Larkfall ~ Phil Legard

Kircher & Schott's Computer Music of the Baroque

06 *Friday Jun 2014*

POSTED BY LARKFALL IN ARCANA, MUSIC AND THEORY

≈ 4 COMMENTS

Here is a piece of music, which was composed with a sort of 17th century computer called the *Organum Mathematicum*, devised by Athanasius Kircher and fully described by his pupil and assistant Gaspar Schott:

It was the last post, touching on Robert Fludd's *Temple of Music*, which reminded me of my interest in the *Organum* in around 2007, which is when the above piece was written. Now that I am free of the limitations of LiveJournal, I'd like to use this post to revisit Kircher and Schott's work.

4

A surviving Organum Mathematicum (Museo Galileo)

The *Organum*, of which a <u>surviving example</u> is shown above, was essentially a wooden chest containing various wooden plates or 'staves' (*baculi*) upon which tables of data and rules were written. Originally built by Kircher as a pedagogical aid for the instruction of the 12-year-old Archduke Karl Joseph von Habsburg, it was fully described in Schott's monumental, posthumous <u>*Organum Mathematicum : Libris IX Explicatum*</u> (1668). The various *baculi* contained therein can be used to plan fortified towns, calculate sundials, cipher messages, perform astronomical calculations, derive astrological data and compose music.

The *Organum* is essentially a variation on Kircher's *Arca Musarithma*, a 'mechanical' composing tool proposed in the second volume of his *Musurgia Universalis* (1650). Here, the box contains various wooden staves containing details of *toni* (similar to our contemporary musical keys, and 12 in total) and various other staves, each one relating to a *strophe* (akin to a musical bar) of a certain number of syllables in length, the primary aim being to compose liturgical song, rather than instrumental music. The *strophes* could be assembled in various orders and, when mapped on to a given *tonus*, would yield a musical composition.
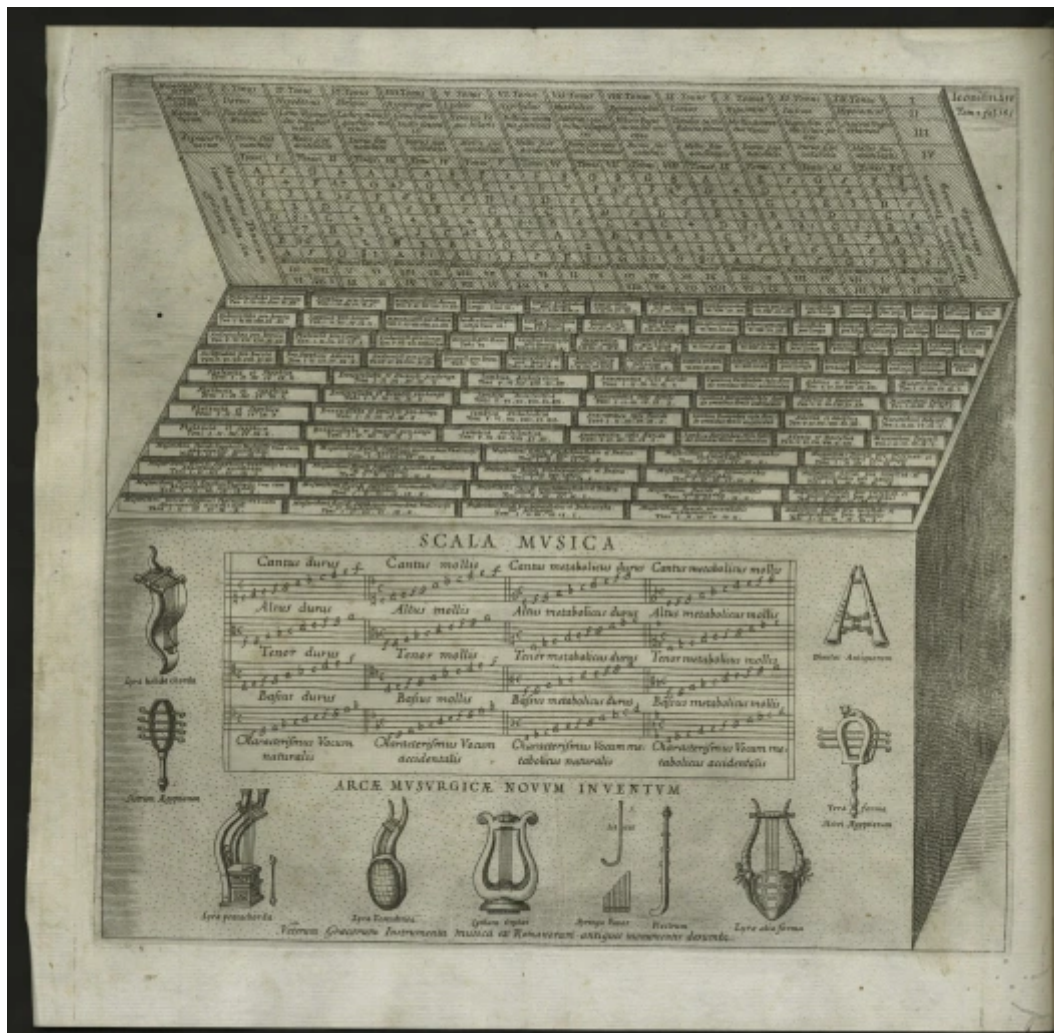
Kircher's Arca Musarithmica, illustrated in the second volume of Musurgia Universalis.

