Chapter 7

Graduation and Regraduation

For those readers not familiar with the terms “graduation” and “regraduation” this chapter will be helpful in gaining a better understanding of this aspect of the luthier’s art. It will also help in understanding some of the numbers in Chapter 8: Known Violins of Sol Roach.

In a nutshell, graduation is the thinning of the top and bottom plates of a violin so as to produce the optimum or desired sound. This process takes place before the instrument is assembled. Regraduation is similar but is done after a violin has been assembled, played, and found to be lacking and needing adjustment. The instrument is then disassembled, additional work done on the plates as needed, and reassembled.

When a luthier sets out to make the finest violin possible, long standing traditions dictate many parameters which he can follow, essentially fine tuning every aspect of the finished instrument for optimum response, tone quality, and power, not to mention the subtle characteristics that each individual instrument will take on. Exacting makers will tune every component of the instrument so that it is in acoustical harmony with itself. The maker can choose to do any or all of these things.

One of the most fundamental procedures in establishing the playing characteristics of a violin is the process of graduating the top and bottom plates of the instrument body. The sound vibrations set up by the strings are transferred through the bridge to the top plate. The sound post on the inside of the instrument contacts the top plate in the area under the right side of the bridge transferring the vibration to the bottom plate. The body of the instrument, comprised of the top and bottom plates and the ribs separating them, is then the means by which the sound is amplified and conveyed to the listener. Not only is the shape of the body important to its sound and response, but the thickness of these components and how that thickness is distributed on the plates is a major determinant in how successful the instrument will be. If the plates are made too thin the sound produced will be responsive but thin and hollow. If the plates are too thick the low range will suffer and the sound will be slow to develop.

Applicable definitions of the word “gradate” are: to shade into the next color, note or stage: to arrange in a progression, scale or series. Among the many meanings of the word “graduate” are: to change gradually, and arranged by degrees.

In a functional sense then, to graduate a violin is the process of thinning the rough cut plates according to some predetermined pattern creating a thickness distribution that will allow for optimum performance. On most violins the plates are generally thinner on the outside edges and gradually thicken toward the center. There are violins that have been made in reverse with thicker wood on the outside, thinning as it moves to the center. This is called reverse graduation. These operations are carried out on the interior sides of the plates.

Regraduation is much the same as graduation but involves taking an instrument that has already been graduated, disassembling it and revisiting the thickness distribution of the plates to achieve a better result.

Sol did a lot of regraduating work. He would take a less expensive mass produced violin that showed potential, disassemble it, and regraduate the plates creating an instrument that exhibited far better playing characteristics than its original cost would suggest.

Regraduation is a practice that is not universally accepted in the violin world. Violin professionals working in the upper levels of the field would feel that regraduating a fine instrument violates the integrity and intent of the artist who created it. To attempt to alter or try to improve an instrument would be to deface and destroy the instrument. Whether by thinning or removing wood, or by chemical treatment, those practices may only offer a temporary sense of improvement before their destructive effects begin to show. Over-thinning of top plates may offer only a temporary improvement in sound, lasting just long enough for the instrument to be sold for a higher price. Overly thinned plates structurally weaken the instrument and may lead to collapse. Wood, once removed, cannot be replaced with satisfactory result.

The argument by master luthiers against regraduation assumes that a violin, in its original condition, is a perfect representation of what its maker intended. They would view their own creations this way. They would probably not respond well to someone judging their labor of love as deficient and claiming to be able to make it better by tearing it apart and redoing their work. Therefore, they probably view their roll in regard to the work of masters of any era, as one of preservation and restoration of the original intent of the maker. This assumes that a maker wouldn't put out a product that wasn't the very best it could be.

A luthier has the right to judge his own work though. If he feels an improvement can be made he has the right to do that. If he feels the tone is not what he intended after the violin has been assembled he has the right to disassemble it and correct the deficiency. Sol Roach often did this, particularly with his earlier instruments. When this was done a notation was included on the tag inside the instrument.

