Flexible Fabrications: Knitting Yarns in Architecture

by

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ABSTRACT

Marginalized as an outmoded domestic handcraft yet accepted as a prevalent industrial process, knitting's simple construction techniques inherently produce strong, lightweight, and elastic fabrics capable of curvature in multiple, simultaneous planes. Knitting is a self organizing process; its structures of pattern generate texture, surface, and form. A review of the past and current practice of knitting within textile production reveals knitting's paradoxical symbolic function; one that is simultaneously culturally loaded and ambiguous. Further exploration within the context of architecture highlights precedents for the architectural translation of knitting as method, material and metaphor. Knitting is proposed as a logical and topological model for architectural production with the capacity to generate an infinite variety of architectural solutions. Linking the ball of yarn with which one knits (a clew or clue) and the basic knit unit (a loop), the myth of the labyrinth provides the guiding thread for this investigation.

FLEXIBLE FABRICATIONS

KNITTING YARNS IN ARCHITECTURE

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CASTING ON THE *CHŌROS*

(AN INTRODUCTION)

Here begins the labyrinth;
its winding corridors mirror the intricate turnings of the world and of the seeker.

Peter Pesic¹

¹ Labyrinth, 7.

1. A simple knit structure.
Source: drawing by Author.

INTRODUCTION

The ancient textile practice of knitting occupies a curious and contradictory place in contemporary society. It is understood simultaneously as outmoded domestic handcraft (the realm of old ladies declining towards senility) and advanced industrial technology (used to slingshot satellites into space, and implanted surgically to forestall cardiac failure). Despite textiles' long history as architectural materials², and the prevalence of knit fabrics in contemporary textile production³, knits seldom feature in architecture. As a discounted and overlooked mode of textile technology, knitting is a potentially fruitful means of subverting habitual (conventional) modes of architectural production while fabricating new ways of thinking and making architecture.

The English word 'knit' refers to the *making of a fabric* by intertwining yarn or thread in a series of connected loops, the *fabric made by knitting*,⁴ or to the *secure joining* or mending together closely⁵ (as when a broken bone knits).⁶ In this last sense, knit metaphorically lends its seamless, closely joined, textile nature to connections of non-textile objects. Collectively, the three meanings reveal knit's triple identity as method, material, and metaphor.

² Gottfried Semper posits textiles as the archetypal origin of all built form (Gottfried Semper, The Four Elements of Architecture and Other Writings, Harry Francis Mallgrave and Wolfgang Herrmann, trans. (Cambridge: Cambridge University Press, 1989), 108.

³ Mary Schoeser, World Textiles: A Concise History (London: Thames & Hudson, 2003), 132. Schoeser estimates that twenty percent of garments worn today are knitted.

⁴ The Heritage Illustrated Dictionary of the English Language, International Ed., s.v. "knit".

⁵ Ibid.

⁶ Richard Rutt, A History of Hand Knitting, (London: Interweave Press, 1987), 5.

‘Knitting’ is from the Old English ‘*cynttan*’ meaning ‘to tie a knot’; related ‘*cnotta*’ means ‘a knot.’⁷ During the Tudor period ‘knit’ meant ‘marry’ as in:

Know well or thou knyrt to fast, for ofte rathe rewythe at last (mid 15th century proverb later reworded as *Marry in haste, repent at leisure*).⁸

In etymological terms, ‘knitting’ is derived from *netting/net* which in turn is from *ne* (not, never, nil, no, none) and *ned* (to bind, tie, connect, knot).⁹ To extrapolate, a knit is simultaneously a fabric of knots and an abstract structure. The knit loop binds *naught* giving *nothing* a presence in the knitted work.

Because textile divisions are culturally specific and commonly based on the intended purpose of the completed object or the gender of the maker, the task of distinguishing knitting from other textile techniques is complex. Textile historian Mary Schoeser advocates categorizing textiles according to the common principles employed in their making which can be summarized by three motions: twisting, interlacing (an over-under action that includes weaving and plaiting), and looping.¹⁰ This investigation will use the term ‘knit’ to refer to the fabric generated by linking successive fibre loops—or the process of making that fabric—regardless of whether the loops are pulled tight or left loose, formed by drawing a loop of thread, or by pulling the entire strand through.¹¹

⁷ Heritage Dictionary, s.v. “knit”.

⁸ Rutt, 5.

⁹ Ibid. Rutt also notes that the modern French word ‘*tricot*,’ derived from ‘*trique*,’ is likely from the same root as the German ‘*strike*,’ from a word meaning ‘rod’ or ‘stick’. “The Italian ‘*maglia*,’ ‘mesh,’ and Spanish ‘*punto di media*,’ ‘stocking point’ are not known to be older.”

¹⁰ Schoeser, 17.

¹¹ Thus for the purpose of this investigation, techniques sometimes known by other names (including knotted knitting, knotless netting, nålbinding, and cross-loop knitting) will be considered knitting techniques.

Knitting's most basic unit is the 'loop stitch' (*noeud coolant*). Gottfried Semper argues that the symbol of the labyrinth is the primordial sign for the loop and the world's "oldest technical symbol"¹²:

...no symbol has a secret meaning that is more far-reaching and more broadly disseminated than that of the mystical knot—the *nodus Herculeus* [Herculean Knot], the bow knot, the labyrinth, the loop, or any other related form and name for this sign. In every theogonic and cosmogonic system it is the universal symbol for the primeval chain of things—for necessity, which is older than the world and the gods. It is that which joins and commands everything. The sacred knot is chaos itself: a complex, elaborate, self-devouring tangle of serpents from which arise all 'structurally active' ornamental forms, and into which they irrevocably return after the cycle of civilization has been completed.¹³

The graphic pattern of the labyrinth represents the loop's dual nature as both knot (line) and naught (path between the lines). According to Western tradition, the labyrinth was the work of the mythical first architect, Daedalus. Although the etymology of the word 'labyrinth' is unknown, Hermann Kern postulates that before it was understood as an architectural construction, the idea of the labyrinth was first manifested as a dance (*labyrinthos*) in which a chain of dancers followed a path whose movements were choreographed by the graphic pattern of the labyrinth.¹⁴

¹² Gottfried Semper, *Style in the Technical and Tectonic Arts; or, Practical Aesthetics*, trans. Harry Francis Mallgrave and Michael Robinson (Los Angeles, Getty Research Institute, 2004), 219.

¹³ *Ibid.*, 155-7.

¹⁴ Hermann Kern, *Through the Labyrinth: Designs and Meanings over 5,000 Years* (Munich: Prestel, 2000), 25.

a

b

2. The "thread of Ariadne" (a) and the labyrinth (b).
 The "thread of Ariadne" (the labyrinth's path) and a Cretan-type labyrinth with seven circuits.
 Source: Kern, Hermann. *Through the Labyrinth*. Munich: Prestel, 2000, 33.

3

4

3. **Labyrinth dance depicted on the Francois vase (detail).**
The dancers form a chain by holding hands. The scene depicts Ariadne and her nurse (right), Theseus (holding a lyre) and the Athenian captives. Attributed to Athenian potter Ergotimos and vase painter Kleitas, ca 570-560 BCE.
Source: Kern, Hermann. *Through the Labyrinth*. Munich: Prestel, 2000, 49.
4. **Section (top) and interior elevation (bottom) detail of a knitted glove.**
Source: drawings by Author.

Daedalus is also said to have fashioned a dancing ground (*chōros*) for Ariadne.¹⁵ As Joseph Rykwert explains, "...the *chōros* was the precosmic space, the place and the "nurse" of all being, on which the craftsman (or architect) God operated."¹⁶ That it is impossible to separate the labyrinth's dancers, from the dance movements, or the path/ground on which they are danced, is underscored by Homer's description of Achilles' shield in the *Iliad*,¹⁷ which reveals the *chōros*' triple signification as architectural construction (a dance floor), the group performing the dance, and also the dance itself.¹⁸ And so to begin our investigation (a labyrinthine fabrication), we construe a *chōros*, cast on a dancing loop, and discover a looping dance.

In almost every ancient tradition, "to dance is to participate in an ageless cosmic movement."¹⁹ Equally, the making of an ancient textile is a cosmological act. Indra Kagis McEwen succinctly describes this understanding when she writes that for the ancient Greeks, the "weaving [knitting] of the cloth is an unveiling insofar as the person veiled (Earth or bride) only appears, properly speaking, after she has been clothed."²⁰ What is made visible through making (or dancing) is *kosmos*, the mutable, embodied rhythm or order of the universe.²¹

¹⁵ Kern, 27.

¹⁶ Joseph Rykwert, *The Dancing Column: On Order in Architecture* (Cambridge: MIT Press, 1996), 386.

¹⁷ Indra Kagis McEwen, *Socrates' Ancestor: An Essay on Architectural Beginnings* (Cambridge: MIT Press, 1993), 57-58.

¹⁸ Steven H. Lonsdale, *Dance and Ritual Play in Greek Religion* (Baltimore: Johns Hopkins University Press, 1993), 115.

¹⁹ Charlotte Heth, *Native American dance: ceremonies and social traditions* (Washington, D.C.: National Museum of the American Indian, Smithsonian, with Starwood Pub., 1992), 93.

²⁰ McEwen, 54.

²¹ *Ibid.*, 42.

The construction of a dwelling for the hybrid that is the child of the knitting (i.e. marriage) of *knitting* (as method, material and meaning) and *dance* will test the potential of knitting as a fruitful logical and topological model for architectural production. A speculative dance school is proposed, the very fabric of which will register, measure, and inscribe the multiplicity of cyclical and reciprocal transactions between the dance of the *kosmos* (universe) and the *kosmos* (embodied rhythm/order) of dance.

