

WHY ARE PIANOS
OUT OF TUNE?

Robin Wilson



Gahu on 'J, K, R' : Carlton Gamer

Phonemes : J, (dʒ), K, R

Speakers:

J K K J J K K J R -

K K J K K J K K J K J K

J J K J K J K J J K J K J K J K J

R (rolled), J and K sustained

3. R
1. J (dʒ)
2. K (voiceless)

Percussion:

(Signature)

Steve Reich's clapping games

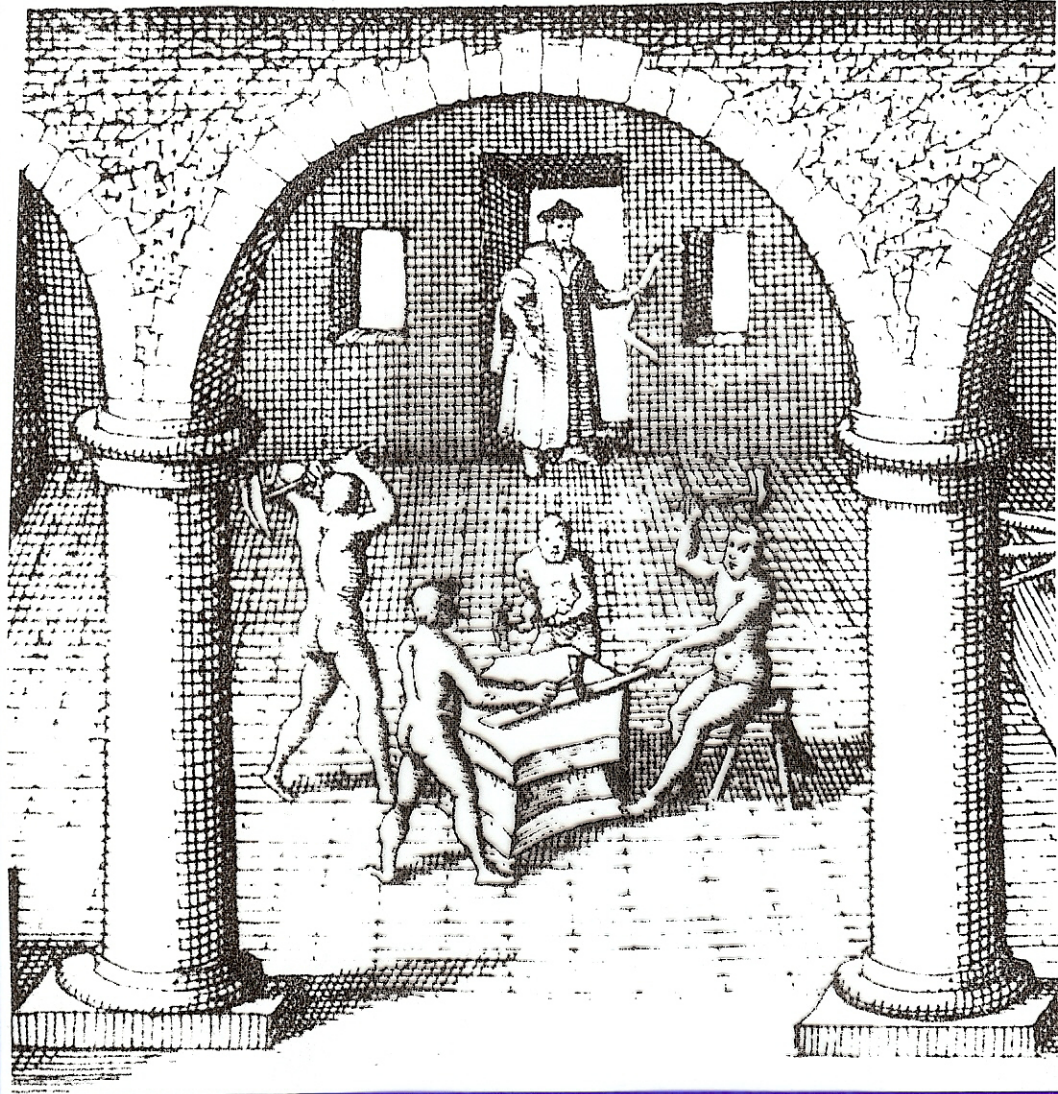
Rhythm 1



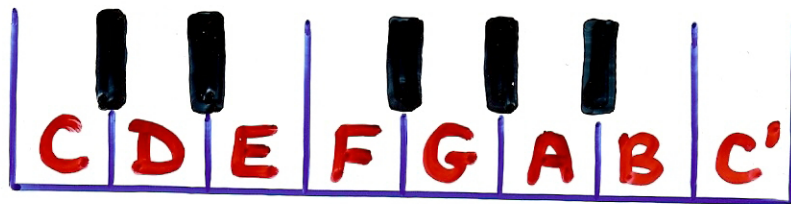
Rhythm 2



Pythagoras at the Forge



Greek tuning



octave	C - C'	2 : 1
perfect 5th	C - G	3 : 2
perfect 4th	C - F / G - C'	4 : 3

The Pythagorean Octave

C	1	256
G	$3/2$	384
D	$9/8$	288
A	$27/16$	432
E	$81/64$	324
B	$243/128$	486
F	$4/3$	341
C'	2	512

C	D	E	F	G	A	B	C'
1	$9/8$	$81/64$	$4/3$	$3/2$	$27/16$	$243/128$	2
256	288	324	341	384	432	486	512
$\overline{9/8}$	$\overline{9/8}$	$\overline{256/243}$	$\overline{9/8}$	$\overline{9/8}$	$\overline{9/8}$	$\overline{256/243}$	

