Chapter 6 Arching and Thickness of the Plates

The next decision for the viola maker, once decisions regarding the outline, including length of the body, string length, the widths, lengths and shape of bouts, and heights of the ribs is a decision how high the arching should be for the back plate and the top plate. The subject of arching in violas should be given much greater attention. It is believed that Stradivari and del Gesu's success for their violins was in part due to the relatively low arching, compared, for example, with Jacob Stainer. One cannot however assume the same would be true for the viola. We are dealing with arching of the top plate. Although there are differences in the height and shape of arching for the back plate, it makes sense to first focus on arching of the top plate. The subject of arching might be divided into height of arching, the longitudinal profile, and the cross-sectional shape of the plate. We have already referred to the significant differences between the arching of the two earliest Cremonese violas, the 1615 contralto viola which had a higher and more prolonged top plate arching compared to the 1620 contralto viola. We have also noted the differences between the two Andrea Guarneri contralto violas most commonly used by makers during the past twenty years or so, the 1676 Conte Vitale Guarneri viola having a higher and more sustained arching than the 1697 Primrose viola. The cut down Brothers Amati tenor violas in use today might be examined for the shape of their arching. For example, on p 14 of *The Secrets of Stradivari* by Sacconi, there is a cut down Andrea Amati tenor viola showing not only a higher arching than found in the 1615 and 1620 Brothers Amati violas but an arching that extends to nearly the ends of the top plate. Stradivari's violas, from 1690 to 1734 show some variability in the height of arching of the top plate, such as that observed in the two Brothers Amati contralto violas. None show a height greater than 19 mm and none have a plateau extending to nearly the ends of the plate.

I have, in Chapter 4 and elsewhere discussed the arching of the 1739 Camillus Camilli viola, which was not only higher but whose arching extended to nearly the ends of the upper plate. The front table of the 1739 Camillus Camilli viola stays high almost to the both ends of the plate. Whether this was intentional on the part of the maker, or a consequence of this viola having been cut down, remains to be determined. The Carlo G. Testore 1710 viola also had a similar front as well as the 15 ¾ inch Testore viola played by Hsin-Yun Huang at the Montreal Viola Congress. I have made all my top plates the same way, i.e. the top plate remaining high as close to both ends as possible. This is very different from the arching of a Stradivari viola found in Sacconi's *Secrets of Stradivari*, pp 76 and 82. The arching of the Testore violas was not as high as the Camilli viola. The arching of my violas based on the Nicola Bergonzi viola extend to the ends of the top plate, but are not as high as my violas based on the Camillus Camilli model (see Appendix C). The Camilli viola may have been cut down as suggested to the writers who described this viola in the February, 2003 issue of the Strad. Study of the large Brescian violas, including those later cut down should be made to determine the longitudinal shape of the top plate in the best sounding violas played in solo works by great artists today.

The cross-sectional arching profiles of the above violas should also be studied in detail. The practice of hollowing or shaping the arching from the edge should be studied. I do not believe this practice makes sense for the viola. For violins, Stradivari is noted to come straight out from the purfling. Stradivari's violas, from 1690 to 1734 show some variability in the height of arching of the top plate, however none are higher than 19 mm. and there appears to be the same method of coming straight out from the purfling. The arching of the Brescian violas might be instructive for makers. For example, the arching of the top plate in the smallest da Salo viola, the Kieveman viola, is high (about 21 mm). The cross-sectional arching of this viola is not hollowed out or straight, but follows a more natural curve, which some makers refer to as a "Brescian arching".

It should be apparent to all violinmakers that it would not be wise to use the graduations provided in posters, other publications, or measurements of other violas to decide on the thickness of top plates. Sacconi provided guidelines for the thickness of the top plates of contralto violas (as well as back plates) in his magnificent work, *The Secrets of Stradivari,* p 72 as follows: 2.4 mm. all over, except 2.8 adjacent to the ff holes.

I have kept a careful record of the top plates of all the violins, violas and cellos I have made to date. The rationale I have followed was to note those instruments and the wood used, which sounded best and then using the record as a guide to the next instrument made. The weight of the near finished plate could then be compared with the example producing the best sound, and adjusted accordingly.

For the past 10 years I have used only three different logs, all Englemann spruce, for the production of top plates, almost all for cellos. I used top plates from these same three logs for the violas I made since attending the 2002 Viola Congress. All top plates were purchased from John Tepper, Shady Cove, Oregon. Average measurements for each of the top plates of my most recently completed violas are as follows:

1. Log CS-6 Top plate, 2.75 mm. sound post side, 2.73 mm. bass bar side: Center 3.7 mm. sound post side, 3.53 mm. bass bar side.
2. Log L-7 Top plate, 2.5 mm. for sound post side, 2.35 mm. bass bar side: Center bouts 3.3 mm. for sound post side, 3.25 mm. bass bar side side.
3. Log RB Top plate 2.47 mm. sound post side, 2.45 mm. other side: Center 3.0 mm. sound post side, 3.0 mm. bass bar side.

One may notice that the thickness of the top plate for CS-6 was greater than the other two plates, from logs L-7 and RB.

The reason for this is that plates from log CS-6 were very different, and very consistently different, from plates from the other two logs.

