Reading the Historical Record from an Early Broadwood Grand Piano

Over the last twenty years it has become more fashionable to leave original surfaces of antiques intact rather than strip and replace finishes, as expert after expert in such public forums as 'Antiques Road Show' drill into the viewing audience the financial importance of "original condition" and preserving historical surfaces. This same mantra easily applies to early keyboard instruments, and forms the basis of this discussion. However, we can push the subject further by demonstrating the value of a historical surface through a careful reading of the data it presents, even in the face of returning a keyboard instrument to service, which often presents requirements for intervention and repair that are incompatible with leaving the instrument untouched. Perhaps more than period furniture or decorative items, keyboards may be subjected to intense structural stress (string tension), and wear and tear for all types, over centuries of use. Hundreds of moving parts are actuated and touched thousands of times during a concert or recital. Returning a keyboard instrument to playing condition has historically required some-to-much disassembly and concomitant reappraisal of the engineering and serviceability of important elements like sound boards and bracing. In the early 20th century the best restorers, including luminaries like Arnold Dolmetsch and John Challis, frequently regarded the period engineering with a sense of their own modern superiority, and added ribs, struts, etc. as their imagination led them on. Today, we are taking a different course towards less second guessing and rethinking of the builder's intent, and an appreciation for the techniques and skills they brought to their work.

This article documents the "reading" of historical surfaces used in the construction of a five octave Broadwood grand piano dated 1791, as an example of how one might glean some insight into the building traditions of the London music trades, some of which are very specific to the requirements imposed by time and structural engineering concerns. Often, our tendency is to think of musical instruments solely in terms of their power to create music as intended, and perhaps as decorative objects while silent. With early instruments however, we have the possibility to look beyond the functional intent, and by studying the object itself both externally and internally, enable a glimpse into the building traditions and business choices confronting the early makers, while perhaps gaining some greater appreciation for the challenges they were overcoming to bring the musical instruments to market while securing a competitive reputation. We might also arrive at an insight into the value sets imposed by two centuries of restorers and technicians who have kept the instrument in playing condition, against the changing demands and expectations of the owners.

Throughout his 2010 book Artifacts in Use : The Paradox of Restoration and the Conservation of Organs[1], John Watson challenges those who restore functional artifacts to treat historical surfaces as fragile evidence of historical craft practice. For those of us who have long felt that the paradox of restoration has needed to be more thoroughly understood, this book joins a rather short list of required reading on the subject, including the PhD thesis and rather readable book Preservation and Use of Historic Musical Instruments by Robert Barclay[2]. Watson summarizes the paradox referred to here with the tale of the Greek hero Theseus, who on returning to Athens after defeating the Minotaur, is celebrated by having his ship preserved as a monument to the event. Over the years as the ship deteriorates and pieces are replaced, the conservators begin to ask the question "at what point will this no longer be Theseus' ship? The city elders considered on the point and pronounced it a paradox!

The paradox for the early musical instrument restoration team is that in the process of 'restoring' an instrument to 'original condition' we may replace, alter, and impose modern values, towards reengineering the instrument into something it never was. At what point has it stopped being a genuine historical instrument and become a copy of itself, or even something chimerical? And when confronted with an instrument that, following due consideration, is judged to be a candidate to be brought back to playing order, what are the considerations consistent with accomplishing that end without significantly altering the historical record of the builder's art, or creating the unintended hybrid of their art and our own? This general subject has been addressed extensively by Barclay and Watson as referenced, in a much more complete way than is possible here. This article simply seeks to understand how understanding and interpreting historical surfaces can enhance the experience of being in the presence of the working instrument once it is returned to service. The term 'historical surfaces' often pertains to those structural surfaces never intended to be seen. These have most often experienced the brunt of alteration in the past, as restorers labored to return an instrument to playing condition at all costs, including partial to complete loss of the original work of the builder through modification and replacement. Throughout this article I have replaced the term 'restoration' with Watson's suggested 'restorative conservation' or derivatives of that term. While slightly pretentious sounding at first, it can be readily argued that it hits closer to the mark when describing the return of an instrument to utility, while respecting the integrity of the instrument as historical evidence. It is hoped that even if the term never gains wide acceptance, the approach might.

The reading of the historical record can offer certain challenges in itself. Some materials, particularly those that are ephemeral in nature to begin with like witness marks (grime accumulations that may indicate lost, shifted, or modern replacements) or used sparingly at most such as glue, may well be lost in the process of taking an object apart to reveal the record. A noted restorer once communicated the discovery of a square piano squirreled away, that on opening the lid after having sat for time out of mind, a thin vertical wall of dust, inches high, was seen where detritus had fallen through the gap at the lid hinge and accumulated undisturbed. Here in this most ephemeral of evidence the historical record speaks of an instrument in an unusual state of rest, lending credibility to any discoveries inside that may indicate more fully than other examples a specific builder's intent, free from years of intervention and alteration.

In the summer of 2010 the author acquired a Broadwood piano dated to 1791[3] and began a conversation within the community of opinion leaders on options concerning the instrument, including taking no action at all, though it must be stated up front that as the personal owner/restoration conservator, there was a presumption of returning the piano to playing condition from the start. This is not an uncommon requirement for the private owner who will be less likely to hold static instruments for display and documentation only, and a prejudice toward restorative conservation in private collections is part of the dynamic we discuss here. The choice to take an intrusive interventional course would offer the advantages of making more of the historical record available, much as an archeological dig will both disturb and reveal at the same time. Many harpsichords are still in existence because of *ravalement* campaigns to widen the compass and allow the instrument to play contemporary music. Today we would not remotely consider such an act, but we would not undo the ravalement of 250 years earlier, treating the instrument in its entirety as a historical document. All interventions made towards returning an instrument to service, regardless of how minor, can be viewed as subtracting from the original work while adding to the ongoing record. The philosophy promoted by Watson simply argues in favor of a light footed approach, which has become far more universal in the last two or three decades.

A piano from this early period in the Broadwood shops does not come available for study so very often, and the decision to correct a major structural failure was made based on many filters, including the likelihood of a success, the value of returning the instrument to playing condition, and the amount of potential information that could be gained from such a campaign. After consultations with John Watson, who described a minimally invasive approach, and David Hunt in the UK who advocated a more radical intervention, a plan with a somewhat more intermediate scope was formulated and executed to remove the soundboard and bottom boards, towards accessing the critical structural elements needed to correct the problem, but working with other original structural members like the wrestplank to return them to service rather than a wholesale replacement. It is not unusual that two respected and recognized experts will form fairly divergent views on how best to proceed with a major instrument restoration. Indeed, as Watson advocates in *Artifacts in Use*, section 1.3, *Window Theory: The Case for Combining Perspectives*, the formation of such differing views is sometimes key to a successful restorative conservation effort. A team approach can bring wisdom and viewpoints unavailable to any single researcher. The level of disassembly indicated is indeed intrusive, though the final plan called for less total replacement of original materials than has been common practice in traditional restorations, in keeping with the restorative conservation philosophy. Along with this disassembly, a sub-plan involved documenting and analyzing as much internal information as presented itself, and to distribute this documentation here to allow access by the community at large.

