An introduction to music acoustics

Overview	How instruments work
Excitors	Bows, reeds, lips and air jets
Resonators	Strings, bores, bells, keys
Timbre	Harmonics and transients
Meet them	Strings, wind, brass, voice? percussion?
Our research	Can this understanding help players and makers?

* Other team members whose work will be described include Andrew Botros, Paul Dickens, Ra Inta, John Smith and John Tann – and many others if we start talking about the research! We gratefully acknowledge the support of Terry McGee Flutes, The Woodwind Group, Gilet Guitars, Harry Vatiliotis and the Australian Research Council. Thanks to musicians, especially Jane Cavanagh.

A physicist looks at instruments:

Component	Strings	Woodwinds	Comments
Energy Source	player's arms	player's breath	inefficient
control oscillator	bow-string	reed or air jet	→ harmonic behaviour (nonlinear)
resonator(s)	string	air column*	→ precise tuning high Q (linear)
match source to sound in air	body	(bell)	(linear)

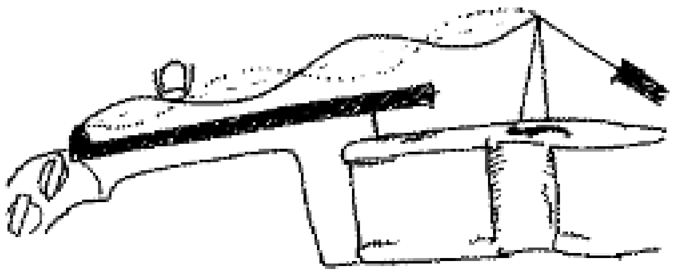
* Resonator***s***:

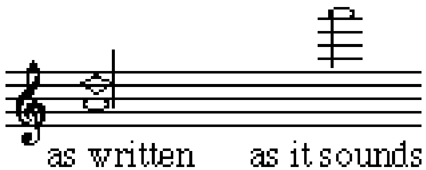
bore of instrument   reed/air jet   player's vocal tract

Here end the planned slides. For the rest of the session, we shall use demonstrations and discussion. Where appropriate, we'll use graphics, animations and sounds from www.phys.unsw.edu.au/music

The topics are listed below in a reasonably logical order of presentation, but the actual order and the depth on each section will depend on the participants.

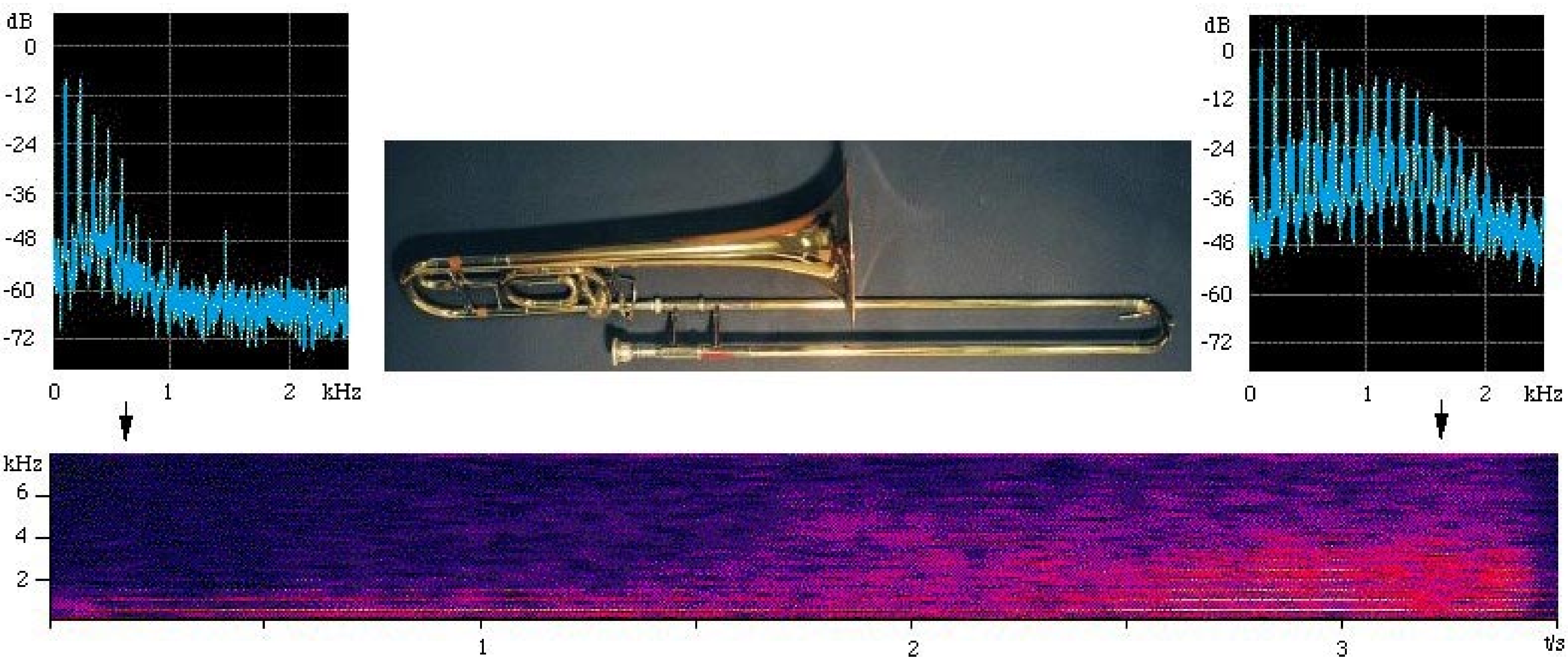
Strings:www.phys.unsw.edu.au/~jw/strings.html