Schott presents a smaller set of *toni* and *strophes*, so that his *Organum* could include other disciplines, although what he does present is a useful summation of the *Arca*, which can be used to create compositions in both simple (or equal) and florid (or diminished) counterpoint. Kircher also provides guidance on modulating between toni over the course of a composition, as well as demonstrating his famed linguistic abilities by setting hymns in Greek, Hebrew, Arabic, Chaldean, and so on.

Lib. VIII. Musurgia Mirifica.																		135

ንዋን፦ ፈለገ፦ ሰማይ ፥፥																	*Gihon falach famai*
																				Nilus fluuius cœleftis

ኀየፈሰብ፦ ውኃት፦ ሰብያ ፥፥															*Zaiflas watu bemai*
																				Qui irrigat falubribus aquis

ዕፁር፦ ተዓሰበት፦ ዕለ፦ ሰውሰ ፥፥												*Madur tamla bebala*
																				Terram replens diuitijs

ወተዓሰበ፦ ሰአለኑ ፥፥ ——										*watamla faalanu*
																				Nos vero abundantia fatiat.

Compofiturus igitur fuper huiufmodi linguam cantilenam, ex Pinace IV. excerpat quat or Mufarithmos quacunque ferie. vt fequitur .deinde affumpto tono quouis eos in harmoniam animabis iuxta præcepta tradita, prodibitque fequens Melothefia.

Melothefia Æthiopica tertij toni Rhythmica.

5654321	5543222	6543223	3456543
8674878	7865767	88658,8	8888888
3456355	2345545	6325655	5654365
1432151	5123525	4123451	8434841

F	7
E	6
D	5
C	4
B	3
A	2
G	8
F	7

Melothefia Æthiopica V III. toni, recto & retrogrado ordine cantabilis.

Gihon falach famai   Zaiflas Watu bemai   Madur tâla bebala   Watâla faalanu.

Ecce paradigma Melothefias Æthiopicæ; eodē prorfus ingenio artificiofam & floridam fupra dicta metra Melothefiam compones, fi floridos è Pinace III.Syntagmatis II. Mufarithmos excerpferis, & tradita methodo operatus fueris.

§. VI.

Kircher's setting of an Aetheopic hymn, from Musurgia Universalis Tom. II.