Perhaps the first objective historical reading concerns how the piano presents as-found, and the manifestation of the instrument's problem. We can read much in the discoloration from sunlight, and shading where it is less disturbed. This Broadwood has seen the usual value cycle as it aged, and we can speculate on its life history without knowing particulars, based on the physical evidence at hand. It was treasured at first and played regularly, perhaps by people of some talent, given the more than usually well distributed wear on the ivory keys. While it was still recent enough to have mattered, the date was obscured on the name board so as to resell it where an early date was considered a liability. Then slowly, it was attended to less often as the 5 octave compass and lack of power left it unable to play the expanding musical genre, as the fairly even wear slows well before the ivory is seriously eroded, where such erosion is the usual fate of instruments with a wider compass. It seems to have become more of a decorative item to be used as a plant stand and display table (the circular dark rings speak of an iron plant holder regularly watered and occasionally moved) while hosting several generations of powder post beetles between the top rail of the stand and the key bed (flight holes and activity around the interface of the bottom key bed strut and stand can only occur while the two are still mated), and during its nadir, stored for many decades on its spine in a dry area (the interior of the spine largely sealed to the outside shows clear evidence it was in this position for a long time), where it probably lost its music desk. At some point well before 1967, its nature as an early instrument brought it back to attention and to the restorer's hand (the initial cut curf in the bottom boards to remove the bottom the first time shows oxidation of the pine consistent with a cut perhaps a century old). It has been restored and altered at least three times in the past; the latest (prior to the present work) and only documented effort was done in 1984 by Watson himself[4], where a generous 12 page record including photographs was produced. The earlier restorations also constitute part of the historical record, though they have obscured the original builder's intent and workmanship somewhat. Approaching a restoration, we are often loath to document the later changes and improvements we encounter, to focus only on what we find still original, but a completely honest reading of the historical record would prompt us to record later restoration information also. In several hundred years, or perhaps less, the values these restorers imposed, no matter how misguided, will put the entire historical record of the instrument into context. The author encountered an early anonymous square at a well know piano rebuilders in SC and spoke with the gentleman who had "restored" it 50 years earlier as a young man. The hammer guide slots were all carefully lined in bushing cloth, which now created a host of problems. When asked what was there originally he replied "nothing as I recall, but we knew that couldn't be right or it would have been too noisy!" Of course hammer guide slots were NEVER lined like this, but it gives us access into a mid 20th C mindset.

The first restorations left the Broadwood grand vulnerable to the subsequent structural failures it experienced. The bottom was crudely sawn into near the spine, and the bottom wrested off. No effort was made to replace lost material when this was tacked back on later. This is the all-too-common consequence of restoration action taken without fully comprehending the engineering requirements of a given instrument. The most obtrusive repairs can include screws and biscuits driven and slotted through the outer veneer of grands at case joints, and a forest of wood screws of every imaginable size driven into square piano case bottoms. These are rarely effective, and always disfiguring. It is usually not possible to effect major structural repairs while an instrument is strung and under tension, and the effort and skill set required to disassemble and reassemble an early piano is generally outside the normal practice of the typical piano technician. The historical record involves the engineering scheme as well. We moderns are quick to second guess the builder and add or take away, but a true restorative conservation effort will bring this activity to a minimum, adjusting an engineering scheme only when the demands of returning the instrument to playing condition would result in greater loss if the engineering were left as-found. Much mischief, including critical soundboard and structural material losses in the 1720 Cristofori piano described by Pollens[5] and the 1937-38 restoration of the Walter piano once owned by Mozart[6] would have been avoided if the restorers had simply worked harder to retain original material and to forsake the wholesale replacement of historical components.

The Broadwood bears the serial number 309 in pencil on the bottom of the damper register consistent with other early Broadwood grands, with 317 recorded in ink on the lowest F key lever side along with the maker name Cainns, and 326 stamped on the action hammer rail top. The register of extant Broadwood grand pianos compiled by David Hunt[7] places this instrument's date of manufacture at 1791, and it is among the oldest Broadwood grand pianos extant. The use of multiple numbers within early square pianos in the Broadwood shop has been noted by other restorers including Hunt, but grand actions are rarely numbered at all. Any confusion over the correct date comes because the name board has had the date partially obliterated, probably to somewhat disguise the original date when the piano was resold early in its life. A gentle cleaning with saddle soap and a damp cloth revealed that the once guessed at date of 1794 which was lightly scratched and inked-in with modern blue ink, is clearly 1791, though obviously faint. The "1" was turned into an open "4", which stylistically is never seen in 18th C English calligraphy. **(Figure 1)** David Hackett[8] has recorded a 1787 Broadwood with the date changed to 1797, and Colm O' Leary [9] reported on a Broadwood dated 1795 whose date was also partially obliterated. By 1806 the use of dates on the name board by Broadwood was intermittent, and ceased a year or two afterwards. Dating the instrument had become a liability in the resale market, and was stylistically out of date by then. Pianos with dates partially or completely obliterated turn up as often as not at auction today.

As with many English grand pianos from this time, the Broadwood had developed ‘cheek warp’, a case distortion condition where the joint of the right cheek to bentside is depressed, sometimes severely so, and the right cheek front is cocked upwards at an angle **(Figure 2)**. Many harpsichords and English pianos suffer from this defect to some extent, depending on the makers’ engineering principles. Viennese pianos, built on sturdy “A” frame construction with relatively massive load bearing members, heavy bottom boards, and a thin outer case, exhibit this condition much less frequently. The English piano appears to have approached the engineering needs brought on through additional tension from increased string diameter by adding cross members and increasing their thickness, when compared to contemporary English harpsichords[10]. Reinforcement to the case walls was kept to a minimum. This means that the case walls, made of 5/16th inch oak, veneered in mahogany of about 1.5 mm thickness on exposed surfaces, is far more free to resonate with the sound board, and English grand pianos are noted for their sonority and sustaining power in the tenor and bass.

The English grand resists the stress of string tension by a series of angled and cantilevered cross members, joined firmly to the ½ inch thick bottom boards, which connect the structure to the key bed by way of the lower belly rail. **(Figure 3)** It is critical that the key bed, spine, cheek, bentside, and bottom boards remain joined as shown with no discontinuity. So long as this remains one piece, twisting and warp are relatively well countered. With only about ¾ inch purchase of the bottom boards to the lower belly rail however, the possibility of partial or complete failure of this critical joint is high. Later Broadwood designs extend this joint, and we can surmise that Broadwoods was seeing this issue early on. In the present case, the bottom boards were indeed separating from the lower belly rail and thus from the key bed, while the upper cheek to bentside joint had begun to fail as well. This had pushed the cheek downward and out, resulting in glue end-joint failure of the right wrestplank joint. Both the corner and wrestplank joints are well made with dowels reinforcing the joints, with the wrestplank also set into a mortise in the cheek, while the bentside presents an overlapping 'birdsbeak' joint (a type of lap joint), but without dovetailing. As-built, this structure is competent for the intended tension, and many rebuilt and properly strung grands can testify to the fact that the engineering is not entirely unsound. Historically though, pianos were restrung in heavier gauges to increase power or through ignorance and lack of thin gauges readily available, and the margin of safety appears to be fairly narrow. A cotton thread strung in an X pattern over the top of the 'box' of the key well, between the top front corners and bentside corner, will reveal the gap caused by this warp, which measured 2.3 cm. in this instance. From this analysis it was decided that action to correct the warp and re-flatten the instrument should be taken.