Because it intertwines the knit (loop) with dance, the yarn (myth) of the labyrinth provides the guiding thread in our search for insights into knitting architecture. According to Greek mythology, Theseus used the *clew* given to him by King Minos' daughter Ariadne, as a guide through the labyrinth. The word 'clew' derived from the Old English 'clewe,' refers to "a ball of yarn or thread," and also "anything that guides or directs in the solution of a problem or mystery."²² We begin our journey by tracing the thread of knitting within textile production. An examination of the cosmological nature of the *labyrinthos* establishes a conceptual model for the speculative dance school. After contemplating in general terms how the translation of a knitting paradigm into architecture might operate, we address how the marriage of knitting and dance can inform the architectural fabric of the proposed dance school on Victoria Island in Ottawa. The result of the union of knitting and architecture is an architectural hybrid (a Minotaur). In conclusion, following a

²² Heritage Dictionary, s.v. "clew" (variant of 'clue').

consideration of existing precedents for knitting within architectural practice, the implications of knitting architecture are discussed.

affai ben che allorchio para bella Sida non sari nessuno idisegno esse
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pura modo opulente e non e senza grande ingegno dintelletto non lo
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re luno dall'altre braccia quaranta nelquale spacio fu il fesso di fuori uale
la curanda senza opposizione e ostaculo nessuno e poi nesi ualera dista
re da queste quaranta altre braccia e ualera dopo darenta in laquale dis
tanza auera poi aduare osare uno fossi di quella larghezza de dodece
in braccia e cosi l'osare tutto distato luno dall'altre secondo che uoluerano
lo osare dalui dno. Ma pte lui intendessi bene che io auero inteso io gli
fogna in questa forma e cosi per distesi locorde a quelle misure e distanze de
qui e disegnato. E questo fano uolmo il signore e cosi. ~~~~~

Descrizione dell'edimento
dinto il castello il quale e
in forma di Labirinto.

5. Filarete: the labyrinth as architectural construction.

Fortress for the ideal city of Sforzinda at the centre of a labyrinth. Florence ca 1400.

The fortress is surrounded by a moat of eight ditches which form a seven-circuit labyrinth. A secret door and a viaduct at the first curve of the canal provide the King Zogalia with a shortcut.

Source: Kern, Hermann. *Through the Labyrinth*. Munich: prestel, 2000, 192.

A YARN OF INFATUATION
KNITTING METHOD, MATERIAL, AND MEANING

Each thread has its own story—
we could leave it or stretch it out or fold it into our creativity.
Whatever we do, the thread will carry its complex mystery,
we imagine its irrational character as a constant intrigue.
And the thread is negative, being pulled from that total positive matrix...
so we keep entering that black hole, looking for the threads to bring back.
If there is a method to the search, it lies somewhere in improvising,
and *informal* pathways back out of the labyrinth.

Cecil Balmond²³

²³ Informal, 123.

OVERVIEW

The English word ‘yarn’ refers to a fibre which can be used to knit a fabric, but it is also a term for a story—particularly one that is fabricated, “often elaborated upon by the teller during the telling.”²⁴ The *work* (labour, effort, time, duration) of the makers is an inherent part of what is knit. Regular yet still dissimilar loops are formed as a yarn is interlaced, generating a structural field in which the tracks of making or histories of the knitter’s gestures are recorded. Knitting is rich in connotations that are tied to the histories and cultural traditions of its production. Yarns of making knit meaning.

We can distinguish between a knitted fabric and its method of construction, but as the following discussion will show, knitted form is an emergent behavior (i.e. inherent to the making process); it is impossible to separate a knitted fabric from its act of fabrication. In order to gain a better understanding of the relationship between to knit, the knit, and what is knit (meaning), it is useful to examine knitting processes and their resultant material variations.

²⁴ Heritage Dictionary, s.v. “yarn”.

METHOD AND MATERIAL

The construction of the first course of loops is referred to as ‘casting on’ and is the “foundation” of a knitted fabric.²⁵ Knitting historian Richard Rutt states:

In theory, the first course can be a simple piece of thread, with no twists in it [...] more often however, the first course is given extra stability and firmness by the twisting or crossing of the loops.²⁶

The oldest forms of knitting, used as early as the Mesolithic age,²⁷ were worked with only fingers or a single needle. These techniques start with a looped fibre strand (thread) through which another thread is drawn. The knot is left loose, usually tensioned around a finger, forming a new loop. The thread is then passed through this new loop, forming a chain. Multi-needle knitting techniques most frequently employ the ‘loop’ stitch. A loop of thread (rather than the entire strand) is drawn through loops of the previous row. If untied or broken, the whole system can unravel. Like Janus, the Roman god of beginnings and endings, the loop stitch has two aspects: a knit face where the ‘legs’ of loops are visible, forming a series of herringbone-like ‘V’ shapes, and a purl face, where the ‘feet’ and ‘heads’ of loops stand in relief, forming a broken (dashed) horizontal line (fig.6).

The most ancient knitted artifacts are knit in the round;²⁸ work spirals in a single direction to create a circular or tubular fabric. Flat knitting is generally done on sets of two needles, often knobbed at one end to keep the work in progress from

²⁵ Rutt, 13.

²⁶ Ibid.

²⁷ Schoeser, 7.

²⁸ Rutt, 23.

6. Knit wale (a), course (b) and loop (c).

Source: Tellier-Loumagne, Francoise. *The art of knitting*. Black, Sandy, trans. London: Thames & Hudson, 2005, 294.

slipping off and unraveling. In flat knitting, stitches are worked in rows. At the end of each row, the work is turned, and a new row of stitches are worked through the loops of the previous course.

When knitting in the round, repetition of the basic knit loop produces a fabric that is referred to as ‘stockinette’, ‘stocking stitch’, ‘single jersey’, or ‘plain fabric.’ The loop’s double aspect simultaneously creates two different surface textures: a smoother side where only knit faces are visible, designated as the ‘front’ (or ‘right’) side, and a bumpier side where only purl faces are visible, designated as ‘reverse’ (or ‘wrong’) side (fig.7). This asymmetry from front to reverse causes a piece of stockinette fabric to curl toward the front at the top and bottom, and toward the back at each side.

Rows of stitches are referred to as ‘courses’ and vertical columns of loops are referred to as ‘wales.’ To obtain a stockinette by flat knitting, courses must alternate between rows of knit stitches on the right side and rows of purled stitches on the reverse side. To keep the knit face of a loop on the ‘front’ side of a finished fabric, every time the ‘reverse’ side of the fabric is turned towards the knitter, the loop must be ‘purled’ (drawn from current front to the back of the work in progress). When knitting in the round, a purled stitch appears as a decorative stitch (“pearl”) in an otherwise knit field.

7. Stockinette stitch: front side (a, c) showing knit faces of loops and reverse side (b, d) showing purl faces of loops.

Source: by Author.

By varying the pattern of knit, purl, and slipped (i.e. not worked) stitches, an infinite variety of knit textures and structures are generated (fig.7-12). Changing the pattern of stitches changes the material properties of the resultant fabric. In flat knitting, knitting the stitches of every course produces what is known as ‘garter stitch’ fabric (fig.8). Garter stitch is fully reversible (front and reverse sides have the same appearance), it does not curl (because knit and purl faces are equalized on each side), and is longitudinally more elastic than stockinette. ‘Ribbing’ patterns are generated by alternating wales of knit and purl stitches (fig.9). These patterns produce a fabric that is very elastic from side to side, and is often employed where the resultant item needs to be very form-fitting (like the cuffs on mittens or collars of ‘turtleneck’ sweaters). ‘Cable’ knitting techniques vary the order of stitches worked in a course, creating a texture in high relief. Stitches are crossed by transferring some stitches off the active needle to the back of the work and passing other stitches to the front of the work. Those passed in front are worked, while those behind are simply held until they are transferred back to the active needle. Cabling techniques can be employed to create deep, serpentine, braided, and honeycomb patterns (fig.13). ‘Lace knitting’ is a technique characterized by stable ‘holes’ in the finished fabric (fig.14). An increase in the number of stitches is paired with an adjacent or nearby decrease (i.e. two stitches knit together) to slant the fabric away from the increase, thereby opening up a hole. Lace knitting produces a very soft fabric and was traditionally used to knit clothing and blankets for infants.

8. Garter stitch: detail (a) and field; front side (b,c) and reverse side (d).
Note front and reverse sides of garter stitch have the same appearance.

Source: by Author.

9. Ribbing stitch: alternate wales of knit 2 purl 2. Front side (a, b) and reverse side (c, d, e) have the same appearance.

Source: by Author.

10. 'Blackberry' or 'Trinity' stitch, reverse (a) and front (b).
Three stitches are made from one (increases) and one from three (decreases) on alternate rows.
Source: by Author.
11. 'Diagonals' stitch, reverse (a) and front (b).
Stockinette field with raised reverse stockinette diagonal ridges.
Source: by Author.
12. 'Moss' stitch, reverse (a) and front (b).
Alternate knit and purled stitches in both courses and wales produces identical texture on both front and reverse sides.
Source: by Author.

13. Cable knits.

Source: Tellier-Loumagne, Françoise. *The art of knitting*. Black, Sandy, trans. London: Thames & Hudson, 2005, 188.

14. 'Birdseye' lace stitch.
Source: by Author.