Sol may have regraduated his own instruments due to changes in his own sense of tone and response. Having worked with it for years, his concepts were ever evolving. It may also represent new influences and associations. From the violins viewed, it appears that a lot of his regraduating of original instruments took place in the early 1920s. It is also apparent from his graduating codes that some manner of major conceptual change took place in 1924 with the addition of more dimensions to the codes. Unfortunately it is not possible to tell exactly where these dimensions are located on the plates without actually disassembling the instruments and measuring the plates with calipers.

The bulk of Sol's regraduation work was not carried out on his own instruments, nor was it done to the instruments of master luthiers. The instruments that have been located that bear Sol's tag, but were not made by him, show that his regraduation work focused on mass produced instruments of lesser quality. These instruments were not intended to be played by a violin virtuoso, but by ordinary people making music for entertainment in the home. Factories in Europe were turning out instruments as fast as they could to satisfy the home music market that had developed in the United States prior to the turn of the 20th Century. These were inexpensive functional instruments, but instruments that had no

need of fine adjustment because the intended end-user would probably never achieve a performance level where they would know the difference. If they did, they could upgrade to a better instrument. Instruments that were under graduated or had thick enough plates could be made better by completing the graduating work that wasn't deemed necessary to satisfy the intended user of the original, and at a price that offered mass affordability.

What can we discover about Sol's graduation methods?

At some point after 1909 Sol began to consistently put a graduation code on his maker's tags. One of the 1903 instruments has the code, but the 1900, the other 1903s, 1907, and three 1909s do not. Of the known violins, a 1911 is the beginning of consistent graduation coding. This may be misleading though, as the original tag was mostly covered over by pictures of two of his grandchildren when the violin was regraduated in 1922. The code was written on a new tag under the right "F" hole that showed the date of regraduation. The original tag may show no code. However, a 1912 that was not regraduated also has the code on its tag. The new tag in the 1911 is probably a copy of what is on the original tag under the pictures with the addition of "Regraduation." Instruments that followed these all contain the code.

The code that Sol used was comprised of a letter to indicate the top or bottom plate followed by a series of numbers (T. 5-6-7 B. 7 X 3/16). Up until 1924 the code for the top plate of an original violin would have three numbers and the bottom plate two. Regraduated commercial violins may have only a two number top plate code. Beginning in 1924 there is seen the addition of a 4^{th} number to the top plate code and a 3^{rd} and sometimes a 4^{th} number to the bottom plate. A 1928 original contains a by-then standard four-number top plate code, but a bottom plate code of five numbers.

The meaning of the code numbers is indirectly revealed by Sol in his 1907 violin and confirmed by the 1911. When being put into playing condition both of these instruments had to be opened in order to properly reset their top plates. The 1907 does not show a code on its tag but has the thickness dimensions clearly marked in pencil on the wood itself. They appear to be the original marks from when it was first graduated. The dimensions on the top plate are 6/64" around the perimeter of the lower, middle, and upper bouts. (A "bout" is the technical term for each of the three distinct areas of violin body shape. Other descriptive terms could be lower lobe, waist or "C" section, and upper lobe.) The fraction 7/64" appears in an elongated oval area beginning just below the "F" holes and running between them to about halfway through the upper bout. In his commentary inside the violin he says that in regraduating it in 1914 he thinned the area around the lower bout to 5/64".

The 1911 violin also shows penciled dimensions on its top plate. They read as the regraduated 1907 violin would read, 5/64" around the lower bout, 6/64" around the middle and upper bouts, and in this case 1/8" in the center oval. One eighth of an inch being only 1/64" larger than 7/64". On the tag the code reads T. 5-6-1/8, corresponding to the top numbers of the fractions shown in pencil on the plate. Numbers are not visible on the bottom plate but are shown on the tag. It then appears that the single numbers are assumed to be the numerator of a fraction with a denominator of 64 unless otherwise noted with a complete fraction like 1/8. The bottom plate code of B. 7 X 3/16 would mean 7/64" X 3/16" with the smaller dimension on the outside.

