Medieval and Renaissance Wind Instruments

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Physics

A wind instrument is a resonant tube excited by some excitation mechanism. Reflected pressure pulses from the tube in turn prod the excitation mechanism into producing further pulses of pressure. The physics of resonant tubes produces a limited set of possibilities which we can use to catalogue instruments. Resonant tubes respond *linearly* to excitation and are easy to model. For example, we can compute the correct places to put finger holes fairly easily. The excitation mechanism is *non-linear* and defines much of the unique character of each instrument.

Reed instruments behave as though one end of the resonant tube is closed, while flute and recorder-like instruments behave as though both ends of the tube are open.

Type of resonant tube	Cylindrical bore	Conical bore	Excitation mechanisms
Open both ends	*Fundamental wavelength = 2 x length*		• flute-like: blowing over a hole in the side • recorder-like: a duct directs air at an edge
Closed at one end	*Fundamental wavelength = 4 x length* *Odd harmonics only*	*Fundamental wavelength = 2 x length*	• double reed • single reed • lips • blowing over open end

The double reed produces a sound especially characteristic of the medieval period. While there were simple single reed instruments, the large single-reed mouthpiece found in modern clarinets (single reed, cylindrical bore) and saxophones (single reed, conical bore) is a later development.

Common instruments

There are many wonderfully strange medieval and renaissance instruments. I am here only going to describe some of the more common ones.

A figure from Baines (1962) showing the prevalence of various instruments over time:

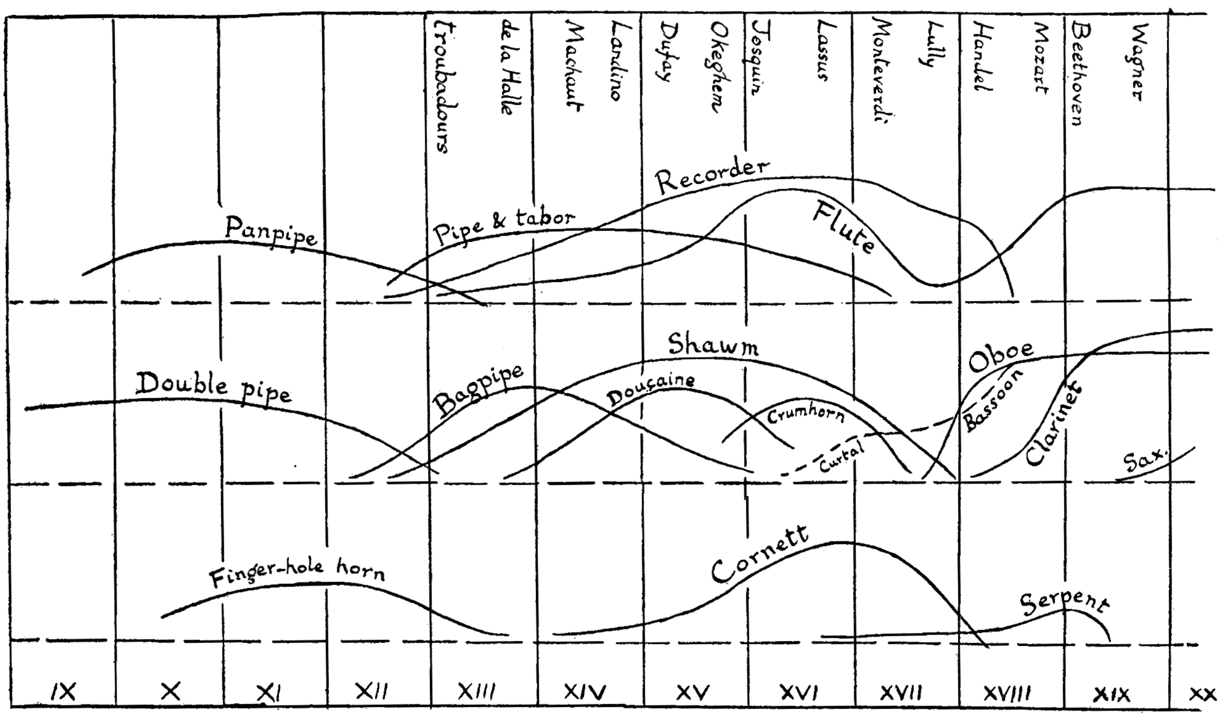

FIG. 49. *Chronological scheme of European woodwind instruments and precursors. Each hump indicates* approximately the period of the instrument's employment in courtly and professional music.