Multiple stranded knitting techniques further vary the structure and texture of knitted fabrics by splicing or carrying more than one yarn in a single course (fig.15, 16). The knit structure does not impose any limits on when or where multi-stranded techniques can start or stop during fabric construction. Adding, changing or discontinuing a yarn can occur at any point within a course or wale. Within contemporary industrial production, knit fabrics are now being designed with fibres that take advantage of so-called ‘intelligent’ technologies which means that the resultant fabric may be breathable, water-repellant, heat or moisture regulating, “...reflective, optical, thermochromic, acoustic, perfumed, anti-bacterial or anti-UV.”²⁹

A knit fabric can be precisely shaped (both two and three-dimensionally) during making by increasing and/or decreasing the number of stitches in a row (fig. 18-21). This is referred to as fully-fashioned knitting and is used, for example, to form the heels of socks and shoulders of sweaters. Increases are constructed by either knitting more than once into a single loop, or by taking up new loops between those already worked (fig.17). Decreases are created by knitting only once into two or more loops. Visible shaping, where the increases are worked a few stitches in from the edges of the knitting, emphasizes the way a knit piece is shaped and performs an ornamental as well as structural role (fig18).

²⁹ Françoise Tellier-Loumagne, *The art of knitting*, trans. Sandy Black (London: Thames & Hudson, 2005), 9.

15

16

15. Multi-stranded knitting diagram, front side (left) and reverse (right).
Using this technique, it is possible to knit with two yarns simultaneously and then separately.
Source: Tellier-Loumagne, Françoise. *The art of knitting*. Black, Sandy, trans. London: Thames & Hudson, 2005, 82.
16. Multi-stranded knitting, reverse side (a, b) and front side (c, d).
Source: Tellier-Loumagne, 80.

17

17. **Methods of working increases (a-d) and decreases (e-g).**
 (a) three stitches worked into one loop, (b) a stitch worked in the foot between two stitches of the previous course, (c) two stitches worked into one loop, (d) a stitch worked in a loop from the course below the course being worked, (e, f) decreases achieved by working two loops into one, (g) decrease made by passing one loop over another and working the second loop only.
 Source: Rutt, Richard. *A History of Hand Knitting*. London: Interweave Press, 1987.
- 18, 20. **Fully-fashioned knitting: decreases within the interior of a knit panel.**
 Source: Tellier-Loumagne, 217.
19. **Fully-fashioned knitting: two colour rib with discrete increases and transfers.**
 Source: Tellier-Loumagne, 214.
21. **Fully-fashioned knitting: sock heel worked with partial knitting.**
 Groups of stitches are held without knitting allowing the work to be created in three-dimensions and also any direction.
 Source: Tellier-Loumagne, 103.

22. **Hexagonal fabric knit by picking up stitches (detail).**
Picking up stitches on each edge creates raised ridges between each hexagon.
Source: Gaughan, Norah. *Knitting Nature*. New York: Stewart, Tabori & Chang, 2006, 31.
- 23, 26. **Fully-fashioned knitting: decreases moving towards the centre.**
Source: Tellier Loumagne, Françoise. *The art of knitting*. Black, Sandy, trans. London: Thames & Hudson, 2005, 216.
24. **Hexagonal fabric construction diagram.**
Each hexagon is begun by picking up stitches from an existing piece.
Source: Gaughan, 33.
25. **Ribbed pentagons picked up from stockinette field.**
Source: Gaughan, 48.
27. **Method of picking up stitches along a horizontal edge.**
Source: Webb, Mary. *Knitting Stitches*. Buffalo, N.Y.: Firefly, 2006, 66.

Even after ‘casting off’, (i.e. linking the last course of loops laterally to lock the wales so that the work can be removed from the knitting needles), additions can be made by ‘picking up stitches’ (i.e. knitting into finished stitches). Stitches can be picked up in a straight or curved line, at edges, or within a knit field (fig.22-27). This means that knit fabrics are not restricted to production in one direction (i.e. lengthways). Knit fields can extend in all directions and into multiple planes to create complex structures. Because there are no straight lines of thread anywhere within its fabric, a knit textile can be distorted in any direction and is capable of curvature in multiple, simultaneous planes. This elasticity (even with non-stretch yarns) is unavailable from woven fabrics, which only stretch along the bias. Typically after the work has been cast off, a knitted piece is ‘blocked’ (stretched over a flat surface or 3D form and pinned to the correct shape and dimensions), and then pressed with an iron. The aim is to allow pressure and steam to penetrate fibres just enough to fix/freeze/set the form without losing elasticity and depth of texture.

Knitting’s simple construction techniques, regardless of whether they are employed by hand or by machine, produce flexible, lightweight, three-dimensional constructions with very high tensile strength. Basic knitting techniques with a few variations (changes in the diameter of the knitting needles, the thickness of fibre strands, or the pattern of knit, purl or slipped stitches), generate a multitude of different material properties and complex textures.

MEANING

Little academic research has pursued the history of knitting. Richard Rutt's book, A History of Hand Knitting, is a notable exception. His research considers knitting in Europe before 1500, focusing primarily on knitting in Britain. (A brief history of knitting technology, primarily based on his research, can be found in Appendix A). Rutt tends to discount if not debunk knitting myths and legends³⁰ in his effort to clarify a chronological development of knit production. Nonetheless, for the purpose of this study, the meanings fabricated by these mythical yarns are as relevant for their architectural potential as the so-called 'historical' accounts of making.

Gottfried Semper speculates that the string is the oldest artistic product³¹ and refers to the knot as an expression of the "earliest cosmogonic ideas"³² of archaic man. As Marco Frascari corroborates, the critical link between textile making and place making "... finds a confirmation in many creation myths, which place textile arts among the first given."³³ Navajo legends tell of the "spider woman" who personifies the textile arts and is believed to have taught the People to weave. What is made visible in the scintillating patterns finely woven, embroidered, or knit into the surface of an ancient Greek textile (*poikilon*), through the knowledge of experience (*sophia*) embodied in the hands of the textile maker, is the invisible rhythm or order (*kosmos*)

³⁰ Marco Frascari, Monsters of Architecture (Maryland: Rowman & Littlefield Publishers, 1991), 8.

³¹ Semper, *Style*, 113.

³² *Ibid.*, 219.

³³ Frascari, 118.

of eternal nature.³⁴ Through its rhythmic surface, a traditional textile acts as a graphic poem or prayer that gives sight to the cosmos.³⁵

Textiles' power to communicate beyond text is immortalized in the story of Arachne. Arachne, a skilled young weaver from Lydia, on the edge of the Hellenic empire, challenges Athena, goddess of the textile arts, to a weaving contest. During the contest, it becomes clear that Arachne can weave as quickly and ably as the goddess. Furthermore, the finished piece is as flawless as Athena's own. Enraged, Athena changes Arachne into a venomous spider. Was it simply Arachne's skill (a prowess that rivalled that of the goddess) that enrages Athena? The story's details suggest that the symbolic content of Arachne's ornamentation threatened Athena more than her workmanship.³⁶ Athena embroidered the council of the gods; proper and orderly scenes that reinforced her position as patron goddess of Athens. In contrast, Arachne's fabric revealed the capriciousness and trickery of the gods by depicting among other episodes of abduction and violation, the "Rape of Europa."³⁷

Although the information recorded is always subject to interpretation, both the practice of knitting and the textiles produced by that practice record information,

³⁴ McEwen, 47-54.

³⁵ Anne West, "Weaving Out Loud", Material matters: the Art and Culture of Contemporary Textiles, Ingrid Bachmann and Ruth Scheuing eds., (Canada: YYZ Books, 1998), 61.

³⁶ Sarat Maharaj, "Arachne's Genre: Towards Intercultural Studies in Textiles," Material Matters: The Art and Culture of Contemporary Textiles, Ingrid Bachmann and Ruth Scheuing eds., (YYZ Books: Canada, 1998), 157-9.

³⁷ Intending to seduce Europa, Zeus disguises himself as a beautiful bull before appearing in the meadow where she and her companions are picking flowers. Tricked by his gentle demeanor, Europa eventually sits down on his back at which point Zeus leaps up and carries her off over the sea to his own island, Crete.

communicate social and religious values, and mark cultural identity.³⁸ Nineteenth century histories of knitting often interpret certain biblical passages and Greek mythologies as describing knit textiles claiming that the “seamless robe stripped from Christ before his crucifixion” and the shroud that the Odyssey’s Penelope fabricated to deceive her suitors were knit.³⁹ Certainly if Penelope had been knitting, it would have been a simple task to unravel her work nightly.⁴⁰

The oldest dateable knit fragments were found in the 2nd century CE grave of a woman at Esch, in the Netherlands.⁴¹ Because knits get worn and wear out, knit fabrics tend to be ephemeral; the fragments are often too small to determine the purpose of the knitted object. Knitted socks with a division for the big toe (possibly so they could be worn with sandals) dating to the 5th century CE, have been found in Egypt and Syria⁴² (fig.33). No accounts have been found to indicate the gender or social status of the makers, so we can glean little more than that the earliest knitting appears to have been executed in the round.

Fourteenth century paintings of the Madonna knitting reveal that at that time, knitting was understood as an ancient domestic (and apparently virtuous) practice performed by women at home. These paintings, including Master Bertram of

³⁸ West, 61.

³⁹ Rutt, 27, 48.

⁴⁰ Penelope was the wife of Odysseus who wandered for ten years after a storm struck the victorious Greek Fleet soon after they put out to sea after the fall of Troy. Everyone assumed that Odysseus was dead and Penelope should remarry, but she detested her suitors and maintained that her husband would return. In the hope that the delay would cause them to lose interest, Penelope insisted that she could not remarry until she had finished making a finely wrought shroud for Odysseus’ father, in preparation for his eventual death. The suitors agreed to wait until the work was finished although it never was because Penelope unraveled each night what she had made that day.