Below is a summary and discussion of the musical materials from the *Organum*, based on the work of Dr. H. J. Vollrath (University of Würzburg), who has created an extensive resource relating to Kircher's invention (in German). I should also mention the work of creative programmer/polymath Jim Bumgardner, who began studying the music of the *Organum* in 2006. While revisiting this material, I was pleased to find that he had since written a paper on his software realisation of the *Organum's* music. Jim also raises some interesting questions in his discussion, which would be worth pursuing in the future. In particular, the question of the 'merit' of the compositions produced by the *Arca* and *Organum* is an

interesting one: they are, of course, all of a particular style, but perhaps we should also remember that prior to the Classical period, music often served a more functional and social role than an 'high art' one. Furthermore, anyone with a little knowledge of the rules could compose with the system, or follow other musical rules (for example, write a <u>cantus firmus</u> and then harmonise it), but these techniques are actually a small part of what making music of any lasting value is 'about'.

What I personally find so pleasing about Kircher's system is that it is inherently symbolic: the lines of counterpoint exist as abstract symbols (numbers), which may be mapped onto a multitude of tonalities and rhythms. This is very much the same way that I have approached the composition of algorithmic music, for example on the two albums recorded under the pseudonym <u>Peter Cora</u> (written with <u>Symbolic Composer</u>) or in my <u>Spacious Mind</u> project.

I. Composing simple (equal) counterpoint

Schott presents four sets of tables for composing simple counterpoint, which reflect the verse structure of various poetic meters. Having chosen a meter, the composer removes the four associated *baculi* from the box:

Meter	Syllables per line	Example
Euripedean (fig. 1a)	6/6/6/6	*Ave maris stella*
Anacreontic (fig. 1b)	7/7/7/7	*O felix ter quaterque*
Sapphic (fig. 2a)	11/11/11/5	*Iste Domini sacratus confessor*
Archilochic (fig. 2b)	8/8/8/8	*Veni Creator Spiritus*

Four meters available for simple counterpoint,

Euripedean baculi.

Anacreontica Stropha. I.

Toni . I . II . III . IV .

5	5	4	3	2	3
7	7	8	6	5	5	5
2	3	3	8	8	7	8
5	3	8	4	8	5	8
3	3	2	8	8	7	8
8	8	7	6	6	5	5
5	5	5	3	4	2	3
8	8	5	6	4	5	1
5	5	6	5	3	2	3
7	7	8	8	8	7	8
2	2	4	5	5	5	5
5	5	4	3	1	5	1
3	3	4	5	4	2	3
8	8	7	7	6	5	5
5	5	4	3	8	7	8
1	1	2	3	4	5	1
3	4	5	4	3	2	3
5	6	5	7	8	7	8
8	8	8	2	5	5	5
1	4	3	2	1	5	1
5	5	5	4	3	2	3
7	7	8	6	5	5	5
2	3	3	8	8	7	8
5	3	1	4	1	5	1

Notæ temporis.

Tripla

Anacreontica Stropha. II.

Toni . I . II . III . IV .

3	3	2	8	7	7	7
8	8	7	6	5	4	5
5	5	4	3	3	2	3
8	8	5	6	3	7	3
5	5	4	3	2	2	2
7	7	7	5	7	6	7
3	3	2	3	5	4	5
3	3	7	8	5	2	5
3	3	2	8	7	6	5
8	8	7	6	5	4	5
5	5	5	3	3	8	3
8	8	5	6	3	4	3
5	5	4	4	3	2	2
7	7	8	2	8	6	7
2	2	8	5	5	4	5
5	5	6	7	8	2	5
2	3	2	8	7	6	7
7	8	7	5	5	4	5
5	5	4	3	2	2	2
5	1	2	3	5	2	5
5	5	4	3	2	4	2
7	7	7	8	2	8	7
3	3	4	5	5	8	5
3	3	2	8	7	6	5

Notæ temporis.

Tripla

Anacreontica Stropha III.

Toni . I . II . III . IV .

