The Queen Mary and Lamont Harps:
A Study of Structural Breaks and Repairs

A thesis submitted for the MMus in Musical Instrument Research
by
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The Lamont Harp – archival photograph courtesy of the National Museums of Scotland

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- Karen Loomis
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All of the tomograms in this document were rendered by the author with the OsiriX v. 3.8 DICOM viewer. Unless otherwise noted, all photographs and images are © Trustees NMS.

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Introduction:

The Queen Mary and Lamont harps are two surviving examples of a musical instrument that was endemic to Ireland and the highlands of Scotland from at least the 12th century to the first half of the 19th century.[1] Amongst the primary distinguishing features of this instrument, referred to in this paper as the "Gaelic harp", were metal strings and a sturdy construction that included a soundbox carved out of a single piece of wood.[2] The Gaelic harp was, by historical accounts, a highly regarded and high status instrument with a unique sound and repertory.[3] Since it fell out of use in the early 19th century, there has been sporadic interest in this instrument and its repertory.[4] The modern revival of the Gaelic harp as an historical musical instrument began in earnest in the 1970's with Ann Heymann's groundbreaking work reconstructing the instrument, its repertory, and its unique playing technique.[5] Interest in this instrument and its repertory has continued to grow in recent years, leading to a need for more research and analysis of the surviving harps.

For any early music performer, access to an original instrument, or a faithful reconstruction, plays an important role in the study of historical repertory and performance practice. In the preface to her first tutor book on the Gaelic harp, Heymann herself states

> "nothing could have prepared me for the lessons that the instrument itself was to teach"[6]

Far beyond being simply a source of physical dimensions for the purpose of building replicas, surviving instruments are a treasure trove of unique, direct, and concrete

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[1] Armstrong, R. B. (1904) *The Irish and Highland Harps*. Edinburgh, David Douglas. Facsimle reprint (1969) New York, Praeger Publishers, Inc., pp. 1-54.
[2] Talbot, J. (late 17th c.) *Christ Church Library Music MS 1187*. Quoted in Rimmer, J. (1963) James Talbot's Manuscript (Christ Church Library Music MS 118): VI. Harps, *The Galpin Society Journal,* 16 (May), p. 67, and Armstrong R. B. (1904) op. cit., p. 28.
[3] Bunting, E. (1840) *The Ancient Music of Ireland, etc*. Dublin, Hodges and Smith, pp. 1 ff. Facsimile reprint (1969) Dublin, Waltons' Piano and Musical Instrument Galleries.
[4] Sanger, K. and Kinnaird, A. (1992) "A Harp New-Strung" in *Tree of Strings: A History of the Harp in Scotland*. Shillinghill, Kinmor Music, pp. 207-211.
[5] Heymann, A. (1988) *Secrets of the Gaelic Harp*. Minneapolis, Clairseach Productions, p. 5.
[6] ibid.

information on construction philosophy, intended and actual use, and modifications that were made to the instrument. The earliest surviving Gaelic harps are particularly interesting objects of study, as they provide a window into the construction and use of this instrument in its form prior to the middle of the 17th century. There are four known intact examples of these early Gaelic harps, the "Trinity" and "Castle Otway" held at Trinity College, Dublin, and the "Queen Mary" and "Lamont" held at the National Museums of Scotland. Fragments of two others, the "Ballinderry" and "Cloyne" (in the first instance, the metalwork, and in the second, the neck and part of the forepillar) are held at the National Museum of Ireland.

To date the research that has been conducted on these harps has been quite limited. The primary source is Robert Bruce Armstrong's excellent 1904 volume "The Irish and The Highland Harps", which to its credit, is still the standard reference on the subject.[7] Aside from Armstrong's careful visual inspections and illustrations, the research that has been done on these harps consists primarily of a limited number of photographs and incomplete measurements, which only provide a tantalizing glimpse at the wealth of information these instruments contain on their construction.[8] Of particular interest is the evidence of historical damage and repair each instrument shows, hinting at much more information hidden below the surface. Historical damage to an instrument can be studied as a means to discovering clues to how it was originally constructed, what the construction philosophy was, and how the instrument was used and modified over time. A visual examination, even a careful one, can only reveal what is on the surface and possibly hint at what is not seen. In order to really get a complete picture, one must be able to look inside the instrument and, furthermore, see inside the areas of damage and repair. To date, there has never been a study conducted of the structural damage and repairs, or even of the interior construction, of any Gaelic harp. There is currently very little published work even showing the inside of any of the instruments. The exceptions are an illustration in Armstrong (1904) of part of the inside of the soundbox of the Otway harp[9] and a photograph in Rimmer (1969) of part of the inside of the soundbox of the Downhill

[7] Armstrong, R. B. (1904) op. cit.
[8] Rimmer, J. (1969) *The Irish Harp*. Cork, The Mercier press, pp. 28-50, for example.
[9] Armstrong (1904) op. cit, p. 28.

harp.[10] In both cases the detail is limited. There are no published descriptions of the interiors of any of the instruments and, with the exception of a conservation x-ray of the Trinity harp (which has never been published or described, and whose whereabouts is currently unknown),[11] no Gaelic harp has ever been x-rayed.

Realizing that a study of the structural damage and repairs as well as an examination of the interior of a Gaelic harp was long overdue and would bring enormous benefit to the study of this instrument, the author chose to embark on a study of the Queen Mary and Lamont harps held in the collections of the National Museums of Scotland, which would involve X-ray computed tomography (CT scanning) of the instruments, allowing an unprecedented direct look at the interiors of the instruments, inside their joints and into the wooden members. CT scanning has successfully been used to detect internal damage and repair of bowed stringed instruments, by detecting internal cracks, splices, and putty used for repairs, as well as making it possible to view the wood grain and woodworm damage.[12]

Permission was generously granted to have access to both harps and to the Conservation and Analytical Research staff and facilities at the National Museums of Scotland Collection Centre in Edinburgh.[13] Arrangements were made and permission was also generously granted to have both harps CT scanned at the Clinical Research Imaging Centre (CRIC), based at the University of Edinburgh's Queen's Medical Research Institute. X-ray computed tomography, often referred to as "CT scanning", is a method of creating a three dimensional x-ray built up of individual two dimensional x-ray "slices" taken by directing a focused x-ray beam cross-ways through the object to a detector on the opposite side.[14] The "slices" are created by

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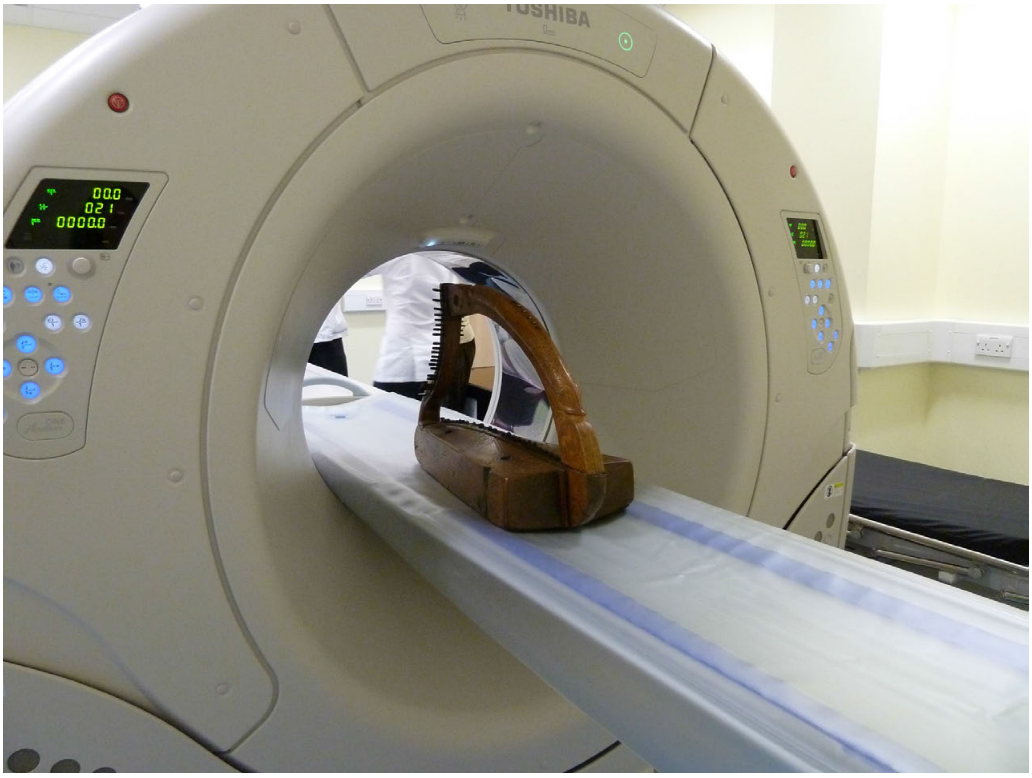
[10] Rimmer, J. (1969) op. cit., p. 65.
[11] Author unknown (1962) Restoration of the Great Irish Harp. *Dept. of Foreign Affairs Bulletin*, 26 February, p. 4
[12] Sirr, S., and Waddle, J. (1999) Use of CT in Detection of Internal Damage and Repair and Determination of Authenticity in High-Quality Bowed Stringed Instruments. *Radiographics,* 19(3) May-June, pp. 639-646.
[13] In addition to CT scanning, examination, photography, and X-Ray fluorescence spectroscopy (XRF) were conducted at the Museums Collection Centre with the generous assistance of the Conservation and Analytical Research staff. Analysis of the XRF data will be used in a future research project, so it will not be discussed further in this paper.
[14] Kalender, W. (2006) X-ray Computed Tomography. *Physics in Medicine and Biology,* 51, pp. 29-43.

slowly passing the object through the plane of the beam as the beam and detector rotate around it.[15] The Queen Mary and Lamont harps were CT scanned with the CRIC Toshiba Aquilion One 320-Slice Computed Tomography Scanner, a new, state of the art instrument that produces detailed 3D images and has a bore large enough to permit passage of the harps through the scanner.[16] Photographs of the Queen Mary and Lamont harps being set up for scanning are shown in figures 1 and 2.

Figure 1.



The Queen Mary harp in the bore of the Clinical Research Imaging Centre Toshiba Aquilion One Computed Tomography scanner on 17 June 2010. Photo: Karen Loomis.

[15] like a spiral cut ham

[16] Wellcome Trust Clinical Research Facility/Clinical Research Imaging Centre (2009) *CT Scanner*. [online] Available at http://www.wtcrf.ed.ac.uk/CRIC/CTscanner.htm [accessed 14 August 2010].

Figure 2.

Setting up the Lamont harp for scanning in the Clinical Research Imaging Centre Toshiba Aquilion One Computed Tomography scanner on 8 July 2010. From l-r, Dr. Martin Connell CRIC IT Support, Tessa Smith, CRIC Radiographer, Dr. Jim Tate, National Museums of Scotland Head of Conservation and Analytical Research, and Karen Loomis, University of Edinburgh MMus student. Photo: Maripat Goodwin.

The files **QM_scan.MOV** and **Lamont_scan.MOV** included on the disc accompanying this paper are video clips of each of the harps being scanned.

The technical terms associated with CT scanning, and used in this paper, are described as follows:

- X-Ray computed tomography ("CT scanning") – a method of obtaining a three-dimensional x-ray constructed of individual, two-dimensional slices (see above for a more complete description).
- Axial plane – any plane through a body that divides it between top and bottom. For the harps, this plane is parallel to the base end of the soundbox.
- Coronal plane – any plane through a body dividing it between front and back. For the harps, this plane is parallel to the soundboard.

- Sagittal plane – any plane dividing a body between the left and right sides. For the harps this plane is perpendicular to the soundboard and parallel to the long axis of the instrument.
- Tomogram – a three dimensional image (or a cross-section of one) produced by assembling individual two dimensional image slices. In the tomograms presented in this paper, the "brightness" of an object represents its relative opacity to x-rays. So, for example, metals are rendered as "bright" or white, in contrast to woods, which are rendered in shades of grey.

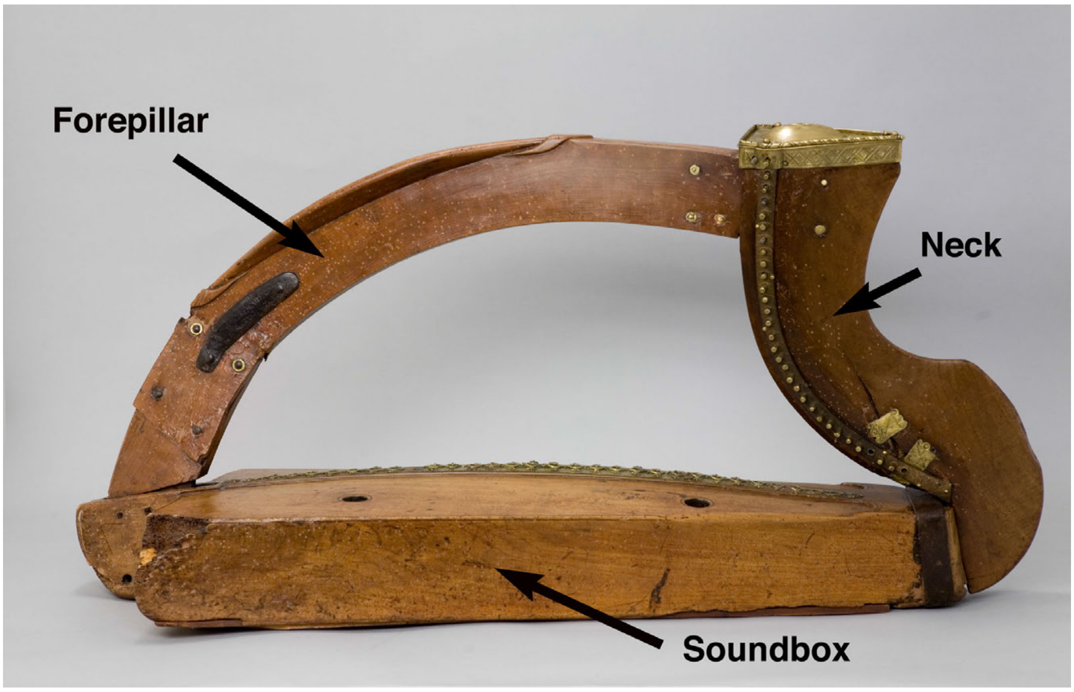
The convention for "left" and "right" used in describing the harps is the same as that used in medicine, where "left" and "right" are determined from the harp's own perspective.

This paper presents the findings of this study in two parts. Part I discusses the structural damage and repairs to the Lamont harp, and Part II discusses the same for the Queen Mary harp. The study of each harp is broken down into examinations of each of the three members of the instrument, the soundbox, the forepillar, and the neck, with a separate section devoted to the neck joint at the soundbox. The basic construction of the early Gaelic harp, and its parts, are described in the introduction to Part I.

Part I: The Lamont Harp – Damage and Repairs

This chapter discusses evidence of damage and structural repairs made to the Lamont harp, as revealed by CT scanning of the instrument. The Lamont harp, like other known surviving early Gaelic harps, has a frame constructed of three members, the "neck", "forepillar", and "soundbox" joined together with mortise and tenon joints. The neck is mortised at its joint with the forepillar, and has a tenon at its joint with the soundbox. The forepillar has a tenon at each end: at the neck joint, and at its joint with the soundbox. The soundbox is mortised at both ends. The three basic parts of the harp are illustrated in figure 3 on a photograph of the Lamont harp.

Figure 3.

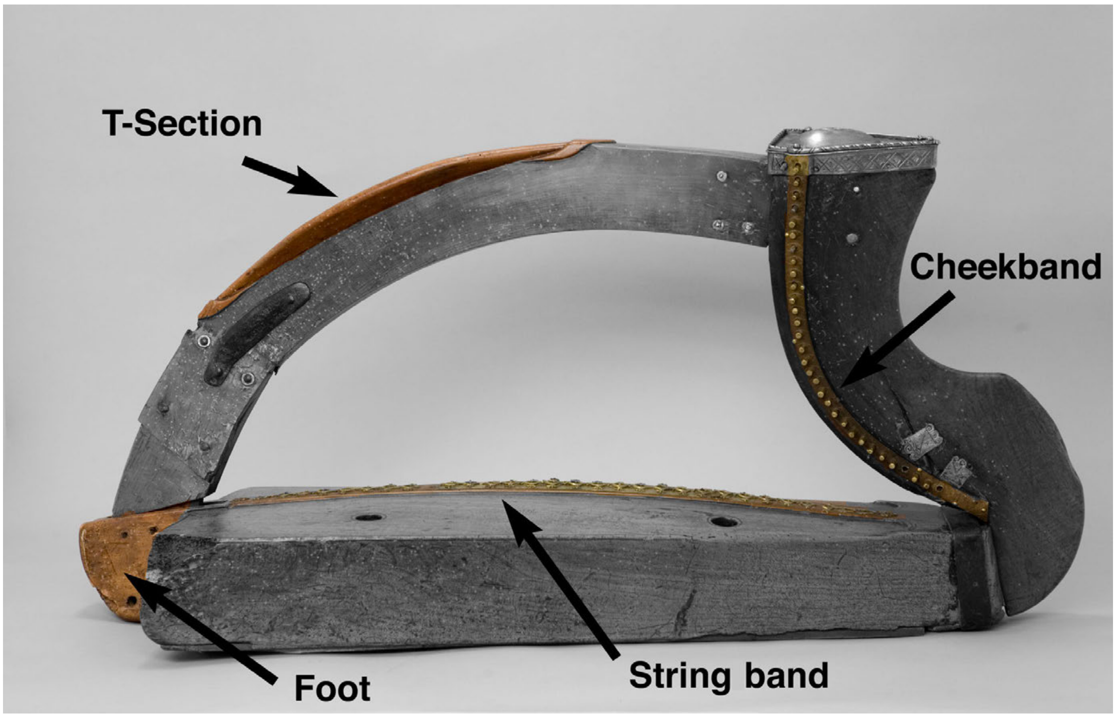


The Lamont harp, illustrating the parts of the Gaelic harp frame. Photo: Maripat Goodwin, courtesy of the National Museums of Scotland. Labels added by the author.

Most notably, the entire soundbox is carved from a single large block of wood, rather than being built up. This is a distinguishing feature of the Gaelic harp, and is a fundamental design characteristic that was maintained until shortly before the instrument fell out of use in the early 19^{th} century.

Other parts of the harp that are relevant to this discussion are the "foot" or "projecting block", which is an extension of the base of the soundbox upon which the harp balances when it is held in playing position, the "t-section", which is a strengthening flange on the forepillar, the "cheekband", which is a metal band attached to the neck through which the tuning pins pass, and the "string band", which is the line of holes in the soundbox through which the strings pass. The path the cheekband follows on the neck is referred to as the "harmonic curve". Presumably, the cheekband's function is to prevent the tuning pins from tearing through the neck under the tension of the strings. The string band is generally a raised, thicker central strip of the soundboard with metal reinforcements, or "string shoes" at the holes to prevent the strings from slicing through the soundboard. These additional parts of the harp are illustrated in figure 4.

Figure 4.



Parts of the Gaelic harp, highlighted in color for clarity, on the Lamont harp. Photo: Maripat Goodwin, courtesy of the National Museums of Scotland. Labels added by the author.

During its working life as a musical instrument, the Lamont harp would have been strung with wire, most likely brass. The historical evidence for this manner of stringing is discussed in the addendum to this paper. It is not known how heavily these harps were strung, but a typical stringing regime for a modern Lamont style replica has a total of over 3500 N of tension.[17] The "stocky" construction of Gaelic harps (the soundboard of the Lamont harp is 10 mm thick[18]) and the evidence of built-in structural reinforcements such as the t-section and the cheekband suggest they were designed to withstand relatively high tension. Nevertheless, even a sturdy harp kept under tension for a very long period of time will show signs of strain and possibly failure at vulnerable points in its construction. This is illustrated beautifully in the archival photograph of the Lamont harp shown in figure 5. This end on photograph of the harp shows the twisting of the neck that has resulted from the torque exerted by the strings, which were strung from the left side of the neck down to the front face of the soundbox.

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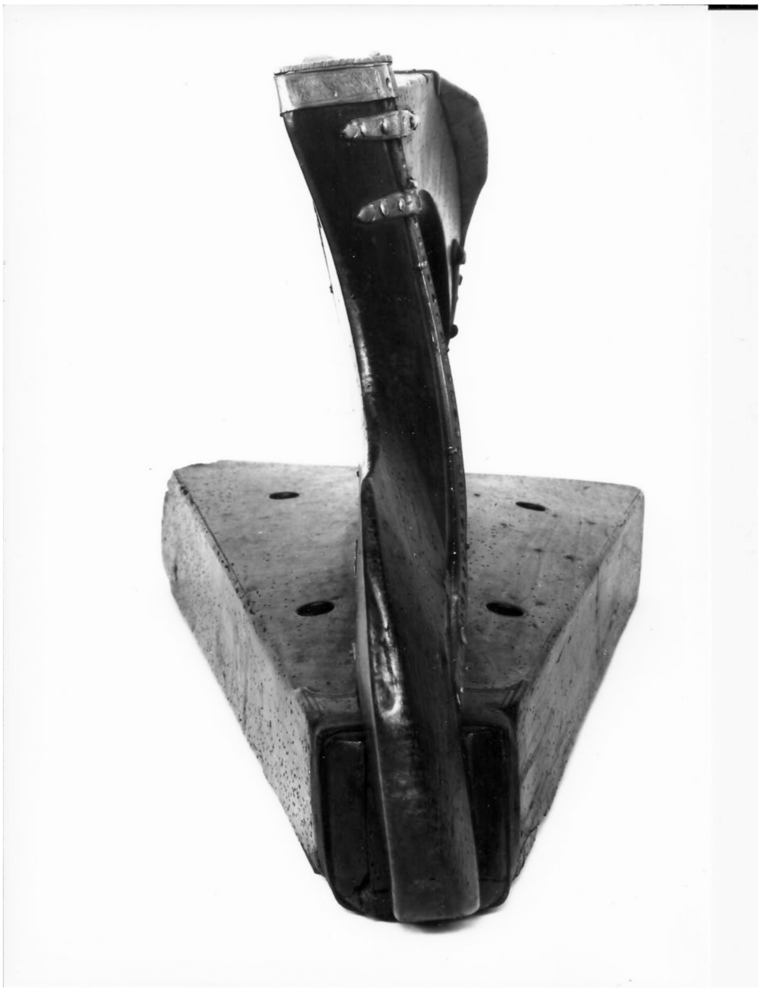
[17] Calculated for the author's Lamont replica using the formula: $T = f^2L^2\varrho\pi D^2$, where f is the tuned frequency of the string in Hz, L is the string length in m, ϱ is the density of the string material in kg/m^3, and D is the diameter of the string. Formula from Rose, M. and Law, D. (1991) *A Handbook of Historical Stringing Practice for Keyboard Instruments*. Lewes, Malcom Rose &David Law, p. 191.