In order to achieve a large positive crown in the soundboard, the spine liner is cut at a ~5 deg. angle, forcing the soundboard to go through an arc as it bridges the belly. The tail liner is cut to an arc as well, but the top of the belly rail and bentside liner is flat. Combined with back-pinning of the bridges, this design results in a soundboard (with a thickness that ranges from 4.5 to 6 mm) that is put at various torsional stresses. Soundboard cracks in this piano design can be dramatic, with flaring exposed edges. By the late 19th and early 20th C, when an appreciation for earlier instruments was returning, these early pianos were often subjected to then-modern reengineering efforts, which included adding ribs to counteract the warping from the described stresses. This piano was one where ribs were added to the last third of the tail section, fixed with screws from the top. In a later restoration, also undocumented, the additional ribs were removed, the screw holes patched with spruce diamonds, and sanded and varnished for appearance. Cracks were again shimmed, but all work was done without removal of the sound board. As Watson points out many times in his book, the value system we impose on the instrument alters and distorts the very thing we are trying to return to more nearly its original condition. We define original however, in terms of our modern sensibilities rather than the minimum needed to make the instrument play. The residual screw holes were unsightly, but here we have added wood, and a sanded surface. Removal of a sound board from an Early Broadwood grand involves removing the damper cover support, cheek rail, hitch rails (screwed, glued, and doweled in) and spine rail, and soaking and heating the sound board to allow it to be lifted out without damage. Once this is done, the bottom can be safely soaked and removed.

On heating of the edge seams of the sound board, the restoration team noted the distinct smell of stables or perhaps a urinal, over and above the somewhat funky organic smell of old hide glue. Once the sound board was removed, samples of glue drippings were harvested from the sound board seams. Additional samples were taken from the ribbing glue joints, and hitch rail glue. These were liquefied in water and pooled on an acetate sheet to dry, and the resulting semi transparent films analyzed with Fourier transform infrared spectroscopy (Nicolet 6700 with microscope FTIR attachment). FTIR is a powerful technique for identifying organic polymers and additives. In this case, we compared FTIR spectra against modern 390 gram-strength hide glue, with and without additions of 5% urea. **(Figure 4)** shows modern hide glue, and **(Figure 5)** the glue obtained from the main ribs. These glues are for the most part identical. **(Figure 6)** gives the glue obtained from the sound board seam, with a doublet between 3200 and 3300 CM-1. A modern glue, with 5% by dry weight urea added, clearly shows this doublet in **(Figure 7)**, and a library sample of urea alone clearly shows the doublet is associated with absorption lines distinct to urea **(Figure 8)**. Compressing a joint where the glue has already gelled produces an inferior joinery, comparable to a cold solder joint. For maximum strength, it is well known that the glue must remain in a liquid state until the surfaces to be glued are fully mated. Soundboards present a challenge because they must be secured around the perimeter, and in the case of a grand piano this involves some 15 linear feet of glue line. The use of urea to retard the gelling of hide glue is well known, but this analysis tells us that specific glues were used in the Broadwood shops depending on whether the object to be glued might come together swiftly, such as attaching a rib, or more slowly like a soundboard. Urea is odorless, and the smell we encountered was almost certainly residual ammonia, amines, and perhaps sulfur bearing compounds released by the heated moisture. We can detect these compounds by smell in part per million quantities, whereas FTIR loses sensitivity below about 1% concentration. The nose is a powerful analytical tool once calibrated and sensitized!

Nail holes appear at intervals of about 6 inches around the perimeter of the soundboard where padded nails were used to clamp the sound board in. We can reconstruct the event of the original installation of this soundboard against anecdotal reports of a room warmed to toasty warmth for gluing up the belly, and this latest evidence of the use of a gel retarding glue which allowed the workman to complete the task alone. Anyone who has installed a soundboard can recall the rather hurried pace at which it needs to proceed. Having a little extra time when temperatures are not always optimal is a big advantage.

In a later alteration, felt was glued around the core of the leather hammers and perhaps the outer layer removed from the tenor and bass hammers (as they now have three layers instead of the more usual four layer found on contemporary pianos to this one), the shanks were charred in attempts to get all the heads shifting properly for una chorda action, and efforts to return the bottom were consistent with an understanding of the bottom boards that they provide a limited structural function. Watson recorded the poor fit of the bottom to the bentside treble and key bed in 1984. Also by that time, the felt had already been removed, though there is evidence that it had also become insect- riddled. This left the leather coverings, original or at least an early recovering, which were documented by Watson in ’84. Leather hammer coverings on grands presents a challenge to historical research, as they can be quite old and still be a later recovering of a type and thickness in variance with the original intent. 190 year-old leather will present to a 21st C researcher as seemingly authentic on a 220 year-old instrument. Felt was an obvious later addition when efforts to impose a less brilliant and mellower pianistic voice were attempted. Indeed, as leather oxidizes and hardens the resulting tone produced has an overly hard attack and can be unpleasant. Here the restoration conservator faces the dilemma of replacement and loss of critical historical evidence, against an unauthentic sound due to retaining the original but no longer serviceable coverings. The decision to add a single layer of brain tanned deer over the existing coverings produced a pleasant voice without in any way changing the existing material, since the new leather ends are glued below the early material, and offers an acceptable compromise.

In his restoration report from 1984, the young John Watson wrote “*Bracing is pine, surprisingly "low grade". Nailed at ends and evidently not "let into" the sides except for lower frame pieces which are dadoed into spine and bentside or cheek*.” On careful inspection though we now find that the pine is of a superior grade, but was surely soiled and oxidized. It is all quarter sawn and almost knot-free material, carefully cut to size and nicely planned to right angles and thickness. The species can be identified as Scots pine (Pinus sylvestris) from microscopic identification of the radial cross section **(Figure 9)**. The liner is also pine and appears to be the same species, but is a lighter color and may represent material chosen from the sap wood, which is easier to bend. Even this softer wood, with curfs cut to allow it to bend, was damaged slightly during installation along the bentside treble, where curvature is at the maximum. The liner is trenailed into the case with oaken dowels and glued, but the bracing is fixed with glue only, clamped up with rosette-head cut nails. The bentside pine liner is knot-free, but knots do appear in the spine liner which of course remains straight. This is evidence of economy in the shop; the highest grade woods are used where grade is critical, and the lower grades cycled to service areas where imperfections will not create an assembly concern, as would happen when knotted wood is bent. When completed, this current restorative conservation effort must include some minimal structural reinforcement in the form of added wood at the belly rail, to compensate for lost gluing surfaces without replacing original wood, so to the extent that any resonance, no matter how minimal, is lost, we will have replaced the value set of maximum resonance desired by Broadwood with the value of stability. A stable instrument might not need further intervention again for many years though, so this value balance is not inconsistent with the restorative conservation approach.

A difficulty with Scots pine is its tendency to shrink with time. Most of the shrinkage is in the tangential direction, and restorers frequently encounter early square piano bottoms, which used Scots pine almost exclusively, with substantial shrinkage[11]. The use of quarter sawn lumber reduces this problem dramatically, and as found, most of the bracing pieces that were loose of their former glue joints, resulted from the twisting of the case as it levered them free of the original joint. Quarter sawn lumber makes inefficient use of the log though, and so comes at a premium price, indicating the concern in the shop for stability. Scots pine is very rigid and strong as compared to other pine species, and all bracing remained free of warping or serious twists within the piece itself.

The preparation of the pine bracing for gluing provides additional insight into the wood shop practice. The wood was first dimensioned, where for example, the liner cross member struts were targeted at 1.0 X 1.75 inches. However, we find the final dimensions differ from the intended targets by as much as 1/16 inch, sufficient to the purpose at hand, but an obvious sign that exact dimensioning was not something the shop spent time on. Marks in the case and adjoining pieces provide clear evidence that this dimensional variation is unlikely the result of simple shrinkage differences. Pieces from the same length of wood all have the same dimension (shrinkage, if any, is uniform), and we can see that the original lumber was at least 6 to 8 feet long before cutting into sections, simply by totaling the individual pieces with a given set of dimensions.