How does one determine the characteristics of the wood used for top plates? Not by simply looking at the wood and the grain of the wood. For example I recently sent samples of wood from two different logs, 1 and 2, (also from John Tepper, Shady Cove, Oregon) which looked almost alike. Each was almost white in color, had very fine straight grain, and no defects or blemishes. Both would be considered very nice wood for violins and violas.

Testing showed markedly different properties, including a density of .483 gm/cc. for # 1 log compared to a density of .398 gm/cc. for # 2 log. Log # 2 not only had an acceptable specific gravity but satisfactory measures on longitudinal and cross sectional stiffness.

Many makers today measure the density of the wood they use today. You can determine the density of top wood by cutting a sample of wood and measure exactly (using the metric system) the length, width and height to determine the volume of the specimen. The sample is then weighed accurately and density determined by grams/ cubic centimeter (cc).

The specific gravity of wood from samples I had sent to Charles Woods, a retired engineer and violinmaker from Ridgecrest, California who tested the samples are as follows:

1. CS-6 .350 gm/cc.
2. L-7 .395 gm/cc.
3. RB .395 gm/cc.

One can see that the density of the plate from log CS-6 is much lower than the L-7 and RB wood. In other words CS-6 wood is much lighter wood. I had used many top plates from this log for cellos with excellent results, however I graduated the plates thicker. If the weight of the near finished plate were a little higher, more wood was removed for final graduation .

There may be other properties of violin top wood, which are as important as density, or even more important such as stiffness of the wood. From Charles Woods (*Wood Testing*, in the June 1996 *Bulletin of the Southern California Violin Makers*):

As an engineer I am more comfortable when I can assign numbers to things rather than guess and go by trial and error. --- I have been making simple tests on all of the wood I have used since I started making in 1987 and have accumulated a lot of data that helps me sort out the good wood from the bad. --- One of the most important measurements that you can make to avoid a poor instrument is to measure the cross grain stiffness relative to the longitudinal stiffness of the spruce top. This can be done by making test samples from the wood billet before carving or bending the plate. My experience has been that spruce with a stiffness ratio of greater than 30 to 1 (longitudinal stiffness 30 times stiffer than across the grain) will result in plates that will not tune very well. If you tune your plates using glitter patterns with a sound generator, you will find that this wood will have a low mode 2 frequency and mode 5 will be distorted. Above 50 to 1 ratio, mode 5 may not even be recognizable. I had to scrap a cello top that had a ratio of 51 because it performed so poorly. A top with a ratio of 27 made a tremendous difference. I would have not wasted my time on the first one if I had heeded my own advice! Excellent spruce will have a stiffness ratio of 15 or less. I had a piece of red spruce that measured 11.

A description of the process of wood testing then follows. Briefly, samples of wood taken from the top plate include a sample cut the length of the plate, 170 mm. long, 25 mm. wide, and 2 mm. thick; and a sample cut across the plate (and grain), length 110 mm., width 25 mm. and thickness 4 mm.

The samples are then suspended between two blocks, 160 mm. and 100 mm. apart for testing the longitudinal and cross-sectional specimens. Calibrated weights are applied to the top, at the middle of the specimen until a deflection of 2 mm. is obtained. Alternately, you could use the same weight on each beam and measure accurately (with a dial indicator) the amount of deflection. I am not trained as an engineer and will not present the formulas for calculating the modulus of elasticity or other results he provides (Speed of sound, Radiation Ratio and Quality factor) in addition to density, longitudinal and cross-sectional stiffness, with the stiffness ratio (longitudinal stiffness/ cross-sectional stiffness).

I hope the above excerpts from Charles Woods' paper, which may not be easily accessed by the reader, may help to understand the differences between logs CS-6, L-7, and RB regarding properties other than the density, which was provided above.

The longitudinal and cross sectional stiffness (Modulus of Elasticity) of plates from logs CS-6 and L-7 are as follows:

CS-6 Longitudinal 108, Crossectional 5.2 (both times 1000)
L-7 Longitudinal 132, Crossectional 6.8

As one can see the stiffness of log CS-6 is much less than that of log L-7. Yet both had the same stiffness ratio. The stiffness ratios of top wood from the three logs above were reported as follows:

CS-6 20.6
L-7 19.4
RB 11.8

One can readily see that the stiffness ratio is nearly the same for logs CS-6 and L -7. Also one can see that even though the density of wood from logs L-7 and RB are essentially the same the stiffness ratios are very different.

It is possible that the stiffness, especially cross-sectional stiffness as well as the ratio of longitudinal to cross-sectional stiffness may be a more important factor for plate graduation than density.

The characteristics of each of these logs had been determined by multiple measurements of samples taken over the years from these logs by Charles Woods, a retired engineer and violinmaker from Ridgecrest, CA. (see article *Wood Testing* in The *Bulletin of the Southern California Association of Violin Makers* Vol. 32, no. 6, June, 1996). He stated in one of his reports (July 12, 2003) that I received: *The L-7 log is such great wood that I haven't used anything else for a couple of years, and have made some really great sounding violins.* Woods (personal communication) told me he no longer needs to tune his plates in view of the consistency of results from using wood from the L-7 log and basing his thickness on previous records of top plates and weight of the finished plates. I have done the same for my cellos and violas.