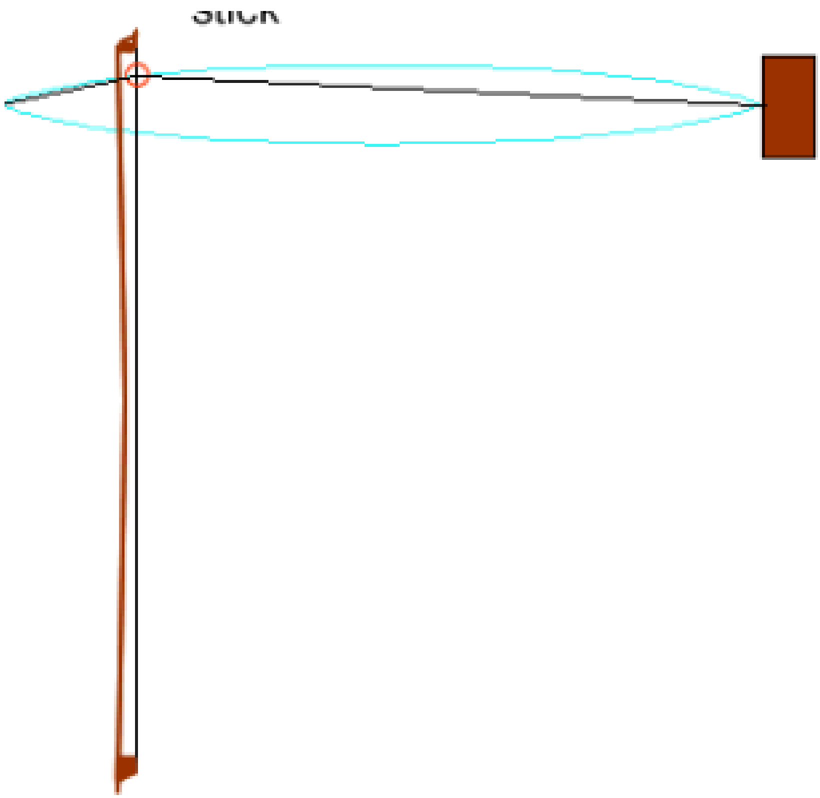


Leads us to

Spectra:www.phys.unsw.edu.au/~jw/sound.spectrum.html



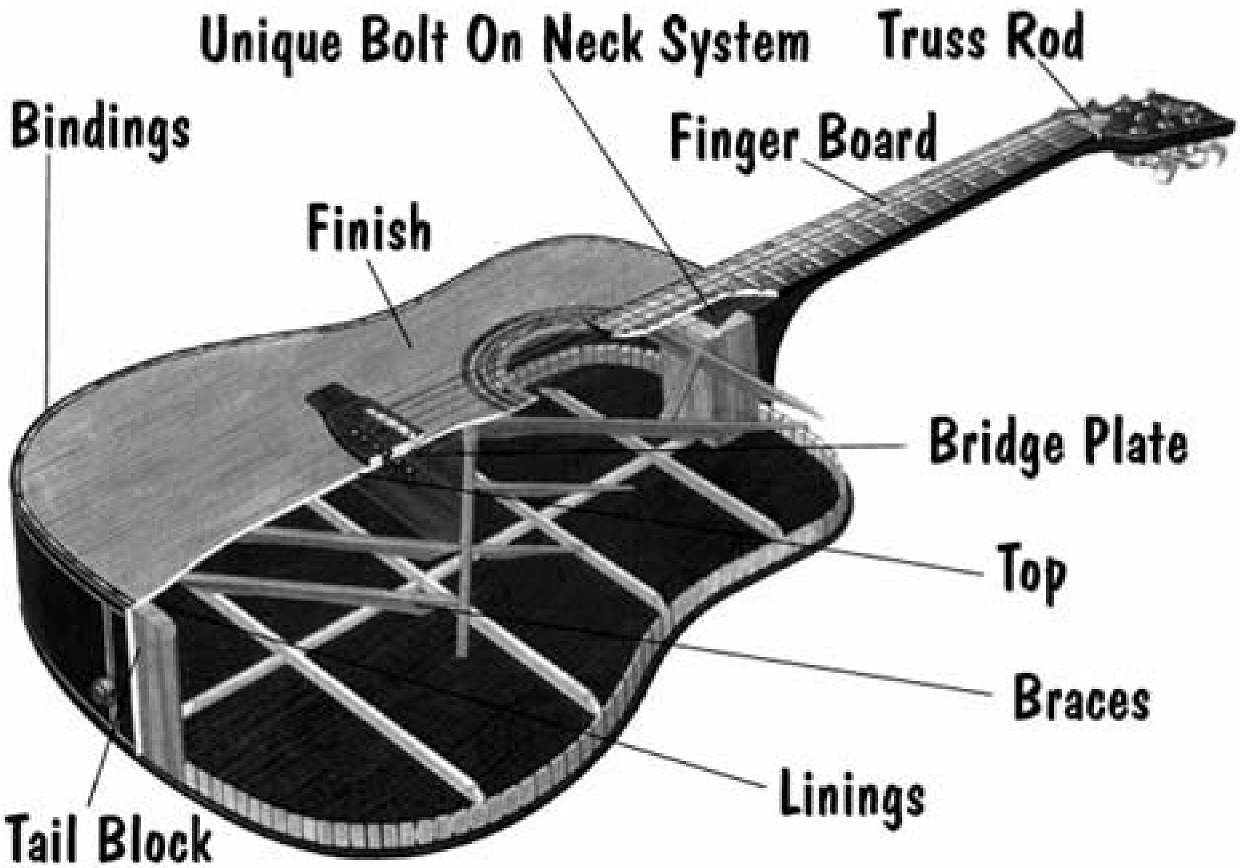
Bows:www.phys.unsw.edu.au/~jw/Bows.html



Violins:www.phys.unsw.edu.au/violin

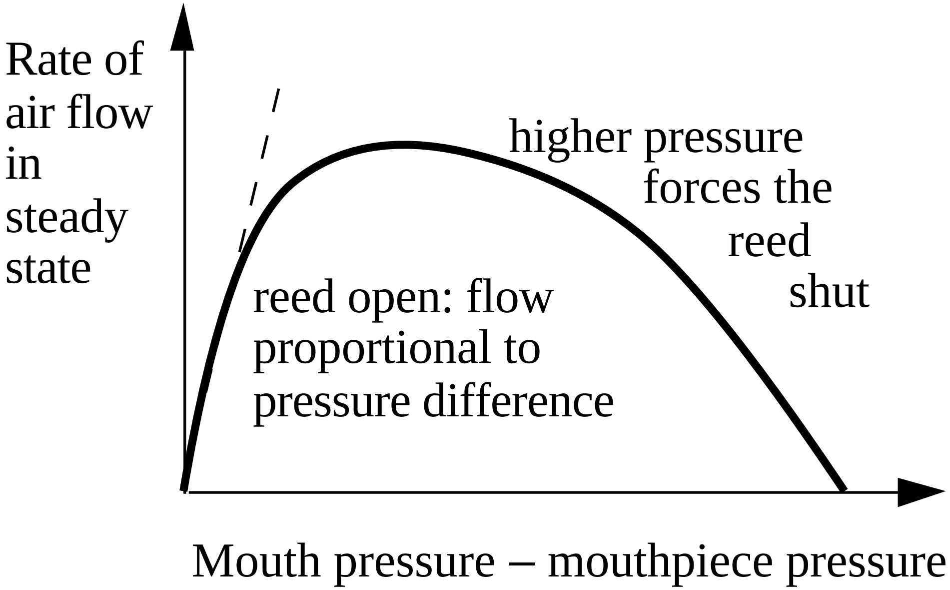
importance of ***vibrato***.

Guitars:www.phys.unsw.edu.au/guitar

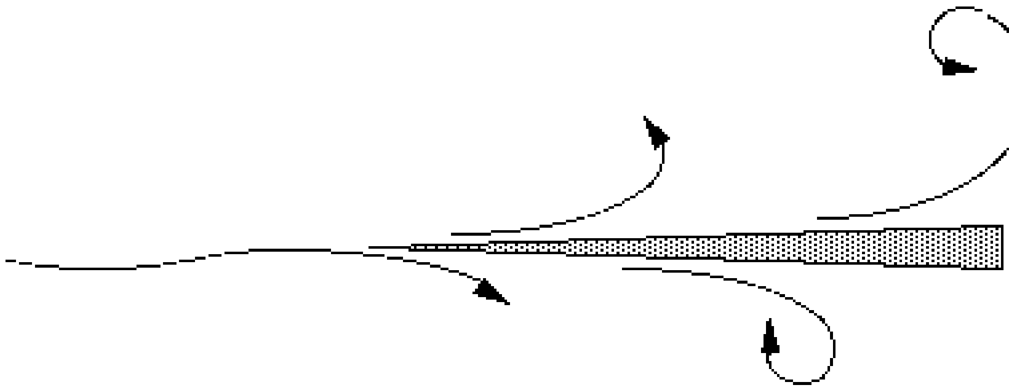

Unique Bolt On Neck System
Truss Rod
Bindings
Finger Board
Finish
Bridge Plate
Top
Braces
Linings
Tail Block

