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TAILORING THE SOUND OF YOUR KEYBOARD INSTRUMENT PART IV: MUSICAL PINS

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During dinner with a well known American harpsichord maker a few decades ago, he described the development of his then-new *Lautenwerk* model. He had worked out a case design consistent with some of the historic descriptions of these gut strung keyboard instruments that had the appearance of a harpsichord, and so he had also used that instrument's typical bridges and pinning. When he strung the design with catgut strings and first tried playing it, to his utter dismay it sounded very little different from the usual bright sound of a harpsichord... not at all lute like, as he and any potential customers would expect from a *Lautenwerck*. After some experimenting, he discovered that when he arranged for the gut strings to contact the wooden bridge first, rather than metal bridge pins, the sound was very like a lute, and that approach became the final version of his model.

It probably seems incredible that the same gut string can sound like either a harpsichord or a lute just by what it comes into contact with. However, it is probably not accidental that samples of the other type of *Lautenwerck*, shaped like large lutes, that I have seen and serviced do not use metal pins either, but small vertical wooden pegs to locate their strings.

In fact, beginner makers of instruments such as violins, guitars, and lutes learn rather quickly that the precise size, radius, hardness of material, depth of notches and grooves, etc., that are used where the strings begin and end their vibrating length, is very important for the sound of their instruments. In contrast, this factor frequently appears overlooked [1 2] and under studied[3] in the copying and restoration of early keyboard instruments.

It is obvious from casual observation of early keyboard instruments that bridge and nut pins hold strings in position. What is not so obvious is that evidence in the historical instruments themselves indicates that the pins' properties were also carefully chosen to serve additional musical purposes. This article will describe the significant musical consequences I have discovered from encounters with bridge and nut pins on various keyboard instruments over the years that made me aware of the differences between using historical pinning practices and typical modern ones.[4]

More than location

If the purpose of bridge and nut pins were solely to hold strings in place, it would only be necessary to find the pin size strong enough to resist the string with the greatest sideways force, and then use that pin size for all the rest of the strings. Most modern pinning and almost all keyboard kits seem to follow this principle, as did I when I first started making instruments. It is certainly more efficient from a modern inventory viewpoint. Below, however, are a few examples of historical practices that appear to have a different viewpoint.

1. Historically, some Italian instruments used both brass pins and iron pins in the same instrument. At least some early fortepianos used two different sizes of brass pins with iron strings and two different sizes of iron pins with brass

strings.[5] It is difficult to see why such material changes would have been made just for holding strings in place.[6]

2. Grant O'Brien has noted that Ruckers used smaller bridge and nut pins in the 4′ choirs than in the 8′ choirs of their harpsichords[7], and smaller pins in the smaller virginal models than in the larger models.[8] It may seem reasonable that 4′ strings would use smaller pins than 8′ strings, except that most of the 4′ strings have just as high a tension as many of the 8′ strings, despite their shorter lengths; so why not use just one size pin? Since most people do not notice the size difference of the pins, it seems unlikely that these sizes were chosen to satisfy a sense of visual proportions. A smaller pin would provide a slightly smaller contact area for the string and this might allow a slightly longer sustain, but even if this proves true, why shorten the sustain of the notes with larger pins when those sizes do not seem to be necessary for strength reasons?

3. Pin sizing became even more sophisticated in the later Franco Flemish instruments. For example, when the great Pascal Taskin reworked a 1764 Goermans double in 1783 he still used a single smaller size pin for all the 4′ nut pins and a larger size for all the 8′ nut pins, similar to the Ruckers practice. At the same time, he expanded to two different sizes of bridge pins in the 8′ and 4′ choirs and three different sizes of back pins.[9] However, the points where each choir changes from 1.0mm bridge pins to 1.3mm pins do not correlate with a significant enough change in tension to warrant the more than doubled pin stiffness. Additionally, it would seem that if 0.9mm back pins were strong enough to work with the tension of the lowest fourteen 4′ strings, using 1.3mm bridge pins (three times stiffer than the 0.9mm pin[10]) for those same strings must have been done for reasons other than strength.

