

Luthier and researcher **FRANÇOIS DENIS** explains how the principles behind medieval cathedral vaulting may have inspired the arching of modern violins

GOLDEN ARCHES

Many masterpieces of the past were created using principles that time has since rendered indecipherable. The distant origins of the violin are an intriguing case in point. The violin is the product of a series of mutations that began well before the instrument came into existence. The most characteristic elements of the violin have been present in the Western world since the Middle Ages, where they appeared over the course of cultural changes that were often far from peaceful.

Very early craft techniques outside the realm of violin making may have had some bearing on the way that arching developed in the construction of stringed instruments. Certain carvings of musical instruments around the doors of some medieval cathedrals provide crucial evidence for this idea. In fact, it appears that bowed instruments have been arched since the 12th century. It is both surprising and enlightening to look closely at the careful attention to detail shown by the makers of these carvings.

Sculpture and instrument making were closely related crafts in the Middle Ages, and had similar techniques. It seems quite likely that some sculptors also constructed musical instruments, either wholly or in part. In any case, the arched bodies of these instruments, whether made from stone or wood, were always constructed from a solid block of material.

Stone and wood were expensive materials at the time, and craftsmen were always looking for ways of using less material. As part of that mission, significant research was carried out into the relationship between form and structural strength. The result was a revolutionary style of architecture that appeared to defy gravity. This new approach spread successfully to many architectural sites that became, in their time, fertile grounds for the exchange of ideas among craftsmen. Instrument makers and sculptors would have benefited from this progressive thinking and applied some of the new ideas to their own work. Clearly, the sound produced

by an instrument also depends on the structural responses of a form under stress. Sound quality requires fine adjustments involving the same criteria used by architects and masons.

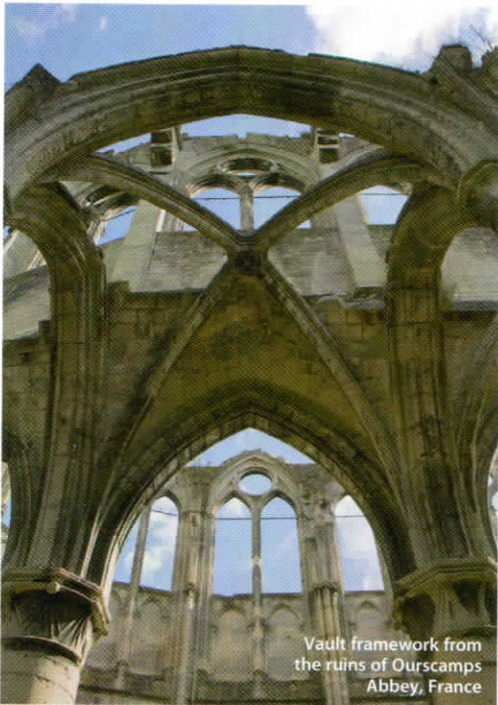
These early techniques relating to the design of architectural vaults and sculpture merit further study since they were the sources of inspiration for arching on instruments that developed later.



