Symmetry

Luthier François Denis may have discovered the set of Cremonese masters worked. He explains his revolutionary

An old joke goes: how many violin makers does it take to change a light bulb? Three – one to get up on the chair to get the job done while the other two argue about how Stradivari would have done it.

François Denis used this story to introduce his presentation on the classic design of scrolls during the British Violin Making Association's seminar in Dartington in September 2001. It shows just how ready stringed instrument makers are to question their art.

Since the end of the classic period of the Cremona school around 1750, makers have tried to discover the secrets of the violins, violas and cellos that have remained the standard for sound and aesthetics for generations of musicians and makers. They have hunted for varnish formulas, treatment processes for wood, methods to determine the thickness of backs and tables – in short, there's not a step in the process for which makers have not sought ultimate answers.

François Denis is one of these seekers. For many years he has studied the enigmatic beginnings of instrument shapes and over the last three years has been presenting his research to his colleagues, becoming known through lectures on violin and scroll design at Cordes-sur-Ciel at Mirecourt and Dartington. Along with the workshops and conferences he has led, he is preparing a monograph on the subject to be published early in 2004. The remainder of his time is spent in his workshop in his hometown of Angers in the Loire Valley, where he makes quartet instruments.

A self-taught maker, Denis began his life's work in adolescence. 'I made my first instrument, a dulcimer, at 15 and I haven't stopped since, although the path has not been a straight one. After scientific studies in secondary school, I tried to get into the school at Mirecourt but they were only admitting very young apprentices at the time. So I studied biology at university while continuing to make all sorts of stringed instruments on the side. After a masters in genetics, I was still more interested in stringed instruments than anything else. So I simply set up shop and started making medieval instruments, viols and especially hurdy-gurdies, which brought me a certain success since folk music was in fashion at the time.'

Several years later, after double bass studies at the conservatory at Angers, he decided to concentrate on making quartet instruments only. It was then that

# of genius

mathematical principles within which the
thesis to **Patrick Robin**

he confronted the problem of being self-taught.

'There are two kinds of autodidacts – those who feel they have nothing to learn from others and those who feel they never know enough. The latter develop a complex over their inadequacy and seek relief in obsessive research. I belong to the second group and this has been one of the driving forces in my work as a maker. Being cut off from the tradition, though, the autodidact does have the benefit of a certain distance. Sometimes I feel like a man without a country facing nationalistic quarrels. When faced with doubt, makers have often sought refuge in traditional values – and not without a certain wisdom. But even if it is right to say that Stradivari would have done it this way, it is nevertheless annoying to accept the notion without any further explanation.'

Denis wanted to find new ways of determining how the early makers shaped their instruments. 'I delved into works on violin making and Simone F. Sacconi's book [The Secrets of Stradivari] was by far the most informative. Even this left unanswered questions, though. I wanted to know more about his understanding of geometry. Roger Hargrave's research on construction methods in Cremona was also a great inspiration for me. I liked his freedom of thought and his questioning of the tradition.

'At first, my approach was purely practical. I tried to develop a method of instrument making that was both quick and responsive and that achieved a stylistic result that would unite in a spontaneous rather than an intentional way what one observes in early instruments. The attraction of the great instruments from Cremona, though, lies in the feeling that freedom of execution was never taken so far that certain principles of conception were not adhered to. For contemporary makers and admirers of this school, the problem is establishing what those principles of conception were. Making copies of instruments allows a ▸

OPPOSITE a viola made by François Denis using proportional methods

ABOVE graduating a violin plate: Denis has made his own simple and versatile set of tools

Photos: left: Jeff Rabillon; right: Patrick Robin maker to get around the problem but doesn't resolve it, since the maker is basically expressing the freedom of others and not his own.'

So how can this problem be solved? 'I see the instrument as a witness to the gestures and methods that served in its making. Once this is assumed, what remains is to understand how an object's style relates to other variables. When a shape appears, it is a product of three variables: its memory of the gestures and methods that produced it; the materials that compose it; and lastly the mathematical calculation. Every functional object made is an attempt to optimise the combination of these variables.'

To better understand the making process, Denis has tried to duplicate the physical and economic environment of the early makers and to work under the same conditions they did. 'I have rethought my tools and developed simpler ones with multiple uses, ones that are easy to make and sharpen. Fewer tools take up less space and result in less moving around. I have carved scrolls without a gauge and even made an instrument by candlelight. Following Stradivari, I have learnt to use small templates for the corners, to glue ribs using string and linings using pins. Rather than seeking to innovate, I have been more interested in non-innovation. This approach is atypical: in today's society with its illusion of continual progress, this kind of approach is not well thought of. I am convinced, however, that it is valid.'

