

# The Vienna Horn - a historic relict successfully used by top orchestras of the 21. century

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After a short introduction into the historic evolution and a discussion on the particular design of this type of instrument follows a detailed comparison with the modern double horn. Input impedance measurements, FFT and other acoustic measurement methods show the influence of the tube length, diameter and shape, F-crook and Uhlmann valves on the sound and response. In comparison with the modern double horn the consequences on the playing technique and performance control are discussed. Sound examples proof the relevance of the results.

## 1 Introduction

The Vienna Horn (Fig. 1) is used by all top orchestras in Vienna with two exceptions: the RSO (Radio Symphony Orchestra) which performs mainly contemporary music and the VBW Orchestra (Vereinigte Bühnen Wien) which plays exclusively musicals use depending on the performed music common double horns and only sometimes the Vienna Horn. The rest of the Austrian orchestras have mixed horn sections, some have exclusively Vienna Horn sections.



Figure 1: Vienna Horn built 2004

## 2 Short History

In 1700 the "Gebrüder Leichnamtschneider" in Vienna presented a new designed handhorn which differed significantly to the well known hunting horn and which should become the common type of orchestra horn for the next 200 years. 1818 the first patent on valves was assigned to Heinrich Stözel and Friedrich Blümel and 1830 the Viennese instrument maker Leopold Uhlmann filed an application for a patent on a new

"double piston valve" which is still used today for Vienna horns (see Fig. 1 and 6).

With the invention of the rotary valve (Fig. 6) by the Viennese instrument maker Joseph Riedl 1832, the Uhlmann valves which were used for all brass instruments gradually disappeared, because of their heavier mass. The triumphal procession of the rotary valve was an important pathfinder for the next step in horn evolution: as a rotary valve could be designed two-storied, two independent tube systems could be switched simultaneously by one valve! The invention of the double horn was therefore only a question of time and took place 1899 in Erfurt (Germany) by Eduard Kruspe (Fig. 2).

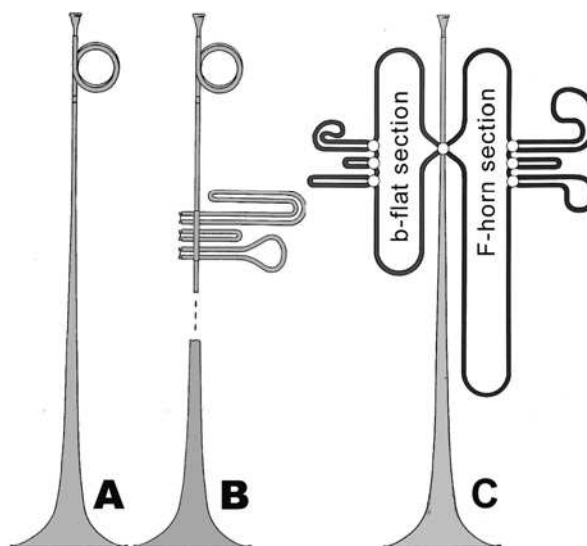


Figure 2: Schematic representation of a natural horn (A), a Vienna Horn (B) and a F/Bb Horn

The idea behind was to switch to a shorter tube (Bb with a tube length of 2.8m). The consequence on the performance control was a better accuracy and less risk for "landing" on a wrong note ("cracks"). On the other

hand, the shorter tube changed the relationship between the length and the bore diameter. The result was less partials at the same sound level, which means a more "dull" timbre and less possibilities for the player to change the colour of the sound consciously.

It is interesting that players and instrument makers favouring the double horn sacrifice the advantage of sound modulation for the benefit of marksmanship.

It can be stated that the main properties of the modern Vienna horn are the same as those of the handhorn in the 18<sup>th</sup> century (bore profile, length, detachable crook, bell shape). The used type of valves is based on an invention made in 1830.

The main reason for the hold on this type of instrument is, that the Viennese musicians (and audience) favour the large variety of possible sound colours although they are aware of an increasing risk of "cracked" notes. [1].

### 3 Peculiarities in the design

The characteristic look of the Vienna Horn is mainly determined by the F-crook and the Uhlmann double pistons and it's interesting that just these two components have no essential influence on the particular sound and response of the instrument. What is always visually striking about the Vienna horn is its separate F crook approximately 105-120cm in length, though the fact that it is removable has no effect at all on the quality of sound, response or intonation. It is true, however, that different crooks can subtly alter the character of the instrument since the F crook comprises almost one third of the total tube length.

