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The Bridge Curve

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Editor's Note: The references are to the author's file of Procedures and Diagrams. Readers desiring further information should contact the author.

INTRODUCTION

The upper curve or arch of the bridge is one of the most critical features in the setup of a violin. The radius, height, tilt and the displacement of the strings greatly affects the action of the bow as it passes over the strings.

The purpose of this procedure is to present a standard model for the string layout and then proceed to evaluate the effects of these settings. Two special gages are presented which are of practical use in the calibration of the bridge.

THE MODEL

In order to begin we must present the parameters upon which the analysis will be based. The computer model shown in figure 1 is based upon the following nominal settings:

- Radius: 40 mm
- Spacing: 11.5 mm between strings
- G Tilt above E: 1.25 mm
- E dia.: .010"
- A dia.: .027"
- D dia.: .034"
- G dia.: .032"
- Instrument Arch Height: 16 mm
- Bridge Height: 34 mm

The strings are embedded one half of their diameter into the bridge grooves. The model can easily be adjusted; however, we will presently concern ourselves with the standard settings only.

STRING DIFFERENTIAL

This is the essential dimension in the bridge layout and must be understood before proceeding. The string differential (also known as string clearance or string rise) is defined as: *"The average difference in height between the bowed string and the two adjacent strings."* Referring to figure 1, we see the bridge viewed from the nut end of the instrument. If the bow hair (line a-b) is placed on the A string at point g, a clearance is produced between the bow and the E and D strings, lines c-d and e-f. This clearance is however variable and difficult to measure. We achieve the same differential if we draw a line across the E and D strings and observe the rise of the A string, line g-h. The important difference here is that we now have the *average* differential which can more easily be measured. The differential of the D string is similarly measured by placing a line at points g and j,