[18] Measurements obtained by the author from CT data of the harp. This is the first reported measurement of the soundboard thickness for this instrument. Detailed measurements of the harp will be presented in a forthcoming paper.

Figure 5.



End on view of the Lamont harp, showing twisting of the neck due to the torque exerted by the strings, which were strung from the left side. Courtesy of the National Museums of Scotland, 5x7 negative film, date unknown.

The story of structural repairs to Gaelic harps, and the Lamont harp in particular, is primarily one of remedying damage caused by the tension of the strings whilst maintaining their ability to function as musical instruments. In this part of the study, details of the repairs made to the Lamont harp as newly revealed by CT imagery, will be examined and discussed.

Section 1: The soundbox

This survey of the Lamont harp repairs begins with the soundbox. Historical evidence indicates that the soundboxes of Gaelic harps were traditionally carved from a single block of wood,[19] and Armstrong (1904) and Rimmer (1964) confirm this in their examinations of surviving instruments.[20] The Lamont, like other surviving early Gaelic harps, has a pronounced rise, or "belly" on the front face of its soundbox. It is not known if this is due entirely to deformation of the wood from the tension of the strings, or if the soundbox was carved to this shape, but some deformation is to be expected under the tension of the strings.[21] Indirect evidence of this is visible on the CT cross section of the Lamont harp soundbox shown in figure 6. The soundbox shows a slight pulling in on its left side, presumably due to the front surface being pulled upwards by the strings.

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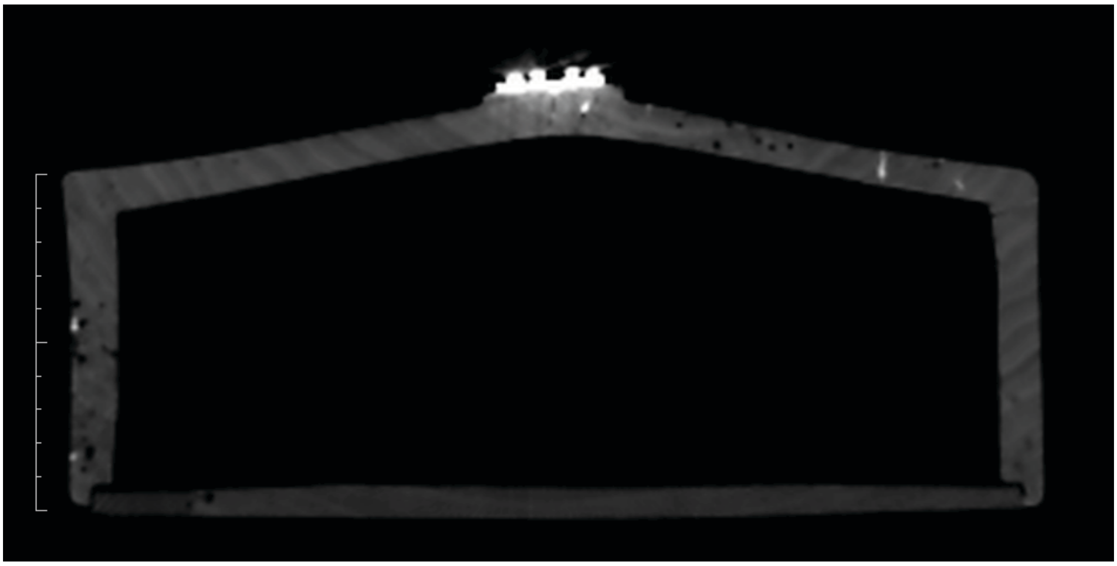
[19] Talbot, J. (late 17th c.) *Christ Church Library Music MS 1187*. Quoted in Rimmer, J. (1963) James Talbot's Manuscript (Christ Church Library Music MS 118): VI. Harps, *The Galpin Society Journal,* 16 (May), p. 67.

[20] Armstrong, R. B. (1904) op. cit., pp. 28-33, and Rimmer, J. (1964) The Morphology of the Irish Harp, *The Galpin Society Journal,* 17 (February), p. 39.

[21] The soundbox of the author's replica of this harp was carved with a flat front face. It has been under tension for 16 years and the belly has risen 16 mm at its highest point.

Figure 6.



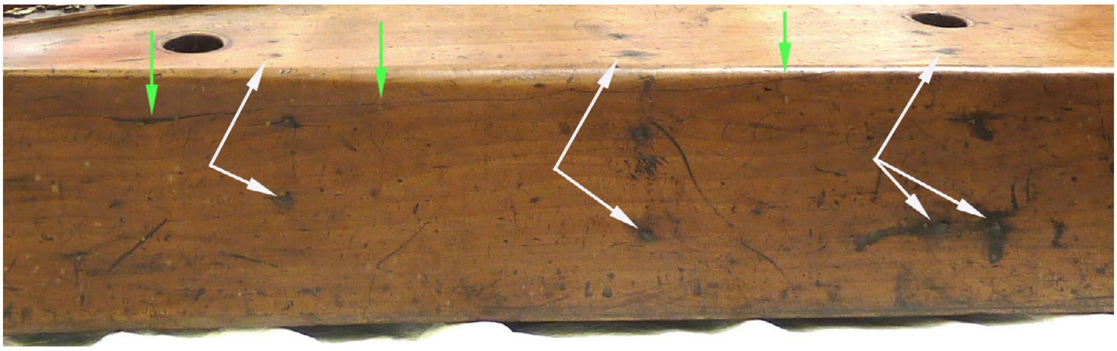
CT cross-section of the Lamont harp soundbox showing the raised "belly" on the front face (towards the top of the tomogram) and the left side pulled in slightly. Each tick on the scale in the tomogram equals 1 cm. Tomogram obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland, 2D rendering by Karen Loomis.

The right side of the soundbox doesn't appear to be pulled in. A possible reason for this is evident upon examination of a repaired crack along that side of the box.

Figure 7 is a photograph of the crack visible on the right side of the harp's soundbox. Also visible in the photograph are nail ends, which appear as lines of several small dark patches on the side and front face of the soundbox. Up to the present, it had been assumed this harp had had its soundbox strapped from the outside, in the manner of historical repairs to some other surviving Gaelic harps,[22] and that the nail ends visible on the outside of the box were left behind, presumably after the straps had been removed.

[22] E.g. the "Kildare", "OFfogerty", and "Downhill" harps. See Armstrong, R. B. (1904), op. cit. pp. 70, 80, and 89.

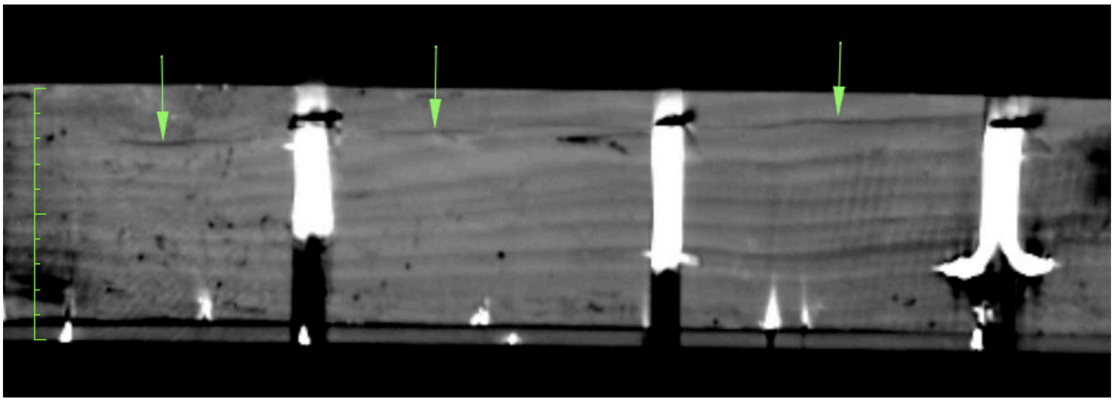
Figure 7.



Photograph of the right side of the Lamont harp soundbox, showing a crack (green arrows). Nail ends are visible as lines of small dark patches on the side and front face of the soundbox (white arrows). Photo by Karen Loomis, courtesy of the National Museums of Scotland.

Figure 8 shows a CT cross-section along the inside wall of the same area of the soundbox shown in figure 7. The crack visible on the outside can be seen running just below the front corner of the soundbox, although it follows a slightly different path on the outside surface of the box.

Figure 8.



CT cross-section along the inside surface of the right side of the Lamont harp soundbox. A long thing crack running just below the top corner of the box is visible (arrowed). Also visible are three metal straps affixed to the inside of the soundbox. The scale is 1 tick = 1 cm. Tomogram obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland, 2D rendering by Karen Loomis.

The tomogram also clearly shows three metal straps affixed to the inside of the soundbox. The nail ends visible on the outside of the soundbox are not left over from exterior metal straps that had been removed. They belong to interior metal straps that are still in place, whose presence was neither known nor suspected until they were revealed in the tomograms.

Before the current research work commenced on the Queen Mary and Lamont harps, the Museum staff and the author had discussed the possibility of removing the back cover of each harp for inspection of the interior of the soundbox. We concurred that, due to the fragility of the instruments and the way in which the covers are currently attached, it would not be advisable to try to remove them. The back cover of the Lamont harp was loose, however, and after it was CT scanned the cover came off upon the instrument's return to the Museum. In addition to the metal straps visible in the tomograms, numerous other items of interest were observed in the interior, which will be discussed in depth in a forthcoming paper.[23] Examination of the inside of the

[23] The interior of the soundbox of the Lamont harp was first observed by Hobrough in 1976 and reported in an unpublished letter in 1979. Hobrough describes some important features

soundbox revealed the metal straps that were first observed in the tomograms. They are embellished with decorative work and appear to have been fashioned from a single strap cut into three pieces. Old nail holes in the metal work suggest it was recycled from elsewhere. The straps are coated in verdigris, suggesting that the metal is a copper alloy. They are nailed over a large vellum patch glued to the inside surface of the soundbox, over the crack. The vellum has writing on it and is itself an entirely new discovery and an item of interest. The vellum document and the straps are currently being researched and will be discussed in depth in a future paper. Figure 9 is a photo of the interior of the soundbox, showing the straps and vellum repair to the crack in the side of the box.

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in the soundbox but, curiously, omits some others. Hobrough, T. (23, January 1979) *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 of Scotland.

Figure 9.

Interior of the Lamont soundbox showing the metal straps and vellum patch used to repair the crack on the right side of the soundbox. Verdigris on the straps indicates that they are made of a copper alloy. The vellum has handwriting, which will be discussed in detail in a future paper. Photo by Karen Loomis, courtesy of the National Museums of Scotland.

At the beginning of this discussion, it was pointed out that, although the left side of the soundbox has pulled in, the right side of the soundbox has not. The crack provides a possible explanation for this. When the harp was brought under the tension of the strings, the soundbox deformed. The front pulled up and the left side pulled inwards. On the right side, it's possible that, instead of deforming, the wood failed and a crack formed, which acted like a hinge as the front of the soundbox pulled upwards.

A notable feature on the front of the soundbox is the presence of a metal band comprising three metal strips inserted under the string shoes along the highest portion of the belly, as shown in the photograph in figure 10. These strips were reported by Gunn (1807),[24] and are visible in an 1888 lithograph by William Gibb.[25]

Figure 10.

The stringband of the Lamont harp showing a metal band inserted under the string shoes from holes #8 - #22. Photo: Maripat Goodwin, courtesy of the National Museums of Scotland.

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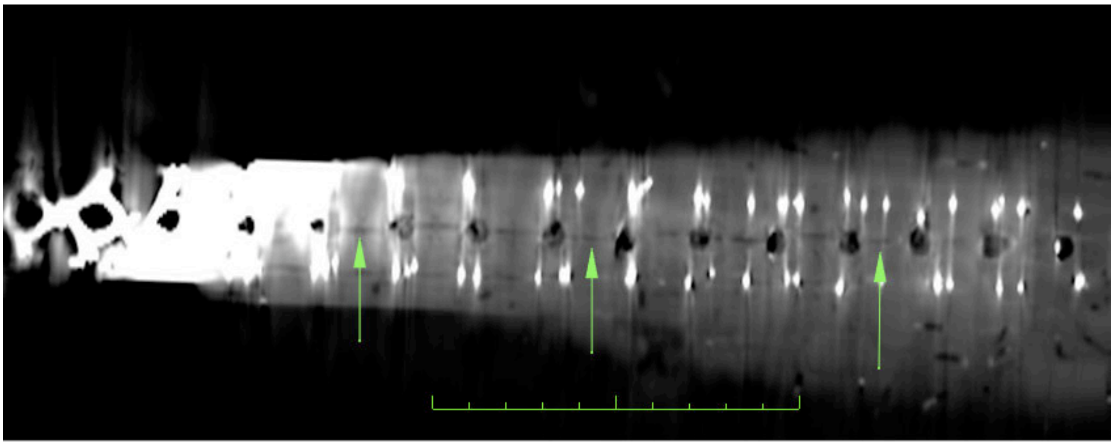
[24] Gunn (1807) *An Historical Inquiry Respecting the Performance on the Harp in the Highlands of Scotland*. Edinburgh, Archibald Constable. *Facsimile CD* (2005) Scotdisc., pp. 5-6.

[25] Hipkins, A. J., and Gibb, W. (1888, reprinted 1921) *Musical Instruments: Historic, Rare, and Unique*. London, A. and C. Black, Ltd., plate III.

Armstrong (1904) examined the string band and concluded that the metal strip was not a repair to a crack, as he did not observe one in this location.[26] The metal band does suggest a repair, however, and tomograms of the string band revealed a 30 cm long crack hidden under the band, running along the center line of the string holes, as shown in figure 11.

Figure 11.



CT cross-section parallel to the front face of the soundbox of the Lamont harp, showing of a crack along the string band (arrowed). The treble end of the harp is towards the left side of the tomogram. The scale is 1 tick = 1 cm. The dark circles are the string holes and the bright dots are nails attaching the string shoes and a metal band to the front of the soundbox. Tomogram obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland, 2D rendering by Karen Loomis.

The metal band was apparently put on the harp as a repair, as it is just slightly longer than the crack and is centered on it. Photographs of the interior of the soundbox confirmed the presence of the crack. Taking into consideration the tension of the strings pulling upwards on the string band, and the presence of the string holes perforating the front of the soundbox, it is not at all surprising to find a crack in this location.

At the base of the soundbox is the foot of the harp, upon which the weight of the instrument rests when it is being played. The foot of the Lamont harp has had its

[26] Armstrong (1904) op. cit., p. 160.

center cut out and a replacement block of wood let in. This is reported in Armstrong (1904),[27] and is described in detail by Hobrough (1979) who observed it from the inside of the soundbox. Hobrough reported seeing the inside end of the replacement block of wood with a π shaped metal strap across it, as well as a crack in the original wood of the foot and a second crack in the base of the soundbox.[28] Figures 12 and 13 are photographs of the outside and inside views of the foot, showing the let in block of wood and the metal strap.

Figure 12.

The foot of the Lamont harp, showing the replacement block of wood that has been let into it. Photo: Maripat Goodwin, courtesy of the National Museums of Scotland.

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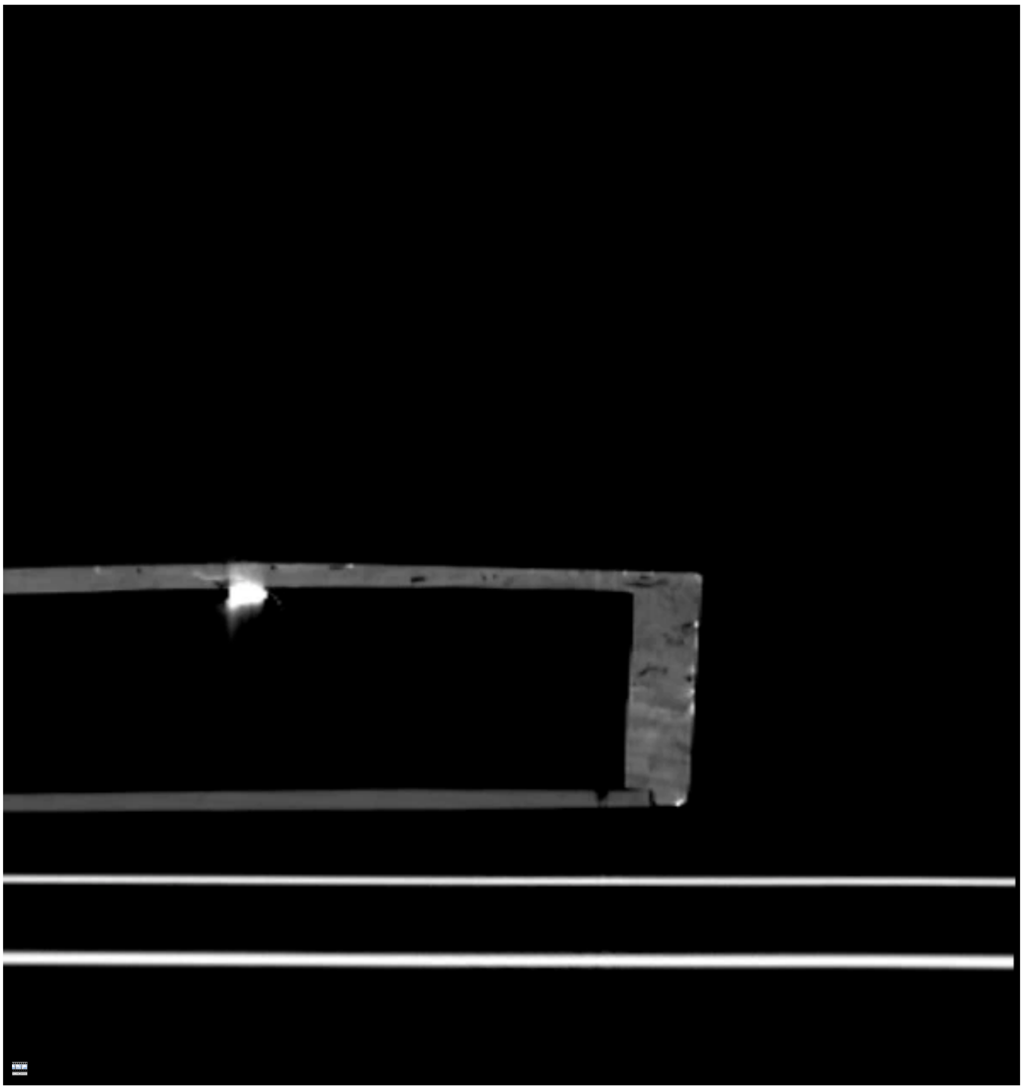
[27] Armstrong, R. B. (1904), op. cit., p. 161.
[28] Hobrough, T. (1979), op. cit.

Figure 13.

Interior view of the base of the Lamont harp soundbox, showing the block of wood inserted into the foot, and the metal strap nailed across it. Photo by Karen Loomis, courtesy of the National Museums of Scotland.

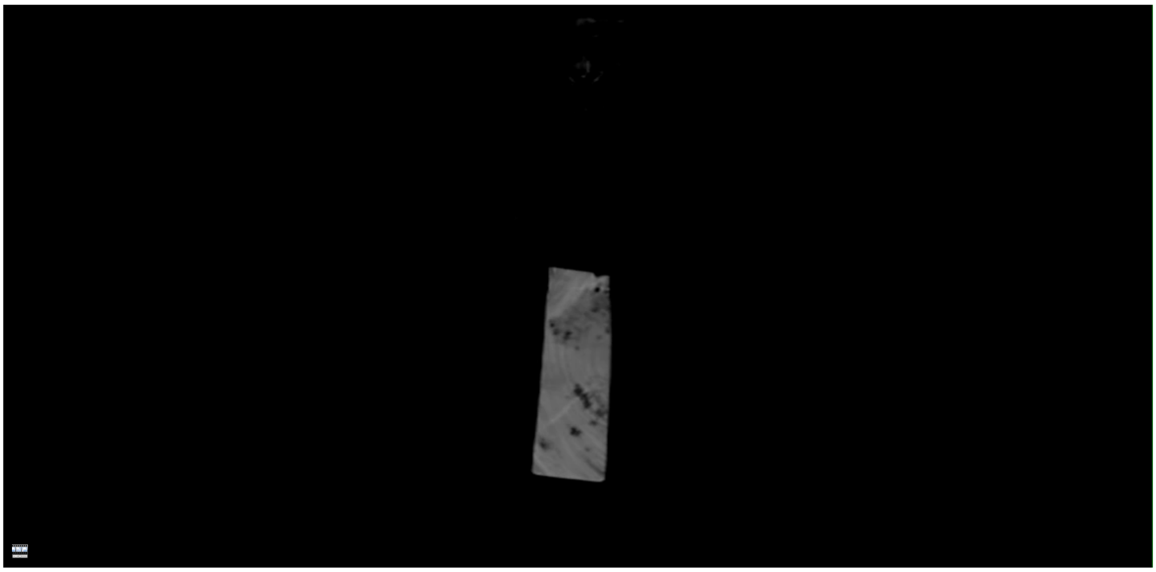
The putty applied to and around the foot suggests decay or woodworm damage. CT cross sections of the foot of the harp do reveal extensive woodworm damage, as shown in the video clips in figures 14 and 15.

Figure 14.



Video clip of the sagittal (side) view of the foot of the Lamont harp, passing through the base of the soundbox. The images reveal the extent of internal woodworm damage, which appears as dark squiggles where the larvae have eaten tunnels through the wood. The wood block let into the foot appears as the lighter grey section at the back of the foot. The front of the harp is towards the top of the tomogram, and the forepillar can be seen extending down into the foot midway through the clip. This video clip is available in the electronic form of this document and also as the file ***Lam_foot_sag.mov*** *on the disc accompanying the paper copy. Tomograms obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland, 2D rendering by Karen Loomis.*

Figure 15.



*Video clip of the coronal (top) view of the foot of the Lamont harp, descending through the harp from above the front of the soundbox. Extensive woodworm damage is visible in and around the foot. The tenon belonging to the forepillar is visible as a lighter grey oblong in the center of the foot. The metal strap attached to the inside of the soundbox is visible as a white line across the inside of the base of the soundbox. This video clip is available in the electronic form of this document and also as the file **Lam_foot_cor_02.mov** on the disc accompanying the paper copy. Tomograms obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland, 2D rendering by Karen Loomis.*

The video clips in figures 14 and 15 contain a lot of interesting information, some of which will be discussed in the section on the forepillar. Focusing for the moment on the foot of the harp, extensive woodworm damage is visible. Some of the external damage has been covered cosmetically with putty, which appears bright in the tomograms.