The 1907 and 1911 violins show the placement of the numbers on the plate so their distribution, or at least starting point, is known. It must be assumed that the plate thickness gradually blends from the thinner outer edge into the thicker center. However, since there is no record of the inside of a 1924 or later violin where Sol begins using four and five numbers in his code, it is not possible to determine what the distribution might have been or what influenced him to add these dimensions. Is the distribution approach the same as the three number layout, or has he adopted something similar to a classic graduation pattern?

How do Sol's dimensions correspond to known classic dimensions?

Based on what we know about Sol's graduation code, the following table shows all of the various dimensions used in Roach violins as taken from the maker's tags inside the violins. They are also shown converted to decimals and millimeters.

64ths	**Decimal**	**Millimeters**
5/64	*.078125*	*1.98438*
5.5/64	*.08593*	*2.18282*
6/64	*.09375*	*2.38125*
7/64	*.109375*	*2.77813*
8/64 or 1/8	*.125000*	*3.17501*
9/64	*.140625*	*3.57188*
11/64	*.171875*	*4.36563*
12/64 or 3/16	*.1875*	*4.76251*
13/64	*.203125*	*5.15939*

From Makers Tags of Known Violins

1903	(?)-5 X 9	B. 6 X 3/16 inside 4588	
1907	T. 5-6-7	B. --------- (not on tag but marked on wood)	
1911	T. 5-6-1/8	B. 7 X 3/16	
1912	T. 5.5-6-8	B. 7 X 13/64	
1912	T.5-6-8	B. 8 X 3/16	
1914	1/8 X 5/16 (only numbers on tag)		
1919	T (?) 5 X 7 ¼	B. 7 X 3/16	bass bar: 9 X 10 6/x
1920	not viewed		
1924	T. 5-6-7-8	B. 6-7-3/16	
1924	T. 5-6-7-8	B. 6-7-8-11	
1924	T. 5-6-7-8	B. 6 X 3/16	
1924	T. 5.5-6-7-8	B. 6-7-8-12	
1924	T. 5-6-7-8	B. 7-8-12	
1925	T. 5-6-7-8 6-7-9	B. 7-8-12	bass bar: 10 ½" long
1925	T. 5-6-7-8	B. 6-7-9	
1925	Tg-5-6-7-8 tag #1	B. 6-7-8=11 B. 6-7-8	
	T. 6.6-7-8 tag #2	B. 6-7-8-11	G. 5-6-7-8
1928	T. 5-6-7-8	B. 5-6-7-8-11	

The following table shows a comparison of dimensions for both top and bottom plates. The graduation plan and its dimensions used as a basis for comparison is a modified Stradivarius plan as presented by luthier David Langsather of Salem, Oregon on his internet website. Dimensions being compared to the Langsather plan are selected codes from the above table of Sol Roach dimensions. Again, it is not possible to know exactly where these Roach dimensions lie on the plates except for the 1911 instrument where they are plainly visible in pencil on the underside of the top plate. The accompanying drawings roughly show the areas represented by the dimensions in the Langsather plan. Decimals are in 1/1000^{ths} of an inch.

