The tuning, tone, and response of wind instruments depends a lot on microscopic effects in the air column, and it is easy to lose one virtue while going after another. Everything affects everything!

Today's acoustics is far enough along that it is possible to organize and coordinate a lot of things the repairman is faced with in his daily work. For woodwinds, the "do and don'ts" of pad choice and regulation, and the coordination of mouthpiece and barrel, or of flute headjoint to the instrument can be dealt with in a very practical way, as can questions like "Should the bore be oiled?" or "How should a joint be fitted?" "What pitch was this horn actually built to?" Among the brass instruments we have similar questions: "How does one make sure the mouthpiece belongs with the horn?" "Is it worse to fix this dent than to leave it alone?" (flute man take notice!) "Can I look for (and fix?) bore errors via tuning experiments?" My goal is to get people started thinking about such questions in a way that shows how closely related they all are to each other acoustically. The discussion can go on from here in a free-wheeling way. Hopefully people will bring odd or sick instruments plus plenty of questions.
**What is a Wind Instrument?**

How are its musical oscillations maintained?

- **Woodwind Defined Acoustically**
  - Sequence of tone holes
- **Brass Defined Acoustically**
  - Air column length varied by pistons or slide
- Sound issues from whatever holes are open
dound issues always via the bell

**Excitation Mechanism (Flow Controller)**
1. Cane reed (Oboe, clarinet, sax)
2. Lip reed (Trumpet, cornet, etc.)
3. Air reed (Flute)

Available to both tribes?

---

**Properties of a Good Instrument**

1. Full steady tone...
   - Sustained, spectrum, small Fm/Am noise
2. Clean start and stop
   - Controllable articulation, dependable
3. Wide dynamic range...
   - (Volume and controllable)
4. Pitch flexibility without loss of tone
   - Tonal flexibility without loss of pitch
5. Large muscular efforts control
   - Small muscular changes, but...
   - With preservation of (2), (3) and (4)

---

**The "tone breeding" process**

1. The reed sends a pressure pulse down the bore
2. This is modified by the tone holes and bell and sent back
3. The return wave produces a new, modified pulse from the reed valve
4. This goes down... Etc Etc....
   - If all goes well, things settle down to a nice, clean, steady regime of oscillation.

"Chewed up return -> Screwed up" pulse from reed (etc)

---

**It is already obvious that**

All this swinging back and forth means that

**EVERY PART OF THE BORE IS CRUCIALLY IMPORTANT**

There is no magic spot that fixes everything.

[even if there were, it might well be the magic spot that spoils some other note?]

A Wind Instrument is a **System**

(Actually each fingering is a system but shared with most others)
In fact, music exploits two air columns.

An older Baroque and Classical era music required a reed wind instrument air column. The vocal tract, larynx, trachea, and subglottal airway are involved. The lungs are also a part of the respiratory system.

The reed instrument air column is responsible for producing sound. The players windway is the reed instrument air column. Upstream and downstream air columns are considered.

Toward the players lungs is the concert hall. We will consider only the instrument air column.

There is a parallelism between the motion of water and of air.

Depth of water

Pressure of air

Cognates

Smooth lifting and falling of a float produced abrupt injection of water in short bursts.

How to usefully characterize an air column:

Remember this experiment:

Oscillator
Stimulus
Response

Room
Microphone
Characterized by point-to-point response in room

We employ a similar technique:

Oscillator
Air column
Response
Characterized by mouthpiece response of air column

One can learn to "read off" the dynamical and musical features of an air column from this signature.

This confers enormous diagnostic power.

Here is a response curve for oboe or saxophone:

Resonances are not quite "aligned."

On a clarinet, this instrument would start sharp, then fall a little and turn weakly.

Demonstrations.
CONCLUSION:
ALL GOOD INSTRUMENTS
(of the self-sustaining oscillator type)
1. ACQUIRE THEIR STABILITY AND CONTROLLABILITY
   (AND ALSO THEIR ADJUSTABILITY)
   AS THE RESULT OF THE POSSIBILITY
   OF ALIGNING MANY RESONANCES
   TO ASSURE QUICK RESPONSE AND NOISE FREE SOUND
Some of this depend on the skill of the instrument maker
Some depend on the skill of the performer
Both aspects are well understood
and can be taught by known methods.
2. THEY PRODUCE SOUNDS OF A TYPE
   THAT THE AUDIATORY SYSTEM
   IS PARTICULARLY WELL FITTED TO RECEIVE
   (EXAMPLES WILL BE OFFERED AS TIME PERMITS)
   SUCH SOUNDS ARE THEREFORE
   "PERCEPTUALLY ROBUST"
   (Partially surviving permits successful recognition)
   THEY CAN SURVIVE THE VOYAGE TO THE EAR

