SUITABLY UNDERSPECIFIED: SYSTEMATIC NOTATIONS AND THE RELATIONS BETWEEN PAPER AND MUSIC

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ABSTRACT

SUITABLY UNDERSPECIFIED:
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by David Griffin

Director of Studies: Professor Naren Barfield
Supervisor: Professor Allan Walker

Through building a taxonomy of drawing, and a set of four drawing research studies aimed at generating innovative cross-disciplinary practices, an argument will be developed that systematised drawings such as the music notation are hybrid representational environments, sufficiently different from other inscriptive practices as to merit a separate classification. The taxonomical model will decentralise specific modes of drawing, in favour of a multi-disciplinary view appropriate to the persistence of its subject as a deeply rooted strategic and executive practice, and the four studies will engage the time-factoring of notation systems as transductive environments, setting the conditions for innovative practices both in and outside of the frame of the inscription.

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List of accompanying material

The DVD contains recordings of eight pieces of music derived from the graphic music notations in the Isometric Projections project. They are digital MP3 files, and can be played on any computer system, MP3 player, or media center. Insert the DVD, open the disc drive on your computer, and select from the list of files. The process of their composition and execution is described in Chapter three, pp.92-97.

The titles of each piece of music corresponds to a set of drawings with the same title, allowing the reader to view images of graphic notations and supplementary drawings, while listening to the organised sounds into which they were translated during the course of the research.

DVD contents

No.	Track title	Duration
1	4 suns	1:52
2	Carbonic IV	0:38
3	Cubic zirconium	2:38
4	Diatom	2:16
5	Tetrahedron	2.47
6	Hexagon	4:50
7	Isotropic scaling	3:05
8	Reciprocal lattice	2:35

Playlist of music scores referenced or included as figures

The reader may find these pieces of music independently, or may own a copy, however, I have pulled them together as a collection on the Web, as a YouTube playlist.
Click the "PhD playlist" link at
<http://www.youtube.com/user/dgriffinphd>
The only piece missing from this list is #5, Kasmets' "Timepiece…" which
may however be found elsewhere on the Web, as indicated below.

1. Bach, J.S. (1734) In allen meinen taten, Choral cantata BWV 97, accessible at <http://www.youtube.com/watch?v=6rqmmUHz-tw>

2. Bach, J.S. (1708) Toccata & Fugue in C major, Music for organ, accessible at <http://www.youtube.com/watch?v=G6sTORRJv5s>

3. Cage, J. (1951) Imaginary landscape No.4, Music for twelve radios, Edition Peters 6718 © 1960 by Henmar Press, accessible at <http://www.youtube.com/watch?v=5A4kcW1QnIk&feature=related>

4. Cage, J. (1951) Music of changes, Edition Peters 6256 (book I); 6257 (book II); 6258 (book III); 6259 (book IV), © 1960 by Henmar Press, accessible at <http://www.blockmuseum.northwestern.edu/picturesofmusic/pages/cage/cageSoundclip.html>

5. Kasmets, U. (1967) Timepiece for a solo performer, BMI Canada, Don Mills CA, accessible at <http://www.musiccentre.ca/influences/composer.cfm?authpeopleid=517&themeid=5 >

6. Schwitters, K. (1922-32) Ursonate, accessible at <http://www.youtube.com/watch?v=JgNL8-FdG-k>

7. Sorabji, K.S. (1930) Opus Clavicembalisticum, IX (Interludium B), accessible at <http://www.youtube.com/watch?v=yEt93DGLUi4&feature=related>

8. Stockhausen, K. (1956) Gesang der Jünglinge, accessible at <http://www.medienkunstnetz.de/works/gesang-der-juenglinge/audio/1/> or <http://www.youtube.com/watch?v=TYZBvt5RRZw>

9. Stump, J. (2005) Score for Faerie's Aire and Death Waltz, from A tribute to Zdenko G. Fibich, accessible at <http://www.youtube.com/watch?v=jXMujWmFzNw&feature=related>

10. Von Beethoven, L. (1820) Symphony no. 9, accessible at <http://www.youtube.com/watch?v=_-mvutiDRvQ>

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This is dedicated to the beautiful Elisa Vergara

and to M. W. Griffin and Cathy McManus Griffin.

Acknowledgements must also go to Cyrilla Mozenter at the Pratt Institute, Rory Harron, and the community at the Glasgow School of Art.

Author's declaration

I declare that, except where explicit reference is made to the contribution of others, this dissertation is the result of my own work and has not been submitted for any other degree at any other institution.

Signat[redacted]

David Griffin

[redacted]

Director of Studies:

Professor Naren Barfield

Preamble and notes on the form of the submission

This submission includes a written dissertation with Figures, plus a DVD of music composed from original graphic notations, and a small selection of digital drawings in Adobe Flash format.

To integrate drawings and text within a single volume, following the standards of the institution to which this document contributes, could lead the reader into a falsely hierarchical sense of the relationship between them. Scaling the many drawings and prints that emerged from the research could become, in that case, an ungenerous act carrying with it an implicit reduction of drawings to support for the writing. But I will argue in this thesis that a music notation amounts to an incorporative inscription of the dialectic of word and image, so I ask the reader to take this publication itself as engaged in that relation.

Additional notes:

> For the sake of reading length, a review of key terms and concepts in the thesis is included in Appendix I (pp.173-178).
>
> Each Figure included in the thesis features a comment in its caption (in bold font) that is meant to position the Figure within the taxonomy presented in Chapter four (p.157). Thus for example, Fig.2 (p.3) reads:
>
> > In allen meinen Taten (detail)... **In the Taxonomy (p.157), this notation can be classified as "Metric>Interval>Common music notation."**

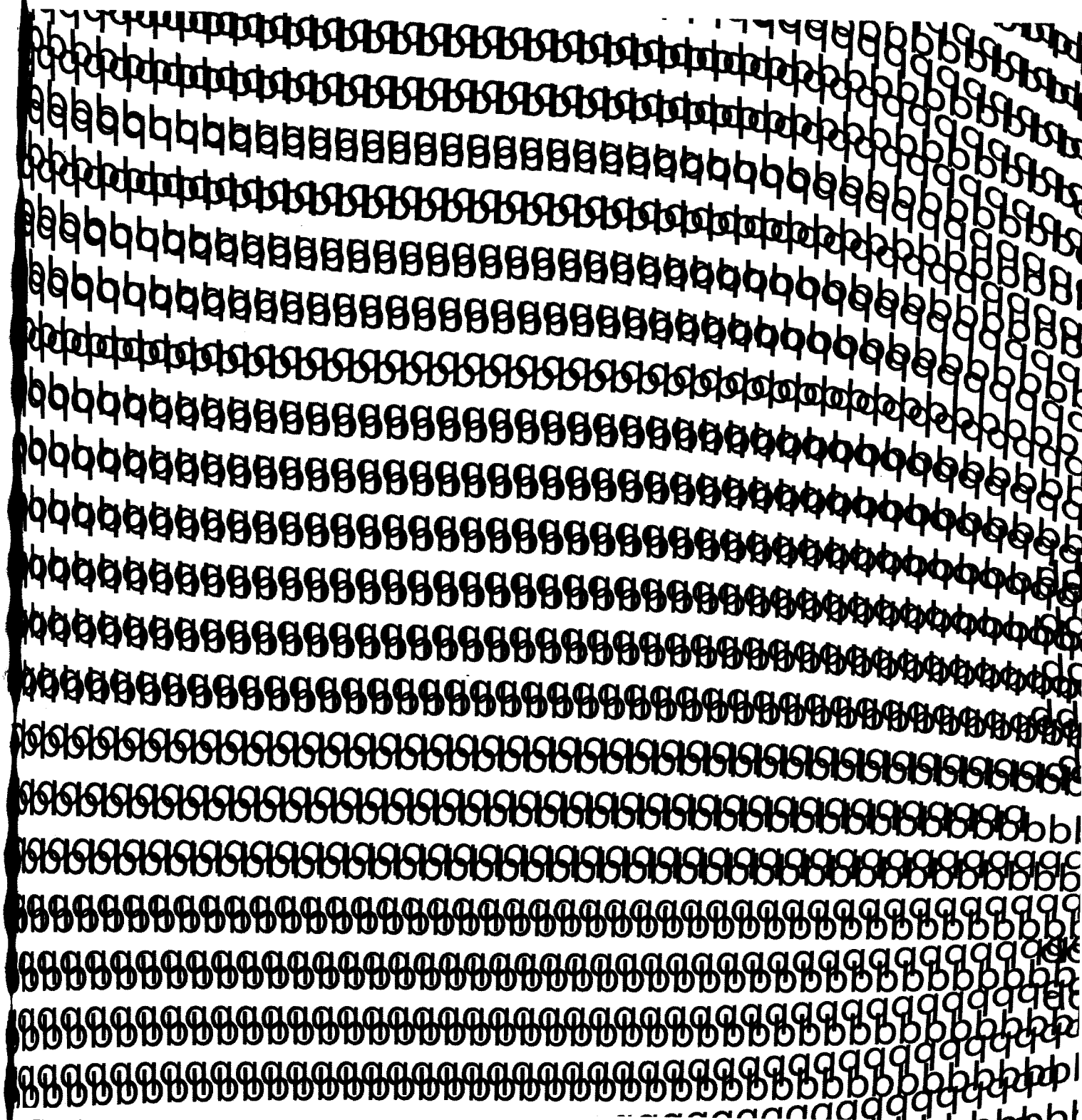

Fig.1: bq; a graphic score for a silent vocal music; one of a series from the drawing research project "Interference," fully described in this volume (Chapter three, pp.119-137); Griffin, D (2011).

Chapter one

Introduction

Because of common underlying conceptual and physical structures, a drawing of a teapot or a steam engine may be used as a drawing of music. From this hypothesis, we will engage with drawing as a practice of 'knowing, thinking, and acting' (Cross, 1995, p.115), exemplified by the common Western music notation system.

In the first section I will describe an artist's intuition that the music notation amounts to a species of design drawing, expressing the same intentions and obligations as projective orthography. Both systems developed to enable the creation and dissemination of plan documents aimed at the manufacture of some *thing*: in the one case, a performance of music, in the other, a teapot (or a steam engine). Each of the two systems works to generate representational views predicated on conventional Western models of production: teapots are objects in space, musical compositions organise sound, but in visualising sound-structures we are not merely mapping scenes to surfaces, as in a picture, nor mapping logical relations or processes, as in a diagram. But is that practitioner's conflation of orthography and music notation supportable? If so, what are the entailments for theories of notation and practice? If *dis*confirmed, where then do music notations belong, as drawing? We understand that music notations are drawing, but drawing *how*? The common notation is a robust system, but has not been clearly enough classified as drawing, and this thesis will therefore answer that question.

Drawing is both support and output for various practices, and we can describe drawings of all kinds in great detail. Meanwhile, contemporary researchers have theorised it as cognitive enhancement, advancing the understanding of its values in pedagogy and communication, in creative work through the discursive sketch, in constrained diagrams in logic and computation, and also in contexts of history and connoisseurship. To more clearly understand and position a music notation's relationships to other drawing systems, then, this research project is framed as an investigation of 'the relations between paper and music' – a line cribbed from the American composer and educator John Cage (1990, p.429). We are thus asking structural questions; how those relations are established and governed, and moreover – at the intersection of theory and practice which this thesis will attempt to navigate -- how they might be exploited.

In the investigation I will use drawing as a research method, developing three experimental music notation systems, tying them to the analysis of a taxonomical model of

drawing. But the reader will also see a fourth drawing project develop in response to the taxonomy. Like a music notation, this diagram is a space-time visualisation; however, by engaging with things that *cannot* be made easier to understand through diagrams, we interrogate the upper limits of their denotational logic. Is there a space that dis-allows the diagrammatic mapping of its relations?

There are five chapters in this thesis, and their order is meant to reflect as well as possible their simultaneous development, allowing us to review the Taxonomy with the Drawing projects in mind, and vice versa. The classification model itself (Chapter four, p.157) anchors the literature review, and is informed by studies of drawing in art and design, scientific visualisations, and performance notations, noting the structural similarities between all these social uses. The model will show that while pictures map from scene to page, and diagrams from logical relations to page, music notations map to and from a space-time conjunction, and I will ultimately argue that this sufficiently distinguishes them from traditional projective and topological orders as to warrant a separate category.

Researcher Barbra Tversky has conjectured that 'translation between descriptions and depictions ought to be possible when the same conceptual structure underlies each' (1999, p.4), and I argue that Drawing provides just that common conceptualising/structuring approach, operating in the spaces between languages. The four drawing research projects developed here, feeding into and out of the taxonomy, weave together interests from a number of fields, providing a wide focus for their resolution. In attempting to build original articulate systems for organising sound, we will come to understand systematic notations like the music notation as 'imagetexts' (Mitchell, 1997, p.89): Metric inscriptions, drawing the future in relation to a present of plotted variables, and a calculus of the body.

1.1 Motivations

The future is description without place,
The categorical predicate, the arc.
(Wallace Stevens, 1945, p.564)

My body is an exchanger of time. It is filled with signals, noises, messages, and parasites. And it is not at all exceptional in this vast world. It is true of animals and plants, of air crystals, of cells and atoms, of groups and constructed objects. Transformation, deformation of information.
(Michel Serres, 1982, pp.72-73)

Fig.2: In allen meinen Taten (detail), Bach J.S. (1720), in Winternitz, E. (1964) Musical Autographs from Monteverdi to Hindemith (Vol.II), Plate 32; Dover Press, NY. **In the Taxonomy, this notation can be classified as "Metric>Interval>Common music notation."**

Through an encounter with a scrap of paper, a yellowed irregular parchment marked over with figures, an index of relationships were illuminated which have sustained and propelled my art practice in its wake. The hand-sized fragment, attributed to Johann Sebastian Bach and framed and hung as any fine artist's drawing might be, triggered the sort of moment of connection and clarity that we hungrily seek through the experience of works of art and music, generating energy enough to sustain a studio practice -- a piecemeal environment of labour that depends on such moments -- for a number of years. While the ultimate purpose of the little manuscript would have been clear to anyone with casual knowledge of the graphical elements of the common Western music notation, it could also have been described simply as an all-over composition of

point, line, and (implied) shape. This is to say that I knew what I was looking at, but the apparent utility of the thing momentarily sifted to the bottom of my recognition, leaving a kind of trace presence as Drawing.

It was a confounding sensation with no clear causal centre, and the memory itself has come to serve as an enduring object for enquiry in my studio production. As a revelation, this may not seem like much. After all, for large portions of the past century the manifold visual properties of the common Western music notation system have been explored as malleable substances -- good for many things, one of which remains the writing of music. Out of the reformations of listening and musical practices that have taken place in the West in the wake of a well-understood confluence of social and technological developments, and the efforts of serial, concrete, electronic, and stochastic music composers in the mid-twentieth-century (for detail, see Kahn, 1999; summary in Licht, 2009; Cage, in Knowles [ed.], 1969), the imperatives of music notation have been more or less unmoored from their historical roles as support for a pitch-centred model of composition, with sequentially organised protocols and a fixed palette of sound. Instead, the urge to mark-up the music composition space has lately been directed towards 'the conditions under which (those sounds) are to be produced' (Behrman, 1965), that is, the production environments to which their directives are directed, which Bach could not have anticipated, and the manner in which they are read (Fig. 3).

For all that, our primary responses to Art and Music are often affective ones, which is to say that while we may seek clarifying language to account for an intuitive response (in my case, that muddy moment of clarity in front of the decomposing scrap, which launched a sustained working habit as a practical filter), we must also recognise the contingent and fractional character of such responses. Far from being some inscrutable mental leap, psychologist D. N. Perkins has written that intuition is a dynamic networking of perception, memory and language (1977), and a feature of human rationality which the philosopher Bergson suggested amounts to 'direct participation in the immediacy of experience' (1974, p.12), in which I pick up an implication that through the drawing-together in works of art or

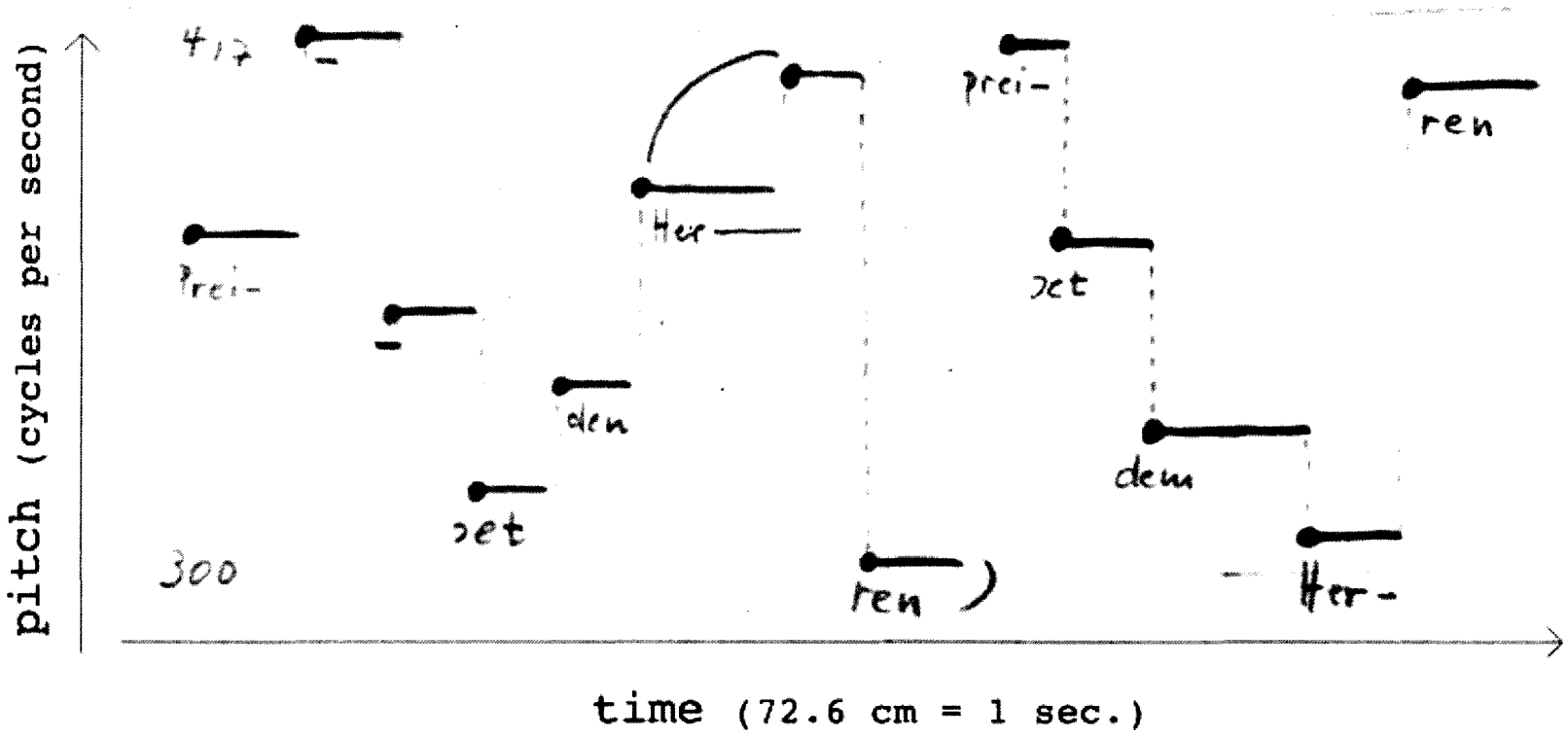

Fig.3: Gesang der Jünglinge, The vertical axis of this graphic represents pitch, while the horizontal represents time... 'the phrase "Preiset den Herrn" is repeated twice, with the resulting eight syllables distributed over thirteen distinct pitches,' Masterpieces of 20th century music: a multimedia perspective, Columbia University, NY; Stockhausen, K. (1956) in Smalley, J. (2000) accessed 25/2/11 at <http://music.columbia.edu/masterpieces/notes/stockhausen/labeledsketchBig.jpg>. **In the Taxonomy (this volume, p.157), this notation can be classified as "Metric>Ordinal>Histograms"**

music, we might extend a private response as an offer to our comrades. In the case of my encounter with a little bit of handwriting by Bach, its "*n'est pas un pipe*" moment has become a rather more stable feedback circuit of action and reflection, invested in works of art and music directed at just that sort of offering.

In its wake, questions about the experience need to be addressed if we are to fully understand what has become a substantial, creatively productive moment, not diminish or dismiss it. The practice-minded studio artist tends to respond to such moments by overstepping explicitly phrased questions as focuses for inquiry, allowing the promiscuousness of the studio to yield re-actions, returning images, and delivering insight, objects, or experiences that can enrich while never quite giving a straight answer. To be less obscure, as an experience of seeing this was a curious blending of domains of personal knowledge. In seeing the scrap I had felt the autographic, all-over drawing of a Pollock, perhaps a Twombly, or the deliberate irresolution of a drawing by Tàpies, rather than the precision expected of a published music notation, marked by the expected regularity of the engraver's stylus. Meanwhile, text-based descriptive approaches have their own limitations, not least of which in this case is attempting to parse a visual experience that had quasi-visual nuances, in order to unpick how it might have set off a cascade of associations, metaphors and remembrances. To frame the research for this thesis along a middle path, I have adapted a bit of text from the American composer and educator John Cage, contemplating 'the relations between paper and music' (Cage, 1990, p.429).

Drawings and music notations are both inscribed images of something, but stand differently in reference to those things and to each other by extension. How can we best theorise these differences? There are technical questions embedded in Cage's wryness, having to do with how the multi-dimensional complex of musical performance can be fixed on the page. In the case of mistaken identity which led to this thesis, what was the nature of my (mis)reading? Was I reading off of, into, or somehow forward? The view on Bach's manuscript was certainly an experience of seeing images, but not any simple external to internal tracing or mapping: not "I saw *x*, and in seeing *x(B)*, had my expectations more or less confirmed;" more like "I saw *x*, and in seeing *x(B)*, saw something further: some undetermined product of *x* and *B*."

Additionally, as a bit of non-sense, the evident visual logic of the fragment enabled me (I felt) to see Bach's propositions in my mind's ear. How was it that I felt enabled to visually listen? Following the handiwork of the scribe, was this a kinaesthetic response (Overgaard and Grünbaum, 2007; Scott, 1996, p.349) to sound or vision, or some mediated muddle? And then taken as focus for sustained creative practice, what other kinds of dimension-mashing could we draw? How might *x* and *B* be further operationalised in order to arrive at some other sum than that implicated in Bach's masterful, if loose use of the common notation?

To satisfactorily explain my conflationary reaction to Bach's ambiguous tracery, and to expand upon its implications, requires grasping the roles and operations of drawing as tools in learning and communication, how pictures relate to non-pictures, and what differentiates drawing systems from each other, and from less conventional types. This is surely an enquiry with impact and interests for a number of art, music or design practices. Surveying the range of questions, I understood the habits of a productive visual art practice were insufficient to address them, and so I have turned toward a creative-practice research model, which Henk Borgdorff succinctly explains has as its intention not merely the sustenance or fulfillment of working practice, but the expansion of understanding – engaging as aesthetic experience, but also generating a halo of insight and reflection in order to 'shift the frontiers' of its enquiry (in Biggs and Karlsson [eds.], 2008, p.54), or as Graeme Sullivan has written 'to create in order to critique' (2006).

To bring resolution to ambiguity, then, I assume a view offered by Scrivener (2002) that a frank study of the complex of studio-based making is critical to creative practice in a research context, and that such a study is most usefully built of both words and images. Before this strategic decision, I had spent many years as a rather militantly visual artist, looking upon the written word as an impoverished cousin to visual practice. There was, and still is in my view, a kind of sweet vitality in the absence of words, in showing not saying -- a forthrightness that cannot *unsay* its meanings. In this context, however, in order to reconcile the wordlessness of art with the theoretical force of writing, I sought a method of writing *with* practice driven by a mental image poached from my supervisor at The Glasgow School of Art, Professor Allan Walker, of oarsmen in the scull: different faces on one effort.

In that spirit – a spirit of overturning vexed relationships between words and images (Mitchell, 1994), mediating between reflective practices of art and philosophy which address similar questions with more or less rigour, and more or less affect -- the thesis will tie the analytical focus of taxonomical classification to the heuristics of drawing in a research-experimental framework, which is to say not a mere description of processes or verification of ideas, but a dialogical process of speculation and navigation between theory and practice. Artist-researcher Mika Elo sketches out for us a research-practice of critical encounters and alchemical exchanges, the 'processing of uncontrollability, or even of impossibility' (in Nimkulrat and O'Riley [eds.] 2009, p.24). In working through the thesis with this in mind, it is hoped that the reader will see insight and impossibilities both materialise from research-practices that are descriptive, but also 'experimental in (an) experiential sense' (2009, p.20).

1.1.1. Synthetic drawing

Anthropologist Timothy Ingold (in 2007) classifies line-making in terms of traces and threads, which is a subtly put difference between push and pull, and a sensitive observation on the differences between leading and following; but in practice – in drawing – lines rarely self-identify in such terms, and their sum is never just the drawing drawn. In her contribution to the discussions around creative-practice as research, Anna Pakes advocates for a view that echoes my graphic practitioner's view, wherein 'reasoning (is) embedded in the activity,' with 'a principled coherence on its own terms

> underwritten by a logic that emerges in and through the activity itself. This philosophical perspective positively characterises action as a rational process, as a mode of knowledge with its own distinctive logic, parasitic on neither deductive nor inductive theoretical reasoning. In this view, action neither requires theoretical explanation nor functions to illustrate insights acquired theoretically: rather, it is in itself intelligent (2004).

From the point of view of one who draws, we will see that the act has value both as verb and noun -- as conversations with the studio, and documents of those conversations. So it is better to approach drawing as a thinking practice as much as a practice of making or planning to make.

Towards that, my initial view of Bach's tracery was one where its functional character became transparent. But later, reflecting through various practices engaged in the studio, that tangled experience introduced the possibility of aurality, through which I became attentive to the desire for a visual-auditory artwork. A quick look at the rationale for this desire shows it is an ancient fixation, spilling over disciplinary boundaries or any merely personal reading (for a succinct timeline of recent audio-visual interests, see Levin, 2000, pp.21-33, or pp.27-137; and of course the "music of the spheres" can take us quite a bit further back, as well as further afield). So while this research project was seeded by reworkings of a momentary equivocation – seeing and hearing at once -- in reviewing analyses and practices of those who work with drawings, including myself, we will come to understand the vitally synthetic nature which makes drawing especially suited to artistic research.

For an immediate example, in the shadow of Bach's document, the cultivation of my production towards a context of scholarly research and creative practice yielded a simple, but not obvious insight that the common western music notation amounts to a species of design drawing, expressing the same intentions and obligations as projective orthography (Willats, 1997). Both of these drawing systems developed to enable the creation and dissemination of plan documents aimed at the manufacture of some-*thing*: in the one case, a performance of music, in the other, a teapot, or a steam engine (for instance). Each system functions both descriptively and propositionally, taking a place in a compositional discourse as sites that can direct us to ways of analysis and building, while revealing (in terms of relative proportion) something of both the maker and their making. Neither system simply depicts or describes its object; rather they are used to generate representational views predicated on conventional Western models of production appropriate to their practices.

Beyond just their dimensional arenas, however, there are differences between the systems that present opportunities for action and reflection both in and out of the studio, in aid of answering the questions raised in that originary moment. The robust Western music notation system is a graphical account of audition, constrained to the music traditions it supports. Intended for use in instruction, analysis, and performance, the system is laid out across a timeline grid of staves and bars, through which we reduce the complicated experience of Music to manipulable sets of objects, with properties that

belong to thinking musically. Although post-recording and computational music has shed the need for an entirely linear grammar of representation, exploring complex technical and conceptual syntheses and new listening practices (Kahn, 1999; Cascone, 2002), therefore taking the score not as an 'object to be read by the performer, (but) a process to be built' (Hanoch-Roe, 2003), the common music notation is built for legibility. We trace paths inscribed through the scheme as instructions from which we form an image of experience and process; from there to enact its content. In this very brief account, temporal and spatial dimensions of design and performance are identified, as well as a code for understanding them.

On the other hand, and no less a puzzle in its synthesis of function and structure, projective orthography is a component-practice directed at building, but constrained to analysis of an object by means of sets of parallel views of its various sides, such that fabricators can read the drawings and make the required object in accord with the compound needs of designer and client (for historical discussion, see Galison, 2000, pp.152-155). The multi-view system presents its users a totalised truncation: pictorial, showing true shapes and measured spatial relationships, but flattening the faces of its object, and denuding them of visual detail, while mounting the inscription on an infinite parallel – indeed, impossible -- orthogonal substructure. As written, this rough description also identifies temporal and spatial dimensions of design and performance, encoded through various conventional attachments and adaptations: the underlying orthographic diagram, a spatialised image of distribution, and the time-factored multi-view format.

Ultimately my response to Bach's manuscript, transformed by mediating practices, reflects a desire to hold performance in hand: to contemplate it as record, as directive, a composition environment, and most importantly a mechanism for making more. Through the building of a classification model for drawing, and a set of four drawing research studies aimed at generating innovative cross-disciplinary practices, an argument will be developed that systematised drawings such as the music notation are hybrid representation systems (defined as 'linking together several kinds of representations' [Recanati, 2008, p.300]) that are sufficiently distinct from diagrams, character-strings, writing or pictures, so as to merit a separate classification. Exceeding the denotative mandate, and orienting users to potential, such notations map neither

from scenes nor schemes to the page. Rather, we are enabled by their articulation to read and write for reconstitution in performance: a space-time conjunction. Seeking the relations between paper and music, tempered above all by a sense of play, we may then ask "What does an oblique plane sound like?" and even provide a view on possible answers in the graphic language of points, lines and planes.

1.2. Goodman and efficacy

'What matters with a diagram... is how we are to read it' (Goodman, 1976, p.170).

After the objective of understanding the music notation *qua* drawing, I contend that the diversity of drawing practices can be best organised in preparation, their relations reviewed, re-cognised, and redrawn, through the development of a taxonomic model. Nelson Goodman's seminal theory of notations will be referenced throughout the thesis as a key text in this task. 'Aesthetic experience is cognitive experience, distinguished by the dominance of certain symbolic characteristics and judged by standards of cognitive efficacy', Goodman writes (1976, p.272), and in seeking to clearly reflect on the issues and implications of symbolic representation, his book "Languages of Art" is an essential starting point for a range of disciplines which examine visual expression and communication, even for those that conflict with or diverge from its conclusions. My own work as an artist and researcher owes a debt to the philosopher's application of words to making rather more precise observations than is usually possible in the helter-skelter of the working studio.

In pursuit of rigour in a context that is notoriously resistant to rigorous analysis, Goodman builds his theory of notations from the cognitive position that 'The drive is curiosity and the aim is enlightenment,' and the efficacy of a symbolic language in meeting those aims is assessed by 'how (it participates) in the making, manipulation, retention and transformation of knowledge' (1976, p.258). Speech can be written, or written about; music can be scored, performed, or annotated; the geometry of things can be plotted, and pictures of Pickwick can be painted; but none of these symbolic expressions are resolute, all are modular and unfinished in their utterance.

We will see his logically derived, if elusive principles reflected throughout this thesis, but as a brief introduction, the philosopher seeks only to explicate the sufficiencies and necessities of symbol systems (1976, pp.127-173). And while he says little about social entailments, the critic W.J.T. Mitchell remarks that if this makes Goodman a relativist, then he is one who

> 'nevertheless maintains that there is a distinction between right and wrong theories, interpretation, and works of art,' and he refuses to reduce this distinction to a matter of power or rhetoric, treating it instead as a product of systematic and structural logic' (1986, p.112).

As a useful exercise, Goodman asks us to consider two linear images: an electrocardiogram, and a Hokusai drawing of Mount Fujiyama (1976. p.229). While specific lines in the two images may resemble each other, they are deployed in schemes with different objectives, and so stand for different things. What matters in the diagrammatic line is the path it traces through a field of data points. Contingencies such as line weight or color are irrelevant. The image itself is a readout, so to change the qualities of its inscribed appearance would not affect its meaning, or at least only under conditions hewing to the external codes through which knowing we may read the readout. In the Hokusai, however, these contingencies are key -- none may be ignored, all are at play. Such pictorial representations are syntactically and semantically dense: any mark made within the pictorial field has the quality of being freely interpreted in its significance, conceivably endless in routes of reference, and therefore, in Goodman's terminology, more or less "replete."

Repleteness is part of the acknowledged formative power of sketching, which case has been laid out by Leonardo among others (in Rosand, 1991, p.62; Goldschmidt, 2003; Tversky, 2002). But this kind of uncertainty is destructive to the enterprise of a notational system, which critically includes communicability delimited in terms of reference, most importantly for the purpose of repeatability for some purpose outside the page. In Bertrand Russell's earlier, if less graphically specific terms: 'In an accurate language, meaning would be a one-one relation; no word would have two meanings, and no two words would have the same meaning' (1923). To avoid repleteness, then, the symbols deployed in a notation scheme must form freely exchangeable classes, and as a

ready example, Goodman directs us to alphabetic representations (1976, p.65), in which all of the character-letters "A," or "a," or "𝒜" represent the same thing: they are graphemes corresponding to a specific sound-making gesture associated with the "A" concept in our English language notation system. Each may be substituted for the others without adverse impact on the meaning of a communication built from the system. And although our fluency of reading might be affected by cursivity, this is irrelevant to the operations through which I can write or read either apple or manzana. In addition, the characters must be scale-free and disjoint such that "A" is never anything but "A." These conditions – disjointness and differentiation – are necessary for the discernable objectives of a notation system, as we understand them from Goodman's flawed, but pragmatic best example, the common music notation (1976, pp.181-83).

We can and should argue with a number of the conclusions Goodman draws in his seminal work. Just to begin, Goodman's essential notion that representation is independent of resemblance is put under stress by a cognitively oriented scientific culture, out of which evidence has emerged, for example, that some kind of neurological programming is involved in facial-recognition (Dipert, 1996, p.378). On his "ahistoricism," see Mitchell (1994, pp.345-362), or Elgin, who interrogates the significance of transcription errors or flawed performances (1991, p.91). Goodman's conviction that an incorrect musical performance is not a true example of the work indicated by the score (1976, pp.116-119) is an aspect of his theory that is in some sense vitiated by developments in the performance arts of the mid to late 20th centuries, and which has been further complicated by interactive computational systems (see Patton, 2007, for a Goodman-busting case of "morphological" music notations). In any case, Elgin suggests that a flawed print is nonetheless an instance of Dürer's "The Four Horsemen of the Apocalypse" than a perfect one. This point stands as a reminder of the difficulties in theorising works of art, in support of which Elgin asks 'Should we say that Menard and Cervantes wrote different novels?' (1991, p.91).

The philosopher Richard Wollheim criticises Goodman's disregard for the intentions of the artist, by which another form of ahistoricism is evident in the underlying notion that there is no particular reason why any meaning ascribed by the artist to the work should be taken as paramount. In Goodman, the artist's intent simply provides one route into and through the work, but Wollheim seeks an accounting

method for meaning in painting as something distinct from meaning in, say, verbal languages. Pictorial means and the thing called Painting come together in the intentions of the artist, and so Wollheim proposes that each work of art can be said to have 'one and only one meaning,' fixed by the artist in the working process, and identifiable in its history of production (Wollheim, 1991, p.40). Yet Wollheim also critiques Goodman's marginalisation of the spectator as a receiver for transmission, writing that 'what we see in a picture is itself a complex issue, and is determined by a variety of factors such as background knowledge, understanding of the style involved, and... "conventions"' (1970, p.538).

In accord with the replete-articulate dichotomy in Goodman's aesthetics, a technical stock market graph is attenuated (1976, p.230), constrained for clear content transmission. Only some visual properties are active in the scheme. In a replete scheme, however, a stroke of colour might find itself interpreted in a number of ways, shifting from exterior to interior of the painted form, signifying continually. The art-historian James Elkins has argued in response that this notion of repleteness amounts to a kind of infinite space for imputation of meaning that is unrealistic, and so in fact is 'a fictional construct, since we would be hard pressed to come up with more than a few variants of any given mark that might be expressively meaningful... it is not well related to the ways that pictures are interpreted' (1995, p.828). Extending this thought in the other direction, Elkins questions the standard of "character-indifference" in Goodman's theory, pointing to our evident inclinations to read off the page, to interpret and impute to and from images, regardless of how we are meant to use them: in this view 'A' cannot truly be equal with (Fig.4, Fig.5, Fig.6), in spite of what we see as their common identity. This is a hybrid of Mitchell's critique of Goodman's ahistoricism -- interpretative potential unmoored from context -- and Wollheim's evaluation of the philosopher's demotion of the viewer as the seat for context. But there is also in it a bit of the sensible recognition that our first hand experiences with art are never just theoretical, always physical or emotional, and so marked by biases and the vicissitudes of the body.

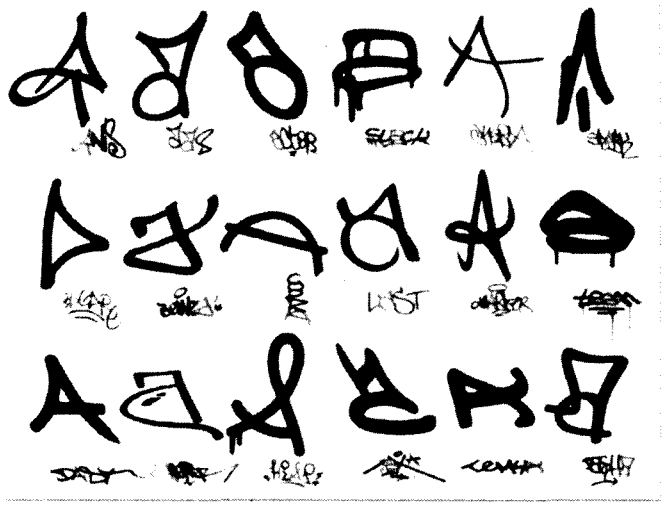

Fig.4: (Top left) *'Alfabeto di Lettere Iniziali'*, Poggi, M. (*c.* 1730), accessed 13/3/11 at <http://www.flickr.com/photos/bibliodyssey/2232192217/>
Fig.5: (Bottom left) Graffiti letters, accessed 13/3/11 at <agalimin.blogspot.com>.
Fig.6: (Right) Donald E. Knuth's "Metafont" system; Hofstadter, D. (1982); in Metamagical themas: variations on a theme as the essence of imagination, Scientific American, 247:4, p 15.
In the Taxonomy (p.157), these letter-pictures can be classified as "Topological>Character-strings>..."

To summarise, Goodman's baseline is that representation is a cognitive predisposition, and that 'denotation is the core of representation, and is independent of resemblance' (1976, p.5). And there are rules both of community but also perhaps of biology
that enable us to bind representation and communication in mediated symbolic languages. Articulate notation systems, for example, are built from disjoint and differentiated schemes –inventories that 'diminish indeterminacy' in their reading (Scaife and Rogers, 1996, p.196), in contrast to the web of marks in a sketch which can be exchanged for a number of possible meanings, and which are 'classifiable only by reference to context' (Bull, 1994, p.210). And while the sketch is the high exemplar of transgression of his theoretical constraints, Goodman nonetheless recognises it by implication as a key practice in the world-making capacities of symbolic language use (1975, p.61).

Certainly, the symbolic practices of art and science contribute to the decomposition, reorganisation, and enhancement of our sense of self and the world, and in the wake of Goodman's theorising the differences between these systems are understood not as antagonisms between fact and assertion, or proof and beauty. Rather, they are understood as differences in the domination of certain characteristics of symbols. The philosopher Michel Serres notes that scientific representations depend upon a kind of precision in their symbolisations, while the products of artistic enquiry exemplify metaphorical, expressive language use. Math is a quantification code, he writes, Physics and Geometry de-cipher; painting encodes and decodes in concert. Applied sciences work with 'the difference between letter and number (*chiffre*)… the difference between a sequence and a word, to the difference between the average and meaning, or the difference between two meanings' (2000, p.143). For Serres – a difficult philosopher I will read for his scientific-cultural apposition to the aesthetics of Goodman -- worlds are made and manipulated by coding, just as Goodman notes that 'mountains can be diagrammed, and heartbeats pictured… Nothing here depends upon the internal structure of a symbol; for what describes in some systems may depict in others' (1976, pp.229-231).

Among other things, this general view clarifies the long remarked upon relationship between music and mathematics as technical disciplines: each system

represents incidence, motion and relative position, and while one seeks understanding through rigorous analysis by means of notations predicated on logical relations, the other seeks understanding through expressive investigations of the symbolic space itself -- through play and re-vision with the terms of the notation, and instrumental performance of its propositions.

Goodman ultimately makes the case that theories of representation are inescapably partial, tangled up with extrinsic aspects that might at least be usefully sorted through a judicious application of logic. In spite of any puzzles which entail from his primarily textual investigation, his work retains its value for theories of practice four decades or so after its publication, and its structure and conclusions converge with the stated aims of this study of the synthetic disposition and ideational (defined as 'generating, developing and communicating ideas' [Jonson, 2005, p.613]) values of drawing, but more than that, of the potential for innovative practices to be developed from that understanding. In assessment of Goodman, Mitchell contends that the philosopher's stance outside of critical issues 'of the "why" in order to trace the "how," cultivates clarity about fundamental questions in the arts that cuts across many of our sterile debates about meaning, intention, reference, and representation' (1986, p.114). It is in this sense that the philosopher's project is contiguous with that of the drawing taxonomy presented in Chapter four.

Finishing his logical exegesis of the riot of symbolic communications with a return to first principles, Goodman notes that we barrel forward, freely using symbolic languages with all their inconsistencies, and despite schismatic relations between proof and beauty, or generic differences between pictorial and conceptual, all languages are directed at understanding, and we judge them against how they participate in that process. The next sections of this thesis will review the cognitive implement of drawing -- paraphrasing Berger's (2005) sensitive observation, how drawing becomes a way to know by hand: how we read, extract, and recognise through drawing.

1.2.1. Drawing research

> Turning the paper into a space of time... (Cage, 1990, p.492)

As posed earlier, the practitioner's question 'What does an oblique plane sounds like?' is unanswerable, except perhaps in the sense of a 'pataphysical inquiry, that is, in the spirit of Alfred Jarry's science of imaginary solutions, which the poet Christian Bök writes is 'neither a rhetorical nor theoretical inquiry, instead through it we posit the "as if (as)... the imaginary solution to the question what if"' (2002, p.26). In any sense, however, such a question is useful as an entry point to creative practice, which often depends on such moments of puzzlement for its sustenance. In fact, that very question was extracted from the marginalia of my journals and sketchbooks, serving its purpose as provocation early in the research timeline. And in seeking answers, a set of case studies have developed which test both the analysis of the taxonomy and the sensibilities of the artist.

If there exists a continuous space of creative action and knowledge production, where an artist-scholar may work equally with materials and thought, the effectiveness of the research here undertaken will lie in an admixture of the interpretive loam of drawing as a reflective practice, buttressed by the analysis of a classification model, in accord with Frayling's conception of research through art (cited by Mottram, in Elkins, [ed.], 2009, p.13). I argue that drawing is particularly suited to a research-directed experimental art practice for a number of reasons explored later, but surely exemplified in its well-known uses as performative, sometimes collaborative, idea-generating method, essential to the discourses of many professions. Donald Schön summarises this usefulness (in 1983, pp.157-159), noting that the "virtual world" engaged by drawing loosens the creative constraints on possibility, and that its direct, spontaneous underspecification encourages reflection in action, while leaving stable residual traces for consideration and reformulation, after innovation and insight. In spite of the difficulties in evaluating artworks in any context, both Borgdorff (2011, pp.54-56) and Goodman (1976, p.258) refer to a capacity for potency in interpretation, shifting frontiers or world-making, as validation.

All four of the drawing studies undertaken here are projects of space-time visualisation. The first three are motivated by a demonstrably ancient human compulsion to perform a continuous sound and vision, seeking productive routes from two-dimensional inscriptions to the multi-dimensional spaces of musical action, to explicate the nature and structure of my Bach-moment by seeking out the relations between paper

and music. And while they have generated observations that were incorporated into the taxonomy (for example, that describing music notation systems as diagrams is insufficient), the fourth study (Chapter three, pp.143-154) developed in response to the taxonomy, as an interrogation of well-known characteristics of analytical drawings. A review of diagrams and diagrammatic reasoning (defined as 'the process of comprehending and making inferences from diagrammatic representations,' in Narayanan, 1997, p.103) was conducted, in which node-link graphics were identified as key methods for visualising non-visible systems. This use of the simplest of graphical methods was then tested by making lines on surfaces, the sum and substance of which are decisively uncertain.

1.2.2. The taxonomy

Classification is a core exercise in learning and communication in the West. As communal approaches, taxonomies are used to build the detailed proofs which are necessary to practices of science, for example, encouraging the review of techniques or concepts in their domains while also providing relational frameworks which can direct its users to insightful conclusions. Chapter two will review the literature around the art and theory of drawing, with attention paid to other taxonomical efforts, building from the perspective of a 21st century fine artist with an abiding interest in the interrogation of conventions as a method of creative inquiry. Its aim, differentiating it from other taxonomies, will be to decentralise specific modes of drawing in favour of a multi-disciplinary view appropriate to the foundational nature and persistence of its subject as a strategic, executive practice rooted farther back in our history than we can clearly see, and bearing fruit across multiple domains of knowledge.

The taxonomy will organise drawing and drawing systems in a way similar to that we obtain from the use of the colour wheel as a model for understanding the relations between hues in art and design. In that spirit, the ontology for the model will incline towards structural aspects of drawing – how we organise for legibility, rather than functional or social aspects. This bias reflects the expectation that understanding the abundance of drawing will come more readily by taking seriously the implications of our enormously long history of engagement with marking surfaces, foregrounding common cognitive values of drawing as a tool for idea generation and communication, rather than contingent expressions of a culture.

In reference to methods of classification, Nelson Goodman notes that 'the response to the question of "same or not the same?" must always be "same what?"' (1975, p.62); and in this spirit, as the thesis develops readers will have the opportunity to validate the reductive choices of taxonomical analysis, and the insistence on the expansive word inscription. After all, taxonomy is a process of exclusion as much as inclusion (Marradi, 1990), and "inscription" encompasses an awful lot of practices after an awful lot of things. In practice, of course, taxonomies are never definitive, they are argumentative, and so Goodman's question can be taken as the very question to ask as we approach the task. The model itself will be presented in Chapter four, derived from reviews of context and the experience of the practitioner. Acknowledging the inextricability of function and structure in drawings and drawings systems, I will describe categorical differences as most usefully located in structure. By way of contrast, the academic Leoni Schmidt describes drawing as critically provisional, anticipatory and "propadeutic" (2008, p.110), and she outlines 'four registers of contemporary drawing... in which materials are carefully chosen to relate with bodies in space and time.' In her theorising, register one foregrounds touch, closeness and remembrance; register two focuses on travel, sequence and pause; register three involves the map, vector and syncope; and register four deploys the pentimento, shadow and chorus. These summary bits of text are based on observations of social drawing practices in the communities in which she has traveled and worked, but they are a step outside the bounds of classification targeted in this taxonomy.

Closer to the spirit, the British painter and academic Stephen Farthing recently produced an admirably stoic working definition: 'I understand drawing as the translation of multidimensional information into readable two-dimensional matter' (2009). This is the generalised definition of a teacher of drawing, made in a cultural context where expanding collections of information from commercial industries, and representation of data sets generated by industrial, financial, medical and communication technologies all have taken advantage of the efficiencies of computational systems for organisation and search. Our evident inclinations have asserted themselves in the ways we sort and search such systems, re-forming heterogeneous databases to legibility through graphical representations in the form of trees, webs, and other structures, which give visual metaphorical contexts grounded in physical knowledge (Bresciani and Eppler, 2009;

Gibbs, et al, 2004; Barwise and Etchemendy, 1998, pp.100-105). The limitation to two-dimensions in Farthing's reductive formula is an inessential result of familiar observations, and ends up excluding quite a bit in potential (for a cogent example, see this volume, Chapter three, pp.144-154). For all that, Farthing's simplicity is useful in a context where questions of technique, distribution and pedagogy are complicated by computer systems (Schenk, 2005; 2007). His definition discounts without disregarding material aspects of drawing, or professionally oriented contingencies, while stressing a generalised translation, which I take to mean something like a conceptual mapping, with interpretive operations performed through the inscription. More stirring in its language is the art-historian Erika Naginski's remark that 'what makes drawing a compelling object of study… is the dynamic collision of hand and mind to which it continually bears witness' (2000, p.79). This is a rather literary take compared to the other more pragmatic one, but it says something essentially similar: that what is in (a) drawing is evidentiary, but also an interaction, rather than any mere artefact or implementation.

1.3. Tracing paper

> …the circle of the proof is drawn, not imagined to be drawn… Thus, the action of the proof is literal, and the object of the proof must be the diagram itself, for it is only in the diagram that the acts of construction literally can be said to have taken place (Latour, citing Netz, 2008, p. 455).

From Farthing's understatement, it is clear that a primary motive in drawing is measurement – even if only a loose gesturing between object, shoulder and paper. In my own practice I have identified this value in the representation of relationships, entities, and forces, or a felt scaling of body to body, no matter the nature of the body or the relationship. In fact, throughout this thesis we will see that all inscriptive practices are motivated in some way by scaling/quantification/measurement – an observation which connects the haptic and emotionally loaded life-drawing experience (Berger, 2005; Brooks, 2002) to more analytical systems such as projective orthography, or the common music notation, with its interval-scaling timeline and vertical pitch space. And of course that motivation has its most explicit, robust application in geometrical drawing, suitably defined by the German mathematician Felix Klein as 'a space together with a set of transformations of that space' (Baker, in Wiebe, 1998, p.191).

Geometry is a partly visual mathematical enquiry developed to take a measure of the field of sensible reality with all its indications, as a kind of wireframe diagram of dimension, incidence, and potential. And while Wiebe senses its presence 'in all technical disciplines, but also in every natural science, and even to some extent in fine arts and philosophy' (1998, p.194), the specific project of geometrical drawing is an explicit examination and calculation of physical relations, and potential. We will see from cognitive studies of drawing that a well-constructed graphical display exploits certain capabilities of the human visual system, displacing difficult logical, memory, and search requirements with a perceptually grounded context for making judgments (Larkin and Simon, 1987 [hereafter referred to as L&S]; Stenning and Oberlander, 1995, [hereafter S&O]). Thus a sound geometrical proof allows inductive responses into the logic of a deductive mathematical problem: line by line, the character-string notation writes forward, while the diagrammatic representation of its formulae shows us problem and solution together.

I am under-qualified to comment on anything mathematical, but these are the observations of one who takes seriously the use and potential of drawing as a method for thinking, and for expanding on that thinking through dialogue. Latour (citing Netz, 2008) observes that visual thinking becomes both deductive and social with geometry, while also becoming a practice that ports us from what we can see to what we can know; and so, not merely analytical but speculative. Through visual thinking over inscribed representations, the culture has moved from exploring natural principles in terms of location, motion and change, to conceptual diagrams and the networks of computational visualisations, meant to allow sensate experience of a different kind of organic system -- which is to say, information.

So now, as a thought experiment, contrast Klein's vision of the work of the geometer against the composition of music in the environment of the common Western notation, and we can clearly see their relationship in the inscription. The focus of Western music has been the organisation and manipulation of pitches, spatialised and made legible through the notation. And while a possible natural relationship between math and music is an enduring adage, it is in the inscriptive practices which inform their traditions that we can see (and manipulate) relations between these symbolic languages most clearly (Fig.7). As in geometrical figuring, then, acts of music inscription, either

traditional or non-traditional, translate between the real spaces of (auditory) experience and the virtual space of the page -- a conjecture-analysis environment (Darke, 1979) permitting us to unpick the specifics of their target domains by prestructuring the problem as a differential one.

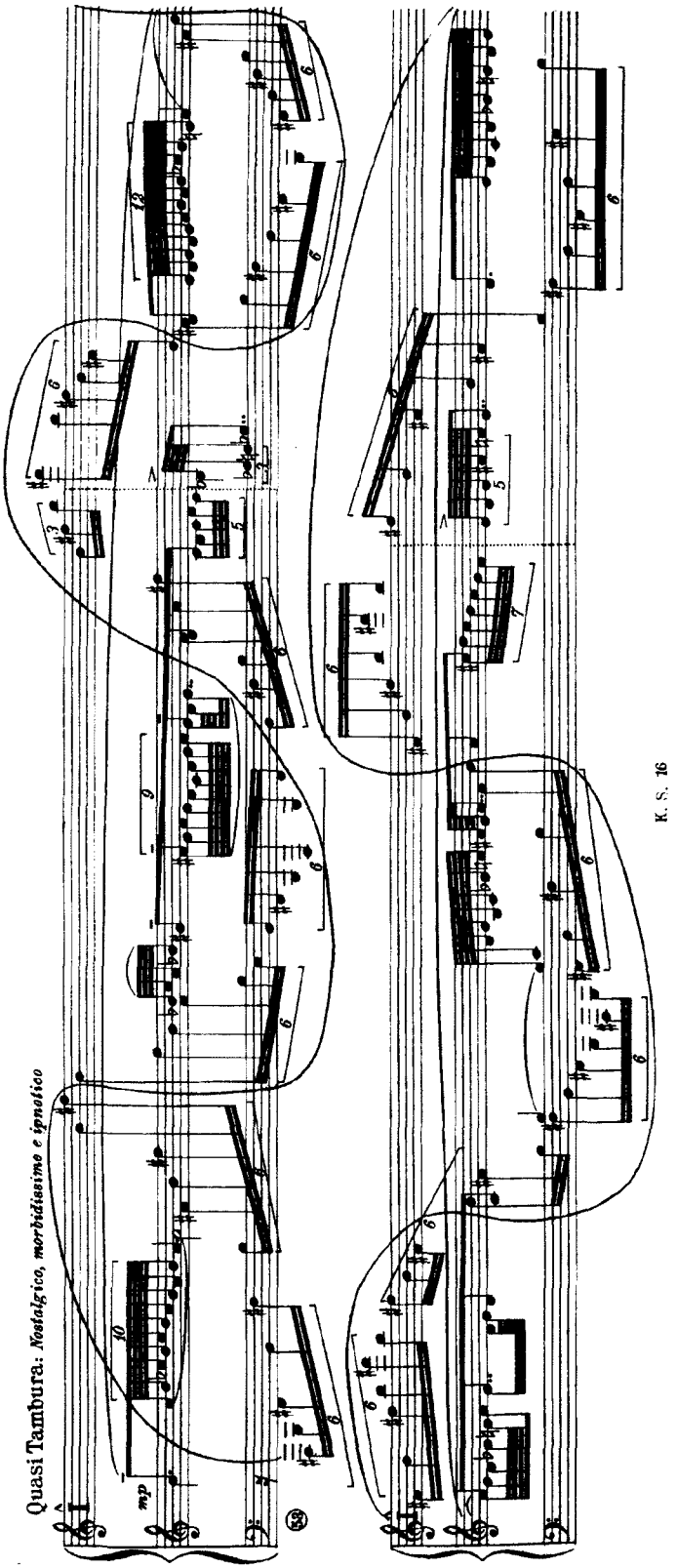

Fig.7: Sorabji's Opus Clavicembalisticum (1930), IX (Interludium B), in Byrd, D. (2010) Introduction: Music Notation and Music Representation, Gallery of Interesting Music Notation, accessed 24/2/11 at <http://www.informatics.indiana.edu/donbyrd/InterestingMusicNotation_files/Sorabji_Slur+Ctxt.png>. **In the Taxonomy, this notation can be classified as "Metric>Interval>Common music notation"**

This is not to say that music is necessarily mathematical, simply that in the inscription, both the music notation and geometrical figures represent and manipulate change and incidence as quantitative operations performed on qualities. In the final analysis they are drawings, but they are not merely pictures, mapping scenes, nor merely diagrams, mapping connectivity: they are representations of principles, mapping a conjunctive space-time dimension of performance. In the terms of their professions, then, Farthing and Klein recapitulate the operation at the core of all inscriptive practices, whether built on the projective diagram of orthography, or the topology of descriptive modes (Willats, 1997, p.70). Both geometrical and musical drawing provide a visual method of understanding transformation through performance: they are heuristic engagements with phenomenal experience, which we may then extrapolate to real world situations, tidily captured in performance of their provisions.

1.3.1. Peirce and semiosis

On notations for mathematical problems, the logician C. S. Peirce writes that 'the very idea (of Algebra) is that it presents formulae which can be manipulated, and that by observing the effects of such manipulation we find properties not to be otherwise discerned' (in Dörfler, 2002, p.1). The particular manipulations theorised here by Peirce involve the conventions of a cognitively more efficient (than Roman numerals) decimal system, with repetitive sequences based on "ten" (Kaput et al, 2002, p.54), encouraging the finding of properties that are more or less inscrutable before the fact of their inscription.

Peirce's semiotic theory is a theory of the creation and manipulation of signs in which word-signs are just one type (Deleuze, 1982, p.30), and thus it has been an important model in the research and development for the taxonomy in Chapter four. Presaging key aspects of Goodman's aesthetics, a typology for Peirce's science of signs includes "'pictures, symptoms, words, sentences, books, libraries, signals, orders of command, microscopes, legislative representatives, musical concertos, (and) performances'" (in Sebeok, 2001, p. 8). The many elaborations and modifications to his complex semiotic theory have limited relevance to this thesis and are better explored elsewhere, but in brief, for Peirce a sign is simply 'something by knowing which we know something more' (Presmeg, 2005, p.106). Cognition involves a factoring between a sign, its object, and interpretant (Peirce, in Büchler [ed.] 1942, pp.99), with modes of

signification in the icon, index and symbol. For Peirce semiosis is logic, and as in Goodman, the efficacy of the display thus encourages us to glean patterns for extraction and investigation, in a looping process of insight generation, in which the sign itself functions to 'make relations efficient' (Deleuze, 1989, p.31). And while in Peirce all signs have some aspect of icon, index, and symbol in them, in so understanding, we are left with an elastic process which Elkins deems 'a muddling negotiation between the enforcing rigour of logic and the myriad phenomena of experience' (2003, p.19).

As a model for drawing and cognition, Peirce's semiosis gives us a small, if disruptive set of concepts with which to understand how signs function in apperception and re-construction. Crucially in this, interpretation is a directed, open-ended interactivity, with destabilised conclusions allowing for reuse, re-action and reinterpretation. And because this thesis focuses on a direct and peculiarly supple form of signification, his ideas have value because of the insistence that the semiosis is a networking process: a feedback response to objects, events, and representations of all kinds, and that cognition is 'not something that takes place within mind within a body, but rather at the connections, in the reactions' (Cunningham, 1998, p.831) -- altogether a ready description of the act of drawing.

At this point I will introduce a distinction made by John Willats (citing Booker, 1997, pp.10-13) between the primary and secondary spaces of seeing and of making-seen. Primary space refers to the geometry of the scene and its distributed physical elements and illumination. Primary space is the geometry of the sensorium, of which we are so little certain except that it is bundled recursively into the very metaphors we use to describe things. Secondary space is where we arrange those metaphors. It is the geometry of making, recycling experiential knowledge through the customs of symbolic representation (for Willats, his Drawing and Denotations systems). From the interface of pencil (pusher) and paper, I return once again to the mixed message of my Bach experience, wherein one context of understanding was ruptured and spilled over into another. I identify Peirce's feedback loop as vitally accounting for the transformations generated from a perceived multiplication of drawing and drawn -- inscribed, as Cunningham puts it, 'at the connections,' at the cross-roads of primary and secondary space, on the page.

1.3.2. The oscillation of arguments

Sound is produced by modulations of air pressure waves, perceived by the cognitive system, (described as 'a model-constructer or interpreter... [with] the capacity to interpret and build models of... internal states' [Kukla, 1992, p.230]), driven to sort, filter and group. In consideration of this view of human knowing, the composer Edgard Varèse famously suggested that music could be best defined as "organised sound" (Wen-chung, p.157). Taking this one step further – taking it towards inscribing that organisation in a social document -- the notation of those waves, their provisional re-formulation and administration as Music, brings the logic of literacy up against the modulations: we read and write with them.

Theorising the active nature of reading, Kenneth Goodman described it as 'a psycholinguistic guessing game... involving an interaction between thought and language' (1967, p.127). But reading and writing are terms generally associated with *verbal* language use, understood to mean an in- or outputting engagement with written words. Recent research has suggested that reading and writing – what Berninger calls "language-by-eye" and "language-by-hand" (et al, 2002, p.39) – share a great deal in the process, though not in a stable, symmetrical relationship. The marks of language-by-hand must be legible, correctly spelled, and so on; and although there are cognitive-developmental issues around reading and writing that are well beyond this thesis to explain, conclusions that language-by-eye and -by-hand are in a conjoint relationship are well established. Thus reading, and its compositional-executive reflection writing, are skills in which anticipation of 'that which has not been seen, of course, is vital... just as the ability to anticipate what has not yet been heard is vital in listening.'

On a rule of economy applied to the interaction, then, this is a view in which we read-into, as much as off of the text, which echoes drawing researcher Gabriela Goldschmidt's remark that in the sketch, we are enabled to read off 'more information than was invested in its making' (2003, p. 78). The logic of literacy therefore always has the 'logic of conjecture' as some portion of it (Cross, in Buchanan and Margolin [eds.], 1995, p.110).

There are broad avenues of inquiry into language-use outside the purview of this thesis, but with respect to marking practices – language-by-hand -- a number of sources

have investigated their values as representational performances, arriving at conclusions remarkably similar to K. Goodman's observations on reading writing. Michel Serres writes that 'One must swim in language, dive in as if lost, for a weighty poem or argument to arise' (in Scheher [tr.], 1983, p.53). Vinod Goel (1995), for a more recent example, has suggested that sketching in design practices is an underspecified, artefactual process feeding back and forward into a creative production loop, generating novel insights into the problem at hand by what Goldschmidt calls an 'oscillation of arguments' (1991, p.123). Here, early in the thesis and awash in language about language, I remind the reader that this is drawing research, motivated by a need to understand a momentary, oddly mediated conflation of space-time representations. Still, fortified by the sheer utility of the written word, we need to acknowledge that analogies (a 'mapping of relations... rather than attributes,' in Gentner, 1983, p.168) will occur, and that these are difficult to negotiate, perhaps ineluctable facts of our image-constructing compulsions.

Only note the richly metaphorical writing of Goldschmidt cited above, in which the arguments are built from some combination of weights and velocities of mark-making, rather than words and sentences. Her use of "oscillation" is key, functioning as an image-schema (Turner, 1992, p.727) from which we are meant to understand that sketches behaves in a dynamic, variable way: lines and marks talk amongst themselves, and whatever it may be that the draughtsperson is after emerges in and through listening to that dialogue.

