Restoration of a Clavichord by Pehr Lindholm 1780

Introduction

To publish a report of an instrument restoration nowadays is to invite censure from the purists. There is much to be said for the present reluctance of many museums to go further than conservation, this being a long overdue reaction against the undisciplined restorational practices which were too common in the recent past. However, there is a category of antique instrument members of which may ethically be candidates for careful restoration and there are repair techniques which are non-intrusive and do not destroy the important evidence which old instruments often carry. I put forward the instrument described here as a suitable candidate because of its sound general condition and because it had previously been worked on in a less-than-ideal way. In a case like this, I think a restoration informed by modern knowledge can be justified.

Several benefits can, I think, be recognised, apart from being able to hear a prime example of Swedish clavichord building. The note names present on other Swedish clavichords and apparently removed from the soundboard were reinstated as an aid to tuning, but were written on two dated paper strips fixed with water-soluble glue so that they can easily be removed. The tightening of the keys was achieved by replacing the worn surfaces with new material which will in future protect the original wood from further wear and can be renewed whenever necessary or can be removed if a better method is available at some future time. This work seems to have established Lindholm's preference for setting his tangents to strike the unisons simultaneously. And finally, a method of reducing the overall tension in the interests of the long-term integrity of the casework and baseboard was tried which does not, I think, compromise too much the essential playing characteristics, and might have an application in other clavichord restorations.

Previous Condition (April 1995)

The following parts are not original:
The unison bridge between the bass end and note A,
The octave tuning pins,
One unison tuning pin from the middle-sized group G# - d#,
Cloth for back-touch and balance points,
Strings and listing,
The two hinges for the keyboard fall board,
Two of the four flap hinges on the lid.

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Two of the four flap hinges on the lid.

The stand is original but the legs now screw in with modern wooden screws and sockets. The exterior and both sides of the lid and flap have been grained rather crudely in recent times. This graining covers the repairs associated with the replacement of the fall hinges, which proves its non-originality.

Most of the unison bridge has been detached from the soundboard in the past. The part FF - A had been replaced somewhat crudely, of beech lighter in colour than the original with rather rough sides, a flat top (not angled down towards the tangents like the original) and pinning in approximately the correct places but with pins not aligned as accurately as the originals. The joint with the second section was crude. The section B^b - b^b seems never to have been disturbed, with very neat gluing to the soundboard. The section b - $g^{\#1}$ had obviously become detached from the soundboard at some time and been bent and twisted by the string tension near to note c, probably when subjected to high humidity. In order to glue it again in place without correcting the bend and twist it had been sawn across just below note b. The other four breaks in the bridge were all cracks along the grain where the bridge is weak due to being sawn round a curve at a large angle to the grain direction. These cracks are between notes $g^{\#1}$ and a^1, within note e^2, within note $f^{\#2}$ and between notes b^2 and c^3. The bridge is therefore now jointed from seven pieces. A small piece had been added to the treble end and an extra bridge pin added, making a total of 131. The octave bridge is intact. Confirmation of a period of high humidity, deduced above from the damage to the bridge, is given by severe rusting of some of the tuning pins where they were in contact with the wood of the wrestplanks. This is particularly so in the bass wrestplank along the end of the case, suggesting that the instrument might have had a period of storage with its right-hand end resting on a damp floor.

The soundboard had been neatly shimmed in five places but all the surface had been crudely rubbed apparently with coarse sandpaper, mostly across the grain, leaving deep score marks and presumably removing the note letters and gauge numbers which are present on other Lindholm clavichords. The makers label (of a kind not among those on pp254-5 of Eva Helenius-Öberg *Svenskt Klavihordbygge 1720-1820*) is slightly damaged on the left and front edges. The soundboard has not been removed, but it is possible that the bridge repairs were made with the baseboard removed.

The keys are slightly worn at the balance point and some of the leather at the key tails was non-original. The cracks in the baseboard had been neatly shimmed.

The touch depth measured down to the first contact with the strings at the front of the natural keys averaged 6.0mm in the bass, 5.7mm in the middle and 3.8mm in the treble with the non-original back touch found in April 1995.

With the following stringing in brass and modern steel at a^1 = 392Hz, the twist was 13.0mm (measured April 1995).