⁴¹ Rutt, 28.

⁴² Ibid., 31.

Minden's *Buxtehude Madonna* (fig.29), are generally interpreted as part of a trend in art that reflected an increasing interest in the "human and emotional aspects of the life of Christ."⁴³ The paintings suggest that during the 14th century, knitting in the round using multi-needle techniques was done at home by women, although it is unclear if it was a common pursuit. By the 16th century, some forms of knitting (such as cap-knitting) were male-dominated and restricted to licensed professionals. Many other forms of knitting were performed by women and children, and employed the poor. That knitting by women was not well remunerated is indicated in a book for teaching French written by John Palsgrave (tutor to Princess Mary who would later become Mary I, Queen of England) in 1530. Included in the meanings for 'knit' was the following passage:

*She that sitteth knitting from morrow to night can scantly win her bread [translated as] Elle qui ne fait que lasser le matin jusques au soyr a grant payne peut elle gaigner son payn.*⁴⁴

Knitting was done at home (hence the term 'cottage' industry) by men, women, children and the elderly. Due to high European demand for long stockings, England's pre-imminence in wool production, and the "rapid and successful diffusion of knitting skills" throughout its working-class, England was the leading exporter of knit hosiery by the second half of the 16th century.⁴⁵

⁴³ Rutt, 44.

⁴⁴ Ibid., 63.

⁴⁵ Ibid., 75, 77.

28. **Roman-Egyptian socks in red wool made by nalbinding.**
Fifth century CE from Oxyrhynchus (a Greek colony by the Nile in central Egypt).
Source: Rutt, Richard. *A History of Hand Knitting*. London: Interweave Press, 1987, 31.

29. Master Bertram of Minden, *The Bustehude Madonna*, ca 1400 CE.
Source: Rutt, Richard. *A History of Hand Knitting*. London: Interweave Press, 1987, 49.

However, knitting is also a social act that is concerned with both making objects and sharing stories. Traditionally people gathered to knit. In rural British knitting communities, after the young children were put to bed, neighbours gathered to knit and socialize. William Howitt (1792-1879) writes: “the whole troop of neighbours being collected, they sit and knit, sing knitting songs and tell knitting stories.”⁴⁶ In general, knitting was a sideline practiced to supplement farming income, and still today connotes industriousness and frugality. Incessant knitting during daily tasks became so prevalent in rural stocking making areas that there are accounts of priests complaining of churchgoers knitting during worship.⁴⁷ Knitting was not only a necessary industry of the poor; to support the thriving English export industry and, “as part of the general imposition of a heavy work ethic on the poor,”⁴⁸ knitting was posited as virtuous. It became seen as both a means of poverty relief and a way of keeping poor people out of trouble. Knitting began at a very young age as indicated in the records of The State of England, 1600, which notes positive gains in gross national revenues due to child labour “...chiefly by knitting of fine jersey stockings, every child being able at or soon after seven years to earn four shillings a week at that trade.”⁴⁹ Poor children were sent to knitting schools which became centres of both instruction and production.

The mythical association of knitting with fate is recorded in Charles Dickens’ novel A Tale of Two Cities (1859) set during the French Revolution. Madame

⁴⁶ William Howitt quoted in Rutt, 119.

⁴⁷ Rutt, 81.

⁴⁸ Ibid., 103.

⁴⁹ Ibid., 77.

Defarge, one of the infamous tricoteuses⁵⁰ (knitting women) relentlessly knits a register of the names of all those sentenced to death by the French Revolution. As their names appear in Defarge's fabric, the condemned are executed at the guillotine. The etymology of the French word '*tricoter*', meaning 'to knit' symbolically links knitting to Lachesis, one of the three sisters who are the Fates of Greek mythology. '*Tricoter*' is derived from Old French '*trique*' a stick for levelling measures of grain. Clotho spins the web of life, Lachesis measures or *knits* it, and Atropos cuts it (fig.30).

In contrast to the tricoteuses, those who knit are typically considered non-threatening. Until the late 18th century, although the English gentry knew how to knit, only those in 'straitened circumstances' would practice knitting.⁵¹ By the Victorian age 'ladylike' knitting became a fashionable pastime for 'ladies of leisure.' It was considered appropriate for the Victorian lady to show some concern for the poor and the 'philanthropic knitting' of 'warm comforts' was one means by which this could be demonstrated (although the practice seems to contradict the upper class belief that knitting was an appropriate way for the poor to be industrious). In order to appear elegant and refined while knitting, English ladies began to hold the right-hand needle between the thumb and index finger as they would a pen. Unlike the poor 'cottagers' who knitted for income and adopted an efficient needle-handling technique (holding a needle under the palm of each hand), the ladies were unconcerned with knitting speed. Philanthropic knitting gained momentum during World War I when British, Canadian

⁵⁰ Rutt, 95. Although Rutt argues that there is no reliable historical evidence of tricoteuses by the guillotine, there are records of tricoteuses knitting and shouting in the public gallery of the National Convention.

⁵¹ Ibid., 97.

and American women knitted socks, mitts, belts, and hats for soldiers as part of the ‘war effort.’ Knitting began to signify an activity for lonely women and (compared with the horrors of war) a comfortable fireside pastime.

In contemporary society, knitting is paradoxically both accepted as a prevalent technological practice, and marginalized as an outmoded domestic handcraft. Considered an industrial process when practiced by professionals, knitting is generally perceived as a craft when practiced by non-professionals. Recently hand knitting as a pastime has grown in popularity internationally, particularly among young adults.⁵² Just as in the past, the knitting community with whom knowledge, techniques and ideas are shared is important to contemporary makers. Knitting’s capacity as a vehicle for communication appears to have resurfaced in the contemporary phenomenon of the knitting ‘blog.’ Through the internet, thousands of knitters around the world gather to share stories in a virtual community.⁵³ Knitters post images and text about projects in progress while readers communicate by posting comments and sending e-mails.

Historically, knit textures, patterns and styles played a significant role in disseminating information and identifying individuals, groups and societies. Today, elaborate, cable-knit sweaters are associated with the Aran Islands (located off the west coast of Ireland). In the Middle Ages, specific cable stitch patterns based on Celtic interlace designs are said to have been used to identify a specific fishing village

⁵² David McFadden, foreword to *KnitKnit: Profiles and Projects from Knitting’s New Wave* by Sandra Gschwandtner. (New York: Harry N. Abrams, 2007), 4.

⁵³ Gschwandtner, 15.

or sometimes even a family. Knit into sweaters, the patterns functioned as “talismans and maps.”⁵⁴ For centuries, knitted hosiery has functioned as an important indicator of social status. By association with the dandies who wore them in Elizabethan England, knit silk stockings were considered immoral. Finely-knit, sheer, and brightly-coloured, long, silk stockings worn with extremely short trunk hose (the 16th century equivalent of the 20th century mini-skirt) were designed to call attention to the shape of a gentleman’s legs.⁵⁵ In contrast, Cromwell’s 1653 Commonwealth was known as the “Blue-Stocking” Parliament because the yarn in the blue or grey hosiery worn by the Parliament’s non-noble members was cheaper to produce than the more fashionable black. Thus the term ‘blue-stocking’ became associated with the ‘mean’ and ‘puritanical.’

Because knitting’s association with utility tends to place it outside the practice of art, artists are beginning to use knitting as a means to critique the contemporary understanding of art, craft, and industry. For example, a group of ‘guerilla knitters’ from Houston known as ‘Knitta Please, combine craft with vandalism by knitting tags for urban objects that range in scale from parking meters to Notre Dame Cathedral. Dave Cole uses construction equipment and safety gear to knit with heavy, toxic, industrial materials (fig.37, 38) challenging associations of knitting with women’s work, and questioning knitting’s non-threatening, domestic connotations.

⁵⁴ Rutt, 128.

⁵⁵ Ibid., 69-71.

30

Knitting On.

32

33

30. Fates, knitting. Source: drawing by Author.
31. The traditional way of holding the needles.
Source: Tellier-Loumagne, Françoise. *The Art of Knitting*. Black, Sandy, trans. London: Thames & Hudson, 2005, 296.
32. The 'fashionable' 19th century English way of holding the needles.
Source: <http://beetonsbookofneedlework.com/images/image289.jpg> (accessed 1 December 2008).
33. A still from Mandy McIntosh's 1996 film *Donkey Skin* which examines the symbolism in traditional Aran knitting.
Source: Gschwandtner, Sabrina. *KnitKnit: Profiles + Projects from Knittings's New Wave*. New York: Harry N. Abrams, 2007, 129.

34. Knitta. Tagged monument in Paris, France.
Source: <http://blogs.glam/glamchic/files/2008/05/knitta1.JPG> (accessed 29 Dec. 2008).
35. Knitta. Tagged trees.
Source: <http://gasparotto.typepad.com/photos/uncategorized/knitta.jpg> (accessed 20 Feb. 2007).
36. Study model: knit wood lattice. Source: by Author.
37. Dave Cole. *Fibreglass Teddybear*, 2003.
Source: Gschwandtner, Sabrina. *KnitKnit*. New York: Harry N. Abrams, 2007, 42.
38. Dave Cole. *Knitting Machine*, 2005.
Source: Gschwandtner, 41.

