

mixtures

Questions

- Mouth tone versus body tone
- Boundary condition of pipe body resonance solution: air column starts at lower lip so both ends are at ambient pressure ($\Delta P = 0$)
- End correction? Pipe appears (sounds) a bit longer than it is
- Derivation and utility of sum and difference tones
- Temperament - scheme to adjust interval sizes to accommodate pure octaves

Tone Generation Process

- Air enters pipe toe and pass through flue
- Impinges on the upper lip creating vortex-like structures (eddies)
- These structures contain a broad spectrum of frequencies
- Only the pipe's natural frequencies are excited/amplified.

Diagram of pipe

Deriving the resonance frequencies of a pipe

The acoustic pressure, that is the deviation from the ambient ($p \equiv P - p_0$), obeys the acoustic wave equation:

$$\frac{d^2 P}{dt^2} = \frac{1}{c^2} \frac{d^2 P}{dt^2}$$

Since the boundary conditions of the organ pipe are that the pressure deviation goes to zero (i.e. $P(x=0, L) = 0$), solutions are sine waves. In medium with sound speed c , the dispersion relation is: $f = \frac{c}{\lambda}$

The resonant frequencies of this pipe is then given by: $f_n = \frac{nc}{2L}$

Comparison of theoretical and experimental spectra

| | Number of half steps |
|-----------------|----------------------|
| Unison/octave | 1, 8, 15, 22, ... |
| 3 rd | 3, 10, 17, 24, ... |
| 5 rd | 5, 12, 19, 26, ... |

Get pitch class via modulo 7 (ex. $\text{mod}_7(24) = 3$ so the 24th is a version of the third.)

Related terminologies

Pipe length

Half-step distance

Diatonic distance

Partials/harmonics

Mixture basics

Contemporary American Organ (p. 67)

Mutation: ranks sounding pitches other than a unison/octave Mixture: combination of unisons/octaves and mutations controlled via one drawknob

Mixture size range from two ranks (12th and 15th) to 8 ranks.

Smallest pipe has speaking length of less than three-eighths of an inch. When a mutation voice is desired to be smallest than this length, instead made an octave lower. This is deemed a break. Happens one or multiple times across the span of the mixture.

Other factors in mixture design: * Pipe types: diapason/principal, flute, etc (different harmonic contents produce varying mixture characters) * Scaling (also affects harmonic content) * Voicing (ex. soft, loud, aggressive, etc.)

Mixture examples

Mixtures with no breaks

- Raushquinte or Grave Mixture
 - Only 12th and 15th
 - *Raush* in German, means intoxication, ecstasy, drunkenness
- Cornet
 - 3 to 5 ranks with a versino of a third on top
 - Common pitch constituents are (12-15-17) and (1-8-12-15-17)
- Sesquialtera
 - 12th and 17th for which series they support (ex. to support an 8' stop, pitches $2\frac{2}{3}$ and $1\frac{3}{5}$ are played)

Mixtures with breaks

- Mixture/Fourniture/Plein Jeu
- Scharf/Acuta
- Carillon/Glockenspiel
- Harmonics

Resultants Provides some of the overtone series to give the illusion of a non-existent, lower fundamental tone.

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32' Grand Cornet on Pedal CCC plays: * Bourdon 16': $16\ 10\frac{2}{3}$ * Gemshorn:
 $10\frac{2}{3}\ 5\frac{1}{3}\ 4\ 3\frac{1}{5}$

(All octaves and fifths.)

Table 2: Monkeys live in the zoo.

| Description | Diatonic number | Chromatic distance | Pipe length (ft) | Common Names |
|-------------------|-----------------|--------------------|------------------|---------------|
| Root, unison | 1 | 0 | 8 | Unison |
| Octave | 8 | 12 | 4 | Super octave |
| Oct + 5th | 12 | 17 | $2\frac{2}{3}$ | Nazard, quint |
| 2 octaves | 17 | 24 | 2 | Fifteenth |
| 2 oct + major 3rd | 17 | 28 | $1\frac{3}{5}$ | Tierce |
| 2 oct + 5th | 19 | 31 | $1\frac{1}{3}$ | Larigot |
| 2 oct + min 7th | Flatted 21st | 34 | $1\frac{1}{7}$ | Septime |
| 3 oct | 22 | 38 | 1 | None |

| Right | Left | Center | Default |
|-------|------|--------|---------|
| 12 | 12 | 12 | 12 |
| 123 | 123 | 123 | 123 |
| 1 | 1 | 1 | 1 |

Temperament