Stiffness matters - Discovery no. 1

The owner of a 30-year-old Italian model harpsichord asked me to improve its sound. The first phase was to restring with an historical Italian type of stringing schedule to replace the 20th-century version it had had on it all those years.[11] A fair number of nut pins also needed to be moved to even out the plectra lengths before it could be re-voiced. Since many of these pins were too short and/or bent and too stiff to straighten easily, I replaced them with pins that I have for years cut from wire myself so I can always have pins of the diameter and length I want.[12] The new pins had the same diameter as the old pins. After these adjustments I proceeded with voicing and after a while I noticed that some of the strings were sounding smoother and clearer than others. I could not even up the differences by voicing. Then I noticed that the better sounding strings had the new nut pins with the softer brass. Experimenting, I replaced the old bridge pins of those same strings with new pins, also made from the softer brass. This change produced even more of an improvement in the sound than changing the nut pins. The softer brass pins (along with the historical stringing schedule) made it possible to produce a sound that appeared more fully formed with much less front end emphasis allowing it to continue smoothly into a long sustain, a sound quite different from what we have come to expect from Italian harpsichords. It did seem to be a sound more consistent with the historical descriptions that identified Italian harpsichords as having a sweet sound and being very useful for accompanying singers. So I changed all the remaining hard bridge and nut pins.

Diameter matters - Discovery no. 2

Since the old (harder) and the new (softer) pins were the same size, the difference in musical results appeared to be due to the lower degree of stiffness of the newer pins. As an experiment I installed 1.23mm pins, also of the softer brass, on a few of this instrument's strings in place of the 1.0mm size, and discovered that the sound moved back in the direction of more front end emphasis with a burst of high overtones, and a quicker decay than the harder pins had produced. Nothing I did with the voicing could smooth those notes with stiffer pins to sound like the rest, so the pins were switched back to the original smaller size. Seemingly small changes in diameter can be significant: the 1.23mm pin is almost twice as stiff as a 1.0mm pin.

Position matters - Discovery no. 3

Italian bridges and nuts, unlike most Northern European harpsichords, have a moulded shape cut into their top so that the pins sit lower within that shape, with the raised crown portion behind the pins[13]. When I worked on one Italian harpsichord I noticed that some of the pins were sitting against the back rise and some were free of this contact. Not sure which way was intended by the modern or the historical makers, I decided to adjust the pins so that they were all in firm contact with the raised bridge or nut portion behind them. During voicing I was not able to get the initial oomph of sound smoothed out as much as I would have liked, and I also noticed that the sound was "grainy" in a way which reduced clarity. I decided to go back and try the other approach and, for a sampling of strings across the compass, bent the bridge and nut pins away from their reinforcing contact with the bridge and nut. The start of the tones smoothed out and the clarity greatly increased. I thought that these qualities provided more musical possibilities for the player, so I then freed the rest of the pins to increase their flexibility also.

Obviously, it is also possible to choose to go in the direction of a more pronounced beginning and a more obvious drop off in sustain. Much more information is needed from the old instruments to better know the choices that various old makers selected, and therefore the musical qualities they were intending for their instruments.

In the somewhat triangular bridge shape with sloped crown found in most Franco Flemish harpsichords and many types of clavichords, the higher up the crown the pin is located, the more rigidly it will reflect the string's vibrations, since the string sitting on the crown peak will be closer to the pin's base; the lower the pin is located on the crown, the more flexibly the pin will interact with the string contacting higher above the pin's base. Most of these bridges appear usually to have been pinned in the centre of the slope, and in these cases how shallow or steep the slanted crown is will make the pin stiffer or more flexible to the string respectively. If a shallow crowned bridge tilts as its area of soundboard rolls towards the bentside, as can happen due to excess humidity or other problems, the string will contact the pin closer to its base and the pin will feel a stiffer reflection of its vibrations, resulting in the instrument's sound changing in that area. Sometimes if the crown angle is shallow enough and the roll too much, the wooden surface of the crown will come into contact with the sounding length of the string and cause a strange sound indeed.