LIFE IS SIMPLER FOR CLARINETS
Without a gum (like) about Cornet Chaps
assum good instrument
2 good mouthpiece
2 good chops
Then:
THE BALANCE WEIGHS BETWEEN
   MOUTHPIECE AND CLARINET
LARGER CAVITY
   SCALE IS STRETCHED IN LOW OR CLARINET RANGE
   USE A LONGER BABEL
   USE A SHORTER BABEL
A PARTICULAR CLARINET
Here it is
SMALLER CAVITY
   SCALE IS COMPRESSED IN LOW OR CLARINET RANGE
   USE A SHORTER BALLEN
WHAT THEN IS THE PITCH OF THE COMPLETE
   (CONNECTED) SCALE -- RELATIVE TO A=440?

ABSOLUTE REQUIREMENTS
FOR A FACED...
(1) THERE MIGHT BE A POINT WHERE EMBOUCHURE
   PRESSURE CHANGES (WITH REED ADJUSTMENT)
   WILL CHANGE FREE VIBRATING LENGTH, FREED
   TEST: will the MPC alone + reed "snap" from well below "normal" to well above
   "normal" pitch eg a range of 8-12 semitones?

   TIP OPENING
   DIFFERENCE
   APPROXIMATE POINT OF EMBOUCHURE PRESSURE

   (2) THE REED MUST "ROLL DOWN" ON THE
   FACED SMOOTHLY AS IT OLDS.
   UNDERALL CONDITIONS (EMBOUCHURE
   AND BLOWING PRESSURE)
   CHECK BEST WITH #2 REED

ESSENTIAL ENLARGEMENT -- DOES NOT NEED TO
   MATCH MOUTHPIECE ID.
Porosity..... Good? Bad?

Flute: — Airtight as possible

Bassoon: — Fair porosity is useful (necessary)

Oboe: — Airtight but soft pads are a great benefit

Clarinet: — Pretty airtight; pads soft pads:

The quickest way to ruin what little tone today's clarinet has is to put cork pads on top joint

Sax: — Kid pads with small discs throughout... then varnish the pads in the LH stack

What about airtightness and hardness of pads?

Review

Resonance... not quite perfectly aligned

More porosity of pads (or wood) with in reason Better cooperation

Beta music at expense of a little more work from the player

Tuning and voicing

1. Get it to sing all notes

Then tune the whole instrument

Only a badly made instrument has bad individual notes

2. Don't use the strobocogn (eh?) as a tuning guide

It knows nothing (It is a measuring tool - one)

Among many, use if so.

3. Tune note relationships with chops set for best tone on each member of the set

Quick "cracking of octaves" with fixed chops has ruined many an instrument in the tuner's shop
OVER THE PAST DOZEN YEARS
WE HAVE DEVELOPED
AN EXTENSIVE SET OF SYSTEMATIC
"PLAYING EXPERIMENTS"

TO UNCOVER THE STATE OF
ALIGNMENT (ETC) OF RESONANCES
AND TO GUIDE THE ADJUSTMENT PROCESSES
OF WIND INSTRUMENTS

FLUTE, CLARINET, BASSOON, SAX, OBOE
AND TO A CONSIDERABLE EXTENT
THE BRASSES

These can be taught, along with their
effective use in the real world.

They are not easily written up....
(Some are not.) Ask George?

ON A CUSTOMER'S HORSE
WHATEVER IT IS \textbf{DONT DO IT}
UNLESS YOU CAN SAY \textbf{BETTER}

1. EXACTLY WHAT EFFECT IT WILL
   HAVE ON ALL PLAYING BEHAVIOR

2. EXACTLY WHAT EVIDENCE YOU
   HAVE FOR DOING IT

3. EXACTLY WHEN THIS CHANGE
   SHOULD NOT BE MADE

4. EXACTLY HOW TO RECOGNIZE
   WHEN THE "DOSE" IS ENOUGH

LEARN THE ANSWERS TO THESE QUESTIONS
ON YOUR OWN GUINEA PIG HORNS