Shawm - double reed - conical bore

Also known as the "hautbois", literally "high wood", a name that eventually evolved to "hoboy", and finally "oboe".

The shawm reed resembles a modern bassoon reed, although with different proportions. The shawm's double reed is not simply a reed squashed flat. Instead there is a complicated procedure in which a strip of reed is carefully prepared then folded over on itself, and the fold cut to form the air entryway. This dates back to at least the 16th century.

Figure from Baines (1962) showing steps in bassoon reed making:

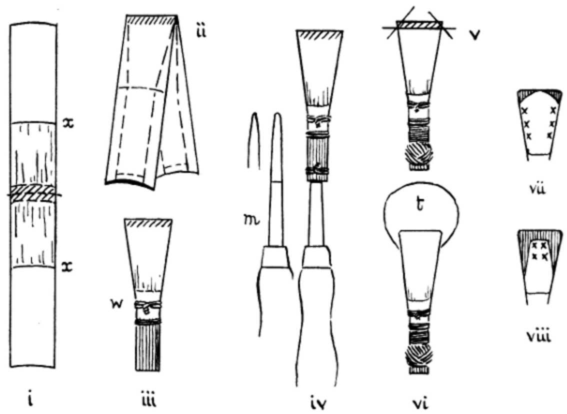

FIG. 12. *Stages in bassoon reed-making.*

A feature found in the shawm but not the oboe is the "pirouette", a cylinder of wood around the reed against which the lips are pushed, allowing the reed to be blown on with greater force.

Douçaine - double reed - cylindrical bore

There is some debate over the exact nature of this instrument. One of the finds from the wreck of the *Mary Rose*, of the fleet of Henry VIII, was an instrument that is proposed to be a douçaine, an instrument mentioned by several medieval and renaissance authors (Myers, 1983). It is similar to a shawm, being a double-reed instrument, but has cylindrical rather than conical bore, producing a softer sound with a fundamental one octave lower than a shawm of the same length.

Crumhorn - double reed - cylindrical bore

Similar to the douçaine, but J shaped rather than straight, and the reed is enclosed in a cap and does not come in contact with the lips. The cap arrangement makes this an easy instrument to play, but it is not possible to overblow into higher registers and it therefore has a limited range.

Bagpipes - single and double reeds - cylindrical bores

The "chanter" pipe excited by a double reed is used to play a melody, while one or more single reeded "drone" pipes drone. All are fed air from a bladder.

Cornett - lips - conical bore

Similar to a shawm, a conical instrument with finger holes, but using the lips to produce sound as with a trumpet. Made with an octagonal cross section and wrapped in leather, for no apparent reason.

Transverse flute / fife - flute-like - cylindrical bore

It's a tube with some holes in it. One end is stopped up. You blow across a hole near the stopped up end. (The mouth-hole acts as one of the ends of the resonant tube, so acoustically it is still open at both ends.) For all their simplicity, transverse flutes are expressive and have a decent range.

"Flute" is the older term. "Fife" derives from "pfiefe" (German for pipe). "Flute" can also be used to refer to recorder-like instruments.

Cheap plastic or metal fifes are available, a good second instrument after a recorder for the SCA.

Recorder / Flageol - recorder-like - cylindrical bore

Actually, the bore of the recorder is not perfectly cylindrical, but shrinks somewhat toward the end of the instrument, purportedly softening the tone.

The name "recorder" dates back to the 14^{th} century. "Flageol" is an Old French term. A diminutive form, "flageolet", seems to have come to strand for this whole family, but I'm not sure when this became common.

Two flageols were sometimes played simulataneously (the ancient Greeks had a similar trick using two double-reed pipes -- the "aulos", plural "auloi").

Tabor pipe / Three-hole pipe - recorder-like - cylindrical bore

This is a recorder-like instrument that can be played with the left hand alone, leaving the right hand free to bang a tabor-drum. It has only three finger holes, yet is able to produce a complete scale. The fundamental register is not used. Instead it is overblown in 2^{nd}, 3^{rd}, and 4^{th} registers. The 3^{rd} register is an interval of a fifth above the 2^{nd}, while the 4^{th} is an octave above the 2^{nd}.