Height matters - Discovery no. 4

I once agreed to overhaul a double manual harpsichord for a charity that played it for critically ill patients in hospitals and nursing homes. It was made from a kit that I respected, but was the worst sounding example that I had ever heard: a very unfocused sound that quickly evaporated. The case was stained brown on a wood only suitable for painting, and for some reason it had bridge and nut pins that protruded about 12mm above the strings, earning it the nickname "The Porcupine". Since I was donating a great deal of labour I vowed not to spend any time on appearances, but only on musical and functional items. I restrung it with better wire and a more appropriate stringing schedule and pitch. Despite occasional bleeding from catching my arms on those tall pins I refused to spend any more unpaid time to cut them down and file them. I requilled, voiced, and regulated all the registers and did a lot of damper adjustments, and the result was still the worst sounding example that I had heard. It did not seem like all the effort had been worth it. No amount of fiddling with the voicing seemed to make any difference. The soundboard stiffness was fine; I could not figure out anything basically wrong with it. It was nearing time to return it to the owners without much to show for their expense and the time that it had taken. Thoroughly disgusted, I finally decided that if I could not do anything more, I could at least get rid of those ugly and dangerous pins. So I grabbed a pair of wire cutters and had at them; cut ends were flying all over the room from the snipping. That, at least, was satisfying. After I cleaned everything up, I tried a farewell play on it. It produced a focused, clear tone with a long sustain! In fact, it had become one of the better sounding examples of its model.

So, it is not only the height of the string above the base of the pin that can affect the sound from the string, but also the height of the pin above the string. No matter what the reasons for this effect,[14] my subsequent shortening of pins that are too long, whether on harpsichords, clavichords or several fortepianos, has so far always resulted in a more clearly focused tone with more sustain. Historical instruments do have some variation in the heights of their pins, so awareness or tastes probably varied, but the effect is there to use as desired.

Angling for changes - Discovery no. 5

I once agreed to look at a kit double manual harpsichord that the husband of a customer had made. The sound in the mid-range had started to become thin and weak. I noticed that the soundboard had sunk in that area and several strings were in contact with their bridge pins but would not stay down on the bridge crown. Quite a few other strings that seemed to be contacting the bridge could be slid up their pins and would remain there when released. The owners did not want major changes performed on the harpsichord, so I carefully bent the bridge pins towards the spine over the strings enough so that the strings would remain seated when they were pulled lightly upward. The sounds of those strings improved significantly and the owners were happy. Exploring some more, I noticed that the notes with the bent-over bridge pins were now better focused, fuller, and had longer sustain than the other strings that had all appeared to be in good contact with the bridge. I found that bending those bridge, and nut, pins slightly towards the spine improved the sound of those strings too.

I later found that several people recommended this angling of pins, including, I believe, in some of the older Zuckermann kit manuals. I cannot confirm historical use of this feature except naturally in the striking action keyboards like clavichords and fortepianos where this angle is viewed as helping to keep the strings from being lifted up.[15] Until recently, all but one instrument I have tried this angling on has improved in the sound characteristics described above. I am not sure why that one harpsichord did not, unless it was because those pins were noticeably corroded and already had an unshakeable connection with their strings.[16] I have found such angling to provide more clarity and longer sustain, and help smooth some of the quick burst of sound in instruments using modern steel-based strings, soft or otherwise. The optimum angle is not the same for all instruments or wire, but if the pins are angled too much the sound quality starts to become pinched, so the instrument will tell you when you have gone too far. This angling can be anywhere from zero degrees[17] to about 10 degrees in harpsichords, to as much as about 20 degrees in clavichords and possibly more in fortepianos.