Unison	
FF,FF#	.80/.70mm brass
GG,GG#	.70/.70 " "
AA	.70/.60 " "
BB^b,BB	.60/.60 " "
C - E^b	.57/.57 " "
E	.57/.51 " "
F	.51/.51 " "
F#, G	.51/.45 " "
G#	.45/.40 " "
A - c#	.44mm steel
d - e	.39 " "
f - $g^{\#1}$	.34 " "
a^1 - c^2	.31 " "
$c^{\#2}$ - e^2	.29 " "
f^2 - g^2	.25 " "
$g^{\#2}$ - $g^{\#3}$	.24 " "
a^3	.29 " "

Octave	
FF	.57mm brass
FF# - GG#	.51 " "
AA, BB^b	.45 " "
BB, C	.40 " "
C# - E^b	.35 " "
E - G#	.30mm steel
A - d	.24 " "

The stringing was from several different workers with different styles of coil and loop. When these strings were tuned to a^1 = 406Hz (June 1996) the twist was 15.3mm. When these were removed samples were kept from each group. With all strings removed, the twist reduced to 7.7mm after three days and 6.6mm after 26 days. At this point the nameboard was able to move 0.4mm to the right and left in its mountings.

The present repairs

The instrument has had little playing, as shown by the very moderate wear on the natural keys, but the keys which are cranked to the right had worn at the balance point on the left and vice-versa, causing the keys to tilt.

Most balance holes were loose, and were coated with Seccotine (a water-soluble fish glue) on the inside which was allowed to dry and then trimmed with a round needle-file. The balance pins vary from 2.58 to 2.65mm in diameter and some are oval. Those balance slots which had worn on one side (mostly due to the cranking) were coated with Seccotine which was filed with a flat needle-file when dry. A second coat was applied when necessary. In most cases, this treatment produced horizontal key surfaces, but keys which were still tilted were corrected by bending the balance pin to left or right. This was done without damage to the holes in the balance rail by dropping a close-fitting sleeve about 200mm high over the balance pin and pressing it gently to left or right.

Adjustments were then made to the leather covering glued each side of the key-tails where they ran in the wooden rack. Much of the leather is pale beige in colour and appears to be original, because it is well cut and it is the only kind of leather which shows signs of being eaten by moths. Repairs had previously been made with light brown leather. In order to distinguish them, the present repairs used dark brown leather. Where tails had original leather but were loose, the leather was cut away and reglued with one or two layers of paper glued underneath, thus preserving the original pale leather, but new leather was substituted when the light brown leather was worn or damaged. These adjustments produced keys which did not rattle and had even gaps between the naturals.

The previous back-touch was a strip of modern green cloth 22mm x 6mm thick (probably piano hammer-rail cloth) liberally glued to the rail. When this was removed, traces of blue-grey cloth, probably original, could be seen glued to the rail. This was left undisturbed and may be seen particularly under notes c^1 and e^{b1}. A new back-touch was prepared by loosely sewing together five layers of black woollen cloth, total thickness 7.04mm, the lowest layer being spot-glued to the rail.

The tangents appear to be undisturbed and in original condition except those of notes e^b, $c^{\#1}$ and e^{b2} which had been filed so that the top sloped backwards. This allowed the strings to slip off the back edge of the tangent. These were filed to the same angle as the others. Two other tangents had slight ridges in the top surface and were smoothed with a fine file.

The strings were removed in June 1996 and the unison tuning pins examined. The iron rod from which they were made has cavities, often 2mm across, which tend to cause string breakage when under the coil and tend to enlarge the hole when they occur in the part of the tuning pin in the wrestplank. Excess rust was removed.

The unison tuning pins are of three different sizes:-

FF - G, 15 notes, 4.7 - 4.8mm diameter x 52.2 - 55.8mm long

$G^{\#}$ - $d^{\#}$, 9 notes, 4.4 - 4.5 mm diameter x 50.6 - 53.0mm long

e - a^3, 42 notes, 4.2 - 4.3mm diameter x 50.3 - 51.7mm long

Judging by the position of the rusted parts, all unison pins originally protruded 36mm. Some tuning pins were found in positions unsuited to their diameter and length, and were repositioned, but most were refitted in the positions in which they were found. Twelve bass tuning-pin holes had previously been drilled out, plugged and redrilled. All but 24 holes needed to be shimmed in order to set the pin with the right protrusion and grip.