Top Plate

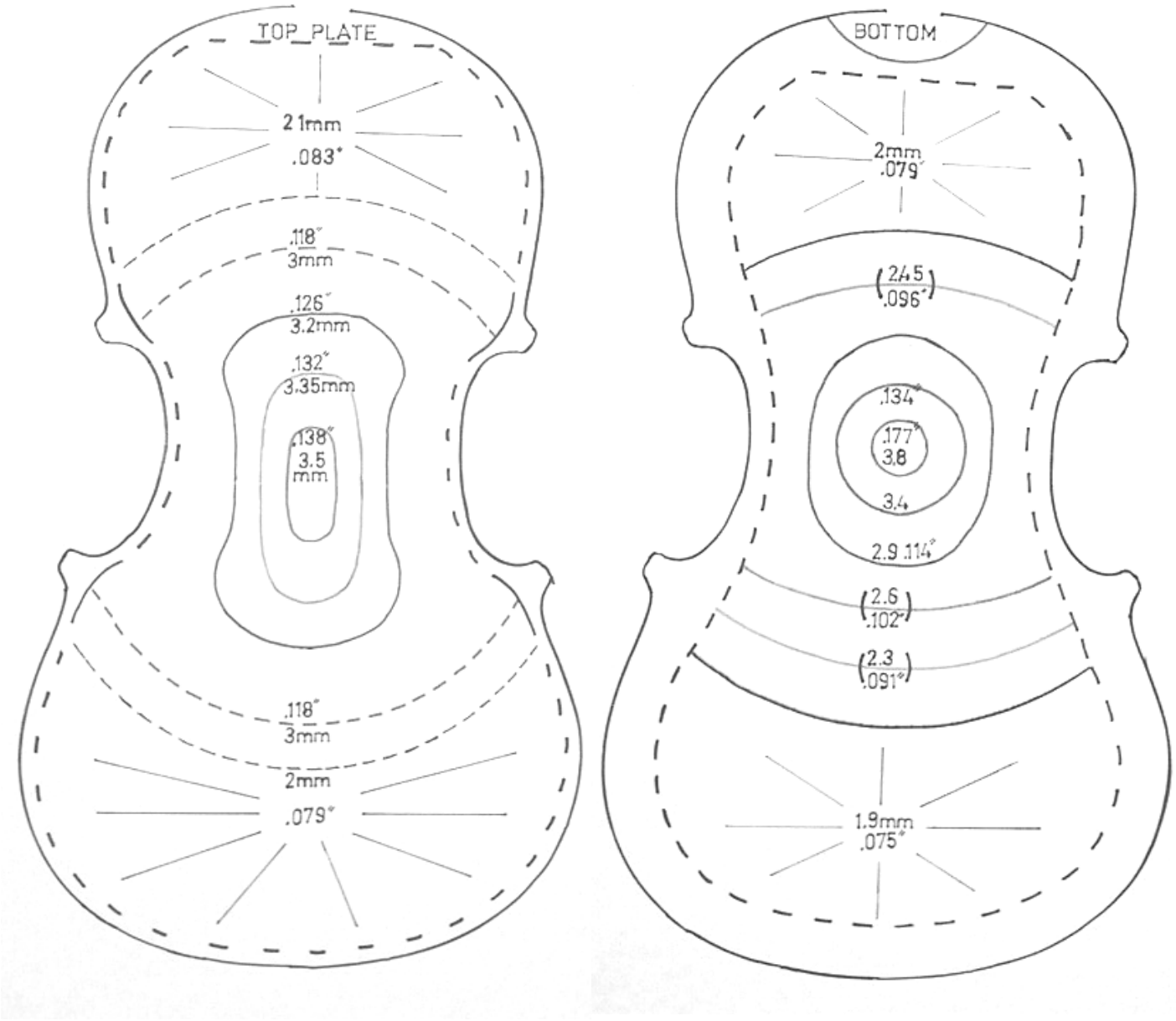
Outer	Bottom / Top				*Inner*
D.L.	.079 / .083	.118	.126	.132	.138
Roach					
1911	.078 / .093				.125
T. 5-6-1/8	5 6				1/8
1924	.078 / .093	.109			.125
T. 5-6-7-8	5 6	7			8
1925	.093	.109			.140
T. 6-7-9	6	7			9

Bottom Plate

Outer	Bottom	Top	Bottom	Top	Bottom	ring	ring	*Inner*
D.L.	.079 /	.075	.096 /	.091	.102	.114	.134	.172
Roach								
1911	.109							.187
B. 7 X 3/16	7							3/16
1924	.093		.109				.125	.187
B. 6-7-8-12	6		7				8	12
1928	.078		.093		.109		.125	.171
B. 5-6-7-8-11	5		6		7		8	11

Modified Stradivarius Plan

By David Langsather of Salem, Oregon



The above diagrams are only a general approximation of the Langsather templates for the purpose of showing the dimensions and the general areas they are found on the plates.