Similar can be stated for the valves: although the experience shows that 'smooth' legato slurs in which the notes appear to flow into one another are often easier to carry out on the Vienna horn, investigations showed, that it is the position on the instrument and not the type of valve which influences the microstructure of slurs.

The contribution of the length of the tube, its cross section and the shape of the bell to the peculiarities of the sound and playing technique of the Vienna Horn is, however, nearly 90%.

### 4 Length of the tube

From the mouthpiece to the end of the bell section the tube length of the Viennese type of horn is about 3.7 metres. With the double horn the player uses the thumb valve to change from one instrument to another: from the 3.7m F horn to the shorter 2.8m Bb horn; with the triple horn the player has a choice of three instruments including an F-alto horn with a tube length of about 1.85m.

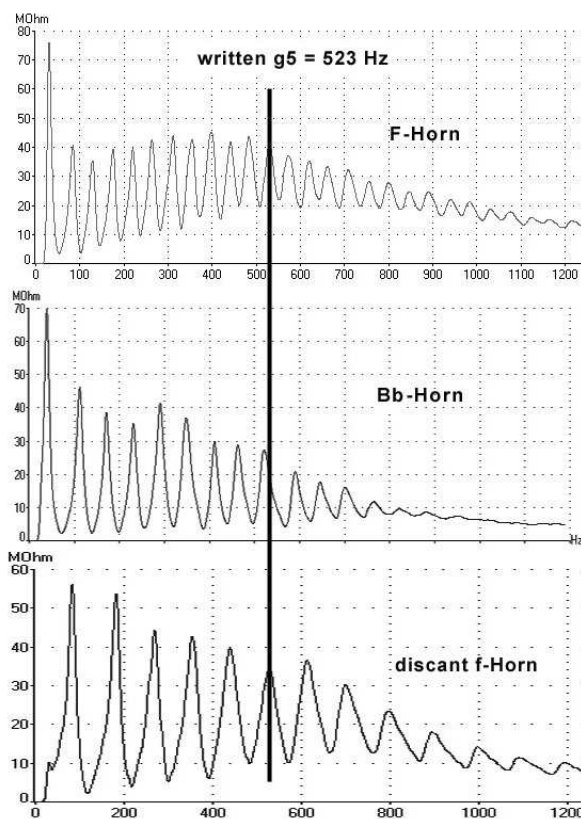


Figure 3: Input impedance of a F-Horn, Bb-Horn and F alto-Horn

Figure 3 shows the measured input impedance curves, the 'acoustic fingerprints' of the three types of horn.

Without going into too much detail, it is a fact that the horn-player usually produces a note (natural harmonics) at those frequencies where the curve shows the greatest amplitude (peaks). The higher the peaks the easier it is for the player to play the harmonic concerned. As can be seen from the curves, the F-alto horn requires the smallest amount of energy (it has the highest peaks). Why should this be so?

#### 4.1 Required energy input

With the flow of air passing through the lips (=energy) the player must cause the air column within the instrument (=mass) to oscillate at the required frequency. Being half the length of the Vienna horn it is clear that the air column of the F-alto horn possesses only half the mass. Therefore a comparable amplitude of oscillation (= volume) also requires only half the energy. In short, in order to produce a standing wave of comparable intensity in the instrument (= volume), the player has to use more energy with Vienna horn than with a double horn.

Tests using a sinusoidal excitation signal with an amplitude of 103 dB and an onset time of 20ms show that the Vienna horn's onset time is about 100-108ms, for the Bb-horn its 90-98ms and for the F alto horn about 60 ms.

The standing wave of the Vienna horn shows an amplitude of about 110-114 dB, the Bb-horn 112-115 dB and the f alto horn 115-118 dB.

## 4.2 Consequences for playing technique

However, that is true only for the start of the note (the first 20-100 milliseconds) in which the oscillation within the instrument is set up. Once the note is present the amount of energy lost through dissipation (what we hear as the characteristic 'sound' of the instrument) and through inner friction merely has to be replaced. This effect is of greater significance for playing routine in those works which contain repeated staccato passages or many short-value notes in the upper register (as for example in Verdi's operas). Such parts are more tiring for Vienna horn players, whereas the many sustained notes in the works of Wagner or Bruckner, for example, favour the Vienna model since less energy is dissipated by the somewhat narrower bell-throat and so less has to be replaced.

## 4.3 Accuracy and "split" notes

Pitching notes with accuracy is to a large extent determined by the overall length of tubing involved. It is a topic which interests players and audience alike, associated as it is in the public's mind with the well-known sound of 'split' notes.

