The Great Highland Bagpipe Plays in \textit{WHAT} Key?

Bill Muzzy
GCRL Science Café
January 28, 2014
Bagpipe Construction

• In its most basic form, the bagpipe is pretty simple.
• It consists of four parts:
  • bag,
  • blowpipe,
  • chanter,
  • and drone,
Not this drone!
These drones!
Operation

Sound made by blowing air into blowpipe every few seconds. Air passes through the reeds in the drone and chanter. Must keep pressure in the bag constant.
Unique Features

• When bag is inflated the chanter always produces a sound.
• Impossible to play the same note twice in a row unless another note (a “grace” note) is quickly inserted in-between.
• So the fingering is awkward and difficult.
Scotland the Brave
Grace notes

Taorluath
GHB Parts

Bag
Two tenor drones
Base drone
Blowpipe
Chanter
In addition

- Five stocks
- Chanter reed
- Two tenor drone reeds
- Base drone reed
- Blowpipe valve
- Mouthpiece
- Bag cover
- Cords
- Yards of linen hemp thread
Chanter reed
Drone reeds
GHB Bagpipe Chanter

- Chanter scale consists of 8 notes
- Low A through high A, or one octave.
- When chanter is closed, an extra note (low G) is sounded.
- The melodic range of the chanter is an octave and 1 note.
Tenor & base drone
Bagpipe drone

- Upper section of drone
- Tuning chamber approximately 3 inches deep
- Bell at top of drone
- Bell cap with hole
History

• The bag pipes - made of wood and leather.
• Instruments of the "common" people.
• Were used, probably without concern, outdoors.
• Bagpipes were peasant instruments and associated with persons of low social status.
History

• Reed pipes used since at least 2800-2500 BC. A set of silver reed pipes of that period, from Ur, still exists
• Instruments producing a continuous droning sound by air squeezed from a bag may have existed as early as 1300 BC, and certainly by last century BC
• The first definite historical evidence of a bagpipe with a chanter appears in a reference to the Roman Emperor Nero
History

From Cantigas de Santa Maria, during reign of Alfonso X "El Sabio" (1221-1284 A.D.). There are 420 poems with musical notation.

• Widespread use of bagpipe in Europe began in twelfth century.
Canterbury Tales

“A baggepipe wel koude he blowe and sowne, And therwithal he broghte us out of towne.”

- Chaucer wrote this collection of tales around the end of the 14th century
Ancient wind instruments

• Numerous wind instruments visible in very old Mediterranean and Asian art and some of the simpler instruments depicted have in some places survived virtually unchanged.
Illustrated book 1619 AD

Fast forward about 350 years to 1619, with an illustrated book by Preatorius
Drones added

- Single drone added in 14th century.
- Second drone added end of the 15th century or beginning of 16th century (1514)
- Illustrations show two drones on some bagpipes produced the same pitch, whereas some bagpipes the drones produced two pitches separated by a musical fifth.
- The third added to the highland bagpipe was the "bass" drone. Different historians give the date as 1600, 1700, or 1800
Turkish Tulum

Irish Uilleann Pipes
Hungarian Duda

Swedish säckpipa
Estonian Tourpill    Indian Sruti upanga
Bulgarian Kaba Gaida  Italian Zampogna
Serbian Gaida     German huemmelchen
Double chanter Double entendre
Bagpipes of the World
Bagpipes of the World
The Threat

Don’t make me get out the bagpipes!
Tuning

Sounds rise like noxious fumes from Goofy’s out-of-tune pipes, while Mickey protects his ears with muffs ...
Tuning

Few things are as obnoxious as an out-of-tune Great Highland Bagpipe (GHB)

Bagpipes heard out-of-tune are the major reason why many people dislike the instrument.
Out-of-tune pipes may lead to:

- Social unrest,
- Dog bites,
- High gasoline prices,
- Shortages of Prozac.
- Divorce lawyers consider badly tuned pipes money in the bank.
Scale

Basic finger position of most simple wind instruments.
The scale is a set intervals
Problem of describing chanter scale gets tied up with temperament and semi tones
Pipers think of the scale of the chanter as consisting one octave
Key vs. Pitch

• The key of the instrument is not necessarily the pitch to which it is tuned.
• The low A on the are commonly tuned to above concert B flat, which is 466.16 Hz.
• With the application of some tape and a bit of adjustment of the reeds, the GHB can be adjusted such that low A on the chanter (and the drones) vibrate at 466.16 Hz.
• This is a concert B-flat tuning of the instrument, but it is not necessarily the key.
GHB Scale
Pipe music has two sharps - F# and C#.
It corresponds to A Mixolydian.
Consonance & Dissonance