Metaphor and analogy are unevenly understood but enduringly considered aspects of symbolic communication, due to their ubiquity and expressive uses in verbal language (Gibbs, 1994, p.121-129). Although metaphor research has tended to put aside non-verbal expressions, recent work coming out of the cognitive turn has advocated for metaphor, metonymy and analogy as more than just alternative ways to say something. Researchers in the field of cognitive linguistics, for example, have asserted that their uses in verbal communication reflect a human tendency to conceptualise difficult to grasp complexes of knowledge in the more compact, familiar terms of physical experience (Lakoff and Johnson, 1980; 1999; or for a review, Tendahl and Gibbs, 2008, p.1825, Neisser, 2003). More generally, Barsalou reviews research into "grounded cognition" theories (in 2008, pp.623-631), which seek to establish that human cognition is bodily grounded; that reasoning and knowledge processes draw primarily from sensory-motor

responses to environments and action, rather than being obscure products of the use of "amodal symbols" for representation (defined in Barsalou, 1999, pp.578-579) like those indicated by Pinker (1990, p.77). Studies from a number of empirical perspectives provide support, suggesting the modular brain makes spatial and temporal connections as a pragmatic affair, rather than a purely symbolic one (for critique, see Davies, 2004, pp.162-164). Barsalou reviews studies (2008) for instance which reveal the mind engaged in cross-modal simulations, re-enacting 'perceptual, motor, and introspective states acquired during experience' (2008, p.618). For example, simply to read a written description for some action engages the appropriate motor system in the brain which represents the physical meaning of the words. Similarly, the presence even of the name a known object will trigger an appropriate response (2008, pp.623-631).

The broader implications of this approach to understanding human cognition is not in the scope of this thesis, except with respect to the uses of external representations as cognitive assists, the efficacy of which are matters of inferential, and metaphoric constitution. The account of metaphor will rest here on extended discussions by Gibbs (1994, pp. 120-207; for summary, Murphy, 1996, p.175) and Goodman (1976, pp. 45-85). We understand and communicate emotions in terms of temperature, or love relationships in terms of journey, because these conceptual mappings allow us to consider and assimilate them in terms of movement and causation. This mapping from one domain of experience to another is not restricted to verbal concepts, but to relational structures and schematic representations such as Goldschmidt's oscillations, or the projections of linear perspective, which map points of view to the space of the page, or cross-modal mappings such as Wolfgang Köhler's well-known "Booba and Kiki" experiment (Ramachandran, 2003, p.38).

The findings of cognitive linguistics are contentious for a number of reasons (Murphy, 1996), among which are problematically un-testable aspects of metaphorical mappings and interpretive contexts, but the field at least encourages the review of metaphor and analogy as crucially cognitive extensions, rather than merely turns of phrase. Lakoff and Johnson (1980) conclude, for instance, that spatialisation metaphors underlie a large part (!) of our conceptualising through language, structuring our thoughts, rather than merely helping us to describe them. Thus, for example, "Good is up," "Purposes are destinations," (1980, pp.462-63). Thus also the commonly reported

experience of music in terms of spatial passage, which musicologist Fred Lehrdal theorises (in 2003, pp.369-372). We then recognise the common music notation as an inscribed mapping of that musical journey, apart from the fact. The composer Robert Morgan describes music composition as temporally unfolding systems of relationships, distinguishable from ordinary, psychological time by their 'pronounced spatial... quality' (1980, p.529). The documents generated in the composition of music propose that one pitch is below another; that rhythm is transition; that two sounds are in some way linked and responsive to each other; and finally, that sound is something to be organised. Varèse also notably used such embodied spatial metaphors in his compositional theorising, describing the planes, masses, and dispersal of a musical passage, or penetration and repulsion in practices of listening (Wen-chung, 1966), finally proposing horizontal and vertical musical dimensions, as well an oddly spatialised expression of "dynamic swelling," which crosses and re-crosses them. We may be unclear on their roles in cognition and communication, but there is little question metaphor is equally at play in our acts of making and reading visual art practices: to point to a landscape painting (a marked surface denoting a landscape) and say "This is a landscape," is to indicate something metaphorical both in the marking, and in the labelling. Tversky argues that our recognition of marks and shapes involves imputation and the telling of a story: we see the bars in a bar graph as containers, and we see lines as connectors, and in so seeing we read them in context as either quantity or tendency, respectively. Similarly, to say of a performance of music that the "strings shimmered above the house" is not literally true, but it communicates as metonymy (the strings/the house) and metaphor (shimmer/above), and under the right circumstances also happens to communicate some aspect of truth (Fig.8).

In conversation, drawing has been analogised to grammatical entities such as noun, verb and predicate. While these tropes may give us easy insights into the object-status and mixed social values of drawing, I suggest that to inquire into whether drawing is a noun or a verb is merely to investigate the truth value of an analogy. This is a problem that needs dealing with if we are to undertake a more refined study -- and a fuller accounting of my experience with Bach's manuscript demands this. Making the strong case for using a classification methodology to underpin this thesis, therefore consider the astronomer Johannes Kepler's well known observations on the movements

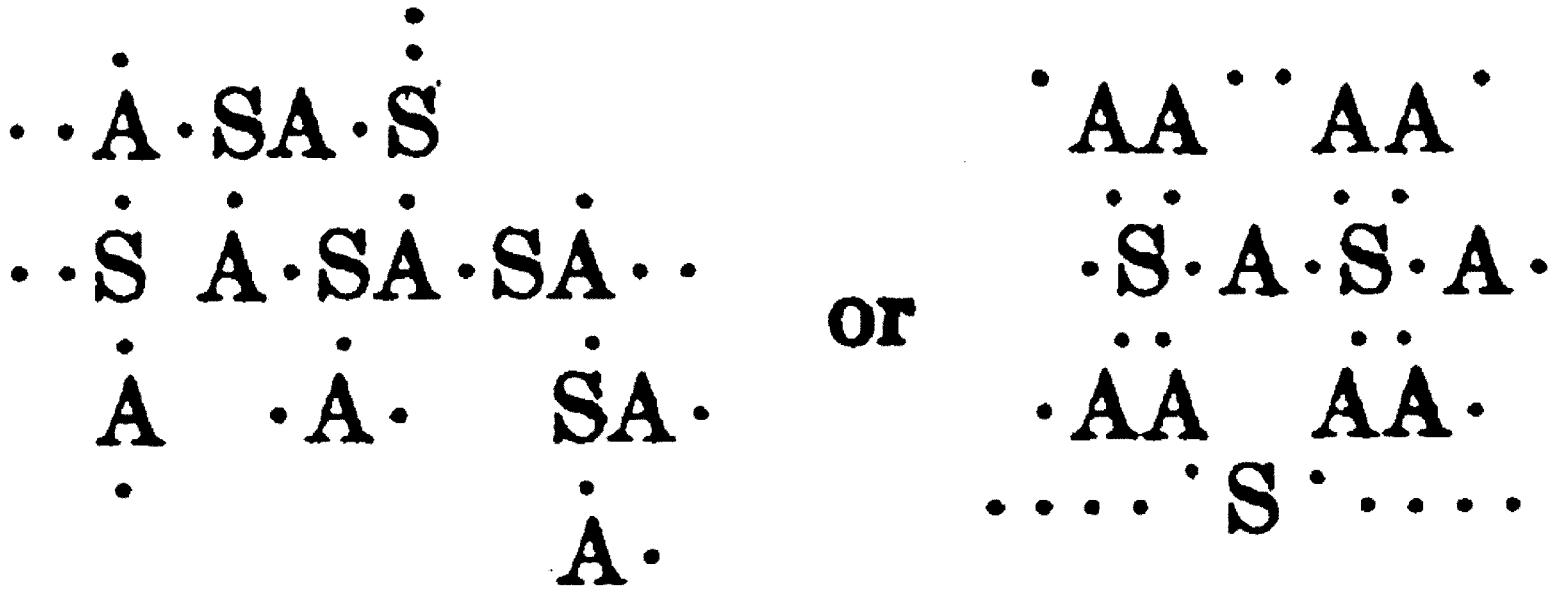

Fig.8: Visual metaphor and notation: a rendering of the precipitin reaction by Michael Heidelberger, '(the diagram) consisted of letters (for example, A for antibody, S for the antigen) surrounded by little dots, representing the arrangement of the molecules in a precipitate (in Cambrosio et al, 2005, p.114). **In the Taxonomy, this notation can be classified as "Metric>Ordinal>Histograms>scattergram"**

of the planets, captured by his analogy of boatmen in a current (Gentner and Markman, 1997, p.46).While stimulating insights into the irregularities of planetary paths, the analogy begged many more questions before becoming actually descriptive: it needed the framework and explanatory power of Newton's gravitational theory. A well-turned metaphor is a catalyst for understanding, while a bad one baffles; the statement 'drawing is a verb' can obscure as easily as illuminate – it is interesting as a reflection, but gets us no closer to an adequate account of drawing. Ergo, taxonomy, and an informing ontology stressing structure.

1.3.3. Drawing into space

The philosopher James Blachowitz has described languages as '(bridges) from physical to symbolic,' noting that 'transformations or transductions across... media make complex communication possible' (1997, p.62). The literary translator Richard Pevear has similarly described his discipline as the moderation of a dialogue taking place in a space between two languages (2006); and although Pevear is referring to the Word, and more specifically the written word, surely other inscriptions may similarly converse across their differences. In related terms, Vinod Goel summarises drawing in the design process as a transformational dialectic across symbol systems (1995). And in her research into the creativity supporting properties of sketching Tversky has also remarked, in conjecture, that 'Automatic translation between descriptions and depictions ought to be possible when the same conceptual structure underlies each' (1999, p.4). With Tversky's conjecture in hand, disregarding the problematic word "automatic," I take Pevear's reference to the spaces between languages (where translation happens) to be the domain of Drawing.

Serres wonders if we even need to 'speak of symbolic exchange?.. since *a symbol is this bringing together* that is the condition of the exchange' (italics are my emphasis; 1982, p.248). In fact, as one who wishes to make paintings and music, I have felt most enabled to get somewhere inside the lacunae of these ritualised symbolic activities through concrete acts of making, providing illumination often enough at the tip of a pencil. The mediation of speech sounds by writing has thus grown verbal exchanges into sustainable systems of civil law, with socially predicated circumlocutions and addenda, over the same time span in which the inscriptive practice of the common music notation has tended the growth of western musical traditions such as harmony and counterpoint by allowing its

users to see the sum of music (audition, organised): to see sounds and silence as objects, to see pitches and instrumental sections as belonging to a tradition, and to use aspects of visuality and temporal experience to read music, but moreover to write it. We inscribe surfaces with displaced marks, reading potential, or "affordances" (Gibson, 1986, p.127; Barsalou, 2008, p.623), that is, what is revealed about possible interactions with the reading of those displacements (for example, how 'a low window cill affords us the possibility of sitting on it' [Lawson, 2004, p.455]); or directing us along routes of reference to some review of social conditions, or even to logical and illogical things. Thus do the direct, simple means of drawing generate the conditions in which symbol systems can transact, working in the spaces between, rendering visible, calculable, and in the case of increasingly articulate notations, executable.

Elkins has written that 'Pictures both stand for and exemplify both objects and quantities, and for that reason representation is also numeration' (1998, p.182). This is pithy but not trite: to draw a picture is a discriminatory process, and discrimination is calculated judgement, analogous to quantification (Blachowicz, 1997; Kukla, 1992). Recall also the metaphorically charged terminology coming from within the debates on the nature of mind and cognition (for a glossary of terms, see Appendix I, pp.198-202), words such as computation and correspondence – a vocabulary of numeracy. There is an intriguing notion here which weaves together various threads, from the translation/transduction referred to by Tversky, Blachowicz and Pevear, to Goodman's efficacy, and Peirce's looping calculations of salience, to observations derivable from the practical work presented in Chapter three, to the very idea of a taxonomical portrait of drawing, which is, after all, a kind of quantification exercise applied to behaviours.

Now drawing in the shadow of my fraught experience with Bach, Chapter three will demonstrate creative exchanges between symbolic systems, mediated by the picture primitives of point, line and plane. In the works of art produced and presented, as well as in the taxonomy which informs them, attention will be drawn to the values of inscriptions as cognitive and executive engines, and through a study of common motivations, we will see the oscillations and backtalk become calculation and instruction.

1.3.4. Knowing by hand

> What interests me here... is the incising or inscribing itself -- which in Raphael's case signals not a passive process of mind but an active and tactile one that pairs gesture and concept, that conflates material and metaphysics. (Naginski, 2000, p.67)

I recognise this as being related in a family way to my experience with the manuscript of Bach. The art-historian Naginski sees philosophy in the turns of Raphael's stylus, just as I saw the physical in Bach's. In this complex of give and take, inference -- interactions yielding information 'not explicitly stated' (McKoon and Ratcliff, 1992, p. 440) -- and intuition are identified as components of rationality, central to symbolic communication. And while I will not seek fuller explorations of the terms, I will continue to use them, situating their vitality in reference to Thomas Kuhn's view of the daily work of scientists.

Miranda Fricker summarises Kuhn's argument for intuition as a 'catalyst for theoretical changes' (1995, p.182), representing a leap from 'an inadequate evidence base' whose target is unknown, and possibly unknowable before the fact. It is not a random process however; rather intuition is generative over a range of possibilities (1995, p.187). For Kuhn, intuition becomes a mechanism for hypothesis formation, from which challenges and counter-examples can take shape, placing it in some conflict with the inherently conservative, corroborating directives of scientific enquiry in the public sphere. Most interestingly, however, Fricker (1995, p.184) summarises Kuhn's thinking in a way that validates my observations on the experience in front of Bach's manuscript:

> it is intuition which enables us to recognize a new question as being like one we have encountered in the past... even though we cannot pinpoint the respect in which they are alike, or say why or how we recognize the likeness.

This dissertation pursues that pinpointing and the likeness-re-cognition which did not issue directly from the experience, but rather, from interpretive practices of art in its wake.

While writing more on the "invisible touch" of Raphael's nimble stylus, Naginski cites Gombrich's remarks on Leonardo's use of the sketch: 'The sketch... is part of a

process which is constantly going on in the artist's mind; instead of fixing the flow of imagination it keeps it in flux' (Naginski, 2000, p.80). Intuition is thus exemplified and embodied in the sketch; the sketch is flux in action, as also suggested by Goldschmidt, Tversky and others. And the corroborative workings of systematic notations in any discipline help to fix the flux. Recall now Naginski's conflation of material and metaphysics in the turns of Raphael's inscribed bodies in space. While we might never come across such a mixed-message from an engineer, busy drawing in the conventional, highly directed ways demanded by his or her industry (why seek to define something so obviously a tool?), in the marking-up of experience that this taxonomy will emphasise in its open-hearted ontology (described in Chapter three), driven by our pattern-seeking proclivities, the intuitive response is identified as a crucial reactive and compositional site, irrespective of drawing mode.

The range of activities under the umbrella of inscription may be differentiated in name and purpose, but theorist Jacques Bertin (1984) defined graphics simply as visual means for the resolution of logical problems, which is comfortably close to equally succinct definitive statements from other domains. 'Analysis is in the act of drawing,' David Rosand writes (2002, p.97), and more than that, drawing is in -- is a foundational component process of -- multiple disciplines, each of which benefits from its conjunction of seeing and making. As a critic and lover of the act of drawing as a fine art discipline, John Berger, and more recently Patricia Cain, has written of drawing as a way of 'coming to know' (Cain, 2004). Cain writes of her emerging recognition that a drawing is 'the by-product of a dialectic of consciousness, as opposed to merely being an object whose purpose (is) the translation or illustration of something already known' (2006, p.4). And in an intriguing antecedent case-study of knowing by hand, Roger Fry, the Bloomsbury based critic of post-impressionism, used drawing as a critical methodology, tracing original works of art to get closer in a tangible way to their meanings -- an interaction with the message, repeating visible structures in the composition to better grasp the structuring intelligence of the painter in the painting. Something like Menard's project, Fry's can be situated in terms of scientific analytical procedures as described by Deleuze and Guattari: 'Following is not at all the same thing as reproducing... Reproducing implies the permanence of a fixed point of view that is external to what is reproduced' (1987, p.372). The critic Fry worked with the paintings, not on them; his marking-up follows with no intention to reproduce.

The archaeologist Helen Wickstead has written of a uniquely hybrid notational drawing in the practice of Stratigraphy (2008; and see Fig.9). As a profoundly collaborative practice, stratigraphic drawings seek to plot the dimensions of an archaeological dig site in order to arrive at plausible narratives which could account for the site relative to the current state of knowledge. As described, this is a puzzling out of spatial and temporal layers, slicing through substantial deposits of earth to create cross-sections – new surfaces, directed at the telling of some fragment of larger stories. In its reductive and dialogical rendering, and its dependence on text-based elaborations – on talk -- the stratigraphic notation is a time-factored and time-factoring record of the human events which may have filled the site, but also of the span of the creation of the document itself. 'We draw contexts,' Wickstead writes (2008, p.16), and while photography might provide a more complete form of documentation, those at work in the field attest to the superiority of drawing for their purpose. The details forfeited in a graphical rendering are made up for in somewhat the same way as we see in Fry's tracery of Cézanne: the thing is simply better understood by the laying on of hands, and the discourse of archaeology thereby includes collective drawing practice. Like other forms of inscription, it is a discriminatory practice where description and interpretation come together, while like the music notation, its aim is to (re)construct narratives beyond the frame.

Now stepping back to Bertin's technical graphics, constrained by usability issues and undisturbed by questions of original and copy, the theorist defines two uses for them: to solve problems and to communicate information. In Stratigraphy, or the heuristic critique of Fry, or the coming to know (by hand) of Berger and Cain, these two uses are merged, just as the 'circle of the proof is drawn, not imagined to be drawn' (Latour, citing Netz, 2008, p. 455).

1.3.5. Recognition in inscription

The composer who creates a work may have the experience described by writers of being taken over by the work. It is begun by him but then a certain remorseless logic continues the work. To that extent to create a pattern is to recognize the continuance of a pattern (Sharpe, 1995, p.38).

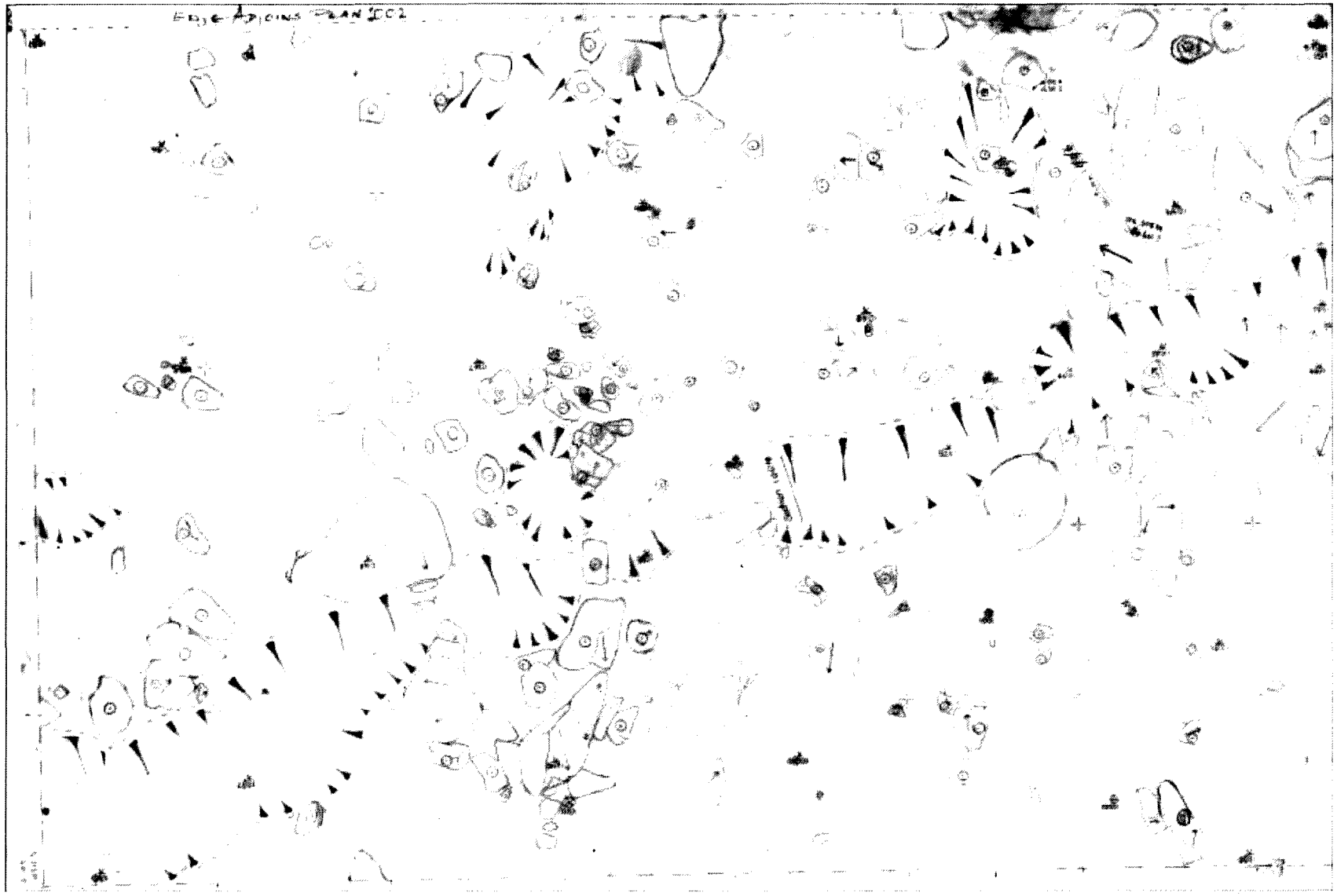

Fig. 9: Collaborative stratigraphic drawing (Kelly D, Feeney, B); Stratigraphy is a collaborative drawing practice meant both to document an Archaeological dig site, but also reconstruct the site in conversation with current scholarly knowledge of its history; from Wickstead, H. (2008) Drawing archaeology, in Duff, L. (ed.) Drawing: the purpose, Intellect Press, Bristol UK.
In the Taxonomy, this notation can be classified as "Metric>Ordinal>Stratigraphy"

It is a common enough observation that drawing is an enactive seeking-out and marking-up that is provisional, but also progressive from incipience to something approaching precision. Any who seriously engage with drawing come to see that we manage better understanding of what we are after through the process of working with and through the activity itself. The novelist E. M. Forster asked 'How can I know what I think until I see what I say,' and in this sense – described in other contexts by Goel, Cain, and Wickstead -- drawing is a process of discovery, even knowledge-constitution, as researcher David Galbraith has theorised in reference to the process of writing (1998). The scribe doesn't merely output some line of thought, set of contours, or group of ideas, but rather engages in a discourse with what is on his or her mind, on the page, and what might emerge from the pencil, given the circumstances and goals of the practice.

'Comprehension and creation go on together,' Goodman writes (1975, p.72) and supporting this, Galbraith's research into the technicalities of how the writer and writing work together to develop insight and build meaning suggests that the constraints at play in systems of written language create a feedback environment in which "disposition," or spontaneous articulations of thought, and the re-organisation of existing ideas interact as a complex (Galbraith, 1998, p.140; 1992, p.63). This enables 'a succession of ideas to be produced… (that are), because of inhibitory feedback, a consequence of the preceding idea' (1998. p. 140). Writing things out, then, is a diagnostic process and an executive reflection of reading: we arrive at points that would be tricky to get to without the integrating pathway provided by the inscriptive practice itself.

Multiple design drawing researchers refer to something very like this discursivity. Goldschmidt, for instance, notes that in its underspecification we are enabled to '(read) off the sketch more information than was invested in its making' (2003, p. 78); and while the written word is a context with a peculiarly useful form of attention to detail, we might expect to find research that demonstrates some measure of Galbraith's theorising and Forster's dictum, applied to other visualisations. In fact, these are quickly found; Larkin and Simon (1987), for example, is a widely cited source which demonstrates the relative values of diagrams against character-string representations in a problem-solving context. Summarising their findings, diagram construction includes a representation of the solution, lightening the load thereby on search and memory tasks in processing, in contrast to character-strings, where inferences must be developed and tracked in order to

produce answers. Recanati (2007) illustrates the idea with one diagrammatic representation, and an equivalent sentential one

T L C

T on-the-left-of L; L on the-left-of C

noting the latter requires a syntax -- the structured representation, and a method of understanding the relations between elements, plus some verification strategy; what she calls an 'inference mechanism (and a rule of transitivity)' (2007, p.511). Researchers Scaife and Rogers write that a diagram constrains its reader to 'particular (ways) of conceptualizing and solving the logic problem' (1996, p.195), which relations may be verified by simple inspection. And Bertrand Russell, much earlier of course, noted the efficacy of geographical maps, writing 'the fact that one place is to the west of another is represented by the fact that the corresponding place on the map is to the left of the other; that is to say, a relation is represented by a relation' (1923).

Finally, presaging Galbraith by centuries, J. S. Bach's explorations of music notation conventions in the Western tradition are widely understood to have made some contribution to a reformation of the professional practice of music composition. His graphical take on the notation allowed him to investigate other, rather more difficult to hear aspects of the world in the symbolic language of music: symmetry, for example, as a dialogue between audition and visuality (Donnini, 1986, p.436; also Fig.10). Bach's practice of compositional writing is discursive between the primary spaces of experience and the secondary space of the page, incidentally enhancing the understanding of "Music" as a thing distinct from the elaborate rituals of audience and orchestration that surround its performances (Kivy, 1984). The social document of the notation is an interface between composer and musical symbolic thought, through which manipulations patterns are discovered, followed or created. The score, as a representation system, becomes connotative, and a composition for music rather than an orchestra.

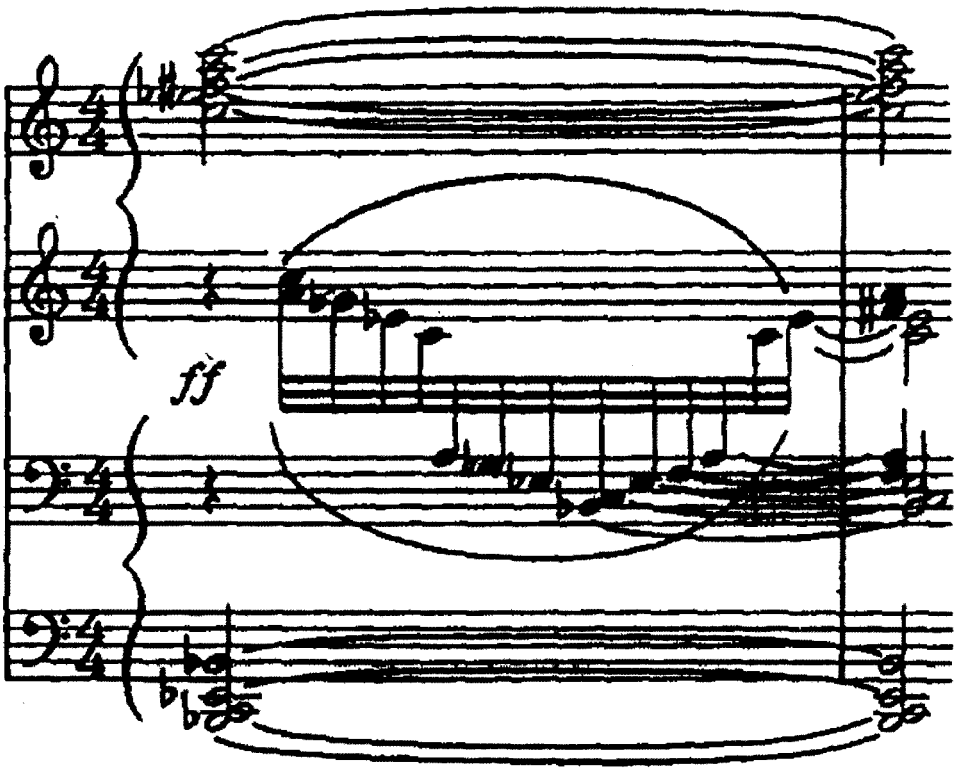

Fig.10: Toccata & Fugue in C major, Bach, J.S. (in Donnini, 1986, p.438). **In the Taxonomy, this notation can be classified as "Metric>Interval>Common music notation"**

1.3.6. Reasoning with inscriptions

The use of external representations as reasoning tools has been theorised as critically valuable component practices in learning (Radford, 2008; Recanati, 2007; Lemon et al, 1999; S&O, 1995; L&S, 1987; Van Sommers, 1982). In particular, self-constructed external representations demand active reconstructions of source material, and dynamic interactions between making and thinking, up against the social pressures of sharing the results as legible artefacts (Cox, 1999). Writing on the differences between constructing external representations and reasoning through extant ones, Cox echoes both Goodman and Peirce, noting that when 'signs… are included in an action, they do more than facilitate manoeuvres that are impossible in the absence of the sign system. They fundamentally transform the action' (1999, p.347). As in Galbraith and Bach, and Euclid for that matter, our engagements with inscriptions are interactions between thought and symbolic language, simplifying our perceptual responses in order to follow the logic of conjecture. Reading Cox' characterisation (1999, p.348), the empirical research of van Sommers (1982) and Goel (1995) then show us inscribed external

representations as interactions between internal and external: as social behaviours in Van Sommers, and as equally social, but professional, solution-directed transport systems in Goel.

Van Sommers investigates processual and mechanical aspects of how we draw, and the entailments of inventing and copying as cognitive processes. We will not describe the author's findings on the roles of memory, planning, imagery and perception, but he does note that in spite of our incomplete understanding of cognitive processes, we may nonetheless look at the neurological system as a filter, and drawing as a model for that system. He also emphasises drawing's dependence on social practices and conventions. More specifically, Goel (1995) addresses the profoundly social practices of design fields, writing that drawings are primarily used to transform across sets of representations, supplying implementations of real-world objectives which can be manipulated and reasoned with; cognition is achieved in a cloud of information, and drawing reflects this process. This is evocative language with clear correspondences to Goodman's notion of the entailments of a dense-articulate dichotomy in symbolic communication.

1.4. Some distinctions

As practices of the fine artist, drawing has been richly described in many places, but Deanna Petherbridge summarises it as 'performative act, idea, sign, symbol, and signifier' (2008, p.27); and while we can never be absolutely certain how tightly our contemporary intentions conform to those of the earliest markings that we recognise as drawing, at the very least we can say we make them for communication. Erika Naginski writes that Raphael's masterful tracery '(wavers) disconcertingly between mimesis and semiosis, line and sign, geometry and letter, figuration and discourse' (2000, p.64). The disconcert she describes is due to the free wheeling nature of our consumption of external representations of all types. We use inscriptions to hold differences in hand, and so there are few clean categories. Pictures and diagrams are different things, but diagrams are pictures, and pictures always have embedded aspects of the diagram. The relative achievement of any drawing has to do with how well it hews to the determined objective: 'how it analyses, sorts, orders and organises; (how) it participates in the making, manipulation, retention and transformation of knowledge' (Goodman, 1976, p.258): a poor drawing is inert, a good one reforms and clarifies our sense of its subject, even if the subject is unclear.

But building towards the ontology for the taxonomy in Chapter four, we should make some simple and necessary distinctions, besides those made by Goodman. For a similar summary in the computational literature, see Perry and Macken (1996, pp.4-15), wherein the researchers usefully collate research sources, seeking perspectives on what makes representations 'picture-like, map-like, diagram-like, chart-like or text-like.' This is not, they write, an attempt to indentify some essential distinguishing structure or function, rather it is an 'exercise of looking for contributing factors to differences that we intuitively feel and exploit, that will lead to better and more useful classifications of the phenomena in which those differences are found' (1996, pp.5-6).

In this chapter we have seen crucial (never inviolable) differences between representations explained in terms of constraints on interpretation. In attempting to differentiate pictures from diagrams, therefore, I will begin with Elkins' observation that pictures lack the kind of constraining syntax possessed by diagrams or writing, and so are 'images taken to be constituted by the in-built vacillation, contradiction, paradox, or uncertainty of "saying" and "showing"' (1999, p.81). I imagine a third, pictorial version of Recanati's cited "T–L–C" proposition would complicate the display by naming names, giving "left of" additional dimensions of complexity (Left from whose perspective? Directly left? How far left?). As a loose definition this also has the virtue of including Goodman's replete-dense distinction, while also confirming that pictures can be anywhere we see them.

But more technically, to draw a picture is to utilise simple tools to engage with varyingly complicated systems of projective mark-making, mapping primary relations in the scene onto the page (Willats, 1997), which are turned out, taken in, and recycled by our cognitive systems. In Raphael's case, by Naginski's reckoning, the objective is to represent bodies moving in space, which is not very much different intentionally from the representations of Bach, Wickstead, Cage, or Fry, or the weirder hybrid marked-up and down by Leonardo in (Fig.11).

To work with a diagram, however, requires understanding the potential of the diagrammed, stressing process, as opposed to spatial relationships. A diagram is a schematic representation of distribution, dependant in some way on prior knowledge, on a key for deriving its meaning (Anderson, 2003, pp.186-187), inscribing isomorphisms

perceptible between representation and represented (Gurr et al, 1998, pp.548-550). Echoing an essential point of Goodman's theory (1976), Macken explains that this is not a matter of resemblance, but of 'robust cognitive correspondence' between some aspect of the symbol and that which it signifies (et al, 1993, pp.1-2). Despite these immediate distinctions from pictures, it remains difficult to speak of diagrams in categorical terms, as there are many inscriptions that demand considering, including maps, networks, charts and hybrids.

The problems of typology linger in recent classification strategies on the use of technical visualisations (see Lohse et al, 1991; Shneiderman, 2002), but what evaluations of the diagram seem to converge to is that their constrained, spatialised displays permit some proposition to be easily searched and recognised by users, while restricting the number of inferential moves necessary to get a view of the solution (L&S, 1987). Less precisely put, but echoing Pevear's take on translation, architecture theorist Anthony Vidler suggests that diagrams 'operate between form and word, space and language… (they are) performative rather than representational' (2000, p.6). In a way unlike pictures, then, diagrams are *used.*

But drawings are prodigal things. Petherbridge (2010, p.13) in fact deems this to be a necessary and useful condition: they will be read and misread regardless of intent. Recognising this, she wisely holds that our understanding of the very different drawings of Frank Gehry and Frank Stella only benefit from their juxtaposition. This compulsion, we might say, is theorised in the factoring of Peirce's semiosis, but also clearly sits at the centre of my originary experience with Bach's music notation. And it becomes in fact a critical problem for a simple dichotomy of depiction and description as taxonomical classifiers, visible as a problem-set in (Figs. 12 and 13), each of which fluctuates across those widely recognised polarities. Each image describes recursivity, even as they differently depict. The projective, existential line of Masson's drawing "calls itself" no less than the logarithmic spiral of the scientific diagram, and the spread of a theoretical continuum of depiction and description folds upon itself, and loses some portion of its classification value.

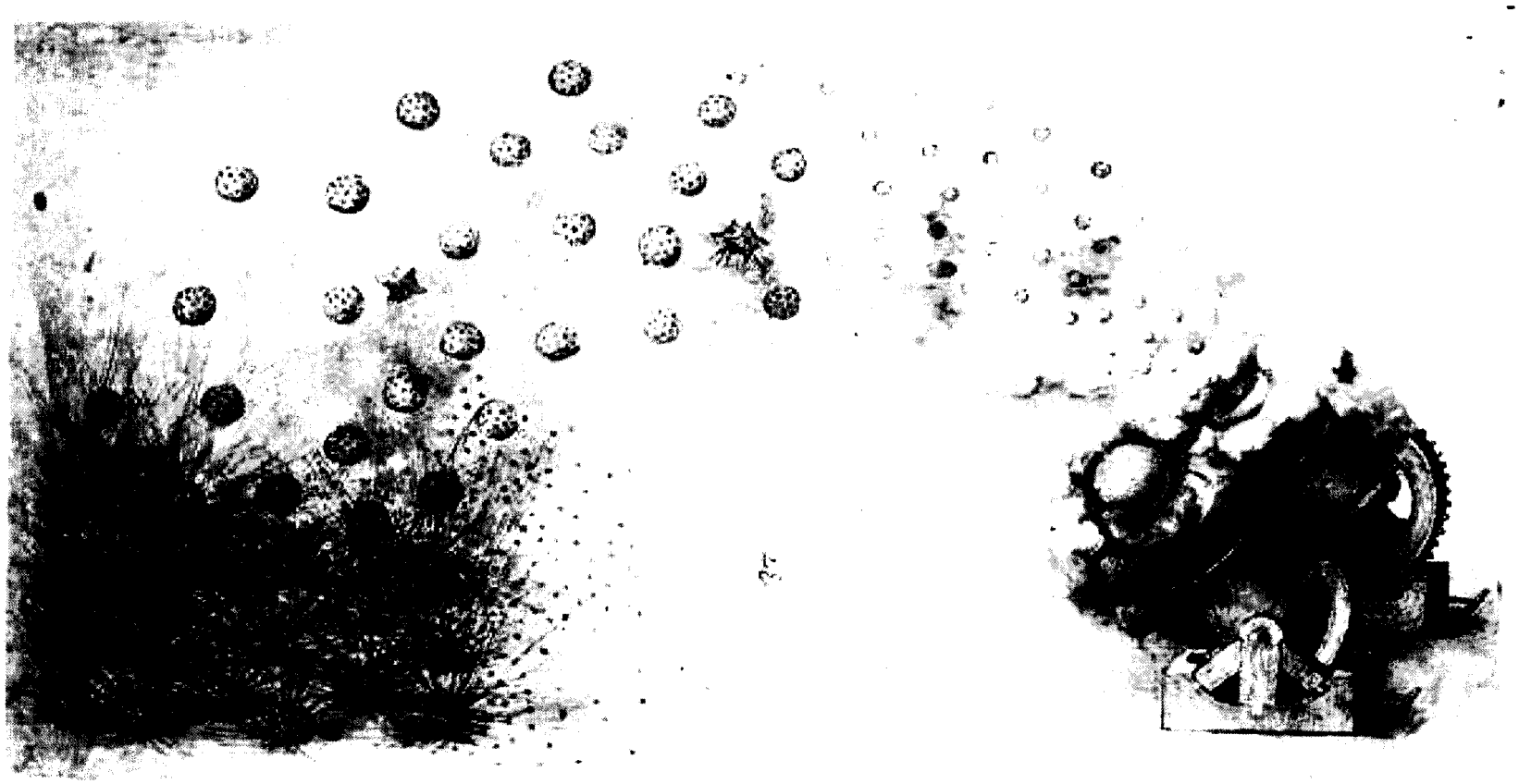

Fig.11: Sketch of a mortar for fragmentation bombs; the drawing is a mixed bag of representational approaches: an oblique projection with no intent to map actual spaces; Da Vinci, L. (2009) in Povoledo, E., NewYorkTimes.com, May 8, accessed 24/2/11 at <http://www.nytimes.com/2009/05/09/arts/09leon.html?_r=1>. **In the Taxonomy, this drawing cannot easily be classified: is it "Projective>Oblique projective geometry>...?" or "Projective>Perspective>quasi/...?"**

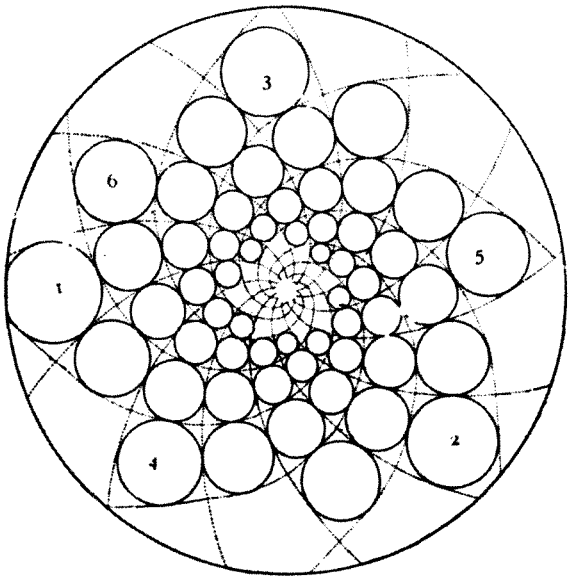

Fig.12: Theoretical diagram of a logarithmic spiral, in Cook T. A. (1979) 'The Curves of Life,' p.100, Dover Publications Inc, accesses 24/2/11 at <https://imagelibrary.ocad.ca/f_images_detail.cfm?/50555153500A0D0800010628/index.htm>. **In the Taxonomy, this can be classified as "Topological/Denotation/Line drawing>Maps>..."**

Fig.13: Automatic drawing; Masson A (1924), 9 1/2 x 8in, ink/paper, © 2007 Artists Rights Society (ARS), New York/ ADAGP, Paris. Classify as **"Topological/ Denotation/Line drawing>Maps>..."; however, as a performance/index, might also track along the "Metric>nominal>..." branch.**

Then again, at the interface of primary and secondary geometries, the hatching in the serial drawing by Robert Crumb (Fig. 14) is oddly little different from the Feynman diagram (Fig.15). Both inscriptions are inscribed views on experiences of energy, represented as lattices indicating cast shadows in Crumb, or interactions of quanta represented as angles of incidence and impact in the Feynman diagram. Each image is a network of picture primitives, mapping both scenes and relations to the page. Moreover, they show us impacts, either as cosmic tragedy or a game of cosmic billiards.

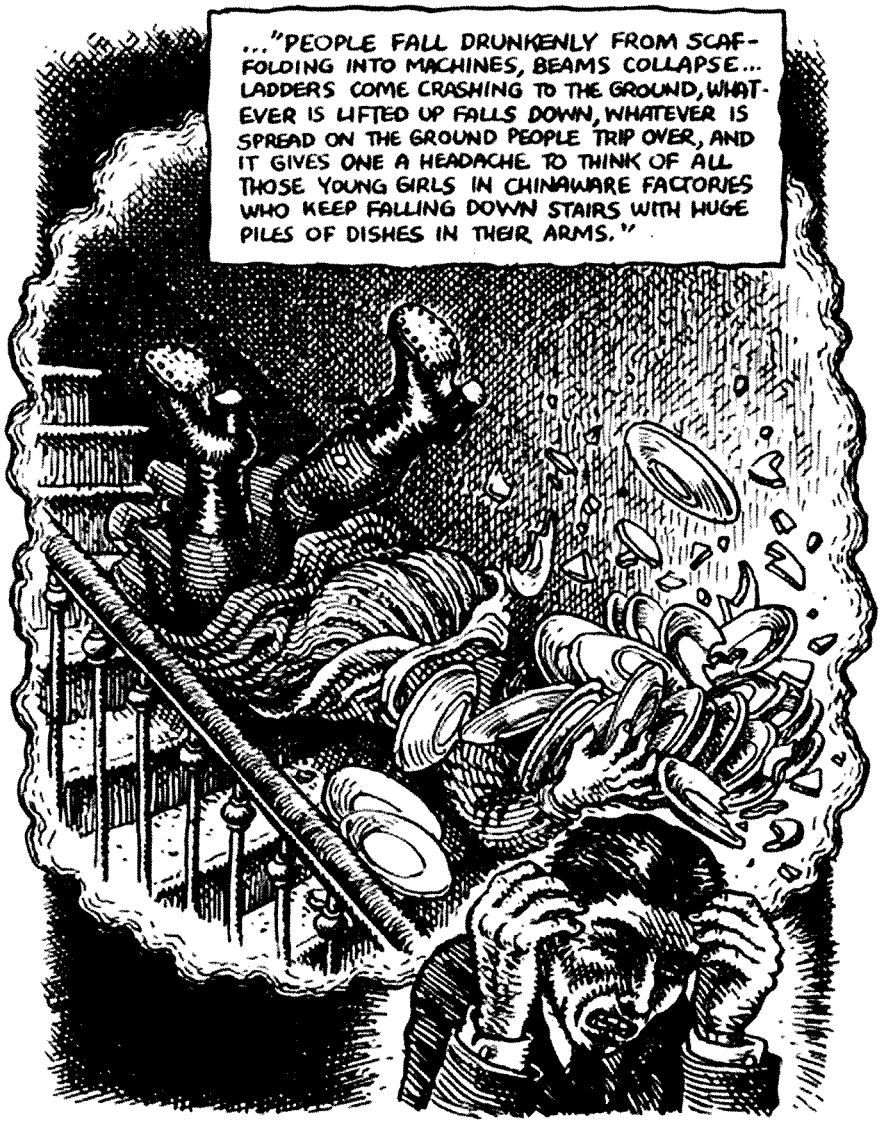

Fig.14: People fall drunkenly; Crumb, R., Mairowitz D.Z. (2007) In Appignanesi, R. (ed.), Kafka, Fantagraphics press, Seattle WA. **In the taxonomy, this is "Projective<Perspective/2-point/"**

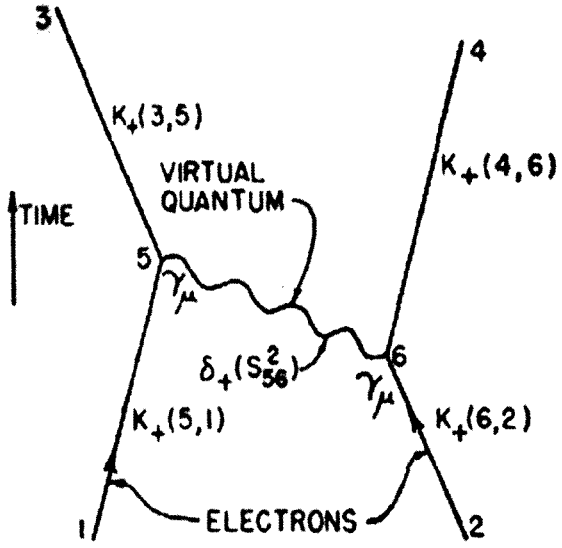

Fig.15: The fundamental interaction Eq.4., Exchange of one quantum between two electrons; in Feynman, R. (1949) Space-Time Approach to Quantum Electrodynamics, Physical Review, 76,6. pp.269-289 **In the taxonomy, this is a "Metric/Ordinal/Feynman diagram..."**

Finally, written texts and character-strings depend equally on the display as pictures and diagrams, but mapping forward in consequence relation (Gurr et al, 1998, p.545), rather than the explicitly spatialised displays of pictures or diagrams. In writing we see an interaction of structure with meaning encouraging detailed, but vitally ambiguous representations (L&S; 1987). Although there are complicated historical relationships between markings and the verbal sounds or concepts they indicate (Ingold, 2007, p.17), written word-signs have been understood, since de Saussure, to be arbitrary in this sense: it is an arbitrary convention that "Duck" refers to the bird-animal. But when dealing with iconic images, there is some measure of Macken's 'robust cognitive correspondence' at play, as we recognise silhouettes or shapes interpretable as Duck-ish, but moreover, which we could (or should) not recognise as rabbit-ish. This ties Goodman's concept of efficacy to the widely understood advantage of diagrammatic reasoning (S&O; 1997) as limitations on abstraction, that is, constraining what may be inferred from the display: how the thing may be read.

The word-sign Duck could alternatively be interpreted as an emphatic warning to avoid a collision with a brick; but using a duck-picture in that case, such an inference would be possible only as a very dry jest. The ability to see differences between these representations is a categorical recognition, in Peirce's terms, of icon versus symbol; and although the possibility of seeing "duck" in a picture is itself a complicated issue, we say that writing is a more conventional system of arbitrary signs.

1.4.1. Notation system

In this first chapter we have seen drawing as a dynamic practice between incipience and conclusion, taking in an overview of research and practice which examines how we think things over and communicate through inscriptions. While all drawings are more or less systemic, from Goodman we understand that notation *systems* will be more efficient applications of what Tversky called the 'cognitive tool' of drawing (1999, p.1). They are conditional inscriptions for communication of performance parameters, encoding 'how-to' knowledge in graphical terms (Green, 1989, p.445), and so must support consistent, repeatable interpretation and performance. Goodman allows that the common Western music notation is the pragmatic best we can manage, despite practical concessions incorporated into the system to compensate for inadequacies (Ingold, 2007, p.23-24) and contingencies.

The classification exercise developed later in this thesis further demands that notation be distinguished from notation system, which is the business of the next chapter of this thesis. It is worth recalling at this point that a thousand years ago the Benedictine monk Guido d'Arezzo saw a surprising practical consequence of his important expansions on staff-based musical notation systems. The system, as Brother Guido felt it playing out, improved upon previous attempts at conventional notation such as the plainchant-directed Neumes (Fig.16) which did not specify pitch, striving instead to visually communicate musical passages as sequences of autographic flourishes, projecting the desired shapes of intonations above the syllables of the lyric to be performed. In contrast to this relatively free denotation, the timeline of the staff notation *regulates*, allowing thereby many more dimensions of the musical performance to be taken as information, fomenting the development of characters for representation in response to this economical view. Through those (undeveloped at that time) conventional graphical qualities, Guido's vocalists were able to learn and recall new melodies in far shorter periods (Palisca, 2010) -- a real, practicable testament to the power of external visualisations in matters of cognition and learning.

Again, there is enough argument surrounding the precise nature of, and relations between mental imagery, schemata, and external representations, that we will simply avoid entering into the debate: I take creative practice as key, and so remain in the world of the user of drawing as persistently useful conjunctive acts, linking ideas and images, from which position I may refer to without having to resolve such questions. Recalling the conflationary call-and-response of Raphael's dynamic stylus, or the cloud of information out of which designers shape their solutions, the tracing and threading of drawings are understood to weave together Nigel Cross' 'knowing, thinking and acting' (1995, p.115). However it may finally be that cognitively oriented drawing research studies make contributions to the practices of artists, they have all so far emphasised the differential, displaced mark through which users propose, compare and contrast what they know against possible routes of resolution.

'Our disposition to language and mentation (reason, emotion and so on) is a disposition to commune,' asserts media theorist Sean Cubitt (1997, p.43), and our uses of pictures, diagrams and writing as plastic enactments of this disposition each offer relative advantages in their consumption. But in all cases they constitute communication -- we

note some feature of our experience of the world (flocking starlings, financial transactions, the phases of the moon), and we record them with marks on surfaces. With these marking documents in hand, we can then point to "it" and explain, or seek explanation and elaboration through actions performed upon the marks and surfaces themselves as proxies.

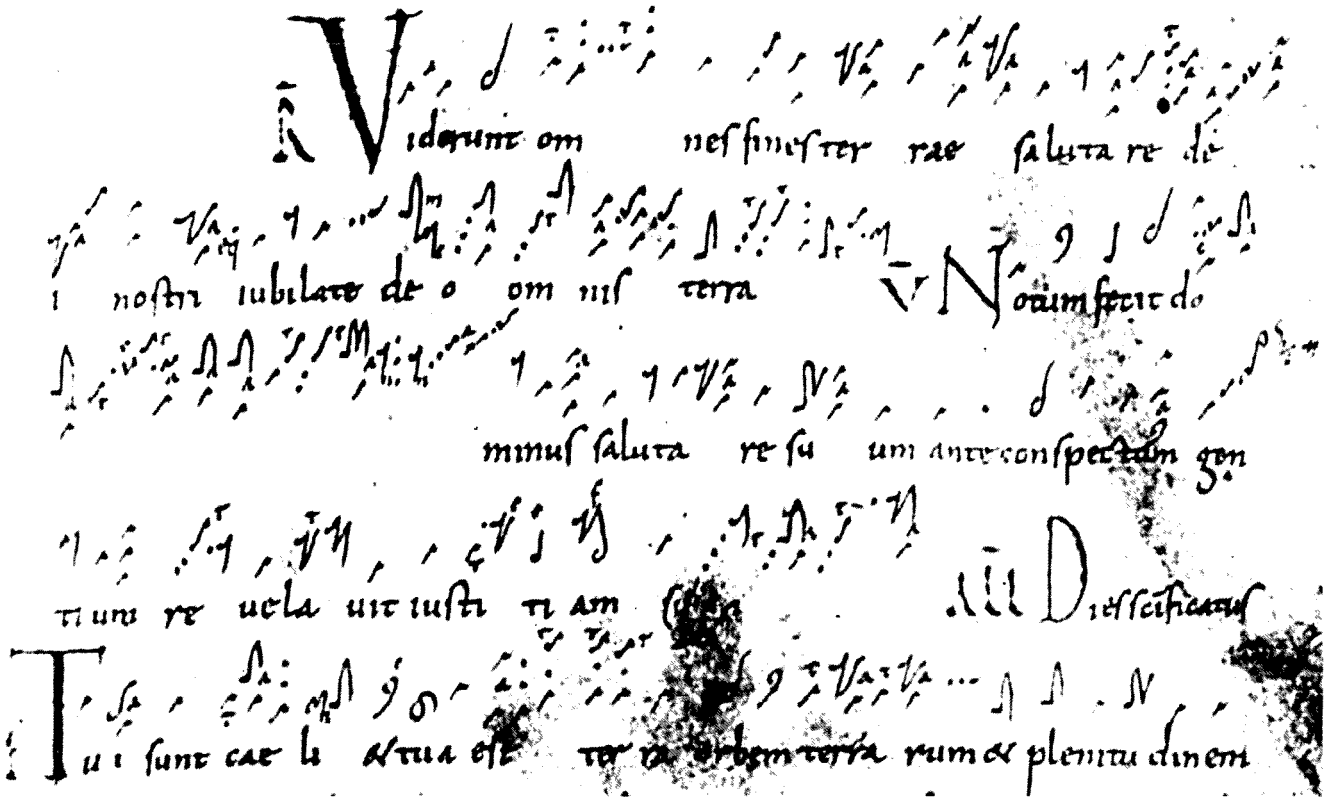

Fig.16: An example of neume notation, Laon, Bibliotheque Municipal, circa 930; a medieval autographic notation system for vocal music, widely used in Europe before the staff notation; in Brunner (1982) p.322.
In the Taxonomy, this notation can be classified as "Metric>Nominal>Neumes"

Chapter two: taxonomies

2.1. Classification, typology and taxonomy

> If worlds are as much made as found, so also knowing is as much remaking as reporting (Goodman, 1975, p.72).

In these next chapters a map of inscriptive practices will be constructed, and in keeping with the spirit of Latour's use of inscription as a summary term for mark-making practices (1986), the ontology that will inform the taxonomy will reflect those general structural properties which have resulted in their persistent, multi-disciplinary usefulness. In this, I will assume Sowa's definition of an ontology as the product of a study of categories (2003), here built on practical and theoretical observations of drawing and research from fine art and non-fine art disciplines, out of which we will come to see that all inscriptive acts are differential acts. Assuming they are made somehow to communicate, and that their efficacy depends on ranging factors, I will restrict the taxonomy's focus to the interchange of primary and secondary geometry in the inscription: that structure on which we hang our inventories of marks in codes.

Classification is defined as a conceptual operation where divisions are imposed on a set of entities based on perceptible properties (Marradi, 1990). Typology refers to a comparative space of these sets, and is a qualitative methodology meant to illuminate meaningful relations between classes, stimulating analysis and insight into attributes, and the search for anomalies (Miller, 1996; Kluge, 2000). Both analytical methods are synthetic activities with no truth value in themselves; as operations of discrimination, they merely organise our thoughts on some aspect of some domain. In this way, Marradi writes, they are related to knowledge in the way that understanding the vocabulary of a language is 'preliminary to knowledge of the statements that can be made in that language' (1990, p.149).

In contrast, taxonomy is a quantitatively oriented task, encompassing more data and intended thereby to renovate our views on the attributes and relations of their targets. Without exploring controversies on the ultimate usefulness of taxonomy, we can surely understand it as a key world-constructing application of symbolic languages, which Goodman stresses is not a passive inclination (1976, p.31), but a sustained dynamic, at work in acts of acts of inference, inversion, and translation.

There are a number of ways to tell such a story, but this particular pursuit will be built from knowledge culled from communities who have investigated their uses in creativity, pedagogy and communication, seeking to determine their roles in cognition, and as support of ideation as an extension. In this, I have examined research that stresses social context, author function (is it instructive or speculative?), and characteristic codes (is it digital or analog; indexical, iconic, symbolic?). I have read reports of computational and A.I. inspired research, and design-related research into questions of production and consumption, all of which have been supplemented by the experiential knowledge and reflections of the drawing practitioner, working in intersections. In addition, I have also noted where different strategies overlap or reiterate, and where they may be over-elaborations in which technical complexities may be broken down, or folded into one another. The questions posed in the wake of my experience with the music autography of Bach are not made more tractable by taking away any portion of these, so I seek to organise the abundance of drawing practices, indicating demarcations but more importantly, noting where these scatter, permitting cross-talk among the abundance.

In an echo of the taxonomical project, W. J. T. Mitchell observes that Nelson Goodman's attempt (in 1976) to logically discipline the unruly complex of art theory and practice has had the effect of generating 'a precise map of common-sense distinctions about representation, a map so precise that it shows us things common sense could never have seen by itself' (1986, p.113). Steering clear of engrossing but untidily defined reviews of pictures, diagrams, writing and counting, Goodman acknowledges the porousness of representation, and frames his principle aim as clarity, not accounting for any particular ideological position, in fact leaving these aside as what Mitchell deems on Goodman's behalf to be economies of habit, 'entrenched interests... and disruptive forces like curiosity and appreciation of novelty' (1986, p.113). Following this, if we accept a view of drawing that it is a language-like activity, in the sense of symbolic encodings for communication (Goodman, 1976, pp.40-42), and constructive methods for giving voice to some aspect of our thoughts -- then to distinguish based on convention is typology, properly speaking, not taxonomy. While this realisation underscores the heroic scale of Professor Pamela Schenk's project (2007; 2005; 1991), which strives to build to a true taxonomical view through deep and detailed social research, it presents no problem for this thesis, which seeks to use creative practice, informed and propelled by the

conceptual ordering of a modeling analytic – a drawing research project that draws itself, in order to unpick the tangle of a meaningful, but unverifiable aesthetic experience which I once had, and to re-present it as knowledge.

In (1976) Goodman divided symbolisation into branches of pictures, text, and notations. And in a response motivated by his art-historian's conviction that Goodman's reduction reduces too much, Elkins reclassifies those three into seven, placed along a range of purity from pictures through various impure mongrels to pure notations (1999, p.166). Once such categorisations are proposed, however, the task of distinguishing between examples proves problematic. Any of us who have seriously engaged with the practice of drawing understands that they are never pure, are always frayed at their edges, or are broken down in our consumption of them; and reading Peirce, Petherbridge or Steinbeck, this observation strengthens the practitioner's sense that this endemic loss of cohesion in the inscription is also a gain.

Therefore, what is accomplished by a classification applied to drawing is necessarily incomplete, reinforcing the sense that while there is likely no absolute key for such a fluidly adaptable activity, the diagnostic perspective of a visual-taxonomical model might serve at least to disambiguate from a purely textual portrait of the same information, and also decentralise specific modes, allowing us to grasp the fullness of inscriptive practice as a kind of human commons, rather than some arcane disciplinary ritual, or master discourse.

2.2 A review of taxonomies of drawing

There have been several taxonomies of classes of inscriptive practices, and how we use them, undertaken since the 1980s, using methods and dimensions which reflect the communities to which they are directed. Not coincidentally, this is an era of computational systems and applications, the GUI, and the Web, which rely in some measure on visual metaphors deployed in hardware and software interfaces, and the abstractions of algorithmic coding systems to map information processes to visual forms (Card et al, 1999). Most crucially, this is a thoroughly commercial social ground that depends upon usability testing as a research methodology, directed at interactions between systems: for instance, a widely cited taxonomy of technical diagrams, by Lohse

(et al, 1991) in pursuit of testable knowledge related to a semiotics of graphic communication (or Chen and Yu, 2000; Card and Mackinlay, 1997).

Visualisation, in this context, is described by McCormick and DeFanti (1987, p.63) as computational transformations of 'the symbolic into the geometric' that allow us to observe and 'leverage existing scientific methods by providing new scientific insight through visual methods.' As in other contexts we have seen here, this allowance is traceable in the move from arbitrary to the specified, diagrammatic representations of geometry.

2.2.1. Computation as a category

I will side with Goodman (represented by Elkins as a proxy, in 1999, p.71) on the question of what kind of inscription a computer-generated image might actually be: in its discrete, strictly coded and syntactically articulate space, the visual impressions of pictorial representations on the screen are products of the calculations of the notation, and as much a form of metadata as the character-strings which underlie its program. And, while data and information visualisations have considerable contributions to make in studies beyond the scope of this thesis (in logic, design and cognition related discussions; see Radford, 2008; Lau and Vande Moere, 2007; Chen, 2000; Card and Mackinlay, 1997; Barwise and Etchemendy, 1983), this taxonomy will focus on the underlayment of graphical action, assuming novel contexts and the engineering requirements of software and hardware as seductive distractions.

Broadly defined, the word computation refers to the application of an algorithmic process to some input in order to derive an output (Weisstein, 2010). Theorist Michael Hamman has described computational systems as 'connotative, not denotative,' suggesting that wired, software-driven devices orient users toward potential, rather than symbolically referencing (1999, pp.90-93). Supporting Hamman's view, in a discussion of interactive music systems, human-computer interaction researcher Thor Magnussen writes that we make use of computers to 'structure a system of signs... (providing) users with a system in which they can express themselves and communicate their ideas... and sometimes provide new ways of thinking and working' (2006, p.2). That these new ways orbit the same sets of concerns as Marshack's early scribe is not to say that the technological differences between practices are insignificant for context, or

that differences between machine-digital and analog are irrelevant, or that structural differences do not inevitably suggest functional differences; only that I seek to argue for a sense of continuity between drawings, notations, and the wired environments which so depend upon coded instruction to provide for our compulsions for images of all kinds.

For instance, compare the solution-oriented processes of design drawing described by researcher Bryan Lawson (1996) with either the threaded boundary-objects of Stratigraphic notations, or a recent art-science collaborative data visualisation project called "Atlas in silico" (see West et al, 2009). The artist-researchers involved in the latter visualisation project have worked towards what they call a discovery-oriented process for massive data sets, identifying points of intersection and departure between disciplines. In this collaboration, they are in effect drawing computationally through these data, searching for patterns and relationships, outputting diagrams and auditory expressions, animations and maps of internal properties of the dataset. They are producing aesthetic experiences of data, and while their output crosses and re-crosses media, searching both for novelty and new ways of looking, the ultimate purpose of the visualisations is insight very much in the ways of Wickstead's and Lawson's accounts of the drawing-through practices of their specialisms. They are all, of course, differentiated along the way in aspects of method, but each practice is communal, conventional and dialogical, driving toward some end that would be difficult to arrive at without the core graphical implementation (Fig.17).

Further to the problem of placement of computer-based imaging in a drawing taxonomy, while we tend to associate algorithms with computer applications, this is hardly an exclusive relation (Faure-Walker, 2010). We might define an algorithm simply as 'a step-by-step recipe' (Cope, in Muscutt, 2007, p.10), or a sequential procedure for producing complexity from simplicity. In this sense, organic processes can and have been described as algorithmic. Thus also the parameters of the common music notation are algorithmic. Indeed, Cage's uses of the hexagrams of the I-ching, or Stockhausen's determined electronic scores, also require automated transformation of conceptual material into performance. Both Cope and Alsop note that computers provide an efficient environment for implementation. As always, it comes to questions of efficacy, in which automation is a contributing strategy.

