

MAKER'S BENCH

Seeing Inside the Violin

by John Waddle

In 1988, Dr. Steven A. Sirr was working at Abbott Northwestern Hospital in Minneapolis, teaching and using Radiology to diagnose patients. Sometimes when there were no patients who needed scanning, he would practice his violin. One day, a nurse came to get him because a patient had just come in with a gunshot wound and needed to be scanned right away. Steve carried his violin to the room with the CT scanner, set the violin down, scanned the patient, and then thought, "I wonder what my violin would look like if I scanned it?" So, he put his violin through the CT scanner, and about a week later, brought the scan images in to my shop and showed them to me. He asked me if the images were interesting.

What we now call Computed Tomography (CT) scanning used to be called Computed Axial Tomography (CAT) scanning. The Merriam Webster definition of the word Tomography is, "A method producing a 3-dimensional image of the internal structures of a solid object (such as the human body or the earth) by the observation and recording of the differences in the effects on the passages of waves of energy impinging on the object."

The way it works is that the person is placed on the CT bed, which moves through the scanner, which passes X-ray light through the body in a spiral motion. The CT scanner measures the amount of the light that gets through the body and hits the detectors. This is called attenuation. The denser the object, like bone, the less light gets through. The number of scans per mm, and the level of energy focused on the object determines the amount of data that can be detected. The scans are converted to DICOM (Digital Imaging and Communications in medicine) files, which can be put into a software program which allows the Radiologist to view the entire set of files as one three-dimensional object. Or they can focus in on a small part of the region that was scanned, for instance the tiniest part of the inner ear, or a crack in a violin. In the computer, the object can also be virtually dissected into its various parts. Medical CT scanners are used to diagnose abnormalities in the human body, and it takes many years of training and experience to know and recognize what is normal and what is not normal when "reading" a CT scan.

When Steve showed me the scans of his violin, I looked at them for a long time and realized that what I was seeing was something I had never seen before, and that I could see things in the scans that would be useful and interesting in understanding more about how violins are made. I could also see variations in outlines, archings and thicknesses. I had been making violins, and repairing them and restoring them, and I knew what violins looked like taken apart, but

CT images are a different way of documenting and seeing.

After I saw the first CT scans of Steve's violin, I wondered what other instruments would look like if we could scan them. I knew that there was a museum in Vermillion, South Dakota, with a famous collection of some of the rarest and most historically important instruments in the world. I started sending inquiries to the museum director, André Larson, asking if Steve and I could come and CT scan some of their instruments. It took a few years, but he said yes.

The museum at that time was called the "Shrine to Music" museum. Its name was later changed to the "National Music Museum." The collections there contain instruments from the Amati family, including the Andrea Amati cello, made some time between 1536 and 1560 for King Charles IX of France, instruments from Guarneri family, and the Harrison Stradivari violin, made in 1693. The Stradivari "Rawlins" Guitar, made in the year 1700, and the Stradivari mandolin, made in 1680, are preserved there, among many others.

Steve and I drove down to Vermilion with our friend Gary Bartig in Gary's pickup truck. Steve and the museum had arranged with the local hospital to borrow their scanner over the weekend, and the museum staff brought over instruments six at a time for scanning. We spent two days scanning instruments. Steve processed the images and shared them with the museum, and we studied each one carefully.

Once an instrument has been scanned, it is essentially digitized in three dimensions. Using a software program designed for processing CT images, Steve, or anyone familiar with the software could measure dimensions, volumes, and densities; this allows a person to determine masses, weights, and balance points. Steve was able to show that the air inside the violin is divided into two equal parts above and below the sound post. The top of the violin is balanced at the bridge position, and the back is balanced at the sound post position.

Repaired cracks, patches, doublings, and damage from wood worms could be seen in the images.

Bruno Frohlich, at the Smithsonian in Washington, DC, acquired a CT scanner and along with Gary Sturm, of the Library of Congress, CT scanned many of the instruments in their collections, which they shared with us, including among other instruments, the Betts Stradivari, the Kreisler Guarneri, and the Brookings Amati violins.

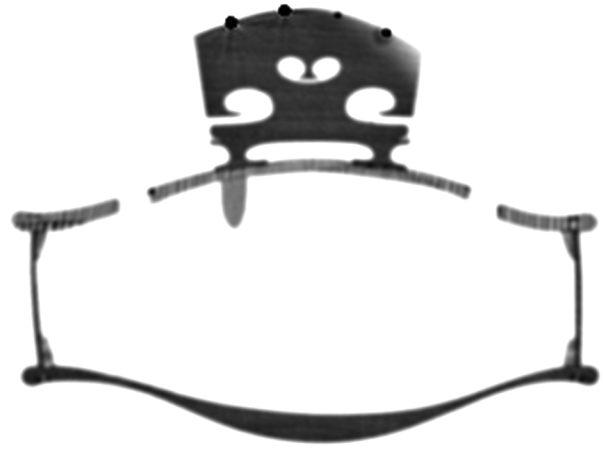


Left: Photo of the back of the Betts Strad.