Much of the internal woodworm damage extends from cracks and follows the seams around the replacement block let into the foot. The adult beetles may have used the cracks and seams as entry points. It's possible that the block was let into the foot as a repair to woodworm damage, and that the infestation continued after the repair was made. Another possibility is that the block was let in to repair a crack in the wood (the base of the soundbox and the end of the foot is end grain), and the adult beetles took advantage of the seams around the repair. The metal strap is nailed to the inside of the soundbox across the repair, presumably to reinforce the bottom of the soundbox, distribute the load on the foot across the base, and to prevent the inserted block of wood from pushing upwards when the harp is resting on the foot. There are two holes through the foot for dowels to secure the replacement block to the original wood of the foot. The tomograms show that these dowels are now missing and that the inserted block has shifted upwards slightly under the weight of the harp.

The current state of the interior of the foot as revealed by the tomograms is of importance from the standpoint of conservation. There is extensive interior woodworm damage compromising the foot, as well as evidence that the block of wood that has been let into it is being pushed upwards by the weight of the harp against an antique iron strap. The Lamont harp is currently displayed in the Museum with all of its weight resting on the foot.[29] Conservation staff are planning to construct a new display stand that takes the weight off of the foot and distributes it over the base of the soundbox. The tomograms of the foot and base of the soundbox reinforce the need for a new stand and will aid conservation staff in considering its design.

Section 2: The forepillar

The most visually striking structural repair on the Lamont harp is on its forepillar, which appears to have snapped in two and had its lower third replaced with a new piece of wood joined by a scarf joint secured by two iron straps and four additional rivets, which can be seen in figure 1 of the left side of the harp, and in close up from the front in figure 16.

[29] The Lamont harp was weighed for this study, and it weighs 8 kg.

Figure 16.

Close up photo of the scarf joint repair to the forepillar of the Lamont harp. The two pieces of wood are fastened together by two iron straps and four additional rivets. Photo: Maripat Goodwin, courtesy of the National Museums of Scotland.

This repair is first reported in Gunn (1807),[30] and is described in detail by Armstrong (1904), who gives a very good account of the nature of the break and the repair.[31] The forepillar has bowed towards the right side of the harp (opposite to the side to which the strings are attached). This would have occurred when the harp was first brought up to tension, and is probably the cause of the break. The point of highest lateral stress would be in the center of the forepillar. This is reinforced by the t-section, however. So, it failed at the first weak point, just below the end of the t-section. The wood around the crack is crushed on the inside face of the curve and on the left side

[30] Gunn (1807), op. cit., p. 6.
[31] Armstrong (1904) op. cit., p. 165.

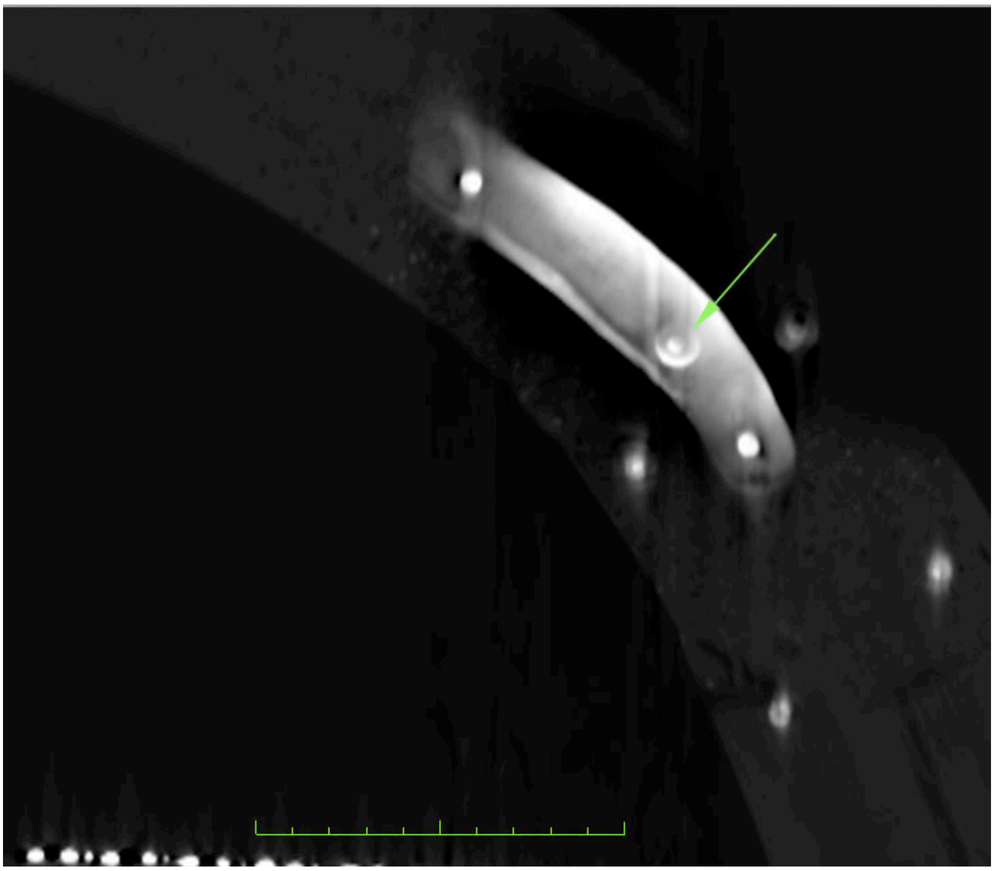
of the forepillar, and the crack has opened up on the front face and on the right side, as evident in figure 17.

Figure 17.

Right hand side view of the crack and repair in the forepillar of the Lamont harp. Crushed wood at the back of the crack is visible in this photo. The crack has opened up on the right side, and on the front face as well. Photo: Maripat Goodwin, courtesy of the National Museums of Scotland.

When the harp was brought back up to tension, the joint apparently pivoted, causing the wood to be crushed at the back. The joint also bowed towards the right, causing the wood to crush on the left side. Essentially all of the damage and repair are in plain view, but the tomograms did reveal an additional rivet hidden underneath the iron straps, as shown in figure 18.

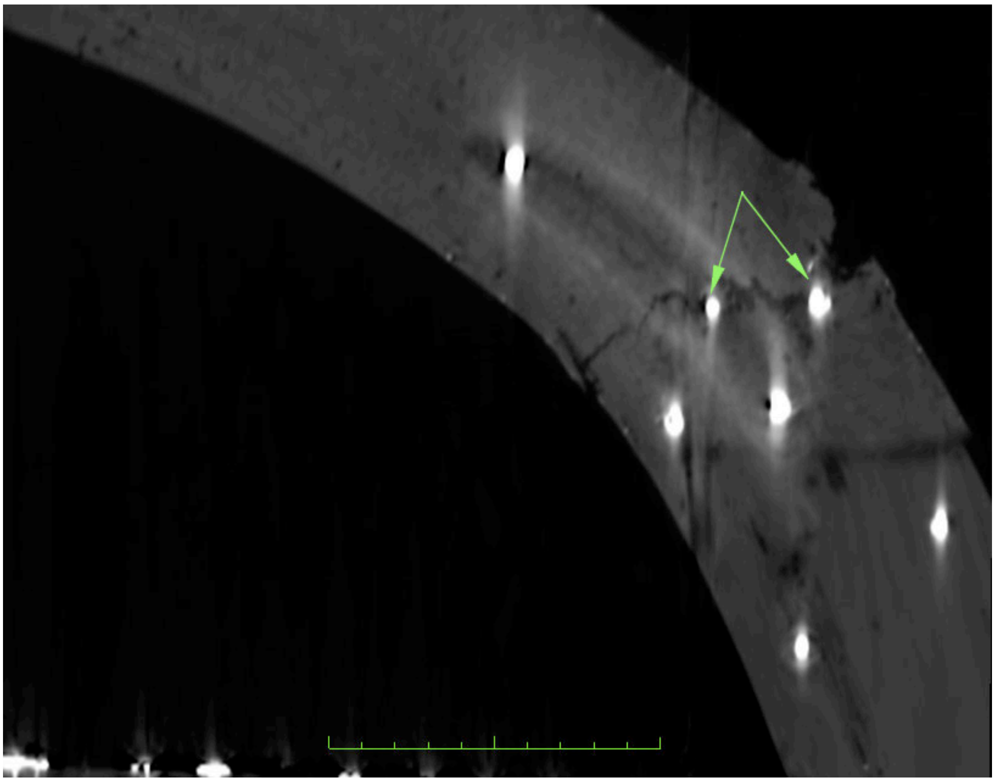
Figure 18.



CT cross-section through the repair to the forepillar of the Lamont harp, revealing a rivet and washer hidden under the iron strap (arrowed). The scale is 1 tick = 1 cm. The soundbox is towards the bottom of the tomogram, and the foot is towards the lower right. Tomogram obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland, 2D rendering by Karen Loomis.

This rivet passes directly through the crack, as does one of the other rivets, as shown in figure 19.

Figure 19.



CT cross-section of the crack through the forepillar of the Lamont harp. Two rivets pass directly through the crack (arrowed). The scale is 1 tick = 1 cm. The soundbox is towards the bottom of the tomogram, and the foot is towards the lower right. Tomogram obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland, 2D rendering by Karen Loomis.

The crack could have spread through the rivets after they were inserted and the harp brought back up to tension and, in this case, the iron straps may have been a second attempt to secure the scarf joint. That would explain the rivet being covered by the straps.

The two video clips of the foot of the harp (see figures 14 and 15, files **lam_foot_sag.mov** and **lam_foot_cor_02.mov**) show the replacement to the lower section of the forepillar, and it appears to be different wood from both the forepillar and the soundbox. The tenon cut into it is smaller than the original mortise in the foot, and a shim has been inserted to fill the gap. The remaining gap appears to be filled with frass. This joint has been secured by three wooden dowels, and at least one of these appears to have broken. There is a gap between the shoulder of the tenon and the front surface of the foot that suggests that the tenon has rotated out of its joint, which would make sense, but looking at the tenon inside the joint in the tomograms, it is difficult to see how it would have fit in the mortise with the shoulder flush against the foot.

Section 3: The neck

The break in the forepillar may be the most visually obvious damage and repair to the Lamont harp, but this is part of a system of structural failure that also involves the neck and its tenon joint with the soundbox. Taken together, these have had a profound effect on this instrument. Figure 5 shows the twisting and rotation of the neck, which would have originally been straight. Damage resulting from the twisting of the neck is evident in Figures 20 and 21, which show its right and left sides at the end where it is joined to the soundbox.

Figure 20

View of the right side of the neck of the Lamont harp near the joint with the soundbox, showing a large crack and two decorated brass patches. Photo: Maripat Goodwin, courtesy of the National Museums of Scotland.

Figure 21.

View of the left side of the neck of the Lamont harp, showing the other side of the split visible in figure 20. Two decorated brass patches cover the crack. The one on the right in this photo runs under the neck to the other side. Photo: Maripat Goodwin, courtesy of the National Museums of Scotland.

The wood of the neck has split, most likely under the tension of the strings, which would have been strung to the tuning pins from the left side of the neck. Brass patches have been nailed across the crack to stop it spreading and to reinforce the neck. The first tuning pin hole passes directly through the split. Armstrong (1904) noted this and commented that this pin hole and possibly the second one could not have been used after the wood split.[32] Figure 22 shows a photo of the left side of the neck joint viewed from the top end of the harp. A block is visible in the joint, indicating that an effort has been made to reinforce the tenon, and suggesting the possibility of additional repair work hidden inside the joint.

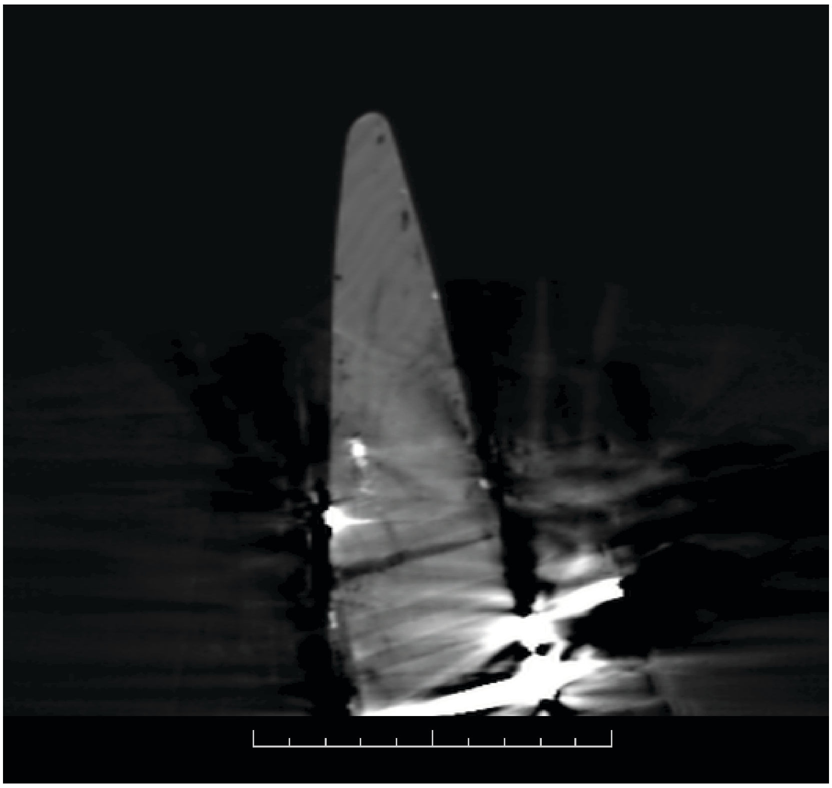
[32] Armstrong (1904) op. cit., p. 164.

Figure 22.

View of the neck joint with the soundbox of the Lamont harp, showing the end of a block in the joint (arrowed). Photo: Maripat Goodwin, courtesy of the National Museums of Scotland.

tomograms of the neck and its joint with the soundbox reveal hidden damage and repairs, providing a more complete picture of the failure of the neck and the work done to reinforce and repair it. Figure 23 is a section across the neck of the harp, which shows the size and nature of the split.

Figure 23.



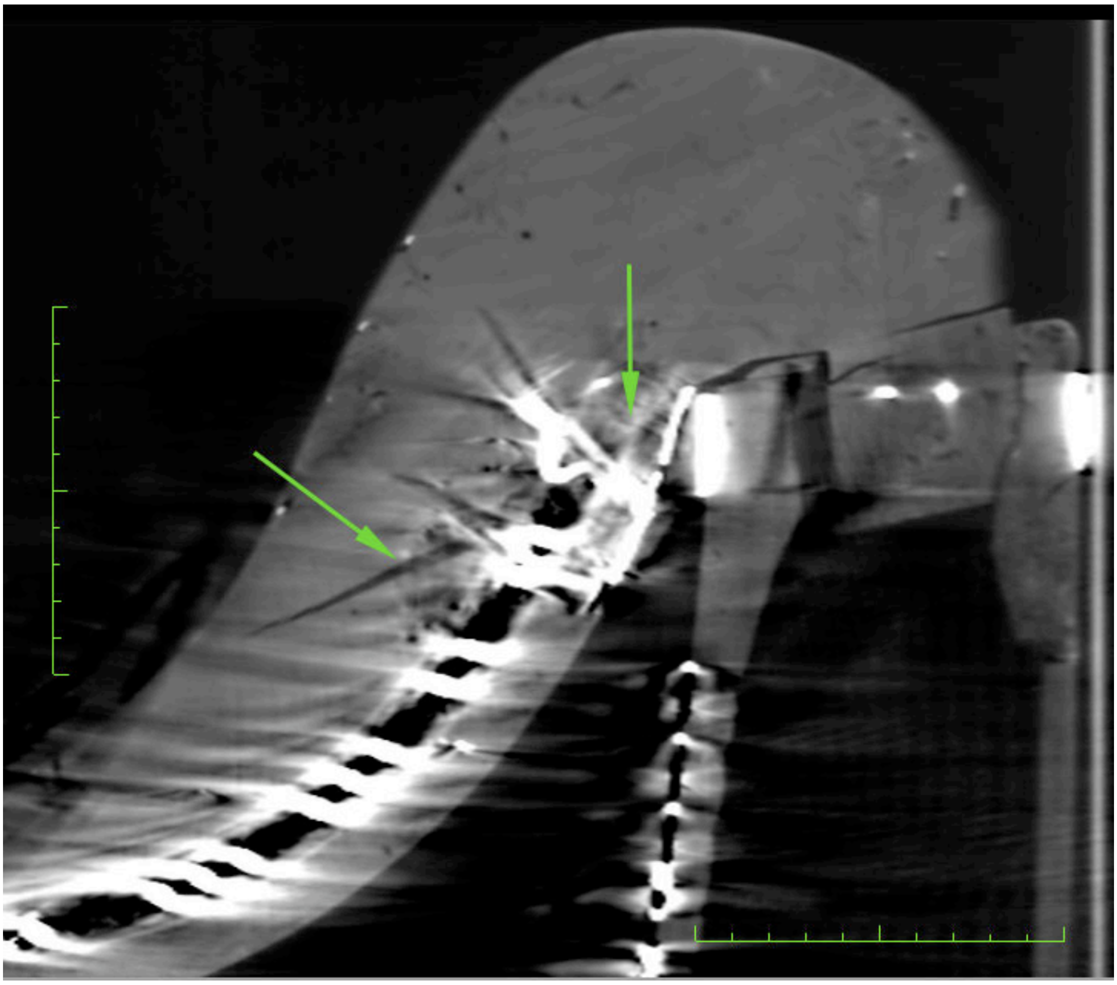
CT coronal cross-section through the neck of the Lamont harp, showing the split in the wood of the neck. The left hand side of the harp is towards the left of the tomogram. The foot of the harp is towards the top of the tomogram. The bright objects at the bottom of the tomogram are tuning pins. The scale is 1 tick = 1 cm. Tomogram obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland, 2D rendering by Karen Loomis.

This tomogram shows the crack as it appears mid-way down the length of the neck. Here it extends almost completely through the wood and it is evident that it has opened up on the left side of the neck. In the photograph in figure 5, the right side of the neck is visibly pinched where the crack has acted like a hinge.[33]

Figure 24 is a tomogram of a sagittal (lengthwise) cross-section of the neck of the Lamont harp. There is a lot of interference in the tomogram from the metal parts, but the split is visible, as are numerous nails used to repair it.

[33] The pinching of the neck was first pointed out to the author by Chadwick, S. in 2009.

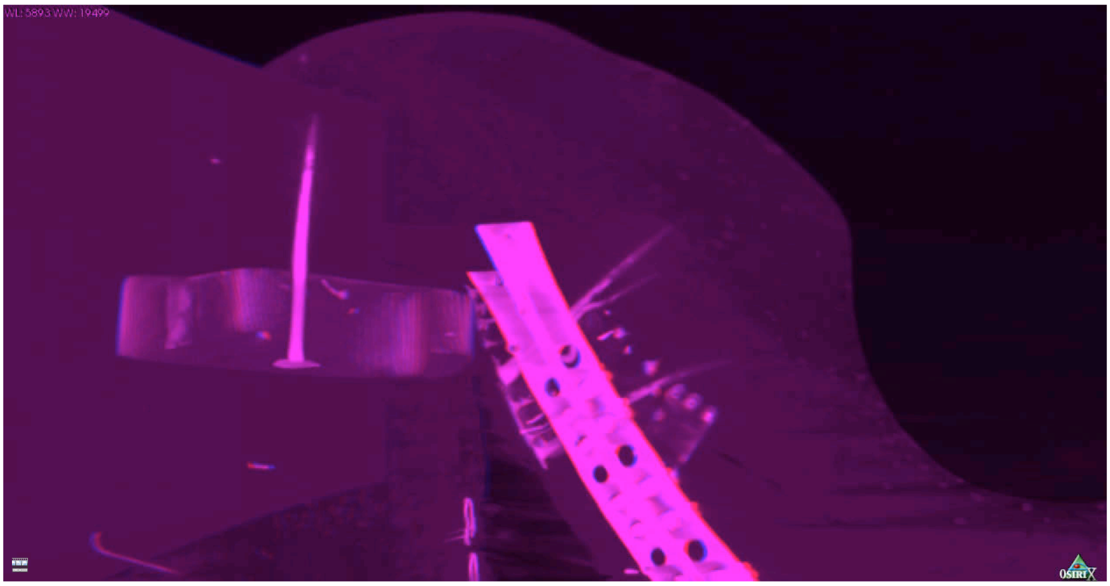
Figure 24.



CT sagittal cross-section of the neck of the Lamont harp, showing where the wood has split (arrowed). Nails used to repair it are visible as the irregular grouping of bright objects in between the arrows. The bright horizontal lines along the neck are tuning pins (some were removed for the CT scanning). The dark arc running along the tuning pins is a scanning artifact of the metal cheekbands. The cavity of the soundbox is visible along the right side of the tomogram. The scale is 1 tick = 1 cm. Tomogram obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland, 2D rendering by Karen Loomis.

The extent of the crack is also visible in this CT cross-section. It's a bit difficult to disentangle the overlapping images of the nails, but the stereo rendering in figure 25 shows the repair work more clearly.

Figure 25.



