Brass Instruments

How Brass Instruments Work

Trevor
I'm standing in the factory where Besson brass musical instruments are built. Since the 19th century Besson has been associated with the technology and manufacture of brass instruments. It's an appropriate place to start this film, which is about the technology of brass instruments.

There are three broad themes that I want to explore. Firstly the basic acoustical principles of brass instruments. Secondly, the way in which technical developments have affected brass instruments and thirdly the relationship between those developments and performers. Indeed in the final sequence of the film we'll be looking at ways in which the latest scientific research is casting new light on that complex relationship.

Caption
how do brass instruments work?

Murray
The one feature which links all brass instruments oddly enough is not the material they're made of. It doesn't matter whether they're made of brass or not but it's the fact that the sound is generated by getting the player to buzz their lips…

…and it's the opening and closing of the lips which generates the sound. That's the characteristic of all brass instruments.

Arnold
The three instruments we see in front of us, a conch shell, an animal horn and a natural brass trumpet are all made so the player can place the lips comfortably against it and blow through the tube vibrating the lips.

Arnold
The conch shell is a naturally constructed tube wrapped round and round with a large opening. The player can place their lips against the small end of the conch shell which has been cut off at that point.

The animal horn similarly has been hollowed out and has a termination, which is fairly comfortable for the player to place their lips against.

But like the conch shell it only plays one good note so these simple instruments have tended to remain as signalling and ceremonial instruments.

Murray
I suppose the first crucial thing was the development of wood and metal working technology which actually allowed people to manufacture tubes of pre-designed form rather than just accepting something which already existed. So wooden trumpets and metal trumpets which go way back of course to the time of the ancient Egyptians, that was the first stage in controlling the shape of the air column that you were going to use as your resonator.

Arnold
The elements of a natural trumpet which turn it from a signalling instrument into a truly musical instrument are, first of all the mouth piece and at the other end the bell flare, which is critical for the reflection of the sound waves inside the instrument.

Murray
The mouthpiece is really serves two functions, one is to allow the lips to be pressed against it and the other is to modify the timbre of the sound.

And when the player buzzes the lips in the mouthpiece [BUZZES LIPS]
the pulses of air that are sent through the lips by the lips opening and closing set up standing wave vibrations in the air column and that's what generates the sound.

Trevor
And does all of the air come out carrying musical notes with it?

Murray
It's an interesting question. In actual fact almost all of the sound energy that the player sends from the lips down through the tubing is reflected when it gets to the bell. That's quite hard for people to appreciate because the bell is open and it doesn't seem obvious why the sound shouldn't just simply radiate out through it but in actual fact more than 90% of the sound energy is reflected back and only a small fraction radiates as sound.

Trevor
How does a player change the pitch of the note that emanates from a brass instrument?

Murray
There are two things, which basically determine the pitch of the note. The vibration frequency of the lips, which is of course under the player's control directly and the resonances of the air column in the instrument. So if a player wants to change the note there are two ways that it can be done. First of all you can alter the resonance frequency of your lips just by tightening them or altering the amount of tissue that you're putting in to the mouthpiece - that's what the player controls setting the embouchure - and by adjustment of the embouchure you can change the basic buzzing frequency of the lips.

But when you have the lips coupled through a mouthpiece to a piece of tubing, then the tubing itself has its own resonance frequencies. There are certain natural pitches that the tubing of a trumpet for example likes to play. And so the player has to interact with that preference of the instrument and choose a lip frequency, which matches closely one of the resonances of the tube. So if you want to play say, the lowest normal note on the natural trumpet, you chose a low lip frequency…

…and you excite that note in the trumpet tube. If you want to play the next one you make your lips buzz at a higher frequency and the note that comes out the instrument is the second resonance and so on.

Trevor
And that's the harmonic series?

Murray
Yes

Caption (with graphic)
harmonic series

Murray
The natural trumpets for example in the Renaissance could only play notes from the second harmonic series upwards its an interesting fact that the first harmonic of the natural trumpet wasn't in tune it wasn't a real harmonic it was too flat just because of technical complications in the making of the tube.
So that it wasn't possible to use that harmonic but from the second harmonic up as far as the 24^{th} harmonic players developed specialised techniques for being able to play these notes. The ones who played up in the very high harmonics were the clarino players and that was a very specialised branch of trumpet playing.