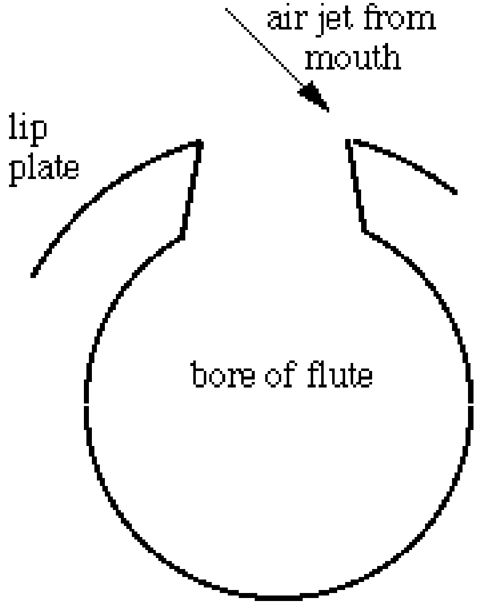
Winds

A reed can close or open the air passage

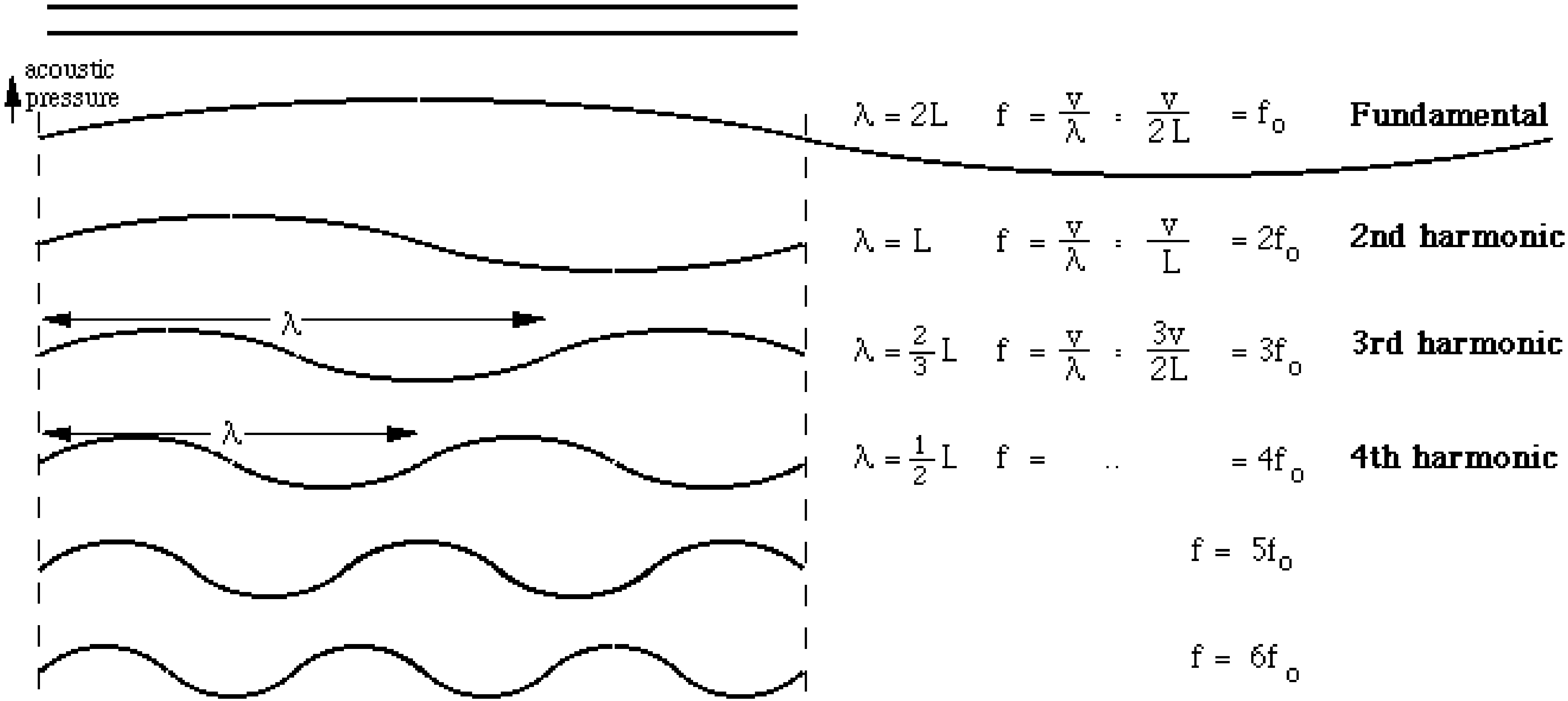


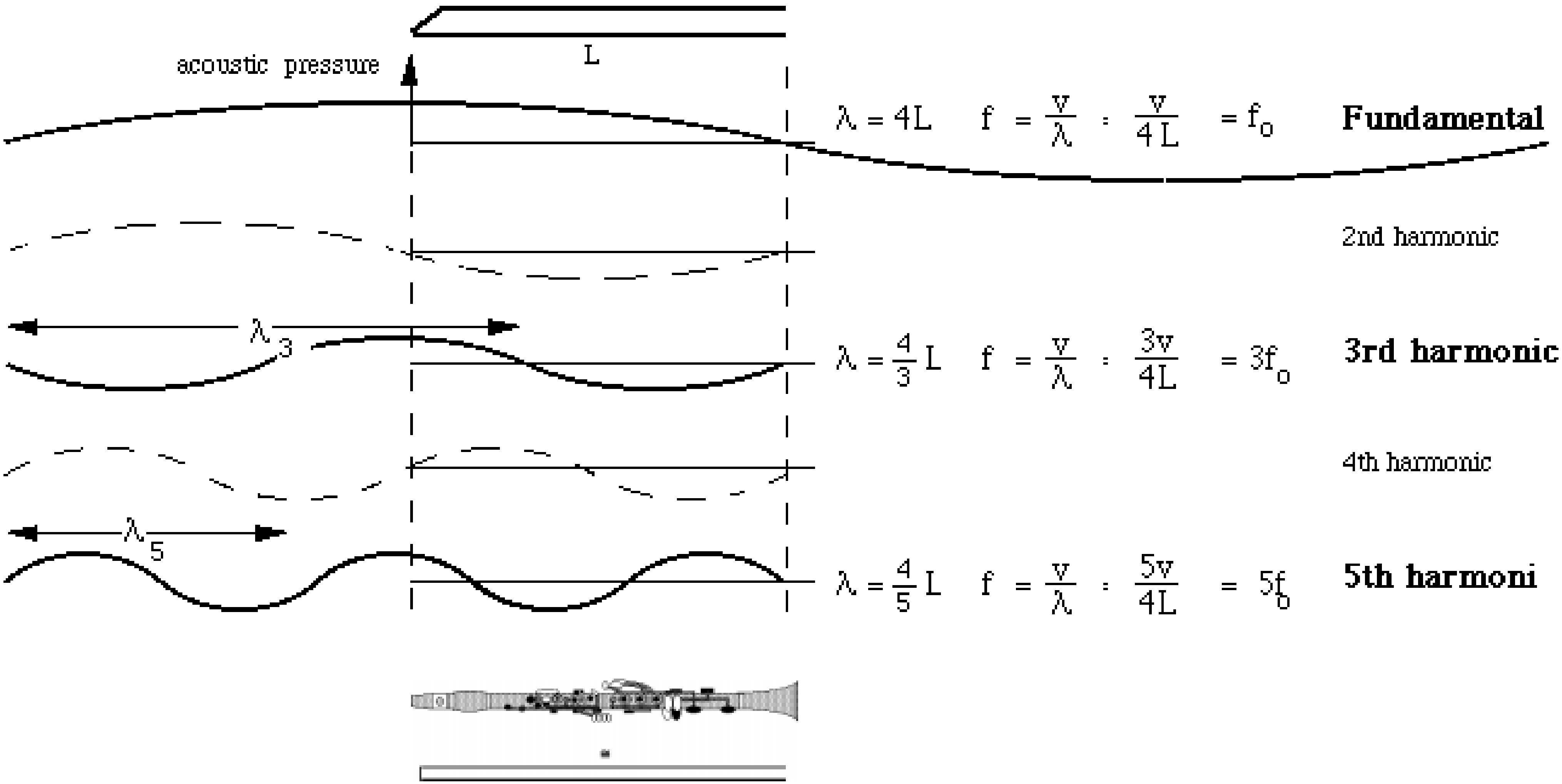
Flute is an open pipe, control oscillator is an air jet

