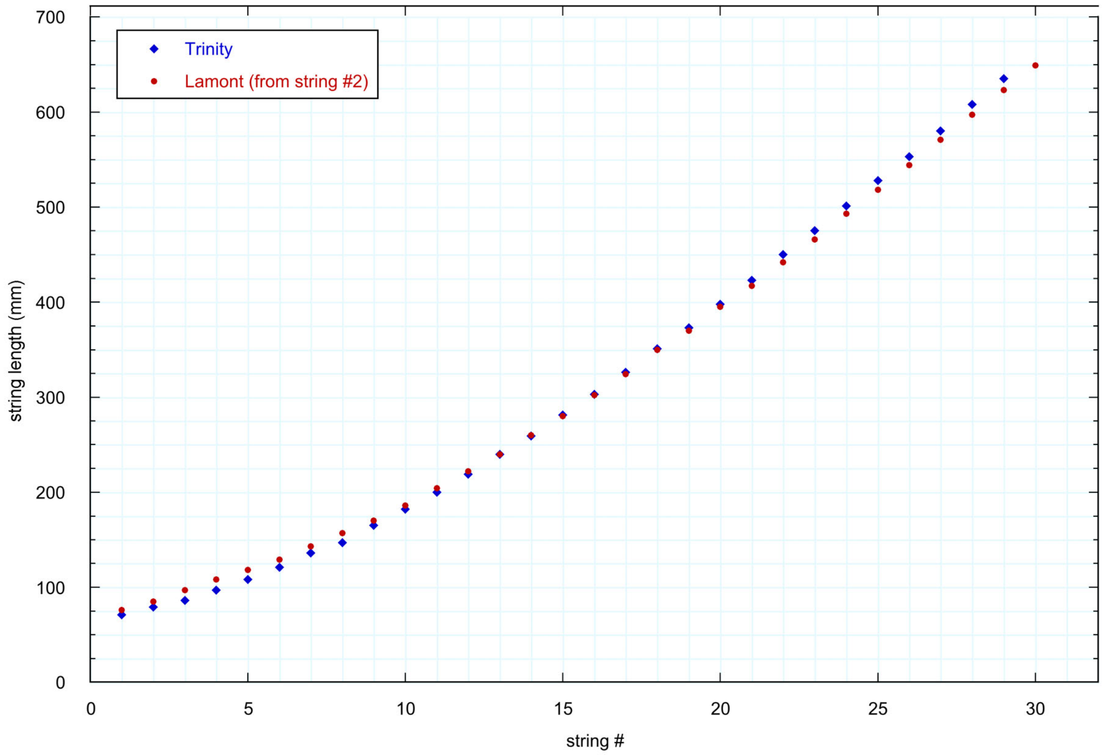

Figure 2.53: *comparison of reconstructed string lengths for the Lamont and Trinity College harps with 'straightened' frames with soundbox bellies, from string #2 on the Lamont harp and string #1 on the Trinity College harp. Note the close correspondence in string lengths. Trinity College harp string lengths from Dooley (2014).*[220]

[220] Dooley, "Medieval Irish Harp," 124.

It is difficult at this point to say if the observed differences in reconstructed string lengths are entirely due to actual differences in construction between these three harps, or if they are due in part to the different approaches to reconstructing the string lengths for the straightened frames. It should also be reiterated that there is currently not enough information to provide definitive answers for the historical compass and pitch of the Queen Mary and Lamont harps. The solutions discussed above are only possibilities, or to quote Lewis Morris's marginalia in the "Robert ap Huw" manuscript, "These modern notes are only my guesses."[221]

Summary

The primary focus of Part I of this dissertation has been the stringing of these two harps. Although it is not possible to definitively identify the specific compass (or compasses) used historically without further information, the reconstructed string lengths made it possible to examine some plausible solutions. The analysis also raises the interesting possibility that the Queen Mary harp might have been scaled for stronger wire for the top strings in the treble, and that this wire could have been iron. Instrument builders will perhaps find the reconstructed string lengths useful, particularly for the Lamont harp, whose severely distorted frame has hindered efforts to build instruments modelled on this harp. Although the lengths derived for the straightened frames are provisional, this analysis of the motion of the frame members may lead to further refinements. It is hoped that instrument builders will also look beyond the string lengths to a deeper understanding and appreciation of the underlying craftsmanship in the construction of these two harps.

The examination of the stringing began with a discussion of the wire fragments discovered in each of the harps. Two fragments (one in each harp) were identified as brass, while a third very small fragment in the Queen Mary harp was identified as iron. Both fragments in the Queen Mary harp were identified as likely dating to the

[221] Lewis Morris, marginalia in, BL Addl. 14905, Lewis, ed., *Musica*, 35. By plainly distinguishing his interpretation from fact, Morris has probably made one of his more important contributions to the manuscript.

restringing in the early 19th century. The fragment in the Lamont harp was identified as possibly dating to the 17th century, although this estimate is open to interpretation given variations in historical brass composition. Analysis of its composition and measurement of the gauge were combined with the reconstructed string length for the straightened frame to calculate the string tension for a plausible solution for the compass and tuning. The relatively high string tension that was found has informed a discussion of the reinforcing straps across the neck-forepillar joint of the Lamont harp, and signs of similar straps on other Irish harps, as possibly being evidence of a change in stringing practice towards higher tension.

As part of the process of determining the string lengths, the stringing arrangements for each harp were deduced based on examination of marks at the string holes, evidence of damage and/or modifications to the instruments, and examination of the tomograms. For the Queen Mary harp, it was confirmed that all of the string holes were used, at least at some point, during the working life of that instrument. For the Lamont harp, it was determined that 31 of the 32 string holes in had been used, with the last string hole in the bass remaining unused. The stringing arrangement for the Lamont harp was determined to have likely changed over time in response to damage to the instrument, starting with a direct string hole to tuning pin arrangement of 31 strings, then a change to an offset arrangement of 30 strings, starting in the treble with string hole #2 strung to tuning-pin #3, with the final string in the bass strung to a tuning pin added to the neck below the cheekbands.

In the course of determining the string lengths, the effect of the string tension on the shape and relative positions of the neck and soundbox of both harps was studied. Additionally, for the Lamont harp, it was established from examination of the tomograms that the belly is entirely due to the string tension pulling up a soundbox that originally had a flat front. The backwards tilt of the foot of this harp was found to also be due to bending of the wood in response to the string tension, rather than a construction feature. It was determined, on the other hand, that the soundbox of the Queen Mary harp may not have been made with a flat front, and that its belly may actually be due to a combination of carving and the effect of string tension. The motion and twisting of the neck of each harp was quantified. Twisting and damage to the neck of the Queen Mary harp was determined to have resulted from repair work that had altered the flexibility of the neck-soundbox joint. The behaviour of the neck tenon in the soundbox joint was discussed for both harps, and the effect it has had on the treble end of the soundbox was determined. Notably, the Queen Mary harp was found to have a more robust design in terms of its ability to minimize damage to the soundbox mortise and neck tenon.

Part II of this dissertation further examines the construction these two harps in order to establish their construction history. This will, it is hoped, provide a deeper understanding, not only of the craftsmanship of these harps, but also of the way in which they were used, as well as providing important clues to their dates of construction.

THE ORGANOLOGY OF THE QUEEN MARY AND LAMONT HARPS

Karen A. Loomis

VOLUME TWO

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The University of Edinburgh
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Part II. Construction

Chapter 3. The Lamont Harp

As discussed in Part I of this dissertation, there are aspects of the construction and repair of this harp that do not appear to be straightforward, for example the mismatched number of tuning pin holes and string holes, as discussed in the stringing section of this dissertation. Examining the surviving evidence on the instrument may provide some clues to how it came to be in its current form, and help us to gain a deeper understanding of its construction.

Forepillar

This examination of the construction of the Lamont harp begins with the forepillar, which has suffered very visible damage and repair, as discussed in Loomis (2010).[222] Further examination of the CT scans of the forepillar has revealed additional damage and repairs, which are discussed below in the context of its construction.

Figure 3.1 (overleaf): *the forepillar of the Lamont harp, viewed from the right and left–hand sides of the harp. Photographs: Maripat Goodwin.*

[222] Loomis, *Structural Breaks and Repairs,* 23 – 28. See also Loomis et al., "Lamont and Queen Mary Harps," 119 – 20, and Armstrong, *Irish and Highland Harps,* 165.

Damage and repair (further to Loomis 2010)[223]

The most prominent apparent repair to this member of the frame is the scarf joint just below the T-section, where the lower portion has been replaced, as can be seen in the photographs in figures 3.1 and 3.2.[224] The forepillar is depicted with this repair in the earliest engravings of the Lamont harp, in Gunn's 1807 report.[225] Crushed wood at the back of this joint and the opening up of the front of it indicate that the harp was brought up to tension after the repair was made.[226] This suggests that it dates to the working life of the instrument, however damage due to a post-historical restringing cannot be ruled out.[227]

Figure 3.2: *the scarf joint on the Lamont harp forepillar, viewed from the front. Photograph: Maripat Goodwin.*

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[223] Loomis, *Structural Breaks and Repairs,* 23 – 28.
[224] Armstrong, *Irish and Highland Harps*, 165 – 66; Simon Chadwick, "The Lamont Harp: Damage and Repairs," accessed 7 August, 2014, http://www.earlygaelicharp.info/harps/lamontdamage.htm, (a newer version of this web page does not explicitly mention the scarf joint); Loomis, *Structural Breaks and Repairs,* 23 – 28.
[225] John Gunn, *Historical Inquiry*, plates I and III.
[226] Chadwick, "The Lamont Harp: Damage and Repairs." See also Armstrong, *Irish and Highland Harps,* 165. Armstrong points out that the two pieces of the forepillar must have pivoted when the harp was brought back up to tension. This would have caused the joint to open up at the front and pinch together at the back, as observed.
[227] Keith Sanger has suggested that the Lamont harp might have been restrung in the early 19th century. See Keith Sanger, "The 'Lamont' Harp," accessed 11 May, 2014, http://www.wirestrungharp.com/harps/lude/lamont_details.html.

Upon close examination of tomograms taken from the CT scans, it appears that most of the shafts of the rivets joining the two pieces of the forepillar are bent and/or damaged. Figure 3.3 shows a photograph of the rivets in the forepillar and how they appear in cross-section on the tomograms.

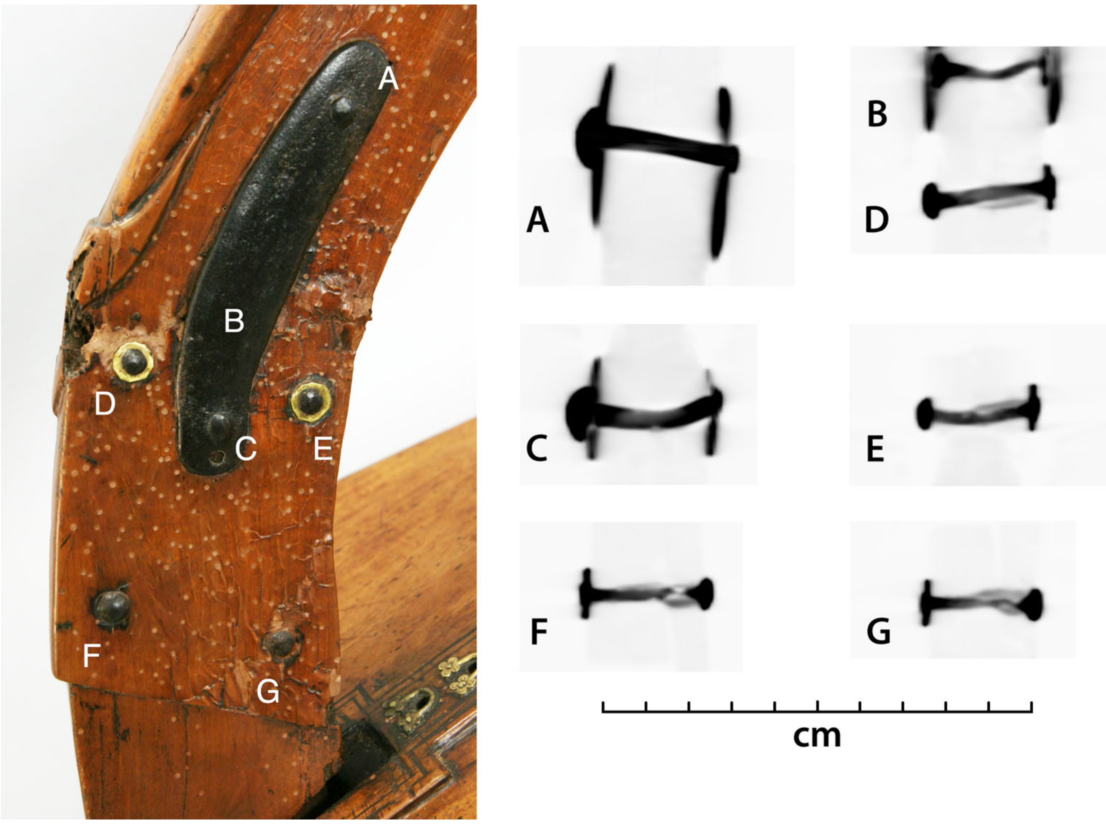


Figure 3.3: *iron rivets in the join between the upper and lower sections of the forepillar. The tomograms on the right show the condition of the shafts. The shaft of the top rivet, labeled 'A', is the only one that does not appear to be compromised. The others are either bent or have cracked. Although not visible in this figure, the head of rivet 'C' has partly sheared off. The scale for the tomograms is 1 tick : 1 cm. Photograph (left): Maripat Goodwin; annotations by the author.*

The lowest four rivets, labeled D, E, F, and G, are split along the shaft in multiple places (with the exception of E which has one large split). It also appears that the shafts may have some corrosion. This could be the result of exposure to moisture when this harp was stored at Dalguise in the 19th century.[228] The shaft of rivet C is bent towards the front of the forepillar and its head has almost completely broken off. Rivet B, which is hidden behind the iron strap, is bent in the same direction. Although it doesn't appear to be cracked or split, it does pass through an internal crack in the wood, so is not actually functional. Rivet A is the only one that appears to be completely sound. This is also the only rivet that doesn't pass through the scarf joint. The other rivets probably bent as the joint opened up when the harp was brought up to tension. Given the apparent state of these rivets, it looks as though there may not be much holding the two pieces of the forepillar together. Although there is no longer any string tension on the frame, the forepillar does support some of the weight of the neck. In light of this it would be advisable to assess the stability of the forepillar join from a conservation standpoint.

Although the join between the two sections of the forepillar has been discussed previously, the repair to the joint with the soundbox has not. Upon initial examination, it appears that the replaced lower section of the forepillar does not match the dimensions of the mortise in the soundbox. Figure 3.4 shows the soundbox where it joins with the lower section of the forepillar.

[228] An early 20th-century archival photograph of the harp shows water drip marks on the forepillar. National Museums Scotland "Lamont Harp archive," H. LT2.

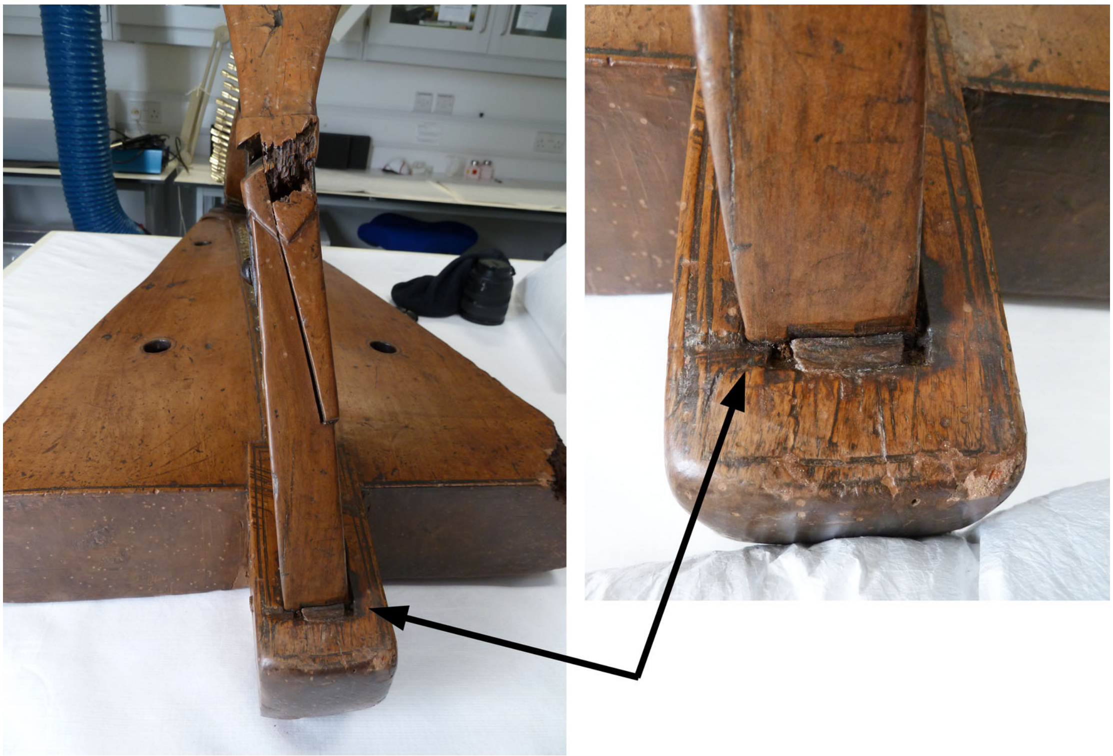


Figure 3.4: *the forepillar/soundbox joint of the Lamont harp (arrowed). It is the replaced lower section of the forepillar that joins with the soundbox. Upon initial inspection, the dimensions of the forepillar do not appear to match the soundbox mortise, which has been enlarged on one side and shimmed at the front end. The front of the forepillar has been chiseled to create a flat surface to press against the shim.*

As can be seen in the photographs in this figure, the soundbox mortise has been enlarged on its right-hand side and has been shimmed at the front end. The front of the forepillar has been somewhat crudely chiselled to create a flat surface to press against the shim. This seems odd, considering the apparent care that was taken in matching the dimensions of lower section of the forepillar to the upper section at the scarf joint. Examination of this joint on tomograms from the CT scans shows that the dimensions of the tenon and its shoulder, versus the mortise and its recess do agree, at least in terms of width. The mortise recess has been cut into on one side to accommodate misalignment of the forepillar. This can be seen more clearly in the two views of the joint shown in figure 3.5.

Figure 3.5: *two views of the forepillar / soundbox joint of the Lamont harp. The width of the mortise and tenon (including the tenon shoulder and mortise recess) do agree. The mortise recess has been enlarged on its right-hand side to accommodate misalignment of the forepillar.*

This dimension of the repair is therefore consistent with it having been made for this soundbox. In the long dimension, the tenon and its shoulder are each over a centimeter shorter than the mortise and its recess, however. This is noticeable in the photographs of the joint in figure 3.5. This discrepancy can be entirely accounted for by the change in the angle of the forepillar to the soundbox due to the decreased distance between the end of the neck and the soundbox as the neck has pivoted forwards. Based on the calculated change in string lengths for the Lamont harp, the straight-line distance between the top and bottom end of the forepillar is 5 cm shorter than it was originally. Some of this shortening is taken up in bending of the forepillar, however the lower section of the forepillar was also made short to compensate for the decreased distance.

At the top end of the forepillar, where it joints the neck, there is another repair that was not discussed in Loomis (2010), as it was only noticed after a careful reexamination of the CT scans of this joint. Examination of the joint in this location is somewhat complicated by interference from the metal end-cap, cheekbands, and straps, although it is possible take cross-sections that show details of its interior. As discussed in Chapter 2 of this dissertation, it is possible to see the forepillar tenon inside the neck joint and to see the tuning pin holes that pass through the tenon. Close examination of the tomograms of the neck/forepillar joint revealed that, in addition to the current line of tuning pin holes piercing the tenon, the end is scalloped by what appears to be the remains of a second line of holes, 1.7 cm above the current ones.[229] This can be seen in the tomograms of the joint in figure 3.6.

[229] Loomis et al., "Lamont and Queen Mary Harps," 120.

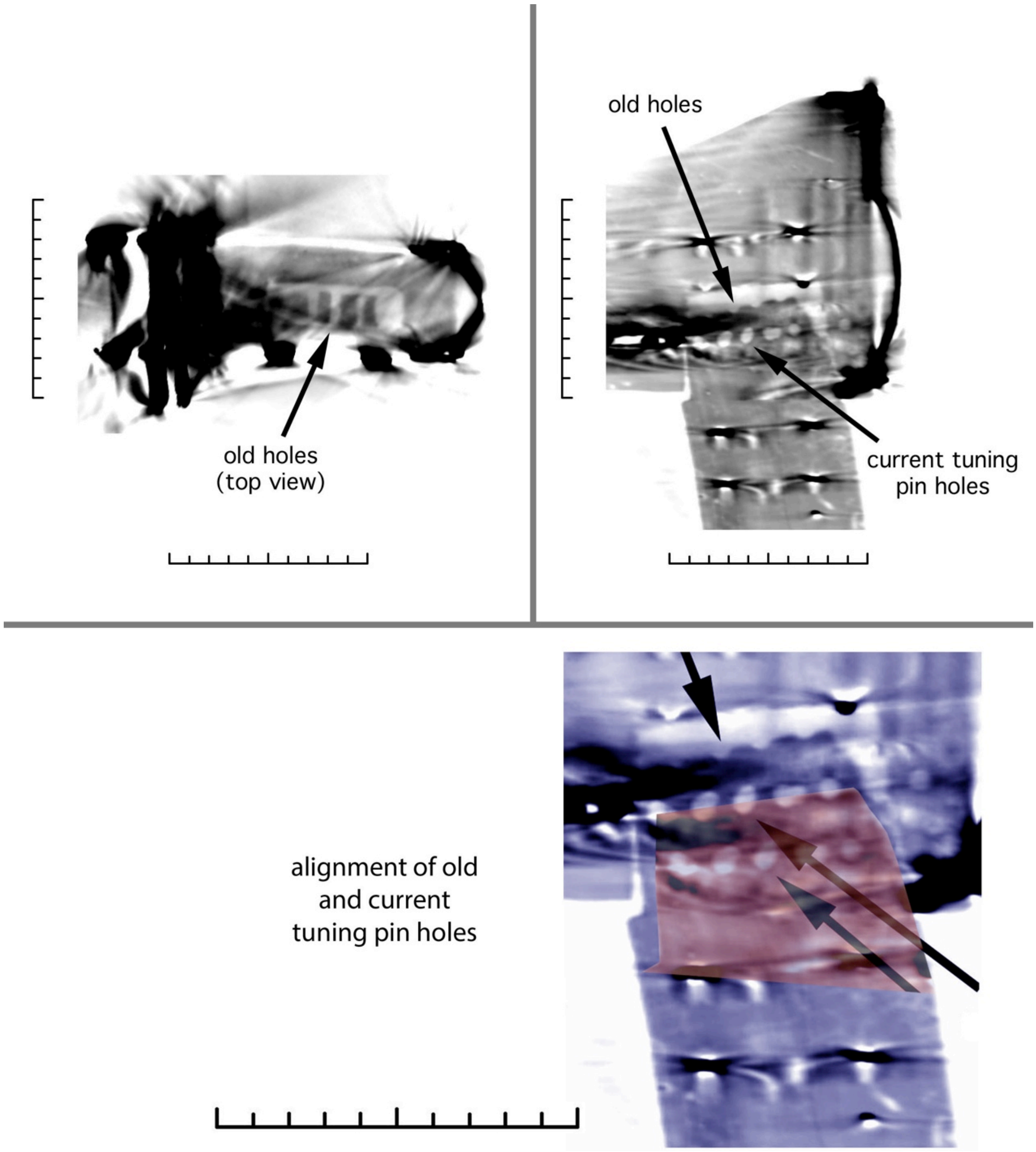


Figure 3.6: *Tomograms of the forepillar tenon of the Lamont harp in the neck joint. At top left is the view looking down from above the end of the tenon, and at top right is the view from the side. The remains of what appears to be a second set of tuning pin holes are visible on the end of the tenon in both of these cross-sections. The composite image at bottom right has a copy of the image of the end of the tenon overlaid on itself (shown in a contrasting colour), but shifted to show the alignment of the two sets of holes. Scale 1 tick : 1 cm.*[230]

[230] An earlier version of this figure appears in Loomis et al., "Lamont and Queen Mary Harps," 120.

Measurements taken off the tomograms of the tenon show that both sets of holes are spaced 12 mm on centre. The second line of holes lies at an angle of 3° to the current set, consistent with their separate locations on the arc of the forepillar. A possible explanation for this feature is that the end of the tenon sheared off through the perforations created by the original line of tuning pin holes. Instead of replacing the forepillar, the tenon shoulder was re-cut and reseated in the joint, and a new set of tuning pin holes was bored through the tenon below the original set.[231] The lower image in figure 3.6 demonstrates that this was likely the case by overlaying a copy of the image of the end of the tenon onto itself, shifted downward and rotated 3° to show the alignment of the two sets of holes on the forepillar. Misalignment of the holes, either in their spacing or their position on the forepillar, would have indicated that the upper section of the forepillar had previously been on a different harp. Their alignment, however, shows that this was probably not the case.

The sheering off of the end of the tenon could have occurred as a result of the string tension causing the neck to rotate towards the left-hand side of the harp, or it could have occurred as a consequence of the break lower down on the forepillar. If that break had been a sudden catastrophic event, the upper part of the forepillar would have swung downwards, forcing the forepillar tenon to rotate in the neck joint. Because the tuning pins that pierce the tenon are fixed in position in the neck, the tenon would have sheered off through the tuning pin holes.

Cross-sections

Figure 3.7 shows a tomographic cross-section of the forepillar. This is actually a composite of three cross-sections, one for the middle of the forepillar, and separate cross-sections for the ends. In order to show the complete forepillar, this was necessary because it is bowed in the middle towards the right-hand side of the harp. The lines labeled A – E indicate the locations of cross-sections taken across the forepillar. These are shown in figures 3.8 – 3.12. For all of these figures the grey-

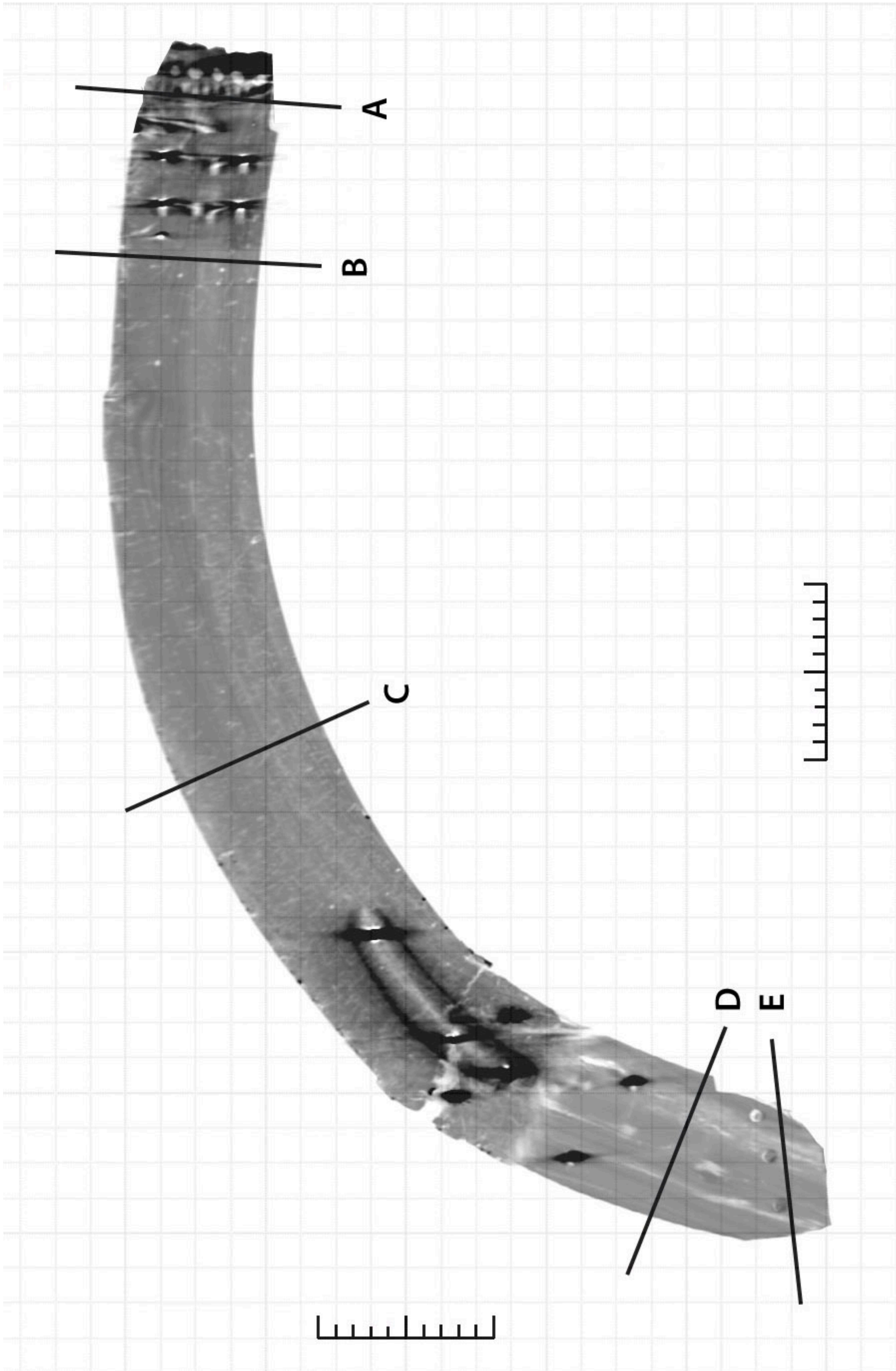
[231] Loomis et al., "Lamont and Queen Mary Harps," 120.

scaling has been set so that the edges of the image of the forepillar are located at its actual physical edges. This has been done so that the dimensions of the forepillar are accurately represented in the figures.

The location of the physical edge was determined by plotting the voxel counts across the edge and locating the point midway between the lowest and highest value. To accurately measure an object in cross-section, the width is taken as the FWHM (full width at half maximum) of the profile of the cross-section. This is the method used throughout this dissertation for measurements taken from the tomograms.

For the cross-sections in figures 3.8 – 3.12, the coloured line in the left-hand image indicates the location of the cross-section shown on the right. The green lines on the measured cross-section on the right indicate where the measurements were taken. The right-hand side of the harp is on the left in each of the measured cross-sections, as indicated in the figures (the view is from the perspective of 'looking up' the forepillar from below). Any image artefacts are due to the metal fittings in the vicinity of the cross-section.

Figure 3.7 (overleaf): *composite tomographic cross-section of the forepillar of the Lamont harp. The lines A – E indicate the locations of the individual cross-sections shown in figures 3.8 – 3.12. The neck joint is located at upper-right and the joint with the soundbox is located at lower-left. Scale 1 tick : 1 cm; grid scale 1 square : 2 cm.*


A
B
C
D
E

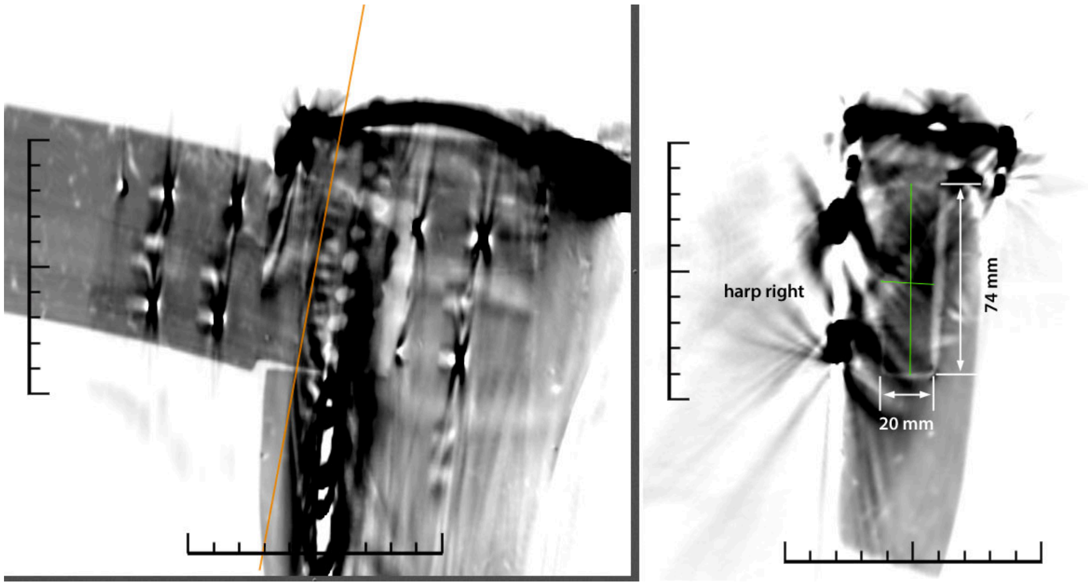


Figure 3.8: *Lamont forepillar cross-section A (see figure 3.7). This is a cross-section of the tenon in the neck joint. Although the image artefacts make it difficult to discern, it appears in the left-hand image that the tenon has no shoulder on the side facing the end of the neck. Scale 1 tick : 1 cm.*

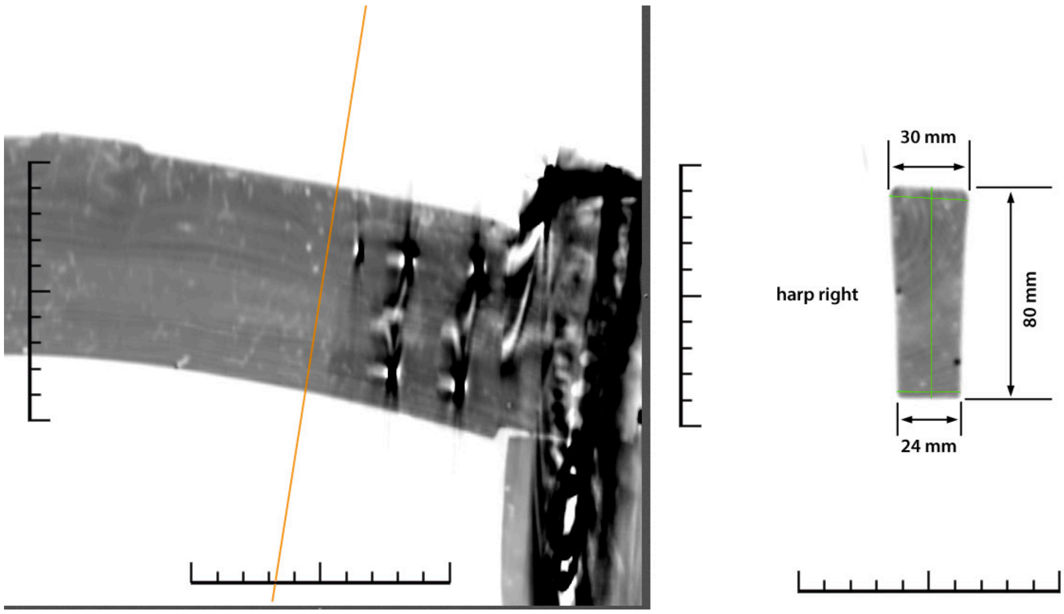


Figure 3.9: *Lamont forepillar cross-section B (see figure 3.7). Note that the forepillar is slightly wedge–shaped. In the cross-section on the right the visible wood growth rings indicate that the centre of the timber is just off the upper right–hand edge of the forepillar. Scale 1 tick : 1 cm.*

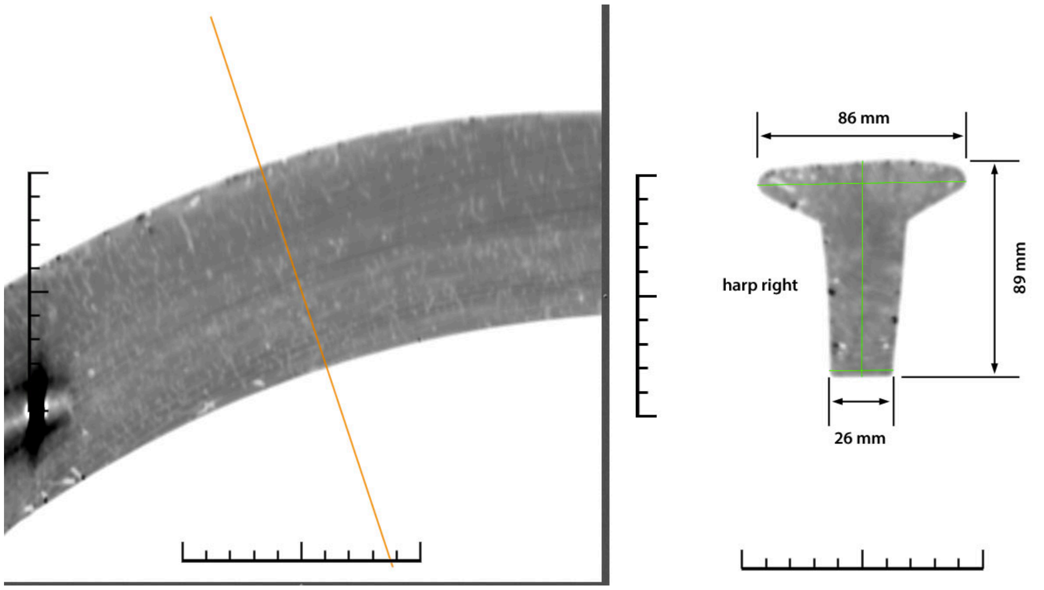


Figure 3.10: *Lamont forepillar cross-section C (see figure 3.7). This cross-section is at the mid–point of the t-section. Scale 1 tick : 1 cm.*

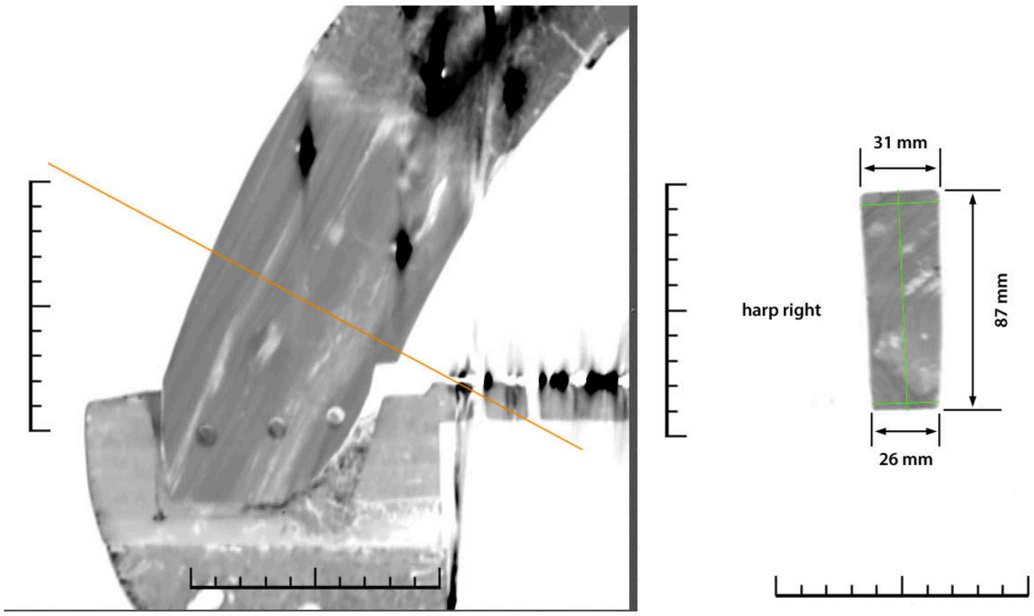


Figure 3.11: *Lamont forepillar cross-section D (see figure 3.7). This cross-section is on the lower 'replacement' section of the forepillar. Note that the tenon does not have a shoulder on its front end. Although not shown in this cross-section, the tenon shoulder is cut higher on the left-hand side of the forepillar versus the right-hand side to compensate for the forepillar leaning to the left. Scale 1 tick : 1 cm.*

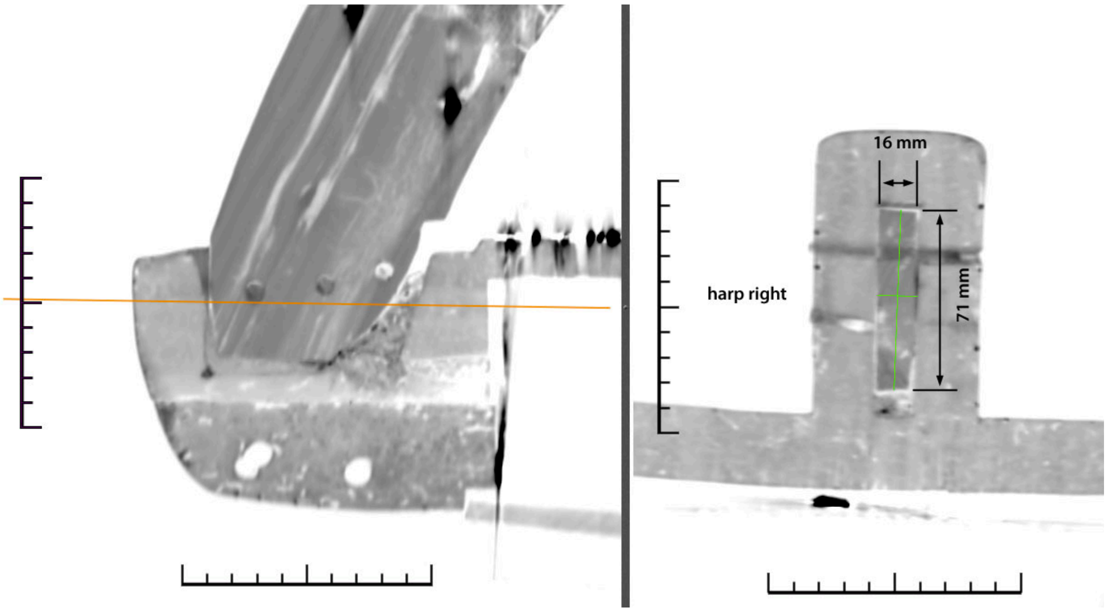


Figure 3.12: *Lamont forepillar cross-section E (see figure 3.7). This is the cross-section of the tenon in the soundbox joint. Scale 1 tick : 1 cm.*

Direction of wood grain

Prior to the commencement of this study it had been hypothesized that the wood grain follows the curve of the forepillar for Irish harps (in particular, the low-headed variety), although it had not been determined if this was actually the case for any of the surviving instruments.[232] Although some of the wood grain is visible in the cross-section shown in figure 3.7, the higher contrast tomogram in figure 3.13 shows it more clearly. It is evident from this tomogram that the direction of the grain in the upper section follows the curve of the forepillar, whereas the lower section appears to be straight grained.[233] It is not possible to tell from this cross-section whether the wood in the upper section was naturally curved (e.g. if it came from a curved branch) or had been bent.[234] Either way, the forepillar is stronger and more flexible with the grain following the curve than it would be if cut from a straight grained timber.

[232] See e.g., Simon Chadwick, "A Historical reproduction of the Queen Mary Harp," *Newsletter of the American Musical Instrument Society* 36, no. 2 (Summer 2007): 16. Paul Dooley has determined that the forepillar of the Trinity College harp was probably made from a curved branch. Paul Dooley, "Medieval Irish Harp," 112.
[233] Loomis et al., "Lamont and Queen Mary Harps," 120 – 21.
[234] One could tell by looking at both sides of the centre of the timber for evidence of reaction wood in the form of non-concentric growth rings.

Dooley (2014) has argued that the in-built flexibility of a forepillar made from a curved grain timber may play an important role in the acoustics of the instrument by counteracting string stiffness in the bass.[235]

Figure 3.13: *high contrast tomographic cross-section of the Lamont harp forepillar showing the wood grain pattern. The direction of the grain in the upper piece follows the curve of the forepillar, whereas the lower piece appears to be straight grained. The joint with the neck is located at upper-right and the joint with the soundbox is located at lower-left in this figure. Scale 1 tick : 1 cm.*

[235] Paul Dooley, "Medieval Irish Harp," 111 – 12.

Decorative work

Although there is little in terms of decorative work on the Lamont harp forepillar, the ends of the t-section are carved in a decorative point. Figure 3.14 shows the upper termination of the t-section as viewed from the front and side.

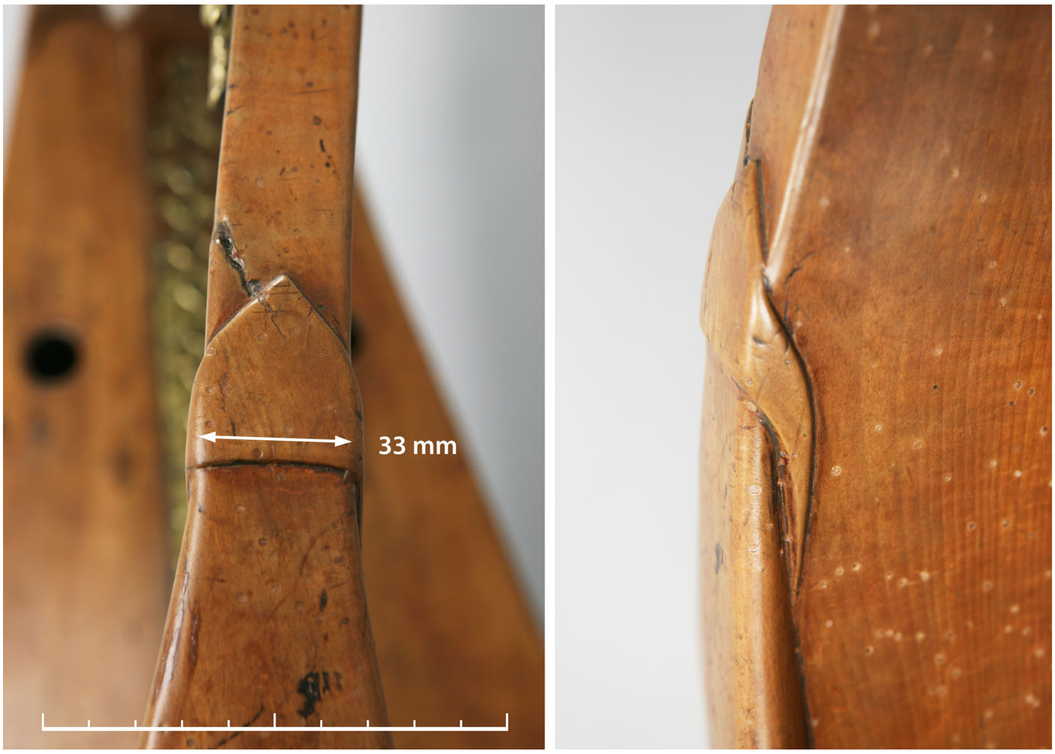


Figure 3.14: *upper termination of the Lamont harp forepillar t-section, as viewed from the front (left) and side (right). Scale 1 tick : 1 cm.*

The center of the front face of the t-section is decorated with two concentric circles.[236] This is shown in the photograph in figure 3.15. This may have been intended for a painted badge, in the manner of the shield on the forepillar of a similar harp depicted in the painting of William Archdeacon, either not realized, or later removed.[237]

[236] This is also discussed in Armstrong, *Irish and Highland Harps*, 166.
[237] "An Irish harper on the continent ca. 1750," Irish Traditional Music Archive, accessed 18 May, 2014, http://www.itma.ie/digitallibrary/image/Irish–harper.

Figure 3.15: *concentric circles on the front face of the Lamont harp t-section. They are located at the centre of the t-section and may have been intended for a painted badge.*

Neck

The structural damage and repair to the neck and the neck/soundbox joint were discussed in detail in Loomis (2010), and the construction of the neck joint at the soundbox and the effect of the string tension on the neck position and orientation were discussed in Part I of this dissertation.[238] This section addresses other details of the neck construction. This includes the tuning pins, cheekbands, end cap, and some aspects of the repair work. Measured cross-sections of the neck are also presented. Additionally, the metal fittings and repair work are discussed in the context of the working history and dating of this harp.

[238] Loomis, "Structural Breaks and Repairs," 28 – 41.

Figure 3.16: *the Lamont harp neck, viewed from the right and left-hand sides. Photographs: Maripat Goodwin.*

Tuning pins

This discussion of the neck begins with the tuning pins. The Lamont harp currently has 30 out of a full complement of 32. With the exception of three that are iron, they are copper alloy with square drive heads incised with decorative work. This can be seen in the examples shown in figure 3.17. Note that one of the pins in figure 3.17 does not match the others, and appears to have come from a different set.

Figure 3.17: *Lamont harp tuning pins: side view (top photo), and end view (bottom photo). The tuning pins on this harp are of the characteristic square-headed design with decorated drive head typical of Irish harp tuning pins. Note that the second pin from the right does not match the others. Photographs: Maripat Goodwin.*

In addition to the one shown in figure 3.17, the Lamont harp has a number of other mismatched tuning pins. In fact, there are at least six distinct designs represented. An attempt has been made here to group these by type in order to ascertain which is the primary (and possibly 'original') group, and which pins are likely to be replacements. The largest group, referred to here as 'group A', is shown in figure 3.18.

Figure 3.18 (overleaf): *Lamont harp tuning pins 'Group A'. The drive heads all have nearly the same profile and decorative work, although there is some variability in the incised lines. Each drive head is shown from the side, with a corresponding photo of the end of the drive head and the string end of the shaft. The numbers below each pin represent its current position in the harmonic curve, counting from the treble end. Note that some of the shafts have hash marks on the string end, while others do not. Photographs: Maripat Goodwin; montage assembled by the author.*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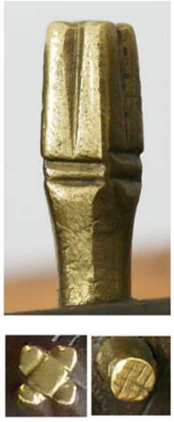
5


6


8


11


14


15


16


17


18


21


26


27

Group A

The drive heads of these pins all have the same profile and could have been cast in the same mould or set of moulds. It is therefore possible that they comprise a 'matched' set. The decoration on the drive heads is in the form of a v-shaped groove incised down the centre of each side, terminating in two or three parallel lines just above the transition to the shaft, and a diamond incised on the end of the drive head. Although the pins appear to have been cast, tool marks visible under microscopic examination indicate that the decorative work was added by hand. This is also evident in the variability in execution amongst the pins. Most, but not all, of the winding ends of the pins are incised with hash marks. In some cases, the hash marks could have worn away. The end of tuning pin #16 does not look worn, though. This pin also has a slightly more tapered drive head than the others in Group A, so perhaps it does not belong to this set.

There are several tuning pins on this harp that appear to be just slightly different from the predominant group (Group A), and in some cases from each other. These have been placed together in 'Group B', shown in figure 3.19. Although these tuning pins have the same decorative design as those in Group A, the shape of the drive heads and the execution of the decorative work are slightly different. It is difficult to tell if these tuning pins belong to the set represented in Group A, or if they came from a different source.

Figure 3.19: *Lamont harp tuning pins 'Group B'. These tuning pins have the same design as those in Group A, but are slightly different in shape of the drive head and in execution of the decorative work. Each drive head is shown from the side, with a corresponding photo of the end of the drive head and the string end of the shaft. The numbers below each pin represent its current position in the harmonic curve, counting from the treble end. Photographs: Maripat Goodwin; montage assembled by the author.*

The remaining tuning pins are more clearly different from those in either Group A or Group B. Three of these are alike and appear to have come from the same source. They are grouped together in 'Group C', shown in figure 3.20. Although they follow the same broad design scheme of the other tuning pins, the v-shaped groove down the sides of the drive head is much deeper and extends onto the shaft. There are also no lines incised across the faces of the drive head, and no hash marks on the string end of the shaft. As with the other tuning pins, the end of the drive head is incised with a diamond, however here the diamond is inscribed with a cross.

Figure 3.20: *Lamont harp tuning pins 'Group C'. This group of three tuning pins is distinctly different in design to any of the pins in either Group A or Group B. Each drive head is shown from the side, with a corresponding photo of the end of the drive head and the string end of the shaft. The numbers below each pin represent its current position in the harmonic curve, counting from the treble end. Photographs: Maripat Goodwin; montage assembled by the author.*

The remaining four copper-alloy tuning pins are shown in figure 3.21, below. These pins do not match any of the others, so are categorized separately as type 'D', 'E', 'F', and 'G'. One possible exception is tuning pin #10 (named 'Type D' here), which resembles the pins in Groups 'A' and 'B', however its drive head appears to have been filed, possibly to make it fit a tuning key, which suggests it may not belong with those pins. The other three tuning pins (types 'E', 'F', and 'G') are unlike any of the others, and are probably replacements. Compared to the pins in Group A, pin #12 ('Type E') has a more prominent, almost tulip shaped, drive head, and pin #29 ('Type F') has incised lines along the edges of each face of the drive head instead of down the centre, and lacks the diamond on the end. Pin #30 ('Type G') has an X incised on each face of the drive head, just above the shaft, has a more abrupt transition from the head to the shaft, and has the diamond motif slightly recessed on the end of the drive head, creating projecting points at the corners.

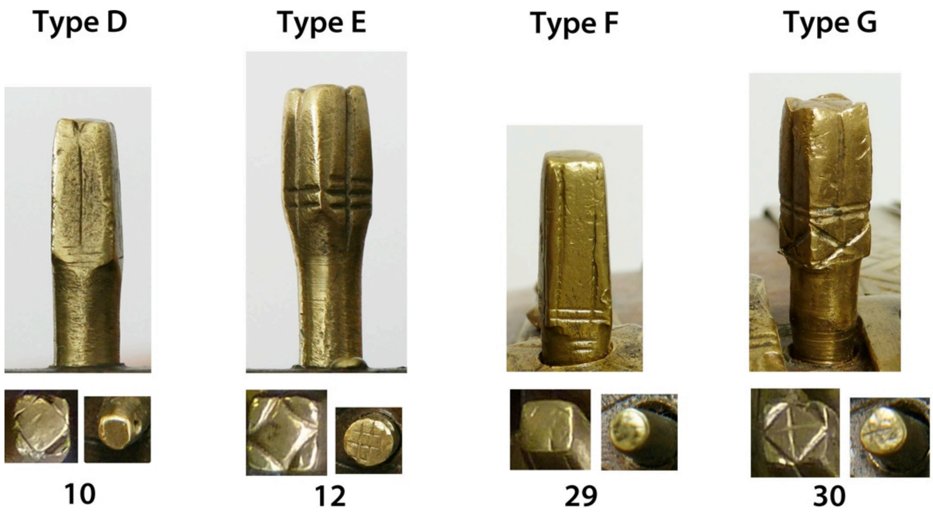


Figure 3.21: *Lamont harp tuning pins not matching any of the others on the harp. These pins are designated type 'D', 'E', 'F', and 'G'. Tuning pin #10 (type 'D') could possibly be categorized with Group B, however. Each drive head is shown from the side, with a corresponding photo of the end of the drive head and the string end of the shaft. The numbers below each pin represent its current position in the harmonic curve, counting from the treble end. Photographs: Maripat Goodwin; montage assembled by the author.*

The three iron tuning pins are shown in figure 3.22. They have undecorated drive heads of square cross-section. All three tuning pins have string holes, in contrast to the former iron tuning pins on the Queen Mary harp that had cleft string ends.[239] None have hash marks on the string end of the shaft.

[239] See the discussion of the Queen Mary harp tuning pins in Chapter 4.

Figure 3.22: *iron tuning pins on the Lamont harp. The drive heads are square in cross-section, undecorated, and have minimal signs of wear. The string ends of the tuning pins are also plain, and are pierced for a string. Each drive head is shown from the side, with a corresponding photo of the end of the drive head and the string end of the shaft. The numbers below each pin represent its current position in the harmonic curve, counting from the treble end. Photographs: Maripat Goodwin and Karen Loomis; montage assembled by the author.*

Composition:

Figure 3.23 shows a pin from Group C (# 22) next to one from Group A (#11), for comparison. In addition to the differences in decorative work on the drive head, the tuning pin from Group C is longer, with a total length of 95 mm versus 90 mm for the tuning pin from Group A. The colour of the alloy is also noticeably different for each of these two pins, indicating that they don't have the same composition. Four tuning pins, two from Group A and two from Group C, were analysed with XRF to determine their composition. The results of this analysis are shown in table 3.1.

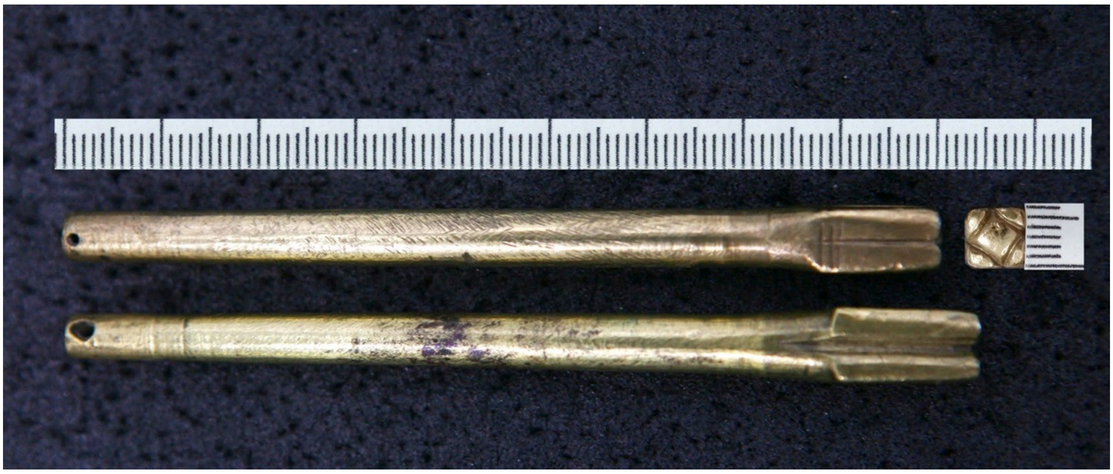


Figure 3.23: *two different Lamont harp tuning pins. Pin #11 (top) from Group A, and pin #22 (bottom) from Group C. In addition to the differing designs of the drive heads, the lengths, and the colour of the alloy are also different. The scale is 1 tick : 1 mm.*

Table 3.1.
Composition of four Lamont harp tuning pins[240]

Group	Pin #	Fe	Ni	Cu	Zn	As	Pb	Ag	Sn	Sb
A	2	0.4	0.3	84.2	10.3	0.8	1.0	0.1	2.9	0.0
A	11	0.4	0.3	81.7	13.6	0.4	0.7	0.1	2.8	0.0
C	3	0.1	0.3	79.7	17.1	0.1	1.0	0.0	1.6	0.0
C	22	0.1	0.4	76.0	20.5	0.3	1.1	0.0	1.5	0.0

Note: surface composition from semi-quantitative XRF analysis. Values are wt% for each element. The maximum measurement uncertainty is +/- 0.2%.

The analysis shows that the composition of the pairs of tuning pins within the same group is very similar, but the composition of the two groups is quite different. Given that the design of the pins is also different, we can conclude that they came from two distinct sources.

240 Jim Tate and Susanna Kirk, "Analytical Research Section Report No. AR 2010/39: XRF analysis of the Queen Mary and Lamont harps," Internal Report. National Museums Scotland, 12 July, 2010.

The compositional analysis contains other important information. As discussed in the section of this dissertation on the wire fragments discovered in the two harps, some compositions of brass were more common than others within a particular time period. While it is not possible to definitively establish a date of manufacture from this information due to the variability in composition of historical brass, we can at least know when similar brass was most likely to be in use, and may be able to narrow down possible dates for these tuning pins.

From the early medieval period, brass was being produced on a large scale in towns in the area of modern day Belgium, using copper sourced from the Harz, with Dinant as an important centre for metalworking.[241] Exports of brass from Dinant and other Flemish metalworking towns to England via Antwerp were well established by the 12th century.[242] In 1466, when Dinant was sacked by the Duke of Burgundy, brass production was effectively shut down.[243] It was later reestablished elsewhere, notably in Nuremburg, which rose to prominence in the brass industry with the Fugger family, who established their business in Nuremburg in 1486.[244] Mitchiner et al. (1987) note that the shift in brass production towards Nuremburg that occurred in the late 15th century resulted in a change in the composition of the alloy, as observed in jetons from this time period.[245] Prior to the 1480's, the alloy generally used for jetons was a low zinc brass with a significant percentage of tin. Typically, the composition was 80 – 90% copper, 4 – 12% zinc, and 3 – 5% tin.[246] As discussed in Chapter 1 of this dissertation, the proportion of silver as a trace element also changed at this time. The Fugger family, notably, had acquired a monopoly on copper from mines in present day Austria and Hungary, and a drop in the amount of silver is seen in jetons produced after the mid 1480's, as the predominant source of copper shifted from the silver bearing ore from the Harz to non-silver bearing ore from mines in present day

[241] Colum Hourihane, ed., *Grove Encyclopedia of Medieval Art and Architecture*, vol. 2 (New York: Oxford University Press, 2012), 292.
[242] ibid.
[243] Mitchiner et al., "Nuremberg and its Jetons," 114 – 15.
[244] ibid.
[245] ibid.
[246] ibid. 115.

Austria and Hungary.[247] Although de-silverization of copper had been practiced since Roman times, the process was incomplete, and brass produced from silver bearing ore in the 15th century typically contained 0.1% or more of residual silver.[248] Of the brass jetons analysed by Mitchiner et al., most of those produced after the mid-1480's contain less than 0.1% silver, and many contain no measurable amount of silver.[249] As also discussed for the wire fragments, the proportion of nickel as a trace element may also be significant, as from circa 1200 – 1450, the primary source of copper for brass production in Europe was the non-nickel bearing ore from the Falun mine in Sweden.[250] Brass produced from this copper typically had less than 0.05% nickel, whereas brass produced from the nickel bearing ores in the Harz and in Austria and Hungary after circa 1450, typically had 0.1% – 0.5% nickel.[251]

As will be shown in the discussion below, the composition of the tuning pins, particularly the levels of trace elements, falls within expected ranges for historical brass from the period relevant to these harps. The exception, however, is arsenic, which is not typically present in brass produced from the 15th century onwards, but was detected in the analysis of the tuning pins.[252] It is notable that arsenic was detected on all of the metal parts of the Lamont harp that were tested with XRF, at levels ranging from 0.1 to 1.1%. It was not detected in the wire fragment, which was analysed with SEM-EDX. In addition to the different equipment used for the analysis, a polished cross-section of the interior of the wire was analysed, not the surface. It was also located within the harp, where it was not exposed to any surface treatments, such as paints, lacquer, or cleaning agents. If possible, a task for future analysis might be to rerun the analysis of the tuning pins on a small cleaned and polished surface to determine if there is surface contamination.

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[247] ibid., 114, 124 – 25.
[248] ibid., 124 – 25, 131.
[249] ibid., 131 ff.
[250] Pollard and Heron, "Brass Industry in Europe," 210 – 14, and Mitchiner et al., "Nuremberg and its Jetons," 126 – 27.
[251] Mitchiner et al., "Nuremberg and its Jetons," 126 – 27, and Pollard and Heron, "Brass Industry in Europe," 210 – 13.
[252] Mitchiner et al., "Nuremberg and its Jetons," 128 – 29. Brass made from Cornish and Welsh copper in the 17th and 18th centuries did typically contain appreciable arsenic, however.

Table 3.2 summarizes the typical historical brass compositions discussed above and compares them to the observed compositions of the Lamont harp tuning pins. Note, however, that **the historical compositions listed here are generalizations only**. While they are typical of the time period (as represented by the composition of jetons), not all brass artefacts contemporary with these dates fall within the listed ranges of composition.

Table 3.2.
Comparison of typical composition of brass jetons by time period to composition of Lamont harp tuning pins

Element	**Typical jeton composition wt%**[253]		**Lamont tuning pin composition wt%**[254]	
	ca. 1450 – 1480's	**ca. 1480's – 1650**	**A**	**C**
Cu	80 – 90	75 – 80	81.7 – 84.2	76.0 – 79.7
Zn	4 – 12	17 – 20	10.3 – 13.6	17.1 – 20.5
Sn	3 – 5	< 2	2.8 – 2.9	1.5 – 1.6
Pb	≤ 1	≤ 1	0.7 – 1.0	1.0 – 1.1
Ni	0.1 – 0.5	0.1 – 0.5	0.3	0.3 – 0.4
Ag	≥ 0.1	< 0.1	0.1	0.0
As	–	–	0.4 – 0.8	0.1 – 0.3

Note: the ranges of historical composition are generalizations only. The maximum measurement uncertainty for the tuning pins is +/– 0.2%

The composition of the analysed tuning pins from Group A closely corresponds to the typical composition of brass jetons produced from circa 1450 to the 1480's. This is true for the proportions of the trace elements as well as for copper and zinc. If the

[253] Summarized from Mitchiner et al., "Nuremberg and its Jetons," 114 – 15, 124 – 25, 131 – 40. Pollard and Heron, "Brass Industry in Europe," 210 – 14.
[254] The data for tuning pin composition is taken from table 3.1.

composition of the jetons is typical of brass from this time period, then the composition of the Lamont harp tuning pins from Group A is consistent with a date of manufacture within the time period of ca. 1450 – 1480's, from copper mined in the Harz.

Although the close correspondence of the data is compelling, it is not possible to come to any definite conclusions about the date of manufacture just from the chemical composition of the brass. For example, these tuning pins could have been made from an older object that was melted down. The analysis does show, however, that the composition of the alloy is not inconsistent with a 15th century date of manufacture for the tuning pins. Since Group A represents the primary set of matched tuning pins on this harp, they may be original to the construction of the instrument, so the analysis does support the possibility of a 15th century date for the construction of this harp.

By contrast, the composition of the analysed tuning pins from group C is consistent with the typical range of composition of brass jetons produced after the mid 1480's. In particular, the absence of detectable silver indicates that the copper was sourced from a non-silver bearing ore. As discussed above, non-silver bearing copper came from mines in the areas of present day Austria and Hungary, which became predominant sources of copper for brass making from the mid 1480's. Again, no definite conclusions about the date of manufacture can be drawn from the chemical composition of the brass. The close correspondence of the proportions of trace elements to the expected ranges within this period of time is compelling, however, and points to this set of three tuning pins being later replacements.

The replacement of at least three tuning pins at the same time means that at some point in its working life this harp was missing multiple tuning pins. This could be related to the damage to the neck. Some of the tuning pins in Group A are worn where the shafts have scraped against the cheekband. Ideally, this should not happen in normal use, and is an indication that these tuning pins were binding due to misalignment of the cheekbands. Under these conditions a tuning pin shaft can quickly become significantly damaged and may become wedged in its hole. Due to the crack in the neck, the position of the left-side cheekband of the Lamont harp has shifted such that there is currently some misalignment with the right-side cheekband. It is possible that this resulted in damage to multiple tuning pins at the same time, necessitating their replacement. Another possible explanation is that the Lamont harp was unused for a period of time during its working life. If a harp is not maintained in tune, over time some of the strings are likely to break. Subsequently, the tuning pins belonging to those strings may be lost, either due to scavenging or simply because they are no longer tied to the instrument.

Comparison with other tuning pins:

Other surviving Irish harp tuning pins have decorative features in common with the brass tuning pins on the Lamont harp, and while there are differences in some of the details and in the workmanship, they can be seen to be variations on a common design scheme. Some examples are shown in figure 3.24.

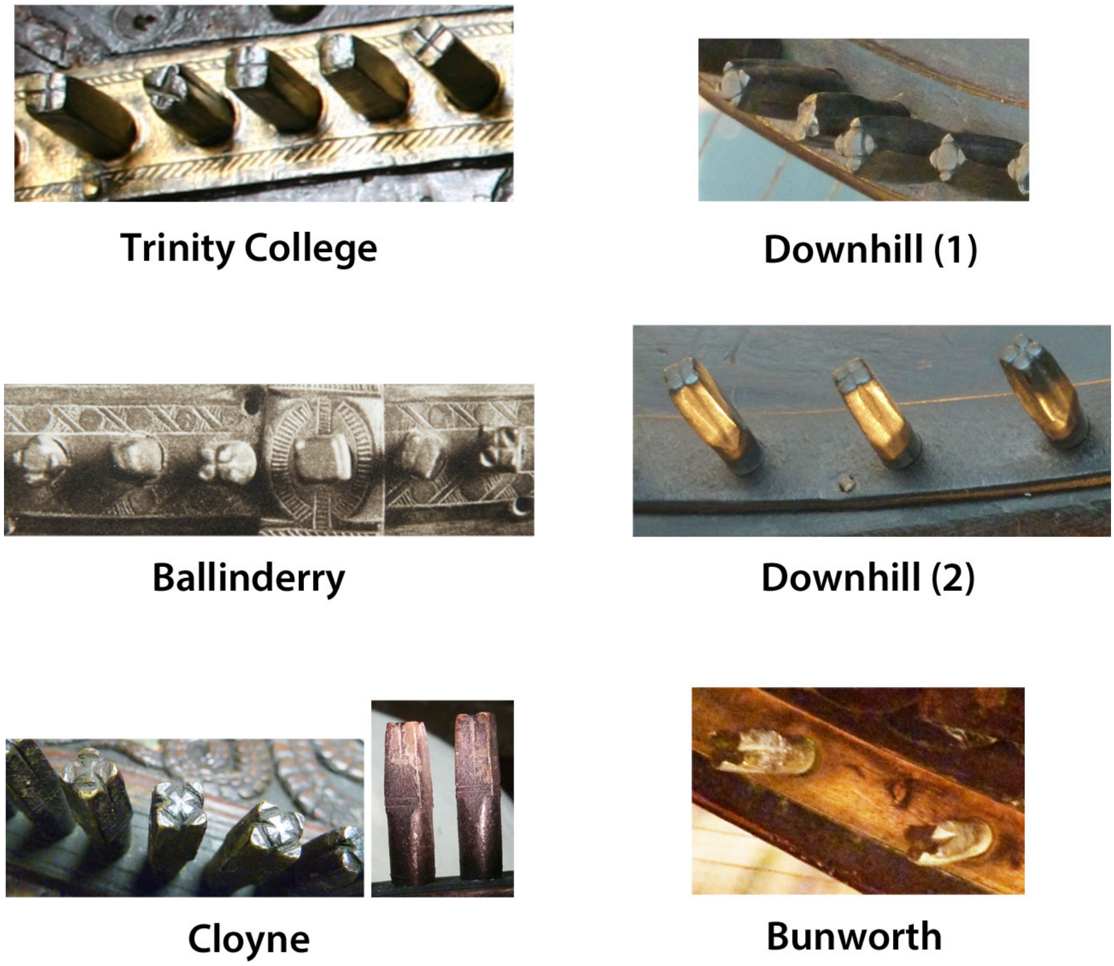

Figure 3.24: *some examples of Irish harp tuning pins typical of the square-headed design with decorated drive ends. Trinity College: ca. 15th century, Ballinderry: ca. 16th century, Cloyne: 1621, Downhill: 1702, and Bunworth: 1734.*[255] *The Downhill harp has tuning pins of two distinct designs: (1) in the treble and (2) in the bass. The Cloyne also has two distinct designs. The decorated copper alloy pins in the main rank (shown), and undecorated iron pins in the seven hole second rank (not shown).*

The tuning pins shown in figure 3.24 belong to the 'Trinity College', 'Ballinderry', 'Cloyne', 'Downhill', and 'Bunworth' harps. The common elements in their design are

[255] Trinity College harp photograph (detail): Paul Mullarkey, Trinity College, Dublin; Ballinderry harp metal fittings photograph (detail): Armstrong, *Irish and Highland Harps*, unnumbered plate opposite 62; all other photographs by the author. 'Trinity College' harp: Trinity College, Dublin; 'Ballinderry' harp fragments and 'Cloyne' harp fragments: National Museum of Ireland; 'Downhill' harp: Guinness Storehouse, Diageo Corp.; 'Bunworth' harp: Museum of Fine Arts, Boston. Images reproduced with the kind permission of The Board of Trinity College, Dublin; Guinness Storehouse Museum; and the National Museum of Ireland.

drive heads that are square in cross-section, with a v-shaped groove incised down the centre of each side, and a decorative design incised on the end consisting of either a diamond, a cross, or a diamond inscribed with a cross.

The characteristic features common to many Irish harp tuning pins make them easily identifiable, even when found separately from the instrument, as has been the case for a number of archeological finds.[256] One such find of particular note is a set of 24 tuning pins discovered in 1967 during excavations at Montgomery Castle in Powys, Wales.[257] This set of tuning pins, referred to henceforth as the 'Montgomery' tuning pins, was brought to the attention of the author in 2012 by Amanda Munday, owner of one of the pins. Munday's tuning pin is shown in figure 3.25, below.

[256] For a survey of archeological tuning pin finds, see Keith Sanger, "Harp Pegs Project (draft)," accessed 22 May, 2014, http://www.wirestrungharp.com/material/harp_pegs.html.
[257] Jeremy Knight, "Excavations at Montgomery Castle – Part II," *Archaeologia Cambrensis* 142 (1993): 202, 204. Graeme Lawson, "Excavations at Montgomery Castle – Part III. Appendix: Musical Instrument Remains from Montgomery Castle, Powys," *Archaeologia Cambrensis* 143 (1994): 197 – 98.

Figure 3.25: *one of a set of 24 matched tuning pins found at Montgomery Castle in Powys, Wales. Property of Amanda Munday; photographs used with permission.*

The remaining pins have been deposited at the Old Bell Museum in Montgomery, where they are on permanent display.[258] Several of these are shown in the photograph in figure 3.26.[259] They comprise a matched set of high quality craftsmanship, in apparently unused and nearly pristine condition. They are copper alloy with decorated drive heads of square cross-section, and appear to be cast, with the incised decorative work added by hand. The decorative motif on the sides of the drive heads consists of a deep v-shaped groove incised terminating at the beginning of the shaft where it is intersected by two sets of parallel lines incised at the midpoint and just above the transition to the shaft. The drive head has a quatrefoil cross-section,

[258] There are 21 tuning pins on display at the Old Bell museum. The author inquired as to the whereabouts of the remaining two tuning pins. A search made at the museum did not find them, so unfortunately two of the original set of 24 pins are currently missing.
[259] Permission to photograph the tuning pins in their display case was kindly granted to the author by John and Ann Welton, curators of the Old Bell Museum.

created by the grooves incised down each side. The end is decorated with a deeply incised cross-pattée with triangular arms.

Figure 3.26: *tuning pins found at Montgomery castle in Powys, Wales. The pins shown belong to a matched set of 24 in apparently unused condition. They are copper alloy with square drive heads decorated in a style characteristic of Irish harp tuning pins. Old Bell Museum, Montgomery. Photographs by the author; ©Powis Estate, from whom consent has been obtained for their use.*

During the excavations in 1967, the Montgomery tuning pins were found in the middle ward of the castle, above a cobble surface that was constructed between 1622 and 1625. They were therefore not deposited before 1622.[260] Montgomery castle was demolished in 1649, and because of the location of the find in the rubble in the inner ward, it was thought that they might have been deposited after the demolition of the castle.[261] Upon review of the archeological report, it has been suggested by Simon Chadwick that they could actually have been at the castle prior to the demolition, for example if they had been stored in one of the buildings in the inner ward and deposited in the rubble when these buildings were pulled down.[262] He has further suggested that, based on their apparent unused state, the resident of the castle during this time period might have commissioned a harp that was never completed. The set of pins would have consequently been left in storage, and possibly forgotten.[263] Since the site of Montgomery castle was not occupied after it was demolished, it is plausible that the pins pre-date the demolition.

Montgomery Castle's primary resident from 1622 to shortly before its demolition was Edward, Lord Herbert of Cherbury.[264] Edward Herbert was an Oxford educated philosopher, poet, statesman, and lutenist who is best known to scholars of early music for the "Cherbury" lute manuscript (a.k.a. the "Herbert" lute manuscript).[265] His association with the tuning pins is particularly plausible because in addition to his deep interest in music, Lord Herbert lived in Ireland from 1624 – 1628, where he was Lord Herbert of Castle Island. While in Ireland, it is likely he would have seen and heard professional Irish harpers playing for aristocratic patrons.[266] The case for his association with the tuning pins is further supported by a letter from him to

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[260] Jeremy Knight, "Excavations at Montgomery Castle – Part I," *Archaeologia Cambrensis* 141 (1992): 142.
[261] Knight "Excavations – Part II," 204.
[262] Simon Chadwick, personal communication, April, 2012. See Jeremy Knight, “Excavations – Part I”, 142 – 43, for a diagram and discussion of the post–medieval layout of the buildings in the inner ward.
[263] Chadwick, personal communication, April, 2012.
[264] Knight "Excavations – Part I," 118 – 20.
[265] ibid., 118. See also Thurston Dart, "Lord Herbert of Cherbury’s Lute-Book", *Music & Letters* 38 (1957): 136 – 48.
[266] Dart, "Cherbury’s Lute-Book," 138.

Francis Lloyd, the manager of his estates in Ireland, written after Lord Herbert had returned from Ireland to live in Montgomery castle. In it he states,

> "[Your] Irish harper shall be welcome if he can play by the book after the English manner and speak good English."[267]
>
> 26 November, 1638

It is evident from his comment to Lloyd that Lord Herbert was interested in having an Irish harper come to Montgomery castle. He could have also been intending to have an instrument made for the harper. It would not have been unusual at the time for a patron to supply the harper with an instrument.[268] If the harp tuning pins found at Montgomery castle were associated with Lord Herbert, given his dates in Ireland and in Montgomery, and the interest expressed in his letter, a likely time frame for their manufacture would be 1624 – 1638, or shortly thereafter.

The decorative motif on the ends of the drive heads can be compared to the cross inscribed diamond motif found on other Irish harp tuning pins, including some of the tuning pins on the Lamont harp, and it is possible that these are two different versions of the same general motif. The motif on the ends of the Montgomery tuning pins closely resembles that on the ends of the tuning pins of the Cloyne harp (see figure 3.24, above), which is particularly interesting given that these two sets of pins may be contemporary with each other. They may represent a popular style of decorative motif for Irish harp tuning pins in that time period, or they may have come from the same workshop.

In comparing the two sets of tuning pins, the Cloyne motif appears to be a worn-down version of the Montgomery motif. Prior to the Montgomery tuning pins coming to light, the decorative work on Irish harp tuning pins was only known from the current worn state of the surviving pins, and it was not known how they would

[267] W. J. Smith, ed., *Herbert Correspondence* (Cardiff: University of Wales Press, 1963), 99.
[268] For example, the Cloyne harp (1621) was commissioned by Sir John FitzGerald of Cloyne for his household musicians Giollapatrick and Dermot Mac Cridan. See O'Curry, *Manners*, 292.

have looked originally, or how much of the decorative work had worn away. The Montgomery tuning pins provide significant insight into this. If the motif on the end of the Cloyne tuning pins was originally like that on the Montgomery tuning pins, then the apparent amount of wear on them suggests that the Lamont harp tuning pins are likely to have as much if not more wear. This would be particularly true for the tuning pins in Group A, which could be over a century older than the Cloyne harp tuning pins. The diamond and the diamond inscribed with a cross are two common decorative motifs on the ends of Irish harp tuning pins. Some of the Lamont pins have the diamond motif, and others (those from Group C) have the diamond inscribed with a cross. Since we can assume that the ends of the tuning pins are worn, it is possible that the plain diamonds could have originally been inscribed with a cross that is now lost to wear, and that what appears to be two different motifs is actually one. At least one of the tuning pins from Group B (#24) has a diamond with a faintly inscribed cross that, with slightly more wear, would be entirely erased.

The decorative design on the Lamont harp tuning pins can be compared to the Cloyne and Montgomery tuning pins. If the diamond incised drive head of the Lamont harp tuning pins is turned 45°, the inscribed diamond takes on the appearance of the cross-pattée with triangular arms comparable to the more distinct cross-pattée on the Cloyne and Montgomery tuning pins. The deeply incised grooves down the sides also give it a quatrefoil cross-section, again comparable to those tuning pins. Notably, both of these motifs have been used as symbols of Christianity. The decorative motif on the drive heads has also been interpreted by Robert Evans as a 'clove' or 'rosebud' design.[269] A photograph of typical cloves is shown in figure 3.27. The shape of the clove, viewed end-on, can be compared to the decorative design on the ends of the tuning pins.

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[269] Simon Chadwick and Robert Evans, "Lamont Harp Replica by Robert Evans," The Wire Branch of the Clarsach Society, last modified 15 January, 2002, http://web.archive.org/web/20020328104736/http://clarsach.net/BobsLamont.htm.

Interestingly, because of their shape, cloves have been used to represent the nails of the crucifixion from at least as early as the medieval era.[270] A possible interpretation of the motif on these tuning pins is that it was intended to have Christian symbolism. Overt Christian symbols are present on some of the other surviving Irish harps, for example the crosses in the decorative work on the forepillar and soundbox of the Queen Mary harp (discussed in Chapter 4 of this dissertation), an IHS monogram on the end cap of the Ballinderry harp fragments, and a probable IHC monogram on the neck of the Trinity College harp.[271] A specific, common symbolic intent for the decorative motif on the tuning pins could explain the appearance of this motif on tuning pins from different makers.

Figure 3.27: *the decorative design of the Lamont harp tuning pins has been compared to a clove, as shown in this photograph.[272] Historically, the clove has been used in Christian symbolism to represent the nails of the crucifixion. The shape of the clove as viewed end-on can be compared to the decorative work on the ends of the tuning pins.*

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[270] Margaret Freeman, *The Unicorn Tapestries* (New York: Metropolitan Museum of Art, 1983), 148.
[271] For a discussion of the IHS on the Ballinderry harp fragments, see Armstrong *Irish and Highland Harps*, 63 – 64, and plate opp. 62; for a discussion of the IHC on the Trinity College harp, see O'Curry, *Manners,* 276 – 77.
[272] As interpreted by Robert Evans. Simon Chadwick and Robert Evans, "Lamont Harp Replica by Robert Evans."

Cheekbands

Moving from the discussion of the tuning pins to the cheekbands, there are some interesting issues with regard to their decorative work, position on the neck, and composition that have not been previously discussed.

The discussion of the decorative work on the cheekbands of the Lamont harp actually begins with an entirely different historical artefact, a 14th – 15th-century arm reliquary from Co. Down in Northern Ireland known as the "Shrine of St. Patrick's Hand".[273] Arm reliquaries were used in Western Europe from the 12th to the 17th centuries, and like other reliquaries of this type, the Shrine of St. Patrick's hand is a hollow vessel shaped to resemble a forearm and hand, held upright. Based on details of the decorative work, this reliquary has been identified as insular Irish.[274] The base is enclosed by a decorated oval plate, and it is this plate that is of interest to the current discussion. The centre of the plate is decorated with an IHS monogram, or Christogram, denoting the name of Jesus Christ.[275] The IHS is surmounted by a cross, and there are four cross-pattées arranged on the rim of the plate. Although the details of the decorative work on the reliquary date it to the 14th – 15th centuries, according to Bourke (1987) the use of Roman rather than Lombardic or Gothic lettering dates the plate on the base to no earlier than the 16th century.[276] A photograph of the plate on the base of the reliquary is reproduced in figure 3.28.

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[273] Cormac Bourke, "The Shrine of St. Patrick's Hand," *Irish Arts Review* 4 (Autumn, 1987): 25. The Shrine of St. Patrick's Hand is on long term loan to the Ulster Museum from the Diocese of Down and Connor in Northern Ireland, and is on display at the Ulster Museum in Belfast, NI.
[274] Bourke, 26 – 27.
[275] Bourke, "St. Patrick's Hand," 27. According to Bourke, the plate may be a repurposed paten. Private communication, April 2012. The IHS denotes the first three letters of the Greek spelling of the name of Jesus. The letters I and H are the upper-case letters *iota*, and *eta*, with the S representing the final form of the Greek letter *sigma*.
[276] Bourke, "St. Patrick's Hand," 27.

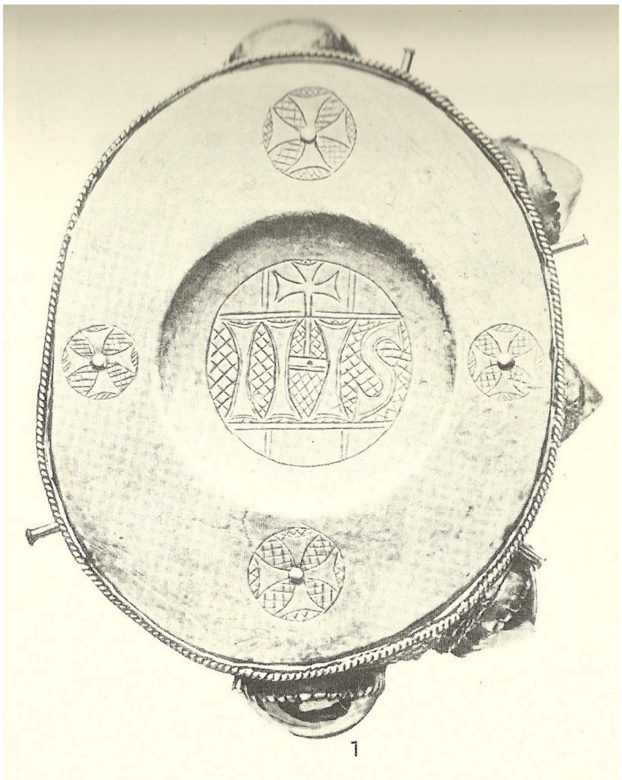

Figure 3.28: *decorated plate on the base of the reliquary shrine of St. Patrick's hand. The plate is inscribed with an IHS monogram surmounted by a cross, surrounded by four cross pattées.*[277]

In his description of the Lamont harp cheekbands, Armstrong (1904) notes, "Upon the right side at the treble end what appears to be S I I I is engraved."[278] This inscription is shown in the photograph in figure 3.29. At the time of Armstrong's publication, the meaning of the inscription was obscure, and has remained so since then.[279]

[277] Reproduced from Adolf Mahr, *Christian Art in Ancient Ireland* (Dublin: Stationary Office, 1941; reissued New York: Hacker Art Books, 1976), Plate 127.
[278] Armstrong, *Irish and Highland Harps*, 162.
[279] ibid., note 1.

Figure 3.29: *inscription on the right hand cheekband of the Lamont harp. Its location is indicated by the red rectangle in the photograph on the right. This is the inscription referred to by Armstrong as "S I I I".*

Figure 3.30 juxtaposes the Lamont harp cheekband inscription with the St. Patrick's Hand reliquary inscription, but with the cheekband rotated so that it is upside-down (which is as it would appear viewed from above the neck of the harp).

Figure 3.30: *(left) the Lamont harp cheekband inscription, as viewed from above the neck, looking down; (right) the IHS inscription on the base of the St. Patrick's Hand reliquary.*[280] *Note the similarity of the two inscriptions.*

[280] Detail of photograph of St. Patrick's hand reliquary reproduced from Mahr, *Christian Art in Ancient Ireland*, Plate 127.

The resemblance of the two inscriptions is remarkable. Given the similarity, it is likely that the Lamont harp inscription is actually an IHS monogram, and may have been modeled after the inscription on this reliquary.[281]

In the 16th and 17th centuries, the IHS monogram was used as a symbol of the counter-Reformation, and was particularly associated with the Jesuits, who were active in Scotland in this time period.[282] The IHS monogram and other Christian symbols were used by some Catholics in Scotland in the post-Reformation period as an identifier and symbol of their faith, as documented by surviving examples found in houses in north-Eastern Scotland.[283] If the cheekband inscription on the Lamont harp is an IHS, then it is obscure, however. There is no crossbar on the H and the inscription is upside-down. It is possible that this was done as an attempt to conceal its meaning from iconoclasts. An early 17th-century example of an obscure IHS has been observed by Donnelly (2005) in Gortnetubbrid castle in Co. Limerick, Ireland.[284] According to Donnelly, "the monogram may have been deliberately carved in a cryptic style to prevent its detection by non-Catholic eyes."[285] The period from the late 16th century to the 18th century was a tumultuous and uncertain time with regard to religion in Scotland, so it seems reasonable that a recognizable symbol of the counter-Reformation would be intentionally rendered in an obscure fashion, in this instance hidden very effectively in plain sight.

The presence of this inscription on the cheekband raises some interesting questions. If it is an intentionally obscure IHS monogram, then it post-dates the Reformation in

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[281] The Lamont would not be the only Irish harp with a Christogram. As already noted, the end cap of the Ballinderry harp is engraved with an IHS, and the Trinity College harp neck is engraved with a probable IHC.

[282] Colm Donnelly, "The I.H.S. Monogram as a Symbol of Catholic Resistance in Seventeenth-Century Ireland," *International Journal of Historical Archeology* 9 (2005): 39. See also Ian Bryce and Alasdair Roberts, "Post-Reformation Catholic Houses of North-East Scotland," *Proceedings of the Society of Antiquaries of Scotland* 123 (1993): 369; and Thomas McCoog, *The Society of Jesus in Ireland, Scotland, and England 1541 – 1588* (New York: Brill, 1996), 178 ff.

[283] Bryce and Roberts (1993), 363 – 72. See also Ian Bryce and Alasdair Roberts, "Post-Reformation Catholic Symbolism: further and different examples," *Proceedings of the Society of Antiquaries of Scotland* 126 (1996): 899 – 909.

[284] Donnelly "I.H.S. Monogram," 40.

[285] ibid.

Scotland. Comparison of the placement and workmanship of the inscription to the decorative border that runs the length of the rest of the cheekband indicates that it is probably not a later addition. This suggests that the cheekband may date to no earlier than the late 16th century. If the cheekband is original, then this would also place a lower limit on the date of the neck, and possibly the rest of this harp. The cheekband may be a replacement, however. Note the placement of it with respect to the crack in the neck, as shown in the left-hand photograph in figure 3.29. A crack of that size opening up in the wood underneath the cheekband would cause it to pull away from the wood where it is nailed in at the end. If the cheekband is original to the neck, then it would have been repositioned when the crack opened up, otherwise it would be out of alignment with the tuning pin holes in the wood. Repositioning of the cheekband should be evident by the presence of a nail hole in the wood beyond the current location of its end. As discussed in the Chapter 2 of this dissertation, the left-hand cheekband does appear to have been repositioned, based on the evidence of nail fragments embedded in the wood. A similar examination of the right-hand cheekband has so far found no evidence of a nail hole, nail fragments, or residual corrosion in the expected location. This is illustrated in figure 3.31.