After dimensioning the lumber, it was sawn into lengths, marked out against a set compass, gauge, or against a template[12]. Scribe marks on the case and liner indicate where the bracing will go. Pieces that are fit to length such as the bottom bracing, fit into mortises in the case or belly rail. The cross members between the liners are cut to length with rabbeted ends against both the spine and bentside liner, and rotated into place against the curve of the bentside as the case was assembled. To provide maximum support for the bentside liner, the bracing there is given a carved knee that is glued and nailed into place. Each pine member was scribed with a tool to allow the glue to seat into the joint and avoid a 'starved joint' which would be brittle. Beeswax impressions of these tool marks were made and examined at high magnification which showed them to have an average depth of 60-90 microns (.06-.09 mm). Every surface that was glued received these scribe marks, which can be seen quite well in raked light **(Figure 10)**. The tool, likely a toothing plane, had teeth spaced at about 1.1 mm, and two or three passes were quickly made to prepare the wood. Nearly all English pianos examined by the author shows these marks, which can be found on other types of furniture as well, though the elaborate bracing and interior spaces provide an excellent record of this preparation particularly in keyboard instruments. The knees themselves were carved to a rounded shape from an angled block by chisel, with an economy of strokes to develop the contour of each one **(Figure 11)**. No two are alike, but the general idea was to avoid touching a rib or cut-off bar while achieving structural support. The taper of the knee into the brace strut was finished after assembly, as slip marks from what was likely a draw knife can be seen in the brace. This additional step produced a 'finished' look to a part that could never be seen after the instrument was completed, speaking to a discipline and workmanship approach that is reflected throughout the instrument. While the engineering to overcome the stress of over 4000 pounds of tension would improve with time, this instrument records a very high level of craftsmanship in early keyboard manufacture.

The soundboard presents us with a great deal of information. Here we find a spruce from old growth forests, quarter sawn and chosen to blend well, with boards about 5 inches wide displaying a wide range of growth rings. During the middle ages, a well documented 'little ice age'[13] occurred in Europe where the growing season was dramatically shortened. During the nadir of this event, growth of less than 0.5 mm per year can be seen in the growth rings. Near the period when the wood was harvested, growth resumed to more normal activity, so ring patterns are often tight and then widen rapidly over less than a decade **(Figure 12)**. The ribs and cut off bar are quarter sawn spruce. They had their ends secured with linen, and the seams in the long boards were also lined underneath with glue impregnated linen. This linen had an approximate thread count of 68, or a fine canvas similar to artists' canvas. Microscopic identification of the fibers clearly shows them to be flax, Linum usitatissimum, with the characteristic round single fiber shape having nodes spaced along the length like bamboo. During the repair of the loose rib ends and seam separations, the linen cloths were removed and soaked. Many were found to be of a quality suitable for returning to use and were re-applied. A similar weight linen canvas material was obtained to replace the material too damaged to reuse, and to complete the job of reinforcing repairs as needed.

During the disassembly, repair, and return of pieces, some effort was made to leave as much raw data in the form of unaltered historical surfaces as possible. The heating of the bentside and belly rails under the tension of shaped jigs to return them to their former shape is intrusive, but with padded clamps and a plan for each step that constrains the adjustments to the minimum needed to achieve the desired end goal, restorative conservation allowed the reading of the instrument while allowing future generations to perhaps read deeper when the instrument again requires service. Not every restorer will have immediate access to a well equipped lab and trained professionals who can assist with materials identification as was the case with this examination. But armed with the eye and a reasonable digital camera, a sensitive nose, and a willingness to examine the minutia in front of them, the modern restorative conservationist can make a far greater contribution than simply returning an instrument to service. It is within their power to uncover enough evidence that we can summon up the spirit of the times and hear the music in this greater context, which was the ultimate ambition of every restorative conservationist to begin with. In briefly explaining the finding to an audience gathered to hear the early instruments, these elements of the builders tradition help them to further experience the music of the period in a deeper context than what simply hearing the instruments alone can bring. If early keyboards are to achieve their maximum potential, it is when the entire instrument is allowed to speak.

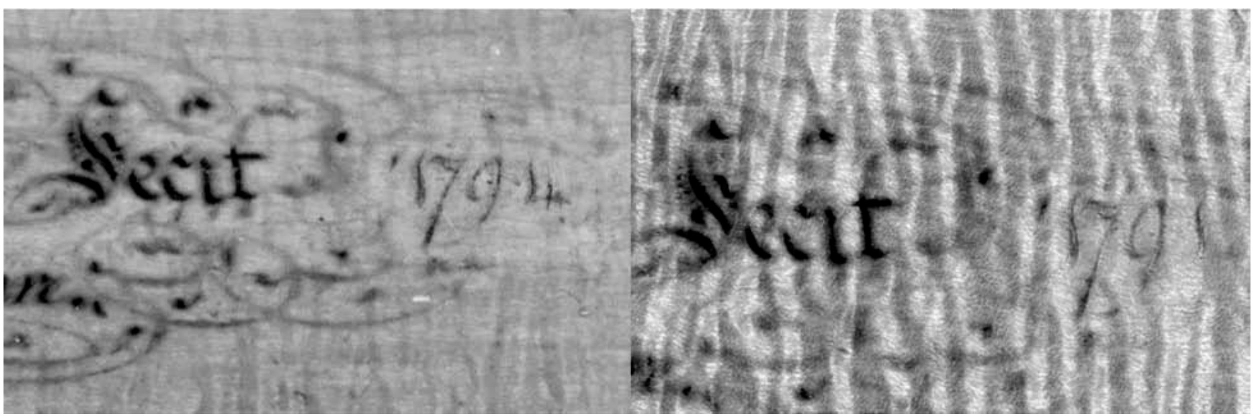

Figure 1, Partial name board date erasure with incorrect and correct restoration

Figure 2, Cheek warp and crossed ribbons to determine extent of displacement.