Britten 'Serenade'

PROLOGUE

Andante

p 8 12 8 9 6 *pp* 10 8 *cresc.* 8 11 10 9 6

a tempo

pp 10 8 *più f* 6 9 6 7 8 6 9 6

animando

a tempo

molto cresc. 6 7 8 6 9 6 10 6 11 *f* 8 12 *ff* 8 13 12 *pp* 8 9 6 10 4 *dim.* *molto rall.* *ppp*

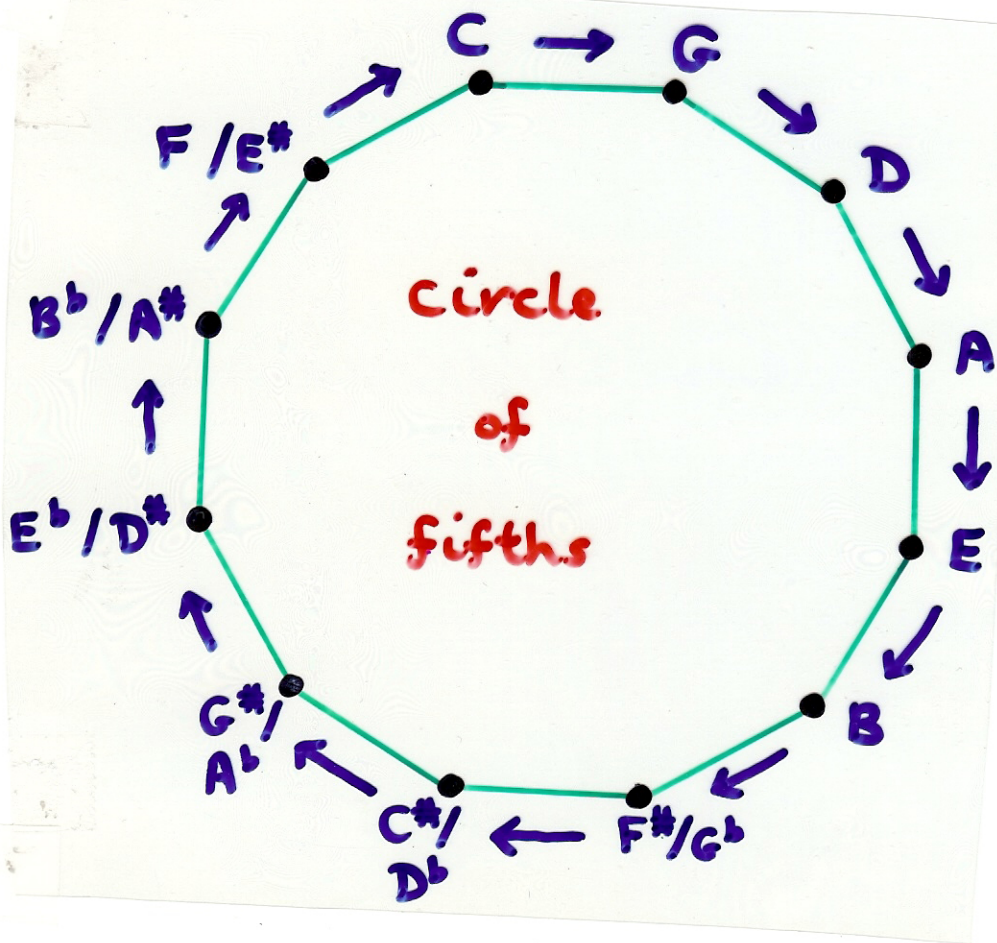
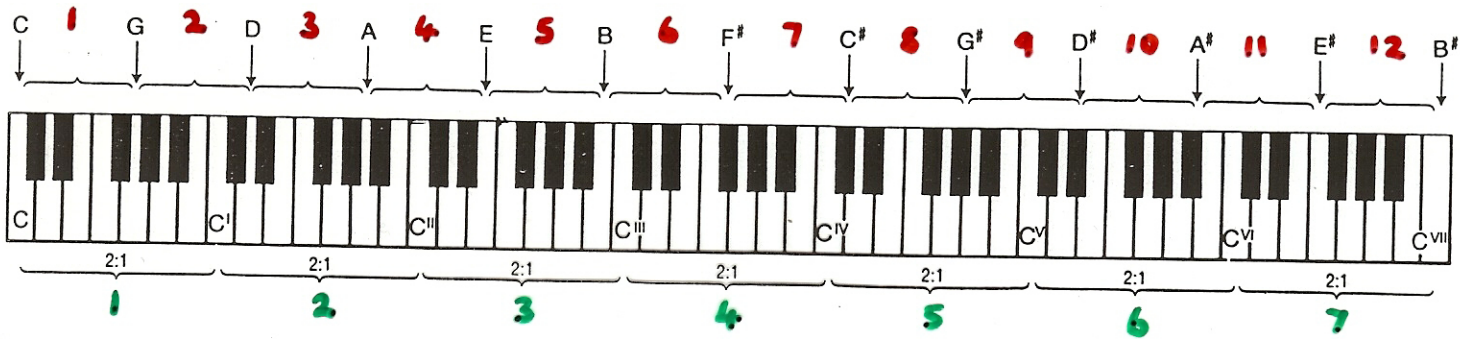
The harmonic series

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 ...



C,, C, G C E G B^b C' D' E' F[#] G' A' B^b B' C'' ...