It is not only through practical experimentation, however, that Denis has explored the variables that he sees as the key to an instrument's conception. For nearly a decade he has become increasingly preoccupied with the final variable that determines an

'While taking nothing away from the personal inspiration of "del Gesù", it seemed clear to me that his freedom of expression existed within a space whose limits could only be understood within a system of thought difficult for us to grasp. A good analogy here is music: in jazz, an improvisation presumes the existence of a theme and can only be created in relation to rules of harmony. The most successful examples of both music and instrument making depend on combining compositional rules and interpretation. The difficulties posed by the decoding of the specific mathematical rules governing stringed instrument construction are what captivated me.'

But how do we find the original theme or the compositional rules when all we have are variations and improvisations? 'We are lucky to have violin moulds that give us

'I HAVE CARVED SCROLLS WITHOUT A GAUGE AND EVEN MADE AN INSTRUMENT BY CANDLELIGHT'

Denis has lectured on Cremonese scroll design at Mirecourt and Dartington

Photo: Jeff Rabillon

instrument's shape: the mathematical calculation. This quest has carried him well beyond the ordinary concerns of instrument making and into the fields of early mathematics and architecture.

Attending an exhibition of Guarneri 'del Gesù' violins in 1994, Denis was struck by the strong boundaries that seemed to govern the master's work. 'Even when "del Gesù" seemed to be improvising in the most casual manner, his results are most often incredibly coherent,' says Denis. 'Some choose to see in his work the expression of an exceptional sensitivity. If this were the case, his aesthetic achievement is nothing other than an instinctive response – but this is not the way I see it.

more useful information than the instruments themselves, so I began research focusing on these moulds. The basic principle of using geometry as an investigative tool is quite simple. The comparison of two measurements gives a number with which one can associate a geometric figure. These can be categorised. There are dozens of them. You can then find the right series of geometric figures to trace all types of shapes, the violin for example. But naturally, it is not as simple as that and things only become interesting when you try to build different models using a single method.

'Stradivari left us ten moulds that can be understood to be variations of a single model. I traced them out, geometrically, and then by various methods tried to find ▸

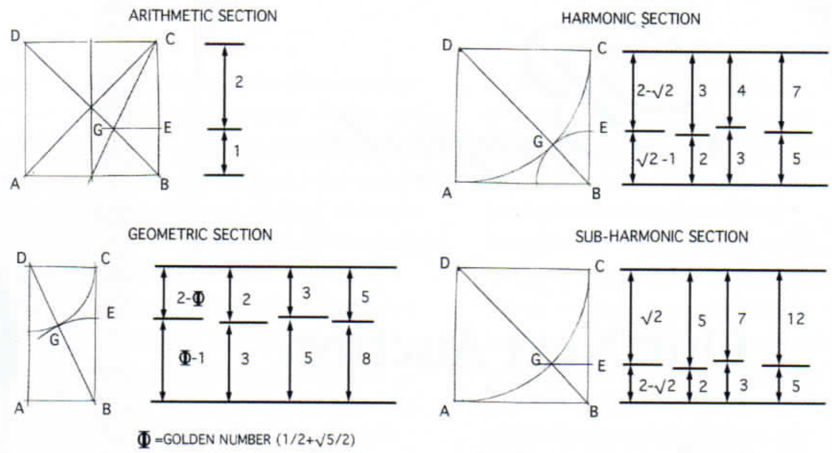

Figure 1 A proportional section is a specific mathematical relationship between three distances, where BC = BE+EC. There are four sections which can be constructed with a ruler and a compass starting from a square or a double square and a diagonal. Before the use of symbolic notation for irrational numbers (√2, √5), sections were expressed by numerical series called *analogia* by the ancient Greeks. This is the case for the ratios of the well-known Fibonacci series which approach the exact value of the geometric section: (1,1)(1,2)(2,3)(3,5)(5,8)(8,13)... so that 3/5 = 0.6; 5/8 = 0.625; 8/13 = 0,615 ≈ 0.618...(√5/2 -1/2). The first four ratios in the harmonic section (1,1)(1,2)(2,3)(3,4)... correspond to consonance in music and we find that 2/5 = 0.400; 3/7 = 0.428; 5/12 = 0.416 ≈ 0.414...(√2-1).

