Craig Kridel and Clifford Bevan, Editors

Questions & Answers

***Editor's Note:** With this issue we inaugurate a new column in the Historical Instrument Section. Throughout the years we have received a variety of questions pertaining to historical low brass instruments. We sensed an annual "questions and answers" column would be of great interest. To launch this issue, I posed one of the most commonly asked questions: Why do the serpent and contrabassoon double orchestral parts when, in fact, they play in different octaves? For the answer I turned to the renowned acoustician and serpentist Murray Campbell from the University of Edinburgh. We greatly appreciate Professor Campbell's thorough and speedy response.*

For future issues of this "Question and Answers" section, please send your questions to Craig Kridel. His contact information can be found on page 2 of any issue of the ITEA Journal.

Serpent and Contrabassoon Acoustics

by D. M. Campbell

Why does the serpent's sound often seem to be an octave lower than its actual playing pitch? As a scientist who spends much of his time probing the arcane mysteries of brass instrument performance I am used to fielding bizarre questions from fellow musicians, but this one, posed by *Historical Instrument Section* editor Craig Kridel, made me stop and think. The question relates, of course, to the bass register of the serpent, which in pre-tuba days was called on to reinforce the bottom end of the orchestra by composers from Händel to Wagner. I have had the privilege of taking part in a number of orchestral performances on the serpent, and the question recalled one particular piece of music: the Overture *A Calm Sea and a Prosperous Voyage* by Mendelssohn. Playing the serpent part in this, I was struck by the fact that Mendelssohn used the instrument as the bass of the woodwind section rather than the brass. My feeling of being an honorary bassoon was strengthened by the realisation that the contrabassoon was doubling the part throughout. Since the contra plays an octave lower than written pitch, the effect should have been of octave doubling; but my memory is rather that the two instruments blended together to give a surprisingly unified sound.

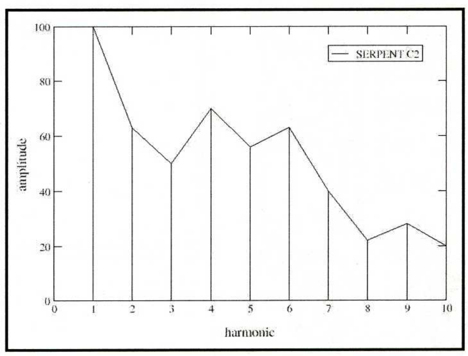


Fig. 1: Spectrum of the C2 on a serpent.

The bottom note of the serpent is a wonderfully rich and fruity sound, but on a C instrument its pitch is C², corresponding to a frequency of 65.4 hertz. The contrabassoon is undoubtedly an octave lower-its bottom C is C¹, the lowest C on a piano keyboard, with a frequency of 32.7 hertz. Why then does the serpent seem to be "as low" as the contrabassoon? The answer lies in the difference in timbre between the two instruments. This difference in timbre is dramatically illustrated by examining the frequency content of each of the sounds.

Any musical note with a clearly defined pitch is actually made up of a whole series of different tones sounding simultaneously. This set of tones is known as the "frequency spectrum" of the sound, and each tone is a "frequency component." For a pitched sound the frequency components are members of a harmonic series: this means that the frequencies of the components are whole-number multiples of the lowest one. The note C² on the serpent, for example, has a lowest component (or "fundamental") with a frequency of 65.4 hertz, and a series of higher components with frequencies 2, 3, 4, 5 ... times 65.4 hertz.

The timbre of a sound is largely determined by the relative strengths of the different frequency components. A spectrum analyser displays the frequency spectrum as a set of vertical lines, each one representing one of the components; the height of each line is proportional to the relative amplitude of that component in the overall sound. I measured the spectrum of a mezzoforte C² on a serpent and obtained the result shown in **Figure 1.** The line joining the tops of the vertical lines shows the overall trend of the harmonics: in this case strongest for the fundamental, dropping in amplitude for the second and third, rising again at the fourth and then falling strongly around the eighth harmonic. This is the spectrum of a full and mellow sound.

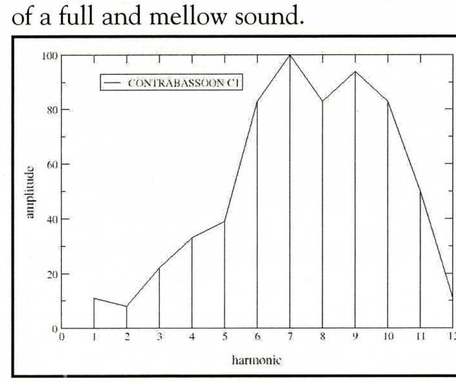
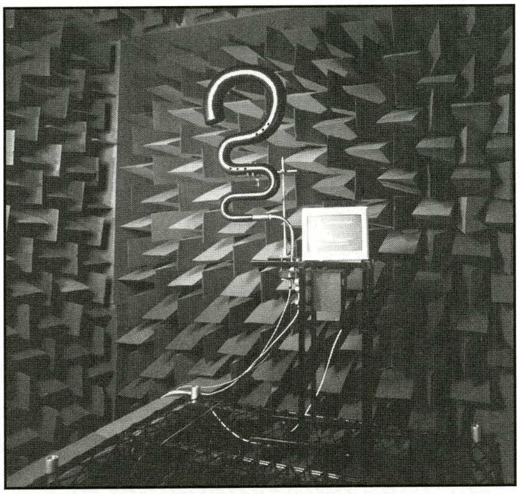


Fig. 2: Spectrum of the C1 on the contrabassoon

A very different story is revealed by the spectrum of the C¹ on the contrabassoon, shown in **Figure 2.** The fundamental is very weak, and the second harmonic even weaker; the amplitude then grows steadily, reaching its maximum at the seventh harmonic before falling away again. This spectrum is characteristic of a very buzzy timbre, lacking fullness but rich in high frequencies. It should be emphasised that other instruments and other players would undoubtedly produce sounds with significantly different spectra, but I believe that the contrast between a strong fundamental on the serpent and a weak fundamental on the contrabassoon is generally valid.

What pitch do we hear from the contrabassoon? If the strongest frequency component is nearly three octaves above the fundamental, does that determine the pitch of the sound? In fact, the mental process by which we identify the pitch of a sound appears to involve a recognition of the whole harmonic spectrum, rather than just the strongest component: the contrabassoon would still be heard at the pitch C1 even if the fundamental were filtered out completely. Nevertheless, the answer to the question posed at the start of this article surely lies in the fact that when, as in many orchestral scorings, the contrabassoon plays an octave below the serpent, it is in fact the serpent which is providing most of the low frequency energy in the composite sound.



Serpent being tested in the laboratory at University of Edinburgh

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