A problem :



7 octaves:

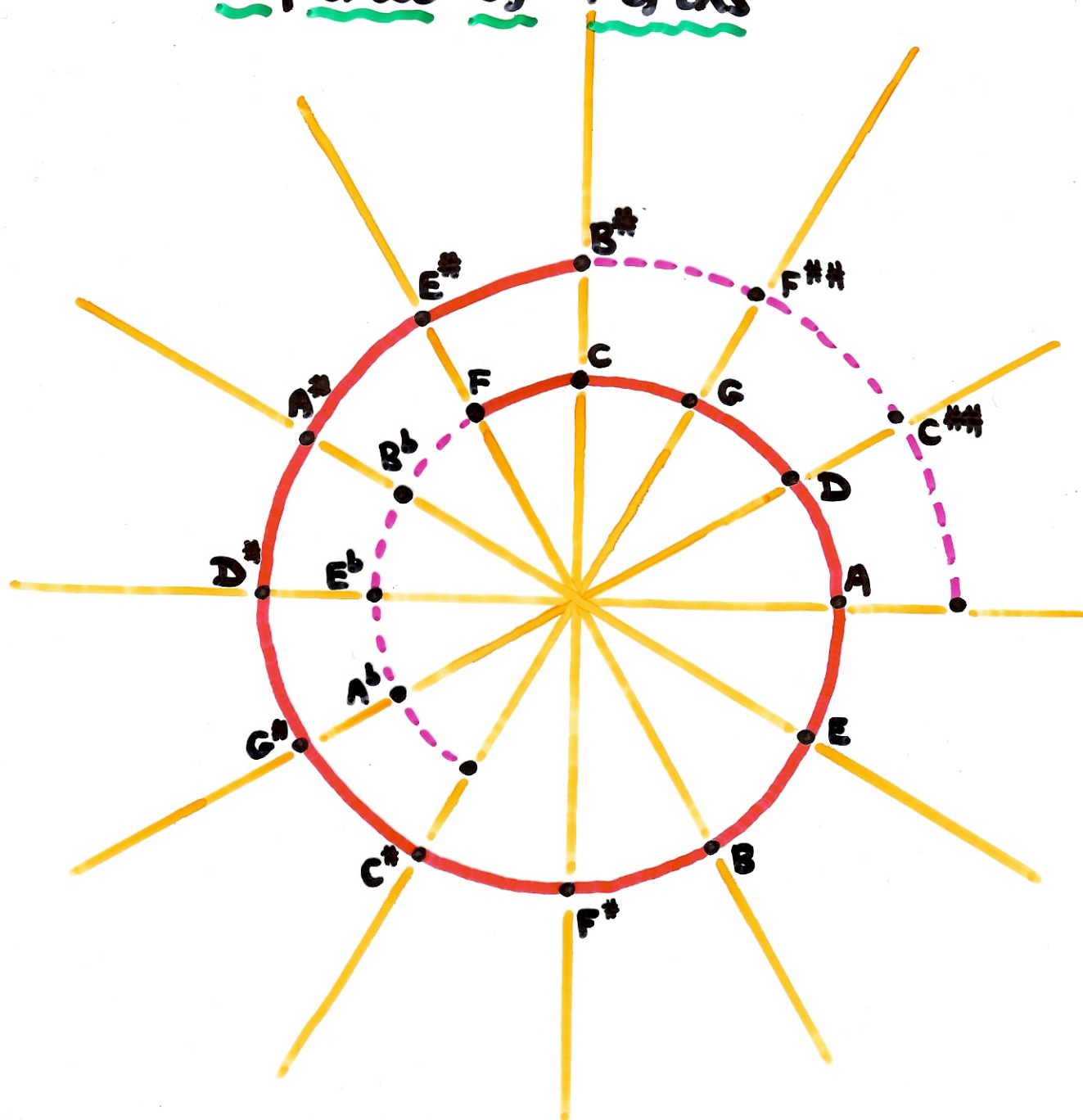
$$\left(\frac{2}{1}\right)^7 = 128$$