'THE THEORY BEHIND THE NOTION OF SECTIONS IS ALIEN TO MODERN IDEAS OF MATHEMATICS, SO THERE IS A DEEPER CULTURAL PROBLEM'

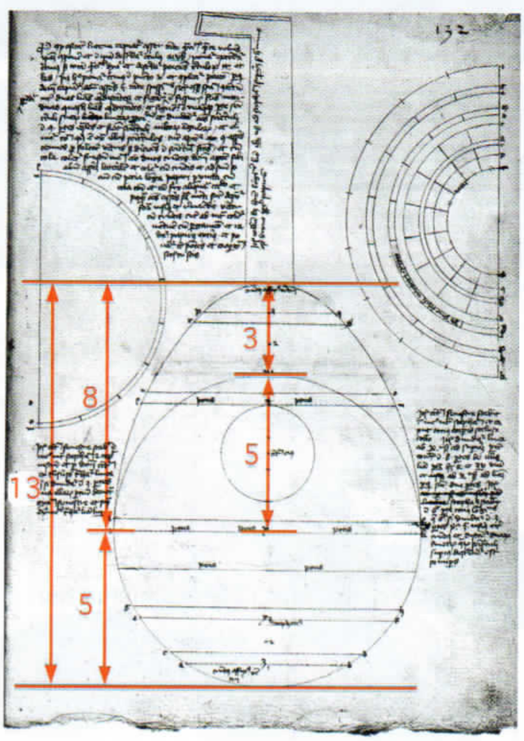

Figure 2 The drawing of Zwolle's lute makes abundant use of *analogia* as defined in figure 1. The form can be seen as derived from either a harmonic section (2/3; 3/4; 5/7) or a geometric section (2/3; 3/5; 5/8; 8/13). In the middle ages this type of drawing was called an *exempla* – a representation drawn from a body of knowledge that could lead to multiple variations.

the elements they had in common. The goal was a limited one. I was trying to find at least one geometric construction that was common to all of them – but I came up empty-handed. I had worked at it so much that I knew the numbers and the associated geometric figures by heart and I could work things out in my head without a compass. I've never worked so hard in my life – my mind was filled with hundreds of different combinations and I became obsessed to the point where I couldn't sleep at night. This lasted for eight months. I even went to the isle of Aix by myself for a week so as to be able to think of nothing else. Nothing worked. Finally, I had to give up!

'After a few months of rest and letting the notions simmer, I came to the realisation that the various moulds did have a common denominator: the ratio of the side of a square 98mm long to its diagonal. This tangible piece of evidence was disappointing in its simplicity, but at the same time gave me cause to continue on. I felt what Howard Carter, the famous Egyptologist, must have felt after digging in the desert for years and finally uncovering the first step that would lead to Tutankhamun's tomb – I was so excited.

'As a result I began studying the ways in which mathematical calculations were undertaken in the Middle Ages and the Renaissance. I also read the most recent scientific works concerning the role of proportion in architecture. It was through these works that I learnt that the relationship of the side of a square to its diagonal is a specific proportion, a section called the harmonic section [see figure 1].

'A section is a proportion that exists in three quantities, one of which is the sum of the other two, hence the name. The harmonic section occupied an important place in thought of the time alongside the geometric section, known as the celebrated golden section. But the problem cannot be reduced to the rediscovery of the harmonic section. The theory behind the notion of sections is alien to modern ideas of numbers and measurements, so there is a deeper cultural problem. While the theory may be simple, integrating the notion is paradoxically difficult – it's like converting to the euro! ▸

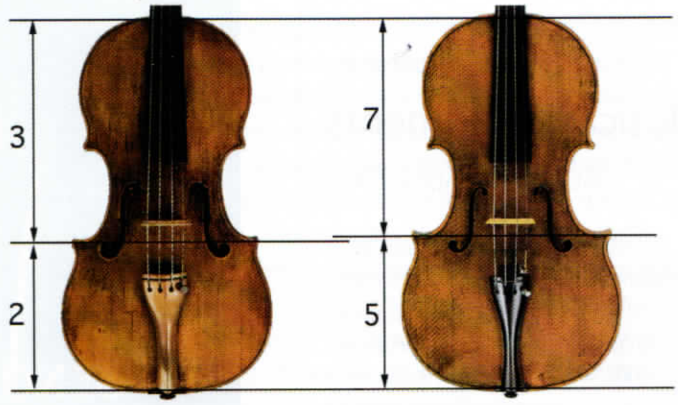

Figure 3 If we apply the relationship shown in figure 2 (measurements taken at the purflings) to instruments of the violin family, we see the same ratios of whole numbers as in the series (2/3; 3/4; 5/7).