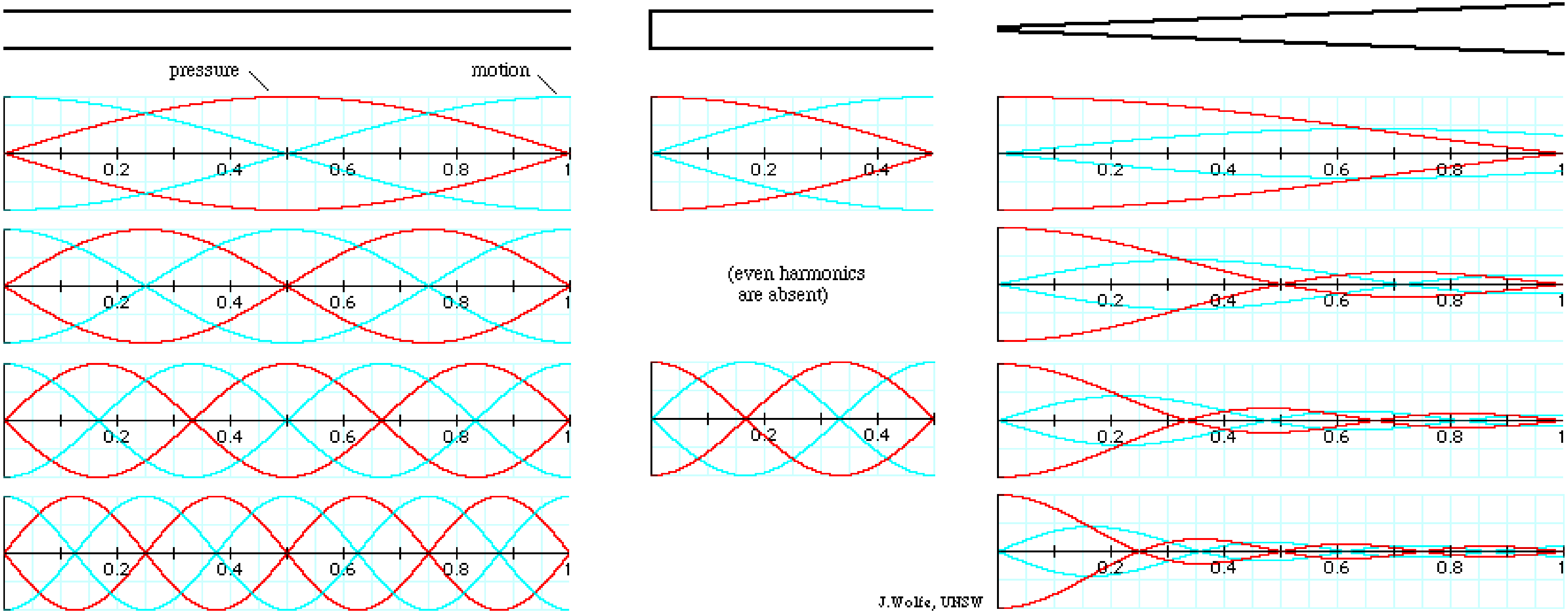




Let's compare the standing waves with those of a string




acoustic pressure
L
$\lambda = 4L \quad f = \frac{v}{\lambda} = \frac{v}{4L} = f_o$
Fundamental
2nd harmonic
λ_3
$\lambda = \frac{4}{3}L \quad f = \frac{v}{\lambda} = \frac{3v}{4L} = 3f_o$
3rd harmonic
4th harmonic
λ_5
$\lambda = \frac{4}{5}L \quad f = \frac{v}{\lambda} = \frac{5v}{4L} = 5f_o$
5th harmoni



Pipes: www.phys.unsw.edu.au/~jw/pipes.html

Flutes: www.phys.unsw.edu.au/~jw/fluteacoustics.html

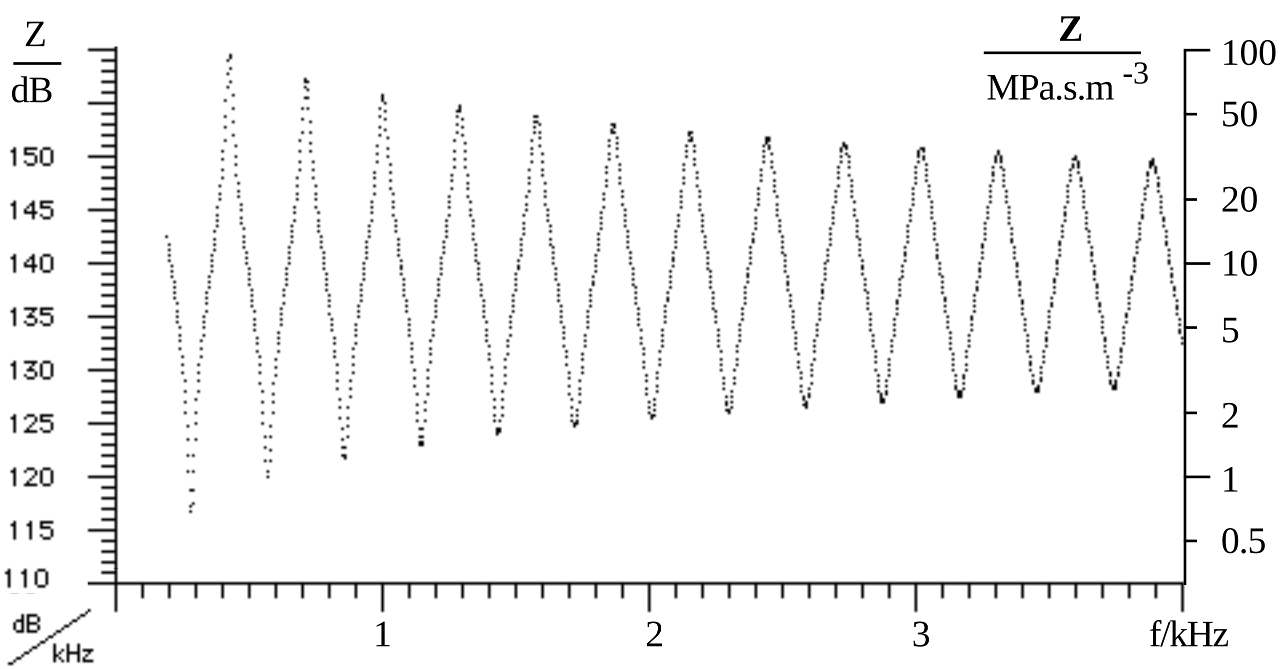
Clarinets: www.phys.unsw.edu.au/~jw/clarinetacoustics.html

Sax: www.phys.unsw.edu.au/~jw/saxacoustics.html

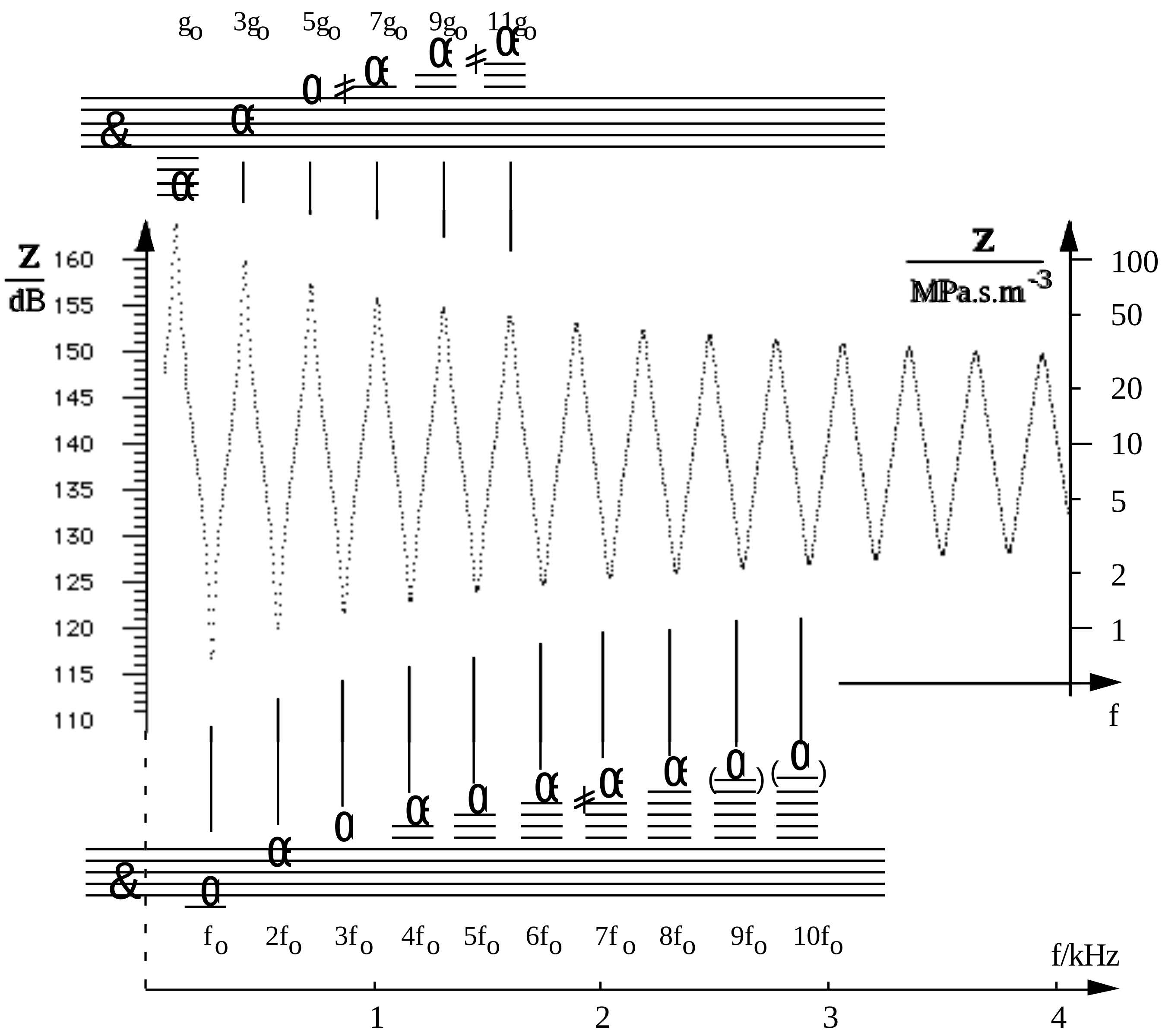
Acoustic impedance:

