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# The influence of valve mechanism of brass wind instruments on the microstructure of slurs - new results

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**Abstract:**
**The sound characteristic of brass wind instruments is determined highly by transients: the starting transients, slurs (transients between two notes), etc. Experiments with musicians revealed, that there is a distinct difference in sound characteristic which depends on the type of valve (rotary-, perinet valve,...). New investigations show that it is not primarily the type of valve which determines the sound difference, but the valve's location within the cylindrical tube. Using newly developed computer-systems, the acoustical characteristics within the instrument during a slur can be illustrated by threedimensional diagrams.**

## 1. INTRODUCTION

Whether a slur with a brass wind instrument can be executed successfully or not depends on the acoustical behaviour of the instrument during the slur. An important factor is the transition region between the starting tone and the target tone.

Two points are of interest:
1. the length of this transition region compared with the overall length of the slur,
2. the shape of impedance for this region (high or low).

## 2. MEASURING METHODS

In order to achieve the impedance characteristic during a slur, it was necessary to make many measurements during the valve action. On this behalf the distance between "not pressed" and "pressed" valves was subdivided into 30 parts. This means, that an impedance measurement was made each 0.5mm for the perinet valve and every 3° of rotation for the rotary valve.

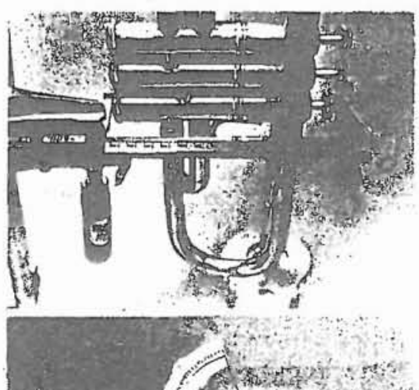

**Fig.1: Mechanical devices for subdividing the valve movement into 30 parts.**

## 3. RESULTS

Fig. 2 shows a typical example: the diagrams on the left side illustrate the measured impedance values of the fundamental frequency of a slur on the trumpet. The waterfall spectra on the right side show the shape of the transients of the first three partials of the sound played by a musician, and verify the measured acoustical characteristic of the instrument during the slur. How can one read the impedance diagrams on the left side: the three axes represent the following: the X-axis - valve movement, the Y-axis - impedance value and the Z-axis - frequency. When the musician plays a slur, he starts at the front left corner and ends at the back right corner. During the execution of the slur he changes the tension of his lips from the starting frequency to the target frequency.

The upper left diagram (Perinet valve trumpet) shows high impedance values between the starting and ending points. This means at each point of the slur there exists a standing wave inside the instrument, which favours a continuous transition between the two tones. The wide "valley" of the lower impedance diagram (rotary valve trumpet) causes a short "noise band" between the two tones and sometimes (like in our example here) even a break down of the standing wave inside the instrument. For a short time the tone sounds weak. This effect (abrupt change in frequency) can be seen in the waterfall spectrum.

The comparison of numerous diagrams of both trumpet models [2] (and also two French horn models [1]) shows no simple relationship between the trumpet (or French horn) models and their characteristical slurs. Therefore it is not possible to say, that perinet valves cause only continuous legato, rotary valves only abrupt change of frequency, or vice versa. Both kinds of instruments have nearly the same number of continuous/abrupt frequency changes during a slur, but at different tones.