Right: CT scan showing the grain structure.

The darker grain lines that run vertically from top to bottom on both sides of the center seam are grain lines of more dense growth, thus harder grain, and on the treble side, would be pretty close to under the sound post. The vertical “smudge” on the right side near the C-bout is a small paper tag on the inside with a number on it—something that would have been put in by another person in its long history, not Stradivari. The two smaller horizontal “smudges” on the right side near the top corner are probably something in the grain. These are all examples of the kinds of things that we can discover when we look at scans and are often not noticed when you look at a violin from the outside.

None of the Amati violin makers, nor the Guarneris, left behind any written materials or artifacts which could be helpful in knowing how they made their instruments; only their instruments have survived. Stradivari left a large number of instruments, and also a large number of his molds, drawings, patterns and tools. The Stradivari workshop produced an astonishing number of instruments. There are drawings for viols, gambas, lutes, violins, violas, cellos, harps, and even cases and bows, but no shop notes about methods or design or records of instruments made or who bought them.



Brookings Nicolo Amati violin, made in 1654.

This is one of my favorite CT images. It is an axial image showing the curvatures and thicknesses of the top and back, and the bass bar under the bass foot of the bridge. The violin was scanned with the strings on the violin. There is a “doubling of the top edge on the bass side where the top is glued to the rib

The technology of imaging advances constantly. The early CT scanners were not nearly as good as the current ones. The amount of detail in the images we are seeing now is much better than it was in the early days because the early scanners could scan every 3 mm, which at the time seemed impressive, but now we are seeing scans taken at 0.5 mm., and the resolution of the images keeps getting better.

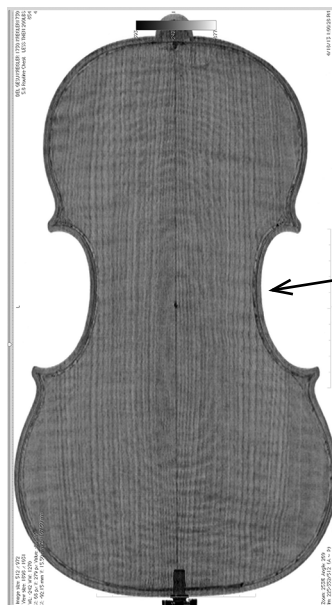
Steve and I are still working together. Over the years, we have gained access to many of the most valuable instruments in the world for study. One of the things we are doing, now that we have something of a database of instruments scanned, is comparing instruments over time within the Amati family, the Guarneri families, and the Stradivari workshop. It’s been interesting to see what an Andrea Amati violin looks like compared to a violin made by his sons Antonio and Hieronymous, and what an early Nicolo Amati looks like compared to a later one by him. We’ve been studying what the early Andrea Guarneri instruments looked like, and how violin making progressed through the years with his two sons, Pietro and Joseph known as Joseph “Filius” Andrea. We can compare an early Stradivari to a Nicolo Amati, or an early Stradivari to one made towards the end of Stradivari’s life. We can compare the instruments Carlo Bergonzi made to those of Antonio Stradivari. We’ve noticed that these makers, while certainly being influenced

by their teachers, did not necessarily copy their master. They were able to make changes and were always experimenting with every aspect of their craft to improve sound and playability.

It is especially helpful when we can hear the instruments played live, and see the instruments in person, obtain good quality photographs of them, and get the CT scans as well, because while just hearing a fine violin being played by a great violinist, in a great hall, can be an important experience in someone's life, for a luthier, seeing and studying the actual instrument is so important, but then remembering what you heard and saw is difficult. Photographs, while not as good as having the instrument in front of you, and the CT scans give even more information.

Now, people are CT scanning instruments all over the world, and sharing their findings. It's common to see a Strad magazine poster on the wall of most of the violin shops in the world with beautiful photos, measurements, and CT scans shown. It's also become common for an extremely valuable instrument to be documented, with a set CT scans as part of the condition report, when it changes hands.

The instruments of the Amati's, Guarneri's, and Stradivari have long been regarded as the most important examples to learn from, and we feel fortunate to have been given access to so many of them. Through careful study, sharing of information and ideas, we all learn and the result is better instruments for musicians.



This is the back of the Kreisler Del Gesu made in 1730. It's in great condition. The little dark dot in the center of the back is a pin, which the Amati family and the Guarneri families used in the construction process. Nobody really knows why they used it.

John R. Waddle is a violin maker, dealer, and restorer whose shop is in St. Paul, Minnesota. He is a 1981 graduate of The Violin Making School of America in Salt Lake City, Utah, and has had his own shop in St. Paul since 1986. John is a member of both The American Federation of Violin and Bow Makers, and the Violin Society of America. ♪