Pipe and tabor player from Arbeau (1589):

Notes on making your own instrument

Wooden tubes

Wooden tubes seem to be the hardest part of making an authentic instrument. I don't presently have a good solution for this. As a minimum, to easily bore a long hole, it seems you will need a lathe.

Alternatively, you could hollow out two halves of the instrument then strap them together. This is how the cornett was made.

If you are willing to put up with an inauthentic material, you could use plastic or aluminium pipe, or bamboo.

Drinking straw reeds

A drinking straw with the tip carefully flattened (eg using your teeth) will make a loud buzzing sound when held between the lips and blown.

By careful thinning of the tip, a softer more pleasing sound can be produced. I currently use a combination of sandpaper and a grinding stone that fits to an electric drill.

The reed may tend to produce a tone that sags away from the resonant frequency of a tube it is attached to. A sufficiently fine tip seems to fix this problem (this is where the grinding stone really seems to help), and careful embouchure control also helps.

Finger holes that are too small can produce notes that sound weakly and are especially prone to sagging in frequency.

Finding a straw large enough to match the size of your resonant tube is important. I have had some success with "sipahh" straws (the kind that contain sugary granules that flavour milk as you suck through them).

This is all something of a black art, but it is possible to very cheaply produce a reed that produces a good first approximation of the buzzy double reed medieval sound, and which allows a degree of expressive control.

Flutes

Creating the mouthpiece of a flute can be as simple as drilling a hole in the side of a tube and stopping up the end. See http://www.cwo.com/~ph_kosel/designs.html

Tabor pipes

If you are willing to put up with a modern material such as plastic or aluminium, the tube of a three-holed tabor pipe is straightforward to make. To this, the head of a soprano or sopranino recorder may be attached. It is important to match the diameter of the tube's bore to that of the head.

Finger hole placement

An open finger hole effectively shortens the instrument. This is a function of the position of the hole, the thickness of the instrument wall (length of the hole), and the relative areas of the bore and the hole. Smaller holes shorten the instrument less.

The mathematics of hole placement is a little involved, see below for details. I have written some software to automate hole placement for cylindrical bore instruments:

http://www.logarithmic.net/pfh/design

See also:
http://homepages.bw.edu/~phoekje/acoustics/mahome.html
http://www.cwo.com/~ph_kosel/flutomat.html

Finger hole maths

I am basing this on Nederveen (1969). Any errors are my own.

The speed of sound varies with temperature.

speed of sound at 25C = 346.1 m/s

The length of resonating air in a tube extends somewhat beyond its open ends. The correction for the end of a tube with inner radius *a* and outer radius *b* is

end length correction = a * (0.821 - 0.13 * (0.42 + (b-a)/a) ^ -0.54)

The following is probably a good enough approximation:

end length correction (approx) = a * 0.7

In summary, for a cylinder or cone with some kind of mouthpiece and with all holes closed:

effective length = actual length + mouthpiece correction + end length correction

I'm not going to get into details about the mouthpiece correction. I suggest making a cylinder or cone of about the right length, then trimming it until it is in tune.

End corrections also apply to finger holes. The resonance extends both beyond the outer and inner ends of the finger hole. This approximation should be good enough:

effective finger hole length = length + 2 * 0.7 * a

A tube with a hole in it behaves like a shorter tube without a hole in it. We'll call this imaginary shorter tube the "substitution tube".

Let

LL = length of tube to left of hole (effective length, includes mouthpiece correction)
LR = length of tube to right of hole (effective length, includes end correction)
LH = length of hole (effective length, includes end corrections)
LS = length of substitution tube

A = area of bore
AH = area of hole

m = 2 * LS / wavelength

For cylindrical instruments with a closed end, *m* may take values 0.5 (fundamental), 1.5, 2.5, etc. For conical instruments or instruments with both ends open, *m* may take values 1 (fundamental), 2, 3, etc.

Solve the following to obtain LS:

0 = A / tan(k*LL-k*LS) + A / tan(k*LR) + AH / tan(k*LH)

where

k = m * pi / LS

The substitution tube length of a tube with multiple holes in it can be obtained by performing a series of substitutions, starting with the hole nearest the end of the instrument.

References

Arbeau, Thoinot (1589). *Orchesography.*

Baines, Anthony (1962). *Woodwind Instruments and their History.* London: Faber and Faber Ltd

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Nederveen, Cornelis Johannes (1969). *Acoustical aspects of woodwind instruments*. Amsterdam: Frits Knuf.