Sound consequences

The way these different pin features can affect these instruments' speech, tone and sustain might be easier to accept if the following points are considered:

1. Mass and stiffness are the two major determiners of sound. More stiffness usually produces higher pitch, and less stiffness lowers pitch.
2. The string does not directly transfer its vibrations to the bridge, but to the bridge pin. It is the bridge pin that conducts string energy to the bridge.
3. Bridge and nut pins can, and usually do, vibrate to varying degrees, at least in harpsichords, clavichords and the early fortepianos. This may be surprising since these pins may seem so stiff, but a simple finger test can confirm this.[18]

Pins with different degrees of stiffness appear to transfer the vibrations of the strings at different rates. It appears that the stiffer a pin is, the more efficiently and quickly it transfers the initial energy of the pluck into the bridge/soundboard unit. The quicker transfer produces a big burst of brighter sound that then changes significantly in volume and timbre, continuing more quietly at a slower decay rate. More flexible pins seem to spread the initial pluck energy into a smoother rate of transfer into the bridge/soundboard, producing an impression of a mellower sound that starts more smoothly and fully formed, and creates the impression of a single rate of decay.[19][20] This result can be heard as more resembling a "singing" tone, which blends better with other instruments and voice, and is more like the sound characteristics of other baroque instruments, while the brightness, and front emphasis of the sound produced by stiffer pins appears more characteristic of modern instruments.

Summary

Since a gut string can sound mellow when in contact with wood or resemble the bright sound of a metal harpsichord string when in contact with metal bridge and nut pins, it seems reasonable to also expect that intermediate sound qualities would be possible by altering the properties of the material the string contacts. Experiences have indeed shown that even long after an instrument has been completed and delivered by its maker, changing the materials and sizes of these pins to approaches used historically do have significant consequences on the speech characteristics, timbre, fullness, and speed and shape of decay. Changing the pin installation heights, amount of pin above the string, and angle of pin can also alter these musical qualities.

Much more research and study is certainly needed on this topic, but, given the musical consequences, it would seem that more accurate copying of historical pin materials, pin size distribution, and installation techniques will increase significantly the likelihood that the musical qualities of an historical copy or restored antique will resemble those intended by its historical maker, and thereby provide players with more of the appropriate musical palette to realise fully the music that was composed for that particular keyboard instrument.

In the meantime, listening to the musical qualities of the instruments with which a keyboard instrument is expected to blend – violin, baroque flute, cello, gamba, voice, etc. – will provide clues as to how the properties of these musical pins might be used to help optimize a keyboard's qualities for its desired role.

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1 Strangely, I have found proportionally far more information about bridge pins in clavichords than in harpsichords and fortepianos. Koen Vermeij's amazing study of eighteen Hubert clavichords, *The Hubert Clavichord Data Book*, (Clavichord International Press, 2000): 261, reveals that bridge pin sizes in those instruments range from 0.7mm to 1.3mm. Sixteen have a thinner size in the treble and a thicker one in the bass, one has 0.7mm pins everywhere, and one is unmeasured. The transition notes of where the pin sizes change are provided for many of the instruments, and all have the pin heights noted.

The 1974 Debenham drawing of the 1751 Fritz clavichord (Victoria and Albert collection) shows .09mm, .08mm, and 0.7mm pins for the 8' strings and 0.5mm pins for its 4', a size that is only one gauge thicker than the lowest strings on that 4'!

The 1974 Loucks drawing of the 1763 Hass (Edinburgh) shows 8' pins 1.3mm FF-a#, 1.14mm a-a^1, and 1.07mm a#'-f^{3}'; and 4' pins 1.14 FF-C#, and 1.07mm D-B.

The 1974 Loucks drawing of the 1784 Hubert (Edinburgh) shows approximately 25 degree angles for its bridge pins.

The 1978 Mace drawing of the 1775 J.H. Silbermann clavichord (Germanisches) shows 1.1mm pins FF-a^1, with the rest using 0.9mm pins, and pin angles of approximately 16 degrees.

Doubtless there is more data, but this might serve here as a sample of historical practices for clavichords.

