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# THE SOUNDPOST IN THE VIOLIN

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## PART II. THE EFFECT OF SOUNDPOST POSITION ON PEAK RESONANCE AND SOUND OUTPUT.

### SUMMARY

In the violin studied the sound output of the lower strings was below that of the E string by 6 dB when no soundpost was present. Varying the position of the soundpost had a large effect on the sound output. When it was placed toward the centre of the violin the output from the three lower strings decreased and resembled the behaviour without a soundpost including the tendency to Wolf. Moving the soundpost away from the centre strengthened the output of the lower strings. The frequency of resonance peaks, A0 and B1- were raised on changing the position towards the centre of the violin while that of B1+ remained unaltered. Removing the sound post lowered the frequency of A0 and B1+ but not B1-. However the strength of B1- was greatly reduced as the soundpost was moved towards the centre and was very weak with no soundpost.

Moving the soundpost away from the bridge foot while remaining in line with it had little effect on the difference between the E string and the lower string output and moving it towards the centre also had a smaller effect and moving it towards the f-hole did not improve the balance as previously found.

It was found that the soundpost had to be cut to the correct length and properly fitted to the new position for consistent results to be obtained. Simply moving one soundpost about gave no indications of trends in behaviour.

INTRODUCTION

Subjective assessment of sound quality by players in the past and makers who have ventured advice for setting up the violin can be summarised as follows:

1.If the soundpost is too tight, the sound will be tense and hard.

2.If the soundpost is too loose, the sound will be soft.

3.If the soundpost is too forward (i.e. near the bridge) the tone is loud and shrill without quality.

4.If the soundpost is moved toward the centre, the lower strings will be loud and strong.

5.If moved toward the f-hole, the upper strings will be strengthened.

This advice seems to be refuted by the recent findings of Jansson E.V. et.al.(1994) in which the frequency response of a violin was determined with and without the soundpost and on moving the soundpost to positions ±5 mm both longitudinally and transverse. Subjective assessment of the sound quality and the effect on features of the frequency response were made.

Of relevance to the work reported here, transverse repositioning toward the centre "suppressed" the low frequency and the tone was "looser". Moved in the opposite direction, the tone was "more rumbling and harder". Longitudinal repositioning affected the high frequency response. Moved closer to the bridge, the tone was "slow and hard"; moved further away from the bridge, it was "non singing and loose". In general they concluded that (1) the top plate (thickness) and soundpost adjustment sideways sets the low frequency response and tonal strength, and (2) the back plate (thickness) and soundpost adjusted lengthwise sets the high frequency response and tonal brilliance.

The subjective assessments by a player are just as vague and no more informative than those by earlier players and makers. The objective measurements, on the other hand, can be repeated.

It was decided to conduct similar experiments using impulse excitation which was shown to give reproducible results when studying the effect of soundpost stiffness, together with the Saunders Loudness Test to measure the sound output. The subjective assessment of tone or sound quality was not attempted. It might be said that sound quality is the result of the intention of and skill with which the player weilds the bow.

## LOCATING THE SOUNDPOST

Documenting the position of the soundpost needs some discussion. The glue line joining the two halves of the top plate may not lie on the centreline of the instrument and is therefore not a reliable datum for measurement and specifying the position of the bassbar and soundpost. There is also the possibility of a one piece top. If the bridge feet are placed symmetrically with respect to the upper eyes of the ff´s and their position related to the spacing of the ff´s at the bridge line then measuring from the inner edge of the ff´s becomes a practical substitute because both bassbar and soundpost are accessible. One has to take the position of the bassbar into consideration when defining that of the soundpost. For a starting point, the "standard" position is taken as a symmetrical one with the bassbar directly under the left foot of the bridge and the soundpost directly behind the right foot of the bridge. The centrelines of these items is implied here. It is assumed that the violin is symmetrical in the placement of the ff´s and the bassbar is positioned to make this possible when the bridge is equidistant from lines projected from the inner edges of the upper "eyes" of the ff´s. The bassbar may not have been placed to be under the bridge foot when the bridge lies "between" the upper eyes of the ff´s. If it lies outside the line of the bridge foot the "symmetrical" position of the soundpost would be outside the right bridge foot. The effect on sound output of a variation in distance between the bassbar and the soundpost has not been documented.

