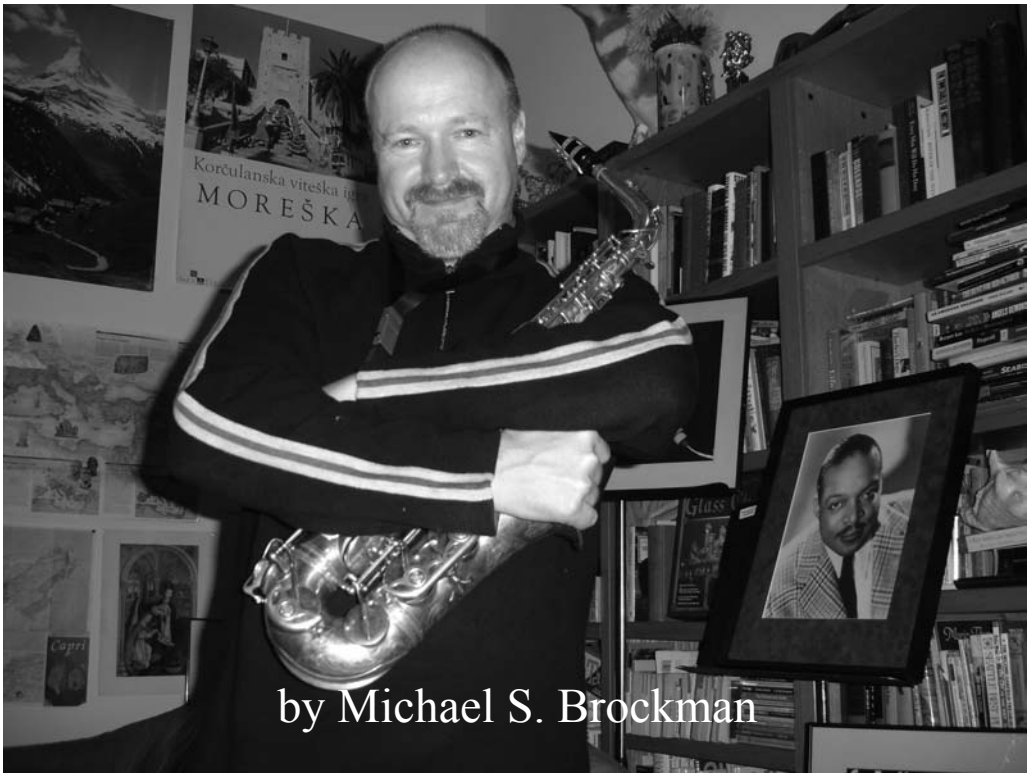
The Frankensax

An Experimental 12 Octave Vent Saxophone

Part I



When I began studying the saxophone under Joe Allard (Figure 1), one of the first things he taught me was how to play middle "D" on the saxophone so it had a full, resonant sound. The trick he showed me is fairly well known. Instead of pressing the regular octave key (using the left thumb) to make low D jump up to middle D, open the side D key as an octave key. This was a great revelation. The long D fingering on my instrument was transformed into a beautiful, full bodied and resonant note that made the "normal" fingering for middle D pale and stuffy by comparison, not to mention sharp (see Figure 2).

"Of course," grumbled Joe with a grandfatherly twinkle in his eye. "That's where the natural octave key for that note ought to be anyway. But d'ya think those idiots would give you an octave key there? Noddonya life!" Joe never told me who "those idiots" were, but I suspect he was referring to all manufacturers of saxophones (and I assume he did not include Adolphe Sax among them, since that would be blasphemous from any saxophonist). Nevertheless, the saxophones we play are intrinsically out of tune, and this is primarily because of the octave key system that persists since the saxophone's original design by Mr. Sax in the early 1840s.

Figure 1
Joe Allard, renowned mentor and teacher at NEC and Juilliard.

