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Mrs. Carleen Maley Hutchins gives life to a new royal family.

ACOUSTICS

Physics for the Queen

by Jonathan Eberhart

An entire family of violins has finally been made according to a consistent acoustical theory.

That music is mathematical is beyond dispute. The structure of chords, the intervals between notes, however beautiful, are firmly bound in cascades of numerical relationships, as are the rhythms that give the muse its life. Yet the art of the instrument-maker, as refined as it has become since its full flowering in the Renaissance, has nonetheless appeared somehow divorced from such impersonal calculation, in favor of the "feel" for a proper design, or of judgment "by ear."

Consider the violin. The design of the queen of instruments reached a peak with craftsmen such as Antonio Stradivari and Giuseppe Guarneri in the seventeenth and eighteenth centuries. Aided mostly by trial and error, and only slightly by the most rudimentary acoustic theory, the masters produced violins which endure even today as pinnacles of achievement.

Even in this technological era, science has pointedly ignored the violin. The supposed successors of the masters, in fact, "have formed a cult that has been plagued with more peculiar notions and pseudo science than even medicine."

This pointed sentiment is that of a woman who is both violin-maker and scientist. But far from experimenting with superscientific electronic constructions of fiberglass and aluminum, Mrs. Carleen Maley Hutchins works in the traditional manner—though with a few hardly traditional tools. Comfortably ensconced in her home laboratory in New Jersey, Mrs. Hutchins measures the resonances of a violin backplate, for example, not by tapping it and judging by ear, but by vibrating the plate with a magnetic driver similar to the core of a loudspeaker and observing the sound waves on an oscilloscope.

For almost two decades, Mrs. Hutchins has been playing matchmaker for a wedding of science and the violin. Such a match at last has taken place, producing from the queen of instruments an entire royal family, ranging from a tiny 16-inch treble violin to a huge contrabass seven-footer.

The new family has eight members instead of four, replacing the conventional violin, viola, cello and bass viol, but Mrs. Hutchins has produced more than a mere instrumental population explosion. The new instruments are all violins, they all sound like violins, except for range, and they share the same expressive qualities, as well as the violin's power—its ability to stay afloat above the sounds of a whole orchestra. By contrast, each member of the traditional family has its own characteristic sound, so that the cello and bass, for example, sound completely different from the higher-pitched instruments, and even from each other.

Mrs. Hutchins didn't do all this by herself. Her chief colleague was the late Prof. Frederick A. Saunders, former chairman of the Harvard physics department and past president of the Acoustical Society of America, who three decades ago took a big first step by locating the position of the main resonances of the wood structure and the enclosed air in several fine violins.

Once this was known, it took almost a quarter of a century to learn how to place these resonances predictably where they were wanted in the instrument while still maintaining the tone quality of the violin. Throughout most of the 1950's, Prof. Saunders and Mrs. Hutchins experimented virtually in the dark, having no existing "violin theory" to go on, moving and reshaping the instrument's f-holes, thinning down the top and back plates, repositioning the bass bar and sound post, and generally trying everything they could think of to see what effect it had on tone and volume. Their task was prodigious: literally developing a science from scratch with dozens of violins and hundreds of experiments when not even the test equipment existed in advance to help them.

The problem in developing an entire family of instruments was to find some measurable physical characteristic of the violin itself that would set it apart from the viola, cello and bass. Seemingly endless tests painted a confusing and frustrating picture for Prof. Saunders and Mrs. Hutchins, because of the wide variations in placement of the two main resonances from instrument to instrument. Finally, however, Prof. Saunders' tests on Jascha Heifetz's superb Guarnerius showed that its two main resonances were near the frequencies of the two unstopped middle strings—the wood resonance near the frequency of the open A (second) string and the main air cavity resonance near that of the open D (third) string.

To the researchers' pleasure, 10 violins selected solely on the basis of fulfilling those two characteristics turned out to be "some of the most musically desirable instruments—Amatis, Stradivaris, Guarneris and several modern ones." By contrast, all the violas and cellos that were tested had their main resonances three to four semitones *above* the frequencies of the open middle strings. Far from being a tragedy, this notable discrepancy was just what the violin-maker ordered—a characteristic physical difference between the violin and its other family members.

Now Mrs. Hutchins knew what she wanted in her new instruments, and she knew, to a large extent, how to make them that way. The final nudge that changed the project from theory-developing to instrument-building was provided in 1958 by composer Henry Brant and by cellist Sterling Hunkins, who proposed that an eight-instrument violin family be constructed, ranging from contrabass to an octave above the conventional violin. The researchers were sold on the idea in 30 minutes.

Building all the instruments from scratch would have been prohibitively time-consuming, she wrote in the February Physics Today, so the search began for ones that could be modified.

- First came the mezzo, closest in the new family to the conventional violin, adapted from an experimental viola made by Mrs. Hutchins which proved to have "amazing power and clarity of tone" despite its shallow, heavy body. Once the full family was developed, another mezzo had to be designed because the original, though capable of holding its own with orthodox instruments, was being somewhat outshouted.
- The next three instruments were made from a set of instruments produced by an earlier violin experimentalist, Fred Dautrich of Torrington, Conn., during the 1920's and '30's. Dautrich's "vilonia" was retuned as a viola and became the alto of the new family, played upright on a peg like a cello. Leopold Stokowski declared that the instrument had "the sound I have always wanted from the violas in my orchestera."
- Think that's confusing? Dautrich's "vilon" was made into the tenor, looks like a half-size cello, and is tuned an octave below the violin. Unfortunately, there is virtually no music for it, since it has no part in classical string literature and its parts in early music have been rearranged for either cello or viola.
- The baritone violin required a year of adjusting top and back thicknesses and rib heights for the proper resonances, starting with Dautrich's "vilono." The present model has a body resonance nearly three semitones lower than was planned, so a future version may attack this problem by shortening the body slightly, which will also allow conventional cello string length.
- Mrs. Hutchins then expanded the top of the family by building a soprano based on studies of half- and three-quarter-size violins. J. S. Bach wrote music for such an instrument.
- The bass was made from—wonder of wonders—an actual bass, although it was a three-quarter-size model with its low E string removed and a high C string added. The instrument has been used in recording sessions and deviates from the common violin shape of the other family members in that it has the sloping shoulders of a conventional bass viol. Its successor will return to the fold with a pure violin shape.
- The instruments at the two extremes—highest and lowest—caused the biggest headaches. A tiny pochette, or pocket fiddle, with a body only seven inches long, was borrowed from the Wurlitzer collection, but had much too low a body resonance. This was corrected in a specially-built model, but strong enough strings proved elusive until Mrs. Hutchins tried carbon "rocket wire," which has since proved useful on several of the other instruments.
- The contrabass towers seven feet high, yet is easy to play as a result of experiments with the length of the fingerboard and tailpiece, as well as with the bridge height. "I have waited all my life to hear such sounds from a bass," said the pleased Henry Brant.

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Violins and brothers all, in concert: alto, tenor and baritone.

Mrs. Hutchins' work still goes on, supported by grants from various foundations, but its climax so far occurred last summer, when all eight instruments were played in a concert at Harvard, dedicated to Prof. Saunders.

Problems still remain, such as the effects of varnish, moisture and various finishes on the vibration of the wood. Mrs. Hutchins, however, looks even beyond to "the possibility of some day being able to write adequate specifications for a fabricated material that will equal the tone qualities of wood!"