*Video clip of CT stereo rendering of the repair to the crack in the neck of the Lamont harp, showing the nails embedded in the wood. The cheek bands and tuning pins are also visible in the tomogram. The video clip is available in the electronic form of this document and also as the file **Lam_neck_stereo_02.mov** on the disc accompanying the paper copy. It is meant to be viewed with red-cyan anaglyph glasses. Tomograms obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland, 3D rendering by Karen Loomis.*

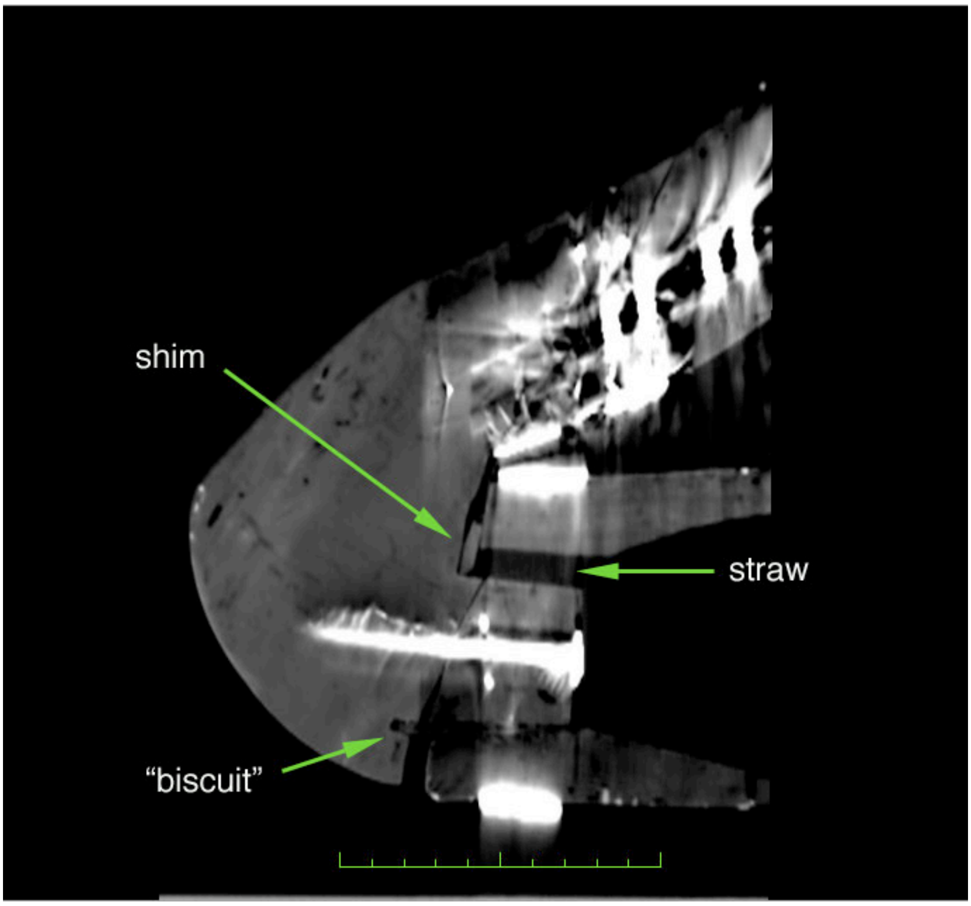
In this rendering, the individual small nails used to affix the brass patches are visible, as well as a small iron plate let into the wood on the underside of the neck. This iron plate is overlaid by the brass strap that runs underneath the neck. The plate is mentioned by Armstrong (1904),[34] and is just barely visible in figure 20. Also visible are three large nails, or spikes, hammered up into the underside of the neck, one of which is bent. The presence of these three spikes was not known before they were revealed in these tomograms. They are evidence of the measures taken to make a repair that would withstand the tension of the strings. Aside from the repairs to the crack in the neck, this video clip also shows a large spike in the neck joint with the soundbox. The evidence of damage and repairs to this joint are discussed in the next section.

[34] Armstrong (1904) op. cit., p. 164.

Section 4: The neck to soundbox joint

The mortise and tenon joint between the neck and the soundbox was also subjected to significant stress and torsion due to the tension of the strings. The tomograms of this joint reveal internal damage and repairs as well as efforts to compensate for the twisting and slumping of the neck of the harp. Figure 26 shows a cross-section of this joint.

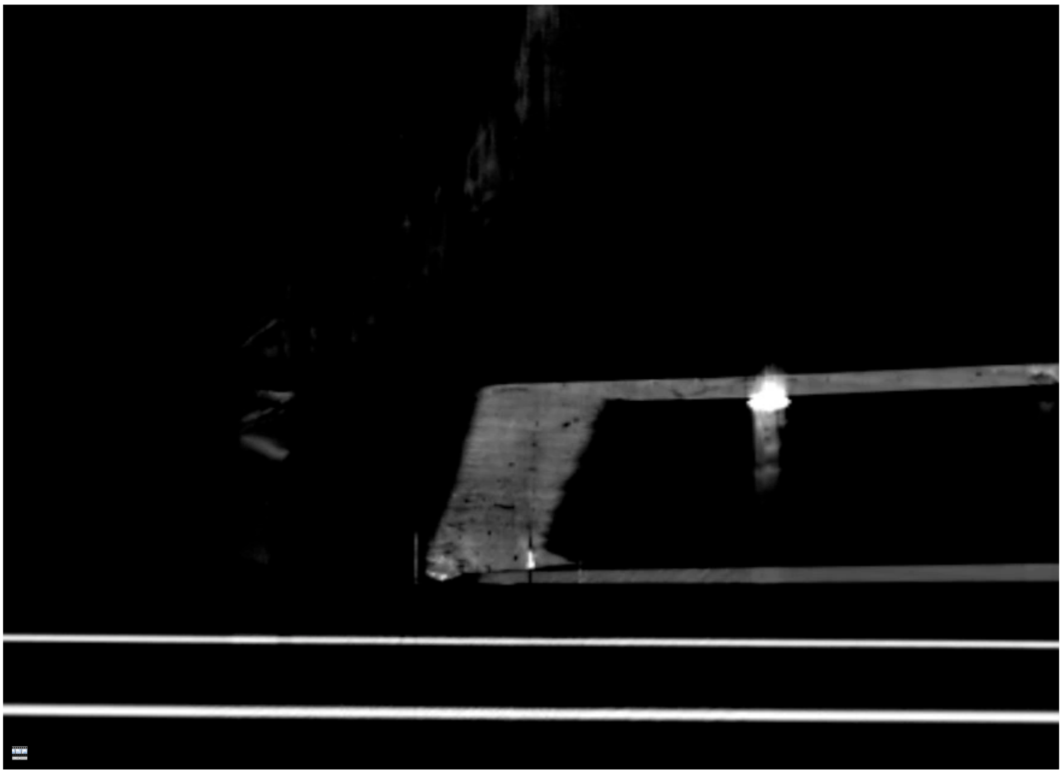
Figure 26.



CT sagittal cross-section of the neck to soundbox mortise and tenon joint, showing a spike through the tenon. Also visible are a shim to raise the neck, a slot and slip of wood (similar to a modern biscuit), and a gap that is filled with straw (arrowed). The scale is 1 tick = 1 cm. Tomogram obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland, 2D rendering by Karen Loomis.

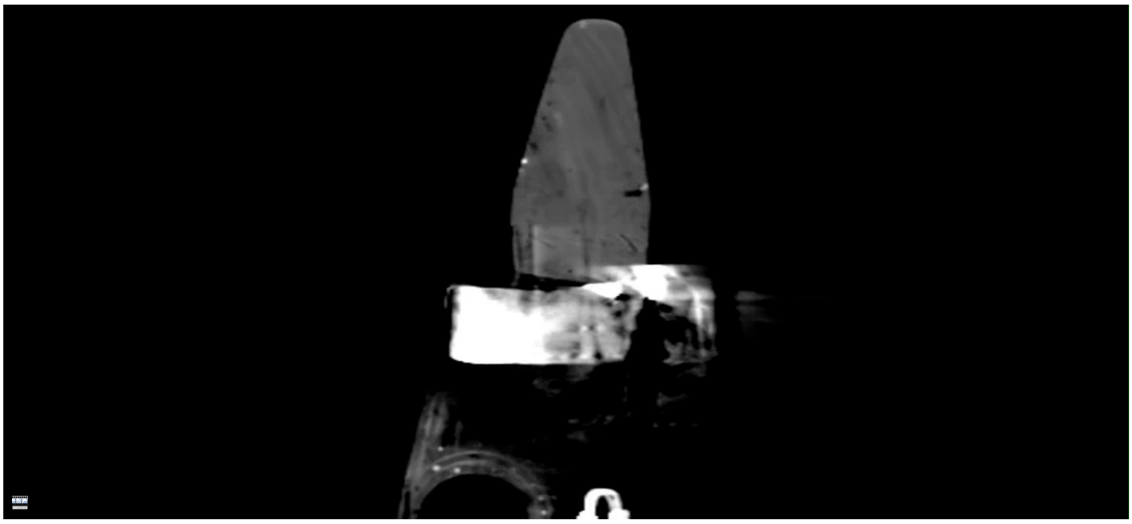
In this tomogram, it is clear that the spike visible in the stereo rendering in figure 25 has been driven through the tenon. Also visible in this tomogram are a shim that has been placed between the neck and the soundbox, and a piece of wood that is slotted into the back end of the neck and nailed to the back of the tenon (a little bit like a modern "biscuit" joint). A gap between the tenon and the front of the soundbox is filled with straw (not visible in the tomogram). More components, and a more complete picture of this joint are shown in video clips viewed from the three axes, as shown in figures 27-29.

Figure 27.



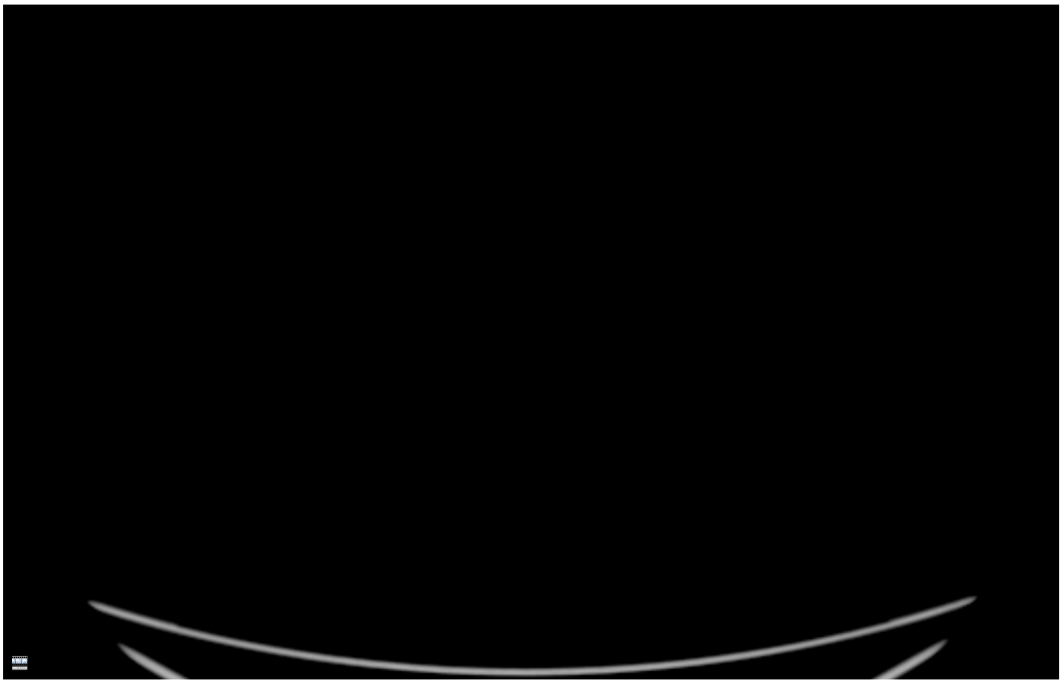
Video clip of sagittal (lengthwise) cross-sections through the Lamont harp, showing the damage and repairs to the neck to soundbox joint. The crack in the tenon can be seen, as well as the metal spike and four wooden dowels used to repair it. The video clip is available in the electronic form of this document, and also as the file ***Lam_neck_sag.mov*** *accompanying the paper copy. tomograms obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland, 2D rendering by Karen Loomis.*

Figure 28.



Video clip of coronal cross-sections (descending from above) through the Lamont harp, showing the damage and repairs to the neck to soundbox joint. The spike and dowels can be seen in the tenon, and the reinforcing block nailed to the tenon's left side is also visible. The video clip is available in the electronic form of this document, and also as the file ***Lam_neck_cor.mov*** *accompanying the paper copy. tomograms obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland, 2D rendering by Karen Loomis.*

Figure 29.



Video clip of axial cross-sections through the neck to soundbox joint of the Lamont harp (starting at the top of the harp), showing the damage and repairs to the neck to soundbox joint. The video clip is available in the electronic form of this document, and also as the file ***Lam_neck_axi.mov*** *accompanying the paper copy. tomograms obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland, 2D rendering by Karen Loomis.*

These three views of the CT data reveal a number of hidden items in this joint. The tenon has sheared off and has been reattached with four long wooden dowels and a metal spike driven up through the bottom of the tenon and extending deeply into the neck of the harp. The spike and one of the dowels have each caused a crack to form in the neck. To reinforce the repair, a flat piece of wood has been nailed to the back of the tenon and a slot to receive it has been cut into the neck. This is presumably to resist the tendency of the neck to pull forward. A block of wood has been nailed to the left side of the tenon to reinforce that side against the twisting of the neck down and towards the left. The coronal view of the joint suggests that the mortise has been widened on that side, presumably to let in the block. A shim has been placed between the neck and the top of the soundbox, which raises the neck up slightly out of its joint. Chadwick (2007) has suggested that the neck was raised up out of its joint to allow it to rotate to the left.[35] It is also possible that it was raised up to compensate for its slumping down. As can be seen in figure 30, the neck has been pulled downward and has twisted to the left.

Figure 30.

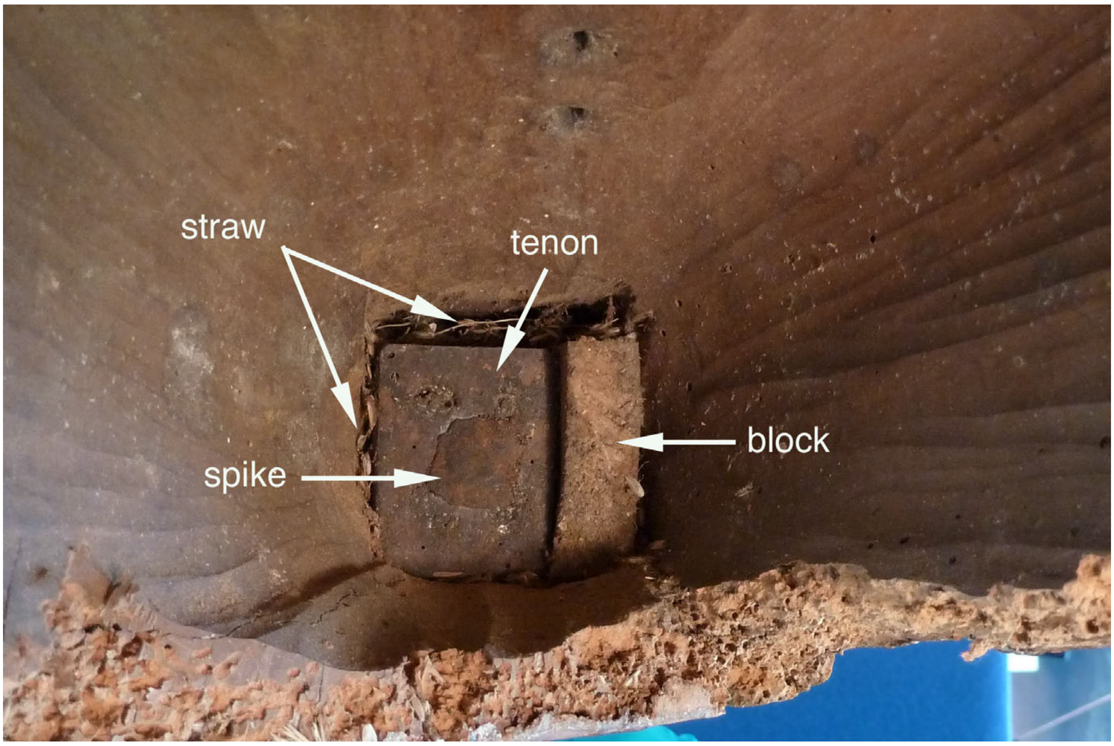
The back of the neck to soundbox joint of the Lamont harp. The front end of the neck has pulled down, causing the back to pull partially out of the joint. The neck has also twisted to the left. Photo: Maripat Goodwin, courtesy of the National Museums of Scotland.

The photograph in figure 30 also shows the iron band around the top of the soundbox. The tomograms show that this band has been placed across a crack on the right side of the soundbox, where the wood has split down from the joint with the neck. This crack likely resulted from the force exerted on the top of the soundbox by the neck tenon, and the band has been put in place to prevent the crack from spreading, and to reinforce the top of the soundbox.

[35] Chadwick, S. (2007) *The Lamont Harp: Damage and Repairs*. [online] Available at: http://www.earlygaelicharp.info/harps/lamontdamage.htm [accessed 5 August 2010].

When the back cover was removed from the Lamont harp, it was possible to view the joint from the inside. A photograph of this is shown in figure 31. Some of the elements of the joint and its repair can be seen in the photo.

Figure 31.



Interior of the soundbox of the Lamont harp, looking towards the neck to soundbox mortise and tenon joint. The end of the tenon is visible, as are the spike and block seen in the tomograms. The straw that fills the gap in the joint is also visible. The front of the soundbox is towards the top of the photo, and the left side of the harp is towards the right. Photo by Karen Loomis, courtesy of the National Museums of Scotland.

The end of the tenon is in view, and the head of the spike can be seen on it. The ends of the four dowels are just barely visible as well. The supporting block nailed to the left side of the tenon is also in view, and the straw mentioned earlier is seen filling the gap in the joint. Hobrough (1979) reported seeing straw in this joint in both the Queen Mary and Lamont harps.[36] This is an interesting feature and will be discussed in a future paper.

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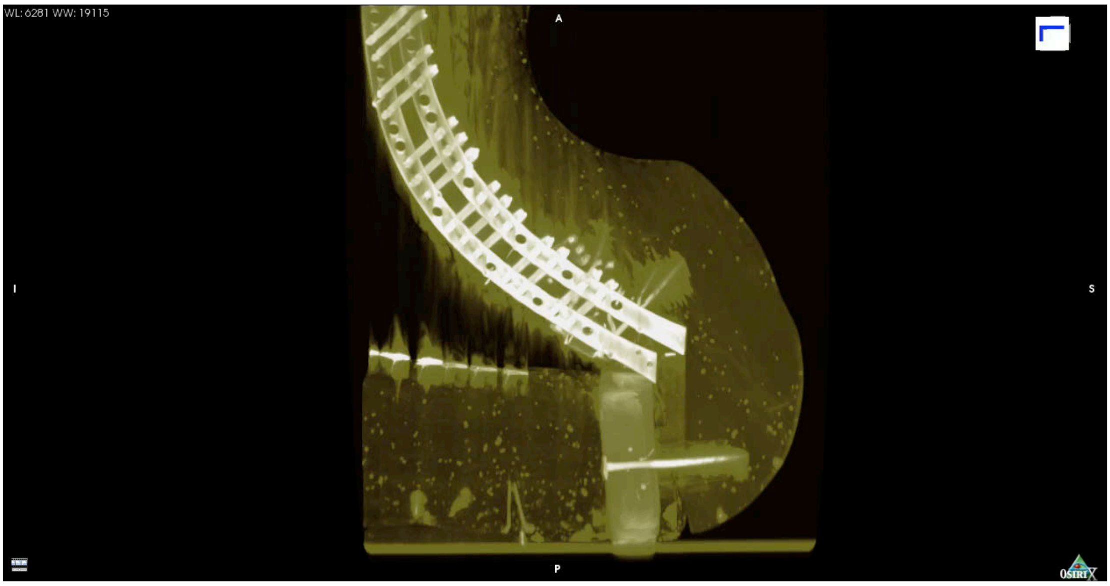
36 Hobrough, T. (23, January 1979) op. cit.

The video clip in figure 32 gives an overview in 3D of the metal repairs to the neck tenon, as well as another view of the repair to the neck crack.

Figure 32.



3D video clip of the neck to soundbox joint of the Lamont harp, showing the spike and nails used to repair and reinforce the tenon. The nails used to repair the neck crack are also visible. The video clip is available in the electronic form of this document and also as the file ***Lam_neck_3D_02.mov*** *on the disc accompanying the paper copy. Tomograms obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland, 3D rendering by Karen Loomis.*

Considering together all of the structural breaks and repairs that have been discussed here, there is a common theme of a harp strained to the point of failure and repaired to continue its useful life. The CT imaging has provided an unprecedented view of the interior of the instrument, making it possible to dissect each break to better understand how and why it occurred and how it was repaired. Until the present study, essentially nothing was known about the construction of the Gaelic harp beyond what could be discerned from a limited number of photographs and the visual inspections reported by Armstrong over 100 years ago. The examination, through these tomograms, of the construction of the harp, the points at which it failed, and the manner in which it was repaired has added immeasurably to current knowledge of how Gaelic harps were built and used. This information, coupled with a planned detailed study of the construction of this and other early Gaelic harps will immediately and directly benefit builders of replica (or reconstructed) instruments, who's construction will be much more informed than at any time previously. Additionally, the images and analysis also provide invaluable detailed information for conservators on the present configuration of the harp and its historical repairs, which will inform the handling and conservation work on the instrument, allowing them to better protect one of the very few remaining early Gaelic harps for future generations.

Part II: Queen Mary Harp Damage and Repairs

This part of the study discusses the examination of damage and repairs of the Queen Mary harp through CT scanning of this instrument. Compared to the Lamont harp, which has visibly suffered significant cracks and repairs, the Queen Mary harp appears to be in remarkably pristine condition, as is evident in the photograph in figure 33.

Figure 33.

The Queen Mary harp, remarkably intact for its presumed age, especially as compared to the Lamont harp. Photo: Karen Loomis, courtesy of the National Museums of Scotland.

There are, however, some interesting defects, breaks, and repairs that are revealed in detail upon examination of the tomograms.

Section 1: The soundbox

Beginning with the soundbox, Armstrong (1904) reports seeing a crack in the string band, extending from the 10th to the 15th string holes, ¼-inch deep and ⅛-inch wide.[37] This crack is readily visible running down the line of string holes, although photographs taken for the current study show it running from the 3rd to the 15th string holes. Most of the crack is visible in figure 34.

Figure 34.

Photograph of the string band of the Queen Mary harp, showing a crack running through the line of string holes (arrowed). Photo: Karen Loomis, courtesy of the National Museums of Scotland.