Figure 3.31: *close-up of the right-hand cheekband on the Lamont harp at the treble end. The arrow indicates where the nail would have been positioned before the crack opened up in the neck. There is no nail hole in this location. Note, however, that there is a linear impression visible in the wood just above the present location of the cheekband indicating the original position of its upper edge.*

If this cheekband was nailed to the neck in the same manner as it is currently, there should be a nail hole in the wood at the location indicated by the arrow in the photograph in figure 3.31. There is nothing in this location, however, and there is also no evidence on the tomograms that there ever was a nail in this location. Just above the upper edge of the cheekband, however, there is a linear impression in the wood that is in the correct position for it before the neck cracked. So, either this cheekband was repositioned without leaving evidence of having been nailed into the wood at the original location, or the impression in the wood is from a different cheekband, with nail holes hidden underneath the present cheekband. Examination of the tomograms shows a possible trace of corrosion from a nail, deeply embedded in the wood near the present location of the end of the cheekband. This is not associated with the nail currently in the end of the cheekband. This could be evidence of an earlier cheekband, but as it is a small trace it is uncertain.

The possibility of the cheekband not being original raises the question as to why it would be replaced, however. If the original cheekband had been damaged, for example when the neck cracked, it might be easier to repair than to replace. It is possible, however, that the original cheekband was deemed inadequate to reinforce the neck against the pull of the strings (hence the crack in the neck). The current cheekbands are a fairly substantial 3.8 mm thick (compared to 0.75 mm for the Queen Mary harp cheekbands).

The composition of the cheekband is also of interest in this discussion. From semi-quantitative analysis with XRF, it was found to be bronze, with low levels of trace elements. The results of the analysis are shown below.

Table 3.3.

Composition of Lamont harp cheekband[286]

	Fe	**Ni**	**Cu**	**Zn**	**As**	**Pb**	**Ag**	**Sn**	**Sb**
Lamont harp right-hand cheekband	0.3	0.5	88.3	0.2	0.1	0.0	0.0	10.5	0.0

Note: surface composition from semi–quantitative XRF analysis. Values are wt% for each element. The maximum measurement uncertainty is +/– 0.2 %.

In contrast to the analysed tuning pins, which are brass, this cheekband is a bronze of 10% tin with very low levels of zinc and other trace elements. It contains trace nickel, and no measurable silver. While not definitive, the trace elements might favour a later (post late 15th-century) date of manufacture, which would be consistent with a post-Reformation, or late 16th-century, date. The left-hand cheekband, which is the

[286] Tate and Kirk, "XRF analysis of the Queen Mary and Lamont harps."

same as the right-hand cheekband in terms of its construction, but has somewhat different decorative work, has not yet been analysed. Based on the workmanship, it is probable that both cheekbands were made at the same time, however a comparison of the alloy composition would verify if this is the case.

The remainder of the decoration on the right-hand cheekband consists of an incised border with a fret, or 'key', motif, as shown in figure 3.32, below. Small, incised marks add to the contour of the design, although this extra detail is missing on most of the upper border.

Figure 3.32: *decorative border on the right-hand cheekband of the Lamont harp. The border is incised in a fret, or 'key', motif. Note the small detailing added to give the pattern some contour. The section of the cheekband shown is the treble end, at the first and second tuning pin holes.*

By comparison, the decorative work on the left-hand cheekband is slightly less refined, as shown in figure 3.33. In place of the fret-patterned border, this cheekband has a plain border and a repeating motif that can be seen either as mirroring the "I" in the inscription on the right-hand cheekband, or as resembling "eyes", with the tuning pin ends as the pupils. Whether this is intended to be an oculus pattern is unknown.

The pattern also mirrors (or is mirrored by) the shape of the boss on the end cap. In place of the inscription at the treble end of the right-hand cheekband, the pattern on the left-hand cheekband continues past the first tuning pin hole, as shown in figure 3.34, finishing somewhat raggedly at the end.

It is possible that less attention was paid to the execution of the decorative work on the left-hand cheekband due to this being the side of the harp more likely to face away from the audience when it is being played. As discussed later in this chapter, the wear on the sides of the soundbox and on the foot of the harp indicate that the Lamont harp was held with the instrument leaning towards the left side of the player's body, with the left hand playing the treble strings, and the right hand the bass. Held in this manner, both the harp and the player present well if the player is turned slightly from forward with the right side of the body towards the audience (or towards the most important members of the audience). The right-hand side of the harp also shows off the decorative ends of the tuning pins, as opposed to the left side, which shows the winding ends. As discussed in Chapter 4, the Queen Mary harp (which was held and played in the same orientation) has marks from badges that formerly decorated the neck, and these are exclusively found on the right-hand side, consistent with this side being more visible to the audience.

Figure 3.33: *decorative work on the left-hand cheekband of the Lamont harp. The motif mirrors the "I" in the inscription on the right-hand cheekband, repeating in between each tuning pin. The section of the cheekband shown is at tuning pins #24 to #27.*

Figure 3.34: *the left-hand cheekband of the Lamont harp, at the treble end. The decorative motif continues somewhat raggedly past the first tuning pin, to the end.*

As discussed in Chapter 2 of this dissertation, examination of the tomograms indicates that the neck and cheekbands were not shortened. While it was not possible to remove the end cap for visual inspection, a small portion of the left-hand cheekband is visible under the end cap, at the hole for the 31st tuning pin, as shown in the photograph in figure 3.35. This hole is located near the end of the cheekband. There is an incised line on the cheekband next to the tuning pin hole. It is difficult to tell, because it is a short section, but the line that is visible appears to be straight, unlike the other incised decorative lines, which curve around the holes for the tuning pins. This straight line may delineate the end of the cheekband.

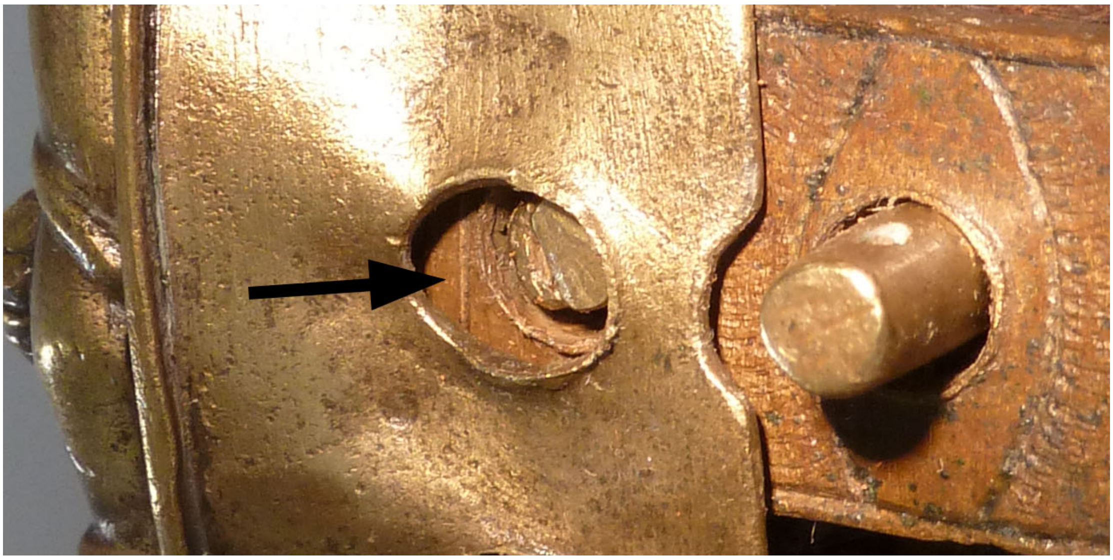


Figure 3.35: *a close-up view of a small area of the left-hand cheekband of the Lamont harp, visible under the end cap. Note that the incised line (arrowed) appears to be straight, in contrast to the lines in the repeating decorative pattern. This line may be additional evidence that the cheekband was not shortened.*

Dimensions:

The cheekband dimensions are given in table 3.4, below. They are the same for both, with the exception of the tuning pin holes, which are slightly larger on the right-hand cheekband, to accommodate the taper of the tuning pins. The shape of both cheekbands is nearly identical. Tomograms of each cheekband are shown in figures 3.36 and 3.37. Ideally, all of the tuning pins would have been removed prior to CT scanning in order to reduce metal interference and to allow the tuning pin holes to be imaged. Several of the tuning pins are firmly wedged in place in the neck, however, so it was not possible to remove all of them. Note that thick metal objects can result in saturation. **In areas where the voxels are saturated, the image of the edge of the cheekband extends up to 1 mm beyond the true edge**. This effect needs to be taken into consideration if using these figures for replicating the cheekbands or taking measurements.

Table 3.4.
Lamont harp cheekband dimensions

dimension	**measurement (mm)**
length	380
width	14 (flares to 17 at treble end)
thickness	4
tuning pin hole diameter	7 (right); 6 (left)

Note: the cheekband length is the straight-line distance from the midpoint of each end, including the part hidden under the end cap. The measurement uncertainty is +/- 1mm for the cheekband length, +/- 0.5mm for all other dimensions.

Figure 3.36 (overleaf): *tomographic image of the right-hand cheekband of the Lamont harp. The treble end of the cheekband is at lower left.* ***Note: in areas where the voxels are saturated, the image of the edge of the cheekband extends up to 1 mm beyond the true edge.*** *Scale 1 tick : 1 cm; grid scale 1 square : 1 cm.*

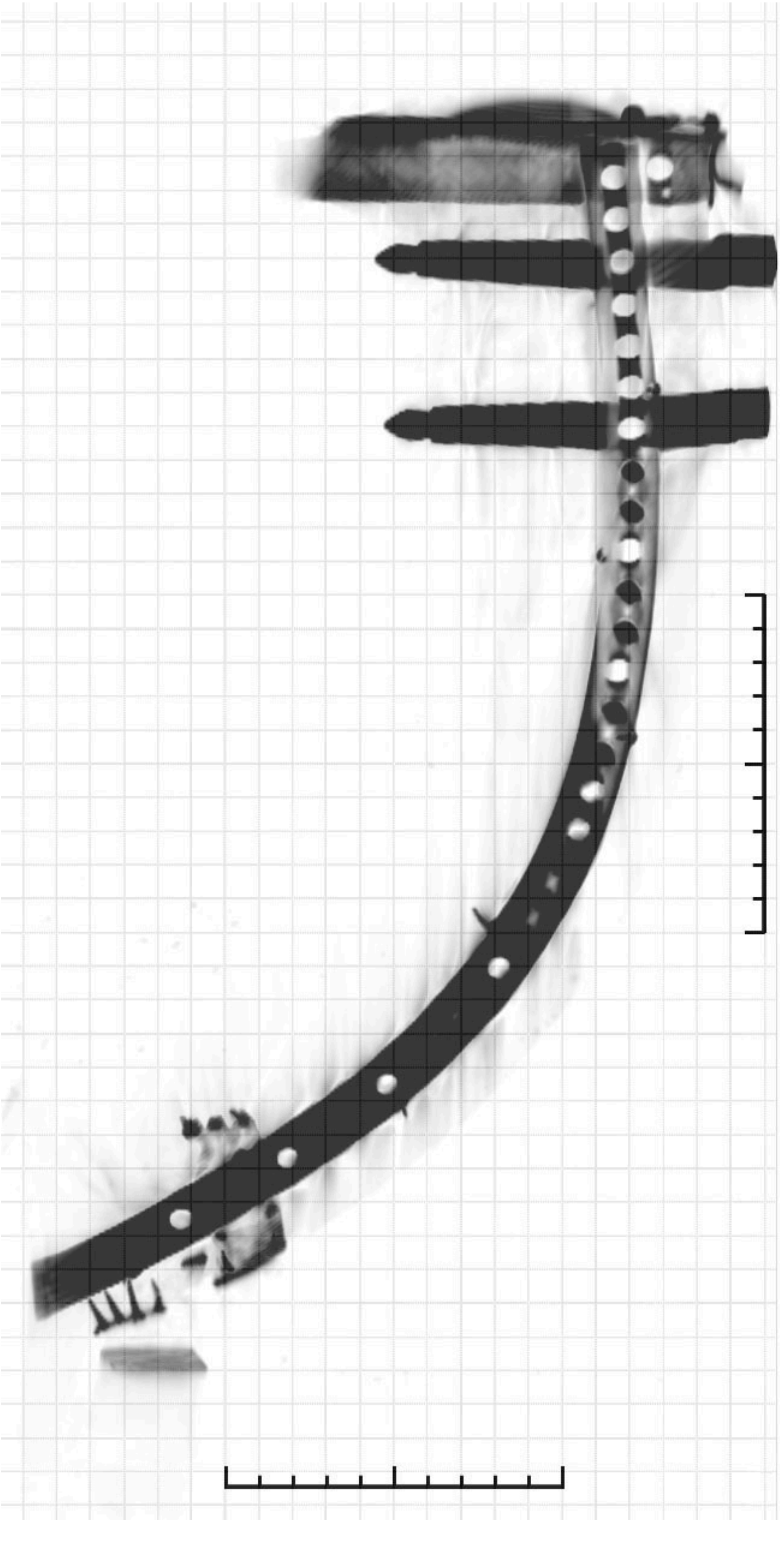
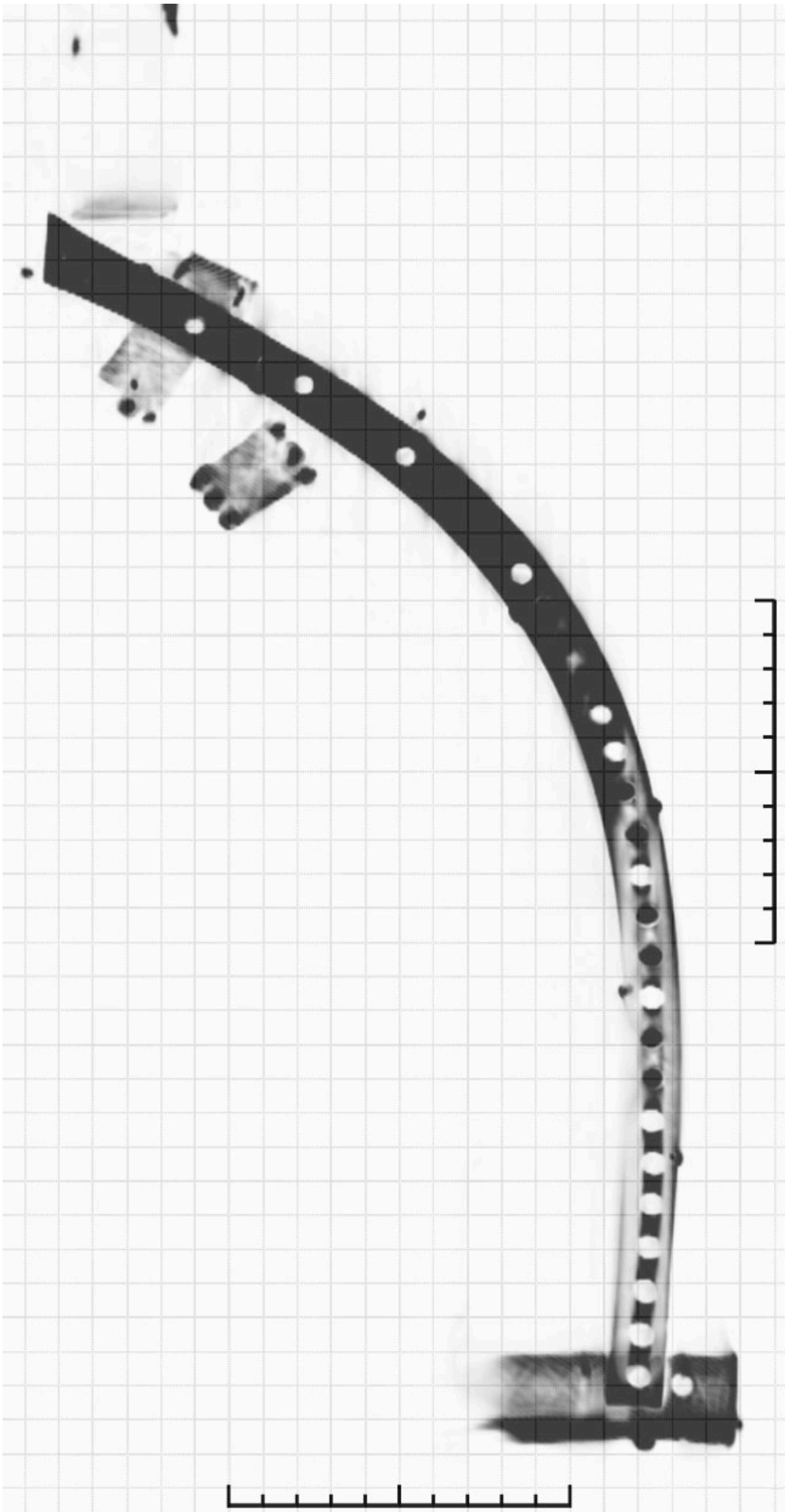


Figure 3.37 (overleaf): *tomographic image of the left-hand cheekband of the Lamont harp. The treble end of the cheekband is at upper left.* ***Note: in areas where the voxels are saturated, the image of the edge of the cheekband extends up to 1 mm beyond the true edge.*** *Scale 1 tick : 1 cm; grid scale 1 square : 1 cm.*



This examination of the cheekbands of the Lamont harp has provided some interesting insights, the foremost being the possibility that the inscription is a post-Reformation IHS monogram. It has also raised some questions that have yet to be answered. Were both cheekbands made at the same time? The nearly identical dimensions suggest that they were, but the composition of the alloy comprising the left-hand cheekband needs to be analysed to confirm this. Are these the original cheekbands for this neck? If they are, then are any of the tuning pins original? The alloy used for the right-hand cheekband is very different from any of the tuning pins that were analysed, although this does not necessarily rule out their being made at the same time. Why does the cheekband inscription so closely resemble the inscription on the base of a reliquary historically associated with Co. Down in present day Northern Ireland? Does the presence of this inscription mean the cheekbands post-date the Reformation?

End cap

In Chapter 2 of this dissertation, the end cap was discussed in terms of the part of the neck and cheekbands that is hidden underneath it, and the implications for ascertaining the original number of tuning pins in the neck. This discussion examines the end cap itself in terms of its construction and decorative work.[287] The Lamont harp is not unique in having a metal cap on the end of the neck. Amongst other surviving Irish harps, the Trinity College and Castle Otway also have end caps, and the Ballinderry harp fragments include a metal end cap.[288]

Figure 3.38 shows the Lamont harp end cap as it currently appears, viewed from the right-hand side, and from the front.

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[287] The end cap of the Lamont harp is discussed in Armstrong (1904). See Armstrong, *Irish and Highland Harps*, 163, Plate II, opp. 160, and Plate III, 5 opp. 162.

[288] For a photograph of the Trinity College harp end cap, see Dooley, "Medieval Irish Harp," 48; for an illustration and discussion, see Armstrong, *Irish and Highland Harps*, 58. For the Castle Otway and Ballinderry harp end caps, see Armstrong, *Irish and Highland Harps*, 63 – 64, and plates opp. 62; and 74, respectively.

Figure 3.38: *the metal end cap on the neck of the Lamont harp, side and front view. Photographs: Maripat Goodwin*

The Lamont harp end cap is constructed from three pieces: a faceplate, a sleeve, and a raised border around the edge of the faceplate.[289] It is attached to the neck from the side, with nails driven through the sleeve. There are currently two nails on the right-hand side, and three on the left, with a hole for a third nail on the right-hand side next to the #32 tuning pin hole. On the front of the end cap, there are three studs with decorated caps. These attach the raised border to the faceplate. They do not extend into the neck. Figures 3.39 – 3.41 show the end cap in more detail. In these photographs the separate pieces that comprise it can be more easily discerned.

[289] The author would like to acknowledge Daniel Tokar for initially discussing the pieced construction of the end cap. Daniel Tokar, e-mail message to author, 14 January, 2008.

Figure 3.39: *left-hand side view of the Lamont harp end cap. The cap is constructed from three pieces, sleeve, faceplate, and separate raised border. It is held onto the neck by nails driven through the sleeve, which is decorated with a geometrical interlace pattern. Photograph: Maripat Goodwin.*

Figure 3.40: *bottom end of the Lamont harp end cap. The interlace pattern on the sides of the sleeve is continued on the bottom end. It has been cut and bent upwards to accommodate the forepillar.*[290]

[290] See also Armstrong, *Irish and Highland Harps*, 163.

Figure 3.41: *front view of the Lamont harp end cap. The three decorated studs attach the raised border to the faceplate, which is decorated with a foliaceous pattern and a large gemstone-like repoussé.*

Figure 3.41 shows the end cap as viewed from the front. Note that the boss is tilted with respect to the vertical axis of the faceplate. This could be unintentional, however the direction of the tilt happens to be opposite the direction of the leftward lean of the neck and forepillar. This does have the effect of creating an illusion that they are more upright when the harp is viewed face on, as in the right-hand photograph in figure 3.38. The illusion would be more effective if the tilt of the neck and forepillar were less extreme. If this was done intentionally by the maker of the Lamont harp end cap, then it is a clever feature, and it would suggest that the end cap was added to the harp after the neck began to tilt over towards the left-hand side.

In his discussion of the Lamont harp end cap, Armstrong (1904) mentions that the raised border is bent upwards across the faceplate along the lower edge of the end cap, so that it is covering part of the incised decorative work on the faceplate. This is evident in his published photograph of it.[291] The raised border also appears to be slightly bent along the left side of the end cap in that photograph. In comparing Armstrong's photograph to the recent photograph in figure 3.41, it is evident that the raised border has been straightened since Armstrong's photograph was taken. A visible dark curved line across the lower end of the faceplate indicates where it was previously. This may have occurred when the harp underwent aggressive conservation work in the early 1980's. An undated archival photograph shows the end cap in the process of being cleaned, as reproduced in figure 3.42, below.

[291] Armstrong, *Irish and Highland Harps*, Plate II, opp. 160.

***Figure 3.42:** undated archival photograph of the Lamont harp end cap (and cheekband) undergoing conservation. Note that the lower part of the raised border on the end cap is bent in this photograph. It has since been straightened. Photograph: National Museums Scotland archive H.LT2.*

This archival photograph probably relates to this relatively recent conservation work. In it, the raised border is still bent. Armstrong had observed that the metal parts of the harp were covered in brown paint.[292] He does note that most of this had apparently been removed from the end cap and neck straps, but that the string shoes, tuning pins and cheekbands were covered in a heavy layer of paint.[293] The conservation work shown in this photograph was likely undertaken to remove that paint. Other archival photographs apparently taken at the same time show the string shoes undergoing the same treatment.

With regard to the decorative work, the end cap is by far the most highly ornamented part of the Lamont harp. The faceplate is decorated with an incised foliaceous design surrounding a prominent repoussé boss that may have been

[292] Armstrong, *Irish and Highland Harps*, 167.
[293] ibid.

intended to resemble a large gemstone. The outline of the boss could also be interpreted as having the shape of a *mandorla*. This shape is mirrored in the motif on the left-hand cheekband.

The sleeve is decorated in an incised angular interlace pattern, although it is left undecorated where it crosses over the cheekband. The small section just below the cheekbands on each side is simply decorated with a rectangle inscribed with an X. The raised border takes the form of a rope moulding along its upper portion, and a fluted moulding along the portion of it below the cheekbands. The decorative pattern on the sleeve happens to be the same as that on the lower portion of the inside curve of the Queen Mary harp. These are shown together in figure 3.43.

Figure 3.43: *angular interlace pattern on the inner curve of the Queen Mary harp forepillar (left), and the end cap of the Lamont harp (right). Note that the pattern is the same on both harps (although mirror reversed). The two photographs are not shown at the same scale. The pattern is 1.5x larger on the Queen Mary harp versus the Lamont harp. Photograph (right): Maripat Goodwin.*

As evident in figure 3.43, the interlace pattern is the same on both harps, except that it is mirror reversed. Because these two harps belonged to the same family, the presence of the same distinctive motif on both instruments is interesting. This could simply be a commonly used motif, and therefore it is only coincidental that it appears on both harps, but if the motif was copied from one harp to the other, for example from the Queen Mary to the Lamont harp, it could place a lower limit on the date of the end cap. According to the provenance of these harps as recounted by Gunn (1807), the two harps were not together before the late 16th century.[294] The end cap would, therefore, not date to earlier than that. This does not necessarily constrain the date of the neck, because it is possible that the end cap is not original to its construction.

The end cap was analysed with XRF, and found to be a brass alloy of similar composition to the analysed tuning pins from Group A. The results of the analysis are shown in table 3.5, below, with the results for the tuning pins from Group A included for comparison.

Table 3.5.

Comparison of composition of Lamont harp end cap and tuning pins from Group A

Location	Fe	Ni	Cu	Zn	As	Pb	Ag	Sn	Sb
end cap faceplate	0.6	0.3	79.6	14.8	0.5	1.2	0.1	3.0	0.0
end cap boss	0.5	0.3	79.8	14.9	0.4	1.0	0.1	2.9	0.0
end cap boss crease	0.5	0.2	80.1	14.3	1.1	0.8	0.1	2.8	0.0
tuning pin #2	0.4	0.3	84.2	10.3	0.8	1.0	0.1	2.9	0.0
tuning pin #11	0.4	0.3	81.7	13.6	0.4	0.7	0.1	2.8	0.0

Note: surface composition from semi–quantitative XRF analysis. Values are wt% for each element. The maximum measurement uncertainty is +/– 0.2%.

[294] Gunn, *Historical Inquiry*, 1, 13.

The difference in measured composition between the end cap and tuning pin #11 is smaller than the difference between the two tuning pins. This close similarity in the composition suggests the possibility that they could have been made together. If the end cap were to date to the late 16th century, then so would the tuning pins belonging to this group, regardless of the earlier date suggested by their composition. This would imply that either the neck was constructed at this time with the end cap and these tuning pins, or the end cap and tuning pins in Group A were later additions. This is speculative, however, as there isn't enough information to draw any conclusions. The pair of straps across the neck/forepillar joint could provide a clue. They are very likely not original to the construction of the neck. If their composition matches the end cap and the Group A tuning pins, they could have all been made at the same time, which would imply that the end cap and Group A tuning pins are later additions. Due to the geometry of the harp frame, it was not possible to obtain XRF analysis of these straps for this study, however. This analysis may be obtainable with hand-held XRF, as part of further research. These straps are discussed in terms of their decorative work in the following section.

Neck – forepillar straps

The pair of reinforcing straps fastened across the neck/forepillar joint are shown in figure 3.44, below.[295] In the section of Chapter 2 on the stringing of the Lamont harp, it was established that these straps were added to the harp after the string tension had shifted the forepillar in the neck joint. Additionally, it was established in the discussion of the forepillar that the straps were added after the tenon on its upper section was recut and reseated in the neck joint.[296] It is therefore evident that these straps are not original to either the neck or the forepillar. Evidence for similar straps on other Irish harps was discussed in the context of the possibility that they may represent a reinforcement added to these instruments in response to increased string tension.

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[295] These straps are also discussed in Armstrong, *Irish and Highland Harps*, 163 – 64.
[296] This is also discussed in Loomis et al., "Lamont and Queen Mary Harps," 120.

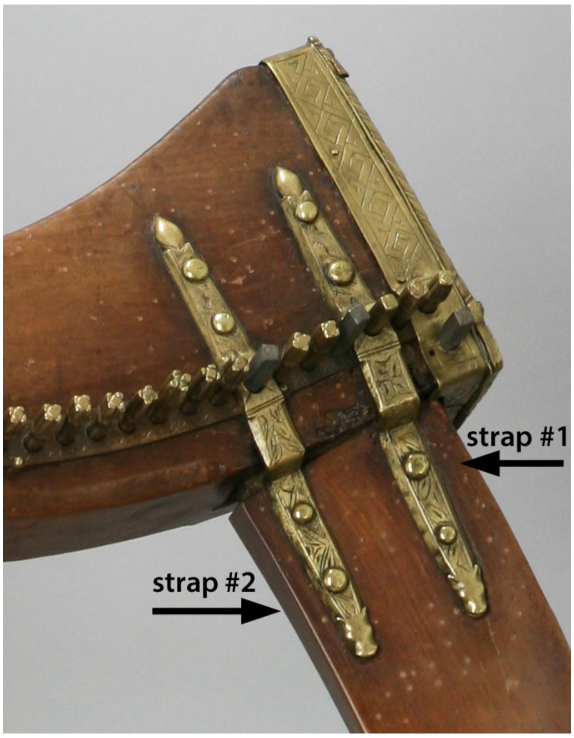

Figure 3.44: *the reinforcing straps across the neck/forepillar joint of the Lamont harp (arrowed). These straps were added after the string tension had caused the forepillar to shift in the joint. They are cast, and decorated with incised lines. Photograph: Maripat Goodwin.*

The straps are cast, and both terminate in an animal head at the lower end. Armstrong (1904) describes the shape of the heads as "dragonesque."[297] Guy Flockhart has suggested, alternatively, that the straps were made to resemble foxes, with the shape of the upper termination representing the bushy tail.[298] Both straps are decorated with incised lines in the same motif, although the execution is not identical. Figures 3.45 and 3.46 show the decorative work in detail for each. The upper section is incised with a two strand twist interlace pattern, and the lower section with a foliaceous design. Although the pattern is broadly the same on both (they are mirror reversed to one another), it is rendered in more detail on the strap further from the end of the neck (strap #2 in figure 3.44). The foliaceous design on the small section below the cheekband is also different on each strap. Figure 3.47 shows the animal heads on the end of each strap in detail.

[297] Armstrong, *Irish and Highland Harps*, 164.
[298] As related to the author by Robert Evans, personal communication, December, 2010.

Figure 3.45: *decorative details on Lamont harp strap #1 (see figure 3.44). The end of the neck is towards the top of this figure. The upper section (top) is incised with a two strand interlace, and the lower section (bottom) is incised with a foliaceous pattern.*

Figure 3.46: *decorative details on Lamont harp strap #2 (see figure 3.44). The end of the neck is towards the top of this figure. The upper section (top) is incised with a two strand interlace, and the lower section (bottom) is incised with a foliaceous pattern. Note that the decorative pattern is slightly different to that on strap #1.*

Figure 3.47: *photographs of the animal head on the end of each strap, enlarged to show detail: strap #2 (left), strap #1 (right).*

Each strap is secured to the neck by three rivets (one through the neck, and two through the forepillar), and a long nail in the neck. The ends of the rivets can be seen in the photograph shown in figure 3.48. All except one of these are secured with crude washers (one of which appears to be copper).[299] One rivet is secured with a decorative stud instead of a washer. It is possible that this is original, and that the washers are replacements. This stud has ridged edges similar to the studs on the faceplate of the end cap, so they could have been made together.

[299] One rivet has had its end broken off and has lost its washer. The hole has subsequently been filled with putty, but the depression left by the washer is still visible.

Figure 3.48: *view of the left-hand side of the neck and upper forepillar, showing the ends of the rivets that secure the straps reinforcing the neck/forepillar joint.*

Figure 3.49 shows a set of snapshots from a video of a tomographic rendering of the CT scan of the end of the neck. These snapshots show the locations of the rivets and nails in the wood. The rivets are visible extending through the neck and forepillar, and the two long nails can be seen to extend into the wood to the centre of the neck. Note that the end of the top rivet for strap #1 appears to be split. This is the rivet that has a stud instead of a washer. This rendering also reveals a nail hidden underneath the animal head on strap #1.

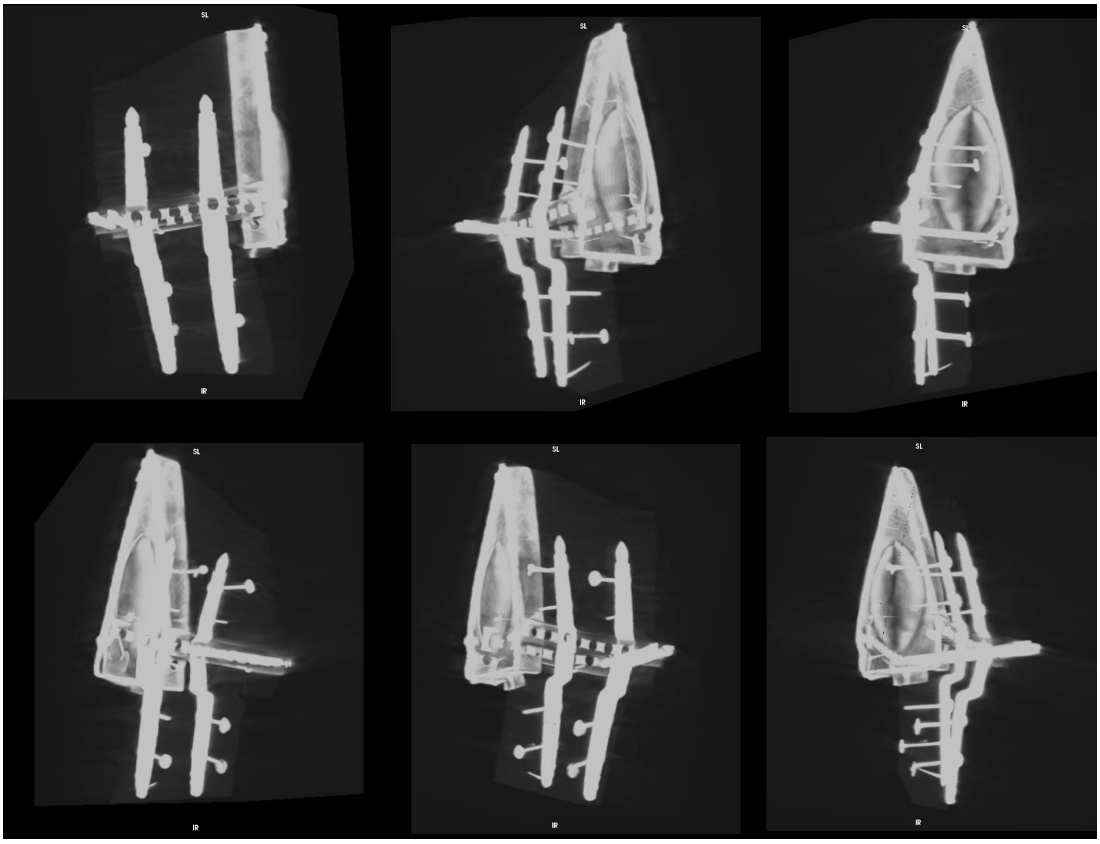

Figure 3.49: *snapshots from a video clip of a tomogram of the end of the Lamont harp neck, showing the rivets and nails fastening the straps to the neck and forepillar. Note that the top rivet for strap #1 (the strap closest to the end cap) is split at the end. Note also the small nail extending into the forepillar from underneath the animal head at the lower end of strap #1. The nails fastening the end cap to the neck are also visible. All except two of the tuning pins were removed from this portion of the cheekband for the CT scanning.*

Metal repair patches

This section discusses two metal repair patches on the crack in the neck of the Lamont harp. These have been previously discussed by Armstrong, and by this author, along with the other repair work to this crack.[300] Here they are examined in terms of decorative work and alloy composition. Figure 3.50 shows their locations on the neck of the harp.

[300] Armstrong, *Irish and Highland Harps*, 164, and Plate III, opp. 162; Loomis, "Structural Breaks and Repairs," 30 – 34; and Loomis et al., "Lamont and Queen Mary Harps," 121.

Figure 3.50: *metal repair patches on the Lamont harp (arrowed), viewed from both sides of the neck. The patch on the right-hand side of the neck (top) is a long thin strip that runs under the neck to the other side, and is the same patch that is visible on the right in the lower photograph. Photographs: Maripat Goodwin.*

Each patch is a thin sheet of copper alloy tacked to the wood with several small nails. One is a small rectangular piece nailed over the crack on the left-hand side of the neck. The other consists of a long strip that runs under the neck from one side of the harp to the other, passing underneath both cheekbands. On the right-hand side of the harp this strip is pierced for tuning pin holes #2 and #3, and on the left-hand side it is pierced for tuning pin hole #1. This would seem to cast some doubt on the suggestion, put forth in Chapter 2 of this dissertation, that the #1, and eventually the #2, tuning pin holes were not used after the neck cracked. A possible explanation for the holes in the patches can be seen in early photographs of the harp, which show a square headed plug occupying the #1 tuning pin hole. It is possible that the #2 tuning pin hole may have had a similar plug inserted into it as well. The plug in hole #1 is shown in the 1807 engraving of the harp published in Gunn's treatise, so it dates to at least the early 19th century.[301] This plug is no longer on the harp. In the archival conservation photographs (mentioned earlier with regard to the end cap) it is present early on in the conservation work, but is later absent. In a photograph of the left-hand side of the neck taken at this time, it is apparent that the 'plug' is actually a square headed bolt with a square nut. Figure 3.51 shows an early 20th-century photographic plate, and one of the circa 1980's conservation photographs. The plug is present in the earlier photograph, and absent in the later photograph.

Figure 3.51: *detail of an early 20th-century archival photograph of the Lamont harp (left), and the same area from an undated (possibly early 1980's) archival conservation photograph (right). Note that the square headed plug in tuning pin hole #1, present in the earlier photograph, is absent in the later photograph (white arrows). Note also that there is a metal strap across the neck/soundbox joint that is present in the earlier photograph, but absent in the later photograph (black arrow).[302] Photographs: National Museums Scotland archive H.LT2.*

It is unfortunate that this small fixture on the harp was removed during conservation, but the early archival photographs may at least reveal why the repair strip is pierced at the tuning pin holes. More significantly, however, it is also apparent from these

[301] Gunn, *Historical Inquiry*, Plate I, opp. 4. For a published early photograph, see Armstrong, *Irish and Highland Harps*, Plate I, opp. 158. Armstrong also shows this on his engraving of the harp in Plate IV, opp. 166.
[302] The author gratefully acknowledges Michael Billinge for pointing out the presence of the strap across the neck/soundbox joint in the earlier photograph.

photographs that a large metal strap extending across the neck/soundbox joint, similar to the strap on the Queen Mary harp, was removed as well.[303] This strap (which incorporates the short strap that wraps half-way around the soundbox, also missing in the later photograph) may have been an historical repair, so it is unfortunate that it was removed during relatively recent conservation work.

With regard to the metal patches, both are decorated with lines pressed into the thin sheet metal, and are cut with scalloped ends, as shown in the photographs in figure 3.52.

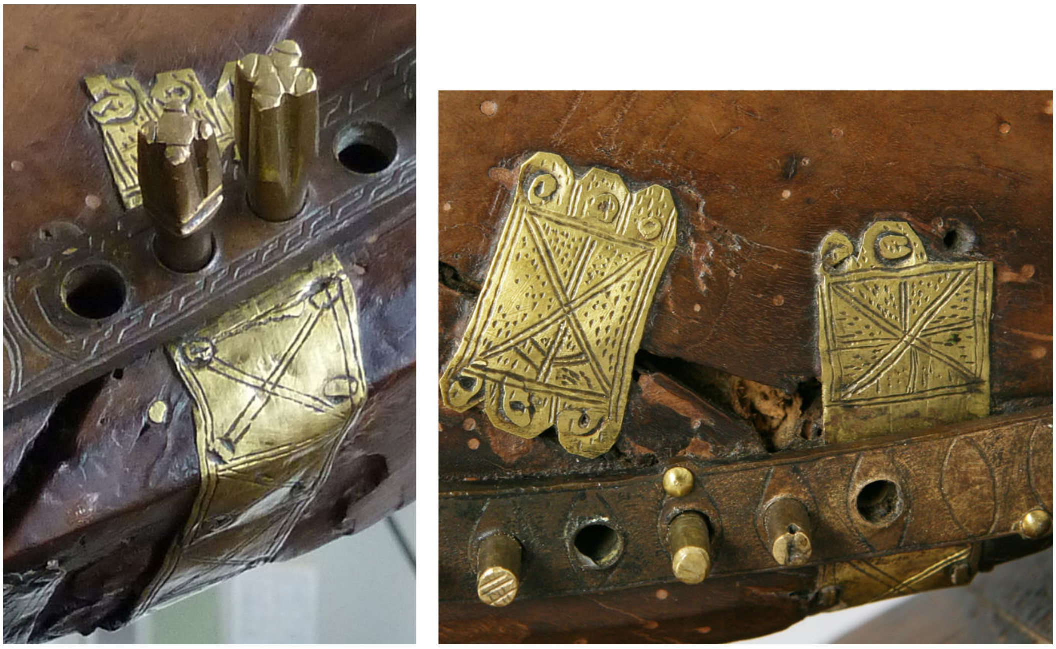

Figure 3.52: *decorative work on the Lamont neck repair patches. The right-hand side of the neck is shown on the left, and the left-hand side of the neck is shown on the right. Photograph (right): Maripat Goodwin.*

The scalloped ends and decorative designs give these patches the appearance of banners or flags. Whether this was the intention is unknown. If they were intended to be flags, the possible interpretation is interesting, however. The long repair patch, shown in the left-hand photograph in figure 3.52, is decorated with five rectangles.

[303] ibid. This strap is also mentioned by Armstrong, *Irish and Highland Harps*, 166.

Four contain a cross that could be interpreted as a saltire, or cross of St. Andrew, which could represent the flag of Scotland.[304] The fifth rectangle contains a pair of overlapping crosses, which bears some resemblance to an early version of the current Union Jack, created after the union of the crowns in 1603.[305] The version of this flag preferred in Scotland in the 17th and early 18th centuries would have had the cross of St. Andrew uppermost, which is how the two overlapping crosses on the repair patch are arranged.[306] Although this interpretation of the decorative work is only speculative, the flag interpretation does create a compelling visual metaphor, with the repair patch bridging the two sides of the crack to bind them together. The decorative design on the smaller repair patch is somewhat different, and its interpretation remains obscure.

The longer of the two repair patches was analysed with XRF to determine the composition of the alloy. The results, given in table 3.6, show that it is a high zinc brass with a significant percentage of tin. The trace elements nickel and silver were not detected. This composition is different from that of the other analysed copper alloy fixtures on the neck, and is therefore unlikely to be related to them.

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[304] Documented use of the saltire as the flag of Scotland dates to at least as early as the mid-16th century. See, for example, the depiction of the saltire as the flag of Scotland on the title plate of the *Lindsay Armorial*, David Lindsay (circa 1542), National Library of Scotland, Adv.MS.31.4.3.

[305] F. Edward Hulme, *The Flags of the World: Their History Blazonry and Associations* (London: Frederick Warne & Co., 1891), 44 – 45.

[306] Hulme, *Flags of the* World, 45 – 46. Hulme quotes a letter dated 7 August, 1606 from the Scottish Privy Council in Edinburgh to King James objecting to the placement of the English cross of St. George on top of the Scottish cross of St. Andrew on the Union flag, as had been specified by proclamation in 1605. Hulme also notes that a depiction of the Union flag with the saltire uppermost appears in a 1701 publication. A circa 1617 ceiling boss from Linlithgow Palace depicts the Union flag with the saltire uppermost: National Museums Scotland, "Ceiling boss of painted wood from Linlithgow Palace, West Lothian," accessed 20 June, 2014, http://nms.scran.ac.uk/database/record.php?usi=000-100-000-709-C.

Table 3.6.

Composition of Lamont harp neck repair patch[307]

	Fe	Ni	Cu	Zn	As	Pb	Ag	Sn	Sb
Lamont harp neck repair (long strip)	0.1	0.0	67.2	31	0.3	1.3	0.0	6.0	0.0

Note: surface composition from semi–quantitative XRF analysis. Values are wt% for each element. The maximum measurement uncertainty is +/– 0.2%.

Because this patch is a strip of sheet metal, the presence of lead suggests it may have been recycled from a cast object. Lead was added to improve the flow of the molten alloy for casting, and would not have been added to brass that was intended to be worked into sheets.[308] The presence of a significant quantity of tin also points to the use of recycled material, such as bronze. While not definitive, the relatively high percentage of zinc, at 31%, is less likely to be found in brass made before circa 1700 than in later brass.[309]

The absence of both nickel and silver means the copper likely originated from non-nickel and non-silver bearing ore. Perhaps significantly to this discussion, in 1691, after a century of failed attempts at establishing copper and brass production in the British Isles, the English Copper Company was established, opening mines in Cornwall.[310] Copper ore from Cornwall is both non-silver and non-nickel bearing, whereas the sources of copper from continental Europe contain either nickel or silver.[311]

Bearing in mind that it is not possible to draw any definitive conclusions from the composition of the alloy, as the above observations are generalizations only, it does suggest the possibility that this repair might date to no earlier than circa 1700. The

[307] Jim Tate and Susanna Kirk, "XRF analysis of the Queen Mary and Lamont harps."
[308] Mitchiner et al., "Nuremberg and its Jetons," 124.
[309] Mitchiner et al., "Nuremberg and its Jetons," 130 – 47.
[310] Pollard and Heron, " Medieval and Later Brass Industry," 203.
[311] Mitchiner et al., "Nuremberg and its Jetons," 125 – 26.

relatively high percentage of zinc observed would also be consistent with this lower limit on the date. This is interesting, as it would mean these repair patches may have been added very late in the working life of this harp, when it was in the possession of its final historical player, John Robertson of Lude.

Summary

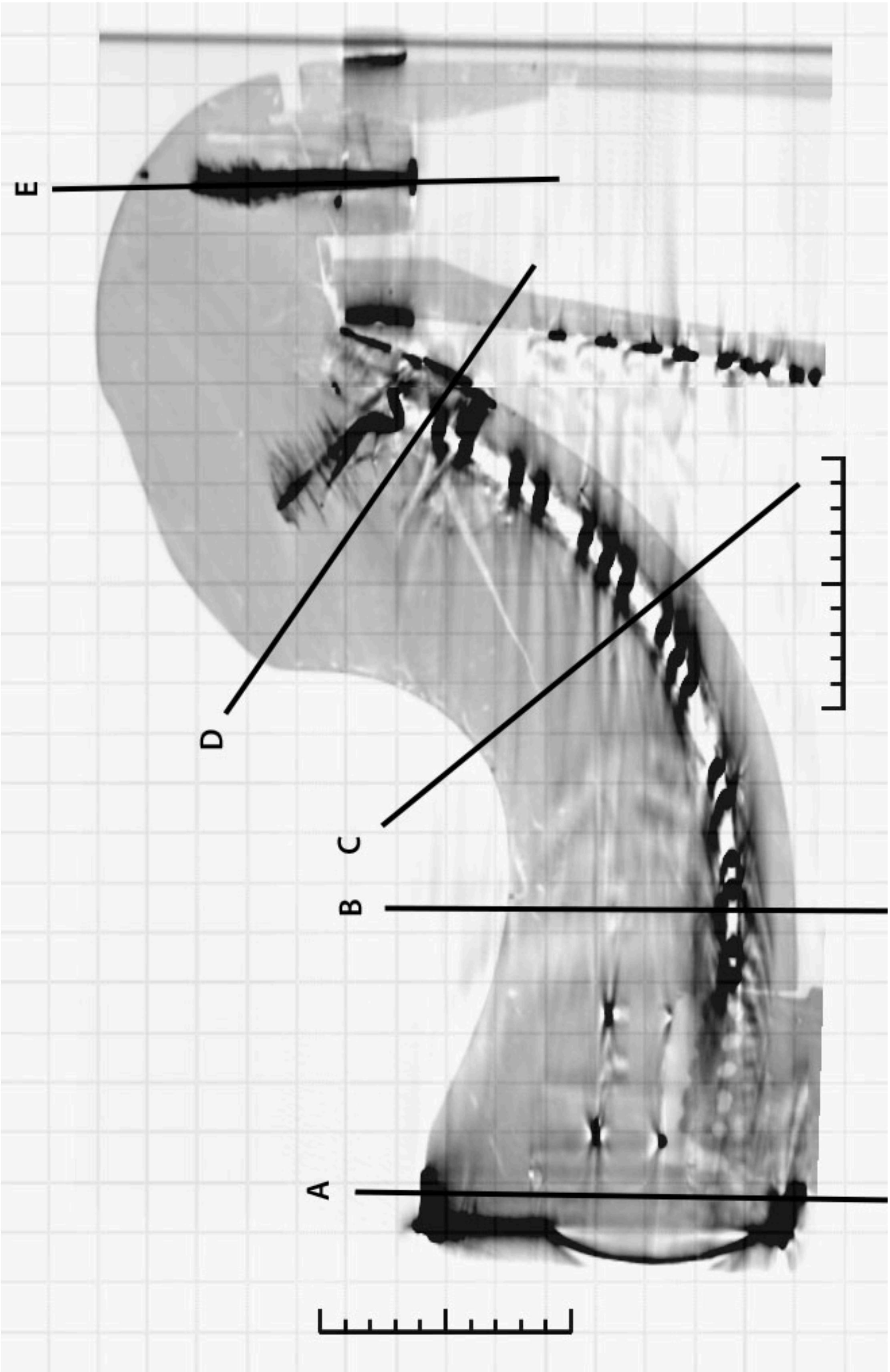
The neck of the Lamont harp holds a number of tantalizing clues to its construction and repair history. Some of the metal fittings are not original to the construction, and are either modifications or replacements. This includes the straps across the neck/forepillar joint and a number of the tuning pins, but may also include the end cap, and possibly even the cheekbands, although the evidence is not conclusive. Some evidence points to a possible late 16th-century date for one (or both) of the cheekbands, the end cap, and perhaps even the tuning pins in Group A, the largest matched set. There is, however, also evidence that may point instead to an earlier, late 15th-century date for the end cap and the 'Group A' tuning pins.

Further research will be needed to establish a timeline for the construction and repair history of the Lamont harp neck. Based on current evidence, it is possible that the neck dates to the second half of the 15th century, and was refurbished in the late 16th century, with replacement or addition of some of the metal fittings, possibly including the cheekbands. Further work is needed to determine whether or not the cheekbands are replacements, however.

Cross-sections

The dimensions of the neck in its current state are shown in the tomographic cross-sections below. The tomogram in figure 3.53 is a lengthwise cross-section. Because the neck is not straight, a composite of three cross-sections was used in order to clearly show its entire length. The lines labeled A – E in figure 3.53 indicate the locations of cross-sections taken across the neck. These are shown in figures 3.54 – 3.58. For all of these figures, the grey-scaling has been set to accurately represent the location of the physical edge of the wood, and the dimensions given in the figures were measured using the method already described. In each of the cross-sections in figures 3.54 – 3.58, the line in the left-hand image indicates the location of the cross-section shown on the right, and the measurements shown were taken at the location of the lines indicated on the cross-section. The right-hand side of the harp is on the left, and the view is from the perspective of 'looking up' the neck from the bass end.

Figure 3.53 (overleaf): *composite tomographic cross-section of the neck of the Lamont harp. This cross-section also shows the forepillar tenon in the neck mortise, and the neck tenon in the soundbox mortise. The lines A – E indicate the locations of the individual cross-sections shown in figures 3.54 – 3.58. Scale 1 tick : 1 cm; grid scale 1 square : 2 cm.*


A
B
C
D
E

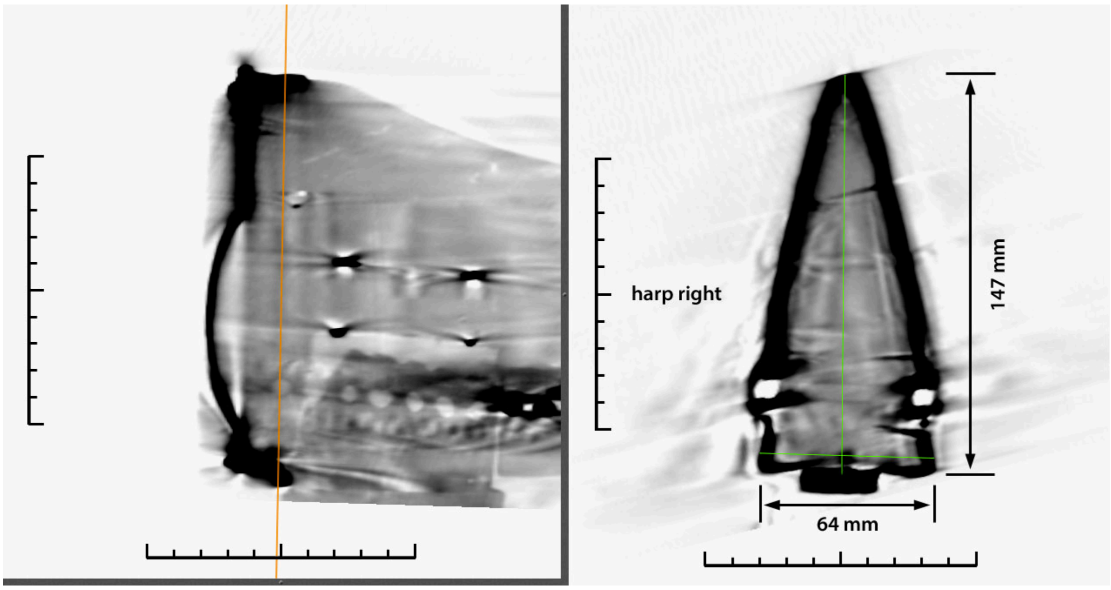


Figure 3.54: *Lamont neck cross-section A (see figure 3.53). This is a cross-section through the end cap. The image artefacts are due to the metal end cap and cheekbands. Scale 1 tick : 1 cm.*

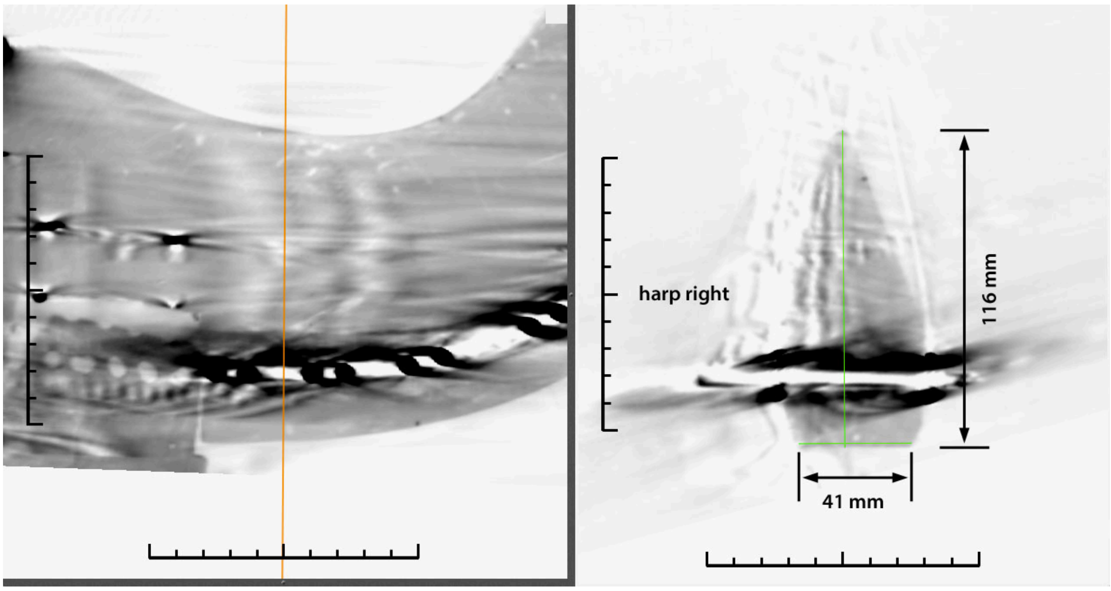


Figure 3.55: *Lamont neck cross-section B (see figure 3.53). The image artefacts are due to the metal end cap, cheekbands, and tuning pins. Scale 1 tick : 1 cm.*

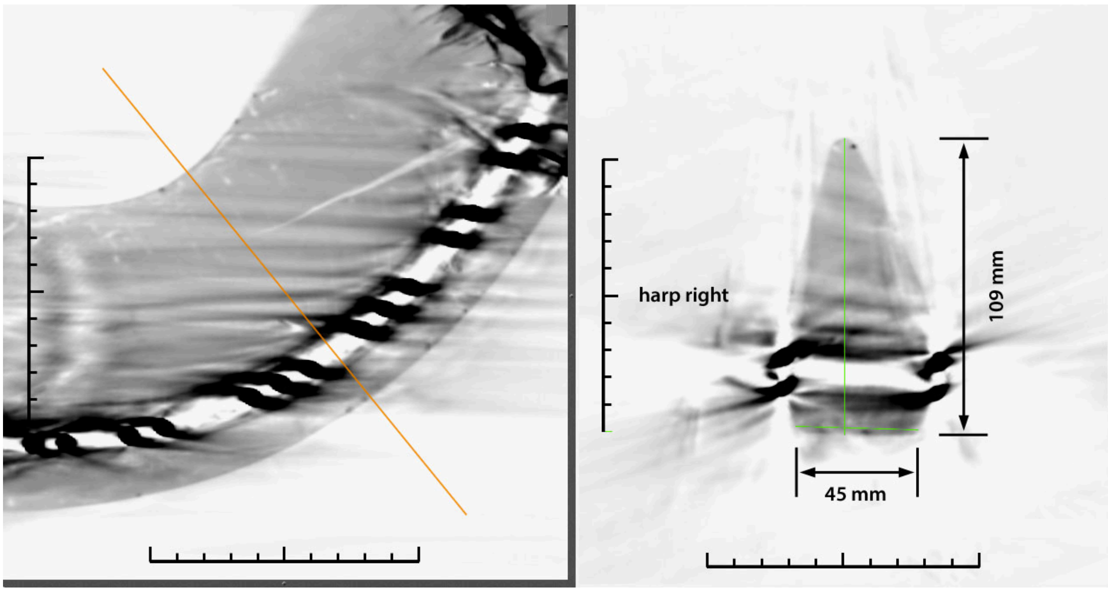


Figure 3.56: *Lamont neck cross-section C (see figure 3.53). The image artefacts are due to the cheekbands and tuning pins. Scale 1 tick : 1 cm.*

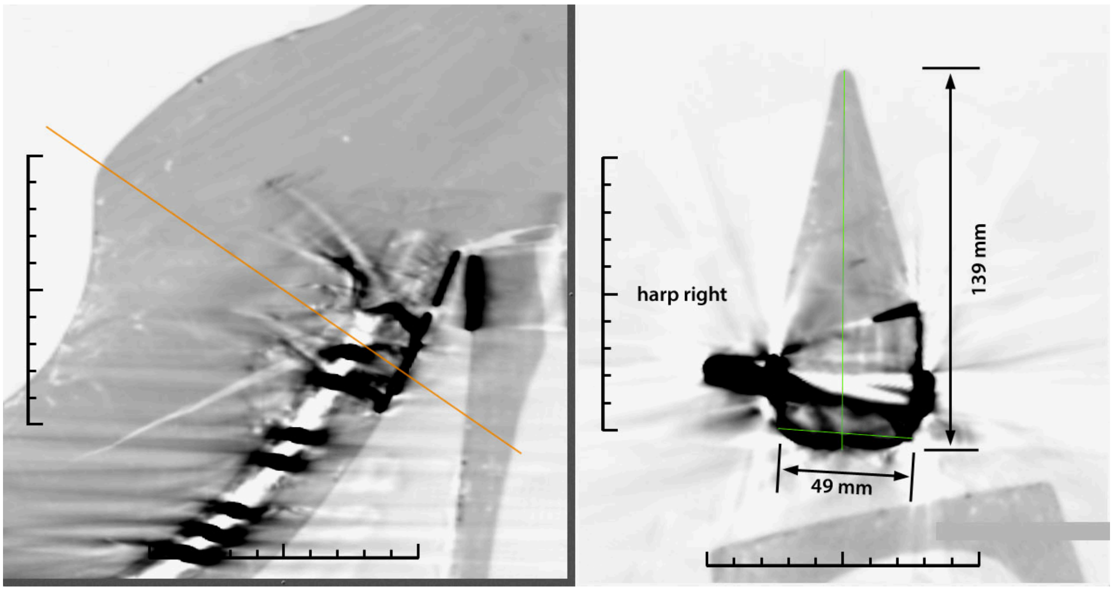


Figure 3.57: *Lamont neck cross-section D (see figure 3.53). This cross-section passes through some of the metal repair work to the crack in the neck. There is a strip of brass sheet metal on the underside of the neck at this location. The image artefacts are due to the cheekbands, tuning pins, and metal repairs to the crack in the neck. Scale 1 tick : 1 cm.*

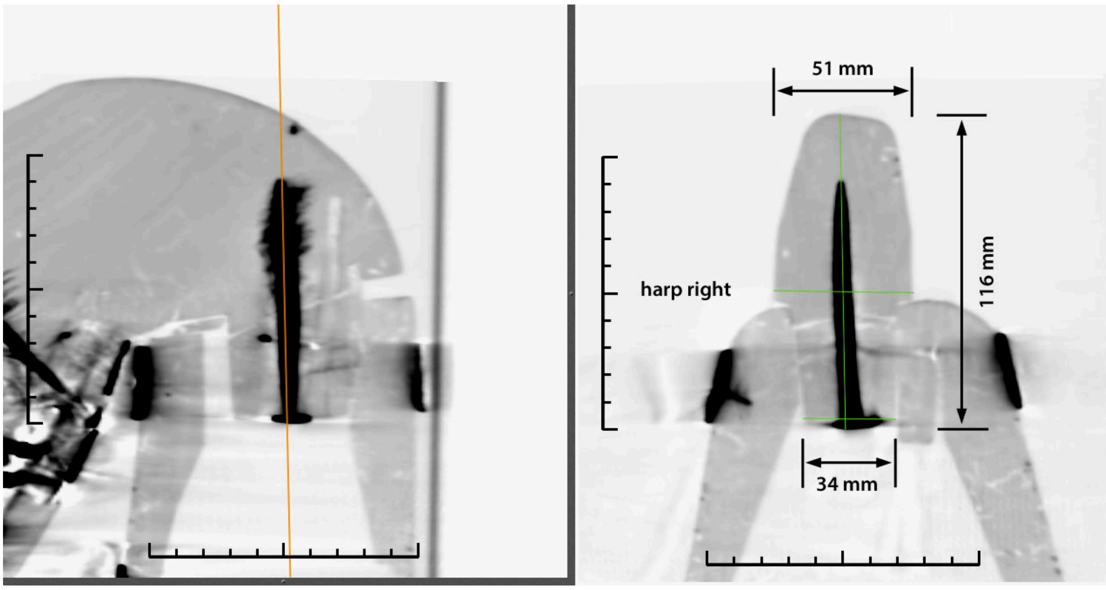


Figure 3.58: *Lamont neck cross-section E (see figure 3.53). This cross-section passes through the neck tenon and an iron spike in the tenon.*[312] *The separate block to one side of the tenon is a repair. Scale 1 tick : 1 cm.*

[312] For a discussion of the spike and other internal repairs to the neck at the soundbox joint see Loomis, "Structural Breaks and Repairs," 35 – 41.

Soundbox

As discussed in Loomis (2010) and Loomis et al. (2012), the soundbox of the Lamont harp is constructed of a single half sawn timber, oriented with the central growth rings towards the front of the box.[313] Some features of the construction, damage, wear and repairs to the soundbox have already been discussed in Part I of this dissertation, specifically the construction and behaviour of the joint with the neck, the rise of the soundbox belly, the wire fragment embedded in string hole #14, and the toggle and wire marks around the string holes. An overview of damage and repairs to the soundbox was also presented in Loomis (2010).[314] This section discusses further evidence of wear and use in the context of understanding its working life, and presents measured cross-sections of the soundbox, including a contour map of the thickness of the front face, which acts as the 'soundboard'. The wood from which the soundbox has been made is discussed separately in Chapter 5, along with the soundbox wood of the Queen Mary harp.

String shoes

The Lamont harp string shoes are described and illustrated in Armstrong (1904), and are shown here in the photographs in figure 3.59.[315] As noted in Armstrong, they are of two distinct designs. The first three shoes in the treble, and the last two in the bass are horseshoe shaped with quatrefoil ends, whereas the remainder are eyelet shaped with an arm extending from each side, ending in a trefoil. Armstrong proposes a possible explanation for the presence of two different designs by noting that the arms of the eyelet shaped string shoes would have overhung the edge of the string band on one side had they been used for the first three string holes, due to the deflection of the line of string holes away from the centre of the string band at this end of the soundbox. This would explain the use of the narrower horseshoe shaped shoes for

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[313] In other words, the front of the soundbox faces the centre of the tree from which it was cut. Loomis et al., "Lamont and Queen Mary Harps," 115.
[314] Loomis, "Structural Breaks and Repairs," 11 – 23, and Loomis et al., "Lamont and Queen Mary Harps," 115 – 19.
[315] Armstrong, *Irish and Highland Harps*, 160.

these holes, although it does not account for their use on the last two string holes in the bass.[316]

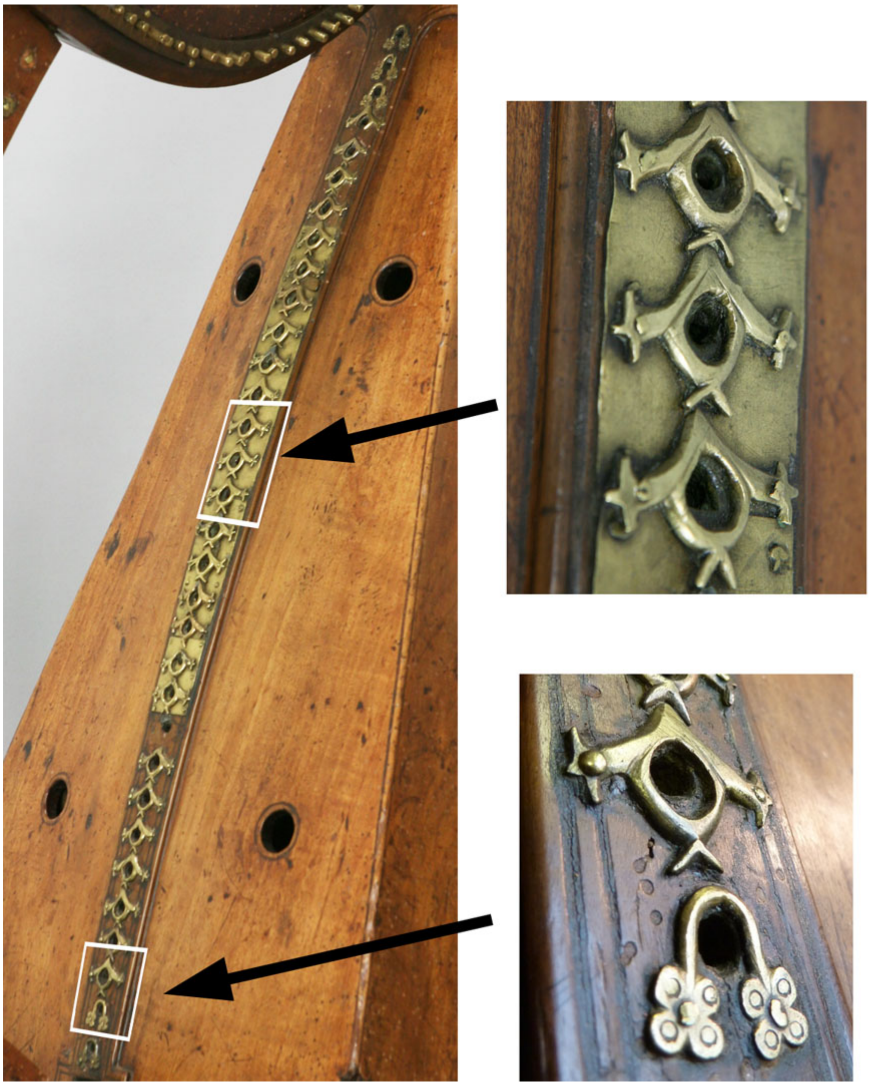

Figure 3.59: *Lamont harp string band and string shoes. There are two designs of string shoe (lower right inset).[317] The first three shoes in the treble, and the last two in the bass are horseshoe shaped with quatrefoil ends. The remainder are eyelet shaped with an arm extending from each side, ending in a trefoil. A section of the string band is reinforced with thin sheets of brass underneath the string shoes (upper right inset). Photographs (left, and upper right): Maripat Goodwin.*

[316] ibid.

[317] Armstrong, *Irish and Highland Harps*, 160.

One possible explanation for the presence of two different designs of string shoe might be that one set consists of replacements. Based on the nail hole patterns, however, this does not appear to be the case. The two designs of string shoe have different nail patterns, but no extra nail holes have been observed at the string holes. This can be seen in the photograph of string hole #23, shown in figure 3.60, and the photograph of string holes #1 – 3, shown in figure 3.61. At string hole #23, which is missing its string shoe, there is only one set of nail holes (corresponding to the eyelet shoes), and there are no nail holes corresponding to the eyelet shoes at string holes #1 – 3. So it is possible that the current arrangement of the two designs of string shoes is original.[318]

Figure 3.60: *string holes #22 – 24 on the Lamont harp soundbox. Hole #23 is missing its string shoe. Nail marks positioned for the eyelet shaped shoe are visible either side of the string hole, but there are no additional nail marks in the expected position for one of the horseshoe shaped string shoes.*[319]

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[318] This does not rule out the possibility that one or both sets of shoes might have been salvaged from another harp, though.

[319] Note the scrap of metal (possibly lead) inserted into the hole on the treble side in place of the string shoe. This shoe may have been lost during the working life of the harp.

Figure 3.61: *string holes #1 – 4 on the Lamont harp soundbox. The first three have horseshoe shaped string shoes. Note that there are no additional nail holes next to them, indicating that they are not replacements for the eyelet shaped string shoes.*

An explanation for the use of two types of string shoe is suggested by Armstrong's observation that the shoes reinforce the string band against splitting as the belly rises, in addition to protecting the string holes from being cut through by the wire strings.[320] It is possible that the builder decided that the eyelet shaped shoes, with their wider arm span, would provide better reinforcement where the soundbox would be pulled up by the strings.

[320] Armstrong (1904), Armstrong, *Irish and Highland Harps*, 160.

Although the shoes are of two different designs, both appear to be copper alloy. It would be of interest to compare the composition to determine if they might have been made together, and to compare them to the composition of other metalwork on the harp, such as the tuning pins. Five of the 'eyelet shaped' shoes are of a distinctly redder hue, and it would also be of interest to compare the composition of these to the others. Due to the geometry of the harp, it was not possible to analyse the composition of any of the string shoes, however it may be possible to do this in a future study with the use of a handheld XRF spectrometer.

As mentioned in the introductory paragraph to this section, the Lamont harp string shoes show possible signs of wear from the strings. This was discovered during visual examination of this harp for the present study, and is the first instance in which possible string shoe wear has been observed and recorded for any of the surviving Irish harps. Figure 3.62 is a photograph of string shoe #10, enlarged to show detail. A groove (actually a pair of overlapping grooves) is clearly visible on the edge of the shoe, and there is a corresponding notch in the wood at the edge of the string hole. The groove and notch are located where the wire string would press against the string shoe and the wood. Upon close inspection, it was found that nearly all of the string shoes have similar grooves, and they all appear to be positioned where the string would press against the shoe.[321] Many have multiple grooves, either closely spaced or overlapping as on the shoe for string hole #10. Two shoes (#19 and #23) show signs of repair in this area, with lead solder over deeply incised grooves.

[321] Loomis et al., "Lamont and Queen Mary Harps," 119.

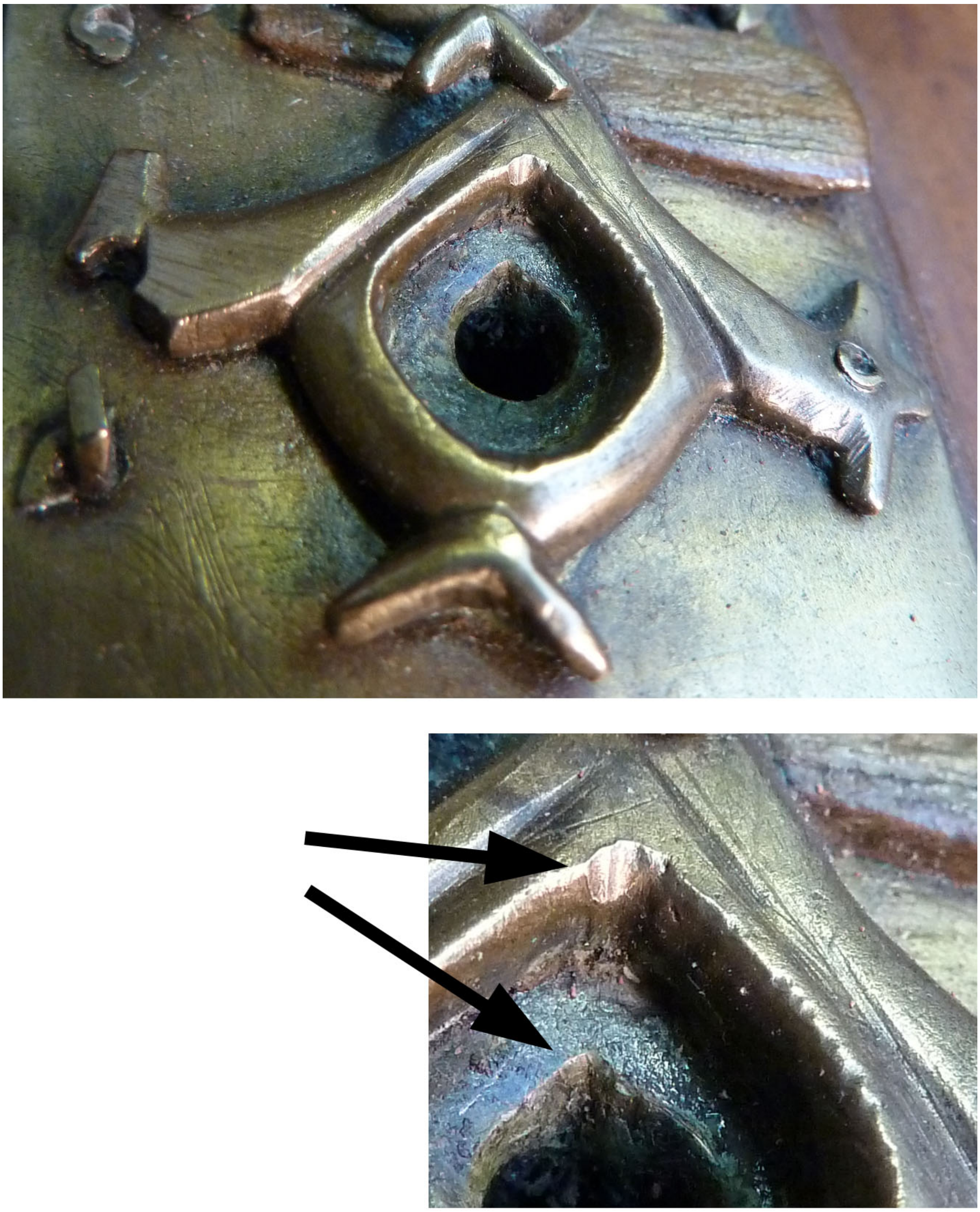

Figure 3.62: *shoe at Lamont harp string hole #10. There is a pair of overlapping grooves in its edge and a corresponding notch in the string hole (inset, arrowed). Note also the several smaller notches along the edge of the shoe on the right hand side.*

Towards the treble end of the string band, the positions of the grooves in the string shoes correspondingly shift where the strings are angled more towards the left side of the harp. This can be seen in the photographs of string shoes #5 and #6 in figure 3.63.

Figure 3.63: *shoes at Lamont harp string holes #5 (top) and #6 (bottom). These string shoes have grooves positioned towards the left side of the harp, corresponding to where the strings would be expected to contact them at the treble end of the string band. The presence of multiple grooves may be evidence of the frame becoming increasingly twisted, causing the direction of the strings to shift more towards this side of the harp.*[322]

[322] Note the verdigris stains in the area of the grooves on the shoe for string hole #6. These may have been left by copper alloy strings.

Based on the appearance and location of these grooves, it is probable that they were created by the friction of the string at the point of contact with the string shoe.[323] Each time a string is either tuned or struck, the wire slides a small distance along the edge of the shoe.[324] Although the motion is very small, many repetitions could cause the observed grooves.[325] Assuming this is what has happened, there is the implication that the strings that made these grooves were of a harder material than the string shoes; otherwise the wear would not have occurred. This is of interest because the hardness of the string shoes would place a lower limit on the hardness of the wire strings (bearing in mind that this is not necessarily representative of the stringing used for the entire working life of this harp). The string shoe material could be tested for hardness, however as this is a destructive test that might require temporary removal of one of the shoes, it may not be feasible to conduct this analysis at present.[326]

Although in most cases the grooves in the shoe align with notches in the wood at the edge of the string hole, for some shoes they do not, as shown in the photograph in figure 3.64. This does not necessarily mean these grooves were not created by the wire strings, however. The misalignment could be due to the string shoes being salvaged from another harp, as suggested in Loomis et al. (2012), although there is another probable explanation. As shown in figure 3.59, strips of brass sheeting were nailed onto a section of the string band, underneath the string shoes, to reinforce it where it had cracked.[327] Armstrong noted that several of the string shoes would have been removed and put back into place to allow for the sheet metal to be inserted underneath them.[328] The string shoes with grooves that are misaligned with the notches in the string holes happen to be located where the brass strips were added to

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[323] Ann Heymann has suggested, alternatively, that the grooves could have been filed into the string shoes, possibly to alleviate buzzing of the string against the edge of the shoe (personal communication with the author).
[324] The front of the soundbox, which is somewhat springy, also moves up and down as the string is tuned or struck.
[325] The several small notches in the side of string shoe #10 could have been made by replacement strings being pulled up through the string hole.
[326] Martha Goodway and Jay Scott Odell, *The Metallurgy of 17th and 18th Century Music Wire* (Stuyvesant: Pendragon Press, 1987), 54 – 57.
[327] Loomis, "Structural Breaks and Repairs," 17 – 18.
[328] ibid.

the string band. It is probable that they were not put back in exactly the same positions after the brass strips were added. This would explain the observed misalignment of the notches and grooves. It also implies that the grooves in the string shoes predate the brass strips, which suggests this reinforcement to the string band may have been added late in the working life of this harp.

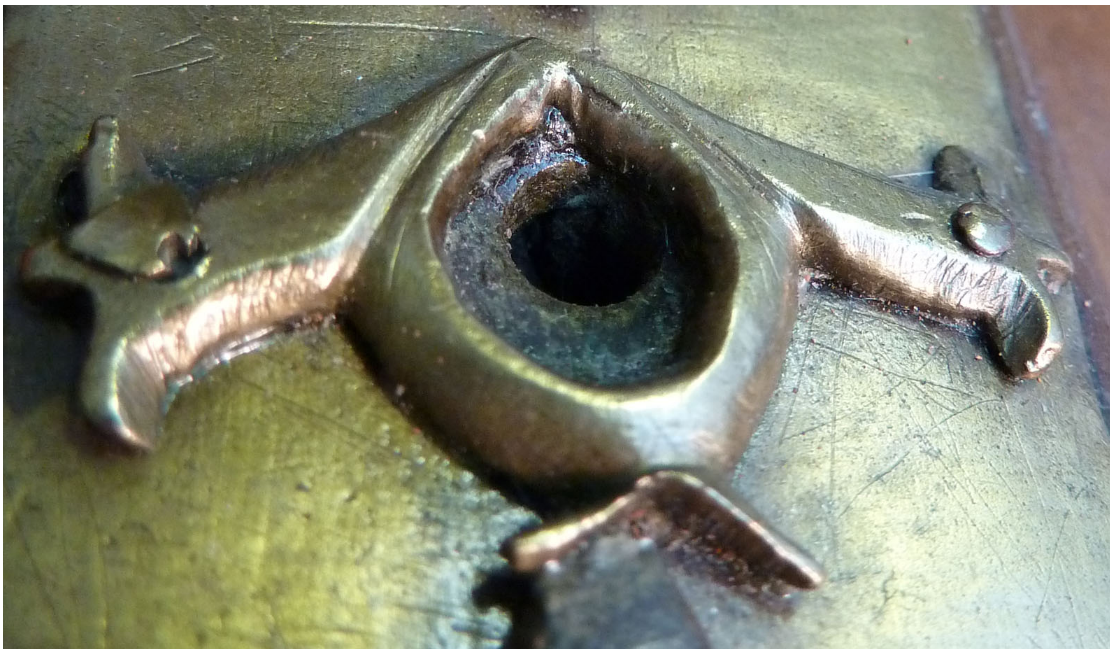

Figure 3.64: *shoe at string hole #11 of the Lamont harp. In contrast to the shoes at most of the string holes, the grooves do not appear to align with any corresponding notches in the string hole wood. The sheet metal underneath this shoe is a repair to the string band. The shoes lying on top of this repair were removed and repositioned back onto the string band, probably resulting in the misalignment of the wear marks in the shoes and the string holes.*

Another observation regarding the string shoes is that the grooves worn into them become less distinct towards both the treble and bass ends of the string band.[329] This is the case for both types of string shoe, so is not necessarily due to the different design of shoe. It may instead be an indication of which strings were used more often. Interestingly, aside from a general tapering off of wear towards the ends of the

[329] This coincides with the quantity of toggle marks observed around the string holes on the inside of the soundbox.

compass, there is also an apparent difference in the degree of wear on some individual string shoes as compared to others near to them. This could potentially provide clues to tuning and performance practice.[330]

It was also observed that the shoe on string hole #1 has no perceptible groove, and that the shoe on string hole #2 has a single very light mark. This is to be expected, based on what is understood about the damage to the top two tuning pin holes and the effect this is likely to have had on the stringing arrangement. Notably, there is a single light mark on the shoe for string hole #32, which suggests that this string hole may in fact have been used, at least at some point. The offset position of this mark, and of a similar mark on string shoe #31, is consistent with it having been used when the harp frame was in its current state, with the forepillar pulled over towards the left side. If it was, then it is also likely that it was after the top two tuning-pin holes had become unusable. It is possible that a straight string hole to tuning-pin stringing arrangement, missing out the top two string holes and tuning pins, was used at some point. A photograph of the shoe for string hole #32 is shown in figure 3.65.

[330] Strings that were regularly raised or lowered by a semi-tone, for example might generate more wear on the corresponding string shoe. A comparative study of the shoe wear could form the basis of future research.

Figure 3.65: *shoe at string hole #32 of the Lamont harp. There is a single light mark (arrowed), possibly from a wire string. The shoe at string hole #31 has a similar mark in the same location. The position of this mark is consistent with the use of this string hole with the forepillar pulled over towards the left side of the instrument, as it is currently.*

The grooves in the string shoes on this harp may provide an interesting record of wear that is indicative of the relative hardness of the wire strings, and reflects the changing shape of the frame, as well as possibly providing some indication of which strings were used more often. The following section examines the use of the string holes from the inside of the soundbox by taking a further look at the string toggle marks discussed in Part I of this dissertation.

Stringing marks inside the soundbox

The indentations observed around the string holes on the inside of the soundbox have been identified as having been made by the string toggles pressing against the wood, and have been discussed as an indicator of which string holes were used. They may also indicate how long the instrument was in use. Because a toggle mark is made when a string is brought up to tension, which normally only occurs when a string is replaced, the number of toggle marks around a string hole should indicate the number of times that string has been replaced. Although a string replacement may not always result in a new toggle mark, the number of these marks can at least be taken as an estimation of the lower limit of the number of string replacements for that string hole. While it is possible to see and tally individual toggle marks around the string holes at the ends of the compass where the marks are less numerous, in the middle third of the compass the string holes are saturated with toggle marks to the extent that it is very difficult to accurately count them.[331] The point of saturation appears to be reached at approximately 40 toggle marks. The actual number may be higher than this, but 40 can be taken as the lower limit. This number can, therefore, also be taken as an estimate for the minimum number of string replacements for each of these string holes. A possible minimum length for the working life of this soundbox can then be determined by estimating the frequency of string replacements. This quantity is not known, but based on current experience with harps strung with brass wire, a conservative estimate might be 5 – 6 years for the strings that are in frequent use. If the lower limit for the number of string replacements is 40, this implies that the working life of this soundbox was no less than 220 +/- 20 years.[332] The person understood to be the Lamont harp's last player, John Robertson of Lude, is known to have died in 1731.[333] The year of his death likely marks the end date of the working life of this harp. Based on this estimate of the length of the working life, the

[331] The number of toggle marks around each string hole is greatest in the middle third of the compass, and tapers off towards the bass and treble ends. This is a direct indication of the comparative frequency of string changes in the middle versus the ends of the compass, with the higher frequency of string changes likely being due to greater use of those strings.
[332] If the number of toggle marks has been underestimated, or if the frequency of string replacements has been overestimated, the calculated working life would be longer.
[333] Sanger and Kinnard, *Tree of Strings*, 214.

soundbox would have been made no later than circa 1490 – 1530. This suggests that a late 15th-century date of construction for the harp (or at least the soundbox) might be more likely than the late 16th-century date indicated by the cheekbands.[334]

There are additional marks in the soundbox that may also be indicative of string replacements. The historian John Lynch, writing in *Cambrensis Eversus* (1662), notes that the strings of the Irish harp were replaced via the sound holes on the front of the soundbox.[335] This method of string replacement, as it is currently practiced, requires hooking the new string onto another length of wire (fashioned with a loop or hook on its end) that has first been threaded through the string hole and soundhole. Figure 3.66 shows a string being replaced through the soundhole of the author's harp.

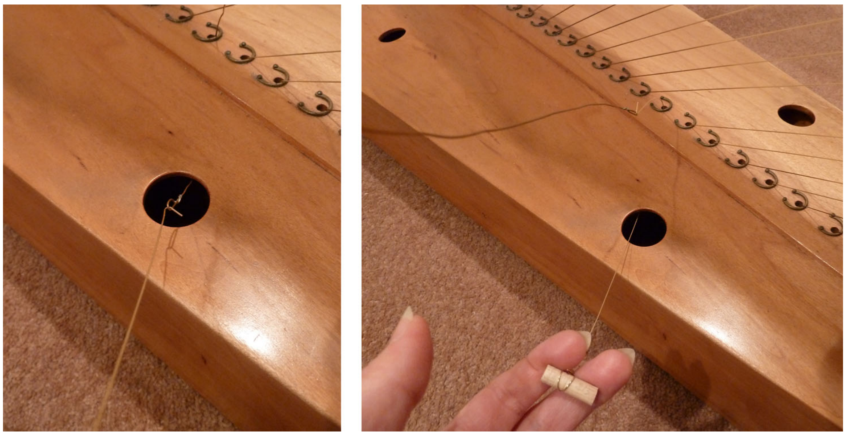

Figure 3.66: *replacing a string via a soundhole. The new string is hooked to the end of a length of wire that has been threaded through both the string hole and the soundhole (left). By pulling up on this wire, the string is then drawn into the soundhole and up through the string hole (right). The toggle prevents the end of the string from pulling through the string hole. Note the hooked end of the wire, visible in the left-hand photograph, which could scratch the inside of the soundbox as the string is drawn through the soundbox to the string hole. The harp shown is by Guy Flockhart (1996).*

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[334] As noted earlier, the cheekbands may not be original.

[335] John Lynch, *Cambrensis Eversus,* vol. I, trans. Matthew Kelly (Dublin: The Celtic Society, 1848), 317. Strings would not have been replaced via the back of the soundbox because the board that encloses it would not normally be removable when the harp is under tension.

Note that in the restringing demonstrated in figure 3.66, the hooked end of the wire could easily leave a scratch inside the soundbox as the new string is drawn through it towards the string hole. Additionally, the wire used to thread the new string has to first be inserted into the string hole and fished out the soundhole. This is often accomplished with the aid of another piece of wire with a hooked end that is inserted into the soundhole to capture this wire and pull the end up through the soundhole. This process could also easily leave scratches inside the soundbox.

Although this method of string replacement may seem somewhat awkward, as noted in Loomis et al. (2012), there is evidence that it was used to replace strings on the Lamont harp. Upon initial visual inspection of the interior of the soundbox, numerous scratches were observed on the inside surface, in the area around the lower left-hand soundhole.[336] Under further examination with magnification, similar scratches were found in the vicinity of all four sound holes. Some of the scratches are concentric to the sound holes, consistent with the process of fishing for the drawing wire to pull it up through the hole. Most scratches generally point towards the string holes, with more pointing in the direction of the string holes in the middle of the compass. Their position and orientation is consistent with a method of string replacement similar to that described above and shown in figure 3.66. Most are located within 4 cm of the centre of each sound hole, and are very fine. They are most easily visible when viewed with magnification and adequate light. Under these conditions, the number of scratches observed was approximately 100 – 120 for each of the right-hand sound holes, and approximately 200 for each of the left-hand sound holes, for a total of approximately 600 – 640 scratches. The higher number at the two left-hand sound holes is also consistent with string replacement, as this is the side of the harp that has the string end of the tuning pins, so it is more convenient to replace a string from this side.

Figures 3.67 and 3.68 show some of the scratches around the lower right-hand and lower left-hand sound holes, respectively. It is not possible to estimate the number of string changes from these scratches, as any individual string change could result in

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[336] Loomis et al., "Lamont and Queen Mary Harps," 117.

several scratches, or none. Their large overall number is, however, indicative of a large number of string changes, consistent with a long working life for this instrument.