For this experimental survey the standard position for the soundpost has been taken to be 5 mm between the nearer surfaces of the treble bridge foot and the soundpost directly in line and on the tailpiece side of the bridge. For the violin used throughout, this has been 19 mm from the f-hole to the nearer surface of the soundpost. This has been the standard position in all the experiments reported here. This does not mean that this was the optimum position for the violin used.

## EXPERIMENTAL DETAILS

Saunders Loudness Curves were determined in a similar manner to those obtained earlier using the same violin, and are shown in Figure 1. The soundpost positions were measured as above, between the adjacent surfaces and in the case of the f-hole, between a reed line extending from the "nick" and closest to the edge of the f-hole on the treble side. The location of the soundpost was expressed with two numbers. The first, indicating the distance behind the bridge and the second, the distance in from the f-hole (reed line) e.g. 5/19 was the "standard position". The soundpost was always placed vertically between the plates. The impedance was chosen to be >60 kg/s (62 - 81) for the replacement soundposts.

FITTING THE SOUNDPOST

Two fitting conditions were used; first, the vertical distance between the plates was measured and posts were made to fit the new positions; second, if the "standard" post was moved to the new locations and a poor fit was found resulting in the upper wing of the f-hole being either raised or lowered compared with the surrounding plate surface when the string tension was re-applied, a new post was made. For this exploratory survey, position changes of about 5 mm in the two numbers were used.

Some general observations on the S.L.T´s. For the violin without a soundpost, determination of the S.L.T. revealed a tendency to "wolf" in the region of 500 - 600 Hz. This is in the vicinity of B1+. The difference in average loudness (dB) between the regions above and below 600 Hz was large (about 7 dB) and, in addition, down about 1 dB overall. Coinciding with the lowered output from the G string as found in the S.L.T., is the reaction of the player that it does not offer enough resistance to the bow.

When the soundpost was "inboard" of the "standard" position there was a tendency to "roughness" in the sound and the loudness was down. This was more noticeable with re-positioning the one sound-post, when the tip of the wing of the f-hole was depressed (about 1 mm). No trend in behaviour was found in these tests.

When a soundpost was cut to fit the positions away from the "standard" position a different picture emerged. A trend was obtained for different lateral positions when the soundpost was 5 mm and 10 mm from the bridge line, respectively. The trend was more evident with the soundpost 5 mm from the bridge. The S.L.T. did not show the large difference between the upper and lower strings when the soundpost was closer to the f-hole. Figure 1 shows the S.L.T's for no soundpost and three positions across the instrument with the soundpost carefully fitted. Table 1 sets out the results for two trials using calculated average dB levels.

Table 1. Summary of output levels for fitted soundposts at 3 positions across the violin for 2 positions from the bridge.

| 1 (mm) | Z (kg/s) | Posn.(mm) | Level (dB) ≤600 Hz | Level (dB) >600 Hz | Difference in level |
|---|---|---|---|---|---|
| 54.7 | 61.3 | 5/15 | 85.69 | 87.32 | 1.63 |
| 55.5 | 110.6 | 5/20 | 83.28 | 86.54 | 3.26 |
| 56.0 | 81.2 | 5/25 | 81.88 | 87.54 | 5.66 |
| No s/post | | | 80.28 | 86.04 | 5.74 |
| | | | | | |
| 54.7 | 61.3 | 10/15 | 84.66 | 87.68 | 3.02 |
| 54.7 | 110.6 | 10/20 | 83.59 | 86.96 | 3.37 |
| 56.0 | 81.2 | 10/25 | 81.18 | 86.07 | 4.26 |

The ambient conditions for these results, were 20 ± 3 C and 40 ±

10% R.H.

The result of moving one soundpost to different positions on the S.L.T. are summarised in Table 2 where it can be seen tha the results are not reliable because of the distortion although they show a similar trend to the results in Table 1.