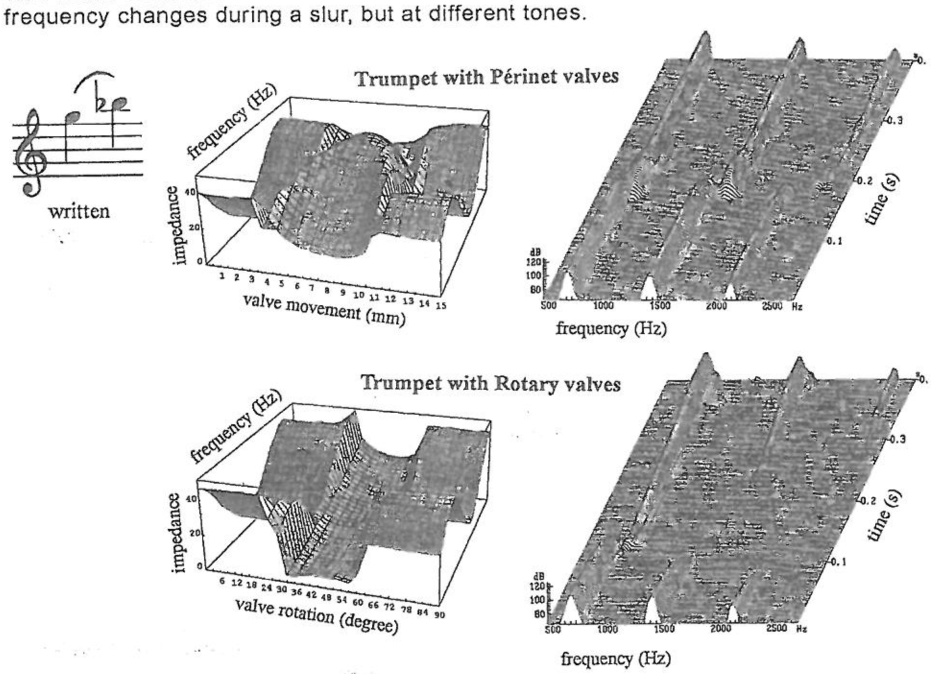


**Fig.2: On the left side are the measured impedance values of a trumpet during a slur (g5-Bb5), on the right side are the waterfall spectra of the corresponding tones played by a musician.**

Fig. 3: For this slur the situation is reversed (compared with Fig. 2): here the abrupt change of frequency occurs with the Perinet valve trumpet and the continuous change with the rotary valve trumpet.

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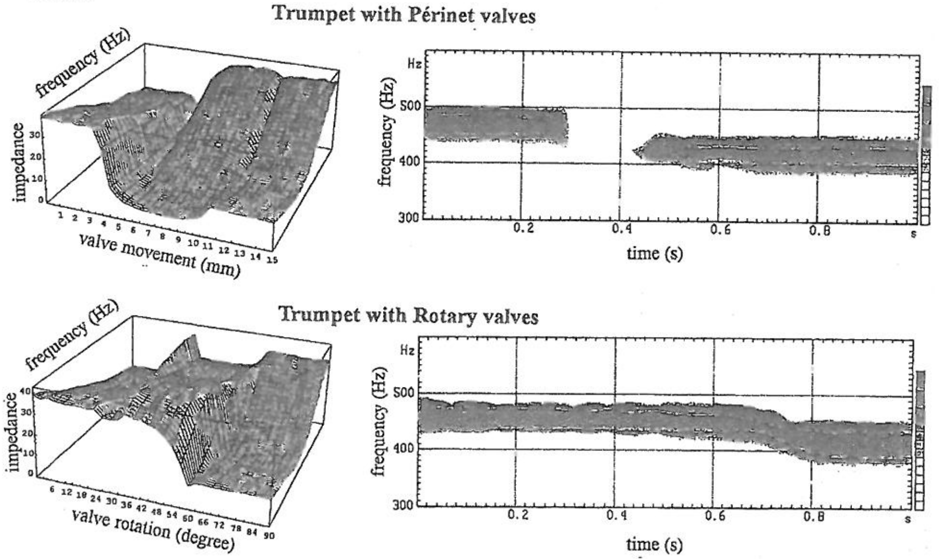



## 4. REASONS FOR THE DIFFERENCES IN IMPEDANCE DIAGRAMS

The question is, what causes the observed differences in the impedance diagrams. Both trumpet models have not only different types of valves, but also another important difference: the valves have different locations within the instrument. Therefore there could be two reasons for the differences in the transition region of the diagrams. Many investigations show that the shape in this region (i.e. the middle section) is determined exclusively by the location of the valve within the instrument.