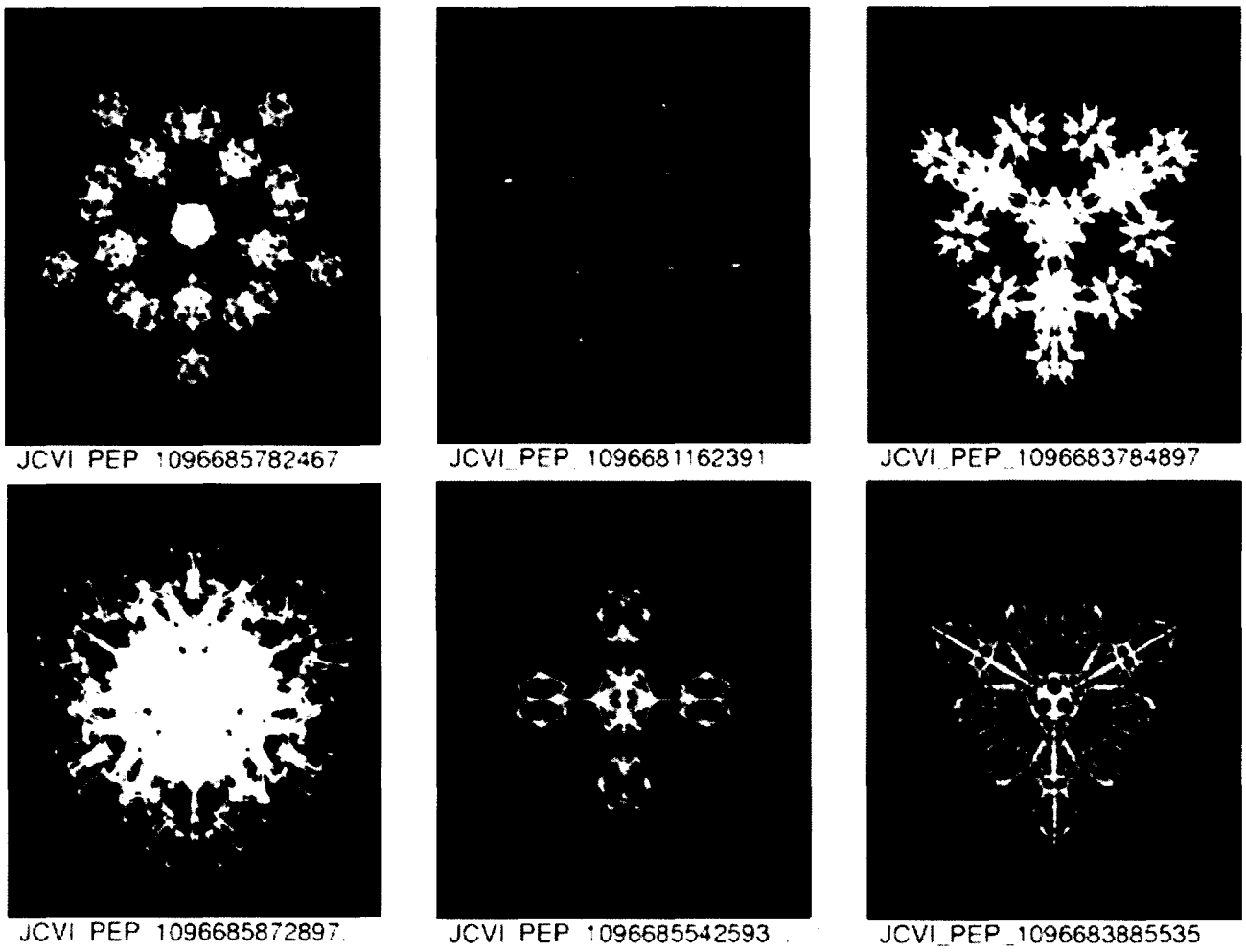

Fig. 17: Shape grammar objects for several GOS records (2D projections), from West (et al, 2009, p.3); data values are programmed to generate these, and other objects. **In the Taxonomy, because of the complex nature of their derivation, these visualisations can be classified along a number of paths: for example, they are undoubtedly "Metric>Ordinal>Histograms," yet the processes they represent are more or less illegible for our expectations of such a graphic. Due to their analogical characteristics, they might also be classified as "Topological/.../Maps/structure mapping/..."**

The taxonomy here developed will seek to address the common structuring principles of inscriptions, how they are made to be read, and how we might better situate them with respect to whatever differences are in the making, to better understand drawing as a method, a methodology, and a mechanism. In our technology-driven context, Whale has posed the question "why use computers to make drawings?" and in response, observing that as we tease out the implications of digital media and artists become as familiar with programming as they have been with the dirt and dust of the studio chalk-box, we may ultimately consider the use of computation systems as a kind of collaboration, rather than simply a novel tool (2002, p.70); something not unlike the interactivity with systems we have seen in Bach, Cage and Galbraith.

2.2.2. On not defining drawing

The task of making any definitive statement with respect to drawing -- something so thoroughly embedded in culture and what it means to be human through pictures and writing is problematic from any stance. Everyone who attempts it feels it necessary to preface their definition with a dismissal of what follows on, but I argue that a taxonomical approach will circumvent the failure of words, allowing us to see it as a field: not some thing in need of definitive explanation, but an operative engagement, better determined than defined, and satisfactorily described only in the light of its vexing diversity and abundance. We could begin the task of not defining drawing, then, simply by acknowledging the problems inherent in any summary portrait of its abundance: absolute classifications are impossible, due to the unfinished nature of our perceptions.

2.2.3. Key concepts and terminology from Willats

In preparing the ground, here is a summary of key terminology from Willats (1997), beginning at the secondary geometry of the page.

We use the Drawing systems to generate view or viewer-centred representations, expressing veridical visual experiences, transcribing properties of objects, spaces and angles, and plotting some measure of relations between primary and secondary geometry. They are systems of projection, and transpose, Willats writes, 'putting things where they go, (mapping) spatial relations in the scene into corresponding relations in the picture' (1997, p.2). They hold what Farthing and others have called an embedded narrative: what we are meant to understand is built into the display. In linear perspective, for example, a space is worked out in the correlation of perceived angles of incidence of forms and light in the primary space of the scene, mapped to convergent orthogonals in the secondary space of the drawing.

In contrast, the Denotation systems do not show true shapes or relations. Willats writes that they 'map scene primitives onto corresponding picture primitives,' (1997, p.4) that is, they schematically correlate properties of the system being inspected with the drawing. Willats describes the underlying topological geometry of such drawings as 'based on the most elementary and general types of spatial properties, which include relations like touching, separation, spatial order, and enclosure' (1997, p.13). Topographical maps and electronic circuit diagrams represent not-necessarily visual

structures, and operate as what Foucault called 'abstract machines... (maps) of relations between forces' (Deleuze, 1987, p.32). As opposed to the sketch, where marks coalesce and break, inference is constrained in denotative drawings by analytical and informative motivations. A silhouette represents the continuity of contained forms. A route map, will tell us enough that we can find our way to a destination, but little more; and just as a coffee mug and a bagel are topologically equivalent, so a severely distorted figure drawing can convey enough that we see it in terms of schematic knowledge of the represented body.

The description–depiction dichotomy is a longstanding, habitual view, wherein any drawing may be more or less accurately situated along its range. 'Between the extremes of pure mathematical theory and life-size working models,' write Fish and Scrivener, 'lie abstract and concrete words, diagrams, maps, drawings, pictures, photographs, sculptures, film and so on' (1990, p.118). Prefacing this taxonomy, then, I suggest the word notation is more usefully understood as an operative principle, rather than merely some type of inscription. This small but non-trivial adjustment highlights critical intentional differences between drawings -- as in Goodman's example of Hokusai and the electrocardiogram, how the marking is organised either as vectors in an elastic space, or in projection as an embodied metaphor.

In his keynote address, Stephen Farthing (2010) laid out a provocatively simple drawing taxonomy which binary arrangement was a set of filters through which drawings might be pressed. The top level, branching at 'pictorial/conceptual' is a familiar split that appears in other classifications. F&S, for example, write that depictions map '(aspects) of external reality onto a two or three-dimensional medium,' noting that they cause 'an experience similar to that associated with the object, scene or event represented' (1990, p.118); they are "modal," possessing intrinsic informational properties. In contrast, description is defined as "amodal," possessing an extrinsic informational profile, that is, legibility is dependent upon contributions to the reading which are external to the inscription. F&S' precisely expressed comments are echoed by Farthing's keynote remarks (2010; Fig.18) on the embedded narrative of pictorial drawings: what we need to know is in the picture, not in reference to some code or key outside the frame of its inscription.

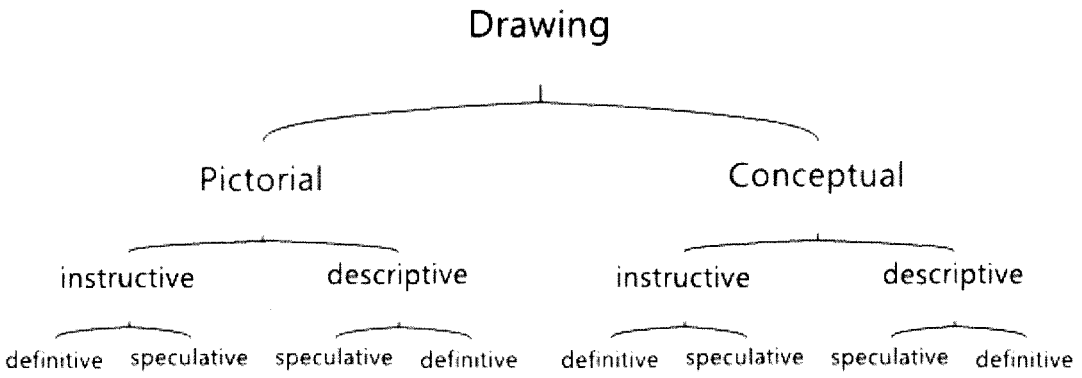

Fig.18: Following a rule of economy, any classification effort will favour certain attributes at the expense of others, and Farthing's model is one example (from a diagram constructed by the author of this thesis, in notes taken during Farthing's presentation at the RMIT/UAL Drawing out 2010 conference, in Melbourne AU.

But unlike Farthing's discursive modeling of intention, F&S do not attempt to bring any further resolution to their continuum through further filters, such as the instructive/descriptive, and the (redundant) definitive/speculative branches. Instead F&S draw our attention to the cognitive values inhered in sketching as a means to bridge sections of their hypothesised continuum, alluding to the novel insight generation of sketching processes in much the same way as a number of researchers and artists cited here. Echoing observations made in this thesis, F&S posit that

> Sketches have the important function of assisting the mind to translate descriptive propositional information into depiction. This depictive information may then be scanned by attentional processes to extract new and perhaps original descriptive information, which in turn can lead to new depiction. The descriptive-to-depictive translation process is a one-to-many mapping intrinsic to inventive thought (1990, p.118).

These particular researchers use language specifically directed at the development of computational systems and interfaces that might take advantage of sketching's capacity for insight generation, and their conclusions recapitulate an essential point in this thesis that drawing is a meta-symbolic activity, roaming in Pevear's spaces between languages.

John Willats puts this point rather more explicitly, suggesting that the sketch can be taken as an example of a metalanguage (really, "metapicture") defined by him as a symbol system used to investigate symbol systems (1997, pp.269-273). To sketch is to

take part in a completely present visual-symbolic operation that allows users to stand outside the problem-space and play with the tics, hesitations and flourishes of the act of drawing itself, generating simultaneous, alternative solutions; or at least generating the conditions in which revisions can be pulled out of the sketch and evaluated, and either discarded or developed. This complex of call and response allows the artist to straddle the view/object-centred dichotomy until necessary, accounting for the interest in sketching processes expressed in multiple research contexts (Goldschmidt, 2003; 1991; Verstijnen et al, 1998; Frith and Law, 1995).

At this point it might seem there is a danger of too tightly indentifying the sketch (as an approach) with various professional practices of drawing. But remember that whatever their domains of use, drawings are never simply poured out onto paper. Goldschmidt (2003), or for that matter Masson or Leonardo, suggests that to make a mark is to make a query; and the response to that query is another mark. So aside from merely permitting views on objects or systems, or their status as objects of connoisseurship, each drawing also embodies and represents a kind of search. And in the sketch, the search is on and through the act itself. Elkins and Mitchell (1994), among others, remind us repeatedly that we read over inscriptions, connecting and relaying what we are seeing with what we are not in a compulsive movement of re-cognition and response, even in the tightly constrained character-strings of mathematical formulae (Elkins, 1999, pp.134-137). Thus drawings are always provisional, and sketching is the peerless constructive act of provisional thinking. In the taxonomy, therefore, the sketch will be regarded as a free ranging class, which essential precepts can stand in summation of the vitality of all drawing.

But in his critique of Goodman's replete/articulate dichotomy Elkins also asserts that there are a finite number of ways we can look at any image, and a finite number of ways any picture may be related to the world outside its surface; and how we come to understand the permutations and possibilities of this complex of cognitive, semiotic and culturally charged relationships is, or should be, a matter of great interest to any of us seriously engaged with making or reading them. In his introduction (1997, p.7), Willats asserts, in fact, that 'the central question in picture perception is: how do lines of ink or patches of paint come to represent features of real or imagined worlds?' And while this particular question is itself a complex of potential studies, the taxonomy here presented

should at least serve to orient our approach to it in terms of structuring: drawing as a querying process through the interface of primary and secondary geometries.

In the task of making an adequate classification scheme, then, the terms description and depiction tend towards wordplay, and are altogether too dichotomous to be useful. The leaky abundance of drawing is not adequately understood by them, so this ontology will carry forward a rather technical argument made in Willats (1997). In his split at the Drawing and Denotation systems we have an artefactually oriented model, and a stronger footing for classification because of the implications of necessity tied to systems of making, of practice rather than merely apperception. Willats accepts the cognitive turn and questions of imagery as they relate to the work of art, but re-presents them in the terms of the artist-practitioner. His method accounts for the interplay between schema and convention when carrying out the cognitive task of drawing, while nonetheless stressing its socially significant praxes. Keeping the focus on the page, the differences between visual and verbal, or pictures and writing, or space and time, are seen to be based on two general approaches to marking-up which are not absolute, which overlap and exchange, and which account for questions of style as something other than mere technical or conceptual novelty.

Furthermore, and most importantly, modulated by Goodman and the insights derived from the drawing research-practice, the principles of Willats lead us to propose a third taxonomical branch in addition to Projection and Topology, which will be here called Metric, encompassing some systematic notations and relational diagrams, with time-factored and -factoring activity spaces.

2.3. The promiscuity of art

Petherbridge writes that 'The complex dynamics of unwitting reinvention are a primary condition, and even a necessary dynamic of drawing' (2010, p.13). Implicit in this experienced remark is that drawing is dialogical -- an inscribed polyphony. Taking in drawing's long history and practice, this taxonomy is built as an explicit and detailed consideration of our compulsion to connect, relate, and make through drawing. But let us say also that the ontology will be built from a fine artist's perspective – a mongrel interest, more content with ambiguity and cross-purposes, perhaps even a little unconcerned with the formal aspects of what graphics theorist Jacques Bertin called

communicating information (Card and Mackinlay, 2007, p.92). Indeed, anyone paying attention to the larger field in which the fine artist operates just now will note the promiscuous domain-crossing of those engaged with it as a discipline, rather than just as a support for some further form of production.

For example, working in public spaces, the Swiss artist Felice Varini gives us a gargantuan manipulation of the orthogonals of projective drawing. In this particular image, Varini marks-up the Place d'Armes such that fragmentary views and occlusions – the phenomenal experience of a city walk -- can have their moment. From a particular spot, represented here as a point of view by the camera-eye, the spaces of the square become screens through which the drawing is filtered (Fig.19). Or perhaps it is the inverse -- inscription filters site. From alternate spots the lines must dis-integrate, and the filter oddly, unexpectedly, proves to be a temporal one. 'The view… does not passively allow itself to be replaced by the floating image, disconnected from things. The viewer is left with a different vision of the city and its buildings' (Mazzola, 2010). This is a vision of difference, of time and space sampled by a large-scale graphical admixture: architectural forms, oblique projections, schematic markings, and perhaps even photography. It becomes a polyphonic space of time no less than the musical score, or the stratigraphic drawing.

Fig.19: Cinq ellipses ouvertes, Varini, F. (2008); an enormous oblique projection, mapped onto the surfaces of a public square. Centre Pompidou-Metz, (en attendant l'ouverture) Place d'Armes, Metz France, www.varini.org, accessed 24/2/11 at < http://www.varini.org/08agra/dos2009/003-agr-09.html>. **In the Taxonomy, this drawing can be classified as "Projective>Oblique projective geometryl>...", or due to the ground on which they are inscribed, "Projective/orthographic projections/..."**

For a more prosaic yet illuminating alternate example of polyphony, Starr and Griesemer (1989) coined the phrase "boundary-object" to refer to the professional situation in which stakeholders, coming from what the researchers called intersecting worlds, resolve their differences through some external representation of the problem space. Resolution of course does not necessarily mean consensus (an industrial design firm is an example, where multiple perspectives and commitments must be accommodated), but rather, that 'at every stage the traces of multiple viewpoints, translations and incomplete battles' can be mediated and consulted over and through the object (Starr and Griesemer, 1989, p.413). Sociologist and critic Kathryn Henderson (1991) applied this idea of an oracular inscription that can speak across differences and points of view in a study of the crucial role of engineering drawings along the production chain. The drawings, she noted, serve as points of contact around which interested parties in the office, on the shop floor, and in the design studio may commiserate and propel their collective endeavour. Henderson observes that 'the drawings and sketches themselves structure the work... (allowing) members of different groups to read different meanings particular to their needs from the same material' (1991, p.449-50). What is this but the polyphony of a communal practice as a kind of distributed cognition? (defined in Cox, 1999, p.348).

The permeable boundaries of drawing described more generally by Petherbridge crucially contribute to their success both as symbolic communication, and as raw material for the creative construction and reconstruction of systems. Their very mutability productively undermines the specification of meaning (Tversky, 2002), encouraging the interplay of intuition with more stable forms of rationality. Because the specific interest of this thesis began from a similar set of concerns as those we see in Varini's work -- an interrogation of the conventions of technical drawing, in pursuit of a time-space drawing method -- an osmotic attitude applied to the analytics of taxonomy could result in something similarly illuminating, a sequence of clearly articulable properties on an axis of performance, giving us readable pathways for analysis applicable to any drawing.

The model itself might take a number of forms: as a table, chart, or metaphorically charged structures such as a tree. Indeed, one of the side issues during the development of this particular model – a diagram of drawing, after all – is its moment of recursion: it is a map which somewhere maps itself. Whatever the approach, as Farthing

asserted (2010), its organisation should at least provide opportunities for recognising relationships and executive principles among categories of use, encouraging users to better articulate what they know, or do not know. As this doctoral proposal has grown from an originary moment within which paper and music became a continuous space of imagination, a de-centralising classification scheme, inspired by Goodman, Peirce and Willats, will serve to soften the inscrutability of certain technical and instrumental issues, underscoring the synthetic nature of all graphic applications, and presenting the field as what it finally is: a compendium of ways to come to meaning.

2.4. The argumentation of design

In this section, which reviews design-oriented classifications, the principle assumption is a problem-solving orientation (Pineda, 1993; Goldschmidt, 1988). Over the past three decades, design-researchers have focused on the various roles for drawing in that critically communal professional environment (Schenk, 2007; Tversky, 1999; Lawson 1995), and while there is a diversity of working practices under the design umbrella, a backbone of drawing undergirds them equally as it does the work of Leonardo or Masson. Much of the design-drawing research has stressed process, with the practice of sketching particularly scrutinised for its role in ideation. Schön and Wiggins (1992, p.135) wonderfully describe drawing as an 'interaction of making and seeing, doing and discovering;' again, a practical search-space.

And of course Goldschmidt called sketching an 'oscillation of arguments which brings about gradual transformation of images ending when the designer judges that sufficient coherence has been achieved' (1991, p.123). Much of the literature on design-drawing circles around this general idea: that to work through inscriptions is to work in provisional dialogue with materials, experience, and objective, in a more or less targeted-search for innovation. In that search, drawing becomes 'a cognitive tool developed to facilitate information processing... reflecting conceptualisations, not perceptions, of reality' (Tversky, 1999, p.1).

This is a common observation, not specific to design, emphasising that the delimiting of inscription at professional requirements is an unnecessary truncation, even as it provides useful resolution to its communities of interested parties. Thus, however, taxonomies of drawing have tended towards domain-specificity in order to make sense, or

to focus on technical aspects and properties of information and data conveyance for the sake of usability, or (as in Farthing,) to mix their terms in such a way as to shake off practical usefulness in favour of discursivity.

2.4.1. Solutions, abundance and social aspects

In pursuit of resolution in a design context, Pamela Schenk has worked on a richly detailed drawing taxonomy, reporting through a series of papers (2007; 2005; 1991) based upon her collections of empirical data from under the design umbrella. Schenk's taxonomy is a sustained look at the 'iceberg' of designerly activity (citing Games, 1995, p. 168), in which the sheer abundance of working drawings is the mountain underneath the pale tip of the solution. Architecture and design researcher Bryan Lawson has also noted this graphical background production can amount to a massive flow (2004), with a range of purposes from speculation to presentation, to the collection of reference material unrelated (possibly) to the problem at hand, but used nonetheless in education and skills development. In seeking to account for this flow, Nigel Cross (1982, p.223) summarised the 'ill-defined' nature of design-problem solving, and the modes of productive operation-by-inscription during the critical early stages of designing, in which suitably unstructured drawing activities provide moments of analysis and re-construction, encouraging insights into potential solutions, and unexpected re-visions.

Among the manifold aims of Schenk's compendium of design-related knowledge (filtered through graphism) is pedagogy, and so, accessibility to ranging levels of expertise; and appealing to all of us who draw, she aims also to collect evidentiary support for understanding certain entailments of drawing as fundamental practices of invention. In the work of the design studio (as in the fine artist's studio) a sustained and sustaining drawing practice has long been recognised as a creativity engine. Schenk writes

> Analysis of a design problem is intrinsically linked to the formulation of ideas, and the synthesis or bringing together of various elements of a design solution is invariably accompanied by some form of evaluation and adjustments to or developments in the solution (Schenk, 1991, p.169).

Schön (and Wiggins, 1992) has referred to these creative entailments as reflective conversations with process recapitulating Leonardo's view of the creative, cognitive value of the sketch as a productive insight generator (Rosand, 1992, p.61).

Schenk (1991) takes a wide-view, from developmental and preparatory drawings produced early in the briefing-stage, through analytical, synthetic and evaluative drawings, finally to presentation and production drawings near the finishing stages, examining how each may either fit into or steer the development of the solution which is their terminus. In developing her taxonomy, she observed the practices of, and conducted interviews with, active designers from many specialisms and levels of seniority, arriving at an expanded typological profile. The range of practices identified in this breakdown were analysed over two decades of development, with adjustments made for what has become a far more aggressively digital milieu. This makes room, she suggests, for new methods and drawing environments with digital conception or execution components, or distance-based collaboration-communication components, in consideration of the educators of cohorts of students for whom the pencil-paper environment is no longer predictably the primary workspace (2007, p.13).

Schenk aims not just at descriptions of praxis, but at explication of the roles which drawing and drawings play in the daily work of design, any one of which may be so tightly interwoven with others as to seem inextricable to onlookers, or even its users engaged in the work. For example, she expresses the relationships between "tasks," and the operations (defined as the 'link between the process of design and the use to which drawing is put during that process' [2007, p.9]) which are directed to fix those tasks to their targets. The following tables (from 2007, pp.10-13) list of uses of drawing, written in descriptive phrases

Table 1: Use of drawing in the design process... (excerpt).
Drawing for accepting and giving instruction
Drawing for collecting visual reference material
Drawing for the initiation of ideas
Drawing for the development and refinement of ideas
Drawing for the synthesis and revision of design solutions
Drawing for production.

types of drawing:

Table 2: Drawing activity: Examples of types... (excerpt).	
To express three-dimensions	Projection
To pass on information	Instruction
To plan out contents of a magazine or book	Imposition

and specific technical skills applicable to the tasks at hand:

Table 3: Drawing Abilities (excerpt)
Ability to draw quickly
Ability to understand how drawn imagery has been constructed
Ability to plan out sequences of actions or images

While Schenk's concerns are with mapping process, uses of drawing, and interpersonal and professional relations radiating from this particularly useful ritualised, communal and collaborative activity, a significant contribution of her analysis emerges through its potential for insight into relationships between older and newer practices which could account for drawing's persistence (whether perceived or authentic) in the face of the sheer ubiquity of computer-centred workflows. Thinking through her classification in fact demonstrates the potential of the analytical tool of taxonomy outside the hard sciences, where conclusions are seen to lack rigour, due to evidentiary limitations. And although parsimony is impracticable in Schenk's domain, and some measure of refutability probable, the logical form and deterministic tenor brings regularity to evaluations of the rich data she has collected. In this sense, her taxonomy provides a model for my model, which seeks to avoid any professional orientation, except as it might illuminate properties which derive from that common root of drawing as a practice of thinking.

2.5. The expression of information and data

The next section will review classifications applied to data and information visualisation which strive for legibility, no less than does the designer or painter, even if the interface of scribe and inscription is utterly unlike traditional methods and environments. The word visualisation used here will refer to what McCormick and DeFanti describe (in terms equally applicable to the I-ching) as transformations of symbolic into geometric, and a 'method for seeing the unseen' (1987, p.63); or what Card and Mackinlay simply call 'the computer assisted use of visual processing to gain

understanding' (2000). In a widely-cited taxonomy of technical illustrations by Lohse (et al, 1991), the researchers describe a classification of five major types (tables, maps, diagrams, networks, and icons) arrived at through studies of user groups -- not the progressive dialectics of Schenk's or Lawson's studies between designer, team, and client, but efficacy assessments by the users of charts and diagrams at the point, so to speak, of consumption.

Written inscriptions generate and transmit copious amounts of information, of course, but cannot be described as information visualisations due to their arbitrary symbolic forms. Although most fruitfully understood in a linguistics context, they are fitted into my model in light of thinking on the relationships between diagrams, pictures, writing and counting reviewed elsewhere. Again, pictures and text are differently expressed, and express differently, but to ignore the ineluctable relations between writing and drawing, as Elkins persuasively suggests throughout his work, diminishes both.

2.5.1. Entity and relationship

There are a number of approaches to the Diagram which examine its cognitive and strategic values in both instructional and problem-solving situations. Its diversity of interests are documented in dedicated conferences and journals reflecting both theory and practice in computational and non-computational contexts, focusing on investigations of 'the cognitive processes -- perception, comprehension, reasoning, generation and manipulation... (and) computational processes -- parsing, interpretation, compilation, execution, generation, and manipulation' of diagrams (Narayanan, 1997, p.107). In general, researchers converge on questions around how information can be best represented, how we interact with diagrams, and technical questions on automation and human computer interactions via diagrams (see Anderson, 2003; Stenning and Lemon, 2001; Pope, 1986). In accord with the aims of the taxonomy, however -- and with respect to the inscriptions themselves -- I will note their theorised consistencies as thinking facilitators in order to extract essential classification parameters for external representations, of which a picture of a cannonade is one no less than a Feynman diagram, or a music notation.

Remember that Nelson Goodman has argued that the robustness of a symbolic language is related to the efficacy of its expressions in the fulfillment of their appointed

tasks. In (1976, p.258), he remarks that "Symbolisation" -- a cumbersome word for the translation of some real experience into a sign indicating that experience -- is judged by how well it serves the cognitive purpose, that is, understanding. And in the title of an early chapter of Edward R. Tufte's seminal volume on data graphics ("Graphical excellence," 2001, pp.13-52), it is clear that the author's use of the problematic word excellence conforms to Goodman's idea, as well as Stenning and Lemon's later theorisation of effective diagrammatic representation as based on constrained inferential potential, or lack of expressiveness (2001, p.31; p.40). Indeed, the five principles of Tufte's influential data graphics theory (2001, p.105) are entirely based on a notion of economy in deployment -- and as printed in the book, they also beautifully express the very theory they describe:

Above all else show the data.
Maximise the data-ink ratio.
Erase non-data ink.
Erase redundant data ink.
Revise and edit.

In Tufte, the term data-ink represents the core informational content of the graphic – that which cannot be eliminated because it indicates the sum of the graphic elements, varying in accord with the data required to convey its message. The expression data-ink ratio refers to the necessary distribution of ink that will clarify, not obscure the data. Avoiding a complete review, of these five principles, the last four serve the first; the last three serve the second; and the last is simply good practice in communication, as I have learned in this doctoral research project. Tufte finally presents a convincing set of visual arguments that even the formal qualities of marks in a data-expressive system – extension, weight, and proportion – crucially serve the efficacy of the graphic, ultimately to the understanding of its message.

In 1735 the mathematician Leonard Euler presented a theoretical solution to the entirely practical problem of whether a route could be plotted to cross each of the town of Königsberg's seven bridges only once. A widely cited example of the utility of external visualisations, the Königsberg bridges problem shows how a difficult to conceptualise problem can be explored using the simplest of mark-making strategies. Reviewing the town plan in schematic terms, Euler produced a negative solution, and his method led

eventually to the development of graph theory (Stam and Reijnveld, 2007, p.2). Summarising Euler's insights much later, Tufte (2001) wrote: 'Often the most effective way to describe, explore and summarise a set of numbers – even a very large set – is to look at pictures of those numbers.' In Euler's work on the Königsberg problem -- which manages both largeness and smallness of scales – he arrived at an answer by judicious mappings of the connective elements of the town, after which we see diagrammatic representation as restructurings of logic problems to allow for deductive and inductive reasoning, for fruitful application beyond theory.

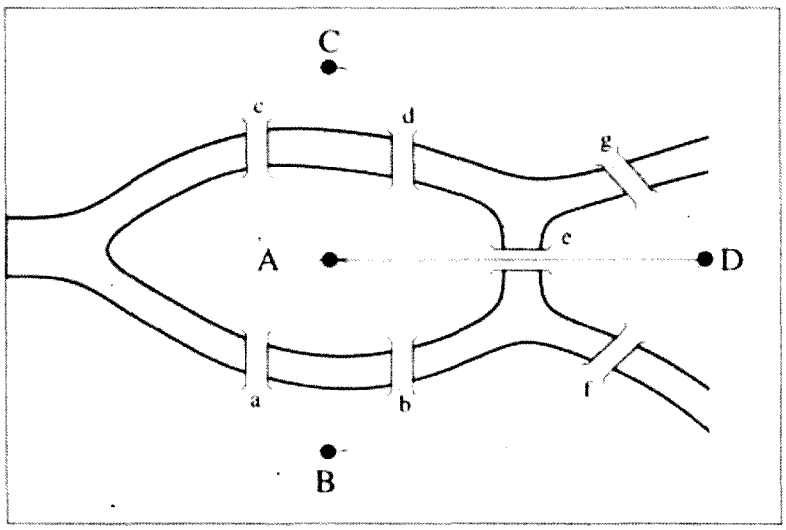

Fig.20: The Königsberg bridges problem (Carlson, 2009);
The question: is it possible to cross all seven bridges only once?

Now visit the figure above (Fig.20) and recall Larkin and Simon's conclusion that 'The advantages of diagrams... are computational... (they are) better representations not because they contain more information, but because the indexing of this information can support extremely useful and efficient computational processes' (1987, p.99). In the Königsberg case, graphic thinking exposed the structure, leading to a kind of metonymically driven insight: Euler did not actually cross the bridges of the town, but used aspects of them (that is, there are seven; they are connectors) to resolve the larger question of connectivity. The topographical diagram, the simplest of denotative drawings in Willats' new analysis, takes connectivity and writes it in summary.

Timothy Ingold notes that as much as a drawn line may work to circumscribe some shape, its tracery primarily represents the 'movement of becoming' (2008, p.18), evocatively underscoring a key principle emerging from this literature survey, that we are

always inscribing some measure of the binary pair of entity and relation. The targets of node-link graphs, or related knowledge representation diagrams (Pope, 1986; Kitano, 2003), or Varini's civic diagrams are difference and emergence. But these are also at the centre of graphic mathematical discourses, as described earlier, reminding the reader that geometrical proofs and the tally-sheet of a music notation are both methods of understanding transformation through performance. Steven Pinker (cited in Lehrdal, 2003, p.271) discusses the binary pair as central conceptual metaphors in verbal languages; and we can listen to them, Lehrdal goes on to suggest, in the symbolic language of music. The pair is also conspicuous in the vital impurity of the sketch – the very embodiment of Ingold's 'movement of becoming.' And they are thus also embedded in the socially charged engagements of life-drawing, where we reach across space to touch a comrade with a stick of dirt.

Finally, although we cannot speak for the ones who made them, Marshack's analysis of notchings to follow the moon emphasises the core motivation of entity-relation representation in drawing: a classification exercise; a paring away of the extraneous or unmanageable. For one moment ignoring larger questions like "what is the moon?" in order to see relative to everything else, this supports Goodman's perception that notations and digitality are kin -- processes of differentiation and discrimination leading to a number of effects that are characteristic of knowledge (1976, p.171).

2.5.2. Graphical objects

Those fields that are concerned with data and information visualisations have taken their approach to taxonomy from the point of view of usability in a context of database technologies and information retrieval, and have developed it with an enviable degree of articulation, most certainly derived from the need to write clearly defined coding in support of computer systems, but also from commercial considerations. Data and information visualisations tend to have these latter pressures, motivated by the exchange of goods and services, or knowledge as a species of those. Yet reading the literature, the sums of their classifications are little different from the collaborative design-processes addressed by Schenk and Lawson, or implications from Farthing's mixed analysis, or for that matter, Goodman's general prescriptions for notation systems (for a useful overview, see Lau and Vande Moere, 2007).

In an influential study, Card (et al, 1999) review graphic communication in this context, and present six ways that visualisations facilitate cognition (1999, p.16). These include the offloading of cognitive effort to the perceptual system, and the use of efficiently manipulable encoding systems, easing the search for salience. On the other hand, echoing Farthing's polemics and Schenk's social process analysis, Ben Shneiderman's influential approach proposes that external visualisations can be described in terms of a typology of tasks and data, representing 'task-domain information actions that the users wish to perform' (1996, p.2). In his scheme there are seven data types described in ways that will be familiar to any who have read Schenk or Willats.

Table 4: The seven data types (from Shneiderman , 2000).
1-Dimensional data (textual documents, linear data, program code)
2-dimensional data (planar and map data, floor plans, page layouts)
3-dimensional (real-world objects, volumetric forms and their spatial relationships);
Temporal data (timelines, e.g. medical records, and data sets with a start-finish syntax)
Multi-dimensional data (relational and statistical databases, in which patterns and correlations among variable qualities are sought through)
Trees (hierarchically presented data, with directed links from level to level)
Networks (complex relational visualisations with possibly arbitrary connections)

Shneiderman's typology is ultimately concerned with interactive web-based and computational applications, so these data types intersect with seven tasks as opportunities to interact with the display, which are expressed in language we recognise from using such databases: overview; zoom; filter; details-on-demand; relate; history; and extract. Alternately, in a playful and comprehensive typological format, Lengler and Eppler developed a table of visualisation techniques which they offer as a 'functional, metaphoric homage' (2007, p.5) to Mendeleev's periodic table of chemical elements. Implicit in this modelling of visualisation formats is that the drawings represented in the cells, like the atomic elements of Mendeleev, are combinatory and iterative.

2.5.3. Transforming data

Bringing us back to first principles in design and communication, computer scientist Ed Chi builds on Shneiderman, proposing a 'Data State Model' as an enhanced taxonomical approach to visualisation, intended to make interactive graphic production issues more accessible by allowing software builders to get a grip on what he calls the "space of design" (2000, p.69). Seeking something similar, Pfitzner et al (2003) consider the cognitive demands of information visualisation interfaces, producing a multi-dimensional taxonomy ambitiously but awkwardly linking data and task types with user

skill-levels, contextual factors, and display dimensions reiterating the picture primitives, colour, visual texture, and orientation, modulated by dynamic or static programming (2003, pp.63-65). Chi's more focused aim is to identify 'the design space of visualization techniques by extracting the crucial operating steps' (2000, p.75), which results in a kind of indirect recapitulation of aspects of Peirce's semiosis. For example, his first visualisation stage is "Value," or raw data, indicating some undetermined, perceptible other – an unprocessed point of information, lacking context or meaning. Such an entity could exist only hypothetically, and is nothing other than *representamen*: the type to which a token corresponds (Smythe and Chow, 1998, p.788). Moreover, abduction -- the logic of conjecture -- seems to be operative in every corner of his design space, so we might simply regard his theorised dynamic 'visualisation data pipeline' (2000, p.69), as the looping semiosis of Peirce's relations, filtered through a computation-technical vocabulary.

Signs are 'in a conjoint relation to the thing denoted, and to the mind,' Peirce writes, and are related to their object 'only in consequence of a mental association... (dependent) upon a habit' (in Arzarello, 2006). These are the habits of a cognitive system seeking patterns and links, using the information of the senses to map, reconstruct, and transform. Chi's computationally driven research gives us another look at the logic of conjecture seeking resolution through inscription, present equally in the work of art, design and science, but now in the domain of software and interface design, and motivated by a conjunction of all three.

Chapter three

Drawing research projects

finding out a simple relation between paper and music (Cage, 1990, p.429)

In these four drawing experiments I will seek to demonstrate that the systematicity in relational diagrams (Tufte, 2001), of which Bach's notation is a specimen, makes them not simply thinking tools (Lucas, 2004) but specifically useful mechanisms for elaboration and proclamation of thought. Setting the stage, I argue that engaging with these drawing research projects requires no particularly detailed knowledge of music theories, merely an openness to consider them as creative parameters incorporating time and space. In the developmental stages of the first three studies, I have stuck to the domain of Western art music as a model, which gives us a stable, if highly ritualised cultural context, with robust notational traditions and underlying theoretical knowledge. Alternative and post-computational music traditions, as noted elsewhere, have a problematic relationship to notation as an aspect of their practices, foregoing the articulation of traditional Western musical thought for a kind of philosophy of performance and composition (Hanoch-Roe, 2003, p.155; Tymoczko, 2000).

An articulate notation scheme should support consistent, repeatable interpretation and performance, highlighting the limitations of the graphic notations found in Cage's seminal book of stochastic and electronic scores (1969; or Sauer, 2009, for contemporary update). Goodman withholds judgement on Cage's work (in 1976), restricting himself solely to terse analysis of their inadequacy to the requirements of his notation theory: stable readings of such notations as design/performance are impossible. This is not to say that they are absolutely un-systematic, or even that they cannot function as scores, merely that there are degrees between poles of repleteness and articulation, and those degrees have real effects on legibility. Thus, I found it prudent to build from stability, to better grasp a sustained notational discourse by using a model with clear dimensions.

The oddity, of course, is that in the secondary space of the page, a mark made is a multiplicity (Ittelson, 1996, p.185), a characteristic Elkins terms "ontological instability" (1995, p.845); through the making of a mark we are also made aware of the surface, and the ripples set in motion between the two in the act. The musicologist Roger

Dannenberg writes in terms similar to Ittelson that a musical tone speaks in multiple voices: as 'an acoustic property, a psychological percept (perceived pitch), and as an abstract symbolic entity relating to intervals and keys' (1993, p.24). In any music notation, however, every mark is assigned a correspondence relationship to some musical structure, giving up thereby a measure of its instability in the visual domain, while taking on some aspect of the problems of auditory representation. And while users of the common Western notation clearly seek to quiet the oscillations (Goodman, 1976, p.170; p.258), experimentally inclined composers such as Cage or Otto Luening (Fig.21) depend upon the ontological instability of marks, seeking to orchestrate rather than distil the rippling. Like neumes, such music-pictures are both autonomous directives and drawings, somehow expressible as music. In loosening the constraints in the scoring document, the composers initiate opportunities for communal musical activities, supplying menus rather than proscriptions.

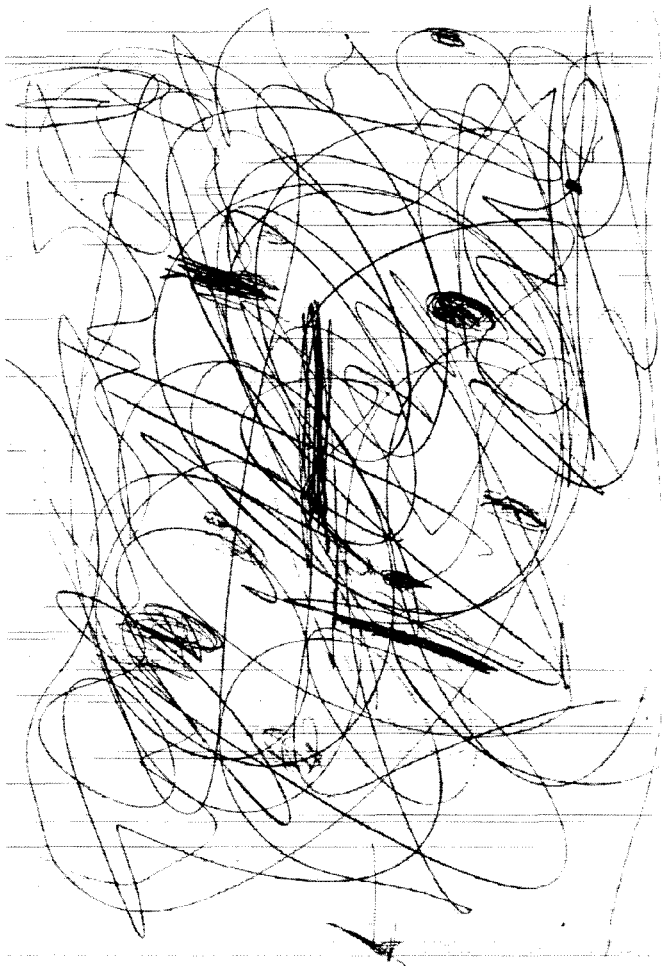

Fig.21: Rorschach symphonic sonata, Luening, O. (1969), pencil, ink and crayon on music paper, in Cage (and Knowles [ed.]), 1969, p.171. **In the Taxonomy, this notation is "Metric>Nominal>Graphic music notations"**

The move from perception to representation begs explanations that are beyond the purview of this thesis, but as suggested earlier, cognitive studies and semiosis emphasise the rationality of that movement. Certainly the connective complexity of our use of symbolic languages distinguishes us as a species, but coming out of the cognitive turn, it seems that non-humans are also capable of picking up some measure of the value of the decoupling and displacement of symbolic languages (van Oort, 2003, pp.258-261), which at least suggests that their origins are not magic, nor even perhaps specifically human, but possess some more or less traceable "fitness" advantage, the nature of which is a biological or anthropological study. In spite of the problems in tracing backwards, however, I agree with van Oort that any account of the utility of external, symbolic representations should take some account of origins, however speculative, as well as their instrumental uses (2003, pp.244-245).

The questions which follow from considering representation in any context are never easy to address. Music representation, for instance, is at least a complex of issues related to structural and expressive properties of sound and sound production, periodicity, and the rendering of noise to signal. And assuming we can speak of these as *things*, they are transitory things which depend on their absence as much as their presence in the experience, if we recognise Cage's famous silent composition 4'33" as music. And of course, we cannot "see" them, strictly speaking, though we commonly describe them as if we can, most definitively in the graphical gestures of the notational discourse. Setting context for this chapter, therefore, addressing the visual representation of in-visible relations, and rationalising desire, we may look to challenging, ancient resources about which all we may ever really know is that they were packed into pouches, and carried along.

3.1. Factoring systems

" Notation ***is telling time. Signs move forward like numbers***, *repeating* themselves, but information is always new. Noël Llinos.

" Whatever music can be made with notation cannot be made without it, and vice versa.

Richard Winslow.

Fig.22: Notation is telling time; Llinos, N. (1969) in Cage and Knowles (eds.) (1969, p.177).

In pursuit of understanding originary motives for marking artefacts as sustained and vital practices, Alexander Marshack's (1972) research into early symbolic communications has encouraged insights into human histories, as well as a renovated timeline for our species' cognitive development (see Elkins, 1996, to whom this particular section of my thesis owes a great deal, if only for his imaginative approach to the work of an equally imaginative anthropologist). By now widely accepted by anthropologists in its general outlines, Marshack's method of detailed examinations of overlooked notches and scratches -- decoupled marks worked on bone and stone -- reveals what the researcher felt is a clearly notational intent in artefacts as ancient as any that we can reasonably identify as "ours," that is, as a product of *Homo Faber* (Fig. 23; for a complimentary, mathematically motivated perspective, see Kaput et al, 2002).

Marshack's meticulous work with these obscure and staggeringly ancient objects, using tools of magnification and enhancement, has plausibly established that the scratches are not merely decorative, nor the aimless scumblings of some Palaeolithic day dreamer, but represent lore-based activities: tracings of perceived periodicities of the moon, for example, deployed as clusters of deliberate marks. The artefacts are mostly portable bits of larger objects, carried presumably in support of daily activities whose nature we can only estimate. They are marked-up with regularity in places which might suggest decoration, but through the attentions of his research-graphical method, Marshack understood he was looking at individual and compound marks with manifest and telling inconsistencies, most notably what he deemed to be "time-factoring and time-factored" characteristics.

Through examination, reflection, and uniquely intuitive scholarship, those marks revealed enough idiosyncrasies and commonalities of execution to imply something more than mere aimlessness. In his work, which will not be further detailed here except with respect to conclusions, Marshack approached the cryptic marks with a scholar's understanding of the necessities of communication and the implications of support for traditions and lore which offset the material limitations of the evidence. This view permitted him to develop an argument that the artefacts were effectively notation systems for tracking the passage of time in reference to insistent, but unknowable things in such communities as existed then; tracking the moon as an event, for example, with multiple impacts on the communal life of prehistoric humans.

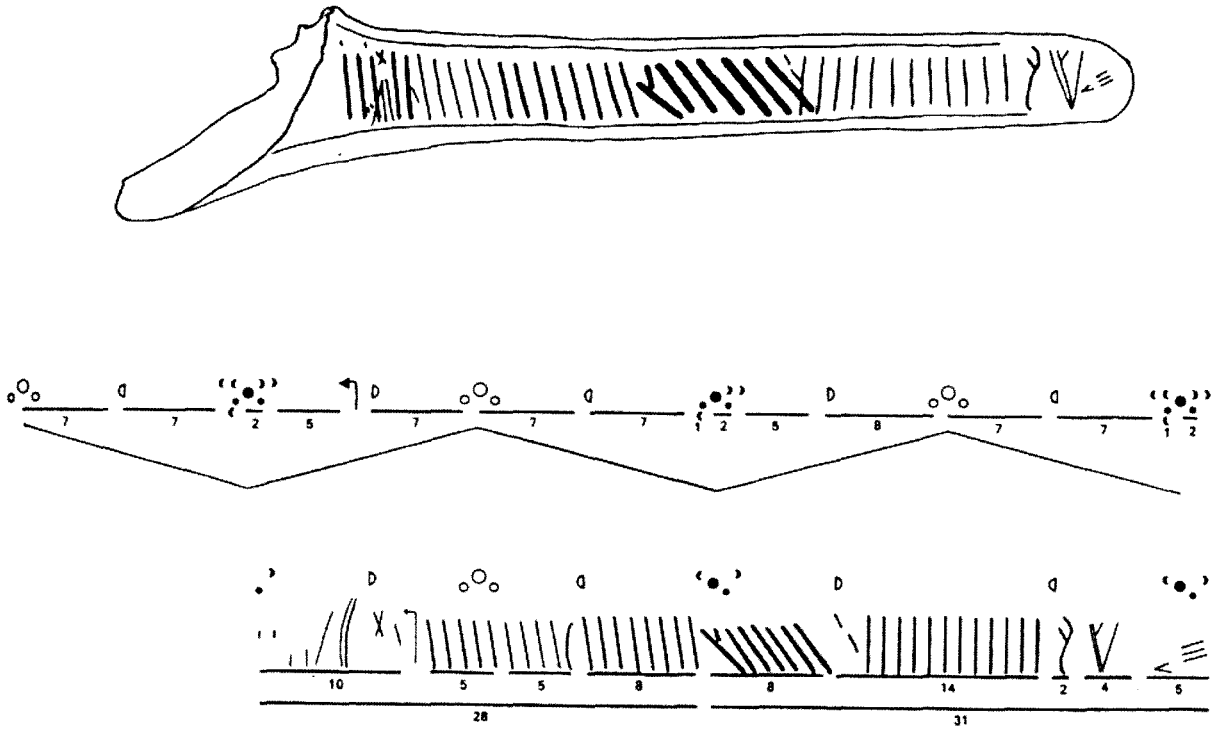

Fig.23: Baton from Le Placard, schematic diagram and correlation with a lunar calendar; Marshack, A. in Elkins, J. (1996) On the impossibility of close reading, the case of Alexander Marshack, Current Anthropology, The University of Chicago press, 37(2), p. 190, Chicago IL. **In the Taxonomy, the top drawing in this figure is "Projective/perspective/...;" the middle and lower diagrams are "Topological>Denotation>Line drawings/ Map projections/..."**

Marshack notes that to create the conditions and sustenance for a culture – an agricultural society, for instance -- entails complex networks of knowledge maintenance and generation, as well as craft traditions, typologies and planning, with all of their time-factoring and -factored entailments. In acculturations around these he recognised that we must assume levels of communication adequate to the task, including uses of both words and images (cultural imprinting, as 'kinaesthetic reference, time reference, geometric reference' [Marshack, 1972, p.114]). This necessitates what is implicated by Goodman in his notation theory as a move from schematic to conventional, from index to symbol, private to public, noticing to directing, and motivation to instruction (1976, pp.127-172).

His research method involved graphical re-enactments of the marked surfaces reminiscent of Fry's art-critical method, and by re-cognising or transposing the inscribed messages into a modern context of scholarship with the technologies of lens, pencil and paper -- knowing by hand, following with no intention to reproduce -- the anthropologist

argued that he gained access to the meanings of otherwise difficult to parse communications, giving insight into their roles as intentional artefactual documents. Concerning one particular sequence of notches on a fragment of mammoth tusk, Marshack writes that

> The man making the composition must have known the "story" or meaning that was being structured by the sequence. In such a system each mark is symbolic, representing one unit of something, and the whole represents something else as a sum (Marshack, 1972, p.39).

All human markings are more or less systemic, encoding even the idlest daydreaming for scrutiny and interpretation, and Marshack sought comprehension from scratchings on bone that had been categorised by some researchers as just that sort of inchoate daydreaming. And while we will likely never fully grasp the significance of those artefacts, reading Marshack we at least recognise their functions, and the human compulsions which they served. In grasping remote symbolic environments, we see marks standing for temporal sequences, which fixation lingers in our contemporary adaptations of notational activities, coming down to a move across representations driven by inscription: Booba and Kiki-like cross-modal abstractions applied to units of some thing changing over time; the marking-up of surfaces relating to sets of sensate experiences. Such complexes of information, projections and inferences, are made far simpler to grasp holistically through notations. We might even argue that they are improbable without tributary symbolisation systems for their expressions and transfers. Of course, any analysis of prehistoric markings also asks for tricky judgements to be made about intention, as Elkins' reviewers note (in 1996, pp.202-207). But at least we can clearly see the obligations of Goodman's theory being addressed in the analysis Marshack undertakes. If he, and Cubitt by extension, are correct, those early markings meant something to their makers, addressing practical curiosities which dimensions were otherwise beyond reach.

In Marshack's wake, further interrogating the common view that pictures must have "come first" in the cultural history of our species, the historian Denise Schmandt-Besserat has theorised that both writing and picture making derive from initial conditions set by our compulsion to count, and to document that counting (1977; 1980). From the

pragmatism of Palaeolithic tokens and symbolic correspondence as an accounting method (in the broadest sense of that expression), to the instructive abstractions of contemporary knowledge representation diagrams, our drive to think over things in the spatialised symbolic terms of de-coupled marks and surfaces, and moreover to share that thinking, has yielded character-string notations, linear perspective, semantic networks, and the tally sheet of music notation.

While attractive in its outlines, there are challenges to aspects of Schmandt-Besserat's elaboration on origins, for example that the sheer diversity of recovered tokens and systems argues for a rather messier chronology than we might hope for; or that clearly demonstrable links between the development of inscribed symbolic languages and some hypothetical cognitive evolution are difficult to support (for critique see Michalowski, 1993). Nonetheless, as a general timeline, it suggests that markings of all types are at least concurrent in our history, providing a rich context for research into the roles of inscriptions in human cultural development. Elkins takes stock of these implications, and speculates on the common provenance of visualising systems: 'pictures, counting, sculpture, and eventually writing all began in a fundamentally graphic... ambiance, where each influenced and borrowed meanings from the others' (1998, p.178). Even the refined markings of contemporary number theories have a residue of the pictographic signs from which their characters evolved through use and recycling over several thousands of years.

Ultimately, systematic drawing involves a move from reaction to intention, from marks to marking. The time-factoring of Marshack's prehistoric surfaces tracked features of communal experience that were otherwise unreachable, and as distilled by Goodman, are enhanced by attenuation, allowing modern systems such as the music notation, or notation systems for movement and dance such as the Labanotation (Guest, 1990; Fig. 24), or the more iconic Sutton system (Fig.25) to become social inscriptions providing frameworks for analysis, instruction, and finally re-action. They become compositional sites for interaction with symbolic languages, evident in the handiwork of Bach.

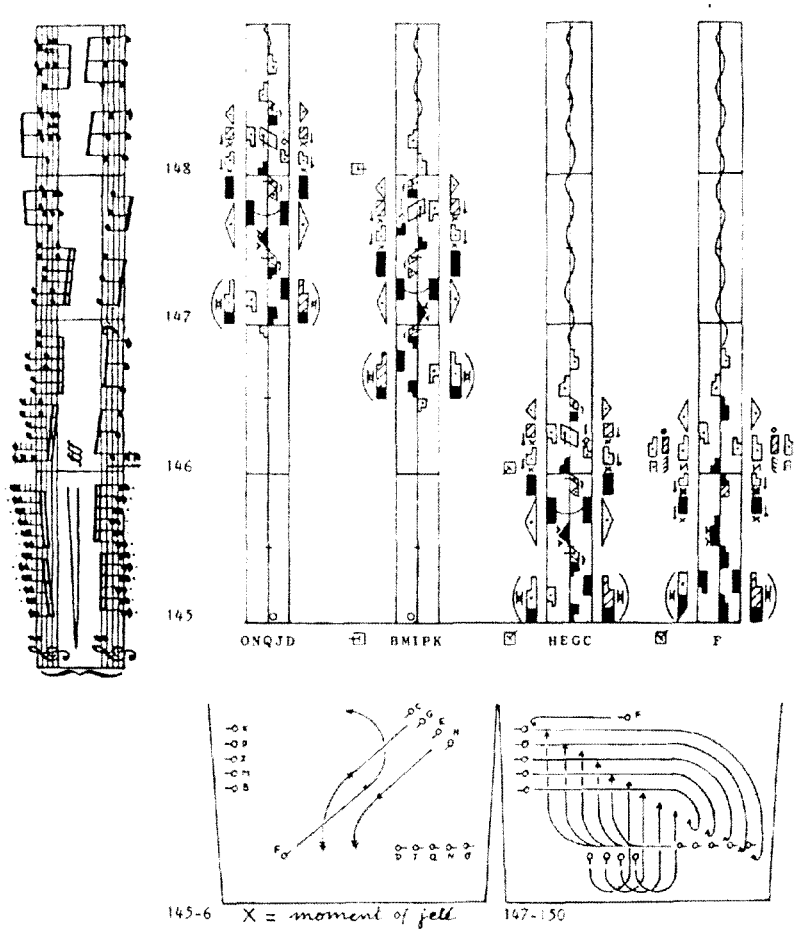

Fig.24: Laban notation, *Schrifttanz*; Laban notation is a scoring system for movement that renders space, time and body to discrete characters in a bottom to top oriented field; Laban, R. (1928) in Guest (1990, p.25).
"Metric>Interval..."

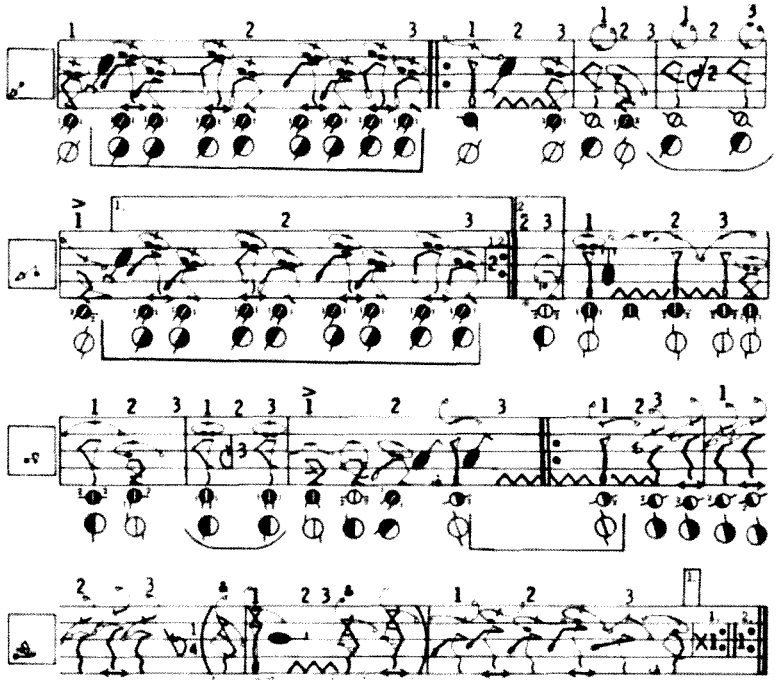

Fig 25: Sutton movement notation; in contrast to the abstraction of Laban's system, this system is oddly iconic, retaining the horizontal timeline and staff of the music notation; in Sutton (1983, p.35).
"Metric>Interval..."

3.1.1. The future-subjunctive tense

> As an art form, music is distinguished by the presence of many relationships that can be treated mathematically, including rhythm and harmony. There are also many non-mathematical elements such as tension, expectancy, and emotion... (and) symbolic or structural relationships existing within and between the dimensions of pitch, time, timbre, harmony, tempo, rhythm, phrasing, and articulation... Finally, music evolves with every new composition. There can be no "true" representation just as there can be no closed definition of music. (Dannenberg, 1993, p.20)

These technical observations with behavioural entailments give a sense of the complexities at stake in the representation of musical thought. The qualities to which Dannenberg refers bear a number of socially activated features that resist simpler mappings. After Marshack's anthropologically tuned observations, Brother Guido's pedagogy, and Bach's graphical creative methodology, we have seen that to address such complexes, a systematic notation *regulates*, and quantifies quality. In practice, in aid of meeting disparate needs, we have also seen that no drawing approach is complete; all are modular and customisable. However, increasingly articulate notation systems allow us to act upon what they map in music, as well as in manufacturing or architectural practices, computing between dimensions of time and space as interactions of entities, relations, knowledge and performance.

Working in the spaces between the symbolic visual languages which we use for such building processes, Max Neuhaus was a percussionist, visual and sound-artist who sought to create audio-visual experiences that refine the ranging observations of Cage on the relationships between sound, silence and music. Making sounds and listening were core to his complex practice, which investigated just those aspects of organised sound that the common music notation excludes: dynamics and the timbral qualities of sound. His work can be viewed as an *in situ* reminder of our condition as vulnerable, communal beings in space-time.

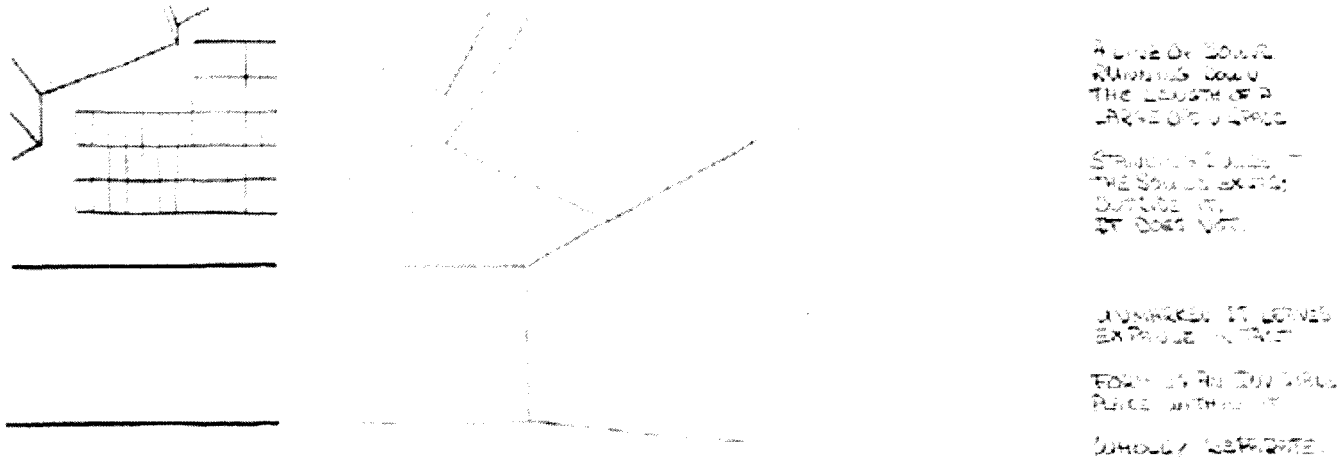

Fig.26: Soundline, Neuhaus, M (1993), pencil on paper, 56x71 cm; 56x33cm; Collection: Fonds national d'art Contemporain, Paris FR, accessed 24/2/11 at <http://www.max-neuhaus.info/images/SoundLine.gif>.
In the Taxonomy, this drawing can be classified as "Projective>Perspective>2-point."
>.

Figure 26 shows his 1993 plan for what he called a 'sound line': a drawing of a space of sound. In its schematic, orthogonal view, there is an attempt to notate something: but what?

Concerning the issues confronted by those who design spaces, Deanna Petherbridge has observed that an architect's use of the sketch 'relates process to ideation… (it is) drawing as a future conditional or subjunctive tense' (in Garner [ed.], 2008, p.37). And while such notations have functions as documents of events and processes, Hanoch-Roe has suggested that their real importance -- what a score is for, in Goodman's sense -- is to delineate a 'relationship to the future' (2003, p.146). In this particular drawing, Neuhaus is addressing the future as a proposition that may or may not be possible to execute, which is a critical difference between diagrammatic renderings as inscriptions that record distributions, and the future-subjunctive tense of the systematic notations which I will build in this chapter, through which we may propose re-distributions.