There are no knitting ‘superstars’ and the act of knitting when practiced by amateurs is often marginalized as ‘laborious’, ‘mundane’, ‘outdated’, ‘unfashionable’, ‘trivial’, or ‘frugal’, and is stereotypically associated with the elderly. Although what is knit can be highly individual, perhaps because it is widely perceived as ‘domestic’ and ‘old-fashioned,’ the makers of knitting tend to remain anonymous. The machine-knit T-shirt for example, functions as an omnipresent sign of contemporary society, yet when printed with text, logos, and patterns, signifies belonging and acts as a potent vehicle for advertising. Despite its apparent ambiguity, knitting’s symbolic function is always culturally loaded and it is precisely this, in combination with knitting’s capacity to produce an infinite variety of patterns in a multitude of textures, finishes and colours, that if translated into architecture, suggests the potential for attachment of meaning that surpasses the capabilities of conventional building materials.

ARIADNE'S THREAD

TRACING THE *KOSMOS* OF DANCE AND THE DANCE OF THE *KOSMOS*

Where female divinities adorn themselves,
 or, as Homeric language actually describes it,
 wrap themselves in *kosmos*, in order to go dancing, the suggestion is that
 the ordering of the dance is a reflection of their adornment, or ordered second skin, and vice
 versa. As *kosmos* clothes the body to make it appear,
 so, through the dance, *kosmos* clothes the ground to make it appear.

Indra Kagis McEwen⁵⁶

I think that when you say “my brother, the sun” it’s not just a pretty phrase,
 And when you say “my sister, the rain” you voice something of this
 conjuring of the animate and the inanimate.
 The dance is one of the most important sites of this relationship.

Paul Virilio⁵⁷

⁵⁶ *Socrates Ancestor*, 44-5.

⁵⁷ *Traces of Dance*, 54.

39. The Thread of Ariadne.
Drawing based on the path
of the Chartres Cathedral lab-
yrinth.

Source: drawing by Author.

40. Theseus's Voyage to Crete, Master of the Campana Cassone.
 Florentine cassone (chest) painting, early 16th century.
 Source: Kern, Hermann. *Through the Labyrinth*. Munich: Prestel, 2000, 13.

GERANOS

Ancient Greek legend places the labyrinth's origin in Knossos on the island of Crete.⁵⁸

Fleeing murder charges in Athens, Daedalus set up residence at King Minos' court.

There he was commissioned by the Royal family to build three architectural projects.

For Pasiphaë (Minos' wife), Daedalus crafted a machine (a wooden, mechanical cow)

that enabled her to consummate her infatuation with a bull. (It was from this unnatural relationship, that the Minotaur was born). For Minos, Daedalus constructed a

labyrinth in which to contain (hide) the monstrous evidence of the Queen's infidelity.

For Ariadne (Minos' daughter), Daedalus 'wrought' a *chōros*. Every nine years,

Athens was obliged to send seven youths and seven maidens to Crete to be fed to the

Minotaur. Theseus was one of these. He entered the labyrinth, killed the Minotaur,

and then, following the thread of Ariadne, escaped the labyrinth with the other

intended victims. As Masud Hasan Taj writes: "The after-life of a monster-dweller, alas is the dwelling itself."⁵⁹ Forever after, the Minotaur was destined to haunt the

labyrinth. Theseus and his companions celebrated their escape by torchlight on the

island of Delos with a nocturnal dance that retraced the twists and turns of their

passage through the labyrinth. This Delian dance was called '*geranos*.'⁶⁰

⁵⁸ Kern, 27.

⁵⁹ Masud Hasan Taj, *Doctoring Strange Loves Or: How I Learned to Stop Worrying Stanley and Love Monsters in Scholarship, Chess, Films & Architecture* (Ottawa: Carleton University, 2004), 3.

⁶⁰ Lillian Brady Lawler, "The Geranos Dance-A New Interpretation," *Transactions and Proceedings of the American Philological Association* 77 (1946):119-124. The etymology of the word *geranos* is disputed. Although *geranos* is the Greek word for "crane", the relationship between the dance and the bird remains unresolved. Lawler claims that in the context of the dance, *geranos* has nothing to do with the crane. She argues that the word *geranos* is derived from the Indo-European root *ger* meaning "winding" or "curling" (used to refer to both rivers and snakes) and proposes the *geranos* as a snake dance. Before the fall of Crete and arrival of the Greek God Apollo, the Earth Goddess at the chthonian oracle of Minoan Delphi was represented by a python. To invoke the presence of the Great Goddess, the Cretans may have performed a nocturnal, winding serpent dance that culminated in the exhibition of a living snake, the goddess incarnate.

Synthesizing accounts by Homer, Plutarch and Pollux, Kern describes the *geranos* as a round dance (similar to the Basque ‘Snail Dance’ represented in fig.41) performed by a chain of dancers with a leader at each end.⁶¹ The leaders ‘pull’ the chain (created by holding hands or a rope) through the dance following the labyrinthine markings on the *choros*. *Chōros* refers to the dance surface/floor/ground, the dance form/movement, and also to the group performing the dance.⁶² A *choros* was a “...group of participants who sang in unison and danced as a corporate body.”⁶³ During the dance at “divinely sanctioned assemblies,” the ancient Greeks believed that the gods would interact with humans and thus the *chōros* represented an important means of communing with divine order.⁶⁴ In preparation to preside over the dance, the female divinities of ancient Greece wrapped themselves in *kosmos*.⁶⁵ *Kosmos* refers to order or arrangement but can also be understood as ornament or adornment (the word ‘cosmetic’ is derived from *kosmos*). McEwen argues that the suggestion is that “...the ordering of the dance is a reflection of their adornment...and vice versa...[furthermore] as *kosmos* clothes the body to make it appear, so, through the dance, *kosmos* clothes the ground to make it appear.”⁶⁶

⁶¹ Kern, 45.

⁶² The Greek word *chōros* is likely derived from the suffixed o-grade form (**ghor-o*) of the Indo-European root *gher* meaning “enclosure.”

⁶³ Lonsdale, 115.

⁶⁴ Ibid., 116. Lonsdale writes: that during these events, “...a lack of clear distinction between divine and mortal is part of a playful fiction recognized by philosophers, poets, and artists.” The famous gold signet ring from Knossos (considered the *locus classicus* for the descending divinity type), attests to Minoan belief in “the power of the dance to attract a celestial presence to a dancing ground through prayer in gesture.”

⁶⁵ McEwen, 44.

⁶⁶ Ibid.

Dances with the power to attract a celestial power were both sacred and mythological. Mythologems are typical across cultures;⁶⁷ the death and rebirth represented by the myth of the labyrinth and its dance signified Knossos' Ariadne, the Eleusian Persephone, and the Ceramese Hainuwele. During the ninth night of the Great Maro Dance (performed on the island of Ceram in Indonesia), Hainuwele descends into the earth at the ninth of nine dancing places:

"The dance itself is the means of her descent. Men and women linked alternately form a huge ninefold spiral. It is a *labyrinth*, the primordial image and replica that through which men have to pass when they die in order to reach the Queen of Hades and be ordained into existence again."⁶⁸

Through its imitation of a mythical gesture, the dance periodically regenerates time. Through myth the individual experiences his/her origin "...as though he [she] were a reverberation...multiplied a thousand fold and his[her] origin were the first note struck."⁶⁹ Thus cities built in periods that knew a living mythology are laid as if they grew out of the absolute beginning where the cosmos began (the first note struck) and the relative beginning (reverberation) where one becomes the continuation (rebirth) of one's ancestors.⁷⁰ Foundation ceremonies (like the ancient Roman 'Game of Troy'⁷¹) execute mythological plans by translating mythological values into acts.⁷²

Construction rituals (ground-breaking ceremonies) and New Year celebrations are

⁶⁷ Carl Jung, "The Psychology of the Child Archetype", *Essays on a Science of Mythology*, trans. R.F.C. Hull (New York, Princeton University Press, 1963), 75.

⁶⁸ Carl Kerényi, "Kore", *Essays on a Science of Mythology*, trans. R.F.C. Hull (New York, Princeton University Press, 1963), 133-4.

⁶⁹ Carl Kerényi, "Prolegomena", *Essays on a Science of Mythology*, trans. R.F.C. Hull (New York, Princeton University Press, 1963) 8.

⁷⁰ *Ibid.*, 10.

⁷¹ The Game of Troy was a labyrinthine dance performed on horseback.

⁷² Kerényi, "Prolegomena", 10.

contemporary remnants of rebirth rituals. Mircea Eliade argues that although those who repeat the rituals no longer ascribe to mythological values they:

...continue to... share in their meaning and their mystery...Doubtless their experiences are, on the whole profane,...But the structure of the myth and the rite remains unaltered by any of this,...[what is signaled] is a new organization of the world and life.⁷³

Calvino suggests that although less precise, the understanding reached through communicating in objects and gestures is more complete than that achieved by communicating through words. He writes that For Marco Polo and Kublai Kahn, communication was happier (and perhaps even more enlightening), *before* they learned to speak the same language. Although the connections between the objects and gestures were not always obvious, in the space around the gestures (a “void not filled with words”), multiple meanings were possible.⁷⁴ This sense is corroborated by Kerényi, who claims the “secret of Eleusis”⁷⁵ could be betrayed more readily by dancing (through “indiscreet gestures”⁷⁶) than by speaking. Danced movement is a signifying act; movement itself is transcribed and the movement itself is read.⁷⁷

In the Western dance tradition, classical knowledge of dance is composed of *choreography* (a description of dance in words, technical terms, signs, pictures, musical or rhythmic notation) and *choreosophy* (the fundamental ideas behind the

⁷³ Mircea Eliade, *Cosmos and History: The Myth of the Eternal Return*, trans. Willard R. Trask (New York: Harper & Row, 1959), 77.

⁷⁴ Italo Calvino, *Invisible Cities*, trans. William Weaver (Orlando: Harvest, 1974), 39.

⁷⁵ Celebrants of the Eleusian mysteries were said to experience an epiphany of “wordless knowledge.”