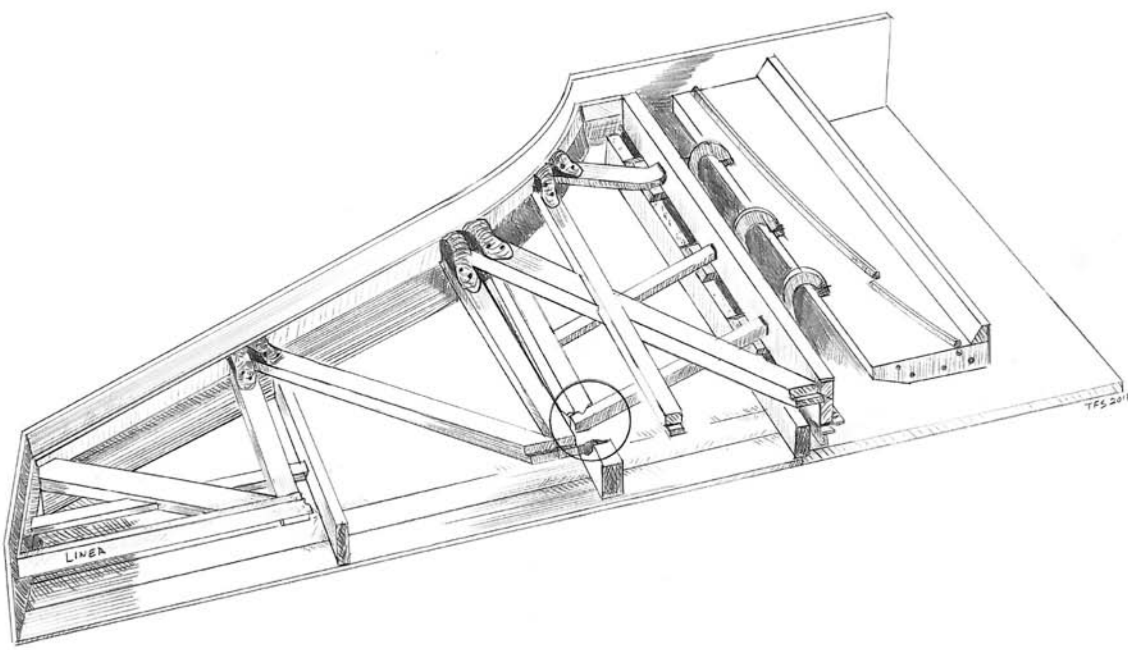

Figure 3, Bracing and layout of 1791 Broadwood grand piano

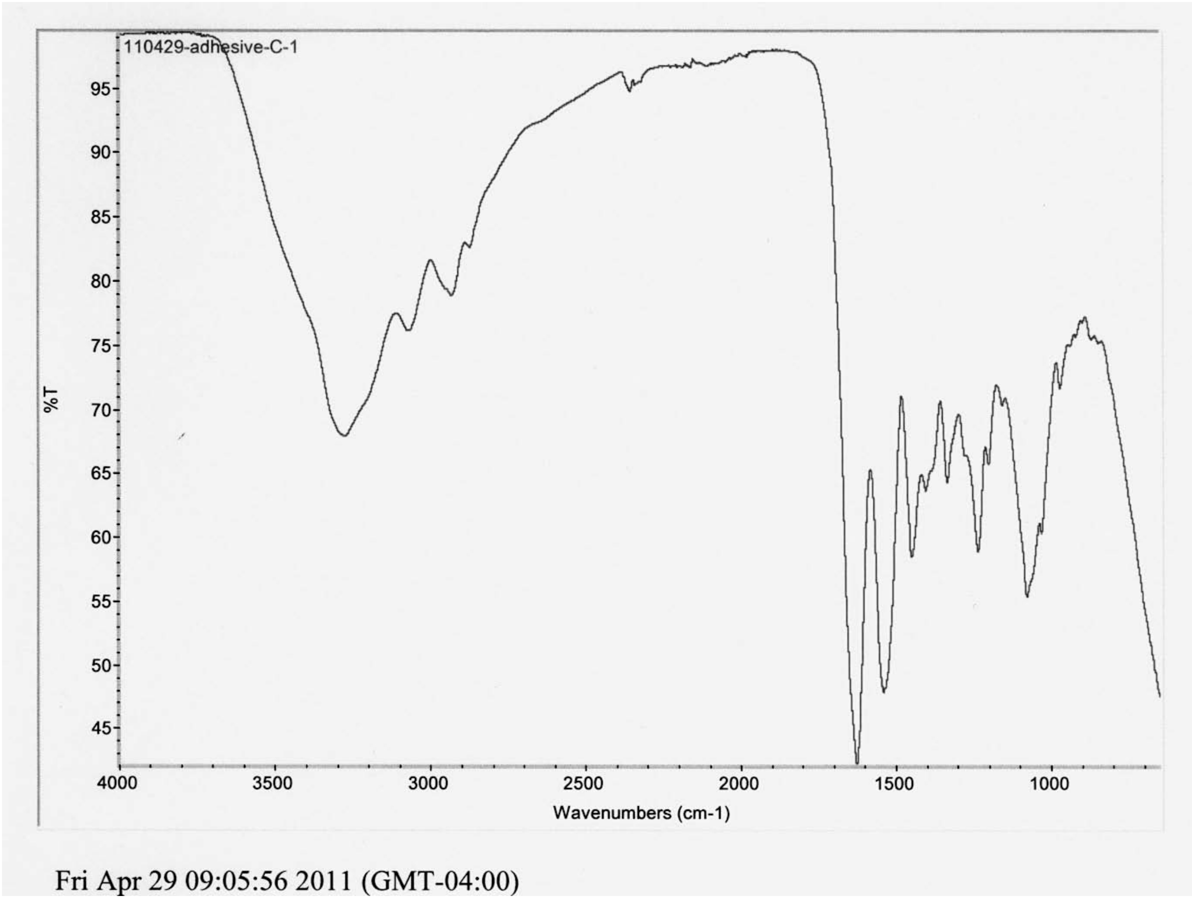

Figure 4, Conventional hide glue FTIR signature. Note the singe absorption at about 3600 cm^{-1}