Technical drawings render, ensuring legibility by removing superfluities --visual (or auditory) textures, for example. Blending the aims of the designer with the mixed propositions of a fine artist, Neuhaus means to show us a space-time of audiovisual installation, summarised in the crucial, lyrical text which shares its space on the page. His drawing conveys the barest of information, contrasting starkly with the richly textured sound-objects (Licht, 2009) which the artist would have us experience. Questions arise (how might sound be focused into a columnar form?) that are often posed, so to speak, from the other direction -- in fact posed in my research journal as a question of sounding an oblique plane. A technical part of this inversion has been addressed by the development of acoustic Laser -- a coherent sound projection machine (see Johnson, 2010). But while Neuhaus proposes no real solution in the graphical space of his drawing, he does show us a view of what he has in mind: a rationally conceived and contained line of sound. As drawn, it is a hybrid of the symbolic languages of music, sculpture, poetry and architecture, providing connective tissue between them through denotative projections. The drawing itself is both object-centred and view-centred, suggesting immersion – a place occupied as much as listened to. Please also note Neuhaus' visual representation of phenomenal sound as absence.

3.1.2. Notation as mechanism not tool

Attempting to step past habitual and colloquial ways of understanding the ranges of our markings, both the philosopher Goodman and the historian-critic Elkins (1998; 1999) have sought, in their ways, to untangle the relationships between pictures, diagrams and writing. The historical dimension of this search led Elkins to consider a pair of seventh century CE theoretical treatments of painting, written by scholars Zhang Yanyuan, and Yen Yen-chih (the 'foremost literatus of his time, [but also] its greatest drunkard' [Acker, 1974, p.65]). Classifying representation relative to painting, in Yen's view there are three modes: the representation of forms (in pictures); the representation of concepts (through the coded abstractions of written characters), and finally, the representation of principles, as exemplified in the hexagrams of the I-ching, which have no clear equivalents in western art theory, but refer to something that looks 'a little like a picture and a little like a word, but (is) neither' (Elkins, 1998, p.7).

I will assume the reader's casual familiarity with the I-ching, but see Chen (1972) for an introduction. In brief, the I-ching is a canonical Chinese document used in a number of contexts over its long history. Considered more or less obscure even by scholars who study it, the Book has been a generator for 'cosmological, numerological or political speculations' (Chen, 1972, p.239), and for divination and other pseudo-scientific processes. Putting aside ultimate questions of legitimacy, its uses derive from automated construction of graphical figures, interpreted against a lexicon that supplies routes to meaning extraction, and re-action (Fig.27). Operating in terms of binary yes/no responses, the Book returns characters and calculated groupings which are conceived of as representations of potential, transition and tendencies -- symbols of flux, thus the title 'Book of changes.' Described in these terms, the I-Ching amounts to a mechanism for semiosis, and as such it has been adapted far outside its original ground, most notably for this thesis in John Cage's application of it as a music-compositional instrument.

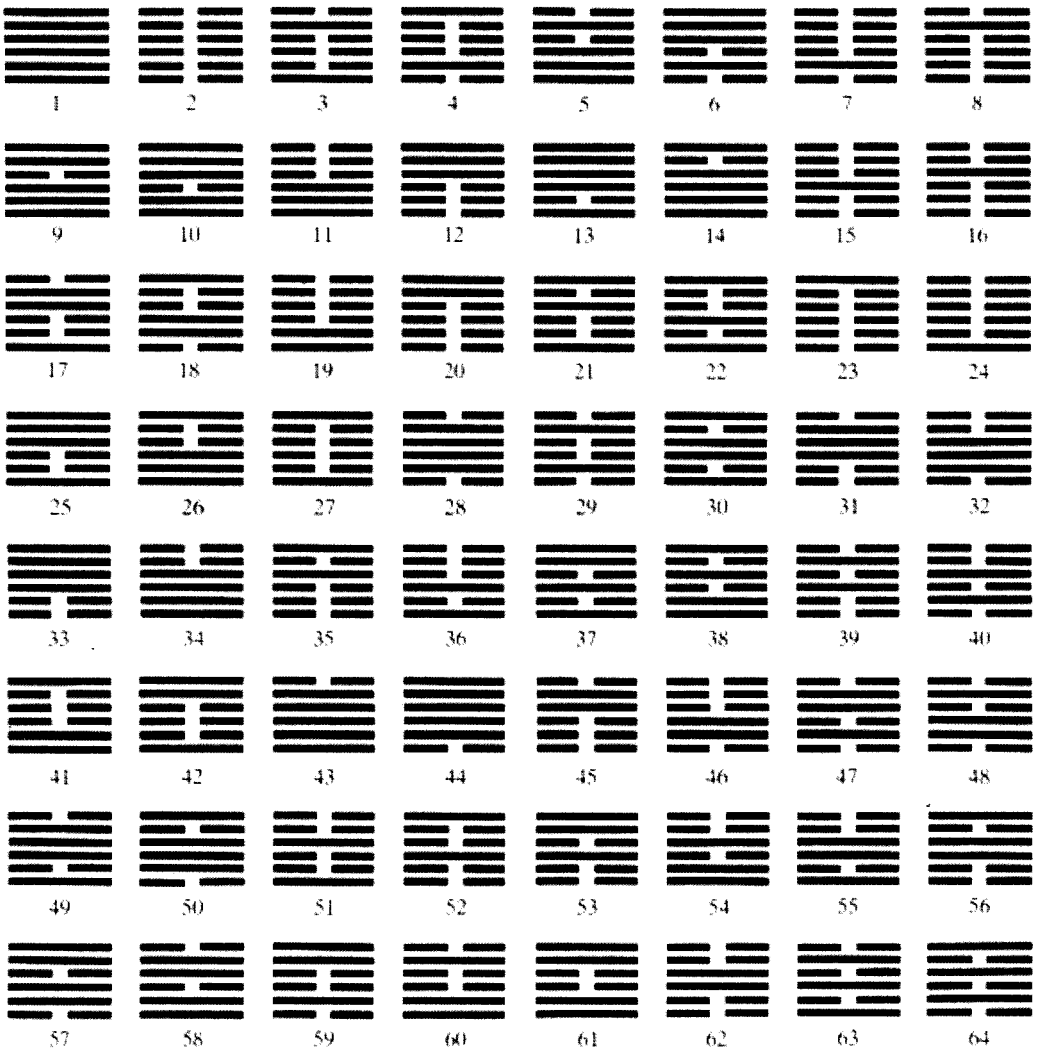

Fig.27: The 64 hexagrams of the I-ching; Armstrong, N. (2008) Music and Technology, at Dartmouth College, accessed 24/2/11 at <http://eamusic.dartmouth.edu/~music3/images/ iching-hexagram-chart.jpg>. Due to the discursive nature of its use, in **the Taxonomy, this may be classified as a "Metric>Nominal>..." graphic.**

A musical philosopher whose work has provided key motivations for my own creative activity for years, Cage's method with the book embeds 'chance' into systematicity. In his wide-ranging and provocative oeuvre, the I-ching became an apparatus of non-intention, permitting arrival at music unburdened of literature, psychology, or other concerns of tradition -- all pressures peripheral to the task of organising sound (Cage, 1972, p.59). His compositions through the Book (again, a mechanism hinging on contingency) evade many of the entailments and obligations of western art music, allowing 'things to come to life of themselves' (Cage, 1972, p.55). For example, in his compositions 'Music of changes' and 'Imaginary landscape No.4' (1951),

Cage approached the Book with sets of queries, developing correlative musical actions in response to the returned information (Cage, 1973, pp.57-59). In addition, these responses are productively reintroduced and queried as matters for re-calculation. Cage's account (in 1973) of his specific compositional processes with the Book recapitulates Deleuze's assessment of the semiotics of Peirce as a system into which 'any material... can be reduced to an utterance' (Deleuze, 1989, p.31), and reminds us also of the inscribed reductions in Marshack's and Schmandt-Besserat's research, or even the painting of Mondrian, where complex entities and relations are stripped down to some simplest character-set, also for a kind of calculation of form. Acker concludes 'Hence we may know that though writing and painting have different names, they are yet of the same substance' (1974, p.66).

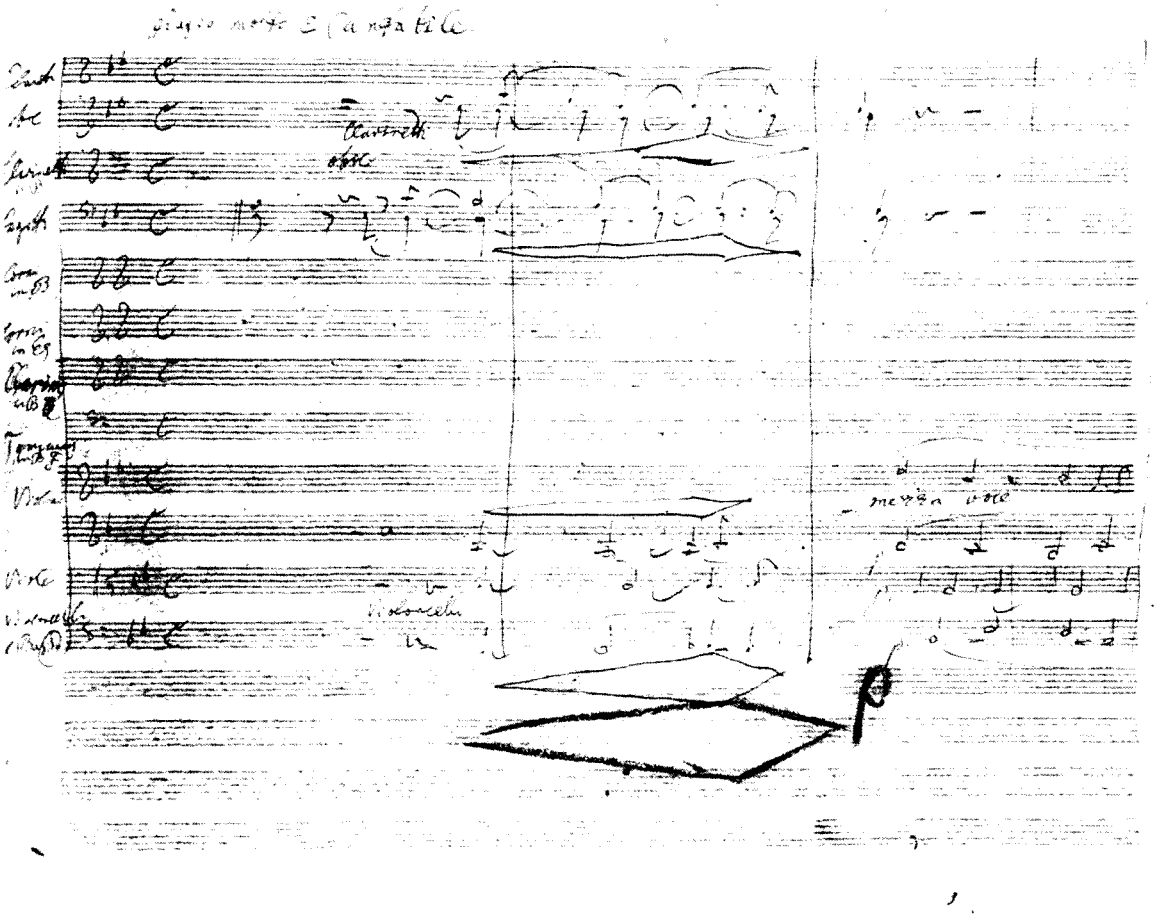

Fig.28: The ninth symphony, Von Beethoven, L. (1817-23) in Winternitz (1964), Plate 91.
Classified in the taxonomy as a "Metric/Interval/Common music notation/..."

Finally, the musical manuscript in (Fig. 28) does not depict spaceships or diamonds, but seeing either of those on the page is simply a seeking of sense from an over-spilling of pencil, eye and mind. We have understood from a review of drawing that

seeing, drawing, and seeing drawing are experiences that converse, and that these conversations are critically important to the working processes of artists and designers. This bit of manuscript by Beethoven is an example of such a discursive site -- a document of the messy discourse of composition. Certainly since the 1940s, we have seen pages that look like it in indeterminate and algorithmic scores. In general, post 20th century compositional practices have fostered the development of a variety of approaches to representation, destabilising the traditional composer/performer/listener triad, and sacrificing aspects of what we understood even before Goodman to be the objectives of a notation system: legibility, repeatability, and so on. In the examples of Udo Kasmets' ordered (Fig.29) or Luening's rather disordered (Fig.21) graphic notations, indeterminacy breaks down the signal between composer and performer: there is no obvious way to distinguish necessary from irrelevant among the points, lines and spaces, or to ensure repeatability from performance to performance. In Goodman's logical, unattainable framework, the articulate scheme becomes a generator of inscriptions for communication of performance parameters, encoding 'how-to' knowledge in graphical terms for decipherment, (Green, 1989, p.445), but in Luening, stable readings as design/performance are impossible, regardless of the composer's intentions (which in this case are clearly not stability).

In principle, the music notation operates as a dynamic scaling system, with readouts organised into timelines which emphasise the relative distributions in primary space onto the secondary space of the page. But breaking open this particular instance of music notation – a language Beethoven spoke with authority and transfiguring power – we are left asking what he means to indicate with the schematic geometry of the hovering shapes in the lower half of the page. What are we to make of them? To what could they possibly refer, in this context? In the custom of the notation, of course, they are likely symbolic characters meant to represent applications of sustain to the notes around which they hover – annotations of performance from the mind's ear of the composer – but from this master's infamously casual hand to the questing eye of the reader, they index something other than just musical qualities of the play.

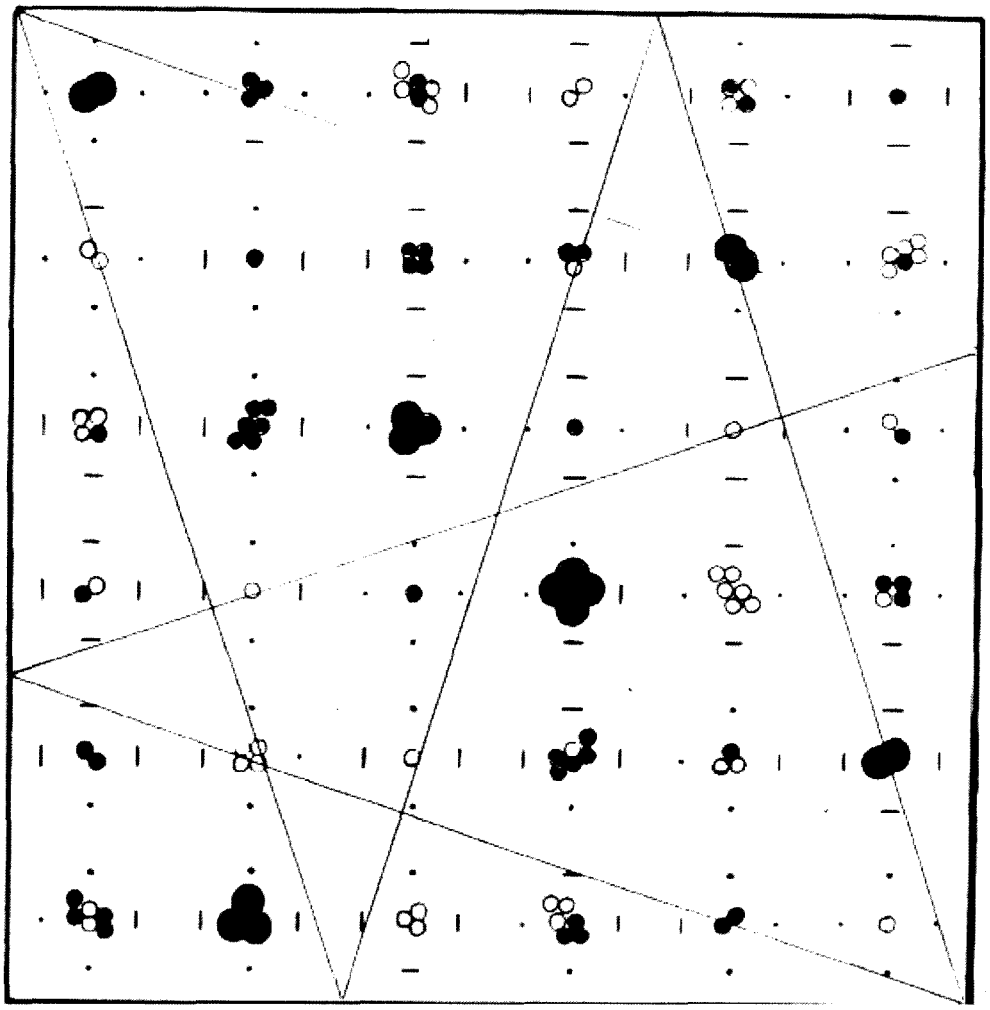

Fig.29: Timepiece for a solo performer, a graphic music notation, the score may be turned and read in any direction and performed by any instrument. Kasmets, U. (1964), pencil on graph paper, 28x22cm, in Cage (and Knowles [ed.], 1969, p.149). **This is a "Metric/Nominal/graphic music notation."**

Articulate music and movement notation systems direct our attention to future action. They are drawings of spatiotemporal events acting both as input and readout mechanisms. In their activity spaces every mark is a character, every character has a behaviour, and their referents – those things which are scored -- are rendered at once static and dynamic: they are both description and proposition. All such notations are algorithmic, intervallic environments in which we use character inventories to represent transformations, contiguities or angles in projection, forces and dynamics, and distributions between the space of audition and the space of vision, but with the value-added capability of being played-back. In the play-forward and play-back, quality and quantity are conflated, and we get a view beyond mere representation, towards production, invention and instruction.

To say that notations are tools for thinking (Lucas, 2004) is therefore insufficient. The Concise OED defines the word "tool" (2008) as an 'implement, typically hand-held, used to carry out particular functions; a thing used to help perform a job.' But this analogy is unhelpful in taxonomical analyses, which are after all attempts to determine rather than define. While "tool" might hold as a principle in a general sense, it does not adequately account for music notation systems as environments in which drawing, reading and writing rub up against each other. From the friction we are enabled to compose our thoughts, and failure, bad ciphering, and creative accounting are possible, but also the construction of something beautiful. The move from schema to convention permits analysis and annotation, but further, in a future-subjunctive tense, permits users to push the envelope of the domain of the notation – to score impossibilities. Such systems are not simply tools for doing a job, therefore, but mechanisms for determining how the job can be done.

3.2. Drawing music

> The point may be compared to an instant of time, and the line may be likened to the length of a certain quantity of time, and just as a line begins and terminates in a point, so such a space of time begins and terminates in an instant (da Vinci, in Richter [ed.], 1970, pp.171-72).

Whatever their intent, all inscriptions are built from a small set of structures well known from pedagogical approaches to the craft of drawing. Reminding us that in practice we do not treat them as utterly discrete, Willats (1997, p.98) suggests that it is in our uses of these picture primitives -- point, line and plane – that we are able to identify useful distinctions between pictorial and denotative drawings. Marks are trace acts, and the picture primitives are the abstractions to which those marks refer, representing 'metaphorical (mappings) for which there is an independent and direct experiential basis and independent linguistic evidence' (Gibbs et al, 2004, p.1197). Thus the contours of Masson and Feynman both perform the minor miracle of mapping spaces or sequences, or some combination of these onto the page, and into the conversation, doing so in terms either of relations or attributes.

In designing the four integrated, dialogical drawing research studies in this chapter, I began from this essentialist view, theorised most significantly for myself by

Paul Klee in his Pedagogical notebooks (1968). This modest set of point, line and plane remains a crucial foundation in teaching drawing skills in the West, and Klee's theorisation of them speaks to his admirable desire to give the visual arts the kind of deep technical language that marks musicological discourse (Perloff, 1983). To develop innovative graphic notations for organising sound, I therefore worked towards an identification of the picture primitives with similarly elemental musical structures, in which search I worked not to avoid, but to take advantage of the ontological instability of the mark – to make of the oscillations a footbridge between spatial and temporal thinking.

Point, line and plane, Klee suggested, are blanks; mark-gestures without absolute reference, open to elaboration as directed forces within a visual-compositional frame. Point is the beginning, the motive thought, the context setting *ur*-moment of mediated visualisation. Further along, and paraphrasing Klee, if line is point gone for a walk, what corresponds to this dynamic in the realm of listening? It is a question that is absurd on its face – 'pataphysical, if we are willing -- but just as the narrative drive of a Stratigraphic notation takes bits of pottery distributed through layers of mud, and builds evidence for a human history, the question may be exactly the kind of problem that a notational environment, as a portable practice of calculation, may be useful in bringing to some sort of resolution, outside the frame of its document.

And while Klee may have left out the vital surface/support element of mark-making from his formulation (that thing from which we decouple), in the design stages of these studies I worked from his theorised primitives as potential compliance-classifiers, looking for assignation to analogous musical referents. Summarising an extended analytical-practical process, the musical concepts of pitch, timbre, and duration were identified as candidates for mapping the picture primitives to the music space, which rationales will be presented in the next sections. Closing a loop that was set in motion by Bach's paper, I preface this report by noting that I have long conducted a visual art practice indebted to the in-visible experiences of listening to and playing music. This loving inclination notwithstanding, I emphasise again that this is drawing, not musicological research. Music is not my field of expertise, in spite of a good deal of time spent playing in it, composing and thinking about music as a serious amateur. But this is a condition I share with Klee, and a number of other primarily visual artists.

Sidestepping detailed exegeses of musical theories, then, I rely on well-established arguments derived from centuries of discourse around the music notation that musical pitch, timbre and duration are primitives in the symbolic representation of musical thought. We will assume the OED definitions of pitch as 'the quality of a sound governed by the rate of vibrations producing it' (2008), and timbre as that 'quality of a musical sound or voice as distinct from its pitch and intensity' (2008). The word duration will be taken as Cage used it (in 1973, p.19), as the foundational aspect of musical behaviour. The ranging artefacts which have resulted test the potential for exchange in a discourse of notation, and should be viewed as sustained conversations, growing from hybrid praxes centred on mechanistic properties of drawing systems, and contributing to the taxonomical study which is later assembled in the thesis.

Drawing research projects

3.3. Study 1 : Isometric projections : point and pitch

> a minimal operator, a difference of angle, the smallest change of direction (Serres, 1982, p.72)

The first of the three drawing-music studies focuses on a pitch-to-point correlation. With Goodman's 'same what?' question in mind, pitch and point provide direct entry to the design and implementation of this experiment by suggesting that we take the problem as one of correspondence -- of one-to-oneness. Long before Klee, of course, Leonardo compared point to an instant in time, but in his teaching Klee characterised point as a kind of beginning, setting context for the compositional, executive graphic activities to follow. In a similarly general way the concept of pitch has been identified as a focal gesture of tonal and serial music, setting the context in some sense for what follows on. These are fraught definitions, of course, but as it should be -- as Leonardo would have it, and Klee as well -- fraught does not mean forbidden, and creative studio-art practice could easily be characterised as depending on such moments of choice and experimental delimitation, at the very least in order to avoid the morbid recognition of uncertainty in the work we produce there. 'Rightness of limitation is essential for growth of reality,' writes A.N. Whitehead (cited in Morris, 1990, p.78), echoing Candy's metaphor of the bounded space of creativity (2007). 'Unlimited

possibility and abstract creativity can procure nothing;' and so we proceed, secure in our uncertainty.

Both of the entities of point and pitch carry with them colloquial (mis)perceptions as singularities – differentiated things, apart from other things. It is a conflation made in the common music notation itself, as well as being embedded in MIDI software architecture for computer music production (for basic definitions of this vital, ubiquitous software standard see Moog, 2009; Dannenberg, 2005). We might even speculate whether the oddly metonymic relationship between pitch and point is an inevitable entailment of our very use of the notation system -- a persistent, important visualising scheme in which four-dimensional sound-gestures are represented as two-dimensional dots, distributed through staves. A pitch-point correlation could then be understood as an inscribed one-to-one tracking, cross-modal mapping, like Marshack's proto-numerical lore-making which has taken on aspects of habit through sustained use.

3.3.1. Acoustic images

The next step in considering the relations between paper and music was to create some flow between domains, after which a set of graphical armatures were drawn from classical Islamic architectural decorations (Bourgoin, 1973) in order to distil that flow. Identifying these patterns as generative models for this first study was a matter of looking down at the floor of my studio, and opening up to the leavings of other things. Fertile pattern-drawings with sacred implications, a general review of context suggests they are inscribed representations of infinity, characterised by a high degree of articulation, mixed with uncertainty, and above all an easily accessible sense of musicality.

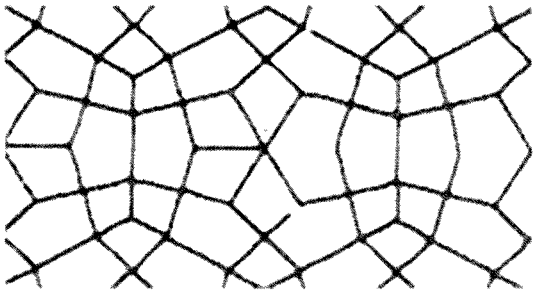

Fig.30: Diatom acoustic image (key diagam), inset against expanded iterations; Griffin, D. (2011)

As an ethical consideration, I note before proceeding that there are particular cultural uses of such patterns which are understood to be expressive of social-theological significance to those who have worked with them. But in my use of them here I argue that just as specific articles of faith are built upon foundations of the human values which clearly predate them, so it is for these patterns: their essential geometry belongs to all of us. I acknowledge their cultural associations, and recognise that their complexities are not completely generic, but I will use them here as diagrams of recursive geometries, and therefore a common legacy of Hellenistic mathematics.

Taking their conceivably endless repeatability and networking logic as tessellations, I reduced each of eight selected patterns to a simplest iteration: a tile that, from the point of view of parsimony, amounts to the core of its algorithmic beauty. Through studio-based play activities drawn out of the project parameters in the early stages, what began to emerge was a directed graphing operation with each tile taken as an entity-relationship graph (Ware, 2008). The simplest of diagrams, entity-relation graphs have key roles in visualising non-visual information in technical disciplines, taking advantage of well-understood perceptual rules, and allowing users embodied interaction with complex data. The graph-theorist Leonardo Peusner explored these qualities himself in a musical context (2002), as an exercise of pleasure and ad hoc analysis, transcribing existing melodies into simple relational structures as a method for visualising their forms. Reminding us of the processing advantages of diagrams generally described in (L&S,

1987), but also evoking Marshack's informed speculations on the obscure motivations of his moon-tracker, Peusner writes that such graphs provide a means to transcribe connectivity characteristics, performing the useful service of relating data to theoretical values in simplified visual terms. They are useful interactive sites, he writes, because they 'allow us to represent structural, logical and sequential information' (2002, p.33) unmoored from explicit mathematical analysis.

So the substrate diagrams of distributed angles in the eight acoustic images are taken as production inscriptions. In them, conjunct lines point to some undetermined measure of wavelengths of sound, and the line-edges indicate spatial and temporal relationships between them. This small character-set of angles of incidence between vertices limits the elasticity typical of node-link diagrams, which can be deformed without loss of meaning. Thus in these acoustic images, a compositional framework is established with the potential we find in other technical drawings, and readable here as isometric projections (Willats, 1997, p.38; pp.55-89). While suggesting that the robust common music notation of Brother Guido is essentially an enhanced entity-relationship graph, these notational drawings developed into event groupings of percussive node-pitches, deployed across a directed network of durational information. Additionally, in the visual artist's studio where abundance could be characterised as the *point* of the play, less constrained drawings and prints have emerged that compliment the directed music-notational works, taking the patterns as opportunities for creative engagement (see Figs. 32-57).

A total of eight diagrams are presented in the following pages, along with derivative drawings and prints. Their titles reflect a perceived resemblance-relation: **4 Suns** (pp.98-99); **Carbonic IV** (pp.100-102); **Cubic zirconium** (pp.103-104); **Diatom** (pp.105-107); **Hexagon** (pp.108-109); **Isotropic scaling** (pp.110-113); **Reciprocal lattice** (pp.114-116); and **Tetrahedron** (pp.117-118). And the title of each drawing also bears the name of its drawing method, developed in the studio practice. These drawing methods are called:

1. **Acoustic image**: The acoustic image from which a simplest configuration is extracted.
2. **Paper**: music scores derived from the acoustic images. The characters in the scheme are vertices, which are assigned musical properties of pitch and duration. Such

assignments are arbitrary - the output of the notation is changed simply by skewing the diagram. But while this represents an intriguing potential, directing us to further work, in this thesis I develop them *as is*.

3. **Interpolations**: play-motivated investigations of the acoustic images, manipulating general organisational qualities, pushing the diagrams into other areas of the drawing taxonomy.
4. **Recursion**: digital drawings in which an acoustic image is built into a brush in Adobe Illustrator. This algorithmic brush – a mark that *is* the pattern -- is then used to trace the selfsame acoustic image. In accord with observations on naturally recursive systems, the recursion-brush is an imperfect copy; visual information is imperfectly transcribed.

Thus, for example, the print on p.99 -- "***4 suns recursion***" -- is drawn from the "*4 suns*" acoustic image (p.98), while *recursion* is its drawing method.

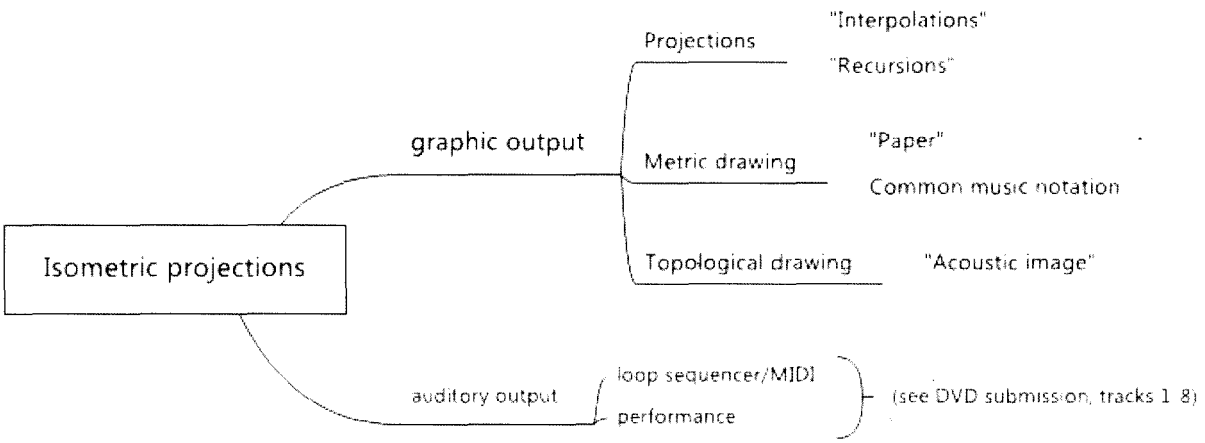

Fig.31: Map of the outputs for the drawing research project "Isometric projections." Use this diagram to relate the original drawings on the following pages (pp. 98-118) to the classifications proposed in the Taxonomy in Chapter four (Fig.83, P.157). In the taxonomy, any drawing may be situated in one of the orders of Topological, Projective, and Metric (for details, Chapter four, pp.154-163). Although no drawing can be *absolutely* placed, "*4 suns recursion*" (p.99), therefore, is a projective drawing.

Finally, to recast the drawings as music (included on the DVD, Tracks 1-8), I worked from a taxonomy of music-sequencer interfaces (Duignan et al, 2005) which sets sound production software in a continuum between highly conventional, difficult to learn programming languages on one side, and more user-friendly interfaces laden with visual metaphors of knobs, dials and sliders on the other. In this interesting

demonstration of theorised processing differences between writing and pictures, I acknowledge the range of choices available, and simply say that I chose one, noting the potential for expansion and further work in other directions. Selecting a commercial looping/sampling software environment – a standard MIDI interface -- I redrew the acoustic images into its timeline, allowing their graph-connectivity to take on some meaning as physical flow. This step into the domain of music involved the resolution of underspecified structures from the drawings. Music asserts itself, feeding-back to the drawing practice, and permitting the development of the sound compositions within the parameters of one particular digital toolbox. In the oscillatory spirit of the sketch, this was an opportunity to grasp the relations of paper and music in action, even if only as muddy paths through glitches in the systems in play, including the cognitive system of the artist.

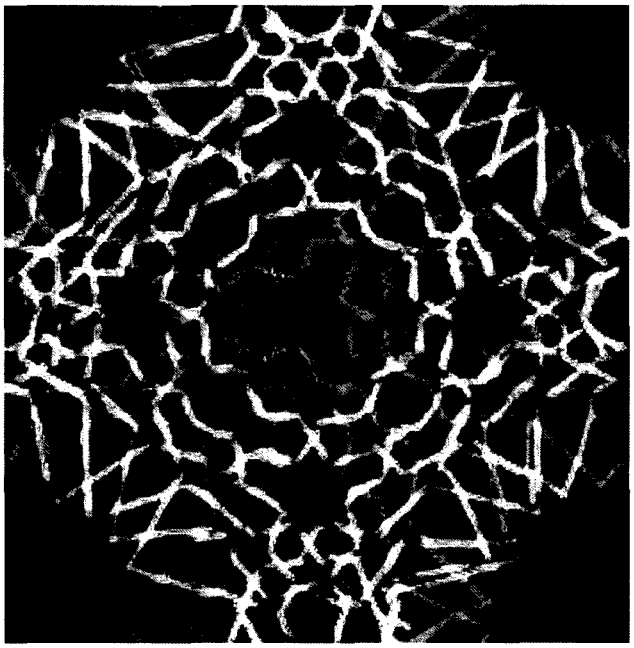

Fig.32: 4 suns acoustic image; crayon, ink on paper, 3x3in, Griffin D (2009)

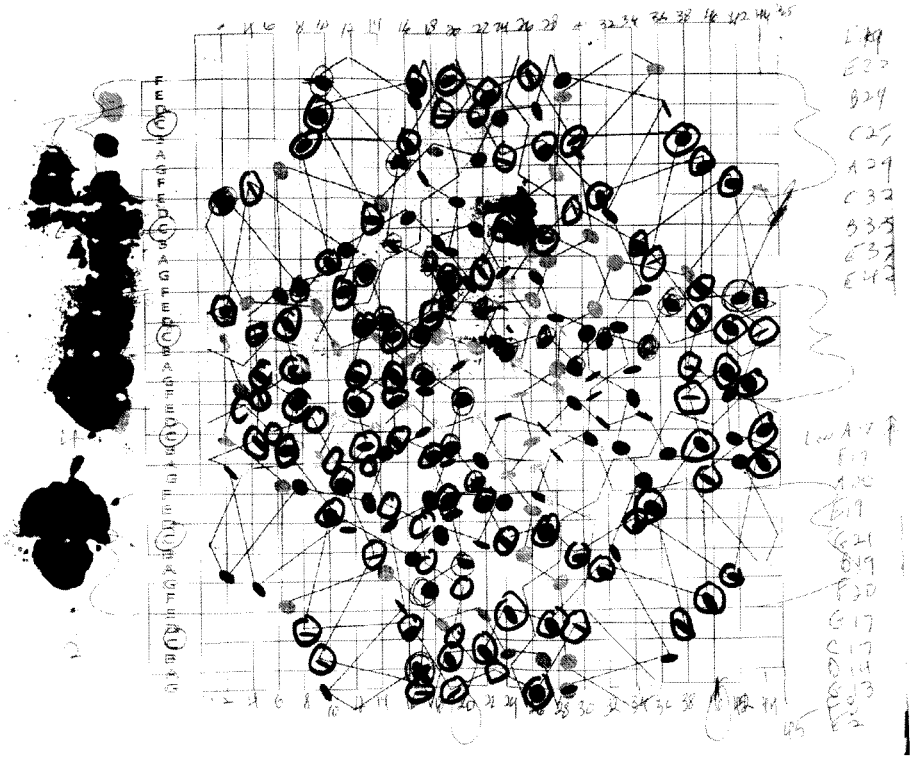

Fig.33: 4 suns paper; ink, gouache on paper, 11x8in.,Griffin, D (2010). This paper is an early chart correlating vertices and angles of incidence as characters in a music notational scheme, following conventions of the common notation.

David Griffin (2011) Isometric projections:

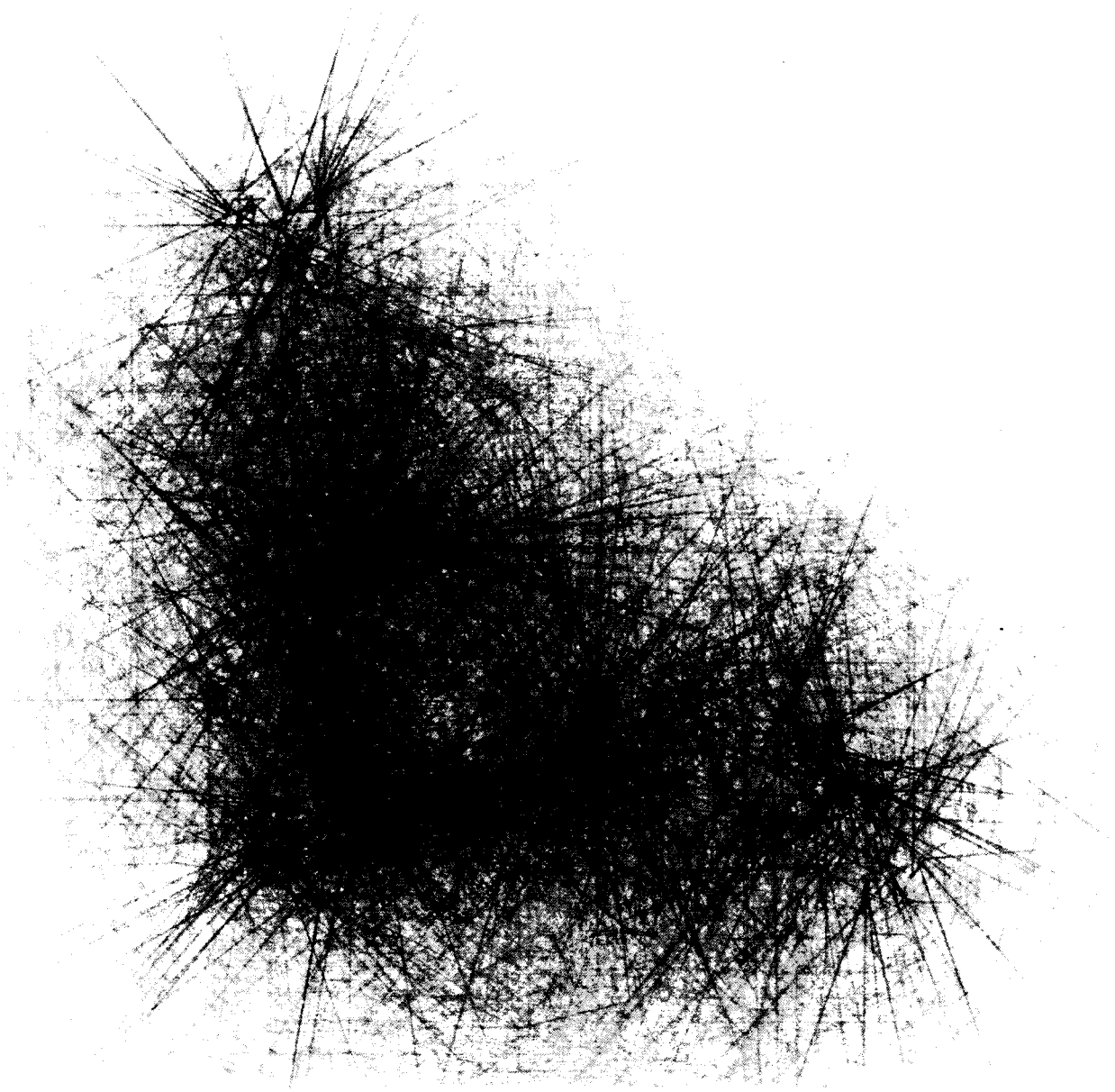

Fig.34: 4 suns recursion; digital print, Griffin, D. (2010). The acoustic image is built into a brush in Adobe Illustrator, which is used to trace the diagram itself. This print was included in an exhibition at the Grace and Clark Fyfe Gallery at The Glasgow School of Art, May 2010, printed at 32x32 inches on Arches paper.

David Griffin (2011) Isometric projections:

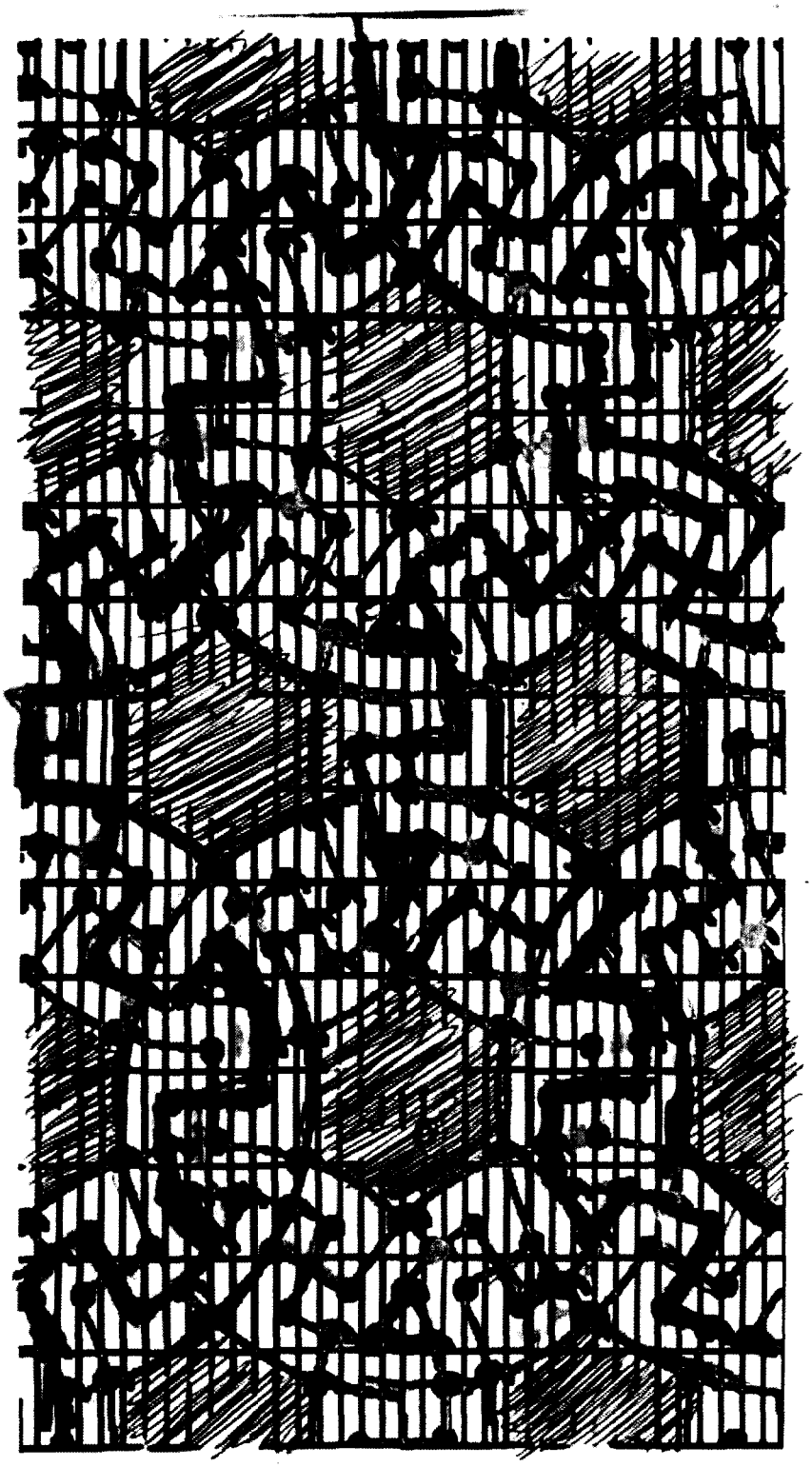

Fig.35: Carbonic IV acoustic image, ink, gouache, crayon on paper , 9x11in, Griffin, D. (2010)

David Griffin (2011) Isometric projections:

Fig.36: Carbonic IV paper; silkscreen on paper, 30x18in, Griffin, D (2009)

David Griffin (2011) Isometric projections:

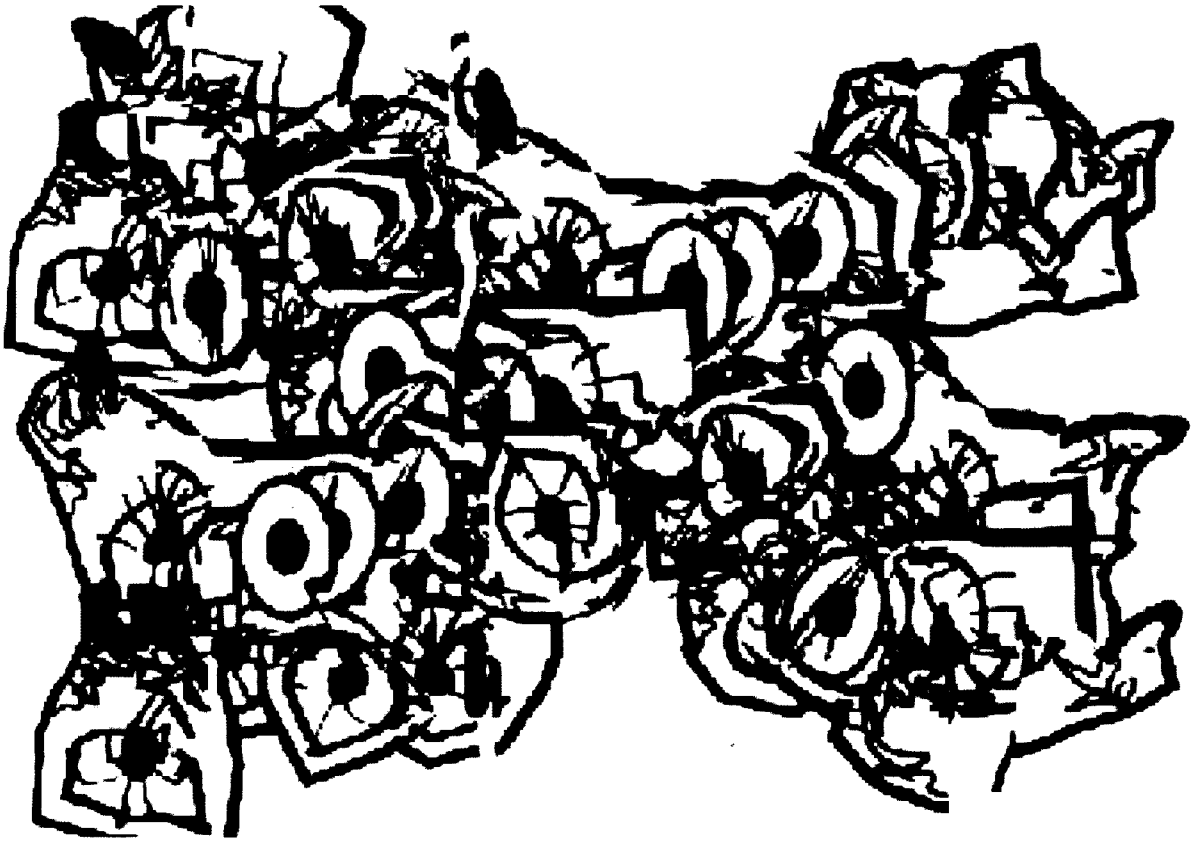

Fig.38: Carbonic IV graph interpolation, silkscreen on paper, 28x20in.

Fig.37: Carbonic IV sketch, ink, pencil on paper, 22x12in, Griffin, D. (2009).

David Griffin (2011) Isometric projections:

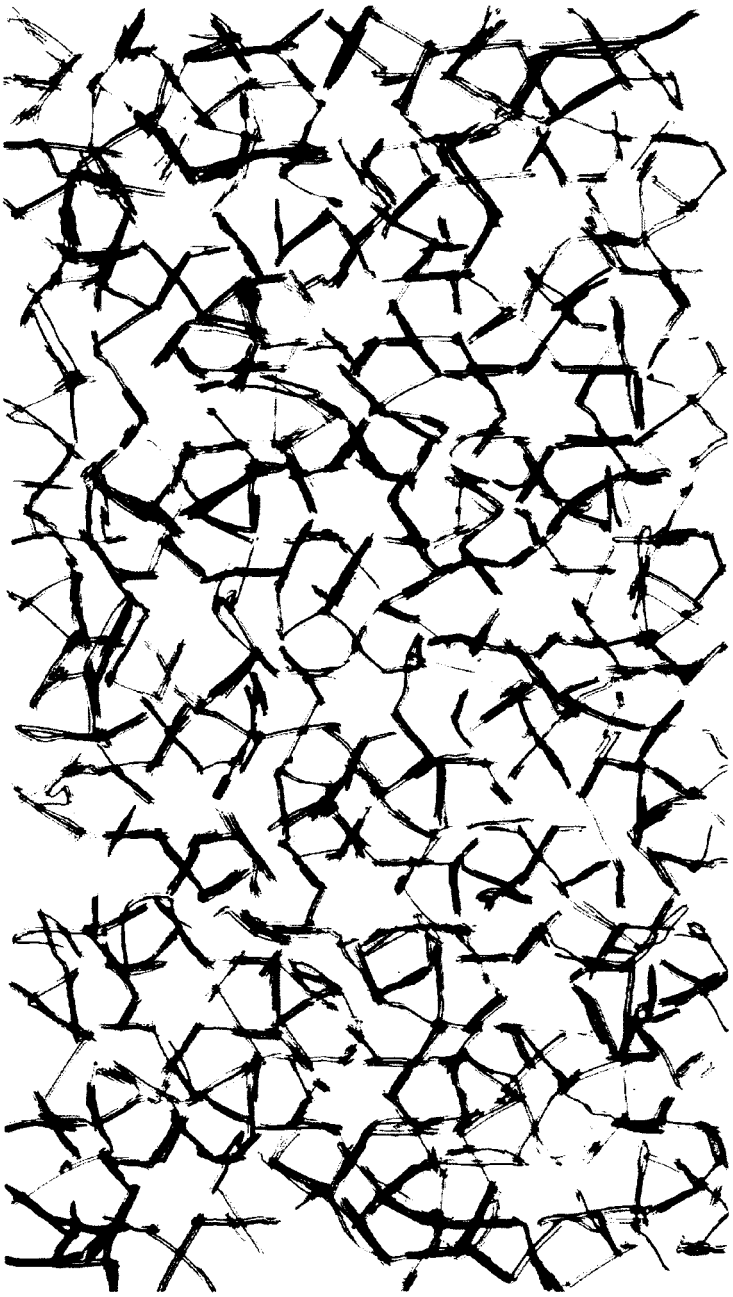

Fig.39: Cubic zirconium acoustic image, gouache on paper, 5x10in, Griffin, D. (2009).

David Griffin (2011) Isometric projections:

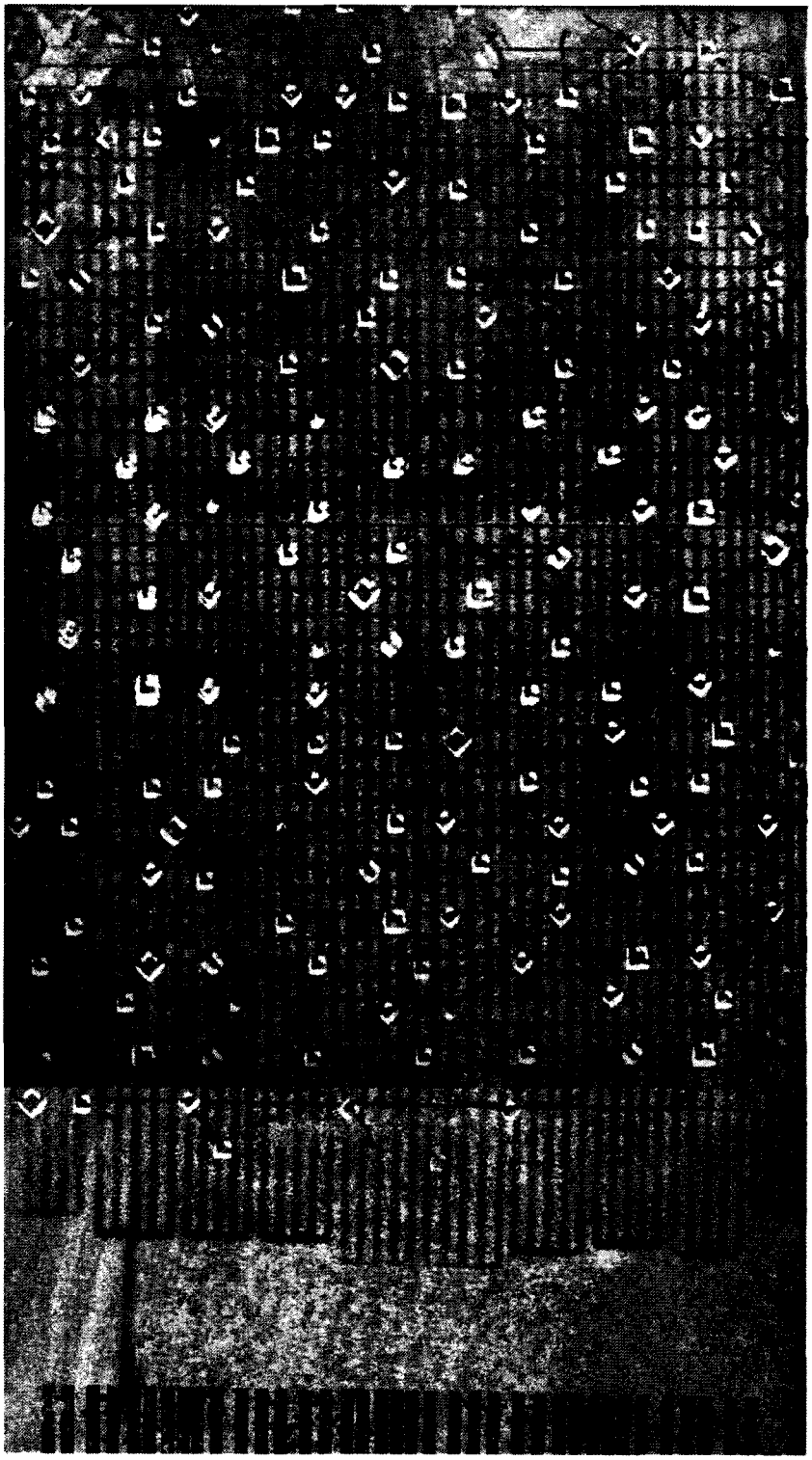

Fig.40: Cubic zirconium paper, silkscreen on paper, 32x18in, Griffin, D. (2009)

David Griffin (2011) Isometric projections:

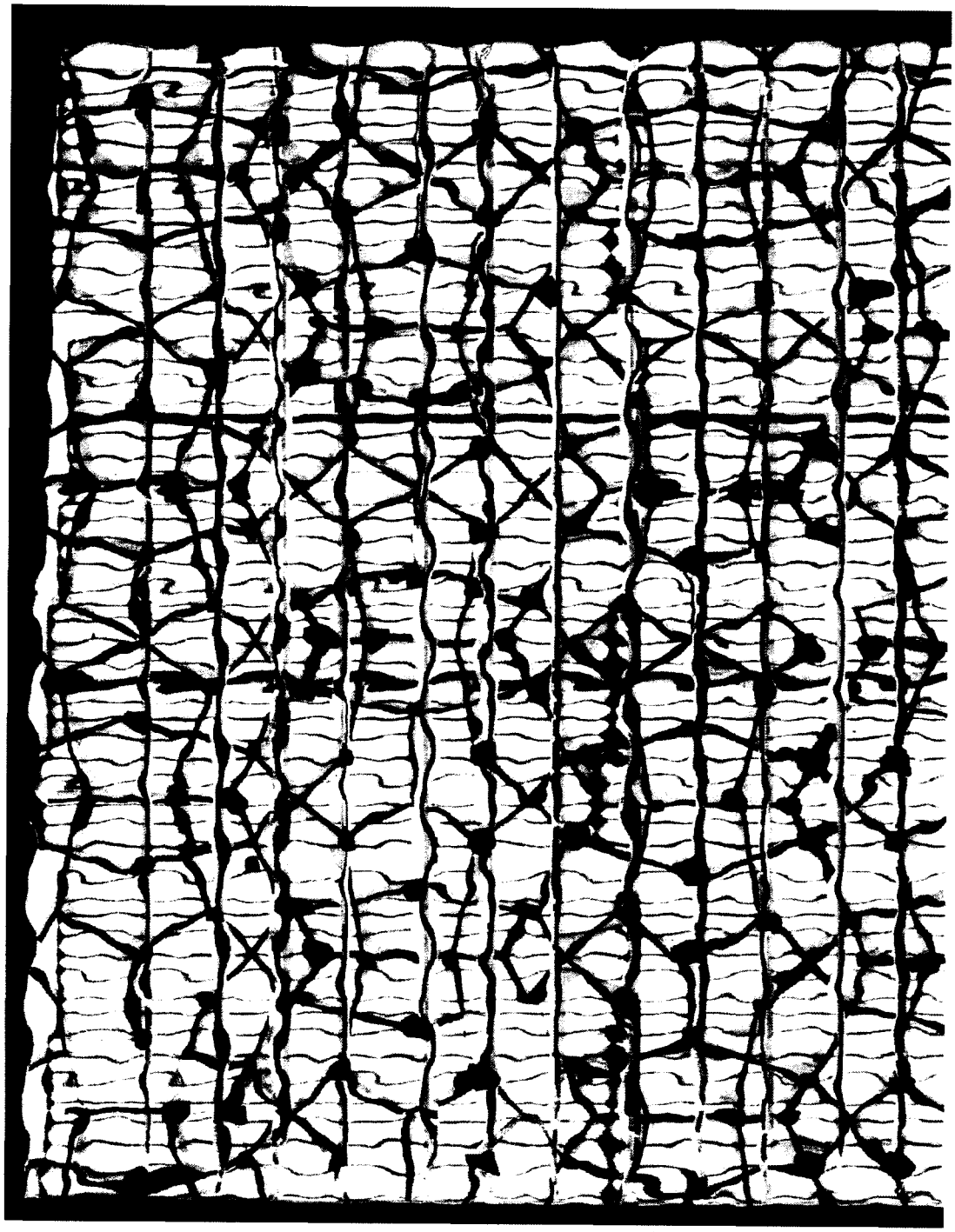

Fig.41: Diatom paper, ink on paper, 8x6in, Griffin, D. (2010).

David Griffin (2011) Isometric projections:

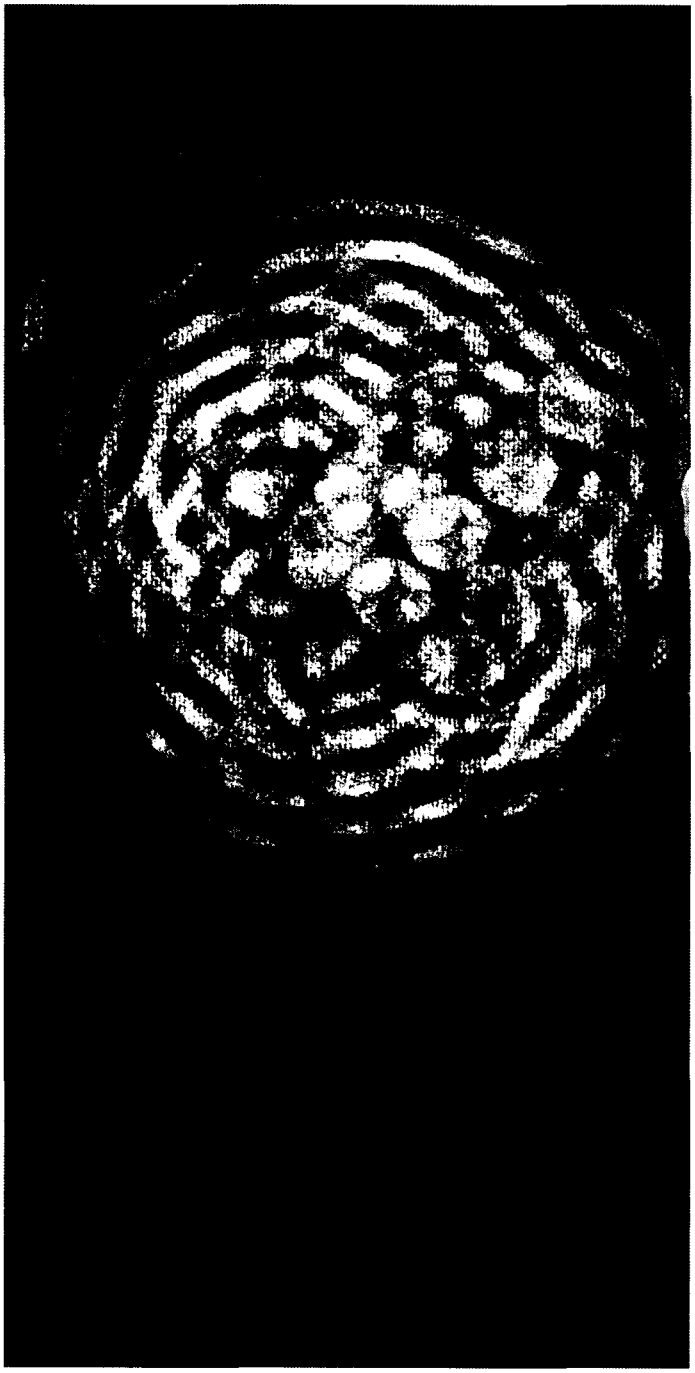

Fig.42: Diatom graph interpolation; acrylic, enamel on wood, 8x18in; graphic design stencils of broken curves and circles were imprinted using spray enamel; Griffin, D (2009)

David Griffin (2011) Isometric projections:

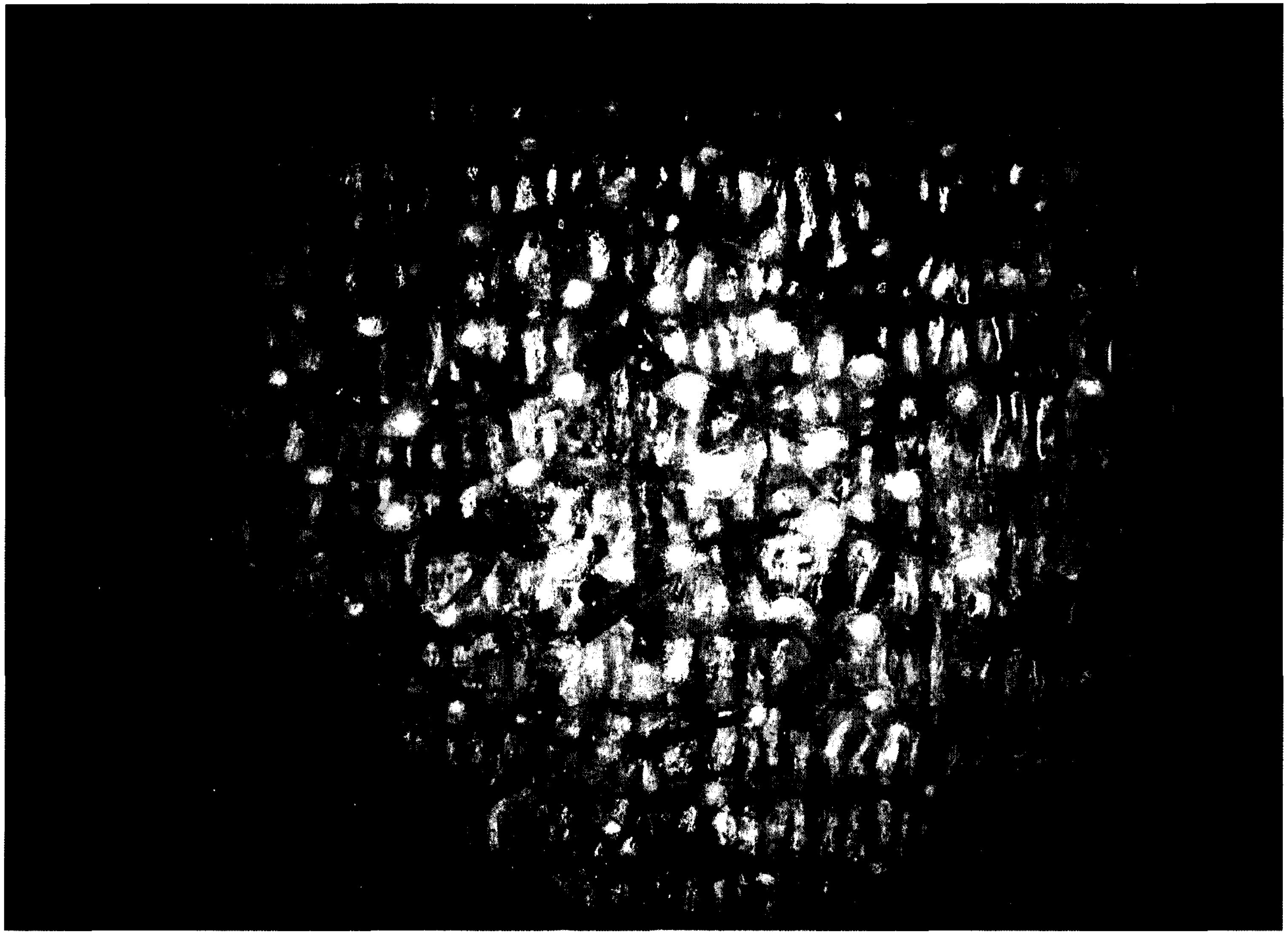

Fig.43: Diatom paper, gouache, crayon and acrylic on paper, 48x40in. The Diatom Paper (this volume, Fig. 48, p.34) was scaled up to 48 inches wide, and treated as a gouache painting. This was exhibited in May 2011 at The Glue Factory in Glasgow; Griffin, D (2010).