Table 2. Summary of output levels for unfitted soundpost (fitted at 4/20 only) soundpost 110.6 kg/s.

| L(mm) | Posn.(mm) | Distortion at f-hole | Level (dB) <600 Hz | Level (dB) >600 Hz | Difference in level |
|---|---|---|---|---|---|
| 55.5 | 4/16 | + 1 mm | 79.62 | 86.96 | 7.34 |
| | 4/20 | 0 | 83.47 | 86.25 | 2.79 |
| | 5/25 | - 1 mm | 81.41 | 86.14 | 4.73 |
| | 9/15 | + 1 mm | 84.41 | 86.54 | 2.13 |
| | 10/20 | 0 | 83.63 | 87.43 | 3.8 |
| | 10/25 | 0 | 81.34 | 85.5 | 4.16 |

It is clear from these results that for carefully fitted soundposts there are differences in the measured output with position. The sensitivity of output to smaller changes in position has not been explored nor has the effect with different violins except for a trial with one other violin. This second trial gave similar results to that above in the table. When the length of the soundpost was made to fit the new position the best result was obtained at position 5/15. The result for this violin with no soundpost present was also similar in that "wolf" notes appeared in the region around 500 Hz (namely B♭, B, C, D♭ on the A string), where the main body resonances occur. It is to be hoped that other studies will be carried out to enlarge the understanding in this area.

It would be inconsistent if these changes in output were connected with body stiffness and there was no accompanying change in the position of resonance peaks in the response curve. In terms of S.L.T's, the output level on the E string (and upper A string) does not seem to depend on the presence of the soundpost, being little changed when it is put in. When the soundpost is installed the stiffness of the body is increased as evidenced by the higher A0 and shift in resonance peaks to higher frequencies and in proportion to the impedance of the soundpost. It would seem, then, that the soundpost has more influence at frequencies below 600 Hz; the first being to suppress the tendency to wolf. The variation in output with position of the soundpost is also of some interest.

Impulse response curves were obtained for the different soundpost positions to see if any correlation existed with the S.L.T's. The curves for soundposts of the correct length are shown in figure 2 and the relevant frequencies in table 3. The relative heights of peaks around 500 Hz in figure 2, show that as the soundpost is moved from outside the bridge foot towards the centre, the height of B1+ changes from being a little lower than B1- (at 5/15) to being markedly higher (about 20 dB at 5/25). Saldner et. al. (1996) found a similar change.

Table 3

| S/post kg/s | 61.3 | | 111 | | 81.2 | | None | |
|---|---|---|---|---|---|---|---|---|
| Position (fitted) | 5/15 | | 5/19 | | 5/25 | | | |
| Peak ($\Delta f=4$ Hz) | Hz | dB | Hz | dB | Hz | dB | Hz | dB |
| Ao | 276 | 68.5 | 280 | 63.5 | 288 | 62.7 | 256 | 62.4 |
| * | 304 | 54.3 | 308 | 45.0 | 304 | 34.8 | 308 | 50.5 |
| | 380 | 70.5 | 388 | 60.5 | 380 | 55.3 | 388 | 77.9 |
| * | 392 | 58.7 | 396 | 42.4 | 392 | 48.5 | 396 | 54.5 |
| | 428 | 79.9 | 420 | 66.2 | 428 | 66.2 | 408 | 78.1 |
| * | 440 | 60.3 | 440 | 53.3 | 440 | 49.9 | 452 | 54.8 |
| B1- | 468 | 83.8 | 472 | 73.5 | 480 | 69.0 | 480 | 61.2 |
| * | 508 | 62.1 | 508 | 55.2 | 500 | 57.5 | 488 | 53.8 |
| B1+ | 536 | 82.6 | 532 | 76.4 | 544 | 80.1 | 520 | 76.7 |
| * | 576 | 67.6 | 580 | 58.1 | 584 | 60.3 | 544 | 58.7 |
| | 580 | 78.4 | 588 | 71.4 | 592 | 74.1 | 552 | 70.5 |

## BODY STIFFNESS TESTS

Supporting evidence for effects accompanying the repositioning of the soundpost was sought by doing some static stiffness tests by loading at the G and E string slots with the violin resting on rigid supports at the four corners. The rigid columns supporting the violin were capped with small polythene buttons to protect the instrument. The violin was fitted up with strings at pitch.

Loads up to 4 N were applied by means of a 5:1 counterbalanced lever. The deflection at the loading point was measured with a 1/10,000 inch dial gauge. The machine stiffness without the violin was 4 x $10^6$ N/m. The bridge used was tested separately on a rigid base with strings at pitch. The apparatus was mounted on a levelled toolmakers surface plate. The results of these static tests are shown in Table 4.