Shimming was carried out by a new method using beech shavings 0.28mm thick produced by a jack plane set deep. A strip of beech about 200mm long was prepared with a top surface 13.1mm wide cut on the quarter. Shavings were planed from the top surface and pieces 24 - 27mm long were cut from perfect lengths. One end was inserted into a split-pin 3.1mm diameter x 51mm long so as to look like a flag on a flagpole. As shown in sketches, the "flag" was rolled round the pin while in contact with wet glue (Seccotine) spread evenly on a flat piece of wood. The roll was then inserted clockwise into the hole to be shimmed (which sometimes needed to be drilled parallel). By twisting the split-pin anti-clockwise, the rolled-up shaving was made to expand and adhere to the outside of the hole and the piece of shaving which was trapped between the two sides of the split-pin broke off, allowing the pin to be withdrawn.
A special tuning pin of traditional tapered pattern about 0.2mm less in diameter than that intended for the hole was then worked anti-clockwise into the shim, to expand it against the outside of the hole, and left in place for about three minutes. It was then withdrawn anti-clockwise to allow the glue to dry. These shims were nearly always successful first time, but could be drilled out and replaced if necessary. The proper tuning pins were worked in with the tuning key, pressing them in firmly while turning until the protrusion was 36mm. They were left in place until each was withdrawn to put on the appropriate string.

All 22 octave tuning pins were crude replacements 4.66mm diameter x 36mm long. New tuning pins were made 4.1mm diameter to match those of the treble unison. The octave wrestplank is 10mm higher than the unison wrestplank (i.e. 10mm nearer to the lid) so the octave tuning pins were made 10mm shorter than those of the unison, i.e. 40mm long. The holes were shimmed with shavings 46mm long and the new pins worked in leaving 27mm protruding.

Since the surface of the soundboard had been treated so roughly in the past (though it did not appear that much had actually been removed), it was felt to be legitimate to improve the surface by sanding along the grain with very fine sandpaper. Note names like those found on other Lindholm clavichords of similar date were written on strips of hand-made paper, one for the diagonal pins and one for those parallel to the end, the paper stained to match the soundboard, and the strips glued in place with water-soluble glue so that they could be removed in future if required. Five soundboard cracks had been neatly shimmed, one of which had opened slightly and needed an extra shim. These had been left a lighter colour but were stained to match the soundboard.

The pins of the non-original bass end of the unison bridge were removed and plugged and the top surface sloped to match the original parts. The rough sides were sanded and a gap in the rather crude joint between it and the original part of the bridge was plugged. The non-original part was then stained to match the rest and new bridge pins inserted in the previous positions but with better accuracy matching the original pins in the rest of the bridge.

The five treble pieces of the original unison bridge had all been firmly glued to the soundboard, apparently with epoxy, very close to their original positions and were not disturbed. The glue was untidy at the joints with the soundboard and some glue was on the sides. This surplus glue was removed. Most of the joints between the parts of the bridge were reasonably tidy, but the joint at note f$^{\#2}$ had an untidy shim which was removed. This crack was trimmed and a new insert 3mm wide was glued in place with one of the g^2 bridge pins in it. Two bridge pins were loose and were secured. The added piece at the treble end with the extra bridge pin was removed, leaving a small step missing from the top end of the bridge, which was replaced with a new piece.

The stringing lists of Lindholm clavichord from 1776 (two examples), 1782, 1785, 1787, all with the same compass FF - a^3 as the present 1780 clavichord were studied from Eva Helenius-Öberg p283 and private communications from Lance Whitehead and Steve Barrell, showing broad agreement between the gauges marked against the tuning pins. The clavichord of 1782 and 1787 had no indication of gauges against notes FF - C suggesting the use of covered strings for the unisons of these notes. The 1785 lacks gauge markings up to and including D and at present has covered strings FF - AA.

The most likely reconstruction of gauges for 1780 seemed to be:

Unison				
FF - C	covered		(8 notes)	
C$^\#$ - D	gauge	00	(2 ")	.622mm
E^b - E	"	0	(2 ")	.561mm
F - G$^\#$	"	1	(4 ")	.505mm
A - c	"	2	(4 ")	.455mm
c$^\#$ - e	"	3	(4 ")	.409mm
f - c^1	"	4	(8 ")	.369mm
c$^{\#1}$ - c$^{\#2}$	"	5	(13 ")	.332mm
d^2 - d^3	"	6	(13 ")	.299mm
e^{b3} - a^3	"	7	(7 ")	.269mm

Octave			
FF - FF$^\#$	gauge	1	(2 notes)
GG - AA	"	2	(3 ")
BB^b - E^b	"	3	(6 ")
E - G	"	4	(4 ")
G$^\#$ - B	"	5	(4 ")
c - d	"	6	(3 ")

The equivalent diameters in mm are taken from Grant O'Brien, "Stringing Materials and Gauges for Clavichords by J C Gerlach and H A and J A Hass, *De Clavicordio* Magnano 1993, p219.