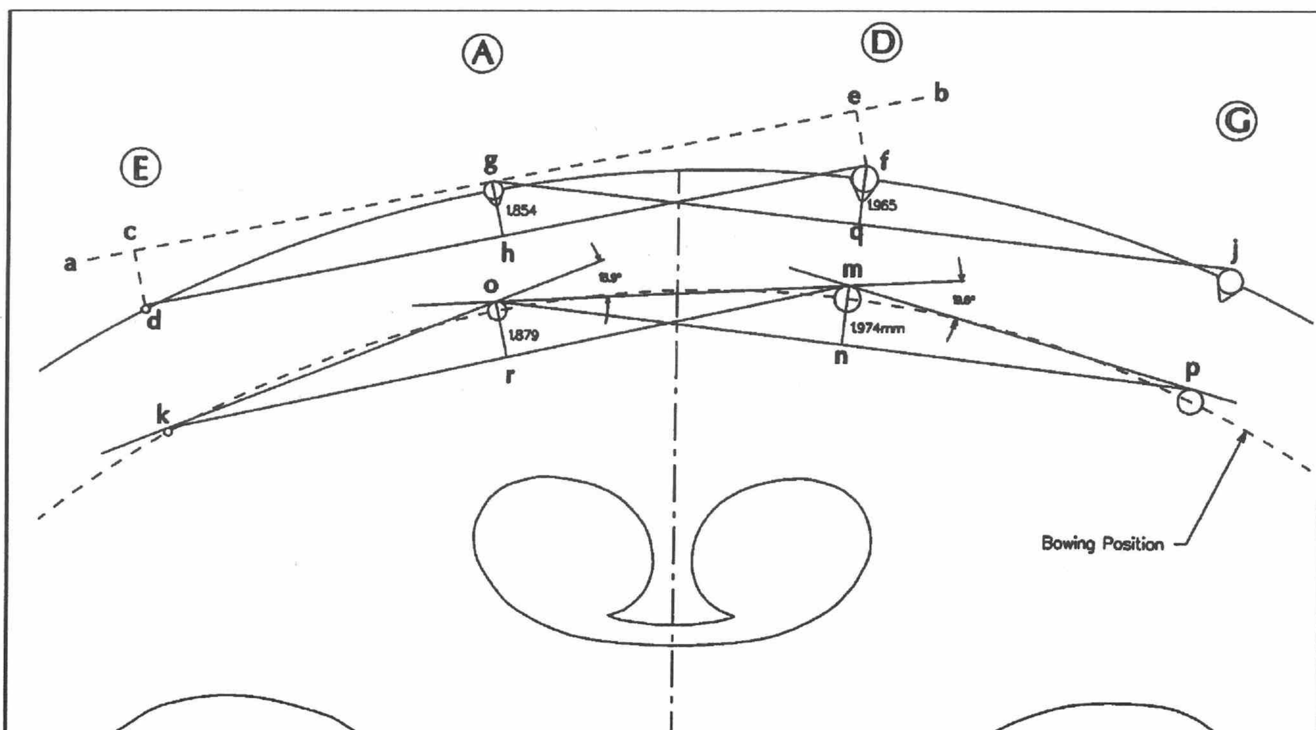

Figure 1. The arch geometry. The upper arch is the actual bridge curve with string relations to it. The lower diagram represents the bowing position which is 32 millimeters in front of the bridge. This is the area which actually affects bowing. The forward dashed arch is not an actual feature, but is shown to clarify the relationships between the various components.

and then measuring the distance f-q. These measurements are 1.854 mm and 1.965 mm respectively, very close to the 2 mm clearance encountered in practice. Thus far, we have been discussing the features and measurements at the bridge itself. Unless we are playing *sul ponticello,* these measurements are not those for general playing. The lower diagram represents the actual *bowing position.* It is presented 32 mm in front of the bridge. The effective arch radius, shown dotted, is reduced to 35.5 mm and the string spacing has been reduced to 10.6 mm. The important thing is that the string differentials, o-r and m-n, have actually *risen* slightly to 1.879 mm and 1.974 mm respectively.

Thus far our discussion has related to an idealized computer model and none of the many lines shown are real. Fortunately, the measurement of the string differential has been reduced to practice in the form of the *String Differential Gage* shown in figure 2. All of the developed dimensions presented herein have been verified on actual instruments using this gage. A detailed discussion of its design and use is discussed elsewhere.

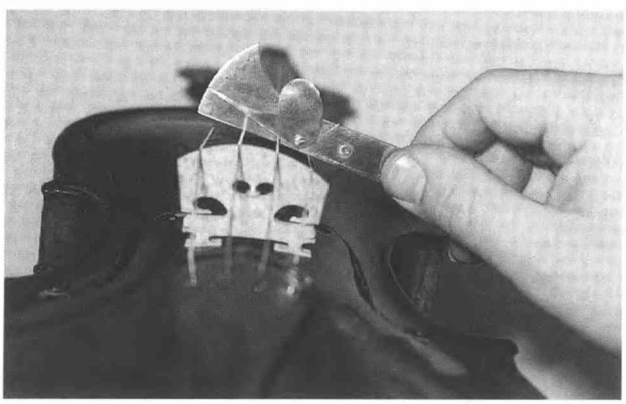

Figure 2. The String Differential Gage (Dwg 545) is a simple mechanical amplifier used to measure the actual string heights. Bowing articulation is directly related to this dimension.

THE ANGULAR DIFFERENTIAL

The previous discussion relates to the obvious and easily measured string clearance, which is apparent to all players. However, another feature, angular displacement is of equal importance, but is not as readily apparent. The Angular Displacement in its simple form is defined as: *"The angular displacement produced by the movement of the bow from one open double stop to another."* Observe in figure 1 that if the bow is placed across the G and D strings at the bowing position (line m-p) and then moved to the A and D strings (line o-m), an angular movement of 19.6 degrees is produced. Similarly, if the bow is moved from the A-D double stop to the E-A double stop, an angular movement of 18.9 degrees is produced. If uniform articulation of the bow is to be achieved, especially in arpeggiation, it is important that these angles be as nearly identical as possible. The displacement of approximately 19° produced by the model is the correct amount of excursion as demonstrated in practice. This produces a total excursion of 38°, which in practical terms, produces a total arm excursion of around 16 inches (406 mm). To verify this, simply arpeggiate the four strings using the upper portion of the bow. This will cause the frog end to travel a distance of 16 inches (406 mm) plus some slight overshoot, depending upon velocity. This, of course, is directly affected by the string differential. If the differential exceeds 2 mm, the angular excursion of the bow will become greater and more difficult. If it is less than 2 mm, it becomes less but faster. The 2 mm differential with a 19° angle is the desired configuration for the classical player. Players of folk music and possibly baroque players who play mainly in the lower positions, usually prefer a lower differential of 1.5 mm or even less in order to achieve a faster string crossing. This is made possible by the fact that the differential is only slightly reduced at the bowing position by the depression of the strings in the lower positions.