If one compares the relationship of the peaks (i.e. playable harmonics) on the frequency axis (Fig. 3) it can be seen that the distance between them diminishes as the tube length increases. On the F alto horn the distance between individual harmonics is 88 Hz, on the Bb horn 58 Hz and on the Vienna low F horn only 44 Hz. For written  $g^2$  on the Vienna horn this represents a semitone, on the Bb horn a tone and on the F alto horn a third. What is more, although the Hertz relationship between individual harmonics is the same throughout the playing range, our brain perceives the distance between the first and second peak as the musical interval of an octave, the same distance between second and third peak as just a fifth, and so on, while between the twelfth and thirteenth peak we can only hear a semitone.

This means that the player of the Viennese instrument has to adjust lip tension with much greater accuracy than the double horn player to the required note frequency in order to avoid 'landing' on a neighbouring peak. Playing the Vienna horn in the upper register consequently requires rather more concentration and

more accurate control of the musculature (minute motor activity).

## 5 Bore profile and sound

The diameter of the cylindrical tube section of Vienna horns is about 10.8mm, while double horns have a considerably wider bore of 11.5-14mm (depending on small, medium or large model). As with tube bore, the bell and bell-throat of the Vienna horn are also narrower, but even differences of a few tenths of a millimetre have a significant effect on the sound.

A narrower bore leads to a greater frictional loss in the standing wave on the inner surfaces of the tube (a factor in all brass instruments!). This is because the oscillation of the air particles is massive limited in an area of 0.2mm distance of the inner surface of the tube. Comparing the proportion of this layer with the total cross section area it can be seen that the share of this layer is 4% of the total cross section using a tube with 11mm bore profile and only 2.6% at a cross section of 15mm.

To compensate for this and the larger mass of the air column of the Vienna horn, more energy (amount of air) has to be introduced during the same time slot. Looking at the lip opening during a *crescendo* one can see a continuously enlargement of the open area till it is limited by the mouthpiece rim. At this point, if the player strengthens the air pressure in the mouth cavity furthermore, the motion of the lips changes significantly: the phase of opening and closing becomes shorter and the phase of complete opening is significantly elongated. Figure 4 shows the cross section area (and the quantity of air which is directly proportional) before and after the limitation of the mouthpiece rim.

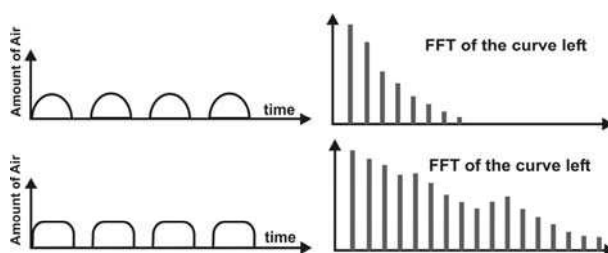


Figure 4: Cross section area and air quantity (left) blown into the instrument before (top) and after limitation by the mouthpiece rim (bottom). Right: corresponding sound spectrum.

Calculating a FFT of such kind of curves explains the significant increase of the harmonic content. The differing combination of partials can be clearly seen in Fig. 5, which shows the spectrum envelopes for a written  $e^5$  played fortissimo with different types of horns. All notes played at the same sound level!

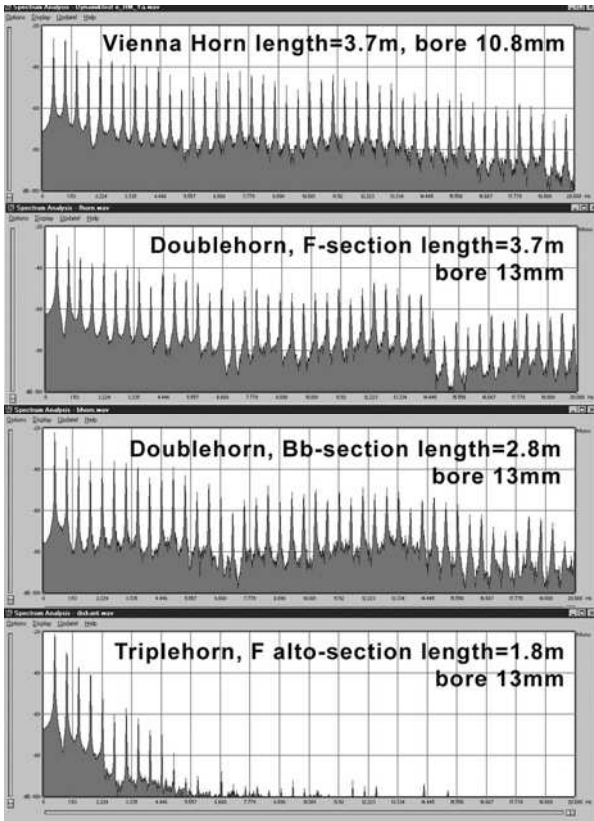


Figure 5: Spectrum envelopes for written e2, played fortissimo. Top to bottom: Vienna horn (55 partials), F-section of a double horn, Bb-section of a Double horn, F-alto-section of a triple-horn (28 partials) with the same sound level.