Table 4 Body Stiffness under Static Load

| String slot | | | | Stiffness values x10$^3$ N/m | | | |
|---|---|---|---|---|---|---|---|
| | S/post position | | | 0/20 | | | |
| E | | | | 150.0 | | | |
| G | | | | 31.6 | | | |
| | S/post position | 5/30 | 5/25 | 5/20 | 5/15 | [illegible] | 5/10 |
| E | | 43.5 | 60.0 | 66.7 | 76.9 | (88)* | (101)* |
| G | | 69 | 36.1 | 41.4 | 39.5 | (40)* | (51)* |
| | S/post position | | | 10/20 | | | |
| E | | | | 57.7 | | | |
| G | | | | 28.8 | | | |
| | No S/post | | | | | | |
| E | | | | 41.7 | | | |
| G | | | | 33.0 | | | |
| | Bridge on a rigid base | | | | | | |
| E | | | | 126.0 | | | |
| G | | | | 92.0 | | | |

* Quick loading, [illegible]

Two conclusions can be drawn from these results. The first is that the treble foot of the bridge is not rigidly held in place and cannot be a pivot point. The second conclusion is that the stiffness at the treble foot of the bridge varies with soundpost position; the stiffness progressively increasing as the soundpost is moved out from the centre of the violin and decreases as it is moved away from the bridge foot. These stiffnesses are about two orders of magnitude smaller than that of the soundpost usually installed.

## DISCUSSION

A general comment on locating the position of the soundpost can be made. It has been assumed that the back face of the bridge was on a line between the inner nicks of the ff´s. This is somewhat arbitrary but in this case this line was made the stop length (of 195 mm).

An early published discussion on the soundpost, Saint-George (1910) points out its importance but is at variance with the findings of the experiments on the violin used in these tests. The advice given was that moving the soundpost "inboard" of the bridge foot would raise the weaker lower strings, while moving it "outboard" would change the balance in favour of the upper strings. In the present work, there is little change in the upper strings but the lower strings are only raised by moving the soundpost "outboard". No detailed discussion is made of the tightness of fit in this respect. In fairness, a tight post is related to "hardness" in the tone, by early writers. The position of the soundpost is clearly linked to the shape of the body modes so that the positions of the bridge, as the source of excitation, and soundpost are interdependent.

Jansson E.V. et.al. (1994) described the effect of moving the soundpost on the disposition of prominent peaks in the frequency response of a violin. It should be noted that the antiresonance at 500 Hz remained unmoved by repositioning the soundpost (their figure 4,5 and 6). A 650 Hz peak was present without a soundpost but did not appear to be present with a soundpost, unless it was moved to 700 Hz when the soundpost was present or repositioned away from the bridge or toward the centre. If the peaks either side of the 500 Hz antiresonance are B1- and B1+ as identified in the present study, removing the soundpost enhanced B1+ but caused B1- to disappear. Moving the soundpost toward the centre enhanced B1+ and diminished B1-; moved toward the f-hole had the reverse effect. This change in B1 prominence was confirmed in the present study. When the soundpost was moved toward the bridge,in the study quoted, the 700 Hz peak was eliminated; moved away from the bridge it was enhanced. The B1 peaks were not affected.

The virtual elimination of the B1- peak with the removal of the soundpost must suggest a reduction in activity. This could be a reduced monopole component due to a change in the disposition of the nodal lines. From Figure 1 in Part I, the nodal lines in the back have changed little while those in the top have moved out to pass through the ff´s. The soundpost pulls one nodal line in the top away from the f-hole accompanied by a change in nodal shape. The more dramatic change in nodal shape for B1+ both in the top and the back has not affected the peak height significantly.

The prominent peak at 410 Hz in the no soundpost case had a nodal pattern similar to B1-. A second pattern at a lower frequency may be due to the influence of a torsional vibration of the neck at this frequency whereas the neck is bending at B1-. Marshall (1985) showed a similar behaviour for B1+ in that for the violin he studied, SUS295, a B1+ mode at 574 Hz with neck bending had a mode at 555 Hz of a similar shape with the neck in torsion. He also showed a mode at 410 Hz (of a different shape to that in this work) with the neck in torsion while his B1- at 466 Hz had the neck in bending.

Rodgers O. (1997) studied the effect of repositioning the top of the soundpost by small amounts behind the right foot of the bridge. He said that the peak amplitude plots for the three soundpost positions showed only minor differences but there were large differences between strings. His subjective assessment of the sound quality agreed with older writers; "the high notes became less brilliant" by moving away from the bridge and the lower notes "became fuller and louder" on moving toward the centre. That these effects were found for small adjustments of the top of the soundpost only (and similarly for the older writers) may have been the result of departing from the good fit of the soundpost and creating unknown stresses.