5	5	5	3	5	4	5
8	8	7	8	7	7	7
3	3	2	8	3	2	3
8	8	5	6	3	7	3
5	5	4	3	2	8	7
7	7	7	5	5	3	5
3	3	2	8	7	8	2
3	3	7	8	5	6	5
5	5	4	3	3	2	3
7	7	2	7	8	7	7
5	5	6	5	4	4	5
3	3	4	5	6	7	3
3	6	5	3	6	5	4
8	8	7	8	8	8	6
5	4	2	8	4	3	4
8	4	5	6	4	8	4
5	5	5	4	3	2	3
7	7	7	7	5	7	7
3	3	3	2	3	4	5
3	3	3	7	8	7	3
5	5	5	3	3	2	3
8	8	7	8	7	7	7
3	3	2	1	5	4	5
8	8	5	6	3	7	3

Notæ temporis.

Tripla

Anacreontica Stropha. IV.

Toni . I . II . III . IV .

8	8	8	2	3	2	3
6	6	5	7	8	7	8
4	4	5	4	5	5	5
4	4	3	2	1	5	1
5	5	5	4	3	2	3
7	7	7	6	5	5	5
3	3	3	8	8	7	8
3	3	3	4	1	5	1
7	7	7	6	8	7	8
5	5	5	4	3	5	5
3	3	3	8	8	2	3
3	3	3	4	6	5	1
5	5	4	4	3	2	3
7	7	6	6	5	5	5
2	2	2	8	8	7	8
5	5	2	4	1	5	1
3	2	8	7	6	5	5
8	7	6	5	4	2	3
5	5	3	3	8	7	8
8	5	6	3	4	5	1
3	4	5	4	3	4	3
8	8	8	8	8	8	8
5	6	5	6	5	6	5
1	4	3	4	1	4	1

Notæ temporis.

Tripla

Anacreontic baculi (reverse side of Euripidean baculi).

Sapphica Stropha. I.

Toni. I.II.III.IV.

Sapphica Stropha. II.

Toni. I.II.III.IV.

Sapphica Stropha. III.

Toni. I.II.III.IV.

Adonia pro Sapphicis.

Toni. I.II.III.IV.

Notæ temporis.

Tripla.
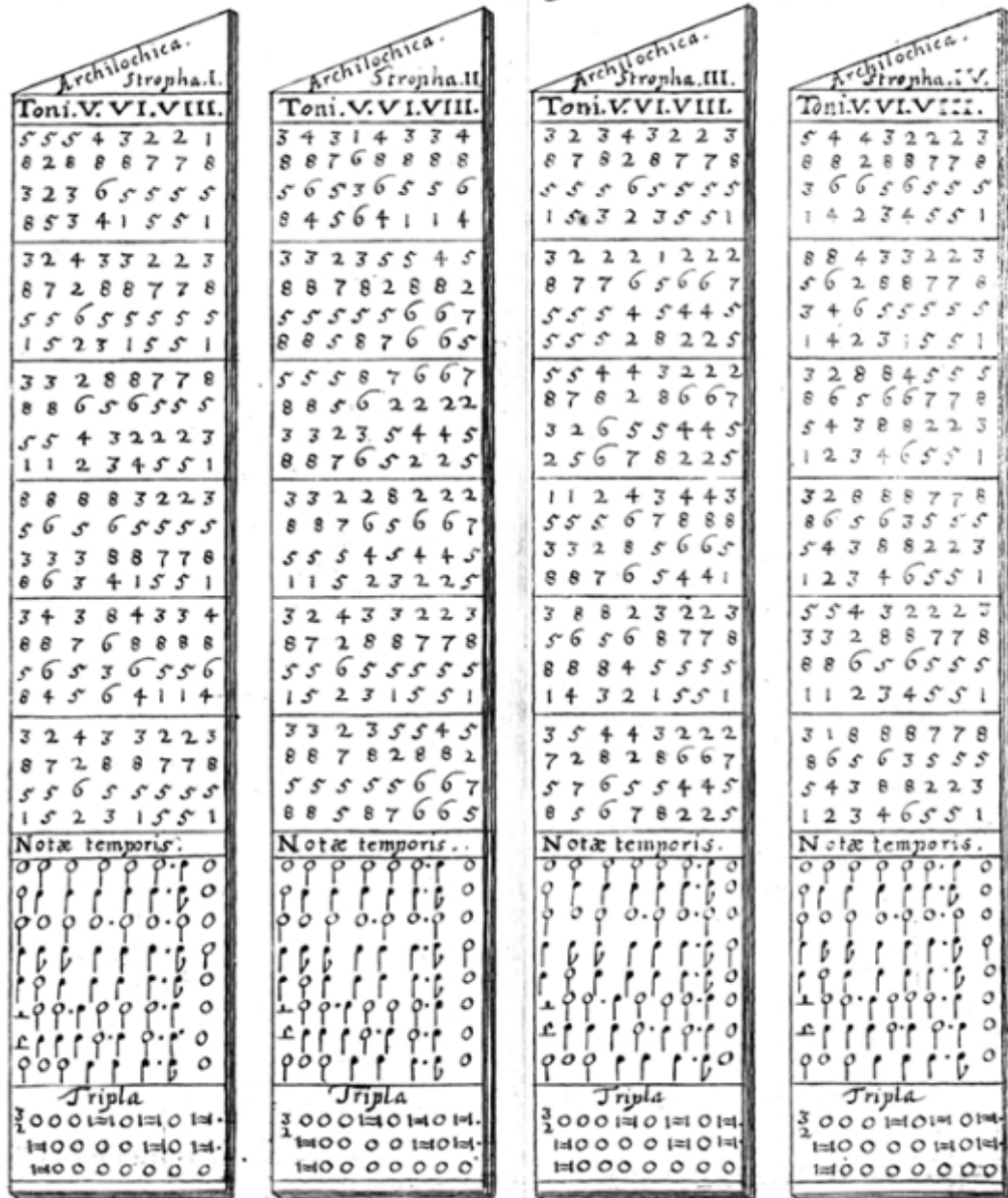
Sapphic baculi.