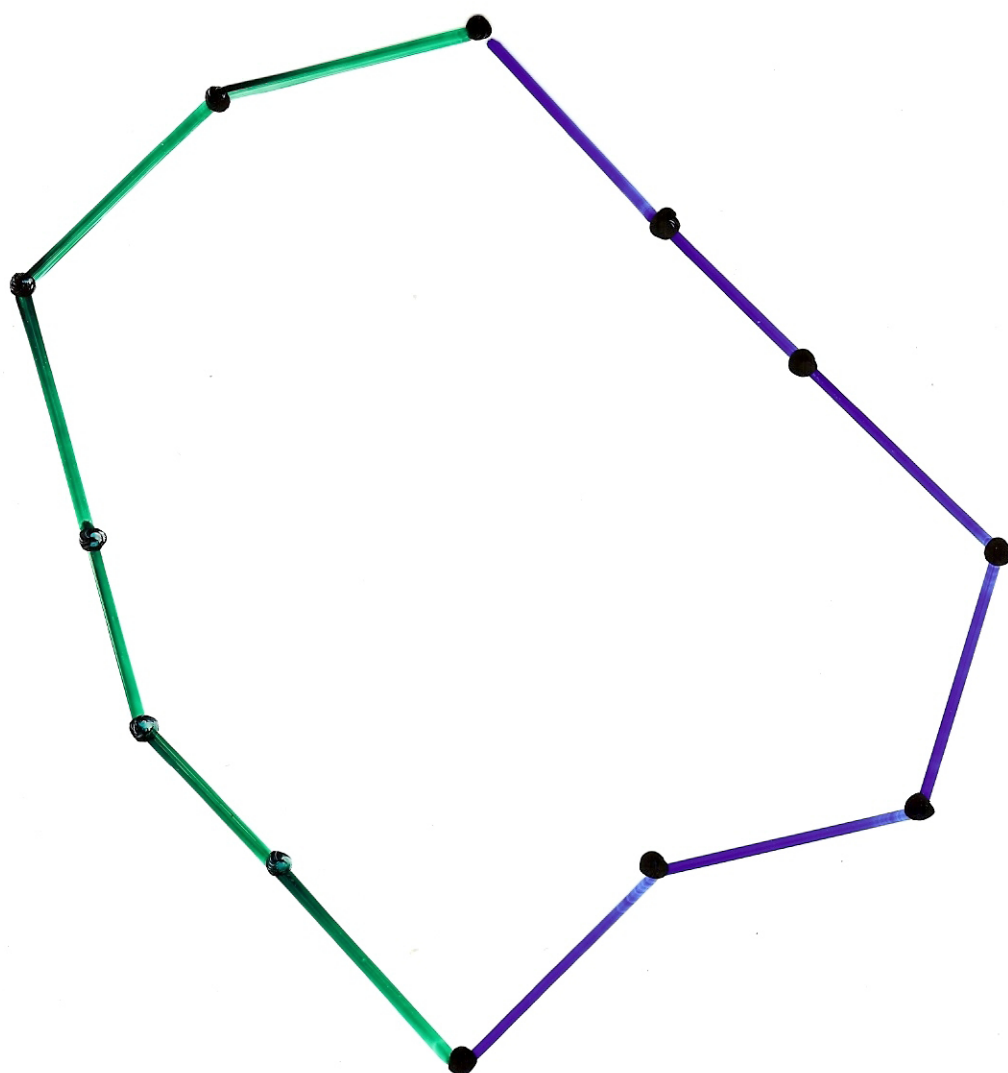
12 fifths:

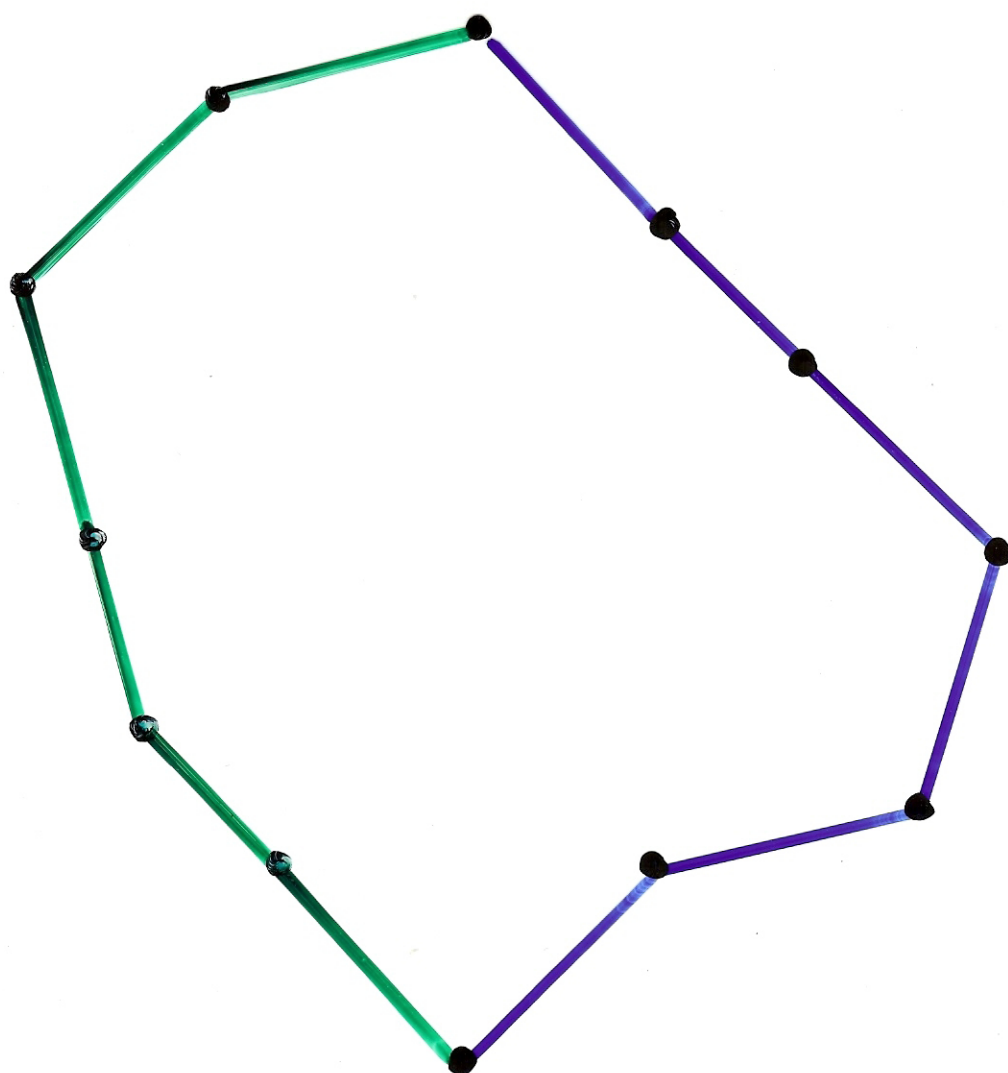
$$\left(\frac{3}{2}\right)^{12} = 129.75$$



