Exciting Your Instrument

Richard Smith

The lungs of a brass player expel air through the vibrating lips. The various forces on the lips during playing are well-documented, but quite complex. It is sufficient to say that the mouthpiece throat acts as a resistance to the airflow giving the lips an "air-spring" to vibrate against. The airflow is modulated by the vibrating lips thus giving it two distinct components (Figure 1):

- An *alternating component* we shall call a.c. that excites and maintains the note in the instrument
- A *direct component* we shall call d.c. that, having caused the lips to vibrate and passed through the mouthpiece throat, plays no further part in the sound production.

The terms a.c. and d.c. are analogous to their equivalents in electrical circuits.

That techical explanation of instrument excitement should help players understand how they make notes, but until now, it has been impossible to demonstrate this principle. The experiments described here show that notes can still be produced when the constriction is put *on the side* of the mouthpiece and the instrument is sealed off by a thin membrane. The membrane transmits only the a.c. airflow into the instrument, setting up a steady oscillation in the normal way.

A regular medium-bore trombone mouthpiece was used for this experiment (in preference to a trumpet mouthpiece) to make working with diaphragms and mouthpiece throats easier. The mouthpiece cup was cut into two parts and a thin membrane, forming a diaphragm impervious to air and water, was stretched across the throat/backbore part to effectively seal off the instrument. The other part of the mouthpiece, mainly the rim and widest part of the cup drilled with a hole the size of the mouthpiece throat in its side to allow the air from the lungs to discharge, was fitted carefully on top of the diaphragm.

The D.C. Component

The effect of the throat of a mouthpiece was not obvious until tests were performed with the modified mouthpiece. It was almost impossible to get the lips to vibrate under these conditions of using a small side hole. However, a solution was found by comparing this acoustical problem with the electrical analogy of a.c./d.c. decoupling – as used in most electronic circuits (Figure 2). This shows that a *resistance* is needed for the d.c. flow to occur. To provide this resistance acoustically, a narrow tube was placed in the side hole to give enough air resistance for the lips to vibrate against and to enable sustained vibration (Figure 3). Furthermore, if the tube is closed at the outer end during note production, the note stops immediately because the d.c. flow is cut off and the lips cannot vibrate. When reopened, the note starts again. This is exactly the same as tonguing, except it occurs *after* the lip vibration. Similarly, in an electrical circuit, it does not matter whether a switch is before or after the light bulb – it will still switch it on and off! In many ways, opening and closing the tube with the finger (or mechanically) is easier than tonguing and can produce a very fast repetition of notes.

The notes produced by this mouthpiece were not different in pitch or sound to those normally played. However, it did take more effort to sustain the notes because the diaphragm absorbed some of the energy.

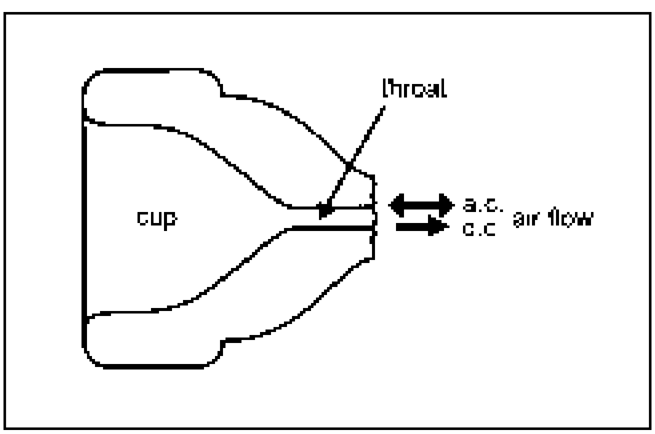

Figure 1. Section through a brass instrument mouthpiece.

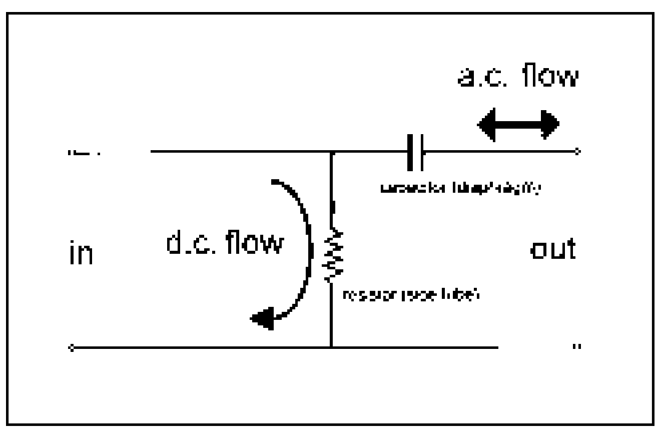

Figure 2. A.C. coupling for an electrical circuit and its similarity to a modified mouthpiece.

The A.C. Component

The "wave," often a sign of audience boredom at stadia events, illustrates how the alternating part of the air travels through the instrument. The wave can travel faster than anyone can run around a stadium; the participants themselves only move a few feet up and down. This analogy is quite accurate, except that in the case of air particles, they cannot see the wave coming and have to wait for their neighbor to pull and push them sideways (in the direction of the wave – hence "longitudinal" wave) before passing their energy onto the next particle. In the same way, the diaphragm in our demonstration and the air particles in the bore of an instrument move only 1.0mm (1/20 inch) from side to side when playing *fortissimo*. Apart from this movement they are stationary and their vibration is passed onto the next particle and so on down through the instrument. This is a longitudinal wave of energy that is travelling at the speed of sound (350 m/s or 780 miles per hour) – far faster than any air particles you can blow into the instrument!