## 6 Legato slurs and the valves

Apart from the F crook the most significant visual feature of the Vienna horn are the double piston valves. (see Fig. 6).

Experience shows that ‘smooth’ legato slurs in which the notes appear to flow into one another are often easier to carry out on the Vienna horn. Even when executed faultlessly, fast note sequences are usually somewhat less sharply defined and may sound fuzzy. On the double horn (in an adagio passage, for example) smooth slurs are more difficult to play. On the other hand the more abrupt change from one frequency to another has its advantage in rapid passages. These are not only easier to play on account of the clearer separation between notes; they also sound technically more brilliant.

Fig. 7 shows the three-dimensional pattern formed by a slur in which a short noise band between the two notes of the double horn, lasting about 15 milliseconds, is clearly visible. Until recently this effect of a slur on the sound pattern was attributed to the different types of valve mechanism.

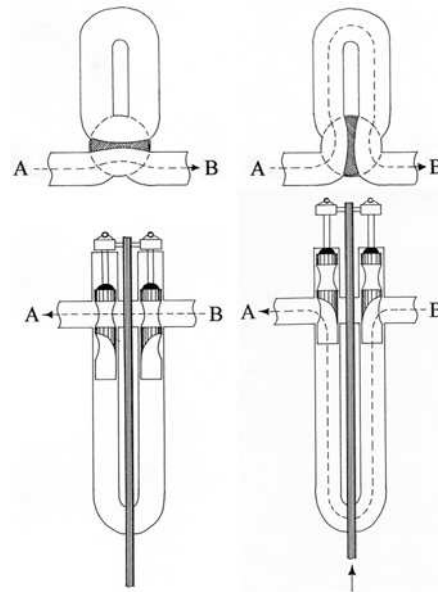


Figure 6: Worldwide used rotary valves (top) and the Viennese double piston valve invented by Leopold Uhlmann 1830 (bottom). Open instrument (left) and pressed valve (right).

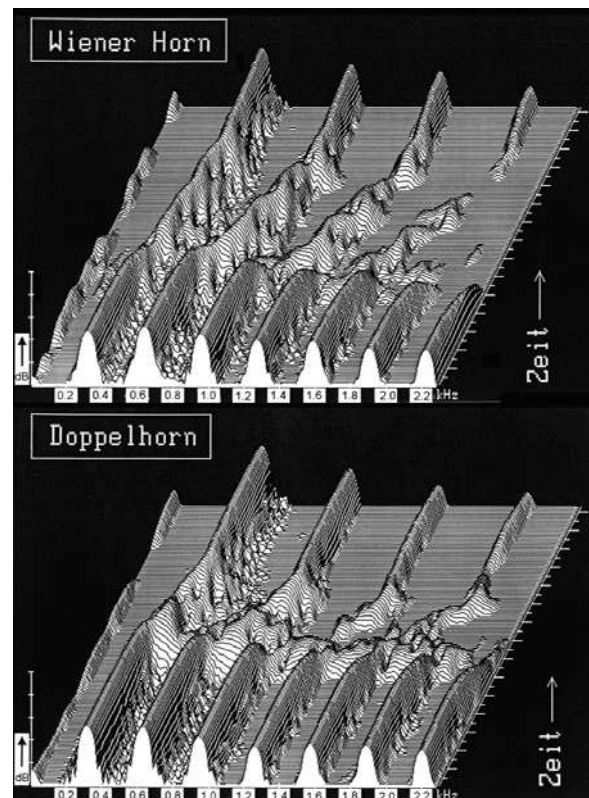


Figure 7: Three-dimensional pattern formed by a slur. Horizontal: Frequency, from front to back: time, vertical: amplitude in dB. Top: Vienna Horn, the notes appear to flow into one another; bottom: Double Horn, the change from one frequency to another is characterized by a short noise band between the two notes.

New research, however, shows that it is not the type of valves so much as the position on the instrument that is the determining factor [2].