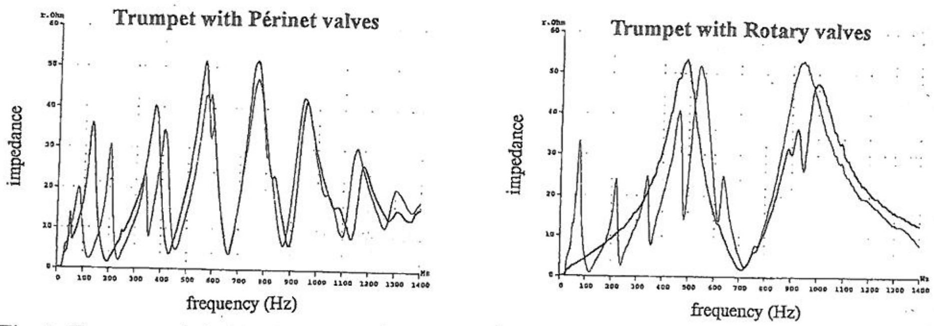



**Fig. 4: The curves in bold print (impedance spectra of the tube ending at the first valve) and the thin curves (spectra of the entire instruments with half pressed first valves) show remarkable similarities. This means that a large amount of the energy is reflected by the half pressed valve.**

The impressive similarity of the curves in bold (impedance spectrum of the tubes ending at the first valve) with the thin curves (impedance spectrums of the entire instruments with half pressed first valve) for both trumpet models allows the inference, that much energy is reflected at the half pressed valve. For frequencies higher than 600 Hz a half pressed valve means the same acoustical termination just like an open end of a tube (see Fig. 4).
Fig. 5 shows the usual locations of the valves and the test location (43cm). The experiment with both valve types at the same location within the trumpet brought forth an interesting result: there are almost no differences in the diagrams. Measurements of other slurs and at other locations confirm this result. Therefore the influence of the valve's location for slurs is evident.

**Fig. 5: The Perinet valves trumpet has valves between 70cm and 80cm behind the mouthpiece. The rotary valve trumpet, on the other hand, has valves between 20cm and 30cm behind the mouthpiece. In order to rule out the influence of these different locations, the first valve of both types were positioned at ca. 43cm.**

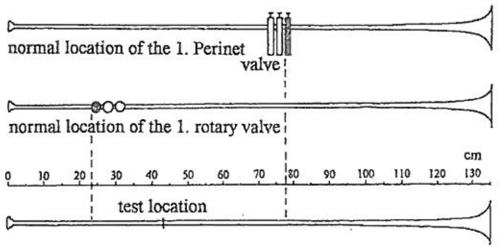
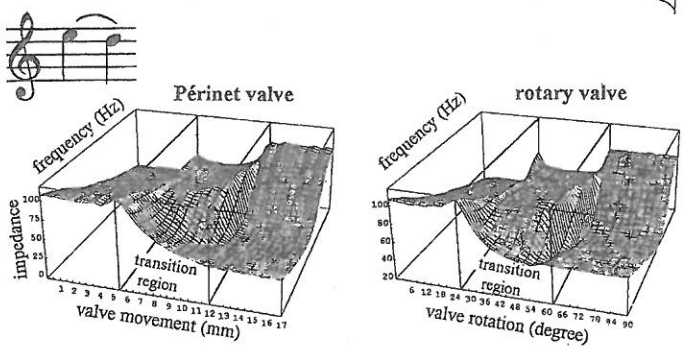



**Fig. 6: The diagrams of test-trumpets (with both valve types at the same location) are nearly identical. This means that the shape of the impedance within the transition region is determined only by the location of the valve.**




<u>But the width of the transition region is determined by the type of valve, and can differ between valves of the same type</u>. The latter resulted in an investigation of three rotary valve trumpets. The cylinder of the valves have different bore diameters. The bores are important therefore, because so long as there is no contact between the vibrating air column and the air within the slide (up to 4mm for the tested Perinet valve and up to 24° of the rotation of the tested rotary valve) the impedance spectrum is almost adequate to the spectrum with inoperative valve.

## 5. CONCLUSION

In most cases a well-trained musician can be able to executed a clear slur by bridging the impedance "valleys" quickly, but surely he feels the resistance of an impedance "valley" or the supporting effect of high impedances. The short cracking noise or "noise band" caused by wide impedance "valleys" are not masked completely by the starting and the target tones, meaning that they can often be heared. The named influences of the location and the type of valve on slurs have been noticed also for French horns.

**References:**

[1] WIDHOLM, G. and SONNECK, G. Wiener Horn versus Doppelhorn, Vienna (WWV Verlag) 1989

[2] CAMPIDELL, S. Die Mikrostruktur von Ventilbindungen bei Trompeten (Dipl.-Arb.) University Vienna 1995