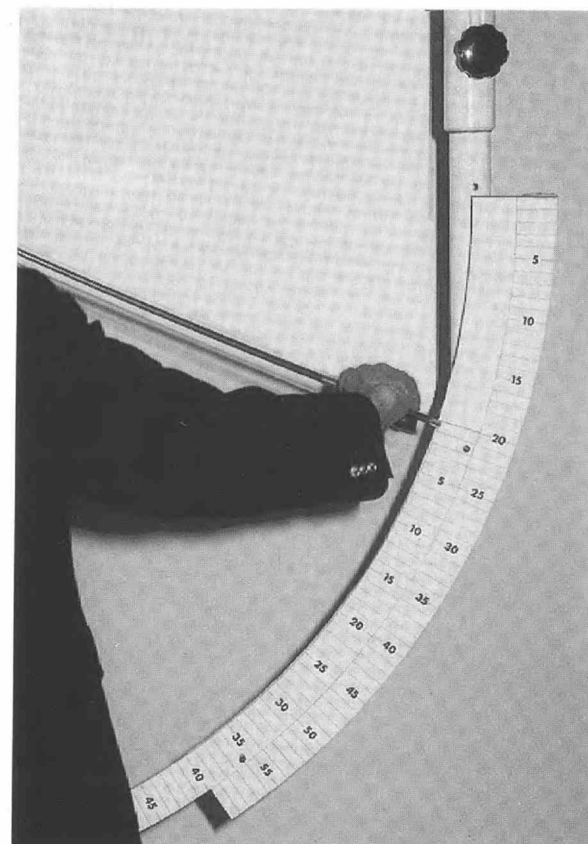

Figure 3. The Inclinometer, a device to measure bow movement as related to bridge curvature. The inner cursor is offset by the amount of tilt, in the playing position, of the particular violin under evaluation. It is shown here at about 20 degrees.

A considerably more sophisticated method of measuring angular displacement has been devised in the form of an instrument called the *Inclinometer* which is shown in figure 3. It consists of two calibrated arcs with radii equal to the length of the bow. The player stands facing the gage and positions himself until the fully-