A second crack is visible running through the string shoe nail holes from the 7th to the 11th string hole. These cracks are not easily detected on the tomograms of the harp,

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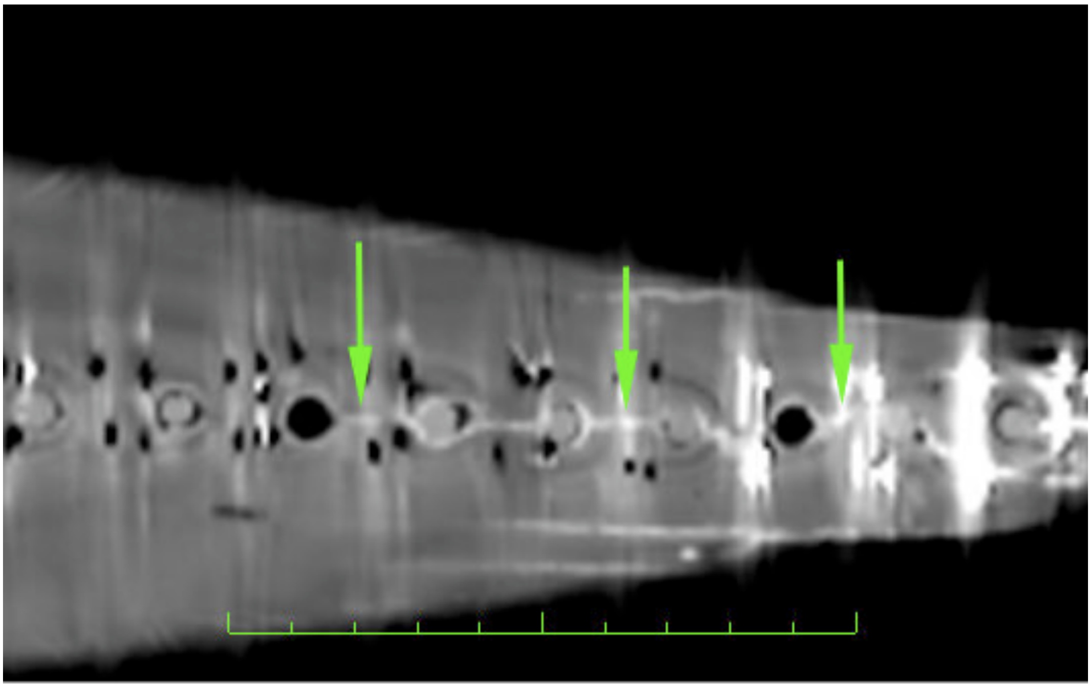
[37] Armstrong (1904) op. cit., p. 179.

due in part to interference from the metal around the string holes. A portion of the crack is visible in the tomogram shown in figure 35.

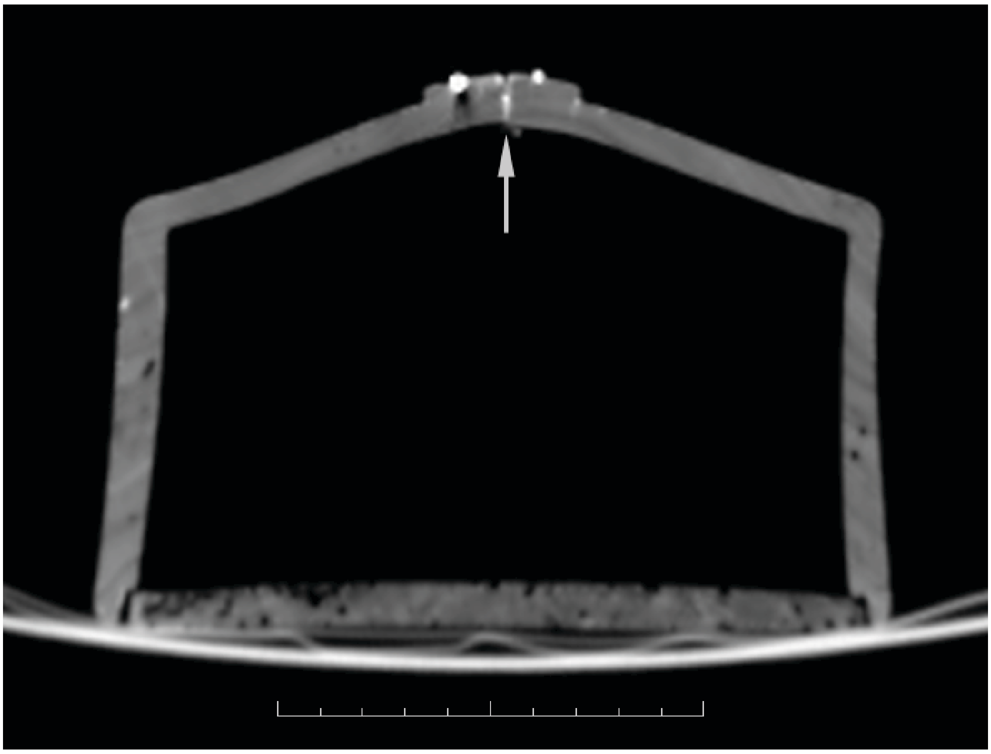
Figure 35.



tomogram of the portion of the string band of the Queen Mary harp from the 8th to the 16th string holes. A crack running along the line of string holes is visible as a light grey line (arrowed). The scale is 1 tick = 1 cm. Tomogram obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland, 2D rendering by Karen Loomis.

On the Queen Mary harp, surface cracks and crevices are filled with a dark, waxy substance that appears light in the CT renderings because it is more opaque to x-rays than the surrounding wood. So, the crack in the string band is visible as a light grey line in the tomogram in figure 3. Armstrong gives a measurement of ¼-inch (0.6 cm) for the depth of the crack. The tomogram in figure 36 shows a cross-section of the crack just above string hole #13.

Figure 36.

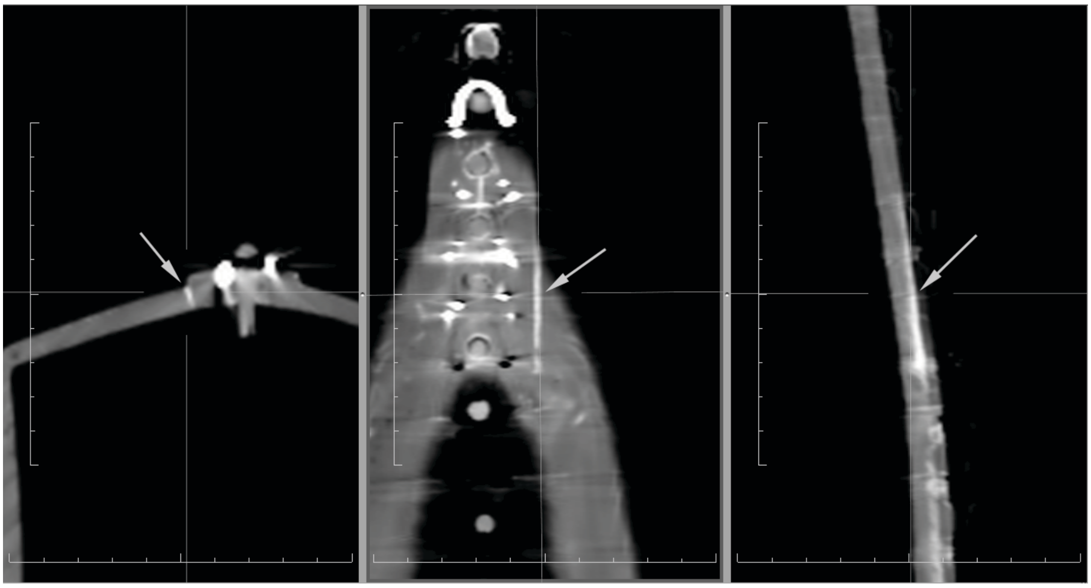


CT cross-section of the soundbox of the Queen Mary harp, showing the crack through the middle of the string band (arrowed). The scale is 1 tick = 1 cm. Tomogram obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland, 2D rendering by Karen Loomis.

It would have been difficult for Armstrong to get an accurate measurement of the depth of the crack, but it can be measured using the CT data. In the cross-section in figure 36, it appears to run almost completely through the soundbox, which is 1.2 cm thick through the string band. The tomogram in figure 36 also shows that the sides of the soundbox appear to be pulled in slightly. This is likely due to the tension of the strings pulling up the front of the soundbox. The tension of the strings probably also caused the crack in the string band.

Close examination of the CT cross-sections of the string band revealed an additional crack that is not visible in the photographs of the harp, and was not noticed on visual inspection of the instrument. This crack is shown in figure 37.

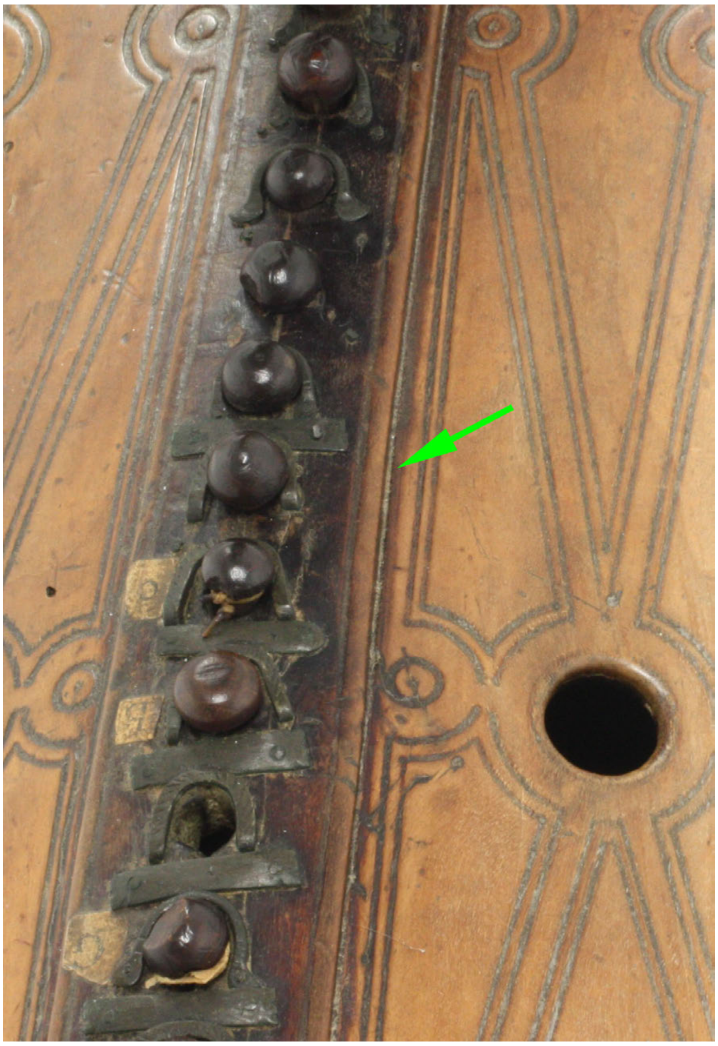
Figure 37.



Three CT views of a crack along the left edge of the string band of the Queen Mary harp (arrowed). The left-hand tomogram is an axial cross-section across the soundbox, with the left side of the harp towards the left in the image. The center tomogram is a coronal cross-section parallel to the front surface of the soundbox, with the treble end of the harp towards the top of the image and the left side of the harp towards the right. The right-hand tomogram is a sagittal cross-section longitudinally through the soundbox, with the front of the harp towards the right side of the image, and the treble end towards the top. The scale is 1 tick = 1 cm. Tomogram obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland, 2D orthogonal renderings by Karen Loomis.

The crack appears to run along the left edge of the string band, from the 6^{th} to the 8^{th} string holes. As can be seen in figure 37, it also appears to extend nearly through the front of the soundbox, which is 0.7 cm thick at that location. Other light grey lines appearing parallel to the string band (e.g. in figure 35) do not extend into the wood, and appear to be part of the decorative lines on the surface of the soundbox. For comparison, figure 38 shows a photograph of the same portion of the soundbox shown in the center tomogram of figure 37.

Figure 38.



Photograph of the area of the soundbox shown in the center tomogram in figure 5. The location indicated in figure 37 is also indicated on this photograph (arrow). Although the crack shows up in the tomograms, it is not visible in the photograph. Photo: Karen Loomis, courtesy of the National Museums of Scotland.

As can be seen in this photograph, the crack is hidden in the corner at the edge of the string band. This sharp corner between the raised string band and the rest of the front of the soundbox is a weak point and plausible location for a crack to form. From the tomograms, the location, size, and extent of a crack that would otherwise have gone undetected can be documented. This information will help conservators, who need to be aware of the vulnerable areas of the instrument and need a record of its current state.

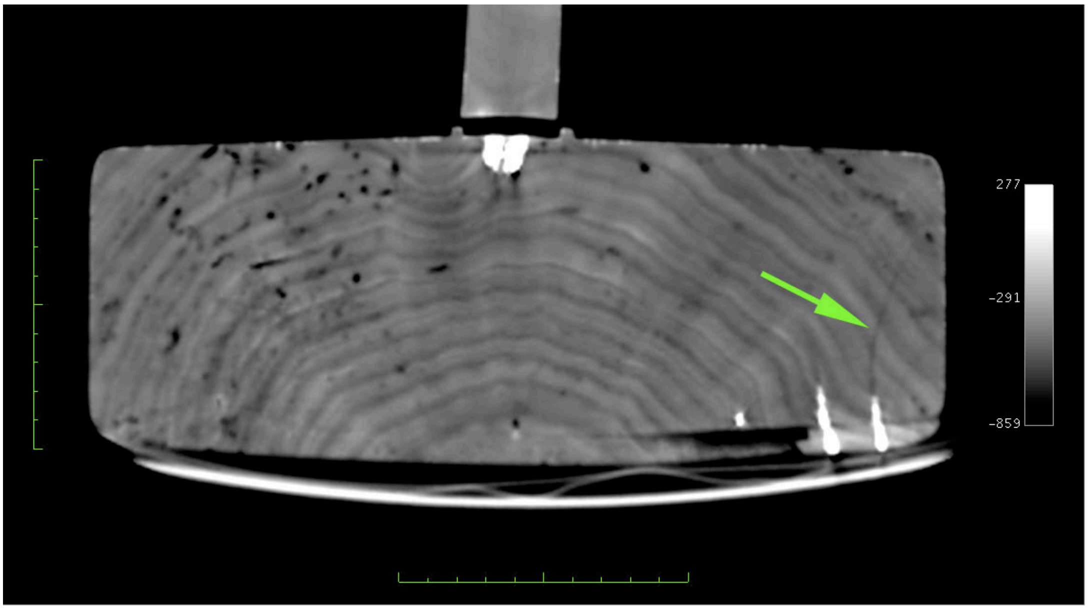
The base of the soundbox of the Queen Mary harp has a crack on its left back corner. This is readily visible, as shown in the photograph in figure 39, and is adjacent to a patch in the same corner of the back cover of the soundbox.

Figure 39.

Photograph of the back left corner of the base of the Queen Mary harp soundbox, showing a crack and an adjacent patch to the back cover. Photo: Karen Loomis, courtesy of the National Museums of Scotland.

As one might suspect from the photograph, one of the nails in the patch appears to be the cause of the crack. The tomogram shown in figure 40 confirms this.

Figure 40.



CT cross-section through the base of the Queen Mary harp, showing a crack extending from a nail driven through a patch in the back cover of the harp (arrowed). The front of the harp is towards the top of the tomogram. The scale is 1 tick = 1 cm. Tomogram obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland, 2D rendering by Karen Loomis.

The arrow in the tomogram points to a crack extending directly from a nail driven through the patch into the base of the soundbox. Armstrong (1904)[38] and Bell (1880)[39] both document this crack, and the patch, indicating that it is an old repair. The patch has been placed on a corner that is worn and the patch itself has some wear, suggesting it is an historical repair made when the harp was still in use.

The back cover of the Queen Mary harp is, or course, even older than the patch, and is very likely original to the harp. This is extraordinary, as the back covers of these instruments are somewhat ephemeral. Most, if not all, of the other surviving Gaelic harps have replacement covers. The evidence for this cover being original is the faint remains of decorative lines, which match those on the soundbox in both design and execution. This decoration is shown in the photograph in figure 41.

[38] Armstrong, R. B. (1904) op. cit., Plate VIII, opposite p. 176.
[39] Bell, C. (1880) Notice of the Harp Said to Have Been Given to Beatrix Gardyn of Banchory by Queen Mary, and of the Harp called the "Lamont Harp" *Proceedings of the Society of Antiquaries of Scotland*. 15, p. 18.

Figure 41.

Photograph of a portion of the back cover of the soundbox of the Queen Mary harp, showing traces of decorative work matching that on the soundbox (arrowed). Photo: Karen Loomis, courtesy of the National Museums of Scotland.

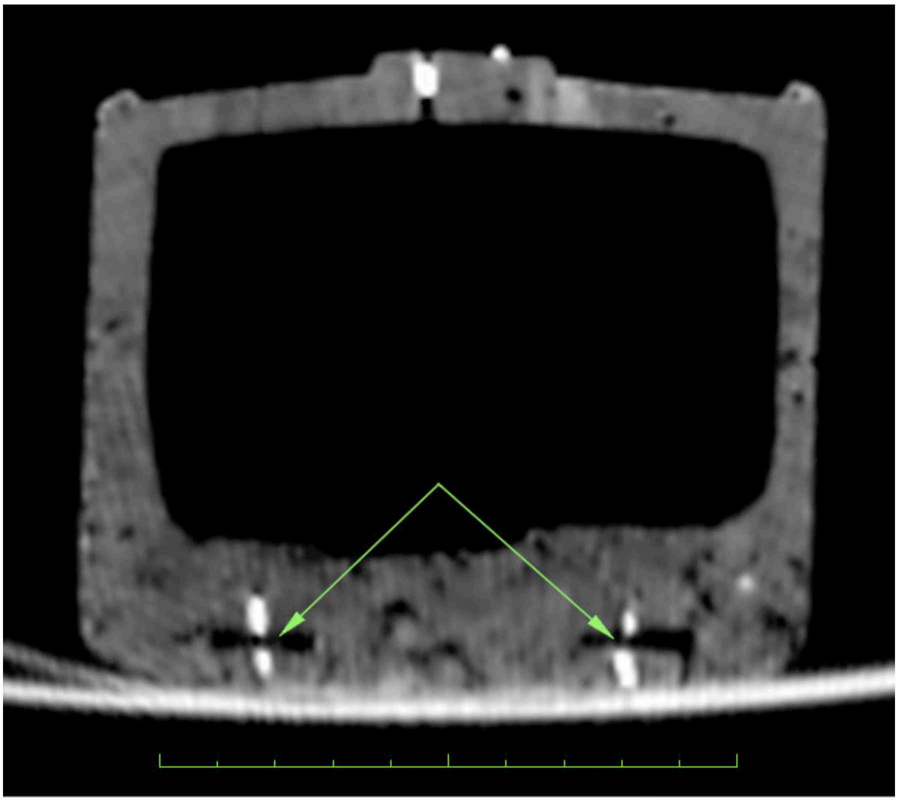
The fact that this cover is very likely original (and may be the only surviving one) makes it an item of importance for conservation. The photograph in figure 41 shows a lot of woodworm damage on the surface, suggesting interior damage as well. This is confirmed by tomograms of the back cover, as shown in figure 42, which reveal the full extent of the damage.

Figure 42.

Video clip of cross-sections through the back cover of the Queen Mary harp, showing woodworm damage. The top of the harp is towards the left side of the tomogram, and the right side of the harp is towards the bottom. The grey swirls outside of the soundbox are images of the table the harp was resting on for scanning. This video clip is available in the electronic form of this document, and also as the file ***QM_back.mov*** *on the disc accompanying the paper copy. The scale is 1 tick = 1 cm. Tomograms obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland, 2D rendering by Karen Loomis.*

The right hand side of the cover particularly has an area of extensive damage that has been repaired with a large patch of filler, which appears as a solid irregular grey area in the tomograms. This information is useful for conservators who may have to stabilize the wood. The tomograms also show the location of all of the nails that are driven into the cover to hold it to the back of the soundbox. Figure 43 shows a cross-section through the upper end of the soundbox and the back cover.

Figure 43.



CT cross-section of the Queen Mary harp soundbox, through the top end of the back cover. Nails driven through the two tips of the cover (arrowed) appear to have been cut. The front of the soundbox is towards the top of the tomogram. The left side of the soundbox is towards the right. The scale is 1 tick = 1 cm. Tomogram obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland, 2D rendering by Karen Loomis.

Two of the nails driven through the back cover appear to have been cut. For comparison, a photograph of the outside of this portion of the back cover is shown in figure 44.

Figure 44.

Photograph of the top end of the back cover of the Queen Mary harp, showing the location of two nails (arrowed) that CT imaging revealed were cut. Photo: Karen Loomis, courtesy of the National Museums of Scotland.

It is important to know the location and number of nails driven into the back cover so that conservators can make an informed decision as to whether, or how, to remove it for inspection of the inside of the soundbox for research purposes. It is equally important to know if any of these nails has been cut. The Lamont harp has numerous nail heads visible around the edge of its back cover (which is not original). During research work on that harp, conservators removed one nail that was protruding out of the back cover. They did not know (and could not have known at that time) that the rest of the nails had been cut, and that that was the only nail securing the cover. While from a research standpoint it was exceedingly interesting to examine the inside of the Lamont harp soundbox, it is better to have the cover removed in a controlled setting.

In addition to the top two nails shown in figure 43, tomograms of the rest of the back cover show that at least three other nails have also been cut. This is very important information for conservators because, unlike the Lamont harp cover, the back cover of the Queen Mary harp appears to be original, as well as fragile, and could be damaged if it came off unexpectedly.

Section 2: The forepillar

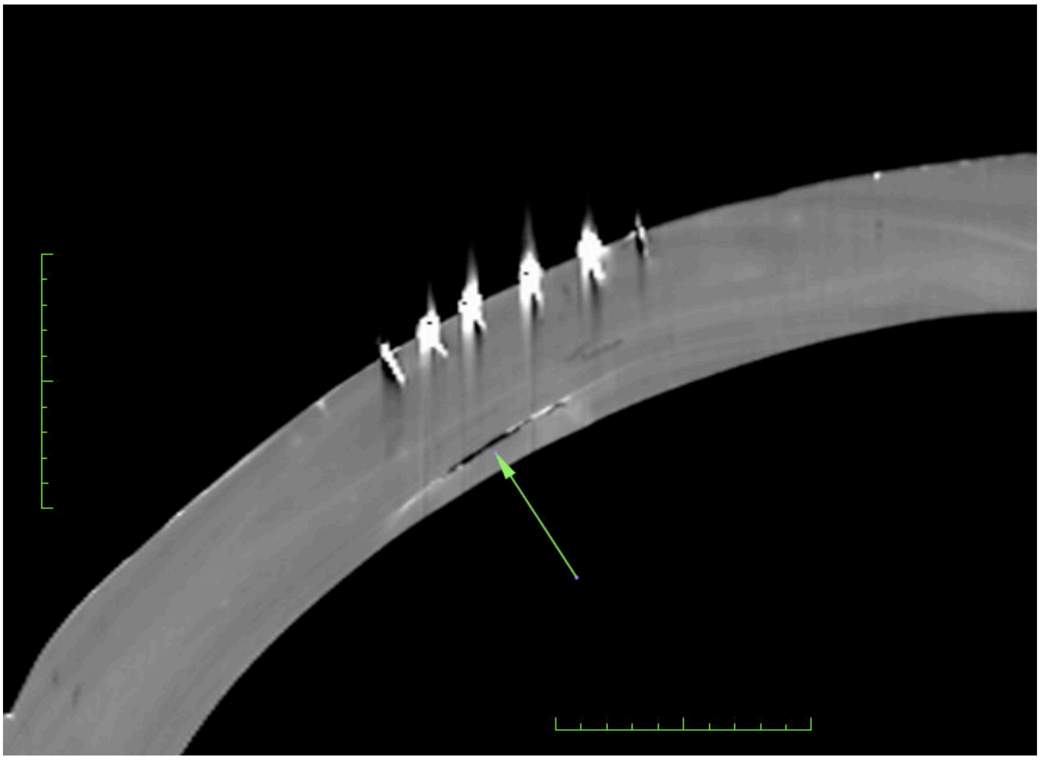
The forepillar of the Queen Mary harp, though otherwise in exceptionally good condition, has a large crack extending along the middle third of its length on the left side, and a section that has been purposely cut out. This is shown in the photograph in figure 45.