Clavichord designs can often have treble pins crowded rather closely together, due to lying on a section of 8' bridge nearly perpendicular to the strings. Using smaller pins in this section could be done to reduce crowding, as well as to reduce the risk of creating closely spaced holes that would make it easier for the bridge to split; however, several of the size changes in the instruments above do not coincide with this crowding, and the avoidance of pin crowding does not explain the similar use of different size pins in harpsichord and fortepiano designs where this kind of pin crowding does not occur.

2 It is not at all uncommon in collections and museums to find a range of anywhere from the replacement of a single missing bridge or nut pin with a pin of an obviously different material, diameter, installation height, and angle from the remaining original pins, up to wholesale replacement of the original multiple-sized pins with a single size of pin made of non-historical materials.

3 If anybody is willing to share any information, or sources for information, about the properties, dimensions, and use of pins in antique early keyboard instruments I would be delighted to receive it, and willingly share it with others, if permission is given, in order that more people can participate in investigating patterns and consequences of historical use.

4 This pin feature is the fourth of the six tonal factors begun in "Tailoring the Sound of Your Keyboard Instrument", *Harpsichord & Fortepiano* 16/1 (Autumn 2011). As discussed in that article, the effects of this factor will also interact with the other wire, pitch, and stringing schedule factors in various ways, as well as determine what can be achieved with voicing, which will be discussed in my next article as the fifth factor.

5 Even less information seems to be available for pin use in fortepianos than in harpsichords or clavichords, so it might be dangerous to predict too much from such a small sample, but something seems to be going on with that instrument also.

6 One possible reason for these choices might be that copper is somewhat self-lubricating and so when present, the reduced friction between string and pin makes tuning more reliable, and produces less contact wear. Iron pins against iron strings might experience more friction and shorter string life, which might explain why that combination appears to have been less used historically.

7 Grant O'Brien, *Ruckers: A harpsichord and virginal building tradition*, (Cambridge: Cambridge University Press, 1990): 109. These pins are made of brass and are about 0.9 to 1.0mm for the smaller pins, and 1.1 to 1.2mm for the larger ones.

8 O'Brien, *Ruckers*: 76.

9 This information comes from the Russell Collection, University of Edinburgh plan (Goujon/Taskin) measured and drawn in 1983 by Edward R. Turner, with research and corrections by Grant O'Brien. 8' choirs: Bridge pins FF-g#^{1} 1.3mm, a1-f^3 1.0mm; Nut pins 1.2mm; Backpins FF to long d 1.2mm, short d to f#^{1} 1.0mm. 4' choir: Bridge pins FF-d 1.3mm, d#-f^3 1.0mm; Nut pins 1.0mm; Backpins FF-A# 0.9mm. All pins are brass. Some work was carried out by Dolmetsch on the bass ends of the nuts of this instrument, but it is doubtful that smaller pins would have been installed at that time without there being evidence of plugging of the original larger holes.

In Taskin's reworking of the Goermans, he fortunately added long lines clearly showing which tuning pins were intended for each marked gauge number, making it possible to know the tensions for the notes, within about one-half semitone around a probable A–1 1/2 pitch. The full tension of the string is actually only felt by the tuning pin and the hitchpin; the nut pin, bridge pin, and backpin only experience a much reduced force from the string's tension due to the shallow side- and up-angles of the string against them.

10 All other properties being the same.

11 The differences between these practices were described in, "Using Appropriate Pitches and Stringing Schedules", *Harpsichord & Fortepiano* 17/2 (Spring 2013): 13-23.

12 I have not found any information on the precise properties of the brass and iron that the historical makers used for pins. However, it is quite certain that they did not have available the hardened brass pins and polished steel pins often used today.

From a convenience consideration, it seems quite likely that the historical makers used larger sizes of wire to cut pins of whatever size they wanted in a particular application, although this conjecture needs some further investigation. I have cut bridge and nut pins from Malcolm Rose brass wire in a variety of sizes for quite a few years. I suspect it might not be quite as soft as the brass used historically, but it certainly appears to test softer than the ready-made brass pins typically used throughout the twentieth century and currently.