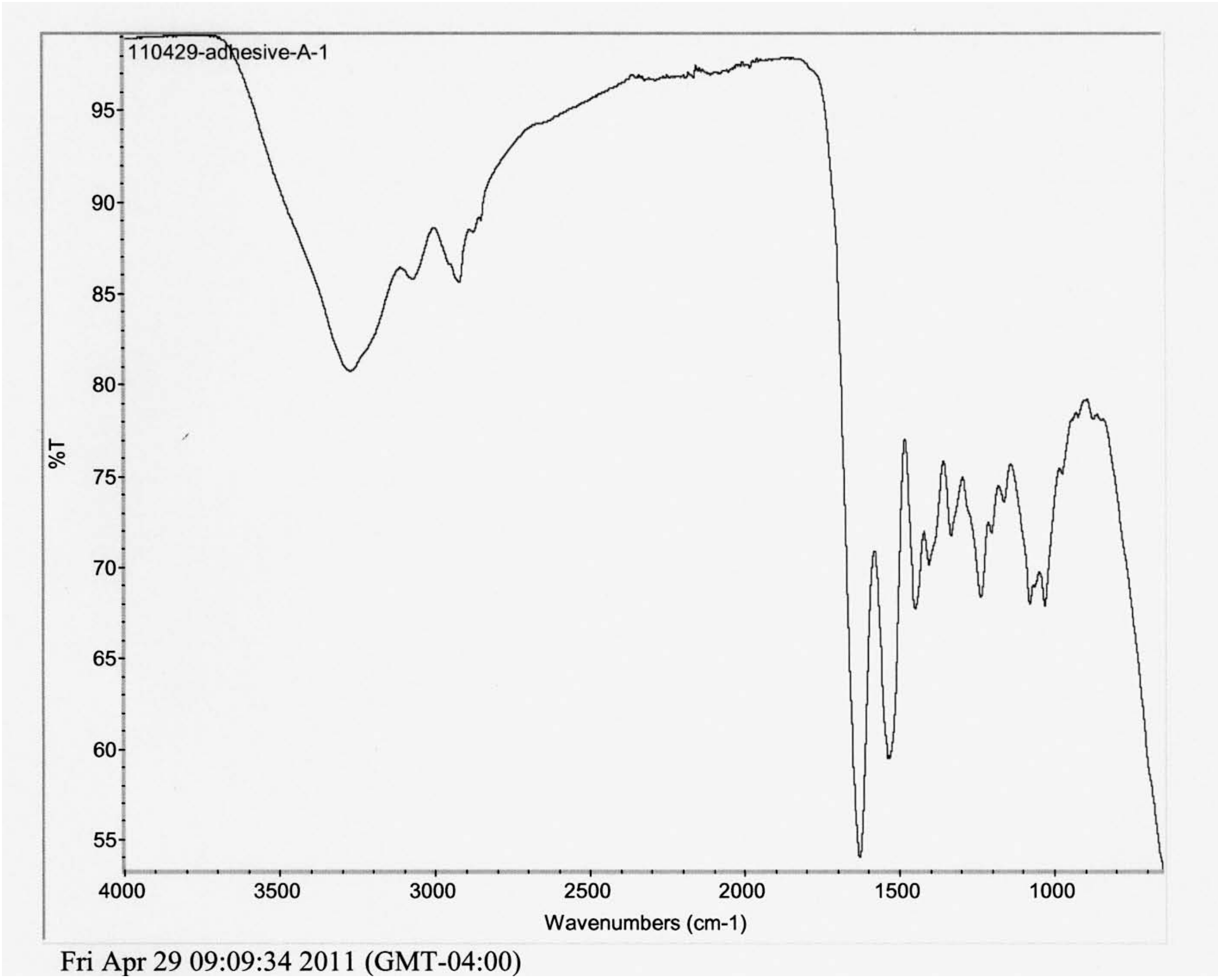

Figure 5, glue signature from rib glue remnant

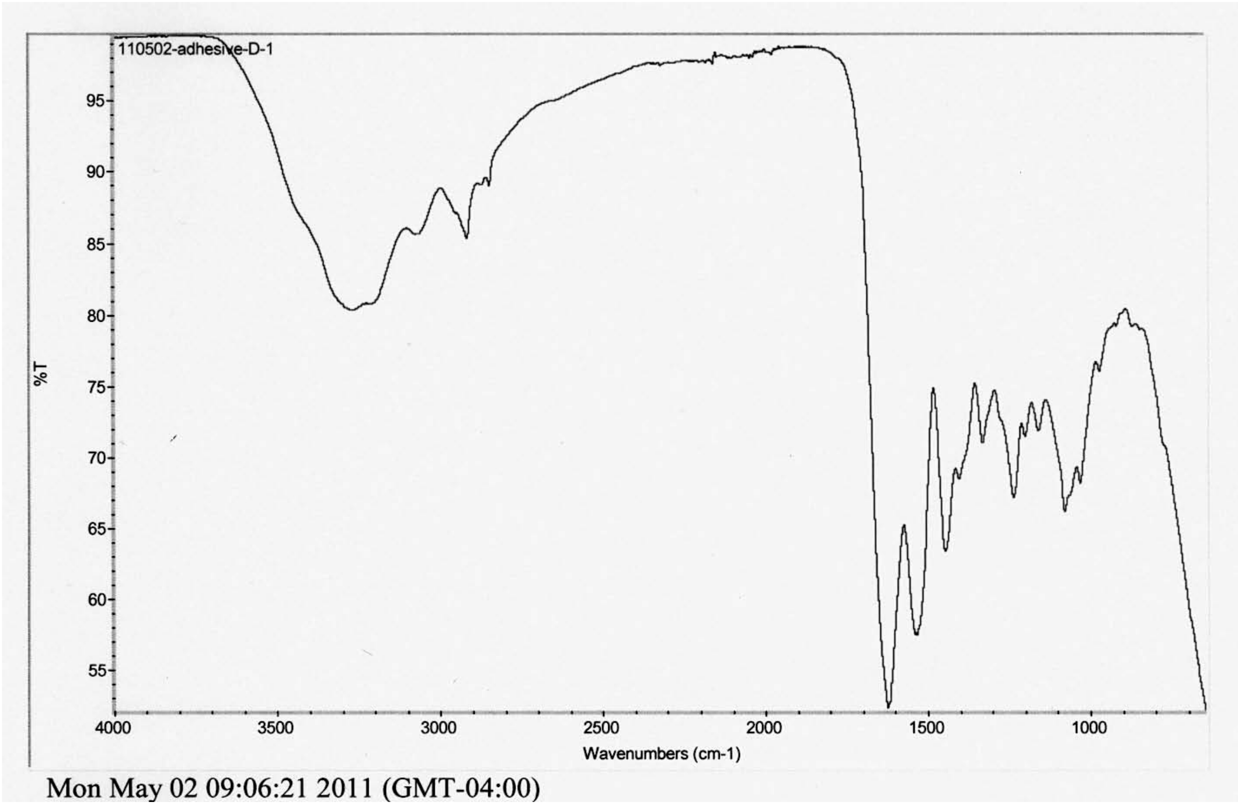

Figure 6, Sound board glue remnant signature. Note double peak near 3600 cm^{-1}

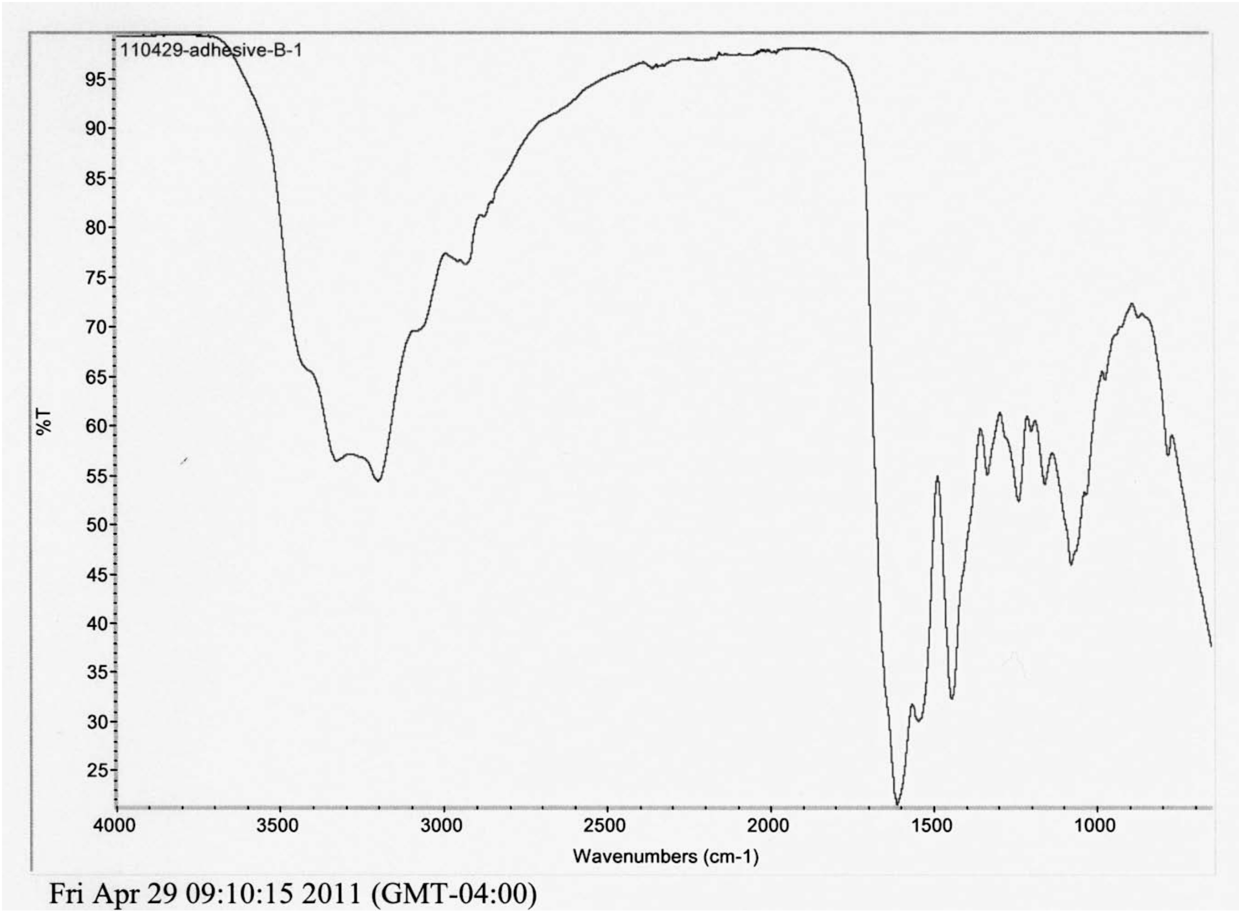