Figure 45.

Photograph of the middle section of the left side of the forepillar of the Queen Mary harp, showing a crack running along the underside of the t-section, and a piece of the wood cut out. Photo: Karen Loomis, courtesy of the National Museums of Scotland.

The crack is approximately 19 cm long, and the cut out section is 10 cm at its longest. Armstrong (1904) describes the crack and the cut out section of wood, stating that the builder of the harp probably encountered a defective section of wood, and needed to cut it out and let in a replacement piece that eventually fell out, leaving the gap.[40] A crack and remnants of what may be glue can be seen on the inside surface of the gap. Figure 46 shows a CT cross-section of the forepillar through the back surface of the cutout section.

Figure 46.



CT sagittal cross-section of the forepillar of the Queen Mary harp, showing the crack on the inside surface of the cutout section (arrowed). The white areas at the edges of the crack may be remnants of glue. The bright spots on the outer edge of the forepillar are decorative metal studs. The treble end of the harp is towards the right of the tomogram. The scale is 1 tick = 1 cm. Tomogram obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland, 2D rendering by Karen Loomis.

The areas rendered as white in and around the crack may be remnants of glue. Examination of the tomograms revealed that this crack doesn't extend further into the forepillar, or along its length. The builder of this piece carefully removed just enough wood as was necessary. It is also apparent that this crack is not related to the longer crack above it, on the side of the t-section.

[40] Armstrong (1904) op. cit. pp. 172-173.

The crack running along the lower side of the t-section, which is not visible in figure 46, can be seen in figure 47, which is a video clip of cross-sections travelling up the forepillar.

Figure 47.

Video clip of CT cross-sections travelling up the forepillar of the Queen Mary harp, showing the crack on the left side of the t-section and the cut out section below it. The grain of the wood is also visible, and reveals the origin of the crack. Decorative metal studs on the outer edge of the forepillar appear as bright flashes in the tomograms. Bright "sparkles" on the surface of the forepillar are traces of vermillion paint. The left side of the harp is towards the right side of the tomogram. This video clip is available in the electronic form of this document, and also as the file ***QM_forepillar.mov*** *on the disc accompanying the paper copy. Tomogram obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland, 2D rendering by Karen Loomis.*

The grain of the forepillar wood can be seen in this video clip. In the middle third of the forepillar, the pith is visible as a dark spot in the center of the growth rings and the crack can be seen radiating from it. It is curious that the builder of the Queen Mary harp chose to have the forepillar run through the center of the limb, as this would make it vulnerable to checking, which is indeed what happened here. In contrast to the forepillar of the Lamont harp, which likely failed due to the tension of the strings, the tomograms reveal that the crack in the forepillar of the Queen Mary harp is the result of the choice of the piece of wood.

Following the grain, it is evident that this forepillar was fashioned from a curved limb. In the past, there has been disagreement over this as a method of construction for Gaelic harps. A forepillar with grain that follows the curve will be stronger than one that is cut across straight grain, but visual examinations of surviving harps has resulted in conflicting opinions. Most modern replicas and reconstructions use straight-grained wood sawn to a curved shape for the forepillar. Hobrough (1979) examined the Queen Mary harp and concluded that the forepillar was plank sawn and that the grain "curves only vaguely" with it.[41] The use of a curved limb has been hypothesized by Chadwick, who used one of apple wood for his replica of the Queen Mary harp, built by Davy Patton in 2006-7.[42] These tomograms provide the first concrete evidence for the historical use of a curved limb for the forepillar of any of the early Gaelic harps.

[41] Hobrough (1979) op. cit.
[42] Chadwick (updated 2009) *The Harp* [online] available at http://www.simonchadwick.net/QM/ [accessed 10 August 2010]

Section 3: The neck

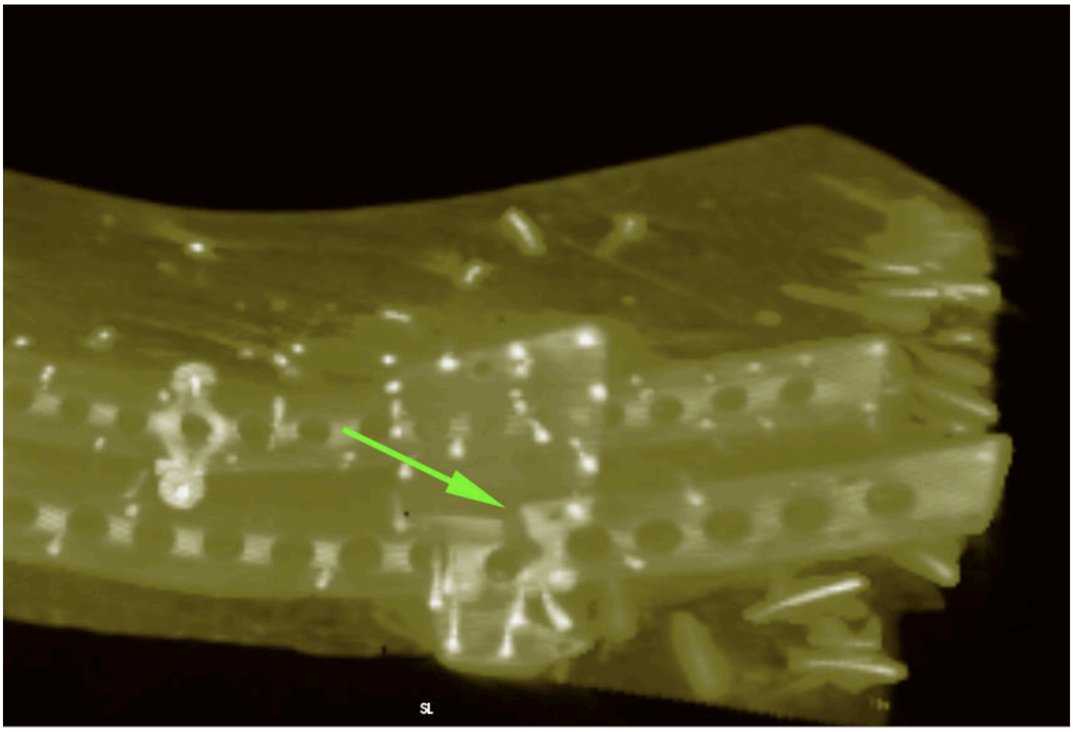
In describing the neck of the Queen Mary harp, Armstrong (1904) mentions a metal patch across the cheekband, just above the joint with the forepillar, and two cracks in the wood near the patch. Figure 48 shows a photograph of the neck where it joins the forepillar.

Figure 48.

Photograph of the end of the neck of the Queen Mary harp, at the joint with the forepillar. A metal patch is nailed onto the neck, across the cheekband, and several diagonal cracks are visible on the neck. Photo: Karen Loomis, courtesy of the National Museums of Scotland.

In this photograph, one can see the metal patch described by Armstrong as well as several small diagonal cracks in the wood. The smooth curve of the cheekband is disrupted underneath the patch. Armstrong (1904) suspects that the patch is covering a break in the cheekband.[43] A 3D reconstruction from the tomograms of the neck confirms Armstrong's suspicion, as shown in figure 49.

Figure 49.

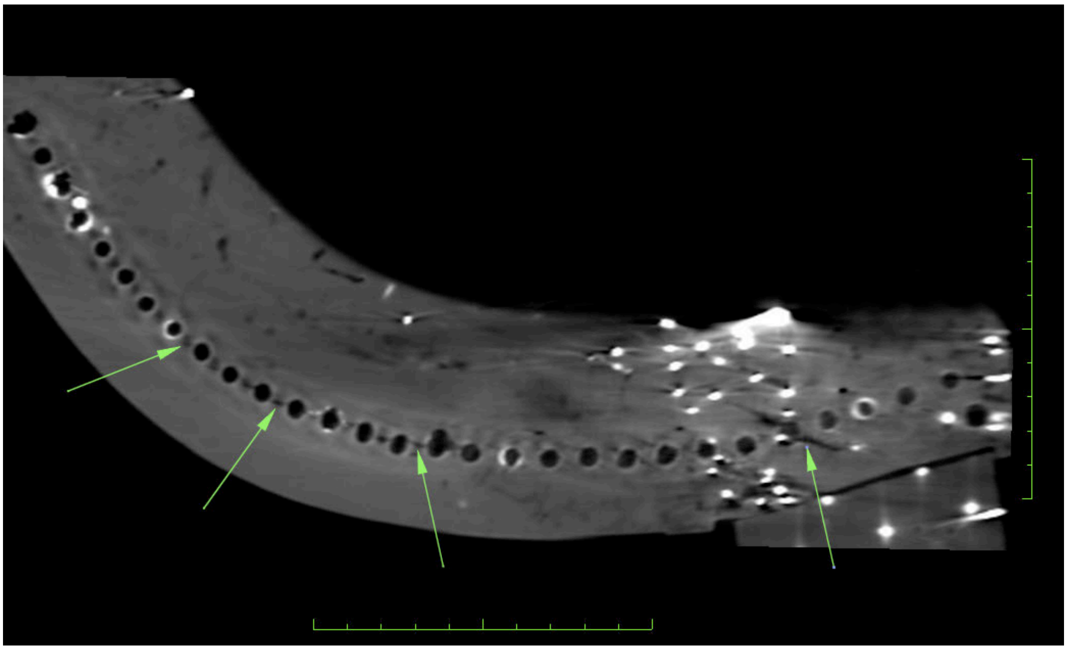


3D reconstruction from tomograms of the neck of the Queen Mary harp, showing a hidden break in the cheekband at the 24th tuning pin hole (arrowed). Tomograms obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland,3D reconstruction by Karen Loomis.

The 3D CT reconstruction shows the metal patch covering a clear break in the cheekband at the 24th tuning pin hole. While this 3D reconstruction shows the metal work in detail, a CT cross-section of the neck shows the wood more clearly, as can be seen in figure 50.

[43] Armstrong (1904) op. cit., p. 178.

Figure 50.



CT cross-section of the neck of the Queen Mary harp, showing an internal crack running diagonally through the 25th tuning pin hole (arrowed). The outline of the metal patch is indicated by the nails driven through it, which appear as bright spots in this tomogram. Other arrows point to a crack running along the harmonic curve, in between the tuning pin holes. The treble end of the harmonic curve is towards the left in this tomogram. The scale is 1 tick = 1 cm. Tomogram obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland, 2D rendering by Karen Loomis.

In this cross-section, an internal crack can be seen running diagonally through the 25th tuning pin hole, which is just to the right of the break in the cheekband. This crack is not readily visible from the outside of the neck, as it is almost completely hidden by the cheekband and the patch.

A photograph of the left side of the neck hints at two additional cracks, which are also mentioned by Armstrong (1904).[44]

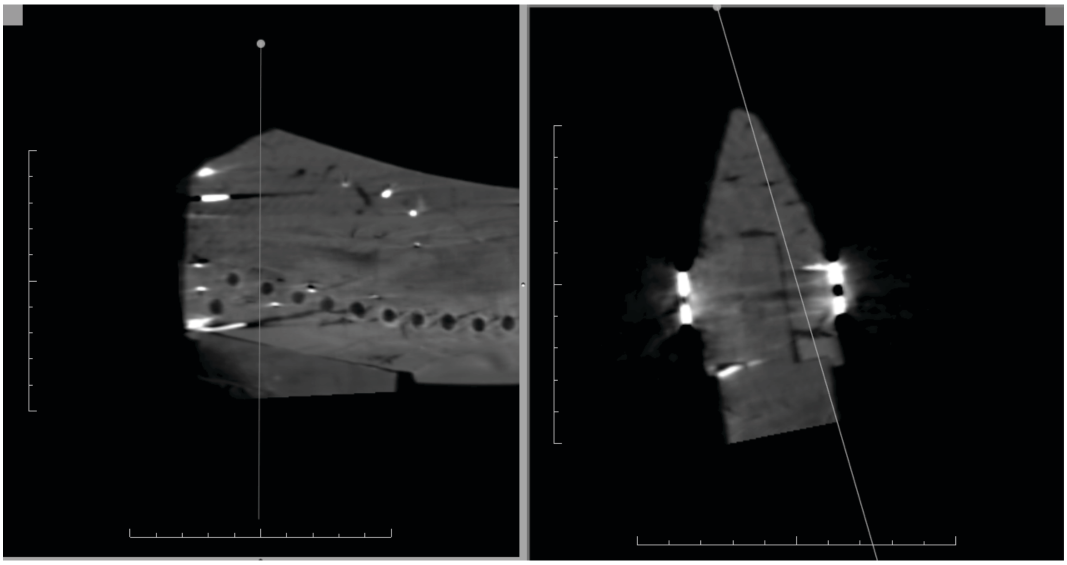
[44] Armstrong (1904) op. cit., p. 178.

Figure 51.

Photograph of the left side of the neck of the Queen Mary harp, showing evidence of cracks (arrowed). Photo: Karen Loomis, courtesy of the National Museums of Scotland.

The extent of these two cracks can be clearly seen in another CT cross section of the neck, as shown in figure 52.

Figure 52.



Two CT cross-sections through the end of the neck of the Queen Mary harp. The line drawn across each indicates the location of the other cross-section. Two diagonal cracks can be seen extending from nails driven into the front face of the neck. The lower crack extends into the neck to the forepillar tenon. Other, smaller cracks are also visible. The top of the harp is towards the top of each tomogram. The treble end of the harmonic curve is towards the right of the left-hand tomogram, and the left side of the harp is towards the right in the right-hand tomogram. The scale is 1 tick = 1 cm. Tomogram obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland, 2D rendering by Karen Loomis.

In the CT cross-sections, the dark markings seen in the photograph in figure 51 are revealed to be the ends of nails driven into the front face of the end of the neck. A crack extends from the end of each nail, and the lower of the two cracks extends into the neck up to the forepillar tenon. Smaller cracks are also visible in these tomograms. Looking at the photograph in figure 51, one can also see that all of the cracks follow the grain of the wood. Gunn (1807) notes that, according to the family history of the instrument, this harp once had gold badges representing the Queen's portrait and the Royal Arms of Scotland affixed to the end of the neck.[45] Including the two nails associated with the cracks, the pattern of nail remnants on the end of the neck and on the top end of the forepillar are consistent with decorative badges having at one time been affixed there. Considering the number of parallel cracks, and the direction of the grain of the wood, it is likely that the nails followed (and possibly

[45] Gunn (1807) op. cit., pp. 13 – 14.

enlarged) existing cracks, rather than causing new ones. Armstrong (1904) makes the plausible suggestion that the tension of the strings pulling the neck downwards caused the wood to fail due to the forepillar stopping the downward motion of the end of the neck.[46]

Here, the tomograms have revealed in detail cracks and breaks that were hinted at on visual inspection of the end of the neck at the forepillar, making it possible to have a complete picture of the extent of the internal damage and to understand its cause. These cracks, and the additional cracks discussed in the next section may provide clues to how heavily this instrument was strung, as well as how it was designed and intended to be strung. Additionally, having a clear map of the internal cracks in the neck, particularly around the joints is important information for conservators, who need to be aware of vulnerable areas of the instrument.

The CT cross-section in figure 50 also shows a crack running through the tuning pin holes along the harmonic curve, from the 8th or 9th hole to the 16th hole. This is interesting because this crack was previously not known to exist. It is a likely location for a crack to form, though, as the tuning pin holes weaken the neck. The need for reinforcement along the harmonic curve has long been the suggested reason for the metal cheekbands, which are characteristic of Gaelic harps,[47] and this crack may suggest that this is the case, as it might have developed into a larger crack had there not been metal reinforcing bands on either side of the neck. Some of the tuning pin holes shown in figure 50 have "bright" rings around their edges, indicating the presence of something metallic. In her examination of the Trinity harp, Rimmer (1961) reported observing that several of its tuning pin holes were "lined with thin metal to get a better fit" for the tuning pins.[48] It is probable that this is what is visible in the CT cross-section of the Queen Mary harp tuning pin holes.

[46] Armstrong R. B. (1904) op. cit, p. 178.
[47] Armstrong R. B. (1904) op. cit., p. 30.
[48] Rimmer, J. (16 October 1961) *Report on Stringing the Trinity College, Dublin, Harp.* unpublished report, source unknown.

Section 4: The neck to soundbox joint

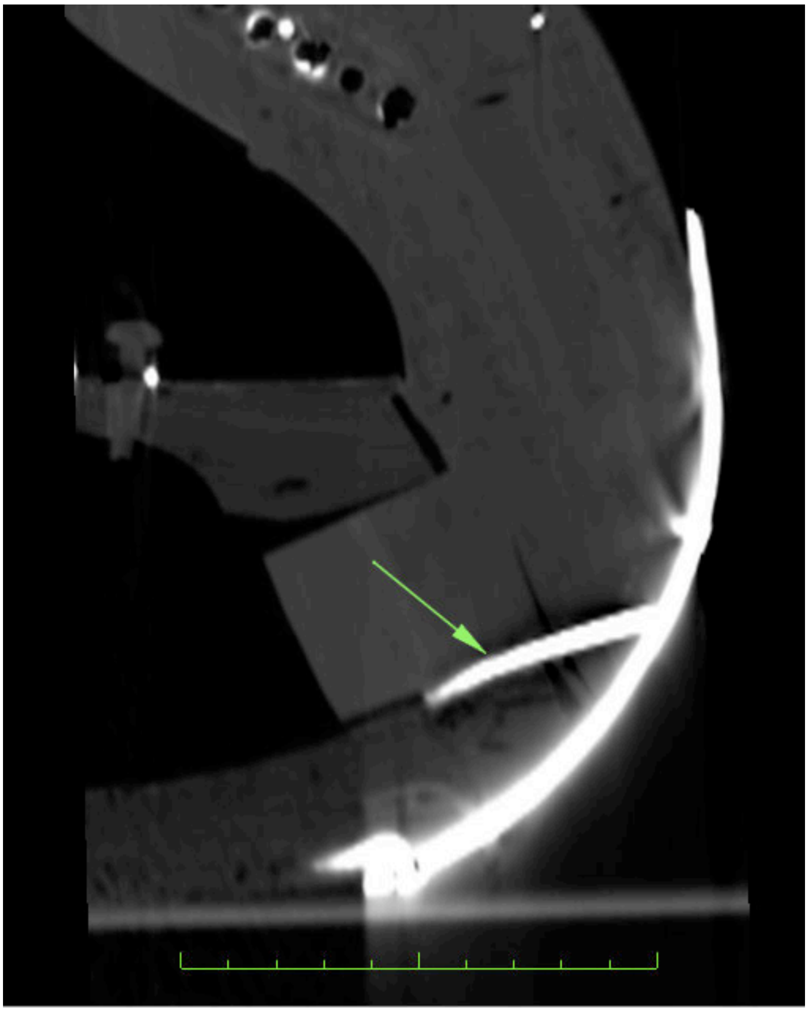
A prominent feature of the Queen Mary harp is a sturdy iron strap nailed across the mortise and tenon joint between the neck and the soundbox. Two views of this strap are shown in figure 53.

Figure 53.

Two views of the joint between the neck and forepillar of the Queen Mary harp, showing the iron strap nailed across the joint. Photo: Karen Loomis, courtesy of the National Museums of Scotland.

Six heavy iron nails are driven through the strap; three into the neck and three into the back of the soundbox. This strap appears to be a repair, its purpose presumably to prevent the neck from slumping downward due to the tension of the strings. CT cross-sections provide views of the interior of this joint, revealing the breaks and repair work. Figure 54 is a cross-section through the joint, along the long axis of the harp.

Figure 54.



CT cross-section through the joint at the neck and soundbox of the Queen Mary harp, showing the neck tenon, which is cracked, and a metal rod in the joint (arrowed), hidden underneath the iron strap. The view and orientation is the same as that in the right hand photograph in figure 53. The scale is 1 tick = 1 cm. Tomogram obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland, 2D rendering by Karen Loomis.

In this cross-section, a crack is visible extending about halfway through the tenon, and the tenon appears to have lifted about 3 mm out of the joint. The iron strap is visible as the "bright" arc along the outer edge of the neck and soundbox. The nails are not visible in this cross section, but what appears to be a metal rod can be seen in the joint, wedged between the mortise and tenon. This object is not one of the nails driven through the strap, and is completely hidden underneath it. Its presence was neither known nor suspected prior to the CT scanning of this harp. Figure 55 gives a more complete picture of the joint with a video clip of a series of cross-sections through it.

Figure 55.