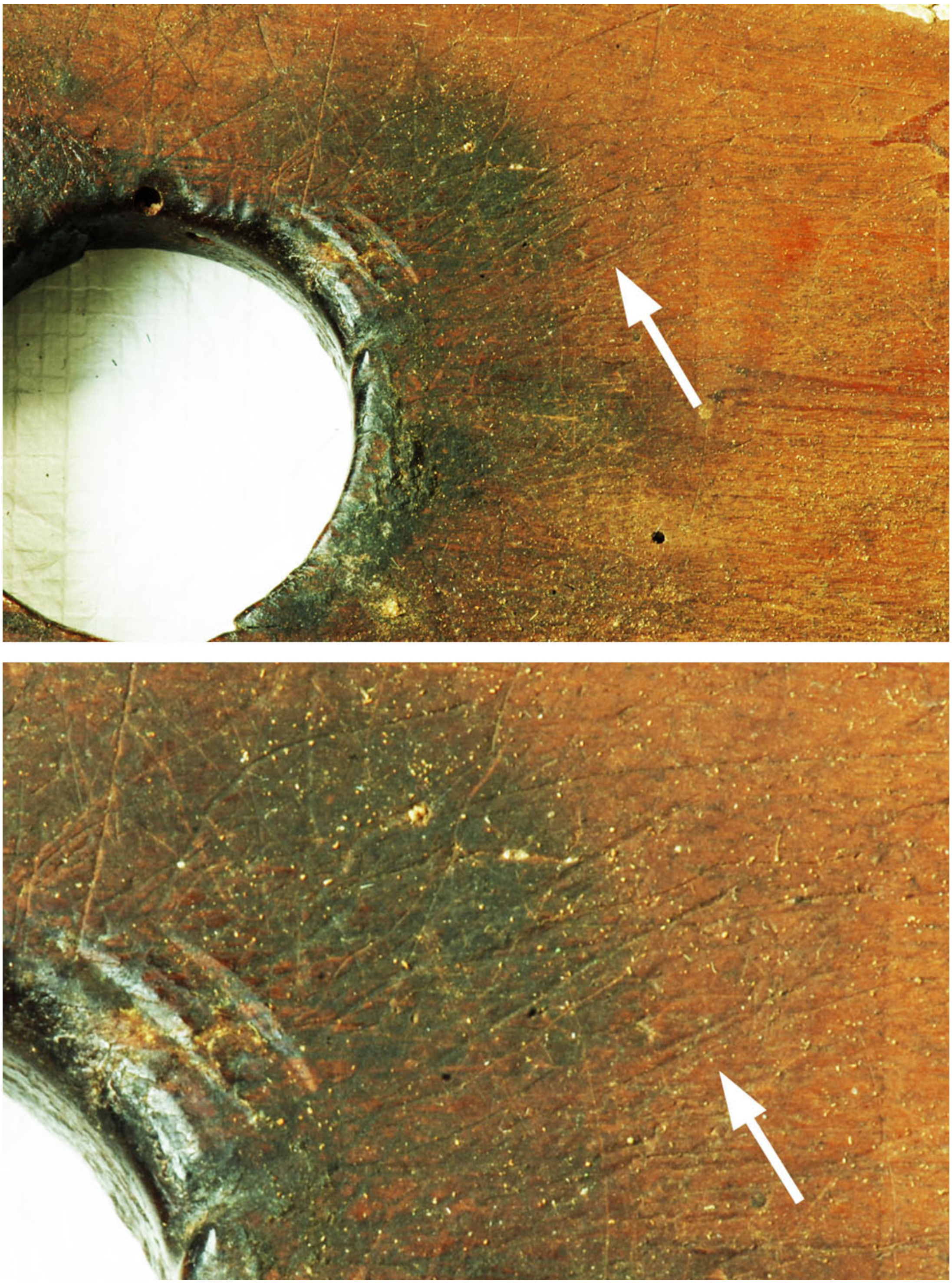

Figure 3.67: *scratches on the inside surface of the Lamont harp soundbox (arrowed), at the lower right-hand sound hole. The scratches predominantly point in the direction of the string holes and are consistent with the replacement of strings via the sound hole. Similar scratches were observed around the other three sound holes. The string band is towards the top of both photographs, and the middle of the compass is towards the top right. The contrast of both photographs has been enhanced to show detail.*

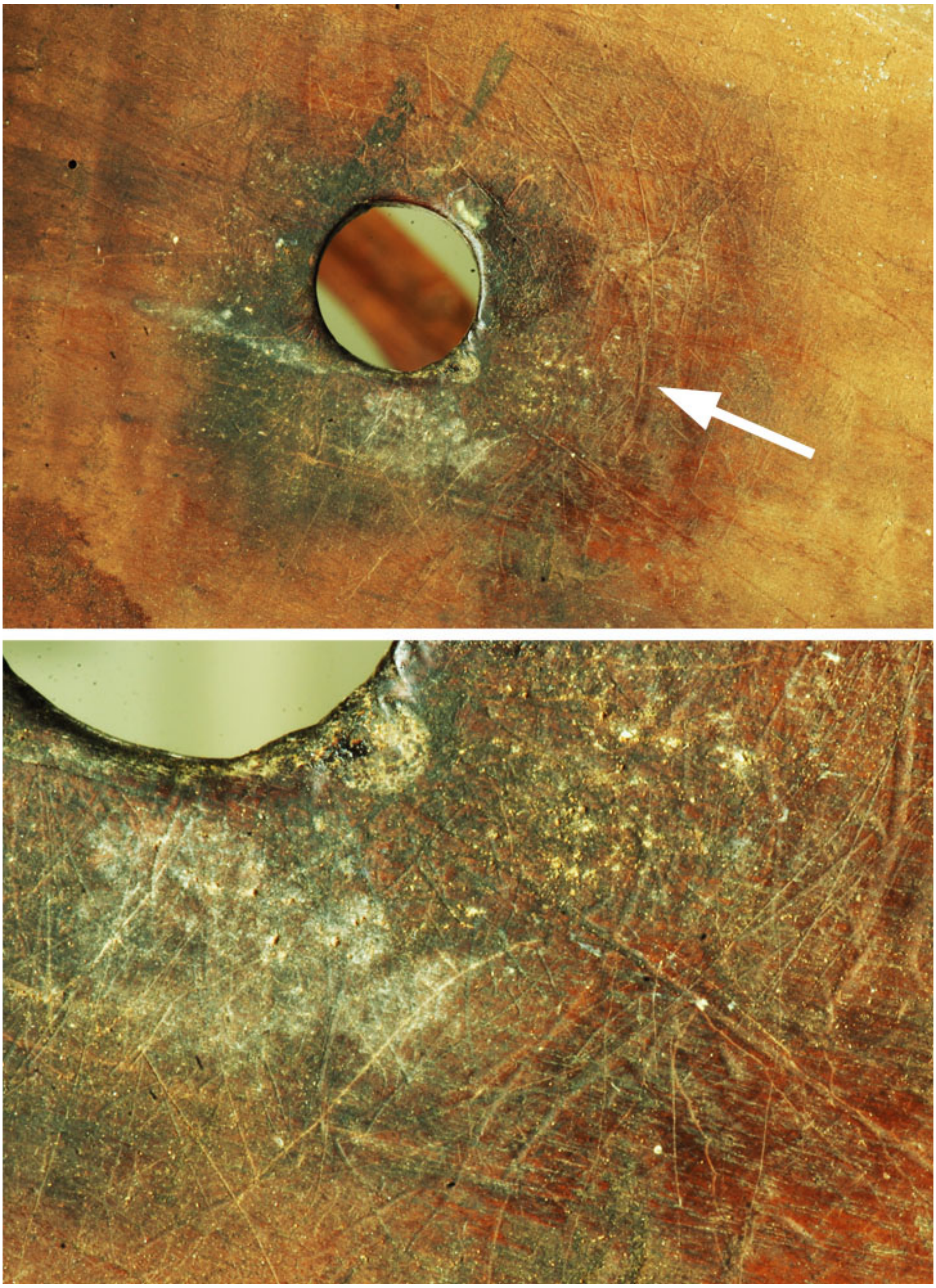

Figure 3.68: *scratches on the inside surface of the Lamont harp soundbox, at the lower left-hand sound hole. Note the semicircular scratches (arrowed). These are consistent with attempts to hook the drawing wire to pull it up through the sound hole. This is more likely to have been done from the left-hand side of the harp, as the string end of the tuning pins is on this side. The string band is towards the bottom of both photographs, and the middle of the compass is towards the bottom right. The contrast of both photographs has been enhanced to show detail.*

In the examination of the Lamont harp wire fragment in Chapter 1, the possibility that thin metal string toggles were used was discussed. The use of thinner, metal toggles has implications for understanding how these harps were strung. The scratches in the vicinity of the sound holes are consistent with stringing through these holes, as described above, in agreement with the historical account from the late 17th century. Both the Lamont and Queen Mary harps have string holes that are relatively large, however (~ 5 mm for the Lamont and ~ 5.5 – 6 mm for the Queen Mary). This is larger than is necessary to pass a wire string through, and is larger than the string holes on the soundboxes of the later, high-headed harps. The builder of the soundbox is not likely to make the string holes larger than they need to be, because they perforate the string band, and larger holes make it more vulnerable to splitting. There must, therefore, have been a reason for making large string holes, and this may have to do with the way the harp was designed to be strung.

It is plausible that the holes are this size because the soundbox was intended to be strung by inserting the toggled string directly into the string hole from the front, rather than by threading it up through one of the sound holes. Although the string holes on the Lamont and Queen Mary harps aren't large enough to insert a wooden toggle in this manner, they are large enough to insert a thinner, metal toggle. It is possible that the earlier, low-headed harps were originally strung in this manner, and that restringing through the sound holes was a later adaptation. It is notable that the string holes on the later high-headed Irish harps are significantly smaller, which may be a sign of a change in restringing practice along with the adoption of wooden toggles. Narrow and broad toggle marks are both clearly visible around the bass string holes (see figure 2.8, page 65). The two types of impressions may be due to metal and wooden toggles, respectively. If this is the case, then it is interesting to note that the narrow toggle marks underlie the broader ones. This is particularly apparent for the toggle marks around string hole #30 in this figure. If a switch from the relatively straightforward method of direct insertion of the toggle into the string hole to the more awkward method of restringing via the sound holes was prompted by changing from thinner metal to thicker wood toggles, there must have been a reason for the change to wood toggles. The possible reason is a matter for speculation, but may eventually shed some light on changes in stringing practices for these harps.

Tool marks

As shown in figure 3.69, the sides and bass end of the soundbox interior appear to have been worked with flat bladed tools, probably chisels. The interior surface of the front of the soundbox is quite smooth, and appears to have been planed.

Figure 3.69: *tool marks in the interior of the Lamont harp soundbox. The sides of the box were worked with flat bladed tools, probably chisels, and have been left slightly rough. The front of the box appears to have been planed smooth.*

At the treble end, where the soundbox cavity transitions into the mortise for the neck tenon, there are gouge marks. These cover both sides and extend partially onto the front interior of the soundbox as shown in figure 3.70 (top). They were left by two different gouges, one with an approximately 1 cm blade (and numerous irregularly spaced nicks in its cutting edge), and another with an approximately 0.5 cm blade.

Both gouge marks can be seen in the photograph shown in figure 3.71. The marks left by the narrower gouge overlay those left by the broader one. The wood was worked in both directions, from the soundbox cavity towards the mortise and from the mortise towards the soundbox cavity. Both sets of gouge marks extend into the smoothed surface farther down in the soundbox, as shown in figure 3.70 (bottom), indicating that this work was done after the rest of the soundbox interior had been smoothed.[337] These marks may represent a later modification to the soundbox, possibly an effort to thin the sides and front in order to improve the response of the instrument in the treble. Additionally, as discussed in Loomis (2010), and Loomis et al. (2012), the soundbox mortise was enlarged at some point to make room for a reinforcing block of wood nailed to the side of the damaged neck tenon.[338] These gouge marks appear to also be associated with this work.[339]

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[337] Loomis et al., "Lamont and Queen Mary Harps," 117.
[338] Loomis, "Structural Breaks and Repairs," 38. Loomis et al., "Lamont and Queen Mary Harps," 117.
[339] For a discussion of the damage and repair to the neck tenon see Loomis, "Structural Breaks and Repairs," 35 – 41.

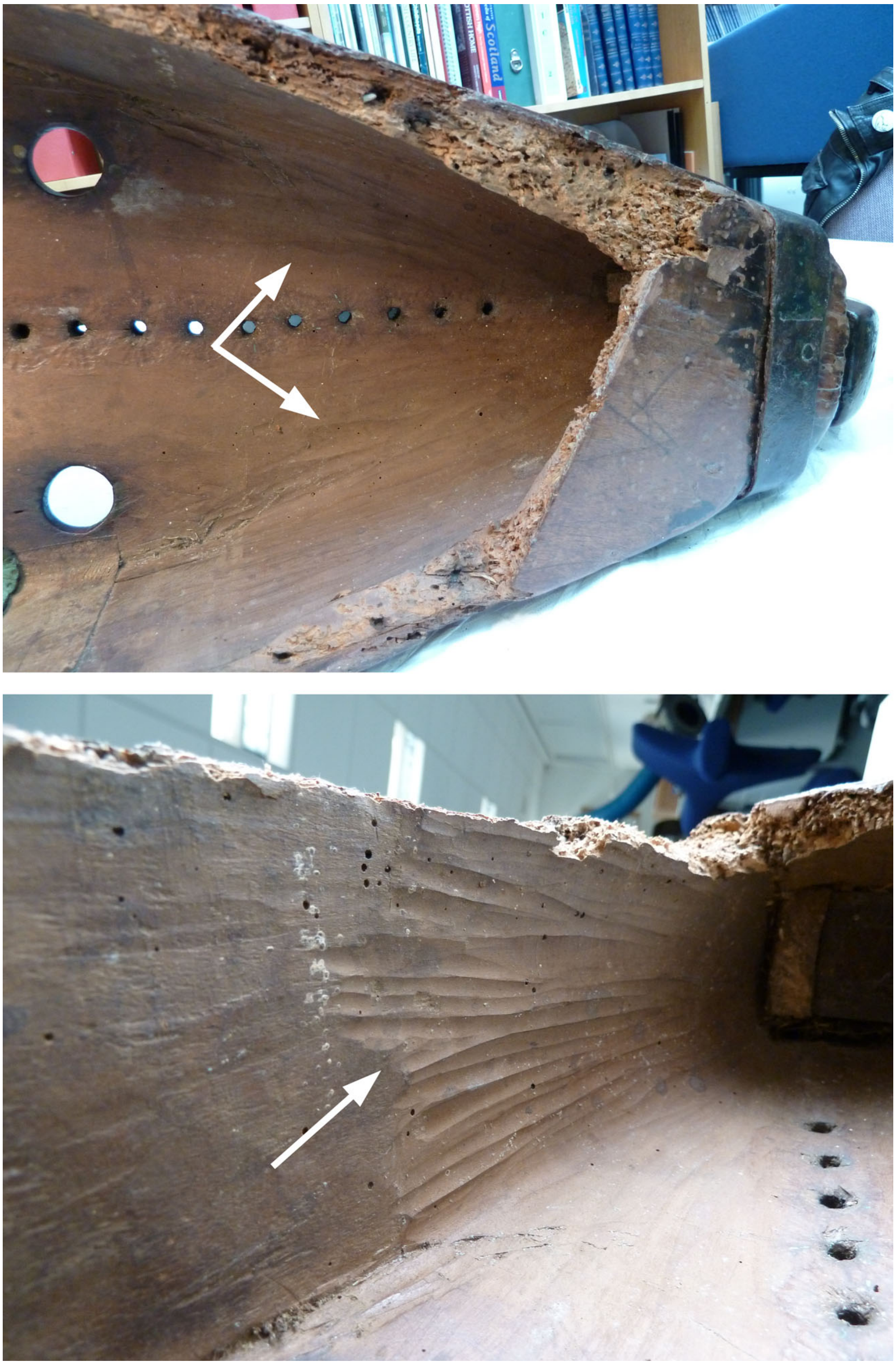

Figure 3.70: *gouge marks in the interior of the Lamont harp soundbox, at the treble end. The marks are on both sides, and the adjacent area of the front (arrowed, top), and extend into the smoothed surface (arrowed, bottom).*

Figure 3.71: *tool marks at the treble end of the Lamont harp soundbox interior. These marks were made by two different gouges, a ~1cm gouge (with numerous small nicks in its cutting edge), and a ~0.5 cm gouge. The view is of the right-hand side of the box. The treble end is toward the left, the front of the box is toward the bottom.*

Inscriptions

There are three known items of written text on the Lamont harp soundbox. The presence of one has been known for a number of years, and the other two were discovered during the course of the current research of this harp. The first runs down the right-hand side of the soundbox, and appears to read:

AL Stewar[t] of CLunie his harp 1650

As it is written, the last digit in the date could alternatively be read as a '6', however. The text has been scratched lightly into the surface, and the words are informally scrawled. Figure 3.72 shows the placement of the inscription on the soundbox. It has been traced over in the photograph to make it more visible.

Figure 3.72: *location of an inscription on the right-hand side of the Lamont harp soundbox. The text reads* AL Stewar[t] of CLunie his harp 1650 *(or* 1656*). The inscription has been traced over on the photograph to make it more visible. Photograph: Maripat Goodwin; annotations by the author.*

The inscription was observed by Christison (1969), who writes,

> "... as scratched on it, in a childish scrawl, can be deciphered A. C. Stuart of Clunie His Harp 1650."[340]

Chadwick (2012) notes that this may be the earliest mention of the presence of this inscription.[341] It is not mentioned by either Armstrong or Gunn, nor is it mentioned by Rimmer. Its presence became more widely known after it was observed and reported by the harp builder David Kortier in 2000.[342] As discussed elsewhere in this dissertation, archival conservation photographs of the Lamont harp show the instrument apparently in the process of being stripped of its surface coatings, possibly down to bare wood. It is likely that the inscription became more visible after this was done.

This inscription lies directly below a long crack in the soundbox and runs across some of the nails associated with a historical repair to this crack. Because the inscription includes a date, 1650 or 1656, it would be helpful to know if the crack or the nails were present when the lettering was scrawled onto the soundbox. Figure 3.73 shows the inscription in detail. By examining the letters, it may be possible to tell if their form or placement was affected by the presence of the crack or the nails, and therefore if the crack and its repair predate the inscription.[343]

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[340] A. F. Philip Christison, *The Clàrsach* (Inverness & Glasgow: An Comunn Gaidhealach, 1969). This source is a pamphlet published as no. 8 in a series. The author gratefully acknowledges Simon Chadwick for bringing this source to her attention, and for the information contained within it.
[341] Simon Chadwick, "The Lamont Harp: Inscription," last modified 28 February, 2012, http://www.earlygaelicharp.info/harps/lamontinscription.htm.
[342] David Kortier, "Trip to Scotland (2000)," accessed 27 July, 2014, http://www.kortier.com/subpages/scot.htm.
[343] The author gratefully acknowledges Simon Chadwick for suggesting this a number of years ago.

Figure 3.73: *photographs of the Lamont harp inscription shown in figure 3.72. The inscription lies directly below a long crack in the soundbox. The "r" in 'Stewar[t]' is directly below a widening in the crack. The "L" in 'Clunie' and the "r" in 'harp' are adjacent to nails associated with an historical repair to the crack.*

Examining the individual letters, it is evident that the 'L' in 'Clunie', and the 'r' in 'harp' both lie adjacent to nails that protrude through the wood, and the 'r' in 'Stewar[t]' lies directly below a widening in the crack in the soundbox. These three letters are shown in more detail in figure 3.74.

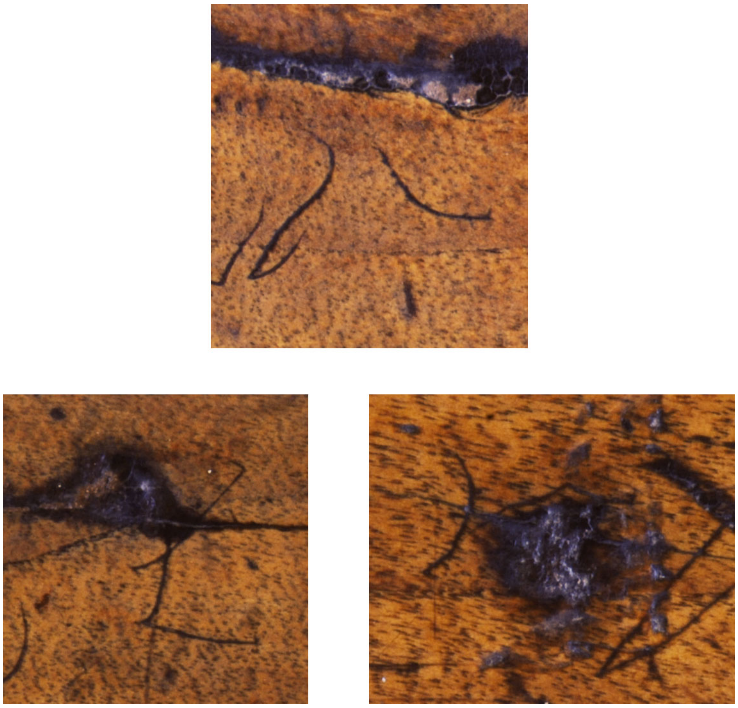

Figure 3.74: *three individual letters from the inscription shown in figure 3.73. At top centre is the 'r' in 'Stewar[t]', at bottom left is the 'L' in 'Clunie', and at bottom right is the 'r' in 'harp'.*

The placement of the "r" in 'Stewar[t]' (figure 3.74, top) is ambiguous with respect to the crack. It could just as easily have been written as it is with or without the crack there. With respect to the nails, the shape and placement of the other two letters is less ambiguous. Note the vertical stroke of the 'L' in 'CLunie'. It terminates at the nail, and is a bit short. Just below the nail there is a diagonal line that may have been added in an attempt to complete and lengthen this stroke past the nail. The 'r' in 'harp' also looks as though it was affected by a nail. The horizontal stroke appears to skirt awkwardly around the edge of the nail, following its contour. It appears from these letters that the nails were likely present when the inscription was written, which means it post-dates the crack and its repair.

While the inscription contains a name and a date for someone who may have played this harp, without more information it is not possible to identify the specific Al Stewart to whom it refers. Keith Sanger has noted that there was more than one Alexander Stewart in the vicinity of Lude during the relevant time period, and that there was also more than one Clunie.[344] Clunie as a place name (and its variants Cluny and Clunes) as well as related names, such as Cluniemor, and Wester Clunie, appears in multiple locations near to one another, and near to Lude.[345]

One possible candidate for the person named in the inscription is an Alexander Stewart of Wester Clunie, who was born in 1639.[346] One argument against it being this Alexander Stewart is that he would have been only 11 years old in 1650, and the handwriting appears as though it may belong to an adult. The inscription could have been written retrospectively, however, or by someone else on his behalf, or perhaps the final numeral in the date is a '6', instead of a '0'.

This Alexander Stewart is particularly interesting, nevertheless, as he was related to the Robertsons of Lude (the family to whom the Lamont harp belonged) through his grandmother, Margaret Robertson of Faskally, the daughter of Alexander Robertson, 7th of Lude.[347] Margaret's grandparents were John Tarlochson/Robertson and Beatrix Gardyn (the same Beatrix Gardyn who is purported to have been gifted the harp now known as the 'Queen Mary' by Mary Queen of Scots).[348] Margaret Robertson is

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[344] Keith Sanger, e-mail messages to author, 1 July, 2011; 11 February, 2013; and 2 March 2013.
[345] For an historical map of the area around Lude, see Sanger, "The Robertson Family and Their Harps." There was a Clunie and Wester Clunie approximately 5 miles south of Lude (3 miles north of present day Pitlochry in Perth and Kinross), and a Cluniemor on the Lude barony.
[346] Charles Poyntz Stewart, ed., *Historic Memorials of the Stewarts of Forthergill Perthshire and Their Male Descendants* (Edinburgh & London: W & A. K. Johnston, 1879), 27 – 28.
[347] ibid. Faskally is situated across the river Tummel from Clunie.
[348] Sanger and Kinnaird, *Tree of Strings*, 214; Archibald Robertson Small, *Genealogy of the Robertson, Small, and Related Families* (Indianapolis: Albert Garret Small, 1907), 23. See also Sanger, "The Robertson Family and Their Harps."

interesting in her own right for having compiled a 260 page manuscript miscellany of 175 Scots and English poems and songs from the 16th and early 17th centuries.[349] This miscellany, originally dating from 1630, survives as a 19th-century copy at the National Library of Scotland (NLS MS 15937), and is examined in detail in the PhD dissertation of Verweij (2008).[350] Although the Robertson miscellany does not contain notated music, many of the song texts appear in other sources with music (for example several are in John Dowland's *The First Booke of Songes or Ayres)*, and as such it provides some insight into the musical world of the family that owned both the Lamont and Queen Mary harps.[351] Noting the research of Sanger and Kinnaird, Verweij (2008) makes the point that "musical activity appears continuously, not only in the household of Lude, but throughout the Atholl area."[352] He goes on to state that

> "Whereas it is difficult to assess the level of interaction between (Gaelic) folk culture and Scots or English music, still the two strands reinforce the idea that the Robertsons of Lude were a sophisticated and cultured family, and connected to the music of the Gaelic Highlands as strongly as to the latest love-lyrics (and perhaps even the music) from London."[353]

The Robertsons of Lude were apparently more than a family who happened to have a couple of harps; they were engaged in the musical world both in their immediate surroundings and farther afield. As Sanger and Kinnaird (1992) note, the Atholl area of present day Perth and Kinross, which includes Lude, was at a geographical and cultural crossroad between the Gaelic highlands and Scots lowlands, and enjoyed a rich and active musical scene, particularly with respect to the harp.[354] With these

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[349] David Stewart, *Sketches of the Highlanders*, vol. ii, Appendix xxix, quoted in C. P. Stewart, *Historic Memorials of the Stewarts of Forthergill Perthshire and Their Male Descendants* (Edinburgh & London: W & A. K. Johnston, 1879), 27.
[350] Sebastiaan Johan Verweij, "'The inlegebill scribbling of my imprompt pen': the production and circulation of literary miscellany manuscripts in Jacobean Scotland, c. 1580 – 1630" (PhD diss., University of Glasgow, 2008), 140 – 200. Accessed 28 July, 2014, http://theses.gla.ac.uk/329/1/2008_VerweijPhD.pdf. The author gratefully acknowledges Keith Sanger for bringing this dissertation to her attention.
[351] ibid., 184.
[352] ibid., 148.
[353] ibid., 148 – 49.
[354] Sanger and Kinnaird, *Tree of* Strings, 145 – 52.

facts in mind, it is not surprising that Margaret Robertson compiled a miscellany of the poetry and music that would have been very much a part of life in the Lude household. While it is only possible to speculate as to the identity of the Al Stewart whose name is inscribed on the Lamont harp, it is interesting to consider that it could have been her grandson.

The second item of written text on the Lamont soundbox was discovered inside it in 2010, during examination of the harp by the author. Its location in the soundbox is shown in figure 3.75. This item is a fragment of a document written on vellum. It consists of a rectangular piece, 7.5 x 33 cm in size, which has been glued to the inside of the soundbox to patch the crack that runs above the "AL Stewar[t] of CLunie ..." inscription described above. This crack and its repair with the vellum patch are mentioned in Loomis et al. (2012) and discussed in detail in Loomis (2010).[355] One corner of the vellum lies next to the lower right-hand soundhole, where there are scratches associated with string replacement, as described earlier. There are numerous such scratches on this corner of the vellum, indicating that it was placed in the harp during the working life of the instrument, and is not a later, post-historical addition.[356]

[355] "Structural Breaks and Repairs," 12 - 16; Loomis et al., "Lamont and Queen Mary Harps," 118.

[356] This corner has come away from the wood, and there are no visible scratches on the wood underneath it. This could either imply that the vellum patch is an early repair, or that the harp was being restrung through the string holes instead of the sound holes prior to the placement of the patch in the soundbox.

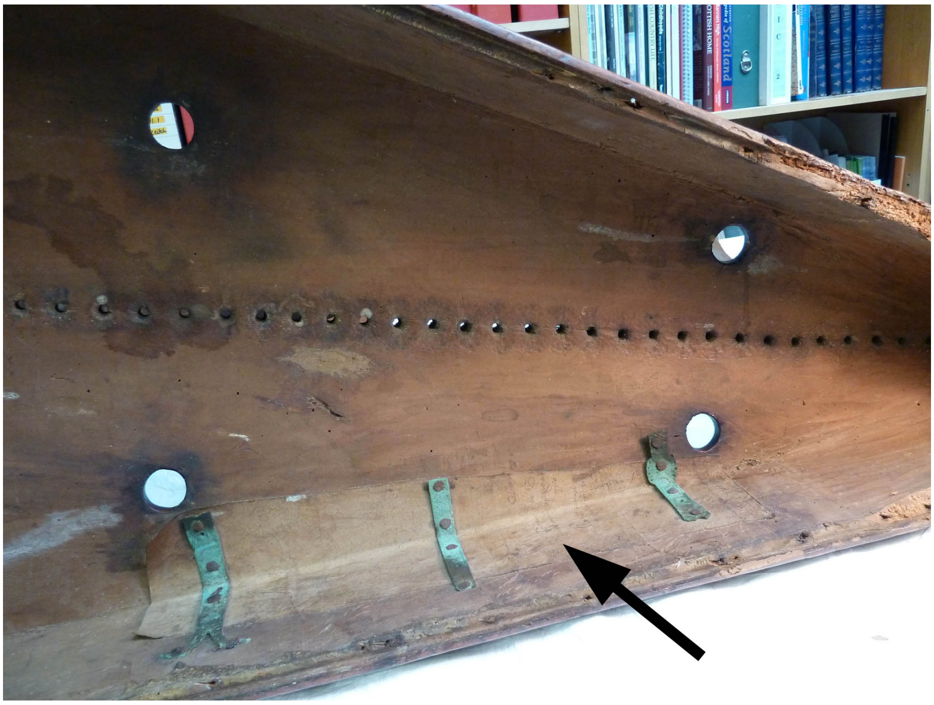

Figure 3.75: *fragment of a vellum document used to patch a crack in the soundbox of the Lamont harp. The vellum is glued to the soundbox interior, and has three copper alloy straps nailed over it. There is a fragment of writing on it in what appears to be a 17th-century hand. The location of the handwriting is indicated by the arrow.*[357]

Figure 3.76 shows the text on the document. It is written in what may be an early 17th-century hand, and appears to be the endorsement for a charter, which is presumably written on the other side of the vellum.[358]

[357] A version of this figure appears in Loomis, "Structural Breaks and Repairs," 16.
[358] David Caldwell and Keith Sanger, personal communication, July, 2010.

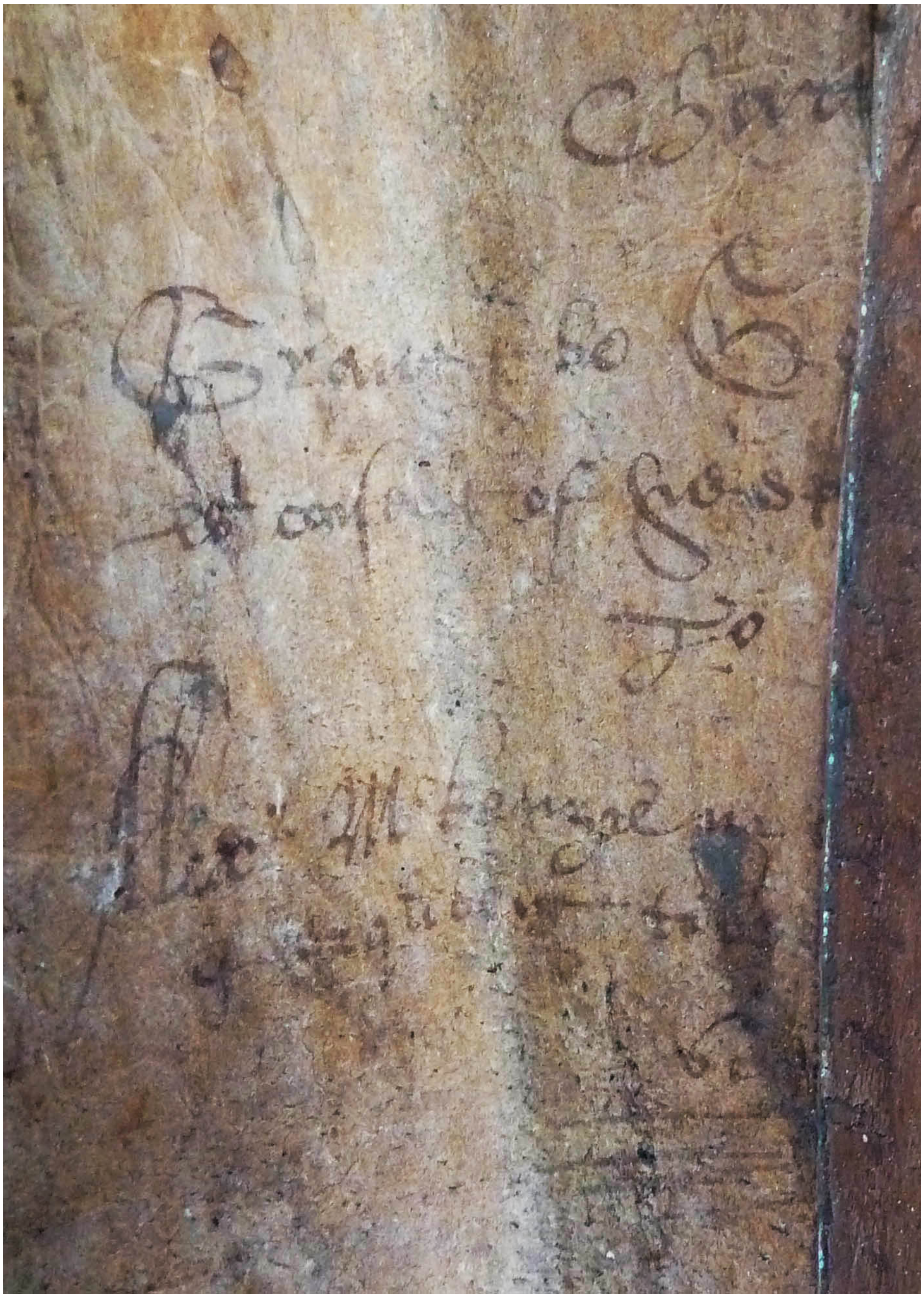

Figure 3.76: *fragment of text on a vellum document glued to the inside of the Lamont harp soundbox, as shown in figure 3.75. The contrast of this photograph has been enhanced to make the handwriting more visible.*

The text is only partially legible, and is cut-off on the right hand side. It reads as follows:

*Chart_*

*Grantit be Ge_*
Wt consent of his
*sp_*
To

Alex McKenzie in ...
at(?) urqll beg(?) t...
6...[359]

There is a cut-off letter at the edge of the document, after the word "in" following Alex McKenzie, so there was at least one additional word in this line. The line below the name is illegible, but may contain a place name. Keith Sanger has read this as *urqll beg* (or *wrqll beg*), possibly preceded by "at" or "of".[360] The final word in this line has not yet been deciphered. Since the discovery of this document, Sanger has undertaken extensive archival research in order to place it in context and therefore determine a lower limit for the date of the repair to the soundbox. What follows is a summary of the results of his research identifying and dating the document.[361]

Sanger has ascertained that this document may have been for a 'tack' (a lease of land) for Urchillbeg from George Stewart to Alexander McKenzie.[362] The area of Urchillbeg was within present day Orchill Mains, which lies along the River Garry mid-way between Blair Atholl and Killiecrankie, near the south-east border of the Lude estate. He also notes that, although tacks at this time were often verbal agreements, this one apparently required the consent of Stewart's spouse (presumably because she held the rights to the land), and therefore would have been less

[359] David Caldwell and Keith Sanger, July, 2010; Keith Sanger, e-mail message to author, 11 January, 2013. An earlier transcription of the text is appears in Loomis et al., "Lamont and Queen Mary Harps," 118.
[360] Sanger, 11 January, 2013.
[361] Keith Sanger, e-mail message to author, 6 June, 2014.
[362] George Stewart is not directly related to Alexander Stewart of Wester Clunie, but in light of their proximity in time and place they may have belonged to the same extended family.

straightforward and more likely to have been recorded. The date of this transaction has been narrowed down based on the style '***of*** Urchillbeg' adopted alternatively by George Stewart and Alexander McKenzie in other documents (the inference being that the person who styles himself as 'of' the location is in possession of the land at that time).[363] As the land would have reverted back to Stewart at the expiration of the tack, the dates during which McKenzie styles himself 'of Urchillbeg' indicate the years the tack was in effect. Based on other documents in which McKenzie and Stewart are named, this was sometime between 1617 and 1621.[364] This means that, if the document in the harp is the one upon which the transaction for Urchillbeg was recorded, it dates to no earlier than 1617, and ceased to be relevant no later than 1621, after the tack had expired.[365] The date 1621 is also significant as the year Alexander Tarlochson (alias Robertson) regained by purchase the family estate of Lude, which had been signed over to the Ogilvy family a century earlier.[366] Sanger notes that the years 1621 – 1623 were a time of intense activity establishing and improving the Robertson's newly re-acquired estate at Lude, and suggests that the repair of the harp could plausibly have been done at this time. The document would no longer have been of use, but may still have been close at hand if a person was looking for something suitable to use as a patch for a cracked soundbox.[367] George Stewart and Alexander McKenzie appear on other documents together with Alexander and John Tarlochson / Robertson, establishing their connection to the family that owned the Lamont harp.[368] Notably, in 1624, Alexander McKenzie is named as a member of the Barony Court assize for the estate of Lude, and in 1636 he is named as Baillie to Alexander Robertson of Lude.[369]

While the identity of the vellum document has not yet been confirmed, if it relates to the circa 1617 tack described above, it is likely that the vellum patch was put in the soundbox after 1621. As Sanger suggests this would most likely have occurred

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[363] Keith Sanger, e-mail message to author, 12 August, 2010.
[364] Sanger, e-mail message to author, 6 June, 2014.
[365] ibid.
[366] Sanger, "The Robertson Family and Their Harps."
[367] Keith Sanger, e-mail message to author, 6 April, 2014.
[368] Sanger, e-mail message to author, 12 August, 2010.
[369] ibid.

sometime in the years immediately following this date, when the document would have still been at hand, and Robertson would plausibly have had a motivation for repairing a harp, possibly an old one that had been handed down in the family, as a symbol of the family's newly reestablished status.[370]

In Loomis (2010), it was ascertained that the crack that was patched with this piece of vellum occurred when the belly of the harp rose under the tension of the strings.[371] This implies that the crack occurred when the soundbox was new, although it is also possible that a significant increase in string tension at a later date could have had the same effect. As discussed earlier, there is evidence that the string tension may have been increased at some point during its working life of this harp. Another possibility is that this is an older crack that had been repaired previously and required a second repair. David Caldwell's initial assessment of the metal straps nailed over the vellum is that the decorative work is consistent with 15th-century West Highland art.[372] They appear to have been repurposed from some other object, and Caldwell has speculated that they could have originally belonged to a casket similar to NMS H.UD 10, which dates to the late 15th – early 16th century.[373] Caldwell (1982) notes that caskets like this may have been common in the West Highlands in this time period, as they are depicted on a number of grave slabs in the region.[374] Figures 3.77 – 3.79 show the decorative work on the straps. If they date to an earlier repair, they would have been removed when the vellum patch was glued into the soundbox, and then nailed back over it.

[370] Sanger, e-mail message to author, 6 June, 2014.
[371] Loomis, "Structural Breaks and Repairs," 12 – 16.
[372] David Caldwell, personal communication 15 July, 2010.
[373] For a photograph of NMS H.UD 10, see "Casket from Eglinton Castle, Ayrshire," National Museums Scotland, accessed 2 August, 2014, http://nms.scran.ac.uk/database/record.php?usi=000-100-002-043-C.
[374] David Caldwell, *Angels, Nobles, and Unicorns: Art and Patronage in Medieval Scotland* (Edinburgh: National Museum of Antiquities of Scotland, 1982), 58 – 59.

Figure 3.77: *copper alloy strap inside the Lamont harp soundbox. This strap is nailed over the vellum patch, at the bass end. The nail holes and cut-off end suggest the strap has been reused from elsewhere. Details of the decorative work are shown in the photographs on the right.*

Figure 3.78: *copper alloy strap inside the Lamont harp soundbox. This strap is nailed over the vellum patch at the treble end. As with the strap shown in figure 3.77, the nail hole and cut-off ends suggest it has been reused from elsewhere. Details of the decorative work are shown in the photograph on the right.*

Figure 3.79: *copper alloy strap inside the Lamont harp soundbox. This strap is nailed over the centre of the vellum patch. As with the straps shown in figures 3.77 and 3.78, the nail hole and cut-off end suggest it has been reused from elsewhere. Details of the decorative work are shown in the photograph on the right.*

Although the repair to the soundbox with the vellum document likely dates to sometime shortly after 1621, whether or not the soundbox also dates to this time period is still an open question. This is relevant to the interpretation of the third known item of written text on the Lamont harp soundbox, which is discussed below.

In December 2012, during examination of the interior of the Lamont harp under extreme raking light, a date was discovered inscribed into the wood. This date appears to read: AD 1451. It is shown in figures 3.80 and 3.81, below. Figure 3.82 shows the letter "A" photographed under different lighting to reveal more detail. The date appears to have been tapped into the wood with the flat end of a chisel.[375] Figure

[375] The author gratefully acknowledges Keith Sanger for suggesting that the inscription appears to have been tapped into the wood with the flat end of this tool.

3.83 shows the location of the inscription in the soundbox. It is lightly inscribed and nearly invisible, except under optimal lighting.

Figure 3.80: *a date inscribed inside the Lamont harp soundbox. The date reads AD 1451. The inscription is in the wood, directly above the vellum document (visible along the lower edge of the photograph).*

Figure 3.81: *the inscribed date shown in figure 3.80, under different lighting. Photograph: Isabell Wagner. Scale added by the author.*

Figure 3.82: *detail of the inscription, photographed under lighting to highlight the crossbar in the letter "A".*

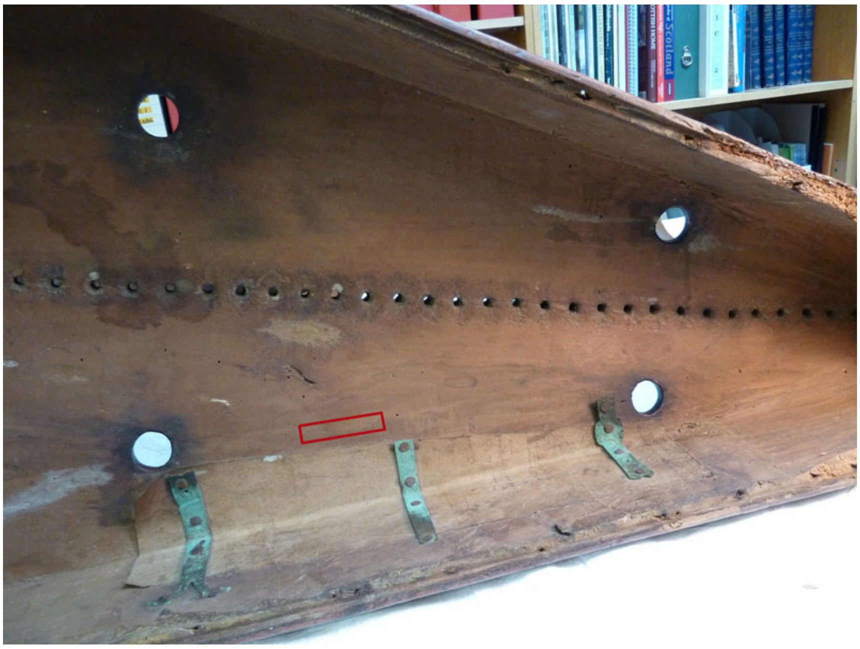

Figure 3.83: *the location of the inscribed date in the Lamont harp soundbox (red box).*

The foremost question pertaining to this date is whether it was inscribed in the soundbox in 1451, or placed there later.[376] The style of the letters and numbers can be

[376] There is evidence that at least some musical instruments were inscribed with a date (and makers name) as early as the 14th and 15th centuries, for example the 1361 Nicholas Faber organ at Halberstadt, and the 1370 Verner organ from Sundre, Gotland. See, Praetorius, *Syntagma musicum, Vol. II*, 98; and Bertil Wester, *Gotisk Resning, I: Svenska Orglar*

examined to determine if it is consistent with the mid 15th century in Scotland. For this, the author is again indebted to the research of Keith Sanger. Figures 3.84 and 3.85 show the dates from the endorsements for two mid 15th century Scottish charters that bracket the date in the Lamont harp soundbox. These are National Records of Scotland GD 132 / 2 and GD 132 / 4.[377]

Image Redacted

Figure 3.84: *dates inscribed on the endorsement to a charter dated 1448. Each side of the outside of the folded charter is inscribed by a different scribe, as is customary (one inscription is the endorsement proper, and the other is an identifier for record keeping). NRS GD 132 / 2 (detail).*

(Stockholm: Generalstabens Litographiska Anstalts Förlag, 1936), 172. A mid 15th-century gittern at Wartburg, Eisenach has a label on the inside of the body with the maker's name. See Herbert Heyde, *Musikinstrumentenbau: 15.–19. Jahrhundert: Kunst, Handwerk, Entwerf* (Leipzig: Deutscher Verlag für Musik, 1986), plate 18. The author gratefully acknowledges John Koster for providing these examples.

[377] The author gratefully acknowledges the National Records of Scotland and Keith Sanger for providing the scans of both charter endorsements, from which these and subsequent figures are derived.

Image Redacted

Figure 3.85: *dates inscribed on the endorsement to a charter dated 1452. As for the 1448 charter, each side of the outside is inscribed by a different scribe. NRS GD 132 / 4 (detail).*

The style of the numerals in figures 3.84 and 3.85 can be compared to those of the Lamont inscription in figures 3.80 and 3.81. Note, however, that the dates in the lower inscriptions in figures 3.84 and 3.85 appear to be in a later hand, so are likely not contemporary with the date on the document.

The date in the Lamont harp soundbox is inscribed in Arabic numerals, and Arabic numerals are also used on the two charters. The numeral "4" in the Lamont harp inscription is closed. Two of the charter dates also have a closed numeral "4" (notably, the two that do not appear to be of a later style of handwriting). The shape of the numeral "5" in the Lamont harp inscription is consistent with the "5" in the 1452 charter, and with the "5" in "25" on the same charter, for both styles of handwriting. The upstroke for the numeral "1" is more pronounced in the Lamont inscription than it is on either of the charters, although it is present on both.

If the endorsements on these charters are contemporary (excluding the two that appear not to be), this comparison suggests that the numerals in the soundbox inscription are at least consistent with the form of numerals found in mid 15th-century Scottish handwriting. It does not exclude the possibility that the date could have been added later, though, as the style of numerals used is not unique to one time period.

It is curious that this inscription was placed inside the soundbox where it would not normally be visible, not even through the sound holes. A possible scenario is that it was placed there at a much later date with the intention of being "discovered" in order to make the harp appear older than it actually is. The most likely circumstance for which there would have been a motive for doing so would have been when the harp was put up for auction in 1904.[378] The auction catalogue describes the harp as dating "probably from the 11th or 12 Century," however, which does not agree with the date inscribed, so it is unlikely that the date was put there for the auction, or that Dowell, the appraiser and auctioneer, was aware it was there.[379] Furthermore, the harp had been continuously on display at the National Museum of Antiquities from 1880 up to the time of the auction, so it is unlikely there would have been an opportunity to add an inscription to the interior of the soundbox.[380] Another opportunity for placing a spurious or retrospective date inside the soundbox could have presented itself when the harp was examined by Gunn, and later Bell, for the Society of Antiquaries. Neither Gunn nor Bell mentions the presence of this date, or of the vellum document also inside the soundbox.[381] As both of these items would have been notable, it is unlikely either was aware of their presence, which suggests that neither had the soundbox open. From the death of John Robertson in 1731 until the harp went on display at the Museum of Antiquities in 1880, the harp appears to otherwise have spent much of its time in storage, either at Lude or, later, at Dalguise.[382] When the harp was still in use, the interior of the soundbox would not have been easily accessible, unless the harp strings were un-tensioned. The last person who could have inscribed this date was Moir Bryce, the antiquarian who

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[378] Sanger, "The Robertson Family and Their Harps."

[379] NMS archive H.LT 1 & 2, *Valuable Antique Furniture: Stuart and Jacobite Collection* ... (Edinburgh: Dowell's, 12 & 14 March, 1904), 10. Sanger notes that the harp was appraised by Alex Dowell upon the death of Steuart in 1903. See Sanger, "The Robertson family and Their Harps."

[380] ibid.

[381] Gunn, *Historical Enquiry*. Charles Bell, "Notice of Two Ancient Harps and Targets," 10 – 16.

[382] Sanger, "The Robertson Family and Their Harps."

purchased the Lamont harp at auction and later bequeathed it to the National Museum of Antiquities of Scotland. He had the harp in his possession until his death, so would have had ample opportunity.

There is evidence that favours an earlier, rather than later, date for the inscription. One point to consider is its location. Inscribing (or tapping in this case) onto the inside of the front of the soundbox with a chisel would be considerably easier with the soundbox lying face down, however with the harp assembled the soundbox can only lie on its side or its back.[383] With the soundbox on its side, which is how the harp would rest with the soundbox open, the natural place to put an interior inscription would be on the side not the front. It is therefore more likely that the date was inscribed when the harp was disassembled.[384] This could have taken place during the repair of the neck, which may have also been when the crack was patched with the vellum document. That would plausibly date the inscription to no earlier than 1621, based on the assessment of the date of that document. The inscription is located just above the vellum document, so it is possible they are associated with each other.

An important piece of evidence stemming from the vellum document is the glue that was used to affix it to the soundbox. A layer of glue was spread onto the area of wood to be patched, and the vellum (probably with glue also applied to it) was placed on top. This is evident from the layer of glue on the wood around the edges of the vellum. Some of this can be seen in figure 3.86, which also shows the inscribed date. The lighting is different from the previous photographs of the inscription, so the glue is more visible. It is evident from this photograph that the layer of glue overlies the inscription. It also appears that the glue has pooled into the inscription in places, for example in the final numeral "1". This would mean that the inscription was already there when the vellum patch was glued into the soundbox. Based on the assessment of the date of the vellum document, it is unlikely, therefore, that the inscription was made any later than the early to mid 17th century, which would rule

[383] Keith Sanger, email to author, 22 January, 2013.
[384] ibid.

out any possibility that it is a post-historical addition to the harp. It could have been done at the time of the repair with the vellum, but why make an inscription in the wood only to carelessly smear glue over it while completing the repairs? It is worth stressing that in the absence of appropriate lighting the inscription is essentially invisible, so whoever glued the vellum into the soundbox may not have been aware it was there. It is therefore probable that the inscription is unrelated to the repair with the vellum, and that it predates it by an as yet unknown amount of time.

Figure 3.86: *excess glue on the wood beyond the edge of the vellum patch in the Lamont soundbox. The glue overlies part of the 1451 date inscribed into the soundbox (arrowed). The edge of the vellum document is visible at the bottom of the photograph.*

Another question with regard to this inscription is the choice of 1451 for the date. Sanger proposes a speculative scenario that may provide some significance for it. The two charters whose dates are shown above relate, as it happens, to the barony of Lude, and it is possible they may be relevant to the 1451 date inscribed in the harp.[385] The 1448 document is a crown charter for Lude, granted to John Donaldson (a forebear of the Robertsons of Lude), and the 1452 document is a new charter, also

[385] Keith Sanger, private communication, 17 January, 2013. E-mail to author 29 June, 2014. See also Sanger, "The Robertson Family and Their Harps."

granted to John Donaldson, elevating Lude to a barony.[386] The endorsements for these two charters are shown in full in figures 3.87 and 3.88.

Image Redacted

Figure 3.87: *endorsements on a crown charter for Lude, granted to John Donaldson in 1448 (NRS GD 132 / 2). Scan: National Records of Scotland.*[387]

[386] ibid.

[387] Provided to the author by Keith Sanger. National Records of Scotland, "Crown charter for Lude, 1448." NRS GD 132 / 2.

Image Redacted

Figure 3.88: *endorsements on a charter establishing the barony of Lude, granted to John Donaldson in 1452 (NRS GD 132 / 4). Scan: National Records of Scotland.*[388]

Sanger has noted that the barony of Lude apparently did not include the nearby land of Clunes (a.k.a. Clunie).[389] The younger of John Donaldson's two sons is identified as Charles (or Tarloch) of Clunes, which may imply he was given Clunie, whereas the elder son, Donald Johnson, was given the inheritance of Lude.[390] It is the 'Charles of Clunes' branch of the Lude family from which the later Robertsons of Lude (who had the two harps) are descended.[391]

[388] Provided to the author by Keith Sanger. National Records of Scotland, "Charter establishing the barony of Lude, 1452." NRS GD 132 / 4.
[389] Keith Sanger, e-mail to author 29 June, 2014.
[390] Sanger, "The Robertson Family and Their Harps."
[391] ibid.

Bell (1880) notes that Burke's Landed Gentry names Lilias Lamont as having married Charles, "fifth laird of Lude," bringing with her the Lamont harp.[392] Although he was never actually a laird of Lude himself, this Charles is the same person as Charles of Clunes, the younger son of John Donaldson of Lude.[393] Even though there is currently no known contemporary written record of the harp being brought from Lamont to Lude (or Clunie), it is notable that at this time members of the hereditary family of harpers to the Lamonts, the 'McEwins', first appear in the areas of Lude and Clunie in association with Charles of Clunes.[394]

With regard to the 1451 date, Sanger notes that this is the year John Lamont, the brother of Lilias, reached the age of legal majority and attained the lairdship of Lamont after having been a ward of the crown.[395] Sanger speculates that Lilias could have been married off soon after her brother became the laird, with the harp possibly forming part of her dowry.[396] If so, that would give significance to the 1451 date in the harp (although this a bit earlier than the circa 1460 date noted by Gunn).[397] It would also provide a reason for the exclusion of Clunie from the barony of Lude that was established in 1452, as it would plausibly have gone to Charles and his wife Lilias, while the elder son, Donald, inherited Lude.[398]

What is most curious about this inscription is its location inside the soundbox where it would not normally be visible, as mentioned earlier. It does not appear to have been intended for public viewing. In light of the possible connection of the 1451 date to the marriage of Lilias Lamont to Charles of Clunes described above, it could conceivably have been inscribed privately by the builder to mark when the harp was

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[392] Bell, "Notice of Two Ancient Harps and Targets," 28. See also Sanger and Kinnaird, *Tree of Strings*, 72; and Keith Sanger, "The 'Lamont' Harp." Sanger has pointed out that the information quoted by Bell is incorrect in that Charles was never a laird of Lude. Keith Sanger, e-mail to author, 22 August, 2014.
[393] Sanger, "The Robertson Family and Their Harps."
[394] Sanger, "The 'Lamont' Harp."
[395] Keith Sanger, private communication, 17 January, 2013; e-mail to author, 29 June, 2014. See also Keith Sanger, "The 'Lamont' Harp."
[396] Keith Sanger, e-mail to author, 29 June, 2014.
[397] Gunn, *Historical Enquiry,* 73. Gunn gives the date of her arrival at Lude as "about the year 1460." Bell gives the date as 1464. Bell, "Notice of Two Ancient Harps and Targets," 15.
[398] Sanger, e-mail to author, 29 June, 2014.

made (as opposed to explicitly commemorating the marriage of Lilias, or the elevation of John Lamont to laird). The soundbox could have been made at the time John Lamont became laird, and the harp given as part of the dowry of Lilias at a later date.

To summarize, although the date of this inscription is unconfirmed, the evidence suggests that it was made when the harp was disassembled, and that it predates the placement of the vellum document in the soundbox. This, and the concurrence of this date with events at Lamont and Lude, suggests the possibility that the date may be authentic. Its placement out of view in a normally inaccessible location suggests it was not intended for public viewing, and that it was placed there by the person most likely to have had access to the disassembled harp at this time, which would have been the builder.[399] It is, therefore, plausible that AD 1451 represents the date of construction of the Lamont harp.

Wear marks

The topics discussed thus far point to a long working life for the soundbox of the Lamont harp. The wear marks along the edges of the soundbox are also suggestive of long use. This section focuses on the location of the wear, as this information has a direct bearing on performance practice for this instrument.

Historically, the Irish harp was played resting on the left shoulder with the left hand playing the treble strings and the right hand the bass strings.[400] This was observed first-hand by Edward Bunting in the late 18th century, and is also apparent from the wear marks on the surviving instruments.[401] The harpist Mary Rowland observed the wear marks on the soundbox of the Trinity College harp when she played it for the

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[399] Although there is no name with the date, given its location there is the possibility that some of the inscription may be hidden behind the vellum.
[400] Bunting, *Ancient Music of Ireland*, 24, note a. Armstrong, *Irish and Highland Harps*, 36. Rimmer, *Irish Harp*, 2.
[401] ibid.

BBC in 1961.[402] An extract of her report on playing this harp contains the following statement:

> "The first time this harp was handled by me it became immediately apparent that the deep wear marks on the soundbox gave absolute indication as to the way it was held, i.e. on the left shoulder, with the left hand playing the treble strings and the right hand the bass. This is the reverse order to all modern harps, which are placed on the right shoulder, with the right hand playing above the left as a general rule, though both hands can be used at will anywhere within the compass of a modern harp. This is not so with the Trinity College harp, for the depth of the wear marks also indicated that the harp had been held in position on its keel by the arms or wrists while playing, thus giving each hand only a limited range of action."[403]

A photograph of Rowland taken at the time she made these observations shows her holding the Trinity College harp with her arms positioned in the wear marks. This photograph is reproduced in figure 3.89.

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[402] Mary Rowland, "Report on Playing the Trinity College, Dublin, Harp," 14 October, 1961, in British Museum conservation report, "15th c. Irish harp formerly known as the Brian Boru harp & now known as the TCD harp," PR02231.
[403] ibid.

Figure 3.89: *harpist Mary Rowland holding the Trinity College harp with her wrists resting on the wear marks.*[404]

The soundbox of the Lamont harp has wear marks similar to those on the Trinity College harp. These are shown in the photographs in figure 3.90.

[404] British Museum, conservation report, "TCD harp." Photograph © The British Museum, used with the permission of The British Museum and The Board of Trinity College, Dublin.

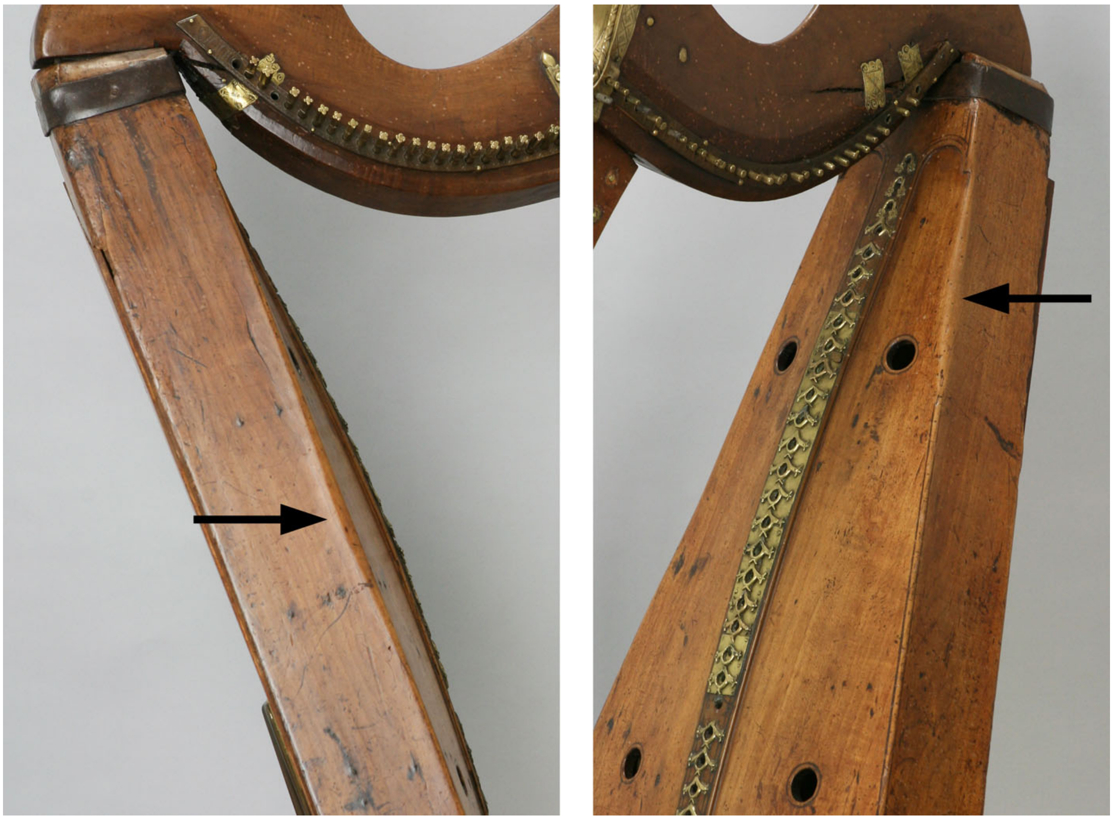

Figure 3.90: *wear marks on the edges of the Lamont harp soundbox (arrowed). The wear is the result of the player's wrist and forearm contacting the edge of the box as illustrated by Mary Rowland in figure 3.89.*

There is a single very well defined worn area along the edge of each side of the Lamont harp soundbox. This is illustrated in figure 3.91. The red lines in this figure indicate the extent of visible wear along each edge of the soundbox, and the arrows indicate the location of maximum wear. Present day musicians playing harps modeled after the Lamont may wish to take the position of these wear marks into consideration when interpreting historical repertory and performance practice. If the position of the wrist or forearm is different to what has been observed on the original instrument, then there is something different in the manner in which the instrument is being held and played.

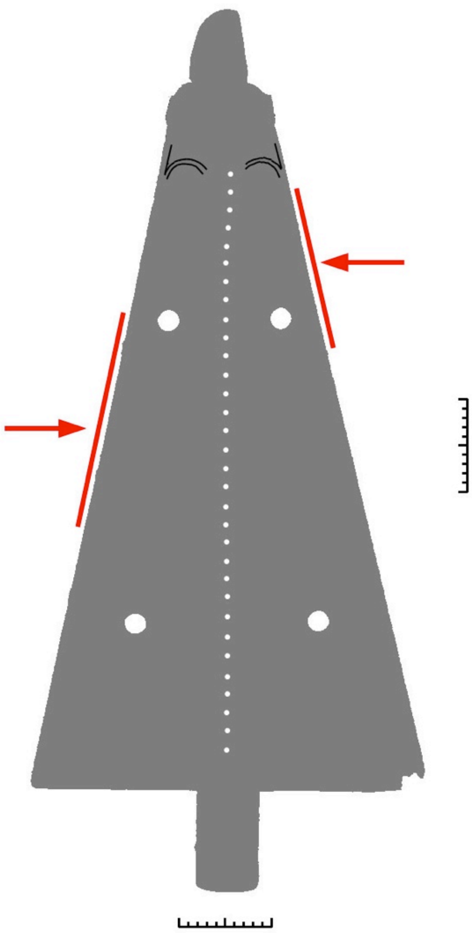

Figure 3.91: *illustration of the location of wear on the edges of the Lamont harp soundbox. The red lines indicate the extent of the visible wear, and the arrows indicate the location of maximum wear. Scale 1 tick : 1 cm.*

Soundboard thickness[405]

The soundboard is arguably one of the most important acoustical elements of any stringed instrument, however, prior to the current study, there existed only very limited information on the soundboard thickness for any of the surviving Irish harps.[406] The few measurements that were available had only been taken at the sound

[405] This discussion is adapted from Loomis et al., "Lamont and Queen Mary Harps,"126 – 28.
[406] For Irish harps, the front face of the carved out soundbox acts as the 'soundboard'. So, although it is not a separate board, for the purpose of this discussion, it is referred to here simply as the 'soundboard'.

holes. Armstrong's published measurements for the Lamont harp soundboard thickness are 3/8-inch (10 mm) at both the upper and lower sound holes.[407] A data sheet in the National Museums Scotland archives gives 11/32 – 3/8 inch (9 – 10 mm) for the thickness at the sound holes, essentially the same measurements.[408] With the data from the CT scans, it was possible to measure the entire soundboard of both the Lamont and the Queen Mary harps, and generate a complete contour map of the thickness.

To obtain these measurements, cross-sections of the soundbox were taken from one of the CT scans and the soundboard thickness was measured at several locations on each. The thickness at each location was determined from the FWHM of the cross-sectional profile, normal to the surface. The resolution of these measurements is 0.5 mm. A 3 cm × 3 cm sampling grid was used, with additional measurements along the edges of the soundbox and in areas of abrupt change in thickness (for example at the edge of the string band). Due to image artefacts associated with the metal string shoes, it was only possible to take a limited number of measurements on the string band. The mapping of the soundboard thickness in this location is therefore much less reliable. There was also the issue of the piece of vellum glued to the right hand edge of the interior of the soundbox, which added to the thickness.[409] The vellum and layer of glue measure approximately 0.5 mm thick and measurements taken through the vellum have been adjusted by this amount.

The resulting contour map of the Lamont harp soundboard thickness is presented in figure 3.92.[410] Each contour represents a change in thickness of 0.5 mm. The coordinate system is that of the CT scanner, with the exception that the scanner's z-axis is referred to on the contour map as the y-axis. For reference, the positions of the string holes and sound holes were measured and added manually.

[407] Armstrong, *Irish and Highland Harps*, 61, and 168 – 69.
[408] Data sheet, "Harp Measurements" (H. LT2 archive, National Museums of Scotland, undated).
[409] The vellum extends from the upper sound hole to just below the lower soundhole. It is affixed at an angle to the edge of the box and covers 2 cm to 5 cm of the front surface from the right-hand edge of the soundbox, starting from the upper sound hole.
[410] The contour maps were generated using the Aabel v. 3.0.5 graphing programme. A version of this figure appears in Loomis et al., "Lamont and Queen Mary Harps," 167.

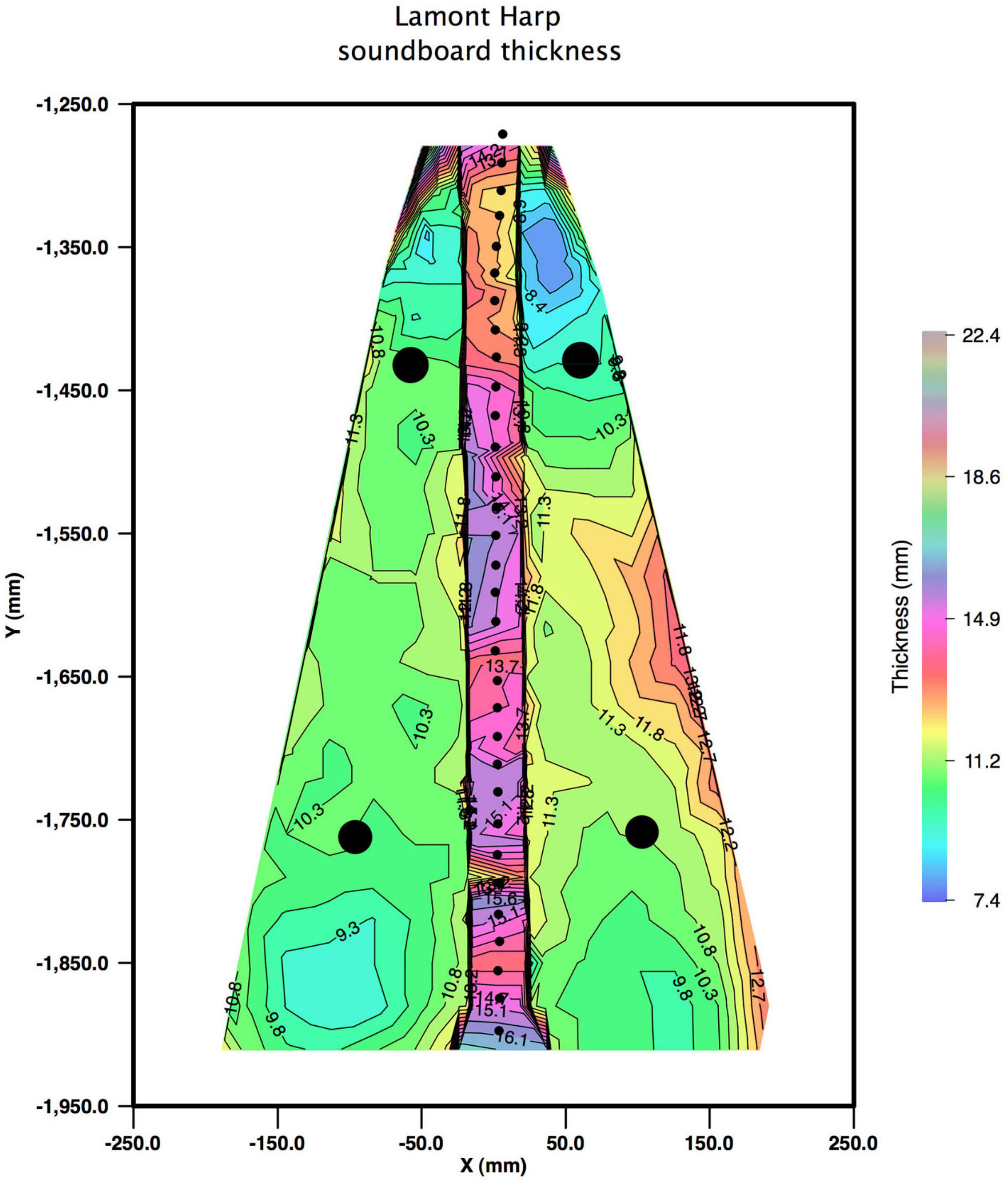

Figure 3.92: *contour map of the Lamont harp soundboard. The treble end of the soundbox is at the top of the figure. Thickness increases towards the red end of the colour spectrum (with the exception of the thickest contours on the string band, which wrap back to the blue). Each contour represents a change in thickness of 0.5 mm. The colours used in this map represent the same thicknesses in the contour map of the Queen Mary harp soundboard (figure 4.98).*

The contour map of the soundboard thickness shows that the Lamont harp soundboard is roughly 10 – 11 mm thick near the sound holes, in agreement with Armstrong's measurements quoted above. Importantly, it has revealed that the soundboard is not of uniform thickness. It is thinner in the treble, decreasing from approximately 10 mm at the upper sound holes to around 8.5 mm on the right-hand side of the harp and 8 mm on the left-hand side (this area of the soundboard also appears to be thinner overall on the left-hand side). This represents a change in thickness of 15 – 20%. Some of this may be due to later thinning of the interior of the soundbox, as suggested by the tool marks shown in figure 3.70, although these are primarily confined to the sides of the box, so some of the observed difference in thickness is likely to be original to the construction of the soundbox. Interestingly, the midsection of the soundboard is thicker on the left-hand side of the harp, where the thickness increases by about 20%, from 11 mm to 13.5 mm towards the left-hand edge. At the bass end of the soundbox, there are also two areas, symmetrically located on either side of the string band, where the thickness decreases by about 1mm, from 10.5 mm to 9.5 mm. This represents a change of roughly 10%.

These contours may have resulted from a combination of the practicalities of working the wood, the need for mechanical stability of the box, and some intentional tuning of the soundbox. They may, however, simply be unintentional variations left by the builder. As will be seen in the next chapter, there are similarities with the pattern of thickness variations observed in the contour map of the Queen Mary harp soundboard, which suggests that the contouring may have been intentional. The thinner treble, in particular, reduces the stiffness where the soundbox is narrow, enabling it to vibrate more easily. This would have an effect on the quality of tone of the treble strings, and it is a standard feature of the soundboards of modern harps to have the thickness taper from bass to treble for this reason.[411] It is therefore plausible that the soundboard was intentionally made thinner in the treble. Possible reasons for the left-right asymmetry in the middle are less obvious. The acoustical and mechanical effects should be examined, though, as they could prove to be interesting.

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411 Chris Waltham, and Andrzej Kotlicki, "Vibrational Characteristics of Harp Soundboards", *Journal of the Acoustical Society of America* 124 (2008), 1775.

The two slightly thinner areas of the soundboard located either side of the string band near the bass end are also interesting. Based on examination of the soundbox interior, this does not appear to be a later modification. The difference in thickness is however quite small, so this may simply be an unintended consequence of the way in which the wood was worked.

Decorative work

The decorative work on the soundbox consists of a pair of lines following the edge of the string band around the eyebrows, and a single line down the sides of the box and around the sound holes. Armstrong describes these lines as "apparently burned in by a hot iron."[412] These decorative lines are not discussed further here except to note that upon visual inspection it was not possible to tell conclusively if they were burned in, although their appearance is consistent with this method. They are shown in detail in figure 3.93, below.

[412] Armstrong, *Irish and Highland Harps*, 161 – 62.

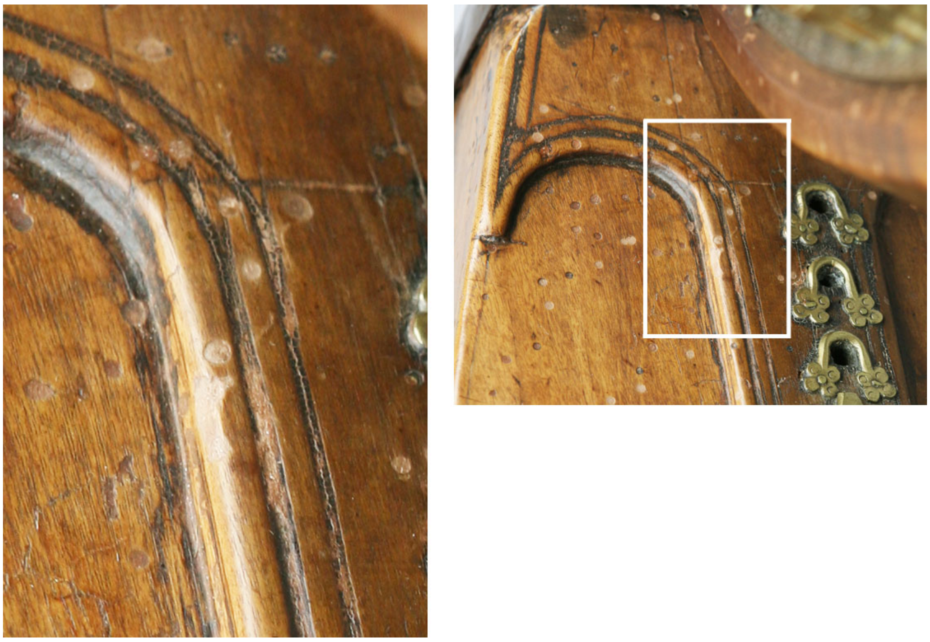


Figure 3.93: *decorative lines on the Lamont harp soundbox. The area inside the rectangle in the photograph on the right is shown enlarged on the left. Photograph: Maripat Goodwin.*

Summary

In terms of construction, the examination of the soundbox of the Lamont harp has shown that it incorporates some features that are particularly advantageous to the acoustics of the instrument and the structure of the frame. The profiled 'soundboard' (the front face of the soundbox) compensates for the increased stiffness at the narrower treble end of the box by being thinner at that end, and the through mortise at the joint with the neck (discussed in Chapter 2) allows for additional flexibility that has a structural as well as an acoustical advantage. The alignment of this through mortise parallel to the long axis of the soundbox does, however, make this joint and the back of the soundbox susceptible to damage by the neck tenon.

The size of the string holes is an interesting and notable feature in that they are large in comparison to the string holes on the later, high-headed harps. This is also true for the string holes on the Queen Mary and Trinity College harps, and it is possible that these earlier harps were originally designed to be restrung by inserting a relatively narrow (metal) toggle directly into the string hole rather than restringing via the sound holes.

The soundbox of the Lamont harp shows signs of having had a long working life. This is evident in the wear on the metal string shoes, the number of toggle marks around the string holes, and the number of scratches left by restringing through the sound holes. Since the end of the working life of this harp is understood to coincide with the death of John Robertson of Lude in 1731, the wear and the quantity of restringing marks suggests an early date for its construction, possibly as early as the late 15th century.

The soundbox also shows evidence of damage and repair, much of which has been discussed in the author's master's thesis on the structural breaks and repairs to the Queen Mary and Lamont harps. Examination of the vellum document associated with the repair to the crack in the soundbox side has shown that this repair was made during the working life of the harp. Research conducted by Keith Sanger on the handwritten text on this document has led to a likely identification and dating of it that points to a date of repair sometime in the second quarter of the 17th century. The metal straps nailed over this document may be of a much earlier, 15th-century design, however, as suggested by David Caldwell.

Perhaps most significantly, the soundbox has the date AD 1451 inscribed in it. While it is not yet known if this inscription genuinely dates to the mid 15th century, it has been established that it predates the placement of the vellum document in the soundbox. Research conducted by Keith Sanger has shown that the style of the numerals is at least consistent with written numerals for Scotland in the mid 15th century, and that the date itself may be relevant to events taking place within the Lamont and Lude estates. When considered along with the age of the soundbox estimated from the restringing evidence, there is now a reasonably compelling case for AD 1451 being the date of construction of the Lamont harp soundbox.

Cross-sections

The dimensions of the soundbox in its current state are shown in the tomographic cross-sections below. The tomogram in figure 3.94 is a cross-section through the middle of the soundbox. The lines labeled A – E indicate the locations of the vertical cross-sections shown in figures 3.95 – 3.99. For all of these figures, the grey-scaling has been set to accurately represent the location of the physical edge of the wood. The dimensions given are derived from the FWHM of the cross-section. In figures 3.95 – 3.99, the lines in the two left-hand images indicate the location of the cross-section shown on the right, and the measurements shown were taken at the location of the lines indicated on the cross-section. The right-hand side of the harp is on the left, and the view is from the perspective of 'looking up' the soundbox from the bass end. Figure 3.100 is a tomogram of the front of the soundbox, showing the positions of the string and sound holes.

Figure 3.94 (overleaf): *tomographic cross-section of the soundbox of the Lamont harp. This cross-section also shows the neck tenon in the soundbox mortis at the treble end of the box. Note that this joint is offset towards the right-hand side of the soundbox. The outline of the mortise for the forepillar is visible in the projecting foot at the bass end of the box. The lines A – E indicate the locations of the individual cross-sections shown in figures 3.95 – 3.99. Scale 1 tick : 1 cm; grid scale 1 square : 2 cm.*

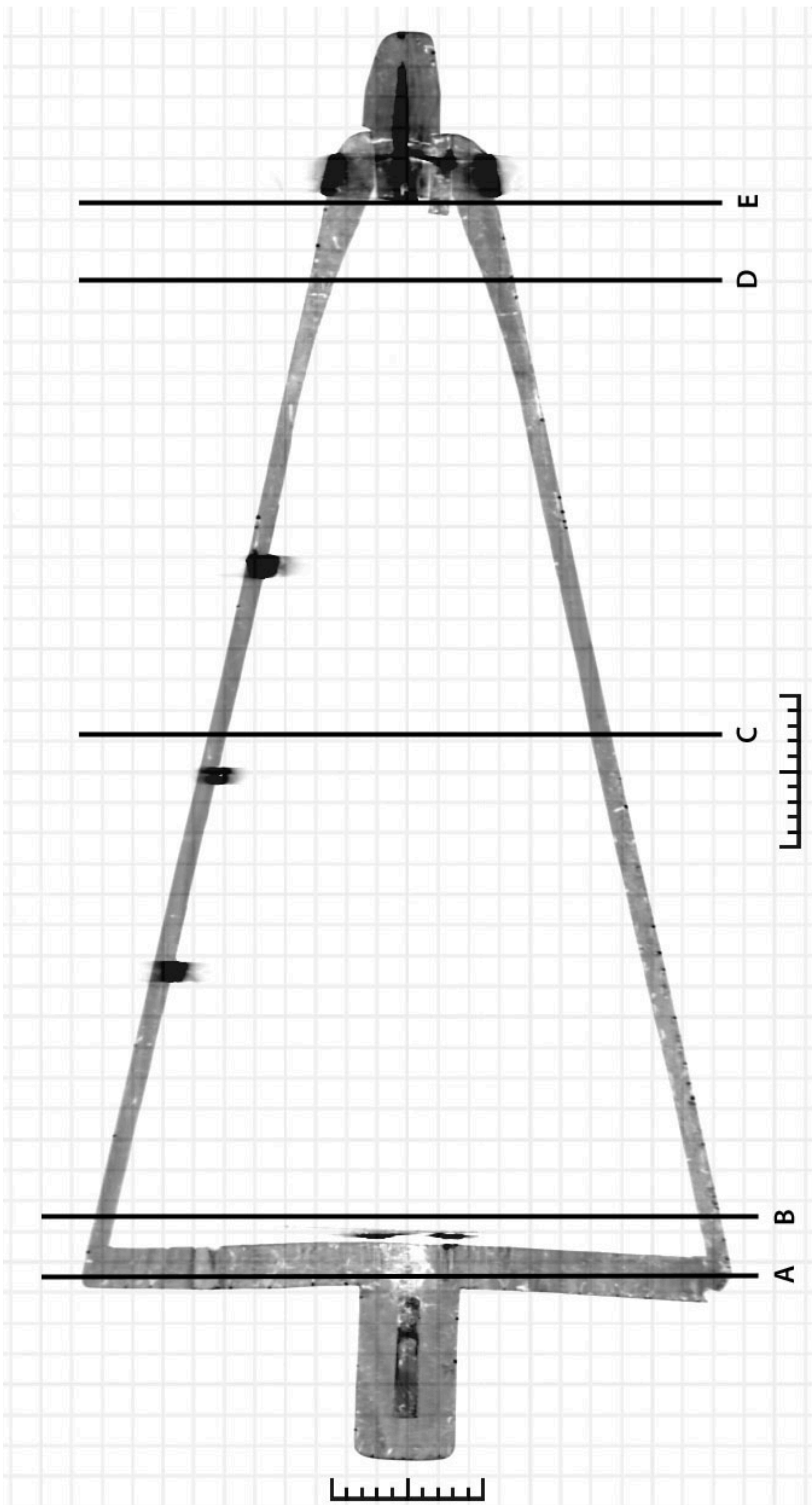
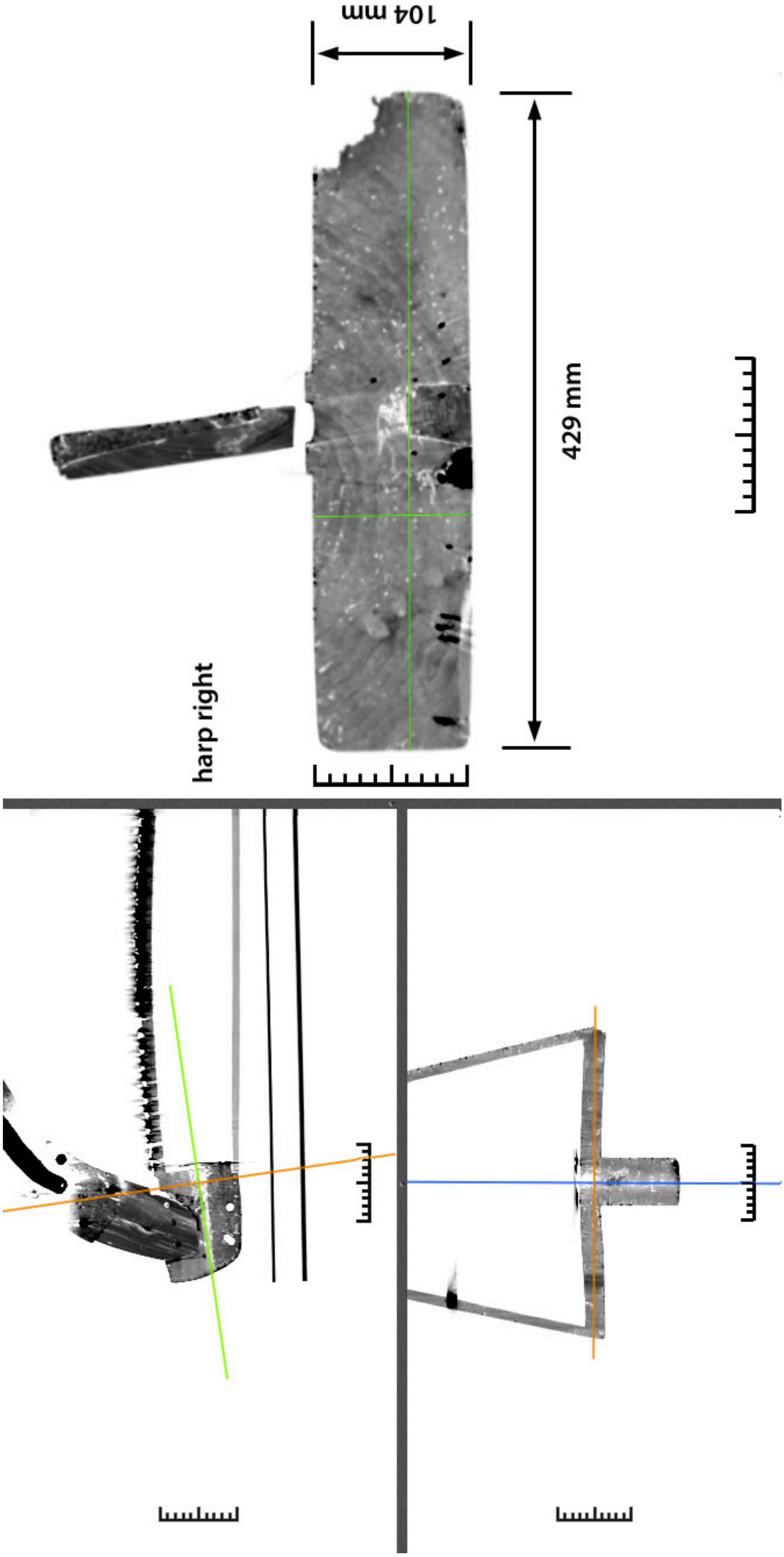
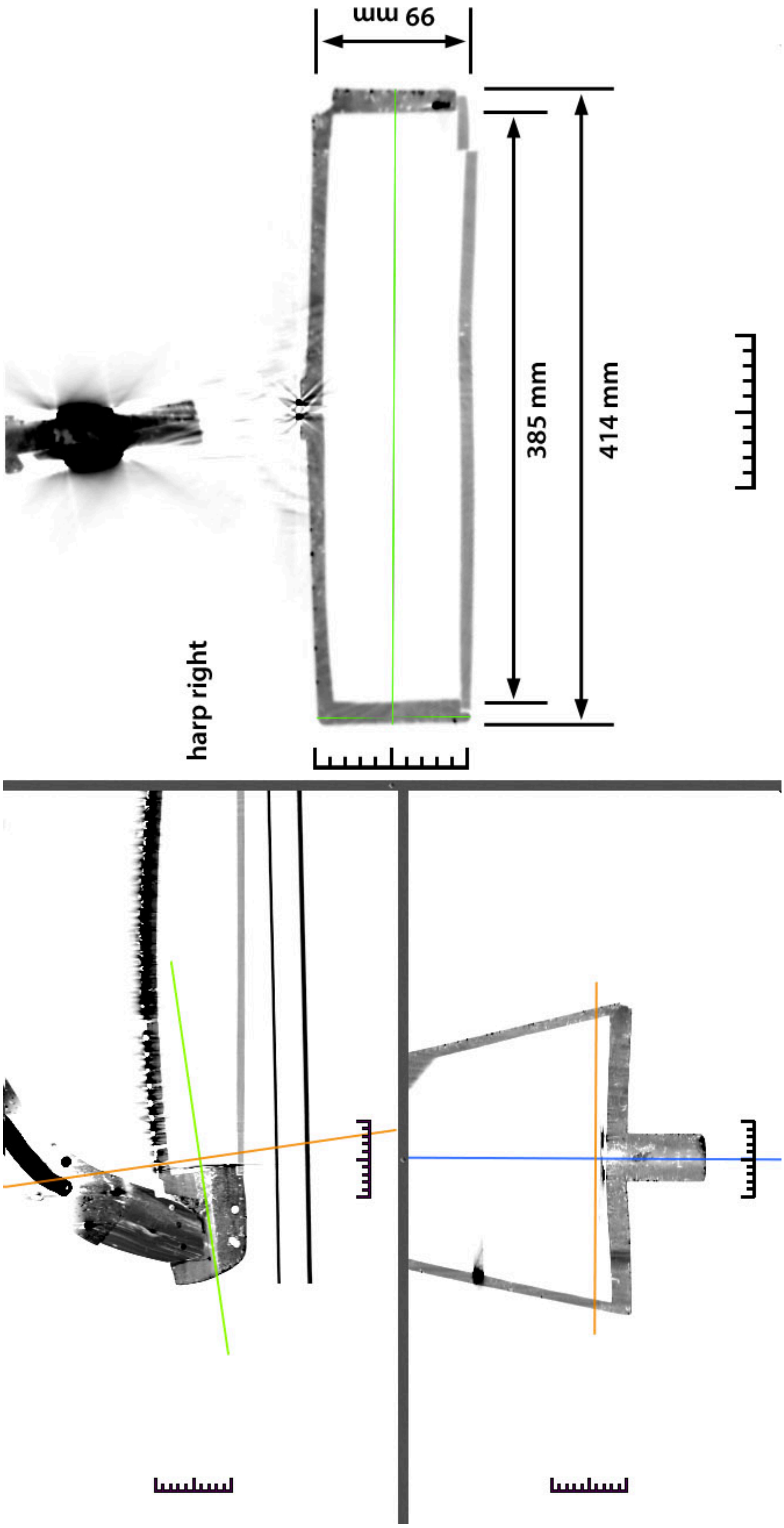

A
B
C
D
E

Figure 3.95 (overleaf): *Lamont soundbox cross-section A (see figure 3.94). This is a cross-section through the bass end of the soundbox, which shows the orientation and pattern of the growth rings. Scale 1 tick : 1 cm.*



104 mm
429 mm
harp right

Figure 3.96 (overleaf): *Lamont soundbox cross-section B (see figure 3.94). The raised string band can be seen in profile at the centre of the front of the soundbox. Note that the interior surface of the soundbox underneath the string band is flat. This makes the soundbox less vulnerable to developing cracks along the edges of the string band. Scale 1 tick : 1 cm.*



99 mm
385 mm
414 mm
harp right

Figure 3.97 (overleaf): *Lamont soundbox cross-section C (see figure 3.94). Scale 1 tick : 1 cm.*

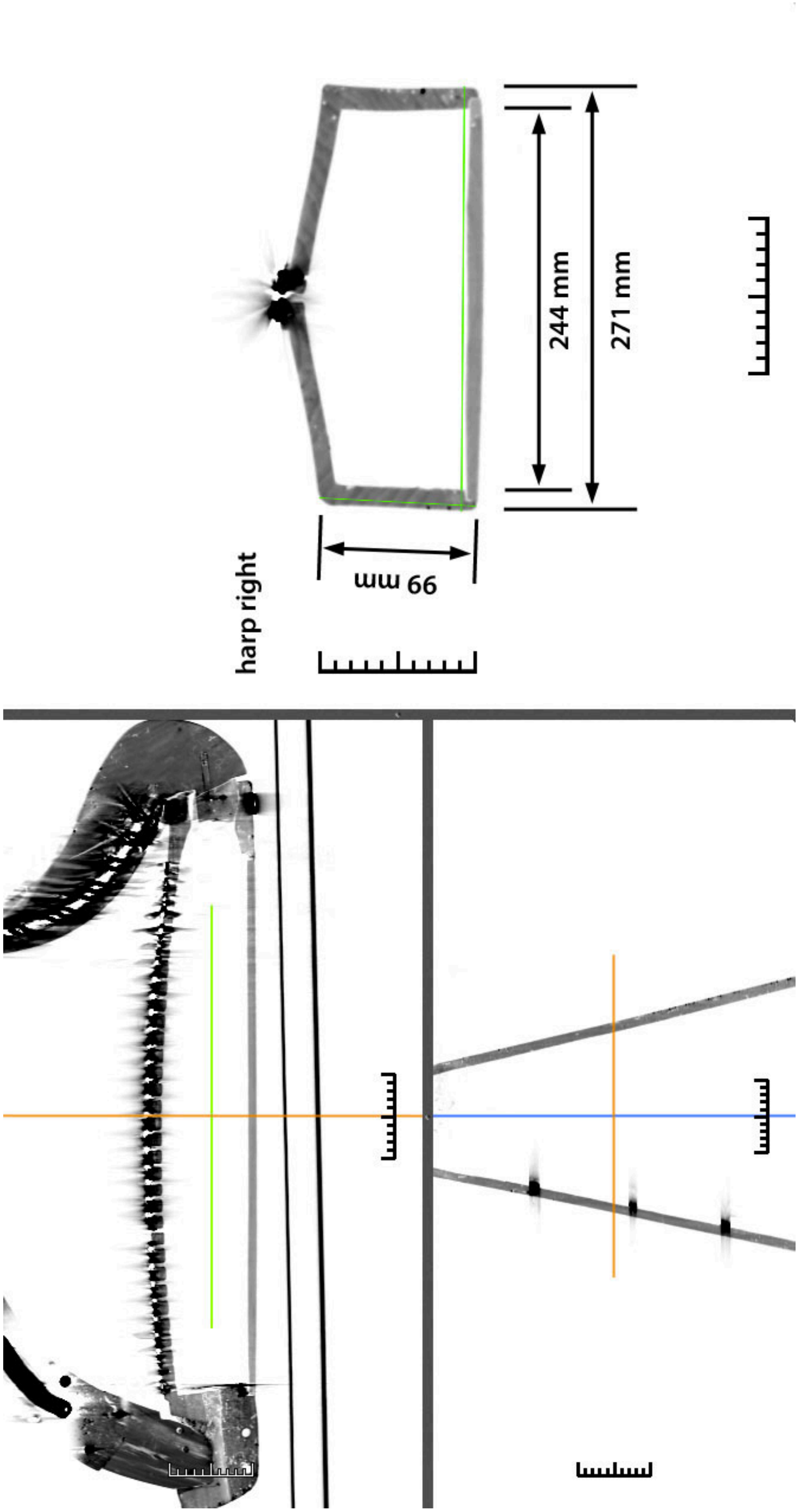
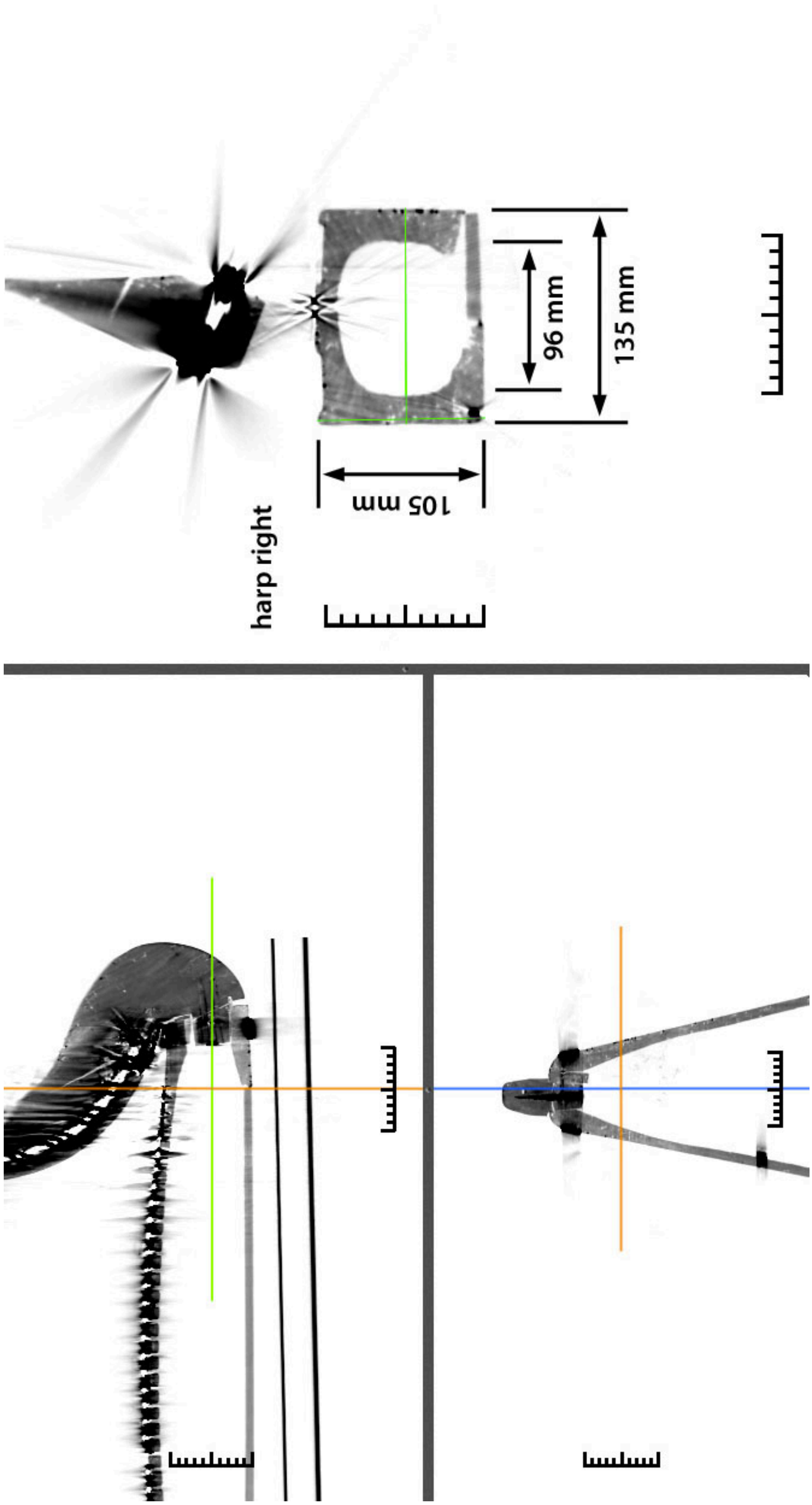
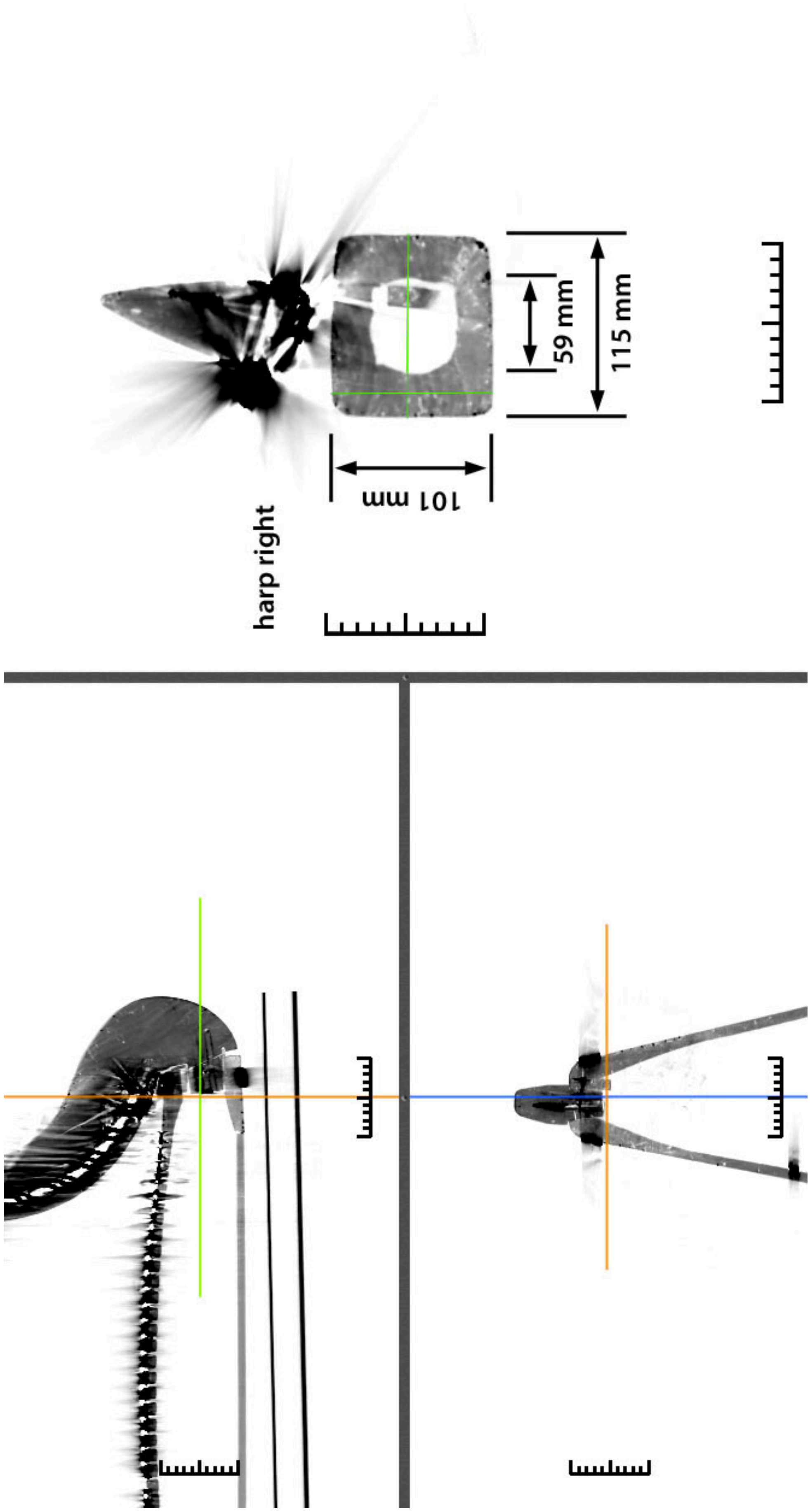

harp right
99 mm
244 mm
271 mm

Figure 3.98 (overleaf): *Lamont soundbox cross-section D (see figure 3.94). Scale 1 tick : 1 cm.*



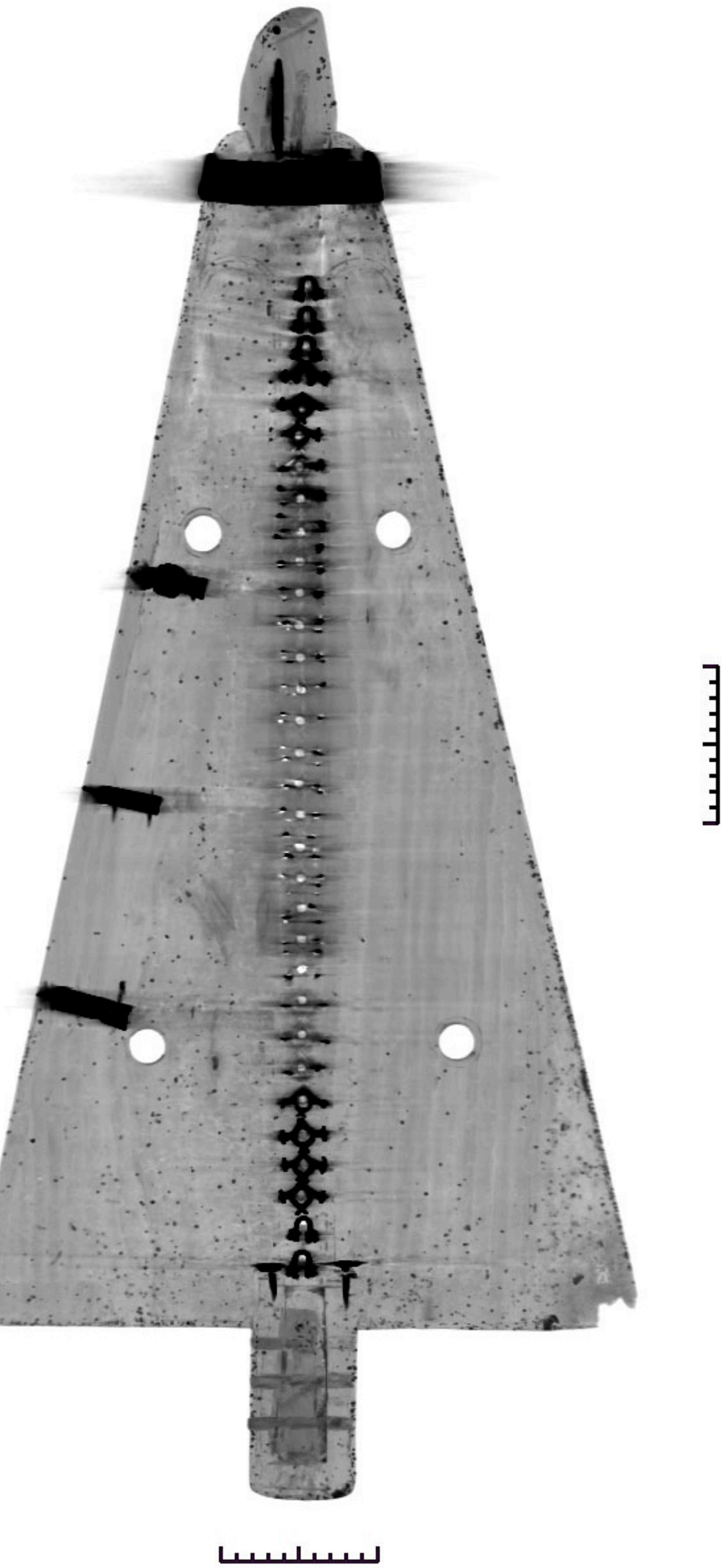
96 mm
135 mm
105 mm
harp right

Figure 3.99 (overleaf): *Lamont soundbox cross-section E (see figure 3.94). Scale 1 tick : 1 cm.*



harp right
59 mm
115 mm
101 mm

Figure 3.100 (overleaf): *tomogram of the front of the Lamont harp soundbox showing the positions of the string holes and sound holes. Because the front of the soundbox is curved due to the belly, in order to show the entire surface this tomogram is a 5.7 cm thick slice. The view is from above the soundbox looking down. The right-hand side of the harp is on the left. Scale 1 tick : 1 cm.*



THE ORGANOLOGY OF THE QUEEN MARY AND LAMONT HARPS

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Part II. Construction (continued)

Chapter 4. The Queen Mary Harp

This chapter presents and discusses details of the construction of the Queen Mary harp not covered in the Part I of this dissertation, and not previously examined in Loomis (2010).[413] This includes the decorative work and materials analyses, as well as signs of wear, repair, and modification not already discussed. Measured cross-sections of the harp are also presented. The chapter is divided into three sections, one devoted to each frame member.