$$\mathbf{Z}(f) \equiv \frac{\text{sound pressure}}{\text{sound flow}} = \frac{\mathbf{p}}{\mathbf{u}} \qquad \left(\text{compare with electricity: } \frac{\text{voltage}}{\text{current}}\right)$$

Measure **Z**(f) for a simple, open cylinder, 600 mm long:

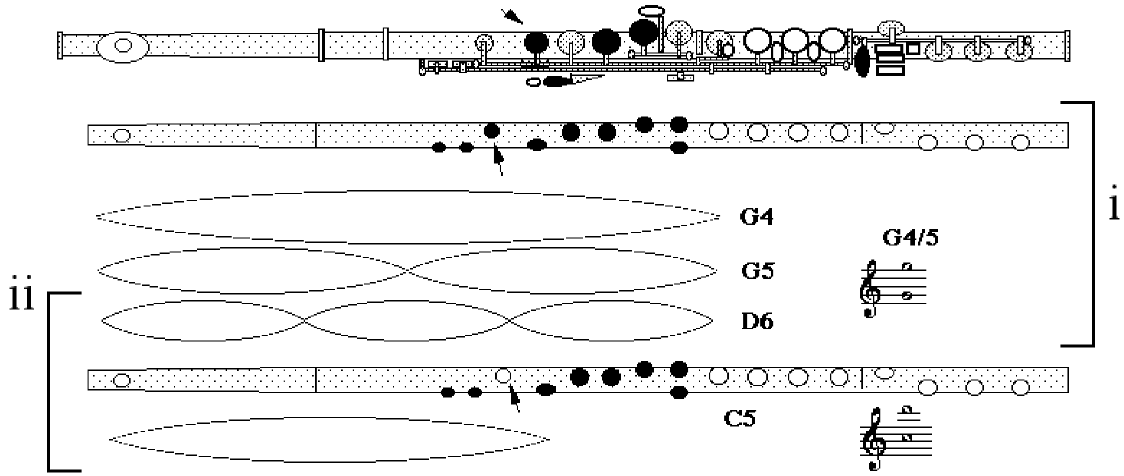


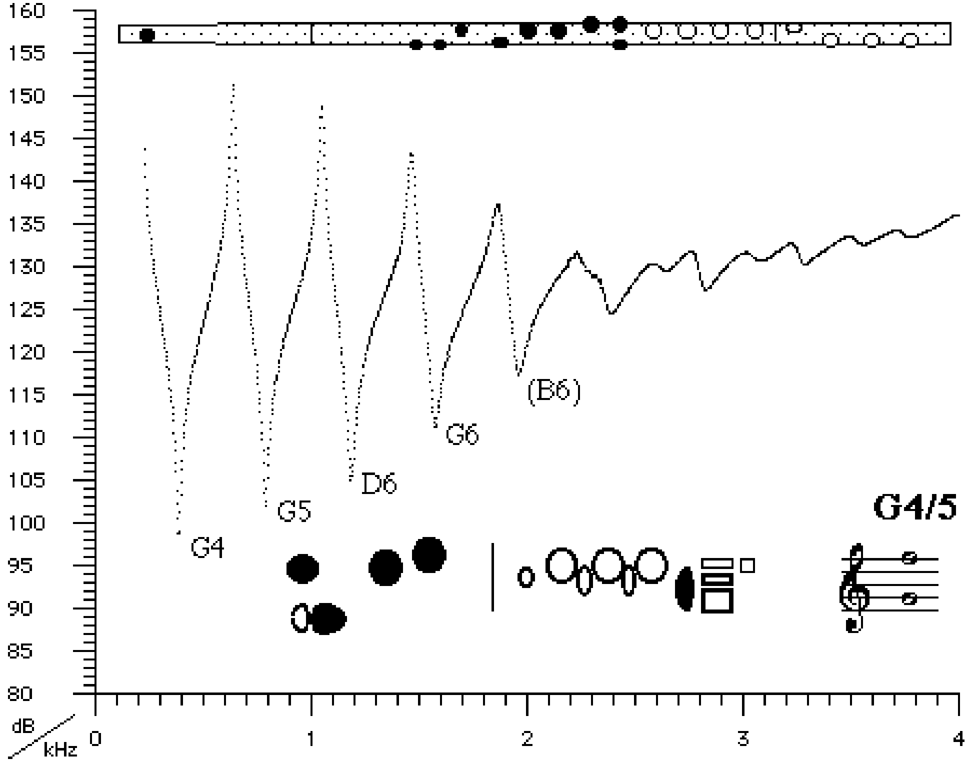
clarinets closed at reed, operate at maxima in Z

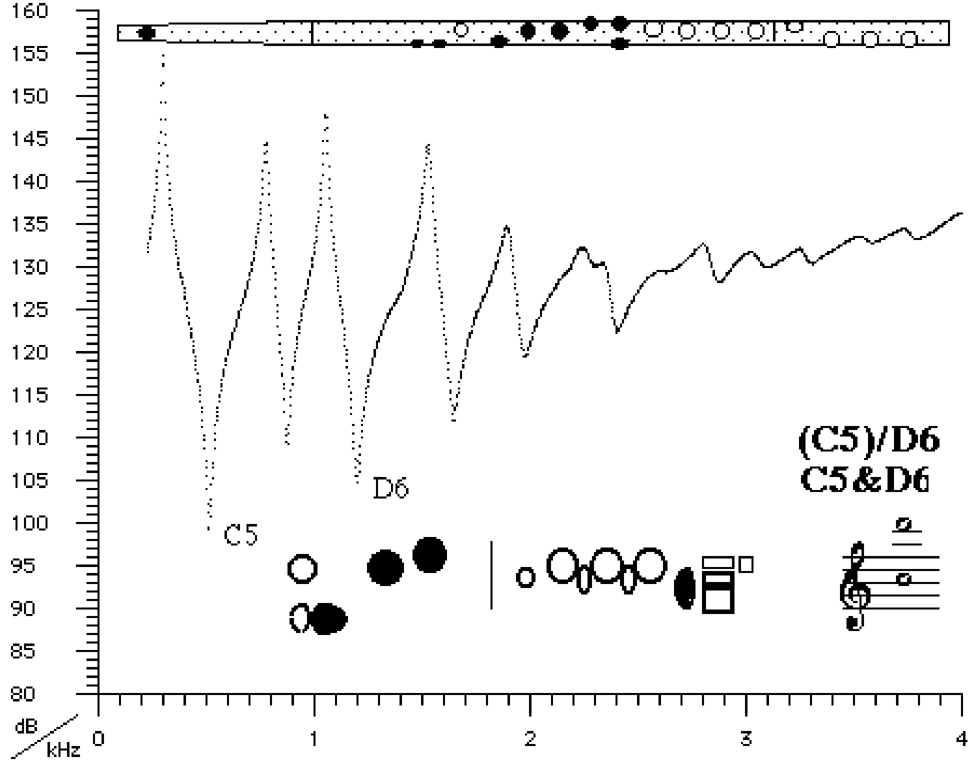


flutes open at embouchure, so they operate at ***minima*** in Z.