Because the original throat has become redundant in providing an air resistance, it can be drilled out to the instrument's bore size (1/2 inch) as shown in Figure 4. When blown, the modified mouthpiece showed no adverse change. If anything, the output from the instrument was improved.

Earlier work illustrates this a.c./d.c. effect in a practical way, where a resistive or stuffy trumpet found to have debis (in the form of loosely packed flakes of silver from the plating process) in the crook of the bell, did not give any resistance to air blown through the instrument (d.c. flow), but was noticeably affecting the a.c. flow as detected by a player. [See: "It's all in the bore!" by Richard Smith, *ITG Journal,* May 1988, pp. 42-45] From this discovery, pulse testing equipment was developed to analyse the reflections caused by similar faults.

The author is grateful for help and advice given by Dudley Bright, principal trombonist of the Philharmonia Orchestra, London.

About the Author: Richard Smith wrote a doctoral thesis on trumpet acoustics before joining Boosey & Hawkes, where he worked for 12 years as chief designer and technical manager responsible for Besson brass. He designed several Besson Sovereign instruments, including the original trumpets used by Derek Watkins and John Wallace. For the past 15 years, his own company has been designing the Smith-Watkins instruments for leading players. He has continued research into the acoustics, testing, and development of brass instruments and is a much sought after presenter of technical lectures and workshops.

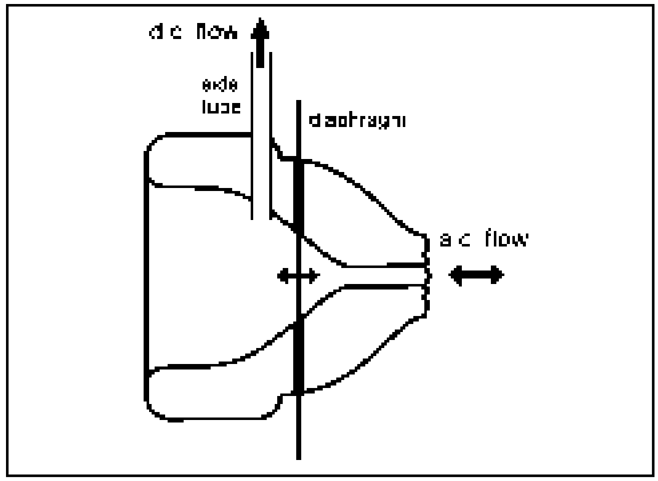

Figure 3. Modified mouthpiece with a diaphragm across the bore and a 'throat' through the side of the cup.

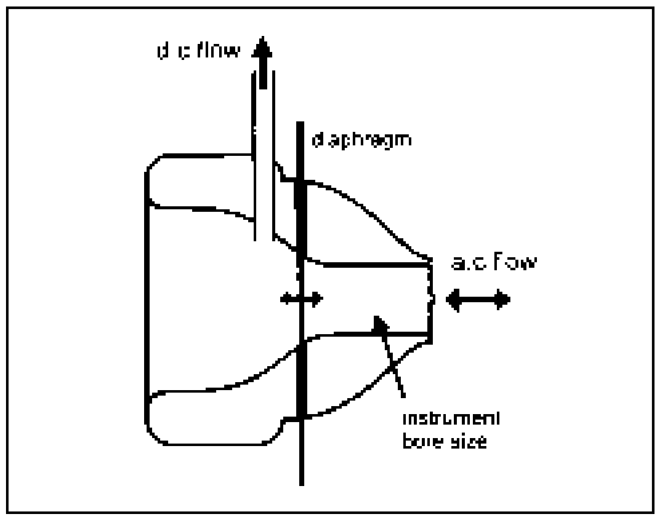

Figure 4. Mouthpiece with with enlarged throat.

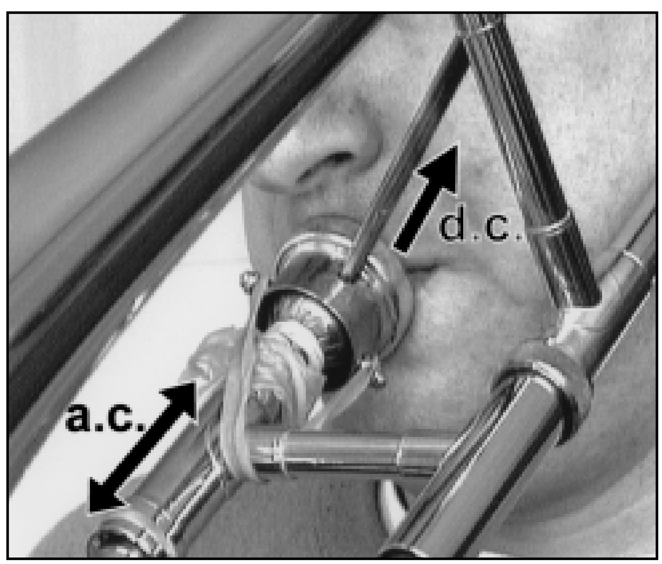

Figure 5. The modified mouthpiece in use with a trombone. This size instrument was chosen to make working with diaphragms and mouthpiece throats easier.