Archilochic baculi (reverse side of Sapphic baculi). NB: The toni listed should also include tonus VII – one of a number of typos in the engravings.

The next stage is to choose an appropriate *tonus*. At the top of each *baculus*, the applicable *toni* are listed – for example, the *Archilochic* meter can use *toni V, VI* and *VIII*. Each *tonus* has a specific *ethos* associated with it:

Key/Tonus	Mood/Ethos
I	Pious, religious, modest
II	Happy, strolling, dancing
III	Tearful, mourning, sad
IV	Groaning, sad, funereal
V	Heroic, wandering, cheerful
VI	Warlike, rousing, glorious
VII	Somewhat sad, mournful, delightful (Espinoza describes it as "uniting pleasure and sadness")
VIII	Cheerful, wandering, beautiful

The toni of the Organum and their corresponding ethoi.

Tonus I. Durus. — Pius. Religiosus. modestus.

A	5
G	4
F	3
E	2
D	8.1
C	✕ 7
B	♭ 6
A	5

Mixtura Tonorum

III	VIII.
VI.	VII. I.

Tonus II. Mollis. — Laetus. Vagabundus. Tripudiosus.

G	8.1
F	✕ 7
E	♭ 6
D	5
C	4
B	3
A	2
G	1.8

V.	VI.
IX.	II.

Mixtura Tonorum

Tonus III. Mollis. — Lachrimosus. Querulus. moestus.

A	8
G	✕ 7
F	6
E	5
D	4
C	3
B	2
A	1.8

Mixtura Tonorum

VIII.	VII
IV.	III.

Tonus IV. Durus. — Gemebundus. Tristis. Funeralis.

A	8
G	7
F	6
E	5
D	4
C	✕ 3
B	2
A	1.8

VIII.	VII.
VI.	IV.

Mixtura Tonorum

Tonus V. Mollis. — Heroicus. Vagus. Hilaris.

F	5
E	4
D	3
C	2
B	1.8
A	7
G	6
F	5

Mixtura Tonorum

V.	VI.
	V.

Tonus VI. Mollis. — Bellicus. Incitatus. Gloriosus.