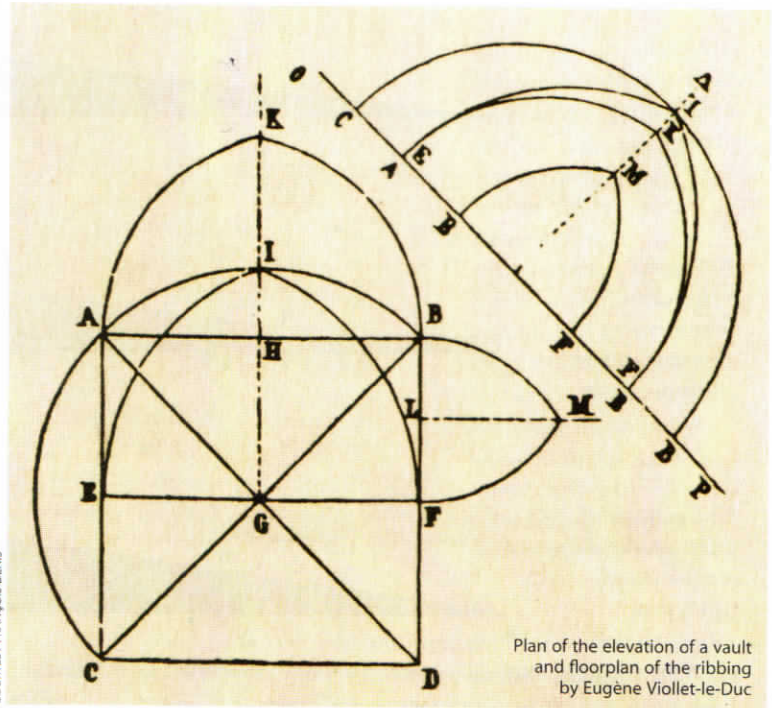
CHRISTIAN FAULT

Example of an arched instrument from a carving in the cathedral of Santiago de Compostella, Spain

IN ARCHITECTURE, a vault is an architectural form that spans a space with a curved surface. The history of the vault provides a good example of how a technological development reflects the political and economic conditions of the day. In short, we know that medieval builders devised techniques that made a construction less heavy by cleverly controlling the action of forces on matter.



Vault framework from the ruins of Ourscamps Abbey, France



Plan of the elevation of a vault and floorplan of the ribbing by Eugène Viollet-le-Duc

Musical instrument arching is, by its very nature, close to both architecture and sculpture

The vault is designed from a geometric framework that channels the effect of active forces.

Since ancient times, craftsmen looking for the best way to reproduce a given form have used a technique called pointing, also known as 'three compass points'. The principle is to note the relative position of three points in space and to be able to reproduce them accurately in the work at hand. We know that these three reference points greatly facilitated roughing out and allowed the most qualified workmen to devote their time to finishing. The combination of these methods turns out to

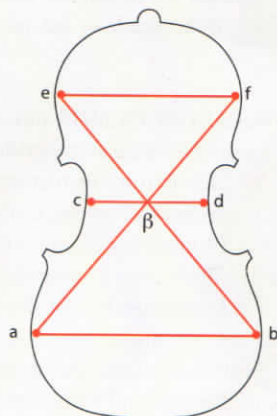
be very useful in the construction of musical instrument arching.

With the architectural example in mind, the widest dimensions of the surface to be covered provide the reference points of a structural framework. The St Andrew's cross, as found on the Scottish flag, is a simple illustration of how the technique works (example 1).

From this framework, makers then determine a series of height reference points with the same technique used by sculptors (example 2).

On the diagonals af and be , the proportional relationship between height and position of points ω is determined from the triangle $a\beta f$ or $b\beta e$; the height $\beta\chi$ of the triangle corresponds to the height of the arching at point β (examples 3 and 4 on page 48). >

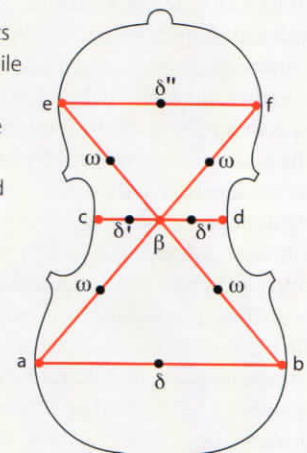
[1] The horizontals ab and ef , being the widest points of the lower and upper bouts, are joined by two diagonals af and be , intersecting in β and placing the horizontal cd .



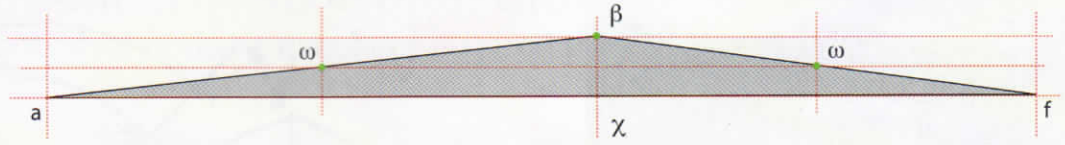
[2] Points δ are the midpoints of the horizontal sections while points ω are the midpoints of each diagonal section. The height (or elevation) of these points can then be expressed as whole fractions of the reference measurement β .