In choosing available modern diameters, it seemed essential to reproduce the treble tensions accurately to match the touch and the loudness the maker intended. If the bass tensions had also been followed, the resulting tension would have been about 41% more at a^1 = 415Hz than that of the previous stringing at a^1 = 392Hz. In order to reduce as much as possible the twisting effect on the case and baseboard, it was decided to make such reductions of tension in the bass as did not spoil the balance between treble and bass or produce too yielding a touch. The bass tension has more effect on the twist than the treble tension because it acts further from the back of the case, the front of the case being weakened by the part cut away for the keys. Stringing was begun in the treble and the bass gauges were chosen experimentally, testing balance and touch as it proceeded.

The following stringing was adopted using wire from Malcolm Rose:-

Unison

FF - GG core .40 brass, winding .30 copper, winding angles 74°, 70°, 65° pitch .65, .80, 1.0mm

GG$^\#$ - C core .40 brass, winding .25 copper, winding angles 70°, 67.5°, 64°, 60°, 56° pitch .73, .85, 1.0, 1.4mm

C$^\#$ - e^b	(3 notes)	.51mm brass
E - G	(4 ")	.47mm "
G$^\#$ - c	(5 ")	.43mm "
c$^\#$	(1 ")	.43mm iron
d - e	(3 ")	.39mm "
f - c^1	(8 ")	.36mm "
c$^{\#1}$ - c$^{\#2}$	(13 ")	.33mm "
d^2 - d^3	(13 ")	.30mm "
e^{b3} - a^3	(7 ")	.27mm "

Octave		
FF - FF$^\#$	(2 notes)	.47mm brass
GG - GG$^\#$	(2 ")	.43mm "
AA - BB	(3 ")	.40mm "
C - D	(3 ")	.36mm "
E^b - F	(3 ")	.33mm iron
F$^\#$ - g$^\#$	(3 ")	.30mm "
A - B	(3 ")	.27mm "
c - d	(3 ")	.25mm "

Pitch a' = 415Hz. Twist under tension = 15.9mm (August 1996)

This stringing undoubtedly reduces the power of the bass but it is easy to imagine the alteration and allow for it in playing and listening. The reduction in the higher notes of the octave strings, amounting to two gauges, makes the transition between d and e^{b} less noticeable than with the original stringing.

Two new tuning pins were provided for the unison strings, one to replace the non-original pin mentioned previously and one to replace an original (which is preserved in the tool-box) which had a cracked top. These were placed next to each other on notes G and $G^{\#}$. The new octave tuning pins 40mm long x 4.1mm diameter did not bring the strings half-way between the unisons, presumably because the originals were a bigger diameter. This was corrected by placing small brass sleeves on the back unison hitchpins above the string loop for the lowest eight notes, the outside of which guided the octave strings into the required position.

The string tension after 216 years has twisted the case but most of this twisting is elastic and reduces to 7.7mm when the tension is removed. Thus 8.2mm of the current 15.9mm twist is due to the present string tension. The tension has bent the balance rail so that the top surface is hollow, the maximum distance of its surface below a ruler supported on its two ends being 0.6mm at about key e. Part of this bend is elastic, as is shown by the nameboard becoming loose when the tension was removed.

The lowest 18 tangents, FF - B^{b}, have a special design including a small upwards projection at the back, as shown in the sketch, obviously intended to prevent the strings slipping off the back of the tangent in playing. Because of the geometry of the clavichord keyboard, this is a particular problem in the bass. The tangent, of course, moves in an arc of a circle with the balance pin as its centre, so that the treble tangents which are a large distance behind the balance pins move almost vertically, while the bass tangents move forward as they rise because of the smaller distance from the balance pin. This distance varies between 330mm for a^{3} and 105mm for FF.

An alternative way of dealing with this problem is to tilt the top surface of the tangent forward, but the consequence is that the back string is struck a little before the front string. The fact that the tangents of this clavichord are almost all undisturbed and in original condition enables us to observe Lindholm's own intention. The present adjustment, which we can assume is very close to original, is that most tangents throughout the compass strike the two unisons as nearly together as can be seen. Those few in which one string can now be seen to rise slightly before the other are random - the first strike is as often the back string as the front string. It seems evident, therefore, that Lindholm intended the unisons to strike together and so needed horizontal surfaces to the tangents and solved the problem in the bass with the projections.

The octave strings of the first 22 notes, FF - d, are placed between the two unisons and can be adjusted up or down by their position on the tuning pin at the bass end and by the pattern of the woven listing. The loudness of the octave is reduced if it is struck much after the unisons because the tangent will have been reduced in velocity by the time it reaches the octave string. The most consistent and reliable sound seems to occur if the octave is struck slightly before the unisons.