Forepillar

The primary focus of this section is the decorative work of the forepillar. The methods of workmanship and the pigments used are examined, and the style of the decorative work and the motifs used are discussed in the context of identifying its age and place of origin. The summary at the end of this chapter compares and contrasts the different styles of decorative work on this harp as a whole, and discusses the possible implications for the estimated age of the harp.

This chapter section also takes a brief look at the pattern of wood grain in the forepillar, which was first discussed in Loomis (2010).[414] This is an important feature of its construction and relates to the following discussion of the joinery, which is examined in the context of ascertaining if the forepillar is original. Measured cross-sections of the forepillar are presented at the end of the chapter section.

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[413] Loomis, *Structural Breaks and Repairs*, 43 – 73.
[414] ibid., 57 – 58.

The following section examines the decorative work of the forepillar in detail, and places it in the context of time and location of construction.

Decorative work

The forepillar of the Queen Mary harp is extensively covered in carved and incised decorative work. This is discussed and illustrated by Bell (1880), Drummond (in Anderson, 1881), and in extensive detail by Armstrong (1904).[415] Figures 4.1 and 4.2 present an overall view of the forepillar as shown from the right and left sides, and the front, respectively. The two ends of the rounded T-section are carved in the shape of matching zoomorphic heads, with intricate foliaceous designs and interlace carved in low relief extending behind them. The middle third of the T-section is predominantly free of decorative carving, with just a single strip of incised interlace running down its centre. This is embellished with a line of silver bosses. Below the T-section, the flat sides of the forepillar are decorated in incised plant-scrolls, and each end of the forepillar has a roundel containing a beast. The inside curve of the forepillar is decorated with incised interlace, as shown in figure 4.3. Figure 4.5 shows the low relief carving on the T-section as viewed from the front.

Figure 4.1 (overleaf): *the Queen Mary harp forepillar, right side (left) and left side (right). The forepillar has a rounded T-section with plant-scrolls and interlace carved in low relief, and matching zoomorphic heads at each end. The front of the T-section is embellished with a line of metal bosses. Below the T-section, the flat sides of the forepillar are decorated with incised plant-scrolls and a roundel at each end, containing a beast.*

[415] Bell, "Notice of Two Ancient Harps and Targets," 17, 19 – 23. Anderson, *Ancient Scottish Weapons*, 123 – 25 and Plate XLIX. Armstrong, *Irish and Highland Harps,* 172 – 73, and Plate IX.

Figure 4.2: *the Queen Mary harp, showing the forepillar as viewed from the front. This photograph shows the zoomorphic heads, plant-scrolls, and interlace on the T-section, and the line of metal bosses in its centre. Photographs showing the forepillar decorative work in more detail from this angle are shown in figure 4.5. Note the contrast in style of decorative work between the forepillar and the soundbox. Scale in cm.*

Figure 4.3: *photographs of the inner curve of the Queen Mary harp forepillar, showing the incised decorative work. At the lower end of the forepillar there is a geometric interlace, in the mid-section a twisted pair of bands, and in the upper section a geometric design with a central key pattern.*

As can be seen in figure 4.1, and in figure 4.5 (below), each zoomorphic head has its own motif of trailing decorative plant-scrolls. The two sides of the forepillar also each have a slightly different plant-scroll motif running up the flat area just below the T-section. In figure 4.4, which shows the bass end of the forepillar, a cross appears to be sprouting from the plant-scroll. There is also a similar cross on the other side of the forepillar. These crosses are first noted by Armstrong (1904), who speculates (considering the crosses also present on the soundbox) that the Queen Mary harp could have been made for a cleric.[416]

Figure 4.4: *decorative work at the bass end of the Queen Mary harp forepillar. The zoomorphic head and plant-scrolls on the T-section are carved in low relief, and the plant-scrolls on the flat sides of the forepillar are incised. Note the cross sprouting from the plant-scroll on the side.*

The forepillar has traces of red pigment on the T-section, and traces of other pigmentation (which now appears brown) highlighting the incised decorative work on the sides and inside curve (see figure 4.3). As can be seen in the photographs of the T-section in figures 4.5, and 4.6, the traces of red pigment are in and around the

[416] Armstrong, *Irish and Highland Harps*, 175, 180.

carved plant-scrolls, and in the crevices on the zoomorphic head, including a dot of pigment in the nail hole in the center of the eye. The pigments on the forepillar have been noted by Armstrong (1904) and are indicated in his diagram of its decorative work.[417] They are discussed later in this chapter section, following the discussion of the style of decorative work.

[417] Armstrong, *Irish and Highland Harps*, 176 and Plate IX.

Figure 4.5: *details of the zoomorphic heads and plant-scrolls on the T-section, as viewed from the front (top: forepillar upper end; bottom: forepillar lower end). Note the traces of red pigment in the field around the plant-scrolls and above the lip of the upper head.*

Figure 4.6: *detail of the upper zoomorphic head on the Queen Mary harp forepillar, as viewed from the left side. This photograph also shows a detail of the plant-scroll motif incised on the flat side of the forepillar. As in figure 4.5, note the traces of red pigment around the plant-scrolls carved in low relief, above the lip of the zoomorphic figure, and in the nail hole in the centre of the figure's eye. Also note that the incised plant-scrolls on the side are surrounded by areas of darker pigment.*

Figures 4.7 – 4.10 show the beasts depicted in each of the forepillar roundels. These figures are incised and finely detailed. On the left side of the forepillar, the upper roundel contains a griffin (figure 4.7), and the lower roundel contains a wyvern (figure 4.8). On the right side of the forepillar, the upper roundel contains a lion (figure 4.9). The centre of this roundel has been hollowed out, possibly (as Armstrong notes) to hold a mounted crystal or stone.[418] The lower roundel on the right side of the forepillar contains a curious scene with an equine creature, identified as a unicorn by Sanger and Kinnaird (1992), apparently feeding a fish to a two footed creature identified by Chadwick as a lindworm (figure 4.10).[419]

Figure 4.7: *roundel on the Queen Mary harp forepillar, upper left side. This roundel is incised with the figure of a griffin.*

[418] ibid., 175.
[419] Sanger and Kinnaird identify the equine figure as a unicorn based on the cloven hooves and the small horn, which is on the end of the snout rather than the forehead. Sanger and Kinnaird, *Tree of Strings*, 59 – 61. Simon Chadwick, "Unicorns," *Simon Chadwick News and Blog*, 11 November, 2010, http://clarsach.scot/2010/11/unicorns.html.

Figure 4.8: *roundel on the Queen Mary harp forepillar, lower left side. This roundel is incised with the figure of a wyvern.*

Figure 4.9: *roundel on the Queen Mary harp forepillar, upper right side. This roundel is incised with the figure of a lion. The centre of the roundel has been carved out, probably to accommodate a mounted crystal or stone.*[420]

[420] Armstrong, *Irish and Highland Harps*, 175.

Figure 4.10: *roundel on the Queen Mary harp forepillar, lower right side. This roundel is incised with a unicorn, apparently feeding a fish to a two-footed monster that may be a lindworm.*

The Queen Mary harp has two distinct styles of decorative work, one of which is entirely confined to the neck and soundbox. The other, which has been shown in the above set of figures, is primarily confined to the forepillar. These two contrasting styles can be seen in the photograph of the harp in figure 4.2. It is important to note that the style of decorative work on the forepillar is also found in two places on the soundbox, in the area above the eyebrows, as shown in figure 4.11, below, and on the foot of the soundbox, as shown in figure 4.12. The area above the soundbox eyebrows has a foliaceous motif that is similar to that found on the forepillar. The hound's head carved onto the foot has eyes, lips, and mouth in the same style as those on the wyvern in one of the forepillar roundels.

***Figure 4.11:** carved and incised decorative work at the treble end of the Queen Mary harp soundbox, above the eyebrows. Note the similarity to the decorative work on the forepillar (inset). The foliaceous motif arrowed is a palmette (see discussion below).*

***Figure 4.12:** comparison of the hound's head on the foot of the Queen Mary harp and the wyvern's head on the forepillar (inset). Note the similarity in style of eyes, lips, and particularly the teeth.*

The style of decorative work on the Queen Mary harp forepillar (and above the soundbox eyebrows) has been identified by Steer and Bannerman (1977) as that used by the late medieval West Highland monumental stone carvers.[421] The authors write:

> "What does seem to tip the balance in favour of a Scottish origin for the Queen Mary harp at least, is the foliaceous decoration on the fore-pillar and upper part of the soundbox, which, in its use of scrolls incorporating palmette and split-palmette motifs, is strikingly similar to the work of the West Highland carvers. In particular, the spiral arrangement of clusters of split-palmette leaves on the fore-pillar is one of the characteristic patterns of the Iona school of monumental sculpture, but as far as we are aware has no parallel in Irish art of the period."[422]

The palmette motif Steer and Bannerman refer to can be seen in figure 4.11. Additionally, the similarity in foliaceous style that Steer and Bannerman note is particularly in reference to the foliaceous vine-like motif they identify as the "plant-scroll" and to the style of leaf commonly employed in this motif, which they refer to elsewhere as the "three-lobed formal leaf".[423] These elements are among the primary distinguishing features of the late Medieval West Highland style of carving.[424] An example of the three-lobed formal leaf is shown in figure 4.13, which is a detail of the Abbot MacKinnon cross shaft on the island of Iona.

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[421] K. A. Steer and J. W. M. Bannerman, *Late Medieval Monumental Sculpture in the West Highlands* (Edinburgh: HMSO Press, 1977), 185.
[422] ibid.
[423] ibid., 15.
[424] ibid.

Figure 4.13: *detail of the Abbot MacKinnon cross shaft (Iona Abbey Site Museum, Historic Scotland) showing the "three-lobed formal leaf" typical of late medieval West Highland sculpture*.

Steer and Bannerman note that the plant-scroll motif may appear with a single stem, or as an intertwined pair, but may also be developed as an elaborate foliaceous interlace involving a number of stems, consistent with the decorative work on the Queen Mary harp.[425] They also point out in the passage quoted above that the particular spiral foliaceous motif used on the forepillar of this harp identifiably belongs to the Iona school of carving, i.e. the particular style of carving employed for monumental art by artisans working on the island of Iona in the inner Hebrides.[426]

An example of a spiral plant-scroll motif is shown in the photograph of the upper portion of the Abbot MacKinnon cross shaft in figure 4.14. In this figure the cross shaft is juxtaposed with a photograph of a portion of the Queen Mary harp forepillar. Note the close similarity in the motifs used on the harp forepillar and the cross shaft.

[425] ibid.
[426] ibid., 15 – 17.

Figure 4.14: *detail of decorative carving on the forepillar of the Queen Mary harp (left), and on the Abbot MacKinnon cross shaft on Iona (right).*

The Abbot MacKinnon cross shaft is the surviving fragment of a free-standing cross on Iona, now kept at the Iona Abbey Site Museum, administered by Historic Scotland. The shaft bears a Latin inscription that reads (in translation):

> "This is the cross of Lachlanus MacKinnon and of his son Iohannes, Abbot of Iona, made in the year of Our Lord 1489."[427]

John MacKinnon was abbot of the Columban monastery on Iona from 1467 to circa 1499.[428] Although at present Iona may seem remote, during the medieval period it was an important Christian pilgrimage site and a major centre for ecclesiastical learning, as well as a vibrant centre for artistic craftsmanship, as evidenced by the

[427] ibid., 110.
[428] ibid., 112.

many surviving examples in stone.[429] A number of other stone carvings identifiably belonging to the Iona school also have similarities to the style of decorative work on the Queen Mary harp forepillar, but the similarity to the motif on the Abbot MacKinnon cross is particularly close. This does not necessarily imply a direct connection with the forepillar of the Queen Mary harp, although it is a possibility. It does, however, point to a likely point of origin of the forepillar on the island of Iona, in the late 15th century.

The abbacy of John MacKinnon, coincides with a period of building and restoration at Iona Abbey.[430] Given the crosses incorporated in the decorative work on the forepillar (as well as on the rest of the harp), and the time period and location to which the style of decorative work appears to belong, it is interesting to speculate that the forepillar might have been commissioned during Abbot MacKinnon's tenure, perhaps as a restoration to an existing instrument (if the forepillar is not original), during a period of general restoration at Iona Abbey.

With regard to whether or not the forepillar of the Queen Mary harp is a replacement, there is the question of the areas of decorative work on the soundbox (above the eyebrows and on the foot) that share style and motif with the decorative work on the forepillar. This is discussed further in the chapter section on the Queen Mary harp soundbox. The following section discusses the materials analysis for the forepillar in the context of the decorative work.

Materials analysis

Non-destructive materials analysis was undertaken for the pigment traces and decorative metal bosses on the forepillar. As discussed in the previous section, the T-section has visible traces of red pigment in and around the low-relief carving. The

[429] See e.g. Steer and Bannerman, *Monumental Sculpture*; and Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHM), *Argyll: An Inventory of the Monuments, Volume 4, Iona* (Edinburgh: H. M. Stationery Office, 1982).
[430] RCAHM, *Volume 4, Iona*, 144.

CT scans of the harp indicated the presence of particularly dense material in the same areas, as illustrated in figure 4.15, below.

Figure 4.15: *photograph of a section of the Queen Mary harp forepillar (top), and a tomogram of the same section (bottom). Traces of dense material appear dark in the tomogram. These largely correspond to visible traces of red pigment on and around the low-relief carving on the T-section.*

The traces of red pigment were analysed with XRF and found to contain high levels of mercury, a dense metallic element. The presence of mercury in the red pigmented areas indicates that this pigment is vermilion, a mercury sulfide compound. No traces of vermilion were detected on the decorative work on the sides and inside curve of the forepillar, so its use appears to have been limited to the T-section.

As mentioned earlier, vermilion pigment is present inside the nail holes in the eyes of the zoomorphic heads (see figure 4.6). Tomograms of these nail holes indicate that they extend deep into the wood. There may have been a decorative boss or stud nailed into the centre of each eye. What is interesting in the photograph in figure 4.6 is that the dot of vermilion pigment is on top of the hole, which means it may have been applied to the forepillar after whatever was nailed into the centre of the eyes had been removed.

Other areas of the decorative work on the forepillar are highlighted with what now appears as a brownish pigment. This can be seen, for example, on the inside curve of the forepillar (see figure 4.3) and along the sides, in between the plant-scrolls and surrounding the beasts in the roundels (see figure 4.10). Due to the geometry of the harp it was only possible to obtain XRF data for an area on the lower end of the forepillar front, where the pigmenting is more faded, or worn off, than in other areas (see figure 4.16, below). XRF data was taken in this location on a darker, pigmented area, and on an adjacent lighter area, and the results were compared. The detected levels of elements were essentially the same in both areas, with the exception of iron, which was higher in the darker area. It is possible that this brownish area on the forepillar was coloured with an iron oxide pigment. The pigment is unlikely to have been umber or sienna (iron based pigments that are yellowish and brownish in colour respectively), as both of these pigments also contain manganese, which was not detected. It is more likely that this was a reddish iron oxide pigment that has, over the course of time, faded to the current brown colour.

Figure 4.16: *two areas on the Queen Mary harp forepillar that underwent comparative analysis with XRF. Traces of iron were detected at higher levels in the darker area as compared to the lighter area.*

It is not known if the other brownish, pigmented areas of decoration have the same chemical signature, as it was not possible to analyse any of these. This should be undertaken in future, perhaps with a hand-held XRF spectrometer, because on close examination it appears that the pigmenting of the incised decorative work was fairly nuanced, as is evident in the faintly visible shading that can be seen in some areas, as shown in the photograph in figure 4.17. It is likely that these are traces of different pigments used to colour and subtly shade the decorative designs.

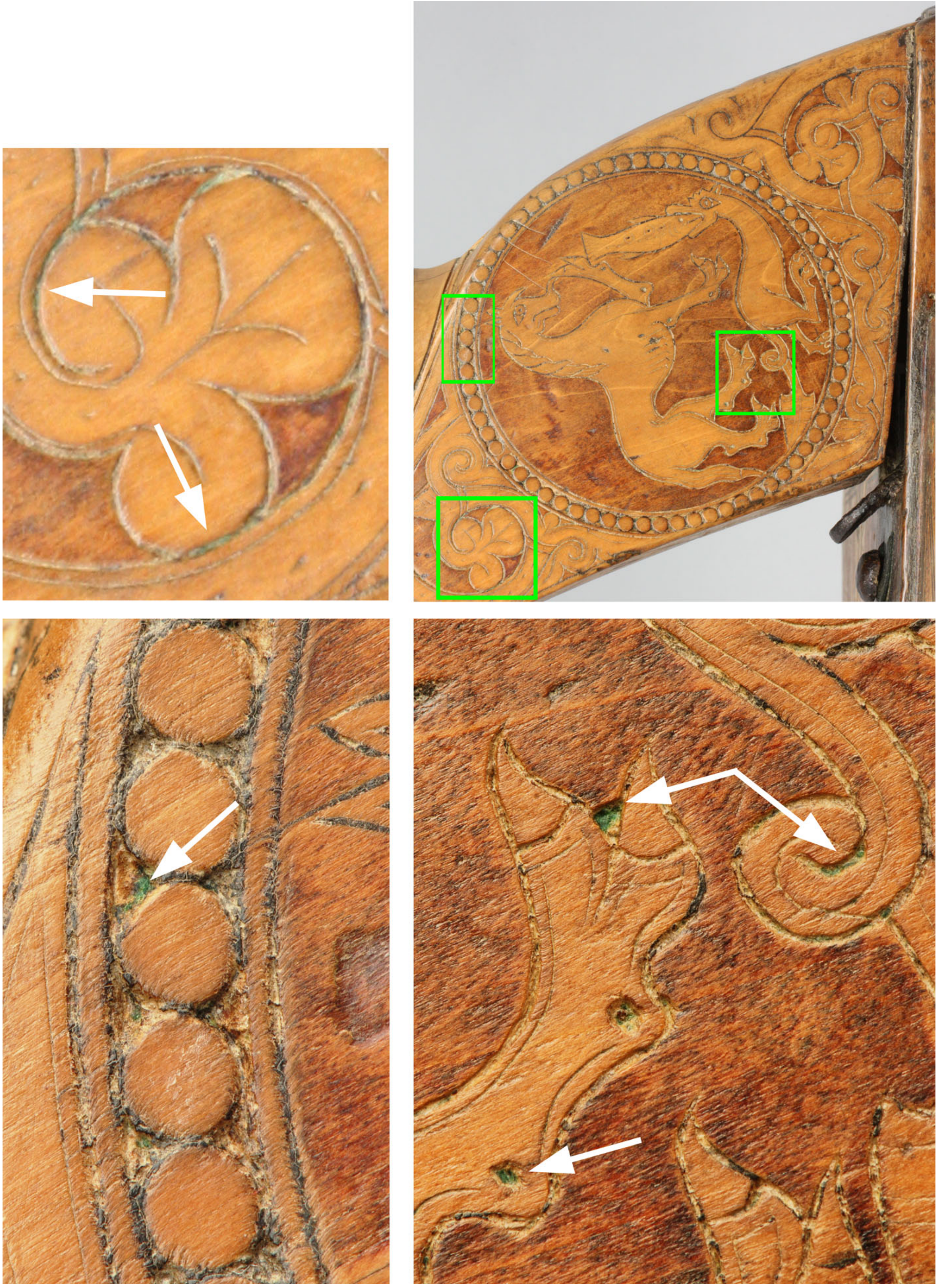
Figure 4.17: *detail of the incised decorative work at the upper end of the Queen Mary harp forepillar, left side. Note the subtle traces of pigmentation on the plant-scroll (arrowed). It appears the tail of the griffin (centre, right) may have been similarly pigmented. Photograph: Isabell Wagner.*

Close examination of the decorative work on the sides of the forepillar also revealed traces of a green substance in the roundel borders, and in the incised lines around the beasts and plant-scrolls, as shown in the photographs in figure 4.18.

A minute sample of this material was taken and analysed with SEM-EDX and found to be composed primarily of carbon and oxygen with copper and lead also present, although at lower levels. This suggests that the material may be a copper compound such as copper acetate or copper carbonate.[431] These are the compounds in verdigris (primarily copper acetate), which was widely used as a green pigment from the 13th century to the early 20th century.[432] Verdigris pigment was also sometimes mixed with lead white, and it is possible that the presence of lead may be indicative of this.[433] It is possible that much of the incised decorative work was bordered in verdigris pigment, but this would need to be established with further examination and testing.

Figure 4.18 (overleaf): *photographs of the lower right roundel on the Queen Mary harp forepillar, showing traces of a green substance in the incised lines of the decorative work (arrowed). The areas shown in detail are indicated by the boxes in the overview photograph on the right. Photographs: (left, upper and lower) Isabell Wagner.*

[431] Lore Troalen, "Queen Mary Harp EDX Analysis," memo to author. 17 December, 2012.
[432] Nicholas Eastaugh,Valentine Walsh, et al., *Pigment Compendium: A Dictionary and Optical Microscopy of Historical Pigments* (Oxford: Elsevier Ltd., 2008), 391 – 92. The compound in the pigment is primarily copper acetate.
[433] Eastaugh et al., *Pigment Compendium*, 396.



It appears from these analyses that the pigmenting of the decorative work on the forepillar was nuanced and may have involved several different pigments. It has now been established that the decorative work carved in low relief on the T-section was coloured red with vermilion, although it is not known if the plant-scrolls themselves were pigmented, or just the surrounding areas. The zoomorphic heads definitely were. It has also been established that the use of vermilion was limited to the T-section, and that elsewhere on the forepillar at least some of the pigmented areas that appear brownish may have been coloured with a red iron oxide pigment. Close examination of the somewhat protected area where the neck slightly overhangs the forepillar joint has revealed evidence of nuanced and detailed colouring of the incised decorative work. Further analysis in these areas may identify additional pigments. Lastly, close examination has revealed traces of green material in the borders of the incised decorative work. Analysis has confirmed that this material contains copper, and therefore may be green verdigris pigment. Further work will be needed to try to identify additional pigments and where they were applied, but it appears so far that the decorative designs on the forepillar may have been richly coloured and subtly shaded, perhaps in much the same manner as 15th-century illuminated manuscript.

As mentioned earlier, the T-section is embellished with a line of metal bosses (see figure 4.2). Four of these remain, along with posts for two more, now missing. A close-up photograph of one of the bosses is shown in figure 4.19. As is evident from the photograph, they were originally hemispherical caps, which are now worn through, revealing the central post and filler material.

Figure 4.19: *close-up of a metal boss on the front of the Queen Mary harp forepillar. This boss is 3rd from the top in a line of (originally) six bosses. Each is a hemispherical metal cap over a central post and filler material, both of which are visible where the metal cap has worn through.*

The boss shown in figure 4.19 is third from the top of the line of bosses. This boss was analysed with XRF to identify the materials from which it was made. The metal cap was identified as a silver alloy containing copper, with other metals present at trace levels. The filler is lead solder with tin, and the post is brass. The results for this set of analyses are qualitative, so it is not possible to provide specific percentages for the elements identified.

The exposed post and surrounding residue for the missing boss at the top end of the line were also analysed with XRF. Again, the post was found to be brass. The residue contains high levels of lead from the solder and traces of silver from the cap, but also contains iron and mercury at levels significantly higher than trace amounts. These elements were not detected at significant levels in the boss solder, so it is possible that they belong to a layer of pigment on the wood underneath the boss.

Nails

According to Gunn (1807), information contained in a letter (now lost) from General William Robertson to the Secretary of the Highland Society noted that the Queen Mary harp at one time bore "in front of the upper arm, the queen's portrait, and the arms of Scotland, both in gold."[434] Gunn goes on to say that this was stolen (along with other valuable embellishments on the harp) during the Jacobite rising of 1745.[435] Nails in the front end of the neck do indicate that something, a plate or large badge, was formerly affixed to it. These may have been the attachments for the portrait and arms mentioned by Gunn, however the pattern of nails on the front of the forepillar, just below the end of the neck, also clearly indicates a former attachment, as shown in figure 4.20.

As is evident in the figure, there are two distinct patterns of nails: a central circular pattern, and surrounding this a larger shield pattern delineated by the outlying nails. The nails in the shield pattern all have the same distinctive head with a central ridge, with the exception of the first two above the bottom point, which have similar flat heads. A variety of different nails comprise the circular pattern. The central ridge on the forepillar has been shaved flat within the area enclosed by the circle of nails, presumably to allow a medallion to lie flat against the surface. A nick in the ridge farther up the forepillar may indicate the position of the upper edge of the shield. An additional pair of holes farther down the forepillar on either side of the central ridge does not contain nails or nail fragments, and it is not clear if these holes are associated with the nail patterns above them.

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[434] Gunn, *Historical Enquiry*, 13 – 14. Gunn uses the term "upper arm" to refer to the neck.
[435] ibid., 14.

Figure 4.20: *nails embedded in the front of the Queen Mary harp forepillar, just below the end of the neck. The nails form a circular pattern and a larger shield pattern. A tomogram of the area has been superimposed on this photograph. The nails appear as irregular white spots in the tomogram. The diameter of the circle indicated in the photograph on the right was measured from the CT data. Scale 1 tick : 1 cm.*

A tomogram of the upper end of the forepillar has been superimposed on the copy of the photograph on the right in figure 4.20, showing the positions of the nails as they appear on the CT scan. The diameter of the circle of nails, as indicated in the figure, was measured from the CT data as 22.5 mm. The CT scan of this area was used to examine the nails from all angles within the wood. Some of the nails in the circular pattern are bent over on the end that is flush with the surface of the wood. It is possible that the nails in this pattern may have originally been set proud of the surface and were later hammered down.[436] The measurement of the circle of nails

[436] The author gratefully acknowledges Keith Sanger for suggesting this.

was requested by Keith Sanger, who has theorized that they may have held a gold coin by its edges, which might explain the large number of nails and having the ends projecting above the surface.[437] Based on the measurement of the circle of nails, Sanger has established that the diameter is the correct size to accommodate a gold half-ryal coin from the reign of Mary, Queen of Scots, and may have been incorporated in the centre of a shield shaped badge.[438] This coin bears the portrait of the Queen on the obverse, and Sanger suggests that this may have been the "queen's portrait in gold" remembered by the Robertson family and referred to in Gunn (1807).[439] In the photograph in figure 4.20 a number of small marks can be seen on the edge of the forepillar. Sanger has noted two larger indentations at 3 o'clock and 4 o'clock on the circle of nails, and has suggested that these two marks are consistent with a narrow object, possibly a blade, having been used to prise up the object held by the nails.[440] Given the Robertson family tradition that the gold queen's portrait was stolen during the 1745 Jacobite uprising, Sanger speculates that the marks could have been made by something like a soldier's dirk.[441]

Wood grain

The CT scans of the Queen Mary harp have revealed that the forepillar is constructed from a single roundwood timber whose grain closely follows the curvature of the

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[437] Keith Sanger, private briefing with the author and NMS staff, 29 October, 2012.
[438] ibid. See also, Keith Sanger, "The 1745 Despoliation of the 'Queen Mary' Harp," last modified 4 April, 2015, http://www.wirestrungharp.com/harps/lude/1745_despoiled_queen_mary_harp.html#_end3. The half-ryal in the collection of the National Museum of Scotland is 22.0 mm in diameter. For a photograph and description see, "Mary, Queen of Scots gold 30-shilling piece or half-ryal, Edinburgh, 1555," National Museums Scotland H.C 180, accessed 28 September, 2014, http://nms.scran.ac.uk/database/record.php?usi=000-100-050-632-C. Sanger has noted that the Arms of Scotland mentioned by Gunn would not have fit on the shield badge with the coin in the centre, but has speculated that the Royal Arms may have been placed on the end of the neck, leaving room on the shield for other adornment, possibly wolf heads representing the Tarlochsons. Keith Sanger, email message to author, 2 March, 2013.
[439] Keith Sanger, private briefing with the author and NMS staff, 29 October, 2012.
[440] ibid.
[441] ibid.

piece, as described in Loomis (2010), and Loomis et al. (2012).[442] This is shown in figure 4.21, below. It is evident from the cross-sectional view of the growth rings that the forepillar includes the centre of the timber. The pattern of growth rings can also be examined for the presence of reaction wood in the form of non-concentric rings, which would indicate that the timber had grown curved rather than being bent after it was cut. Viewed in cross-section, it does appear as though there may be some narrowing of the spacing of growth rings towards the inside curve of the forepillar, although with the limited view afforded by the cross-section, it is difficult to say for certain. It is, however, probable that this was a naturally curved timber, possibly a branch.

Dooley (2014) has argued that the forepillars of Irish harps were constructed to have a degree of flexibility, or 'springiness' that would be advantageous to the acoustics, particularly of the bass strings, and that the use of a curved timber provides more flexibility and resilience than a forepillar made from a straight-grained plank.[443] The fact that both the Queen Mary and Lamont harp forepillars were constructed from curved timbers is consistent with this theory.

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[442] ibid.; Loomis et al., "Lamont and Queen Mary Harps," 124.
[443] Dooley, " Medieval Irish Harp," 111.

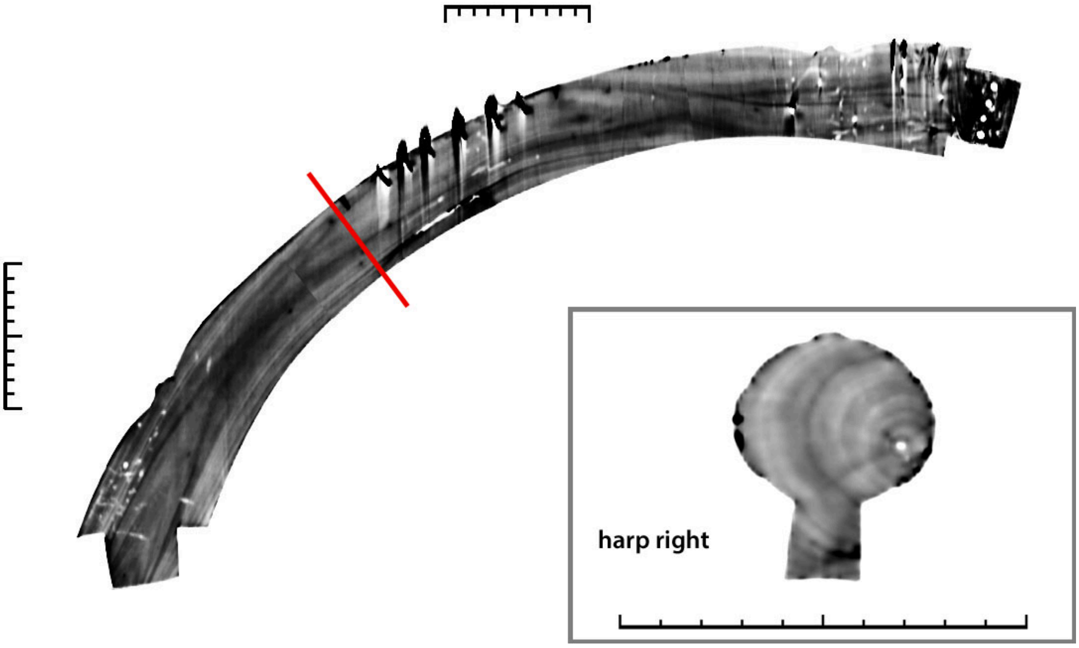


Figure 4.21: *tomograms of the Queen Mary harp forepillar showing the direction of wood grain. The lengthwise cross-section is a mosaic of three tomograms. The red line indicates the location of the cross-section shown in the inset. The right-hand side of the harp is towards the left in the inset. These cross-sections show that the forepillar has been made from a single curved piece of roundwood, possibly a branch. Scale: 1 tick : 1 cm.*

Forepillar joints

The tomograms in figure 4.22 show the forepillar joints with the neck and soundbox in cross-section. It appears as if the tenons aren't a good fit to their respective mortises. As mentioned above, the forepillar was made with a high degree of skill, so these apparently poorly fitting joints at the ends seem incongruous. Most, if not all of the discrepancy between mortise and tenon can be accounted for by the shifting, bending, and compression of the wood due to the string tension acting on the frame, however.

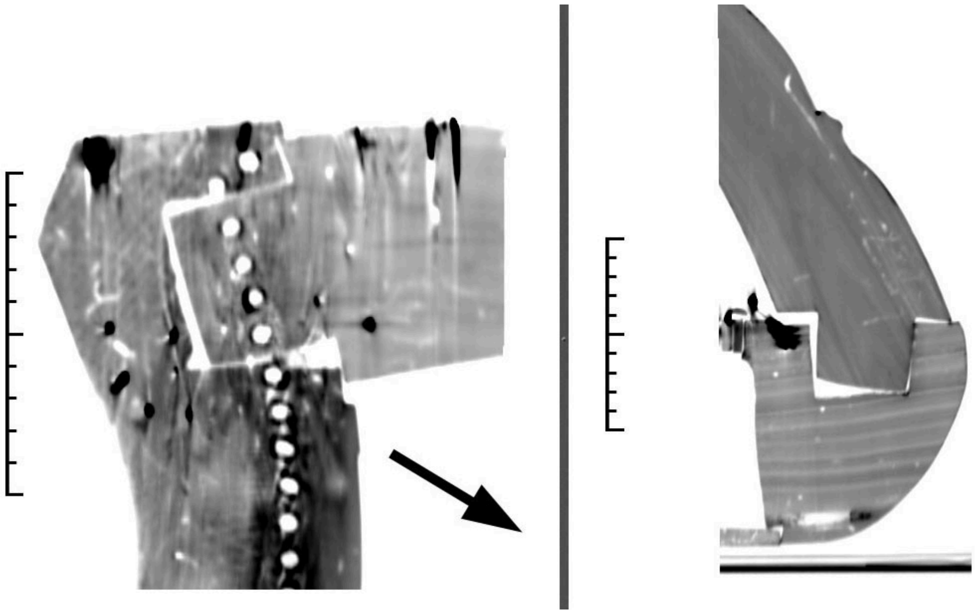


Figure 4.22: *tomographic cross-sections of the forepillar joint with the neck (left), and soundbox (right) of the Queen Mary harp. The arrow in the left-hand cross-section indicates the direction of the force acting on the neck due to the strings. Note the gap between the back of the tenon and the mortise, and the position of the tenon shoulder versus the mortise recess. In the right-hand cross-section, note the angle of the tenon in the mortise, and note also the angle of the front wall of the mortise versus the back wall. Scale: 1 tick : 1 cm.*

As can been seen in the tomogram of the forepillar/neck joint shown on the left in figure 4.22, there is a gap between the back of the tenon and the mortise. At first it appears as if either the tenon or the mortise was not accurately cut. This is not the case, however. The string tension has pulled the neck in the direction indicated by the arrow in the figure. This has forced the neck down onto the forepillar and has caused the wood to split along the grain (which happens to be roughly perpendicular to the direction of the force). As a result, the front of the mortise has been pressed against the forepillar tenon, and the back of the mortise has pulled away from the tenon, opening up as observed in the cross-section of the joint.

The forepillar tenon at the joint with the soundbox, shown on the right in figure 4.22, also appears to be a somewhat poor fit to its mortise. There is a gap at the back and at the bottom of the mortise, and the tenon is seated at an angle. Here, the string tension has forced the forepillar forward in the joint, pushing the front wall of the mortise outward slightly (note the angle of the front wall versus the back wall). In fact, the forepillar has pushed through and broken the front lip of the mortise recess, as shown in figure 4.23. This movement has caused the observed gap between the back of the tenon and the mortise.

Figure 4.23: *damage to the foot of the Queen Mary harp as a result of the forepillar being forced forward in the soundbox joint. The forepillar has pushed through and broken off the front lip of the mortise recess (arrowed).*

The string tension has also bent the forepillar, causing the middle to bow outward and the ends to angle inward. This accounts for about half of the observed gap at the bottom of the mortise. The tenon has also very likely been bent backwards as a result of pushing against the front of the mortise. Although the wood grain pattern visible in the tomogram suggests that it must not have bent very much, even a small degree of bending will have contributed visibly to the angle of the tenon and the observed gap at the bottom of the mortise.

Figure 4.24 shows the gap between the forepillar shoulder and the lip of the mortise recess at the soundbox joint, due to the forepillar shifting forwards as described above. This photograph also shows the edge of something down inside the mortise (arrowed in the figure). This object was first noticed on the CT scan of the joint, and is shown in the tomograms in figure 4.25.

Figure 4.24: *photograph of the forepillar/soundbox joint showing the gap between the forepillar shoulder and the lip of the mortise recess. Note also the thin light object embedded in the mortise (arrowed).*

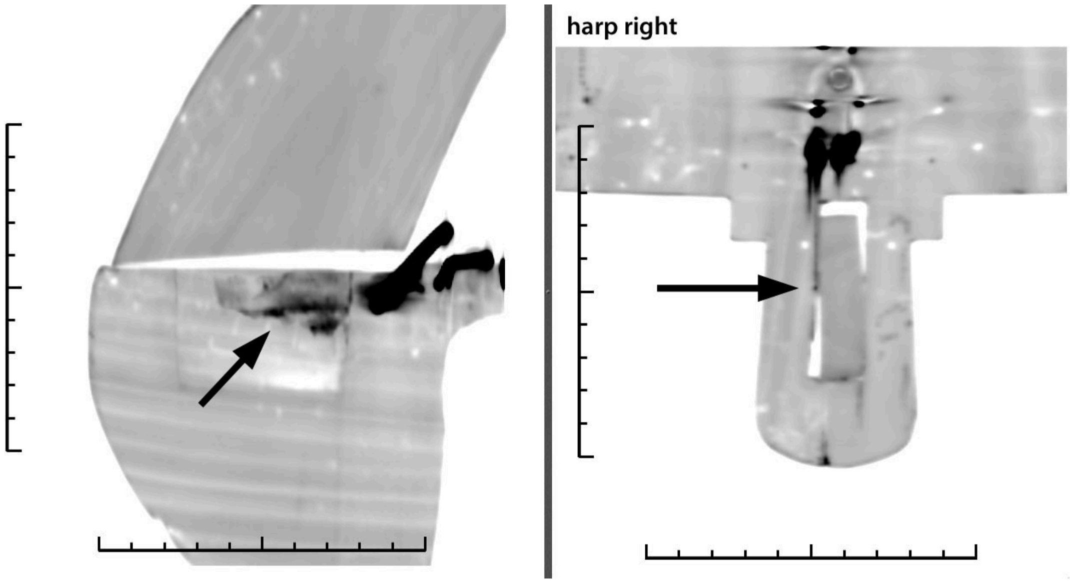


Figure 4.25: *tomographic cross-sections of the Queen Mary harp forepillar/soundbox joint. The cross-section on the left is aligned with the right side wall of the mortise (arrowed, right). There is something visible on the tomogram, which may be a scrap of parchment.*

The tomograms in figure 4.25 show what appears to be a scrap of something on the right side wall of the soundbox mortise. Close examination of this area on additional tomograms from the CT scans show what could be a layer of glue between it and the mortise wall, although this is uncertain. Based on the similarity in appearance to the tomograms of the Lamont harp vellum document, this object could be a piece of parchment.

This small scrap could be significant for understanding this harp. Note that some of the edges appear to be cut and others appear torn. It is a piece of something larger that might have been glued to the inside of this mortise and then removed at some point, and it is in a location that is not accessible without first removing the forepillar. It is unlikely that the forepillar has been removed since the iron strap was nailed across the neck/soundbox joint, though. The strap prevents movement of the neck, so it would be difficult to remove the forepillar without causing damage, as the end of the neck would have to be bent upwards at least 4 cm to lift either end of the forepillar out of its joint. This scrap may be evidence that at some point before the addition of the iron strap something (perhaps a shim) was glued into the mortise. At a later date most of that item was removed, leaving the scrap. This could only have been done when the forepillar was off the harp. Removing the forepillar is not something that would be done casually, because it requires de-stringing the instrument and taking the frame apart, as this is held together by the string tension. If the forepillar had been removed, the most likely reasons would be to either make repairs that cannot be done with it on the harp, or to replace it. There are no signs that this forepillar has had any repairs that would require it to be off the harp, so it is possible that the item in the mortise was removed when a previous forepillar was taken off the harp to be replaced with the current one.

There could have been good cause to replace the forepillar. It is critical to the structure of the harp. If it loses its integrity, the frame will collapse under the string tension, causing severe damage to both the neck and the soundbox where they join at the treble end of the harp.[444] As Dooley (2014) notes, in order to provide a certain degree of flexibility, the forepillars of Irish harps were likely constructed to be "just strong enough to withstand the tension of the strings," so structural failure is a possibility, and a forepillar would not necessarily need to be structurally damaged in order to need replacement.[445] Dooley has pointed out that a number of the surviving Irish harp forepillars have become permanently bent by the string tension acting on them.[446] Under normal use a forepillar may become bent to the extent that it is no longer suitable and needs to be replaced. It is possible that the forepillar of the Queen Mary harp could have been replaced for either of these reasons. If the current forepillar is not original, that could have a bearing on the assumed date and location of origin of the Queen Mary harp, as that has largely been based on the style of decorative work on this part of the frame.

[444] The damage to the neck-soundbox joint of the Lamont harp is a good example of this.
[445] Dooley, "Medieval Irish Harp," 111.
[446] ibid.

Summary

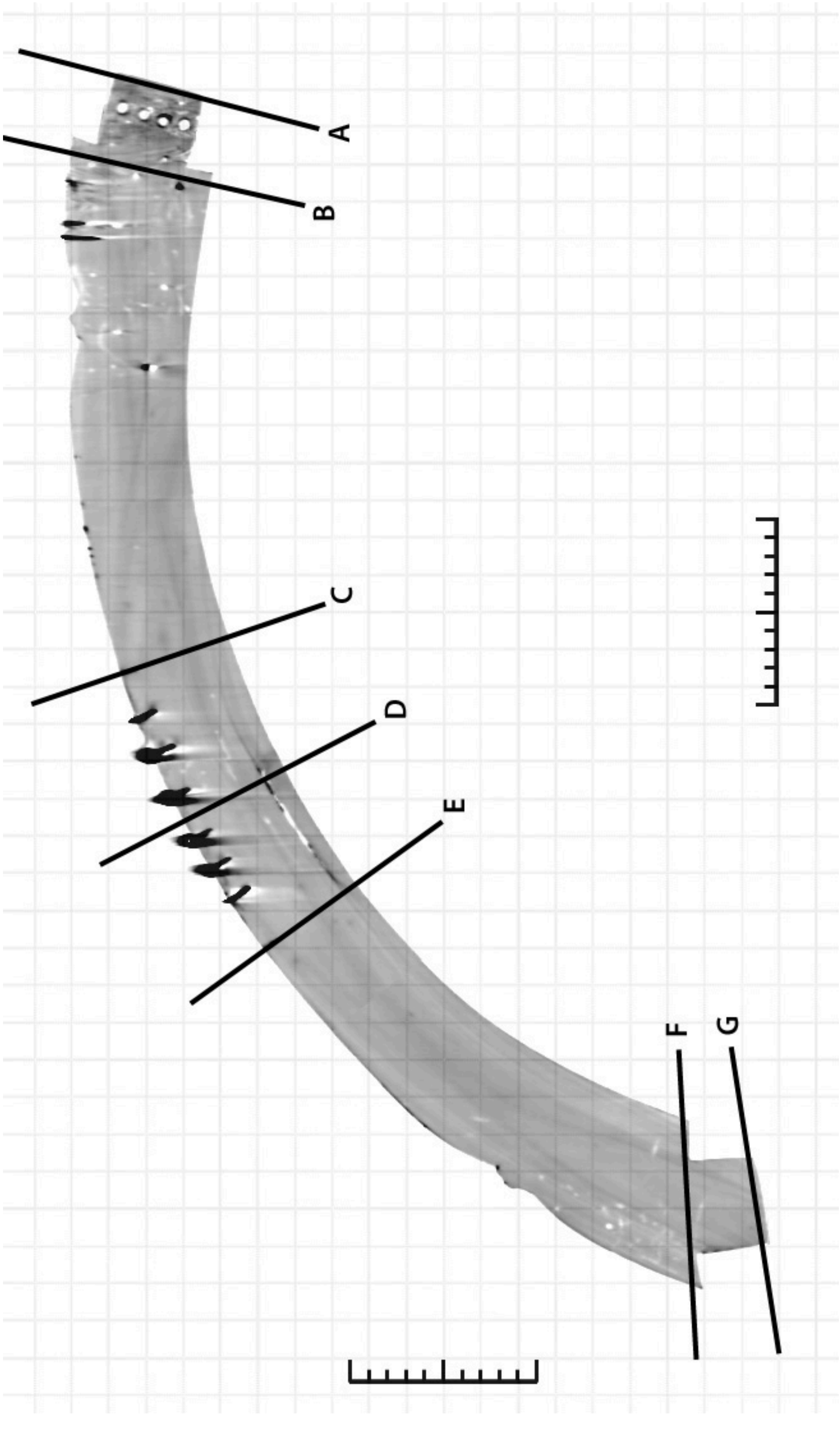
The workmanship employed in making the Queen Mary harp forepillar was of a very high caliber, with substantial attention paid to executing the details of the decorative work. Although the decorative work on the T-section and on the rest of the forepillar are of the same style, it is worth noting that they are executed differently and may represent the workmanship of two different craftsmen, probably working together to complete the piece. The T-section, with its zoomorphic heads and plaited plant-scrolls carved in low relief, is sculptural, whereas the remainder of the decorative work on the forepillar, intricately drawn with fine incised lines, then subtly shaded and coloured, is reminiscent of the work of a manuscript illuminator.

The high level of craftsmanship suggests that this piece may have been commissioned for a person of wealth and/or high rank. The particular style of decorative work indicates the island of Iona in the late 15th century as a probable location and date of construction for the forepillar, perhaps on behalf of someone with a connection to the abbey, as suggested by the crosses incorporated into the motif. It would be useful to date the wood, however, to determine if its age is consistent with this date of construction. In this chapter section, the question of whether or not the forepillar is original was discussed. While the evidence suggests it may be a replacement, it is not conclusive, and further research is needed, as this has a direct bearing on understanding how the frame was designed to work, and on the presumed age and origin of the rest of the harp.

Cross-sections

The dimensions of the forepillar are shown in the tomographic cross-sections below. The tomogram in figure 4.26 is a lengthwise cross-section of the forepillar. Because it is slightly bent towards the left side of the harp, a composite of three cross-sections was used in order to show its entire length. The lines labeled A – G in the figure indicate the locations of cross-sections taken across the forepillar. These are shown in figures 4.27 – 4.33. For all of these figures, the grey-scaling has been set to accurately represent the location of the physical edge of the wood using the method already described. The dimensions given in the figures are the FWHM of the cross-section. For figures 4.27 – 4.33, the line in the left-hand image indicates the location of the cross-section shown on the right, and the measurements shown were taken at the location of the lines indicated on the cross-section. The right-hand side of the harp is on the left, and the view is from the perspective of 'looking up' the forepillar from below.

Figure 4.26 (overleaf): *composite tomographic cross-section of the forepillar of the Queen Mary harp. The lines A – G indicate the locations of the individual cross-sections shown in figures 4.27 – 4.33. Scale 1 tick : 1 cm; grid scale 1 square : 2 cm.*


A
B
C
D
E
F
G

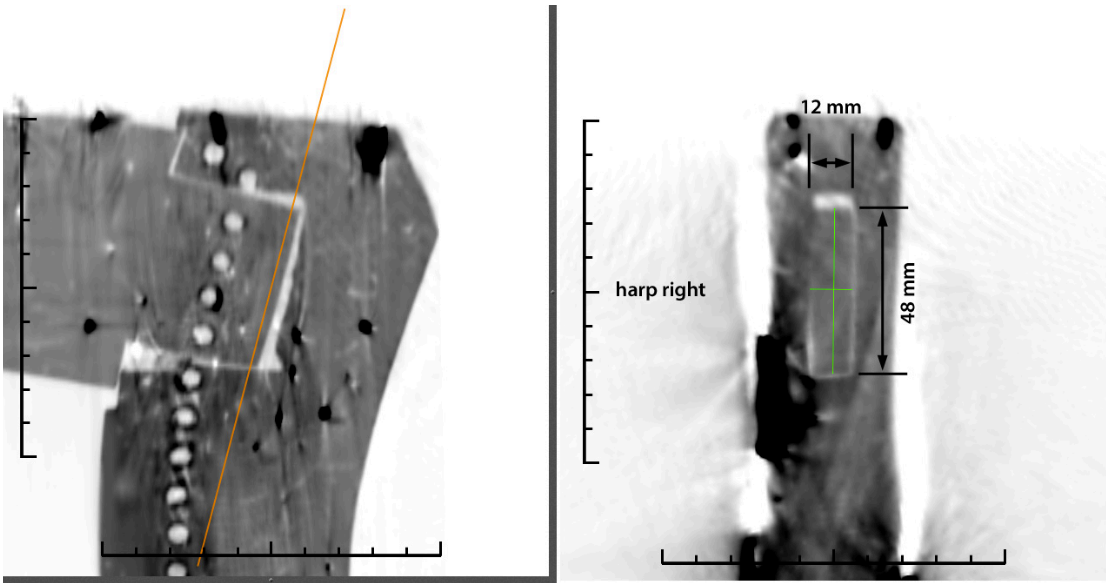


Figure 4.27: *Queen Mary forepillar cross-section A (see figure 4.26). This is a cross-section of the tenon in the neck joint. Scale 1 tick : 1 cm.*

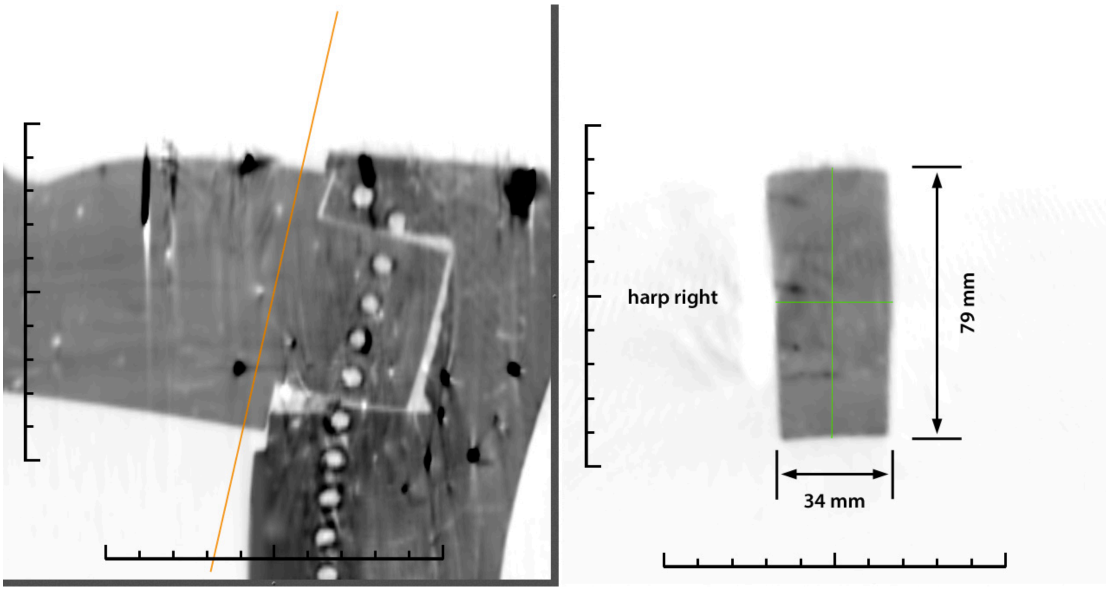


Figure 4.28: *Queen Mary forepillar cross-section B (see figure 4.26). Scale 1 tick : 1 cm.*

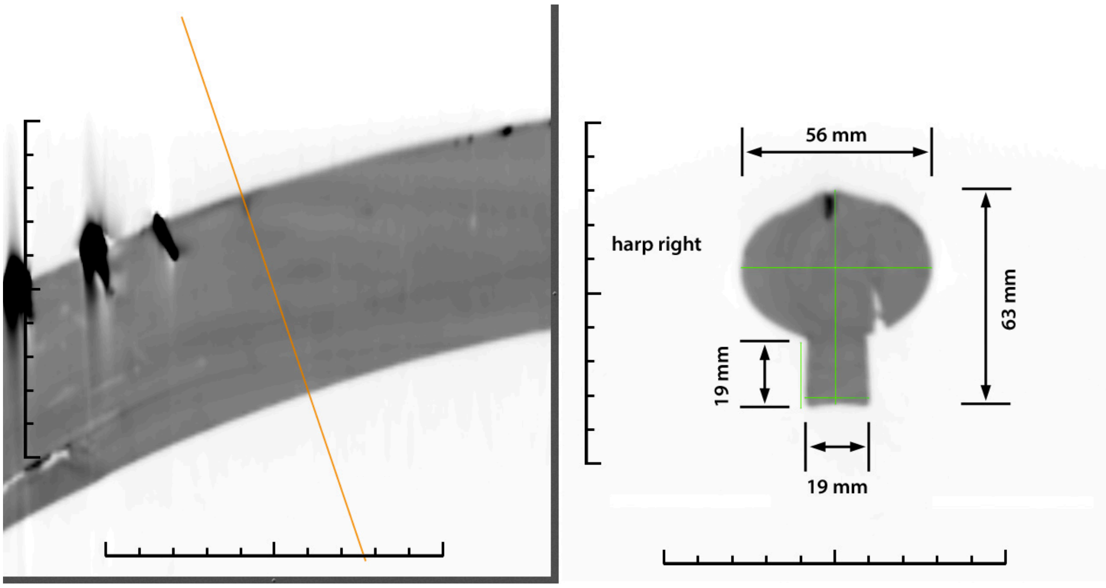


Figure 4.29: *Queen Mary forepillar cross-section C (see figure 4.26). This cross-section includes the T-section. Note the crack, which originates at the centre of the growth rings. Scale 1 tick : 1 cm.*

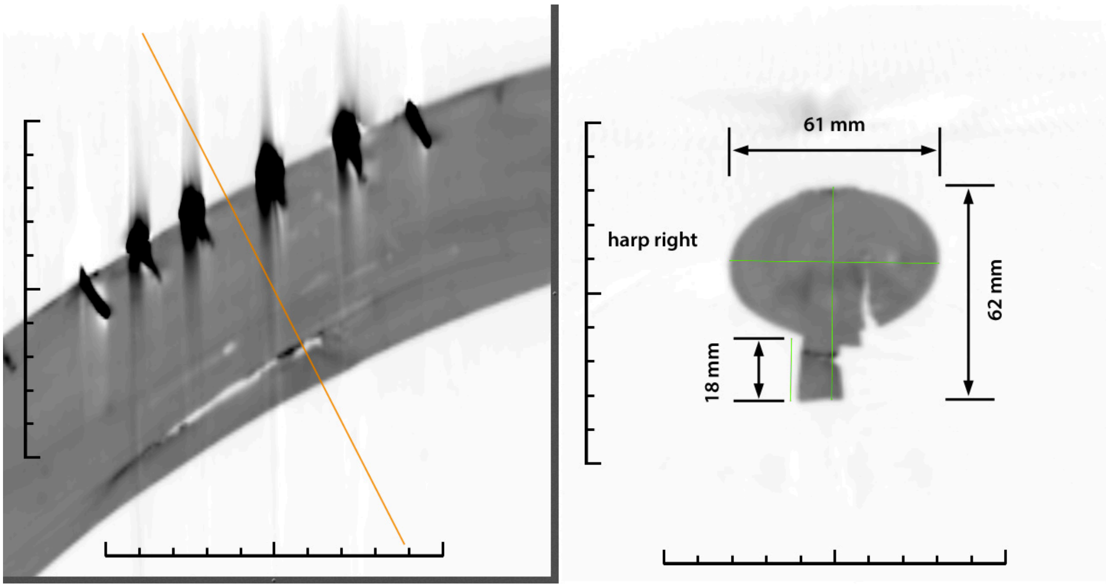


Figure 4.30: *Queen Mary forepillar cross-section D (see figure 4.26). This cross-section is located at the centre of the T-section. The projection below the T-section is narrowed due to the missing inset piece of wood (see figure 4.1). As in the cross-section in figure 4.29, the crack in the T-section originates at the center of the timber. Scale 1 tick : 1 cm.*

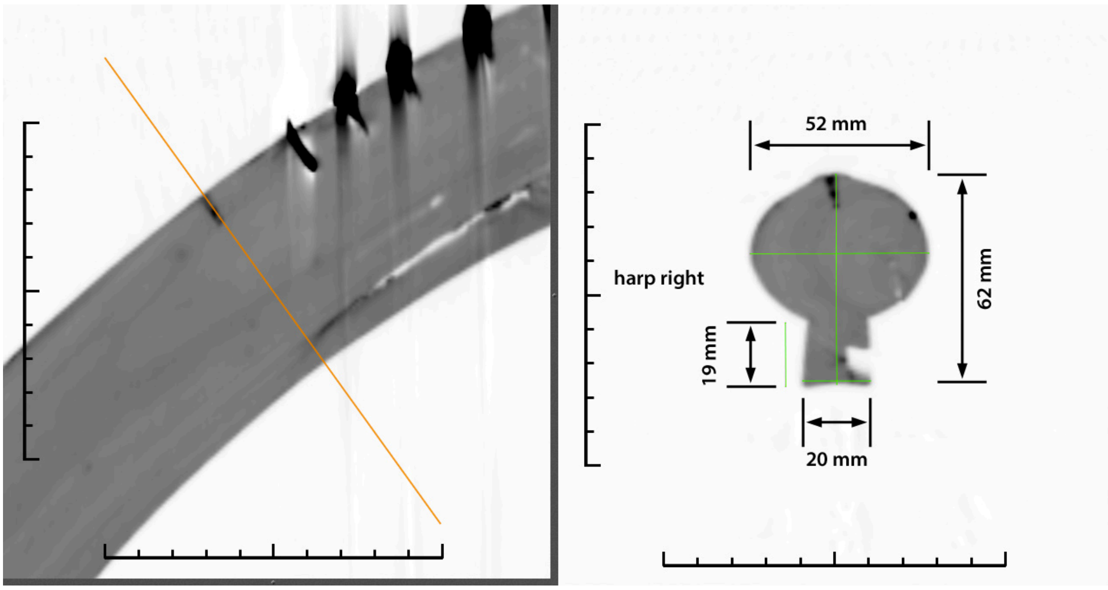


Figure 4.31: *Queen Mary forepillar cross-section E (see figure 4.26). The gap in the projection below the T-section is due to the missing inset piece of wood (see figure 4.1). Scale 1 tick : 1 cm.*

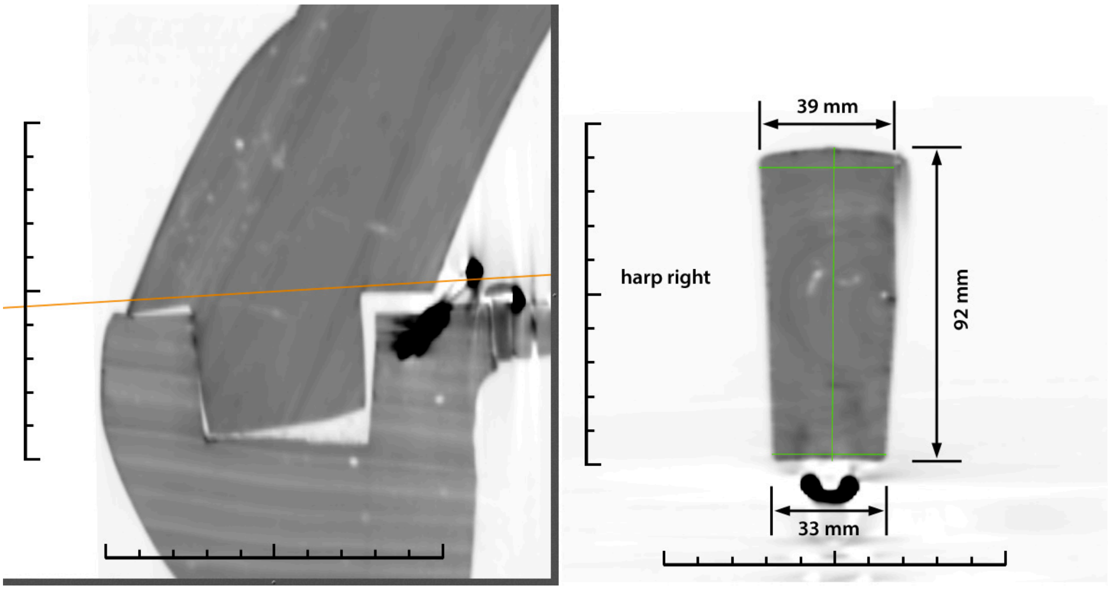


Figure 4.32: *Queen Mary forepillar cross-section F (see figure 4.26). The growth rings (just visible) indicate the location of the center of the timber just below the surface of the wood on the left side of the forepillar (the right-hand side of the image). Scale 1 tick : 1 cm.*

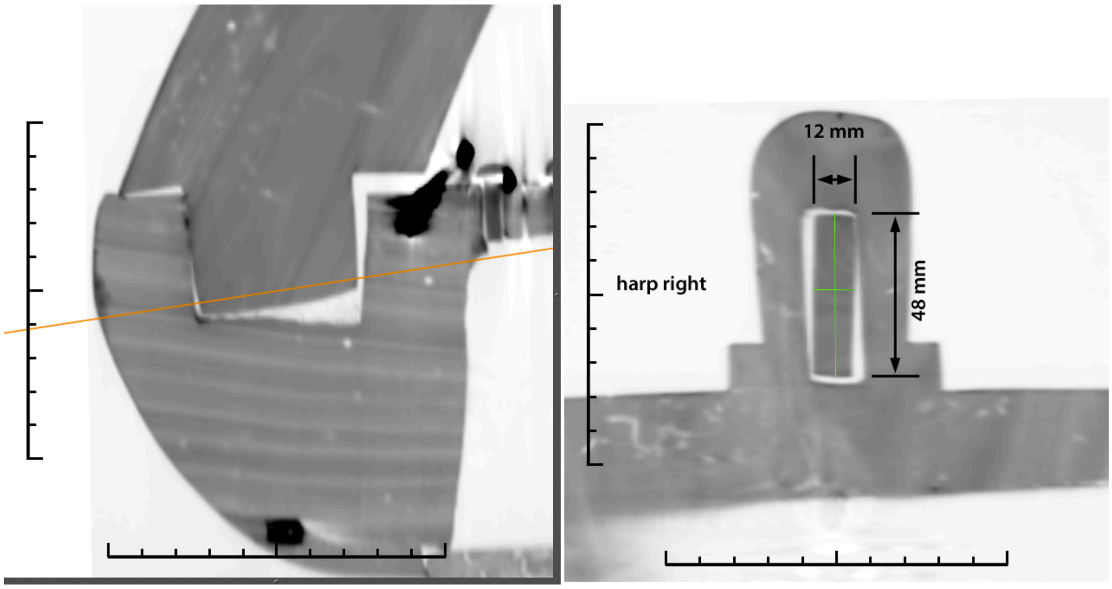


Figure 4.33: *Queen Mary harp forepillar cross-section G (see figure 4.26). This is the cross-section of the tenon in the soundbox joint. The soundbox appears slightly skewed in the right-hand image due to the cross-section being taken perpendicular to the forepillar, which is tilted towards the left side of the harp. Scale 1 tick : 1 cm.*

Neck

The neck was discussed in Chapter 2 of this dissertation, in the context of damage and twisting that have affected the string lengths. This chapter section looks at some other aspects of the construction and current state of the neck, focusing primarily on the metalwork, while further examining signs of damage and wear. The tuning pin holes are also discussed, particularly with respect to material found lodged within them. Signs of decorative embellishments are discussed as well. As will be evident in the discussions, each of these features of the neck of this harp provides some insight into its working life. The decorative work on the neck is also shown, but is discussed in more detail in the context of the decorative work on the soundbox, in the next section of this chapter. Measured cross-sections of the neck are presented at the end of the section.

Tuning pins

As already discussed in Part I of this dissertation, the neck has holes for 30 tuning pins, of which 29 are original to its construction. These pass through the cheekbands. The hole directly beneath the cheekbands at the bass end of the neck is a later addition. There are currently 21 remaining tuning pins in the neck. As noted in Chapter 2, the tuning pin for the 30th string is now missing. When the harp was examined and photographed by Armstrong at the beginning of the 20th century it had a full complement of 30 tuning pins. In an archival photograph dated August 1981, 29 tuning pins are still present (figure 4.34, below), including the pin for the 30th hole.[447]

[447] This photograph appears to have been taken for the "Angels, Nobles, and Unicorns" exhibition, based on a hand-written note on the sleeve. This has been confirmed by David Caldwell, former Keeper, Scotland and Europe, National Museum of Scotland. Personal communication, 6 May, 2015.

Figure 4.34: *an archival photograph of the Queen Mary harp, dated August 1981, showing the harp with 29 tuning pins (National Museums Scotland H.LT1 archive, photograph E/0058).*

The appearance of the ends of these pins corresponds generally to those in the photographs of the harp published by Armstrong in 1904, as well as in some undated archival photographs that may pre-date the one taken in 1981. When the Queen Mary harp tuning pins were examined by Keith Sanger in mid-1982 for measurement of the string holes there were still a total of 29 (missing the tuning pin in hole #27, in corroboration with the 1981 photograph).[448] In a set of archival photographs dated May 1983, however, eight additional tuning pins appear to be missing, bringing the number down to the currently remaining 21. This later set of photographs, reproduced at reduced size in figure 4.35, shows the Queen Mary harp tuning pins laid out side-by-side, out of the harp, with each pin numbered.[449]

[448] Keith Sanger, personal communication, 25 March, 2014.
[449] National Museums Scotland, "Queen Mary harp archive," H.LT1 (National Museums Scotland Library), unnumbered negatives.

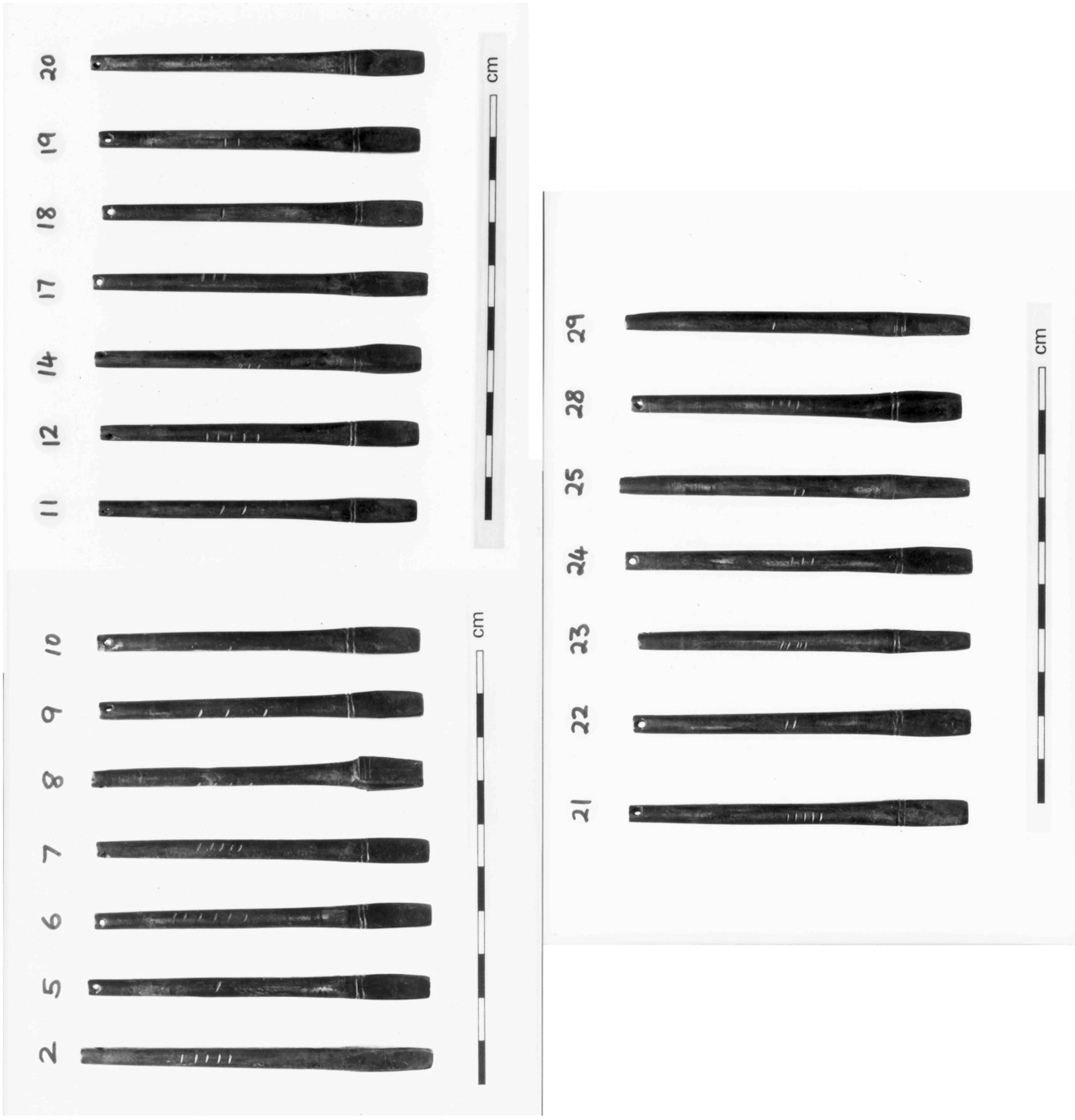


Figure 4.35: *archival photographs of the Queen Mary harp tuning pins, dated May 1983. A total of 21 pins are included in the photographs, with gaps left in the numbering scheme for pins either not included or missing. Note: the current order of the tuning pins is different from the order indicated in these photographs. Photographs: National Museums Scotland archive H.LT1.*

There are 21 pins photographed, with gaps in the numbering scheme for a total of nine missing tuning pins out of 30. So, as recently as 1982 this harp had 29 tuning pins out of the full set of 30, but sometime between 1982 and 1983, eight tuning pins were removed from the harp, and are currently unaccounted for. Figure 4.36 shows a detail of the 1981 photograph, in which the string ends of the tuning pins can be seen more clearly. Accompanying this is a detail from an undated (probably earlier) archival photograph, showing the drive ends of all 30 tuning pins.

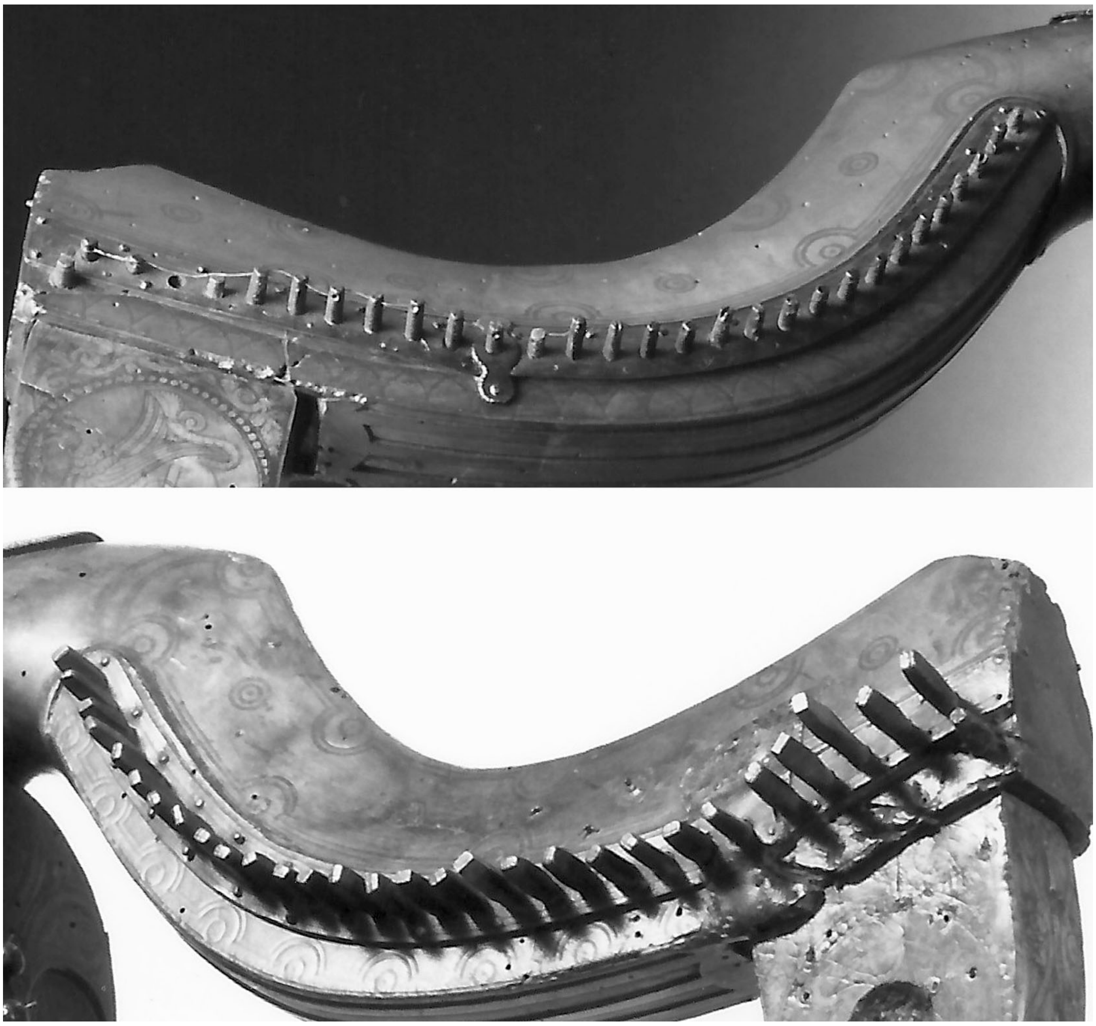


Figure 4.36: *(top) detail of the photograph in figure 4.34, showing the Queen Mary harp tuning pins as they appeared in 1981, viewed from the string ends; (bottom) detail of an undated (probably earlier) archival photograph showing the drive ends of all 30 tuning pins. Some of the string ends appear to be slotted and some of the drive ends appear to be less worn than others. Fragments of gut string are also visible in the top photo, attached to some of the tuning pins.*

In the close-up of the 1981 photograph shown in figure 4.36, some of the tuning pins appear to have slotted string ends. When he examined this harp, Armstrong noted that eight tuning pins were iron, five with slotted string ends and three with string holes. He speculates that these were probably supplied by Gunn and Elouis in the early 19th century.[450] When Keith Sanger examined the pins in 1982, he also identified 5 with slotted ends.[451] The positions of these particular pins in the cheekbands, as recorded by Sanger, correspond to gaps in the numbering scheme in the photographs of the 21 remaining pins, taken in 1983. Additionally, there were three pins without slotted string ends that are also not present in these photographs. These are the three iron pins with string holes identified by Armstrong. All of the remaining tuning pins are copper alloy.

Perhaps someone concluded, as did Armstrong, that these eight iron tuning pins were non-historical replacements. Nevertheless, it is unfortunate that they were removed. They may have dated to the restringing of the harp by Elouis in the early 19th century, but they also could have been historical replacements dating to the working life of the harp. This is particularly likely for the tuning pin for the 30th string hole, which Armstrong described as "much worn." If some or all of these tuning pins were historical replacements, the need for several replacement pins could have been an indication that the Queen Mary harp was unused for an extended period of time. Unfortunately, as the pins are now missing, they can no longer be examined. Even if they did only date to the restringing by Elouis, they would, nevertheless, have been close to 180 years old when they disappeared in 1982 – 83. Perhaps these tuning pins were only intended to be separated from the others temporarily, and for some unknown reason were not returned to the harp. It is, however, unfortunate that as recently as the 1980's over one-quarter of the tuning pins should disappear, unnoticed, from such an important surviving historical harp.

The following discussion examines the remaining tuning pins. The numbering used here is based on their position in the neck at the time of this project. As mentioned in the discussion of the missing tuning pins, a set of photographs taken in 1983 numbers each pin by its position in the neck. In the intervening time between the 1983

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450 Armstrong, *Irish and the Highland Harps*, 171, note 2.

451 Keith Sanger, email message to author, 25 March, 2014, and personal communication. The author gratefully acknowledges Keith Sanger for sharing his notes from 1982, on the Queen Mary harp tuning pins.

photographs and the commencement of the current project the order of the tuning pins has largely been rearranged, therefore the numbering used in those photographs is different from the current numbering.[452]

The remaining tuning pins in the Queen Mary harp neck are all copper alloy. Tuning pin #5 was analysed with XRF and found to be brass with trace amounts of tin and lead also present. Based on the XRF spectrum, the alloy has a high ratio of copper to zinc. Unfortunately, quantitative data is not available for this analysis, so the percentages of the elements present in the alloy are not known. Quantitative analysis of the composition of the tuning pins should be obtained in future research. There is a very small peak in the spectrum at the expected location for nickel. In light of the discussion earlier in this dissertation pertaining to nickel as a trace element in historical brass alloys, it would be very interesting to know how much nickel is present in this brass.

The drive heads are rectangular in cross-section, in contrast to the tuning pins of the other surviving Irish harps (including the Lamont harp), which have drive heads that are square in cross-section. Similar rectangular drive head copper alloy tuning pins have been discovered individually as archeological finds in Ireland and Scotland, however, and these may also be harp tuning pins.[453]

With two exceptions, the Queen Mary harp tuning pins appear to belong to a matched set. These tuning pins all have an incised grid on the end of the drive head, a cross on the end of the shaft, and a pair of lines at the bass of the drive head. Each of the tuning pins, including the two that don't match the others, has a set of incised hash marks on the shaft. These marks are of particular interest and are discussed later in this section. The lengths of the matching tuning pins range from 75 – 80 mm,

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[452] This is worth pointing out because the 1983 archival photographs, which are reproduced in this dissertation, have been used by other researchers. In order to avoid confusion it is important that future researchers are aware of the reordering of the tuning pins.
[453] Keith Sanger, "Harp Pegs Project," accessed 2 October, 2014, http://www.wirestrungharp.com/material/harp_pegs.html. Sanger has compiled a catalogue of archeological tuning pin finds currently in museum collections. A copper alloy tuning pin with a rectangular drive head was discovered by a metal detectorist in Scotland in 2009 (currently privately owned).

however most are 75 – 78 mm long. A representative tuning pin is shown in figure 4.37.