F	8
E	7
D	6
C	5
B	4
A	3
G	2
F	1.8

II.	V
	VII.

Mixtura Tonorum

Tonus VII. Durus. — Subtristis. Querulus. voluptuosus.

G	8
F	✕ 7
E.	6
D	5
C	4
B	3
A	2
G	1.8

Mixtura Tonorum

III.	IV.
VIII.	VII.

Tonus VIII. Durus. — Hilaris. Vagus. Amoenus.

G	8
F	✕ 7
E	♭ 6
D	5
C	4
B	3
A	2
G	1.8

III.	IV.
VII.	VIII.

Mixtura Tonorum

The eight toni.

The *baculus* with the appropriate *tonus* is removed from the box and set in front of the composer. Note that some *toni* are marked as minor (*molle*) and in these cases the B is usually flattened. Additionally some other notes are also marked flat and sharp. These accidentals should be employed when the succeeding note either descends (e.g. in *tonus II* E-D becomes Eb-D) or when it rises by one semitone (e.g. in *tonus II* F-G becomes F#-G). Note also that in the minor *toni,* the Bb can also be 'sharpened' (e.g. made natural again) in similar circumstances.

Having chosen the meter and *tonus,* the composition can begin. Each meter has four *baculi,* one for each 'strophe' or line in the verse. Schott provides an example of setting *Ave Maria stella* in the Euripidean meter:

1. Looking at the baculus for the first strophe, choose one set of numbers. These numbers relate to the four voices (cantus/soprano, alto, tenor, bass). The first three voices can shuffled into any order, but the bass part must be unmoved. Schott picks this set:

C: 3 4 5 4 2 3
A: 8 7 7 6 5 5
T: 5 4 3 8 7 8
B: 1 2 3 4 5 1

2. A rhythmic scheme can now be chosen from the lower section. In this simple counterpoint one rhythm is applied to all the voices. There are two groups of schemes, for common and triple time. Schott's example chooses 1/4. 1/8 1/4 1/4 1/2 1/2.

3. The *tonus* is now consulted and numbers mapped to pitches. Where accidentals are indicated, take these into account based on the tone that follows them. Note that the Bb has also been 'sharpened'/naturalised in the given example. Schott does not (as far as I see) explain why: it seems most likely that the purpose is cadential (the last chord in many schools of counterpoint always being major), or perhaps because the *cantus* in the next *strophe* rises, or perhaps it also mirrors the harmonic rhythm established by the first three syllables?

C: 3 4 5 4 2 3	B	C	D	C	A	#B (e.g. natural)
A: 8 7 7 6 5 5	G	F	F	bE	D	D
T: 5 4 3 8 7 8	D	C	B	G	#F	G
B: 1 2 3 4 5 1	G	A	B	C	D	G
	1/4.	1/8	1/4	1/4	1/2	1/2

Mapping from the numeric scheme onto the tonus.

The result may be notated thus:

Schott's first Euripidean strophe.

II. Composing florid (diminished) counterpoint

The process for composing florid counterpoint is very much the same, and for this purpose Schott provides tables for the Euripidean and Archilochic modes. These *baculi* are double-sided – one side shows a series of tonal numbers, the other side a corresponding rhythmic schema:

Strophā I. — Toni. I. II. III. IV.

```
2432 15 17 67
765 43 2 82
2 27 755
5 23715

733 27171
55 66 55
28 844 323
534 451

57728767
345755
82343212
17371s

8888221717
555555
333232
888785

66711 71
444555
882323
442151

712323
5571171
234555
532151
```

Stropha II. — Toni. I. II. III. IV.

```
3217 6 55
1765 414323
55 33 88
15 63 41

823347
55 17 6 5
3283323
87 6543

55543282
772221717
255555
557785

823545
558777
328332823
876373

8233 2222
516767
34 5545545
88 8725

888 767
5565545
332222
884525
```

Strophā III. — Toni. I. II. III. IV.

```
1234 5545
545 676 7
328222
876525

5565545
888787
334323282
884565

721111767
575645545
3 4 3322
371125

3333323
771777
5535 45
34556573

34 65545
771217
54323282
328765

5535 45
171777
3283323
856373
```