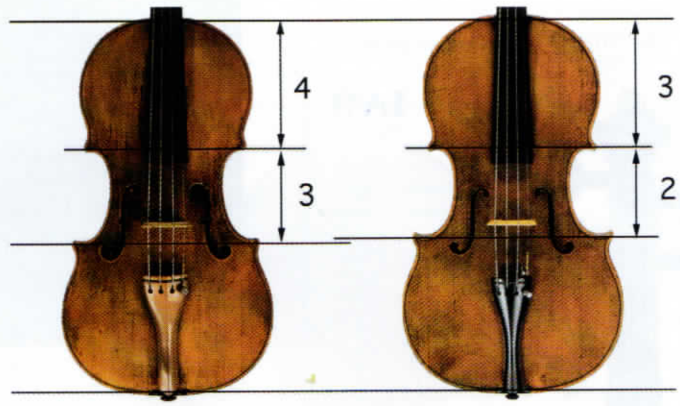

Figure 4 These relationships can be used to position all the integral elements of an instrument. Applying a ratio of 3:4 locates the upper corners of this Andrea Amati violin, whereas the ratio of 2:3 identifies the corners of this viola made by his son.

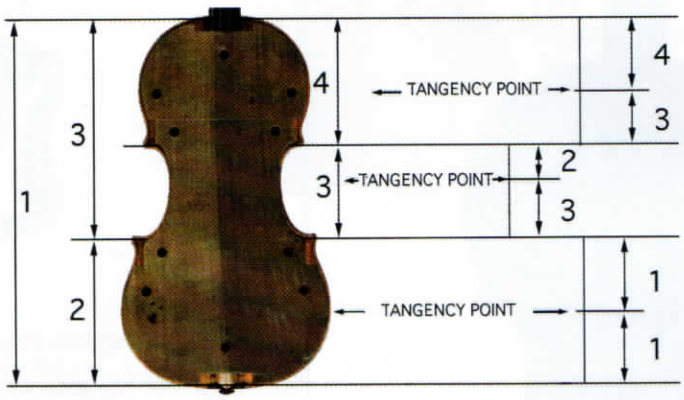

Figure 5 Each section positions one basic element and supplies all the information necessary to trace the form. By rearranging the ratios the maker could build an entire family of instruments. Surprisingly, this mould, Ms1 (part of the workshop inherited from Stradivari), can be superimposed on the violin made by Andrea Amati in 1566 for Charles X of France.

'Early mathematicians had a particular way of establishing correspondences between whole number values and irrational geometric values. For them, the square root of 2 ($\sqrt{2}$), for example, was a value close to that of the relationship between the numbers 5 and 7, such that what can be drawn with a compass could also be described by whole number values. These principles are part of a field of knowledge called *arte symmétria*, or the art of symmetry, an area of learning almost completely forgotten today.

'A specific example of this art of symmetry occurs in the manuscript attributed to the 15th-century astronomer and physicist Henry Arnault de Zwolle [see figure 2]. This work contains a drawing of a lute with an accompanying description of the method used to draw it. It includes the whole body of geometry and principles of proportionality which would be used to develop all new instruments created during the Renaissance, including the violin. The relationships of the different parts of the lute are given in terms of comparisons between two dimensions. Let us take one element measuring 5 parts and another of 7 parts. This is a harmonic proportion since these numbers approximate the irrational relation between 1 and $\sqrt{2}$ ($5/7 = 1/\sqrt{2}$). If instead of 5 and 7 we have 5 and 8, we are dealing with a geometric section as these numbers approximate the irrational relation between 1 and the golden number ($1/2 + \sqrt{5}/2$).

'Whereas today we conceive of a shape as the whole of its measurements, the ancients never thought that a graphic representation could be an image of a physical reality. It was first and foremost a representation of the relationships which made it up. Zwolle's drawing allows us to demonstrate the incredible ingenuity of that system and especially to explain beyond a doubt its powerful analogical properties. Starting from a well-conceived model we can construct an infinite number of variations along the same lines. Philosophers of antiquity said that analogy imitates nature as it has the power to create both something similar and something different. This is precisely what is of interest to us.'