OUR TWO OCTAVE VENT SYSTEM

A Bad Compromise

There has long been discussion among inventors and acousticians (including the renowned Arthur Benade and Allen Loomis) regarding the possibility of having several octave vents on the saxophone, even as many as one for every note on the instrument. The current system for octave keys on the saxophone is a compromise, and a rather ineffective one at that. It uses only two octave vents (one up high on the neck, and one lower down on the body) controlled by the pressing of a single key operated by the left thumb. The lower of the two octave vents serves seven pitches on the saxophone (low D, Eb, E, F, F#, G, and G#). The upper octave vent normally serves everything else (A and above, with some exceptions in the extreme altissimo register).

This two octave vent system is what Adolphe Sax devised with his invention of the saxophone around 1842, and patented in 1846. Except for some improved key mechanisms, it has remained essentially unchanged. With Sax's clever placement of the two vents, the system manages to serve the entire saxophone, but this requires that the performer be willing to adjust for bad intonation and unresponsive behavior (by changing embouchure, wind pressure, and even fingerings) on several notes. The simplicity of having only two octave vents to deal with (as opposed

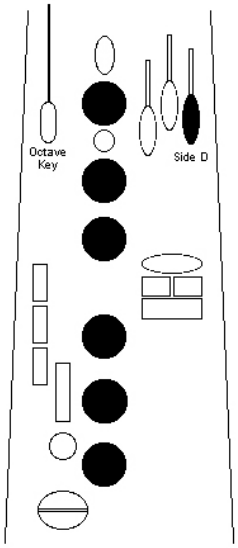


Figure 2
Allard's Long D fingering, with side D substituted in place of the normal octave key.

to four or five, as we have on the bassoon) is balanced against several drawbacks: a middle D and high G# that respond weakly to their octave vents; a high A that is extremely sharp; and an instrument design requiring "adjusted" pitches that play flat in one register and sharp in another (middle C# comes to mind).

Most saxophone models use a clever mechanism that automatically alternates between opening one octave vent on the neck and one on the body. The automatic closing of one vent and opening of another occurs as the player moves from high G or G# to high A. Each saxophone manufacturer has taken a different approach to making this automatic mechanism operate smoothly using levers and springs, most with a high degree of success in their designs. Sax's first models had two separate keys to operate the two octave vents. Switching octave vents at the appropriate time was the responsibility of the performer. This is still the case with most fine oboes, as professional artists prefer having direct control over which octave vent is open.

It is interesting to note that in 1881 Adolphe Sax received a patent for improvements to the saxophone that included adding a 4th octave key to facilitate the high tones from E to G (apparently a 3rd octave key had also been introduced earlier into his designs). In 1938 Allen Loomis (who was the chief research engineer for the C.G. Conn company) patented a saxophone design that included four separate octave vents, all operated automatically by a single thumb key. Neither of these enhanced octave key designs by Loomis or Sax was considered practical, and neither was widely adopted by saxophone makers.

THE ALTERNATIVE "NATURAL" OCTAVE KEYS

After Joe Allard taught me to play low D with side D as its octave key, I soon discovered that there is an alternative "natural" octave key available for almost every note in the lower register of the saxophone (low Bb through low F#). They are each located an octave higher than the low fingered note, which means they are half way up the length of the air column of the low note fingered. In other words, when fingering low Eb the natural octave key is side Eb. For low Bb, side Bb is the natural octave key (or one can simply lift the second finger off the A key). For low C, side C is the natural octave key and for low F, high F is the natural octave key, and so on. Many natural octave keys, such as the side D (used in conjunction with the low D fingering) can be opened as wide as you like. Some must be opened only a small amount to create a tiny break in the air column, mimicking the small opening of a traditional octave vent.

Most of the alternative "natural" octave keys are sonically superior to the regular octave key operated with the left thumb. The occasional use of all these alternative octave keys in my own performing led me to the idea of drilling new octave vents to mimic the behavior of opening an existing key as an octave vent. A list of the alternative "natural" octaves already available on commercially made saxophones is provided in Appendix 1 of this article. An additional option for Selmer Series III users is described in Appendix 2.

CREATING THE 12 OCTAVE VENT SAXOPHONE

I have taught the use of the alternative "natural" octave keys for many years to my students at the University of Washington. Last year I got to thinking, "what if there were a real octave key for every note on the horn, each with its own special opening?" With the placement of natural octave keys in mind, I purchased an inexpensive, used saxophone and proceeded to test some theories.