Strophā IV. — Toni. I. II. III. IV.

```
3282 7171
17 56 55
543 8 4323
123451

882323
6542555
21171171
432151

11 711 71
665455
442823
445651

4321751 71
666655
8 4 3282322
445651

44 4323
6 6 6555
12 1711 71
445151

5565414323
11176545
334888
88 4341
```

Euripidean baculi for florid counterpoint (obverse)

Euripidean baculi for florid counterpoint (reverse)

Archilochic baculi for florid counterpoint (obverse)

Archilochic baculi for florid counterpoint (reverse)

Note that there are often more notes in these lines than syllables in the meter, therefore allowing the creation of melismatic passages. Schott provides the following example, again in *tonus II*:

	A	C	B	A	G	D	A	F	E	#F
C: 2 4 3 2 1 5 1 7 6 7	1/1.	1/2.	1/2	1/2	1/4	1/4	1/1	1/4	1/2	1/1
A: 7 6 5 4 3 2 8 2	F	E	D	C	B	A	G	A		
	1/1.	1/2	1/2	1/2	1/1.	1/4	1/4	1/1		
T: 2 2 7 7 5 5	A	A	F	F	D	D				
	1/1.	1/2	1/2	1/2	2/1	1/1				
B: 5 2 3 7 1 5	D	A	B	F	G	D				
	1/1.	1/2	1/2	1/2	2/1	1/1				

Mapping from the numeric scheme onto the tonus.

Notated as:

Schott's example of diminished counterpoint.

III. Composing a cantus firmus with counterpoint

The final set of *baculi* move away from the combinatoric manipulation of large musical phrases and allow the composer to explore the setting of words in varying meters, based on the composition and then harmonisation of a bass voice. Schott gives the following example:

1. The text to be set is *Laudate Dominum omnes gentes*. It is divided into two groups: a six-syllable group (*Laudate Dominum*) and a four-syllable group (*omnes gentes*).

2. A single two-sided *baculus* is removed from the box, which shows various numerical and rhythmic fragments corresponding to syllabic counts – each has two species, one in which the penultimate syllable is longer than the final (*syllaba pen. longa*), and one in which it is shorter (*syllaba pen. brev.*).

The 'baculus bassi' for composing the bass voice.

Schott chooses the following numerical and rhythmic fragments:

5	3	1	5	5	1
1/1	1/2	1/2	1/2.	1/4	1/1

8	4	5	1
1/1	1/2	1/1	1/1

'Laudate Dominum' and 'omnes gentes'.

Which are mapped onto *tonus VI*:

Laudate Dominum

5 3 1 5 5 1	C	A	F	C	C	F
	1/1	1/2	1/2	1/2	1/4	1/1

Omnes Gentes

8 4 5 1	F	B	C	F
	1/1	1/2	1/1	1/1

Mapping onto the sixth tonus.

3. The following *baculi* are now used to compose the counterpoint:

Contrapuntal baculi (obverse).

Contrapuntal baculi (reverse).

The bass voice is copied onto the appropriate staff on some manuscript paper. Next, for each note of the bass voice, the appropriate *baculus* is consulted. For each of the baculi, above bass staff, are shown staves for the other voices with a selection of notes indicated that can be chosen to create vertical harmonies with the bass voice. The numbers therefore indicate their relation to the bass note, e.g. a 3 indicates that note is a diatonic third above the bass. For each bass note, the numbers 3, 5 and 8 should be distributed between each of the three upper voices, while noting the following rules:

Care should be taken not to have two consecutive 5s or 8s – if this is the case then swap intervals with the voice below.

The voices should also be kept close together, avoiding wide intervals (e.g. more than an octave between parts), since they sound more harmonious this way.

Schott's final composition of the phrase *Laudate Dominum omnes gentes* looks like this:

Laudate Dominum omnes gentes.