Figure 7, Conventional hide glue with urea added and double peak at 3600 cm^{-1}

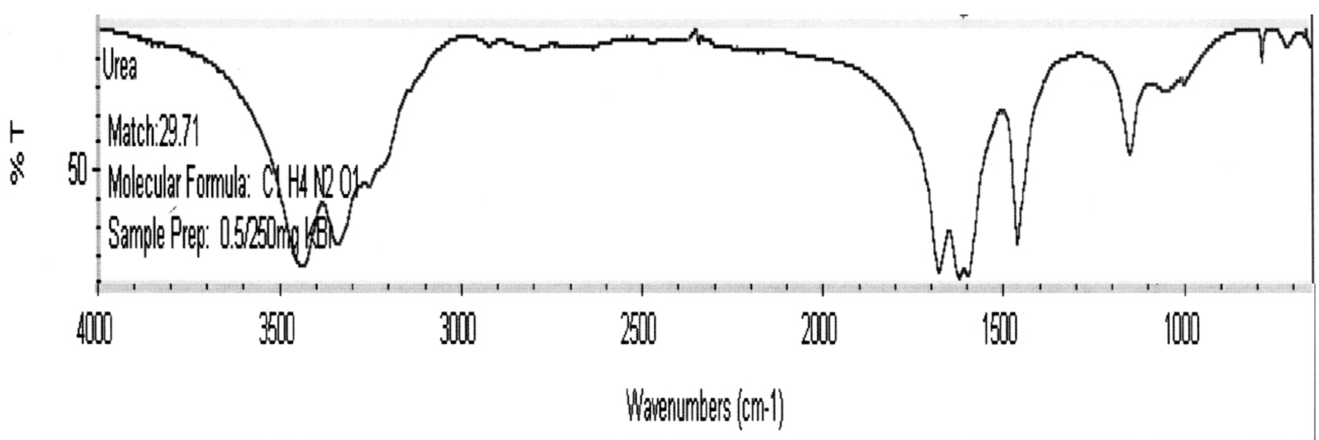

Figure 8, FTIR signature for pure urea

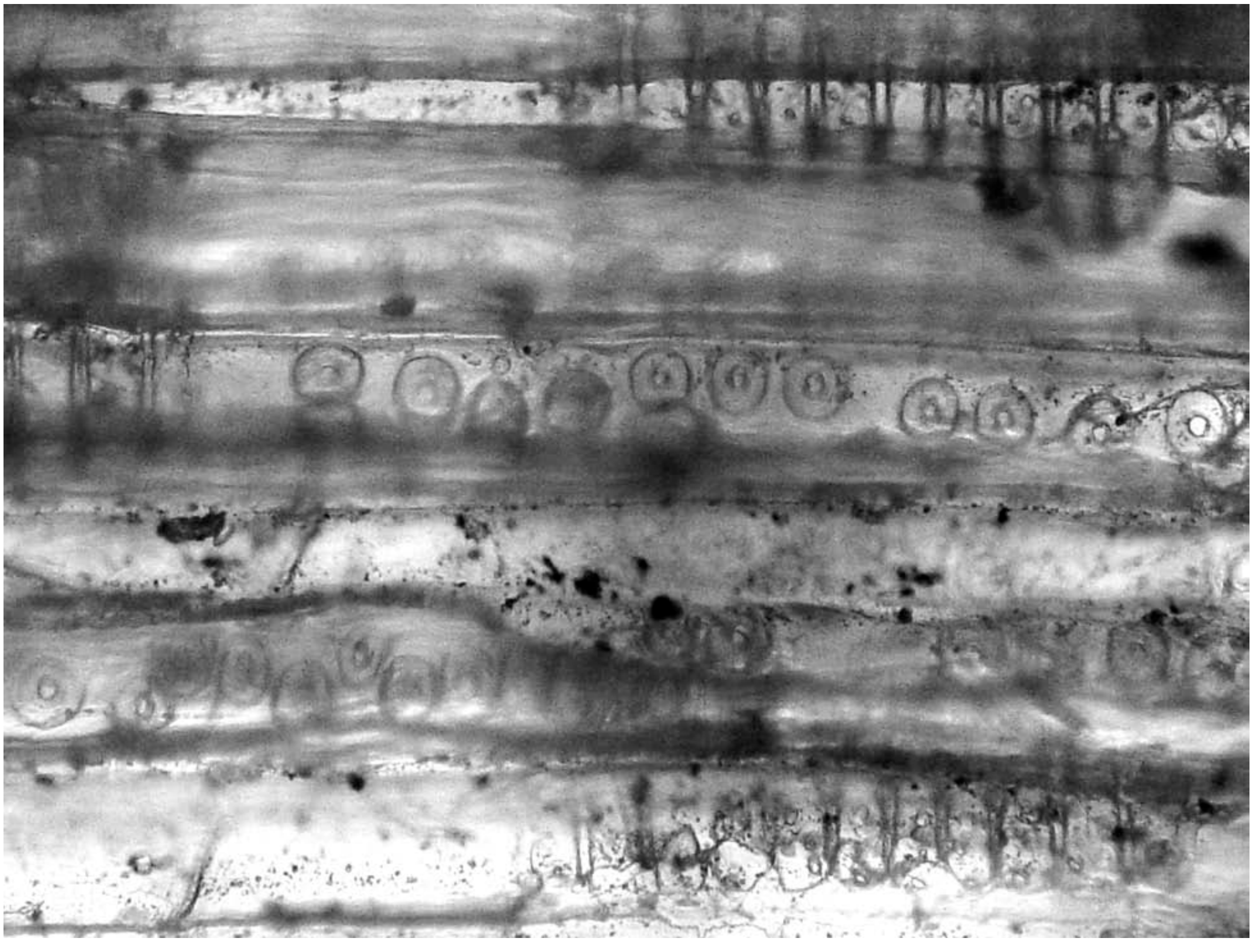

Figure 9, Radial cross sectional slice from strut a 100X with conventional structure of Scotts pine