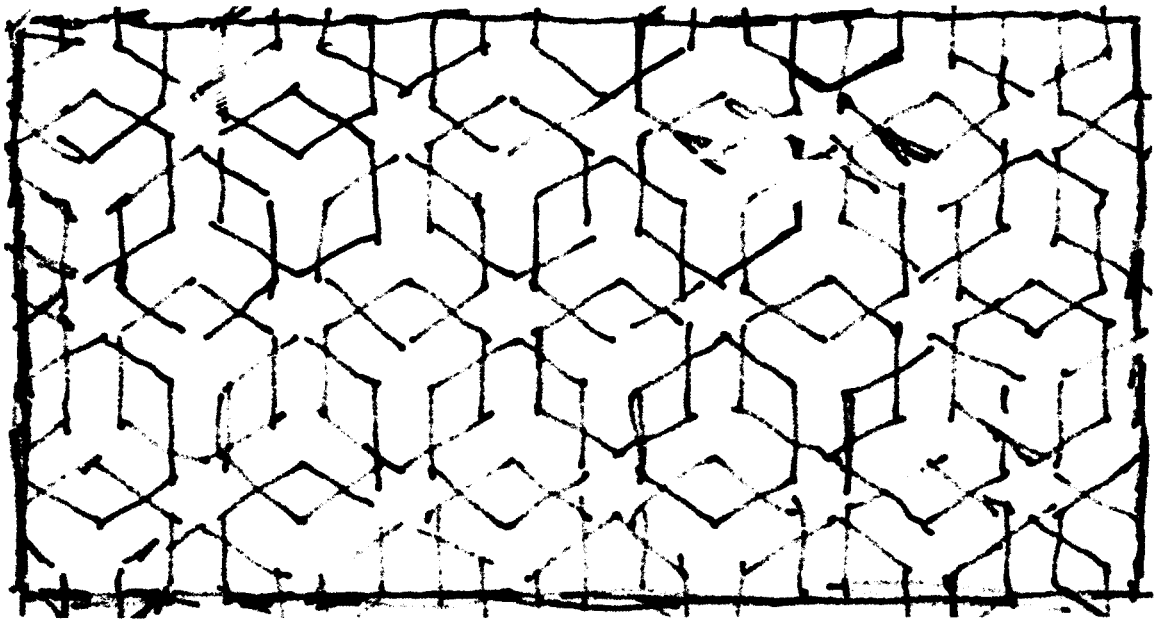

Fig.44: Hexagon acoustic image, gouache on paper, 6x4in, Griffin, D (2008).

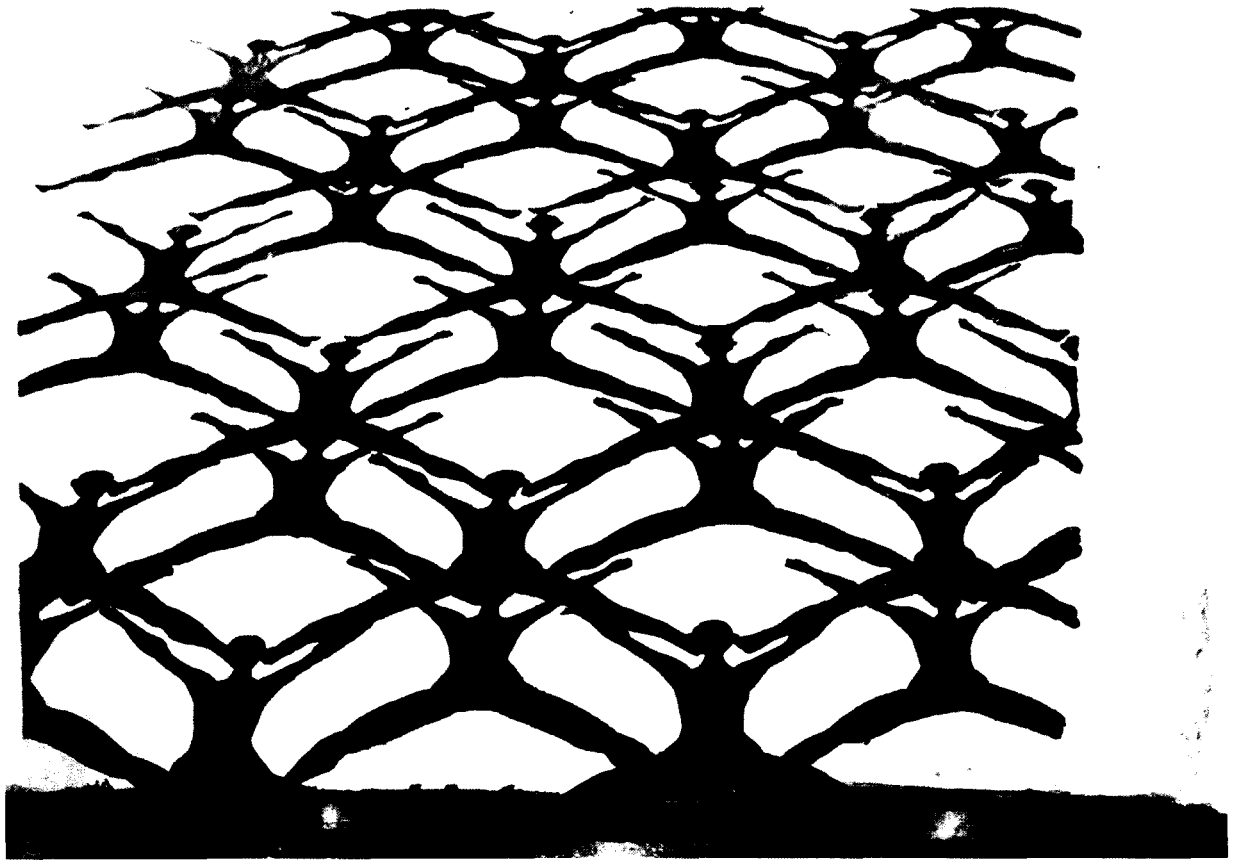

Fig.45: Hexagon graph interpolation, Griffin, D (2008) acrylic on paper, 50x34in. This early drawing in the project links the wireframe of its acoustic image to Isometric drawing paper – a commercial product featuring a pre-printed oblique grid. This professional paper is familiar to designers who use oblique projections, and so this drawing also represents the genesis of an overarching theme in the project itself, reflected in its very title..

David Griffin (2011) Isometric projections:

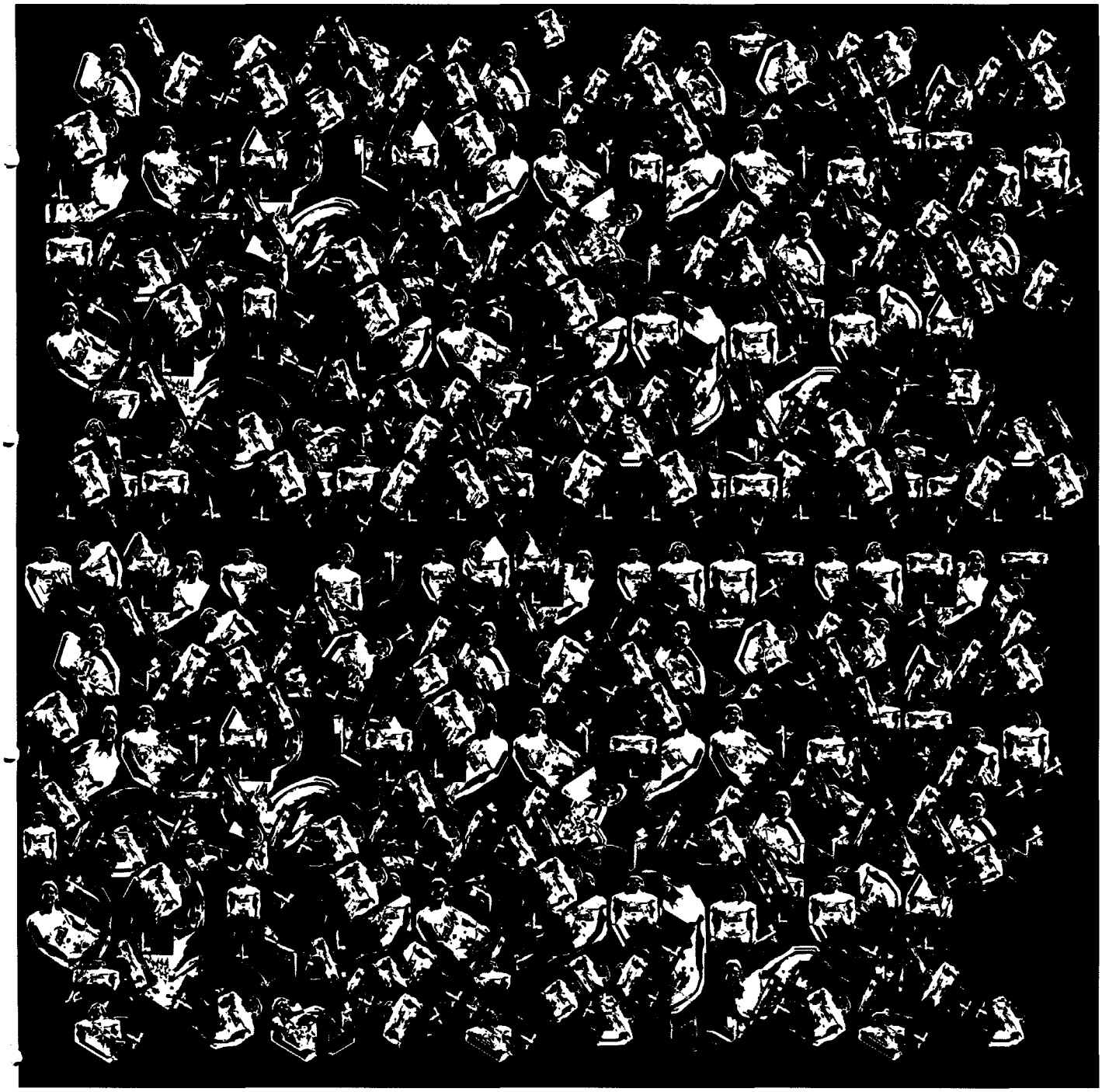

Fig. 46: Hexagon Kouros recursion; an anomalous digital drawing in the series. I built a brush in Adobe Illustrator out of a simple photographic reproduction of a Kouros -- the standing youths of archaic Greece -- then used that bush to trace the hexagonal acoustic image. Griffin, D (2011).

David Griffin (2011) Isometric projections:

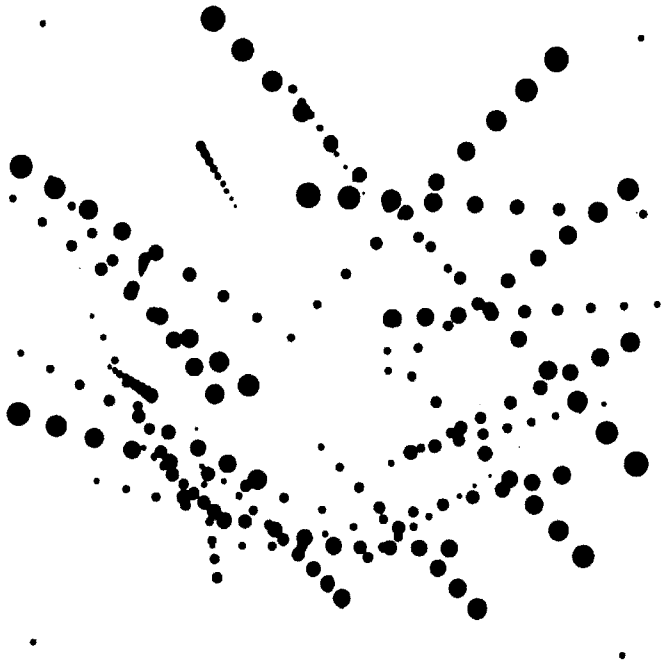

Fig.47: Isotropic scaling dot matrix interpolation, ink on paper, 6x6 in., Griffin, D (2011)

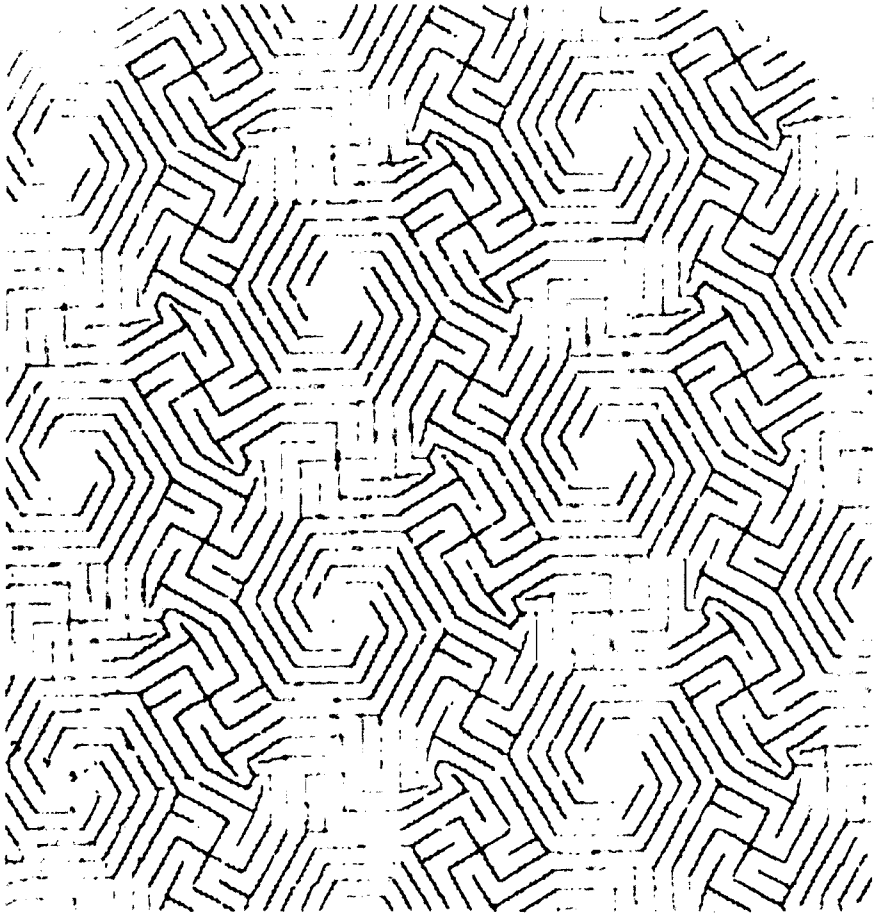

Fig.48: Isotropic scaling acoustic image, ink on paper, 8x8 in. Griffin, D. (2011)

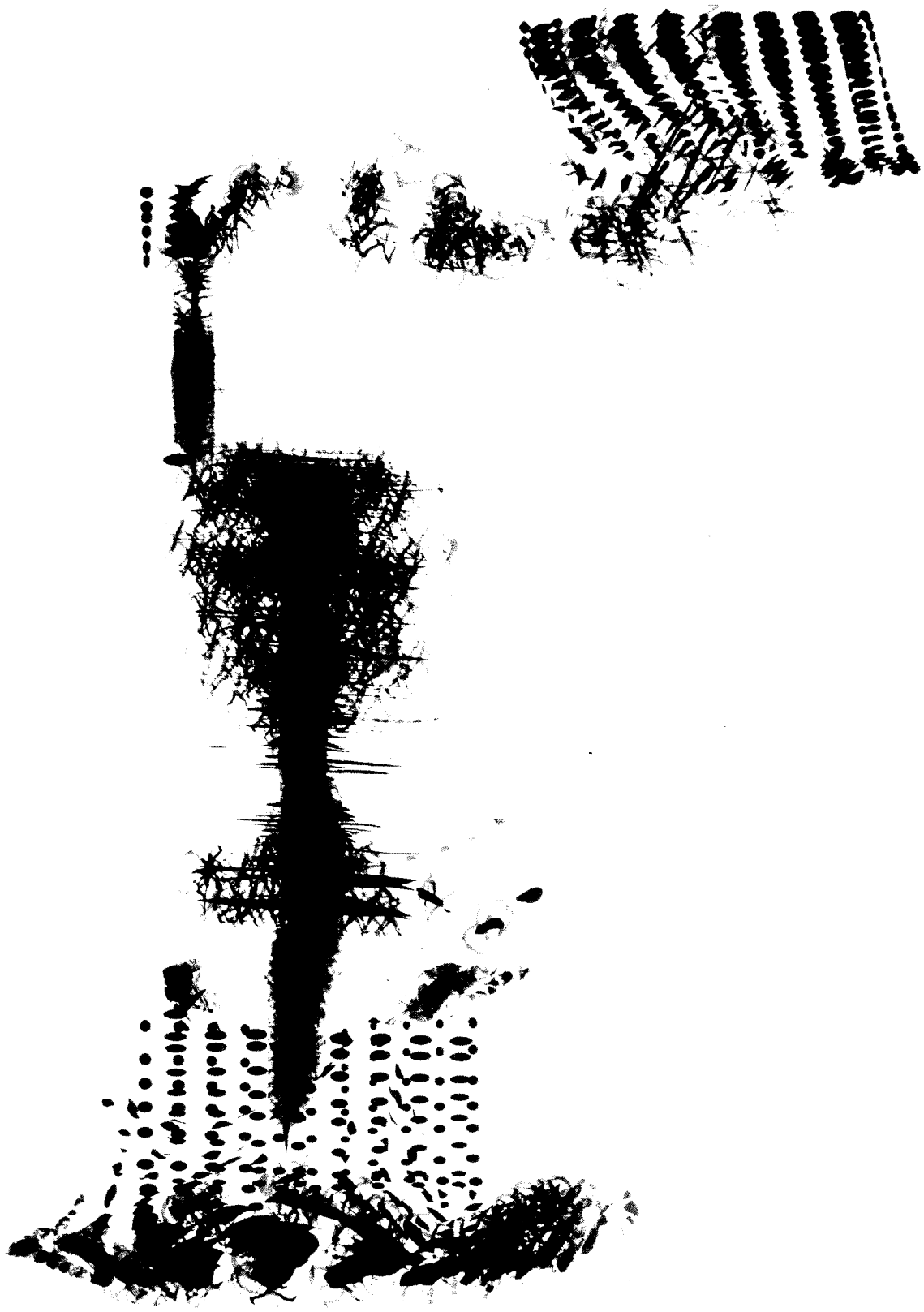

Fig.49: Isotropic scaling eddy, digital drawing, Griffin, D (2010).

David Griffin (2011) Isometric projections:

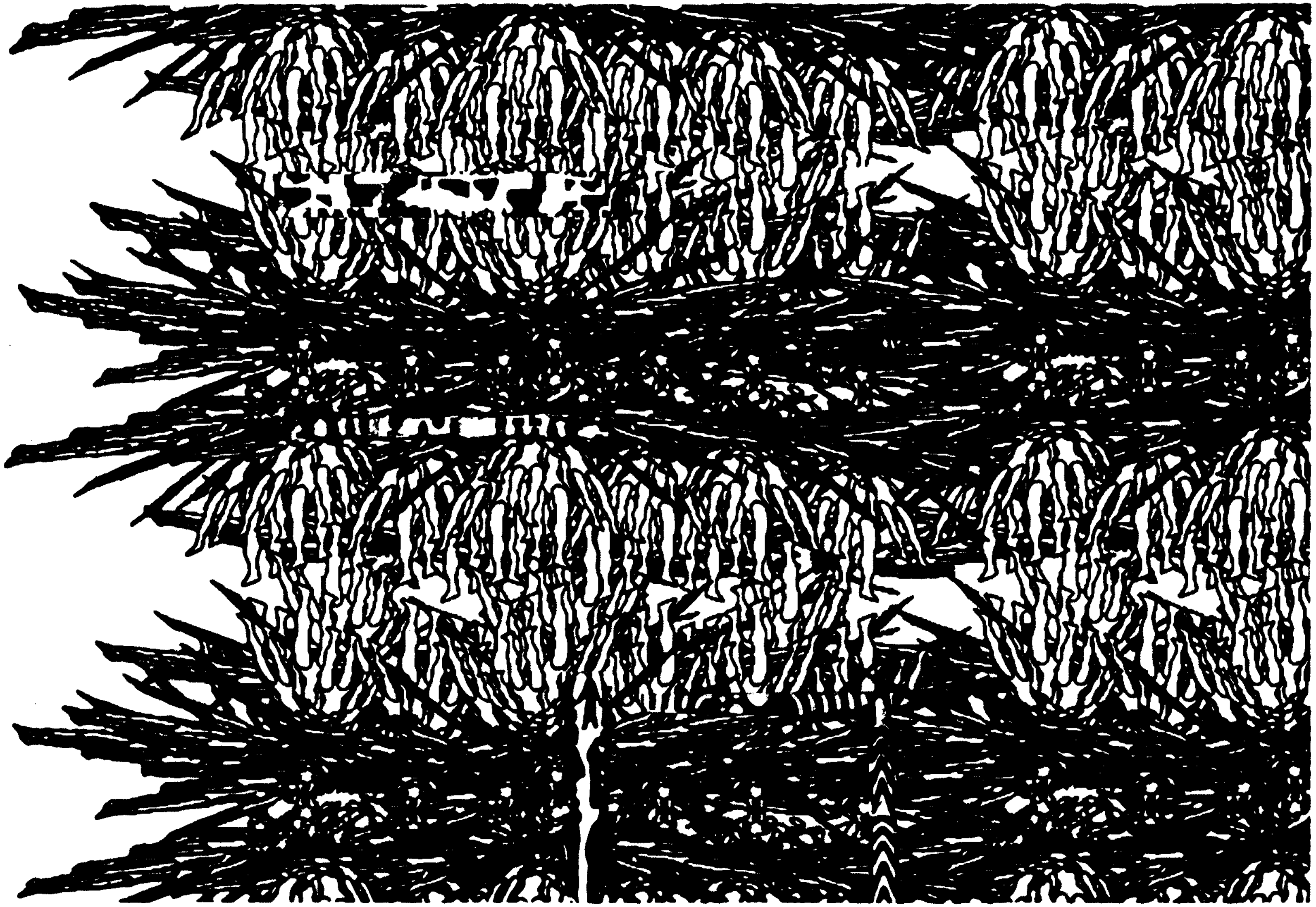

Fig.50: Isotropic scaling graph interpolation; ink, acrylic on paper, 53x32in. A series of inkjet prints of a digital tracing of the acoustic image are tiled together into a large scale, and then traced by hand, and collaged with other items from the studio floor. Griffin D. (2009)

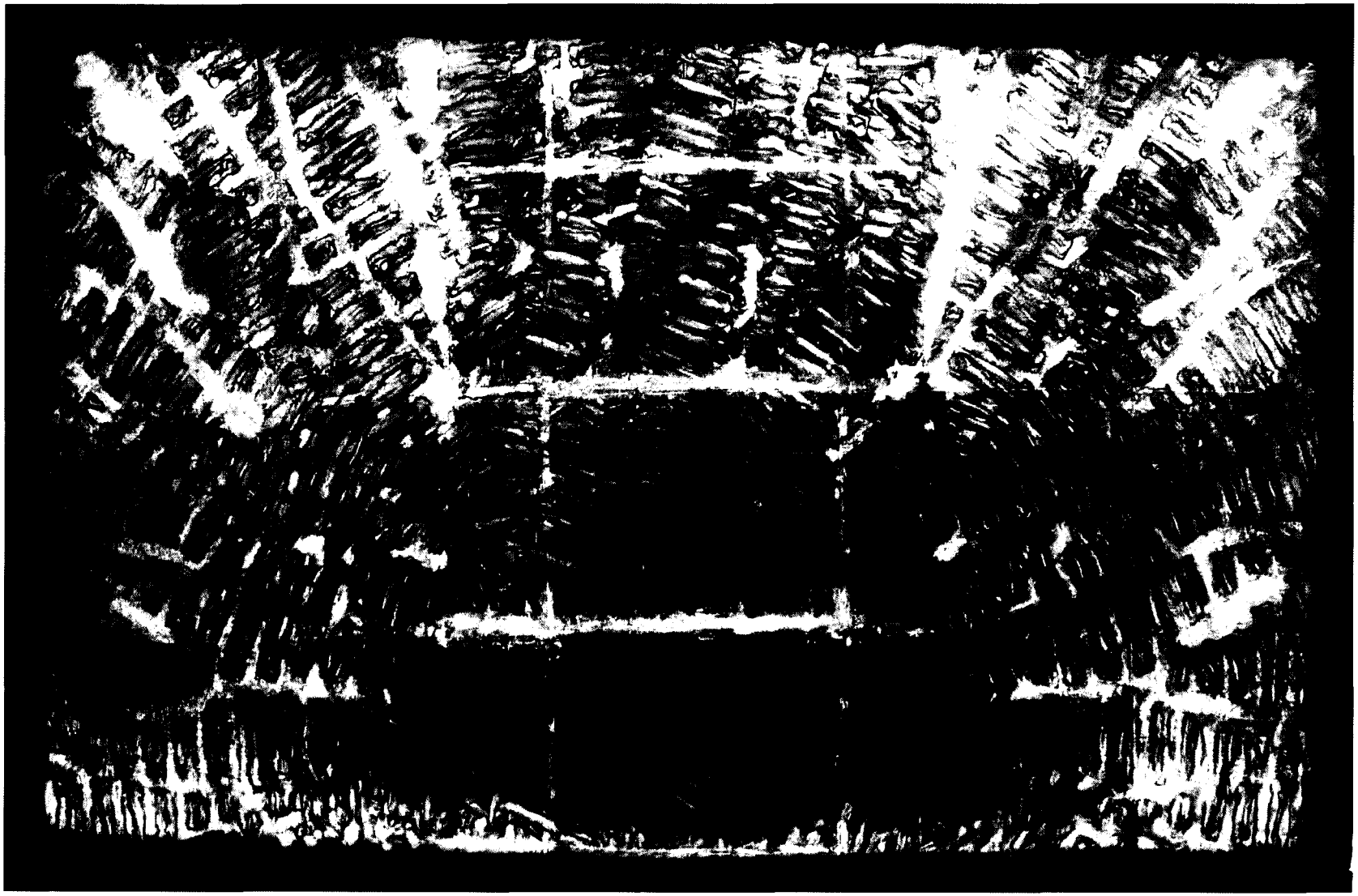

Fig.51: Isotropic scaling interpolation, crayon, acrylic on paper, 52x33in. This was exhibited in May 2011 at The Glue Factory in Glasgow, along with a number of other drawings included in this Volume of the thesis. Griffin, D (2010).

Fig.52: Reciprocal lattice graph interpolation; ink on vellum, 22x8in. An inkjet print was pulled roughly out of the printer during the cycle, generating a blobby print, with streaks developed where the ink was violently smeared. This print was exhibited at the Grace and Clark Fyffe Gallery at GSA. Griffin, D (2009)

David Griffin (2011) Isometric projections:

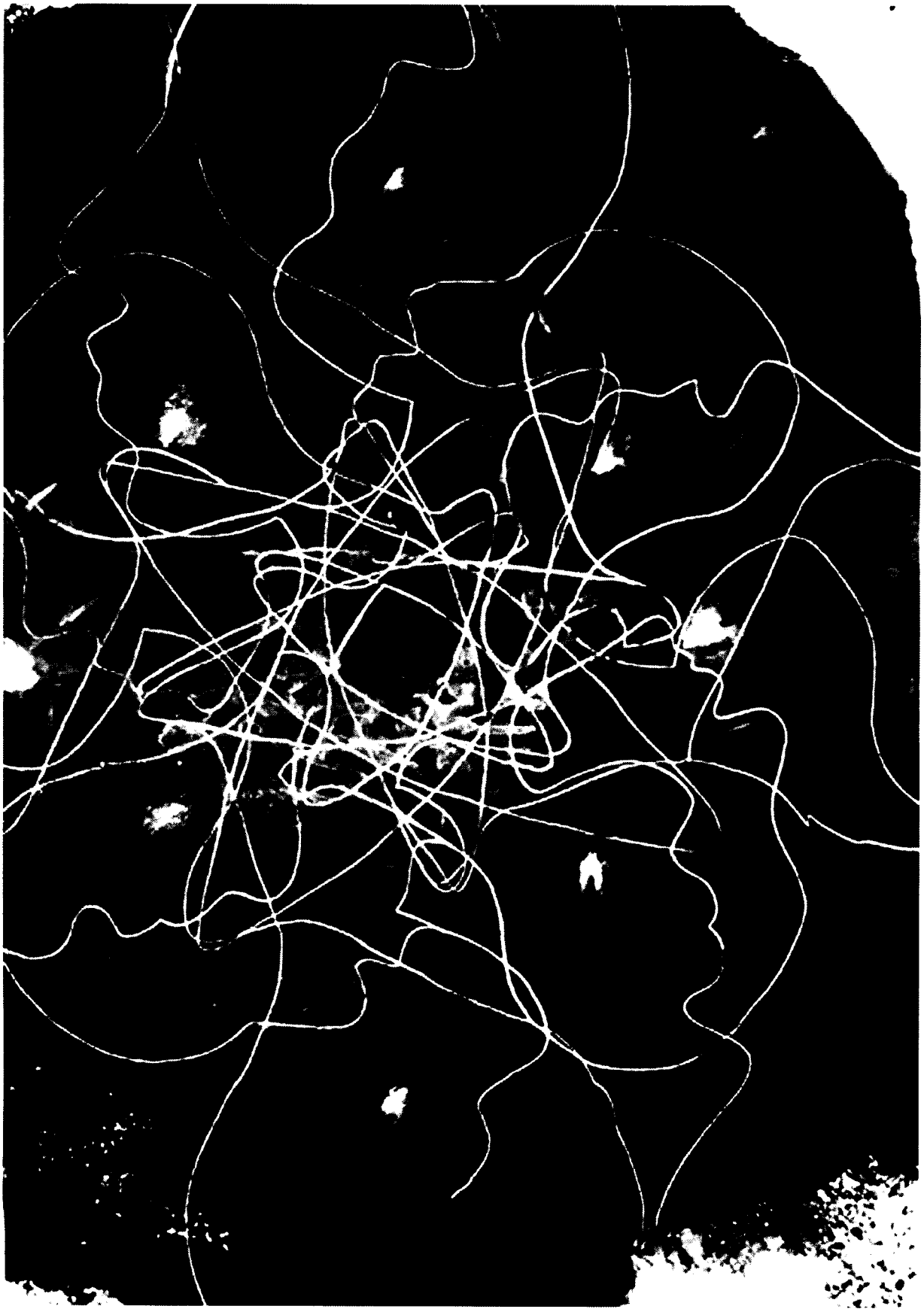

Fig.53: Reciprocal lattice interpolation, crayon, ink, charcoal on paper, 52x34in. This was exhibited in May 2011 at The Glue Factory in Glasgow; Griffin, D (2010).

David Griffin (2011) Isometric projections:

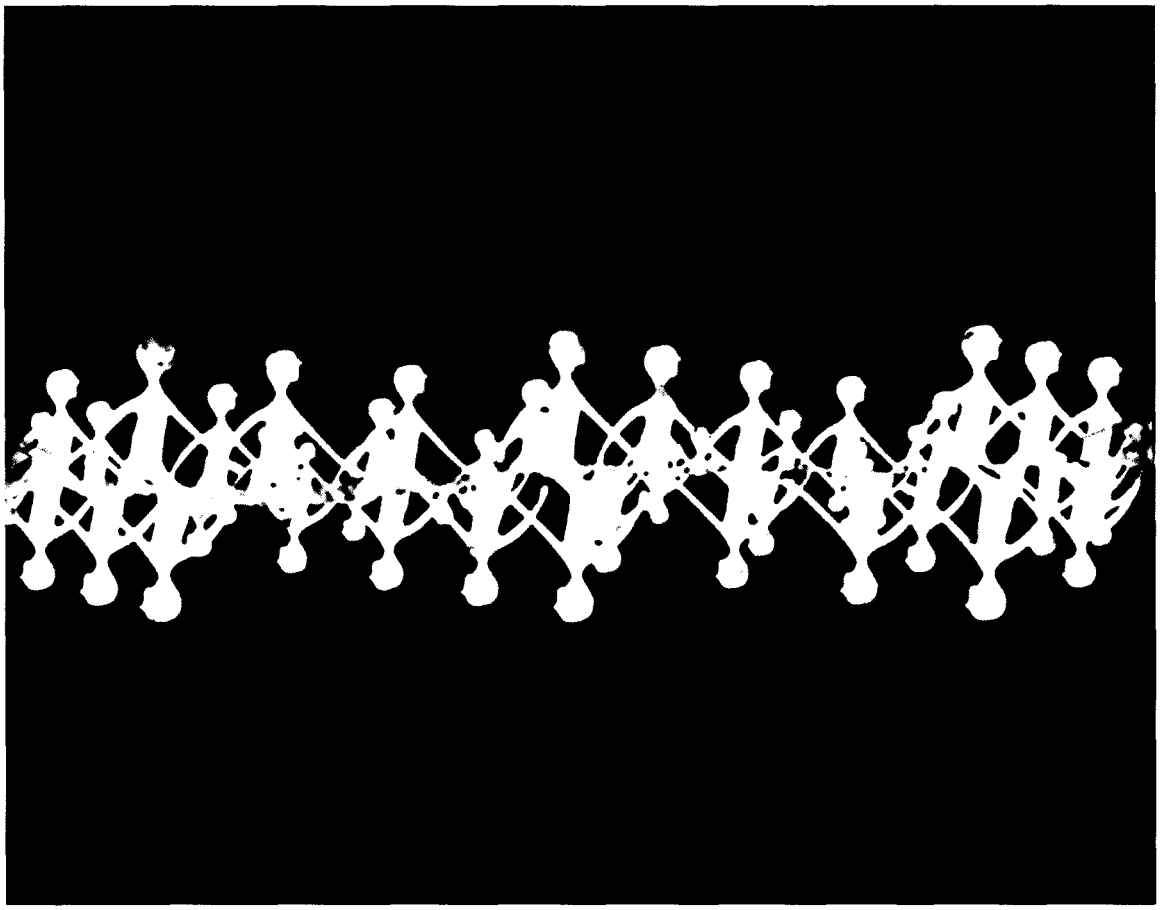

Fig.54: Counterpoint; acrylic, ink on paper, 14x10in; two identical prints of three rows of walking figures are torn in half, and their upper halves reassembled in an inverse mirror relationship. The result appears as a kind of counterpoint; Griffin, D (2009)

David Griffin (2011) Isometric projections:

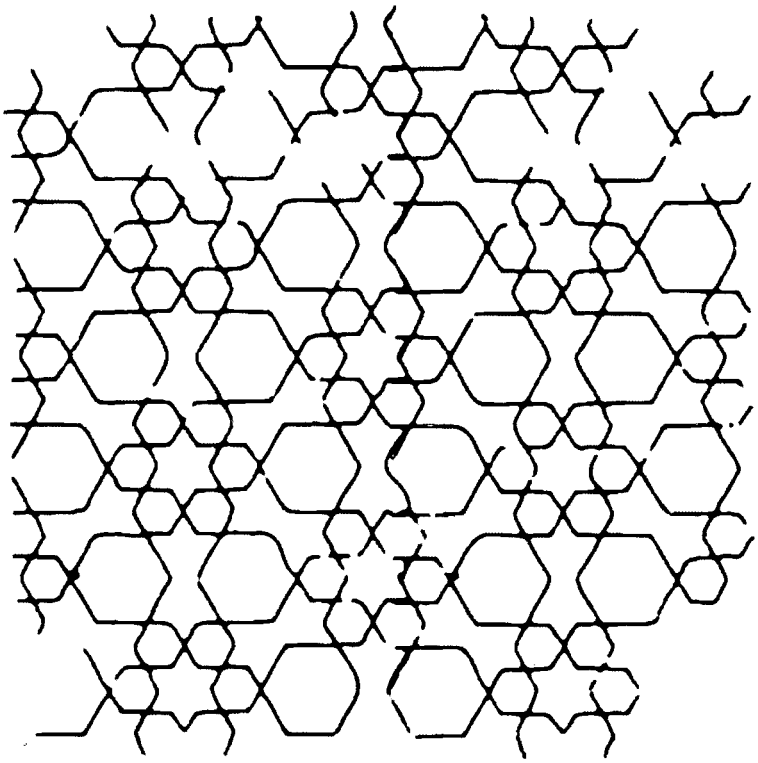

Fig.55: Tetrahedron acoustic image, ink on paper, 4x4in, Griffin, D (2010).

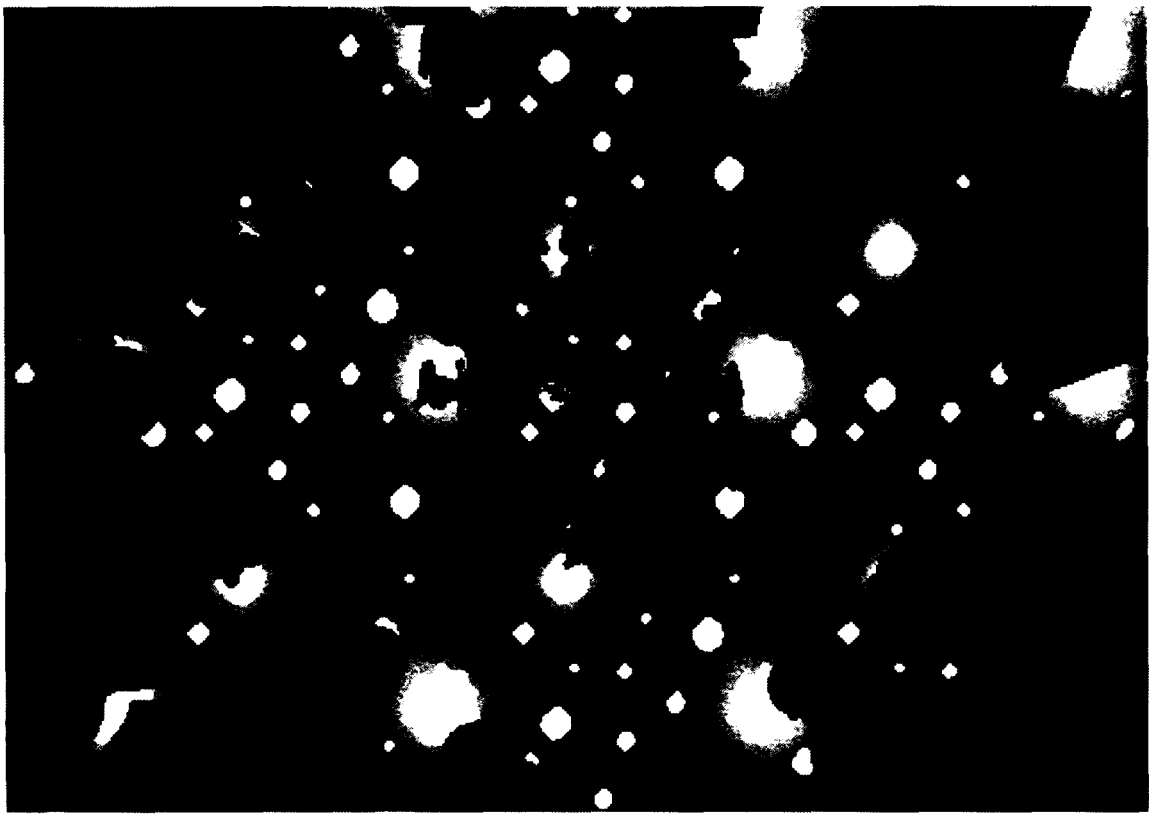

Fig.56: Tetrahedron graph interpolation, digital drawing, dimensions variable, Griffin, D (2010).

David Griffin (2011) Isometric projections:

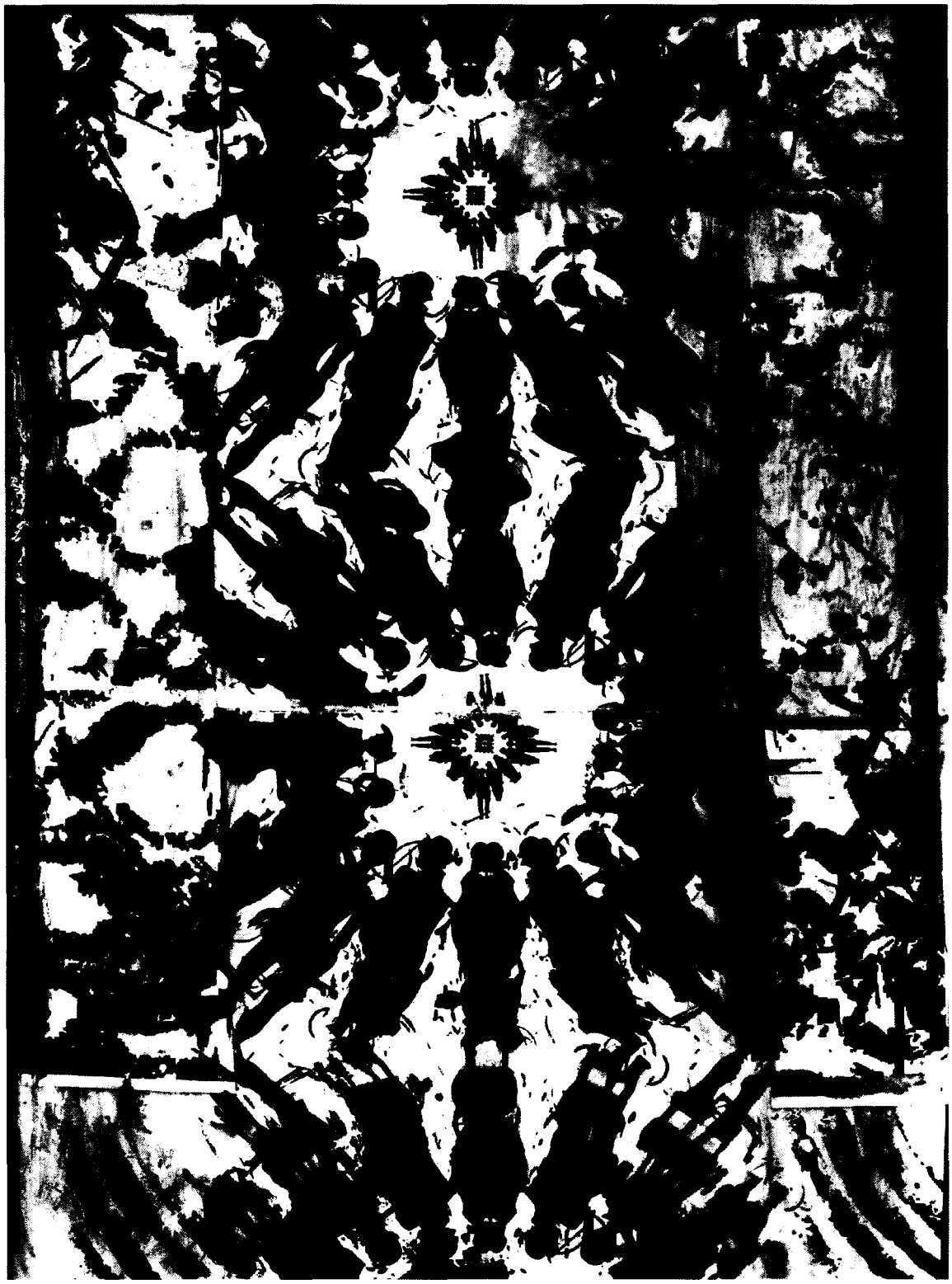

Fig.57: Tetrahedron graph interpolation, ink, crayon, acrylic on paper, 14x8in. This is a detail from a larger piece of lumber, 48x 14 inches, meant to be read up and down as a vertical post. Griffin, D (2011).

David Griffin (2011) Isometric projections:

3.4. Study two : Interference : line and timbre

> The vowel is a soul -- that is to say, wind -- and the consonant is a body -- that is, a limit and the temporal prison of the soul (Serres, 1982, p.189).

The following section will describe the rationale for the second of three drawing-music studies. Here, I work to correlate the graphical abstraction of line to the musical concept of timbre, eventually finding a notation for the timbral qualities of the human voice: a scoring system for vocal music. The reader will see that the system depends on the notated forms of (English) vowels and consonants -- the structuring phonemes of speaking. Their roles in the system here developed, however, direct us to *silence* as a vital aspect of our experience.

Whatever it may be used to represent, a line drawn is at least the addition of a second dimension to point. Directing our attention, lines become scaling or way-finding instruments, locating contours, orienting, identifying phenomenal aspects of vision, or relations in some target domain. Euclid, the natural scientist, described line as length without breadth. Returning to Klee's notebooks, the teacher writes (approximately) that line is point gone for a walk. Finally, in the panoramic view of anthropology – a view in which Klee's walking meets Euclid's abstraction in hybrid cartographic documents – Ingold suggests that whatever uses to which we may put a line, its basic function is to mark-up relationships: start to finish, body to body, routes and shared properties (2007). While not quite definitive, common to all these assessments are implications of motion and dynamism, and also of course, measurement.

Timbre, in contrast, is a notoriously difficult to define concept-parameter of audition, despite abundant research exploring its cognitive value as a condition of sound production, and a source of information in perception (Fales, 1999; Mcadams, 1999). It can be argued however that this lack of consensus reflects the diversity of interests in its potential in perceptual studies, musical comprehension, and communication, rather than any mere lack of understanding. Colloquially identified through analogy with visual dimensions of either texture or colour ("the colour of a sound") its complexities as an auditory and musical experience are put this way by Dannenberg:

> With timbre, we are still learning what to represent. My explanation is that, starting with sound, we picked out the two things we understood, pitch and amplitude, and called everything else timbre. So timbre is by definition that which we cannot explain (1993, p.25).

Timbral properties of sound have been a keen interest for musicologists, but also for technical disciplines such as acoustics, and digital synthesis and re-synthesis, where it is measurable along a number of metrics, with respect to characteristics like envelope (the "shape" of sound over time), or some other aspect of periodicity (Dannenberg, 1993; Rudy, 2007). However far outside the purview of my project, in such technical analyses the content of sound is analysed by spectrographic displays. Software tools such as the Acousmograph (Geslin & Lefevre, 2004; Kahn, 1999) and Sonic Visualiser (2010), for example, allow their users to enter the space of auditory representation to annotate, explicate and even amend specific regions of sound -- performing graphical operations on data relationships, revealed in the display. And while I did not finally pursue this avenue of practice, more fruitfully explored in a number of places (Godøy, 2010; Healey and Theibaut, 2007), as a realisation and turning point for the research into practice, it provided an odd moment of reflection which directly addressed and over-turned the propositions of a key bit of text in this study: in these technical visualising tools we can identify a place where Goodman's attenuated electrocardiogram meets and mates with Hokusai's chisels and brushes. The re-drawing of spectrographic displays – that is, graphical actions upon auditory information – provided a conceptual entry point for research in this second experiment (Fig.70).

Timbre has been theorised to act as a vehicle for deciphering the nature and contents of the spaces between sound source and self (Fales, 1999), reminding us that as cognitive beasts we seek to parse the dimensions into which we are embedded. Both timbre and line are crucial conceptual pieces of this search, most relevantly performing similar experiential functions in the re-vision of experience in the inscription. We see and draw lines as connectors in primary and secondary spaces, and we listen to a kind of network of harmonics and overtones. Each is an estimation, then, or a summation performed for our incomplete perceptual tendencies, orienting us to interpretative contexts (Rudy, 2007, pp.6-7). And summation is a principle in inscriptive practices, particularly in graphics such as the music notation, which gives us portraits of the

psychological time described by the composer Morgan (1980, p.529). Thus, this notation project inscribes line and timbre as exchanges between oneself and exterior, between perception and interpretation, between paper and music.

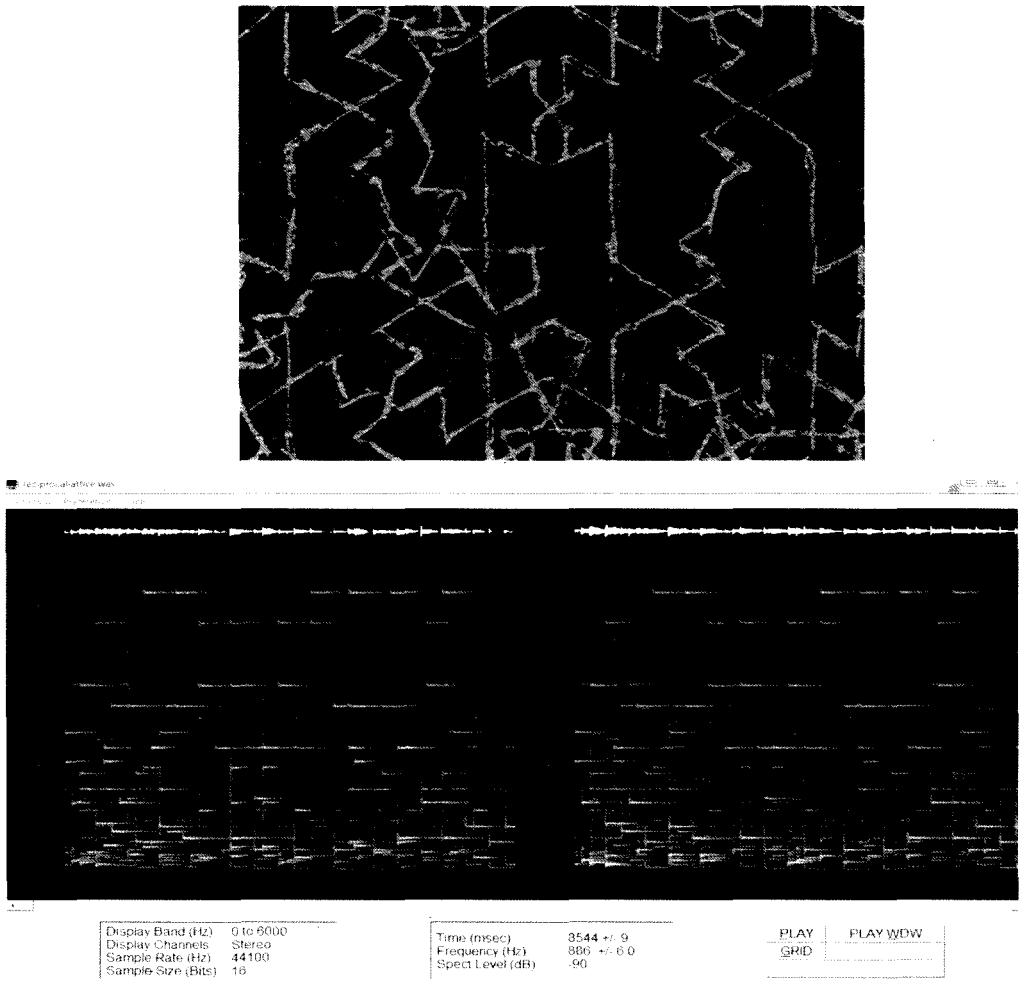

Fig. 58: Timbre visualisation: "Reciprocal lattice" – Above, a acoustic image from the "Isometric projection" Project, had its musical output (see the DVD, Track 7) taken into a spectrographic software system, screen captured beneath. The spectrogram shows the loudness, frequency, and periods of the notes across its timeline as values of blue (Generated by the author in *Spectrogram16*, a freeware application from Visualization, LLC software).

3.4.1. Writing music

In the pages of my research journals, this second notation study took its second major turn on a commonly held musicological view that the spoken word is an essentially timbral system (Cogan, 1969, p.76). We express our thoughts through networks of vocal tones produced in utterance of our needs. With respect to the marking-up of these verbal gestures,

Ingold reminds us that reading is never a mute engagement with lines. The characters of writing and speech 'are aspects of same thing' in performance (2007, p.17). Ingold notes also that written marks as specimens of line-making call up specific sounds in response. And in his 'The Creations of Sound,' the poet Stevens writes

> We say ourselves in syllables that rise
> From the floor, rising in speech we do not speak.

I like this image of the voice rising from a firmament of action, a foundation coming through us in the notes of expressive vocalizing, in syllables: language and the voice a chemical re-action, rather than mere speech, telling things. His lyric suggests that the work of the artist/poet is to watch this reaction, perhaps reporting on, or at least attending to its effects. Certainly in poetry the ineluctable connections between writing and speech are clear: we don't read in silence, but in full, physical awareness of the body. In the project of inscribing for the voice we therefore join the literary artist and the instrumental music composer, who are likewise engaged in marking-up strategies for creation and dissemination of audible ideas. And of course, there is also the venerable and wholly attractive idea that music is an art of the voice, at all times in its history made to be spoken aloud, proclaimed or whispered.

This expansive view gives us the word as both score and script – as indication and enaction (see Goodman on the differences, 1976, p.199-201). In order to draw an integrated sound-vision experience in the spaces between words and images, then, this study will simply recast a 'pataphysical entry point (What does an oblique plane sound like?) in terms of our demonstrably human desires to make music with our voices, and then to write an image of that experience. Putting it as query: can we both show and say? We can then seek ways to create a continuous space of the voice and writing by means of the difference engine of a notation system.

3.4.2. The voice

Research over the months of this developing practice included examinations of Kurt Schwitters' colossal tone poem "Ursonate," (excerpted Fig.82, below), but also musicologist Fred Lehrdal's intriguing notations of the prosody of the spoken word (2006), which amounts

to a renovation of the medieval Neumes which predate the five line staff notation (Pryer, 2002; Healey and Thiebaut, 2007, pp.1079-1080). The poet works with words and breath, while the musician works with sound and silence, and although linguistic and musical gestures have differences in the experience, in their rhythmic structuring they can be understood, says Lehrdal, as 'formally and cognitively equivalent' (2001, p.340). The musicologist explores this difference by treating an excerpt from the poet Robert Frost as an object of musical composition, in order to bridge these symbolic languages in ways both like and unlike the neumes, or Schwitters' poem: the phonetic and prosodic stresses of both music and speech allow for such translations, mediated in the notation.

Ursonate
Introducción:
Fümms bö wö tää zää Uu,
pögiff,
kwii Ee.
Oooooooooooooooooooooo,
dll rrrrr beeeee bö
dll rrrrr beeeee bö fümms bö, (A)
rrrrr beeeee bö fümms bö wö,
beeeee bö fümms bö wö tää,
bö fümms bö wö tää zää,
fümms bö wö tää zää Uu:

Fig. 59: Ursonate; Schwitters, K. (1922-32), accessed at <http://www.ubu.com/historical/schwitters/ursonate.html>.

I also came to consider a phonetic scale developed by musicologist Wayne Slawson (1985). I will not detail Slawson's work here, but will summarise his "Sound-colour dynamics" scale as a route to composition in timbral terms, rather than the *solfège* -- that persistent pitch-scale model key to the Western notation system. Supporting the cognitive view of timbre summarised earlier (Fales, 2002), in Slawson's model, a scale of nine vowel sounds gives shape to syntactic and semantic information delivered as vocalising (1985, p.159). In the pencil and paper environment of my sketchbook practice, working through Schwitters' unstoppable performance, Lehrdal's analysis, and Slawson's compositional theory, a vocal notation exercise has developed which draws together timbre and line, aimed at the seductive notion of making timbre calculable in inscription.

Taking these sources forward, the sonorities of vowel sounds are embedded into speech by the triggers of consonantal gestures. Consonants are the mortar which fixes the timbral

qualities of vowels into speech. Hard, breathless controllers of the dynamic qualities of our voices, consonants do not in themselves create sound, rather they delineate vocal shapes in silence, connecting and combining, determining but not specifying pitch and volume, thereby creating the conditions for legibility. 'Articulated language begins with the sowing of consonants,' Michel Serres writes

> But consonants are interruptions of the voice. Rupture, stopping, bifurcation of this flow... They multiply the inclinations and angles in the course of the voice; they multiply the dams and the deflectors; they encode the white layer (noise); they multiply directions and suddenly produce meaning... consonants strangle voices. They squeeze them (Serres, 1982, p.189).

As Serres indicates, if they produce any sound at all, it is in friction -- as passage by and against flesh, bone and teeth. The pitching of the voice in speech is a matter of breath and gestures of tongue and lips; vowels are breath, and consonants those movements which shape their content (Roach, 1998, pp.10-35). But how do we notate silence -- something not *absent*, but also not present? Kurzon (2007) presents a typology of silence in social exchanges, where each instance bears the same sensation of non-presence for participants, but with different intentional functions. His "conversational, thematic, textual and situational" silences amount to displays of consent or dissent, communicating attitudes of reception and interpretation, knowledge states, or signs of withdrawal. Kurzon's typology provides useful information about the structuring silence within speech, but in this project I refer specifically to the gestures involved in making vocal utterances. Not the rhetorical pause, or mere quietude, but the expressive acts which frame those attitudes. After this, I ask the reader to make (and describe) the sound of "T." Without producing the breath that allows us to perceive "t" as a formant in speech, all we have are the positions of the mouth, tongue and teeth, ready to intone "tree."

3.4.3. The alphabet

The musical signal is represented by the symbolic score. The score is a document by which the composer gives the terms of an audible calculation to performer and audience. Thus the score shows us where noise and signal differentiate: it is a tally-sheet, a calculus of the body, with the performance as its sum. While the common music notation necessarily struggles with

timbre – ignores it really, in favour of those larger structures of pitch which are supported by its scheme -- what has emerged from this picture/music primitive correlation is a relatively clear path to notations that focus on the readymade linear representation of consonantal speech non-sounds, from the alphabet. Taking a graphemic connection between drawn line and vocal timbre, and then focusing on the subset of characters which give dynamic dimension to our utterances, the systematic notations worked out in this practice are represented in Figs.61-71. They are layered letter-fields, set at angles to each other and to the frame and surface of the page, which function as the axes of the notational space. As drawings, the relative pitching of these layers results in interference patterns, as each aligns and moves apart from the ones above and below. And in the process of developing them as notations, a moment of spatialisation occurred where the manipulation of layers became the drawing of pictures, and their systematicity opened up. The small relative movements of the characters in the field generate larger structural wave forms, becoming the key to their potential as scores. As a guide to tracking the complex of research and practice that lead to these notations, Fig.60 (below) organises aspects of the notations relative to the taxonomy presented in Chapter four of this thesis (Fig.83, p.157).

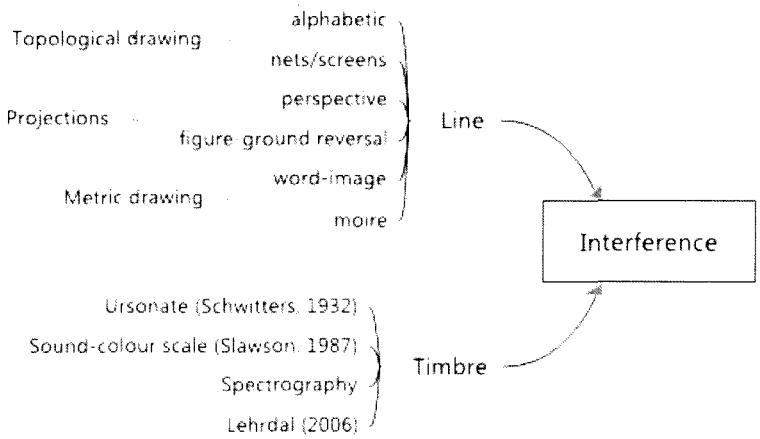

Fig.60: Interference: a map of the graphic research through which the primitives of Line and Timbre were incorporated into a notation system for silent vocal music. Using the taxonomy (Fig.83, p.157), the reader may analyse the range of view- or object-centred representational strategies at play in each drawing on the following pages (Figs.61-71, pp.126-136), and sort them into their relevant orders. For example, the drawing "*r screens*" (Fig.62, p.128) is built on a 3-point perspective model, which situates it as a **"Projective>perspective>3-point perspective" drawing.**

I remember a particular childhood daydreaming activity, performed most memorably in Sunday Catholic church services, of scanning typeset pages and watching the self-organisation

of the marks on the printed page become just such spatialised images. These particular drawings are connected to that autopoietic rumination, while additionally becoming that other thing: a score for musical performance. As an opportunity to see and hear music, the drawings give us the line-by-line organisation of the word: something like Ursonate, but rather than a relentless cascade of punctuated rhyme, an inscribed composition of movement-sounds, connected to glottal and labial gestures that quiver in their potency, while never quite articulating.

One lesson of 4'33" is that silence is active; not merely spaces between utterances – not negative spaces, relational or featureless -- but the essential bed out of which they rise and fall. Can there not therefore be a positive form of notation for silence other than merely the courtesy of extended rests, the "bird's eye" of fermata, or equivocating notations of the breath for instrumental performance? How do we see and then hear the differential gesture drawn between expression and structure, between the ground and the syllable, the message delivered? How do we listen to, and moreover, how can we draw incipience?