Video clip of sagittal (lengthwise) cross-sections through the Queen Mary harp, showing the iron strap and nails driven through it, as well as the metal rod wedged in the joint. A crack can be seen in the tenon, and a small wedge is visible between the back of the neck and the soundbox. This video clip is available in the electronic form of this document, and also as the file ***QM_neck_sag_09.mov*** *on the disc accompanying the paper copy. Tomograms obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland, 2D rendering by Karen Loomis.*

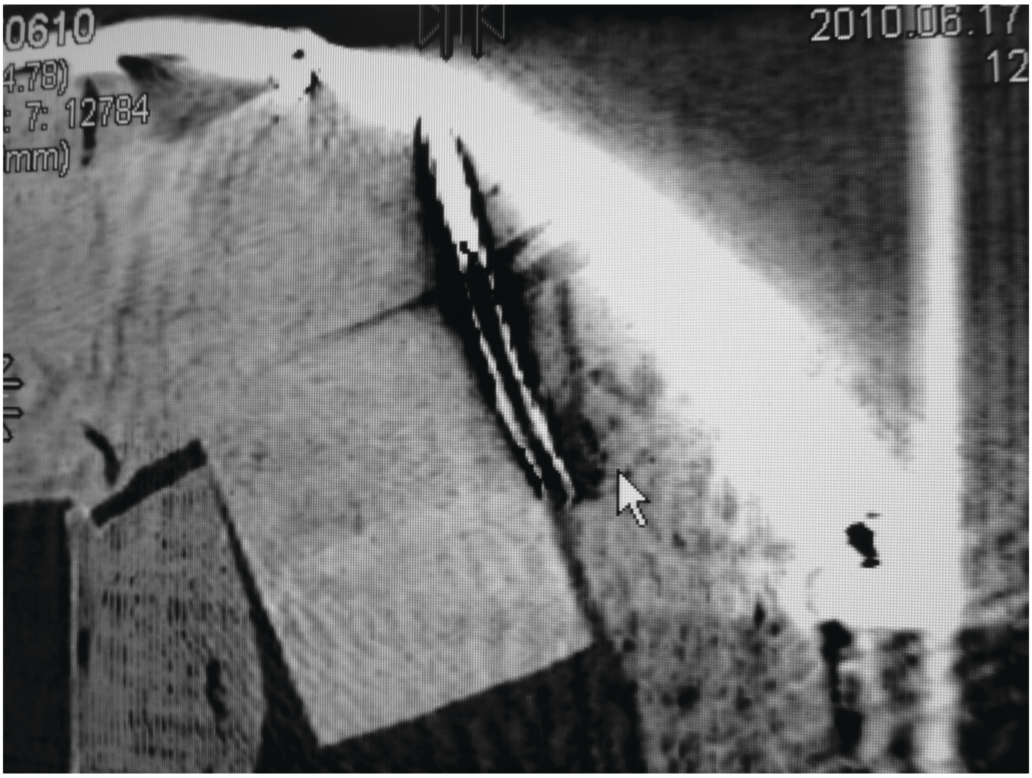
In this video clip, the nails can be distinguished from the metal rod. The crack in the tenon can also be seen, as well as a small wedge at the back of the neck. The video clip in figure 56 shows a series of cross-sections parallel to the front of the soundbox, descending through the entire length of the neck, into the joint with the soundbox.

Figure 56.

Video clip of CT cross-sections parallel to the front of the soundbox, descending through the length of the neck into the joint with the soundbox. Nail remnants are visible in the front end of the neck, as are the cracks running between the tuning pin holes, and metal fragments (possibly shims) inside the pin holes. A crack can be seen extending from one side of the tenon. The shim is visible as a thin wedge at the back of the neck, and the metal rod and nails in the neck appear as bright spots. This video clip is available in the electronic form of this document, and also as the file ***QM_neck_cor.mov*** *on the disc accompanying the paper copy. Tomograms obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland, 2D rendering by Karen Loomis.*

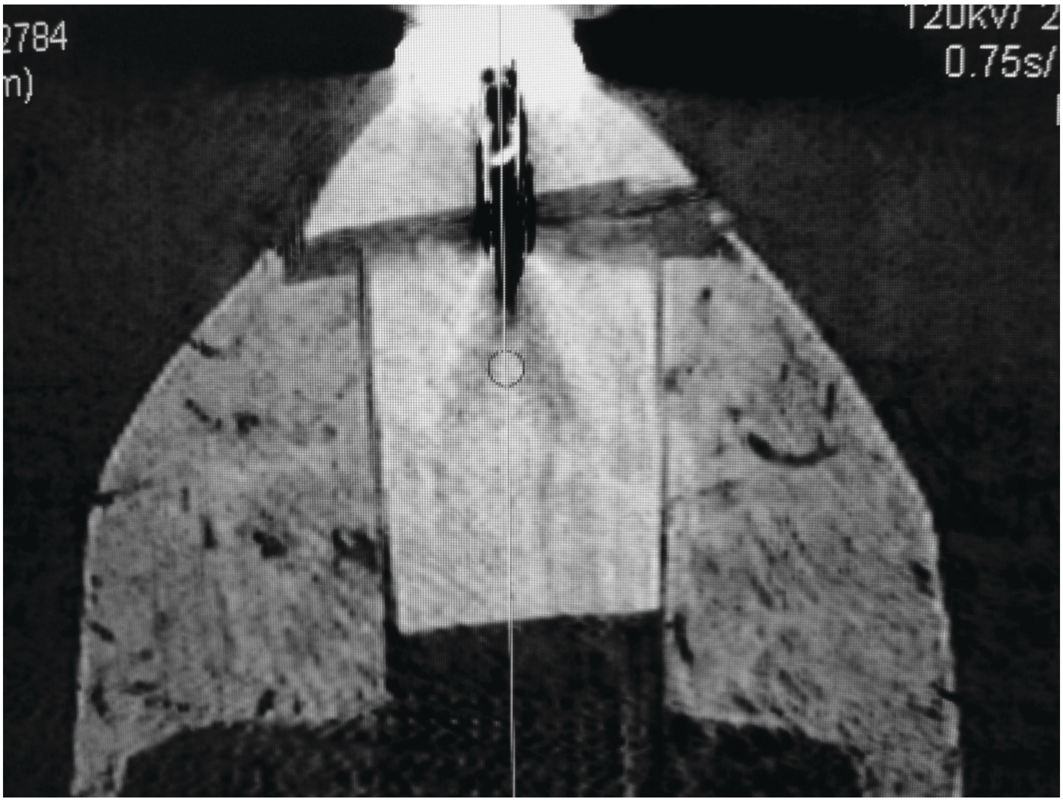
This video clip and the clip in figure 55 show that the tenon has rotated slightly out of its joint towards the left side of the harp, and a crack has opened up from the back-right corner of the tenon. This is very likely due to the tension of the strings pulling the neck down and towards the left side of the harp. Looking at the wood in these tomograms, the end grain is on the front and back faces of the tenon (facing the front and back of the soundbox), and it is evident that the tenon split along the grain. The metal rod may have been inserted as a wedge in the gap between the back of the tenon and the mortise. Initial images displayed as the harp was being scanned suggest that the rod may be hollow or channel shaped as shown in figures 57 and 58, which are snapshots of the data acquisition screen.

Figure 57.



Snapshot of a screen of data taken during the scanning process, showing a sagittal (sideways) view of the neck to soundbox joint of the Queen Mary harp with what may be a hollow metal rod in the neck. tomogram obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland. 2D rendering by Tessa Smith, CRIC.

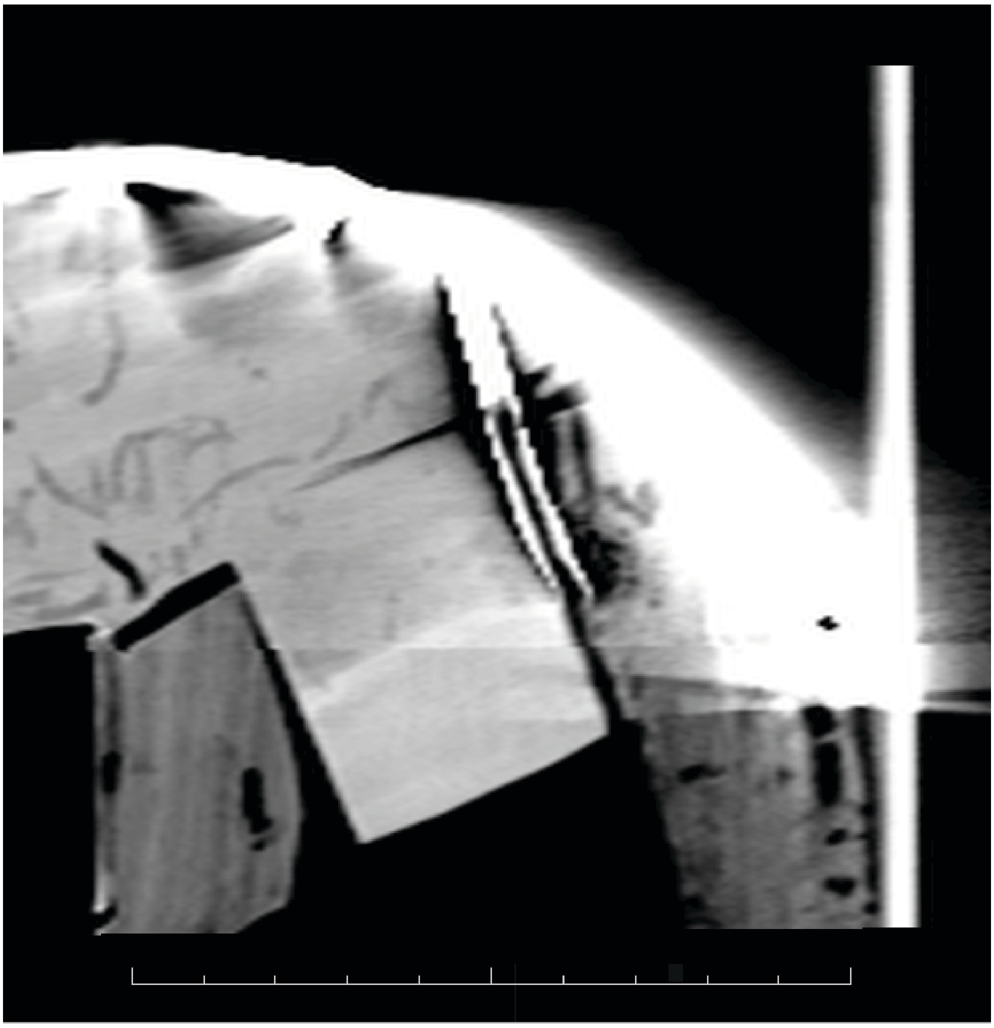
Figure 58.



Snapshot of a screen of raw data taken during the scanning process, showing a coronal (parallel to the front of the soundbox) view of the neck to soundbox joint of the Queen Mary harp. In this tomogram, the rod appears to be channel shaped. Tomogram obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland. 2D rendering by Tessa Smith, CRIC.

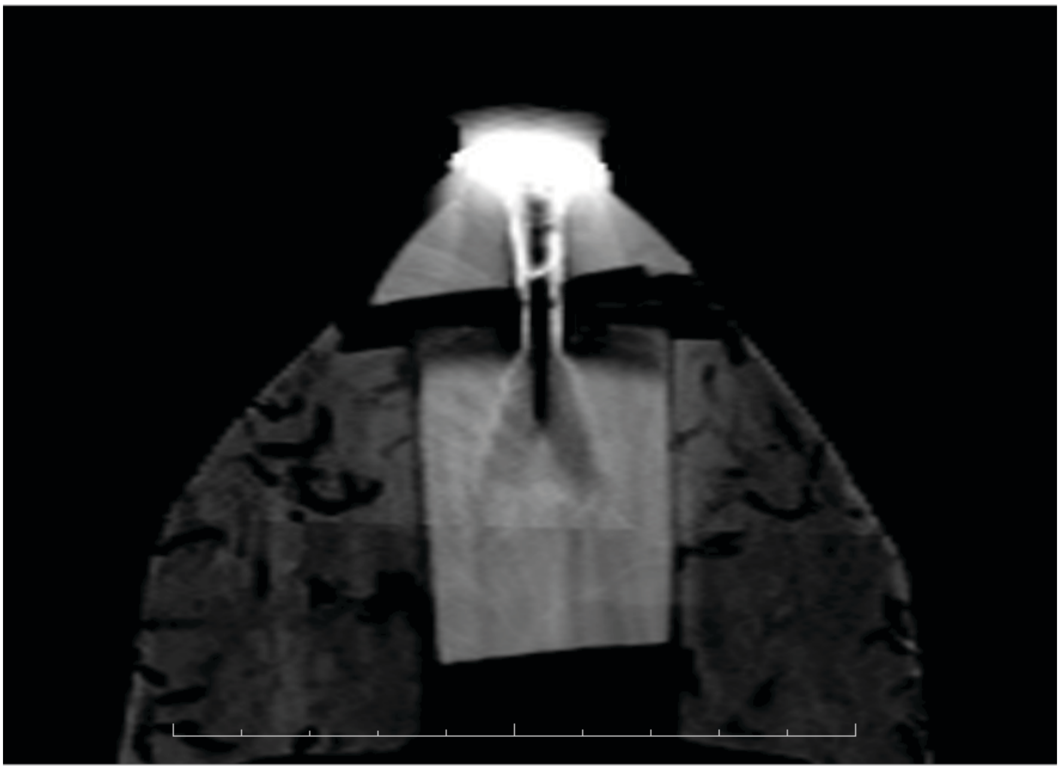
It is possible to reproduce these tomograms with processing as shown in figures 59 and 60, but it is not at all clear that the apparent hollowness of the rod is not an artifact of the image processing.

Figure 59.



A post-processed cross-section of the neck joint of the Queen Mary harp similar to that shown in figure 57. *The scale is 1 tick = 1 cm. Tomogram obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland. Minimum Intensity Projection, thick slab mode 6. 2D rendering by Karen Loomis.*

Figure 60.



A processed cross-section of the neck joint of the Queen Mary harp similar to that shown in figure 58. *The scale is 1 tick = 1 cm. Tomogram obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland. Minimum Intensity Projection, thick slab mode 6. 2D rendering by Karen Loomis.*

The CT cross sections contain other interesting information, particularly the video clip of the coronal cross-sections (parallel to the front face of the soundbox) shown in figure 56. Some of the details discussed in the previous section, on the neck of the harp, can be seen in this clip. The ends of nails that are supposed to have held decorative badges are visible on the end of the neck, as is the crack running along the harmonic curve, in between the tuning pin holes. The metal fragments inside some of the holes can also be clearly seen.

The neck to soundbox joint in the Queen Mary and Lamont harps have failed in similar ways, though the Lamont's more drastically. This joint appears to be a weak point for both of these harps. Perhaps the stringing changed over time, causing them to become more heavily strung than originally intended, which would lead to the failure of the neck joint. Another possibility is that the weakening of the wood with age and woodworms, simply caused an already vulnerable joint to fail.

Conclusion:

As is evident from the discussions presented here on the structural damage and repairs to these two early Gaelic harps, the CT scanning revealed hidden damage and/or repair work in every member of both harps. In every instance, there was newly discovered information that has advanced current understanding of the construction of these two harps, in particular, and early Gaelic harps in general.

To review what was discussed in the preceding sections on the harps, the soundbox of the Lamont harp was discovered to have internal repairs to a crack in its right side, and a crack was revealed hidden underneath a metal strip on the string band. The foot of the harp was discovered to have extensive woodworm damage and its repair work was imaged fully for the first time, revealing its current deteriorated state. Tomography of the repair work to the forepillar of the Lamont harp revealed a rivet hidden underneath the iron straps used for the repair work. The split and repair work to the neck of the harp were fully imaged for the first time, revealing the extent of the crack and numerous nails driven into the underside of the neck to repair it. The tomography of the neck to soundbox joint of this harp uncovered a treasure trove of entirely new information on the structural damage and repair work to this joint. The tenon was revealed to be sheared completely off and reattached with a large spike and four dowels, reinforced with a supporting block nailed into its side and a slip of wood wedged into the joint and slotted into the back of the neck. Additionally, a shim was discovered in between the neck and soundbox, raising the tenon out of its socket.

On the Queen Mary harp, despite its outward appearance of being nearly intact, numerous internal cracks and splits were found, in addition to some hidden repair work. On the soundbox, a crack was discovered along the edge of the string band. A previously known crack was imaged and its depth accurately measured for the first time. A crack in the base of the soundbox was confirmed to have been caused by a nail driven through a patch in the back cover. The full extent woodworm damage to the back cover was imaged for the first time as were the location of all of the nails affixing the cover to the back of the harp, several of these were discovered to have been cut. Examination of cracks in the forepillar led to the discovery that it was fashioned from a curved limb, whose curvature it closely follows, and that the pith of the limb runs through it. The tomography showed that the most extensive crack was actually checking radiating from the pith. On the neck of the harp, a long suspected break in the cheekband was discovered hidden underneath a metal patch. Several small surface cracks were found to have additional related cracks hidden below the surface of the wood. An internal crack was also discovered running along the harmonic curve. At the neck joint with the soundbox, the tenon was found to have split similarly to the neck tenon on the Lamont harp, though not completely through. The nails driven through the iron strap at the back of the neck were imaged for the first time, and a post was discovered, hidden under the strap and wedged into the joint.

As mentioned earlier in this paper, the story of both of these harps is one of moderate to severe damage in the form of strain and failure of the wood caused by the tension of the strings. The nature of the repairs, specifically the degree of effort put to reinforcement against the tension of the strings tells us something about how these harps were used, and is a testament to the determination of their owner to keep them in working condition. One has to wonder if both of these instruments, particularly the Lamont harp, were strung more heavily than originally intended by their design. Stringing styles can change over time. Did changing musical tastes dictate ever increasing tension for early Gaelic harps to the point that the instruments suffered structural failure?

Though not related to the way in which the instruments were designed and used, from a conservation standpoint, the evidence of extensive woodworm damage is of great importance. Both harps have areas that are critically damaged by woodworms. In particular, the foot of the Lamont harp (upon which the entire 8 kg weight of the instrument is currently resting), and the back cover of the Queen Mary harp, which may be the only surviving original back cover of any Gaelic harp. Certainly this information will be of use to conservators who can take steps to protect vulnerable areas of these instruments.

This study has enormously advanced current knowledge and understanding of the early Gaelic harp, and it has only just begun to scratch the surface of the store of information contained in the CT scans of these two harps. A great deal of complementary information has also been obtained in the photographic and analytical work conducted at the National Museums Collections Centre. It is hoped that the research and analysis of these two harps will continue and that the opportunity will arise to research other early Gaelic harps. This work will have an immediate benefit in helping creating a clearer and fuller picture of how these instruments were constructed and used. It is also hoped that this work will create a body of information that will benefit future generations of people who admire this instrument and its music.

Addendum: Discovery of a Wire Fragment

During the course of this study, a fragment of wire was discovered embedded in one of the string holes of the Lamont harp. As only the second piece of wire to be found to date on any surviving Gaelic harp, the author felt that this discovery was important enough to include as an addendum to the thesis.

Information fundamental to understanding and recreating the sound of historical stringed instruments lies within the stringing material that was used. The physical properties of the strings determine the pitch, timbre, and feel of the instrument, which in turn effects interpretation of historical performance technique and repertory, as well as the sound produced. Historical musical strings are ephemeral, however, and though samples do exist, they are not common.[49] This is true for wire strings as well, in particular for the strings of the Gaelic harp. There is very little information on the stringing of these instruments, though a few historical sources offer tantalizing bits of information. The earliest is the *Topographia Hibernica,* written in the late 12th century by Geraldus Cambrensis.[50] In his passage describing the playing of the Gaelic (Irish) harp, he writes, "Actually, bronze [copper] strings are used, not strings made of hide [gut]".[51] So, from Geraldus we learn that strings in the 12th century were wire and were probably a copper alloy (the Latin word *aeneis* he uses can mean either copper, bronze, or brass). For the Queen Mary and Lamont harps, historical references from the 16th to the early 18th century are most relevant, as this is the time period during which these two instruments were most likely in use. Gunn (1807) quotes the Scottish historian George Buchannan writing in the late 16th century on the

[49] Goodway, M. & Odell, J. S. (1987) *The Historical Harpsichord Volume Two: The Metallurgy of 17th and 18th Century Music Wire*. Stuyvesant, Pendragon Press, p 1.
[50] Page, C. (1987) *Voices and Instruments of the Middle Ages*. London, J. M. Dent & Sons Ltd, p. 218.
[51] Geraldus Cambrensis (1188). J. F. Dimock, ed. (1867), London, quoted in Page, C. (1987), page 230, alternate text quoted in Hawkins, J. Sir. (1776) *A General History of the Science and Practice of Music*. London, T. Payne and Son, p. 8. (The original Latin is *"AEneis quoque utuntur chordis, non de corio factis* [or "*non de intestinis vel corio factis"* in Hawkins].")

harp in Scotland: "some are strung with brass wire, others with intestines of animals;"[52]

In 1581, Vincenzo Galilei writes that Gaelic harps "commonly have strings of brass and a little steel [iron] in the treble"[53] and in 1619, Praetorius describes the Gaelic harp (*Harpa Irlandica*) as having "coarse brass strings".[54] Chadwick (2004) quotes an interesting passage in Philip O'Sullivan Beare's 17th century treatise, *Zoilomastix*, which specifically mentions brass (or bronze) and silver wire for the Gaelic harp:

> "If you were to be faithful to the historical truth, you would pass on the fact that the strings of the harp are never of iron, but are of brass and silver."[55]

And in his late 17th century Manuscript, Talbot gives a description of the Gaelic (Irish) harp; pointing out that it has brass strings.[56]

These sources represent essentially all of the known historical information on Gaelic harp stringing prior to the late 18th century. Modern instrument makers have had to make intelligent assumptions regarding the stringing of replicas of these harps, and modern performers have had to play replicas of instruments for which the string materials, gauge, pitch and gamut are almost entirely unknown. Samples of historical wire harp strings would add a great deal of information to the understanding

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[52] Buchannan, G. (1579) *Rerum Scoticarum Historia*. (The original Latin is "quarum aliis chordae sunt aeneae, aliis e nervis factae.") Quoted in Gunn, J. (1807) *An Historical Enquiry Respecting the Performance on the Harp in the Highlands, &c*. Edinburgh, Archibald Constable and Company, pp. 68-69, electronic facsimile (2005), www.scotpress.com, Scotdisc.
[53] Galilei, V. (1581) *Dialogo di Vincentio Galilei Nobile Fiorentino Della Musica Antica et Della Moderna*. Fiorenza, Giorgio Marescotti, p. 143. (The original Italian is "hanno comunemente le corde d'ottone, & alcune poche d'acciaio nella parte acuta.")
[54] Praetorius, M. (1619) *Syntagma musicum*. Facsimile reprint (2001), Forchert, A. ed., Kassel, Barenreiter-Verlag Karl Votterle GmbH & Co. KG, p. 54. (The original German is "*grobe dicke Messings*.")
[55] Beare, P. O'Sullivan (c. 1625) *Zoilomastix*. Quoted in Chadwick, S. (2004) *Stringing: History*. [Online] (Updated May 2006) Available at http://www.earlygaelicharp.info/stringing/history2.htm [Accessed 21 July 2010]. (The original Latin is "*Qui si praestitisses historicam fidem, fides nunquam ferreas, sed aeneas, vel argentas lyrae, et tympano a musicis nostris aptari, tradisses*" English translation by Nicholas Carolan, quoted by Chadwick.)
[56] Talbot, J. (late 17th c.) *Christ Church Library Music MS 1187*. Quoted in Rimmer, J. (1963) James Talbot's Manuscript (Christ Church Library Music MS 118): VI. Harps, *The Galpin Society Journal,* 16 (May), p. 66-67.

of the stringing of these instruments. Bunting (1840) mentions a harp discovered 4 metres under the surface of a bog near Limerick in 1805 with three brass strings still on it.[57] Sadly, this specimen has since disappeared. Although some wire has been found at archeological sites in the British Isles, none of it has been directly linked to a harp.[58] In the 1990's, a single fragment of wire was found corroded to a tuning pin belonging to the Ballinderry harp fragments.[59] The remains of this harp consist of a set of metal fittings for the neck of what must have been a 36-string instrument, found in the Crannog of Ballinderry in Ireland in the 19th century.[60] The surviving metal work is reminiscent of that found on the Lamont Harp. This wire fragment is the first modern discovery of a plausibly historical wire *in situ* on an early Gaelic harp.[61] It is a 4.8 mm long, 0.7 mm diameter specimen of copper alloy containing 10% zinc.[62]

As discussed in the author's thesis: *The Queen Mary and Lamont Harps: A Study of Structural Breaks and Repairs*, the back of the Lamont harp came off, allowing inspection of the inside of the soundbox. Upon visual examination of the string holes, the author found a fragment of wire embedded in hole #14.[63] The fragment is shown in figure 1 and, judging from the coating of verdigris, is probably a copper alloy.