⁷⁶ Kerényi, “Kore”, 135.

⁷⁷ Charles R. Varela, “Cartesianism Revisited”, *Human Action Signs in Cultural Context: The Visible and Invisible in Movement and Dance*, ed. Brenda Farnell (Metuchen, N.J.: Scarecrow Press, 1995), 221.

dance through which the language/notation is understood).⁷⁸ Originally, to choreograph was “to trace or to note down dance.”⁷⁹ Floors, patterned with the rose shape of the *contrapasso* directed 17th century French and Italian court dancers’ paths in a circular interlacing⁸⁰ (fig.42). A cosmic theory of ballet, *Harmonie Universelle*, formulated by Father Mersenne (1636) was based on the belief that the magic letters imprinted by God in organic and inorganic life are legible, and furthermore, they are the means by which nature expresses and explains itself.⁸¹ At the end of each musical sequence, Mersenne’s dancers formed a planimetric, metaphysical figure to be ‘read’ by the audience above. In a similar vein, in Dante’s *Paradise*, Canto XVIII, flame-bearing celestial dancers move singing through the heavens, regrouping at the end of each musical phrase. The Eighteenth century ballet master Pecour’s track drawing for the *Bourrée d’Achille* (fig.44) is an example of the choreographic system of representation that evolved. The dance figure is traced with notations indicating the specific steps to be performed along the path.

KINESPHERE

Born in Hungary in 1879, Choreographer and dance scholar Rudolf von Laban revolutionized twentieth century thinking about movement concepts with his innovative dance notation (known as ‘Labanotation’). He was:

⁷⁸ Vera Maletic, *Body-Space-Expression: The Development of Rudolph Laban’s Movement and Dance Concepts* (Berlin: Mouton de Gruyter, 1987), 155.

⁷⁹ Laurence Louppe, *Traces of Dance: Drawings and Notations of Choreographers*, trans. Brian Homes and Peter Carrier (Paris: Editions Dis Voir, 1994), 14.

⁸⁰ Ann Hutchinson Guest, *Choreo-graphics: A Comparison of Dance Notation Systems From the Fifteenth Century to the Present* (New York: Gordon and Breach, 1989), 12.

⁸¹ Louppe, 26.

41

42

la Bourée d'Achille.

43

44

45

46

41, 43, 45. Lars-Ivar Ringbom's 1938 attempts to interpret the path of the labyrinth as a track drawing: "maiden's dance" (36), "geranos" (38) and "Game of Troy" (40).
 Source: Kern, Hermann. *Through the Labyrinth*. Munich: Prestel, 2000, 275.

42. The rose pattern of the *contrapasso*.
 Source: Hutchinson Guest, Ann. *Choreo-graphics*. New York: Gordon and Breach, 1989, 12.

44. Choreographic track drawing by Pecour using Feuillet notation, 1700 CE.
 Source: Guest, 15.

46. Choreographic track drawing of the Basque "Snail Dance."
 Source: Kern, 50.

...the first to posit the writing of dance as a consignment, not of formal figures, but of deep sensorial realities which inhabit the body, or as the ensemble of the organic score on whose basis we conceive space, and project ourselves into it.⁸²

Laban was primarily interested in the roots of human movement and in the factors involved in generating movement phenomena.⁸³ He sought universal movement forms that could be used as an educational technique that would apply to all aspects of life—not only dance performances.⁸⁴ This “movement education” was intended to counterbalance what Laban characterized as the repetitive movements of the industrial worker that he believed were responsible for the deterioration of bodily and mental abilities.⁸⁵

An interest in crystallography led Laban to study the “inherent range of movement patterns”⁸⁶ embodied in the points and surfaces of crystalloid forms. Imagining energy radiating from the human body’s centre of gravity and extending out toward the corners of an icosahedron, Laban formulated the concept of the ‘*kinesphere*’ (fig.47). Combining the Greek word for movement (*kinesis*) and sphere, the kinesphere is a personal sphere of movement defined by the limit of the normal extension of the limbs. The kinesphere distinguishes the immediate space of the body from more distant space. As part of his movement education program, Laban developed a series of directional exercises he called ‘scales.’ The scales link sets of possible points on the kinesphere with whole body movements. Laban’s sketches of

⁸² Louppe, 29.

⁸³ Guest, 107.

⁸⁴ Laban, 10.

⁸⁵ Ibid., 7.

⁸⁶ Ibid.

the scales (fig.48) indicate “trajectories of dynamic forces”⁸⁷ and demonstrate his emphasis on the movements (inclinations) over poses (static points). According to Laban’s choreosophy, bodily structure and the structure of movement in space are fundamentally interrelated. Space is not an empty receptacle but an area created through movement.⁸⁸ The body is not separated from space; body movements *create* space and time. Two factors characterize any movement: *shape* (generated by “stretches of space”) and *rhythms* (generated by “stretches of time”).⁸⁹

Effort, the circulation of fluctuating displacement of weight with respect to the body’s centre of gravity that constitutes space on the basis of “intensified circulations of weight at a given place in the continuing momentum,”⁹⁰ is Laban’s “essential (yet qualitative) ordering principle.”⁹¹ Rhythm (the exchange of tension and relaxation), is intrinsic to the body (i.e. comes from within the body) not externally applied.⁹² The body is the score. Music does not stimulate dance, but arises (like dance) from rhythmical movements of the body.⁹³

Hence, the site of choreographic inscription is a “relay surface” between corporeal movements and the space of projection “where the inner score can unfurl.”⁹⁴

⁸⁷ Louppe, 71.

⁸⁸ Maletic, 140.

⁸⁹ Laban, 94.

⁹⁰ Ibid., 31.

⁹¹ Louppe, 36. Four elements characterize Laban’s concept of movement: kinetic content (flux/flow), dynamic content (force), rhythmic content (velocity, referring to time), and metric content (degree of extension, referring to space), 54.

⁹² Maletic, 165-166.

⁹³ Ibid., 160. Laban’s concept of *eurhythm* (good rhythm) requires duration in time as it flows sometimes smoothly and at other times less smoothly.

⁹⁴ Louppe, 16.

47. **Rudolf Laban, the three dimensional planes that generate the structure of the icosahedron.** Vertical plane (a), sagittal plane (b), horizontal plane (c), inner structure (three dimensional planes of the icosahedron (d) icosahedron (e).
Source: Maletic, Vera. *Body-Space-Expression; The Development of Rudolph Laban's Movement and Dance Concepts*. Berlin: Mouton de Gruyter, 1987, 62.
48. **Rudolf Laban, sketches of the scales.**
Source: Louppe, Laurence, ed. *Traces of Dance; Drawings and Notations of Choreographers*. Homes, Brian and Peter Carrier, trans. Paris: Editions Dis Voir, 1994, 31.

Immanent within a choreographic drawing is the memory of movement like an echo or reverberation of itself.⁹⁵ Kern claims that the graphic pattern of the labyrinth choreographs the *geranos* but, if the idea of the labyrinth was first manifested as a dance, then it is the danced movements that inscribe the graphic pattern of the labyrinth on the *chōros*.⁹⁶ Ariadne's thread is the "visceral traversing"⁹⁷ of the dancing body's circulations through space. The void (not the lines) of the graphic pattern traces and is traced by the *geranos*; the labyrinth embodies the concept of choreography not a representation, but as a "trajectory" between lived movement and the sign.⁹⁸

Laban's notion of dance provides the conceptual model that will engage the knitting of the speculative dance school. Dance is construed as total immersion into the "universal flow of movement,"⁹⁹ a way of knowing which "actively links the dancer with the world in the act of perception."¹⁰⁰ Movements of the *chōros* (corporeal body) are understood to generate the space of the *kosmos* (universe), thus defining a reciprocal relationship between the *kosmos* of dance (inherent, mutable, rhythms embodied in the movement of the *chōros*) and the dance of the *kosmos* (rhythmic circulations of the forces of the universe). Guided by this conceptual dance model, the architectural drawing is understood as a choreograph that is not a record of,

⁹⁵ Louppe, 13. Based on this, contemporary choreographer Merce Cunningham attempts to decipher the records of movement that paper bears within itself—innate dances traced by an aleatory choreography.

⁹⁶ Kern, 25. Kern hypothesizes that "...the dance surface that Daedalus "cunningly wrought" for Ariadne, according to Homer's description (*Iliad* 18.592), certainly bore the path markings—possibly inlaid in marble that enabled the chain of dancers to execute their labyrinthine movements."

⁹⁷ Taj, 78-79.

⁹⁸ Louppe, 11.

⁹⁹ Laban, 104.

¹⁰⁰ Maletic, 163.

but precedes its first performance. Just as the graphic pattern of the labyrinth on the *chōros* embodies and makes visible the invisible trajectory of the *geranos*, the knit of the architectural fabric of the speculative dance school will trace and be traced by the reciprocity between dancers and the *kosmic* dance.¹⁰¹

¹⁰¹ Where '*kosmic*' refers to *kosmos*, the mutable, embodied rhythm of the universe (see pages 8-9).

CONSTRUCTING PASIPHAË'S MACHINE

TRANSLATING KNITTING KNOWLEDGE INTO ARCHITECTURAL ACTION

In Eudoxia, which spreads both upward and down,
with winding alleys, steps, dead ends, hovels,
a carpet is preserved in which you can observe the city's true form.
At first nothing seems to resemble Eudoxia less than the design of that carpet,
laid out in symmetrical motives whose patterns are repeated
along straight and circular lines, interwoven with brilliantly coloured spires
in a repetition that can be followed throughout the whole woof.