• Around ~500 BC it was known that certain notes sounding together are heard as a consonance (a smooth, pleasant combination of notes.)
• This occurs when the ratio of their frequencies is a fraction with small integers in the numerator and denominator.
  • i.e. 3/2, 9/8, 5/4
• As such the two notes have many harmonics in common.
Frequency - cps & Hz

- The unit of frequency is the number of cycles per second (cps) of a periodic phenomenon.
- One of the common uses is the description of the sine wave,
- Replace in the 1960 with the hertz (symbol Hz).
Octave

- There are 12 notes in an octave (Think piano)
- Each of them are exactly 100 cents apart.
- This is the 12-tone equal temperament system.
- It is an artificial compromise; it is not natural and it is not in keeping with the physics and mathematics of sound.
- This does not suit bagpipes as certain notes will clash
Twelve Tone Scale—Why?

- If the interval between two notes is a ratio of small integers, such as 2/1, 3/2, or 4/3, they sound good together — they are consonant rather than dissonant.
- The twelve-tone equal-tempered scale is the smallest equal-tempered scale that contains all seven of the basic consonant intervals to a good approximation — within 1 %.
Cents defined

• Scientists have a standard unit for measuring the size of perceived intervals between two frequencies vibrating at a given ratio.
• This unit is called a **cent** because it equals 1/100th of a half-step.
• There are 12 half-steps (semitones) in an octave, and so one octave = 1200 cents. By definition.
Cents

• With keyboards and other fixed intervals the scale is divided into equal values

• These intervals are sometimes expressed in "cents", where 1 cent is equal to the 12th root of 2.

• \( c = 1200 \times \frac{\ln(fb/fa)}{\ln(2)} \) or

• \( c = 1200 \times \frac{\log_{10}(fb/fa)}{\log_{10}(2)} \) or

• \( c = 1200 \times \log_2(fb/fa) \)
Overtones

• When a resonant system such as a blown pipe or plucked string is excited, a number of overtones may be produced along with the fundamental tone.

• In simple cases, such as for most musical instruments, the frequencies of these tones are the same as (or close to) the harmonics.
Natural Frequency

• When an object is forced into resonance vibrations at one of its natural frequencies, such as a guitar string or an air column enclosed within a drone it vibrates in a manner such that a standing wave pattern is formed within the object.
Overtones

Fundamental
Fundamental x 2
Fundamental x 3
Added together
Harmonics

- Each natural frequency that an instrument produces has a characteristic vibration.
- These patterns are only created within the instrument at specific frequencies.
- These frequencies are known as harmonic frequencies, or merely harmonics.
- The harmonic frequencies are related to each other by simple whole number ratios.
- This is part of the reason why such instruments sound pleasant.
Solo piping

- Solo pipe music the concern is the frequency ratio is always that between the chanter and the drones.
- Since the drone notes are "A" (one or two octaves below the chanter’s low A) the frequency of each note on the chanter is defined by the ratio of its frequency to that of low A.
- For example, low A will have a ratio of 1:1, and high A will have a ratio of 2:1.
- C# will have a ratio of 5:4
## Notes, Frequency, Ratio & Cents

<table>
<thead>
<tr>
<th>Note</th>
<th>Hz</th>
<th>Ratio</th>
<th>Cents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low G</td>
<td>414</td>
<td>8:9</td>
<td>-203.9</td>
</tr>
<tr>
<td>Low A</td>
<td>466</td>
<td>1:1</td>
<td>0.0</td>
</tr>
<tr>
<td>B</td>
<td>524</td>
<td>9:8</td>
<td>203.9</td>
</tr>
<tr>
<td>C(#)</td>
<td>583</td>
<td>5:4</td>
<td>386.3</td>
</tr>
<tr>
<td>D</td>
<td>629</td>
<td>27:20</td>
<td>519.6</td>
</tr>
<tr>
<td>E</td>
<td>699</td>
<td>3:2</td>
<td>702.0</td>
</tr>
<tr>
<td>F(#)</td>
<td>777</td>
<td>5:3</td>
<td>884.4</td>
</tr>
<tr>
<td>High G</td>
<td>828</td>
<td>16:9</td>
<td>996.1</td>
</tr>
<tr>
<td>High A</td>
<td>932</td>
<td>2:1</td>
<td>1200.0</td>
</tr>
</tbody>
</table>
Recap

• All parts of the GHB defined
• Bagpipes are very old
• Found in many countries
• Range of notes
• Tuning the GHB
• Gracing and embellishments
• Playing techniques
• Sound defined
• Twelve notes in an octave
• GHB scale unique because of drones
• Need for tempering GHB scale
16 Chanters & 48 Drones
The GHB plays in WHAT key?

D major

sort of