The issue of where a denoted thickness may lie on the wood of a plate when only a number is given in the code is frustrated by the many distribution possibilities that have been found in use through the years. In 2003 Jeff Loen of Kenmore, Washington made a presentation at the convention of the Violin Society of America in Baltimore, Maryland entitled "Thickness Graduation Mapping: Surprises and Discoveries." Based on the mapping of thickness graduation patterns of hundreds of fine Golden Aged (pre-1750) stringed instruments, Loen found that overall plate structures were classified as "uniform" (common on top plates), "concentric" (common on back plates and on some top plates), "longitudinal" (less commonly used on top and back plates), and "irregular." He also found that many Cremonese violins in demand by the best players were carved in reverse of the usual patterns.

The lack of numbers from the outside to the inside on the Roach 1911 example assumes that the thickness increases gradually to the center. A more thorough examination would require taking the violin apart and measuring at points corresponding to the areas on the Langsather plan. In the case of the top plate the location of the numbers is the same as his 1907, leading one to believe that all three-number top plate codes were handled the same way.

In the Roach 1924 top plate example, the location of the 7 is not known. Along with the addition of more code numbers in 1924, did he also begin using a more concentric distribution? In the Roach 1925 example it is not known whether the 6 belongs at the bottom of the plate and the 7 the top or whether the 6 represents the thickness around the entire perimeter. This particular 1925 shows so many numbers and variations of them on two tags that it's impossible to tell which numbers are the real numbers used in the instrument. I only used the 6-7-9 as a comparison because the 9 shows its thickness to be closer to the inner dimension in the David Langsather pattern.

By 1928 Sol is showing numbers on his bottom plate that correspond to the inner and outer dimensions with just a slightly different slope. Some dimensions differ by only one thousandth of an inch.

Plate Tuning Frequency

Another issue of concern to luthiers, in addition to plate thickness distribution, is plate frequency. Violin top and bottom plates are actually tuned to musical notes. The goal of the maker may be to achieve a particular pitch when the plate is struck in a certain way and then to make sure that this pitch is even across the entire plate. Since no piece of wood is the same, there may be variations in thickness that deviate from the graduation plan to achieve the desired uniformity of pitch.

To complicate this process the final pitch of the plates is not only affected by the physical aspect of their carving but by the varnish used to protect them, the ground system used to prepare the wood, if it is used, and the effects of ultra violet light on the wood. When all of the variables are accounted for, the frequencies of the plates as recommended by Langsather for his modified Stradivarius pattern is 322 Hz for the top plate and 353.5 Hz for the bottom plate. Translated to modern musical pitches the top plate would sound an F above middle C and the bottom plate a G. These pitches are approximate, as the difference, according to Langsather, should really be about ¾ of a whole step.

How does this relate to what we can determine about Sol's procedure? Johnstown, Pennsylvania technician Harold Wilson, who has worked on Roach violins still in the area, stated that he felt Sol tuned his plates to F#. Tapping the plates of my Roach 1911 produces an easily distinguishable F# for both the top and bottom plates. My Roach 1924 is different. Its top plate taps an F# while it's bottom plate taps a G#, the same basic intervallic relationship as the Langsather model.

Langsather states that in carving the plates the starting pitch must be different than the expected final pitch due to the effects of the varnish, ground system and ultra violet light. A ground system involves a process of wood preparation that seals the wood before finishing. A ground system affects pitch to the extent that the plates can actually be made thinner, making for a lighter weight instrument. Exposure of the wood to ultra violet light or sunlight will raise the pitch of the plates. Luthiers will hang the rough carved plates in the sun or place them in an ultra violet light box until they have stabilized before setting the final pitch. If this isn't done a finished instrument will change as it is exposed to light during normal playing, changing its playing properties.

It is not known if Sol Roach made a conscious decision to set his plate frequencies at F# or G# as opposed to F or G or whether they just ended up there as a result of ignorance of the effects of finishing systems or sunlight and time. The results that these differences make in the final product are probably more subjective than scientific. Langsather states that some frequencies produce more pleasing tones than others, but who is to say what is pleasing or not pleasing to a person.

It is not known whether Sol used a ground system on any of his instruments. It is known that in his earlier instruments he didn't, as the narrative in his 1907 violin outlines his finishing procedure as of 1914, of which he seemed very proud.