[57] Bunting, E. (1840) *The Ancient Music of Ireland, Arranged for the Piano Forte*. Dublin, Hodges & Smith, facsimile edition (1969) Dublin, Waltons' Piano and Musical Instrument Galleries, p. 20.
[58] Chadwick (2004) *Stringing: Archaeology*. [online] Available at http://www.earlygaelicharp.info/stringing/archaeology.htm [accessed 22 July 2010].
[59] Evans, R. (1997) A Copy of the Downhill Harp. *The Galpin Society Journal*, 50 (March), p. 124.
[60] Armstrong, R. B. (1904) *The Irish and Highland Harps*. Edinburgh, David Douglas. Facsimle reprint (1969) New York, Praeger Publishers, Inc., pp. 63-64.
[61] Chadwick, S. (2004) op. cit. [Accessed 20 July 2010].
[62] Evans, R., op. cit., p. 124.
[63] String hole numbers start with #1 at the treble end of the harp.

Figure 1.

Wire fragment in string hole #14 of the Lamont harp, viewed from the inside of the soundbox. The hole is 5 mm in diameter. (photo: Karen Loomis, courtesy of the National Museums of Scotland)

It's important to consider whether or not the fragment remaining in the Lamont harp is a piece of historical wire. Gunn (1807) and Bell (1880) establish, based on family records and a published eyewitness account, that the last person to play the Lamont harp was John Robertson of Lude[64] (born before 1673, died. c. 1730)[65], whose family had long been in possession of this and the Queen Mary harp, and who was an accomplished player of the instrument.[66] Furthermore, Robertson's repertory survives

[64] Gunn, J. (1807), op. cit., p. 96, and Bell, C. (1880) Notice of Two Ancient Harps and Targets. *Proceedings of the Society of Antiquaries of Scotland*, 15, p. 29.
[65] Small, A. R. (1907) *Geneology of the Robertson, Small, and Related Families*. Indianapolis, A. G. Small, p. 24.
[66] ibid.

and indicates that he played the music characteristic to the Gaelic harp.[67] In the early 19th century, Gunn, on behalf of the Society of Antiquaries of Scotland, had a new set of brass strings put on the Queen Mary harp with the intention of restoring it to playable condition.[68] The Queen Mary harp was chosen for restringing over the Lamont, due to its apparently better state of preservation.[69] After Gunn concluded his research on the harps, they were returned to their owner, General Robertson of Lude, who did not play the harp (Hipkins (1888) states that General Robertson, not his grandfather John Robertson, was the last player of both harps, but this appears to be a misreading of the information in Gunn (1807) and Bell (1880)).[70] Both harps remained with the Ludes until the late 19th century, when they passed by marriage to the Steuarts of Dalguise.[71] Bell (1880) notes that while they were in private hands during much of the 19th century, their existence was "forgotten by the general public and almost lost sight of even by antiquaries."[72] Which suggests that the Lamont harp was left essentially untouched from when Gunn had it until Bell examined it in the late 19th century, at which time it was put on display at the National Museum of Antiquities of Scotland. It is unlikely, therefore, that the Lamont harp was ever restrung during the 19th century.

When identifying historical string material, it is also important to be aware that modern "prop" strings are sometimes put on harps for display purposes. The Lamont harp is currently displayed without strings. In 1904, the Lamont and Queen Mary harps were both auctioned off as part of the Durrant-Steuart estate.[73] The Lamont harp was sold to Moir Bryce, an antiquarian who later bequeathed it to the National Museum of Antiquities (now the National Museums of Scotland) upon his death in

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[67] Gunn (1807) op. cit., p. 96-97, and Chadwick, S. (2004) *Sources for Gaelic Harp Music: John Bowie* [online] (updated January 2006) Available at: http://www.earlygaelicharp.info/sources/bowie.htm [accessed 22 July 2010].
[68] It is not known if either the Lamont or the Queen Mary had any surviving strings when they were lent to the Society of Antiquaries for examination by Gunn.
[69] Gunn (1807), op. cit., p. 16-18.
[70] Hipkins, A. J., and Gibb, W. (1888, reprinted 1921) *Musical Instruments: Historic, Rare, and Unique*. London, A. and C. Black, Ltd., p. 4.
[71] Sanger, K. and Kinnaird, A. (1992) *Tree of Strings: A History of the Harp in Scotland*. Shillinghill, Kinmor Music, p. 72.
[72] Bell (1880) op. cit., p. 13.
[73] Auction catalogue (12-14 March 1904) *Valuable Antique Furniture Stuart and Jacobite Collection*. Edinburgh, pp. 9-10, H. LT2 archive, National Museums of Scotland.

1919, at which time the harp came into the permanent possession of the Museum.[74] It is not known if Bryce ever had strings put on it, however, a glass photographic plate, possibly dating from the time the Lamont harp was acquired by the Museum from Bryce, shows it without strings.[75]

Figure 2.

Print from a glass photographic plate of the Lamont harp, possibly early 20th century. H. LT2 archive, courtesy of the National Museums of Scotland.

A photograph in Armstrong (1904) also shows it without strings.[76] None of the later photographs of the harp in the Museum archives show it with strings, suggesting that the museum did not put display strings on it. It's reasonable to conclude that this fragment is likely a piece of historical wire dating at least to the early 18th century, and possibly earlier, as there appears to be enough room in the string hole to pass a new string through with the fragment in place. It is, therefore, an item of extreme interest and merits close examination.

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[74] Bryce, M. (25 October, 1918) *The Lamont Harp*. Letter to Moncrieff, S., Society of Antiquaries of Scotland, National Museum of Antiquities, Queen Street, Edinburgh, and Macritchie, C. A. (1919) *Proceedings of the Society*. 8 December, p. 12. H. LT2 archive, National Museums of Scotland.
[75] Unlabled glass photographic plate, H. LT2 archive, National Museums of Scotland.
[76] Armstrong, R. B. (1904) op. cit., plate opposite p. 158.

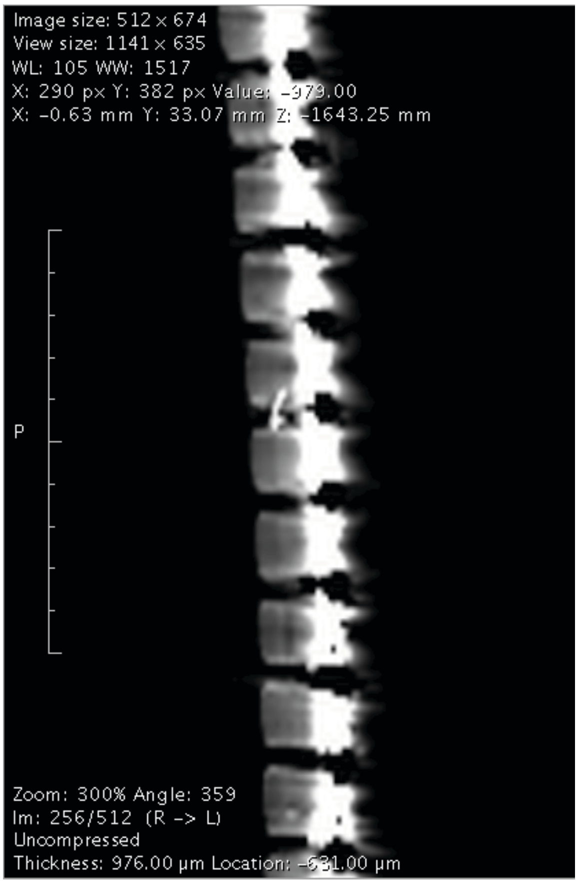
Although the wire fragment was discovered visually, had the back of the harp not come off, it is likely that it would have been noticed on the Tomograms, which show even small metallic objects in clear contrast to the wood. Regardless of how the fragment was discovered, the tomograms of the Lamont harp contain important information that supplements the initial visual examination of it and is essential for directing further work.

The photograph in figure 1 only shows one end of the fragment, tomograms of the Lamont harp revealed the rest, hidden further up the string hole and, as it turns out, embedded in the wood. Figure 3 shows a sagittal (side view) cross-section of the harp through the string band in the soundbox, showing the string holes and the wire fragment, and figure 4 is a detail of this cross-sectional view, showing the wire fragment and the surrounding wood. Firstly, the appearance of the image of the fragment in the CT view shows that it has a high degree of opacity to x-rays, comparable to the known metal objects on the harp and much higher than the surrounding wood. This confirms that the object observed in the string hole, and visible in the photograph in figure 1, is metallic. The profile of it apparent in figures 3 and 4 suggests that it is a piece of wire.

Figure 3.

Tomogram of the Lamont harp through the string band, showing the string holes. The white areas are metals, and the grey areas are wood. The metal areas on the string band are the string shoes nailed to the front of soundbox, through which the strings pass. The treble end of the harp is towards the top of the tomogram, and the inside of the soundbox is towards the left. A portion of the forepillar is visible in the lower right. The wire fragment (arrowed) is readily visible. The scale is 1 tick = 1 cm. Tomogram obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland, 2D rendering by Karen Loomis.

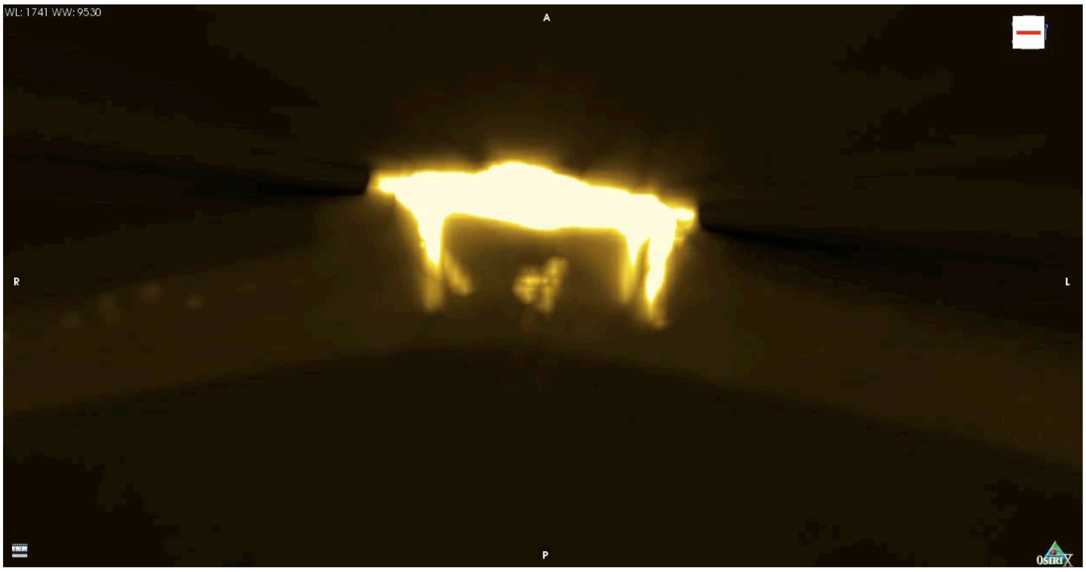
Figure 4.



Detail of CT cross-sectional view through the string band of the Lamont harp. The inside of the soundbox is towards the left side of the tomogram, and the treble end of the harp is towards the top. As in figure 5, grey areas are wood and white areas are metallic. The straight end of the wire fragment appears to be embedded in the wood. The scale is 1 tick = 1 cm. Tomogram obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland, 2D rendering by Karen Loomis.

The tomogram in figure 4 shows that approximately 5 mm of the wire fragment is embedded in the wood surrounding the string hole, however it doesn't show the overall shape of the fragment. This is revealed in figure 5, which is a 3D reconstruction from tomograms of a cross section of the Lamont harp (see also the file wire_fragment_6.mov included with this document).

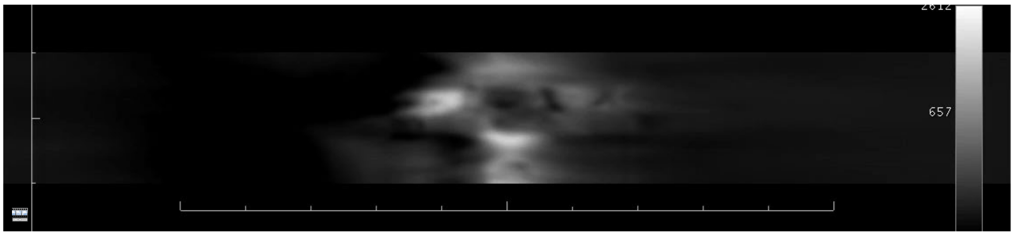
Figure 5.



3D rendering of tomograms of a cross section of the Lamont harp showing the wire fragment embedded in string hole #14. The front of the soundbox is towards the top of the tomogram. The inside of the soundbox is towards the bottom. The very white object just above center is the string shoe for hole #14. The wire fragment is visible as the smaller object "floating" between the nails of the string shoe. The video clip is available in the electronic form of this document and also as the file ***wire_fragment_06.mov*** *on the disc accompanying the paper copy. Tomograms obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland, 3D rendering by Karen Loomis.*

Figure 5 shows that the end of the fragment that is not deeply embedded in the wood is bent downwards, towards the inside of the soundbox, and close examination of the coronal cross sections (parallel to the plane of the soundboard) shown in figure 6 suggests that the tip of this end may actually be embedded in the wood as well.

Figure 6



*Video clip of coronal cross sections (parallel to the plane of the soundboard) passing through string hole #14 from above the soundbox. The string hole is dark, and white dots appearing within it are cross sections of the wire fragment. The white "armed" object that appears centered on the string hole at the beginning of the clip is the string shoe. The two white dots to either side of the string hole are nails. The treble end of the harp is towards the top of the tomogram. The embedded end of the fragment appears as a vertical streak, and the other (possibly embedded) end appears as a white dot on the edge of the string hole at about the position of 1 o'clock. The video clip is available in the electronic form of this document and also as the file **wire_cor.mov** on the disc accompanying the paper copy. Tomograms obtained at the Clinical Research Imaging Centre, courtesy of the National Museums of Scotland, 2D renderinsg by Karen Loomis.*

This information is crucial to any decision as to how, or whether, to remove the wire fragment for analysis. It would have to be removed without damaging the surrounding wood and ideally would be removed intact. Had the tomograms not been available, an attempt might have been made to pull the wire out in a manner that could have caused it to become more deeply lodged in the string hole or could have caused the embedded end to snap off. The soundbox wood of the Lamont harp is fragile and the string hole could also have been damaged. Forthcoming discussions with Museum conservation staff will include these tomograms and an informed decision will be made as to how to proceed with the wire fragment.

The photograph in figure 1, and the tomograms in figures 3 – 6, hint at the twisted shape of the fragment, suggesting that it might be part of a toggle knot. Historical sources describe Gaelic harp strings as being fastened to wooden toggles to keep the string from pulling through its hole in the soundbox. As Talbot describes it, "strings pass from the head [neck] and are fastened on the inside by a noose drawn over a bit of wood."[77] Armstrong (1904) quotes "Dr. Lynch"[78] mentioning toggles when

[77] Talbot, J., quoted in Rimmer, J., op. cit., p. 67.

describing restringing through a soundhole: "Through these holes the pegs attached to the strings were passed when new strings were required"[79] and Bunting (1840), in naming the parts of the Gaelic harp in use in the late 18th century, includes the "wooden pegs to which the strings are fastened."[80] The inside of the Lamont harp soundbox shows numerous impressions around the string holes that were very likely made by toggled strings. Figure 7 is a photograph of these impressions, which were first reported by Hobrough (1979)[81] and will be discussed in depth in a future paper, but for the moment they serve as a strong indication that the strings were knotted or looped around a toggle which rested against the inside of the soundboard.

Figure 7.

Toggle marks visible on the inside of the soundboard of the Lamont harp. The treble end of the harp is towards the right side of the photo. The wire fragment is in the second hole from the right. Photo: Karen Loomis, courtesy of the National Museums of Scotland.

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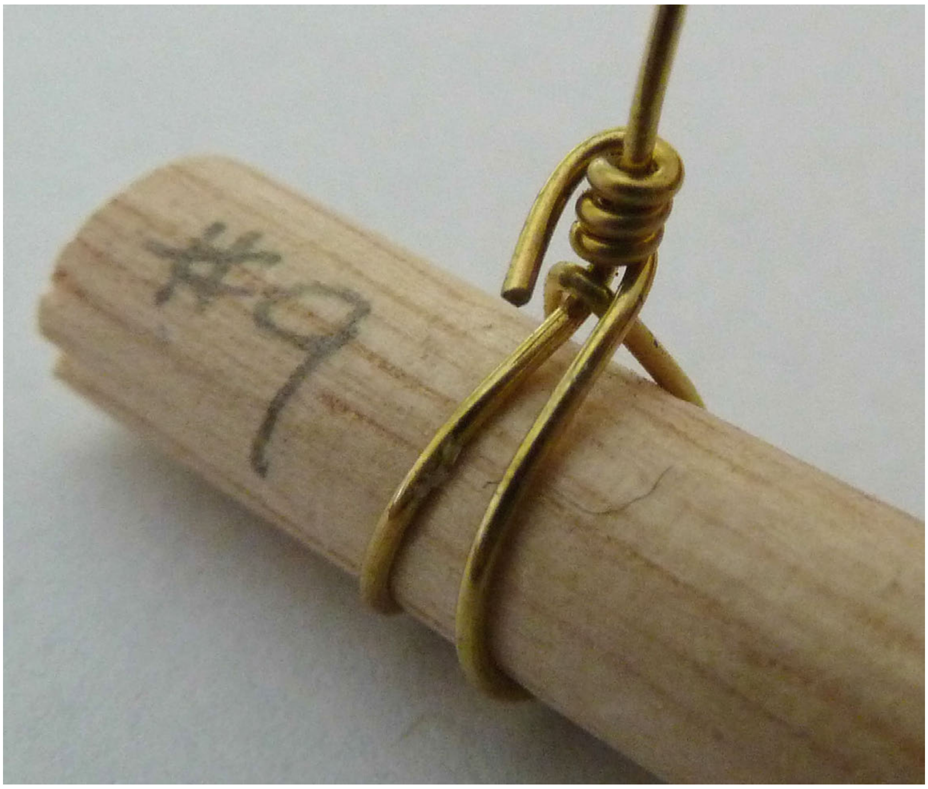
[78] Probably John Lynch, author of *Cambrensis Eversus* (1662).
[79] Armstrong, R. B. op. cit., p. 28-29.
[80] Bunting (1840), op. cit. p. 20. Here, he is referring to the wooden toggles that hold the strings to the soundboard, not the tuning pins.
[81] Hobrough, T. (23, January 1979) *Notes on the '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 of Scotland.

Figure 8 shows a modern toggled string knotted in the manner developed and described by Heymann (1988).[82]

Figure 8.



A modern toggle with Heymann style knot. The toggle is 6 mm in diameter and the wire is 0.56 mm yellow brass. Knot and photo by Karen Loomis.

This is the toggling knot currently in use on most replica Gaelic harps. There is no historical information on the manner in which the strings were fastened to the toggles and no historical toggled strings are known to have survived, so the existence of a possible partial toggle knot is of great interest. Though there isn't enough information in the wire fragment to indicate how it was originally fastened to the toggle, thanks to the tomograms, there is now some information upon which to speculate. Measurements taken from the CT data reveal that the length of the longest straight section of the fragment is 1.0 cm. Chadwick (2010) has suggested that this may be the "tail" end of a toggle knot (several mm longer than that shown on the

[82] Heymann (1988) *Secrets of the Gaelic Harp*. Minneapolis, Clairseach Productions, pp. 123-124.

modern toggle knot in figure 8, but not implausible) that became lodged in the wood like a barb when the string broke.[83] This does occasionally happen with modern toggle knots, and the author keeps a stiff wire rod to hand for the purpose of dislodging the ones that do. It's possible that most of the knot broke off in the attempt to dislodge it from the string hole, leaving the fragment.

This wire fragment is a significant discovery for research of the Gaelic harp. There are now two known pieces of surviving string material (which does not seem like a lot, but is twice as much as before). Furthermore, this fragment was found *in situ* in a string hole, making its location on the instrument quite certain,[84] as opposed to a string fragment found on a tuning pin, which could easily have been moved from its original position. To date, stringing practice for the revival of the Gaelic harp has been based on nearly non-existent historical information. It is not known if stringing practices currently in use for modern replicas of Gaelic harps resemble any historical stringing for these instruments. Assumptions that are made about the stringing affect all aspects of the revival of this instrument, including the design of modern reconstructions, interpretation of the surviving repertory, and the sound produced (which in turn feeds back into performance practice and instrument design). Information on the composition and diameter of this fragment will make it possible to propose a plausible historical stringing regime for the Lamont harp. A recently worked out stringing regime for a replica of this harp is, as it turns out, scaled from string #14,[85] the same string position at which the wire fragment was discovered. For the record, the wire proposed for that string was 0.44 mm red brass, and the author looks forward to discovering how this compares to the actual wire in string hole #14 on the original Lamont harp!

[83] Chadwick, S. (20 July 2010) *Discussion on the nature of the shape of the wire fragment in the Lamont harp*. [video conference] (Personal communication).
[84] There is more than one possible string length, however, even with the original form of the instrument reconstructed. Inspection of the toggle marks on the inside of the soundbox revealed that string holes #1 and #32 (the first and last) were probably not used, which means there are two extra tuning pins. So, for example, the wire in string hole #14 could have been strung to pin #13, #14, or #15, resulting in three different possible string lengths.
[85] Loomis, K. (2009) *A Revised Stringing Regime for the Flockhart Replica of the Lamont Harp*. [unpublished].

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