So where does that leave us with Stradivari's moulds? 'What is remarkable is that the principles outlined by Zwolle are found in the shapes I've studied created by Stradivari. The shape is created ▸

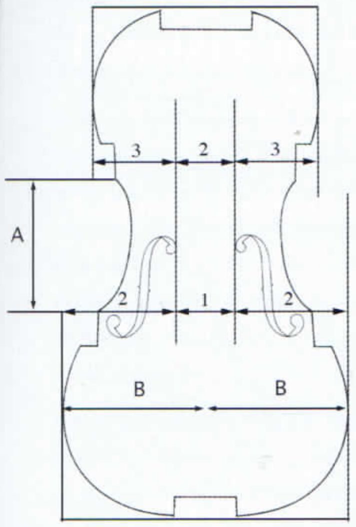

Figure 6 This combination of sections constructs a set of horizontal and vertical lines which position and limit the different parts of the instrument and even position the points of tangency for the arcs. It is important to understand that these specific measurements are equivalent to proportional geometric constructions. Horizontally, the divisions occur according to the principle of *symmétria*, another fundamental notion of proportionality established in antiquity. The width is divided into a central region surrounded by two equal parts (arithmetic symmetry 3 = 2+1 = 1+1+1; geometric symmetry 13 = 5+8 = 5+3+5 or 8 = 3+2+3; sub-harmonic symmetry 10 = 3+7 = 3+4+3...). Modern symmetry is nothing other than the ancient and enigmatic *symmétria*, but it no longer carries any sense of proportionality. It should be noted that division by *symmétria* necessarily takes into account the placement and dimensions of the f-holes.

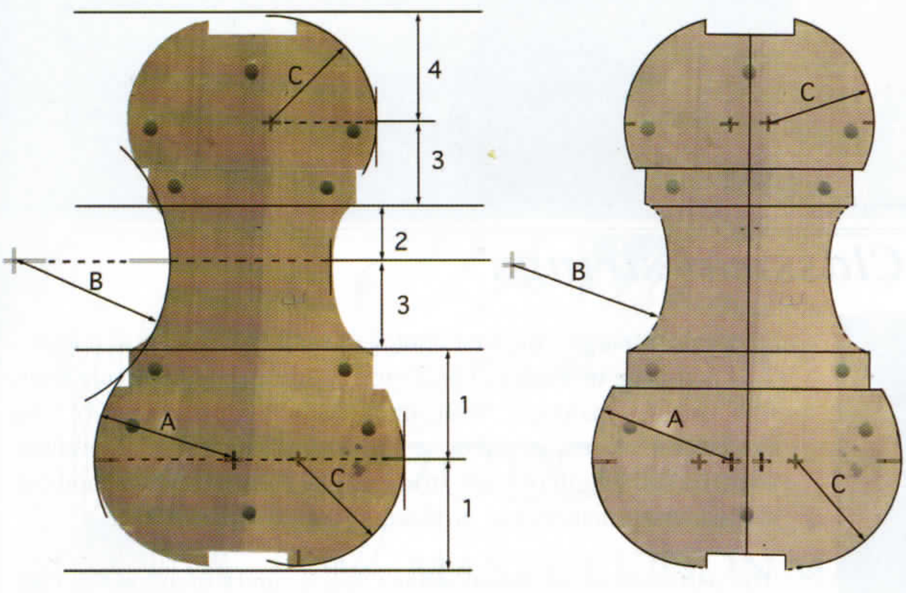

Figure 7 The form is traced from the construction lines. Note that the measurement of the arcs is taken directly from the segments A and B in figure 6. However simple this may appear, there is an art to using the dividers, which consists of learning a group of nine combinations, derived from section theory. The tracer, knowing all the different cases, was able to draw every possible shape and he would have no difficulty finishing the drawing of the form Ms1. Mathematical theory has replaced this lost art of tracing. Its rediscovery would allow makers a complete mastery of form.

within a framework where the points of tangency of arcs and the major limits of the different parts are governed by the analogical values of proportional sections. It is clear that Stradivari comes at the very end of this tradition and this makes the study of his work as difficult as it is exciting. From several points of view he may seem less rigorous than his predecessors from the end of the 16th and the beginning of the 17th centuries. Once we understand how Stradivari introduced his variations and how they fit the archetypical system he inherited, we can get a clearer view of the extent of the variables available to one of the greatest craftsmen of the 18th century. His worries were the same ones we have today – increasing or decreasing dimensions, for example, while responding in the best way possible to specific demands. But there is an important difference. His work was still guided by a solid theory that informed all his choices, whereas we are working by trial and error.'

Denis explains that other documents of a similar nature to Zwolle's dealing with architecture show that there existed a body of knowledge that was applied to all the arts of the period. 'Just as paintings and architecture reflect ideas of the period, so too do musical instruments,' he says. 'But they are ideas written in a language we cannot yet fully understand. We are still making these instruments to the best of our ability, but by attempting to understand the "grammar" that underlies their language, we can recover an important part of our history and shed more light on the art of those great craftsmen we so revere.' ■