Figure 4.37: *a tuning pin belonging to the Queen Mary harp, viewed from the side (upper image) and the front (lower image). This is currently in hole #29, and is representative of the appearance of all except two of the remaining tuning pins. The end of the drive head (inset, upper) is incised with a grid, and the string end of the shaft (inset, lower) is incised with a cross. The tuning pin also has a set of incised hash marks in the middle of the shaft.*

As mentioned above, two of the tuning pins don't match the others. Figure 4.38 shows tuning pin #2. This tuning pin has a drive head that is longer and thinner than the others, and lacks the pair of incised lines at its base and the grid on its end. With a length of 82 mm, tuning pin #2 is also slightly longer overall than the other tuning pins. Its alloy is also more yellow in colour. Quantitative XRF analysis should be done on this tuning pin to determine the composition of the alloy for comparison with the other tuning pins. Tuning pin #2 does have a few characteristics in common with the others. It has the incised cross on the end of the shaft at the string end, and also has a set of hash marks at the centre of the shaft. This may be an early historical replacement. It probably does not belong to the additional, 30th tuning pin hole, however, as that hole is larger than the others and the shaft of this tuning pin would be too narrow to fit it properly (although the 30th hole could have been enlarged at a later date).

Figure 4.38: *tuning pin #2 of the Queen Mary harp. This tuning pin does not match the others (see figure 4.37). The drive head is narrower and has no incised lines on it, and the colour of the alloy is also different. This tuning pin does have the cross on the string end of the shaft, and the incised hash marks in the middle of the shaft, however.*

The other tuning pin that is different from the others is #9, which is shown in figure 4.39, below. Upon close examination it is apparent that a 1.5 – 2 mm thick copper alloy layer has been soldered over the existing drive head, as shown in the inset at upper left in figure 4.39. It is not clear if this was intended to be a repair or a modification. The end of the drive head is incised with a grid like the others, although it is somewhat indistinct, but the pattern of incised lines on the face of the drive head is not the same as on the other tuning pins. The string end of the shaft is also lacking an incised cross. Like all of the other tuning pins, however, the shaft has a set of incised hash marks at its centre. This tuning pin could be a replacement reused from another harp (possibly with the drive head modified). Quantitative XRF analysis of the alloy of this tuning pin (and the modification/repair to the drive head) and of a representative sampling of the other tuning pins should be undertaken in order to determine whether or not they were made from the same batch of brass.

Another interesting feature of tuning pin #9 is the waist in the shaft, located about 1/3 of the distance between the ends of the pin from the string end. This is shown in detail in the inset at upper right in figure 4.39. This waist appears to be wear, although shaft wear is normally found closer to the ends, where it is caused by the cheekband coming into contact with the tuning pin. Some of the tuning pin holes in the neck of the Queen Mary harp have material embedded in them (see the discussion below), which could cause wear in this location on the tuning pin shaft.

Figure 4.39: *tuning pin #9 of the Queen Mary harp. The drive head of this tuning pin appears to have been modified or repaired with a layer of copper alloy soldered over it (inset, upper left). The shaft of the tuning pin has a waist (inset, upper right) that appears to be wear.*

Measurements for the Queen Mary harp tuning pins are given in table 4.1, below. The shaft taper is the diameter of the shaft measured directly below the drive head and at the string end. The drive head measurements are length × width × height. The width and height are the dimensions at the end of the drive head. Note that the drive heads are tapered (see figures 4.37 – 4.39). The length is the overall length of the tuning pins including the drive head. The measurements for tuning pins #2 and #9 are included separately, as they are different from the others. The dimensions of the drive head and shaft taper are quite consistent amongst the matched set of tuning pins, so the dimensions given in the table represent the average values rounded off to the nearest 0.5 mm. The overall length for these pins is given as a range from the minimum to maximum measured values.

Table 4.1.
Queen Mary harp tuning pin measurements

tuning pin	**drive head (mm)**	**shaft taper (mm)**	**length (mm)**
matched set	17.0 × 5.0 × 3.5	6.0 – 4.0	75 – 80
#2	19.5 × 5.0 × 2.0	5.5 – 4.0	82
#9	16.0 × 5.5 × 2.5	6.0 – 4.0	76

As mentioned earlier in this section, each of the Queen Mary harp tuning pins has a set of incised hash marks on the shaft, about midway between the ends of the pin. These can be seen, for example, in the photographs of the tuning pins in figures 4.37 – 4.39. They are positioned on the part of the shaft that is normally hidden from view when the tuning pin is in the neck. The hash marks were first recorded in the set of unpublished archival photographs of the Queen Mary harp tuning pins taken in 1983.[454] These marks were undoubtedly known to some researchers, but are not

[454] See figure 4.35.

mentioned prior to being noticed in these photographs by Simon Chadwick while conducting research in 2006 for his commissioned replica of the Queen Mary harp.[455]

The hash marks appear to be carefully and purposefully inscribed. Their number varies from 1 – 6, with an even distribution of pins numbering 1, 2, and 5 marks, and one pin each with 4 and 6 marks. Pin #24 has two sets of hash marks, numbering 1 and 3, on opposite sides of the shaft. Figures 4.40 and 4.41 present a gallery of the hash marks on each tuning pin, for comparison.

[455] Simon Chadwick, "Historical Reproduction," 16. The hash marks are not explicitly mentioned in this article, but are shown in a photograph of one of the reproduction tuning pins on a personal web page discussing the project. Simon Chadwick, untitled page on the Queen Mary harp replica, last modified, March 2009, http://www.simonchadwick.net/qm/. The hash marks, and the archival photographs showing them were brought to the author's attention by Simon Chadwick in 2007.

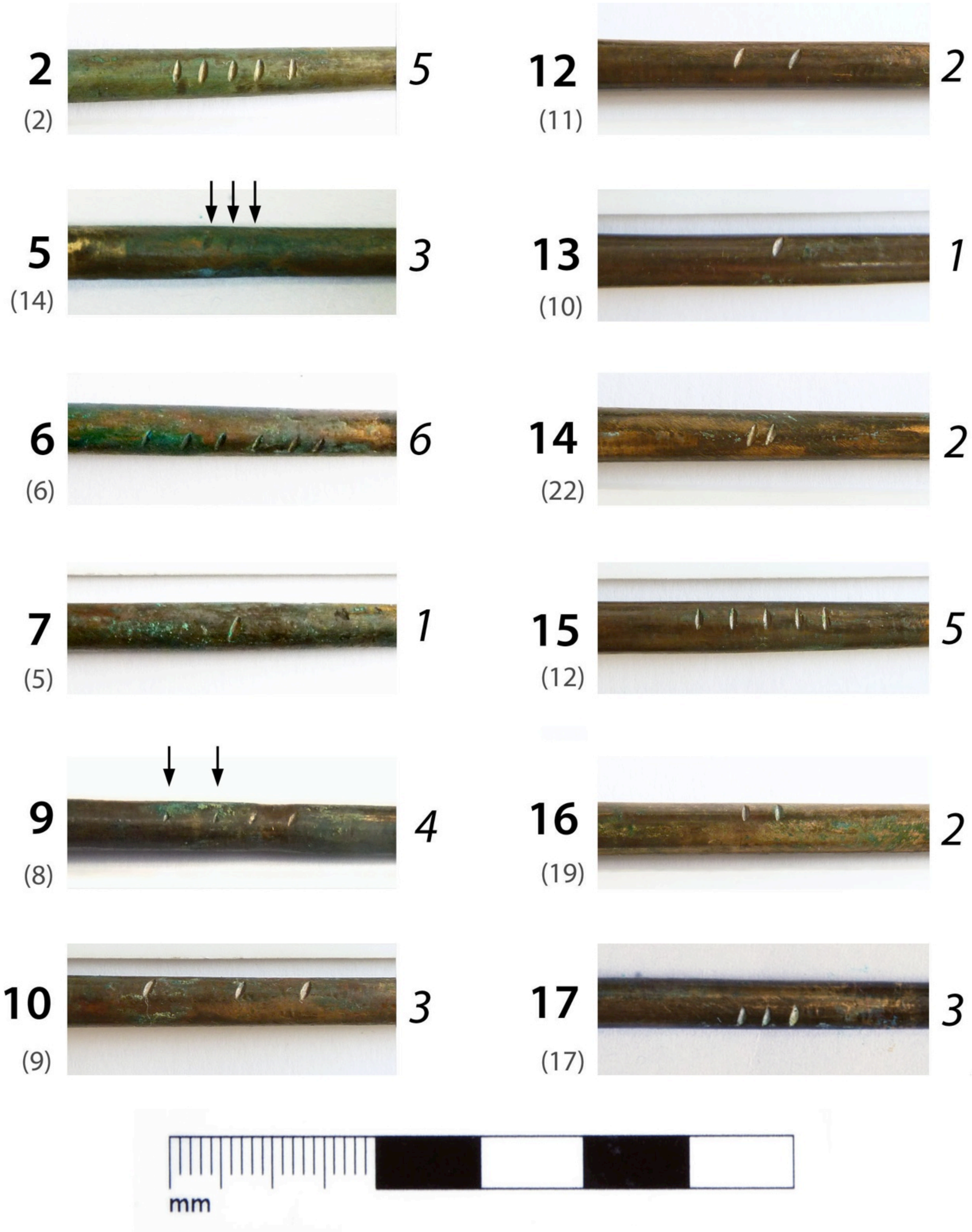

Figure 4.40: *a gallery of the incised hash marks on the Queen Mary harp tuning pin shafts for pins 2 – 17 (for pins 18 – 29 see figure 4.41). The number of marks on each shaft is indicated in italics to the right of each photograph. Where the marks are indistinct their locations are indicated by arrows. The number in bold to the left of each photograph indicates the current order of the tuning pin in the neck. The number below this in parentheses indicates the order of the tuning pin in the 1983 archival photographs reproduced in figure 4.35. The shafts are all oriented with the drive heads to the left. Scale in mm as indicated.*

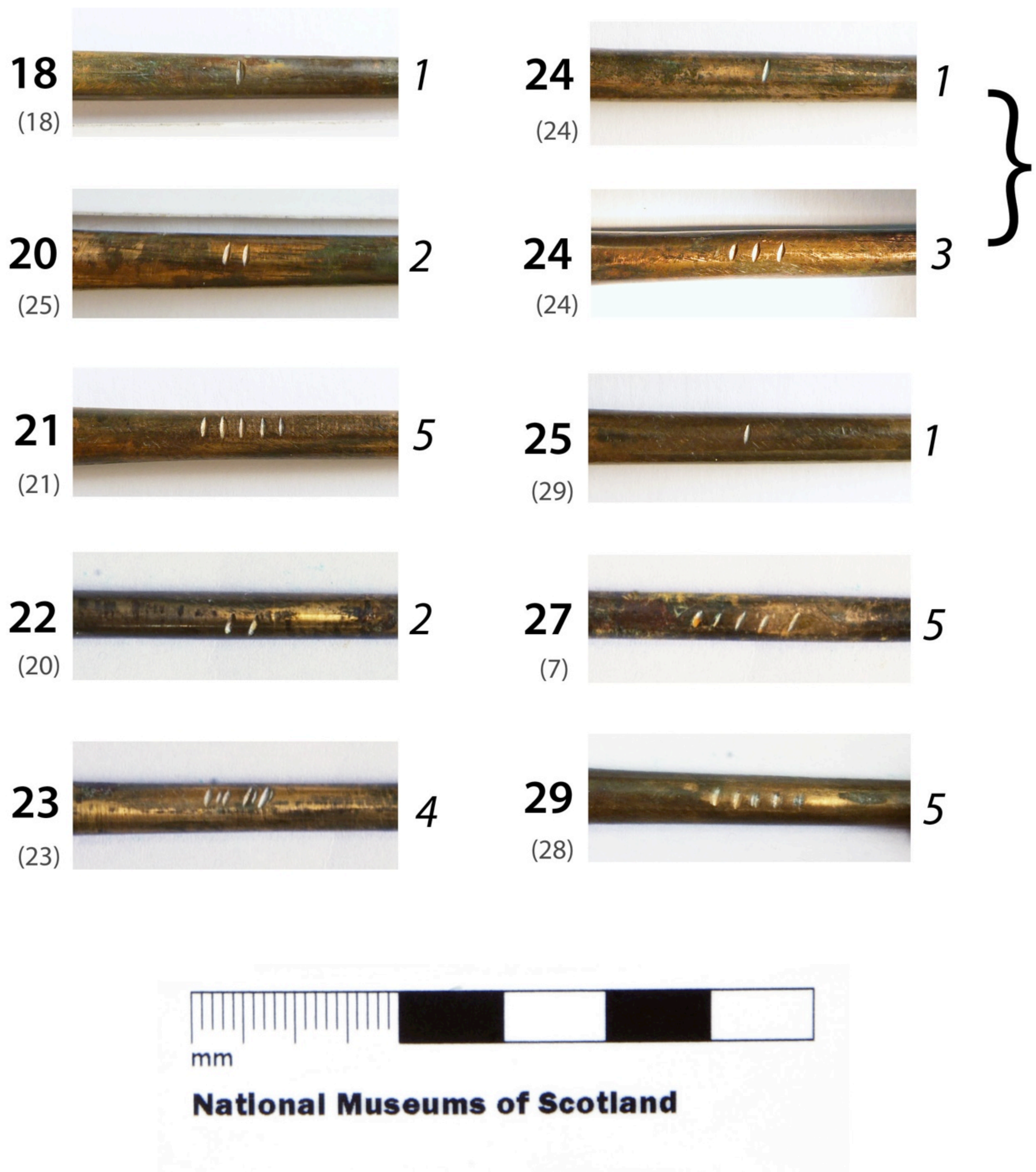

Figure 4.41: *a gallery of the incised hash marks on the Queen Mary harp tuning pin shafts for pins 18 – 29 (for pins 2 – 17 see figure 4.40). For an explanation of the numbering system, see figure 4.40. Pin #24 has two sets of marks, so is shown twice. Note that pins #23 and #29 have partly double sets of marks. The shafts are all oriented with the drive heads to the left. Scale in mm as indicated.*

These hash marks are unique to the Queen Mary harp tuning pins. There are no known similar markings on the tuning pins of the other surviving Irish harps, however many of these tuning pins have not yet been fully examined. There are also no known similar markings on any of the archeological finds of tuning pins.

At present, the interpretation of these marks remains a matter for speculation. Interestingly, tuning pin #2, which is probably an historical replacement, also has the hash marks, as does tuning pin #9, where they overlap what may be wear on the shaft as discussed earlier. So, it is possible that the marks on the Queen Mary harp tuning pins are a later addition. Again, it is very unfortunate that the iron tuning pins are missing, as it would have been helpful to know whether or not these also had been incised with hash marks.

Tuning pin string holes

Each of the tuning pins has a hole for the string near the end of the shaft opposite the drive head. These string holes are not all the same size. As part of the current study of this harp, photomicroscopy was used to measure the string hole diameter for each of the tuning pins. Figure 4.42 shows a photomicrograph of the string hole in tuning pin #17, as an example.

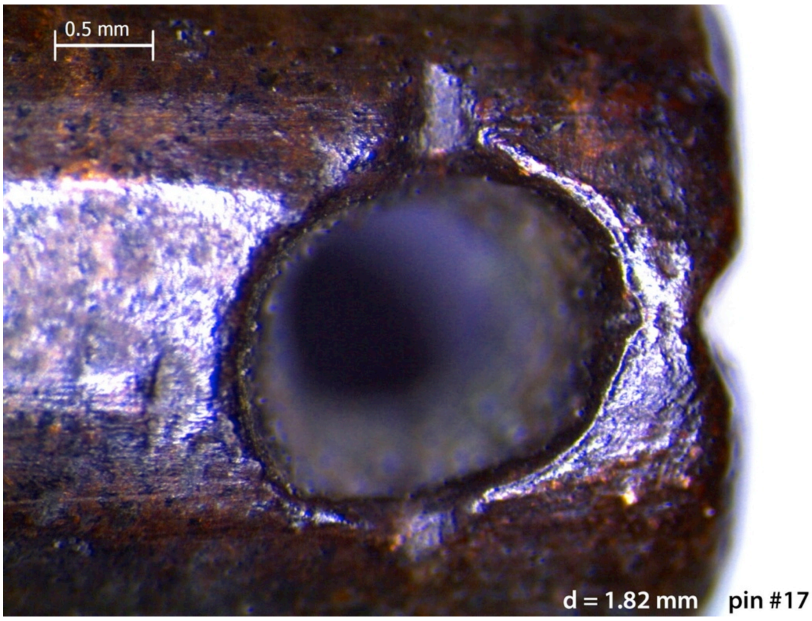

Figure 4.42: *a photomicrograph of the string hole in tuning pin #17 of the Queen Mary harp. The size of the hole is taken as the minimum distance across the hole, measured at the surface. Note the string wear along the upper and lower edges of the hole.*

The string hole in tuning pin #17 is typical in that it is slightly irregular in shape. Most of the string holes are either roughly oval or ovoid. The size of the string hole is taken as the minimum distance across the hole at the surface. This dimension provides an indication of the maximum diameter string that will fit into the hole. It is understood that the order of the tuning pins has been rearranged, probably on a number of occasions, particularly after the harp was no longer in use and was unstrung. Figure 4.43 shows the measurements of the string holes, arranged in order of increasing size.

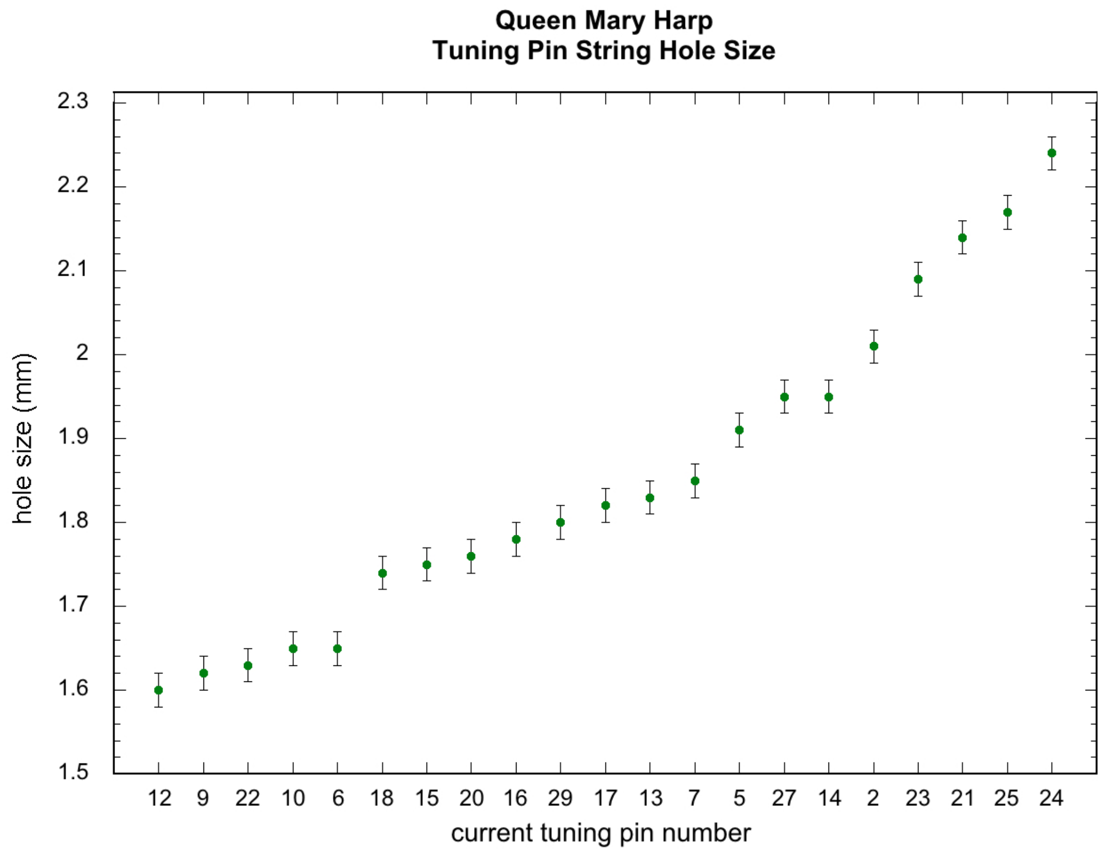

Figure 4.43: *measurements of string hole size for the Queen Mary harp tuning pins. The measurements have been ordered by increasing size. The numbers below the x-axis are the current positions of the tuning pins. The size of each hole is measured as the minimum distance across it at the surface of the tuning pin. The error bars reflect an uncertainty in the measurements of +/- 0.02 mm.*

The measured string hole sizes range from 1.60 – 2.24 mm, +/- 0.02 mm. The measurements, as plotted in figure 4.43, appear to steadily increase. This does not imply that the maker of these tuning pins graduated the string hole sizes this finely, or at all. It is, to a certain extent, simply a consequence of sorting the data. There would have been no advantage to graduating the sizes of the holes, and it would have necessitated keeping the tuning pins in order.[456] It is likely that all of the original tuning pins were made with string holes of the same size, sufficiently large enough to accommodate any of the strings. The observed differences in string hole size may therefore be due to holes being enlarged at a later date to accommodate thicker strings. If this is the case, then only the tuning pin holes that needed it would be enlarged, which would presumably be those located in the bass at that time. This could even have occurred on more than one occasion, resulting in a mix of string hole sizes.

It is known that the Queen Mary harp was restrung, post-historically, in the early 19th century, first with wire and then with gut.[457] Unfortunately, it is not known if the sizes of any of the tuning pin string holes were enlarged at this time to accommodate the strings that were used, so what can be ascertained about the historical stringing from the tuning pin string hole sizes is limited by this. Assuming the tuning pins were made with a single string hole size, as suggested above, what can be understood is that the largest diameter strings originally used would have been no larger than the smallest string holes, currently, and in practice at least a few tenths of a millimetre narrower, to allow easy insertion of the string into the hole. The smallest string holes are just over 1.6 mm across, so the original set of strings would therefore not have exceeded ~1.2 mm in diameter, and are likely to have been narrower.

A notable feature of the tuning pin string hole shown in figure 4.42 is the prominent wear marks at the upper and lower edges of the hole (as viewed in the figure). These are due to the winding of the wire string as it emerges from the hole. Similar wear marks are present to a greater or lesser extent on most (although not all) of the tuning

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[456] There is no correlation between the number of hash marks on the tuning pin shaft and the string hole size.
[457] Gunn, *Historical Enquiry*, 18 – 24.

pins. The side of hole on which the wear mark is present indicates the direction of the winding. A wear mark on the upper edge of the string hole (as viewed in the figure) indicates a winding that tightens as the drive head is turned clock-wise (i.e. the string comes off the tuning pin on the side facing the player). A wear mark on the lower edge of the string hole (as viewed in the figure) indicates a winding that tightens as the drive head is turned anti-clockwise (i.e. the string comes off the tuning pin on the side facing away from the player). Which way the tuning pins were wound historically has been a question for some current players, as it does affect the angle of the strings, which is particularly noticeable in the treble end of the compass. It is evident from the wear marks that the tuning pin shown in figure 4.42 was wound both ways, presumably at different times. A few of the Queen Mary harp tuning pins have just one wear mark, on either the upper or lower edge, but most have wear marks on both edges, suggesting that both winding directions were used. It is possible that, after the neck rotated forwards, the winding direction was changed to have the string come off the tuning pin on the side facing away from the player (anti-clockwise winding) to slightly compensate for the decrease in the angle of the strings to the front of the soundbox. Interestingly, there is also a small wear mark on the side of the hole facing the end of the shaft. This is also present on a few of the other tuning pin string holes. Perhaps the wire was occasionally looped over the end of the shaft and passed back through the hole before being wound around the pin. This is feasible on these tuning pins because the string holes are placed very close to the end of the shaft.

Tuning pin holes

The Queen Mary harp was CT scanned with the tuning pins removed from the neck. This made it possible to see the insides of the tuning pin holes on the tomograms. Dense, possibly metallic, material was detected inside several of them. The presence of this material was first reported in Loomis (2010) and Loomis et al. (2012).[458] It

[458] Loomis, "Structural Breaks and Repairs," 64. Loomis et al., "Lamont and Queen Mary Harps," 126.

can be seen in the tomographic surface rendering in figure 4.44, which shows the first five tuning pin holes at the treble end of the neck. This rendering highlights both the tuning pin holes and any dense material, such as metals.

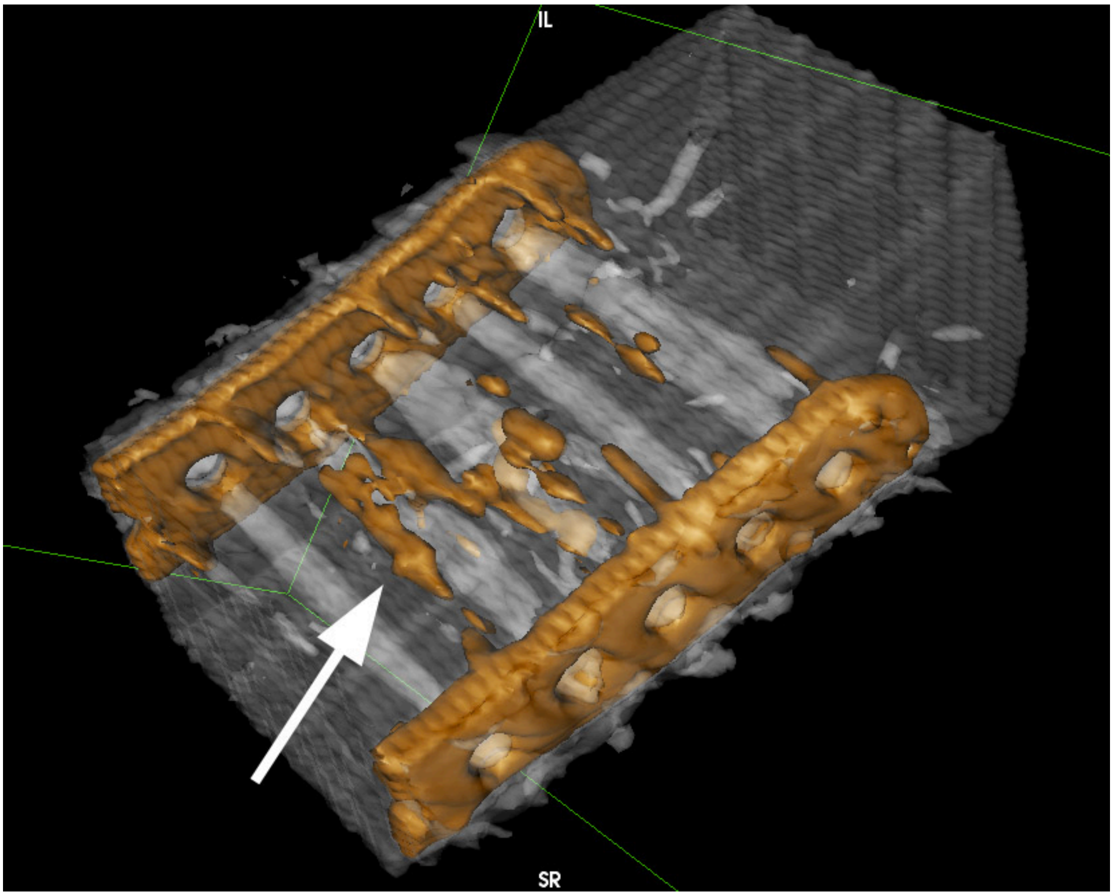

Figure 4.44: *tomographic surface rendering of the first five tuning pin holes at the treble end of the Queen Mary harp neck. The holes for the tuning pins and other voids in the wood are rendered as light grey areas. Very dense material, such as the metal cheekbands, is rendered light brown. Note the dense, possibly metallic, material in the tuning pin holes (arrowed). It is also possible to see in this rendering that tuning pin holes #1 and #3 had to be re-bored after the maker's tool veered off course.*

In the tomographic surface rendering in figure 4.44, very dense objects, such as the metal cheekbands, are rendered as light brown. Voids, such as the tuning pin holes, are rendered as light grey. The rendering shows the presence of dense, possibly metallic material in some of the tuning pin holes.

In her examination of the Trinity College harp during conservation work undertaken by the British Museum in 1961, Joan Rimmer observed that several tuning pin holes were "lined with thin metal to get a better fit."[459] When the CT scan of the Queen Mary harp revealed material in several of the tuning pin holes, it was theorized that this was probably also shim material. As tuning pin holes become enlarged due to wear, the shafts of the pins need to be pressed further in to grip the wood tightly enough to keep the strings tensioned. Eventually, with long use, a point may be reached whereby pressing the shaft further into the hole will cause it or the drive head to come into contact with the metal cheekbands. This is undesirable, as it will damage the tuning pin and may cause it to bind. The most obvious solution is to shim the tuning pin holes. This hasn't been necessary (yet) for most modern-built historical replicas, presumably because it takes many years of use before the tuning pin holes are sufficiently worn down to require shimming. It is interesting, therefore, to observe this practice on the historical instruments, and to discover what materials were used.

When the Queen Mary harp was reexamined at the NMS Collections Centre in December 2012, the tuning pins were removed and the tuning pin holes were visually examined. The tuning pin holes in which the CT scan showed the presence of dense material were all lined with deposits that were orange in colour. The rest of the tuning pin holes were lined with deposits that were verdigris in colour. The orange material was found to be a layer of fine powder. Figure 4.45 shows the contrasting appearance of the material in the tuning pin holes.

[459] Joan Rimmer, "Report on Stringing the Trinity College, Dublin Harp" (unpublished report, 16 October, 1961), 2. The author gratefully acknowledges Simon Chadwick for providing a copy of this report.

Figure 4.45: *tuning pin holes 13 – 16 of the Queen Mary harp. Hole #13 appears to be lined with a layer of orange coloured material (arrowed). Hole #16 appears to contain similar material. The other two tuning pin holes contain verdigris coloured deposits.*

Small samples of the orange powder were taken, and are awaiting analysis, but a larger, darker fragment, taken from tuning pin hole #3 was analysed with SEM-EDX and found to be iron. This was an irregularly shaped fragment measuring 5 × 2.5 × 1.5 mm.

Iron seems an odd choice of material for shims, but there is an alternative explanation for the orange deposits. As discussed earlier, several of the tuning pins went missing in the 1980's. When Armstrong examined this harp with its full complement of tuning pins, he noted that eight pins were iron.[460] There are currently nine tuning pin holes with orange deposits. Assuming there was some swapping around of tuning pins, it is very likely that these orange deposits, and the dense material associated with them that appears on the tomograms, are corrosion from the iron tuning pins, and not shim material.

[460] Armstrong, *Irish and Highland Harps*, 171, note 2.

Although the dense material discovered on the tomograms does not appear to be associated with shims, some clear evidence of non-metallic shimming was found in tuning pin hole #23, as shown in figure 4.46, below.

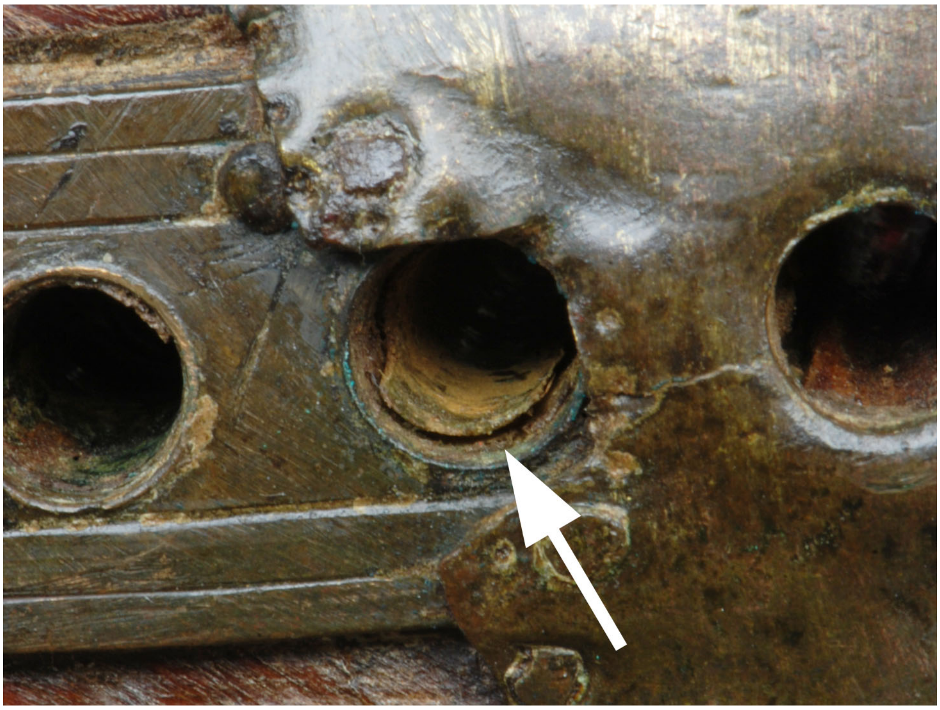

Figure 4.46: *a shim in tuning pin hole #23 of the Queen Mary harp (arrowed).*

The shim in this tuning pin hole was extracted and found to be a feather quill, as shown in figure 4.47. Judging from the size, it came from a relatively large bird.

Figure 4.47: *the shim extracted from tuning pin hole #23 of the Queen Mary harp - a feather quill!*

Cheekbands

The cheekbands of the Queen Mary harp are each made from a thin plate of copper alloy. The right-hand cheekband was analysed with XRF and found to be brass with trace amounts of tin and lead also present. Based on the XRF spectrum, the alloy has a high ratio of copper to zinc. Unfortunately, quantitative data is not available for this analysis, so the percentages of the elements present are not known. The spectral signature is nearly identical to that for the analysis of tuning pin #5, however, which suggests that the tuning pins and cheekbands were probably made together. Quantitative analysis of the composition of the Queen Mary harp cheekbands and tuning pins should be conducted to confirm that this is the case, though. The close similarity in composition of the Queen Mary harp cheekband and tuning pin is in contrast to the Lamont harp, which has bronze cheekbands and brass tuning pins.

Both cheekbands are decorated with a pair of incised lines along the upper and lower edges. This can be seen in the photograph in figure 4.45, which shows a section of the right-hand cheekband.

Armstrong (1904) noted that both cheekbands had probably broken, with the left-hand cheekband break hidden under a small metal strap at tuning pin hole #19, and the right-hand cheekband break hidden under a large, crude metal patch at tuning pin hole #24.[461] The CT scans of the neck confirmed the break to the right-hand cheekband hidden under the metal patch, as is discussed and illustrated in Loomis (2010), and Loomis et al. (2012).[462] As discussed Chapter 2 of this dissertation, the left-hand cheekband has bowed out on the left side as a result of the bass end of the neck turning towards the left. At tuning pin hole #19 it has either broken, or it has been cut and spliced to reduce the bowing. This is shown in the photograph in figure 4.48. In this photograph, the bass end of the neck is towards the left. The section of the cheekband on the bass side of the tuning pin hole has rotated slightly upwards to follow the shift in position of this end of the neck due to cracking of the wood as a result of the string tension. The ends of the cheekband on either side of the tuning pin hole have been carefully spliced together. The upper and lower edges are offset such that one of the incised decorative lines appears to continue across the break.

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[461] Armstrong, *Irish and Highland Harps*, 178.
[462] Loomis, "Structural Breaks and Repairs," 59 – 61. Loomis et al., "Lamont and Queen Mary Harps," 125 – 26.

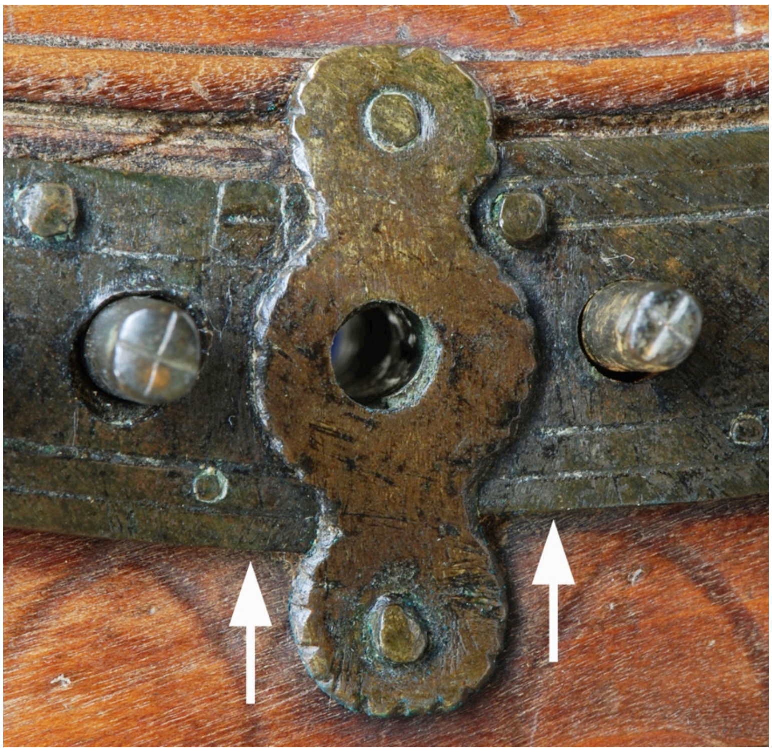

Figure 4.48: *repair to the left-hand cheekband of the Queen Mary harp, at tuning pin hole #19. Note that the upper and lower edges of the cheekband are offset on either side of the tuning pin hole (arrowed). The ends are hidden under the metal strap. The bass end of the neck is towards the left in this photograph. Photograph: Isabell Wagner.*

The cheekband dimensions are given in table 4.2, below. They are the same for both, with the exception of the tuning pin holes, which are slightly larger on the right-hand cheekband to accommodate the taper of the tuning pins. Tomograms of each cheekband are shown in figures 4.49 and 4.50.

Table 4.2.

Queen Mary harp cheekband dimensions

dimension	**measurement (mm)**
length	306
width	16
thickness	0.75
tuning pin hole diameter	6.0 (right); 4.5 – 5.0 (left)

Note: the cheekband length is the straight-line distance from the midpoint of each end. The measurement uncertainty is +/- 1 mm for the cheekband length, +/- 0.5 mm for the width, and +/- 0.01 mm for the thickness, which was measured with a digital caliper.

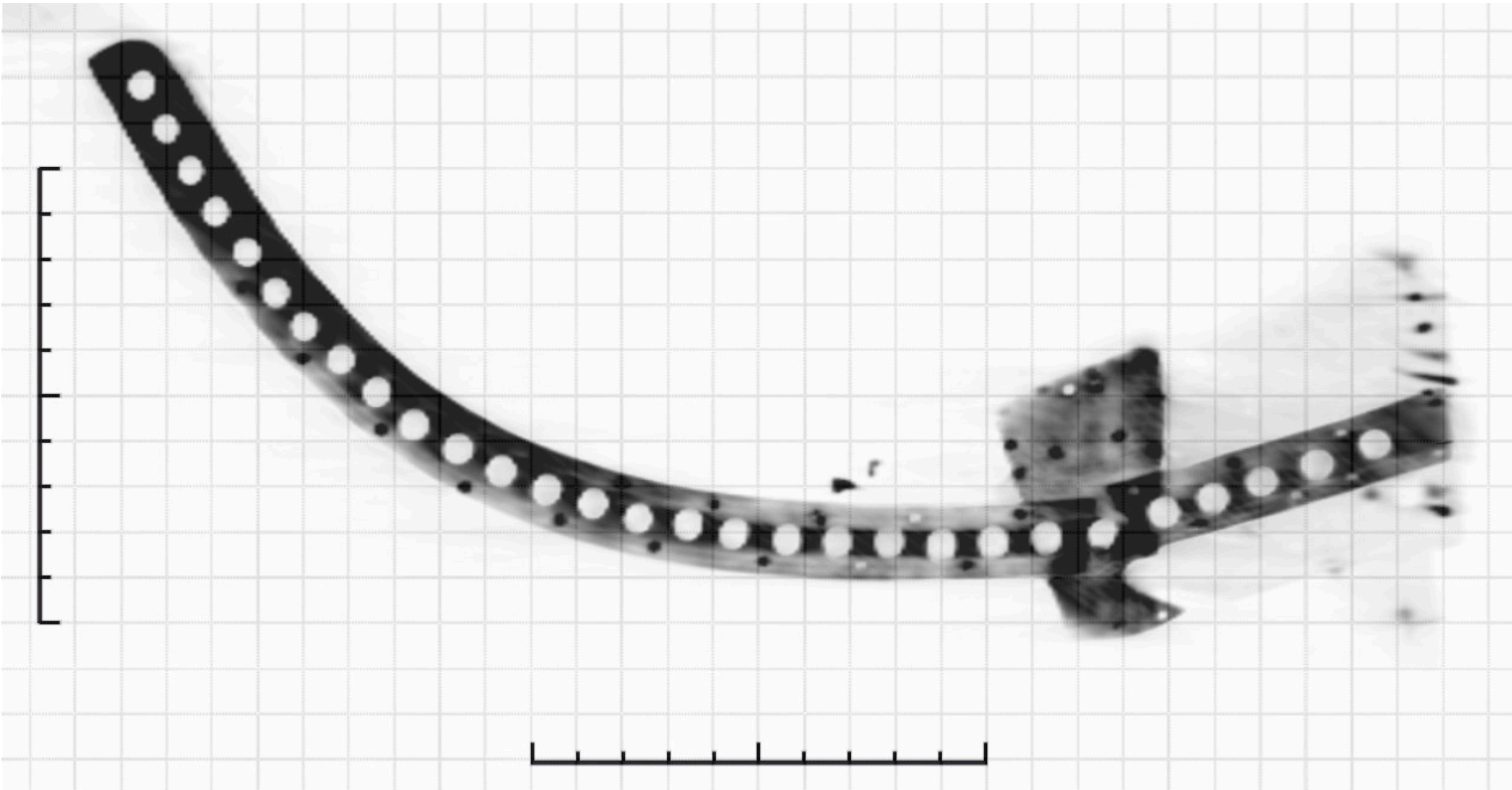

Figure 4.49: *tomogram of the right-hand cheekband of the Queen Mary harp. The treble end of the cheekband is on the left. Scale 1 tick : 1 cm; grid scale 1 square : 1 cm.*

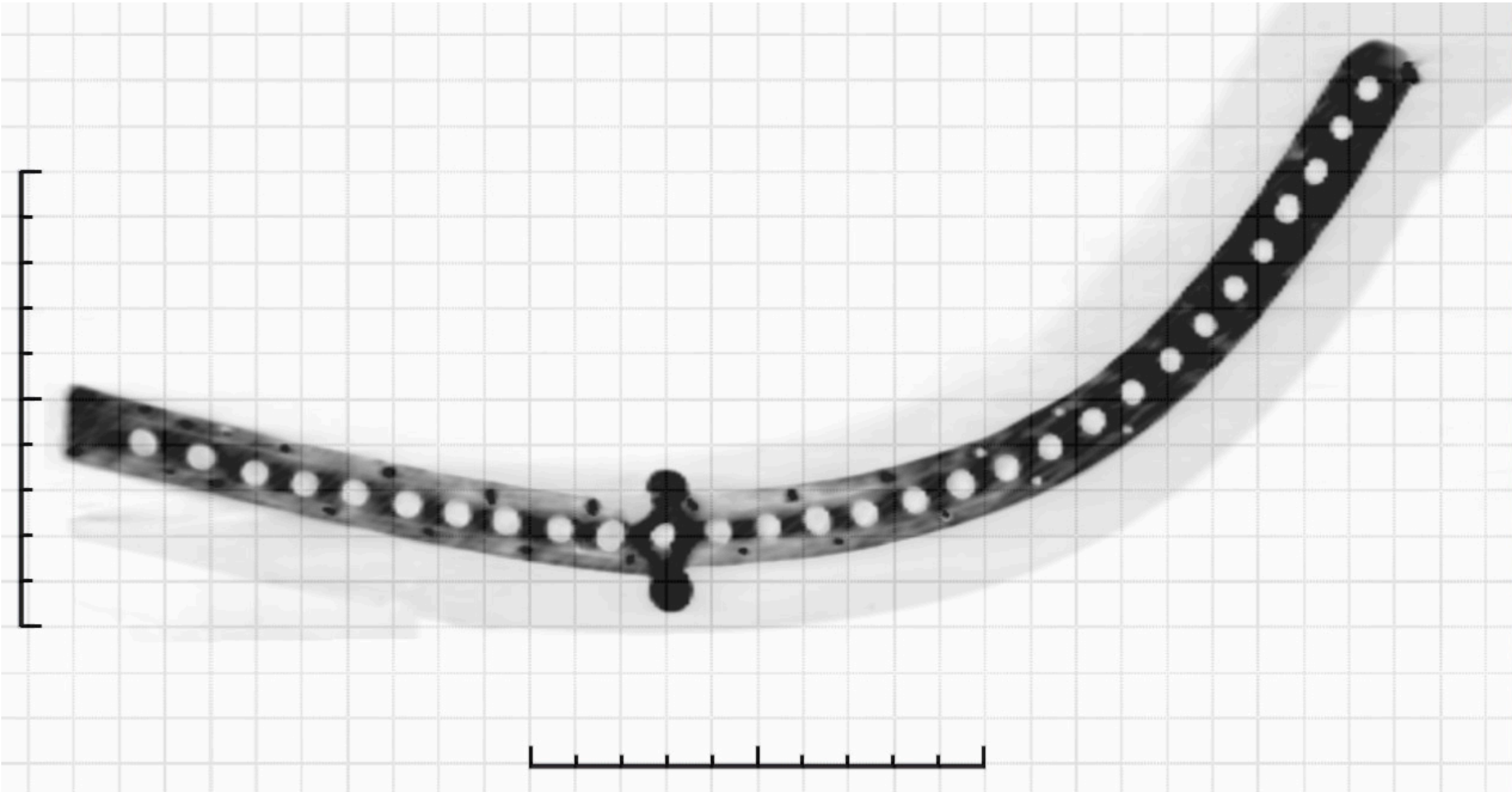

Figure 4.50: *tomogram of the left-hand cheekband of the Queen Mary harp. The treble end of the cheekband is on the right. Scale 1 tick : 1 cm; grid scale 1 square : 1 cm.*

Decorative work

The decorative work on the neck of the Queen Mary harp is first mentioned in Gunn (1807), where it is also first depicted in an accompanying engraving of the harp.[463] It is also briefly discussed in Bell (1880), and is discussed and diagrammed in detail in Armstrong (1904).[464] The neck is chiefly decorated with a ring and dot motif executed in the same style and manner as the decorative work on the soundbox. This is shown in the photographs of the neck in figures 4.51 and 4.52. For this reason, the decorative work on the neck is discussed jointly with the decorative work on the soundbox, later in this chapter. This section discusses the evidence for embellishments to the decorative work on the neck.

Figure 4.51 (overleaf): *neck of the Queen Mary harp, left side. The wood is decorated with a ring and dot motif, and arcades (below the cheekband). The decorative work is executed in the same style and manner as the decorative work on the soundbox.*

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[463] Gunn, *Historical Enquiry*, 16, and Plate II.
[464] Bell, "Notice of Two Ancient Harps and Targets," 20 – 21. Armstrong, *Irish and Highland Harps,* 174 – 75, and Plate VIII, opp. 180.

Figure 4.52 (overleaf): *neck of the Queen Mary harp, right side. The wood is decorated in the same motif as the left side, with the exception of the area below the cheekbands, which is decorated in concentric semi-circles instead of arcades. The right side of the neck bears evidence of having been adorned with decorative badges, medallions, and/or other embellishments. Two oval stains (arrowed) indicate the former locations of decorative badges.*


National Museums of Scotland

In his history of Scotland, *Rerum Scoticarum Historia* (1582), George Buchanan writes of the harpers in the Scottish highlands:

> "Their only ambition seems to be, to ornament their Harps with silver and precious stones : the lower ranks, instead of gems, deck theirs with crystal."[465]

As discussed in the chapter section on the forepillar, Gunn reports that the harp formerly bore, in gold, the Queen's portrait and the arms of Scotland, and additionally a "jewel of considerable value" in the circular depression on the upper right-hand side of the forepillar.[466] The neck of the harp bears evidence that it had, at one time, also been decorated with badges and possibly other items. This can be seen in the photograph in figure 4.52. Two dark, oval outlines on the neck (arrowed in the figure) indicate where badges were once located. These can be seen in detail in the photograph in figure 4.53, below. There is visible evidence of nails or nail holes at the ends of both oval outlines, and the smaller oval also has two circular impressions that may have been made by washers.

[465] George Buchanan, *Rerum Scoticarum Historia*, ed. James Man (Aberdeen: James Chalmers, 1762), 20; translation as quoted in Gunn, *Historical Enquiry*, 68.
[466] Gunn, *Historical Enquiry*, 13 – 14.

Figure 4.53: *the two oval stains on the right-hand side of the Queen Mary harp neck. Nail holes are visible at the ends of each oval. The smaller oval also has indentations from what may have been washers, or tabs, probably used to hold a badge in place.*

Evidence of nails and other attachments can be seen elsewhere on the right-hand side of the neck. The locations of all of the nails can be clearly seen in figure 4.54, which shows the photograph of the neck in figure 4.52 overlaid with a tomogram. The tomogram highlights the presence of metal objects, including nail fragments hidden below the surface of the wood. In this figure, the locations of the two dark oval stains have been highlighted in green. They do not appear on the tomogram. The tomographic images of the nails and other attachments appear as white dots or short lines. In addition to the nails that held the oval badges, there is a nail to the upper right of the smaller oval (also visible in the photograph in figure 4.53), and two loose scatterings of nails and other attachments to the right of the larger oval. These can be seen in detail in the photograph in figure 4.55, which shows, in addition to nails, some bent hooks and broken clasps. Additionally, there are a few nails above the metal cheekband patch.

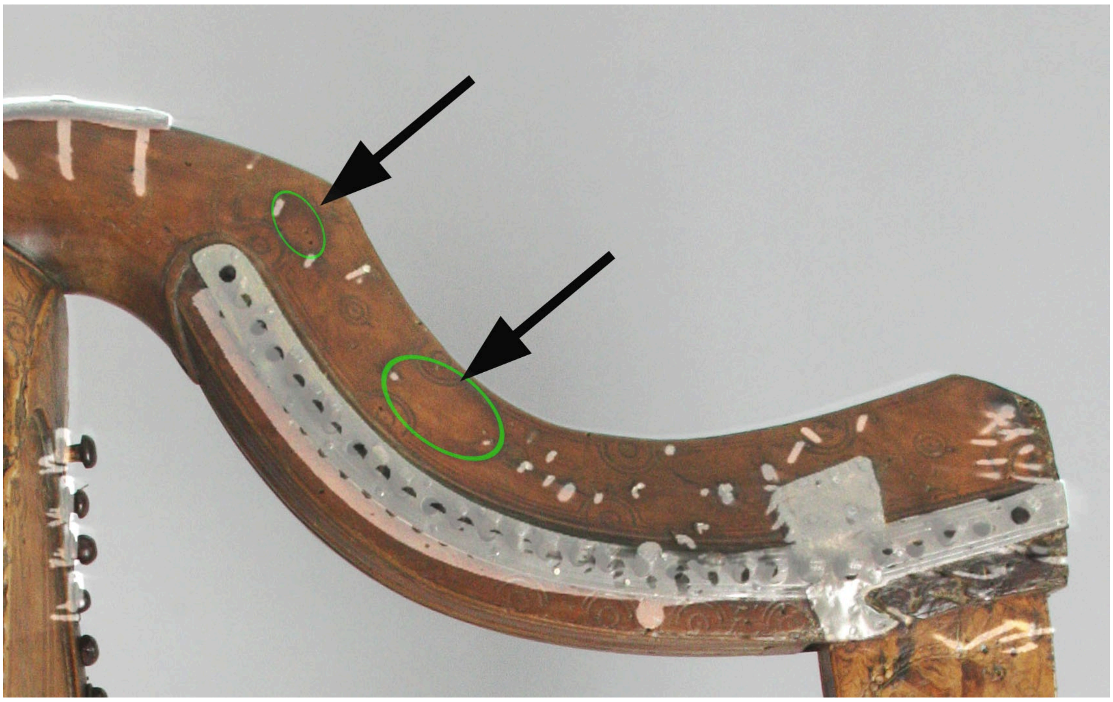


Figure 4.54: *photograph of the Queen Mary harp neck, overlaid with a tomogram to reveal the locations of nails and other metal attachments, which appear as white dots or short white lines. The outlines of the two oval stains (arrowed) have been added.*

Figure 4.55: *detailed view of an area on the right side of the Queen Mary harp neck, showing embedded nails and hooks. These were probably used to secure decorative embellishments onto the neck.*

It is clear from this evidence that at some point much of the right-hand side of the neck may have been decorated with badges, medallions, or other enrichments. In contrast, there is only one nail on the left-hand side of the neck. This is not unexpected. As discussed in Chapter 3 of this dissertation, these harps were traditionally rested on the left shoulder, with the left hand playing the treble strings and the right hand playing the bass strings. As will be discussed later in this chapter, the wear marks on the soundbox of the Queen Mary harp indicate that this was the practice for this particular harp, and that, additionally, wear to the foot indicates that it was also held leaning over towards its left. If the harper were to perform facing the important members of the audience, the right side of the neck would be presented slightly towards them, and the left side, slightly away and down. It is notable that the right-hand side of the neck bears the drive ends of the tuning pins, which are more decorative and less unsightly than the string ends with their windings.

The tomogram in figure 4.54 shows a cluster of nails at the bass end of the neck (at lower right in the figure). These are driven into the face of the neck end. Figure 4.56, below, shows a photograph of the end of the neck overlaid with a tomogram to reveal the locations of the embedded nails.

Figure 4.56: *the bass end of the Queen Mary harp neck. On the left is a photograph of the neck. On the right, the photograph is overlaid with a tomogram to reveal the locations of embedded nails.*

With the exception of the nails for the ends of the cheekbands, all of the nails visible in the tomogram in figure 4.56 are driven into the end of the neck, presumably to attach something to it. As discussed in the chapter section on the forepillar, Gunn mentions that this harp at one time supposedly bore the Queen's portrait and the arms of Scotland "in front of the upper arm [neck]."[467] The earlier discussion of the nails in the forepillar explores the possibility that they may have held the decorative items to which Gunn refers. It is apparent from the nails visible in figure 4.56 that something was also affixed to the end of the neck. This could have been the Queen's portrait, or the arms of Scotland, or something else entirely. One interesting feature of the positions of the nails is that four are actually driven into the sides of the neck very close to the end. Two are located at the bottom corners, and two cross each other just below the peak. They are just below the surface and have split the wood as a consequence of being driven in so close to the end. This suggests that the end of the neck may have had a cap, comparable to the metal end caps on the neck of the Lamont and Trinity College harps, but with a very short sleeve.

[467] Gunn, *Historical Enquiry*, 14.

Summary

This chapter section discussed some elements of the construction and current state of the neck not discussed elsewhere in this dissertation, focusing particularly on the tuning pins. These were examined and found to be, with two exceptions, a matched set very likely made together with the cheekbands, based on the analysis of the composition of one cheekband and one of the tuning pins. All of the tuning pins, including the two that don't match the others, have similar sets of hash marks on their shafts, suggesting that these marks may be a later addition. Wear observed at the tuning pin string holes indicates that the tuning pins were wound in both directions, possibly at different times during the working life of this harp, which is notable because the choice of winding direction has an effect on the string angle, particularly in the treble.

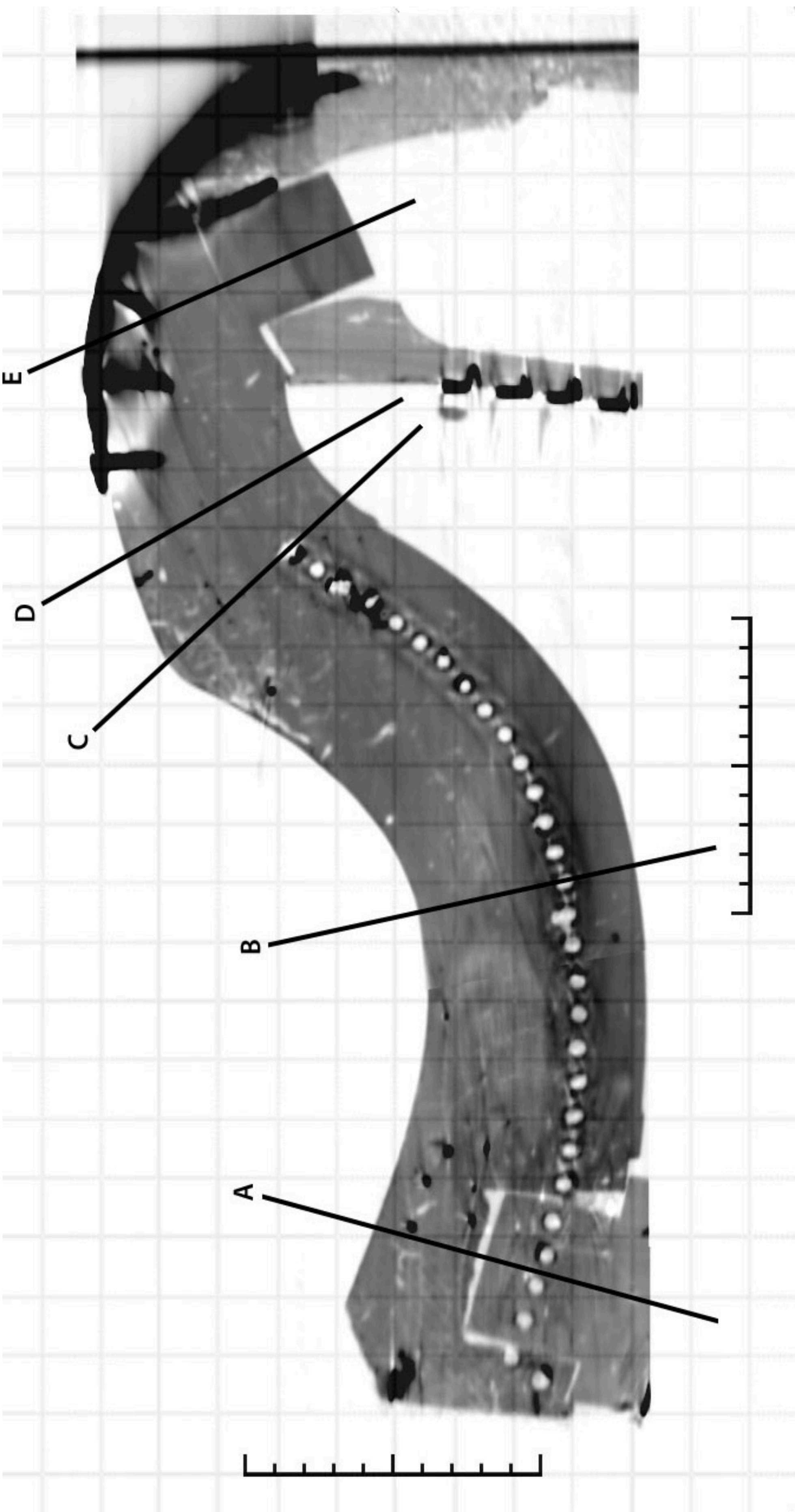
The tuning pin holes were also discussed. The dense material that had been detected in them during examination of the CT scans was analysed and ascertained to most likely be corrosion and fragments from iron tuning pins, not shims, as was previously theorized. A shim was discovered in one of the other tuning pin holes, however, and this was identified as a feather quill.

Signs of former embellishments to the neck were examined. Notably, these were confined to the right-hand side of the neck and the face of the bass end, the areas that would be most visible to the intended audience with the instrument resting on the player's left shoulder, played left-hand treble and right-hand bass.

Cross-sections

The neck is carved from a single quarter sawn piece of wood, with the grain direction aligned with the long axis and the centre of the timber below and to the left of the piece. This can be seen in the end grain visible on the face of the bass end, as shown in figure 4.56. The dimensions of the neck are shown in the tomographic cross-sections below. Figure 4.57 is a lengthwise cross-section of the neck. Because it is slightly twisted and bent towards the left side of the harp, a composite of three cross-sections was used in order to show the entire length. The lines labeled A – E in the figure indicate the locations of cross-sections taken across the neck. These are shown in figures 4.58 – 4.62. For all of these figures, the grey-scaling has been set to accurately represent the location of the physical edge of the wood using the method already described. The dimensions given in the figures are the FWHM of the cross-section. For figures 4.58 – 4.62, the line in the left-hand image indicates the location of the cross-section shown on the right, and the measurements shown were taken at the location of the lines indicated on the cross-section. The right-hand side of the harp is on the left, and the view is from the perspective of 'looking up' the neck from the bass end. The image artefacts are due to the metal cheekbands.

Figure 4.57 (overleaf): *composite tomographic cross-section of the neck of the Queen Mary harp. The lines A – E indicate the locations of the individual cross-sections shown in figures 4.58 – 4.62. Scale 1 tick : 1 cm; grid scale 1 square : 2 cm.*


A
B
C
D
E

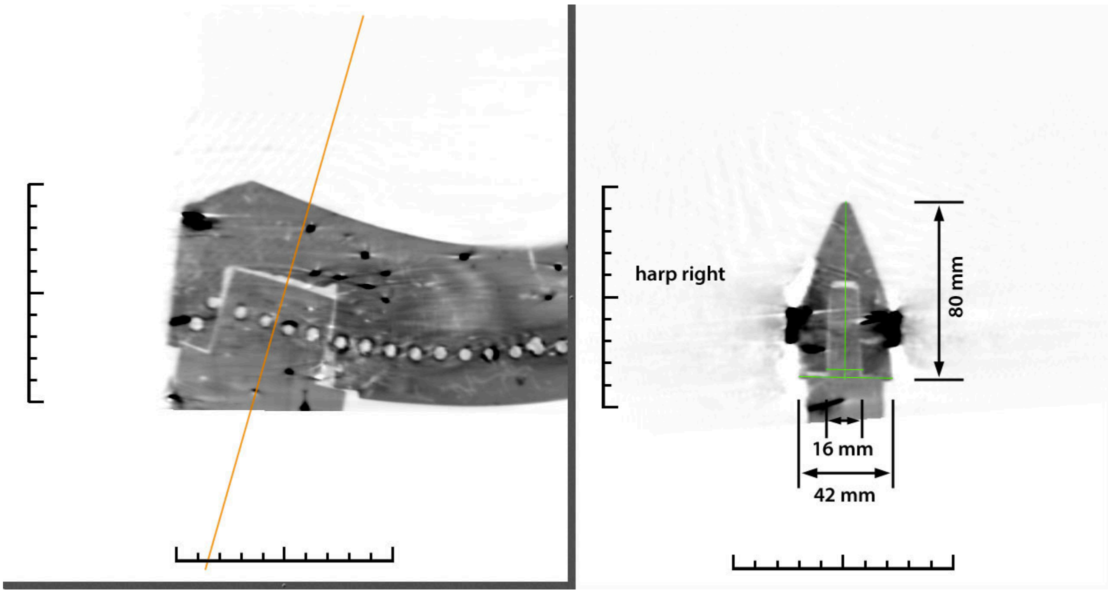


Figure 4.58: *Queen Mary neck cross-section A (see figure 4.57). This is a cross-section through the forepillar tenon. Scale 1 tick : 1 cm.*

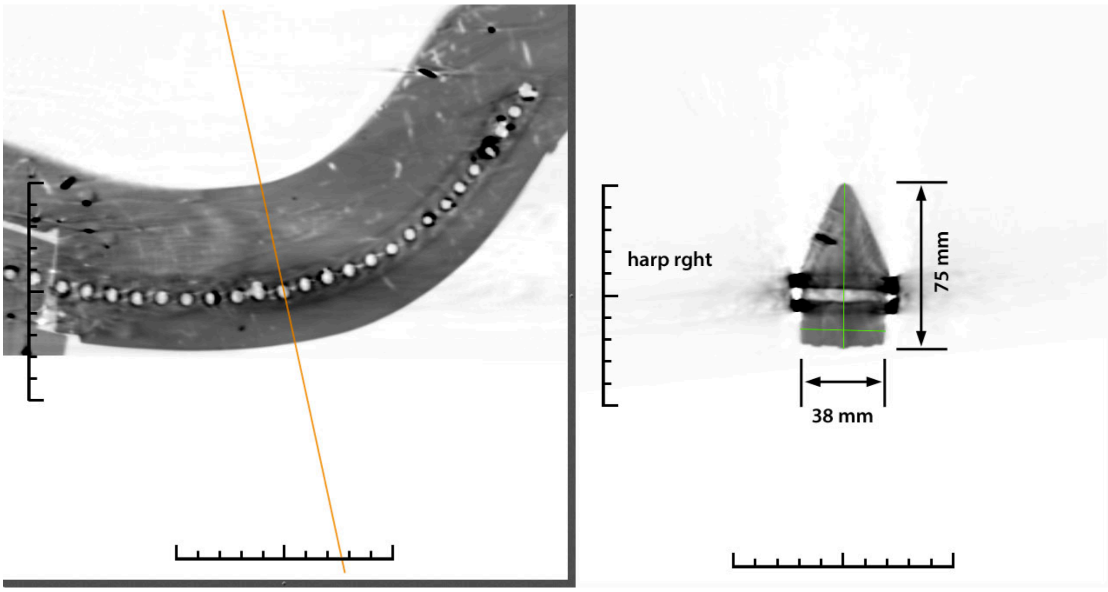


Figure 4.59: *Queen Mary neck cross-section B (see figure 4.57). Scale 1 tick : 1 cm.*

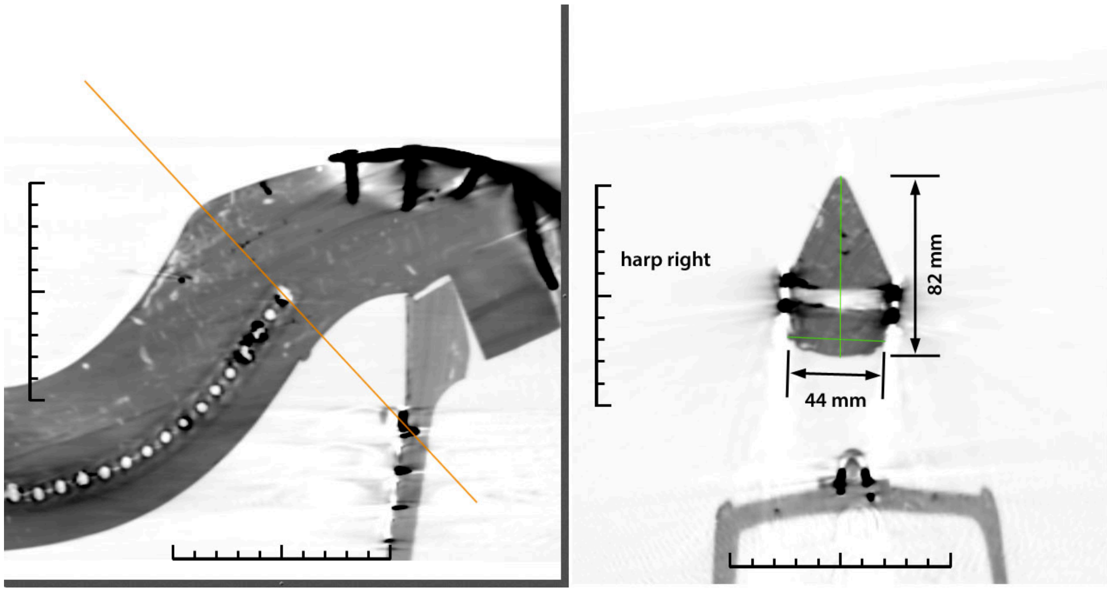


Figure 4.60: *Queen Mary neck cross-section C (see figure 4.57). Note that the cross-section of the soundbox appears distorted because the cross-sectional plane for the neck passes through it at an angle. Scale 1 tick : 1 cm.*

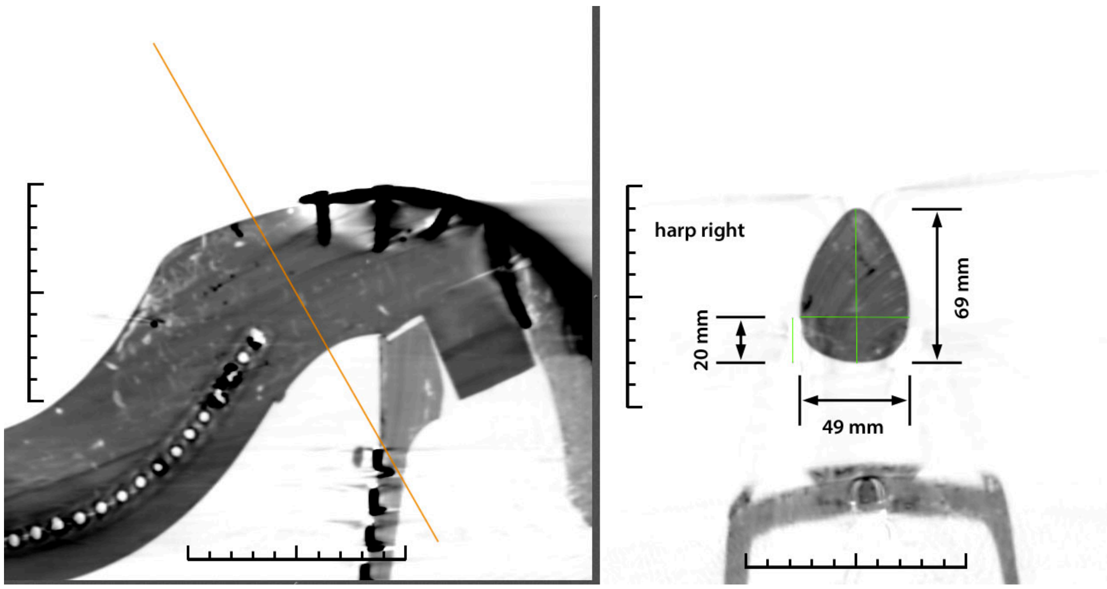


Figure 4.61: *Queen Mary neck cross-section D (see figure 4.57). As in figure 4.60, the cross-section of the soundbox appears distorted because the cross-sectional plane for the neck passes through it at an angle. Scale 1 tick : 1 cm.*

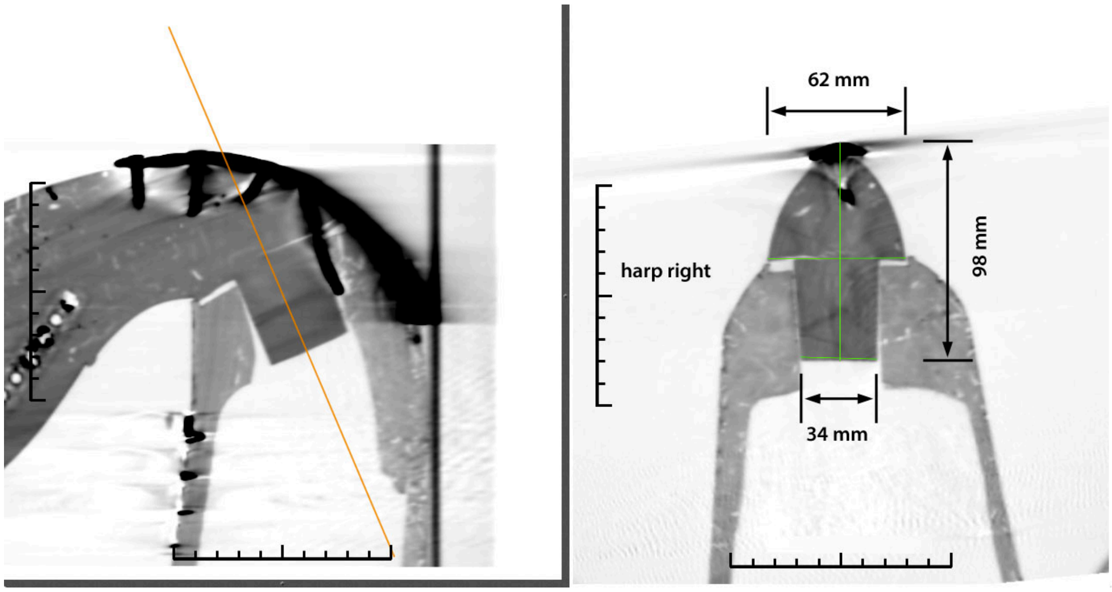


Figure 4.62: *Queen Mary neck cross-section E (see figure 4.57). This cross-section passes through the neck tenon. As in the previous two figures, the cross-section of the soundbox appears distorted because the cross-sectional plane for the neck passes through it at an angle. Scale 1 tick : 1 cm.*

Soundbox

The soundbox of the Queen Mary harp has been discussed in Loomis (2010) and Loomis et al. (2012).[468] Aspects of its construction and damage were also discussed in Chapter 2 of this dissertation in the context of the stringing, in particular, the soundbox belly and the mortise for the neck joint. This chapter section examines aspects of the soundbox construction not previously discussed. It begins with the decorative work, examining the motifs, methods, and materials used. Tool marks in the soundbox interior, and wear and other signs of use on both the interior and exterior are also examined and discussed in detail, including signs of modifications. A contour map of the thickness of the soundbox front, and measured cross-sections are also presented.

Decorative work

This discussion of the soundbox begins with the decorative work. As mentioned in the previous section, the style and execution of the decorative work on the neck is the same as for the soundbox, and is included in this discussion as well.

As previously discussed, the decorative work of the Queen Mary harp has been illustrated by Gunn (1807) and Bell (1880), and is discussed and diagramed in detail by Armstrong (1904).[469] As shown in figures 4.63 and 4.64, the soundbox of this harp is decorated in a geometrical design of crossing bands, medallions and a ring and dot (or concentric ring) motif that may be intended to represent bosses.

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[468] Loomis, "Structural Breaks and Repairs," 44 – 55. Loomis et al., "Lamont and Queen Mary Harps," 122 – 24.
[469] Gunn, *Historical Enquiry*, 16, and Plate II. Bell, "Notice of Two Ancient Harps and Targets," 18 – 20. Armstrong, *Irish and Highland Harps*, 173 – 74, and Plates VI and VII opp. 176.

Figure 4.63: *decorative work on the front of the Queen Mary harp soundbox. It is decorated in a design of crossing bands, incorporating medallion, ring and dot (or concentric ring), and cruciform motifs (arrowed).*

Figure 4.64: *decorative work on the left-hand side (top), and right-hand side (bottom) of the Queen Mary harp soundbox. The motif is similar to that on the front, with a cross-of-arcs or ring knot at the treble end.*

The decorative work continues on the bass end of the soundbox, which is decorated in the ring and dot or concentric ring motif, as shown in figure 4.65, below. The neck is also decorated with this motif, as shown in figures 4.51 and 4.52 in the previous chapter section.

Figure 4.65: *The bass end of the Queen Mary harp soundbox with decorative work consisting of a ring and dot or concentric ring motif.*

Armstrong (1904) noted that this motif also appears in two places on the back cover of the soundbox, as shown in figure 4.66.[470] As discussed in Loomis (2010) and Loomis et al. (2012), the design and workmanship appears to be the same as that on the rest of the soundbox and on the neck, so it is likely that the back cover of this harp is original.[471] This would make the Queen Mary harp the oldest surviving Irish harp to retain the original back cover to the soundbox.

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[470] Armstrong, *Irish and Highland Harps*, 174 and 179, Plate VII.
[471] Loomis, "Structural Breaks and Repairs," 51. Loomis et al., "Lamont and Queen Mary Harps," 124.

Figure 4.66*: decorative work on the back cover of the Queen Mary harp soundbox (arrowed, and insets) consisting of the same motif used on the rest of the soundbox and the neck. The workmanship also appears to be the same.*

The decorative work on the soundbox also incorporates a number of cruciform designs. In addition to the crossing diagonal bands, which could be interpreted as saltires, there are a pair of Latin crosses at the bass end of the soundbox front on either side of the string band, as shown in figure 4.63. Additionally, the two 'medallions' prominently placed midway up the front of the soundbox each contain an equal arm cross. Here, the incorporated ring and dot or concentric ring motif appears to evoke bosses, rendering the design reminiscent of some early Medieval

Anglo-Saxon disc brooches.[472] The treble end of each side of the soundbox is decorated with a motif that can be interpreted either as an encircled cross-of-arcs or as a ring-knot. These are shown in figure 4.67, below. While this motif is found in the Medieval monumental art of the West Highlands and islands, it is also found in numerous other locations in Scotland, as well as elsewhere in the British Isles, and has a long history of use as a Christian symbol dating from at least as early as the 6th century to as late as the end of the 15th century.[473] Further research is needed in order identify the specific style used on the harp soundbox, as this would help to identify the date and location of its construction.

Figure 4.67: *the crosses-of-arcs or ring knots on the left-hand (top) and right-hand (bottom) sides of the soundbox. Note that the design on each side is unique.*

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[472] See for example, the early 9th-century Pentney hoard brooches. "Six Disc Brooches from the Pentney Hoard," accessed 20 October, 2014, http://www.britishmuseum.org/explore/highlights/highlight_objects/pe_mla/s/pentney_hoard_brooches.aspx.

[473] For early examples in Ireland, see John Sheehan, "The Crux of the Matter: Pillars, Slabs, and Boulders," in *The Unquiet Grave: The Development of Kerry's Burial Grounds Through the Ages*, ed. Michael Connolly (Tralee: Kerry County Council, 2012), 115 –17. For late examples see the cross-of-arcs consecration crosses on the Linlithgow Palace chapel, erected in the late 15th century by James IV. John Dunbar, *Scottish Royal Palaces: The Architecture of the Royal Residences during the Late Medieval and Early Renaissance Periods* (East Lothian: Tuckwell Press Ltd, 1999), 121. For vaguely similar ring-knot motifs in the West Highlands, see Steer and Bannerman, *Late Medieval Monumental Sculpture*, 54 – 57.(see figure 12 (11) and figure 13).

As discussed in the section of this chapter on the forepillar, two areas of the soundbox are decorated in a different style from the rest of the soundbox and the neck, sharing instead decorative elements in common with the forepillar. These are the area above the eyebrows, which is carved in low relief in a foliaceous design of the same late medieval West Highland style identified on the forepillar, and the foot of the soundbox, which is carved in low relief to resemble a hound's head, with details of the facial features executed in the same style as on some of the beasts in the forepillar roundels (see figures 4.11 and 4.12). The chapter section on the forepillar also discussed the possibility that it may not be original, and the contrasting style of decorative work suggests this as well. The style on the soundbox and neck is largely quite distinct from that on the forepillar, and also lacks most of the characteristic elements typical of late medieval West Highland monumental art exemplified on the forepillar. Furthermore, as discussed later in this chapter section, the workmanship and the tools used are different from those used on the forepillar, with the notable exception of the two areas of the soundbox already mentioned.

It would be reasonable to conclude that the soundbox and neck might not have been constructed in the same location or time period as the forepillar, except for the existence of a late medieval West Highland grave slab at Keills Chapel in Argyll with a representation of a harp remarkably similar to the Queen Mary, complete with the same distinctive soundbox decoration. This carving, and its resemblance to the Queen Mary harp, has been noted by a number of authors.[474] Unfortunately, the carving has worn down to the point that the details of the decorative work are now no longer visible. These details were recorded, however, in drawings and rubbings made

[474] Anderson, *Ancient Scottish Weapons*, 25. Armstrong, *Irish and Highland Harps*, 155, 173, and unnumbered plate opp. 154. Steer and Bannerman, *Late Medieval Monumental Sculpture*, 146, and Plate 23 (C); and Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS), *Argyll: An Inventory of the Monuments, 7: Mid-Argyll and Cowal: Medieval and Later Monuments* (Edinburgh: H. M. Stationary Office, 1992), 90 – 91.

between 1867 and 1904.[475] Figure 4.68 shows the grave slab with the harp, as drawn by White in 1875.[476]

Figure 4.68: *drawing of a late medieval grave slab at Keills Chapel in Argyll (left), and a detail showing the harp (right), reproduced from White (1875).*[477] *The pattern of lines represented on the soundbox bears a striking resemblance to the decorative work on the soundbox of the Queen Mary harp.*

[475] RCAHMS, *Argyll 7*, 91. For a discussion and comparison of the illustrations of the carving see Simon Chadwick, "Keills," last modified September, 2014, http://www.earlygaelicharp.info/keills/.

[476] T. P. White, *Archaeological Sketches in Scotland: Knapdale and Gigha,* (Edinburgh and London: William Blackwood and Sons, 1875), Plate XXXVI, and 91.

[477] ibid., Plate XXXVI.

Steer and Bannerman (1977) date this grave slab to the end of the 15th century, and identify it as belonging to the Loch Sween school of West Highland monumental carving.[478] There is also a Latin inscription, partially worn away, which identifies this as the grave of a father and son, with the son having commissioned the grave slab.[479] Steer and Bannerman speculate that they may have belonged to a family of hereditary harpers, possibly attached to the MacNeills of Gigha, the most important family in the area around Keills in the 15th century, and note that the presence of the MacBhreatnaich family of harpers is recorded on Gigha in the same century.[480]

They also note that, based on archeological evidence, this grave slab and other carved stones belonging to the Loch Sween school were probably made in a workshop in Keills, near the mouth of Loch Sween.[481] They further note that the presence in the area of two powerful families, the MacNeills and the MacMillans, and the strategic location of Keills at the primary port of entry to the mainland from one of the sea-routes in the inner Hebrides "led to a concentration of superior craftsmen in the area, some of whom may have been directly employed by the Lords of the Isles."[482]

The close similarity of the decorative work on the soundbox of the Queen Mary harp to the representation of the harp on the Keills grave slab may suggest that the harp was made in its entirety in the West Highlands / Islands in the late 15th century. While Steer and Bannerman point out that musicians and musical instruments can travel, they conclude that the style of foliaceous decorative work on the forepillar and above the eyebrows on the soundbox is what ultimately makes the case for the Queen Mary harp having been made (in its entirety) in the West Highlands.[483] Steer and Bannerman don't, however, consider the possibility that the forepillar and the carving above the eyebrows on the soundbox could be later additions.

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[478] Steer and Bannerman, *Late Medieval Monumental Sculpture*, 146.
[479] ibid.
[480] ibid.
[481] ibid., 58.
[482] ibid.
[483] ibid., 185.

It may be helpful to consider the Trinity College harp, which is remarkably similar to the Queen Mary.[484] Although the pattern of distinctive geometric decorative motifs on both harps is closely similar in design and execution, the Trinity College harp has absolutely none of the characteristic late medieval West Highland foliaceous carving anywhere on it. As discussed earlier in this chapter, Dooley (2014) has established that the forepillar of the Trinity College harp is very likely not original.[485] As is the case for the Queen Mary harp, the style of decorative work on the forepillar of the Trinity College harp is different from that on the neck and soundbox. It is quite possible that the forepillars of both of these harps are replacements, and that the decorative work on each reflects the location and time period in which the replacement was made. If so, even though the forepillar of the Queen Mary harp may have been made in the West Highlands / Islands (specifically, Iona) in the late 15th century, the neck and soundbox could have been made elsewhere and/or at an earlier date.

Decorative workmanship

The following discussion examines the methods used to create the decorative work on the soundbox and neck of the Queen Mary harp. As mentioned earlier, the workmanship further distinguishes the two decorative styles on this harp. This can be seen in the photograph of the treble end of the soundbox shown in figure 4.69.

[484] ibid. A number of authors have noted the remarkable similarity of these two harps. See for example, Dooley, "Medieval Irish Harp," 108. For comparative illustrations, see also Dooley, "Medieval Irish Harp," 116 – 17, and 121 – 22.
[485] Dooley, "Medieval Irish Harp," 111.

Figure 4.69*: contrasting styles of decorative work at the treble end of the Queen Mary harp soundbox. On the left, the area above the soundbox eyebrows is carved in low relief in a foliaceous design typical of late medieval West Highland monumental art. The geometric pattern of lines and circles dominating the soundbox and neck can be seen on the right. Note the apparent difference in workmanship.*

Figure 4.70 shows a detail of the decorative work on the soundbox. The geometrical motifs were largely constructed with a pair of compasses and a straight edge. The point at which the compass pierced the wood at the centre of each circle or arc is visible on the tomograms of the soundbox, and upon visual examination a small split in the wood can also be seen at these locations. Armstrong observed some of the layout lines for the decorative pattern, one of which can be seen in the photograph in figure 4.70 (arrowed).[486]

[486] Armstrong, *Irish and Highland Harps*, 173.

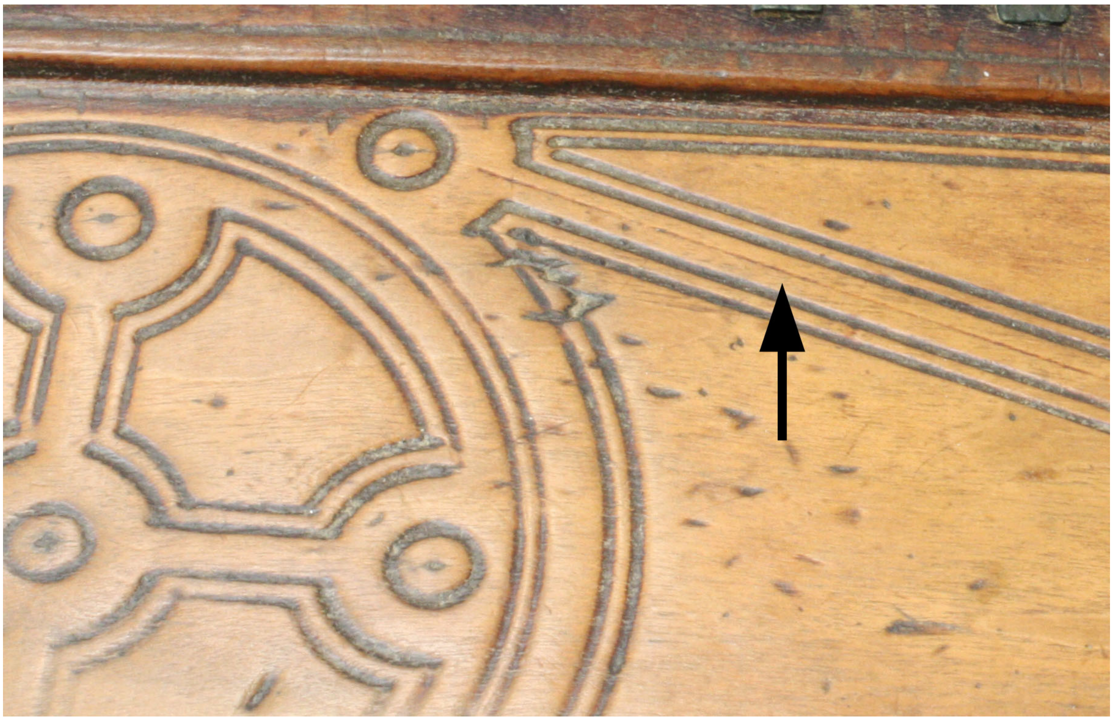

Figure 4.70: *detail of decorative work on the Queen Mary harp soundbox. The lines have been constructed with compass and straight edge. One of the layout lines for the pattern is still visible (arrowed).*

One of the curious features of the decorative lines on both the soundbox and neck is that they impart a slightly embossed appearance to the surface of the wood, somewhat like embossed leather. This can be seen in the photographs in figures 4.71 and 4.72, below. It is a subtle effect that modern builders of fully decorated copies of this harp may have had some difficulty replicating. Close examination of the decorative lines under magnification shows that they appear to have been pressed into the wood with a blunt tipped tool, hence the overall embossed appearance.

It is notable that the geometrical decorative scheme on the soundbox and neck differ in both style and execution from the foliaceous decorative work above the eyebrows, and the dog's head decorative work on the foot. While the former appears to have been pressed into the wood with a blunt tool, following compass and straight edge layout lines, the latter has been carved in low relief with a sharp tool, or tools, in a fluid, organic style. These contrasts suggest the decorative work was done by different artisans.

Figure 4.71: *detail of the decorative lines on the soundbox of the Queen Mary harp. It is apparent from the wood grain (arrowed) that the line has been pressed into the wood with a blunt tipped tool.*

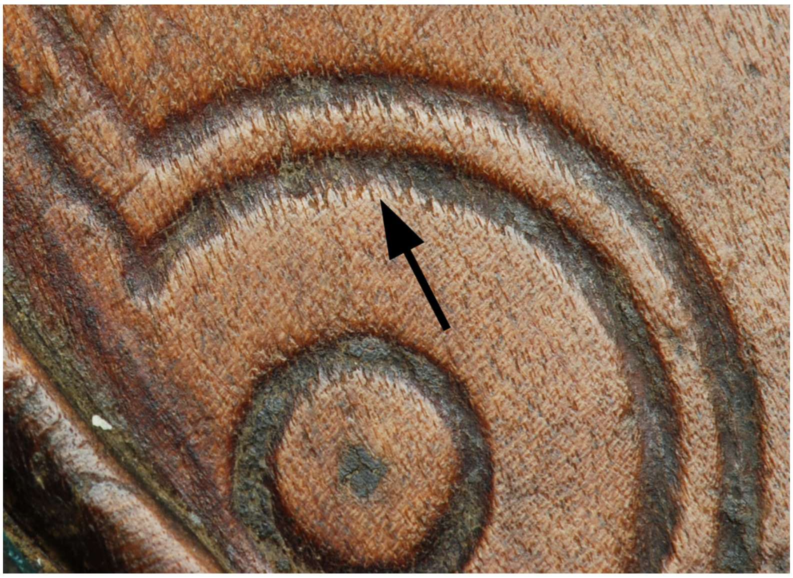

Figure 4.72: *detail of the decorative lines on the neck of the Queen Mary harp. The workmanship and method used appears to be the same as for the lines on the soundbox. As shown in figure 4.71, the wood grain (arrowed) suggests that they have been pressed into the wood with a blunt tipped tool.*

Decorative work materials analysis

As can also be seen in figures 4.71 and 4.72, a dark waxy material is embedded in the decorative lines. The same, or a similar, material is embedded in cracks and crevices in the wood on all parts of this harp. This appears prominently as a dense material on tomograms of the harp, as can be seen in the tomogram of the soundbox in figure 4.73. A very small sample was taken from one of the soundbox decorative lines and analyzed with SEM-EDX and XRF to determine its composition. This revealed that the material in the decorative lines is primarily composed of carbon with a significant amount of copper also present, along with smaller amounts of several light elements, including sulfur, oxygen, silicon, and calcium, and the metals lead, iron, and bismuth.[487]

The presence of carbon with oxygen in this material suggests an organic compound. Carbon with oxygen and silicon may also indicate the presence of a silicate (i.e. 'dirt').[488] It is highly likely that some proportion of the lighter elements comes from accumulated wax and dirt. Bell (1880) and Armstrong (1904) both observed that the lines that comprise the geometric motifs on the soundbox and neck appeared to have been burned in.[489] This could account for some of the carbon in the sample.