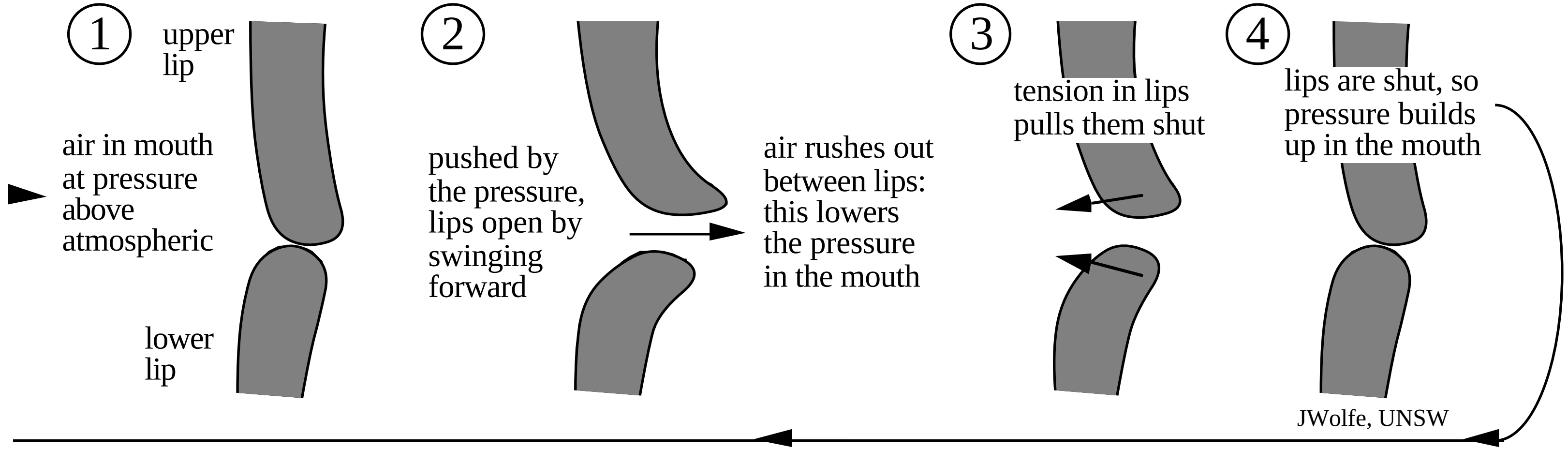
Some details about fingering:



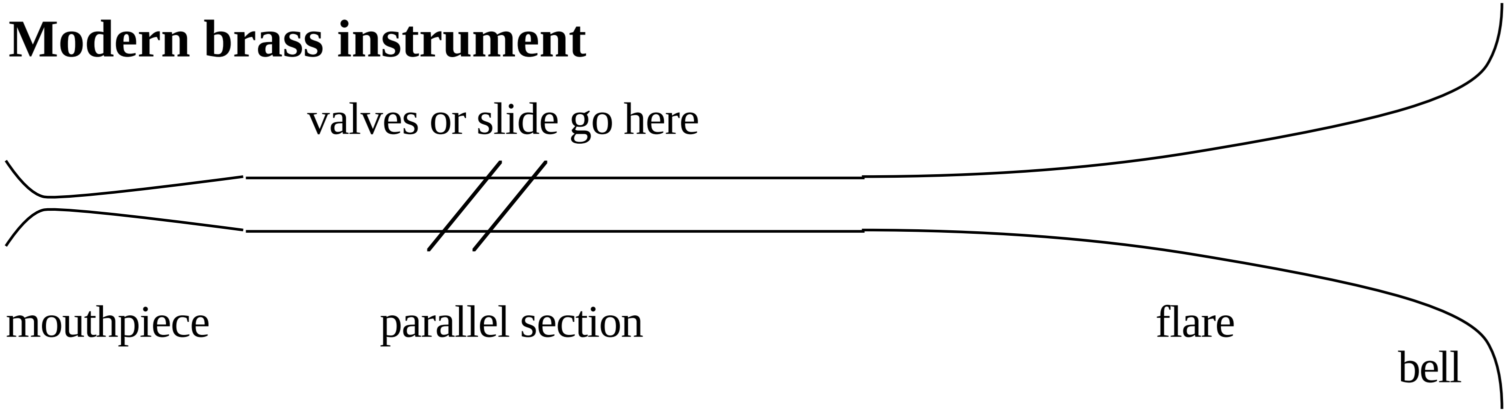




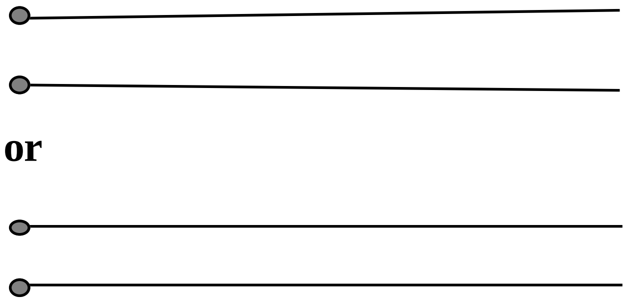
Brass:www.phys.unsw.edu.au/~jw/brassacoustics.html