The backtouch thickness which was adopted (uniform from bass to treble) gave a depth of touch at the front of the naturals to the point of touching the strings of 5.0mm in the bass, 4.9mm in the middle and 3.0mm in the treble. Of course, the actual playing depth is more than this. The sharp tops are 9.2mm high and the natural plates 2.0mm thick, making the sharps 7.2mm above the naturals when the levers of naturals and sharps are level. The vertical dimensions of the keyboard are therefore consistent with the above depths of touch. This depth of touch enables the bass keys to be removed without difficulty, although it is necessary to lift the strings a little to do so for keys below c. A thicker backtouch, giving less touch depth, would make the keys more difficult to remove, which is perhaps confirmation that the present depth is substantially correct.

String lengths

Note	unison length	% scale	octave length	% scale
FF	1710mm	52% brass	1295mm	79% brass
AA	1627mm	62% "	1146mm	89% "
C	1540mm	70% "	1045mm	95% "
F	1365mm	84% "	878mm	93% iron
A	1208mm	93% "	747mm	100% "
c	1087mm	100% "	648mm	103% "
f	887mm	94% iron		
a	727mm	97% "		
c^1	609mm	97% "		
f^1	455mm	97% "		
a^1	370mm	99% "		
c^2	314mm	100% "		
f^2	242mm	103% "		
a^2	196mm	105% "		
c^3	167mm	106% "		
f^3	130mm	111% "		
a^3	106mm	114% "		

The figures for % scale show how closely the string lengths conform to a theoretical scale, doubling or halving at the octave. The string length of c^2, i.e. 314mm is arbitrary assumed to be 100% and it can be seen that Lindholm does not use a uniform treble scale, probably because his iron strings are stressed considerably below breaking point. The chosen pitch of a^1 = 415Hz is not based on these string lengths, and Lindholm unfortunately has not indicated where the strings should change from iron to brass, which would give a good indication of the intended pitch. Having chosen 415Hz, the string lengths show that brass can be taken without breaking as far as c in the unison and D in the octave, and so the scaling of these strings was taken as nominally 100% for brass. It will be seen that this stringing changes to covered strings at 70% brass scale.

Tensions

note	tension pre-1996	assumed original tensions	1996 tensions
unison	a^1 = 392Hz	a^1 = 415Hz	a^1 = 415Hz
FF	6.69kg	7.00kg?	6.00kg
AA	7.22kg	7.50kg?	6.57kg
C	7.06kg	8.00kg?	7.00kg
F	7.88kg	8.68kg	7.52kg
A	6.77kg	8.76kg	7.82kg
c	7.77kg	10.00kg	8.96kg
f	5.50kg	7.27kg	6.92kg
a	5.86kg	7.75kg	7.38kg
c^1	5.82kg	7.69kg	7.32kg
f^1	5.79kg	6.19kg	6.12kg
a^1	5.05kg	6.50kg	6.42kg
c^2	5.14kg	6.62kg	6.54kg
f^2	3.54kg	5.68kg	5.72kg
a^2	3.39kg	5.91kg	5.96kg
c^3	3.49kg	6.08kg	6.12kg
f^3	3.77kg	5.31kg	5.35kg
a^3	5.81kg	5.61kg	5.65kg

octave

FF	8.87kg	7.81kg	6.77kg
AA	6.87kg	7.88kg	6.09kg
C	6.39kg	7.50kg	5.81kg
F	4.20kg	7.13kg	5.70kg
A	3.08kg	6.62kg	4.38kg
c	3.29kg	5.72kg	4.00kg
Approximate total tension	774kg .76 ton	1086kg 1.07 ton	989kg .973 ton

It should be noted that the assumed original stringing increases in tension from the treble to note C and decreases again below this note. This decrease of tension is probably intended to maintain an even touch in the bass, where the distance between the tangent and hitch pins also decreases. This distance actually begins to decrease at nearby note f, where the hitchpins turn the corner from the rear hitchrail to the end hitchrail. This pattern of tensions is followed in Hass clavichords, which influenced the Swedish school of builders.

The present stringing follows the assumed original values in the unison down to f^1 but is moderately reduced in tension below this point in the unison and octave. This reduces the total tension by about 1000kg or 10% but the reduction of the baseboard twist is likely to be about 15% because the bass strings have more effect on twist than those of the treble.

The instrument was recorded by Colin Tilney for the BBC on 2nd September 1996.