I drilled ten new octave vents into my saxophone, three in the neck, six in the instrument body, and one through the pearl on the first finger B key (see Figures 3 and 4). In the body, I drilled one octave vent for each pitch of the horn from low Bb through Eb, and one for low F#. Vents for low G#, middle A, and middle Bb were drilled in the neck (see figures 5 and 6).

I skipped drilling new octave vents for low E and F, as the placement of octave vents for those pitches would fall very close to the existing lower octave vent already on the body of the saxophone. I did not drill an octave vent for low G, as this would have required drilling directly through the tenon joint.

Next, I soldered chimneys and sleeves into the new octave vents to help create reliable closing and opening (see Figure 7). Then I soldered

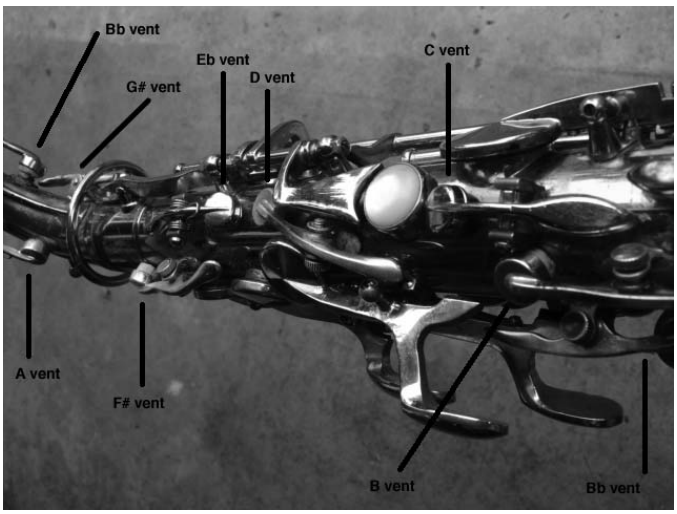


Figure 3
Brockman's experimental saxophone with 12 octave vents (new C# vent, and original two vents are not shown).

to the body and neck of the saxophone a number of water keys (salvaged from old trumpets and such) so that I could open and close the new octave vents at will (see Figure 8). Except for those on the neck, I positioned the water keys so I could reach them with either my left or right thumb, stretching my hand up or down the instrument in much the same way as is required for bassoon playing. I studied bassoon as an undergraduate in addition to saxophone, so this thumb activity is familiar to me.

Adding ten new octave vents to the two normally provided on the saxophone gave me a choice of twelve octave vents to open at will for any note I fingered on the saxophone. I later drilled additional vents

Figure 4
Detail of half-hole octave vent drilled into the left hand first finger B key.

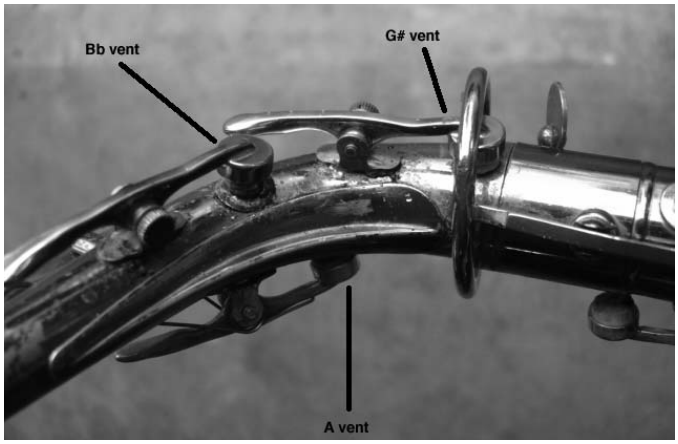


Figure 5
Detail showing the octave vents on the neck for (left to right) middle Bb, middle A, and low G#.