The metals are responsible for the relatively high density of this material, and their presence in the sample is interesting. They may have been components of pigments, although this is speculative. The presence of bismuth, in particular, is curious, and was unexpected. This heavy element was used historically in 'bismuth white', however, an early 19th-century pigment.[490] Notably, bismuth white is unstable and will turn dark over time when exposed to sulfur in the air.[491] The significant presence of copper in the sample is also interesting. If this copper (either alone or in

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[487] Results of analysis conducted by Lore Troalen, NMS.
[488] The presence of silicate was suggested by Lore Troalen.
[489] Bell, "Notice of Two Ancient Harps and Targets," 19; and Armstrong, *Irish and Highland Harps*, 173.
[490] Ralph Mayer, *The Artist's Handbook of Materials and Techniques* (London: Faber and Faber, 1982), 43.
[491] ibid.

combination with either the lead or bismuth) had been a component of a pigment, that pigment would have been green in colour. More analysis is needed, however. It may be possible to identify the compounds in the material with other methods of analysis. The material also should be examined for layering. It is possible that these decorative lines were green at some point (possibly contemporary with the forepillar green pigmenting), but that dirt, wax, and later applications of other pigments (now darkened), have obscured the colour. Unfortunately, it was not possible to examine the layering of this sample due to it breaking apart. So it is presently unknown how the different elements, for example the metals, were distributed throughout it. This sample was extremely small, less than 0.5 mm, and a slightly larger sample would be desirable for this analysis. Furthermore, a sample of the material that is also embedded in the cracks and crevices should be taken and analyzed for comparison.

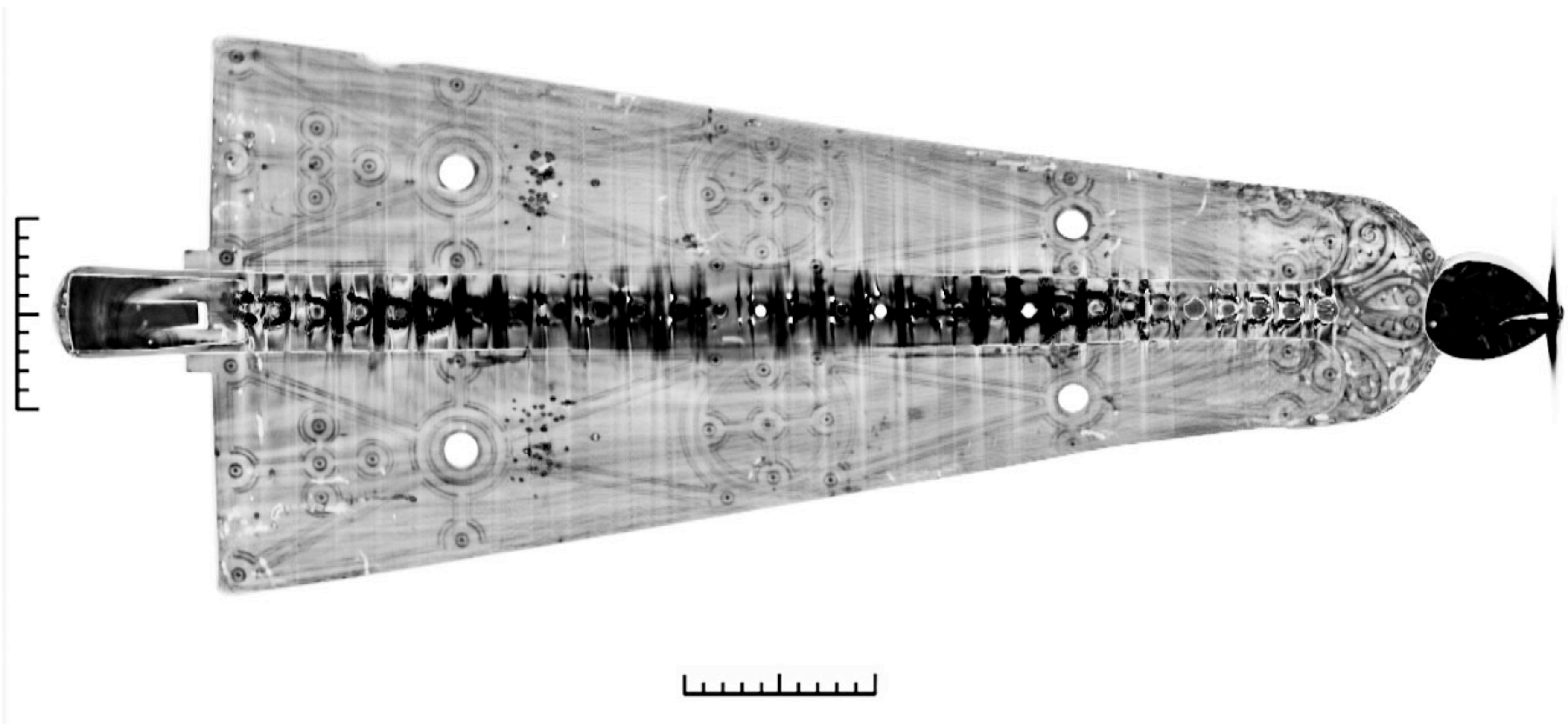

Figure 4.73: *tomogram of the front of the Queen Mary harp soundbox. The decorative work is highlighted by the dense material embedded in and around it.*

Nails

In addition to the decorative lines on the front of the soundbox, the tomogram in figure 4.73 also highlights the positions of embedded nail fragments and associated corrosion. As can be seen in this figure, there is a prominent cluster above each of the two lower sound holes. The marks left by these nails are also visible in the photograph of the soundbox front shown in figure 4.74.

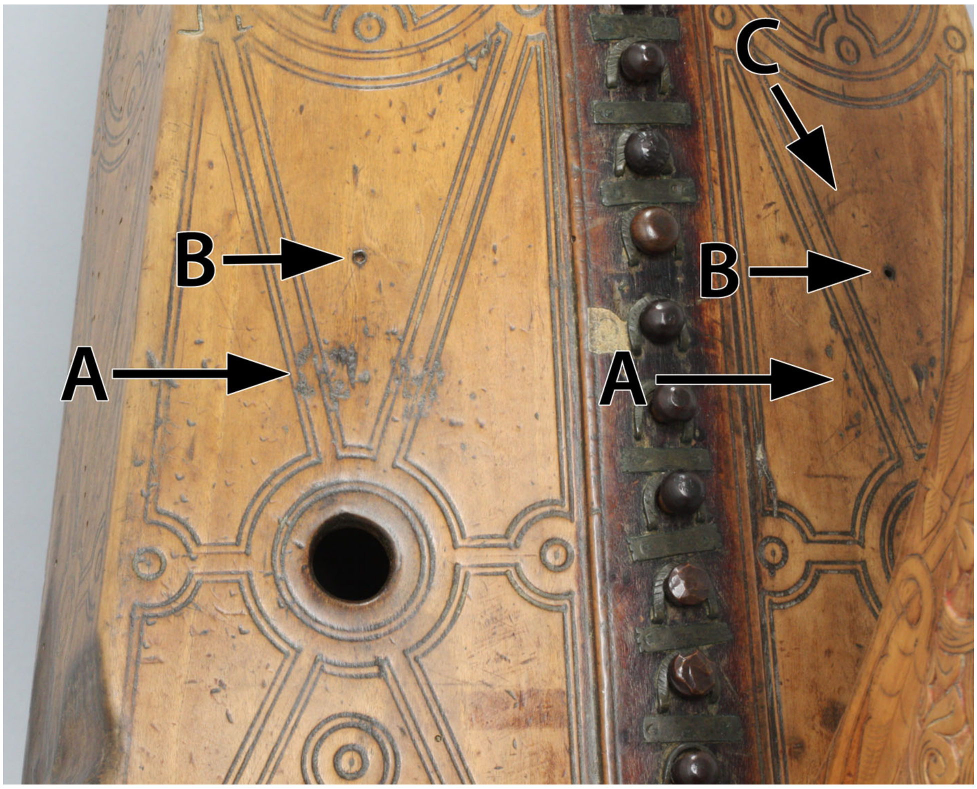

Figure 4.74: *clusters of nail marks above the lower sound holes on the front of the Queen Mary harp soundbox ('A', arrowed). There is also a single, slightly larger hole above each cluster ('B', arrowed). It is evident from the mark above the hole on the left side ('C', arrowed) that these holes held circular badges.*

These clusters of nail marks suggest that something was repeatedly tacked to the soundbox front above each of the two lower sound holes. What that might have been is unknown. Above each cluster of nail marks the soundbox is pierced with a single small hole. The hole on the left-hand side of the string band has a mark around it (labeled 'C' in figure 4.74) that indicates that these two holes held circular badges approximately 3.5 cm in diameter.

Soundbox interior

The soundboxes of Irish harps are enclosed at the back by a cover, so the soundbox interior is not normally accessible. The back cover of the Queen Mary harp soundbox was removed for examination of the interior by the luthier Tim Hobrough in 1976.[492] In a letter to the then National Museum of Antiquities, he noted the tool marks and observed that the inside surface of the front (effectively the 'soundboard') "appeared to have been worked with a bent blade," possibly a bent gouge, and that these gouge marks ran across the grain to the sides of the soundbox.[493]

Tool marks provide invaluable information on the method of construction, so Hobrough's observations are of particular interest. No photographs, drawings, or additional records of the soundbox interior existed prior to the current research project, however. Removing the soundbox cover for examination and photography of the interior was discussed with the museum conservation staff. This was initially ruled out due to the fragile state of the cover, and because it appeared to be nailed to the soundbox in several places. Additionally, when it became apparent during the course of the research that the back cover is probably original, it became even more imperative that handling and risk of damage to it should be minimized.

Given these constraints, the surface renderings generated from the CT scans of the harp were used to image the inside surface of the soundbox to look for tool marks. For this purpose, the surface was defined to be where the voxel values reach the mid-point from minimum to maximum at the interface of the surface of the wood and the surrounding air, with the 'maximum' taken as the average observed value in the

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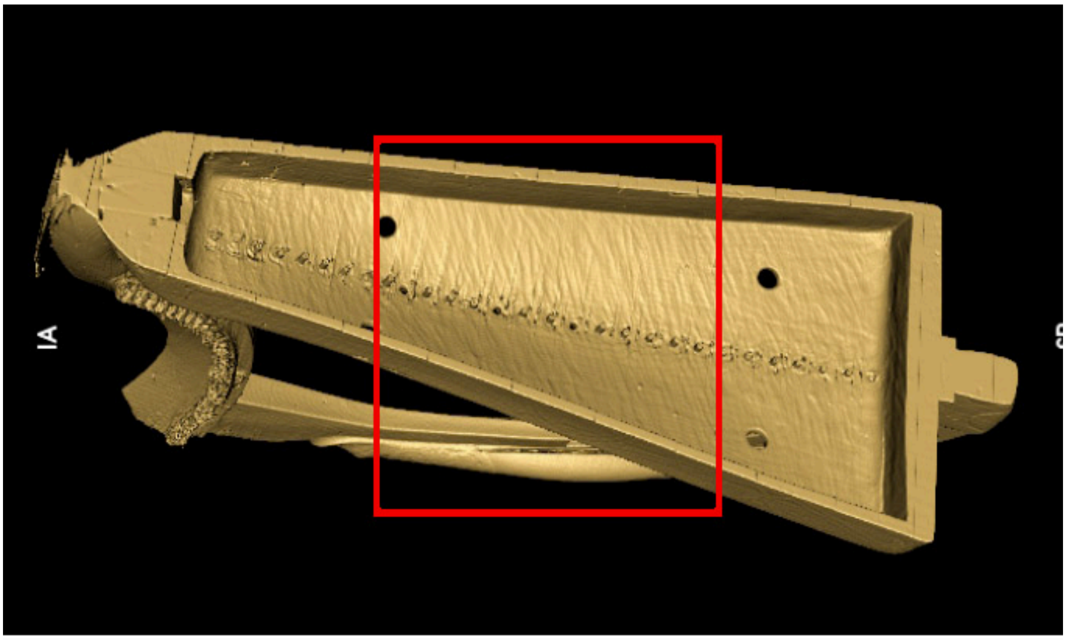
[492] Tim Hobrough, *Tim Hobrough to R. B. K. Stevenson, Keeper, National Museum of Antiquities of Scotland,* 23 January, 1979, letter, National Museums Scotland, *H. LT2 archive*.
[493] ibid.

interior of the wood. This provided a reliable estimate of the location of the surface. A surface rendering of the soundbox interior is shown in figure 4.75. For this rendering, the soundbox has been virtually sliced in half lengthwise and the back half has been removed to reveal the interior. As reported in Loomis et al. (2012), tool marks are visible on the surface rendering generated from the CT scan, appearing as shallow irregular furrows running across the inside front surface of the soundbox.[494] They cover the entire front side of the interior, and appear to have been made with a gouge or a similar tool, in agreement with Hobrough's observation.

Figure 4.75 (overleaf): *surface rendering of the Queen Mary harp soundbox interior. The soundbox has been virtually sliced in half lengthwise, and the back half has been removed to reveal the interior. The location of the surface has been defined as being at the mid-point between the minimum and maximum voxel values at the interface between the air and the wood. The shallow, irregular furrows running across the inside surface of the soundbox front are tool marks. The narrow, straight lines are image artefacts caused by the metal string shoe nails.*

[494] Loomis et al., "Queen Mary and Lamont Harps," 122.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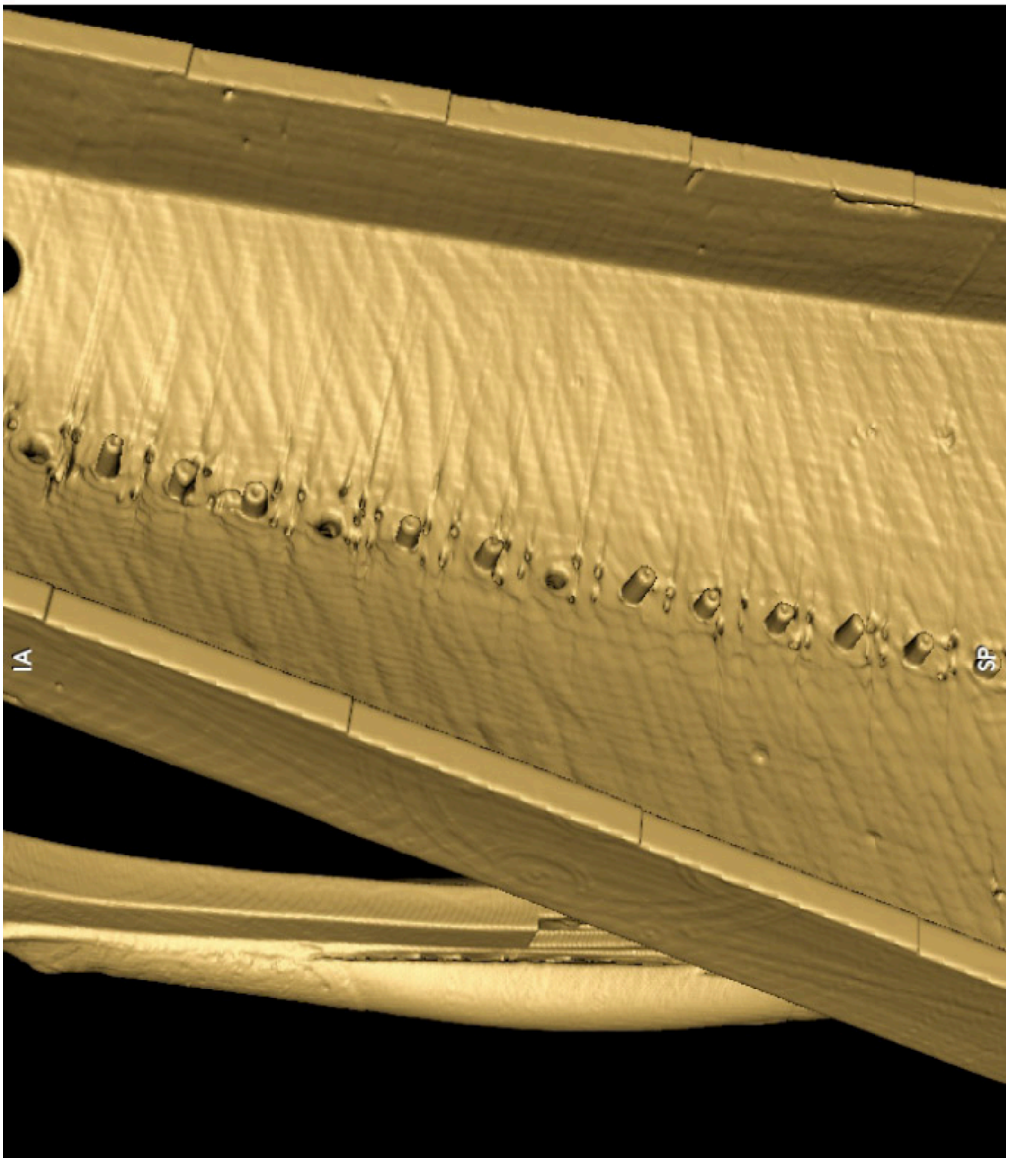
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The detection of tool marks on surface renderings of the soundbox helped to prompt a reassessment of the feasibility of safely removing the back cover to allow examination of the soundbox interior. An additional motivation was access to locations for wood sampling, as discussed in Chapter 5 of this dissertation. Tomograms of the back of the harp were used to identify the locations of nails and screws in the back cover. It was ascertained that none of the nails were intact, and it was evident that the back cover was being held in place by two small modern brass screws. It was also evident that two additional modern screws did not penetrate into the soundbox wood, so were not functional.[495] The decision was therefore made to remove the back cover. This task was undertaken by Ticca Ogilvie, Head of Artefacts Conservation at NMS. As shown in figure 4.76, tomograms of the back of the harp were used as a guide during this procedure. Had these not been available, the cover would not have been removed.

Figure 4.76: *the back cover of the Queen Mary harp, prior to removal. Tomograms of the back of the harp (displayed on the laptop to the left) were used to facilitate safe removal of the cover.*

[495] Loomis, "Structural Breaks and Repairs," 53 – 54.

Figure 4.77 shows the soundbox with the back cover removed, revealing the interior. This figure includes a surface rendering of the soundbox interior for comparison. It is apparent from the comparison that the tool marks are accurately depicted on the surface rendering, demonstrating that this is a reliable method for imaging tool marks on wood surfaces in the interiors of musical instruments, provided the tool marks are larger than the resolution limit of the CT scanner.

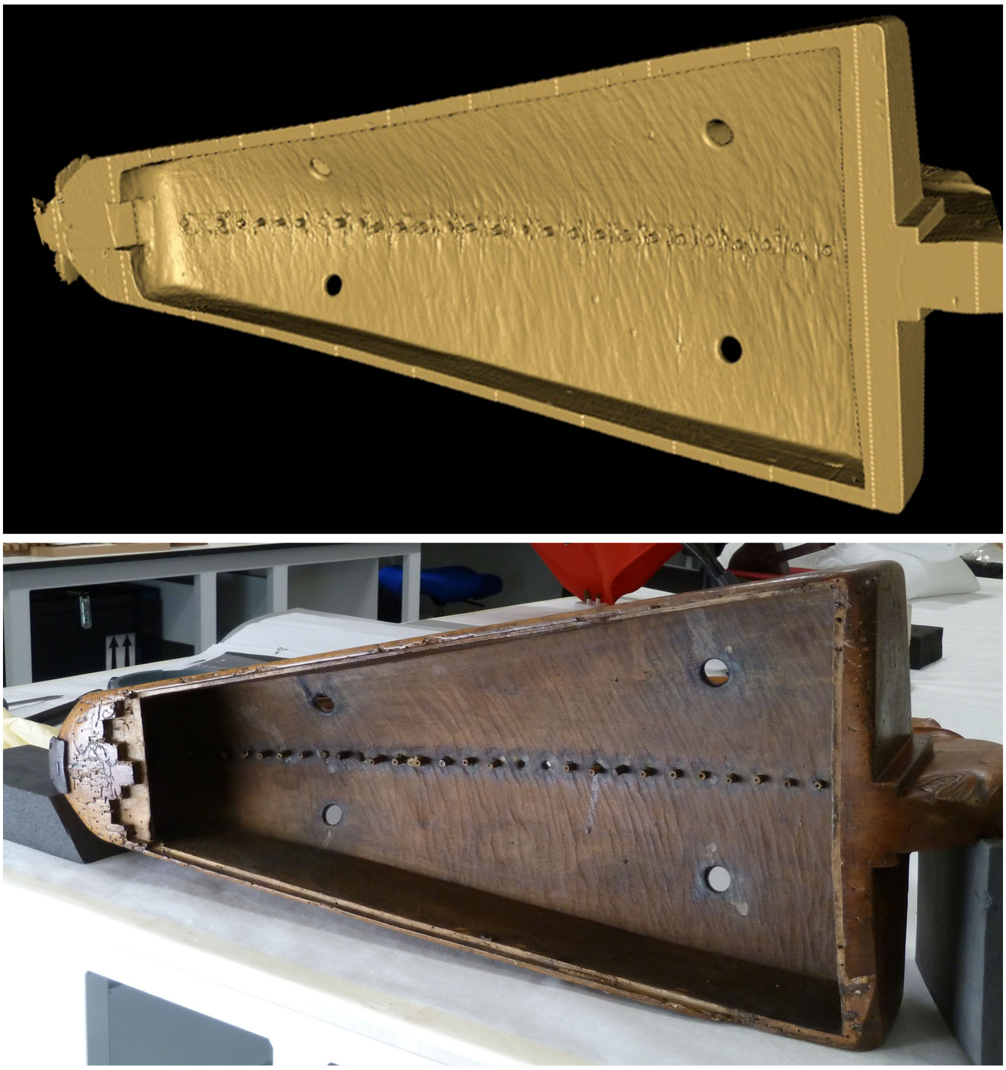

Figure 4.77: *photograph of the interior of the Queen Mary harp soundbox (bottom), and tomographic surface rendering (top). The inside surface of the soundbox front has been worked with a gouge or similar tool. The appearance of the surface of the wood in the photograph can be compared to the surface rendering (the drip of varnish below the string holes, right of centre, can be used as a point of reference).*

Another view of the soundbox interior, shown in the photograph in figure 4.78, shows the undercut area at the treble end, and the neck joint. Note that the tool marks on the interior front surface continue all the way to the treble end of the box. This photograph also shows the through mortise joint with the neck, discussed in Chapter 2. The end of the neck tenon can be seen in the mortise.

Figure 4.78: *interior of the Queen Mary harp soundbox, looking towards the treble end. This photograph shows the undercut area at this end of the soundbox, and the neck joint.*

Figure 4.79 shows the tool marks in more detail. The widest marks are slightly larger than 1 cm across, and the surface has been very evenly worked right up to the sides of the soundbox. This can be seen more clearly in the top photograph in figure 4.80. In contrast to the front, the sides of the interior have been smoothed with a serrated tool, possibly a toothing plane.

Figure 4.79: *tool marks on the inside front surface of the Queen Mary harp soundbox. The widest marks are slightly larger than 1cm across. Bottom photograph: Isabell Wagner.*

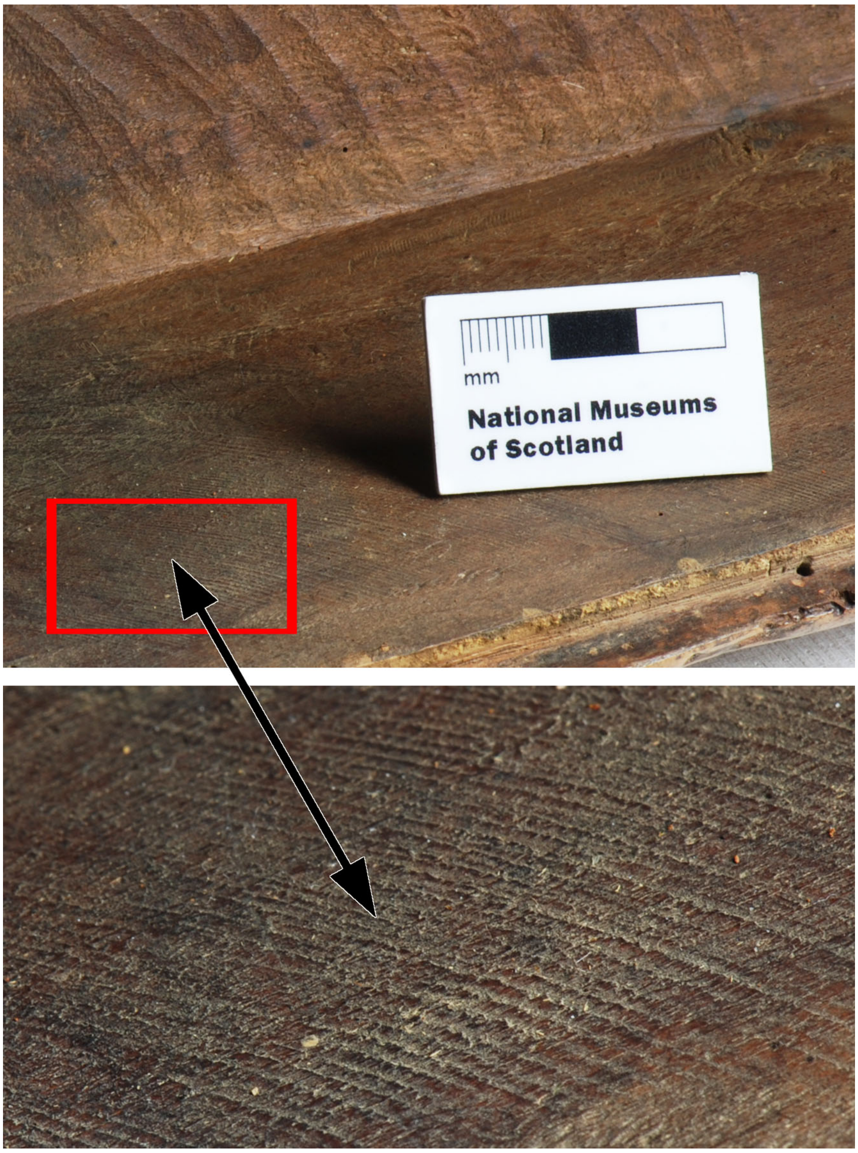

Figure 4.80: *front and side of the soundbox interior (top). The tool marks on the front extend right up to the sides, as shown in this photograph. Note the contrast in the way the two surfaces have been worked. The sides of the soundbox have been smoothed with a serrated tool (detail, bottom). Photographs: Isabell Wagner.*

The contrast in the manner in which the sides were worked versus the front is interesting, and raises the question as to why the maker chose to do this. It could be argued that the front was left 'rough' as it was not deemed necessary to smooth it because it is an interior surface and therefore not visible. The sides have been carefully smoothed, however, and they are also not visible. Care was also taken to work crosswise towards the sides for the entire length of the soundbox. This includes the undercut area at the treble end, despite this being a difficult space in which to work in this direction.[496] It is therefore possible that the interior surface of the soundbox front was intentionally finished in this manner. While it may not be possible to ascertain the intention of the maker, the potential effects on the performance of the soundbox can be considered. The 'furrows' across the soundbox made by the tool may effectively behave like micro-ribbing, increasing the flexibility of the soundbox front without significantly compromising the strength. The depth of these furrows is more than 10% of the thickness of the soundbox front in most places, which is enough to produce a small but not insignificant effect. Since the front of the soundbox acts as the soundboard, this could have a noticeable effect on the acoustics of the harp, as well as possibly making the front of the box less susceptible to splitting as it is pulled up by the string tension.

Interior modifications

The interior of the soundbox at the bass end is shown in figure 4.81. This surface has been worked with a flat chisel or similar tool. This is not the original workmanship, however. It is a later modification. The bass end of the soundbox front was originally radiused where it transitions to the bass end of the box. It is evident that the bass end of the box has been thinned, because this radiused corner has been cut into. The chisel work is sloppy and haphazard in comparison to the rest of the workmanship in the soundbox interior. It is therefore likely that the thinning of the bass end of the soundbox was not done by the original builder. It also appears to have been done without an appreciation for the purpose of the radiused corner, which was to make the transition from the front to the bass end less vulnerable to splitting.

[496]A series of scratches on one side of the box interior suggest the end of the tool (possibly with the handle removed) coming into contact with the side of the box while being used in the confined space.

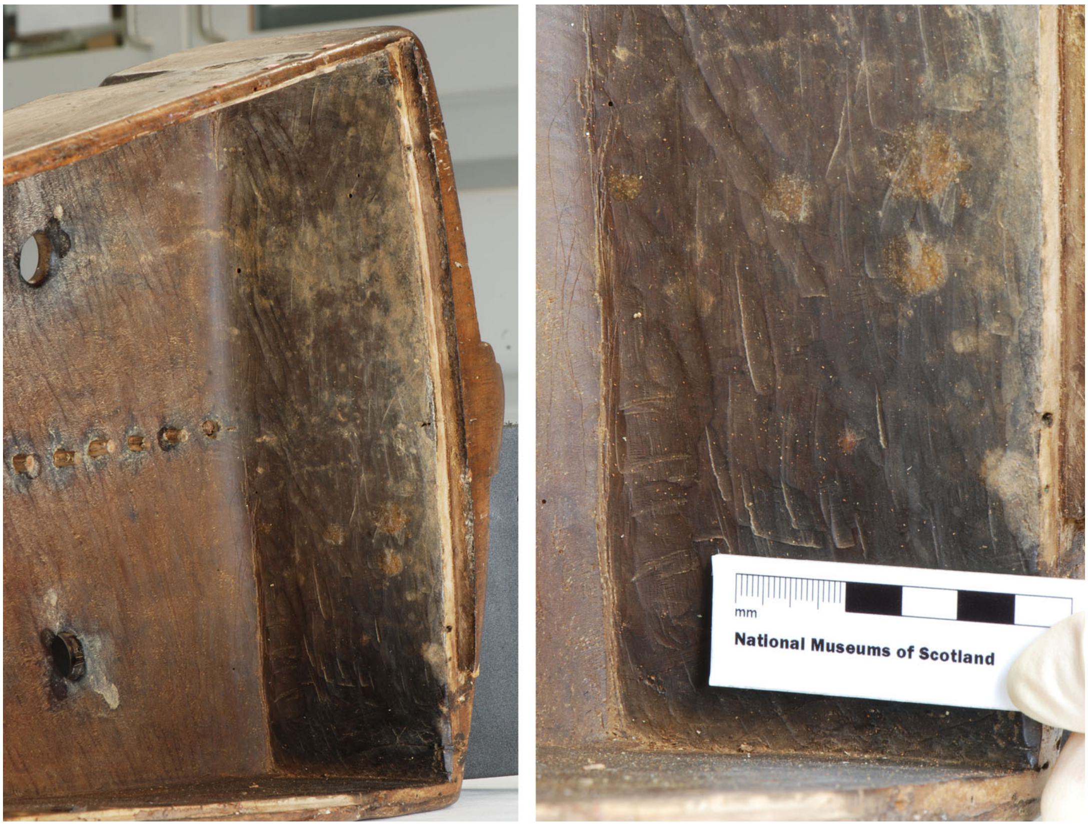

Figure 4.81: *chisel marks on the bass end of the soundbox interior of the Queen Mary harp. This is a later modification to thin the bass end of the box, and is sloppy and haphazard in comparison to the rest of the workmanship inside the soundbox. Note that the radiused corner, where the front of the box meets the bass end, has been cut into.*

Stringing marks inside the soundbox

As discussed in Chapter 2, the string holes are surrounded by numerous marks left by the string toggles. These can be seen in figure 4.79, above. These marks appear dark because a layer of varnish has been applied to the inside of the soundbox and the wood around the string holes that had been crushed by the toggles took up more of the varnish, causing these areas to appear darker. This stain is very likely not historical, and was possibly applied at the same time as the varnish that seeped down into the string holes and onto the 19th-century pegs. In the chapter on the construction of the Lamont harp, the number of toggle marks was used to estimate the length of the working life of the soundbox. Due to the uneven, furrowed surface of the Queen Mary harp soundbox interior, it was not possible to estimate the number of toggle marks. It can be stated, though, that they are very numerous and overlapping, probably to the point of saturation.

In Chapter 3 of this dissertation, the section on the Lamont harp soundbox discussed the scratches observed in the vicinity of the sound holes, which are consistent with having been made during string replacements. Similar scratches were observed at each of the sound holes in the soundbox of the Queen Mary harp. These scratches are underneath the layer of varnish on interior of the soundbox, making them difficult to see and probably obscuring many of them, so it is not possible to get an accurate count of their number. There are at least 70 – 80 scratches visible around each sound hole, but the actual number is likely to be higher. Figure 4.82 shows some of the scratches near the lower left sound hole. As can be seen in this photograph, the scratches are underneath the varnish layer.

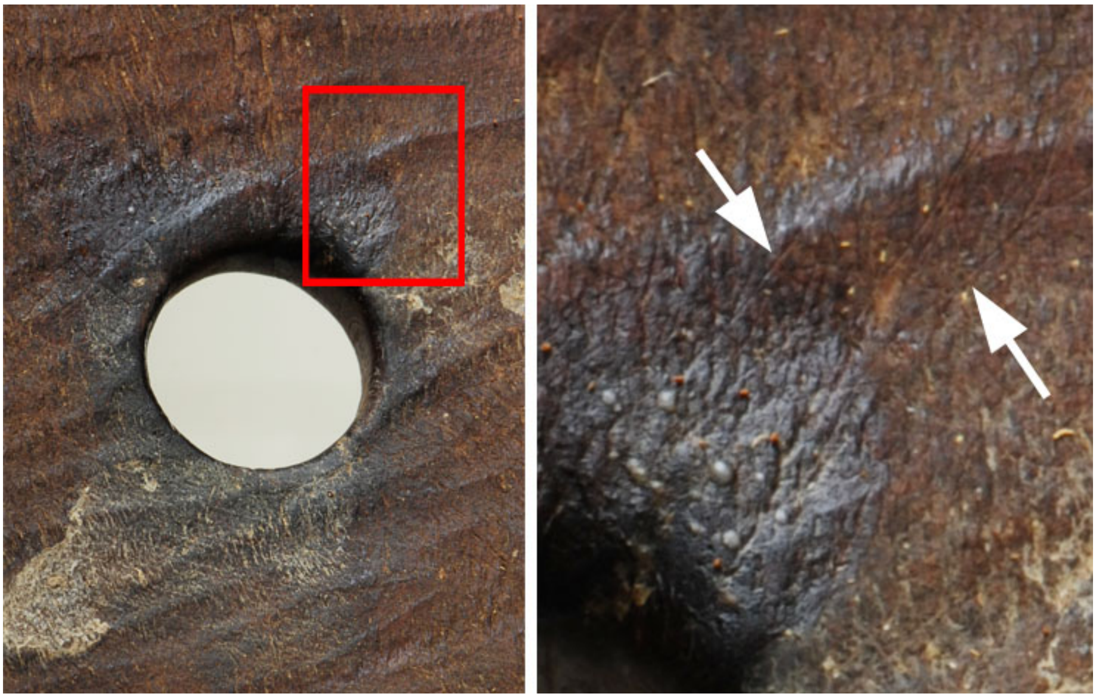

Figure 4.82: *scratches near the lower left sound hole of the Queen Mary harp soundbox (arrowed). They are similar to those observed in the Lamont harp soundbox, and are consistent with having been made during string replacements through the sound hole. Note that the scratches are underneath the layer of varnish on the wood. The string band is toward the right of the photographs.*

String shoes

The string holes in the Queen Mary harp soundbox are fitted with horseshoe shaped string shoes. As noted by Armstrong (1904), there are three different styles of shoe.[497] Eight string holes have horseshoe shaped shoes with flattened ends that are nailed into the string band. Of these, two have straight ends, and the other six have slightly flared ends.[498] Otherwise, these two styles of shoe are very similar. Nineteen string holes have shoes that are horseshoe shaped staples.[499] Two string holes, #5 and #18, are missing their shoes. The three styles of string shoe are shown in the photograph in figure 4.83.

Figure 4.83: *String shoes #3 – #7 on the Queen Mary harp soundbox. Shoe #3 is horseshoe shaped with straight ends nailed into the soundbox. Shoe #4 is similar in style, with flared ends. Shoe #7 is a horseshoe shaped staple. These are representative of the three styles of string shoe on this soundbox. Also shown in this photograph is a small metal strap between string shoes #6 and #7.*

The string band also has small metal straps nailed across it. These were nailed in between each string hole, although several are now missing. Their purpose is to

[497] Armstrong, *Irish and Highland Harps*, 168, and Plate VII opp. 176.
[498] ibid.
[499] ibid.

reinforce the string band, and they were probably added after it had begun to split down the middle. This split can be seen in figure 4.83. One of these straps is shown in this figure, in between string holes #6 and #7. These straps have been nailed over the ends of the nailed in style of string shoe. Some of the staple style string shoes overlap the straps, as is evident in figure 4.83.

At each of the two string holes that are missing shoes, there is an impression in the wood that matches the shape of the nailed in shoes with the flared ends. Examination of the remaining shoes, both visually and on tomograms from the CT scans, has revealed nail fragments and nail holes in the vicinity of several of the staple style string shoes. The locations of these are consistent with the nailed in style of string shoe. Additionally, at string hole #10, which has a staple style string shoe, there is a fragment that appears to be the broken end of one of the shoes of the nailed in style with flared ends, still attached to its nail. This is shown in figure 4.84.

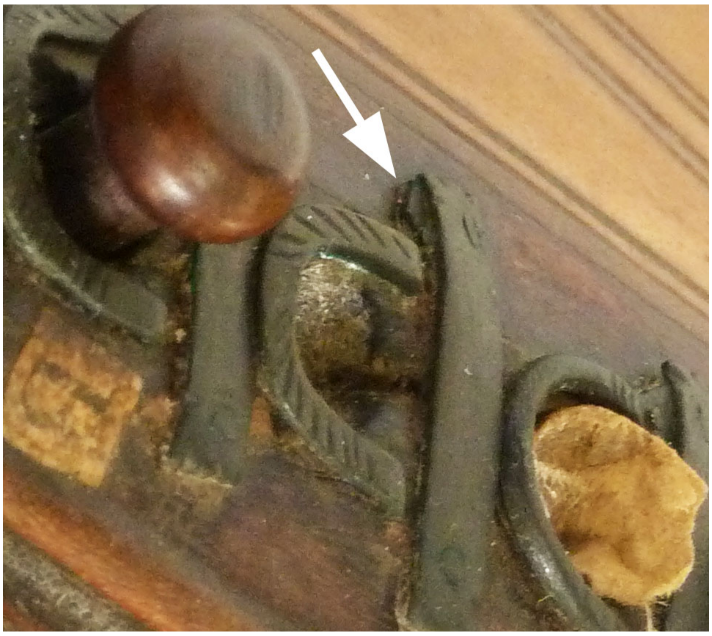

Figure 4.84: *String hole #10 in the Queen Mary harp soundbox (centre). This string hole is fitted with a staple style string shoe, but a fragment adjacent (arrowed) appears to be the broken off end of a nailed in style shoe. Tomograms of this string hole show that the fragment is attached to a nail.*

The staple style shoes appear to be replacements for the nailed in style shoes with the flared ends. Although not all of the string shoes were replaced, the ones that were, which is two-thirds of the full complement, may have been broken, lost, or compromised (the two that are now missing may have been lost later on). The staple style shoes are slightly more substantial than the nailed in shoes, so they may have been intended to provide additional reinforcement to the string band after it developed the split. The two nailed in shoes that have straight ends may be earlier replacements, made to resemble the rest of the shoes on the harp at the time. The nailed in string shoes with flared ends appear to be the original string shoes for the Queen Mary harp soundbox. Figure 4.85 shows a face-on view of one of these string shoes.

Figure 4.85: *string hole #27, which has a string shoe of the nailed in style, with flared ends. This appears to be the original style of string shoe for the Queen Mary harp soundbox. The wooden string peg is not historical, and probably dates to the early 19th century.*

The replacement of so many string shoes at one time may indicate a refurbishment (as opposed to running repairs). It's possible that the small metal straps were added at the same time. XRF analysis to determine the composition of the string shoes and the metal straps for comparison may determine if this is the case. Due to the geometry of the harp, it was not possible to conduct XRF analysis for the present research project, however it would be possible to obtain this information with a handheld XRF spectrometer.

The replacement string shoes have some string wear. This is similar to the wear observed on the Lamont harp string shoes, but not as deep. It is generally very light, although a few of the shoes have slightly more wear, for example the string shoe at hole #13, shown in figure 4.86, below. The other string shoes have minimal string wear, however. The light wear, overall, could be due to the hardness of the alloy used to make the string shoes, or could be due to them being added to the harp relatively late in its working life.

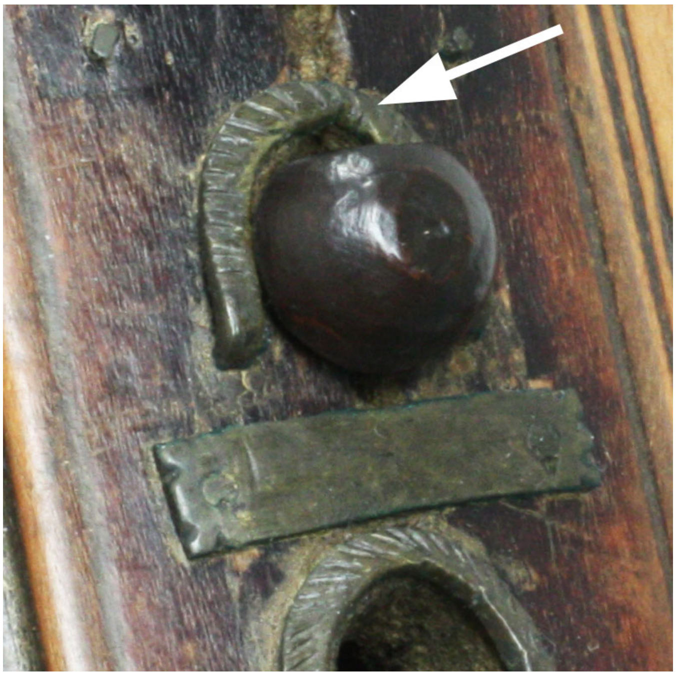

Figure 4.86: *wear on the string shoe at string hole #13 on the Queen Mary harp soundbox (arrowed).*

Back cover

Removal of the back cover provided an opportunity to examine it in detail and how it fits onto the soundbox. The back of the soundbox was rabbeted along its edge to take the cover. At the treble end the rabbet expands into a crenellated design. This is shown in figure 4.87, below. The rabbet and the back cover are 8 – 9 mm deep.

Figure 4.88 shows a 3/4 view with a scale, and figure 4.89 shows a detail of one of the crenellations. The tool marks from the maker's blade are still visible.

Figure 4.87: *face-on view of the crenellation at the treble end of the back of the Queen Mary harp soundbox. This forms part of a rabbet around the opening at the back of the box into which the back cover is set.*

Figure 4.88: *the crenellation on the back of the soundbox shown in detail with a scale. The rabbet and the back cover are 8 – 9 mm deep.*

Figure 4.89: *detail of one of the crenellations on the back of the Queen Mary harp soundbox. Marks from the maker's blade are still visible (arrowed). The shaft of a nail that once attached the cover to the soundbox can be seen near the top of the photograph.*

Figure 4.90 shows the inside face of the back cover, revealing signs of multiple repairs. The surface is covered in a dark coating (possibly a preservative) that was apparently applied with the cover propped up on the tips of the crenellations. It has turned dark where it was exposed to the air. On top of this, a dark resinous material was used to patch the right-hand side (left side in the photograph). The cover was put back on the harp before this had dried, causing it to drip across the cover onto the inside of the soundbox. Although this material appears black on the cover, where it has dripped onto the soundbox it is dark brown and appears to be hide glue. The same area of the cover was later patched with a red consolidating material. This was also used on the opposite side, the lower right-hand corner, and the top left crenellation.

The back cover is riddled with extensive woodworm damage. Much of this may have occurred in the 19th century, when both this harp and the Lamont where stored at Stewartfield house on the Dalguise estate.[500] The woodworm exit holes perforate the coating and the dark patch that overlays it, suggesting that this work on the cover may date to at least the early 19th century, when the Queen Mary harp was restrung for the Highland Society, or perhaps even earlier.

Figure 4.90 (overleaf): *inside face of the back cover of the Queen Mary harp soundbox. The wood has been coated with a layer of material that has sheeted down its length. It has been patched in a number of places, and at least twice on its right side (left in the photograph). There is extensive woodworm damage that is also visible on the outer face of the cover. The smaller piece of wood to the right is a patch for the cover's lower left-hand corner. The scale is cm.*

[500] Keith Sanger, "The Robertson Family and Their Harps."


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National Museums of Scotland

The lower left-hand corner of the back cover has been repaired with a wooden patch (shown in figure 4.90). This was noted by Bell (1880) and Armstrong (1904), and is discussed in Loomis (2010).[501] Both sides of the patch are shown in figure 4.91. It is deeply worn on the outer corner, and is therefore very likely a repair made during the working life of the harp.[502] It is attached to the back cover by a tongue and groove joint. At some point it was also nailed to the soundbox, but the nails have corroded and are not functional. A modern brass screw is also not functional, as it does not penetrate the soundbox.

Figure 4.91: *the wood patch for the lower left corner of the Queen Mary harp back cover. The patch is attached to the back cover by a tongue and groove joint. Several nails along its edge are corroded and not functional. The modern brass screw is also not functional, as it does not penetrate the soundbox when the cover is in place.*

[501] Bell, "Notice of Two Ancient Harps and Targets," 18; Armstrong, *Irish and Highland Harps*, Plate VII, opp. 176; Loomis, "Structural Breaks and Repairs," 49 – 50.
[502] Loomis, "Structural Breaks and repairs," 50.

The bare wood of the back cover, which is light in colour, can be seen in the tongue and groove joint for the patch, as shown in figure 4.92.

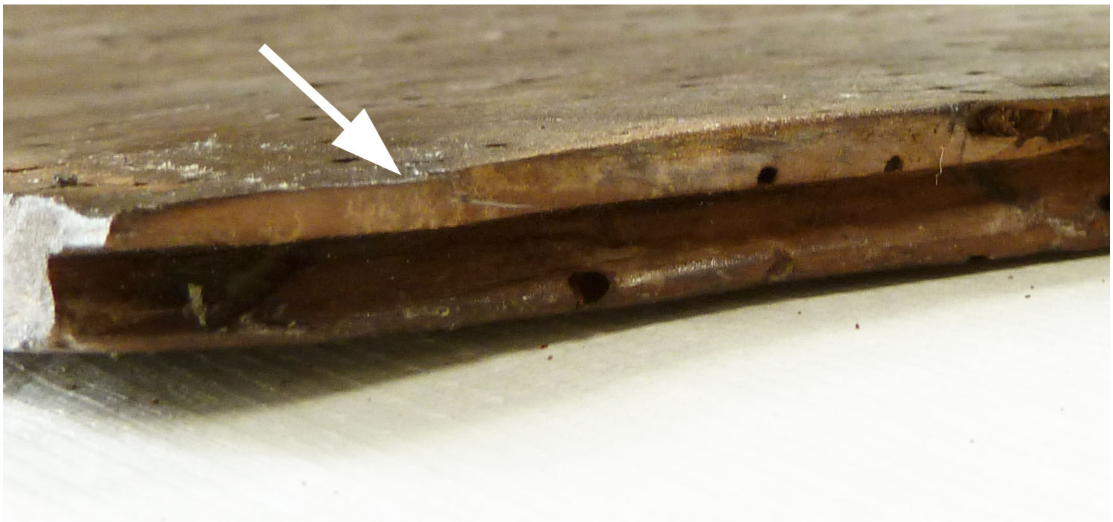


Figure 4.92: *detail of the back cover of the Queen Mary harp soundbox showing a section of the tongue and groove joint for the corner patch. The bare wood of the back cover, arrowed, is light in colour.*

Although the wood grain is not visible on either face due to varnish and other surface treatments, it is visible in tomograms of the back cover, as shown in figure 4.93. This shows that the back cover has been made from a single slab cut piece. The cover is also slightly cupped towards its inside face, indicating that the outside face was oriented towards the centre of the timber when the piece of wood was cut.

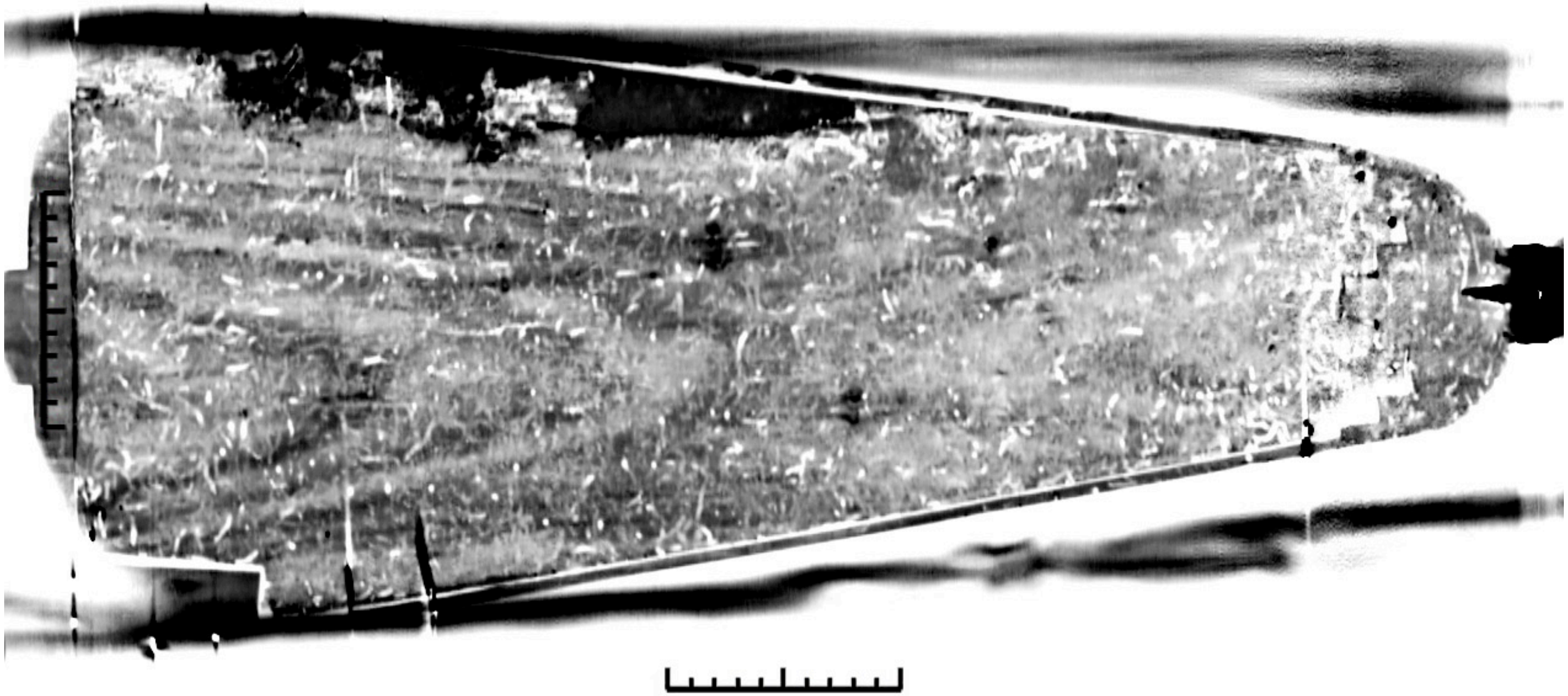


Figure 4.93: *tomogram of the back cover of the Queen Mary harp soundbox. The visible wood grain shows that the cover was made from a single slab cut piece. The tomogram also shows woodworm damage and patches of repair work. Scale: 1 tick : 1cm.*

Wear marks on the soundbox exterior

Chapter 3 of this dissertation discusses the wear on the edges of the Lamont harp soundbox due to the player's wrists and forearms, and possibly the ball of the hand at the treble end of the compass. The Queen Mary harp has similar wear on the edges of its soundbox. As for the Lamont harp soundbox, the location of this wear is consistent with the left hand playing the treble strings and the right hand playing the bass strings. The wear is deep, suggesting a long working life, and its location along the edge is well defined, suggesting consistency in the way in which the instrument was held and the portion of the compass each hand played most often. The depth of the wear can be seen in the photograph in figure 4.94, which shows the left-hand edge of the soundbox.

Figure 4.94: *wear on the left-hand edge of the Queen Mary harp soundbox (arrowed). The wear is deep and well defined. Photograph: Isabell Wagner.*

There is a single, well-defined worn area along the edge of each side of the soundbox, as was observed for the Lamont harp. This is shown in figure 4.95, below.

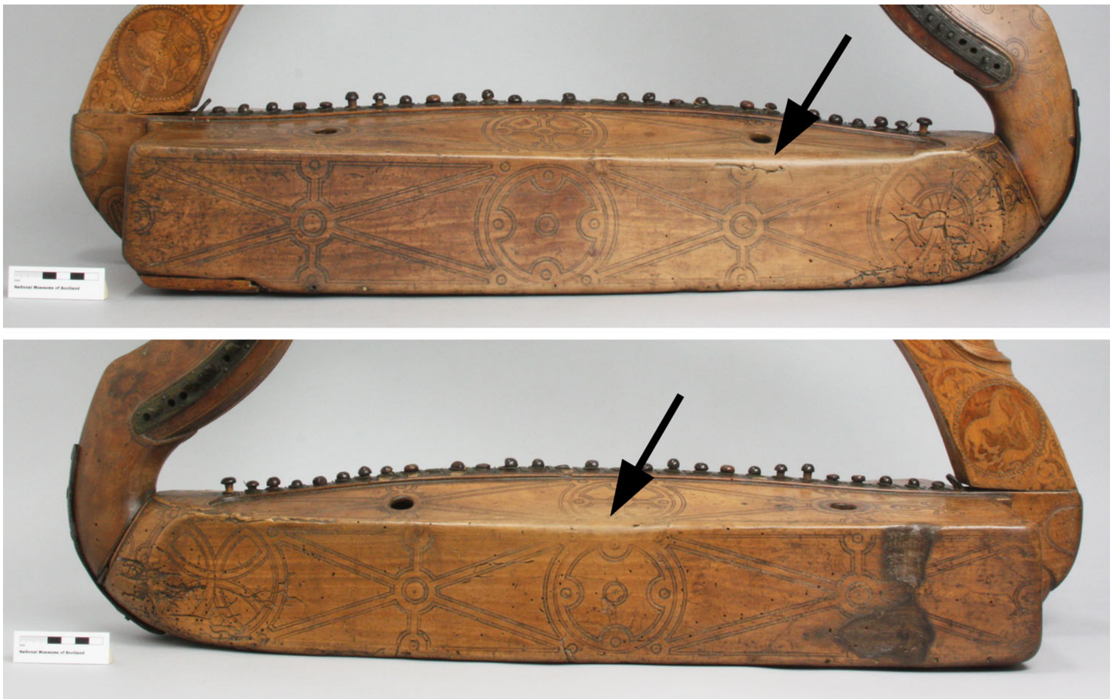


Figure 4.95: *location and extent of wear on the left (arrowed, top) and right (arrowed, bottom) edges of the Queen Mary harp soundbox. The wear is the result of the player's wrist and forearm contacting the edge of the box, as observed for the Lamont harp.*

Figure 4.96 illustrates the location and extent of the wear on both sides of the soundbox. The red lines in this figure indicate the extent of visible wear, and the arrows indicate the location of maximum wear. This figure can be compared to figure 3.91, which illustrates the location and extent of the wear on the Lamont harp soundbox. Present day musicians may wish to take the position of these wear marks into consideration when interpreting historical repertory and performance practice on replicas of this harp.

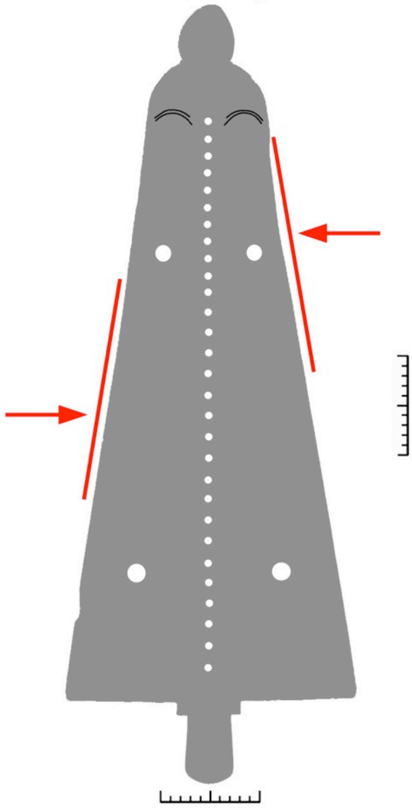


Figure 4.96: *illustration of the location of wear on the edges of the Queen Mary harp soundbox. The red lines indicate the extent of the visible wear, and the arrows indicate the location of maximum wear. Scale 1 tick : 1 cm.*

The foot of the Queen Mary harp soundbox also has extensive wear and, like the wear along the edges of the soundbox, this is illustrative of the way in which this harp was held. The wear to the foot is diagramed in Armstrong (1904), and is shown in the photograph in figure 4.97, below.[503] There are two important observations to note about the wear. Firstly, while there is considerable wear to the bottom of the foot, there is no appreciable wear on the bass end of the soundbox, with the exception of the back left-hand corner. This indicates that this harp was not held with the bass end of the box resting on the player's lap. While being played, the harp rested on the foot. The second important observation is that the wear to the bottom of the foot is asymmetric, with more wear on left side. This indicates that while being played the harp was held tilted over towards the left, and further indicates that the instrument was held with the treble end of the soundbox resting on the player's left

[503] Armstrong, *Irish and Highland Harps*, Plate VII opp. 176.

shoulder, which is consistent with the left hand playing the treble end of the compass and the right hand the bass.

Figure 4.97: *the bass end of the Queen Mary harp soundbox, showing wear to the bottom of the foot (arrowed, centre), and the back left-hand corner (arrowed, right).*

The back left-hand corner of the bass end of the soundbox is also deeply worn, as shown in figure 4.97. This is the corner that has been repaired with a wooden patch. As previously mentioned, the repair patch is also worn. The wear to this corner is consistent with the harp being held with the bass end of the box resting on both the foot and the back left-hand corner, as noted by Chadwick (2014).[504] The angle of the wear to the bottom of the foot and this back corner is the same, which supports this interpretation. The wear to the back left-hand corner is also further evidence that this harp was held towards the left side of the player's torso.

[504] Simon Chadwick, "Playing Position of Medieval Gaelic Harp," 20 January, 2014, http://clarsach.scot/2014/01/playing-position-of-medieval-gaelic-harp.html.

Soundboard thickness[505]

This section discusses the thickness of the front face of the soundbox, which acts as the soundboard. For the purposes of this discussion it is referred to here simply as the 'soundboard'. As discussed in the chapter on the construction of the Lamont harp, although the soundboard is among the most important acoustical elements of the construction of any stringed instrument, there has to date only been limited knowledge of the thicknesses of the soundboards of the surviving Irish harps. Armstrong (1904) published measurements taken at the upper and lower sound holes of the Queen Mary harp, as 1/4 inch (0.6 cm) and 5/16 inch (0.8 cm), respectively.[506] The thickness of the rest of the soundboard was unknown, however, and due to the age and uniqueness of both this and the Lamont harp, and the possibility of abrasion of the surfaces, measurement with a Hacklinger gauge would not have been advisable. One of the CT scans of the harp was therefore used to map its thickness.

The method used to map the Queen Mary harp soundboard is the same as that described for the Lamont harp. For the Queen Mary harp, a 2 cm × 2 cm sampling grid was used, with additional measurements along the edges of the soundbox and in areas of abrupt change in thickness (for example at the edge of the string band). As discussed for the measurement of the Lamont harp soundboard, due to image artefacts associated with the metal string shoes it was only possible to take a limited number of measurements on the string band. The mapping of the soundboard thickness in this location is therefore less reliable.

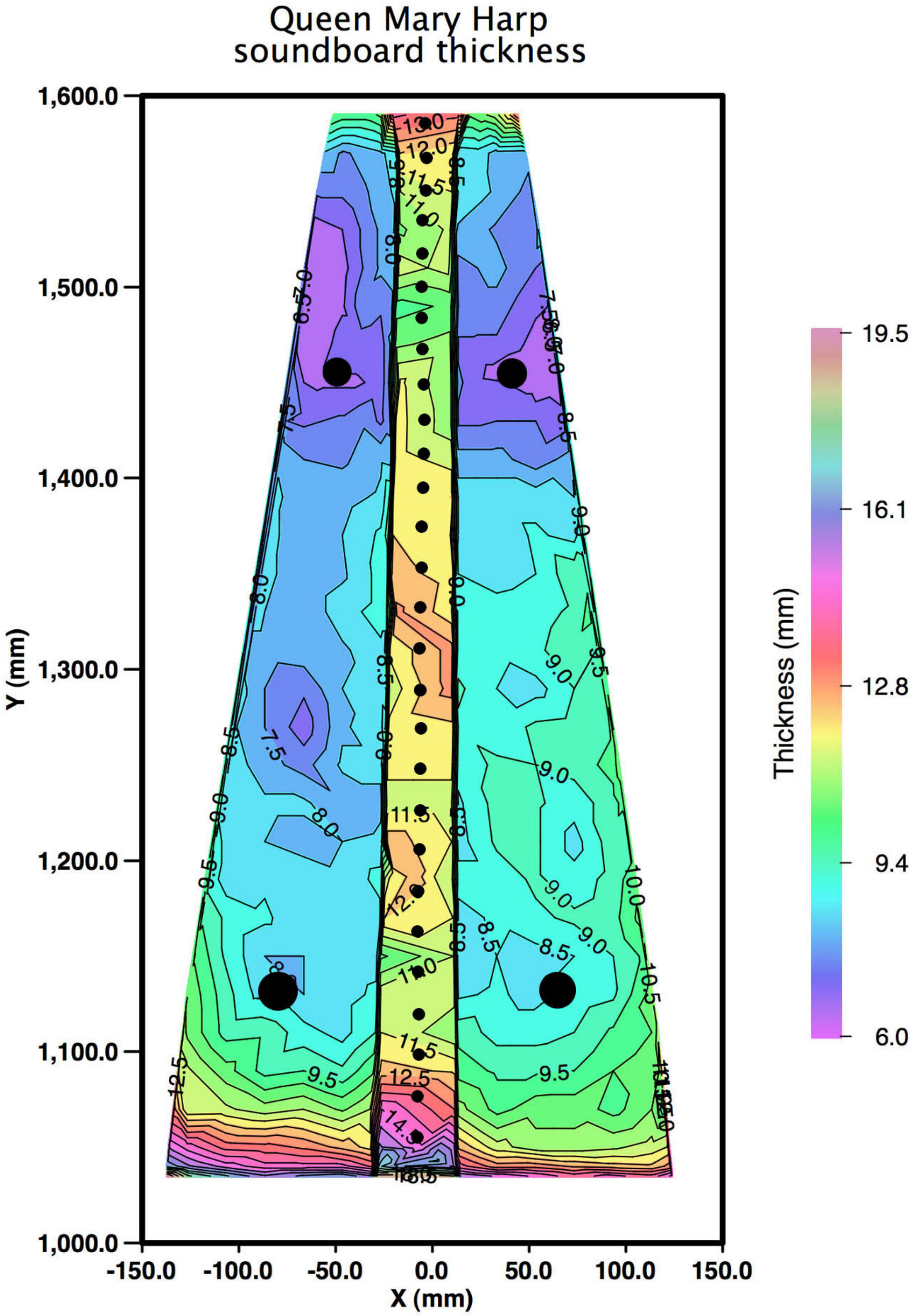
The resulting contour map of the Queen Mary harp soundboard thickness is presented in figure 4.98.[507] Each contour represents a change in thickness of 0.5 mm. The coordinate system is that of the CT scanner, with the exception that the scanner's

505 This discussion is adapted from Loomis et al., "Lamont and Queen Mary Harps,"126 – 28.
506 Armstrong, *Irish and Highland Harps*, 168 – 69.
507 The contour map was generated using the Aabel v. 3.0.5 graphing programme. A version of this figure appears in Loomis et al., "Lamont and Queen Mary Harps," 167.

z-axis is referred to on the contour map as the y-axis.[508] For reference, the positions of the string holes and sound holes were measured and added manually to the map.

Figure 4.98 (overleaf): *contour map of the Queen Mary harp soundboard. The treble end of the soundbox is at the top of the figure. Thickness increases towards the red end of the colour spectrum (with the exception of the thickest contours on the string band, which wrap back to the blue). Each contour represents a change in thickness of 0.5mm. The colours used represent the same thicknesses in the contour map of the Lamont harp soundboard (figure 3.92).*

[508] The signs of the x and y coordinates have been reversed for the purpose of plotting the contour map with the top of the harp facing up.



Some notable features are apparent in the contour map of the Queen Mary harp soundboard. Most importantly, it confirms that the soundboard is not a single thickness. It is thinner in the treble, decreasing in thickness from 8 mm just below the top sound holes to 6 mm along the sides of the soundbox above these sound holes. In the mid-section of the harp there is a large area on the right-hand side of the soundboard that is thinner than the left-hand side. Here, the thickness is about 7.5 mm compared to 9 mm in areas of the middle of the left-hand side. At the bass end the soundboard thickness rapidly increases from about 8.5 mm just below the lower sound holes to 10.5 mm close to the bottom edge, where it rolls over into the rounded corner. It is worth noting that the soundboard thickness measured in the vicinity of the sound holes agrees with Armstrong's published values.

The photograph of the soundbox interior in figure 4.78 shows that the treble end of the soundbox does not appear to have been reworked at a later date, nor does any other part of the front face of the soundbox interior, with the exception of the edge adjacent to the bass end of the box described earlier, so the observed gradations in thickness are most likely original to the construction of the soundbox. The relative thinness of the soundboard in the treble is of particular note. The thickness decreases by 30% as compared to the mid-section, which is a significant reduction. As discussed for the Lamont harp, a thinner soundboard in the treble will compensate for the increased stiffness that would normally result where the soundboard narrows, and soundboards of modern harps are tapered from bass to treble for this reason. While it is possible that it is a coincidence that the soundboard of the Queen Mary harp, like the soundboard of the Lamont, was made thinner in the treble, given the level of craftsmanship otherwise exhibited in the construction of this soundbox it is more likely that this was intentional, with the most probable reason being the acoustics of the instrument.

It is interesting that both the Lamont and Queen Mary harp soundboards exhibit the same left-right asymmetry in thickness in the mid-section, and that both are thicker on the left side. While this could be coincidental, possible mechanical or acoustical advantages should be investigated.

Summary

The construction of the soundbox of the Queen Mary harp shows a high degree of craftsmanship. Examination of the decorative work has revealed that the lines of the geometrical motifs were pressed, rather than incised, into the wood. The decorative work on the back cover of the soundbox shows the same method and workmanship, indicating that this is very likely the original back cover to this soundbox. Significantly, this is therefore the only soundbox of any low-headed Irish harp to retain its original back cover.

Analysis of a sample of the dark material in the decorative lines on the soundbox showed the presence of elements associated with organic molecules as well as metals, specifically a significant amount of copper with lesser amounts of lead and bismuth were detected. The organic compounds probably include wax, but charred wood may also be present, given the possibility that the lines were burned in. The metals suggest the possible presence of pigments. Further analysis is recommended to try to identify the chemical compounds present, and a larger sample should be taken in order to look for and identify possible layering of different substances in the material.

The difference in both design and execution of the geometric versus the foliaceous decorative designs suggests the work of two different craftsmen, and the possibility that the foliaceous designs were added later should not be ruled out without further analysis. The foliaceous designs belong to the late 15th-century Iona school of monumental decorative carving, as determined by Steer and Bannerman.[509] Although the geometric designs appear on the harp depicted on the grave slab at Keills, further work is needed in order to confirm that they are native to this time period and location. Dating of the wood is also recommended, if feasible, in order to try to determine if all parts of the harp frame date to the same time period.

Examination of the interior of the soundbox has revealed tool marks that indicate a high degree of attention was paid to the interior surfaces. The sides have been

[509] Steer and Bannerman, *Late Medieval Monumental Sculpture*, 185.

smoothed with a serrated tool, and the front (the 'soundboard') has been worked methodically with a gouge the entire length of the box to produce a regular, furrowed surface. Haphazard chisel marks on the bass end of the soundbox suggest later modification by a less skilled craftsman.

Signs of a long working life for the soundbox are evident in the numerous toggle marks around each string hole, and the restringing scratches in the vicinity of the sound holes. The uneven surface of the wood and a layer of varnish prevented an accurate estimate of the numbers of these marks, however.

Stringing marks are also visible on a number of the string shoes. Examination of the string band both visually and with CT has revealed that the string shoes that are of the staple design are not original, but are replacements for the nailed in style, of which only a handful remain. The design of the replacement shoes may be an indication that an attempt was made to reinforce the string band after it began to split.

The use of tomography to image the interior surface of the soundbox prior to removal of the back cover demonstrates that this method can be used to accurately image tool marks on surfaces in inaccessible areas of musical instruments, provided the tool marks are larger than the resolution limit of the CT scanner. The use of a CT scan of the harp to facilitate the safe removal of the back cover is further evidence of the power and versatility of CT as a tool for the study of early musical instruments that may otherwise be difficult to examine due to age and fragility.

Opening the soundbox also allowed examination of the inside surface of the back cover. This revealed multiple episodes of repair and/or preservation, some of which predate much of the woodworm damage to the back cover, suggesting these may be old repairs. The apparent effort put into preserving this piece of wood is consistent with the back cover being original. Although both the interior and exterior surfaces of the wood are obscured by varnish and/or other coatings, it was possible to see the wood grain by examining a tomogram of the back cover. This showed that it was made from a single slab cut piece of wood.

The exterior of the soundbox of this harp has signs of wear that are a result of the manner in which the instrument was held and played. Examination of the wear to the foot indicates the harp was held tilted over towards the player's left side. The wear to the edges of each side of the soundbox is consistent with the left hand playing the treble and the right hand the bass. The position and extent of the wear on each side has been diagramed as a guide for present day musicians wishing to recreate historical performance practice.

Possibly the most significant feature of the construction of the Queen Mary harp soundbox is the design of the mortise for the joint with the neck, which is discussed in Chapter 2 of this dissertation. The undercutting of the treble end of the soundbox to create a through mortise, and the angling of this mortise are particularly advantageous to the acoustics of the instrument and to the structure of the frame, as has been discussed. This, and the features of the soundbox discussed above are evidence of the high degree of skill and attention to detail involved in its construction.

Cross-sections

The dimensions of the soundbox in its current state are shown in the tomographic cross-sections below. The tomogram in figure 4.99 is a lengthwise cross-section through the middle of the soundbox.[510] The lines labeled A – E indicate the locations of the vertical cross-sections shown in figures 4.100 – 4.104. The grey-scaling of the tomograms has been set to accurately represent the location of the physical edge of the wood. The dimensions given are derived from the FWHM of the cross-section. In each figure the lines in the two left-hand images indicate the location of the cross-section shown on the right. The measurements shown were taken at the location of the lines indicated on the cross-section. The right-hand side of the harp is on the left, and the view is from the perspective of 'looking up' the soundbox from the bass end.

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[510] The front of the soundbox, including the positions of the string and sound holes, is shown in figure 4.73.

Figure 4.99 (overleaf): *tomographic cross-section of the soundbox of the Queen Mary harp. This cross-section also shows the neck tenon in the soundbox mortise. Note that this joint is offset towards the right-hand side of the soundbox, as it is on the Lamont harp soundbox. The lines A – E indicate the locations of the individual cross-sections shown in figures 4.100 – 4.104. Scale 1 tick : 1 cm; grid scale 1 square : 2 cm.*

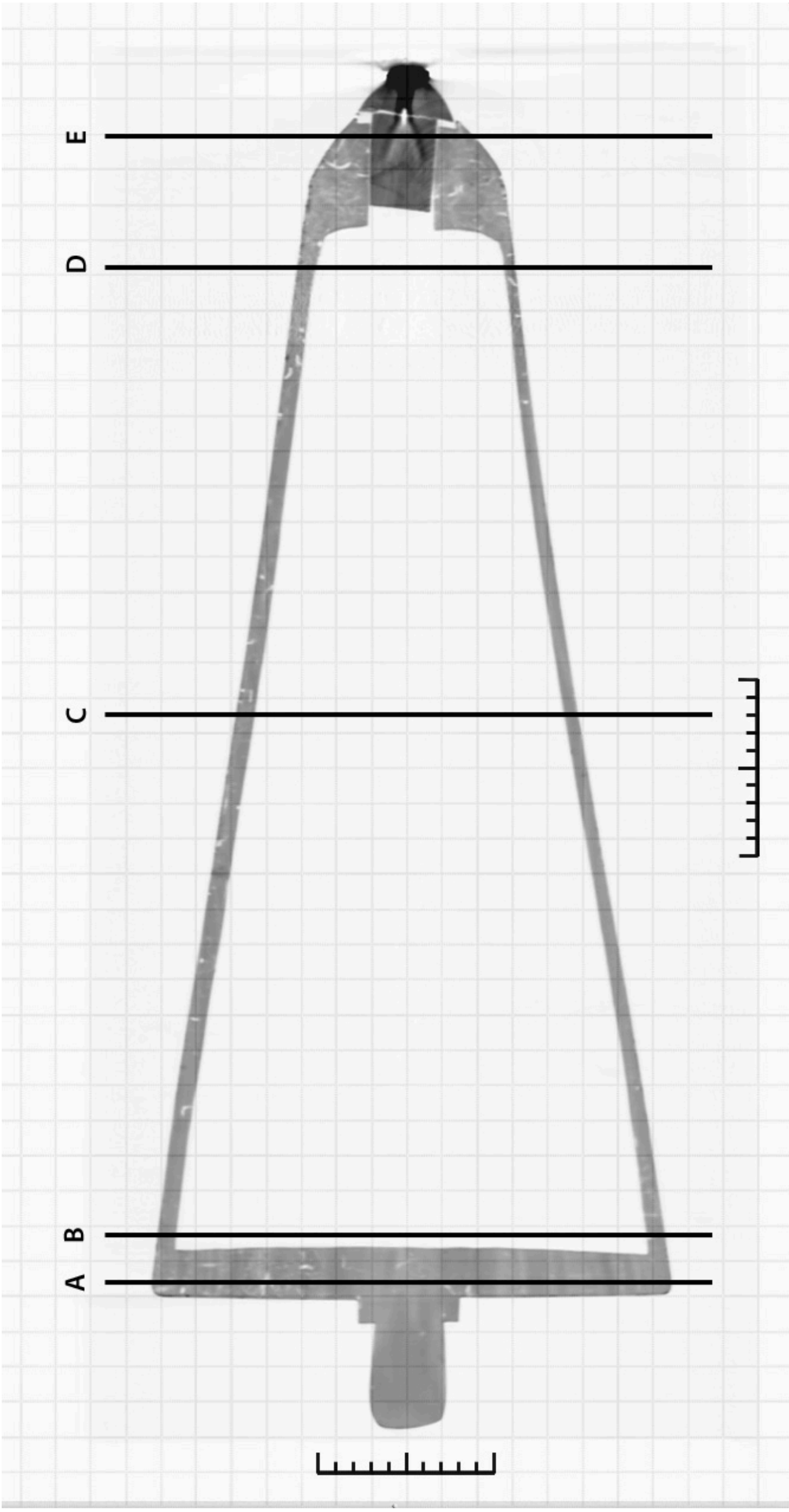

E
D
C
B
A

Figure 4.100 (overleaf): *Queen Mary soundbox cross-section A (see figure 4.99). This is a cross-section through the bass end of the soundbox, which shows the orientation and pattern of the growth rings. Scale 1 tick : 1 cm.*

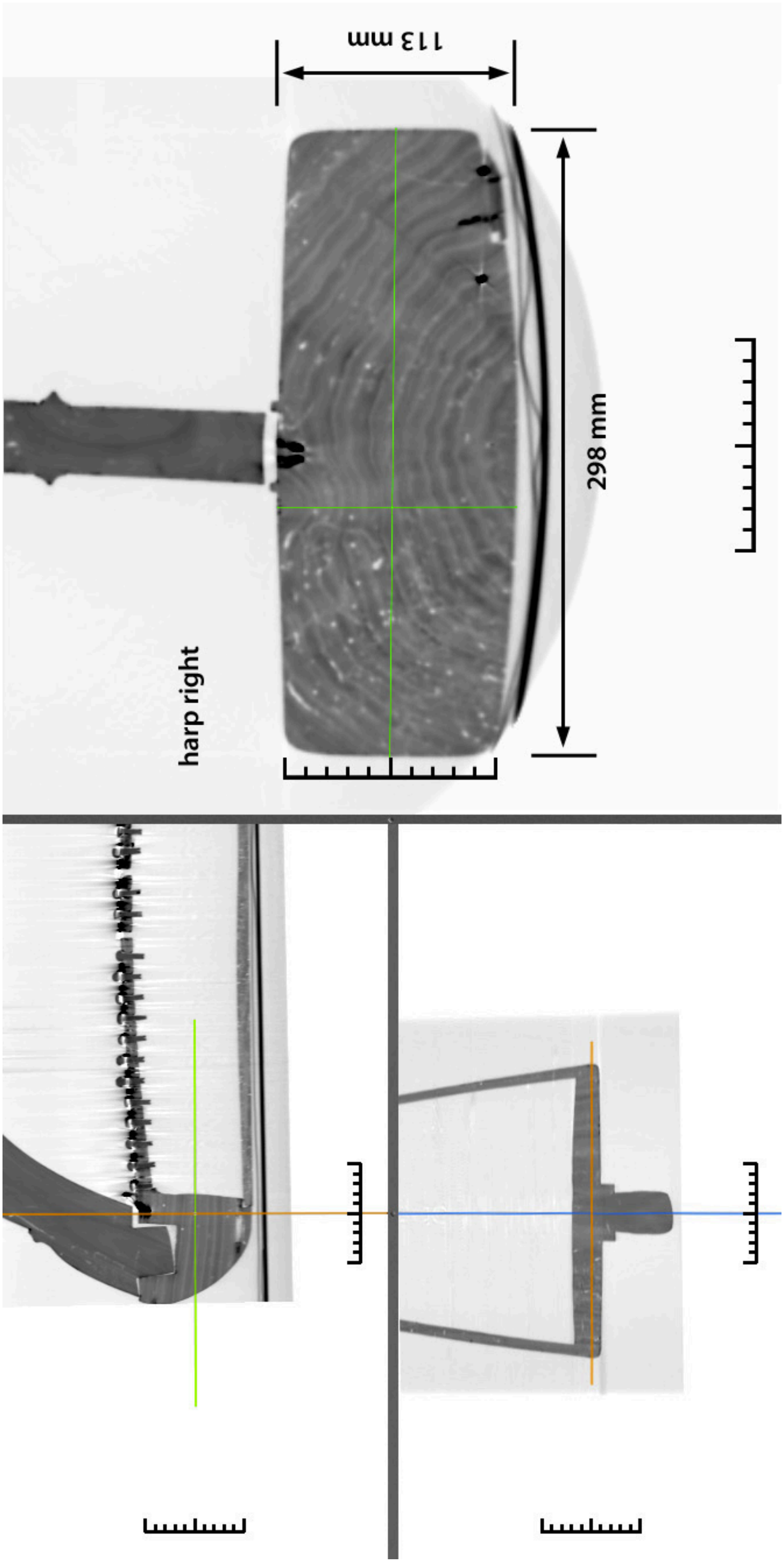

harp right
298 mm
113 mm

Figure 4.101 (overleaf): *Queen Mary soundbox cross-section B (see figure 4.99). The raised string band can be seen in profile at the centre of the front of the soundbox. Note that the interior surface of the soundbox underneath the string band is flat, as it is on the Lamont harp soundbox. This makes the soundbox less vulnerable to developing cracks along the edges of the string band. Scale 1 tick : 1 cm.*

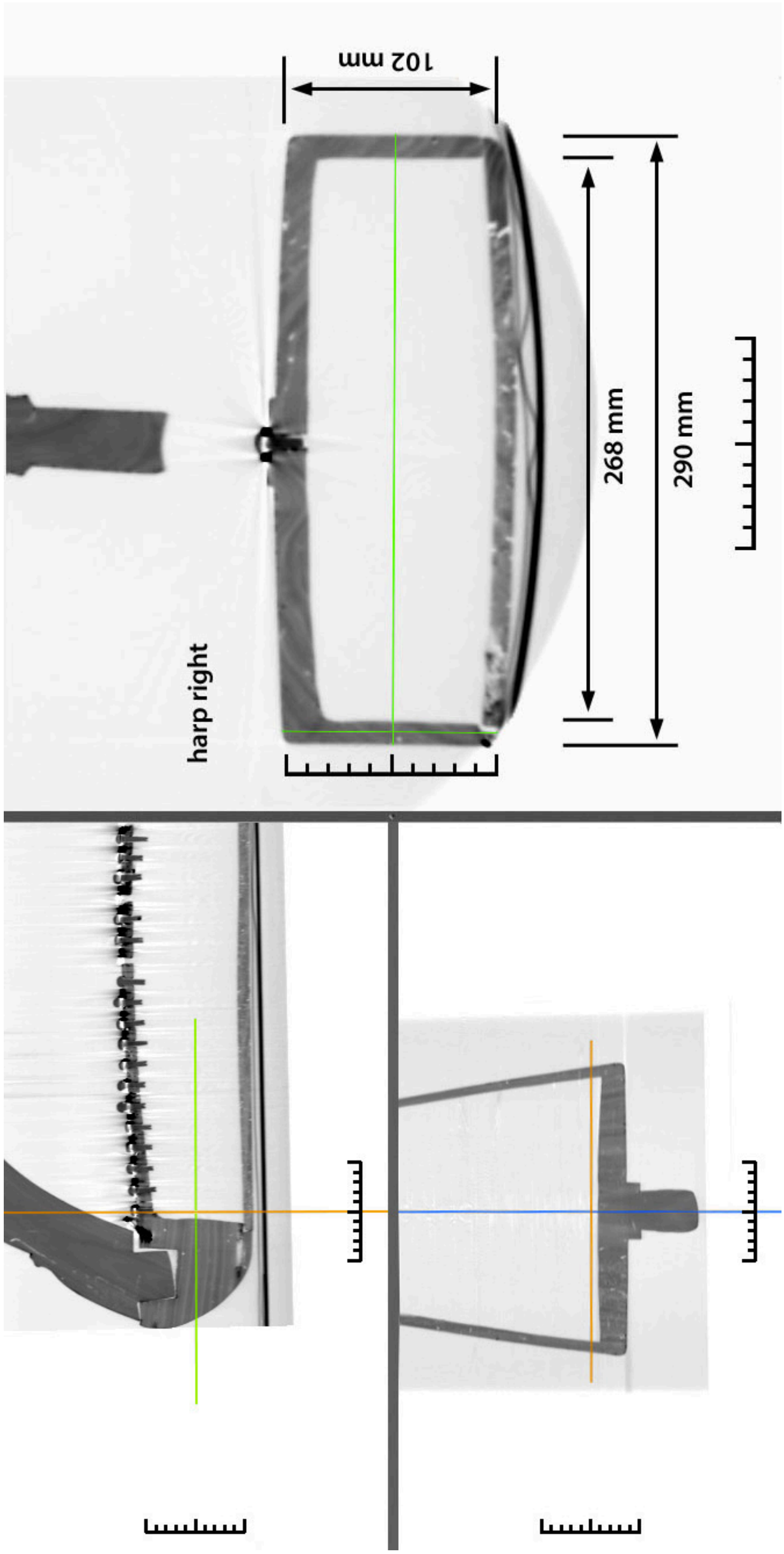

harp right
102 mm
268 mm
290 mm

Figure 4.102 (overleaf): *Queen Mary harp soundbox cross-section C (see figure 4.99). Note that the sides of the soundbox are visibly pulled in due to the front being pulled up by the string tension. Scale 1 tick : 1 cm.*

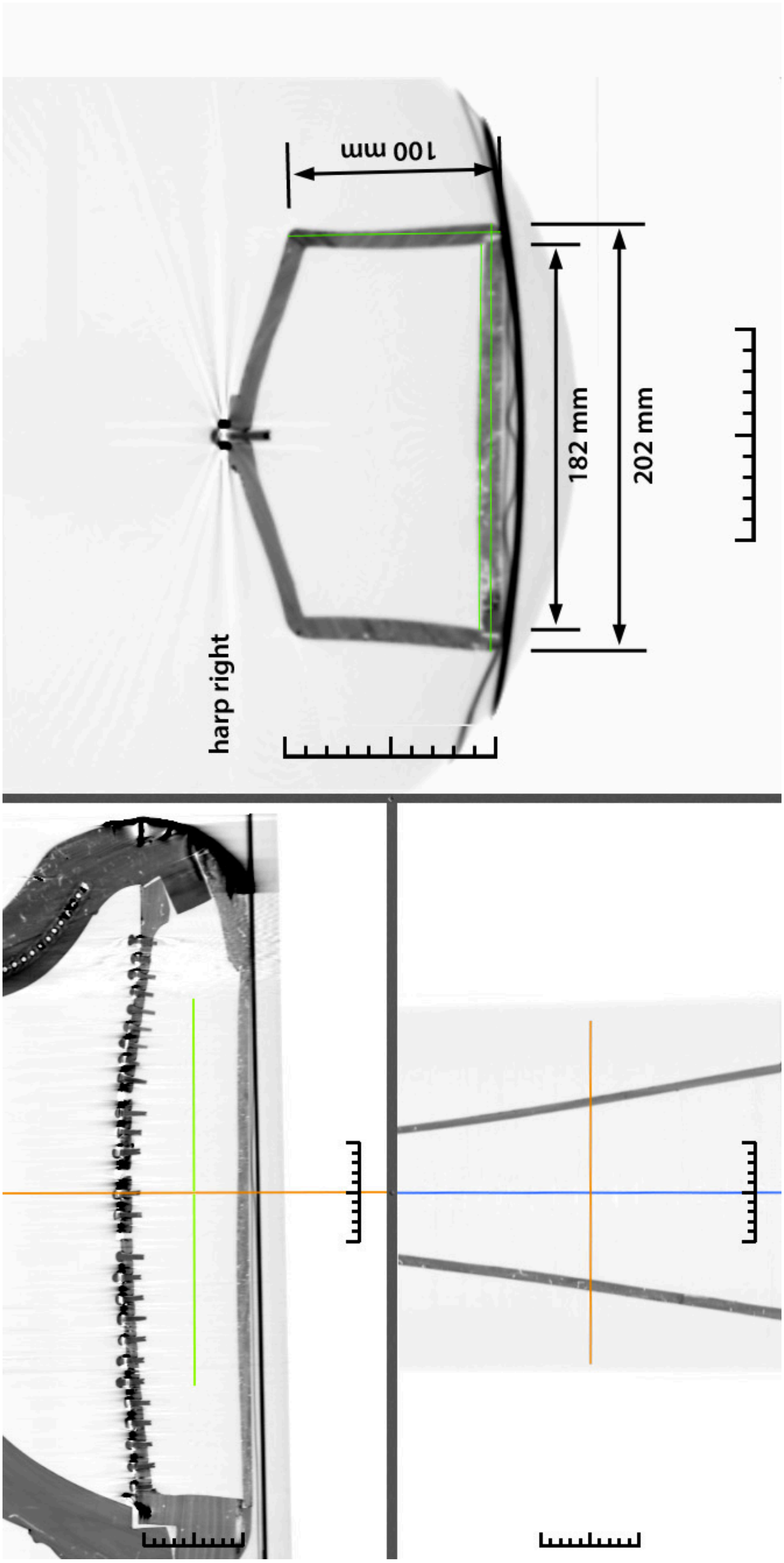

harp right
100 mm
182 mm
202 mm

Figure 4.103 (overleaf): *Queen Mary harp soundbox cross-section D (see figure 4.99). Scale 1 tick : 1 cm.*

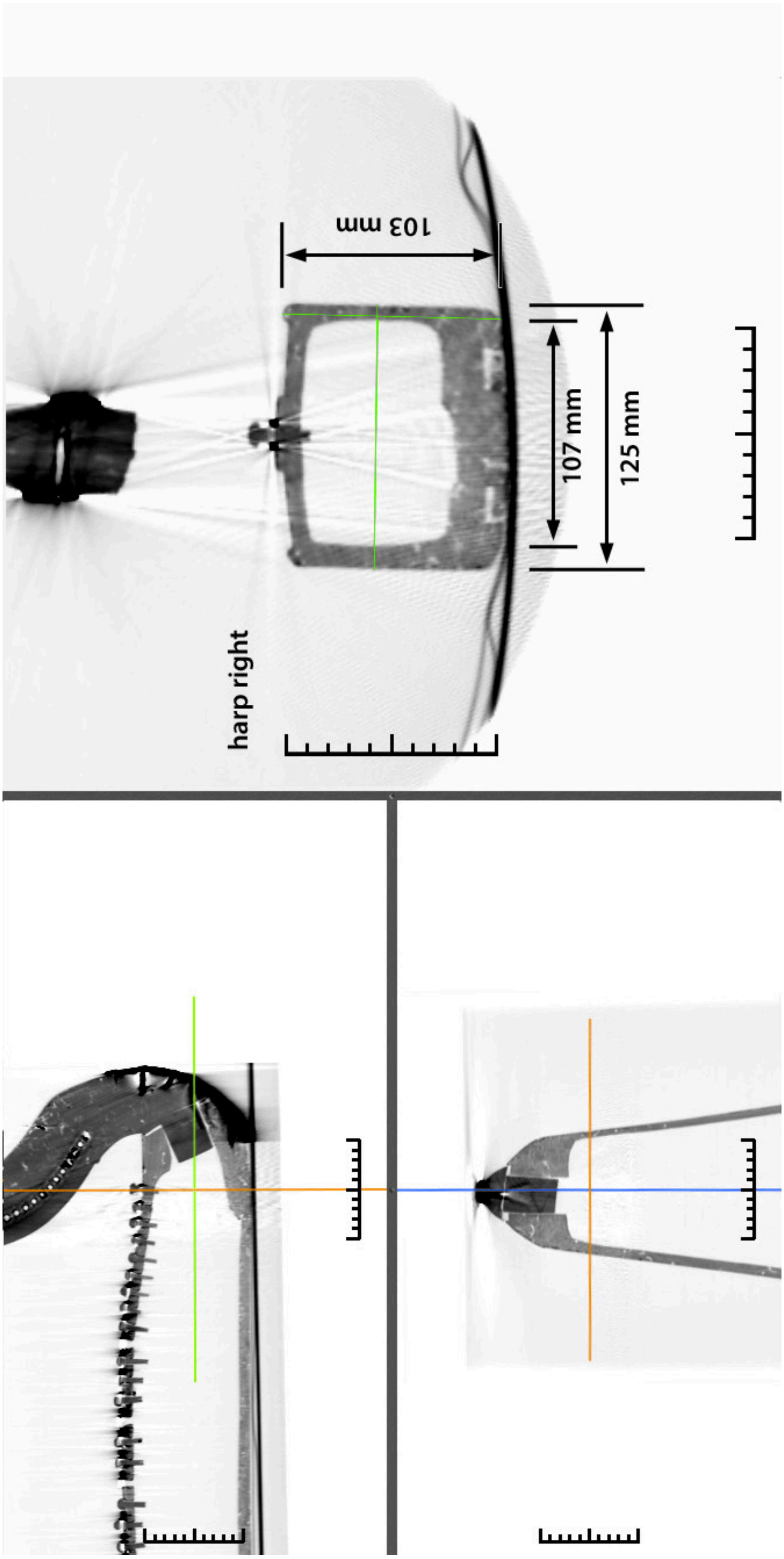
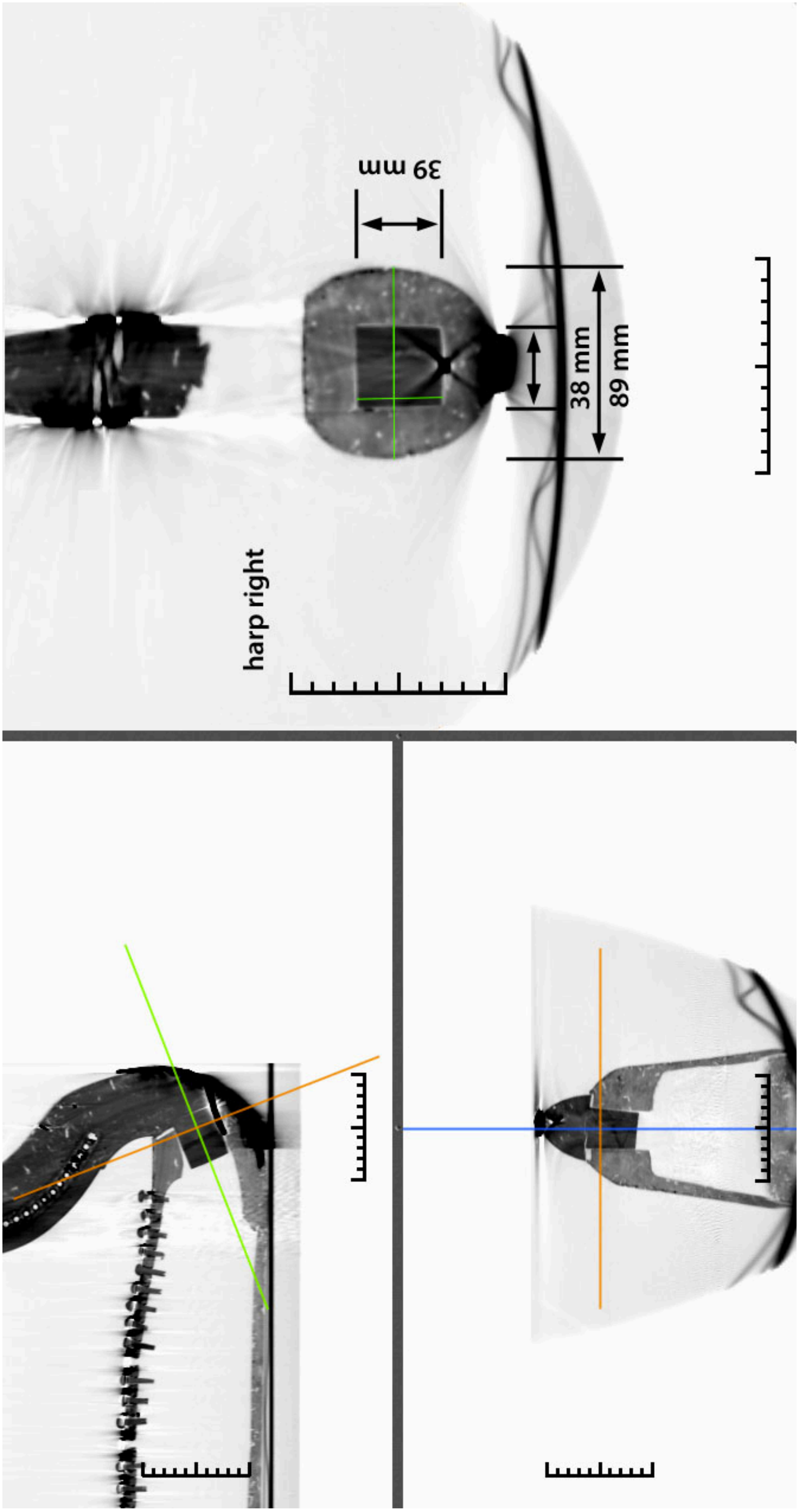

harp right
103 mm
107 mm
125 mm

Figure 4.104 (overleaf): *Queen Mary harp soundbox cross-section E (see figure 4.99). In order to show the dimensions of the mortise, this cross-section is aligned with the axis of the mortise and tenon joint instead of the long axis of the soundbox. Scale 1 tick : 1 cm.*


harp right
39 mm
38 mm
89 mm

Chapter 5. Wood Identification

For the study of historical musical instruments, the choice of wood is an important consideration in an examination of their construction. Its physical characteristics affect the acoustical and mechanical properties of the finished instrument, and luthiers have customarily used care in selecting the wood, often showing a preference for a specific species of tree.[511] It is therefore of interest to identify the woods used in the construction of the surviving Irish harps.[512] A number of sources note that, historically, Irish harps were made of willow by tradition, a choice of wood considered by some to be an important characteristic of their construction.[513] Few confirmed species identifications are available for the surviving harps, however, and to what extent they actually reflect this tradition is an open question. Rimmer (1969) names the woods used for several, but does not clearly cite the sources of these identifications or the methods used, so her information has to be reassessed.[514]

There has been speculation regarding the wood used to construct the Queen Mary and Lamont harps for as long as there has been interest in these two historical instruments. Gunn (1807) states that the forepillar and neck of the Lamont harp were made of plane tree, and Joseph Anderson (1881), then *Custodier* of the National Museum of Antiquities in Edinburgh, commented that the soundbox of the Queen Mary harp was made of willow, information that was later quoted in Armstrong.[515] Armstrong speculated, based on his visual examination, that the neck of the Queen

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[511] Neville Fletcher and Thomas Rossing, *The Physics of Musical Instruments* (New York: Springer, 1998), 719 – 23. Voichita Bucur, *Acoustics of Wood*, (New York: Springer, 2006), 173 – 74. Iris Brémaud, "Acoustical Properties of Wood in String Instruments Soundboards and Tuned Idiophones: Biological and Cultural Diversity," *Journal of the Acoustical Society of America*, 131 (2012): 807.
[512] See, for example the recent wood species identification for the Downhill harp, which identified the wood as alder (*Alnus spp*.).Michael Billinge, "Building a Reproduction of the Downhill Harp," 10.
[513] O'Curry, *Manners and Customs of the Ancient Irish*, 271. Rimmer, "James Talbot's Manuscript," 67. Farmer, "Notes on the Irish Harp," 101. See also, Anderson, *Ancient Scottish Weapons*, 123.
[514] Rimmer, *Irish Harp*, 75 – 78.
[515] Gunn, *Historical Inquiry*, 2. Joseph Anderson, *Ancient Scottish Weapons*, 25. Armstrong, *Irish and Highland Harps*, 180.