EXAMPLE OF RELATIVE MEASUREMENTS

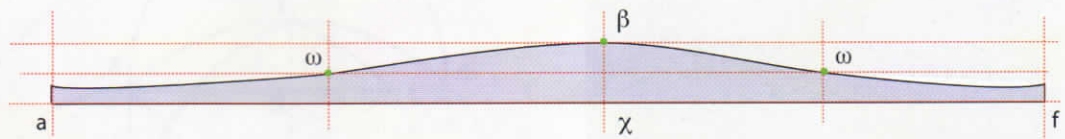
Back	Table
$\delta = 4/5$	$\delta = 4/5$
$\delta' = 4/5$	$\delta' = 4/5$
$\delta'' = 7/10$	$\delta'' = 4/5$
$\omega = 1/2$	$\omega = 1/2$



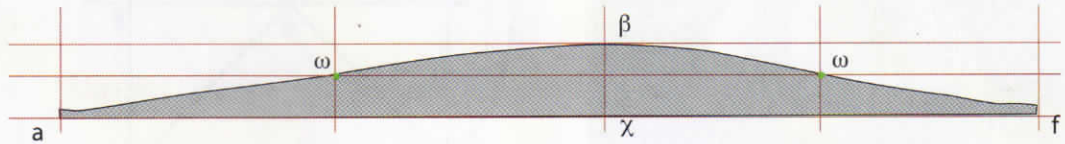
[3] Typical diagonal scheme in building arching



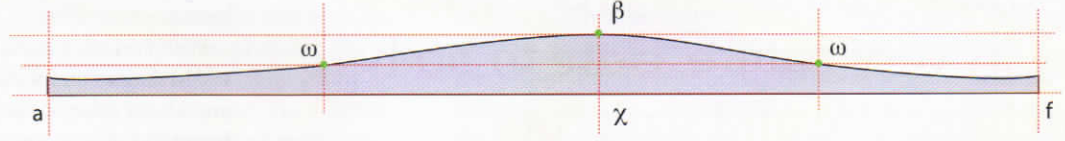
[4] The final profile of the arching is derived from the previous scheme



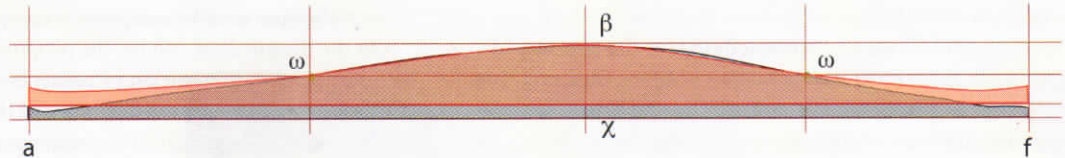
[5] This diagonal profile of a viola made in Brescia by Maggini shows points ω set in the middle of segments ac and cf at the same height



[6] On this diagonal profile of a violin made in Cremona by Guarneri 'del Gesù', the height reference points are placed as in Maggini's viola



[7] Profiles of the two archings from Brescia and Cremona superimposed



THERE ARE CHARACTERISTIC differences in arching between musical instruments made in Brescia and those made in Cremona, as well as quite distinct construction principles. Nevertheless, comparisons of the diagonal profiles of the respective archings show similarities (examples 5 and 6).

By scaling these two profiles to the same size, we find that they are identical in the area between the two points ω . Thus the heights of points are fixed in the same manner, and the differences in these archings simply reflect two different uses of a common principle. In fact, in Cremona the calculation of the height of the arching at ω includes the height of the edge (red outline), which is not the case in Brescia (grey outline) (example 7).

It becomes apparent that a distinctive feature of both schools depends on the method by which the heights of the edges are calculated, or, in a more general way, on the way the total height of the instrument is divided up. In Brescia, high arching is associated with low ribs, whereas in Cremona, low arching is associated with relatively high ribs. Note that for craftsmen of old, measurements