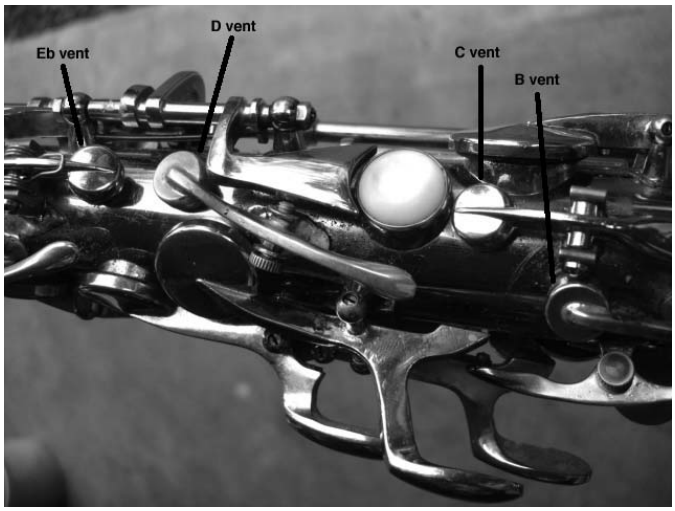


Figure 6
Detail showing the octave vents for (left to right) low Eb, D, C, and B, clustered around the left thumb rest.

below the low Bb octave vent, in an experiment to find "other nodes" to be discussed in Part II of this article (to be published in a follow-up issue of *Saxophone Journal)*.

NAMING CONVENTION FOR PITCHES DISCUSSED

For the remainder of this article I will refer to the lowest pitches on the saxophone as "low Bb" through "low G#." Pitches above these are referred to as "middle A" through "middle F#." Moving upward, G at the top of the treble staff is referred to as "high G" and notes above it are "high G#" through "high F#." Beginning with the G that is four ledger lines above the treble staff, all pitches are referred to as *altissimo*.

Figure 7
A chimney and sleeve for the middle Bb octave vent are soldered onto the neck.

Figure 8
Detail of an added key mechanism.

HOW OCTAVE VENTS WORK

Air Columns And Nodes

All woodwinds operate on the principle that air is blown over a reed (or a sharp edged surface, as on a flute) to set the air column vibrating inside an instrument. The length of the air column is determined by the number of keys pressed and held closed. The more keys pressed, the longer the air column, and the lower the pitch produced. When we play

a low F on the saxophone, the air column ends at the upper edge of the tone hole just below the F key. When we play a low Bb, there is no other tone hole that remains open (except, of course, on low A model saxophones) and the air column ends at the bell.

The saxophone's octave vents (and those of the bassoon and oboe) work by partially interrupting the vibration of the air column. Pressing an octave key uncovers a small hole partway down the length of the air column, creating an opening where a small amount of air can escape. Fingering a low note (without any octave key) and blowing air into the instrument produces the fundamental (also called the first harmonic) for that fingering. Fingering the same low note and pressing an octave key causes the fundamental to be dampened, and the 2nd "harmonic" or "partial" (also referred to as the 1st overtone) to take over. The 2nd harmonic is one octave higher than the fundamental (see Figure 9).

There is a 3rd harmonic that is perfect fifth above the 2nd harmonic, and a 4th harmonic that is a perfect fourth above the 3rd harmonic. These are normally achieved using extra manipulation of the embouchure, oral cavity, or both. There are, of course, many more harmonics that extend far above the 3rd and 4th harmonics, all of them making up the "overtone series" for the note fingered on the saxophone.

PRODUCING A PERFECT OCTAVE

To produce the 2nd harmonic one octave higher with the greatest accuracy of intonation and ease of playing, the vent opened by pressing an octave key should be placed half way up the length of the air column. The exact placement of an octave vent for a note on the saxophone must take into account several factors including the increasing width of the saxophone's conical bore, but for most intents, it is sufficient to discuss the best placement as half way up the length of the air column for the fingered note. I placed each new octave vent at the exact position where it would meet the "node" of the air column that causes the sounding of the 2nd harmonic.