Trott (1984) in a paper devoted to the cello, suggested zero phase difference over a wide frequency range as a test for maximum coupling at the ends of his soundpost. He suggested this as a test for a good fit. A poor fit allowed the phase difference to go from zero to negative at a low frequency. He also suggested that impedance matching of the soundpost with the bridge plus strings as seen by the soundpost could improve instrument sound quality. This means that when fitting up, such aspects could be considered. However close matching might increase the tendency to wolf. He measured the soundpost position from the endpin and the centreline of the instrument, looking from the scroll, so its relation to the bridge was not deduceable.

From the results obtained it would appear desireable to install the lightest soundpost with an impedance >60 kg/s in a position about 5 mm behind and outside the line of the treble bridge foot by about 5 mm for the violin used in these trials. More experience is needed before any generalisations can be made.

The body stiffnesses measured in this work may be compared with the effective stiffnesses determined for B1- and B1+ (unpublished work). For soundposts of similar stiffness, that for B1- increased from 0.5 x $10^6$ N/m at 5/10 to 1.0 x $10^6$ N/m at 5/25 while the stiffness of B1+ remained about 1.0 x $10^6$ N/m. These latter values are for a dynamic method and might be expected to be higher than the results of static tests quoted above.

It must be the case that without the soundpost, the lower strings have a reduced output due to a less efficient Helmholtz resonance, compared with the E string. Installing a soundpost raises this output and adjusting its position adjusts the balance. The results outlined apply to a violin that has a louder E string, using the test described, than the lower strings. It is not known whether this is typical for all violins. It is possible that the initial balance may be quite different. It will certainly be different in degree. It is not known how a change in stiffness of the bassbar might affect the balance. What is clear, is that the range of possibilities is greater than previously thought. Measuring the static stiffness of the bass and treble sides of the violin without a soundpost may give a clue as to how to proceed.

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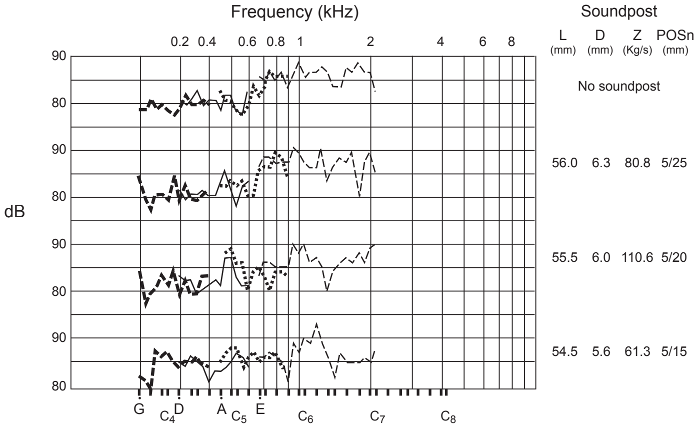

*Figure 1.* Saunders Loudness Curves for violin No 1 with soundposts located in the positions shown.

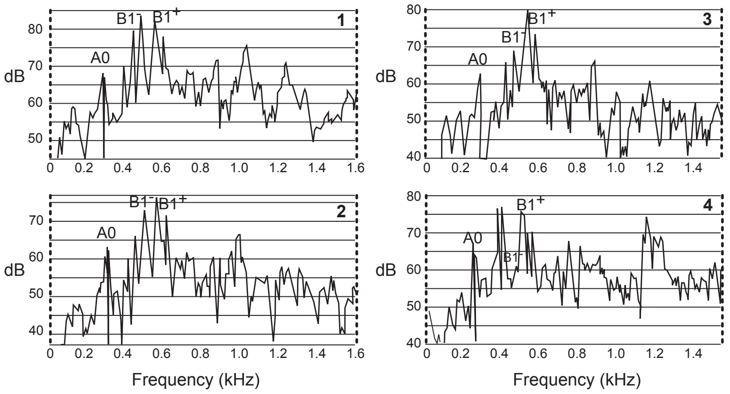

*Figure 2.* Tap response curves for violin No. 1 with soundpost set in the positions shown.

1. Soundpost 61.3 Kg/s at 5/15
2. Soundpost 110.6 Kg/s at 5/20
3. Soundpost 81.2 Kg/s at 5/25
4. No soundpost