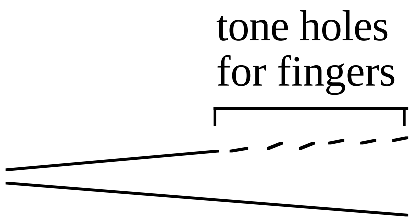
Modern brass instrument

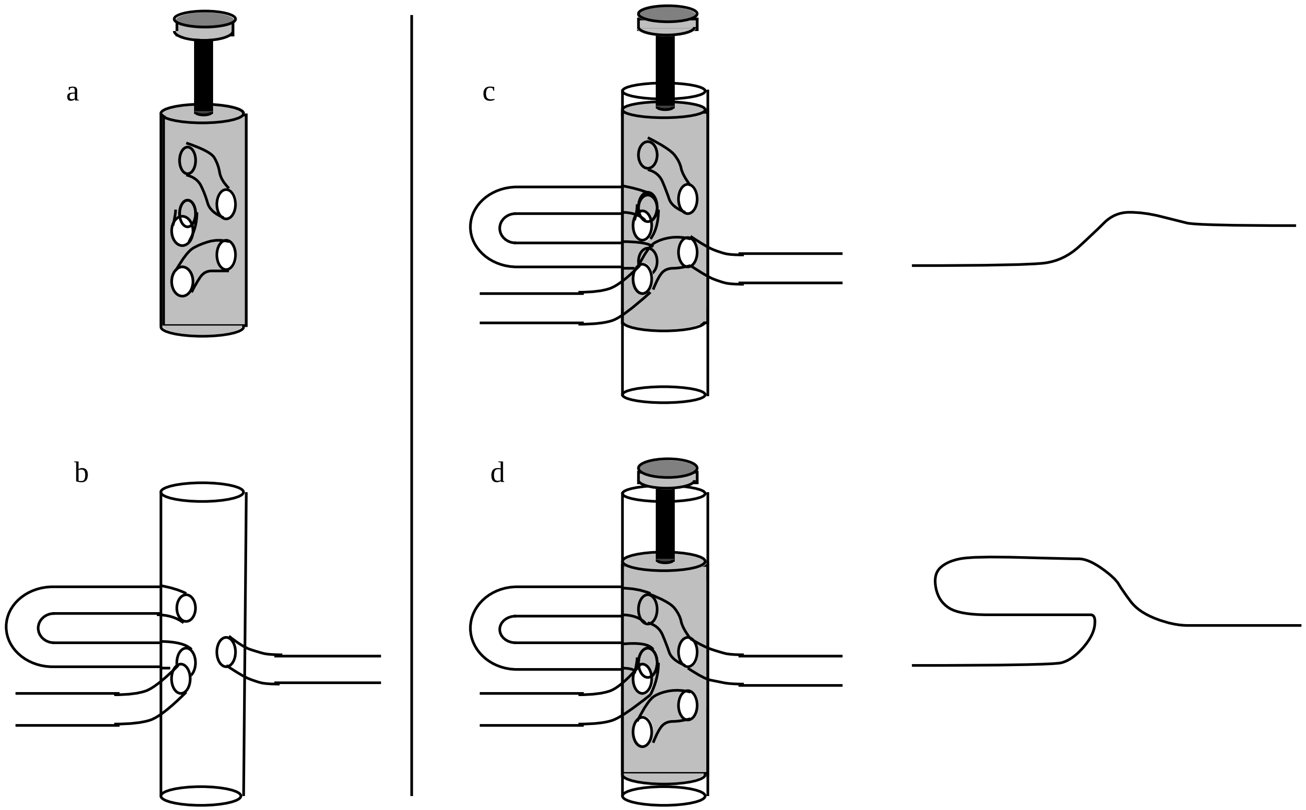


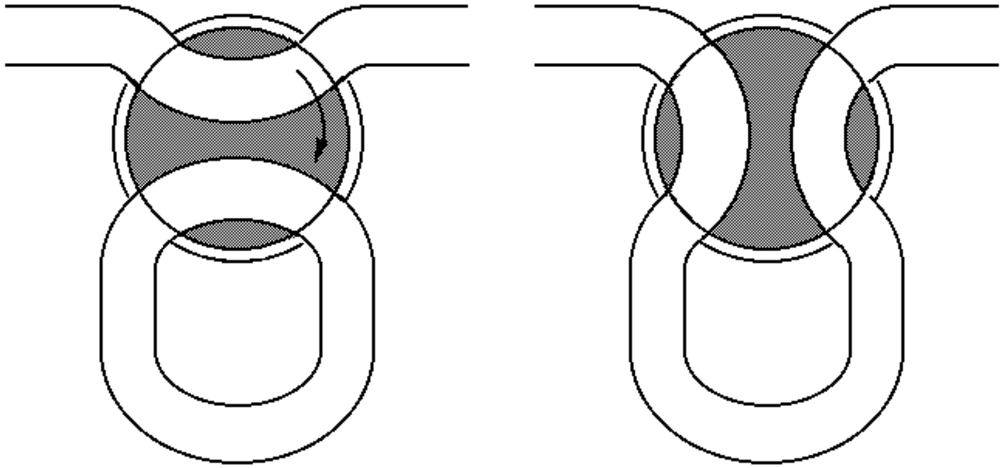
Didjeridu

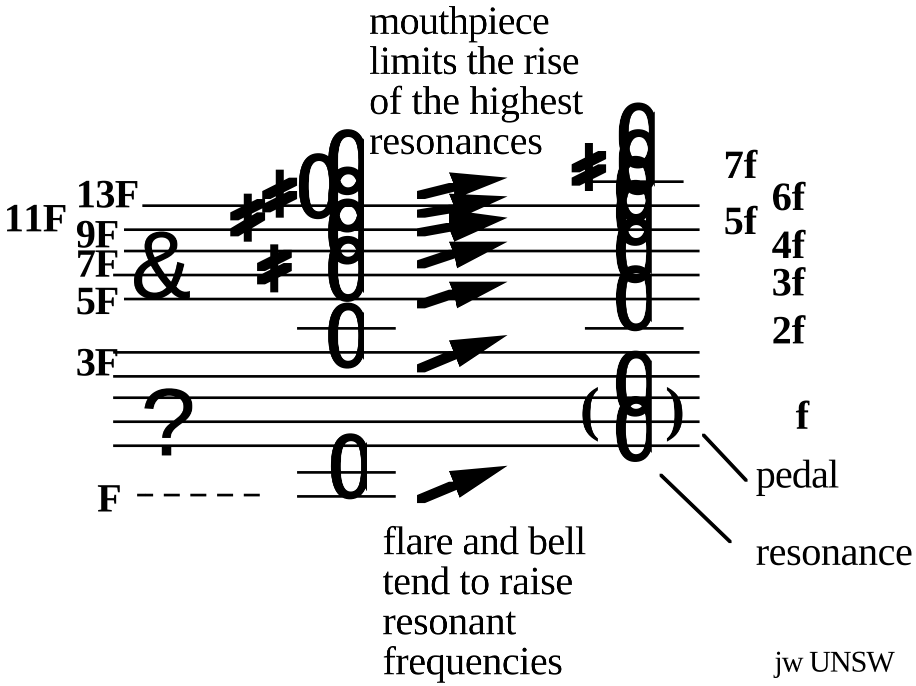


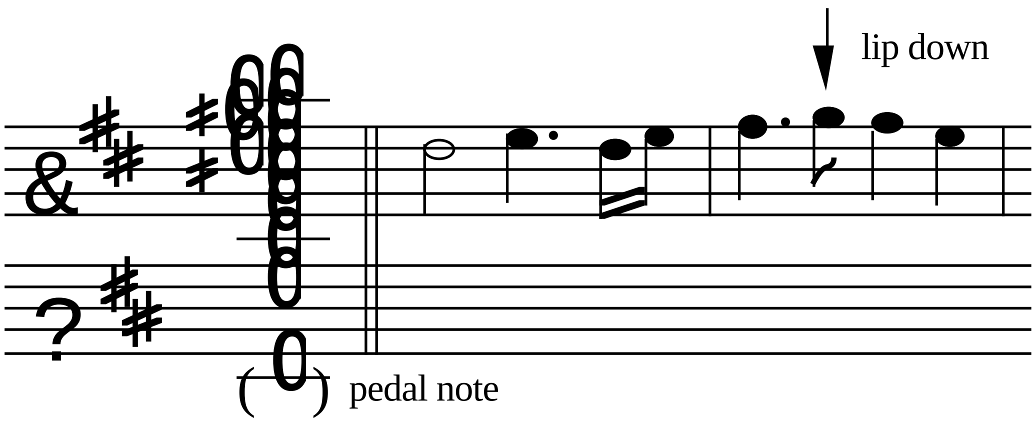
Cornetto or serpent



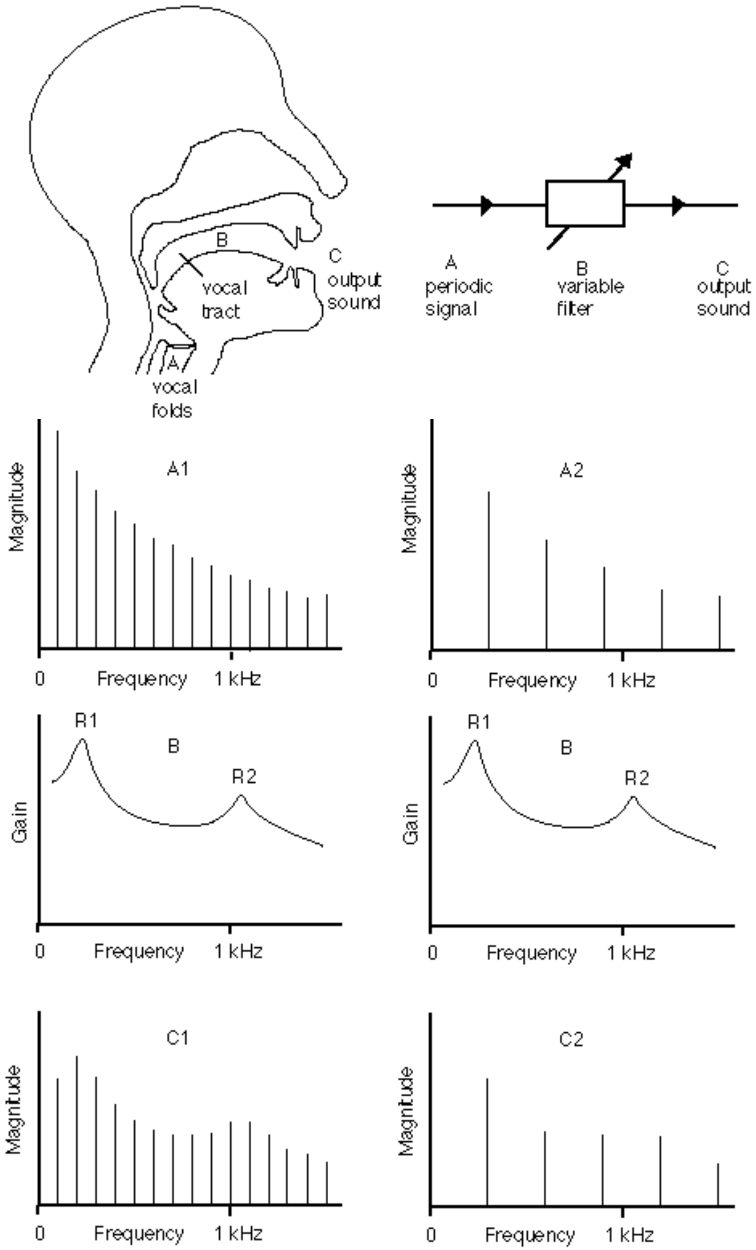

a
b
c
d

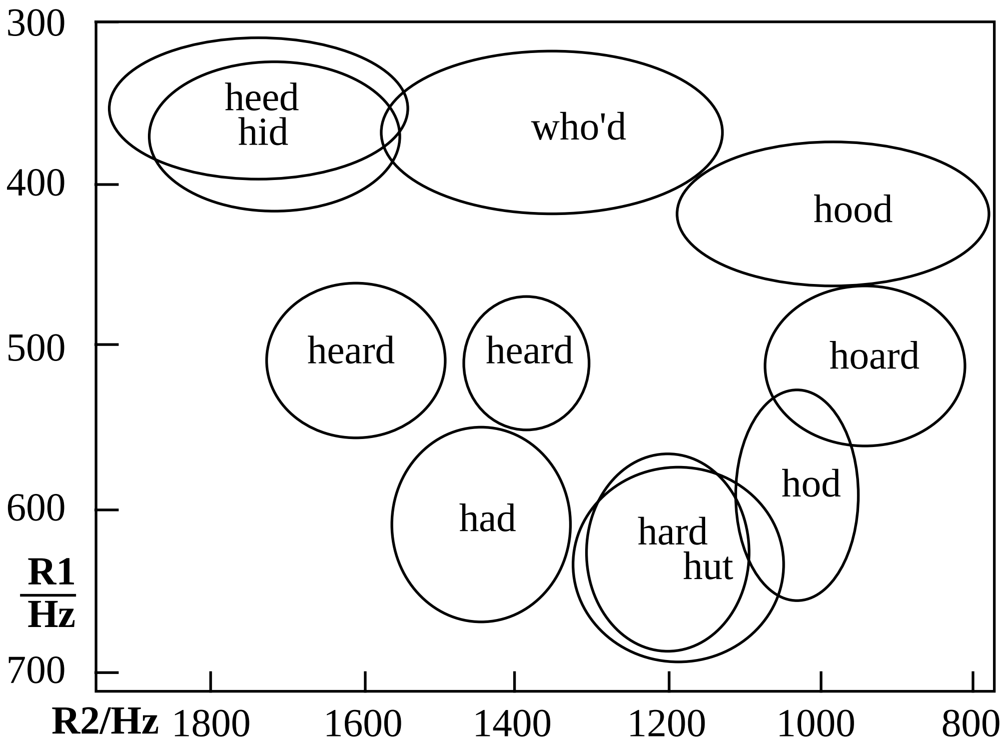


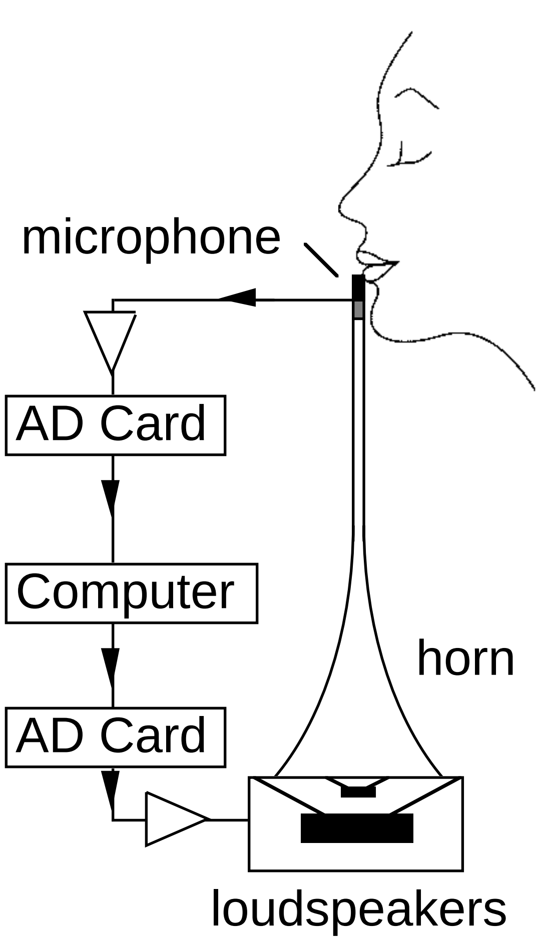