Consonants don't actually sound, of course, which makes the idea of performance of these notations' propositions challenging, but also frankly beautiful. We must ask how we can perform or record organised sound without sound. A silent music is a tantalising possibility after 4'33" (Cage, 1973, p.276), but the notation for such vexed utterances should be possible under contemporary conditions as something other than blank spaces, or extended rests in the system. There is surely some measure of irony in attempting to create a relational performance system for textual notations, generally understood as ambiguous and relatively taxing on cognitive processing. By rendering breathlessness as a character in the scheme, is it possible that these score drawings give us a positive notation for silence -- for incipient noise as music? As a long-time admirer of Cage, this is in fact a consummation devoutly to be wished. The resolution of such questions will come in working toward performance, and the practical assignments of values to each axis of these relational diagrams will be a matter of playful interest.

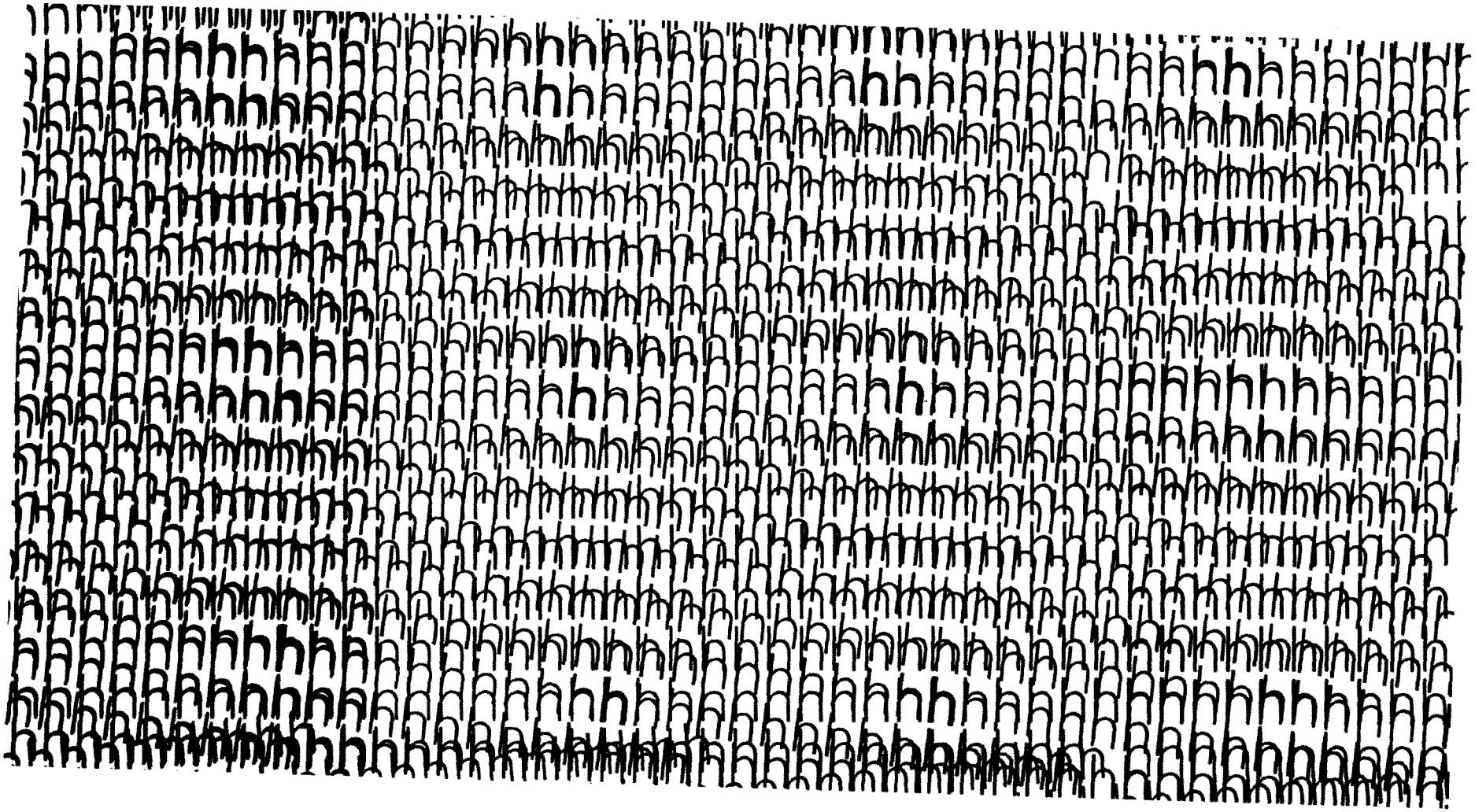

Fig.61: H net; four screens of the letter 'h' cross at shallow angles. The shapes and angles of incidence of characters and layers build spatialised spin, and nervous movement. Complicated by the breathiness of our pronunciation of the 'h' sound, how such a set of impressions might be read and performed as vocal music is a matter of creative interest and social interaction. This image was printed and exhibited at both The Grace and Clark Fyfe Gallery, in May 2010, and The Glue Factory in 2011. The print was 22x12in.; Griffin, D (2010).

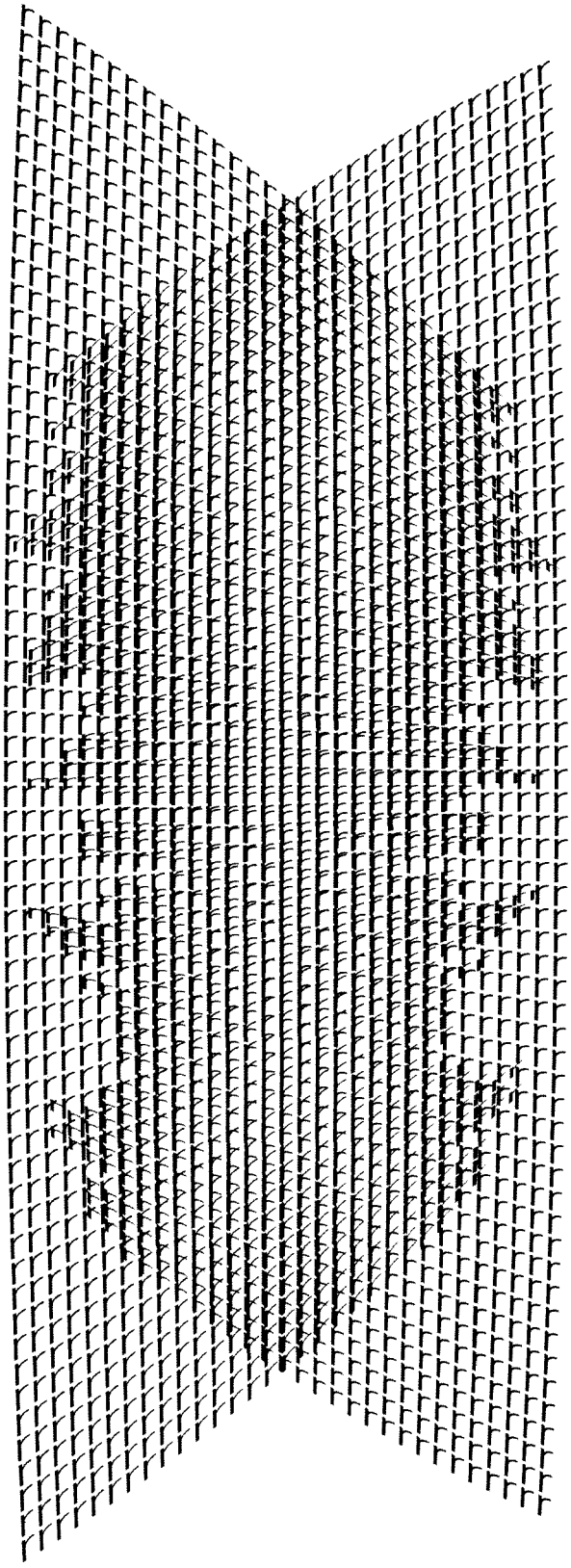

Fig.62: r screens; two panels of the letter 'r' cross each other, with a 3-point perspective. Printed and exhibited at The Glue Factory, Glasgow, n May 2011; Griffin, D (2011)

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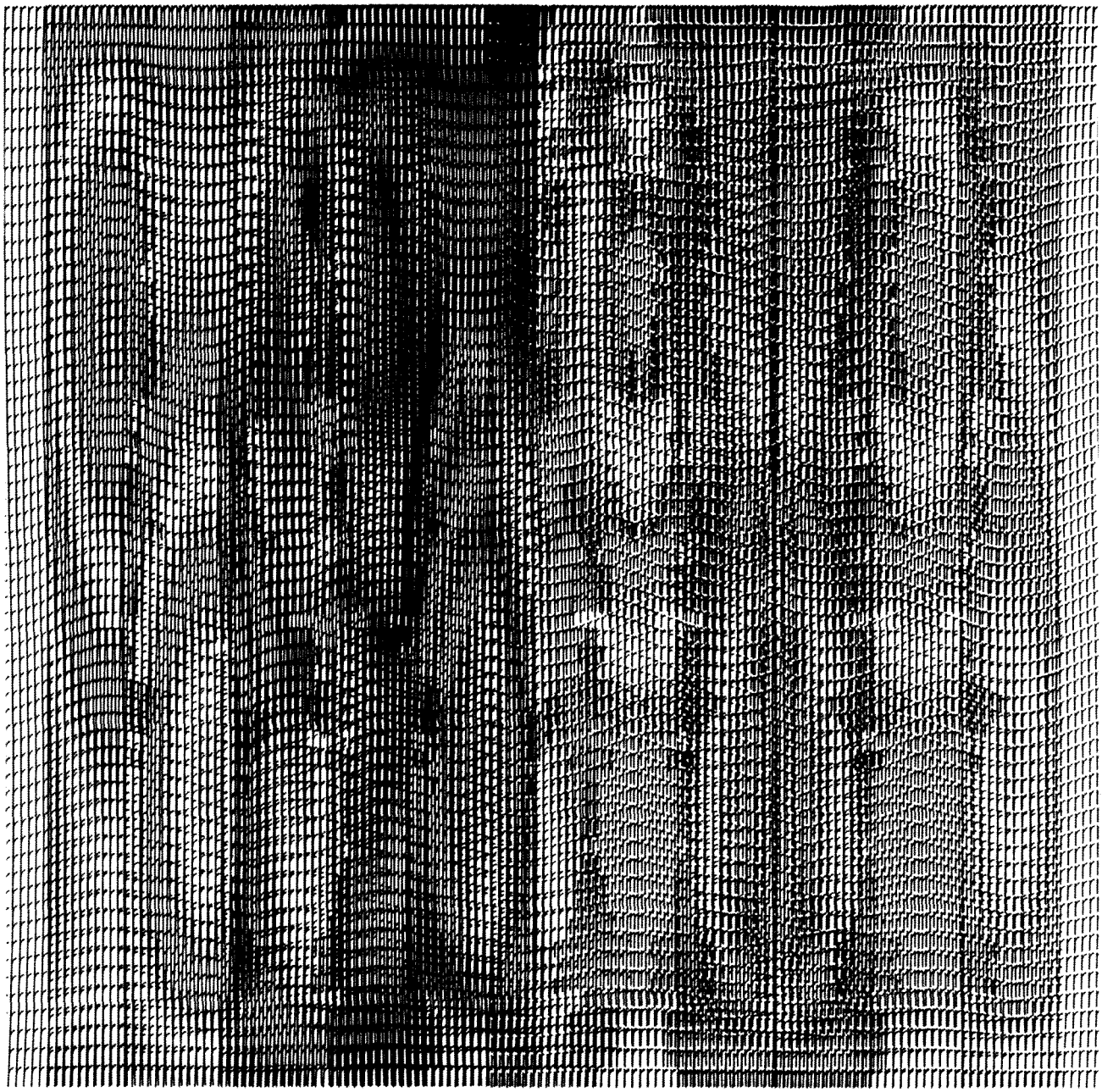

Fig.63: r net; a series of six 'r' screens are threaded through each other. This image was printed and exhibited at The Glue Factory in May 2010. The print was 30x30in. Griffin, D (2010).

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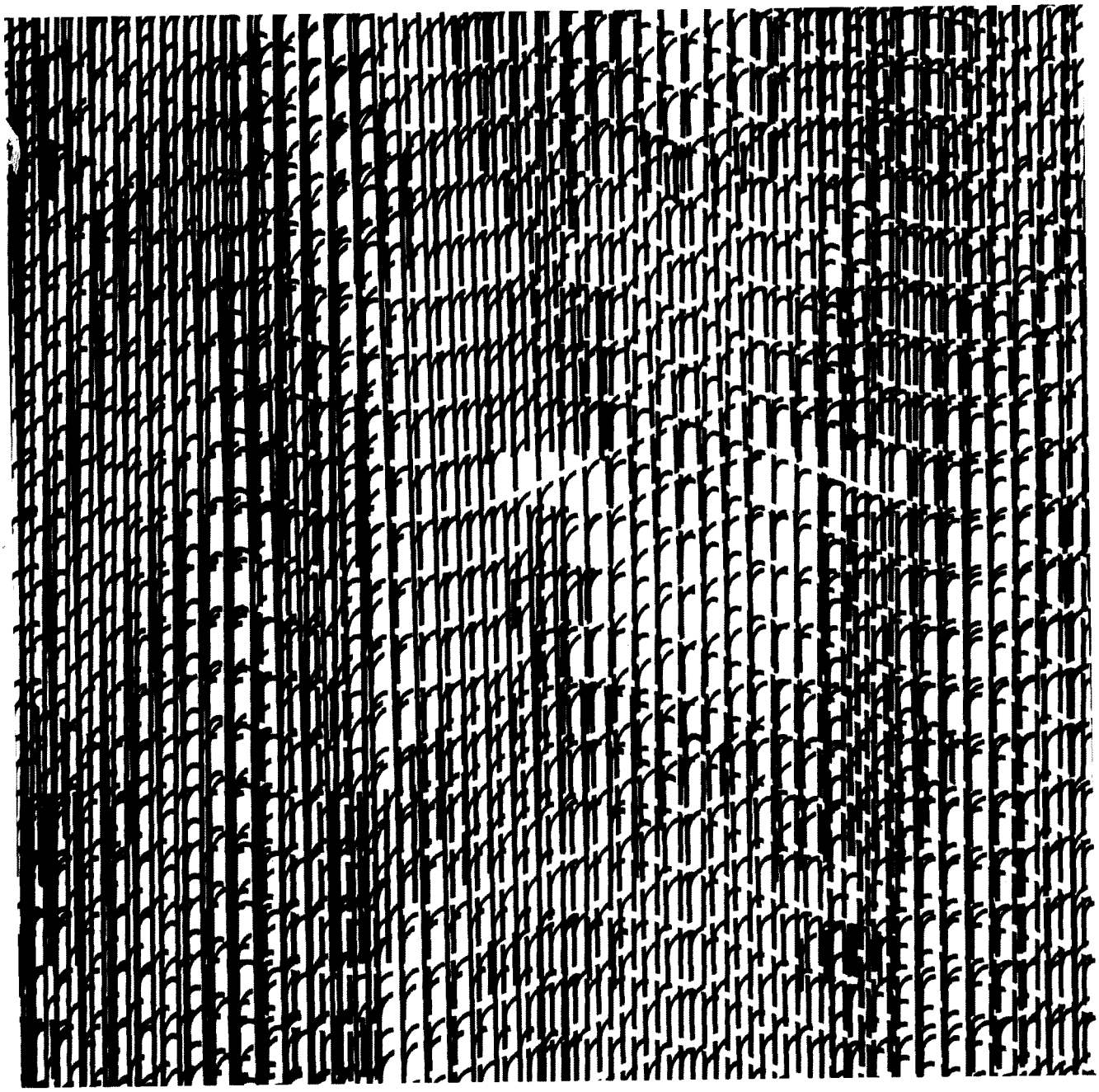

Fig.64: R net detail, Griffin, D (2010)

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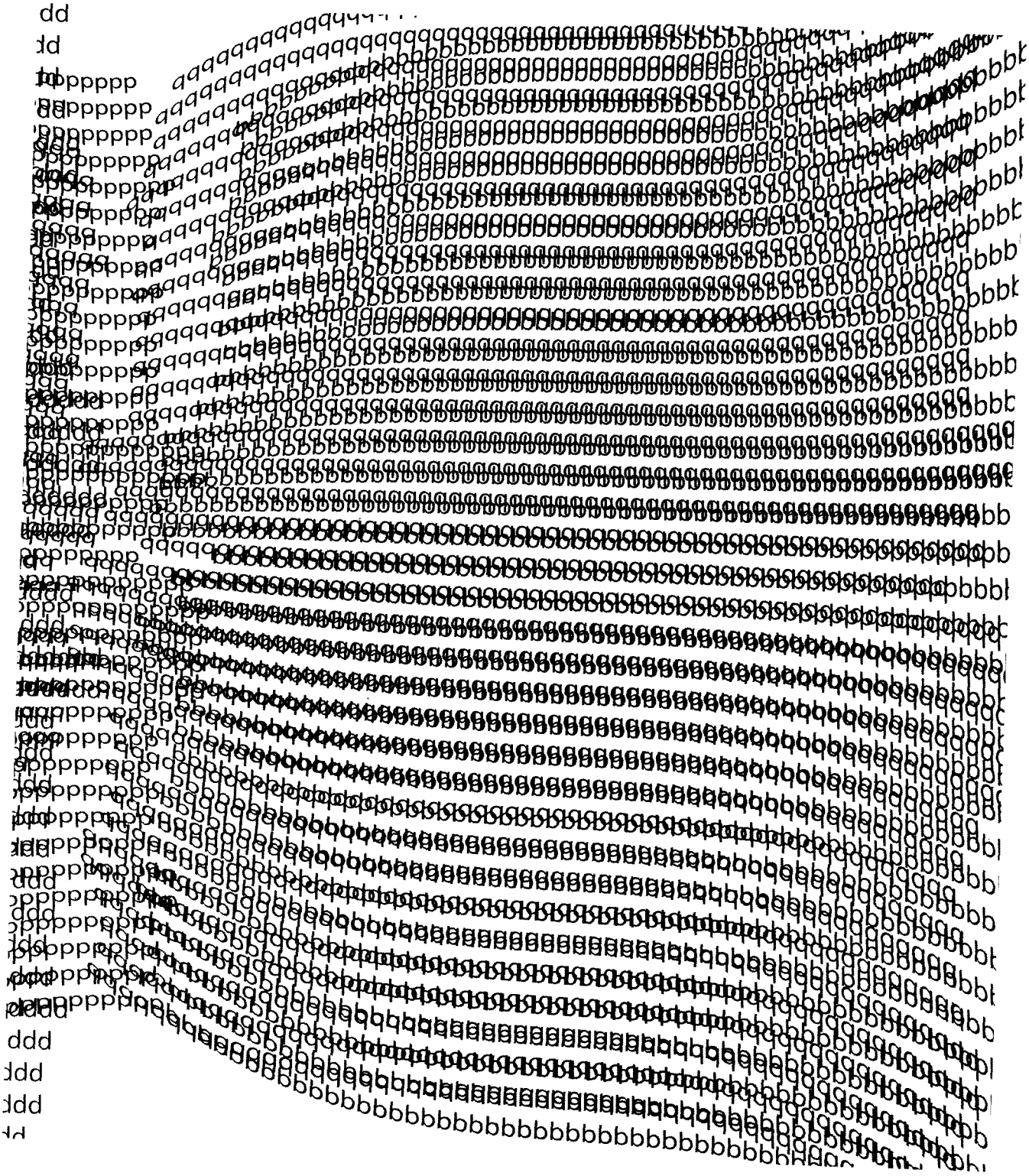

Fig. 65: bqpd (detail); screens of the letters 'b, p, q, and d' are woven together. The physical resemblance between each of these letters, in the font style chosen, permits some strange effects, such as the merging of 'b' and 'p' to become a kind of 's.' This image was printed and exhibited at The Glue Factory, Glasgow, in May 2011. The print was 34x16in. Griffin, D (2011).

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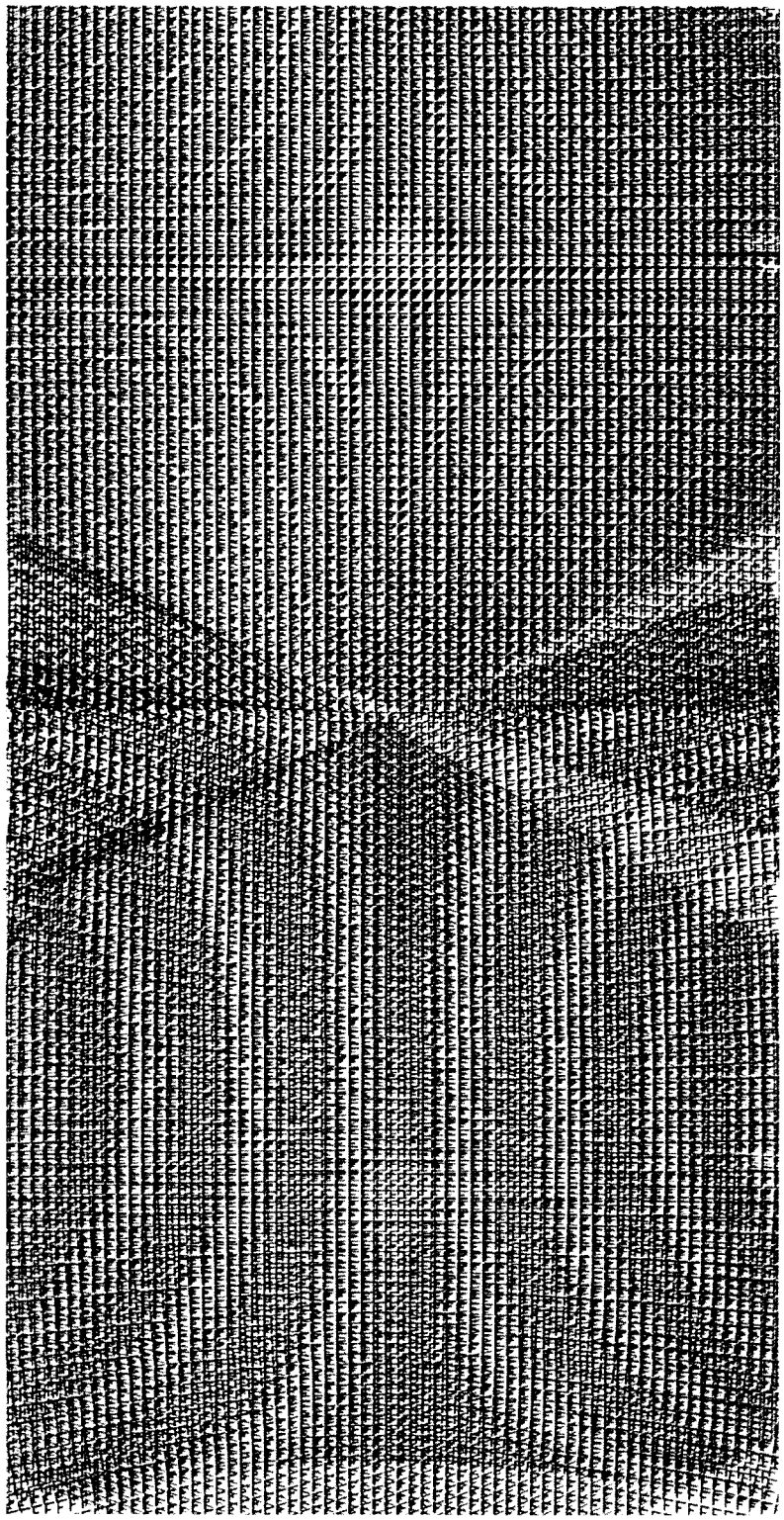

Fig.66: F web, digital drawing, This print (20x20in.) was exhibited at the Grace and Clark Fyfe Gallery at GSA, May 2010, Griffin, D (2010).

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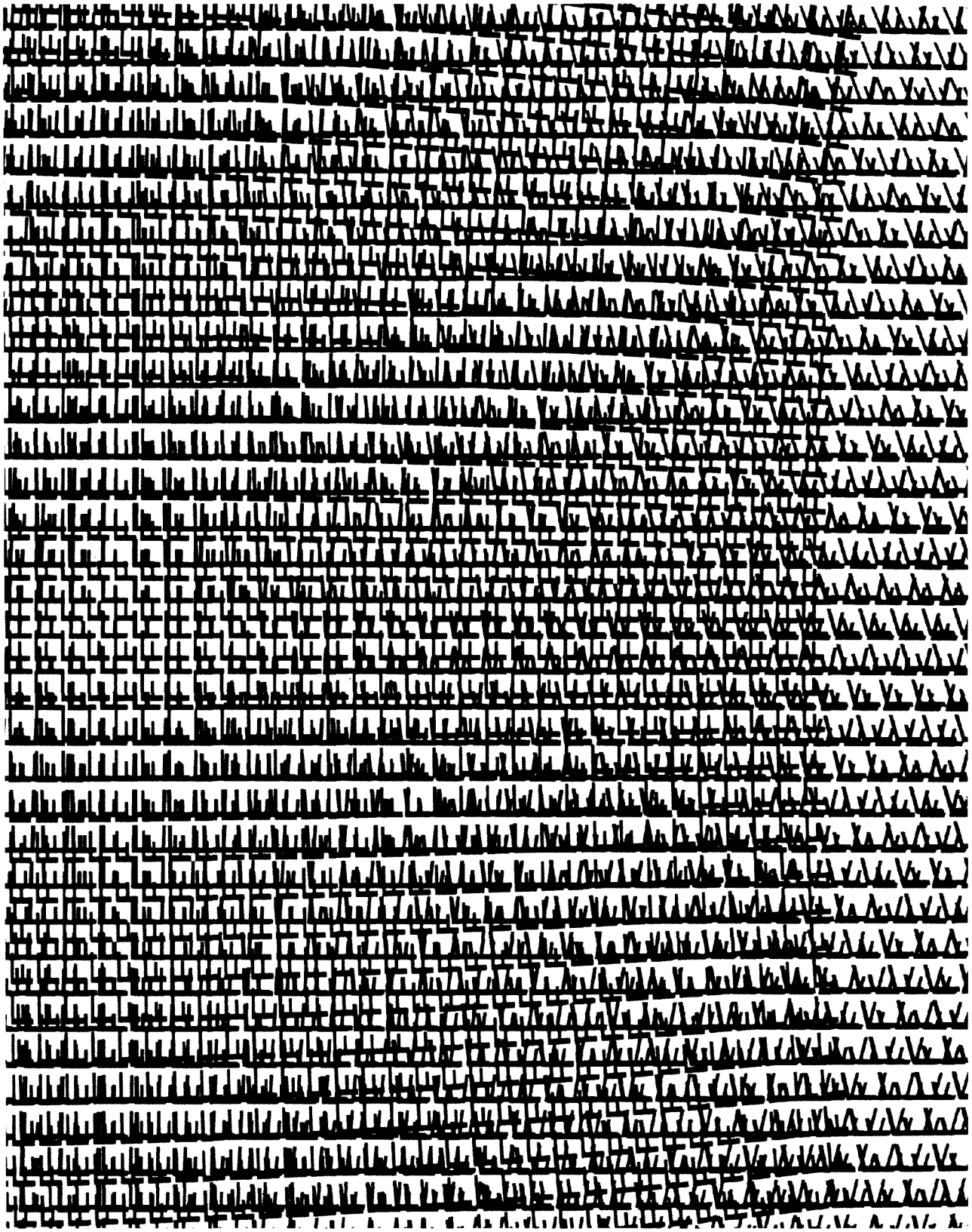

Fig.67: F web detail, digital drawing, Griffin, D (2010)

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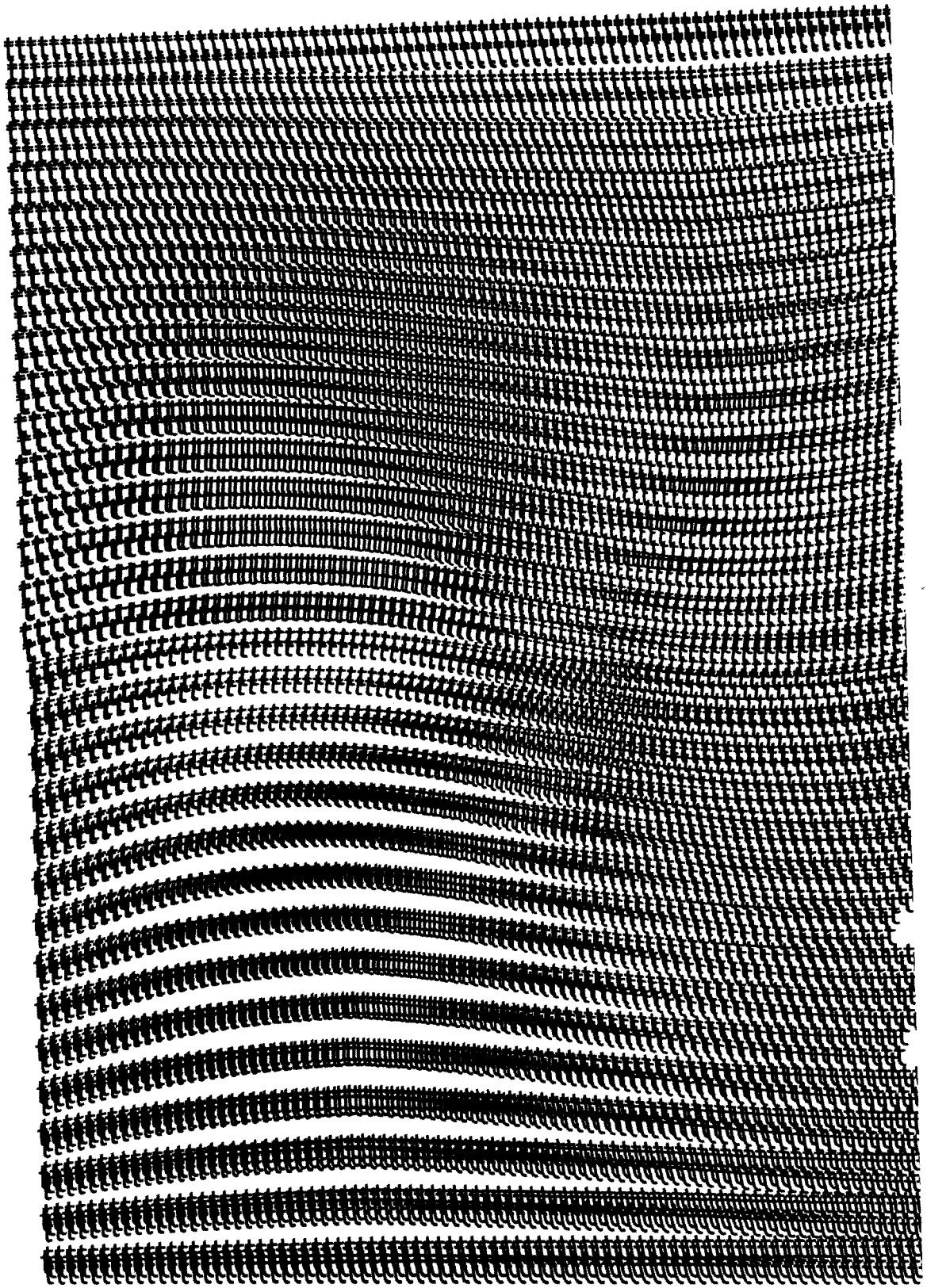

Fig.68: t, digital drawing, Griffin, D (2011).

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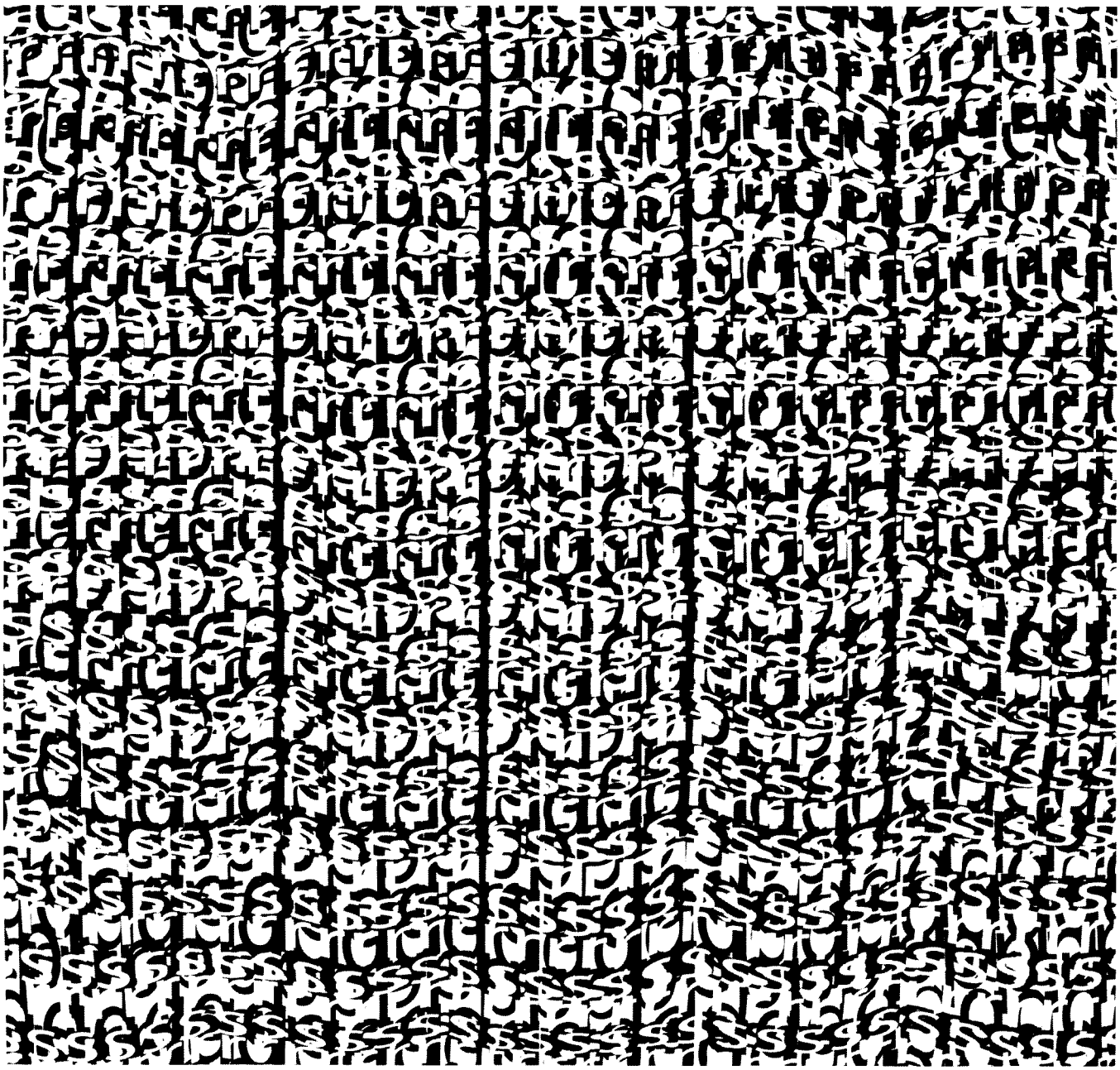

Fig.69: rs weave; four screens of black and white 'r' and 's' are woven together, and a figure-ground reversal becomes a texture; Griffin, D. (2011)

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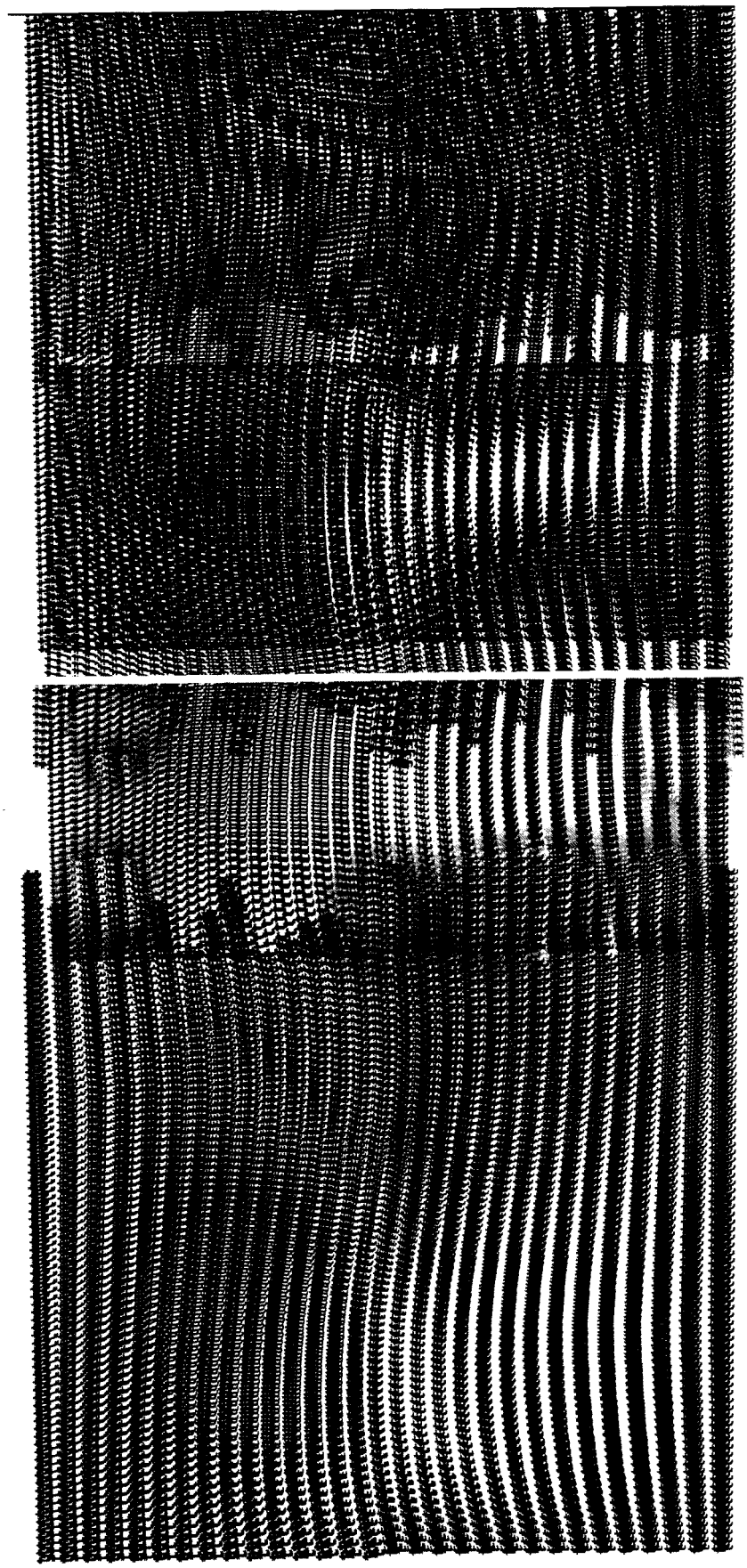


Fig.70: t squared; digital drawing, dimensions variable; a web of 't' becomes curved surfaces and folds; the image was printed at 34x16 inches, and exhibited at The Glue Factory, Glasgow, in May 2011; Griffin, D. (2011)

David Griffin (2011) Interference:

Fig.71: MZ; this image was printed and exhibited at The Glue Factory, Glasgow, in May 2011. I feel it worth reporting that the two small nieces of Dr. Laura Gonzalez (GSA) loved this piece most of all. It was printed at 36x36 in.; Griffin, D. (2011)

David Griffin (2011) Interference:

3.5. Study three : Anechoic chamber orchestra : plane and duration

Noise is a person... (Serres, 1982, p.51)

In this third study, graphical plane is associated with the musical concept of duration, broadly defined as the temporal dimension of musical experience. The reader should note that unlike the first two studies, which have been developed into music generating systems, this third notation is at a developmental stage. Therefore, the following report represents an element of action research, wherein problems and potential solutions are being drawn through and evaluated in journals and notebooks, and are provisionally reported. I argue for its inclusion simply because it finishes a thought that is at the heart of these drawing experiments – a correlative method of visual thinking between picture primitives and musical primitives -- and because this account exemplifies an essential value of drawing as a research method, which is to say, its discursivity and that curious quality of the sketch-space as a site for arriving obliquely at solutions, rather than driving toward them.

In this project, the word duration is understood in Cage's sense (1973, p.19) as the elemental time-factoring aspect of musical action, rather than the philosopher Bergson's more general conceptualisation, which gives us metaphorical images of rolling and unrolling spools, or the drawing out of an elastic point similar to Klee's walking line. Cage, a trained percussionist after all, saw duration as the prime order of musical action, subsuming more specific terms like metre, tempo and other aspects. In his work and his thought, both sounds and silence are given shape and meaning by duration, however un-determined; and whatever their sensible differences might be in the performance, they were divided unnecessarily by the conceptualisations and formalisation of Western musical practices (Cage, 1973).

The focus in this thesis is notation, and we look to re/construct relations between the thing and its sign. To that end, in a presentation-workshop which I conducted on these studies at the Drawing Research Network 2010 conference at the University of Brighton, the artist and academic Deanna Petherbridge interrogated my correlative choices in their implementations, finally asking why I had not chosen to examine duration and *line*, instead of plane, which seemed to her somehow more intuitively *right*, embedded as it is in both Klee's and Bergson's compelling analogies. Petherbridge was ultimately asking after a kind of embodied metaphorical

sense (which she felt would be shared by many) that the passage of time is a line. I responded that in the interest of perversity (a word I use in the sense of Poe's narrator in [2008, pp.105-110]), I suspected that while the rightness of the line/duration relationship is somehow more *obvious*, it masks weaknesses that would limit the possibilities for creative way-finding. However easily we may see the passage of time as a linear structure, Cage or Bergson's concept of duration is multi-dimensional. Duration is *passage;* line draws our attention to relations, but duration is the field in which those relations are traced.

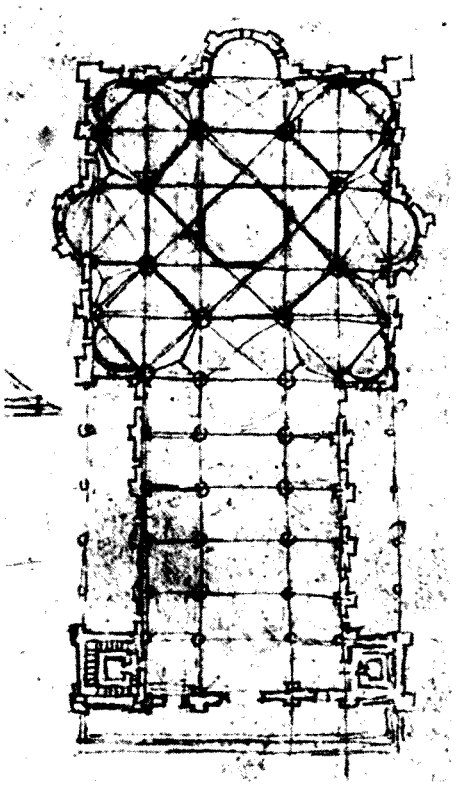


Fig.72: Two drawings of churches (detail), No.2 from manuscript B; a freehand plan-view of planar shapes indicating structures and organisation of built forms; Da Vinci, L., in Richter, J.P. [ed.], 1972, Pl.XCVI, p.134. Insitut de France, Paris;

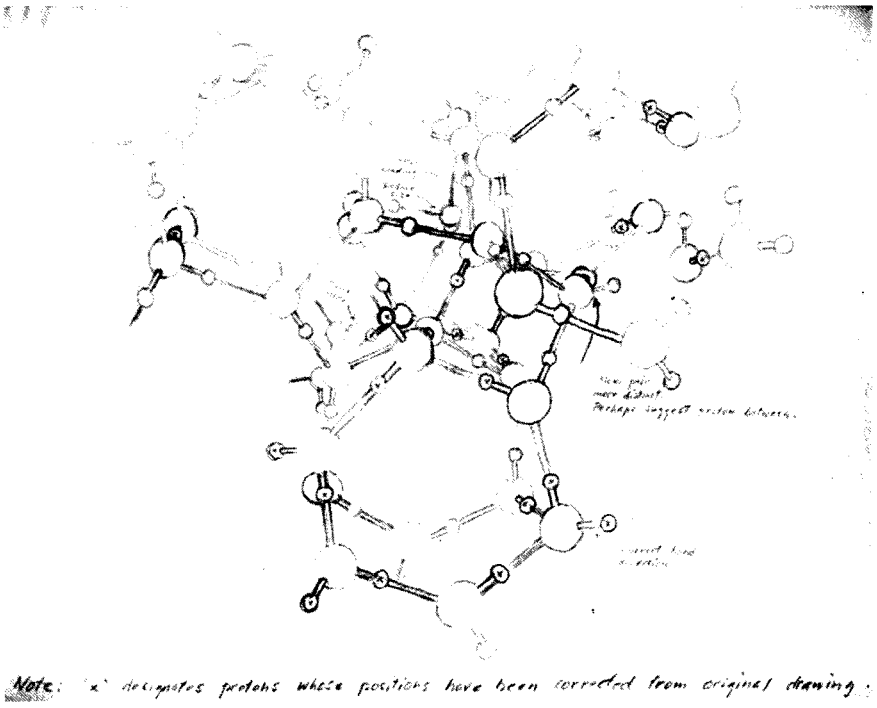


Fig.73: Annotated pencil sketch of the structure of ice; Hayward, R. & Pauling, L. (1964), 2010, Oregon State University Libraries, accessed 29/06/11 at <http://osulibrary.oregonstate.edu/specialcollections/coll/pauling/bond/pictures/1964b4.1-ice.html>

Now stepping back to Klee's pedagogy, he describes plane simply as a closed line -- a return, and the realisation of a symbolic third dimension in the graphic space. Planes show length, breadth and height, inscribed in projection as bodies in space, or topologically as relations. A simple shape may be suspended between articulation and density, in Goodman's

terms (1981), while a complex, inflected shape can set in motion a chain of references and interpretations. Planes *contain*, and therefore they embody an extra dimension of significance, specifying volumes and surfaces, or representing crystallisation, therefore growth, and the rhythms of organic systems: plane is virtual duration (Figs. 72 and 73).

3.5.1. Anechoic chamber orchestra

In addition, through a simple survey of Western art practices and writing on practice, an argument can be detected that all of the work of art orbits the body, irrespective of the discourse. This argument will not be reviewed here, merely observed. It is visible in the model and the mark conjoined in the life-drawing studio; it is audible in the marking of time by the beating of a drum, and in the voice as an exchange between inside and out. Once drawn out, this set of connections turned the trajectory of the research to Cage's well-known formative experience in the acoustically dead space of the anechoic chamber at Harvard in 1951:

> in that silent room, I heard two sounds, one high and one low. Afterward I asked the engineer in charge why, if so silent, I had heard two sounds. He said, 'Describe them.' I did. He said, 'The high one was your nervous system in operation. The low one was your blood in circulation' (in Kahn, 1997, p.581).

Within an environment of putative quiet Cage heard the sounds of his living -- the systems within his own body, framed by the engineer's metaphors of high and low. It was a hypothetical silence permeated by a vitally stochastic composition; neither silence nor music, properly speaking, and yet both.

In the study developing here, therefore, a notation system factoring time and space as embodied processes will be explored: not some abstraction, but the actual corpus as an organic regulatory system and an instrument of musical expression. Just as the sectional parts of a chamber orchestra are drawn out on the page, and drawn together in the performance, our circulatory, digestive, nervous, and respiratory systems generate a composition of the self. But in the argument of a notational system, how do we represent such things? Piero Della Francesca's use of design-drawing conventions (Fig.74) treats the head as a three-dimensional surface to be plotted, allowing us perhaps to flatten the surface out in a Mercator projection, or some other

cartographic convention. Meanwhile, the common music notation inscribes most durational information as textual or phatic addenda somewhere along its horizontal axis. Surveying directions for this developing study, then, I can see cross-disciplinary interactions with visualisation and sonification systems (for definition see Yeo and Berger, 2005; Barrass and Kramer, 1999) as graphical resources, taking a measure of the systems of the body as an opportunity for scoring.

As for performance, every pulse and breath constitutes a performance according to such a scoring system; every word spoken is an expression of the cognitive system; every minute of bodily function is a minute of music. It will be a most purely stochastic system, perhaps the purest, and with the data I will have a score for performance of the sounds and images of that process – my physical process, written as music.

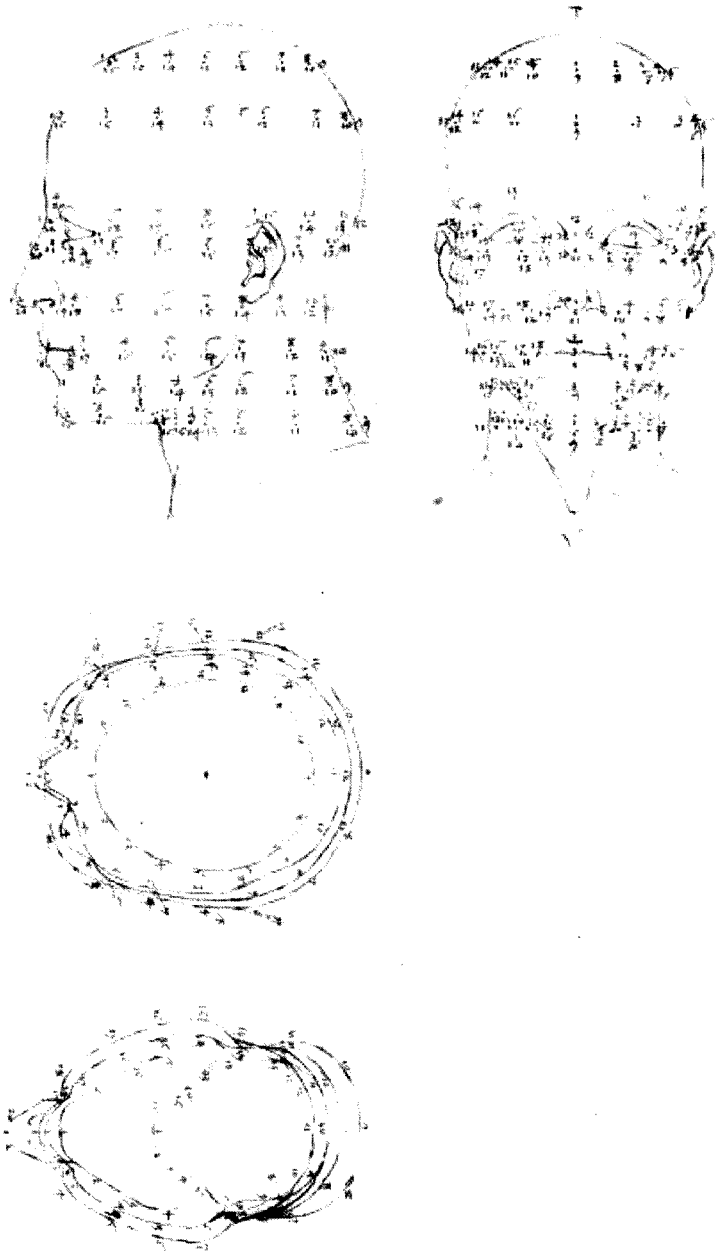


Fig. 74: *De prospectiva pingeni*; *Book 3, figure lxiv*, Della Francesca, P (c. 1470-1480), Biblioteca palatina di Parma, 2006, Scala, Florence / Art resource, N.Y.

Early in the research for this thesis, I speculated on similarities between the common music notation and multi-view projective orthography (of which this drawing by Piero Della Francesca is an early specimen). In Schott (2008) the author considers the state of the art of contemporary neuroimaging practices, noting that key modern brain-imaging conventions are technologically rendered extensions of Piero's orthogonal method, as described in his text *De prospectiva pingeni*. In this figure, Piero draws plan and elevation views of the human head, with 128 coordinate points over eight sections, through which contour lines could be traced. He developed this method to represent the head in space, with all its rotations and tilt angles. This is a use of projective drawing practices, uniquely applied to the dynamic body, and by extension, any complex three-dimensional form. What would it take to orient this visualisation method towards organising the sounds and pulses of the body?

. Study four : Ut pictura poesis

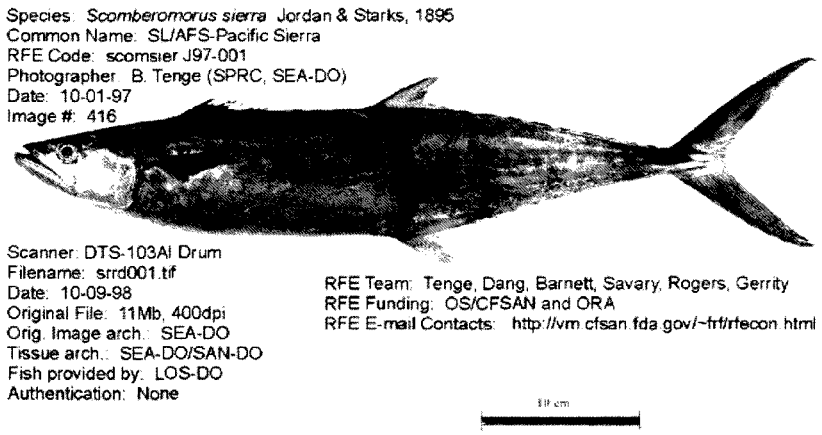


Fig.75: The sierra; Regulatory Fish Encyclopedia: U.S. Food and Drug Administration, Comsier, S (2010) J97-001, 1993-2009.

> We could, if we wished, describe the Sierra thus: "D. XVVOL.II-15-IX; A. VOL.II-15-IX;" but we could see the fish alive and swimming, feel it plunge against the lines, drag it threshing over the rail, and even finally eat it. And there is no reason why either approach should be inaccurate. Spine-count description need not suffer because another approach is also used. Perhaps, out of the two approaches we thought there might emerge a picture more complete and even more accurate that either alone could produce (Steinbeck J, Ricketts E, 2001).

This fragment, pulled from a hybrid work of documentary and literary writing by the American novelist John Steinbeck and his partner, the marine biologist Ed Ricketts, seeks to exemplify a balanced interaction between enquiries of art and science, and offers us a cascade of images that reflect the categorical requirements of the technician, the tinkering of the novelist, and finally, the desire to eat. It is a triangulation which ultimate objective is understanding, communication, and then living. In these few sentences, Steinbeck shows us a map of the fish in the coded language of numeracy, but also a representation of experiential, physical dimensions: What is it to see, to struggle with, to haul in, and finally consume the animal? Ricketts would point out that statistical summations -- character-string notations -- are conventional and powerful elements of our experience of things and the communication of those experiences, yet for Steinbeck and his fisherman, such descriptions cannot tell the whole story. They represent a specific kind of reasoning as much as they do a fish, and the novelist suggests this

incompleteness might be resolved by retrospective and analogical approaches from the mind's eye of the hunter, and the novelist. Once again, 'Our disposition to language and mentation (reason, emotion and so on) is a disposition to commune,' asserts Cubitt (1997, p.43), and if it is true that the object of all formal inquiry is understanding, then Steinbeck and Ricketts – novelist and biologist – are simply engaged in dialectical extensions and admixture of their disciplines for that: to include the sea and the struggle to better know the fish.

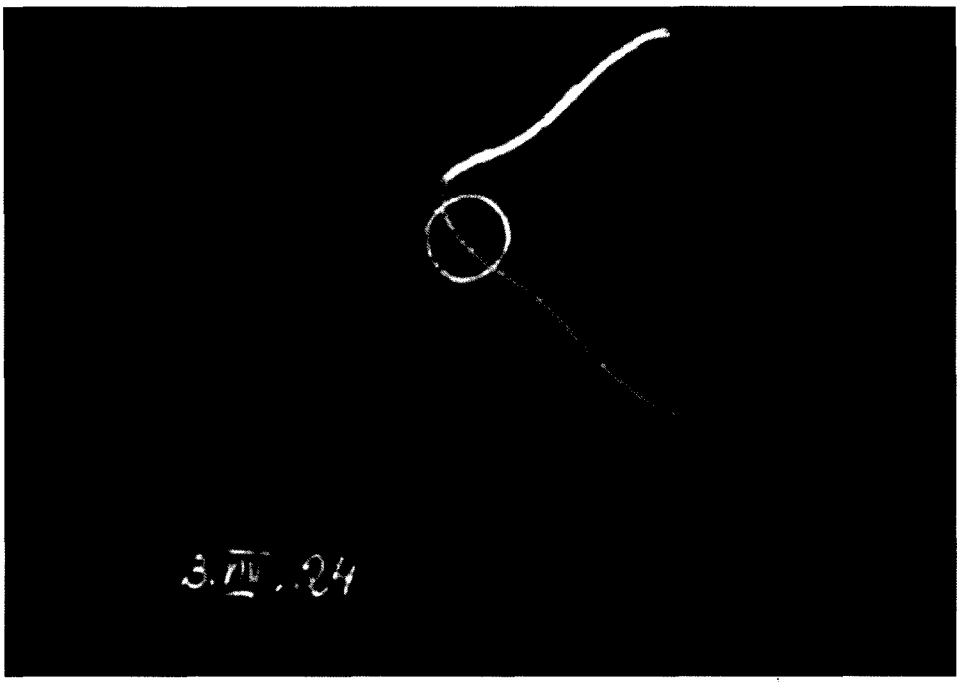


Fig.76: The Realm of the Angels; Steiner, R. (1924). Steiner visualised his philosophical speculations on chalkboards as a lecture supplement. This particular chalkboard drawing happens to be a passable analogue to the drawings proposed in this equally speculative, but more technical research project. Collection of Rudolf Steiner achlassverwaltung, Dornach, Switzerland.

The focus of the research in this thesis is a study of notations as environments that integrate symbol systems, extending compositional logics to pictures, sounds and movements, and permitting us to create the conditions for innovative performances outside the frame of the notation. Our uses of external representations provide us with scaffolds from which we can build, synthesise or even test out these speculations: They extend 'our mind's ability to visualise' (F&S, 1999, p.118). Out of this work -- in fact, as a direct response to insights derived from the literature review for the taxonomy -- a drawing project is developing with intriguing possibilities for interdisciplinary action. These drawings will be graphical applications of certain

technologically sophisticated tools normally used in measurement and industrial cutting or incising tasks: the coherent light of laser, here used for its linear values -- a kind of pure line applied not to paper, but to the geometry of space itself as support, in what I regard as a seeking-out and marking-up of a series of impossible proportions (Fig.76).

3.6.1. Word and image

W. J. T. Mitchell offers Lessing's Laocoön as a text that seeks to illuminate the relationship of time and space in the sister arts of painting and poetry (1998, p.95-115). Held in the head, so to speak, such graphics amount to interleavings of time and space, soiling Lessing's well-known literary distinctions between the dimensions of representative action that distinguish the visual and verbal arts. They are intended as programs of creative practice that push to an extreme the values of inscription as a mechanism of exchange between dimensions, acknowledging that, as with Steinbeck's/Ricketts' fish, no single representation can tell the whole story. Although not absolutely fixed, even for Lessing, Mitchell reviews the philosopher's distinctions, which are bound to an opposition of idealisations: in Lessing, painting and sculpture are spatial arts, primarily of the eye and directed in their significance by our perceptions of the spaces in which we move; while poetry is an interior art of time and passage. Dismissing this as a categorical mistake, Mitchell writes:

> Works of art, like all other objects of human experience, are structured in space-time, and... the interesting problem is to comprehend a particular spatial-temporal construction. A poem is not literally temporal and figuratively spatial: it is literally a spatial-temporal construction (Mitchell, 1998, p.103).

The critic argues against Lessing's schismatic relation as an ideologically motivated trap, and a utopian hectoring directed at those at work with aesthetic theories, also noting that the word-image dialectic sustains itself as a matter of interest in a range of contemporary contexts informed by digital practices and theoretical currents which tend to dissolve the kinds of artificial boundaries Lessing proposes, in spite of demands for coherence and consistency.

Nelson Goodman's project in 'Languages of art' suggests that there are, in any case, few resolute distinctions to be drawn between pictures, diagrams or words, *qua* inscription. In his

analysis, representation is always a mixed engagement: words and pictures mingle unbidden, and any attempt at a 'pure' expression is problematised from the outset. As a matter of practice, then, how might we reconstitute Lessing's dichotomous relationship from a post quantum-mechanical perspective which he could not have anticipated? Such a question is enough, from the point of view of the artist-researcher, to begin to explore working processes that might take into account the strangely enhanced horizons opened to us by new technologies, the deeply integrated technical and computational perspective through which we may re-view them, as well as renovated notions of what constitutes an image worth considering (Elkins, 1995). Such a start may also allow for something of the kind of wandering, heterogeneous art-making which is at the core of Nicolas Bourriaud's conceptions for contemporary art discourse (2009).

3.6.2. Drawing into space

We should begin by remembering Ittelson's characterisation (cited in Appendix I of this paper) of a mark as an artefact of human intention, "decoupled" from its real-world source. Among other things, this drawing research project will show this decoupling to be deeply and perversely problematic. I have put the title "Ut pictura poesis" to the two principle drawings discussed here, after another ancient, analogical project, which considers the relationship of poetry to pictures, as an alternative to the sound-vision dialectic of the other drawing projects.