Mary harp might also be willow, but that the forepillar "is of a harder wood, and is closer grained."[516]

In 1969, wood samples were taken from the soundbox, forepillar, and neck of both the Queen Mary and Lamont harps and examined microscopically by A. J. Hayes of the Department of Forestry and Natural Resources at the University of Edinburgh.[517] The result of his analysis was that neither harp was made of willow, but that all parts of both harps were actually European hornbeam (*Carpinus betulus*). In his report to the National Museum of Antiquities of Scotland he wrote,

> "After a considerable amount of difficulty I have now succeeded in identifying the wood from which both the Lamont and Queen Mary Harps were constructed. I think that I mentioned to you, that my first impression was a Rosaceous timber, possibly hawthorn or apple, but microscopic examination shows this not to be the case. I am now 99% certain that the timber used was hornbeam (Carpinus betulus L.)."[518]

He also states that "the wood used in the sounding box, forepillar, and harmonic curve was identical in both cases."[519]

The European hornbeam identification was first cited in Rimmer (1969), and may have been requested for that publication.[520] In the intervening years since 1969, this wood species identification has met with some informal skepticism, however. It is curious that Hayes identified all parts of both harps as hornbeam, as the woods of some of the frame members do not appear to resemble each other. This is particularly noticeable for the Queen Mary harp, whose forepillar is made of a visibly lighter wood than the neck (see figure 4.7, for example). Additionally, hornbeam seems an unusual choice for hand carving a large hollowed out soundbox, as it is a very hard

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[516] Armstrong, *Irish and Highland Harps*, 181.
[517] Alan J. Hayes, *Alan J. Hayes to C. E. Curran, National Museum of Antiquities of Scotland*, 18 February 1969, letter, National Museums Scotland, H. LT2 archive.
[518] ibid.
[519] ibid.
[520] Rimmer, *Irish Harp,* 76 – 77.

wood that is difficult to work. As is evident from Hayes's letter, however, his identification was based on microscopic examination of wood samples taken from the harps. As this a reliable and standard method for species identification, it is difficult to argue against the results based only on the appearance of wood surfaces that may be obscured by layers of surface material.

It is apparent from Hayes's letter and accompanying report on the wood identification that, although he was fairly certain of his results, the identification had been difficult and he may have had some small lingering doubts about the results. His report was reviewed by Ticca Ogilvie, Head of Artefacts Conservation at National Museums Scotland, and a woods scientist, who noted that the information for the species identifications was incomplete. The structure of wood is three-dimensional, and definitive species identifications should ideally have samples aligned with each of the three primary planes within the wood, as shown in figure 5.1.

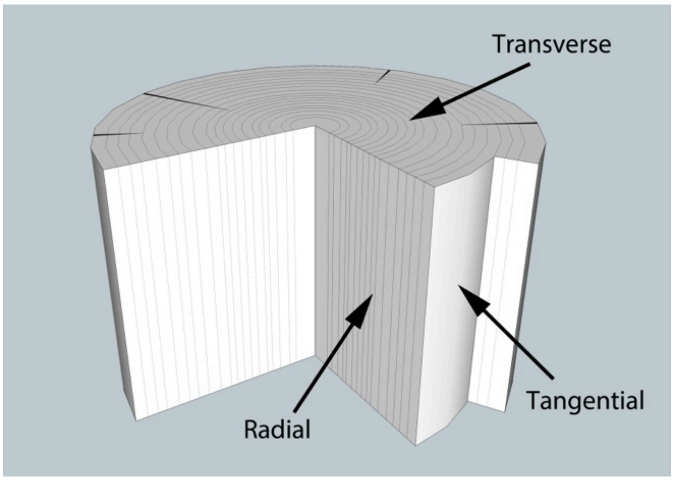

Figure 5.1: *the radial, transverse, and tangential planes of a timber.*

When the Queen Mary and Lamont harps were examined in the lab, it was evident where wood samples had been taken, as shown in figures 5.2 – 5.4. For the Queen Mary harp, a sample was taken at the bass end of the soundbox, and in the cut out area of the forepillar. For the Lamont harp, a wood sample was taken from the lower section of the forepillar where the two pieces are joined, and possibly directly above this on the upper section. A soundbox sampling location was identified on the inside edge of the upper-left soundhole.

***Figure 5.2:** evidence of previous wood sampling on the forepillar (arrowed, top) and soundbox (arrowed, bottom) of the Queen Mary harp.*

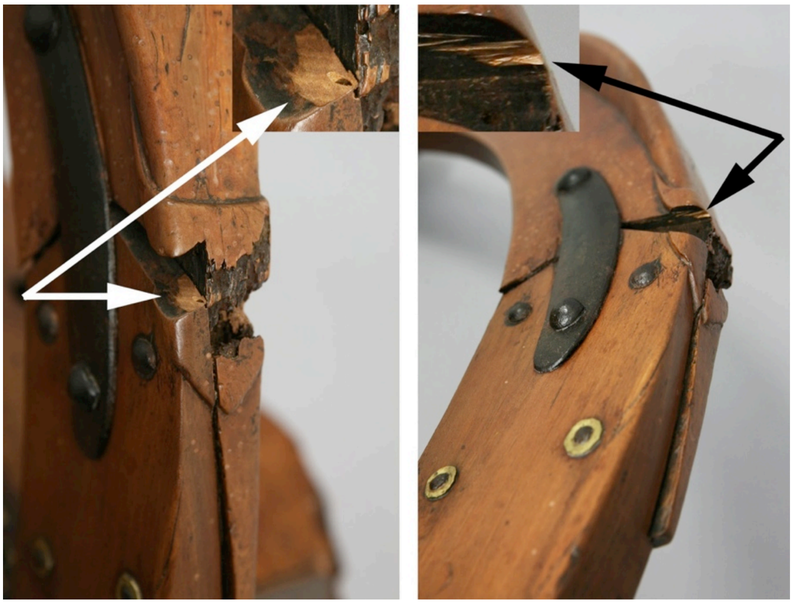

Figure 5.3: *evidence of previous wood sampling on the lower section of the forepillar of the Lamont harp (left, arrowed), and possibly the upper section (right, arrowed).*

Figure 5.4: *evidence of previous wood sampling on the inside edge of the upper-left soundhole of the Lamont harp soundbox (arrowed).*

No evidence of sampling was found on the neck of either harp, however archival photographs of the Lamont harp (possibly dating to the 1980's) show it in the process of being stripped of its varnish, which would have erased any evidence of wood sampling on the exposed areas of the harp. One of these photographs is shown in figure 5.5.

Figure 5.5: *archival photograph of the Lamont harp, possibly taken during restoration work in the 1980's. A large area of the soundbox has had its varnish removed. This photograph is one of a series showing the harp in the process of having its wood and metal-work stripped of surface coatings.*

Significantly, the sampling locations identified are all in only one of the three planes of the wood. While it is possible some sites were overlooked, or that some (in the case of the Lamont harp) were obscured by later restoration work, it is also possible that Hayes was limited in the areas that he was permitted to sample.

When the CT scans of the Queen Mary and Lamont harps were examined, it was immediately apparent that the wood of some frame members was denser than others, as shown in figure 5.6. This seemed odd, considering Hayes's identification of all of the wood as belonging to the same species of tree.

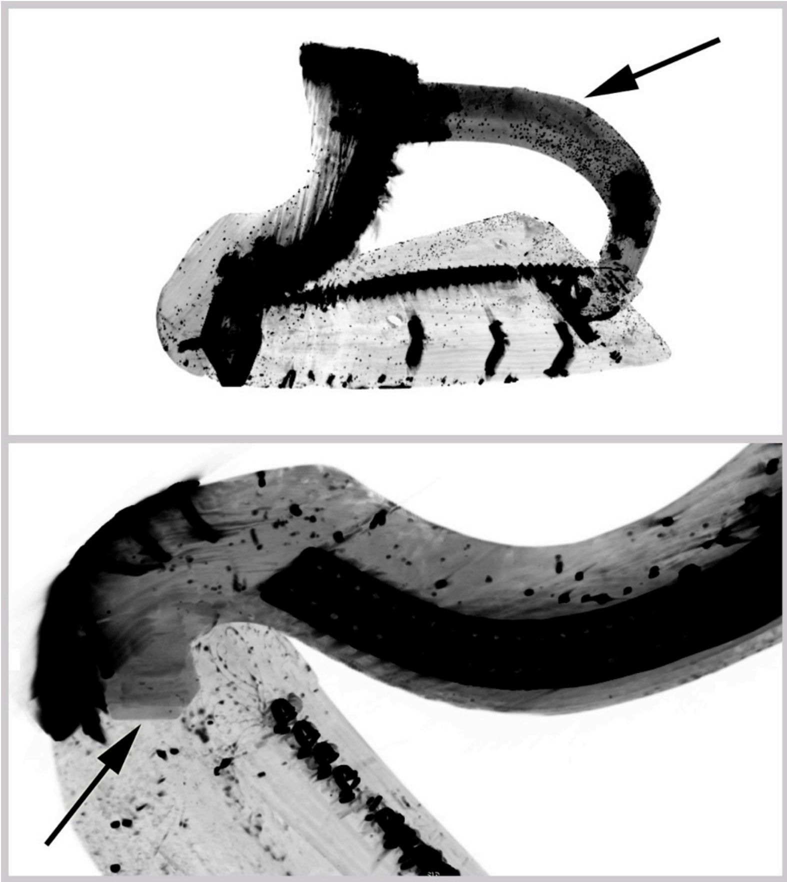

Figure 5.6: *tomograms of the Lamont harp (top) and the Queen Mary harp (bottom). Areas of higher density are rendered as darker shades of grey. The forepillar of the Lamont harp (arrowed, top), and neck of the Queen Mary harp (arrowed, bottom) appear to be constructed of higher density wood than the other frame members.*

While the tomograms provide qualitative information for the densities, it would be more useful to know the actual densities of the individual wooden members of the two harps. Stoel and Boreman (2008) have demonstrated that it is possible to use CT to measure the density of wood in musical instruments.[521] The density of each frame member of the two harps was therefore measured from the CT data for comparison to each other as well as to the expected range of densities for air-dried European hornbeam. To determine the densities, the average radiodensity was measured in virtual sample volumes of wood within each member and converted to density in g/cm^3 using the relation

[521] Berend Stoel and Terry Boreman, "A Comparison of Wood Density between Classical Cremonese and Modern Violins." PLoS ONE 3(2008): 1 – 7, accessed 21 February, 2010 doi: 10.1371/journal.pone.0002554.

$$\rho\ (\text{g/cm}^3) = \left(\frac{HU}{1000}\right) + 1.0$$

where ρ is the density in g/cm^3, and HU is the radiodensity value of each voxel in Hounsfield units.[522] It is worth noting that by utilizing the CT scans in this manner, it was possible to obtain samples from anywhere inside the instruments without physically cutting into the wood, making this measurement entirely non-destructive. The samples were chosen away from the surface of the wood to avoid possible contamination of the data by surface materials, and were chosen to include both early and late wood at different locations within each member so as to obtain an average representative density over as much of each piece of wood as possible. Care was also taken to avoid including areas of insect damage, metal fragments, and image artefacts.[523]

The mean and range of density over all of the samples measured for each member of both harps is presented in table 5.1. The average size of each sample volume is also shown in this table. It was necessary in some cases to use small volumes in order to avoid contamination. On average, six samples were used for each member. For the upper section of the Lamont harp forepillar a total of twelve samples were used to compensate for the small sample volumes that were necessary to avoid areas of insect damage.

[522] Paul Brinkmann, Wolfgang Frobin, and Gunnar Leivseth, *Musculoskeletal Biomechanics* (Stuttgart, Georg Theime Verlag, 2000), 162. Also, Martin Connell, e-mail message to author, 15 March, 2011.
[523] Finding suitable sampling locations in the back cover of the Queen Mary harp and the upper section of the Lamont harp forepillar was difficult due to extensive insect damage.

Table 5.1.

Measured wood densities for the harp frame members

	density range (g/cm^3)	**mean density (g/cm^3)**	**mean sample volume (cm^3)**
Queen Mary harp			
soundbox	0.49 – 0.57	0.53	0.99
forepillar	0.63 – 0.66	0.64	0.99
neck	0.73 – 0.80	0.76	0.23
back cover	0.47 – 0.51	0.50	0.20
Lamont harp			
soundbox	0.48 – 0.55	0.53	0.49
forepillar (upper)	0.77 – 0.88	0.82	0.13
forepillar (lower)	0.70 – 0.74	0.72	0.37
neck	0.57 – 0.61	0.60	0.30
back cover (larger panel)	0.38 – 0.41	0.40	0.25
back cover (smaller panel)	0.36 – 0.37	0.36	0.25

The densities in table 5.1 and are plotted in figure 5.7 with expected range of densities for air-dried European hornbeam included for comparison. Based on published values, the density of seasoned wood of the European hornbeam species, *Carpinus betulus*, ranges from approximately 0.67 – 0.79 g/cm^3.[524]

[524] H. G. Richter and M. J. Dallwitz, "Commercial Timbers." A. E. Zanne, et al., "Global wood density database," Dryad, last modified, 2009, http://hdl.handle.net/10255/dryad.235. Gokhan Gunduz et al., "The Density, Compression Strength and Surface Hardness of Heat Treated Hornbeam (Carpinus betulus) Wood," *Ciencia y Technología* 11, no. 1 (2009): 66. Ahmad Samariha, "Effect of Altitude Index on Growth Rate and Physical Properties of Hornbeam Wood (Case Study in Mashelak Forest of Iran)," *World Applied Sciences Journal* 13, no. 9 (2011): 2058.

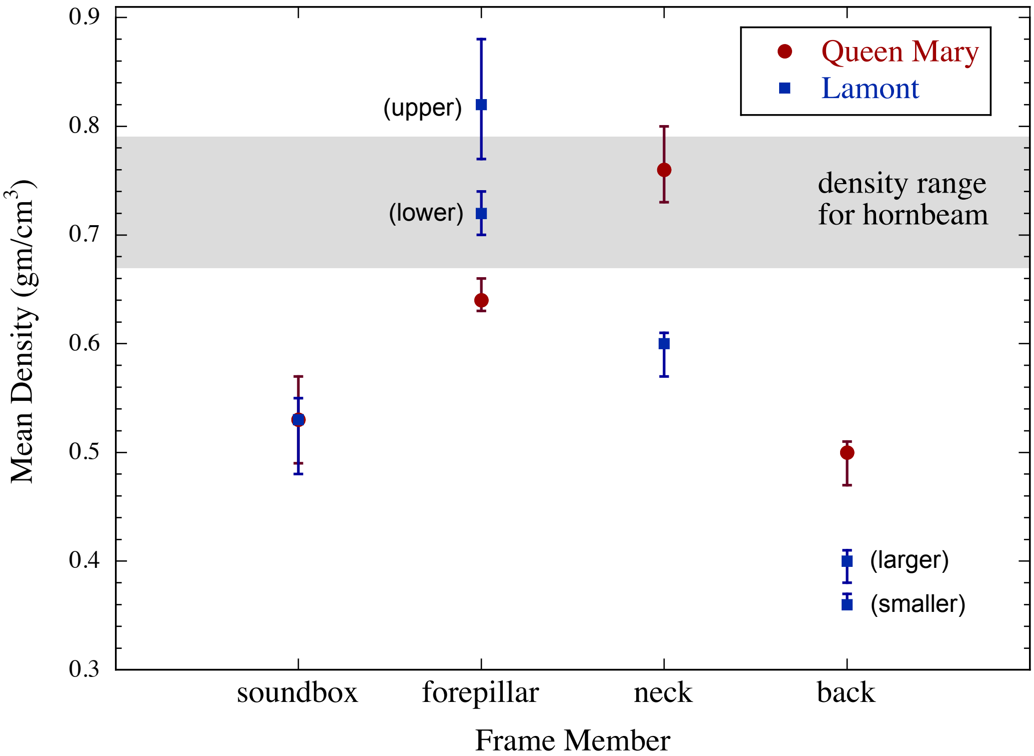

Figure 5.7: *densities of the wood members of the Lamont and Queen Mary harps, as calculated from the measured radiodensity in sample volumes of CT data. The grey band represents the expected density range for European hornbeam. The data points labeled "upper", "lower", "larger," and "smaller" refer to the separate parts of the Lamont forepillar and back cover respectively.*

The results shown in table 5.1 and figure 5.7 reveal a range of distinctly different densities for each of the frame members of the two harps. Furthermore, they show that some of the measured densities are outside the expected range for European hornbeam. While it is not possible to determine the species of wood from the density alone, these results and the possible issues with Hayes's identifications justified resampling the wood for microscopic analysis to re-identify of the species. This was undertaken for both harps in 2012 – 2013 and is discussed below.

In December 2012, wood samples were taken from the Queen Mary and Lamont harps for the purpose of species identification. The sampling and identification were undertaken by Ticca Ogilvie, at the National Museums Scotland Collections Centre. Due to the age and fragility of the wood, and the uniqueness of both harps as artefacts, every effort was made to minimize the invasiveness of the sampling while ensuring useable samples were obtained. To facilitate selection of suitable sampling locations, tomograms from the CT scans of the harps were consulted to assess the orientation of each frame member with respect to the direction of the wood grain. As discussed in Chapter 4, tomograms of the back cover were also consulted to ensure its safe removal in order to access the interior of the soundbox for wood sampling. For both harps, samples of the soundbox and neck were taken from inside the soundbox. The sampling locations are indicated in figures 5.8 and 5.9 for the Queen Mary and Lamont harps respectively.

Figure 5.8: *locations of wood samples taken from the Queen Mary harp for the current project. Clockwise from top left: soundbox and neck (A) and (B), respectively; forepillar (C); back cover (D); and soundbox thin section samples - TS, tangential (T), radial (R), and two transverse samples (X).*

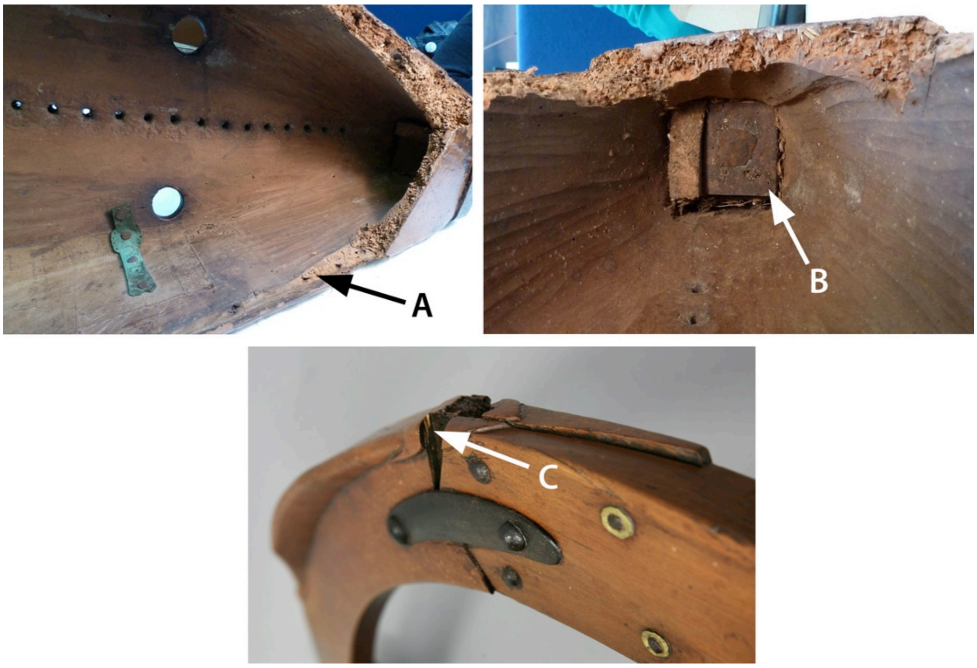

Figure 5.9: *locations of wood samples taken from the Lamont harp for the current project. Clockwise from top left: soundbox (A), neck (B), and forepillar - upper section (C). The area of previously exposed wood on the forepillar was re-used for sampling. The lower forepillar section and back cover have not yet been sampled.*

The standard procedure for microscopic wood species identification is to take a very thin sample (ideally one cell thick and several millimetres across) for each of the three primary planes of the wood. Upon removal of the first sample from the Queen Mary harp soundbox it became apparent that this method would be problematic. Due to the extremely fragile state of the wood, even with careful handling it would be difficult to prepare the samples for examination on a microscope slide without them disintegrating. It is likely that Hayes encountered the same problem, so in addition to possibly not having a full set of samples, he may have had difficulty preparing the samples that he did have.

For the present study, there was an alternative method of sample preparation and analysis available. Instead of thin samples, Ogilvie proposed using a micro-scalpel to remove very small blocks (approximately 2 – 3 mm on a side) for imaging with

SEM.[525] This method was carried out, with the samples cut such that the surfaces aligned with the three primary planes of the timber. The samples were imaged with SEM by Lore Troalen, Analytical Scientist at the National Museums Scotland Collections Centre. This method of sampling and analysis kept the samples intact and preserved the fragile cellular structures. As a comparison, a known piece of European hornbeam was also sampled and imaged using the same technique and equipment.

As at this writing, a complete set of high-resolution images of each plane of the wood has been obtained for each of the soundboxes, and for the Queen Mary harp neck. A partial set has been obtained for the forepillar of the Queen Mary harp, and the samples of the back cover of the Queen Mary harp, and the neck and forepillar of the Lamont harp are currently awaiting further preparation for imaging. The images of the samples acquired thus far were sufficient for definitive identification of the wood for both soundboxes, which is discussed below. Both the forepillar and neck samples of the Queen Mary harp require additional imaging for a positive identification of the wood.

A SEM image of the sample from the Lamont harp soundbox is shown in figure 5.10. This wide field view shows the sample size, and the alignment of its sides to the transverse, radial, and tangential planes of the wood.

[525] SEM analysis has been used for species identification of archeological woods in instances where identification by other methods has been problematic. See for example Caroline Cartwright, Lin Rosa Spaabæk, and Marie Svoboda, "Portrait mummies from Roman Egypt: ongoing collaborative research on wood identification," *The British Museum Technical Research Bulletin* 5 (2011): 49 – 58.

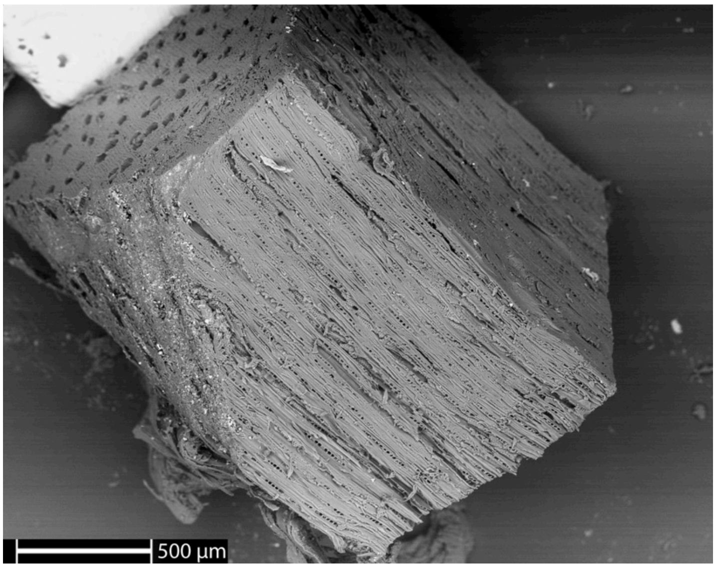

Figure 5.10: *SEM image of a micro-sample of wood taken from the soundbox of the Lamont harp. The sample has been cut to reveal the three primary planes of the wood. The tangential plane is facing the viewer, the transverse plane is facing the upper left of the image, and the radial plane is facing the upper right. All samples were taken and prepared by Ticca Ogilvie, National Museums Scotland.*

The SEM images of the wood samples are shown below, with a discussion of the primary identifying features.[526] For all of the images of the transverse plane the vertical axis of the image is aligned with the radial axis of the timber, and for all of the images of the radial and tangential planes the vertical axis of the image is aligned with the vertical axis of the timber.

Queen Mary harp soundbox

A number of features are visible in the cross-sections of the Queen Mary harp soundbox sample that uniquely identify the wood. These identifying features are discussed below and, where applicable, are compared and contrasted with comparable features in the hornbeam sample. The transverse plane of the soundbox sample is shown in figure 5.11.

[526]All images were acquired by Lore Troalen, Analytical Scientist, National Museums Scotland Collections Centre.

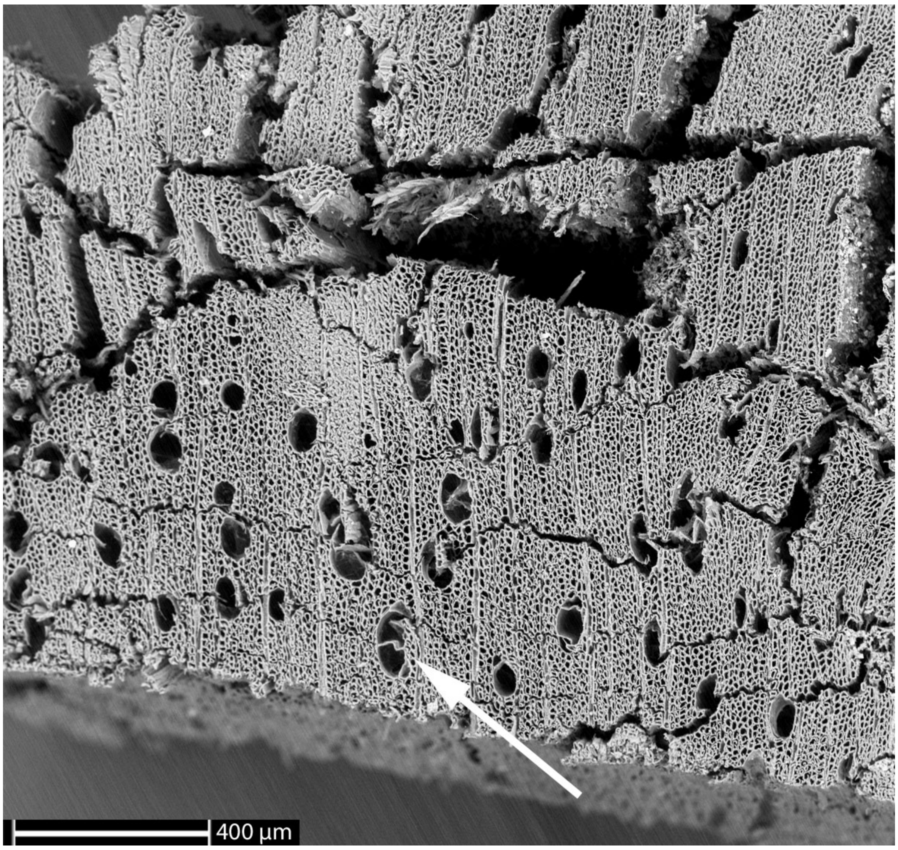

Figure 5.11: *SEM image of the transverse plane of the wood sample from the Queen Mary harp soundbox, showing the pattern of pores. Some pores occur in radial multiples of two (arrowed).*

Wood has a three-dimensional structure comprised, in hardwoods, of vessels and fibers extending vertically up the timber, and rays, extending radially from its centre. The dark ovals in the image of the transverse plane are the pores, the ends of the vessels. It is apparent from their distribution that this is a diffuse porous wood with some vessels occurring in short radial rows of two (arrowed in figure 5.11).

The identifying features noted for this plane of the sample are therefore as follows:

- vessels are present
- vessels occur in multiples
- vessels occur commonly in short radial rows of 2 – 3
- wood is diffuse porous

For comparison, the transverse plane of the European hornbeam sample is shown in figure 5.12. The identifying features are the same as for the sample from the Queen Mary harp soundbox.

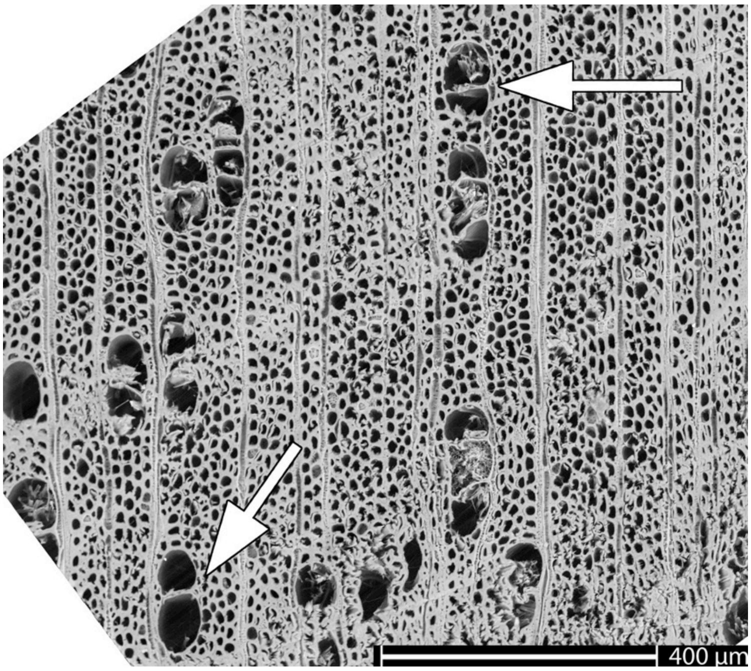

Figure 5.12: *SEM image of the transverse plane of the sample of European hornbeam (Carpinus betulus). Some pores occur in radial multiples of 2 – 3 (arrowed).*

The radial plane of the soundbox sample is shown in figure 5.13.

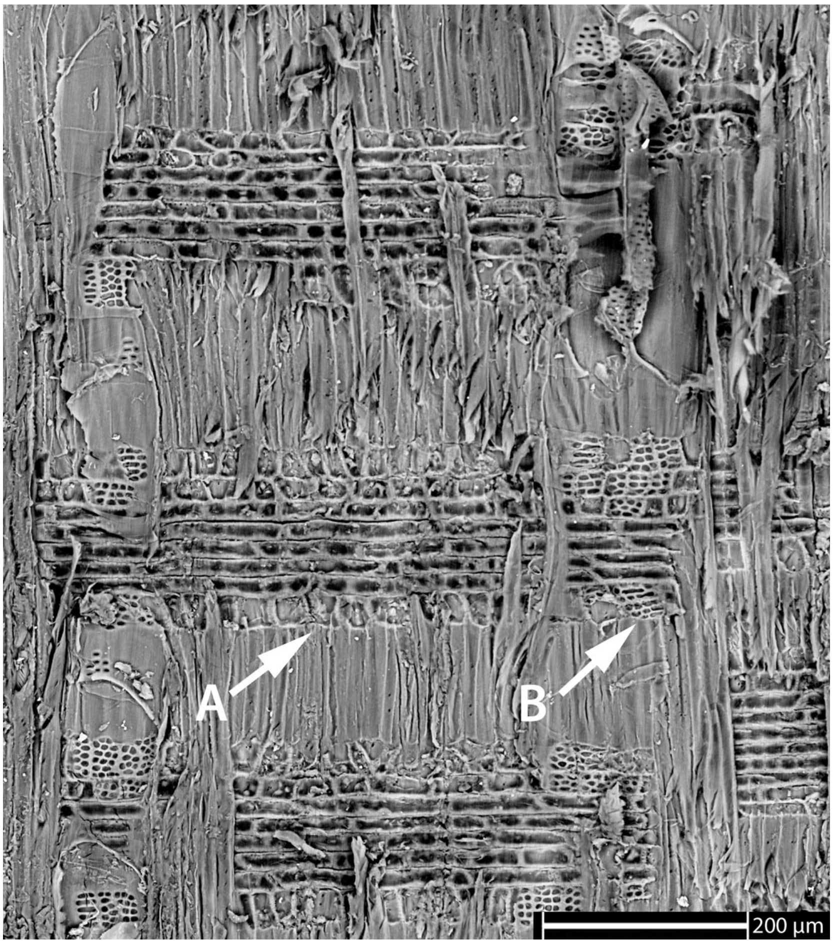

Figure 5.13: *SEM image of the radial plane of the wood sample from the Queen Mary harp soundbox. Upright ray parenchyma cells are present ('A', arrowed), and vessel ray pits are confined to the marginal rows ('B', arrowed).*

The vessels and fibers are seen in lengthwise cross-section in the radial plane. The structures resembling 'brick walls' are the rays.[527] They are comprised of 'horizontal' ray parenchyma cells, with 'upright' cells in the margins ('A' in figure 5.13). The structure resembling netting is composed of the vessel-ray pits. In this wood they are confined to the marginal rows of the rays ('B' in figure 5.13). A magnified view of the area in the upper right of figure 5.13 is shown in figure 5.14.

[527] The author kindly acknowledges Ticca Ogilvie for providing the brick wall comparison.

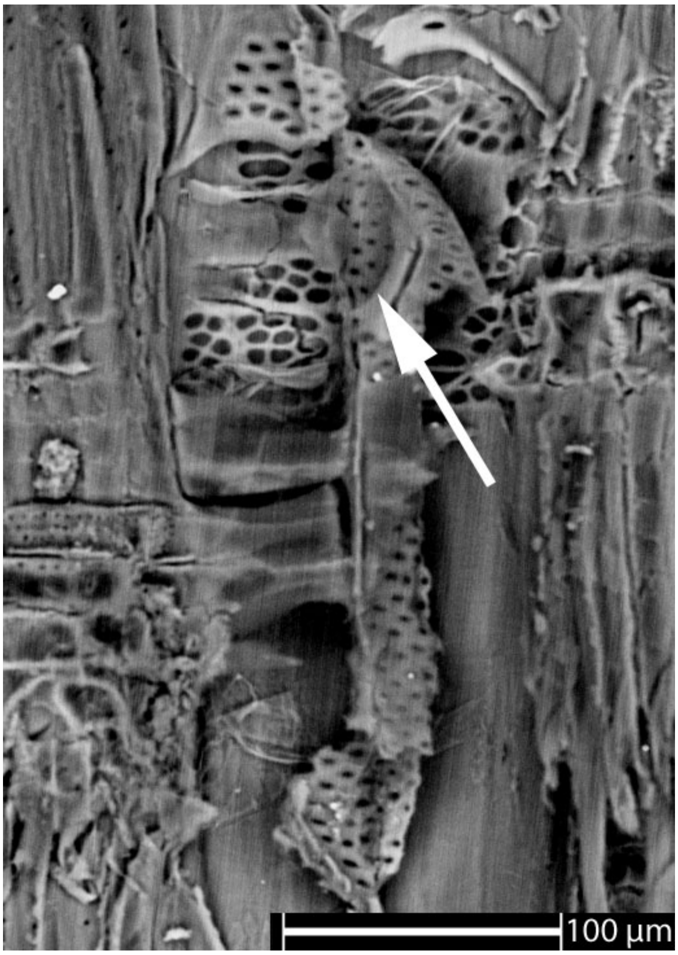

Figure 5.14: *detail of the radial plane of the wood sample from the Queen Mary harp soundbox. A fragment of wall adjoining two vessels runs vertically down the centre of the image. The inter-vessel pits (arrowed) are arranged alternately. The larger pits to the left and right of centre are vessel-ray pits.*

The torn structure in the centre of figure 5.14 is the wall separating two adjoining vessels. The holes (arrowed) are the inter-vessel pits. In this wood they are arranged alternately. The identifying features noted for this plane of the sample are therefore as follows:

- rays are present
- rays are heterocellular
- vessel-ray pits are restricted to marginal rows
- inter-vessel pits are arranged alternately

For comparison, the radial plane of the hornbeam sample is shown in figure 5.15.

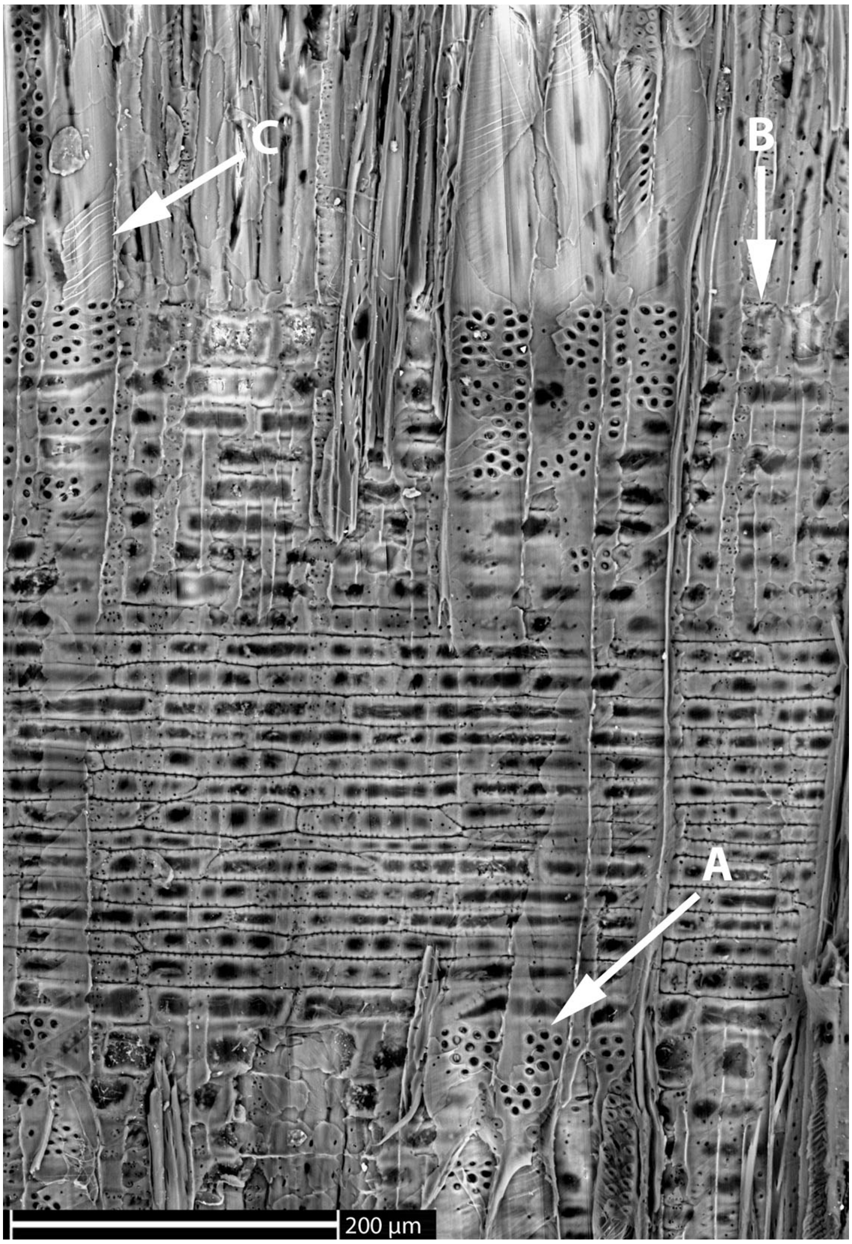

Figure 5.15: *SEM image of the radial plane of the sample of European hornbeam wood (Carpinus betulus). The vessel ray pits are confined to the marginal rows ('A', arrowed), and upright ray parenchyma cells are present ('B', arrowed). The fine diagonal lines in the vessels (labeled 'C', arrowed) are helical thickenings in the vessel walls.*

Although the European hornbeam sample has the identifying features observed in the Queen Mary harp soundbox sample, it also has helical thickenings in the vessel walls

('C' in figure 5.15), which are absent in the wood from the soundbox. The absence of this structure in the soundbox wood, notably, rules out the identification of European hornbeam (*Carpinus betulus*) as the wood used to make the soundbox of this harp.

The tangential plane of the soundbox sample is shown in figure 5.16.

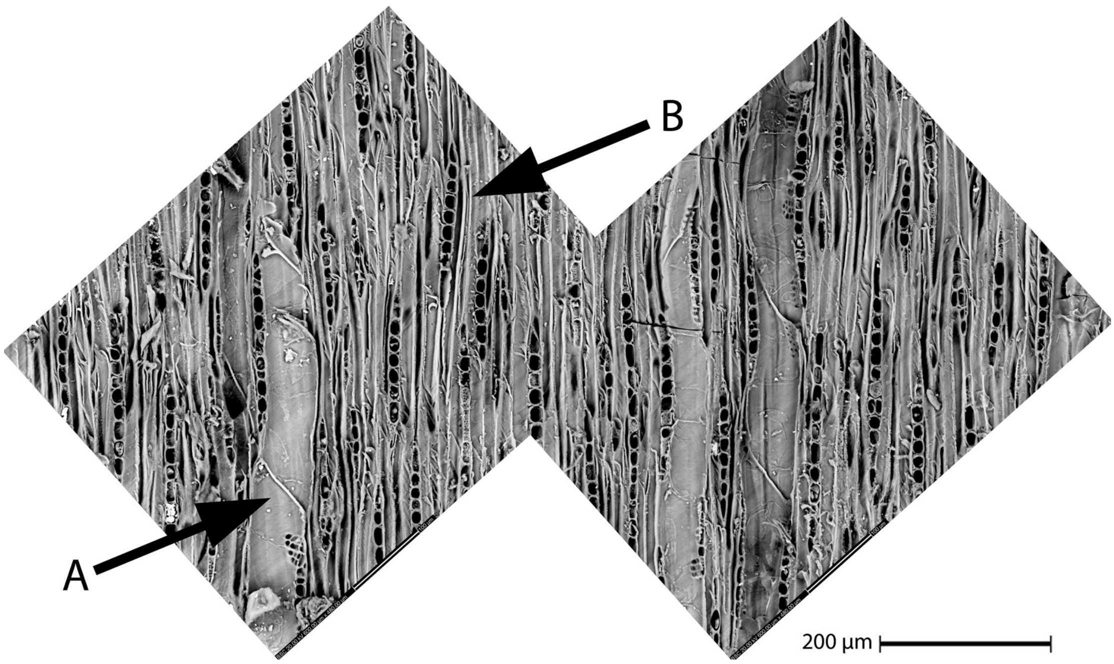

Figure 5.16: *mosaic of two SEM images of the tangential plane of the wood sample from the Queen Mary harp soundbox. Rays and vessel walls are visible in cross-section (arrowed). The vessel walls ('A', arrowed) do not have helical thickenings (see figure 5.15). The rays ('B', arrowed) are uniseriate (one cell thick).*

In the tangential plane the vessels are seen in lengthwise cross-section ('A' in figure 5.16), and the rays are seen end-on ('B' in figure 5.16). As in the image of the radial plane for this wood sample, there are no helical thickenings present in the vessel walls. The rays are exclusively uniseriate (one cell thick), and there are no aggregate rays (rays grouped together). The identifying features noted for this plane of the sample are therefore as follows:

- rays exclusively uniseriate

- aggregate rays are absent
- vessel wall helical thickenings are absent

For comparison, the tangential plane of the hornbeam sample is shown in figure 5.17.

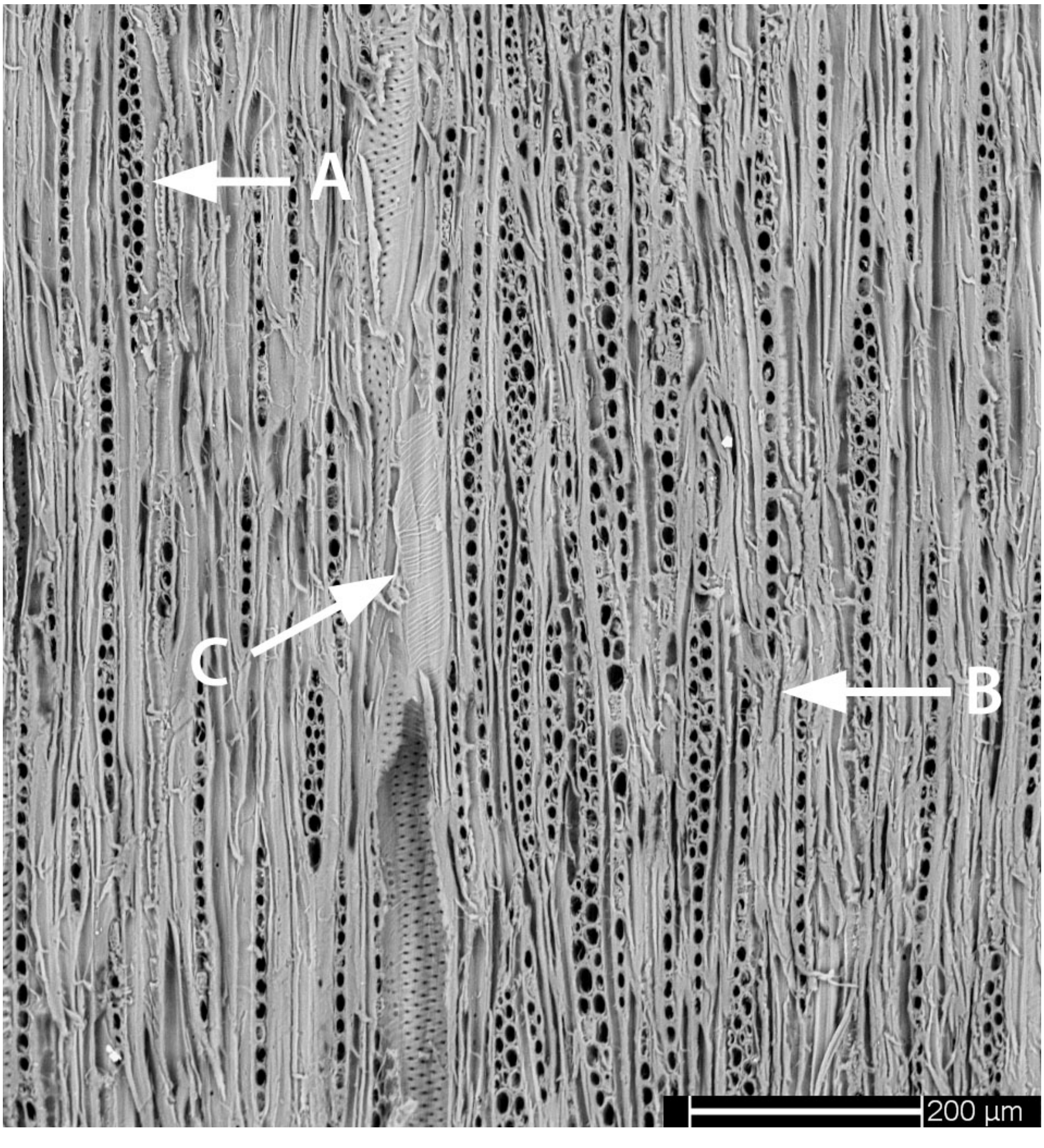

Figure 5.17: *SEM image of the tangential plane of the sample of European hornbeam wood (Carpinus betulus). Some rays are multi-seriate ('A', arrowed). Aggregate rays composed of groups of individual rays are also present ('B', arrowed). Helical thickenings are visible in the vessel walls ('C', arrowed).*

The helical thickenings noted in the vessel walls in the radial plane are also visible in the tangential plane. In contrast to the soundbox sample, some rays are multi-seriate ('A' in figure 5.17), and aggregate rays are present ('B' in figure 5.17). These features also rule out European hornbeam for the identification of the soundbox wood.

The identifying features of the sample of soundbox wood, notably, refute Hayes's earlier identification. The soundbox of the Queen Mary harp is not made of European hornbeam. Furthermore, the identifying features noted for each of the three planes of the wood are sufficient to uniquely identify the soundbox wood as willow (*Salix spp*.), in agreement with what has been said to be the wood traditionally used to construct Irish harps.[528]

Lamont harp soundbox

As discussed earlier, all of the wood of both harps had been previously identified by Hayes as hornbeam (*Carpinus betulus*). It has been shown above, however, that the Queen Mary soundbox is willow. In the following section, SEM images of a wood sample taken from the Lamont harp soundbox are presented, and cellular features that uniquely identify the wood are discussed. As before, the vertical axis of the image of the transverse plane is aligned with the radial axis of the timber, and the vertical axis of the images of the radial and tangential planes are aligned with the vertical axis of the timber.

The transverse plane of the soundbox wood sample is shown in figure 5.18.

[528] Richter and Dallwitz, "Commercial Timbers."

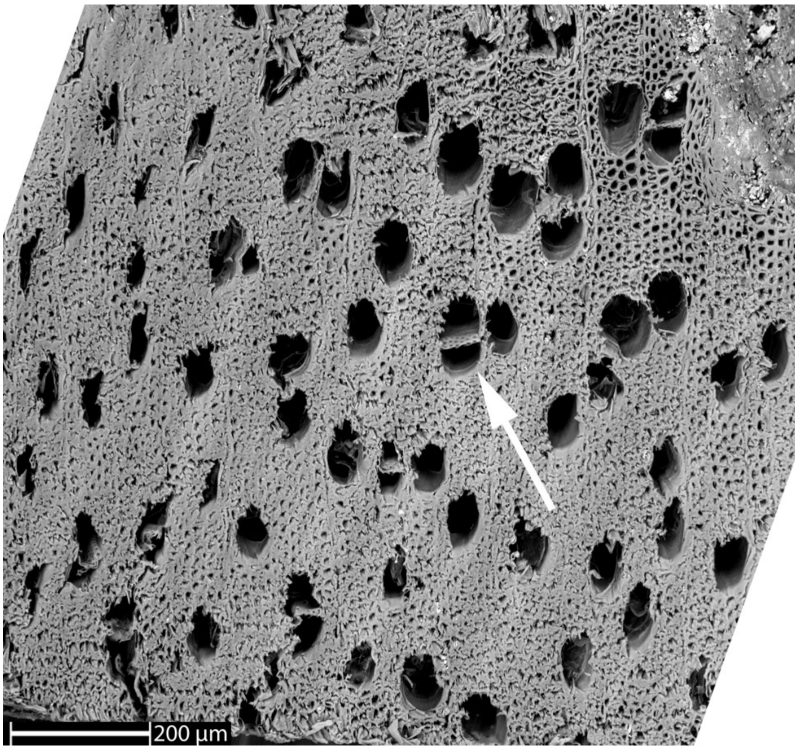

Figure 5.18: *SEM image of the transverse plane of a wood sample from the Lamont harp. The dark ovals are pores. Some occur in radial multiples of two (arrowed).*

This is a diffuse porous wood with some vessels occurring in short radial rows of two (arrowed in figure 5.18). The identifying features noted for this plane of the sample are therefore as follows:

- vessels are present
- vessels occur in multiples
- vessels occur commonly in short radial rows of 2 – 3
- wood is diffuse porous

Figure 5.19 shows the radial plane of the soundbox wood sample.

Figure 5.19: *SEM image of the radial plane of a wood sample from the Lamont harp soundbox. Upright ray parenchyma cells are present ('A', arrowed), and vessel ray pits are confined to the marginal rows ('B', arrowed). The vessel walls do not have helical thickenings ('C', arrowed).*

Rays are present, and are comprised of 'horizontal' ray parenchyma cells, with 'upright' cells in the margins ('A' in figure 5.19), the vessel-ray pits are confined to the marginal rows of the rays ('B' in figure 5.19), and helical thickenings are absent from the vessel walls ('C' in figure 5.19). The identifying features noted for this plane of the sample are therefore as follows:

- rays are present
- rays are heterocellular
- vessel-ray pits are restricted to marginal rows
- vessel wall helical thickenings are absent

Figure 5.20 shows the tangential plane of the soundbox wood sample. The inter-vessel pits ('A' in figure 5.20) are arranged alternately, the rays are exclusively uniseriate ('B' in figure 5.20), and no aggregate rays are present. As noted for the radial plane, helical thickenings are absent from the vessel walls ('C' in figure 5.20). The identifying features noted for this plane of the sample are therefore as follows:

- inter-vessel pits are arranged alternately
- rays are exclusively uniseriate
- aggregate rays are absent
- vessel wall helical thickenings are absent

Notably, as for the soundbox wood of the Queen Mary harp, the absence of helical thickenings in the vessel walls, and the absence of multiseriate and aggregate rays rules out European hornbeam for the identification of this wood, refuting Hayes's identification. Furthermore, the identifying features noted for each of the three planes of the wood are sufficient to uniquely identify the soundbox wood of the Lamont harp as willow (*Salix spp.*), also in agreement with what has been said to be the wood traditionally used to construct Irish harps.[529]

[529] Richter and Dallwitz, "Commercial Timbers."

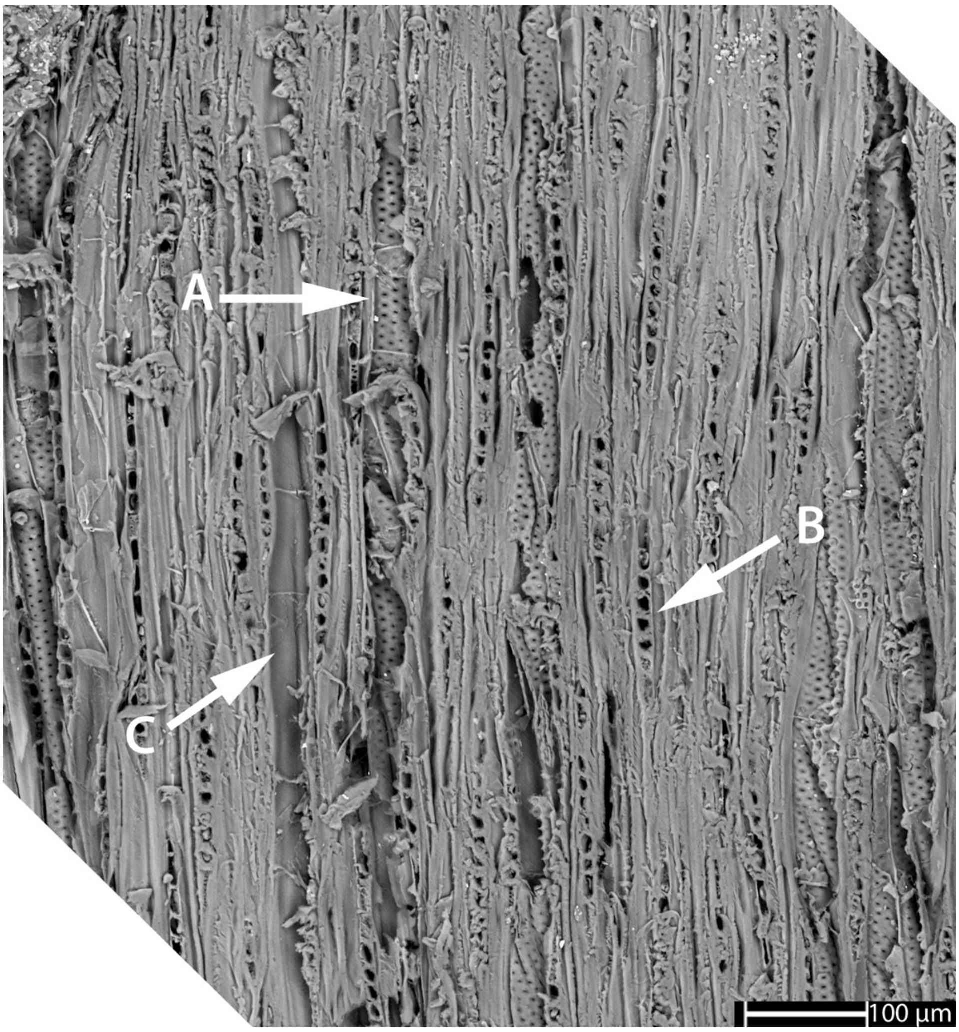

Figure 5.20: *SEM image of the tangential plane of a wood sample from the Lamont harp soundbox. The inter-vessel pits are arranged alternately ('A', arrowed), the rays are exclusively uniseriate ('B', arrowed), and helical thickenings are absent from the vessel walls ('C', arrowed). No aggregate rays are present.*

Summary

The results of these wood species identifications contradict the earlier findings of Hayes (1969), which identified all of the wood of both harps as European hornbeam (*Carpinus betulus*). As discussed above, Hayes used microscopic examination of the cellular structure of samples from both harps to arrive at his species identification, a standard and reliable technique. It is, therefore, important to understand why the current identifications contradict his results.[530]

As discussed previously, the wood of both harps is fragile and the present identifications were made feasible by utilizing SEM to examine prepared blocks instead of thin sections. As is evident from some of the images (figure 5.11, for example), even with this method the samples were beginning to fracture in some instances. The samples taken by Hayes would have been thin sections for examination under a microscope, and as mentioned earlier, he is likely to have had some difficulty obtaining and preparing suitable samples due to the fragility of the wood.

An additional issue is that all of the locations identified as his probable sampling sites lie in the transverse plane of the wood. No evidence was found of sampling in either the radial or tangential planes on any of the wooden members of either harp. Although some sampling sites may have been overlooked, it is possible he did not, or was not able to, obtain samples in the other planes. It is reasonable to assume the museum would have prohibited the taking of samples in areas that would be easily visible, and there are no signs that he took samples from the interior of either soundbox. It is therefore probable that Hayes was not able to acquire all of the samples he would have wanted for a positive identification of the wood.[531] There may be evidence for this in his letter to the museum, where he notes the following identifying features:

> "The structure of the wood shows a predominance of pores arranged in radial multiples, simple rays, small fibres and not very much soft tissue, although there was some suggestion of terminal parenchyma. In addition both ray and pore size are similar to those of hornbeam."[532]

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[530] The issues with Hayes's identification were raised in conversation with Ticca Ogilvie.
[531] Ticca Ogilvie, personal communication.
[532] Alan J. Hayes, *Alan J. Hayes to C. E. Curran.*

None of the features he mentions would require examination of the radial or tangential planes, as all of these structures can be observed in the transverse plane alone.[533] Curiously, he refers to 'simple rays' as an identifying feature. This is a term formerly used to refer to uniseriate rays (rays that are one cell thick) as defined in Büsgen and Münch (1929).[534] European hornbeam (*Carpinus betulus*) has both multi-seriate and uniseriate rays, however.[535] As discussed previously, exclusively uniseriate rays were observed in the soundbox wood of both harps as one of the identifying features of willow (*salix spp*.). The features Hayes lists in his report are not entirely unique to hornbeam, and if they are the only features he observed, they are insufficient to definitively identify the wood.

As discussed earlier in this chapter, the neck and forepillar wood has not yet been identified for either harp. Preliminary results indicate that the neck and forepillar of the Queen Mary harp are not made from the same wood as the soundbox, and furthermore indicate that the wood used for the forepillar is different from the wood used for the neck. The Queen Mary harp frame is therefore constructed of three different species of wood. Further work is planned to complete the imaging and analysis of the woods, and complete identifications for both harps will be forthcoming.

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[533] Ticca Ogilvie, personal communication, December 2012. The parenchyma cells referred to are the axial parenchyma cells, not the ray parenchyma cells, and are observed in the transverse section.
[534] M. Büsgen and E. Münch, *The Structure and Life of Forest Trees*, trans. Thomas Thomson (London: Chapman & Hall, Ltd., 1929), 111. Büsgen and Münch also note that they are "best recognised on cross (transverse) sections".
[535] Richter and Dallwitz, "Commercial Timbers." Büsgen and Münch, *Forest Trees*, 113. See also the images and discussion of the hornbeam sample presented in this dissertation.

Conclusion

Research outcomes

This dissertation has presented a study of two of the earliest extant Irish harps, the Lamont and Queen Mary of the National Museum of Scotland, utilizing analytical tools and methods from the fields of medicine, artefact conservation, and organology for an unprecedented examination and analysis of their stringing and construction. In the process, this study endeavoured to address four fundamental questions that are of importance to scholars, musicians, and luthiers with an interest in these harps. The findings that relate to these questions are discussed below.

What are the dimensions of these harps?

The CT scans of each harp were used to generate a set of measured cross-sections of each of the frame members, with a resolution of 0.5 mm. In addition to external dimensions, these cross-sections show the internal construction and dimensions of the joinery. The ability to image the internal construction has significantly advanced current understanding of how these harps were built, and how each behaves as a mechanical system. This is particularly notable for the form of the neck/soundbox joint of both harps. Largely unknown prior to this study, the use of a through mortise joint, especially of the design used for the Queen Mary harp, has mechanical and acoustical advantages that can now be employed by present day builders of harps modelled after these instruments.

The CT scans were also used to map the thickness of the front of both soundboxes (the 'soundboards'), the first time this has been done for any historical harps. This led to the revelation that both are thinner at the treble end, comparable to modern harps, a construction practice with clear acoustical advantages that can now also be employed by present day builders of harps modeled after these instruments.

Additionally, examination of the string holes in cross-section indicated that the soundbox of the Lamont harp was constructed with a flat front, and that the belly is entirely the result of string tension, resolving a longstanding question regarding this aspect of its construction. In contrast, a similar examination of the Queen Mary harp string holes indicated that the soundbox belly of this harp is the result of a combination of carving to shape and string tension.

What are the original string lengths?

The CT scans of each harp were used to examine and measure the motion of the frame members. Using this information, it was possible to calculate string lengths for each harp with a straightened frame in addition to measuring the current lengths. This was particularly important for the Lamont harp, whose frame is significantly twisted. Analysis of evidence of stringing and of damage to the frames was used to reconstruct the number and arrangement of strings for both harps. This was of particular interest for the Lamont harp, due to the apparently mismatched number of tuning pin and string holes. It was determined conclusively from examination of the tomograms of the Lamont harp that the neck was originally made for 31 tuning pins, resolving a long-standing question regarding its construction. Significantly, it was possible to not only reconstruct the probable original stringing arrangement for this harp, but also a later modified stringing arrangement that compensated for damage to the neck.

The reconstructed stringing arrangements and string lengths were used to explore possible solutions for pitch and gamut for the harps at different stages of their working lives. Notably, one plausible solution for the straightened frame of the Lamont harp places the pitch of that instrument in the range of A 464 – 471 Hz, coinciding with a common pitch standard in use in 16th and 17th-century Europe. One possible stringing solution for the Queen Mary harp places the pitch of that instrument near this, at just below A 460 Hz, although a number of other solutions are also possible. Interestingly, the analysis of the string scaling of the Queen Mary harp indicated that it was probably designed for a stronger stringing material in the treble, possibly iron.

What are they made of?

Materials used in the construction, decoration, and repair of these two harps were identified with the use of non- and minimally invasive analytical techniques. This dissertation opened with an analysis of wire fragments discovered in both harp soundboxes. The CT scans made it possible to identify and image these fragments in normally inaccessible areas and also made it possible to safely extract the wire fragment embedded in the string hole of the Lamont harp soundbox.

The detailed analysis of the composition of the two copper alloy wire fragments, which were discovered to be brass, allowed a thorough comparison with known historical brass alloys. Based on this, and an assessment of their locations in the instruments, it was determined that the fragment discovered in the Lamont harp may be a piece of an historical string, possibly dating to the 17th century. Notably, prior to this study, only one other historical Irish harp string fragment had been discovered and analysed. The analysis of the Lamont harp string fragment provided valuable information for exploring the stringing regimes of this harp, particularly the measurements of gauge and density, making it possible to calculate a string tension for comparison to current stringing practices for instruments modeled after it.

The metal fittings and repairs on both harps were analysed, where possible, providing the first analysis of these parts of the construction for any of the surviving Irish harps. The analyses confirmed that the tuning pins of both harps are brass, and quantitative analysis of the Lamont harp tuning pins allowed comparison of the alloys of pins of different designs from within its mixed set, and comparison to the other analysed brass metalwork on this harp. Comparing the composition of the different metal parts indicated which ones might have been made together, for example the cheekbands and tuning pins of the Queen Mary harp, which have a nearly identical composition.

The analysed cheekband of the Lamont harp was identified as bronze, in contrast to its brass tuning pins, an interesting distinction in light of other evidence that suggests it might not be original.

The Queen Mary harp is purported to have had some precious metal embellishments. Analysis of the bosses on the front of the forepillar determined that they are composed of a silver alloy with copper. The hypothesis put forward by Keith Sanger, that a gold Scottish half-ryal coin may have been affixed to the forepillar was investigated, and the pattern of nails on the front of the forepillar was shown to be the correct size to hold this coin.

The materials analysis also included pigment traces and other surface material on the Queen Mary harp. This was of particular interest in light of the extensive decorative work. Traces of red pigment in and around the low relief carvings on the forepillar were identified as vermilion, a costly pigment that may hint at a high status for the owner. The areas of incised decorative work on the sides and back of the forepillar were shown to have clear evidence of nuanced pigmentation that may originally have been richly coloured. One of these areas was analysed and found to have a slightly elevated level of iron, indicating possible use of an iron based red pigment. Traces of a green substance found in the incised decorative lines was analysed and found to contain copper and lead with other elements, suggesting the possibility of a green pigment containing verdigris and lead white. The dark material in the decorative lines on the soundbox and neck was analysed and found to consist primarily of carbon and oxygen with a significant amount of copper also present. Some of the carbon may be evidence that these lines were burned into the wood, and the copper could indicate the presence of a verdigris pigment, now obscured by dirt, wax, and possibly other pigments.

The materials analysis of paramount importance to researchers, luthiers, and musicians is the identification of the woods used to construct the harps. These harps had both previously been identified as being made entirely of European hornbeam (*Carpinus betulus*). The CT scans indicated that the frame members had different densities, however, and the data from the scans was used to quantify these for comparison. Additionally, visual examination of the harps indicated that there may not have been sufficient sampling for a positive identification. This evidence prompted the decision to resample the harps for a re-identification of the woods. In addition to determining the densities, the CT scans were used to facilitate safe removal of the back cover of the Queen Mary harp, allowing access to the soundbox interior for sampling, and were used to aid in selection of appropriate sampling sites on both harps. The wood identifications are still in progress, but both soundboxes were positively identified as willow (*Salix spp*.), refuting the earlier identification of European hornbeam (*Carpinus betulus*) that had been a source of some controversy for over 40 years.

How old are they?

The age of these instruments is a somewhat complex topic. Both were presumed to date to circa the 15th century. For the Lamont harp this was based on the Robertson family claim (as related by Gunn) that this harp came from the Lamont family by marriage in 1460. Although a marriage did apparently take place at around this time, a lack of additional evidence pertaining to the harp meant that the 15th-century date of construction was unconfirmed and could be spurious. For the Queen Mary harp, the dating was based on its resemblance to the harp depicted on the 15th-century grave slab at Keills. Like the Lamont harp, the lack of additional evidence meant this date was unconfirmed. Furthermore, the estimates of the age of the instruments had not taken into account the possibility that some parts of these harps might not be original.

Examination of the decorative work on the forepillar of the Queen Mary harp confirmed that its style is wholly consistent with it having been constructed in the late 15th century by one or more craftsmen of the Iona school of late Medieval West Highland monumental art, probably in a workshop on the island of Iona. Despite the overall resemblance to the harp depicted at Keills, the possibility that the forepillar is not original, and the marked difference in style and execution of the decorative work on the soundbox and neck versus the forepillar suggested that the neck and soundbox may predate the forepillar.

Examination of the lower section of the forepillar of the Lamont harp indicated that it is not part of the original construction. No evidence was found that the upper section is a replacement, but the possibility has not been ruled out. The mismatch between the number of tuning pin holes in the neck and string holes in the soundbox is curious, and whether or not the neck and soundbox were made together remains an open question. Examination and analysis of the neck suggested that it could have been constructed in the second half of the 15th century, with a major refurbishment possibly in the late 16th century. In particular, analysis of tuning pins from the primary group indicated that their composition is consistent with some historical brass known to date from circa 1450 to the 1480's, whereas the inscription on one of the cheekbands has been identified as a probable obscured IHS monogram, dating it to no earlier than the late 16th century. Evidence was found that indicated that the cheekband may not be original, and therefore could represent part of a refurbishment. It was noted that, based on materials analysis, some historical repairs could have been made as late as the end of the 17th century.

The number of toggle marks around the string holes was shown to be evidence of a very long working life for the soundbox that could place its construction in the late 15th century, and the likely identification by Keith Sanger of the vellum document inside the soundbox indicated it was probably repaired in the early 1620's.

Potentially the most significant advancement towards determining the age of the Lamont harp was the discovery of the date AD 1451 inscribed in the soundbox. Although the date of this inscription has not been confirmed, it was established that it was likely present at the time of the repair with the vellum document, and therefore probably dates to no later than the early 17th century. Events contemporary with the 1451 date at both the Lude and Lamont estates (as researched by Sanger) suggested it could be genuine.

Methodology review

The methodology developed for this research project successfully combined materials analysis tools used in artefact conservation and research (specifically XRF and SEM-EDX) with medical imaging (specifically CT), and organological analysis to conduct an exhaustive study of these two historical musical instruments while minimizing the physical impact on them. This was combined with a thorough visual assessment, which identified areas of interest for further analysis, and a complete photographic survey, which allowed for extensive additional assessment as well as direct comparison with tomograms derived from the CT scans of the harps. This approach resulted in numerous discoveries that have significantly advanced current knowledge of these two important historical harps, and by extension harps of this type in general, as no study to date of any surviving Irish harps has been conducted with this level of detailed analysis.

The use of XRF made it possible to conduct entirely non-destructive analysis of metalwork and pigment traces in situ. It was also very effective at detecting the presence of elements at low concentrations, making it a particularly useful tool for analysis of pigment traces. Where sampling was necessary, SEM-EDX allowed for analysis with very small samples, while providing high-resolution imagery of microscopic structures. The wood species identification, in particular, would not have been feasible without the use of SEM.

The cornerstone of this study has been the CT. The usefulness of CT as a tool for the detailed study of the construction of musical instruments cannot be overstated. The CT generated a complete three-dimensional record of the interior and exterior of each harp with a resolution of 0.5 mm, and did so entirely non-invasively. This allowed for examination and measurement of all parts of the construction, as well as areas of damage and repair. This was of particular use in areas that would otherwise be entirely inaccessible to examination. Because CT is sensitive to density, the scans of the harps provided a complete three-dimensional image of the wood grain pattern in all parts of their construction. It also highlighted the comparative differences in density of the wooden members, as mentioned above, and allowed for quantitative measurement. Traces of high-density pigments were also detected on the CT scans, as well as traces of corrosion and small fragments of metal left behind by nails in the wood. Furthermore, the CT scans of these harps have generated a resource of information and imagery that will allow researchers and instrument builders to conduct their own examinations and take their own measurements without removing the harps from their museum cases.

Further research

The Lamont and Queen Mary harps

Some of the analysis begun in the current study needs to be continued to completion. Foremost is the identification of the wood. The soundboxes of both harps have been identified, and this work needs to be continued for the re-identification of the remaining parts. Additional materials analysis is also needed for some of the metalwork and pigment traces. Some areas of the harps, for example the string shoes, were inaccessible to the XRF analyser. These could be analysed with a handheld unit, however. Some of the qualitative XRF analysis should be followed up with quantitative analysis. This is particularly of interest for the brass tuning pins and cheekbands of the Queen Mary harp.

Further analysis should be conducted on the pigment traces observed in the incised decorative work on the Queen Mary harp forepillar. It is probable that multiple pigments were used, and it would be of interest to try to identify them. Additionally, the material embedded in the decorative lines on the soundbox and neck should be resampled for the purpose of examining it for possible layering, and the similar material embedded in cracks and crevices on the harp should be sampled and analysed for comparison.

Other Irish harps

As mentioned above, the current study is the most detailed to date conducted on any of the surviving harps of this type. It is also the only one to have employed CT, XRF, and SEM-EDX analysis. Knowledge and understanding of the construction, use, and evolution of this instrument would be significantly advanced by adapting the methodology used here to study these other harps. Not all of these instruments are small enough to fit through a CT scanner at present, but there is a significant research benefit to scanning those that are, while conventional radiography could, at least, be undertaken for the larger instruments. As the majority of the analysis conducted for the Lamont and Queen Mary harps was non-destructive, limiting research of these other instruments to the non-destructive analyses would still yield a substantial new body of information for them.

The Lamont and Queen Mary harps represent two of the three earliest surviving Irish harps. The third is the Trinity College harp. Together, they are the only known surviving Irish harps that pre-date the 17th century (excluding, perhaps, the surviving metalwork for the Ballinderry harp). Despite being arguably the single most copied historical harp in the world, with uncounted numbers of instruments modeled after it currently being played by musicians, absolutely nothing is known of the internal construction of the Trinity College harp, and no analysis has ever been conducted on its construction materials.[536] It would therefore be of particular interest to apply the methodology used here to perform a similar study of this harp. This would also permit direct comparison of details of its construction to the remarkably similar Queen Mary harp, which would advance understanding of both of these instruments.

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[536] Although Rimmer (1969) states that the forepillar, neck, and soundbox are willow, it is unknown if the harp has actually ever been sampled, as no species identification report has come to light. Rimmer, *Irish Harp,* 78.

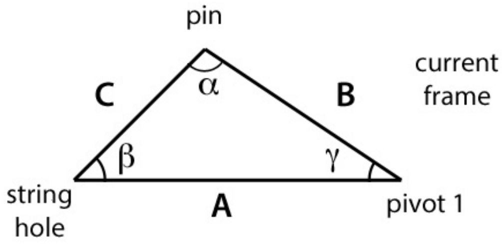
Other instruments

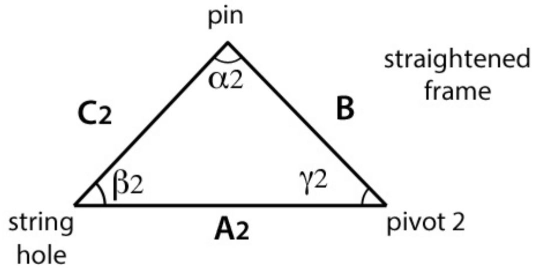
This study has demonstrated the power and versatility of CT as a tool for examination and analysis of musical instrument construction, particularly when used in concert with other analytical tools and techniques. It is the recommendation of this author that researchers interested in the construction of other musical instruments consider employing this methodology. As has been shown in the pages of this dissertation, the potential for substantial advances in knowledge and understanding is considerable.

Appendix A:

Method for determining string lengths for the Lamont harp with a "straightened" frame

For each pin – shoe pair, a triangle can be drawn from the point of contact of the string at the pin to the point of contact at the shoe, and from there to the point where the neck has pivoted against the top end of the soundbox. The side of the triangle from the string shoe to the pivot point is the distance along the soundbox, the side from the pivot point to the pin is the distance along the neck, and the side from the pin to the shoe is the speaking length of the string. The current position of the pivot point is indicated on the tomogram in figure 2.13. Assuming the neck tenon was originally seated in the joint as indicated by the worked edges visible in the cross-section, this point would have originally been at the point of contact of the front of the neck with the soundbox as also indicated in that figure. Due to the shifting of the position of the neck in the joint, this point has moved 10 mm from its original position to its current position. As discussed above, the neck has pivoted forward by 5.9°, as measured on the tomographic cross-section of the joint (see figure 2.13). The triangles representing the relative positions of the tuning pin, string hole, and pivot point for the "current" and "straightened" harp frame are shown in the diagrams below.





The sides and angles of the two triangles are labeled as follows:

A = distance from string hole to current location of pivot point of neck (pivot 1).
A_2= distance from string hole to original location of pivot point of neck (pivot 2).
B = distance from pivot point of neck (current location) to tuning pin
C = current distance from tuning pin to string hole = current string length
C_2= distance from tuning pin to string hole, corrected for the rotation of the neck about the pivot point and the shifting of the pivot point
α = angle between B and C, β = angle between C and A, γ = angle between A and B.
α_2 = angle between B and C_2, β_2 = angle between C_2 and A_2, γ_2 = angle between A_2 and B.

The (x, y, z) coordinates of all tuning pins and string holes, and the two pivot point locations were measured directly from the CT data. The tuning pins were measured at the left-hand outer edge of the cheekband where the string would be tangent to the forward side of the pin. The string holes were measured on the front surface of the string shoes (where present), at the treble end, where the string would contact the shoe. The current position of the pivot point (pivot 1) was measured on the neck at the point where it would have seated against the front of the soundbox (as indicated in figure 2.13). The original position of the pivot point (pivot 2) was measured on the front side of the soundbox at the point where the neck originally seated against it (as indicated in figure 2.13). The lengths of sides A, A_2, B, and C are calculated from the coordinates using the standard distance formula given in Chapter 2. For the frame in its current state, the angle γ is calculated from the cosine formula:

$$\cos \gamma = \frac{A^2 + B^2 - C^2}{2AB} .$$

The angle γ_2 is equal to γ plus the measured forward rotation of the neck:

$$\gamma_2 = \gamma + \Delta$$

where Δ is the measured forward rotation of the neck. For the Lamont harp,

$$\Delta = 5.9° .$$

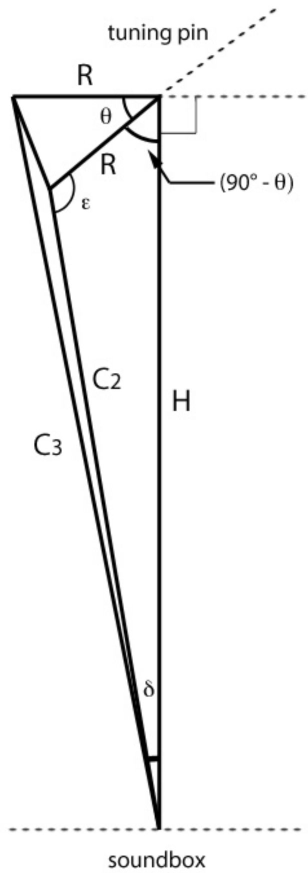
The length of C_2 is calculated from the cosine formula:

$$C_2 = \sqrt{A^2 + B^2 - 2AB(\cos \gamma_2)} .$$

The length C_2 is the string length corrected for the forward rotation and the shift of the neck.

The correction for the forward tilt and the shift of the neck is an intermediate result. The neck has also rotated around its long axis, towards the left-hand side of the harp. As discussed above, this rotation has tilted the string ends of the tuning pins down towards the soundbox, shortening the string lengths. Although the motion of the neck is, in this case, a straightforward rotation, solving for the resulting change in position of the string ends of the tuning pins is complex due to the offset between the tuning pins and the axis of rotation. The following solution presents an approximation, by placing the axis of rotation of the neck through the centre of the tuning pins, at a right angle to their long axis (the tuning pins are all essentially parallel to one another).

First, the rotation of the neck around the axis through its tenon is eliminated. This repositions the forepillar and the neck directly above the string band, but does not significantly affect the string lengths. With the neck above the string band, for each string hole – tuning pin pair, a triangle can be drawn from the string hole to the string end of the tuning pin (at the point of contact of the string), and from there to the centre of the tuning pin, as shown in the diagram below.



The side of the triangle from the string hole to the string end of the tuning pin is the string length C_2 calculated above, the side from the string end of the tuning pin to the centre of the pin is the measured distance along the pin, and the side of the triangle from the centre of the tuning pin to the string hole is the height of the tuning pin above the string hole, measured to the centre of the pin. If the rotation along the long axis of the neck is removed, the tuning pins should be oriented with their long axis parallel to the front face of the soundbox, as shown in the diagram above. A line can be drawn from the string hole to the string end of the tuning pin in this "un-rotated" position. The length of this line is the revised string length, corrected for the rotation of the neck about its long axis. This length can be derived by applying basic trigonometry to solve the triangles. The relevant sides and angles of the triangles in the diagram are labeled as follows:

C_2 = result of the previous calculation; distance from tuning pin to string hole, corrected for forward rotation and shifting of the neck
R = measured distance from end of tuning pin at point of contact of the string to mid-point of tuning pin. This distance is 30 mm
H = distance from mid-point of tuning pin (along its length) to string hole in soundbox
C_3 = revised string length, corrected for neck rotation about its long axis (in addition to previous corrections)
θ = measured rotation of the neck about its long axis; the angle between current and "un-rotated" orientation of the tuning pin. For the Lamont harp, $\theta = 20.5°$
δ = angle between H and C_2
ε = angle between C_2 and R.

The revised string lengths, corrected for the neck rotation (in addition to the previous corrections) are determined by solving for C_3. This is the hypotenuse of the right triangle formed by R and H, so the length of C_3 can be determined from the Pythagorean formula if R and H are known. R is a measured quantity (the measured distance from the mid-point of the tuning pin in the neck), and H can be derived by applying the sine rule to solve the triangle formed by C_2, R, and H as follows:

$$\sin\delta = \frac{R\sin(90-\theta)}{C_2} = \frac{R\cos\theta}{C_2} ,$$

$$\varepsilon = 180° - [(90-\theta)+\delta] ,$$

and

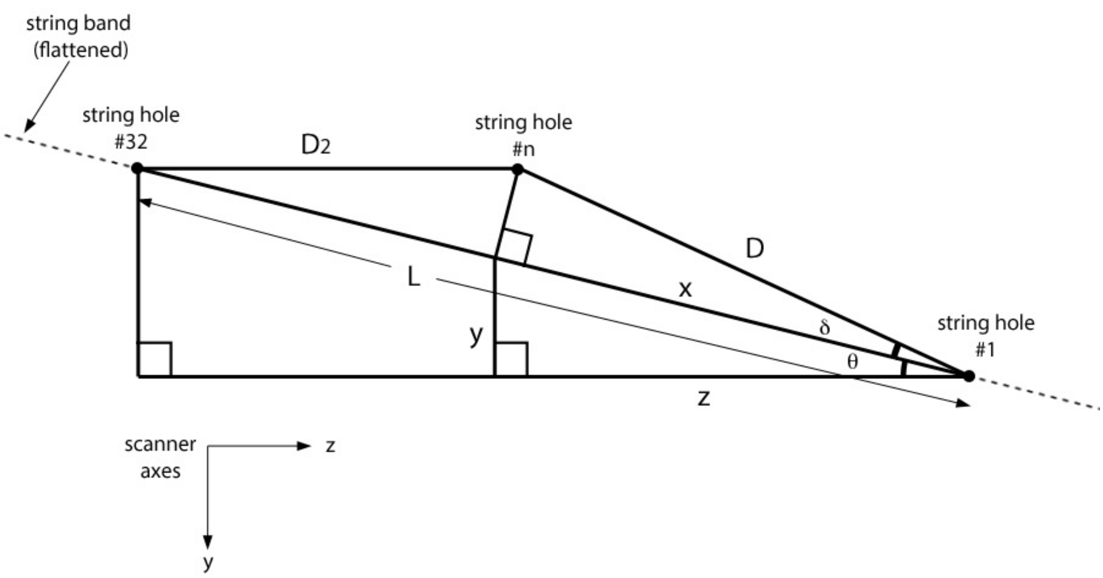
$$H = \frac{C_2 \sin \varepsilon}{\sin(90 - \theta)} = \frac{C_2 \sin \varepsilon}{\cos \theta} \; .$$

So, the length of C_3 is determined from the values R and H as follows:

$$C_3 = \sqrt{R^2 + H^2} \; .$$

The length of C_3 is the string length for the harp frame with the neck restored to a completely un-rotated position and fully seated in the joint with the soundbox.

The remaining correction to the string lengths is for the belly of the soundbox. This is obtained by taking the positions of the #1 and #32 string holes as the end points of a flat string band and using trigonometry to determine the position of the string holes for a flat fronted soundbox. The corrected string lengths are then determined from these coordinates and the corrected coordinates of the tuning pins. The diagram below shows how the corrected string hole coordinates are determined. Note: the soundbox of the harp is tilted with respect to the scanner coordinate system. This is reflected in the diagram. The tilt angle is exaggerated for the purpose of the illustration.