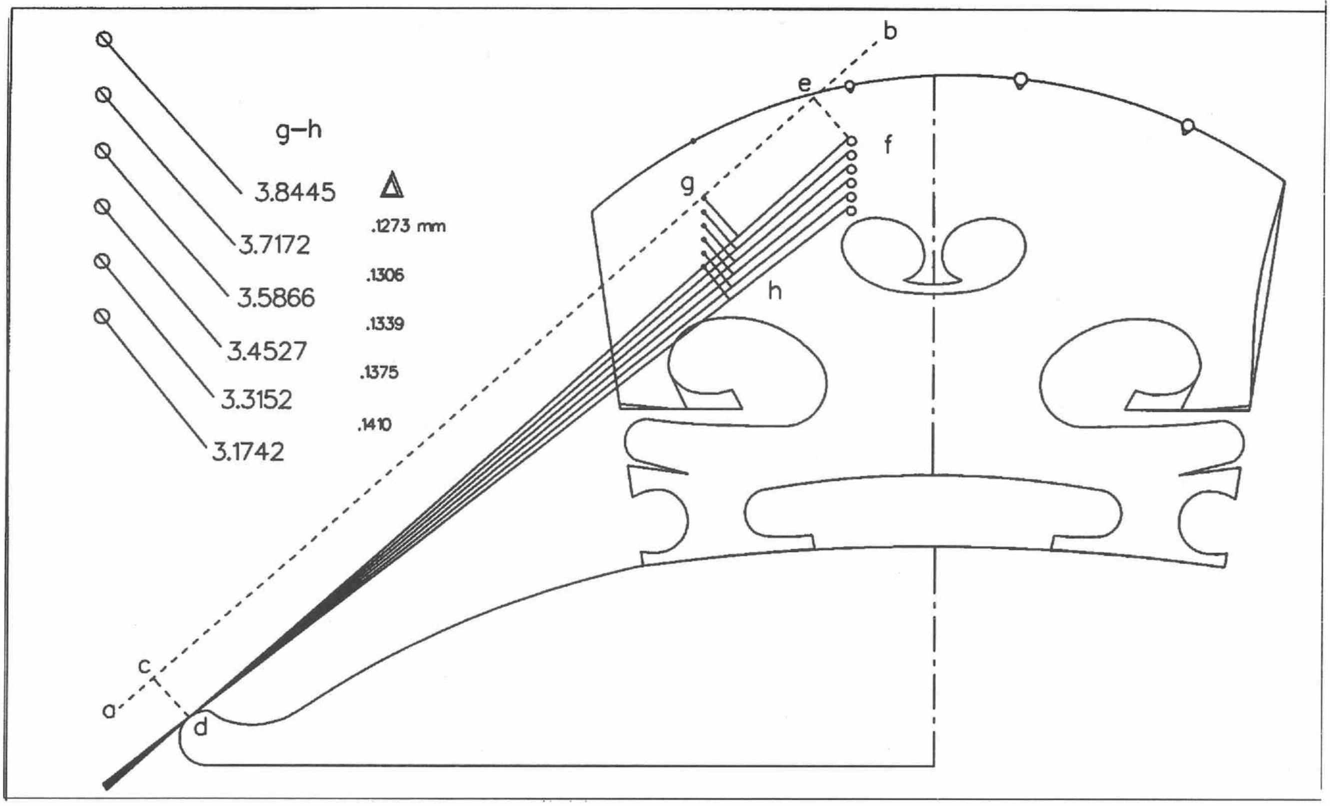

Figure 4. The effect of changing the bridge height upon the C bout clearance. Each millimeter of bridge height change causes an increase or decrease of approximately one-eighth of a millimeter in C bout clearance.

extended bow just reaches the gage. The device is adjusted to suit the height of the player by means of the knob shown in the upper right of the illustration. A tremolo is bowed at the tip on the open D and G strings. The button of the frog will strike an average position on the gage after some acclimation. The inner cursor is moved to this position and locked. This establishes *the tilt of the violin.* This position is largely determined by the shoulder rest used by the player as well as by habit. The illustration shows the instrument tilt set at 20 degrees, which is fairly normal. Now the A and D strings are similarly bowed. If the bridge is calibrated correctly, the button should point to the 19 degree position on the scale. Likewise, when the E and A strings are bowed, the button should point to 38 degrees, confirming the bridge calibration. These are essentially static measurements. There is some overshoot when all strings are arpeggiated. The amount will depend upon velocity, but it usually does not exceed 5 degrees.

THE C BOUT CLEARANCE

This area of discussion is reserved for last, since an understanding of the foregoing material is essential in order to move ahead into this rather complex, but nevertheless extremely important area of bridge geometry. Having discussed the top surface of the bridge in figure 1, we will now move back and observe the bridge in relation to the violin body as shown in figure 4. The dotted line represents the bow passing over the E string. The average clearance between the bow hair, and the C bout and the A string is represented by the lines c-d and e-f. Since this average condition is virtually impossible to achieve, the clearance is measured using the string differential gage. The gage is placed on the C bout and the A string at the bowing position as shown in figure 5. The E string rises to produce the dimension g-h which is, in fact, the average of c-d and e-f. The C bout clearance is thus defined as: *The average height of the E string above the C bout and the A string.*

This clearance is quite independent of the *curvature* of the bridge, but is related to its height and tilt, as well as to the width and arch of the instrument. This clearance is of fundamental importance in bowing of the instrument. It is my experience in testing thousands of instruments that this clearance must be a *minimum of*