Trying to use iron bridge and nut pins has been a problem in modern times since the phosphorus-iron that I presume was the historical material has not been available until very recently, and the soft carbon-steel that has been available corrodes too easily to be something to rub a string against for very long. Trying to use harder, polished steel pins in order to gain corrosion resistance makes a much stiffer pin, which moves its musical properties even further from that of historical pins. If historical iron pins had similar internal damping levels as historical iron wire ("Tailoring The Sound of Your Keyboard Instrument, *Harpsichord & Fortepiano* 16/2 (Spring 2012): 20-26), this property would very likely also affect the sound in a way that would not be heard with modern soft steel pins.

13 Some historical Italian harpsichords appear to have their pins sitting against the raised portion behind them; one antique I inspected recently had its vertical nut pins sitting slightly in front of this rear "wall"; still others have this rear wall slightly slanted back resulting in vertical pins definitely being free of contact.

14 It was definitely surprising that so much change could occur from shortening the pins. It took a while to figure out a possible reason. The Finger Test, described in endnote 17 below, appears to confirm that strings do make bridge and nut pins vibrate. If so, it seems reasonable to assume that more string energy will be used to vibrate a very tall pin than to vibrate a short pin. The energy needed to move the extra mass will reduce the amount of energy transferred to the bridge and that available to couple with the string vibrations, and thereby reduce the string's sustain. Further, the taller pin waving around may interfere with the string settling into its harmonic vibrations and therefore diffuse the sense of pitch....? Worth exploration anyway, especially since many historical clavichords and fortepianos appear to have kept this height quite low compared to some modern approaches.

15 I find it interesting that the same pin angle is apparently used from bass to treble in these instruments, even though usually the longer strings have much less angle and force of lift than the shorter strings where the pins are much closer to the tangent or hammer. However, when I have tried reducing that pin angle in the bass of clavichords, for instance, so there is still no string lift at the bridge pin, but so that both the up- and twisting-forces on the bridge as well as the pressure and friction of the string on the bridge are reduced, the sound has become less full and singing. So perhaps this angling was done for musical as well as mechanical purposes.

16 In fact, quite a few people have commented that brand-new instruments often sound a bit brash, and after even a month start to sound more mellow, even more so with additional aging. Perhaps, as the shiny slick new strings and pins begin to dull in colour (corrode) a more secure contact is made between them.

17 On two harpsichords on which I used the new reproduction of historical phosphorus-iron wire [i.e., the Stephen Birkett so-called p-wire], angling the pins on those instruments did not seem to benefit the quality of the sound. In fact, they sounded best when the pins were vertical, as contrasted to my experience of near-universal benefit of angling pins on instruments that use the modern steel-based wires (Rose, Vogel, Zuckermann, modern music wire, etc.).Your results may vary. Both of these instruments also used historically-sized softer brass bridge and nut pins which may have influenced this result.

18 If the damper is raised from a string, a fingertip can be stroked lightly and quickly sideways across the nut pin, and a faint sound will probably be heard from the string. If not, try lightly flicking the top of the pin sideways with a fingernail. If you are not sure the sound you hear is the string, lightly touch the string with a finger and see if the sound stops. The stiffer the pin is, the less you will hear. The more flexible the pin is, the more easily finger vibrations are transferred to the string, which means that vibrations from the string also transfer to the pin, and back to the string. Since the initial release of a plucked or struck string provides far more shock to the pin than a fingernail, it seems reasonable that the string and pin are exchanging vibrations under playing conditions.

19 The full reasons for all these results are not yet established, but it could be that the less-stiff pins flex with the initial shock of the pluck, not as efficiently transferring the high frequencies into the bridge, while still returning the vibrating pin energy back to the vibrating string.

20 The degree of these musical qualities present will also vary quite a bit depending on the voicing approach used.