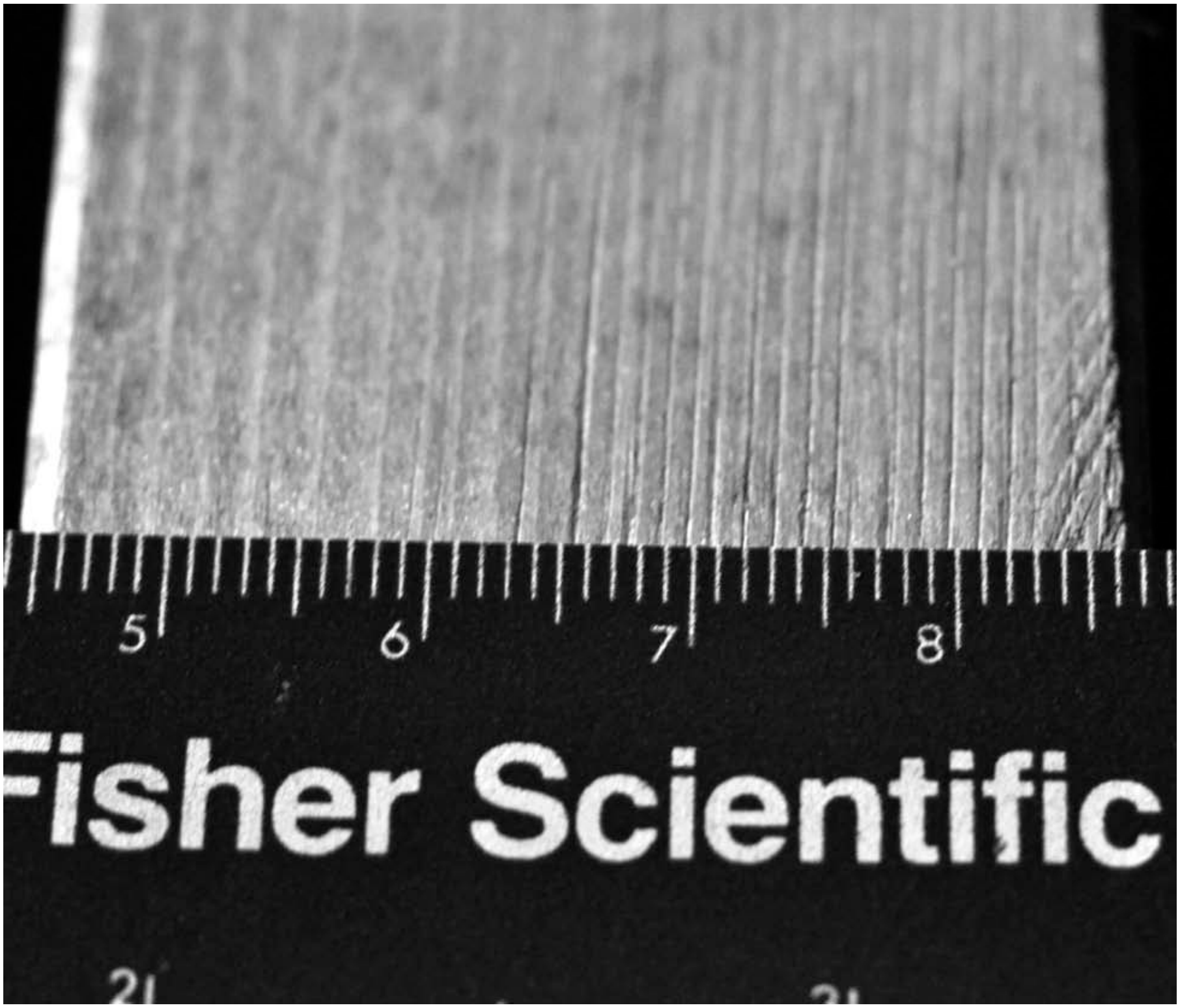

Figure 10, Scribed marks on pine for enhancing glue joints

Figure 11, carved knee at liner bracing showing marks from knife at far right

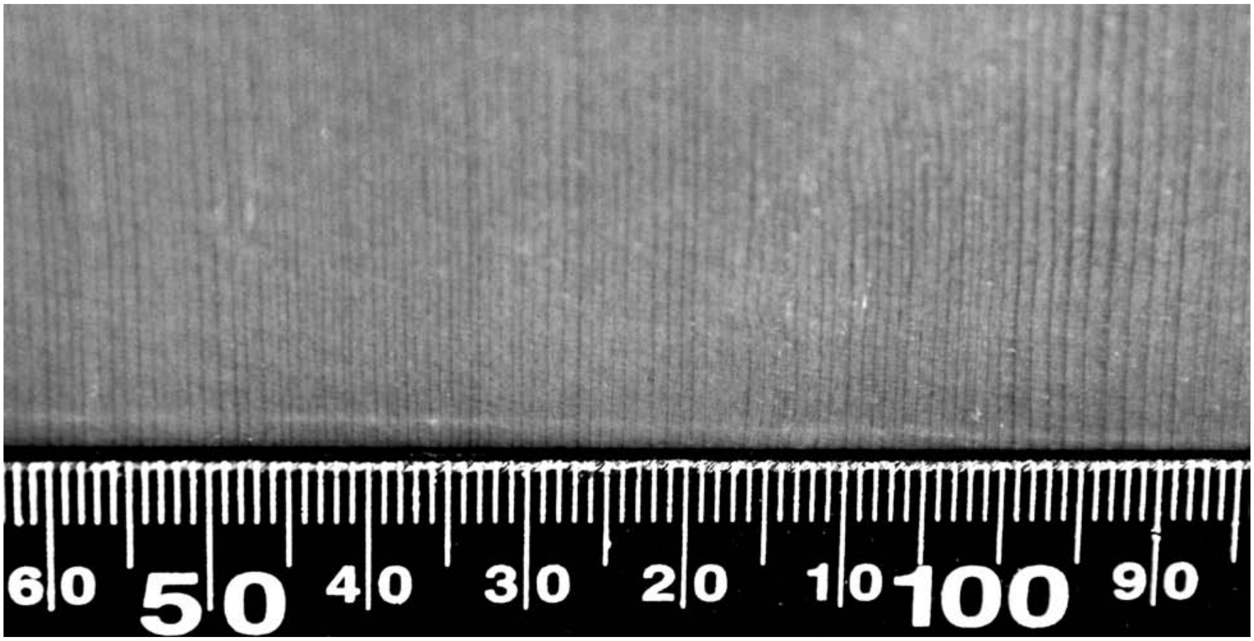

Figure 12, Sound board growth ring signature showing wide range of growth rates in the tree

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[1] John R. Watson, *Artifacts in Use: The Paradox of Restoration and the Conservation of Organs*, (OHS Press, 2010)

[2] Robert Barclay , *Preservation and Use of Historic Musical Instruments: Display Case or Concert Hall* , (Maney Publishing, 2004)

[3] Martha Clinkscale, *Makers of the piano 1700-1820* (Oxford, 1993), 42, item 6

[4] John Watson, *Organological Description and Restoration Report: John Broadwood Grand Piano Forte of 1794 (sic), Joseph & Glenda Rawley, Owners, High Point, North Carolina*

[5] Stewart Pollens, *The Early Pianoforte,* (Cambridge, 1995), 90

[6] Michael Cole, *The Pianoforte in the Classical Era* (Oxford: Clarendon, 1998), 208.

[7] www.fortepiano.co.uk, Instrument Registers; Broadwood Grands, a register of 273 extant instruments to 1837

[8] Private correspondence relating to a piano acquired at auction. The name board read “Johannes Broadwood Londini Fecit…” with a date of 1797 which must have been changed, as the firm had changed names to Broadwood and Son in January 1794 and all subsequent pianos were so lettered. Careful inspection revealed the poor forgery.

[9] www.squarepianotech.com, Restoration Reports, 1795 Broadwood Restoration, Colm O’Leary

[10] Frank Hubbard, *Three Hundred Years of Harpsichord Making* (Harvard, 1967). The excellent renderings of a Kirkman harpsichord serve as a guide for comparative anatomy of a typical English harpsichord construction VS a contemporary piano.

[11] www.squarepianotech.com Restoration Reports; the reports on the 1793 and 1795 Broadwood, and the 1785 Longman and Broderip describe baseboard shrinkage of as much as 3/8 inch in width out of a total width of approximately 18 inches. The boards may also separate at glue lines along their length, though that is not common.

[12] Michael Cole, *The Pianoforte in the Classical Era* (Oxford: Clarendon, 1998) Appendix III

[13] Brian Fagan, *The little Ice Age: How Climate Made History, 1300-1850* (Basic Books, 2001)