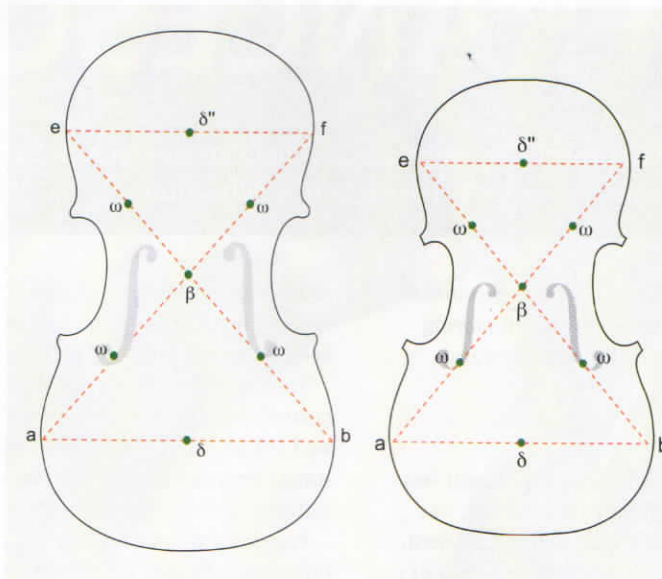
followed on one from another. Using that principle, the initial place where measurements are extracted from becomes crucial for the construction. This problem is rather like architects having to decide whether the height of a cornice should be deduced from the height of the façade or the height of the roof (example 8).

HISTORICAL DOCUMENTS about craft techniques are very rare. However, there is some evidence worth mentioning. X-rays of 16th-century instruments that were hanging above a burial chamber in Freiberg Cathedral revealed the presence of a central soundpost pinned to the back at the intersection of a St Andrew's cross joining the two widest spans of the instrument (example 9). We also know that Cremonese violins show traces of a similar pin on the back. This mark could have served several functions that gradually fell into disuse over the course of the 17th and 18th centuries. One of them could have been related to arching and its graduation.

With regard to tools, the violin maker Joël Klépal has drawn my attention to an article on violin making in the encyclopedia by Diderot & d'Alembert from the 1750s. The authors show two types of calipers used in a Parisian workshop at that time. The wooden calipers were used for thicknesses, and the two metal calipers for arching clearly relate to an equivalent set used by Stradivari. This suggests that iron calipers would have been used to determine height reference points in arching rather than thicknesses.

Lastly, some Italian Renaissance viols still bear the typical outside ribbing of the Gothic viol (**example 10**). The framework of this ribbing suggests that, as in architecture, some schemes more complex than the St Andrew's cross may have been tried locally.

ACCORDING TO Eugène Viollet-le-Duc, an informed 19th-century observer of medieval architecture, style emanated from principles of construction. Once confronted with the diversity of archings of old instruments, the existence of implicit underlying principles in the making process should be self-evident to a modern instrument maker. If these principles really existed, they must be linked in some way with what has been discussed here, since musical instrument arching is, by its very nature, close to both architecture and sculpture.



[8] The archings of the Maggini viola and the Guarneri 'del Gesù' violin seem to have been made with the same ribbing scheme. The relative measurements of height reference points are also the same: $1/2$ of β for the points ω and $4/5$ of β for the points δ . Maggini's measurements do not take account of the height of the edge, so this value has to be added to the height of the arching, giving it its characteristic humped look.

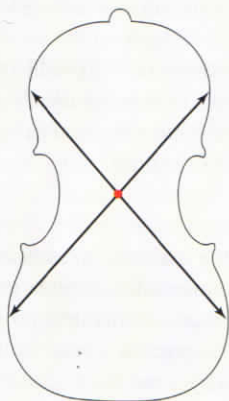
Simple, flexible and consistent with our historical knowledge of the subject, this process shows all the expected qualities of a valid principle. Thus, an inexperienced student using this process can construct classical arching on their first attempt, unaware of the difficulties of doing so without the aid of the principles I have discussed.

Finally, as with other early measurement systems, the classic model serves as a basis for a variety of interpretations. Frameworks and divisions, other than those briefly mentioned here, are therefore possible. This procedure is not a constraining shackle but essentially a guide for creativity in violin making. ■

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[9] The positioning of the pin in some violins (here the 'Kortschak' Guarneri 'del Gesù') matches the scheme of a St Andrew's cross, reminding us of the setting of the soundpost with a pin in the Freiberg instruments (right).



[10] Example of exterior ridge arching in a Renaissance viol



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