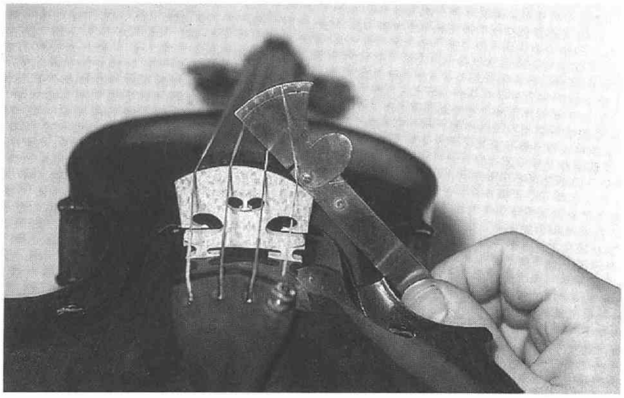

Figure 5. The String Differential Gage used to measure the C bout clearance. This clearance must not be less than 3 millimeters. Interestingly, this clearance is the same on the cello!

three millimeters. Even slightly less will produce bowing difficulties as evidenced by wear damage to the edge of the C bout. It is rather surprising to note that this clearance is exactly the same on the viola and the cello! (It is however about seven millimeters on the bass.) The tolerance is rather small since it seldom rises above four millimeters.

THE BRIDGE HEIGHT

The height of the bridge is dictated by the height of the fingerboard. If the fingerboard is low, the bridge must be cut correspondingly low in order to achieve proper string action. The minimum tolerable fingerboard height is determined by the C bout clearance. If the C bout clearance falls below three millimeters, some corrective measures must be taken. The most obvious is to reset the neck if this is indeed the fault. The question is: how much correction is needed to achieve a given C bout clearance? Figure 4 presents a diagram in which we will analyze the effect of raising the bridge height in increments of one millimeter, and then observe the resulting changes in C bout clearances.

In the model shown, placing the string gage upon the C bout and the A string (line c-d), produces a clearance of 3.845 mm (line g-h) when the bridge is in the highest position. If the bridge height is dropped uniformly by one millimeter, the C bout clearance is reduced to 3.717 mm, a difference of .127 mm. As can be seen in the diagram and the table, each millimeter decrease in height of the bridge, produces a decrease in C bout clearance of between .127 and .141 mm, or slightly more than one-eighth of a millimeter. Note that the changes in bridge height are made at the bridge itself, since that is where the changes would be made, but that the measurement of the clearances are taken at the playing position as shown in the diagram. The diagram also makes clear that these relationships are affected not by the bridge height alone, but by the arch height and the width of the C bout of the particular instrument.

THE BRIDGE TILT

Figure 6 illustrates the effect of bridge tilt upon the C bout clearance. In this model, the E string height remains fixed, while the G string side of the bridge is raised in increments of 1 millimeter or approximately 8.1 degrees. This condition would normally be caused by a tilted fingerboard or by a distortion in the belly of the instrument. Again, all measurements are taken with the string differential gage at the bowing position. It is important to observe from the diagram and the included table, that for each millimeter of bridge *tilt*, the C bout clearance is changed by over a quarter of a millimeter; twice as much as was effected by a uniform *height* change in the previous discussion. The implication of this effect is that it may be used judiciously to increase C bout clearance as an alternative to resetting the neck or other more radical procedures. The most common cause of excessive bridge tilt is tilt of the fingerboard. The obvi-