The first of the two drawings proposed is composed of a one-second burst of Laser, aimed at the centre of our Milky Way Galaxy (Fig.77). The line drawn will thus have approximately 300,000 kilometres of length to consider, and will result from a series of technical questions related to orientation, distance, and other physical matters, in support of an event that takes one second to begin, and something on the order of 25,000 light years to complete, assuming completion is possible (Masetti, 2008; Fig.78). Remember that researchers in technical disciplines, as users of data and information visualisation systems, are often tasked to describe what seem to be irresolvable conditions and an array of processes that are far easier to enumerate than to illuminate, and which tabular approaches do little to clarify. Key studies in visualisation practices have established that simple node-link graphs are critically useful in such tasks: their portability, flexibility, and collaborative qualities make them most persuasive and probing tools, bridging theory and practice, and extracting some measure of sensible reality

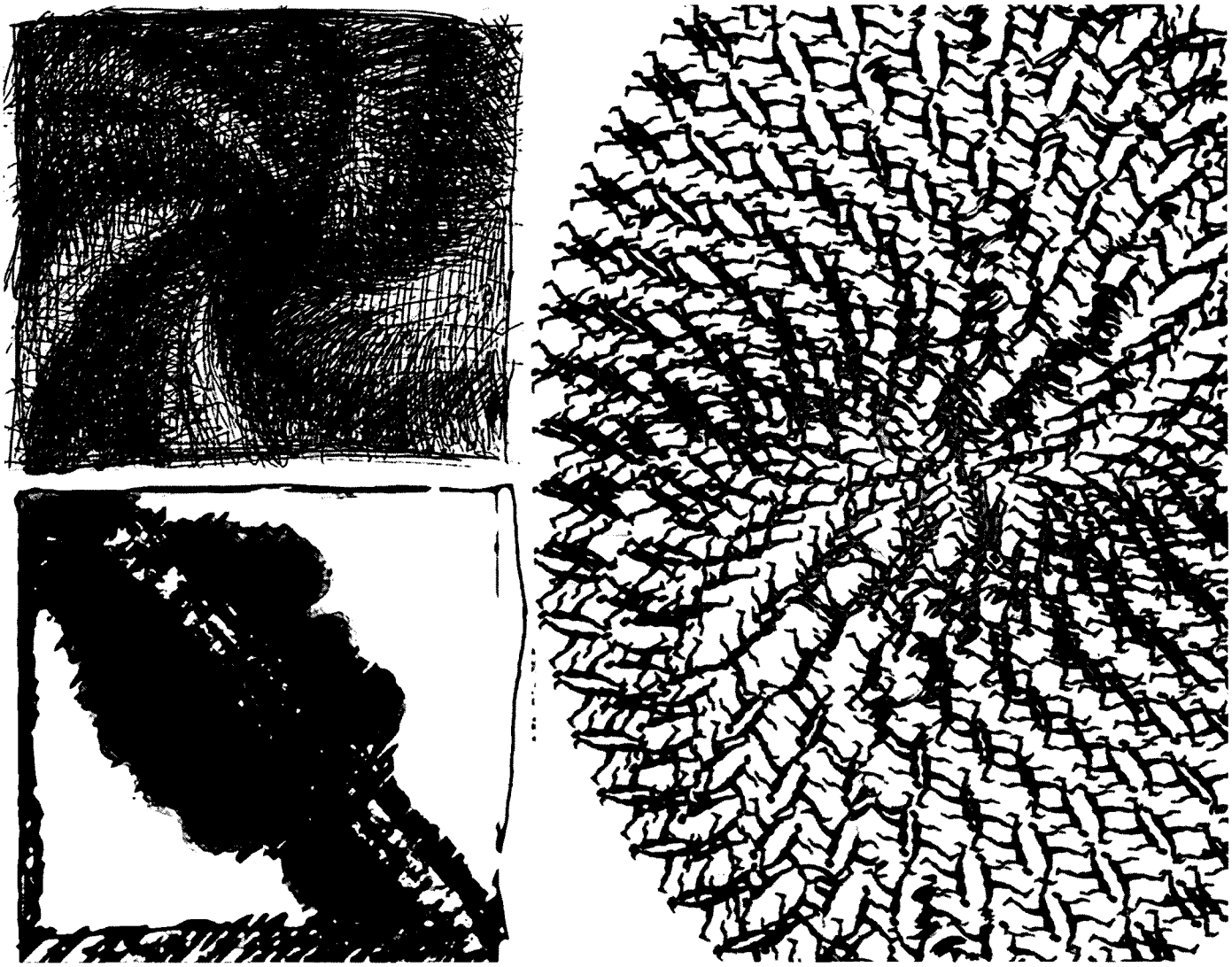


Fig.77: Ut pictura poesis; a multi-view projection of the Milky Way galaxy. From the research journals of the artist; Griffin, D (2009-10). This is a composite ink and digital drawing showing a section, plan and auxiliary view. An orthographic projection of such an ephemeral thing will be a compound metaphor, built on a drawing-dependant predisposition towards simple image-schema.

from otherwise invisible entities (see Ware, 2008; Tufte, 2001; Smith et al, 2000; Krohn, 1991). Latour has written that 'the simplification of the universe, both in terms of the qualitative diagram and in terms of the small and well-regulated language, makes inspection of the entire universe possible. Hence, 'generality is made possible' (citing Netz, 2008, p.454). This drawing will test that observation. It is a node-link diagram, meant to enable graphical thinking on complex problems, inscribed in a context where their pragmatic utility is met by senselessness; the simplest of modelling systems, in other words, drawn to scales that are actually incomprehensible.

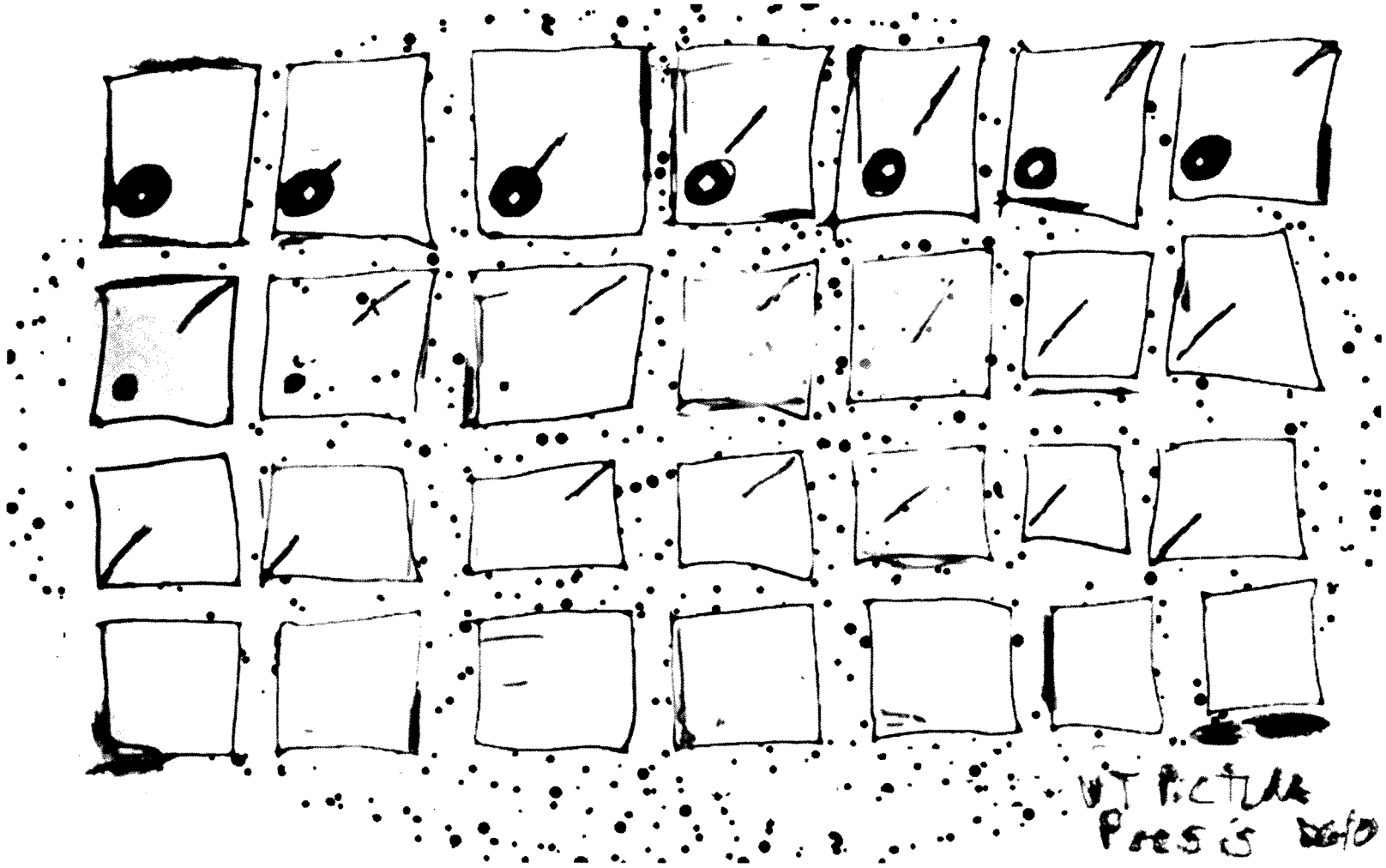


Fig.78: Ut pictura poesis, developmental cartoon; ink on paper, 6 x 4in. In this drawing, a set of narrative panels depicts a line emerging from a circle. The line travels away, bisecting each panel, to end at an irresolute ending; from the research journals. Griffin, D (2010).

The second and much smaller (briefer) drawing will draw a semantic network between our planet and the other planetary bodies in our immediate space (Fig.79). This is also an absurdity in fact, delivered in the soft fiction of metaphor. As a coordinated, collaborative drawing, each of the lines drawn will link us directly to those seven familiar, mythically charged entities with which we share our local physical space, and this semantic network will have the additionally absurd property of anywhere from seven to ten billion kilometres of linear length. Among other things, the very idea of scale and scaling is thus muddied, and like Steinbeck, we must seek refuge in a cascade of numerical and literary views on the problem, all of them facilitated by line (Fig.80). Topologically inscribed, and in conversation with scientific and mathematical inquiries, these drawings will become diagrams with impossible phenomenal and conceptual characteristics -- lines made on surfaces, but the sum of those lines and surfaces will be decisively uncertain. They will be seen only in retrospect, in the mind's eye, as tests of intuitive thinking on unattainable dimensions, thereby generating a number of questions about the relationship between artistic and scientific knowledge, and how these disciplines can actually engage. Through the use of the simplest of data visualisation strategies – a graph writ large – we may derive an object-lesson about irresolvable conceptual realities; and as drawing research, the project will encourage interactions with other fields in support of a gesture whose existence is equally a matter of time and space.

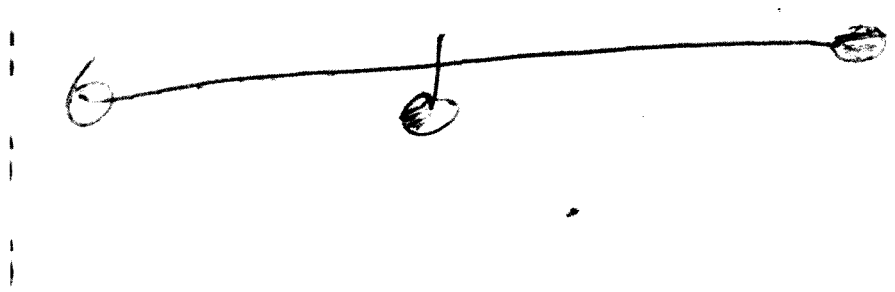


Fig 79: Ut pictura poesis 2: developmental sketch for the second of two LASER drawings; ink on paper, 6 x 5in. From the research journals of the artist; Griffin, D (2009-10). A colossal node-link diagram will be constructed, forming a connection between our planet and the others in our "local" space; this diagram gives us a semantic network that expresses coherent relations, with incoherent predicates -- not least of which is that the Earth is "central."

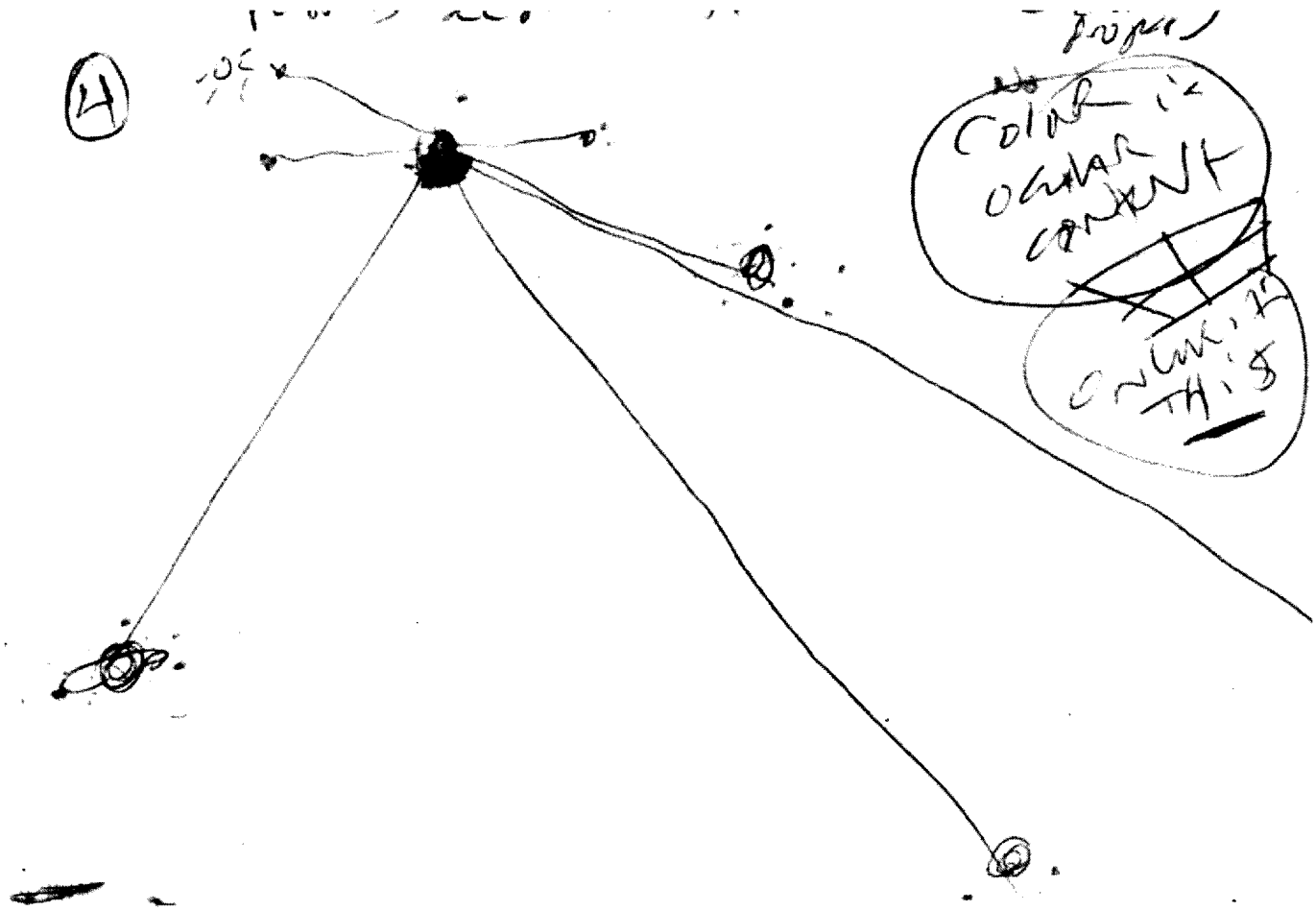


Fig 80: "Ut pictura poesis 2:" developmental sketch for the second of two laser drawings; ink on paper, 3 x 1.5in. From the research journals of the artist; Griffin, D (2009-10). This very small notation shows a schematic entity-relationship graphic, and it also represents the "Eureka" moment from which the much of the theoretical and practical direction of this creative practice research project developed.

3.6.3. Entity relations

Leonardo Peusner has asserted that a key method in visualising non-visual information has been the node-link graph: its entity-relationship modelling provides a tool for recording and understanding relationships, from 'molecular skeletons in chemistry, (to) particle interaction, and thermodynamic networks' (2002, p.33). Peusner describes their usefulness in plain terms as allowing us to represent structural, logical or sequential information without the need to use "real" math. Meanwhile, behavioural scientist Laurence Smith (et al, 2000, p.85), citing Lynch, has written that graphs are "revelatory objects that simultaneously analyse what they reveal."' And despite an absolute *in-visibility*, the set of drawings I am proposing here are graphs in this sense. Through their application onto the tangle of misrepresentations and distortions which have grown in the spaces between what I know and what I do not, or can not know, those who

see the drawings have an opportunity to examine intuition as a rational response to unreasonable quantities. This is Steinbeck's notion of a cascade of representations applied to a kind of absence, rather than a kind of fish.

At the scale of human experience -- best measured in handfuls, and footfalls -- it may not be possible to comprehend those distances at either end of the range between atomic and astronomic spaces. Our very scale seems to prohibit the direct mapping of physical behaviours from our experience onto subatomic structures. We are prisoners of this incomprehension such that it is problematic even to apply metaphorical terms to our situation (Dawkins, 1999). However, as a useful external aid, we can hold in our hands and look upon diagrammatic representations like Bohr's model of the atom (Fig.81). In the task of bringing physics and perception together, the scholar Arthur Miller has thoughtfully observed that Bohr's notation gives palpability to ideas with troubling implications, allowing an intuitively embodied grasp of physicality for what may never be anything more than a theoretically inscribed entity. 'Clearly, any visual imagery of atoms could not be of the sort produced by a combination of our perceptual systems and cognitive apparatus' (Miller, 1995, p.186). The Bohr metaphor nonetheless remains lodged in our imaginations as a spent image, a traction-free argument, now recycled as a simple display graphic or iconic logo in corporate or industrial contexts, which allows us to see a truth about things we can never perceive as factual, but only in estimation.

Since the shiver of uncertainty has had to be incorporated into the aims and expectations of the physical sciences, those of us who wish to grasp the operative principles of matter and light have had to abandon Bohr's schematic representations. In the wake of quantum mechanics other models have developed which take a node-link graphical turn to order questionable logical relations. The Feynman diagram (Fig.82), named for the physicist who developed their reductive, chalkboard graphism from his quantum mathematical figuring, visualises the non-intuitive interactions of atomic things. Through its use we may engage with relations that are more reliably described in the arcane proofs of mathematical discourse, but which are made tangible -- more real, even perhaps for Feynman -- in his spatialised inscriptions. Quantum mechanics, after all, provides an infamously bizarre set of questions to be addressed. Crossing bridges in Königsberg, as Leonard Euler attempted to do without doing, is the least of our problems in this particular problem set (Carlson, 2009). But as in Euler's

solution (discussed later), given the premises, the diagram becomes both a view on and a description of its intractable problems.

Seeming to refer directly to the word and image dialectic in the context of a Feynman diagram, the physics professor Milan Jaros writes that 'paradoxically, both theoretical physics and poetry not only share the common origin (in divination and cosmogony) but - as it turns out - the common fate in that today they both explore "credible impossibilities" via narrative structures' (2005, p.7).

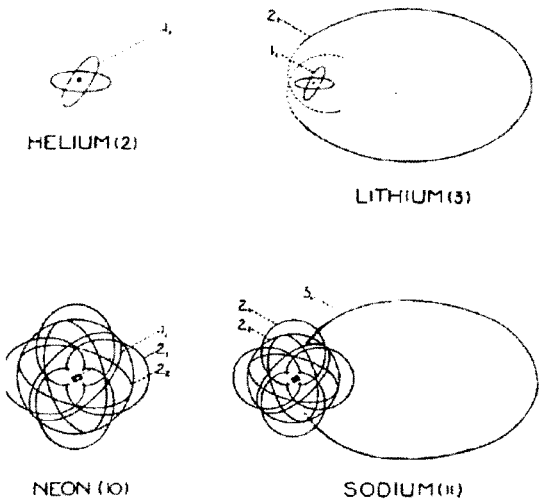


Fig. 81: Schematic depictions of atomic elements; with florets as embodied metaphors for physical interactions (from Miller, 1995, p.185).

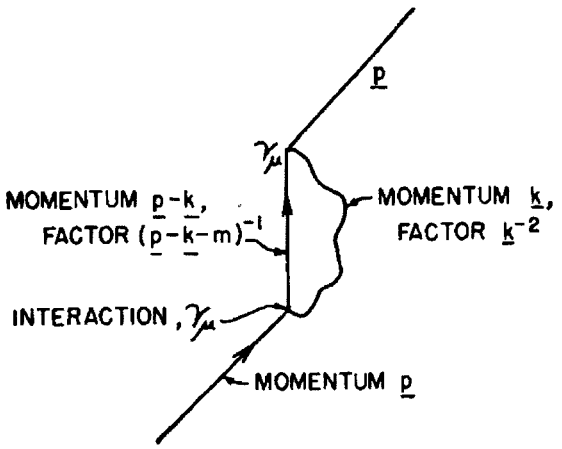


FIG. 3. Interaction of an electron with itself. Momentum space, Eq. (11).

Fig.82: A diagram representing elementary particles and their interactions, from Feynman, R. P. (1949).

3.6.4 Taking a measure

In the modeling of physical knowledge in the inscriptions of Bohr or Feynman, or the life-drawing studio, or even the use-free casting of the number of lines of coherent light which are described here, it is difference rather than depiction that is the thing. There will need to be a range of consultations and computations undertaken for these differences to be integrated into a drawing research context – for the lines to be enacted; and moreover, there must be a pragmatic recognition of infeasibility built into the work. This futility reflects some measure of the general condition of representation, at least from the perspective of either the painter or the poet (I am

unable to speak for the cosmologist). Certainly if there is beauty in them, it is in their very impossibility. As components of a drawing-research project, the actual inscriptive acts will be measured in time: they are thus works of visual art that are, contra Lessing's distinction, equally temporal as spatial, and like the Bohr model, may retain some form of existence in the mind's eye only if luck prevails, long past their post date.

We may enter into additional flows of metaphor, asking questions about the relative direction of "the centre" of the Milky Way Galaxy, both here and now, and so long from the moment of the line's enaction. Where and when, exactly, shall we point our line-maker into space-time? How long must each line be in order to form a continuous connection between us and any of our planetary neighbours (a question with at least two correct answers)? Exactly where is this drawing? What is the significance of an external representation with which we are prohibited from interacting, not because it is hidden away but because it is beyond us? Moreover, what is the relationship between such a drawing and its putative object? Is it good? Is it a hypothesis? Does it provide variables and experimental frameworks for discourse? Are these entirely rhetorical drawings? How are we to judge their success or failure as plans, as ideas, as propositions? How, in other words, can such a thing become an integrated component-practice of research, become legible? More practically, is there a window of opportunity through which we might connect ourselves to all the planetary bodies on the same evening, opening up the possibility of another conclusion devoutly to be wished -- that is, a multi-national coordinated drawing activity?

Finally, leaving aside any earth-bound obstructions, we must answer questions about diffusion, or what might interfere with line-formation and coherence in those spaces lying between the nodes of these enormous edges. Furthermore, what are the odds of such an occurrence? And of course, there is the sweet likelihood that our current state of knowledge is simply inadequate, which will reveal the project as a mere phantasm of a worldview. The spine-count of Steinbeck's Sierra can be adequately measured, after all, with the edge of a knife, but how to apply the knife to something which dimensions we cannot see, nor even really intuit?

In an informal response to a presentation of these drawings at the RMIT/UAL Drawing Out 2010 conference in Melbourne, Australia, the painter Stephen Farthing described them as

"rhetorical," and while possibly true, the drawings nonetheless suggest a rich vein of epistemological as well as merely technical questions, with intriguingly unstable answers – certainly a vexed condition to which any productive art practice aspires. But they are not merely rhetorical. They will be drawn in fact; and then the meaning of that expression is confounded, joining others in the wake of this drawing research. They are pictures, but are free of aesthetic qualities insofar as they cannot be directly apprehended, or at least not for long. But they are also free of use, that is, they are not representative, cannot exemplify or denote anything but some view on our own limitations, and of course they may be utterly wrong. As external representations with which we cannot interact, they will represent things that are quite un-representable.

'Pyramids, cathedrals, and rockets exist not because of geometry, theory of structures, or thermodynamics, but because they were first a picture,' wrote technology historian Eugene Ferguson (1977, p.827; Fig.96). Now if we recall Steinbeck's suggestion that 'Perhaps, out of several approaches, there might emerge a picture more complete and even more accurate that any could produce on its own,' by means of mapping operations with both visual and literal properties – and the hub of which is "us"-- there might emerge an opportunity to give voice to unsayable things, and perhaps to say by showing. As drawing research, the project will rely on technical and social interactions and communication, in support of a gesture whose existence, such as it may be, is equally a matter of time and space, and moreover, of fantasy as a function.

Chapter four: the taxonomy

4.1. Space and time inscriptions

Billions of galaxies are never bigger, when they are counted, than nanometer-sized chromosomes; international trade is never much bigger than mesons... (Latour, 1986, p.20).

Defined earlier as a kind of symbol-driven guessing game, reading is a cyclical complex, beyond the remit of this thesis to fully explicate, but performed in a more or less perfunctory way when levels of expertise are achieved. As a practice of thinking over representations, reading is subtle in procedure while converging towards the cognitive purpose, and in pursuit of this purpose, Paul Valéry suggests that the writer's work is not a mere application of words to thoughts, but a synthetic symbolic tuning in which there can be no optimal meaning dredged from a text (Tamplin, 1976, p.812). In this view, the principle must apply also to the re-actions of the reader: diving into language, as Serres has written, and then drawing through form and meaning, presumably to find the surface. It is a process comparable to other views of translation referenced in this thesis as dialogical work, and a transfer of understanding, rather than a cold mapping. In reading an inscription, we draw on contextual knowledge and the presence of perceptible attributes relating to distribution, regularity, and detail, and decide how to approach the thing – say, a tree -- then we diagnose/attribute/extract provisional meanings. We might recover the inscription's character in terms of a tree-picture (with some aspect of resemblance to the organism; a modal representation, with attributes specified in the display), or a tree-diagram (emphasising logical relations; an amodal representation of connectivity and sequence), or as a symbolic conveyance for the tree-concept ('connected with its object by virtue of the idea of the symbol-using mind' [Peirce, 1942, p.114]).

Like Latour's mediated scale shift from one impossibility to another, in the epigram above, acts of translation allow us to span the "'gap between a hypothetical perfect language and the concreteness of a living language'" (Ricoeur, in Kearney, 2007, p.152). And as Latour suggests, this thinking over the representation can equalise discrepancies, or bridge a vague idea to the tangibility of performance, or scale incomprehensibilities to the handfuls and footfalls of our limited mental spaces.

The physiological nature of our abilities to make such decisions cannot be examined in detail here, but in this taxonomical context, I argue that we ground our search for salience in the inscription in apperception of its internal construction, putting aside the

affordances and unruly potencies in the reading game. In drawing, of course, production and potential are only separable in theory. In practice, the representational, communicative, and instrumental roles go on together. The creative underspecification of sketching is an example of such a unified structural-functional enterprise. While it is frequently called an "unstructured" approach (for instance in Purcell and Gero, 1998, pp.389-390), this is wrong: the sketch is a search through structuring; it is as much building as finding. The analytical category of "structure" is therefore a fiction, but a useful fiction, grounding what we see in how we make.

Incidentally, as a critical preparatory and executive tool in making, we draw: sketching, relating, imagining, mapping, describing, depicting, showing, or saying. Aside from their functions, the markings in all of these practices are more or less projective or denotative, emphasising attributes or relations. Projection and topology quietly underlie Goodman's theory, as well as Tufte's, and they are a pan-historical pair between which flutters Elkins' woolly picture-to-notation array (in 1999, p.166), also providing contexts for distinguishing between markings as either accident or artifice (evaluated in a summary of expected notation characteristics, derived from Marshack, in Elkins [1996, pp.200-201]). However, the notation studies in Chapter three, informed by the disposition of the ontology, suggests an additional family which I will call Metric: relational diagrams, systems of systems – essentially the focus of this dissertation (Fig.101) -- each species of which uses some admixture of diagrammatic reasoning, iconicity, and the quasi-pictorial nature of character-strings (Elkins, 1999, pp.135-137) in order to map a space of time. Hybrid systems such as the music notation have been insufficiently accounted for in other taxonomies, tending to be subsumed either into categories of diagram, or as in Farthings' "*Plan de dessin*" (2006), to be vaguely associated with an unwieldy number of relations -- their complexes misunderstood, and so thrown down as a kind of hub. As a contribution to the multi-disciplinary dialogue around the music notation, I have attempted in this thesis to more specifically inspect it as a drawing, to show clearly its relationship with other drawing or drawing systems, and uncover how the system operates.

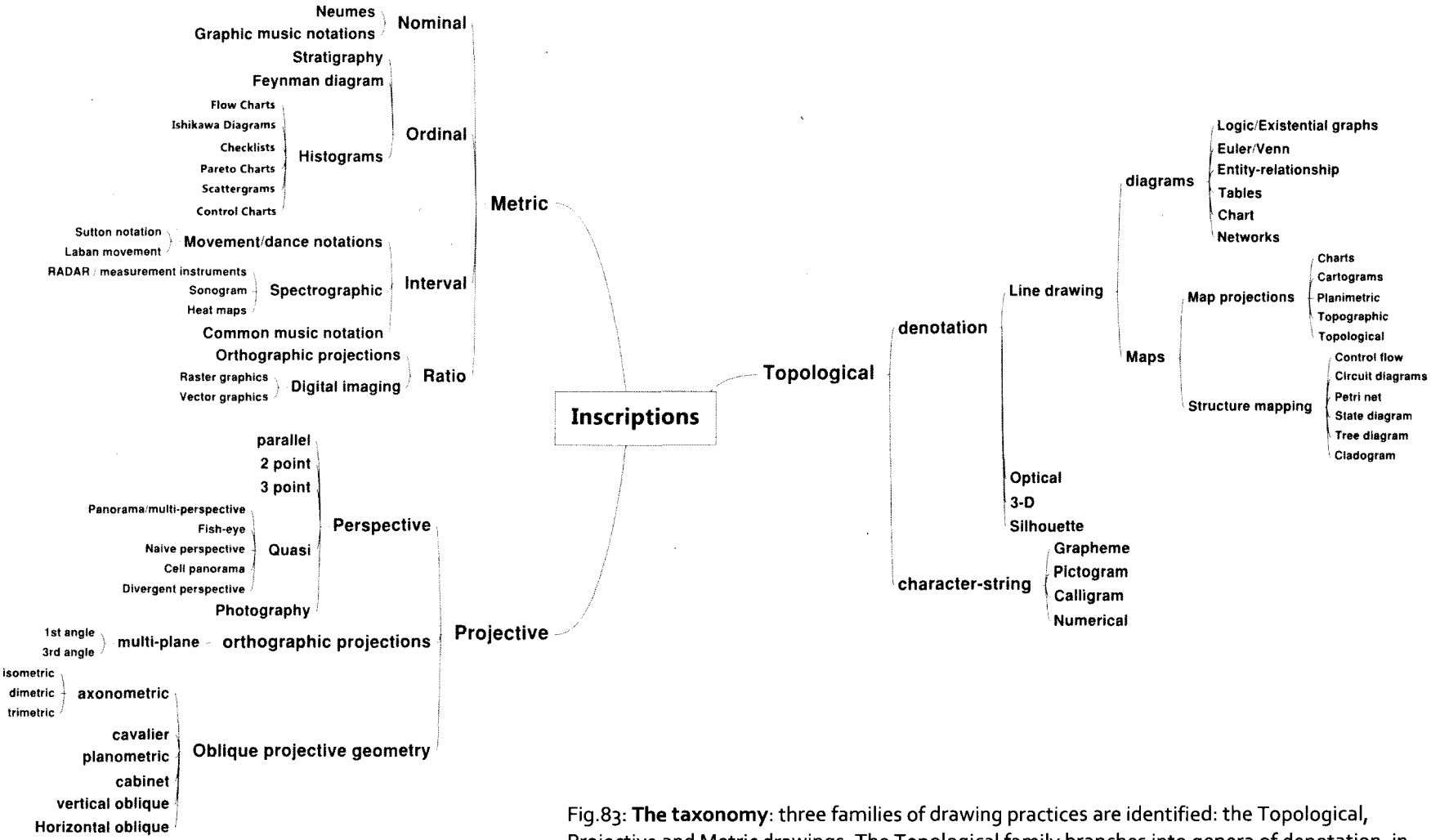


Fig.83: **The taxonomy**: three families of drawing practices are identified: the Topological, Projective and Metric drawings. The Topological family branches into genera of denotation, in accord with Willats (1997), branching further into species of maps, diagrams, the denotation systems; and also character-string notations. The Metric family branches into four genera based on Stevens' (1947) nominal, ordinal, interval and ratio scales of measurement.

i. **Nominal**: Neumes apply autographic squiggles to vocal-musical outlines as a kind of arbitrary name for particular sound gestures. They are loosely legible as instruction, but there is no sense in which the markings may be absolutely identified in the sequence.

ii. **Ordinal**: Stratigraphy marks up its site/subject as sets of cross-sections, within which the order of distribution of the artefacts and other objects in time and space is the salient aspect. A Feynman diagram is a problematic one to categorise here, but in spite of its odd pictorialism, it is a space-time coordinate diagram describing particle interactions in terms of undetermined position in the activity space. Histograms and variants have an axis and abscissa representing data and frequency (Dean and Illowsky, 2009), used in estimation of the distribution of some thing over time.

iii. **Interval**: Distribution is standardised in the display, giving users a precise sense of difference than ordinal scales. The music and movement notation systems, as well as spectrographic displays, present intervals as characters in a timeline scheme.

iv. **Ratio**: Colin Ware describes the ratio scale as accessing 'the full expressive power of a real number (Ware, 2008, p.24). I have included digital inscriptions here because in each of these, the output image is the product of numerical operations, including the possibility of zero.

4.2. Metric drawing

Hewing to Goodman's and Willats' concerns with how representation works, my classification stresses organisation; in spite of heterogeneity and inconsistent interpretive functions, how the puzzles of productive representation are related and resolved in practice. This could be taken the other way. As in Schmidt (2008) we could assume structure, and then describe manifestations of drawing as a social practice of physical and meta-physical engagements with memory, movement, and pentimento as a document. But I acknowledge that I have put aside important values of and for specific practices, and remind the reader that this denuding of social significance is temporary. After all, out of this exercise I have generated novel, challenging notations for collaboration and performance, rather than bone dry case studies. And while the choices may remind us of the artifice of Goodman's ahistoricism, they should also recall the purpose of that reduction.

Willats usefully defines projective drawing as the mapping of 'spatial relations in the scene into corresponding relations in the picture,' and denotational drawing as the mapping of 'scene primitives onto corresponding picture primitives' (Willats, 1997, pp.2-4). But

drawings like the music notation address explicitly temporal events, factoring between axes as a dynamic system, and generating a readout; and they are oriented both into and out of the frame of the inscription, with an embedded and an external narrative or key. Thus they are sufficiently differentiated from the parsimonious diagrams of Euler, the way-finding of maps, the ambiguities of text or underspecified drawing systems -- not because these inscriptive practices are not in some ways temporal, but because time is not a character, so to speak, in their schemes.

All things are both spatial and temporal, in the sense that W. J. T. Mitchell indicates (1998, p.103), but in making a tree inscription we do not target the temporal dimension of the tree, except as interpretive content, or perhaps as time-factored, hierarchical sequences in diagram. Even Duchamp's strangely lucid "Nude Descending a Staircase" (1912) can only suggest through inscribed metaphors of fanning lines, tonal transitions, repetition, and diagrammatic directions of across and down. But metric notations, factoring movement, have additional concrete instructional motivations, and a compositional, future-subjunctive tense. They do not simply map from scene or sequence to surface, but work in a conjunctive dimension of performance: they are space-time notations. This is not the tracing of semblance or distribution, as in our other tree-inscriptions, but of reaching for communicable correspondences between differently orienting experiences.

In order to speak across perceptual modes, Forceville (in Gibbs [ed.], 2008, pp.462-482) suggests that we need engagements between (at least) two sign systems. As Pevear, Tversky, and Latour have each suggested in their ways, such engagements are made -- the in-betweens bridged, translations achieved -- through systematising notations which regulate the cognitive tool of drawing. Goodman, of course, predicates his notation theory on community obligations achieved through increasing articulation, in his terms, attenuating the noise to achieve signal. Converging on these observations, Michel Serres (1982, pp.72-73) writes that

When we do not understand, when we defer our knowledge to a later date, when the thing is too complex for the means at hand, when we put everything in a temporary black box, we prejudge the existence of a system. When we can finally open the box, we see that it works like a space of transformation… One side of nonknowledge is chaos; the other, system. Knowledge forms a bridge between the two banks.

The traditional music notation, for instance, permits us to map pulses onto picture primitives, onto the page, then away again, remade to music. Similarly, the Labanotation encourages calculations of sinew, breath, and reveries on those onto the page, rendering leftward motions of the hand as characters for computation in both virtual and actual spaces of activity. No thing can actually be reduced to number or mere order, suggests Serres, except as input into a systematic operation, in some process of transformation, or translation. The pulses of music are not things that can be explicitly pictured or even distributions that can be denoted. Thus, such a representational complex must behave like a control interface -- a surface of exchange between experience, sign-system, and user. It cannot simply label or concatenate. Like Valéry's translator-poet, we must be enabled to constitute searches for form. A metric drawing is therefore a control interface; not a mere mapping to the page, as in projective or topological drawings, but a blending space with multimodal objectives – and always about passage through a conjunctive space of time.

A metric drawing allows us to hold the moon in hand, or mesons, or the pulses of the body, finally to construct bridges and arguments from their evanescence. And, as demonstrated in Chapter four's "Ut pictura poesis," while we may never adequately define music, or grasp the entirety of the arguments, we may nonetheless draw them out, to grasp something more of ourselves.

4.2.1. The order metric, and its four classes

Echoing Peirce's commentary on algebraic formulae, James Blachowicz writes that 'traditional cognitive theory holds that knowledge processes are analysable as formal operations on symbolic representations' (1997, p.57). However, the productive, inscribed work of the composer or the choreographer is never accountable as a merely statistical operation; their graphic inscriptions take advantage of the same aspects of marking up that the generalisations of the Euclidean space of the page offers the geometer. 'The advantage gained in utilizing notational systems is clear,' writes Blachowitz, 'we can manipulate them with greater accuracy and efficiency than analog models would allow. That is, we can calculate with them' (1997, p.13). Here is the very moment that motivated this document, when what was perceived, or imagined perceived, became plastic material for creative interaction. But systematic notations are flawed. They work, or rather we work them, but in their displacements from the things which they circle, they are frequently deemed even by users to
have failed in their appointed tasks. They nonetheless exemplify drawing as a mechanism of creativity, with which we can build, or build bridges between symbolic languages.

In aid of developing the idea of a Metric family as a classifier in the taxonomy, I have adopted the four measurement scales – nominal, ordinal, interval, and ratio -- defined by S.S. Stevens in loose pursuit of an answer to the question of whether it is possible to measure human sensation (1946; in an information visualisation context, see Ware, 2008, p.25; for problematic quantifications, see Real et al, 2000; for critique see Velleman and Wilkinson, 1993). One uncontroversial definition of measurement is that it is a rule-based assignment of numbers to objects or events (Marradi, 1990; Stevens, 1946). In the broader sense of applying symbolic characters to real things as proxies, it is also a practice of discrimination and classification, where perceived correspondences between objects and counting systems are determined, resulting in representations which become plastic in the semiotic sense Peirce describes as manipulable formulae through which 'observing the effects of such manipulation we find properties not to be otherwise discerned' (Dörfler, 2003). Quantification of qualitative entities in this sense is a practice with a long history, provocatively reviewed in Marshack, of course, but more recently renewed in the fields of information and data visualisation design.

In this adoption, we concede that the common music notation, as an important exemplar species, addresses inherently imprecise contexts which are likely not cleanly measureable (an unsatisfying response to Stevens' motivating question). Similarly, in navigating immensely complex calculation sets for the culture of dance, the Labanotation – a factoring of bodily action -- seeks to plot entities and relations by segmenting the dancer and aspect-characters of her movements into a vertical timeline, exploring isomorphic (2010) relations between phenomenal experience and organising marks. This reduction to manipulable and elastic symbols is at the heart of the drawing practice in this submission, wherein I generated notations for organising and speculating on time and space in performance.

If the principle intent of any score is to delineate a 'relationship to the future' (Hanoch-Roe, 2003), then a notation such as Stump's (Fig.102) calls attention to the real problems of adopting Stevens' theoretical formulation of measurement scales, which that researcher acknowledged in anticipation, writing that 'no scale used by mortals is perfectly free of (the) taint' of bias, limited applicability, and imprecision (1946, p.680). The mechanism of the music notation treats gestures of sound-production as cyphers, but in the paring away -- a 'hallmark of abstract thought' (Blachowicz, 1997, p.62) -- metric drawings render referent into concept, permitting the remaking of observation into

utterance. Those utterances may be garbled by imprecise or incorrect readings (which might of course be a motivation, as in Stump's notation, so superficially redolent of orthographic projections), but they are nonetheless time-machines which exploit drawing's synthetic cognitive advantages to a productive, rather than merely reactive engagement.

The metric-inscriptive act of music notation translates the multi-dimensional space of audition into the secondary space of marking, encoding for further passage. In the articulation they become the control interfaces inquired after in the previous section between experience, sign system, and user, allowing both views and manipulations on the sum and substance of their art – in all cases, space and time. Thus it is that in drawing that we find our best opportunity to accomplish the measurements of sensation Stevens would have us consider.

4.2.2. The geometry of inscriptions

In a metric classification we are extending geometric analogies derived from Willats, but also a more generic view described by Latour, who itemises the advantages of working through inscriptions, noting that in their two-dimensions we 'merge (their propositions) with geometry.. (which) result is that we can work on paper with rulers and numbers, but still manipulate three-dimensional objects "out there"' (citing Ivins, in 1986, p.20). In these terms, we have noted that both pictorialism and the written word in the west have been theorised to be derivative of our social compulsions to count and to document that counting. As cited, Schmandt-Besserat persuasively traces the evolution of systematised marking through artefactual tallies 'developed to keep track of property, beginning with a simple one-mark one-piece of property relation, developing into numerals as tallies became cumbersome for large sums and calculations' (in Tversky, 2001), resulting in the abstract numeracy which has allowed us to use numbers as something other than tokens. The logic of the social inscription becomes an 'articulated continuum of signs so that (every marked surface) will have a measure of pictoriality and of writing' (Elkins, 1998, p158).

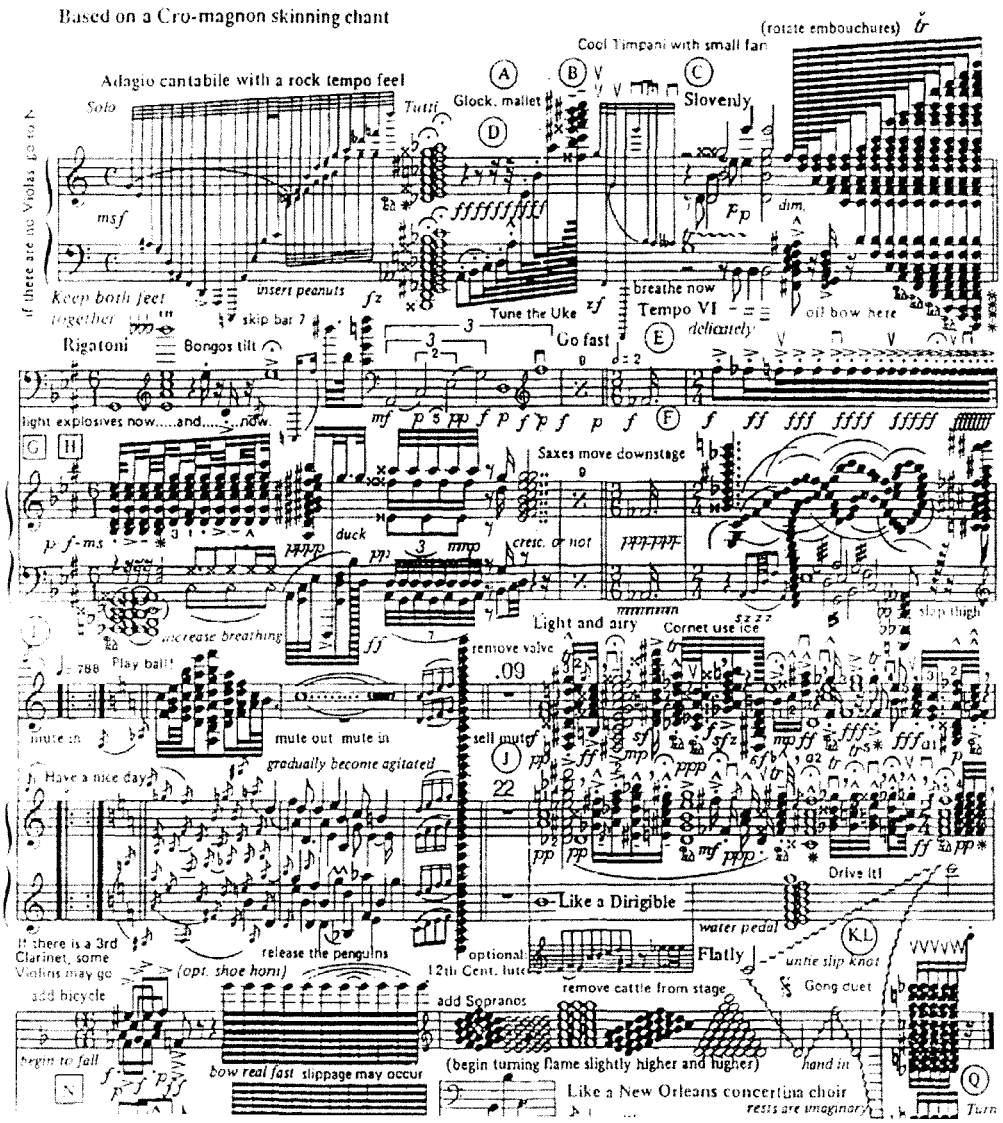


Fig.84: An impossible notation: Score for Faerie's Aire and Death Waltz, from A Tribute to Zdenko G. Fibich; Stump, J.(2005) accessed 14/4/11 at <www.faeriesaire.com>. **In the Taxonomy, this notation is "Metric>Interval>common music notation," or possible "Metric/.../graphicmusic notations."**

Tufte discusses what he calls narrative graphics of space and time, and relational graphics as methods to plot, present and understand complex multi-dimensional data. Echoing Deleuze on Peirce, Tufte suggests that their benefit is that 'any variable quantity could be placed in relationship to any other variable quantity, measured for the same units of observation' (2001, p.46). Tufte in fact refers to relational graphics as the "greatest" of all graphics because of this insight generating utility,

> which permits possible causal relationships to be grounded in a present of plotted variables, allowing us see the rate of evaporation of water relative to some objective schema, for instance, or the relationship between thermal conductivity and temperature in copper, or to compare employment and inflation, or to calculate expressions of fear and rage as social

behaviours (Fig.85). Music and music notations are both inscriptions, but while we sing the one -- actually conversing with singing and song -- with the other we orchestrate, nudge, proscribe, and diminish, from a place of thought. Standing for silence, paper is a material surface on which we work, but as we seek to fold, crumple, etch or shape it, through the mediating influence of articulate, metric notations, the paper becomes a space of time. They are hybrid representational systems, in Recanati's sense (2007, p.511), mechanisms for speculative action and instruction driven by the cognitive values of marking-up, grounded in the entity-relation metaphor at play in all drawings, and applicable to grapes, anger, music, or leftward motions of the hand. The relations between paper and music, then, prove to be kind of calculus of the body, a reckoning of present, future, and past, through which we can fashion a proportional methodology.

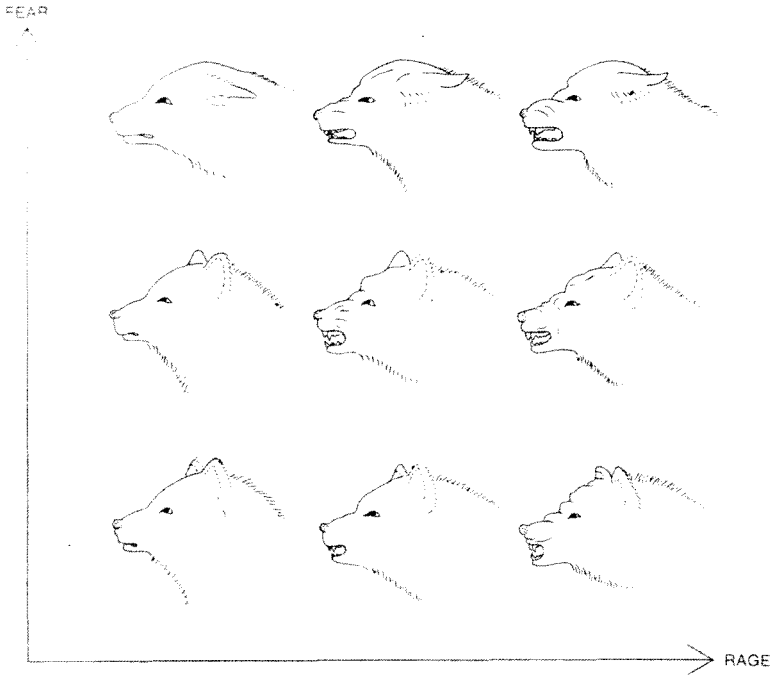


Fig.85: Fear and rage: in which the facial expressions of the animal and its underlying mood are computed from the axis of fear and the abscissa of rage; Zeeman, E.C. (1976) Scientific American, 234:4, p.67; cited in Tufte (2001, p. 50). **In the Taxonomy, this drawing is "Metric>Interval>..."**

Chapter five

5.1. Description is revelation

In Cage's philosophy, impossible silence underlies all; meanwhile Serres incongruously (or not) writes of the noise which underlies all things. This conflicting descriptive language has the same target, suggesting something about our phenomenal experience that is only sensible, in their cases, in the marking-up of musical or philosophical writing. Consider Cage's silent piece, 4'33," which is a performance of nothing, and therefore excerpts the silence of everything else, then read Serres: 'in hearing and in space itself, in observers and observed, (noise) passes through the means and tools of observation, be they material or logical, be they channels that were constructed or languages…' (in Schehr [tr.], 1983, p.50). The mediation, the making of the mark, the materialising logic of drawing, is a breaching of noise/silence, is the first step in organising chaos. The relation between paper and music is rational.

The relationship between system and output – between paper and music -- is conventional. The music notation is also, of course, a recording device, providing a site for music analysis, but it is incompletely described in those terms. The notation mixes the transcription spaces of Willats' topographic and spatial relations, channelling the transience of music as down and across to the static page, but then back. In its deletions of superfluities the notation is digital, but is also in some sense analog, as its intention is reconstitution in performance: it re-presents, but *forward.* Extracted from the originary moment with Bach, then, my sense that I could see the performance from the drawing is key, as the relation between paper and music proves to be a relationship of possibility and recursivity, of the present to future and past. Stepping back to one of the first epigrams in this thesis of epigrams, the poet Stevens (1945, p.565) seems to speak directly to the central question, writing

> … everything we say
> Of the past is description without place, a cast
>
> Of the imagination, made in sound;
> And because what we say of the future must portend,
> Be alive with its own seemings, seeming to be
> Like rubies reddened by rubies reddening.

The relation of paper to music is description without place, duration without time; it is a casting, and so a calculation. And calculations return, yielding rubies reddened by rubies reddening.

A drawing of music plots, it sculpts signal from noise. For an immediate example, in my "Interference" vocal music notations (this volume, Chapter three, pp.141-146), there is an attempt to score glottal gestures. In the resulting drawings, the problems of a silent vocal music are put in terms of the consequence-relations of written text, resolving into wave structures that surface from the warp and woof of dynamic speech triggers. The generated interference patterns are propositional audiovisual sequences, but also metaphors for physical events, forming a moiré screen over space-time. They ask for the impossible, engaging the existential metaphors offered by Cage and Serres, conveying motion with static, yet spatialised alphabetic characters, compelling the reader to remember and perform the sound generating gestures they represent, but to choke those sounds off as they begin.

5.2. Summary and conclusions

Contemporary drawing researchers have advanced the understanding of its broad values in pedagogy, in communication, and in creativity through the discursive sketch, or equally in constrained diagrams and diagrammatic reasoning with respect to logic and computation; but also in more traditional contexts of the histories of drawing practices, and connoisseurship. Much of this ongoing research theorises the direct simplicity of drawing as a cognitive enhancement, and as a structuring activity with social and semiotic entailments (Riley, 2004). And while this dissertation had its roots tangled in a moment of imaginative mis-conception, as artful inscriptions – as artefact and document, as notes to composer and performer; points, lines, and planes, visualising sound or proposing visions on audition – my experience with Bach's paper speaks to all those identified avenues of drawing research.

To bring some resolution to the many questions raised by my exchange with a man long dead, I have sought to expand my working processes to include the rigours of writing, while embracing the scattershot abundance of fine art drawing practice as a creative method -- simply opening up that abundance to the reflective practices of scholarly research. As previously stated, I spent many years as a rather militantly visual

artist, looking upon the written word as an impoverished cousin of visual practice. And while not utterly changed, nuances in that perceived relationship have been detected in the shadow of the word. For example, the very idea of "showing, not saying" is at the heart of theorised distinctions between diagrams and text as representational inscriptions; thus an unnecessary distinction is dissolved, and the work is enriched, not burdened by the word.

In order to reconcile what I saw to be the wordlessness of visual art and the theoretical force of writing, I have sought a method of writing with practice, tying the analytical focus of taxonomical classification to the heuristics of drawing, in a research-experimental framework -- a dialogical process of speculation and navigation between theory and practice. I have attempted to make a statement in a blended scholarly and artistic way, not timidly nudging, or idiosyncratically shading bits of theory (although I admit that idiosyncrasies are present in the writing), but striving to make a coherent point with value to both artists and scholars concerned with drawing. To avoid the extended artist statement, unstable scholarship, or post hoc mythologising, I have tried not to merely make works of art, nor simply to examine a working process, but to conduct a study of making -- to report and clarify the interactions of doing, watching, and redoing; tracing the entailments of studio practice with both words and pictures: to more deeply understand notation systems through a program of making, and then comment on them as fecund sites of invention. In a bit of irony, at the end I have come to understand systematic notations as precisely the way to both show and say -- the very embodiment of a quest to write with practice.

Adapting a bit of writing from the composer and educator John Cage, I configured the thesis question as an investigation of the relations between paper and music, which contains a suggestion of the liminal that stimulates the painter, but also provides a focus for traditional research, asking after the structure of those relations: how they are established, and moreover – at the intersection of theory and practice which I have attempted to navigate -- how they might be exploited. A set of drawing research studies was developed to test the capacities of systematic drawing as a mechanism for creativity, and to bring about innovative creative practices by constructing graphical environments for performance, hewing as closely as possible to Goodman's pragmatic, impossible guidelines for articulate symbolic languages. Each of the studies threaded

together a number of fields of enquiry, highlighting drawing as a peculiarly roving thinking practice, and providing a wide focus for their resolution.

The focal object for the literature review conducted in Chapter two was the classification model presented in Chapter four, developed to sort out what we know about drawing and drawing systems in their outlines and overlaps. In the process, my early intuition that multi-view projective orthography and the music notation were close kin was *dis*-confirmed – although they are both in a sense design drawing methods, there are too many structural differences between them. The model was motivated by a selection (not exhaustive, but representative) of taxonomical exercises which examined the practices of design drawing, data visualisation, and the mongrel interests of the fine artist, interrogating them for dominant and useful themes. In that spirit, the ontology inclined towards structural aspects of drawing – how we organise for legibility -- rather than its manifold functional or social aspects. This bias reflects the expectation that realising the abundance of domains serviced by drawing will come by taking seriously the implications of our enormously long history of engagement with marking, foregrounding its cognitive values, rather than some aspect of its artefactual status. Minimising cultural contingencies in the analysis has also had the heartening effect of bringing together Lascaux and the virtual studio as sites in which we draw, rather than conceiving their differences in terms of rupture.

Both the drawing experiments and the taxonomy emerged from a review of research into drawing and cognition, and theories of semiosis inclusive of non-verbal signification. Nelson Goodman's notation theory (1976) and John Willats' analytics (1997) were identified as key points of reference in the explication of drawing systems. The differential nature of all modes of drawing is acknowledged, but relational diagrams such the common music notation or the Labanotation combine diagram, text, and picture, becoming calculators with a readout for analysis, annotation and scoring performance outside the frame of the inscription. Such systematic notations are distinguished as a third geometry of construction in the taxonomy, identified as metric: hybrid representation systems, possessing time-factored and –factoring aspects which clearly demarcate them from others. Taking the composition space of the music notation as a space of calculation, the performance is its result. Performance in this context is a transformation from the symbolic document to the phenomenal reality of sound, and the

relationship between these two experiences – score and performance, paper and music – are recognised in terms of embodiment as a point, a movement, a passage, a swelling, a diminishment.

While I cannot here describe the extensive arguments around human cognitive development and language acquisition and use, we can at least say that in learning to communicate, the user learns to work with rules, with expertise characterised by transparency in use: in thinking through the system. However, in attempting to learn a new language, or in this case in developing new notations, that transparency needs clouding, so that we may think about the system itself. We need the system to be

> simultaneously transparent and opaque. This "coordinated transparency" (Hancock, 1995) represents a synthesis of meaning and mechanism, a situation (desirable but not always easily achievable) in which fluency with and within the medium can temporarily be replaced by a conscious awareness of its (usually invisible) internal structures (Kaput et al, 2002, p.11).

And if I may, this can stand as a description of the method I undertook here: merging the enactive discourse of drawing with the introspection and reflection of writing. The practice sought to demonstrate notational drawing in a mechanistic analogy, a mechanism that transforms quality into quantity, into a composition system with which we inform practices, rather than necessarily being the practice itself.

Clouding the mechanism gives us opportunities to speculate and draw spatiotemporal flow, marking-up intangibilities, drawing transience as if it were some-*thing*. The systems that developed have yielded unexpected outputs, and in aid of the synthetic self-consciousness Kaput discusses, the first three of the four projects developed from a breakdown of the traditional Western mark-making primitives of point, line and plane, correlated to similarly primitive musical-auditory concepts. These correlations map across well-understood schemes with problematically different dimensions for their expression. The two sets of primitives were identified in order to make sense of the complexities of notational discourse by constructing a series of simple provisional models: to watch the behaviours of the systems as they developed, as well as to watch those of their developer. I have attempted, in other words, to untangle the roots

of this dissertation by examining how inscriptions and their scribe work to exploit the cognitive and creative advantages of marking-up, to generate conditions for transformation/translation/transduction as creative operations.

Reviewing the subtitle of this thesis, paper is a material substance, and music is not, and their relations are established through deployment of the assets of decoupled marks as exercises of reaction and interaction -- of practice. Just as Marshack's Palaeolithic scribe followed without reproducing, aspects of our experience are explored quite by hand, through cultured re-visions taking place in the secondary space-time of metric drawing: through scumbling and attenuation, metaphor, and transformations performed over representations. Demonstrating the relations between paper and music by managing the oscillations, they are semiotic systems through which we create documents for visualisation and dissemination of both possible and impossible futures, built on a present of plotted variables.

As examples of impossible yields, the second drawing study amounts to a positive notation for a silent music, while the fourth gives us a pair of entity-relation graphics inscribed into profoundly problematic contexts, factoring space and time like a music notation, but in this case *exponentially*, using prosaic inputs to yield poetic and emphatically unstable outputs, the veracities of which are in some sense irrelevant.

5.3. Further work

In other taxonomies, drawing systems like the common Western music notation have been uneasily handled. Meanwhile, Tufte recognised the importance of what he called relational diagrams (2001), but did not make the connection to professionally enabled systems such as the music notation -- a system far older than his data visualisation context, yet which is configured in ways clearly identifiable in his data visualisation theory (2001). I make that connection: they are relational graphics, factoring spatiotemporal experience. Modeling them for the taxonomy, I have replaced Farthing's subway metaphor (2006) with a bush-form – exchanging a witty urban journey for a network that emphasises branching structures, thereby decentralising particular modes. While losing the humour and the illumination of the painter's embodied passage metaphor, I contend that my taxonomy shows readers the relations between systems more accurately, even if absolute determination is finally unattainable.

The Metric classification makes a contribution to the dialogue around the significance of systematic drawing as a crucial hybrid mechanism for learning, and composition from that learning. It emphasises specifically scalar purposes, and thereby links yet sufficiently differentiates those drawings under its umbrella from pictures, diagrams or text, or character-strings. A metric classification emphasises the quantitative treatment of qualitative information which is the core operation of its activity space, answering S.S. Stevens' desire for a measurement of human feeling, while supporting Petherbridge's notion of a future-subjunctive tense: they are inscriptions that permit speculations on speculations. Systematic notations factor vision and audition, breath and the body, time and space, word and image; and they are crucially, vitally, working documents with primary values residing outside the page.

Notwithstanding the traditions of connoisseurship which gave me Bach's hand under glass, such notations are not intended for art galleries, but for the stage, in the mind's eye, ear or throat of the performer. As we have seen in the taxonomy, drawing systems work from diagrammatic-substrates (the orthogonals of perspective drawing, or the grid in the music notation), so how might we change a musical proposition by swapping out this substrate? To what degree is syntax implicated in the semantic content of the propositional work done in the scheme? What if we perform a truly geometrical transformation on the staves? What effect, for example, will mapping to a spherical activity space have on the expression of its music? Such a transformation is efficiently produced by computational systems. Taking the flat grid of the common notation, bending the Euclidean delimit, and wrapping it around a sphere is surely an exciting prospect (Fig.104).

The four drawing research projects each demand collaboration and performance, presenting a number of opportunities for future work, in addition to making intriguing contributions on their own. As indicated, the second study makes a contribution by becoming a positive notation system for silent vocal music. Even if we take Cage's relatively recent 4'33" only as a decisive gesture, the idea of a silent (or near-silent) music is a long-established one, and this particular take provides a practicable inscriptive method for vocalising silence, eliminating the need for novel punctuations of page-long rests, or enormously long ties, which are the only other options in the common notation.

As a context for scoring performance parameters, they hold up to Goodman's scrutiny, yet leave room for interpretation and development in the performance of its directives. Yet if strictly performed, they will produce no sound.

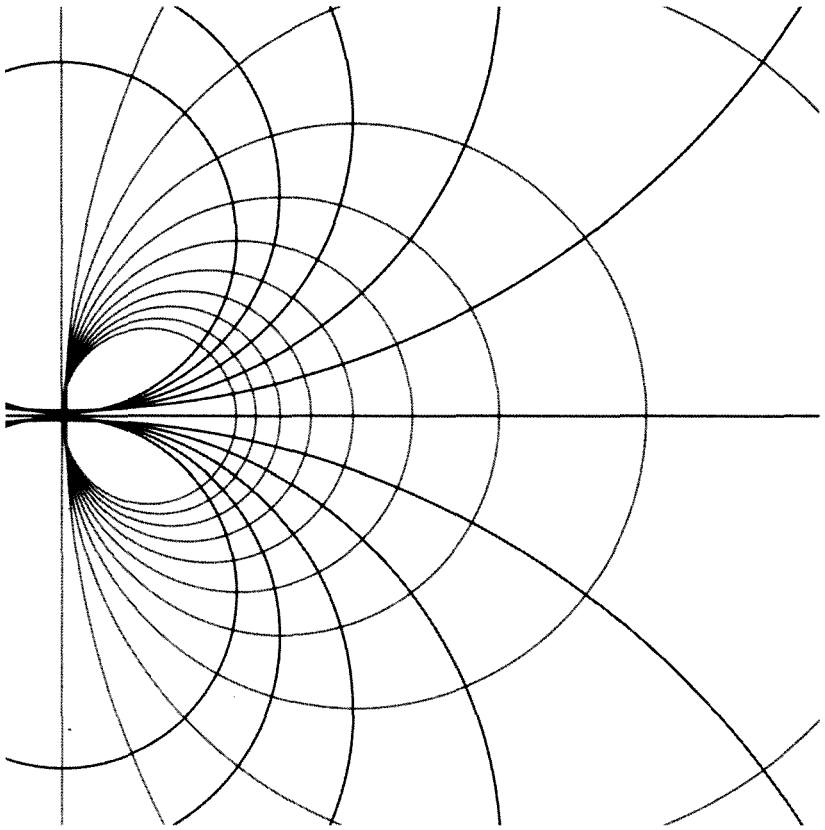


Fig.86: A coordinate grid after a Möbius transformation, Lokal_Profil (2009) Creative Commons Attribution, Share Alike2.5 Generic, accessed 28/3/11 at <http://en.wikipedia.org/wiki/Conformal_geometry>.
In the Taxonomy, this notation is "Metric>ratio>..."