Spiral of Fifths





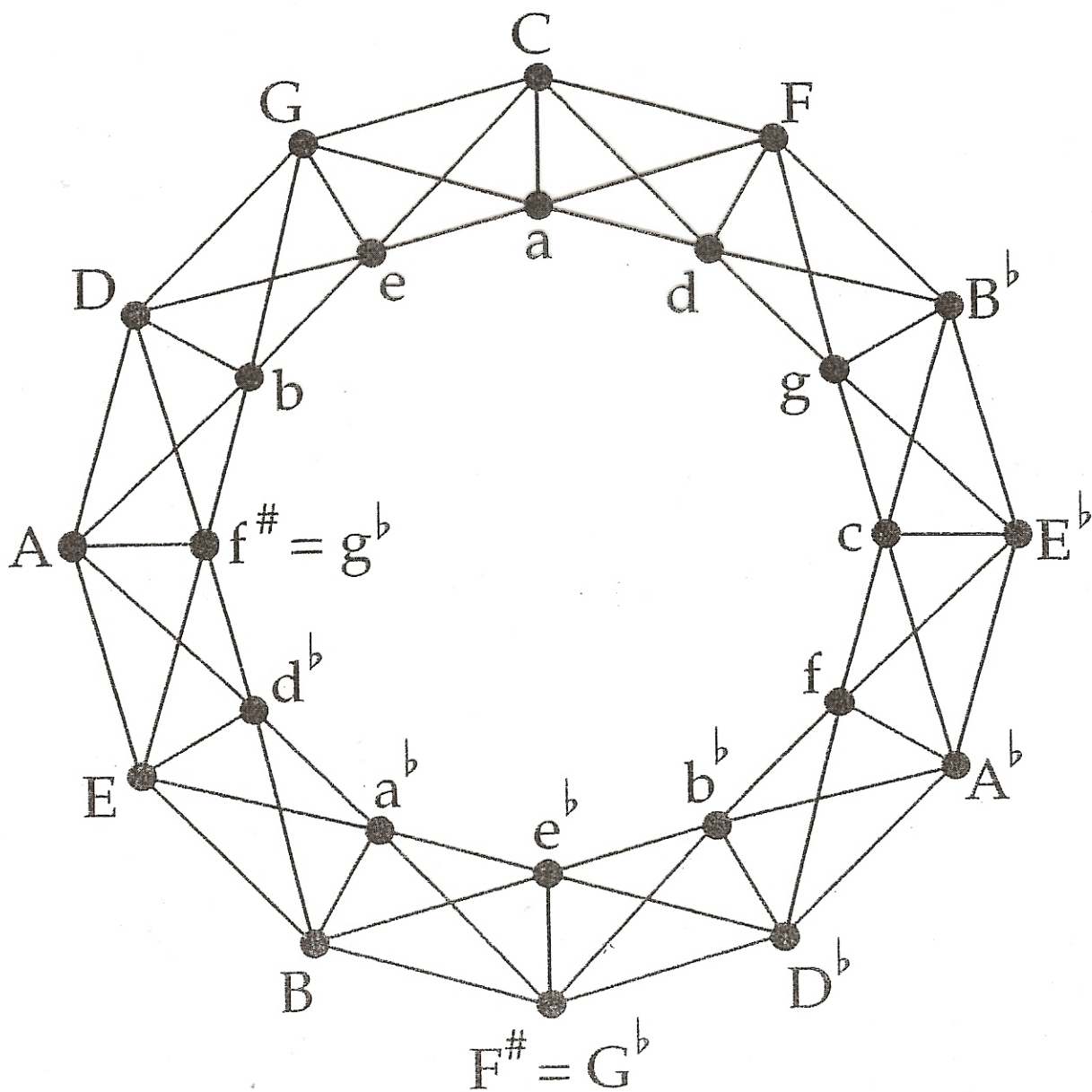


Key - changes:

C to F sounds natural

C to F# does not

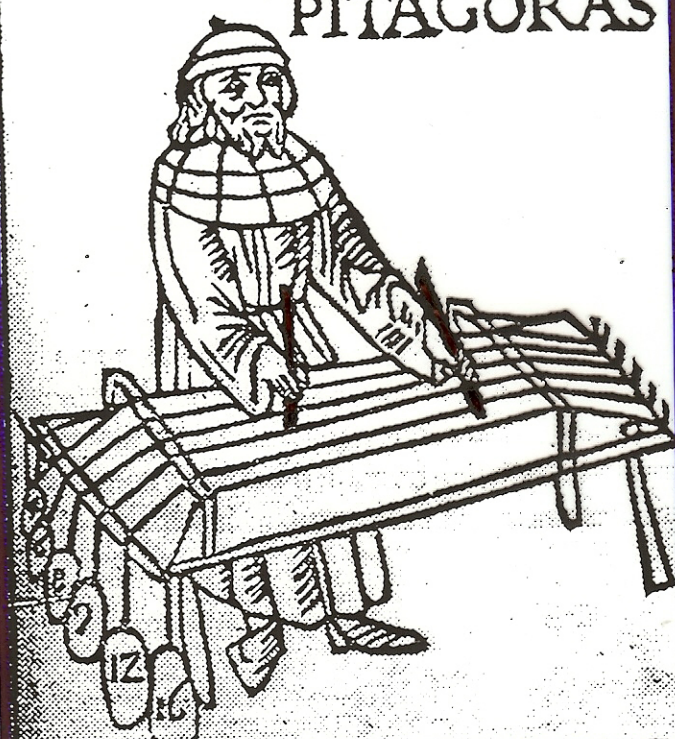
take $C \rightarrow G \rightarrow D \rightarrow A \rightarrow E \rightarrow B \rightarrow F \#$