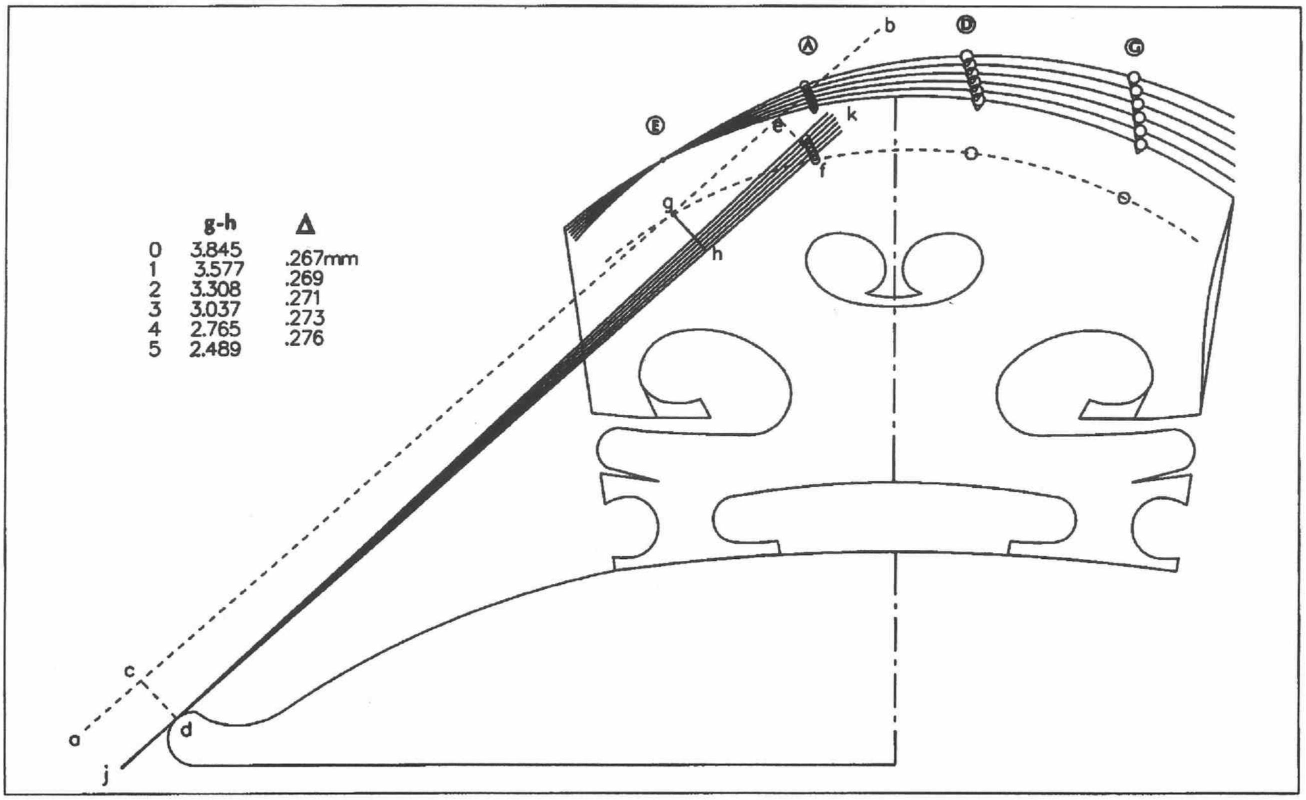

Figure 6. The effect of changing the bridge tilt upon the C bout clearance. The E string height remains fixed. For each millimeter of height change of the G string, the C bout clearance changes more than one quarter of a millimeter; twice as much as when the bridge is uniformly raised or lowered. The vectors g-h shown are as measured with the string differential gage.

ous cure is planing of the fingerboard to drop the bass side. As an example, assume that the tilt of the bridge is at position 4 in the model. This could produce an insufficient C bout clearance of 2.77 mm. By lowering the G side of the bridge by one millimeter, the C bout clearance would be increased to an acceptable 3.04 mm. The actual measurement of the bridge tilt as well as fingerboard alignment and tilt relating to this area is accomplished with an instrument known as the *Orthometer.* The use of this instrument is fully explained in the related procedures shown below.

SUMMARY

This discussion, limited to the upper surface of the bridge and its effects on string and C bout clearance only, is summarized as follows:

- The string differential is 2 mm for the violin, 2.2 mm for the viola, 3 mm for the cello, and 4 mm for the bass.
- The angular differential is 19 degrees per open double stop for the violin. This produces a total bow excursion of about 16 inches at the frog.
- The minimum C bout clearance is 3 mm for the violin, viola and cello, and 7 mm for the bass.

REFERENCED TOOLS

- The String Differential Gage No. 543
- Bass Differential Gage No. 639
- The Inclinometer No. 662
- The Orthometer No. 585
- The Cello Orthometer No. 586
- The Bass Orthometer No. 587

RELATED PROCEDURES

- Carving of the Bridge Proc. 116-3
- Planing the Fingerboard Proc. 104-1
- The Orthometer–Aligning the Neck, Fingerboard and Bridge Proc. 106-3