This method of simple harmonic counterpoint is somewhat similar to one demonstrated by Thomas Campion (1567-1620) in his treatise *Of Making Foure Partes in Counterpoint* [from p.81 in this PDF]. Campion uses this simple table to help composers make add counterpoint to a bass voice:


Campion's table.

Jeff Lee wrote a brilliant explanation of how this contrapuntal method is applied – his website is now gone, but can be found via Archive.org. He applied the method to the bass voice of Orlando de Lasso's *O Occhi Manza Mia* (published 1581) and found that the resulting counterpoint is exactly the same as in de Lasso's original composition!

This partially answers Jim Bumgardner's question about whether the music of the *Organum* was in vogue during the period: yes, and no. It was perhaps not the most cutting-edge music – the various species of counterpoint being codified since the early 16th century. However, akin to Robert Fludd's *Temple of Music* (published 50 years prior to the *Organum*), this still reflected the fundamental principles of the compositional manuals of the time – Campion's work, for example, was published by John Playford well into the 17th century.

Kircher & Schott's contrapuntal *baculi* also remind me of a tool or compositional *aide-memoire* from Fludd's *Temple*, which shows the harmonic relationships (thirds, fourths, fifths, octaves) across the gamut, which could also be used for the same purposes as the contrapuntal *baculi*:
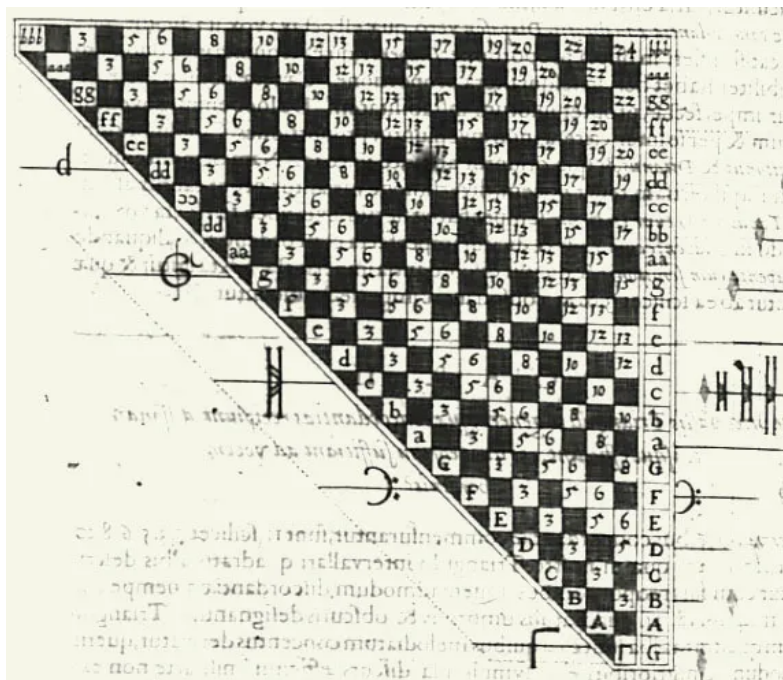
Fludd's harmonic gamut.

Phew. That was a long post! If you need more time to ponder these things, how about doing so while listening to this mix that I recently put together, presenting some recent and some perennial musical obsessions?

thoughts on "Kircher & Schott's Computer Music of the Baroque"

1. *said:***joannahruby**

   June 6, 2014 at 10:26 pm

   magical.

   REPLY

2. Pingback: Omnium Gatherum: June 11th, 2014 | The Hermetic Library Blog

3. Pingback: Tradition and Innovation: Speculative Music and the Hexadic System | Larkfall

4. Pingback: Enquieriel & Co. – Selenus' Musico-Angelic Cipher | Larkfall

5. *said:***grailrunner**

   March 25, 2022 at 8:46 pm

A really clear and welcome explanation, thanks! I started pulling this particular string after reading about Kircher's Arka in a book about his works and was going crazy trying to find a lucid example I could follow to understand how this all was supposed to work. Great job.

Your comment is awaiting moderation.

REPLY

Create a free website or blog at WordPress.com.