mouthpiece
limits the rise
of the highest
resonances
11F
13F
9F
7F
5F
3F
F
7f
6f
5f
4f
3f
2f
f
pedal
resonance
flare and bell
tend to raise
resonant
frequencies
jw UNSW

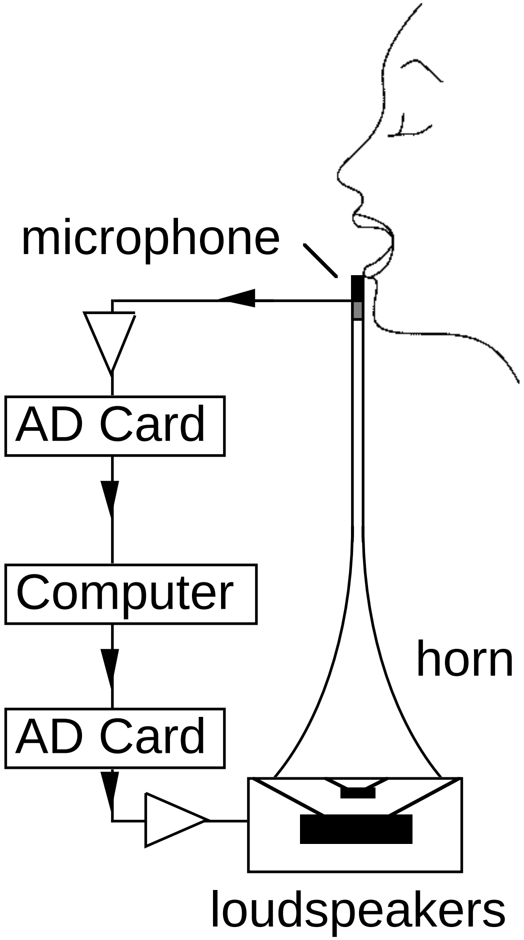

lip down
pedal note

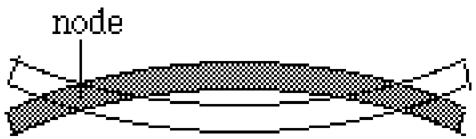
Voice: www.phys.unsw.edu.au/speech











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