A triangle can be drawn from string hole #1 to #32 to the hole whose position is to be corrected, string hole #n. This triangle sits on top of a right triangle that represents the tilt of the harp with respect to the z-axis of the coordinate system of the CT scan. The relevant sides and angles of these triangles are as follows:

L = distance from string hole #1 to #32
D = distance from string hole #1 to #n
D_2 = distance from string hole #n to #32
x = distance from string hole #1 to the point perpendicularly below string hole #n
y = the perpendicular distance to the z axis from the point defined by x
z = distance along the z axis to the point defined by y
δ = angle between D and x
θ = angle between x and z (the tilt of the harp in the CT scan coordinate system).

First, the angle δ is determined by applying the cosine formula:

$$\cos\delta = \frac{L^2 + D^2 - {D_2}^2}{2LD} \ .$$

The lengths x, y, and z are then determined from the Pythagorean theorem:

$$x = D\cos\delta$$
$$y = x\sin\theta$$

and

$$z = x\cos\theta$$

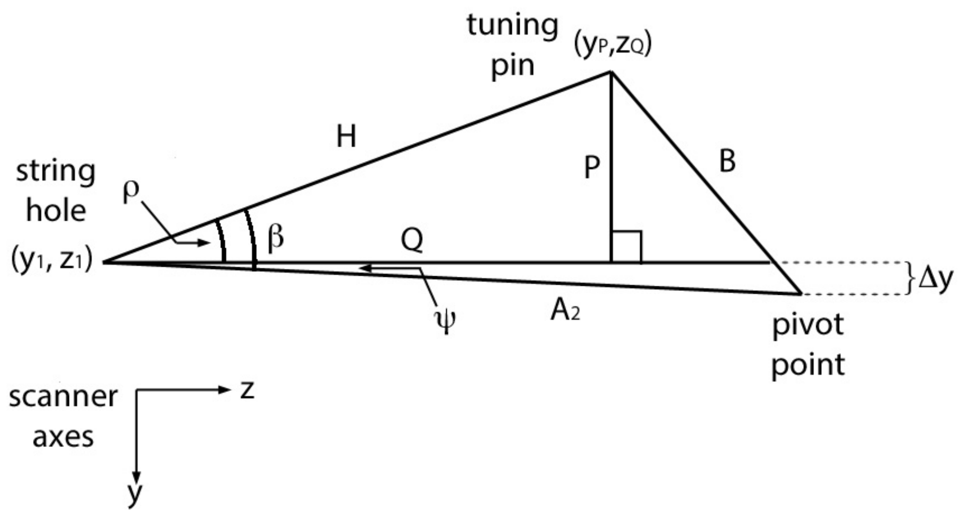
where

$$\cos\theta = \frac{|z_1 - z_{32}|}{L} \ .$$

Here z_1 and z_{32} are the measured z-coordinates of the #1 and #32 string holes, respectively. The corrected (y, z) coordinates are then obtained by adding the distances y and z to the coordinates of string hole #1. The x coordinate of the string hole remains unchanged.

The pulling up of the belly has also caused a very small shortening of the overall length of the string band. This shortening is 2 mm from string hole #1 to #32, however, which is not large enough to warrant the work required to adjust the positions of the string holes.[537]

The coordinates of the tuning pins and string holes at the points of contact of the string were also derived for the "straightened" frame. A diagram of the relative positions of a string hole, tuning pin and the pivot point of the neck is shown below.



The relevant side, angles, and vertices of the triangle formed by these three points are as follows:

(y_1, z_1) = measured coordinates of string hole[538]

(y_P, z_Q) = coordinates of tuning pin for straightened frame

A_2 = distance from string hole to original location of pivot point (pivot 2)

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[537] The shortening is due to the difference between the straight-line distance from string hole #1 to #32 and the distance along the arc from string hole #1 to #32. The derivation is not included here.

[538] This calculation uses the measured coordinates of the string holes (uncorrected for flattening).

H = distance from mid-point (along its length) of tuning pin to string hole in soundbox

B = distance from pivot point (current location) to tuning pin

P = distance along y axis from tuning pin to point (y_S, z_Q)

Q = distance along z axis from string hole to point (y_S, z_Q)

β = angle between A_2 and H

ρ = angle between Q and H

ψ = angle between A_2 and Q.

Because QPH is a right triangle,

$$P = H \sin \rho$$

$$Q = H \cos \rho$$

The length P is used to find the y-coordinate of the tuning pin:

$$y_P = y_1 - P$$

where y_1 is the measured y-coordinate of the string hole.[539]

The length Q is used to find the z-coordinate of the tuning pin:

$$z_Q = Q + z_1$$

where z_1 is the measured z-coordinate of the string hole.

In order to determine these quantities, it's necessary to derive the angle ρ.

$$\rho = \beta - \psi$$

The angles β and ψ can be derived and ρ found from them using the formula above. The cosine formula is used for the triangle A_2BH to find the angle β:

[539] Because the y-axis points downward on the CT scans, the y coordinate of the tuning pin is actually lower than the y-coordinate of the string hole, hence $y_P = y_1 - P$.

$$\cos\beta = \frac{H^2 + A_2^{\,2} - B^2}{2HA_2}$$

The angle ψ is in a right triangle that has A_2 as the hypotenuse and Δy as its opposite side, so,

$$\sin\psi = \frac{\Delta y}{A_2}$$

where the length of Δy is

$$\Delta y = |y_1 - y_2|$$

The coordinates (y_P, z_Q) of the tuning pin at the point of contact of the string are obtained by substituting the value obtained for the angle ρ into the equations for y_P and z_Q above. The x coordinate of the tuning pins is taken as the coordinate of the centerline of the neck plus the length of the pin from the midpoint to the point of contact of the string.

Appendix B:

Table A.1.

Some solutions for the compass and pitch of the Queen Mary harp:
brass stringing

scale	# of strings	frame	compass	stringing	pitch (Hz)
diatonic[540]	29	no belly	c – c′′′′	yellow brass[541]	354 – 362
diatonic	29	belly	c – c′′′′	yellow brass	362 – 370
diatonic w/ unison strings	29	no belly	c – b′′′	yellow brass	397 – 405
diatonic w/ unison strings	29	belly	c – b′′′	yellow brass	400 – 408
diatonic	29	no belly	F – f′′′	yellow brass	530 – 542
diatonic	29	belly	F – f′′′	yellow brass	542 – 554
diatonic w/ unison strings	29	no belly	F – e′′′	yellow brass	595 – 607
diatonic w/ unison strings	29	belly	F – e′′′	yellow brass	599 – 611
diatonic	30	no belly	c – d′′′′	yellow brass	321 – 328
diatonic	30	belly	c – d′′′′	yellow brass	328 – 335
diatonic w/ unison strings	30	no belly	c – c′′′′[542]	yellow brass	354 – 362
diatonic w/ unison strings	30	belly	c – c′′′′	yellow brass	362 – 370
diatonic[543]	30	no belly	F – g′′′	yellow brass	481 – 491
diatonic	30	belly	F – g′′′	yellow brass	491 – 502
diatonic w/ unison strings	30	no belly	F – f′′′	yellow brass	530 – 542
diatonic w/ unison strings	30	belly	F – f′′′	yellow brass	542 – 554

[540] The solution for a pure diatonic scale is the same as that for a diatonic scale with both the unison strings and the gap in the bass.
[541] The scale used is 270 mm for the length of c″ at A440.
[542] The solutions for the harp with 30 strings with unison strings are the same as the solution for the harp with 29 strings with a pure diatonic scale.
[543] The solution for the harp with 30 strings, starting on F in the bass is the same as that for the harp with 29 strings starting on G in the bass.

Table A.1 (continued).

Some solutions for the compass and pitch of the Queen Mary harp:
brass stringing, with iron treble strings

scale	**# of strings**	**frame**	**compass**	**stringing**	**pitch (Hz)**
diatonic	29	no belly	c – c''''	8 Fe treble strings[544]	383 – 388
diatonic	29	belly	c – c''''	8 Fe treble strings	405 – 411
diatonic w/ unison strings	29	no belly	c – b'''	8 Fe treble strings	430 – 437
diatonic w/ unison strings	29	belly	c – b'''	8 Fe treble strings	455 – 462
diatonic	29	no belly	F – f'''	8 Fe treble strings	574 – 581
diatonic	29	belly	F – f'''	8 Fe treble strings	607 – 635
diatonic w/ unison strings	29	no belly	F – e'''	8 Fe treble strings	644 – 654
diatonic w/ unison strings	29	belly	F – e'''	8 Fe treble strings	681 – 692
diatonic	30	no belly	c – d''''	8 Fe treble strings	362 – 367
diatonic	30	belly	c – d''''	8 Fe treble strings	372 – 377
diatonic w/ unison strings	30	no belly	c – c''''	8 Fe treble strings	383 – 388
diatonic w/ unison strings	30	belly	c – c''''	8 Fe treble strings	405 – 411
diatonic	30	no belly	F – g'''	8 Fe treble strings	542 – 550
diatonic	30	belly	F – g'''	8 Fe treble strings	557 – 565
diatonic w/ unison strings	30	no belly	F – f'''	8 Fe treble strings	574 – 581
diatonic w/ unison strings	30	belly	F – f'''	8 Fe treble strings	607 – 635

[544] The scaling has been determined for the harp with the top 8 string positions in the treble strung with iron, and the strings in the middle of the compass strung with yellow brass.

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KAREN LOOMIS, DAVID CALDWELL, JIM TATE, TICCA OGILVIE
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The Lamont and Queen Mary Harps

'Here are two harps: the largest one is the loudest, but the small
one is the sweetest; which do you wish to hear played?'
(John Robertson of Lude, on the Lamont and Queen Mary harps)[1]

For nearly one thousand years, the harps of Ireland and the Highlands of Scotland were musical instruments of high status in Gaelic society.[2] The unique sound of these instruments was highly regarded, historically,[3] and their characteristic construction was readily recognized and noted.[4] In recent years, growing interest in historically informed performance of the repertory has created a need for new research into the construction of the surviving harps. Of these, the Lamont and Queen Mary are two of the three most important examples (see Figure 1 in the colour section). The third is the iconic Trinity College Harp of Trinity College, Dublin, commonly known as the 'Brian Boru' harp. Together, these harps represent the instrument in its earliest surviving form.[5]

For much of their working lives both the Queen Mary and Lamont harps belonged to the Robertson family of Lude, in Perthshire, Scotland.[6] Usually dated to the fifteenth century,[7] their last historical player was John Robertson of Lude (died 1731),[8] whose description of their sound is quoted at the beginning of this paper.[9] They are now two of the most important cultural artefacts in the collections of National Museums Scotland, and are on permanent display in the National Museum in Edinburgh. The primary source of information on the construction of these two instruments is Robert Bruce Armstrong's *The Irish and The Highland Harps*, which is still the standard reference work on

[1] Quoted in Donald Mackintosh, *Collection of Gaelic Proverbs, and Familiar Phrases* (Edinburgh: William Stewart, 1819), p.200. The authors would like to thank Simon Chadwick for pointing out the original printed source of this quotation.

[2] Robert Bruce Armstrong, *The Irish and the Highland Harps* (Edinburgh: David Douglas, 1904); facsimile reprint (New York: Praeger Publishers, Inc., 1969), pp.1–54.

[3] Geraldus Cambrensis, quoted in Christopher Page, *Voices and Instruments of the Middle Ages* (London: J. M. Dent & Sons Ltd, 1987), pp.229–30.

[4] For example in Michael Praetorius, *Syntagma musicum* (1619); facsimile reprint, A. Forchert ed., (Kassel: Barenreiter-Verlag Karl Votterle GmbH & Co. KG, 2001), p.54; and Joan Rimmer, 'James Talbot's Manuscript (Christ Church Library Music MS 118): VI. Harps', *The Galpin Society Journal* XVI (1963), pp.66–67.

[5] For an overview of the surviving harps, see Simon Chadwick, 'The Early Irish Harp', *Early Music* XXXVI (November 2008), pp.521–31.

[6] Keith Sanger and Alison Kinnaird, *Tree of Strings* (Temple, Midlothian: Kinmoor Music, 1992), p.53.

[7] The date of these harps is yet to be determined with any certainty.

[8] Sanger (1992), p.150.

[9] Armstrong (1904), p.181.

the subject. With recent advances in imaging and analytical tools, however, it is now a good time to resurvey these harps to see what new information we can discover and insights we can gain concerning their history and construction.

In 2010, a collaborative research project on both the Queen Mary and Lamont harps was undertaken by the authors at the University of Edinburgh, National Museums Scotland, and the Clinical Research Imaging Centre (CRIC) of Queen's Medical Research Institute. The museum kindly granted permission to the first author to have access to both harps and to the Conservation and Analytical Research staff and facilities at the National Museums Scotland Collection Centre in Edinburgh. Permission was also kindly granted to have both harps CT scanned at CRIC.

CT scanning, formally referred to as x-ray computed tomography, builds a three-dimensional x-ray, or tomogram, that can be viewed from any angle or in any cross-section. For the two harps, this meant it would be possible to look into and through the wood to see the interior construction and to see inside the joints. The Queen Mary and Lamont harps were CT scanned on 17 June and 8 July 2010, respectively, on the CRIC 320-multidetector row CT scanner.[10] The data was rendered and analyzed with the OsiriX DICOM viewer software package.[11] Prior to CT scanning, each harp underwent technological analysis at the Conservation and Analytical Research labs at the National Museums Collections Centre. The harps were examined, photographed, and selected areas of interest analyzed with x-ray fluorescence (XRF) and scanning electron microscopy – energy dispersive x-ray spectroscopy (SEM-EDX) to determine materials composition.[12]

Thanks to the combined approach of the CT scanning and laboratory analysis, we now have a vast body of new information concerning these two instruments. The CT scanning has indeed made it possible to see the interiors of these harps and into their wooden members to survey their construction, asses the state of the wood, and discover any interior damage and repairs. This work was complemented by a visual and photographic examination in the conservation lab, which provided a record of the exterior of the instrument, flagged up areas of particular interest, and also generated some new insights of its own. These interior and exterior surveys were supplemented by the XRF and SEM-EDX, which provided information on some of the materials used in the construction and repair of the harps.

In this paper, we report on many of the new findings for each harp. This is the first step in the process of analysis and interpretation of all of this new information. The first part of this paper surveys the new findings for the Lamont harp, with a section devoted to each of the three members of the frame, plus an additional section devoted to the neck joint at the soundbox. The second part uses the same approach for the Queen Mary harp. The final part of this paper takes a further look at some of the CT data to map the thickness of the soundboards, which is a very important topic and central to our understanding of these instruments. The sound-board mapping represents a 'first go' at some of the analysis that will be undertaken in the coming months with the new data on these two harps.

Before commencing with the report of the new findings, it is useful to briefly review the basic construction of the harps. The Lamont and Queen Mary harps are of the form described as 'small low-headed' by Rimmer.[13] The construction of these instruments is described in detail by Armstrong and is summarized here.[14] The frame is constructed of three parts: soundbox; forepillar; and neck. The three members of the frame are joined by mortise and tenon joints and are intended to be held together by the tension of the strings. Each part of the frame is constructed from a single piece of wood, including the soundbox, which is made from

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[10] Aquilion ONE, Toshiba Medical Corporation, Nasushiobara, Japan. The scans were run at 135kVp for the Lamont harp, and at 120kVp for the Queen Mary harp. The bit depth of the data is 16-bits, and the diameter of the scans is 50cm.

[11] OsiriX is an open-source image processing application for DICOM format images, www.osirix-viewer.com, consulted 11 January 2011.

[12] Jim Tate and Suzanne Kirk, 'Analytical Research Section Report No. AR 2010/39: XRF analysis of the Queen Mary and Lamont harps' (National Museums Scotland, 12 July 2010). XRF data was obtained with an Oxford Instruments ED 2000, running Oxford Instruments software ED 2000SW v. 1.31. SEM-EDX data was obtained with a CamScan MX2500 SEM using a Noran Vantage EDX system running Vista software.

[13] Joan Rimmer, *The Irish Harp* (Cork: Mercier Press, second edition, 1977), p.2.

[14] See Armstrong (1904), pp.168–80.

a large block of wood hollowed out from the back.[15] A separate board encloses the opening in the back of the soundbox. The strings pass through the front of the box, which is reinforced down its centre by a raised band of wood with metal reinforcements (referred to as 'string shoes') at the string holes to prevent the strings from tearing through the wood. The soundbox is mortised to the forepillar at its bass end. The forepillar, which is under compression from the tension of the strings, has an elongated flange-like 'T-section' in its centre for added structural strength and is joined to the neck with a tenon at its top end. The neck, through which the tuning pins pass, is reinforced on each side with metal cheekbands. The tuning pins are inserted into the neck from the right hand side, and the strings are strung to the exposed ends of the pins on the left side of the neck. To complete the triangular frame, the neck is tenoned into the top of the soundbox. In this paper, the following conventions are used to refer to the sides and ends of these harps: 'left' and 'right' are from the harp's perspective (as viewed by the player holding the harp), 'forward' is towards the forepillar, 'back' is towards the back of the soundbox, and 'down' is towards the bass end of the soundbox.

The current set-up of the two harps is as follows. The Lamont harp has holes for 32 strings in its soundbox and holes for 31 tuning pins in its cheekbands, with an additional hole directly beneath the bands at the bass end. The Queen Mary harp has holes for 29 strings in its soundbox, with a metal loop added for an additional string at the bass end. It has holes for 29 strings in its cheekbands, with an additional hole directly beneath the bands at the bass end. The numbering convention for the string and tuning pin holes starts at #1 from the treble end of each harp.

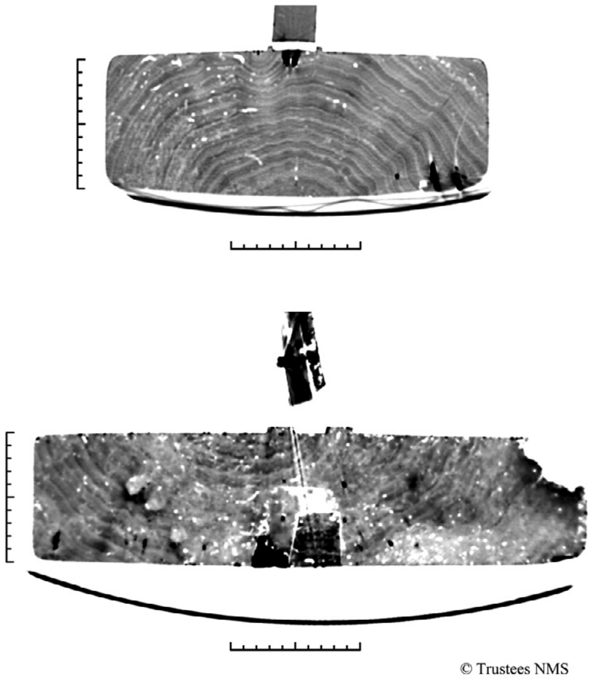

Figure 2. *Tomograms of the Queen Mary harp (top) and Lamont harp (bottom), showing the direction of the growth rings in the soundbox wood; scale: 1 tick : 1cm.*

THE LAMONT HARP

SOUNDBOX

The CT scans have revealed extensive woodworm damage, particularly to the foot of the harp, where a replacement block has been let in. The grain of the wood can be seen, so the pattern of the growth rings is visible on the tomograms. These clearly show that the soundbox is constructed from a half sawn boxed timber, with its central growth rings oriented towards the front, or playing surface (Figure 2). The centre-line of the tree lies 5cm to the right of the centre of the string band, so the box is not quite centred in the log from which it was cut.

The tomograms have revealed that the front of the soundbox varies in thickness; the gradations have been mapped and are discussed later in this paper. The walls of the sound holes are straight, while the inside edges and corners of the box are not rounded over, with the exception of the treble end of the cavity. Here the soundbox cavity gradually constricts to transition to the mortise for the neck joint, which is open to the interior of the box (Figure 3). The mortise is cut parallel to the long axis of the box. Examination of the tomograms suggests that the mortise may have originally been offset towards the right-hand side of the harp, and was later enlarged as part of a repair to the neck joint. The top end, or shoulder, of the box appears to

[15] The wood of the frame members of both harps was sampled in 1969. All parts were identified as European hornbeam, *Carpinus betulus L.* This identification has subsequently met with considerable skepticism amongst researchers and instrument builders, and a re-identification of the wood is planned for both harps. Alan J. Hayes, letter to C.E. Curran, National Museum of Antiquities of Scotland, 5–6 Randolph Crescent, Edinburgh, H. LT2 archive, National Museums Scotland, 18 February 1969.

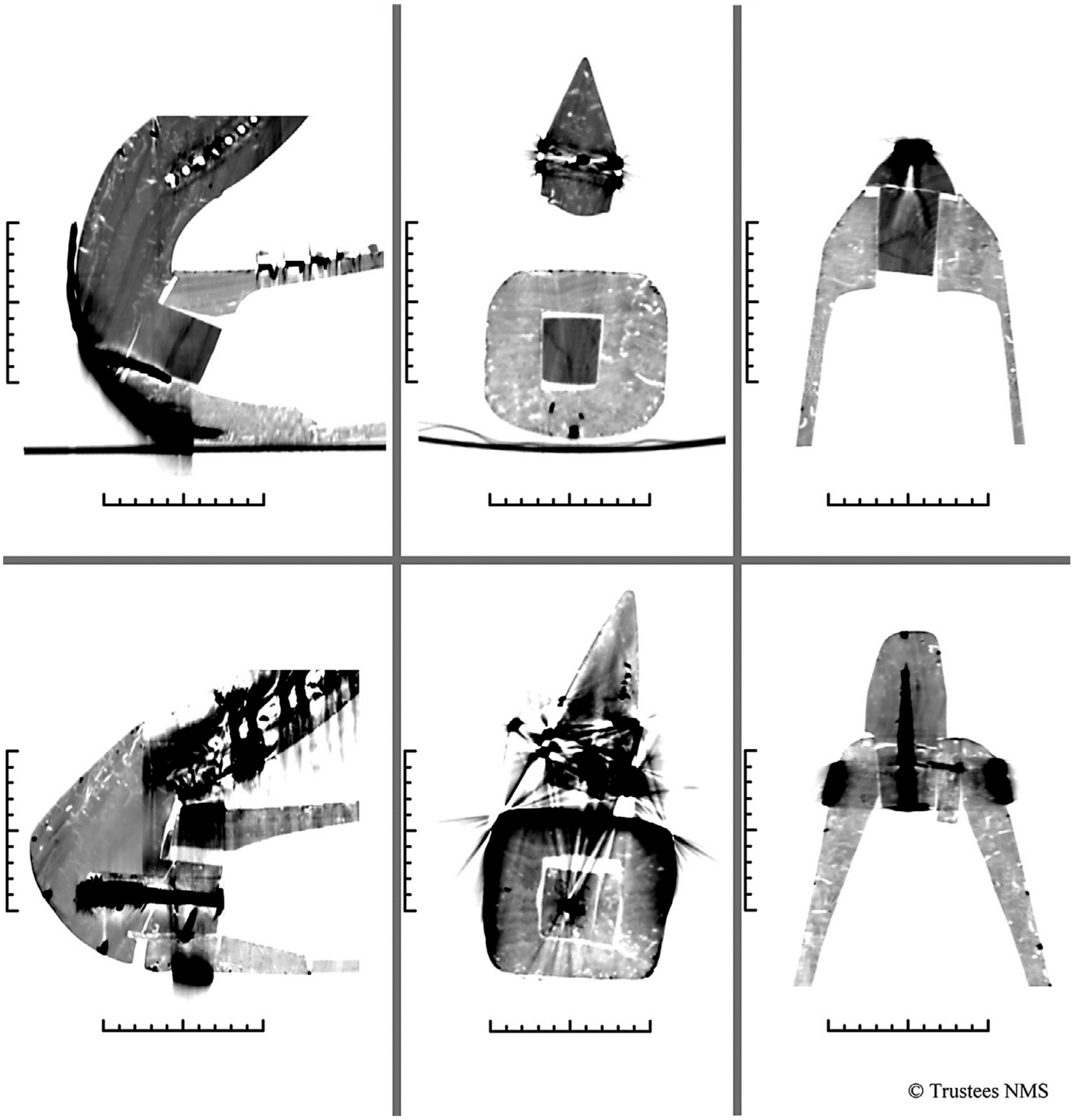

Figure 3. *Three orthogonal views of the neck joint at the soundbox for the Queen Mary harp (top) and the Lamont harp (bottom). These tomograms are (from left to right) sagittal, axial, and coronal views (sideways, end on, and parallel to the top of the soundbox, respectively). Both harps have visible damage and repair work to this joint; scale: 1 tick : 1cm.*

be cut at a slight forward angle, such that the back of the box is a little higher than the front. The face of the neck that seats against the box is likewise cut at an angle, and the tenon is cut at a slight angle to this face. When seated in the joint it is parallel to the long axis of the box.

The back cover of the soundbox was removed and the interior examined and photographed (Figure 4 in the colour section). The inside of the soundbox had previously been examined by Hobrough, who described the following important findings in a report to the National Museum of Antiquities of Scotland: the tool marks; the undercutting of the treble end of the box; the visible interior portion of the neck joint (with repair work and grass); the damage and repair at the bass end of the box; and marks left by the string toggles.[16] The current examination of the soundbox has confirmed Hobrough's earlier findings, and our observations are described below.

The inside surface of the soundbox is smooth up to the point at the treble end at which the original opening in the back of the box would have terminated (the opening has enlarged due to extensive damage to the wood). The remainder of the box has been undercut up to the joint with the neck. The inside surface at this end is covered with long gouge marks aligned with the long axis of the box. Evidence from the tool marks suggests that at least two sizes of gouge were used. The ends of the gouge marks extend into the smoothed area of the box, indicating that at least some of the gouge work was undertaken after the surface of the rest of the box had been smoothed. There are also numerous indentations that appear in circular patterns around the string holes on the inside of the soundbox (see Figure 5 in the colour section). These indentations are on average 2.5cm in length, and were probably made by string toggles, as they are consistent with their expected size, shape and location. An initial count taken around a few representative holes places the number of toggle marks at approximately 30 to 40, but a closer examination will be undertaken to get a more precise count. These marks are an important clue to the age of the instrument, as they are a direct indication of the number of times the strings have been replaced. Closer in to the string holes, there are other indentations that appear to be from wire strings. There are also verdigris stains associated with some of these wire indentations, indicating that copper alloys were used for at least some of the wire stringing for this harp. It should be noted here that the bottom string hole in the bass, #32, does not appear to have any toggle or wire marks around it. The top string hole, #1, also does not appear to have any toggle or wire marks around it. String hole #2 has some toggle marks, but fewer than the other string holes (approximately 12–16, but this is a very rough estimate). The neck of this harp is cracked through the top two tuning pin holes, and Armstrong notes that these two tuning pins were probably not usable after the crack formed.[17] There may be a link between this and the number of toggle marks around string holes #1 and #2, as well as the apparent addition of a 32nd tuning pin at the bass end of the harp.

One additional mark of interest inside the soundbox is a set of semi-circular and linear scratches around and pointing to the lower left sound hole. These may be the result of wires having been fished for and pulled through the sound hole prior to being threaded up through the string holes to replace strings on the harp. There are historical references to this method of restringing, but this would be the first direct evidence of it having been used.[18]

At the bass end of the interior of the box, an iron strap in the shape of a letter pi is nailed across the box directly above the foot (visible in the tomogram in Figure 6, in the colour section). The replacement block of wood that has been let into the foot is visible on visual inspection, as is a crack extending from this repair.[19] There are two holes through the foot intended for dowels to secure it to the original wood. It is evident from the tomograms that these dowels are now missing and that the block has shifted upwards slightly under the weight of the harp. The iron strap has been partially forced out by the movement of this block. From a conservation standpoint, this is an important observation, because the harp is currently displayed upright with all of the weight of the instrument resting on the foot. There are now plans to redesign the display stand to take the weight off the foot and redistribute it over the base of the soundbox.

Some new discoveries were made in the current examination of the soundbox. Upon visual examination of the string holes, a fragment of wire was discovered in hole #14. It is 3cm in length and is partially embedded in the wood. The visible portion is covered in copper corrosion products (verdigris) and is bent and twisted. The size, shape, and the degree to which it is embedded in the wood were determined from examination of the tomograms. There are plans to analyze this fragment to determine its physical properties. This wire fragment is an exciting and significant discovery, as there is little historical information on the stringing for any of these harps. Prior to the current study, only one other wire fragment had been discovered

[16] Tim Hobrough, 'Notes on the 'Queen Mary' and 'Lamont' Harps', Letter to Stevenson, R. B. K., Keeper, National Museum of Antiquities of Scotland, Queen Street, Edinburgh, H. LT2 archive, National Museums Scotland, 23 January 1979.

[17] Armstrong (1904), p.164.

[18] Armstrong (1904), pp.28–29, n.7.

[19] This is described in Tim Hobrough's letter to the National Museum of Antiquities of Scotland, Hobrough (1979).

on an Irish harp.[20] The location of this fragment *in situ* in its string hole makes it even more interesting because we know where on the harp this particular wire was strung.

Looking at the exterior of the soundbox, an approximately 35cm long crack runs along the right hand side of the box, following the grain of the wood. The presence of this crack was previously known, as were three equally spaced lines of nail marks running perpendicular to the crack and extending over onto the front surface of the box. Corresponding to the location of the nail marks, the tomograms have revealed three metal straps on the interior of the soundbox (see Figure 6 in the colour section).[21] The straps were inspected visually when the soundbox was open: they are coated in copper corrosion products and are decorated with a geometric design of dots, lines, and circles. The end of the lowest strap is cut in the shape of a fishtail. These straps appear to have been cut from a single, longer strap that has been reused from elsewhere, and are nailed over a vellum document. The vellum, discovered when the soundbox was examined for the current project, is glued to the inside of the soundbox, over the crack, as part of the repair. This document has writing on it in what may be an early seventeenth-century hand.[22] It appears to be the endorsement for a charter, presumably written on the other side, which is facing the wood.[23] The writing on the exposed side is partially legible and reads as follows: 'Chart_ / Grantit be Ge_ / Wt consent of his sp_ / To / Alexr McKenzie in / … / 6…'[24] The line below the name Alexander McKenzie contains a place name that is currently indecipherable, but it is hoped that further examination may enable the identification and date of the document, and thus place a lower limit on the date of the repair.[25]

Near the treble end of the instrument, there are additional cracks in the soundbox. Two run underneath the external iron strap at the top end of the box. One of these, on the right hand side of the box, towards the back of the instrument, extends for 13cm from the shoulder of the box. This crack is visible from the exterior of the soundbox, but its full extent is more readily visible on the tomograms. The other crack extends from the left side of the neck joint at the front of the box towards the string band; it is 5cm in length, is not visible externally, and therefore was not known to exist prior to the CT scanning of the harp. A third crack, hidden underneath thin strips of brass covering a section of the string band, was also revealed on the tomograms and later inspected visually from the interior of the soundbox. Armstrong, supposing that the metal strips had been added as reinforcement, had examined this portion of the string band and reported that he was unable to detect the presence of any cracks along the string holes.[26] It would not have been possible for him to see this crack, however, because it is completely covered by the strips of brass. Measurements taken from the tomograms indicate that the crack is 30cm long and extends from string holes #8 to #22, running down the centre of the string band, through the string holes. The strips of brass are evidently a repair to this crack and serve to reinforce the string band, which would have been vulnerable to splitting, due to being perforated by the string holes and being pulled upwards by the tension of the strings.

Looking at the finish of the wood on the outside of the soundbox, small traces of paint or varnish are evident in crevices on the front of the box. Photographs in the National Museums Scotland archives (possibly taken in the 1960s or 1970s) show the Lamont harp in the process of having its layers of wood finish removed down to bare wood.[27] The harp currently has a clear finish, but appears dark in photographs taken in the early twentieth century, and in the later photographs it also appears dark on the areas of wood that had not yet been stripped.[28] All of these photographs are black and white, so the colour of the finish is unknown. The exterior of

[20] Robert Evans, 'A Copy of the Downhill Harp', *The Galpin Society Journal* L (1997), p.124. The wire fragment was discovered on a tuning pin belonging to the Balinderry harp fragments.

[21] The straps appear just below the string band, evenly spaced along the side of the soundbox.

[22] David Caldwell and Keith Sanger, personal communication (July 2010).

[23] Caldwell and Sanger (July 2010).

[24] Caldwell and Sanger (July 2010).

[25] The writing is currently being investigated by Keith Sanger.

[26] Armstrong (1904), p.160.

[27] National Museums of Scotland H-LT2 Archive. The photographs also show the metalwork in the process of being polished. A report relating to this conservation work has not yet come to light.

[28] National Museums of Scotland H-LT2 Archive.

the bottom end of the box is currently covered in a thin layer of brown paint and the inner edges of the sound holes have surviving traces of a reddish-brown pigment. The first author and Simon Chadwick observed the pigment in the sound holes prior to the commencement of the current study, while the harp was in its display case at the National Museum. This pigment and the brown paint on the bottom end of the harp probably predate the stripping of the harp to bare wood. A small sample of pigment from inside the sound holes was analyzed with SEM-EDX and found to be primarily composed of carbon and oxygen, together with traces of other elements, suggesting it is an organic compound.[29]

A final important detail on the soundbox is the string shoes. As mentioned earlier in this paper, the function of the metal string shoes is to reinforce the edges of the string holes to prevent the wire strings from cutting through the wood. The string shoes on the Lamont harp appear to be made of a copper alloy and are in a variety of shades of yellow to reddish-yellow, suggesting that they are composed of differing proportions of copper with other elements. The inner edges of most of the shoes have vertical grooves in them. Some shoes have two or three distinct grooves. Some string shoes show signs of repair at these locations, with grooves on top of the repair work. The position of these grooves is consistent with them having been made by the strings, and the location of the grooves shifts for the shoes in the treble end of the harp in a manner consistent with the changing angle of the line of strings at that end of the instrument.[30] In light of the observations of the toggle marks around the string holes on the interior surface of the sound box, it is interesting to note that there do not appear to be any grooves on the topmost string shoe, and there is only one light groove on the #2 string shoe; there may also be one light groove on the lowest string shoe. While it is plausible that the observed grooves were created by the strings, it should be noted that inside some string holes grooves are also evident in the wood and some of these do not align with the grooves in the shoes. Additionally, there are also some deeply grooved shoes with no corresponding grooves in the wood where the wire would have cut into the string hole. Perhaps the shoes were recycled from another harp, or have been moved (as some would have been when part of the string band was reinforced with strips of brass).[31]

FOREPILLAR

The forepillar of the Lamont harp displays prominent and dramatic visible damage and repair work. The forepillar is broken and has had the bottom portion replaced below the T-section (see Figure 1 in the colour section). The replaced section is joined to the original part of the forepillar by a scarf joint secured by four rivets and a pair of iron straps, as discussed by Armstrong.[32] The forepillar is depicted with this break and repairs in engravings made for John Gunn's 1807 treatise on the Lamont and Queen Mary harps.[33] Visible damage to the wood at the scarf joint resulting from pivoting of the joint indicates that the harp was brought up to tension after this joint was made, suggesting that this is an old repair made during the working life of the instrument.[34]

The tomograms of the forepillar have made it possible to see inside the repair work and have revealed an additional metal post underneath the iron straps. The post passes directly through the midpoint of the break in the forepillar, and has a washer at one end. This could be an additional rivet, but it is also possible that it is a pin attached at one

[29] Tate and Kirk (2010), p.5.

[30] Joan Rimmer observed 'friction marks' on the string shoes of the Trinity College harp, and noted that when she restrung the harp, the position of the strings aligned with the observed marks on the string shoes. Joan Rimmer, 'Report on Stringing the Trinity College, Dublin, Harp'; unpublished report dated 16 October 1961, p. 2.

[31] Ann Heymann has suggested that the grooves could have been filed into the shoes to remedy buzzing of the strings. Ann Heymann, personal communication (28 April 2011).

[32] Armstrong (1904), p.165.

[33] John Gunn, *An Historical Inquiry Respecting the Performance on the Harp in the Highlands of Scotland* (Edinburgh: Archibald Constable, 1807); facsimile CD (Scotdisc, 2005), plates I and III.

[34] Simon Chadwick has written a discussion of the damage and repair work to the forepillar, presenting the possibility (originally suggested by harpmaker David Kortier) that the scarf joint attaching the lower portion may have been part of the original construction and that shifting of this joint under the string tension could have led to the observed break and the need for subsequent repairs in the form of the iron straps. Chadwick also discusses damage to the wood as evidence of the harp having been brought back up to tension subsequent to the repair work. See Simon Chadwick, 'The Lamont Harp: Damage and repairs', <http://www.earlygaelicharp.info/harps/lamontdamage.htm>, consulted 5 September 2011.

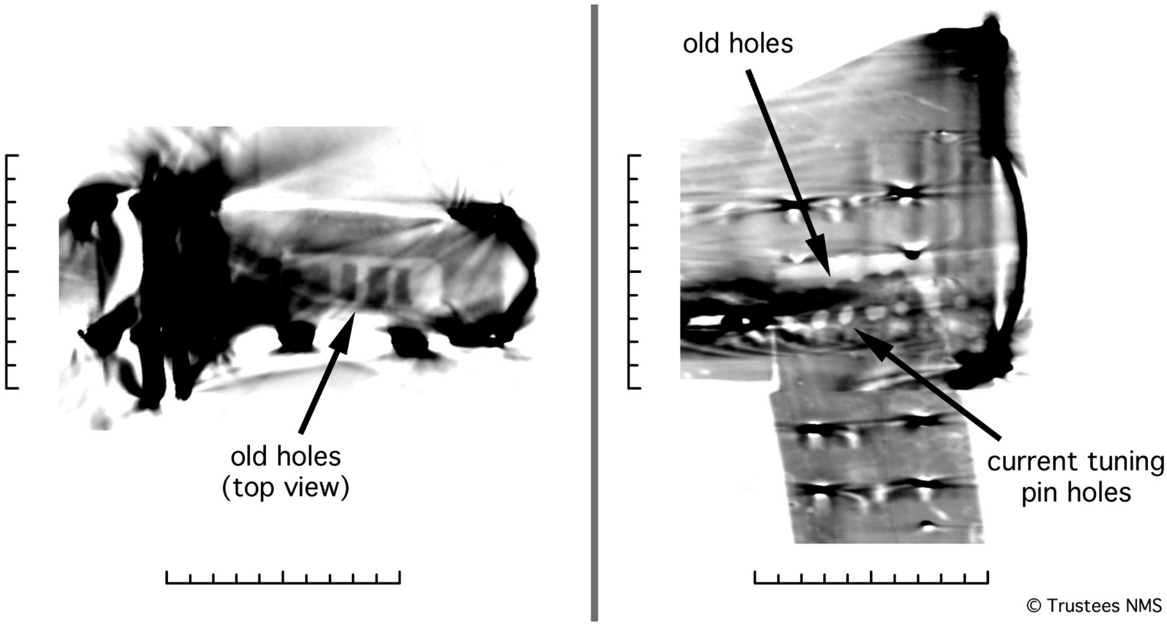

Figure 7. *Two tomographic views of the forepillar tenon of the Lamont harp in the joint with the neck. The left-hand image is the view looking down from above the end of the tenon. The right-hand image is the view from the side. There appear to be the remnants of a second set of tuning pin holes on the end of the tenon. Scale 1 tick : 1cm.*

end to the underside of one of the straps, as it is not clear from the tomograms if it is just touching the strap or if it is attached to it.[35]

The lower section of the forepillar ends in a tenon for the joint with the soundbox. This tenon is held in the mortise in the foot by three wooden dowels. The tomograms reveal that the back and middle dowels are broken and that the tenon has rotated forward out of its joint by 1cm at the back of the forepillar. This is additional evidence that the harp was brought up to tension after the lower portion of the forepillar was replaced.

At the top end of the forepillar, where it joins with the neck, hidden damage and repair to the forepillar tenon were discovered on the tomograms of the inside of the joint. On both the Queen Mary and Lamont harps, the tuning pin holes pass through the tenon in this joint. These holes are visible in the tomograms. On the Lamont harp, however, in addition to the expected line of tuning pin holes, the end of the tenon is scalloped by what appears to be the remains of a second line of holes, 1.7cm above the others (Figure 7). A possible explanation for this is that the original end of the tenon sheared off through the perforations created by these holes, and that the tenon was re-cut and reseated in the joint. This will have resulted in this end of the forepillar being shortened by 1.7cm, and consequently, any estimates of original string lengths and scaling will need to take this into account.

The damage to the tenon may have been caused by the lateral force applied to the joint by the twisting of the neck towards the left side of the harp as a result of the string tension. There are two large brass straps placed across this joint on the right-hand side of the forepillar. They are each affixed to the neck and forepillar with four large rivets, and prevent any further motion of the neck in this direction. Examination of the other side of the forepillar shows that the rivets have not been repositioned. If the tenon was re-cut and the forepillar shifted up by 1.7cm, these straps must have been put on the harp after the repair was completed. This is an interesting and potentially important point, as the Irish harp depicted by Praetorius in his Syntagma musicum and the Ballinderry harp fragments in the National Museum of Ireland are both equipped with similar straps in the same location.[36]

Looking beyond the damage and repairs to examination of the wood grain in the forepillar of the Lamont harp, it is evident from the tomograms that the grain of the wood in the upper section follows

[35] Keith Sanger, personal communication (2010).

[36] Praetorius (1619), plate XVIII. For a photograph and description of the Ballinderry fragments, see Armstrong (1904), pp. 63–64, and plate facing p.62

the curvature of the forepillar. This is not easily discernable upon visual inspection of the forepillar. The wood grain of the lower section of the forepillar is straight. This piece of wood also has fewer wood worm holes and a wider grain than the upper section.

NECK

As with other parts of the harp, the neck has extensive woodworm damage. There is also evidence of considerable structural damage and repair to the wood in the vicinity of the joint between the neck and the soundbox. This is discussed in detail below. Looking first at the metal work on the neck, there is a decorative cap covering the end of the neck where it extends beyond the forepillar. XRF analysis has shown that this end cap is of a copper alloy, consisting of 80% copper, 15% zinc and 3% tin. The cheekbands on each side of the neck are thick plates of an alloy of 88% copper and 11% tin, with trace amounts of other elements.[37] Several of the tuning pins have grooves worn into their shafts where they have rubbed against the cheekband. The tuning pins on the Lamont harp vary in colour and decoration. Though all have the same general decorative design (with the exception of two later replacements), several distinct variants were observed. Four pins were analyzed with XRF and were found to be copper alloys with varying amounts of zinc (10 to 21%), tin (1.5 to 3%), and traces of lead and other elements.[38]

A notable physical feature of the end cap is that its sleeve is too long to allow it to fit onto the end of the neck, due to the position of the forepillar near the neck end. One side of the cap sleeve has been cut and bent backwards to allow it to fit.[39] This has led to some speculation as to why the cap doesn't fit properly and the condition of the end of the neck underneath it. A plausible explanation is that the end of the neck has been shortened, perhaps as a result of damage. The placement of the last tuning pin hole beneath the cheek bands, out of line with the others, would seem to support this theory. It is just possible to see through the cap in the tomograms (Figure 7). Underneath it, the end of the neck is neatly finished with no sign of having been damaged, and the cap fits snugly onto the wood on the front and sides. The ends of the cheekbands can also be seen under the cap. They terminate right at the end of the neck on each side. There is no partial hole for a 32nd tuning pin at the end, suggesting that they probably have not been shortened.

The neck as a whole has suffered significant damage, which appears to be the result of the string tension. It has twisted along its long axis and has rotated in its joint with the soundbox. At the treble end, a large crack has opened up on the left side, where the wood has torn along the grain (Figure 1 in the colour section). As with the forepillar, the visible damage and repair is described in detail in Armstrong.[40] Two thin metal straps are nailed across the crack. One of these has been analyzed and is an alloy of 67% copper and 31% zinc, a different composition from the other metalwork on the neck. This strap runs under the neck to the right side where the crack extends through to that side. There is another brass patch and an iron strap on the underside of the neck. The tomograms reveal the extensive internal damage and repair work to both the neck and the neck joint at the soundbox (Figure 6 in the colour section). The crack in the neck is 16cm in length and extends through it at the end closest to the joint with the soundbox, and nearly through it along most of its length. In addition to the metal patches three large nails have been driven up into the neck from underneath. These are 6–7cm in length and each has a washer. One of the nails is bent as if it has encountered very hard wood. The neck would have had to have been removed from the harp in order to drive in these nails.

NECK JOINT AT THE SOUNDBOX

Continuing to the joint at the soundbox, there is visible evidence of distress and repair. The neck has rotated in the joint; it has also pivoted forwards due to shortening of the forepillar, and has twisted due to the tension of the strings pulling down on its left side. These will have caused the tenon to rotate and pivot forwards and to the left in the mortise in the box. The end of a block of wood is protruding from the left side of the joint, suggesting that an effort has been made to reinforce the tenon. The tomograms reveal the full extent of the internal damage and repairs made to the joint (Figure 6 in the colour section and Figure 3). The tenon has sheared off completely, and the joint has been re-secured with four wooden dowels reinforced by a 9cm long spike. The spike and one of the dowels have each caused a

[37] Tate and Kirk (2010), p.5.

[38] Tate and Kirk (2010), p.5.

[39] See Armstrong (1904), p.163.

[40] Armstrong (1904), p.164.

crack to form in the neck. A thin piece of wood has been slotted into the neck at the back and nailed to the back of the tenon. A block of wood has also been nailed to the left side of the tenon to strengthen it and to reinforce it against the twisting of the neck downwards and towards the left. This is the block whose end is visible from the outside of the joint. Looking at the cross-sections of this joint on the tomograms (Figure 3), the mortise appears to have been enlarged to make room for the block. The neck has lifted 0.5cm out of the joint and tilted slightly towards the left. A shim has been inserted in the gap between the neck and the top of the soundbox.

The neck joint was also visually examined from the interior of the soundbox when the box was opened. The ends of the spike and dowels are visible from the inside of the box, as is the reinforcing block nailed to the side of the tenon. There are gaps between the tenon and the front and right sides of the mortise. These are packed with dried grass, many with their seed heads still attached (see Figure 4 in the colour section).[41] The grass is packed deeply into the joint and may have been put there to keep the neck from shifting while the harp was being brought back up to tension after the joint was repaired.[42]

THE QUEEN MARY HARP

SOUNDBOX

The grain and pattern of the growth rings of the wood is visible in the tomograms of this harp. They show that this soundbox is constructed from a half sawn boxed timber, with its central growth rings oriented towards the back of the soundbox. The front and sides of the soundbox are of varying thickness and will be discussed later in this paper. The CT scanning has revealed extensive woodworm damage, particularly in the back cover and at the treble end of the box on the left-hand side.

The interior of the soundbox has not been opened due to the fragile state of the back cover, but evidence of tool marks inside the soundbox is visible on surface renderings of the tomograms. These show what appear to be shallow linear grooves, consistent with the use of a gouge, on the inside surface of the front. The grooves appear to be angled slightly towards the diagonal, from the lower left of the harp towards the upper right.

The interior edges and corners of the soundbox are not significantly rounded over, with the exception of the inside of the front surface at the treble and bass ends, where the edge rolls over rather than coming to a sharp angle. The sound holes are cut straight into the box. They are not angled or undercut. The front of the soundbox is arched along both its long and short axes. This arching, referred to here as the 'belly', is centred approximately on the mid-point of the length of the box, but falls off more quickly in the treble than in the bass (Figure 8). Along the width of the soundbox, it is centred near the mid-point of the string band, but is higher to the left of the string band, giving the belly a slightly skewed profile. The sides of the soundbox are pulled in, as can be seen in cross-sections of the box (Figure 9). This has probably been caused by the front of the box being pulled upwards, and is taken as evidence that the belly is the result of the string tension bending the wood.[43] It is not yet clear if there is visible evidence of this in the wood grain. At the treble end of the soundbox, the cavity constricts at the transition to the mortise for the neck joint, which is open to the interior of the box. The mortise comes up at an angle to the front of the box, and is offset towards the right-hand side of the harp. Where the neck seats against the soundbox the outside surface of the box is angled to be perpendicular to the mortise. The neck tenon, in turn, is cut perpendicular to the side of the neck seated against the top of the soundbox (Figure 8). There is visible damage and repair work to this joint, which is discussed in more detail in the section on the neck joint at the soundbox.

On the surface of the soundbox, the geometrical decorative lines appear to have been either cut or burned in. In their current state, they have an 'embossed' appearance, as if they were pressed into the wood, but it is not clear how this effect was accomplished.[44] The lines are filled with a dark waxy substance (as yet not analyzed); the same or similar substance is found in cracks and crevices on all parts of the harp. It is clearly visible in the tomograms as a dense material, and may therefore contain a

[41] Hobrough,'Notes on the 'Queen Mary' and 'Lamont' Harps'.

[42] Guy Flockhart, personal communication (December 2010).

[43] Simon Chadwick, personal communication.

[44] The first author gratefully acknowledges Simon Chadwick for discussions relating to the decorative lines on the Queen Mary harp and possible methods for their construction, and for pointing out that their visual appearance may not be consistent with the use of pyrography. Personal communication (6 September 2011).

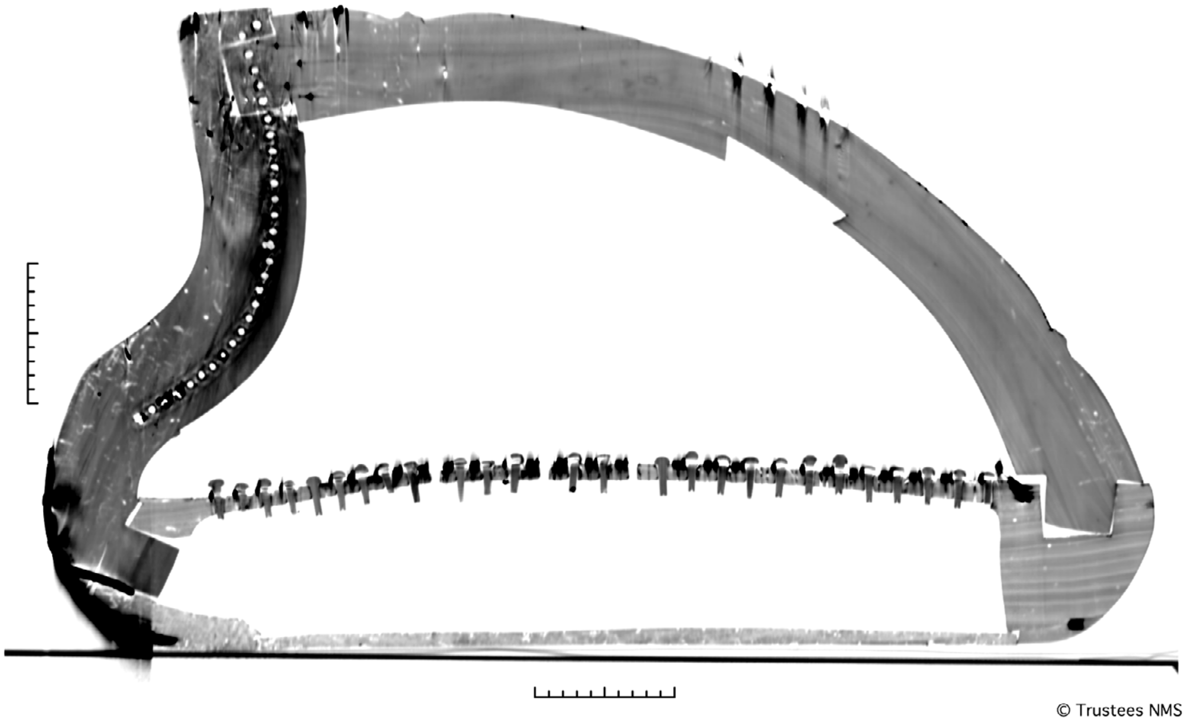

Figure 8. *Sagittal tomogram of the Queen Mary harp. The soundbox cavity, joints, and wood grain are all visible in this cross-section. In order to show all three joints, the cross-section is angled slightly to the long axis of the soundbox. Scale 1 tick : 1cm.*

metal (see the tomogram on the left in Figure 15 in the colour section). Layout lines scored onto the soundbox for the pattern of decorative work were observed and photographed.[45] The centre of each circle in the design contains a dot, which shows on the CT scans as a prick mark, consistent with the point of a compass having been positioned there. The surface of the soundbox also has numerous nail marks, which are visible to the eye under close examination but are more easily seen on the CT scans due to traces of metal corrosion or small fragments of metal left behind in the nail holes. There are two loose clusters of nail marks symmetrically located on either side of the string band 4cm above the lower sound holes (Figure 15 in the colour section). Above these there are two small holes through the wood, also symmetrically located either side of the string band, 7cm above the lower sound holes. Around each of these holes is a partial circular impression, 2cm in radius, which may have been left by decorative medallions.

The tomograms of the Queen Mary harp show what appears to be a fragment of wire 0.6cm in length embedded in the interior of the front of the soundbox, along the string band next to string hole #13.[46] The tomograms also show what appears to be a second, smaller, fragment embedded in the end of the wooden knob inserted in string hole #15. If the back cover of the harp can be safely removed, the fragments will be inspected and possibly removed

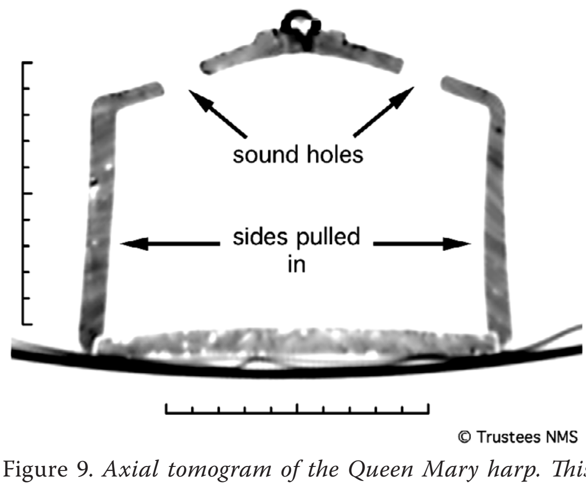

Figure 9. *Axial tomogram of the Queen Mary harp. This cross-section across the soundbox shows the straight-sided profile of the sound holes, the arch of the belly, and the pulled-in sides of the soundbox. Scale 1 tick : 1cm.*

[45] The scored lines are described in Armstrong (1904), p.173.

[46] Discovered by Simon Chadwick during examination of tomograms of the Queen Mary harp (December 2010).

for analysis. It is not known if these fragments are historical, or if they date to the restringing of the harp with brass wire in 1806.[47]

The back cover to the soundbox has the most extensive wood damage of any part of the Queen Mary harp. Some of this has been cosmetically repaired with what appears to be modern filler. The wood is darker in colour than the soundbox and has traces of decorative work that matches that on the box in both design and execution.[48] This suggests that the back cover of this harp may be original. The wood has been flat sawn, as evident from the grain that is visible in the tomograms. Several nails have been driven into the wood around the edge of the cover, in order to affix it to the back of the soundbox. Some of the nails appear to have been either cut or broken.

FOREPILLAR

The forepillar is carved from a timber that includes the centre of the wood, and the pith is visible in the tomograms (Figure 10). The curvature of the forepillar closely follows the grain of the wood, which is itself curved, so it is likely that this member was fashioned from a curved limb. A crack 19cm in length on the left side of the T-section opens up from the pith at the centre of the wood and follows the grain. This is undoubtedly an instance of 'checking' as a consequence of including the centre of the wood in the finished piece. A 10cm cut-out section on the left side underneath the T-section has a crack at the back which is not related to the larger crack in the T-section. Traces of what appears to be glue can be seen in the tomograms of this smaller crack.

The decorative carving on the forepillar contains traces of a red pigment (see Figure 11 in the colour section). XRF analysis has shown that the pigment contains significant amounts of mercury, indicating that it is almost certainly vermilion.[49] A red pigment is also embedded in nail holes in the centres of the carved decorative eyes on the T-section, suggesting that they were originally painted red and that something was nailed into the centres after they were painted. The pigment in the eyes was analyzed with XRF and also found to contain a significant amount of mercury. Vermilion pigment has so far only been detected on the forepillar, but the dark waxy substance found in the decorative work and surface crevices on the soundbox also appears in cracks and crevices on the forepillar.

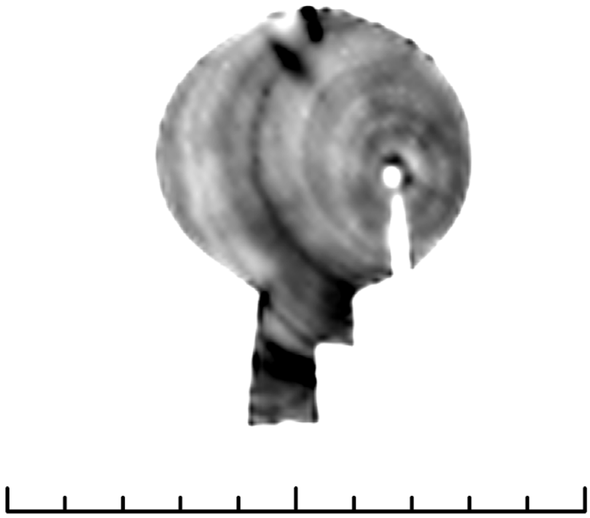

Figure 10. *Tomographic slice across the forepillar of the Queen Mary harp. The growth rings of the wood are visible, and the pith can be seen to the right of centre in the forepillar. Some checking is also apparent. Scale 1 tick : 1cm.*

The front of the T-section has four very worn decorative bosses and two posts (which may have originally held two additional bosses). Close examination has revealed that the bosses were originally hemispherical caps. XRF analysis was conducted and has shown that they are composed of a silver copper alloy with traces of lead, zinc, tin, and gold. They are attached to brass posts with a solder containing lead and tin.[50]

Areas of the decorative work on the sides and inside curve of the forepillar are highlighted by contrasting shades of wood, which is due to pigmenting of the wood, rather than inlay. Two contrasting areas on the inside curve of the forepillar were examined with

[47] This was done by Muir Wood and Co. at the request of the Highland Society for a performance by the Swiss pedal harpist, Joseph Elouis. Elouis replaced the brass wire with gut, fragments of which are still on the harp. Sanger (1992), p.203; and Sanger, personal communication (6 June 2011).

[48] Armstrong (1904), p.179.

[49] Tate and Kirk (2010), p.2.

[50] Tate and Kirk (2010), p.2.

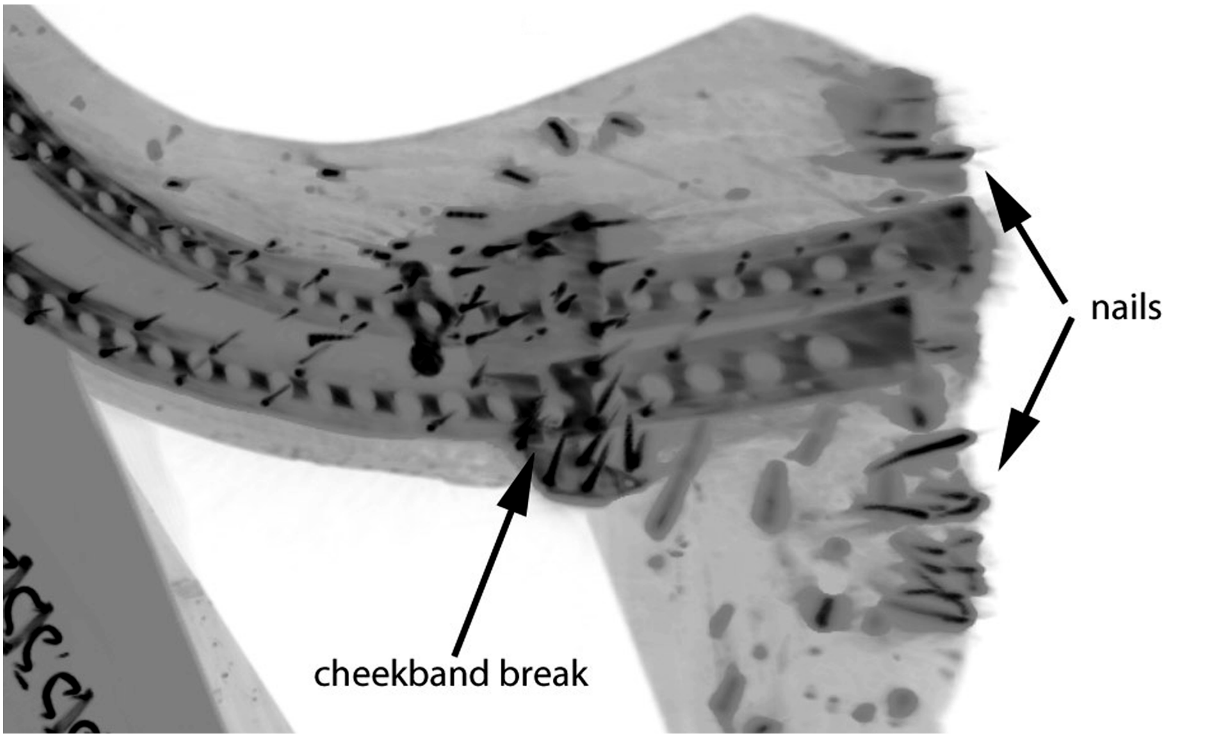

Figure 12. *Tomographic three-dimensional projection of the end of the neck of the Queen Mary harp, where it joins with the forepillar. This three-quarter view shows the break in the cheekband and the long nails in the forepillar and neck end. These reportedly once held gold medallions with a portrait of Mary Queen of Scots and the arms of Scotland.*

XRF and compared.[51] The surface of the darker area had slightly elevated levels of iron, but more data would need to be taken to confirm whether this is due to a pigment containing iron. The Queen Mary harp has four decorative roundels on its forepillar, two on each side at the top and bottom ends. The tomograms revealed a central pin-prick extending 2–3mm into the wood in each roundel, suggesting the use of a compass to construct the design. These construction marks are not readily visible to the naked eye, but stand out in the tomograms. They appear to be filled with the same dense dark waxy substance found in other crevices of the harp.

Above the T-section, numerous nails are embedded in the wood on the front and sides of the forepillar and are prominently visible on the tomograms (Figure 12). The nails on the front face extend 1–1.5cm into the wood. These and similar nails embedded in the end of the neck are consistent with Gunn's report of the top of the forepillar and/or front end of the neck having at one time been decorated with gold medallions of the queen's portrait and the arms of Scotland.[52] The end of one of these nails was analyzed with XRF and found to be a copper alloy with a relatively high zinc content.[53]

Looking at the workmanship of the joints, neither of the tenons at the ends of the forepillar fits its mortise particularly well (Figure 8). The tenon at the bottom of the forepillar has rotated slightly out of its joint, but even if it were not rotated, there would still be a gap between the tenon shoulder and the foot of the soundbox because the tenon is angled such that it cannot seat completely in the joint. The tenon at the top of the forepillar is also angled in its joint with the neck. The holes for the tuning pins pass through this tenon, and it is apparent from the line of holes visible in the tomograms that the tenon has not moved or rotated significantly since the forepillar was installed on the harp and the holes were bored through the tenon.

NECK

The neck is carved from a single piece of wood, with the grain running lengthwise along the long axis; the grain does not appear to be curved as it is in the forepillar. Numerous nails and nail fragments are

[51] Tate and Kirk, unpublished data.

[52] Gunn (1807), p.14.

[53] Tate and Kirk, unpublished data.

embedded in the wood along the sides and at the end of the neck at the forepillar as may be seen in Figure 12. The nails at the end of the neck extend 1–1.5cm into the wood. Internal cracks extend from two of the nail ends and follow the grain of the wood. These may have been caused by the nails, but similar cracks near the end of the neck where it joins with the forepillar are not associated with any nails. One moderately sized crack runs diagonally through the 25th tuning pin hole. On the right side of the neck, a metal patch is nailed over the cheek band at the 24th tuning pin hole. Armstrong noted this in his description of the Queen Mary harp and suspected that the patch was covering a break in the cheekband, based on the visible jog in the otherwise smooth curvature of the band.[54] Indeed, the tomograms reveal a clear break in the cheekband underneath the patch (Figure 12). Armstrong also suggested that the cracks in this end of the neck might have been the result of the forepillar pushing up on the end of the neck, which is being pressed against it by the tension of the strings.[55] The internal cracks visible in the tomograms tend to support this theory. Farther up the neck, towards the treble end of the harp, there are additional internal cracks. In the middle section of the neck, where the angle of the line of tuning pin holes is closely aligned with the direction of wood grain, a crack runs from the 8th or 9th hole to the 16th hole (Figure 8). It extends almost completely through the wood in places. The presence of the metal cheek bands may have prevented this section of the neck from sheering off under the tension of the strings. The cheek bands themselves are thin plates found upon analysis with XRF to be of a copper zinc alloy, with a high copper content.[56] One of the tuning pins has also been analyzed and found to be of nearly the same composition.

The tomograms reveal that some of the tuning pin holes contain thin irregular sheets of a dense, possibly metallic material (Figure 8). In some instances the material looks like it is lining the inside surface of the hole, in others it appears to be crumpled. In her examination of the Trinity College harp, Rimmer reported that several tuning pin holes were ‘lined with thin metal to get a better fit’ for the tuning pins,[57] so it is possible that this is what is visible in the tomograms of the tuning pin holes of the Queen Mary harp.

NECK JOINT AT THE SOUNDBOX

A sturdy iron strap has been nailed across the neck joint at the soundbox and a small wooden wedge inserted at the back. Six heavy iron nails are driven through the strap: three into the neck and three into the back of the soundbox. The strap is clearly a repair (or remediation), as it covers up some of the decorative work on the neck. The CT scanning has revealed the full extent of the damage and repairs (see Figure 13 in the colour section). The tenon has a crack that opens up from the back right-hand corner and follows the grain of the wood. The neck has lifted about 3mm out of its joint and has tilted slightly forwards and towards the left side of the harp. A metal rod extends through the neck and into the joint. The three nails driven through the iron strap into the neck extend deep into the wood. The nails driven into the soundbox are bent, following the grain of the wood. The small wooden wedge fills the gap that has opened up at the back of the joint.

The iron strap is preventing the neck from rotating forwards out of the joint. This, in turn, is preventing the tenon from shearing off, or pushing through the back of the soundbox.[58] The metal rod is wedged between the mortise and tenon, and extends up through the back of the neck to just under the iron strap. This object, which was discovered upon examination of the tomograms, is not one of the nails driven through the strap, and is completely hidden underneath it. It could be a pin attached to the underside of the iron strap, or it might be an earlier attempt to stop the tenon from shearing off the neck.

THE SOUNDBOARD THICKNESSES OF THE QUEEN MARY AND LAMONT HARPS

In addition to having an unprecedented view of the interiors of the harps from the CT scans, it is now possible to take measurements of all of their parts, particularly interior measurements, which were previously unobtainable. One of the most important acoustical elements of these instruments is the soundboard, formed by the front of the hollowed out

[54] Armstrong (1904), p.178.
[55] Armstrong (1904), p.178.
[56] Tate and Kirk (2010), p. 2.
[57] Rimmer (1961), p.2.
[58] Guy Flockhart, personal communication (December 2010).

soundbox. Until now we have only had Armstrong's soundboard thickness measurements taken at the sound holes: ⅜-inch (10mm) at both the upper and lower sound holes for the Lamont harp; ¼-inch (6mm) and $\frac{5}{16}$inch (8mm) at the upper and lower sound holes, respectively, for the Queen Mary harp.[59] A data sheet in the National Museums Scotland archives lists these measurements, with the addition of '$\frac{11}{32}$–⅜ inch' (9–10mm) for the thickness of the Lamont soundboard.[60] With the data from the CT scans, we can now measure and map the thickness of the entire soundboard of both harps, providing us for the first time with a complete picture of this vitally important aspect of their construction.

To obtain these measurements, axial slices from the CT scans were taken across each soundbox and cross sections were then taken at individual points through the soundboards. The thickness at each point was determined from the FWHM of the cross-sectional profile across the soundboard, normal to the surface, and the location of each measurement was taken from the inside face of the soundboard.[61] The resolution of these measurements is 0.5mm. For the Queen Mary harp, measurements were taken in a 2cm x 2cm grid with additional measurements along the edges of the soundbox and in areas of sudden change in thickness (for example at the edge of the string band). For the Lamont harp (which has a larger soundboard) a 3cm x 3cm grid was used, with similar additional measurements. One limitation of CT scanning is image artefacts in the form of streaks that can appear in the tomograms in the vicinity of metal objects. Due to image artefacts from the metal string shoes, it was only possible to take a limited number of measurements on the string bands. The mapping of the soundboard thickness in this area is therefore much less reliable. For the Lamont harp there was also the issue of the piece of vellum glued to the right hand edge of the interior of the soundbox, which added to the thickness of the soundboard.[62] The vellum and layer of glue measure approximately 0.5mm thick and measurements taken through the vellum have been adjusted by this amount.

The resulting contour maps generated for each harp are presented, along with a tomogram of the soundboard for comparison. These are shown in Figures 14 and 15 in the colour section.[63] On the contour maps, each line represents a change in thickness of 0.5mm. Areas of equal thickness have been mapped using the same colours for both harps. Thinner areas are represented by the blue end of the spectrum and thicker areas are represented by the red end.[64] The coordinate system is that of the CT scanner, with the exception that the scanner's z-axis is referred to here as the y-axis.[65] For reference, the positions of the string holes and sound holes were measured and added manually.

Looking at the contour map of the Queen Mary harp soundboard, some notable features are apparent. The soundboard is thinner in the treble, decreasing in thickness from 8mm just below the top sound holes to 6mm along the sides of the soundbox above the sound holes. In the mid-section of the harp there is a large area of the right-hand side of the soundboard that is thinner than the left-hand side. Here, the thickness of the soundboard is about 7.5mm compared to 9mm in areas of the middle of the left-hand side. At the bass end of the soundbox, the soundboard thickness rapidly increases from about 8.5mm just below the lower sound holes to 10.5mm close to the bottom edge, where it rolls over into a rounded corner.

The contour map of the soundboard of the Lamont harp also has some interesting features. As with the Queen Mary harp, the soundboard is thinner in the treble, decreasing in thickness from approximately 10mm at the upper sound holes to around 8.5mm on the right-hand side and 8mm on the left-hand side. This area of the soundboard appears to be thinner overall on the left-hand side, possibly as a result of the mortise being enlarged on that side for the repairs to the neck tenon. The midsection of the soundboard is

[59] Armstrong (1904), p.161, and pp.168–69.

[60] Data sheet, 'Harp Measurements' (H. LT2 archive, National Museums of Scotland, undated).

[61] The measurements were obtained from the tomograms with the OsiriX v. 3.9 software package.

[62] The vellum extends from the upper sound hole to just below the lower soundhole. It is affixed at an angle to the edge of the box and covers 2cm to 5cm of the front surface from the right-hand edge of the soundbox, starting from the upper sound hole.

[63] The contour maps were generated using the Aabel v. 3.0.5 graphing programme.

[64] It was necessary to wrap the colour mapping to allow for a few very thick areas, such as the ends of the string bands, and the bottom edge of the soundbox of the Queen Mary harp.

[65] For the Queen Mary harp, the signs of the x and y coordinates have been reversed for the purpose of plotting the contour map with the top of the harp facing up.

thinner on the right-hand side than the left, however, similar to the soundboard of the Queen Mary harp. In addition to being about 1mm thicker overall on the left side, the thickness of the soundboard increases from 11mm to 13.5mm towards the left-hand edge of the box. At the bass end of the soundbox, where the soundboard of the Queen Mary harp thickens, there are two areas, symmetrically located on either side of the string band, where the thickness of the soundboard decreases by about 1mm.

These contours may have resulted from a combination of the practicalities of working the wood, the need for mechanical stability of the box, and some intentional tuning of the soundboards. Although we don't know the original intentions of the builders of these two harps, we can now at least see the results of their handiwork, and while it is beyond the scope of this paper to analyze and discuss the full acoustical effects of the soundboard profiles, there is at least one obvious feature. The thinned treble, in particular, reduces the stiffness of the soundboard at that end of the soundbox, enabling it to vibrate more easily. This is a standard feature of the soundboards of modern harps, and it is plausible that the soundboards of these harps were intentionally thinned in the treble for this reason.[66] The reason for the left-right asymmetry in the mid-ranges of both soundboards is less obvious. This asymmetry may or may not have been built in intentionally, but the acoustical and mechanical effects should be examined as they could prove to be very interesting. In very general terms, with its thick and presumably stiff bass and thin treble, the soundboard of the Queen Mary harp probably favours the treble end of the instrument's range. In contrast, the Lamont harp has a relatively thinner, and therefore more flexible, soundboard in the bass. This, along with the proportionately wider bass end to the soundbox, may produce a relatively louder bass. While both harps are too fragile to be strung and played, the soundboard mapping helps us to understand how they may have sounded and may make it possible to build replicas that behave more closely like the original instruments.

CONCLUSION

As is evident from the findings presented in this paper, there is now a vast body of new information concerning the construction and current state of the Lamont and Queen Mary harps. For the first time it is possible to view the interiors of the joints of the instruments and to take measurements. We can look at how the members are fitted together, and see any internal damage and hidden repairs. It is also possible to identify some of the choices made by the maker in terms of the orientation of the wood grain, and we can see the extent of woodworm damage. The photographic survey has given us an updated and much deeper knowledge of the exterior construction and decorative work and has pointed us towards potential areas for further research. Finally, the laboratory analysis has provided us with some of the first information on the materials used to construct, decorate, and repair these two instruments.

For the Lamont harp the CT scans reveal an instrument strained to the point of failure in all parts of its frame and repaired to continue its useful life. Previously unknown damage and repair work was discovered in each of its members. We now also have a photographic record of the interior of the soundbox, which alone holds enough physical clues to the setup and use of this instrument to keep researchers occupied for some time.

For the Queen Mary harp the laboratory analysis with XRF reveals that it has a forepillar that was richly decorated in vermilion paint and silver metalwork. The CT scans show previously unknown characteristics of the interior construction that will make it possible to build new harps that can more closely reproduce its sound. They also show that hidden underneath its fairly well preserved exterior, this harp also has evidence of internal damage.

Based on what has been learned from the current work, there are plans to re-examine both harps and to conduct additional laboratory tests to ultimately create a complete corpus of information on their materials and construction. The analysis and interpretation of the existing data is just beginning. There is a lot of information, and it holds many clues to the construction of these instruments and the history of their working life. It also raises just as many very interesting new questions, which will be considered and explored as this research continues.

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[66] Chris Waltham, and Andrzej Kotlicki, 'Vibrational Characteristics of Harp Soundboards', *Journal of the Acoustical Society of America* CXXIV (2008), p.1775.

Assistant Artefacts Conservator, National Museums Scotland; Dr Suzanne Kirk, Analytical Scientist, National Museums Scotland; Jackie Moran, Assistant Curator, Scotland and Europe, National Museums Scotland; Dr Martin Connell, Queen's Medical Research Institute, University of Edinburgh; Tessa Smith and Danielle Bertram, Radiographers, CRIC, Queen's Medical Research Institute; David Brian, Superintendent Radiographer, CRIC, Queen's Medical Research Institute. The authors would also like to thank Maripat Goodwin for photography of the Lamont harp.

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The Lamont and Queen Mary Harps

Figure 1. *The Queen Mary harp (top) and Lamont harp (bottom), two of the earliest surviving Gaelic harps. The bottom photo shows damage and repair to the forepillar of the Lamont harp. Both harps are shown at the same scale. (National Museums of Scotland, Edinburgh) Top photo: K. Loomis; bottom photo: M. Goodwin. © Trustees NMS.*

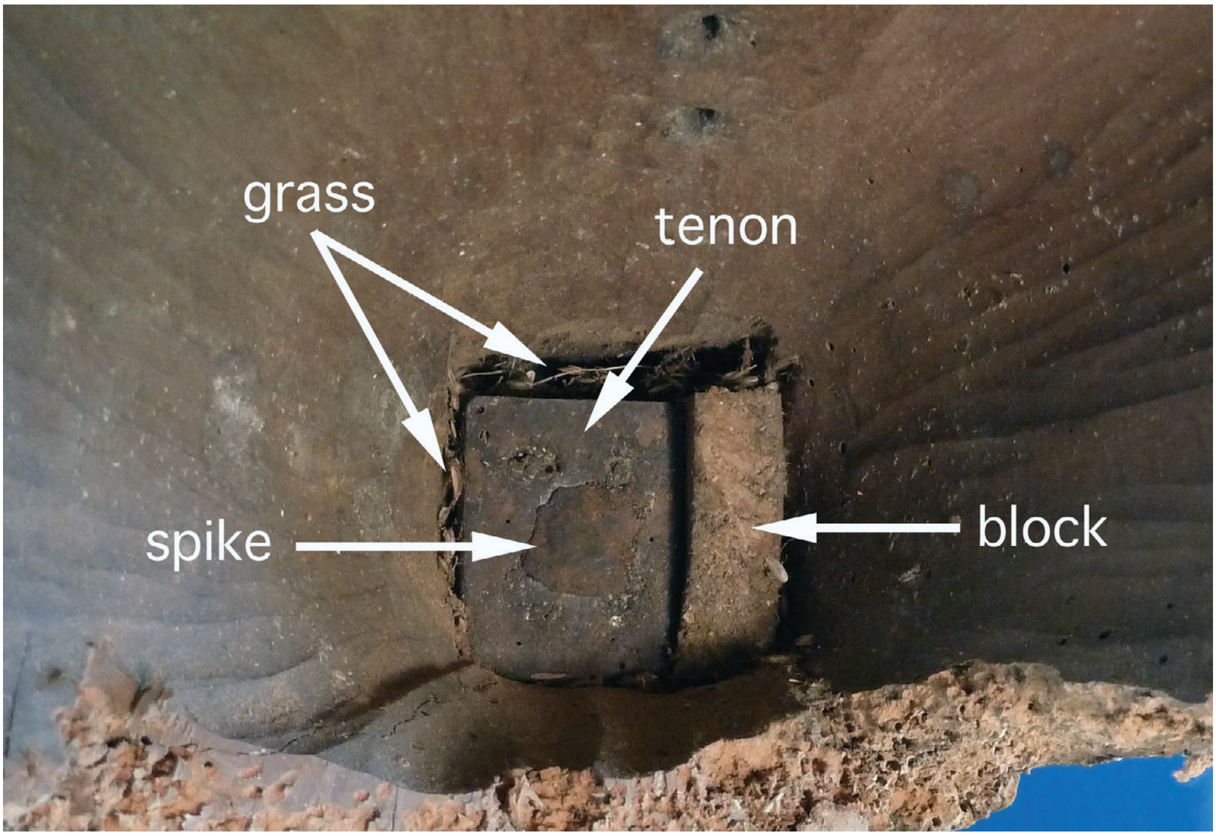


Figure 4. *Interior of the soundbox of the Lamont harp showing toolmarks and repairs to the neck (photo by Karen Loomis, courtesy National Museums Scotland).*

Figure 5. *String toggle indentations, wire impressions, and verdigris stains around the string holes on the inside of the soundbox of the Lamont harp (photo by Karen Loomis, courtesy National Museums Scotland).*

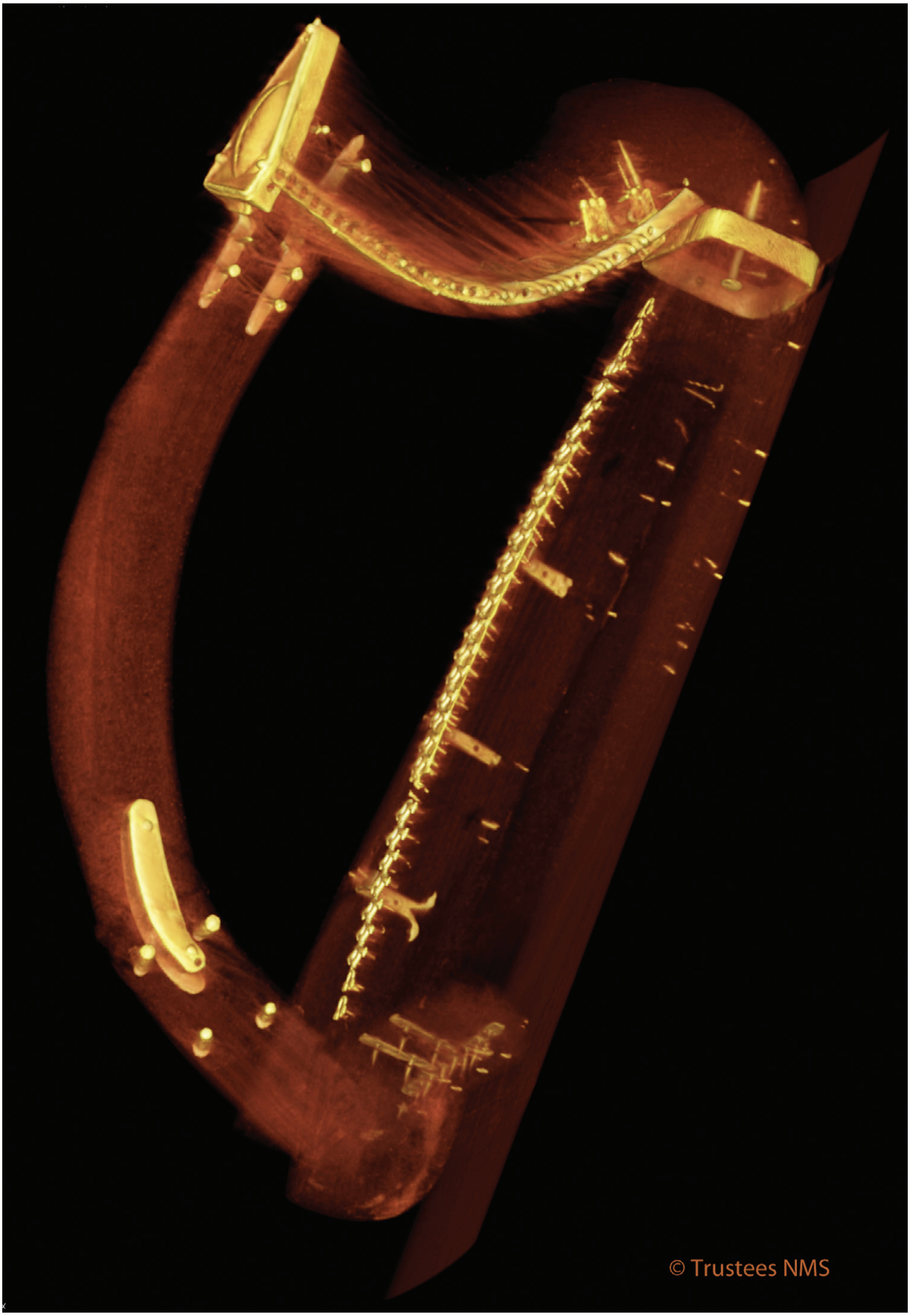


Figure 6. *Tomographic volume rendering of the Lamont harp, showing metal repair work on the inside of the harp.*

Figure 11. *Photographic (top) and tomographic (bottom) views of a section of the forepillar of the Queen Mary harp revealing traces of vermilion (photo by Karen Loomis, courtesy National Museums Scotland).*

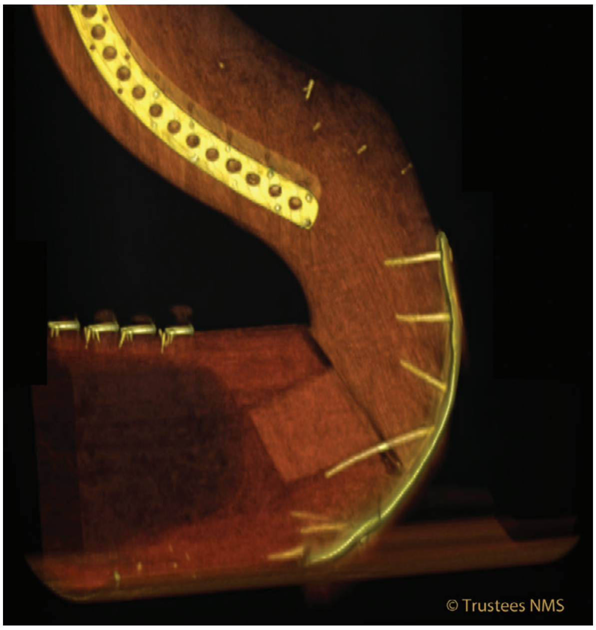
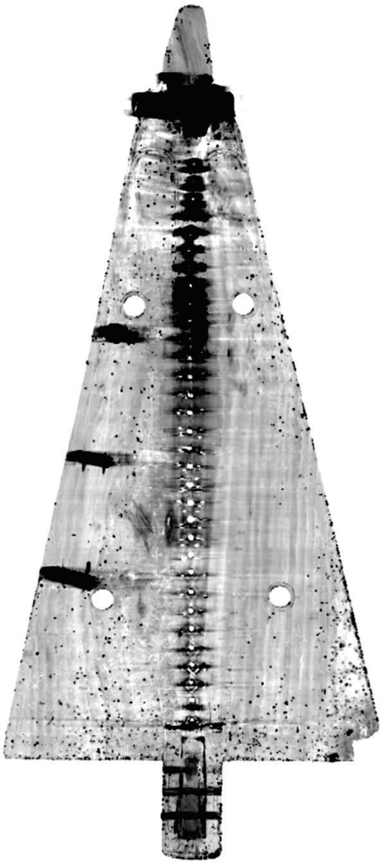
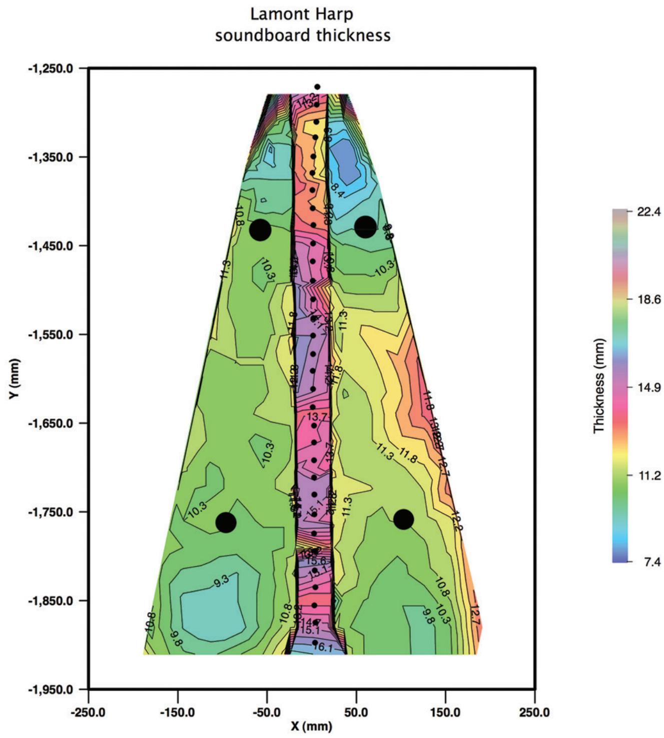


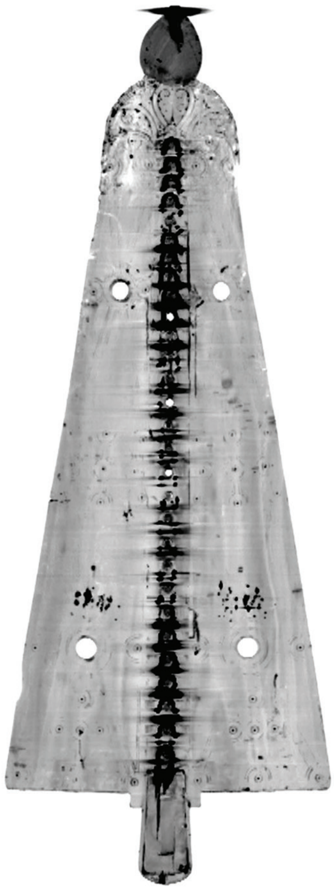
Figure 13. *Tomographic volume rendering of the neck joint at the soundbox of the Queen Mary harp. The nails holding an iron strap in place can be seen, as well as a crack in the tenon. A metal rod, not driven through the strap, is visible at the back of the joint, wedged in between the mortise and tenon.*

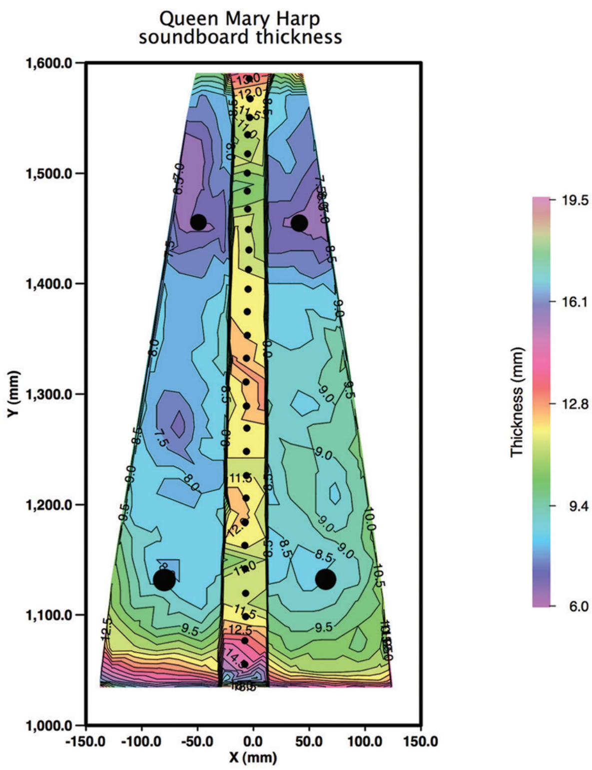
Figure 14. (Facing page, top) *Contour map of the soundboard of the Lamont harp. Thickness increases towards the red end of the colour spectrum (with the exception of the thickest contours on the string band, which had to wrap back around to the blues). Each contour represents a change in thickness of 0.5mm. The colours used in this map represent the same thicknesses in the contour map of the soundboard of the Queen Mary harp. A tomogram of the soundboard is included in the figure for comparison with the appearance of the wood. (Tomogram © Trustees NMS).*

Figure 15. (Facing page, bottom) *Contour map of the soundboard of the Queen Mary harp. Thickness increases towards the red end of the colour spectrum (with the exception of the thickest contours in the extreme bass of the soundbox, which had to wrap back around to the blues). Each contour represents a change in thickness of 0.5mm. The colours used in this map represent the same thicknesses in the contour map of the soundboard of the Lamont harp. A tomogram of the soundboard is also included in the figure for comparison with the appearance of the wood. (Tomogram © Trustees NMS).*




Lamont Harp
soundboard thickness
Y (mm)
-1,250.0
-1,350.0
-1,450.0
-1,550.0
-1,650.0
-1,750.0
-1,850.0
-1,950.0
X (mm)
-250.0
-150.0
-50.0
50.0
150.0
250.0
Thickness (mm)
22.4
18.6
14.9
11.2
7.4




Queen Mary Harp
soundboard thickness
Y (mm)
1,600.0
1,500.0
1,400.0
1,300.0
1,200.0
1,100.0
1,000.0
X (mm)
-150.0
-100.0
-50.0
0.0
50.0
100.0
150.0
Thickness (mm)
19.5
16.1
12.8
9.4
6.0