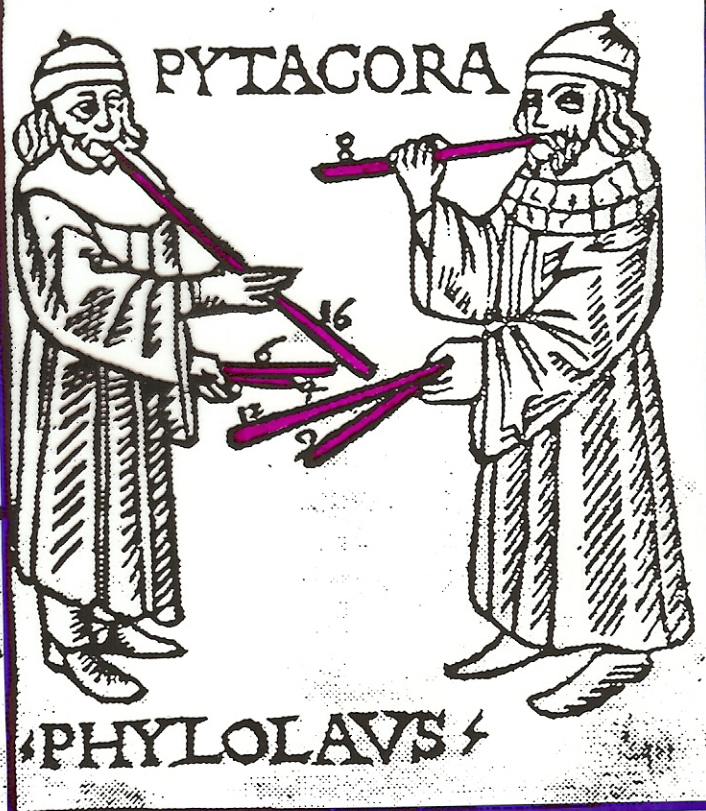
IV BAL



PITAGORAS



PYTACORA



The Seven Liberal Arts





octave	$C - C'$	$2 : 1$
perfect 5th	$C - G$	$3 : 2$
perfect 4th	$C - F / G - C'$	$4 : 3$
major 3rd	$C - E$	$5 : 4$
major 6th	$C - A$	$5 : 3$
minor 3rd	$A - C' / E - G$	$6 : 5$

Getting from C to D

$$C \rightarrow G \rightarrow D$$

$$3/2 \div 4/3 = 9/8$$

$$C \rightarrow F \rightarrow D$$

$$4/3 \div 6/5 = 10/9$$

Just Intonation

C	1	256
G	$3/2$	384
F	$4/3$	341
E	$5/4$	320
D	$9/8$	288
A	$5/3$	427
B	$15/8$	480
C'	2	512

C	D	E	F	G	A	B	C'
1	$9/8$	$5/4$	$4/3$	$3/2$	$5/3$	$15/8$	2
256	288	320	341	384	427	480	512
$\overline{9/8}$	$\overline{10/9}$	$\overline{16/15}$	$\overline{9/8}$	$\overline{10/9}$	$\overline{9/8}$	$\overline{14/15}$	

Marin Mersenne

HARMONIE VNIVERSELLE.

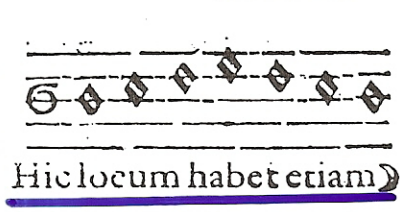
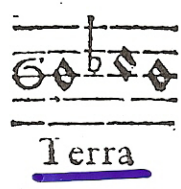
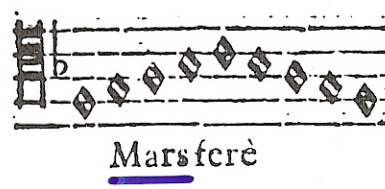
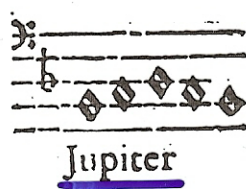
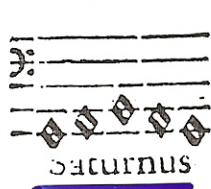


Ex antiquo marmore Illustissimi Marchionis Mathiei Roulle.

M. de la Roche.

Nam & ego confitebor tibi in vasis psalmi veritatē tuam:
Deus psallam tibi in Cithara, sanctus Israel. *Psalmus 70.*