The fourth notation study, "Ut picture poesis," presents multi-disciplinary opportunities for creative and technical collaboration, but in this case, the collaborations will come in the form of consultations with experts in a number of technical fields quite apart from the visual arts, in pursuit of planning and executing what must be the largest drawings ever made. I have in fact initiated such contacts at my home University (OCAD) in Toronto, Canada, with a view to securing support over the next twenty-four months to stage the drawings as public performances. And while their factual status is under extreme pressure (ironically from the facts as we currently understand them), their potential as research exercises generate a number of epistemological and practical questions, obviating the impossibilities in their propositions. They are, as Farthing

critiqued them in Melbourne, rhetorical drawings; but I contend this is a good thing – it is their strength as creative-practice research instruments: they might yield tremendously freakish fruit.

Finally, the third drawing project, "Anechoic chamber orchestra," is unfinished in ways that the others are not, and therefore represents the study with the longest future profile. As it is developing, the project will open up potential engagements with sonification and visualisation tools and technologies, folding them into social and ethical questions related to our health industries, under stress in their own domains, in addition to emphasising that the organic movements of the body are musical movements. This project does not represent any theory of the body, but merely puts a public ear to an intrinsically private conversation.

But what does it mean to discuss an unfinished drawing, as research? A great many artists and scholars have discussed the critically, vitally unfinished character of drawing – that drawings are always in some sense underdone, that underspecification is the source of their resilience as practices within practices. The "eureka" moments of creativity through the notations created here are professional achievements, exhilarating and insight-generating in the same ways as my experience with Bach's fragment. Yet until the "Anechoic chamber orchestra" produces its first public performance, we are left with eureka, and a number of technical questions, and questions on the nature of creativity. On the other hand, the orchestra plays even now.

Appendix I: Review of terms

The following is a review of terms commonly used throughout the thesis, with definitions and determinations from the relevant literature.

Representation is defined here relative to Goodman, who characterises it as a 'symbolic relationship that is relative and variable' (1976, p.43). In the same spirit, the theorist W. J. T. Mitchell asks us to review the problems of representation, concluding it may best be defined as a dialectical relation -- not some thing, but 'a process in which the thing is a participant' (1994, p.420). In a commonly cited definition, David Marr writes that representation is 'a formal system for making explicit certain entities or types of information, together with a specification of how the system does this' (Riley, 2001). I suggest that reading Marr, we are simply given a recapitulation of Goodman's crucial idea of efficacy, that 'What matters with a diagram... is how we are to read it,' (1976, p.170). But representation is a product as well as a process, which distinction will be freely abused in this thesis, as one follows from the other, and as context will be adequate to tell us which is which. The term "external representation" refers to such a product, and includes pictorial, textual and diagrammatic entities, any of which may be made or experienced by an individual in Mitchell's dialectical relationship (1994, p.420; Cox, 1999).

From the cognitive turn taken by Western research interests over the past century, we understand cognition both as a product of thinking, and as a fluid exchange between perception and conception, channelled by constraints on how we see (Pinker, 1990, pp.79-88), and the cultural contexts that inform what we see (McGinn, 1989). Cognition should generally be understood here in the terms of Goodman's aesthetics (1976, pp.258-260), which contains a description close to those in the literature around drawing and cognition, investigating the complicated operations around the material, experiential and interpretive tasks of making images. As a multi-disciplinary research program, cognitive studies reject a mind/body division, referring to notions of embodiment with respect to symbolic communications (Barsalou, 1999; Lakoff and Johnson, 1999). Understood in a general way, 'cognition is the ability to reduce uncertainty' (Gergely and Anshakov, 2010, p.1), which underscores the contextual, computational nature of its processes, operating 'at the interface between biology and

behaviour' (Frith and Law, 1995, p.203). In this view, minds are products of biological processes, and what minds do are ineluctably grounded in physicality and lived experience. Thinking is seen to be a process of interaction, and knowledge 'is visceral and incarnate, whether that thinking is primarily artistic or... linguistic' (Johnson, 2011, p.149).

While Ittelson reminds us that the 'perception of markings is a pragmatic affair enmeshed in a complex of individual, social, and cultural processes applied to the interpretation of forms that always underdetermine meanings' (1996, p.185) – that making a mark guarantees nothing in terms of the transmission of information -- cognitive scientist Steven Pinker notes an insight of visual cognition studies that 'the output of the mechanism of visual perception is a symbolic representation or "structural description" of the scene, specifying the identity of its parts and the relations among them' (1990, p.77). In making and reading graphs and diagrams, this perceptual ordering streamlines processing, as the reader 'need only refer to the symbols representing the aspect of the scene that is relevant to its own computations.' Thus symbolisation is seen to be a cognitive function, and as Goodman asserts, their efficacy is key to the ways in which we might use them as output or input for further examination. I will take an agnostic position on arguments in cognitive sciences around the possible relations between internal and external visualisations as focal points for these reductions (for discussion see Hegarty, 2004; Pinker, 1990; 1997, pp. 211-298), only noting the increasing interest in the use of diagrams, graphs and external representations of all kinds among researchers interested in their relative benefits in studies of perception, reasoning tasks, and their uses in "amplifying the mind's eye" (Fish and Scrivener, 1990).

With respect to computational theories of mind, Pinker (2005) notes it is a metaphorical label meant to suggest that rationality is an organic apparatus offering analogous functions to computer systems, providing a technical vocabulary for conceptualising brain functions in terms of representation, with languages acting as interfaces. This posits mind as emergent from evolutionary processes of selective pressures operating on successions of random mutation (in the case of our species, operating on clever social and predatory beasts). Intelligence is therefore modelled as a feedback mechanism operating differentially between current and goal states (Pinker, 2005, p.2; 1997, p.524). One contentious result of the cognitive turn is that we are asked

to concede that the complexes of our behaviours and symbolic expressions – however moulded by context -- are emergent from modular neurological systems; that reality is reasoned from the connections between environment and the requirements of the organism (Lakoff and Johnson, 1999, pp.21-23). Although we cannot here explore implications of these ideas outside the graphical space (there is much we must put aside, including questions of education and skill-level in drawing and reading drawings [see Goldschmidt, 2003; Frith and Law, 1995; Van Sommers, 1984). But with taxonomy in mind, we will look at the insight-generating aspects of graphs (Semetsky, 2009, p.200; Leja, 2000, pp.102-103), reasoning diagrams (Stenning and Oberlander, 1995), the writing process as a crucially artificial feedback and forward operation (in Galbraith, 1998), but also Bach's enhanced music inscriptions: each permitting some answer to be indicated and followed around the inscription.

In practice, any drawing is more or less schematic or conventional. And while convention is understood here as 'regularity… and recurrence' in execution and consumption (Bull, citing Lewis, 1994, p.211), the researcher Bryan Lawson (1996) presents "schema" as pragmatic re-cognition, useful in the formulation of actual responses to propositional information in design problem-solving. E.H. Gombrich agrees that we may take schemata as essentially conceptual, as visual formulae giving us an experience-based starting point directed at representational ends: a 'means to probe reality and wrestle with the particular' (Gombrich, 1977, p. 148). See Bull (1994) for a Goodman-inflected discussion about schema relative to convention; or Turner (1990, p.465) for schemata as 'skeletal organisations of conceptual knowledge,' or Pinker (1990, p.95), for schema as a structural description, relationally active in perception, and used in the construction of representations.

The word interpretation will be defined as in Goldschmidt (1988, p.236) as critical readings of, and playful interactions between object and knowledge, leading to a stability of meaning found 'beyond the additive sum… of its parts.' This dynamic comes close to a summary of the semiosis described by C.S. Peirce (discussed in later sections), which provides an illuminating model of human cognition, not least for its explanatory suggestions with respect to my encounter with the handiwork of Bach.

George Whale offers that the "'language of drawing," to use Edward Hill's term... looks more like a babel of languages, of which observation-based drawing is but one' (2002, p.70). The more specific question of whether Drawing is or is not a language will not be addressed here – the babel model works for taxonomical analyses; but we will note that researcher Barbara Tversky has written of the language-*like* properties of drawing. 'Depictions of all kinds can be separated into elements and the spatial arrangements of elements,' she writes, noting these may be bits of data, objects, towns, or larger conceptual suites (1999, p.3). The various relationships between them may be spatialised, or they may reflect 'nonspatial relations, such as money or power.' Tversky further argues that a 'view of drawings as segmented into a small number of elements that can be combined to form an infinite number of drawings is similar to views of language' (1999, p.4) which she roughly describes as combinatorial, and thus compositional systems (defined in Bara et al, 1999, pp.5-6). Thus, the word language will be used to broadly indicate symbolic communication systems, rather than just speech or writing (Goodman, 1976, pp.40-41, and pp.225-26).

The words analog and digital will also be understood as in Goodman (1976; Blachowicz, 1997, pp.62-67), not as dichotomous machine-computational concepts, but as points on a continuum of specificity. As a general definition, I accept Stenning and Lemon's view of a diagram as 'a plane structure in which representing tokens are objects whose mutual spatial and graphical relations are directly interpreted as relations in the target structure' (2001, p.36). This definition is accepted only provisionally, however, because in the drawing research project "Ut pictura poesis" (pp. 143-154) we see two entity-relation diagrams (Ware, 2008, p.23) inscribed into puzzling contexts where "planar" becomes irrelevant, and the relations between drawing and target are found to be hopelessly convoluted. And finally, a picture lacks the kind of syntax that writing or diagrams possess, which constrains the reader's interpretive use of the image; therefore pictures are defined as external images 'constituted by the in-built vacillation, contradiction, paradox, or uncertainty of "saying" and showing"' (Elkins, 1999, p.81).

The word creativity refers to evaluative, constructive processes directed at bridging 'what we know and what we don't know' in some not-necessarily artistic domain (Sullivan, 2011, p.115). Creativity is a process of action in response to constraints, writes Linda Candy (2007), and the nature of these constraints may be cognitively or socially

activated, intrinsic or extrinsic, working either to inhibit or enhance discovery in 'the cracks and erasures of the structures in place' (Sullivan, 2011, p.116). Creativity is, in this view, a speculative rationality -- a bounded activity space that supports the perception and construction of paths through and between constraining borders (Candy, 2007, p.366); it is a search through potential or viability, rather than a search for some optimal result.

Michel Serres reminds us that translation is both a practice and theory (1982, p.71), and the word will be used here in a general sense, with a caution that there is a rich history and literature around the process. We generally understand the word as applied to movement from one verbal language to another, striving to establish and maintain consistency of intended meaning. But out of the discipline of Translation studies, equivalence relations between source and target texts are understood to be unstable (Zaskeyin, 2009; Schaffner, 2004; Hermans, 1998); the translator must deal with cultural and contextual differences, as well as syntactic or symbolic ones. Translation is not the mere performance of a cold mapping of meaning from one literary construction to another; it is dynamic, working back and forward between source and target, as much creation as reconstruction. In fact, the very use of language has been analogised to translation. Paul Valéry suggested that the poet's work 'consists less of seeking words for his ideas than of seeking ideas for his words and paramount rhythms' (in Tamplin, 1976, p.812), echoing Paul Ricoeur's insight that translation is an operation between languages, but also within a language, or a language-user. The act of speaking, public or private, is an exchange between inner and outer, is itself an act of translation.

Appendix II: Exclusions and routes not taken

Colour as a visual-musical correlation

In preliminary research, I considered and discarded attractive yet problematic audio-visual conceptualisations, such as the more or less intuitively felt, analogical mapping of colour onto sound (see Gage, 1999 for detailed discussions). There are a number of remarkable paths which can be traced between the visual dimensions of colour and musical dimensions, starting in classical Greece, but more reasonably from Newton, Goethe and Helmholtz, right through our technically motivated environment (Gianakkis, 2001, pp.43-78; Baer, 1971). Certainly a ready analogy can, and has been made between the wave-based properties of phenomenal sound and colour (Rothschild, 1970). Both Newton and Goethe saw this relationship as a vital, productive scientific observation; and although in much of his thinking, as in his abstract drama 'der Gelbe Klang', Vassily Kandinsky suggests that colours exemplify a great deal more than merely hue, value and saturation (Sheppard, 1981), I put these concerns aside because of what I consider muddying intersections of professional vocabulary in colour and music theories, and a lingering feeling that the richly expressive and structural qualities of colour are purely ocular, with no real auditory analogue; therefore accessible to a project such as this only through colloquial scumblings of language. Mostly however I put aside the colour-music analogy in the interest of perversity: it is a commonly held relation, although its source is far from clear -- and so for the sake of creativity is dismissed in my own work.

Synthesis: Software and hardware as working environments

The implications of computer digitality run outside the scope of this paper, but in relation to narrower concerns, I will note that digital *images* seem to touch on all three of Mitchell's variable meanings of the union of the words image and text: "image/text" as a problematic gap; "image-text" as designating relations between visual and verbal; and "imagetext" as composite expression (1997, p.89). The idea of hybrid symbolic expression is not new, Mitchell reminds us, but it is persistent, and with peculiar relevance now, gathered as we are around the hearth of the worldwide web, and absorbed by static and moving photographed images – either of which are proper simultaneous discourses of image and text.

Digital artist George Legrady has suggested that "art-configurations" – his term for algorithmic art -- get right into the word and image dialectic (1992); they are

structured like language, giving us logical procedures through which data is orchestrated into visual form. But most critically (and very like the music notation, notes Legrady), digital images are also numerically significant, so are unlike traditional pictures in that they are iterable and mutable, while at the same time are unlike words in their statistically determined routes of reference.

The convergence of noise and music in the West through the ubiquity of radio, recording and related technologies has equally reformed music compositional and listening practices (Kahn, 1999), but in spite of the totalising seductions of the laptop music production environment (Cascone, 2002), the common notation remains a key to the continuity of music pedagogy, providing ready access to the complexities of music theory, although limiting rupture in the composition. For rupture, we must attend to research and practice in electronic environments, organising sound from within digital architectures, and exploring the potential of computational and algorithmic character-strings, and hardware infrastructures, to create interactive -- even generative -- audio, visual and audiovisual outputs.

The ancient fixation of a unity of sound and vision has most recently, persuasively been driven by computation. For an overview of recent research and practice in computer driven visual music, see (NIME, 2011; Magnusson, 2006; Ariza, 2005; Levin and Lieberman, 2005; Evans, 2005; Gianakkis, 2001 pp.43-78; de la Puente et al, 2002; Levin, 2000; McAlpine et al, 1999; Dannenberg, 1993). In these contexts, the work mostly comes to some combination of the design and synthesis of individual sounds, their organisation into a score, with performance mediated by software and hardware systems. Computational visual-music research has pursued a number of directions, touching not only on technical fields with an interest in audiovisual productions, but also cognitive and perceptually oriented enquiries (Godøy, 2010; van den Doel and Pai, 1998). Summarising, Giannakis and Smith (2001) classify such visual music studies into categories of sound synthesis and re-synthesis, colour vision research, or cross-modal/synaesthetic studies. But for reasons stated in the body of the thesis, and implicitly in the practice, I have stuck to the pencil and paper interface, using computer systems not as directive but as a natural part of the composition process -- stepping back from the black-box system of hardware and software in order to generate the conditions for innovative practices by drawing.

Certainly if we wish, we could come to an understanding of computational concerns by exploring proprietary software packages for crossing the visual with the auditory, such as Metasynth, or Hyperscore (Farbood et al, 2007), or the Acousmographe (Geslin and Lefevre, 2004), which digital toolsets allow graphical representations for annotation and analysis and creation in a sound production and new music contexts (Rudy, 2007, p.12). For research on sonification -- turning the table on Cage and Luening -- see Gianakkis and Smith, 2001; Yeo and Berger, 2005a, 2005b, Brouse et all, 2006). Meanwhile, musicologist Steven Pope (in 1986) laid out a technical view of programming music based on the use of state-transition diagrams, and control-flow models and networks, each of which finds rich contexts for use in computational environments (Sowa, 2003). At the time he wrote his paper (there have since been significant changes in computational power), Pope observed that the new music-compositional paradigms (amply reviewed in Kahn, 1999) must find new music notation approaches that are customisable, extensible and unique to each composer, even to each composition; that is, not configured merely to support or sustain a particular aesthetic, like Brother Guido's (presumably closed) common western notation, but some "open" system.

In his paper, Pope proposed the use of knowledge representation diagrams for this new, modular and open music scoring approach. But how would they function? A Petri-net, for instance, is a diagrammatic tool for analysis of processes in systems with many components, rendering complexities into visualised equations for location and force. Can discrete diagrams like Petri-nets, used in chains or as characters in a scheme, work as a systematic notation in the sense of the score? This has intriguing implications for my approach, and for further work in other directions. Can we steer their analytical natures toward proposition and expression? Bach worked through his notations, but a state-transition diagram such as Pope considers is just a directive, and as such will yield a music of feedback without exchange, noise rather than signal. Can the logic flow in both directions, as script and score, in analysis and as a component-process of creativity? Can music notations based on Petri-nets be anything other than technocratic instruction, or post hoc map, mediating between user-and-user only?

Appendix III

Alternatives models for taxonomy

As future work, a second order of "Function" could be developed in the taxonomy. In this re-model, the two orders of Structure and Function would represent the progeny of Willats' secondary space of re-construction and my sense that drawing is most crucially a cognitively motivated query-response. In their research on the cognitive activities at play in graphical representation, Scaife and Rogers suggest that the placing of constraints or conditions is key to their communication value. The visual modelling of a geometrical problem, for example, encourages efficient cognitive processing of the problem dimensions through 'direct perceptual recognition' of relations' (1996, p.189). While such an image can be constructed a number of ways -- including with the character-strings of Algebraic writing-- a graphic solution, they write, '(restricts or enforces) the kinds of interpretations that can be made. The closer the coupling between the elements in the visual display and the represented world, the more tractable the inferencing.' Similarly, S&O (in 1995) seek to more precisely differentiate the inferential conditions of graphical, linguistic and combined forms of representation: a representation has intrinsic features not related to 'low-level differences to do with media' which determine what can be inferred from it, as a matter of processing. Calling this character specificity, they note that certain species of diagram, for example, 'compel specification of classes of information, in contrast to systems that allow arbitrary abstractions' (S&O, 1995, p.99), such as the word.

However, any graphic may be modified in its uses and therefore in its inferential potency, which we have seen demonstrated in practice on a number of fronts reviewed in this thesis, and as S&O demonstrate (1995, p.104). This buttresses Goodman's notion that representation is 'relative and variable' (Goodman, 1976, p.43), while making the incorporation of a Functional order in the taxonomy problematic, as we will have to account for a graphical entity 'in terms of the expressiveness of representation and key combined, rather than in terms of representation alone' (S&O, 1995, p.105). We cannot examine S&O's framework in any depth (for a useful brief, see Recanati, 2008, pp.300-303), but certainly their descriptions of the properties of Minimal, Limited and Unlimited abstraction representation systems (MARS, LARS, UARS) echo Goodman's theory that the constraints of the articulate scheme – the specificity of the characters and their

deployment allows for the coherent communicative power of the systems they support: simply, MARS and LARS are cognitively more efficient than UARS.

As a real-world example noted by Brother Guido a thousand years ago, the articulation of the systematised musical inscription constrains our understanding of the represented, rendering the density of musical action calculable. As we hear through the work of Cage or Cardew, this restrictive logic is a conventional property of notation, not of the domain which it serves, so while S&O's theorisation reminds us that 'What matters with a diagram... is how we are to read it' (Goodman, 1976, p.170), it is clear that the work of writing music marks the music, as much as it does the paper.

Fred Lehrdal makes two "aesthetic claims" (in 1992, pp.118-119). First, that the 'best music utilizes the full potential of our cognitive resources,' and then that best music 'arises from an alliance of a compositional grammar with the listening grammar.' As suggested in S&O, and in Goodman, and Tufte, we should place Lehrdal's use of the word "best" in reference to the efficacy of the symbolic experience, in pursuit of understanding as 'a product of art and discourse' (Goodman, 1976, p.33). From the notion that representation is dynamic, we can then re-stake Lehrdal's claims on a visual ground. The best drawing is a dialogical experience of perception and interpretation. Structure and function must ultimately be fully integrated, which will result in a three-dimensional model of some speculative depth. But in the rough work of this Appendix, a functional order is defined as derivative, extraction as a function of constraint and abetment.

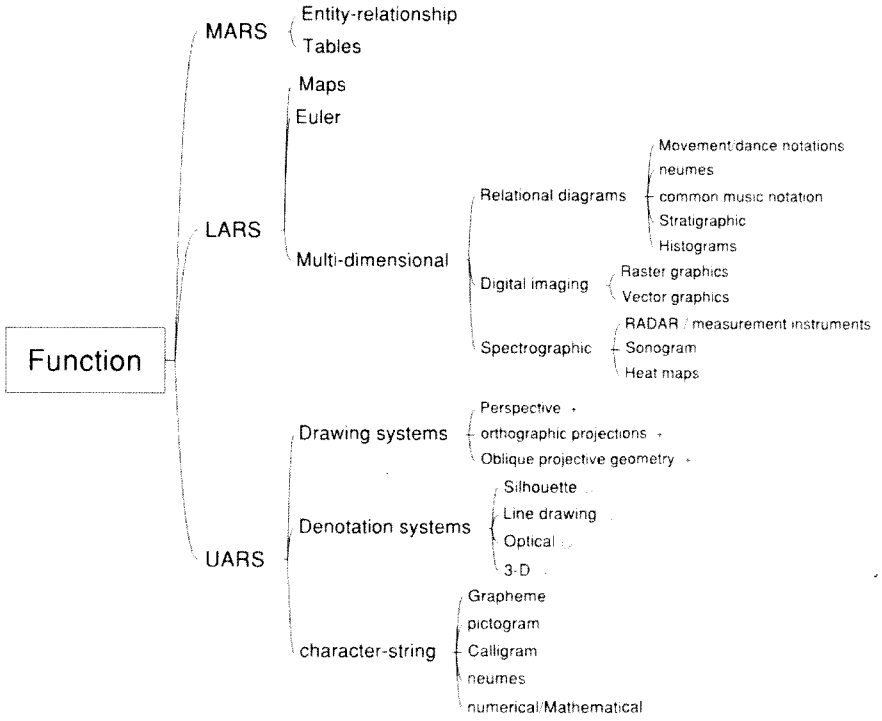


Fig.87: The order function.

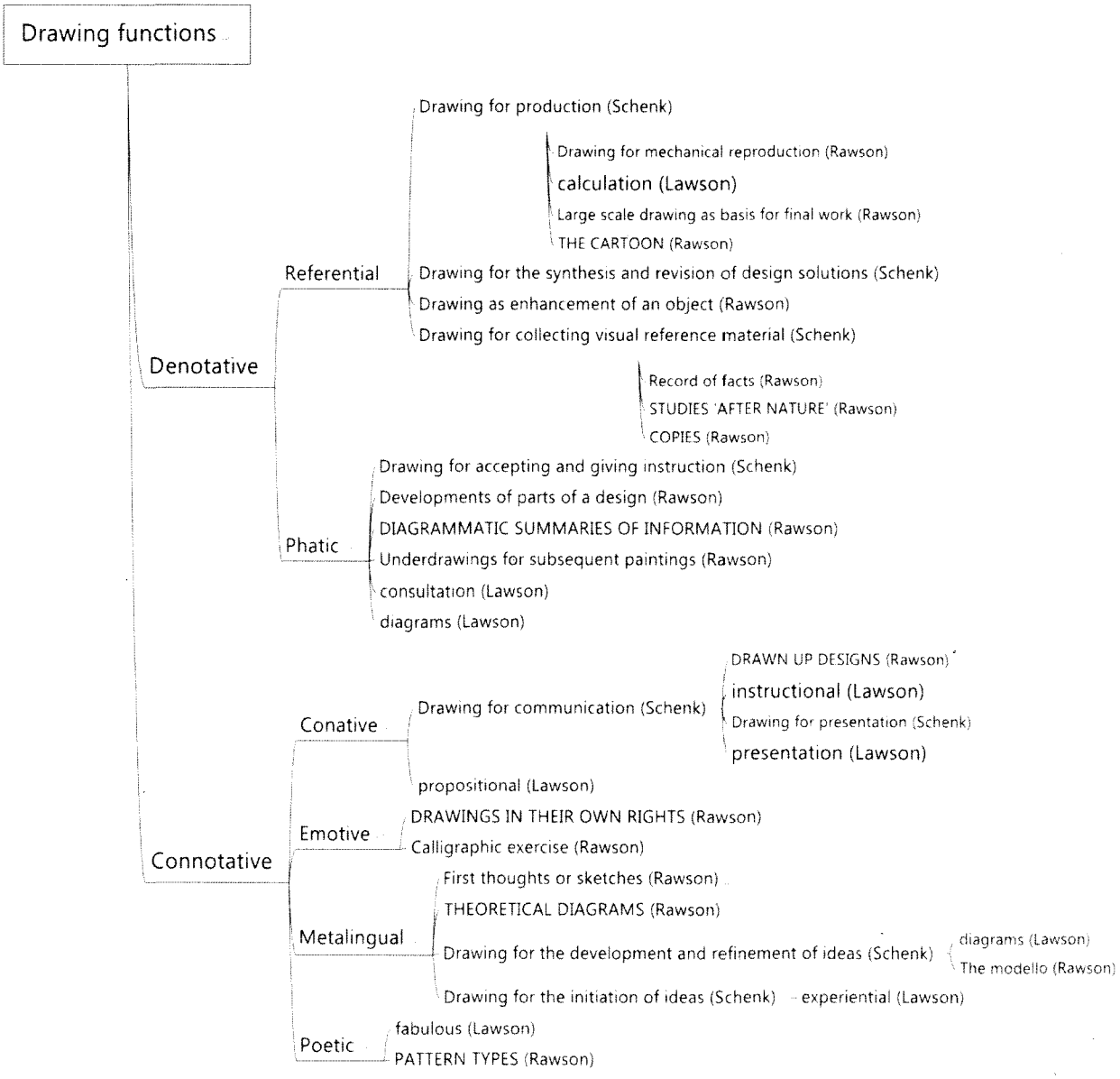


Fig 88: A typology from Schenk, Lawson and Rawson: a comparative modelling of typologies from the writing of two design-researchers, Pamela Schenk, Bryan Lawson, and the more generally historical view of Philip Rawson, each of whom constructed similar profile-typologies in their work on the uses and functions of mark-making. After review, I adopted Jakobson's modes of communication, as applied by Clive Ashwin (in 1984) to design drawing practices, explicating their complexities in terms of semiotic theories. (Schenk, 2007; Lawson, 2004; Rawson, 1969) are slotted into the model.

Workshopping the research

In September 2010 I was invited to present this research at a workshop session at the Drawing research network (DRN) 2010 conference, held at the University of Brighton, UK, with the theme Observation: Mapping: Dialogue. The workshop I conducted included approximately twenty conference attendees, including the conference's keynote speaker Deanna Petherbridge. I introduced attendees to a simple exercise intended to convey a sense of the complexities and issues of structure and expression that make visual notations of auditory experiences so problematic. The exercise began with participants copying the opening lines from the American poet Wallace Stevens' "The pediment of appearance:"

> Young men go walking in the woods,
> Hunting for the great ornament,
> The pediment of appearance.

Participants were asked read and speak the lines aloud or quietly to themselves, and finally to produce a "neume" notation, in response.

Neumes, as described earlier in this thesis, were music notational drawings before Brother Guido's regulating staff-notation, nearly a thousand years ago. Neumes did not specify pitch, striving instead to visually communicate musical passages as sequences of autographic flourishes, projecting desired intonation shapes above the syllables of the lyric to be performed. Their weakness, relative to the staff notation, was their inherent ambiguity, their lack of articulation. The choir master communicated intention to his singers on the basis of the consistency of his own instruction and use of the neumes he created or employed. Each performance, therefore, was likely to be substantively different than the previous one, and certainly the training of new singers, and the learning of new musical pieces would require a great deal more time and non-musical communication and instruction – an observation Guido himself made in the wake of his staff-notation, which reduced the learning time to a matter of days, rather than weeks.

The results of the conference workshop exercise were interesting for a number of reasons. It was first and foremost exactly the sort of exercise a room full of artists and art-educators would predictably enjoy, purely as a matter of playful, social drawing.

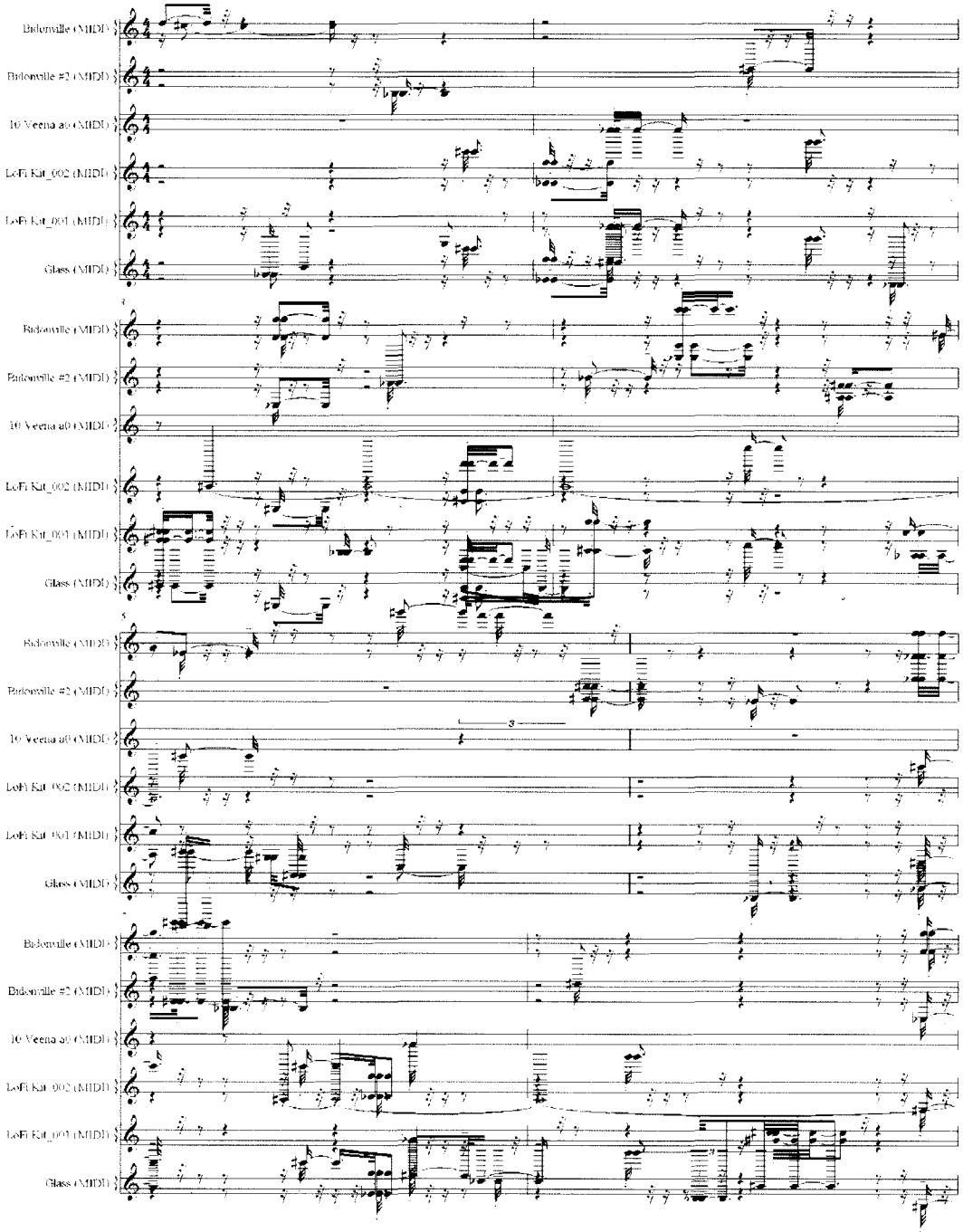
Because of the multimodal abstraction of neume-drawing, the sense of drawing as a skill-based activity was disrupted, diffusing the kind of social tension that might have otherwise existed, had we been engaged in drawing pictures: participants were empowered to simply start making marks on paper. Reading poetry, and attempting to map the pitching and prosodic movements of vocalising encouraged constant revision both to the drawings, as well as to the manner of recitation over the ten minutes of the exercise. This made clear to the participants the value of articulation in a notation system – the move from schematic drawing to conventional systems, for further development outside the graphical space.

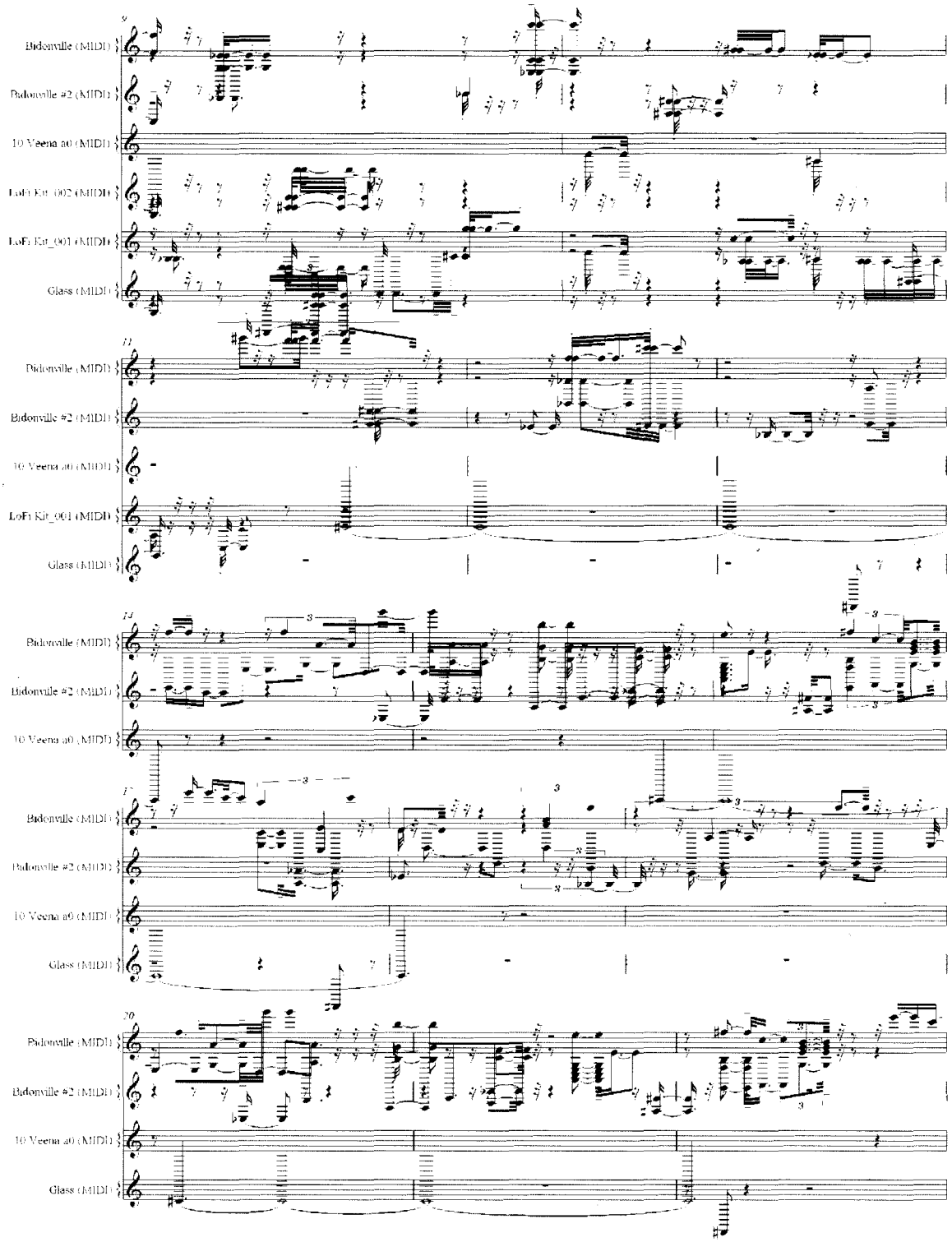
Those with some level of musical experience reported memories of writing music, and of doodling along to music, speculating on possible overlaps between the two approaches. Those with little or no experience with music reported other kinds of notation memories. One participant had been a barrister's assistant, and had gained expertise in formal shorthand writing, and had discovered – or recovered – aspects of this abbreviated autographic squiggling as they surfaced in the neumes being generated in response to Stevens' poem. It was a rewarding exercise, pleasurable and engaging to those who took part, and I have added a more refined version of it to my studio-teaching practice at OCAD University, in Toronto, where I teach a first-year Drawing course.

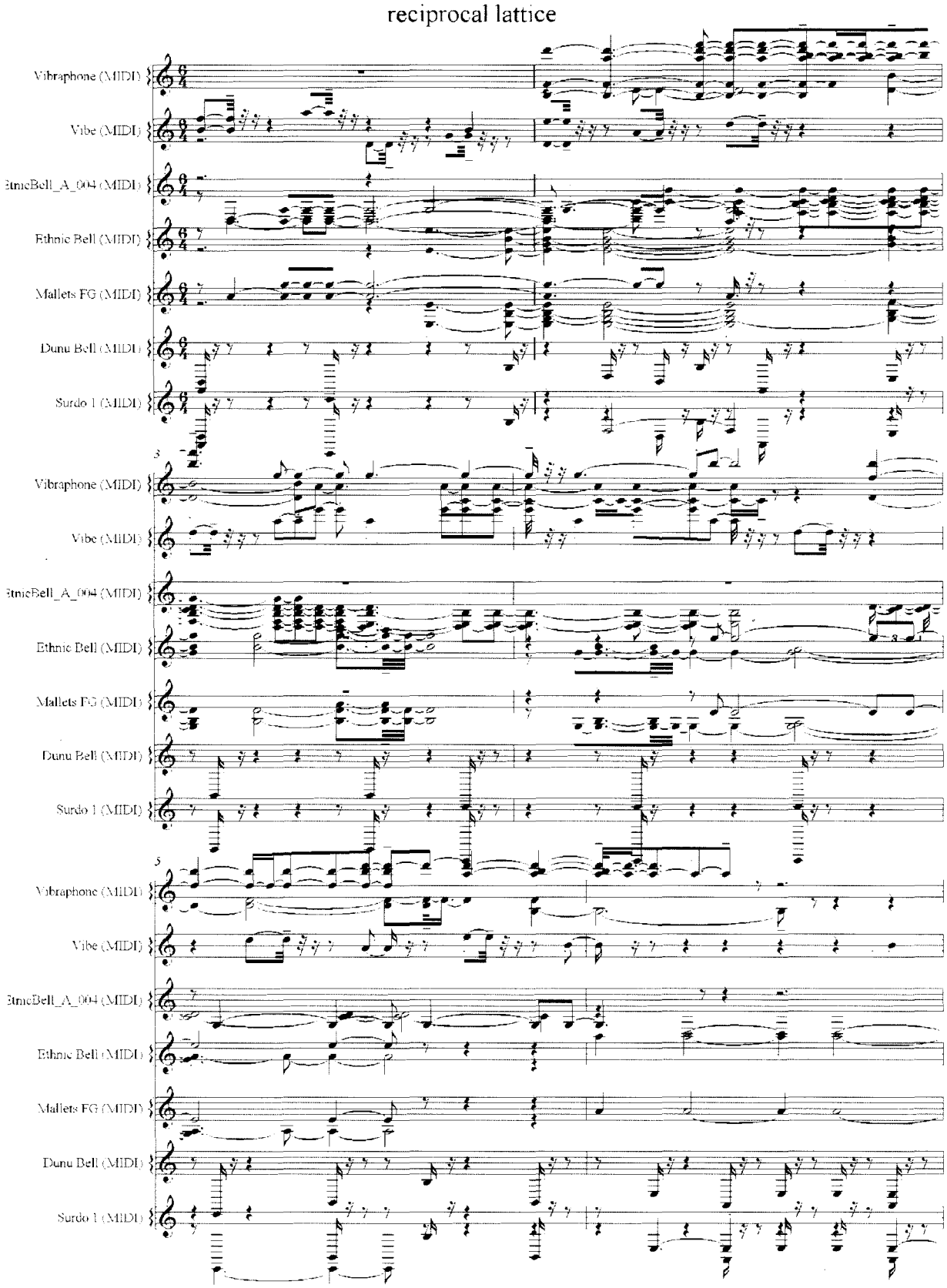
Revisiting the common music notation

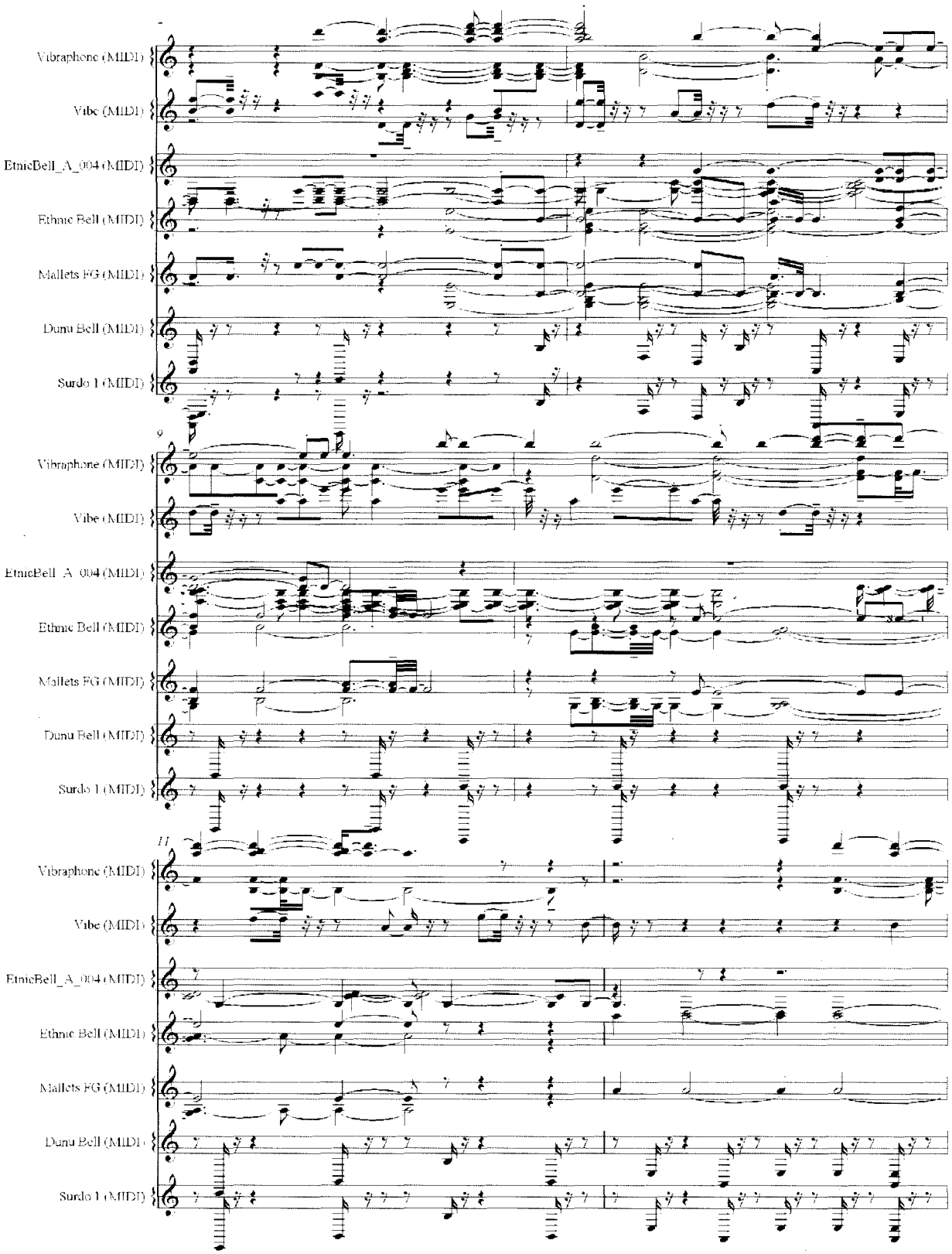
Finally, I have taken advantage of the capacity to map back and forth from digital music output to traditional music notations of commercial MIDI software. Like the word-processor, music notation software packages such as Sibelius have become central production environments for composers, allowing users to compose directly into a graphical interface that mimics the five-line staff, or to input music through connections between electronic instruments and the computer, then annotate, print and modify. In this step, I have used the translation engine of Sibelius to remake the notations of the "Isometric projections" project into the common notation system. Assigning specific values in the western notation tradition to the Acoustic image-tiles derived in the Isometric projections project, the process raises a number of questions worthy of investigation. Are the scores readable and playable as automated readouts of the graphical input? (Fig.89, below)

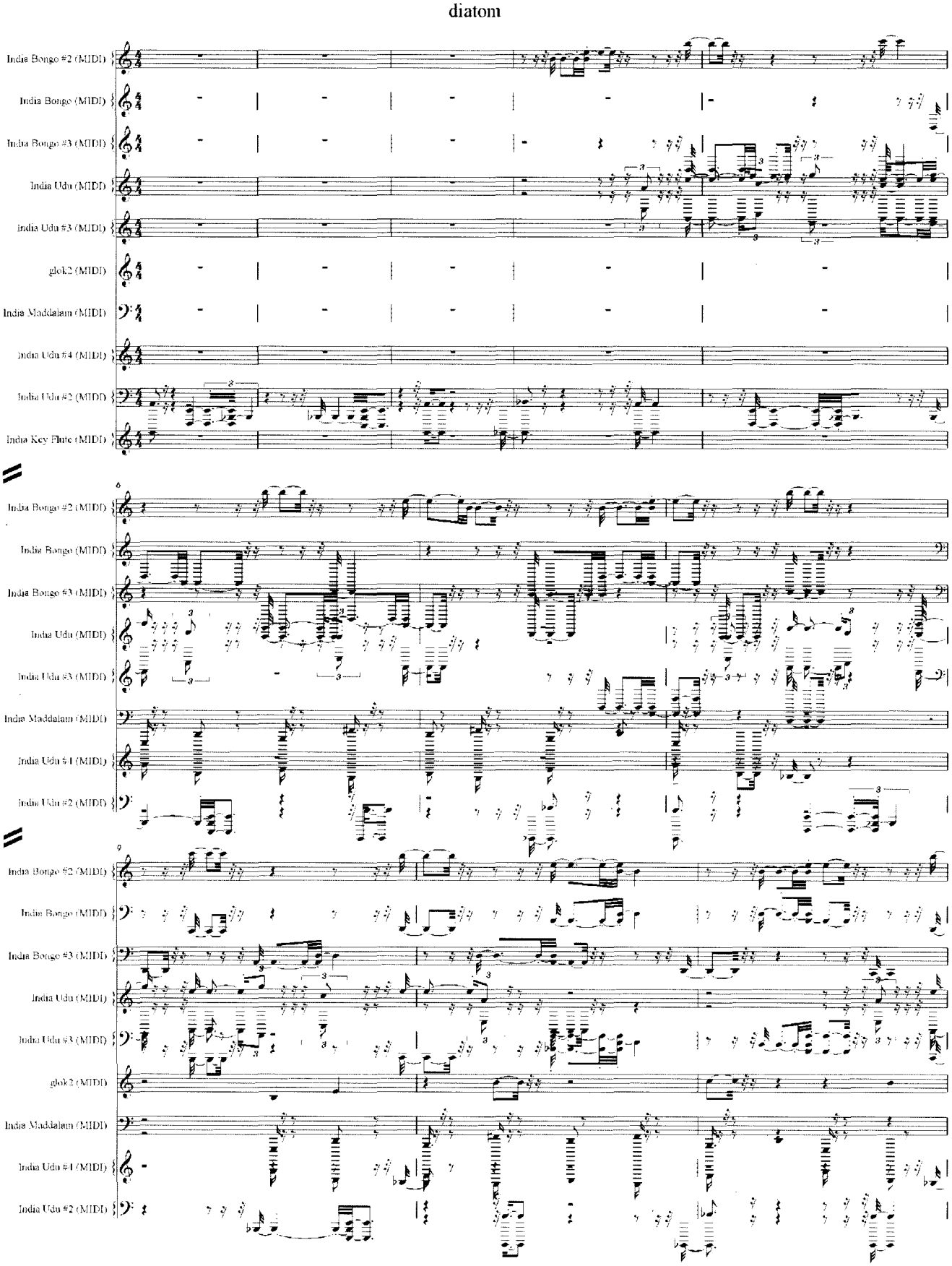
isotropic scaling lor

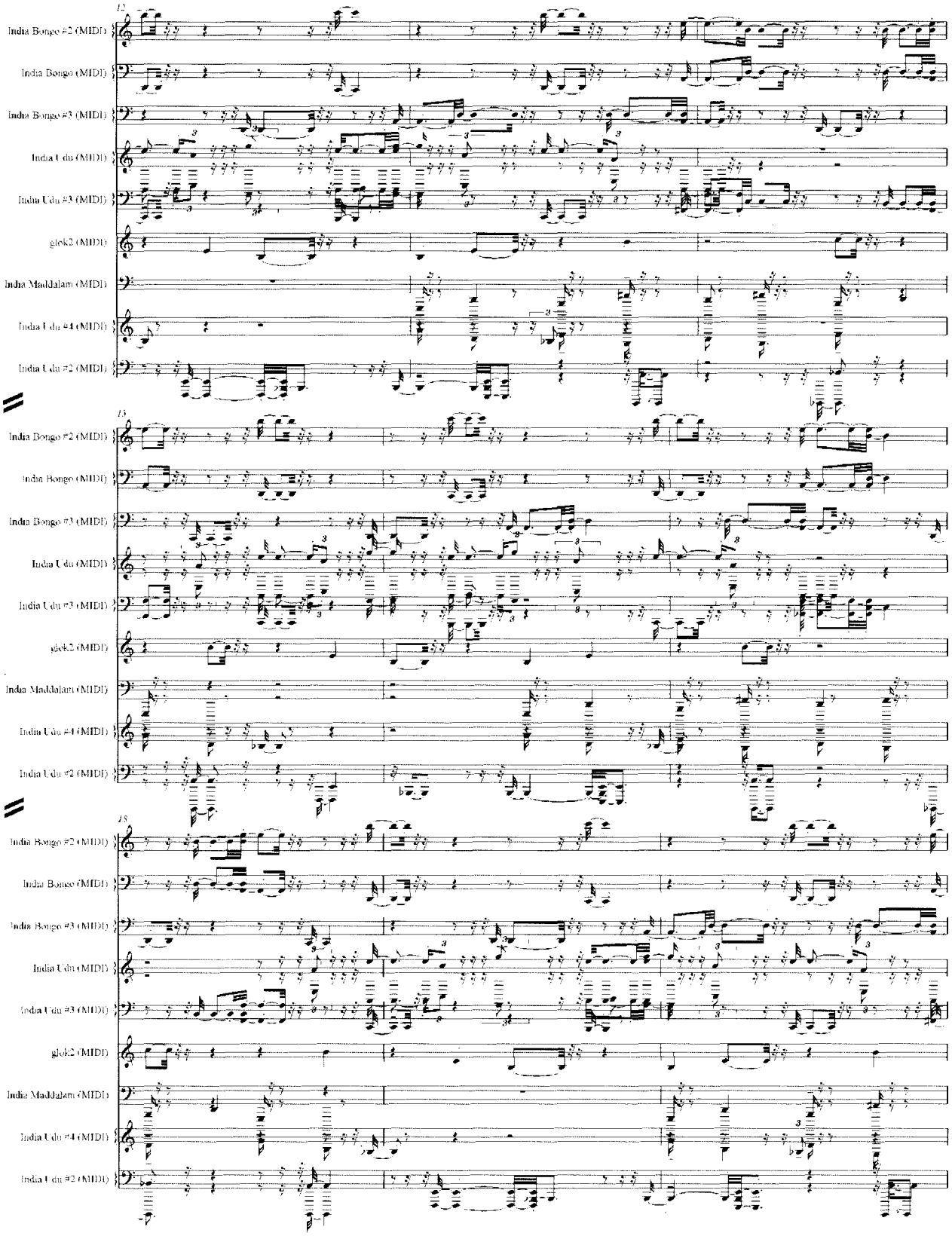



Bidonville (MIDI)
Bidonville #2 (MIDI)
10 Veena a0 (MIDI)
LoFi Kit_002 (MIDI)
LoFi Kit_001 (MIDI)
Glass (MIDI)

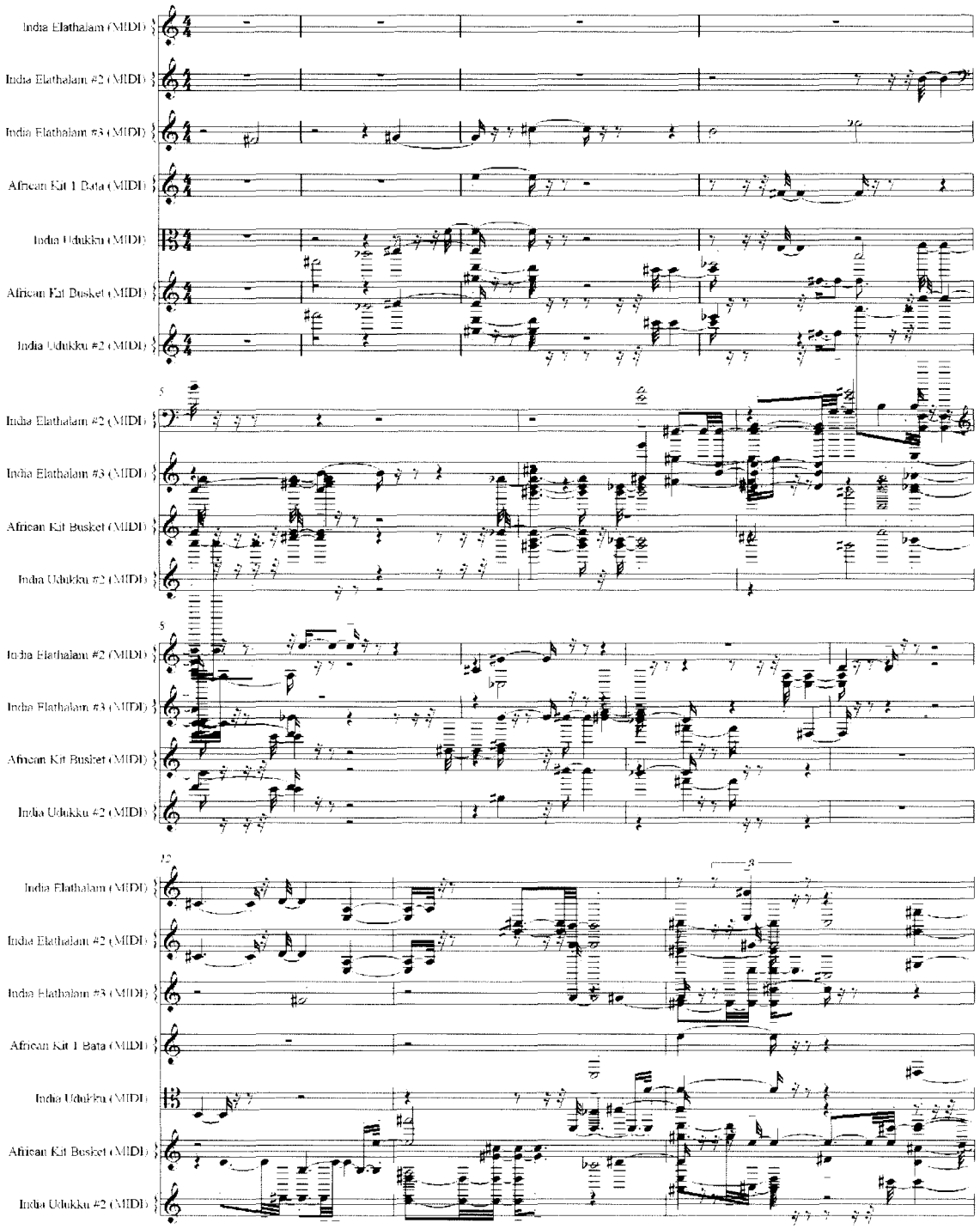

reciprocal lattice
Vibraphone (MIDI)
Vibe (MIDI)
EthnicBell_A_004 (MIDI)
Ethnic Bell (MIDI)
Mallets FG (MIDI)
Dunu Bell (MIDI)
Surdo 1 (MIDI)
3
5


2
Vibraphone (MIDI)
Vibe (MIDI)
EthnicBell_A_004 (MIDI)
Ethnic Bell (MIDI)
Mallets FG (MIDI)
Dunu Bell (MIDI)
Surdo 1 (MIDI)
9
Vibraphone (MIDI)
Vibe (MIDI)
EthnicBell_A_004 (MIDI)
Ethnic Bell (MIDI)
Mallets FG (MIDI)
Dunu Bell (MIDI)
Surdo 1 (MIDI)
11
Vibraphone (MIDI)
Vibe (MIDI)
EthnicBell_A_004 (MIDI)
Ethnic Bell (MIDI)
Mallets FG (MIDI)
Dunu Bell (MIDI)
Surdo 1 (MIDI)


diatom
India Bongo #2 (MIDI)
India Bongo (MIDI)
India Bongo #3 (MIDI)
India Udu (MIDI)
India Udu #3 (MIDI)
glok2 (MIDI)
India Maddalam (MIDI)
India Udu #4 (MIDI)
India Udu #2 (MIDI)
India Key Flute (MIDI)
6
9


12
India Bongo #2 (MIDI)
India Bongo (MIDI)
India Bongo #3 (MIDI)
India Udu (MIDI)
India Udu #3 (MIDI)
glok2 (MIDI)
India Maddalam (MIDI)
India Udu #4 (MIDI)
India Udu #2 (MIDI)
15
India Bongo #2 (MIDI)
India Bongo (MIDI)
India Bongo #3 (MIDI)
India Udu (MIDI)
India Udu #3 (MIDI)
glok2 (MIDI)
India Maddalam (MIDI)
India Udu #4 (MIDI)
India Udu #2 (MIDI)
18
India Bongo #2 (MIDI)
India Bongo (MIDI)
India Bongo #3 (MIDI)
India Udu (MIDI)
India Udu #3 (MIDI)
glok2 (MIDI)
India Maddalam (MIDI)
India Udu #4 (MIDI)
India Udu #2 (MIDI)

4suns


India Elathalam (MIDI)
India Elathalam #2 (MIDI)
India Elathalam #3 (MIDI)
African Kit 1 Bata (MIDI)
India Udukku (MIDI)
African Kit Busket (MIDI)
India Udukku #2 (MIDI)
5
12

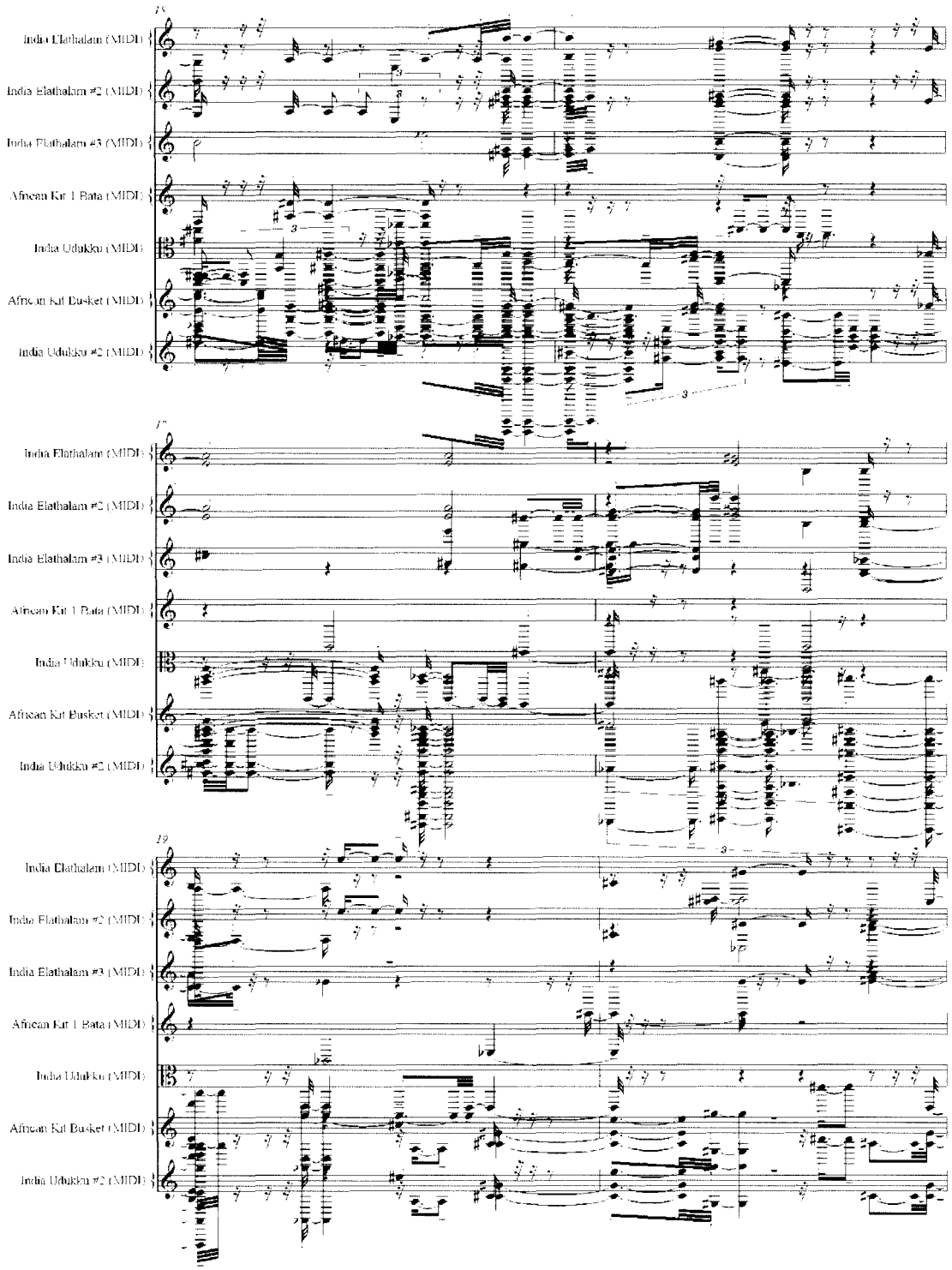


Fig.89: (The author) 2011, Common music notations generated by a MIDI engine

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