I consider the placement of the existing octave vent on the body to

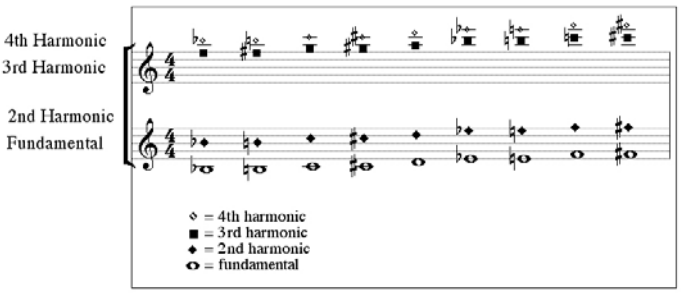


Figure 9
Low Bb though low F# on the saxophone, with their 2nd, 3rd and 4th harmonics (or partials).

be just about perfect for use with low F. It is almost exactly half way up the air column for a low F (see Figure 10). Accordingly, I did not drill a new octave vent for that note. Physical measurements of air columns and placement of octave vents must take into account the added air column length that would extend past the saxophone mouthpiece if the mouthpiece were absent, and the conical air column not truncated, as designed by Adolphe Sax (see Arthur H. Benade's *Horns, Strings and Harmony*, published by Doubleday & Co. Garden City, N.Y., 1960, pp. 213-214).

FRANKENSAX PART II

In part II of this 2-part series, I'll continue with "understanding the basic physics," "Adolphe Sax's Plan to use two approximate vents," "three pitches per octave vent," "the impractical first finger half hole," "the

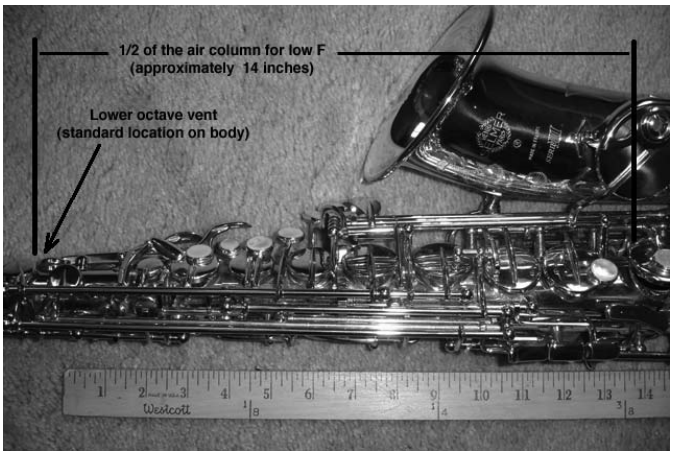


Figure 10
Measurement showing the length of the air column for low F on an alto saxophone, and the standard octave vent on the body, located approximately half-way up the air column.

results of using 12 octave vents," and "finding other nodes." I will also make conclusions about my experiments, and offer some suggestions for future saxophone designs.

Appendix 1
LIST OF THE ALTERNATIVE "NATURAL" OCTAVE KEYS ALREADY ON OUR SAXOPHONES

As stated earlier, there are many keys already on all saxophones that can very effectively be used as alternate octave keys, especially when opened only a tiny bit so as to imitate the function of a small octave vent. Below is a list of alternative octave key options:

Original Low Pitch	Its Natural Octave Key
low Bb	Side Bb key
low Bb	Lift 2nd finger A key
low B	Side C (not in tune)
low C	Side C
low C#	Lift 1st finger B
low D	high D key
low Ed	high Eb key
low E	high E key
low E	regular octave vent is also good
low F	high F key
low F	fork F key
low F	regular octave vent is also good
low F#	high F# key (if available)

The alternative octave keys listed above are available on all modern saxophones. For general practice of intonation, they can be very useful (for example, comparing the pitch of a fingering using its alternate octave key with that of the same fingering using the "regular" octave key). In performance, these fingerings can solve many problems, provided you have enough time to employ them. Using them in fast passages is often unfeasible.

Since the octave vent located on the body of the saxophone (opened by the regular octave key) is in a near perfect position for use with F or E, there is little need to use "alternative" octave vents to produce middle F or E.

Appendix 2
A NOTE TO SERIES III PLAYERS

The Selmer Series III saxophone has an very nice auxiliary C# key

that opens in the middle register to improve the intonation of middle C#, but closes automatically in the upper register. As an experiment, I have disabled the automatic mechanism for this key, and added a simple (non-permanent) device that lets me manually open/close this key at will. I am able to use this auxiliary C# key as an alternative octave key very satisfactorily for making low C# jump to an excellent middle C#. §

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