Kepler's planetary scales



Newton's diagram

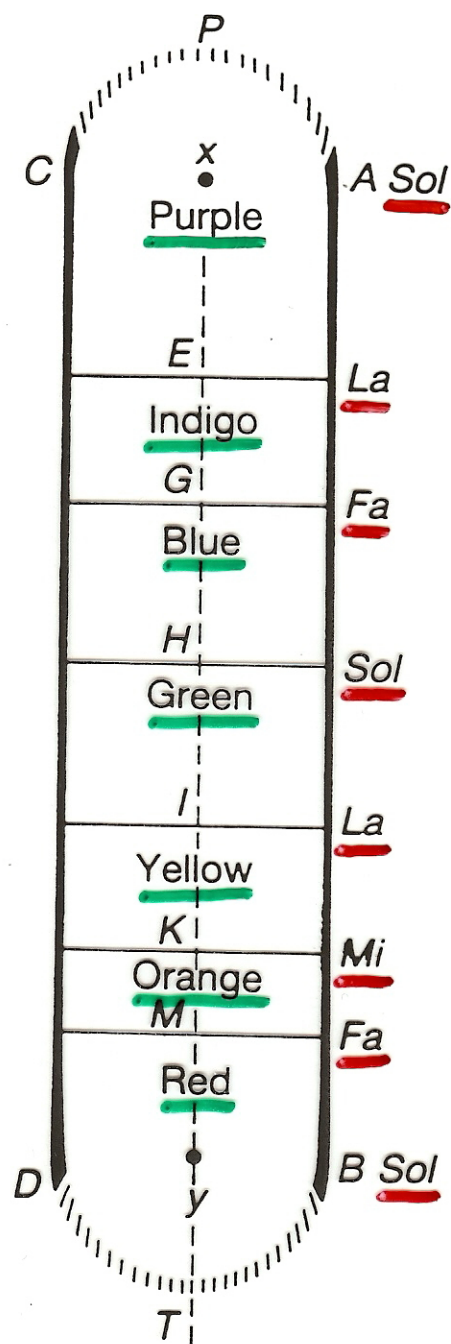
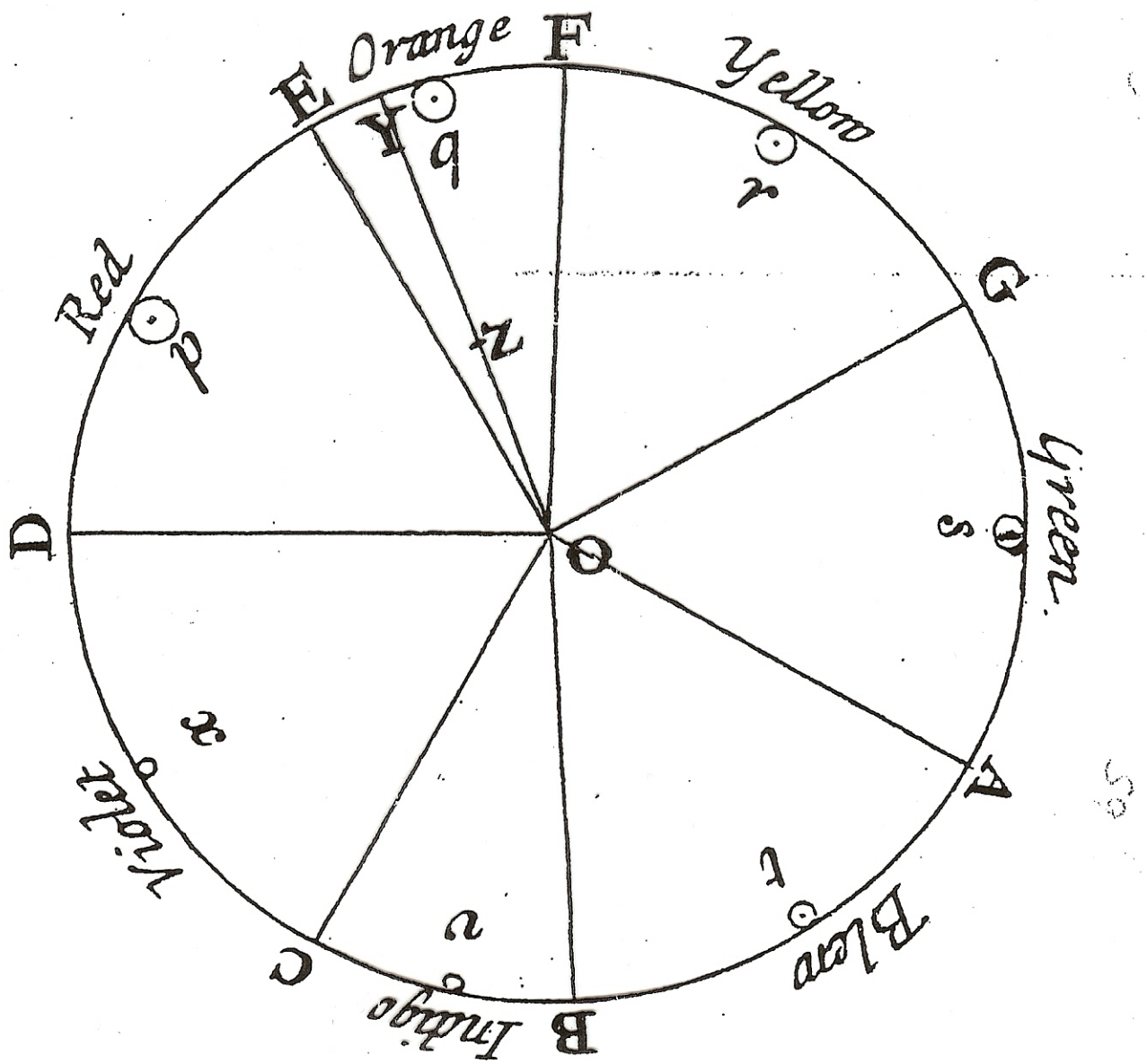


Fig. 11.