Italo Calvino¹⁰²

¹⁰²Invisible Cities, 96.

Can knit materials become tectonic? What happens as knit materials increase in scale to become architectural? How can knitting engage an architectural program? How does the knit respond to site? Can knowledge of knitting be translated into architectural action? A knitted fabric is a structural system that works completely in tension. If a 'knit architecture' is to be self supporting, at least some of its structural elements need to act in compression. Can knit materials gain enough compressive strength to become architectural without sacrificing flexibility? How do you make a 'stretchy' floor or a 'stiff' lace?

Three different approaches were explored. The first approach, suggested by the compressive strength of the knitting needle itself, involved investigating 'frames' with varying degrees of stiffness. In each case, the model consisted of a flexible knit stockinette field that was either formed on or connected to a frame (fig.49). The second approach involved trying to 'freeze' (or 'lock') a fabric knit with a flexible yarn. Study models were knit in stockinette using a flexible fibre (cotton or steel), stretched over pneumatic forms and then stiffened (with starch or plaster) to 'freeze' their shape before the forms were removed.

The third approach was to translate the continuous, curvilinear looped thread into a series of articulated straight elements (fig.54) and then knit those compressive elements directly into the fabric during making. Articulated 'threads' composed of short compressive units of equal length, joined end to end using hinge connections,

were interconnected according to a stockinette pattern. A second variation involved bending stiff metal strips into looped courses and then inter-looping the courses following the pattern of the garter stitch (fig.51, 52, 56). The bends in the strips gave the metal ‘threads’ additional compressive strength without sacrificing elasticity.

All three approaches resulted in elastic, three-dimensional structures with some structural integrity. Considering the huge variety of textures produced in knitting by simply varying stitch pattern, loop size, and/or yarn, an infinite number of architectural fabrics could be produced. What the study models failed to provide was a clear indication as to how knit meanings might be translated into architecture; a more strategic approach was required.

A strategy is not solely an overall plan of action but also the art of using stratagems; deceptions or maneuvers designed to deceive or surprise an enemy.¹⁰³ When Pasiphaë fell in love with the white bull (given to King Minos by Poseidon), in desperation she called upon Daedalus to help her consummate her unnatural infatuation. Daedalus’ machine (a mechanical, wooden cow) disguises Pasiphaë and thus deceives the object of her affection. The result of the successful deceit is the birth of the hybrid. In order for knitting knowledge to be translated into architectural action we, like Daedalus, need to construct a ‘machine’ that will deceive.

¹⁰³ Heritage Dictionary, s.v. “strategy”.

49. 'Frame' study models.

Adjustable, stiff orthogonal frames: Two-dimensional (b), three-dimensional (a,c), knit field suspended between two frames, one orthogonal and one circular (d), and knit field interlooped with flexible, curvilinear frame.

Source: by Author.

50. 'Freezing' study models.

(a, b, d, e): stockinette cylinder knit with cotton yarn in the round, shaped over inflated form and then stiffened with starch to 'freeze' the shape.

(c): flat-knitted piece constructed with steel wire, draped over form and then stiffened with plaster to 'freeze' the shape.

Source: by Author.

Compressive element study models:

- 51. Knit copper lattice composed of bent copper strips.
- 52, 56. Knit steel lattice composed of bent steel strips.
- 53, 55. Knit wood lattice composed of compressive elements of equal length joined by pinned connections. Tightening the pinned connections locks ('freezes') the three-dimensional form.
- 54. Sketches showing various translations of the curvilinear knit loop into a loop of articulated straight elements.

Source: by Author.

An understanding of how knitting operates within textile practice suggests a way of operating within architecture. Knitting operations can be loosely classified as material stratagems, methodological stratagems and metaphorical stratagems, all with the potential to act as architectural ‘deceptions’ in order to construe and construct architecture.¹⁰⁴ Although the list is by no means comprehensive, the following outlines how knitting operations can be classified. Of course many operations will bridge multiple categories (as our discussion of knitting within textile practice has shown).

MATERIAL STRATAGEMS

(i) Stitch Operations

Stitches (units) can be knit or purled (units may be joined in front or in back).
 Stitches (units) can be slipped (i.e. left unworked or disconnected at one end).
 Stitches (units) can be worked into one or more stitch(es) in a preceding course.
 Stitches (units) can be worked into one or more preceding course(s).

(ii) Course Operations

The yarn (fibre) of knit fabric need not be continuous.
 Number of stitches (units) in a course can be increased or decreased.
 Between each course, yarn (fibre) can be changed.
 Within each course, yarn (fibre) can be changed by splicing or connecting.
 Each course may consist of more than one yarn (fibre).
 Variations in stitch (unit) assembly patterns (these generate textures).
 Variations in choice of yarn. (Architecturally this could incorporate weatherproofed coatings, insulation (i.e., wool, mineral fibres), conductivity, or optical fibres).

¹⁰⁴ As our earlier discussion revealed, although we can distinguish material, method and metaphor in knitting, they are impossible to completely separate as they are inherently linked through making.

METHODOLOGICAL STRATAGEMS

Knitting can be worked flat or in the round (producing a tubular form).

Fashioning/ Shaping/Increases and decreases (these produce 2D and 3D form as an inherent part of making).

Picking up stitches (making can continue in any direction and into multiple planes).

Detailing (local material properties can be varied as part of the material making process).

Seaming (seams can become structural laminations or lashing).

Aggregation (pre-formed units can be joined into assemblies).

Hemming (edges may be reinforced).

Gathering (materials may be folded or gathered after forming).

Buttons, zippers (a third material may be introduced as a connector between two panels).

Operable flaps (hinging).

Collars/sleeves (local panels/zones may be rolled up or pushed back).

METAPHORICAL STRATAGEMS

Joining (drawing together).

Tactility (both a hands-on approach and a particular preoccupation with surface texture).

Duration/Durability (knitting as a slow technique that forms products over time).

Knit clothing strategies (e.g. layering, wrapping)

Reciprocity between the knit and the body.¹⁰⁵

Knitting is a social act and, architecturally speaking, knitting cannot operate on its own; operations are selected according to their ability to work/interact with specific aspects of the program or site. Needless to say the translation of knit material, methodological and metaphorical operations is always a game of interpretation involving play, looseness and slippage.

¹⁰⁵ In some cases, the body of the wearer is the primary form giver; for example, the hand wearing the glove gives the knitted object its form and this form changes constantly with movements of the body. In other cases (such as with a knit scarf that is wrapped and draped about the body), although the body shapes the scarf, some of the draped form is due to the texture and structure of the knit itself. Form is further shaped by body movements, wind, moisture, etc.

FABRICATING THE LABYRINTH

CRAFTING A DWELLING FOR THE DANCING KNIT HYBRID

Surrounded by a world full of wonder and forces whose laws we may divine,
may wish to understand but will never decipher,
that touch us in a few fragmentary harmonies and
suspend our souls in a continuous state of unresolved tension,
we conjure up in play the perfection that is lacking.

We make for ourselves a tiny world in which the cosmic law is evident
within the strictest limits, yet complete in itself and perfect in this respect.

In such play we satisfy our cosmogonic instinct.

Gottfried Semper¹⁰⁶

¹⁰⁶ Style in the Technical and Tectonic Arts; or, Practical Aesthetics, 82.

In fabricating a dwelling for the knitting-dance hybrid, by knitting program, site and construction, the monstrous inhabitant is embodied in the architectural fabric of the dance school.

KNITTING PROCESS OVERVIEW

The process of knitting the speculative dance school occurred in four stages. In the first stage, the dancing body/bodies of the building's inhabitants, both human (generated by the rhythms of the speculative program) and *kosmic*, were imagined through drawing. A material/methodological strategy was defined by selecting an appropriate 'yarn' in response to the site. Picking up stitches from the fabric of the existing structure, the 'fabric' generated through knitting with the selected material was used to "clothe" (make visible) the imag-(in)-ed dancing bodies. In the final stage, the textural and structural qualities of the knit fabric of the building were further articulated (detailed) to emphasize the dance between the site and program.

SITE

The ruins of the Willson Carbide mill on Victoria Island in Ottawa were chosen as the site for the speculative dance school. In a geographic sense, the site is a knot—as an island joining the land cut by the flow of the Ottawa River, and also as a swirling disturbance in the flow of the Ottawa River just below the Chaudiere Falls. In a cultural sense, the site sits at the tangled junction of Native, French, and English cultures. In a temporal sense, the site knits past-present-future, connecting a place that is sacred to the native Algonquin Nation, with a place scarred by the ruins of the

57. Aerial photograph showing the site location (red) on Victoria Island, Ottawa.

Significant architectural landmarks (brown) within sight of the Carbide building include: the Centre Block of the Parliament Buildings, the Supreme Court of Canada, the National Library and Public Archives building, the Canadian War Museum, the Museum of Civilization, the National Gallery of Canada, and Notre Dame Basilica.

Source: Google Earth. <http://earth.google.com> (As viewed 5 December 2007).

industrial activities of the early European colonists, and a place that sits as an uncertain placeholder for Ottawa's future aspirations. Visually and by traffic circulation (road, river, bicycle path, and walking trail), the site is located on a loop connecting key cultural-political landmarks including the Parliament Buildings, the Supreme Court of Canada, the War Museum, the Museum of Civilization, the National Gallery and Nôtre-Dame Basilica (fig.57).