If the valve mechanisms are placed in a similar position on the tubing the sound of a slur with a Vienna valve is absolutely identical to that of a rotary valve! If the valve during a slur is situated at a point where the standing wave within the instrument for the starting note possesses an antinode the slur will be 'abrupt, clear'; if it is at a node the slur will be 'smooth'. Fig. 8 shows the input impedance inside the mouthpiece in the plain of the lips during a slur.

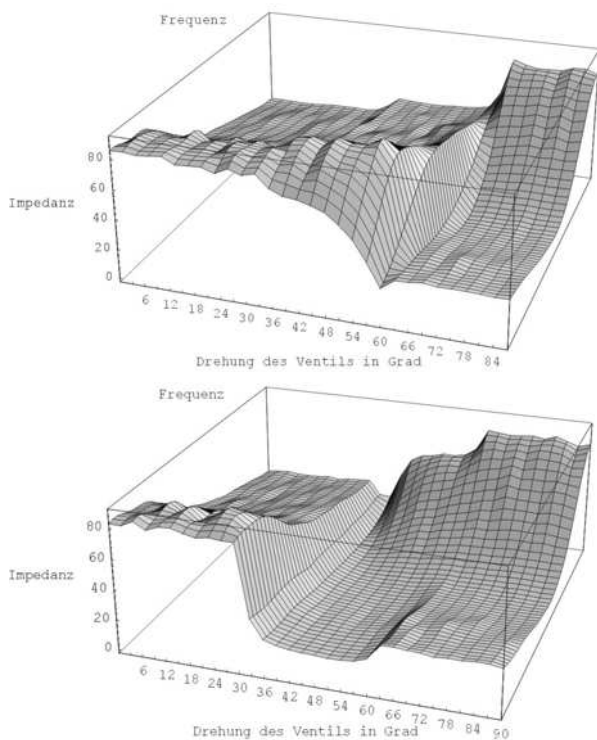


Figure 8: Changes in input impedance inside the mouthpiece in the plain of the lips during the performance of a slur. Top: smooth slur, the valve section is positioned at a node of the standing wave. Bottom: clear and abrupt slur, the valve section is positioned at an antinode of the standing.

As the valve finger-plate is depressed the player makes constant adjustments to the tension of the lips in such a way as to move from the frequency of the starting note to the frequency of the target note. In the diagram the player 'travels' from front left (starting note) to back right (target note). If positioned at an antinode the break of the standing wave after the first third of the slur, which causes the noise band, is clearly seen. If, on the other hand, the valve mechanism is positioned at a node the continuing high impedance allows a smooth, glissando-like slur.

## 7 Summary

The typical Viennese style of horn-playing can be seen as a consequence of the instrument itself, as well as of a musical taste transmitted from generation to generation, combined with the musician's own personality and preference.

Vienna horns are characterised by a more distinctive 'spectrum dynamic'. The player is in a better position to affect the tone colour. On the whole the player has available a greater palette of possible tone colours than with the double or triple horn. For the same input by the player the Vienna horn sound is fundamentally richer in partials, while the total volume of sound produced is somewhat less. The psychoacoustic fact, that the impression of *fortissimo* for the audience is mainly determined by the sound colour and not by the objective sound level means, that Vienna horns playing 'fortissimo' are less likely than double horns to 'hide' or mask other instruments (such as the violins in symphonies by Bruckner).

In contrast, the 'energy requirement' is (sometimes) rather greater, as also the need in the upper register for a more exact adjustment of lip tension in order to avoid 'cracked' notes.

The positioning of the valve mechanism in the Vienna horn enables the player consciously to influence timing and tonal quality of a legato slur. A smooth, glissando-like merging of notes is helped by the position of the valves. But in very fast note sequences ('runs') the separation of the individual notes is less easily heard by the listener.

The Vienna horn gives the player a greater range of possibilities for musical articulation. In sustained notes the sound quality is fundamentally richer in partials. In changing note sequences the player has better control in articulating slow procedures (slurs), though rapid sequences tend to show up an inherent sluggishness (tube length!). This has to be counteracted by increased concentration and energy input on the part of the player.

## References

- [1] G. Widholm, 'Akustik und spieltechnische Besonderheiten des Wiener Horns'. *Proc. "Das Instrumentalspiel"*, Doblinger, Wien, pp. 157-185 (1989)
- [2] G. Widholm, 'Influence of valve mechanism on the microstructure of slurs played with brass wind instruments', *Proc. Institute of Acoustics*, Vol. 19, Part 5, St. Albans, UK. pp. 407-412, (1997).