Equal temperament

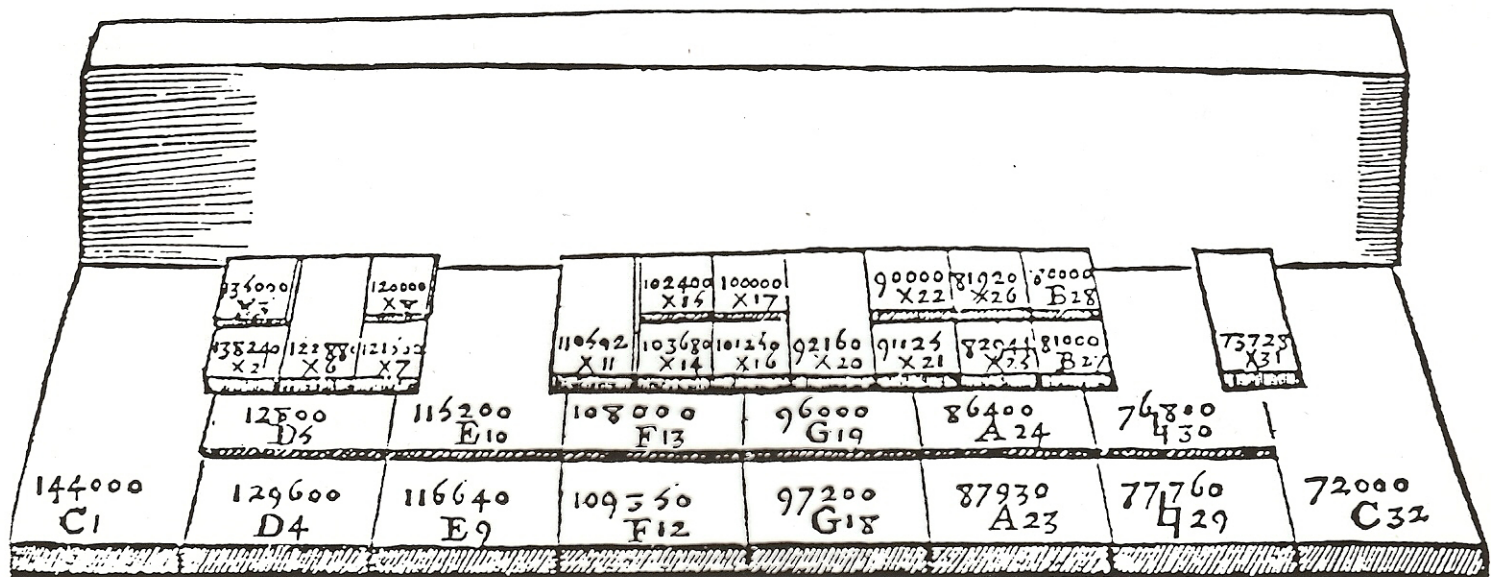
All semitones have ratio

$$\sqrt[12]{2} \text{ to } 1 \quad (\sim 1.059 \text{ to } 1)$$

Comparing Scales

	Pyth.	Just	Mean	Equal
C	1	1	1	1
D	1.125	1.125	1.118	1.122
E	1.266	1.25	1.25	1.260
F	1.333	1.333	1.337	1.335
G	1.5	1.5	1.495	1.498
A	1.688	1.667	1.671	1.682
B	1.898	1.875	1.869	1.888
C'	2	2	2	2

Mersenne's 31-tone keyboard



ORGANUM:
From Canto LXXXI

Ezra Pound

Carlton Gamer

Realization by digital synthesis)

ETS 31*

Introduction: [J = c.60]

8ve.pc: 6.08 6.26
sf

6.01 6.19 6.29 7.06 7.26 7.16
accel. rit.

5.29

mp niente mf p

Time (in beats): 0.0 0.5 4.5 5.0 5.5 6.0 6.5 7.0 7.5 9.5

Voice filter:

7.26 8.03 7.26 7.21 7.26 7.08 8.08 7.13

7.08 7.11 7.08 7.03 7.08 6.21 7.16 6.26

Text (in natural speech rhythm): "What thou lov- est well re- mains, / the

Approximate durational values:

8.03 7.26 8.26 8.08 8.08

7.16 7.16 7.23 7.10 7.13 7.15 7.28 7.21 7.29 7.21 7.21
7.03 7.13 6.18 7.00 7.05 7.18 7.13 7.16 7.08 7.08

6.29 6.16 7.05 6.00 6.21 6.28 7.10 7.03 6.13 6.16 6.06 6.29 6.29

rest is dross / What thou lov'st well shall not be left from thee /

Interlude: [J = c. 58]

7.08 7.11 7.13 7.26 7.18 7.21 7.23 8.05 7.28 8.28 8.20 Voice filter:
7.26 7.16 6.26 7.26 7.05 8.18 7.28

p *cresc.* *mf* *p*

7.20 7.23 7.25 7.15

5.29 6.19 6.26 7.08 6.08 6.29 7.05 7.18 6.18 8.07 7.10 7.10 7.18 7.07

T: 0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 6.5 7

"What thou lov'st

8.07 7.30 8.10 8.12 9.12 9.04 9.04 8.15 9.15 8.25 9.02 8.02 8.10

7.28 7.12 7.30 8.02 8.30 8.12 8.12 8.07 8.17 8.07 8.05 7.25 7.23

7.10 6.30 7.20 7.15 8.22 8.12 8.12 7.17 7.28 6.10 7.15 7.13

6.18 6.20 7.02 6.23 8.02 7.25 7.25 6.28 7.20 7.15 7.13

well is thy true her- i- tage / Whose world, or mine or theirs /

31 = d

8.05 7.28 8.00 8.13 8.23 9.05 9.00 8.13 9.10 9.05 8.18 8.20

7.16 7.18 7.13 7.26 7.05 8.08 8.10 8.02 9.02 8.15 8.07 7.30 7.10

7.16 7.18 7.13 7.26 7.05 7.18 7.21 7.23 8.23 7.26 7.28 7.10

7.08 7.10 7.03 6.26 6.18 7.00 7.13 7.15 7.13 7.18 7.20 7.02

or is it of none? / First came the seen, then thus the

3



19