The first human inhabitants to control the water and lands surrounding the Ottawa River were the Kichesippirini, part of a family of tribes now known as the Algonquin Nation.¹⁰⁷ The name 'Algonquin' has a serendipitous connection to the speculative dance school. According to historian Phil Jenkins, '*Allegon-kin*' is an Etchemin word meaning 'dancer'¹⁰⁸ that the French explorer Samuel de Champlain mistakenly recorded as the name of the local people (after eavesdropping during a Kichesippirini raiding party celebration).¹⁰⁹ The Algonquin call themselves '*Anishinabeg*,' which means "human being." Victoria Island remains part of an unresolved native land claim as the Algonquin Nation argue that the pre-existing rights of their people to these lands were specifically recognized by the Royal Proclamation of 1763.

¹⁰⁷ Phil Jenkins, *An Acre of Time* (Toronto: Macfarlane Walter & Ross, 1996), 39.

¹⁰⁸ Ibid., 40.

¹⁰⁹ Gordon, M. Day. "The Indians of the Ottawa Valley" Canadian Museum of Civilization, created: February 29, 2000 last update: November 15, 2005, www.civilization.ca/cmc/archeo/oracles/outaouai/30.htm (6 June 2008). According to Day, Champlain mistakenly understood that these people were called "Algoumequins", which Day claims is a Malecite word meaning "they are our relatives or allies."

During the 1800's, the Chaudiere district (including what is now Hull, Victoria Island, and Lebreton Flats in Ottawa) was the site of the "biggest sawmills in the world."¹¹⁰ Massive stacks of lumber dominated the land (fig.57) and huge rafts of timber filled the river (fig.61).

A stone mill, now in ruins, originally housed the Ottawa Carbide Company established in 1904 by Thomas Willson, to produce calcium carbide and acetylene gas (fig.58). According to historians, the long bays running along the east-west axis of the building were compartmentalized to "mitigate the dangers of acetylene gas production."¹¹¹ During its construction, the mill survived the Great Fire of 1900 which, according to the April 27, 1900 report by the New York Times destroyed the Inter-Provincial Bridge, connecting Hull and Ottawa, and all the other buildings in the area.¹¹² Although the building escaped the Great Fire, it was twice damaged by fire in the 1970's.¹¹³ Between 1922 and 1945, the Carbide Mill housed first an aircraft depot and later a Photographics and Records Section as part of the Royal Canadian Air Force station on Victoria Island.¹¹⁴

¹¹⁰ Jenkins, 129.

¹¹¹ Canadian Museum of Civilization, "History of Hull," www.civilization.ca/hist/hull/rw_19e.html (15 Nov 2007). Willson sold the American patent for the process to a firm which later became the Union Carbide Company.

¹¹² The New York Times, "Ottawa and Hull Swept By Flames" April 27, 1900.

¹¹³ National Capital Commission, "NCC Designated National Heritage Buildings in the Capital Region," www.canadacapital.gc.ca/bins/ncc_web_content_page.asp?cid=16300-20450-27615-27616&lang=1 (25 September 2007)

¹¹⁴ Barclay Thompson, "RCAF Station Victoria Island," British Commonwealth Air Training Plan Museum, Brandon Manitoba, www.airmuseum.ca/bios/barclay.html. (15 September, 2008).

58. Carbide Mill earlier in the 20th century.
Source: Canadian Museum of Civilization. http://www.civilization.ca/hist/hull/re_19e.html (as viewed 15 Nov. 2007).
59. Knitted glove, reverse side showing junction of ribbed cuff and stockinette field.
Source: photo by Author.
60. Knit study: stockinette, reverse side. Source: by Author.
61. Canadian one-dollar bill, reverse side, final year of printing 1989.
62. Bird's-eye view of Ottawa by H. Brosius, 1876.
Source: Canada at Scale, Library and Public Archives Canada.
http://www.lac-bac.gc.ca/maps/3_0_exp/05140323_e.html (as viewed 14 Dec. 2008).
63. Spiraling knit ribbed pentagon detail.
Source: Gaughan, Norah. *Knitting Nature*. New York: Stewart, Tabori & Chang, 2006, 48.

- 64. Multi-stranded stockinette, steel wire and nylon fishing line.
- 65. Site shoreline.
- 66. Carbide Building, partial view of existing west facade.
- 67. Knit 2 Purl 2 ribbing.
- 68. Stockinette, front side.
- 69. Carbide Building, long bays in 'ruins.'

Source: all knitting and photos by Author.

- 70. Site shoreline driftwood.
- 71. Study model: knit copper lattice.
- 72. Carbide building, existing load bearing stone construction.
- 73. Shadow study: steel wire knit in the round.
- 74. Stump weathered by site conditions.
- 75. Knit study: ribbing.
- 76. Knit study: garter stitch.
- 77. Carbide building: limestone wall detail.

Source: all knitting and photos by Author.

KOSMOS

According to Laban's concepts, rhythms are inherent to the body and not externally applied, thus *kosmic* and human dancers are conceived (through drawing) as fluctuations of tension and relaxation generating and arising from the topological and atmospheric conditions of the site. The speculative program (Appendix B) is used to conceptually distinguish three types of spaces: studio spaces (primarily focusing on atmospheric aspects of the site), public spaces (including circulation responding to city and site topography) and service spaces (imagined as tactile, internal places). Much of the new and existing ground level is designated as public space that will link danced and 'every day' movements (café, gallery/exhibit space, and open-air amphitheatre). The studios, located on more private upper floors, are dedicated to the interaction between human movements and *kosmic* movements (including light, air, moisture and gravity).

METHOD, MATERIAL, AND MEANING

Peter Zumthor describes the idea of the precise yet sensual use of materials arguing that the use of a certain material can bring out specific "meanings that can only be perceived in just this way in one building."¹¹⁵ Because the site's history is so strongly tied to the forests on which both the Algonquins and the timber industry depended, wood presented itself as the most appropriate material for the speculative project.

¹¹⁵ Peter Zumthor, *Thinking Architecture* 2nd ed. (Birkhäuser: Basel, 2006), 8, 10.

The first material problem became finding a way to knit with wood. Rather than imagining a yarn as a continuous member, pre-spinning looping techniques were used as the inspiration to articulate the ‘yarn’ as a series of discrete compressive elements ‘knotted’ together. This led to the development of a knit wood lattice composed of compressive units of equal length joined by pinned connections. The units were arranged loosely according to the structure of knit stockinette. Multiple iterations were necessary to develop a ‘fabric’ that retained three-dimensional elasticity and extensibility but could be locked into shape (i.e. ‘frozen’) by tightening the pinned connections. The fabric’s inherent formal configurations were tested using suspension models.

Extending the principles of form-finding with hanging chain models (such as those used by Gaudi in the early 1900’s), Frei Otto found:

By analogy with the inversion of the catenary, the form of three dimensionally curved girders with rigid and movable bearings—the lattice shell—can be determined by inverting the *suspended form of a net with an even mesh.*¹¹⁶

Only tensile forces are at work in suspended nets, and by inversion, only compressive forces are represented in the inverted models. Otto’s method proved to be a serviceable, albeit idealized, means of approximating an optimal arrangement of form, mass and forces and led to the development of computer programs capable of modeling complex forms using numerical methods.¹¹⁷ This investigation loosely assumed that suspension models could be used to investigate knit meshes as well as

¹¹⁶ Frei Otto et al, Frei Otto, Bodo Rasch: Finding Form (Stuttgart: Edition Axel Menges, 1995), 137.

¹¹⁷ *Ibid.*, 136-138.

woven meshes. Further study models of the suspended knit wood lattice identified a number of emergent fabric configurations with the potential to (in)-form the third stage in knitting the dance school.

Applying clothing and fashioning operations metaphorically, the knit gives the dancing body visible form. We have defined *kosmos* as the mutable, embodied rhythm or order of the universe (like the figure of a dance) which appears through making. To rephrase, what is made visible by applying a clothing operation to the imagined coalescence of dancing bodies is *kosmos*, the mutable, embodied rhythm of the universe *and* the figure of the dance. Understanding the knit addition to be ‘picked up’¹¹⁸ from stitches (piers and stone blocks) of the original structure (sometimes closely and at other times loosely) in dialogue with the programmatic requirements of the dance school, the form and structure of the dance school were further refined through drawing and modeling. Seams were knit as ‘ridges’ of structural reinforcement, connecting the aggregation of three dimensional knit units.

In the final stage of knitting the dance school, textural qualities of the architectural fabric were articulated to heighten perception of the reciprocity between the *kosmos* of dance and the dance of the *kosmos*. Surfaces, openings, perforations and screens were detailed in order that the fabric of the building might record, modulate, and communicate movements (changes) in the register of light, wind, moisture and precipitation. Larger openings are visible from a distance and at a closer

¹¹⁸ For a description of the technique, refer to additions made by ‘picking up stitches’ (p.28) and shown in figure 27 (p.27).

perceptual distance become doors and windows. Smaller articulations at the level of circulation become places for people to stop and sit.

Materials were specifically chosen (primarily wood, galvanized steel, and concrete) for their ability to accept and record time and change (as an ongoing record of making). Sprung floors in studios and rubber flooring on staircases minimize impact and produce different sounds in response to the rhythm of dancers' feet. Concrete floor finishes in the public spaces on the ground floor make the interior spaces extensions of exterior spaces including the low-roofed, south courtyard entry, high-walled interior courtyard, and open air theatre (which is sunken and bermed into the likely contaminated 'ruins' of the existing building's long, southern bay).

The adaptive reuse strategy adopted reveals the building's history in its interlaced threads. Broken ends of stair treads are left in place in the walls of the old mill. No attempt is made to cover existing scars or burn marks. New openings are defined with different materials and the glazed 'bridge' connection between the new and old parts of the structure make the dweller aware of their passage from one to the other. Circulation through the corridors of the dance school knits together multiple yarns of site history as views of various landmarks are encountered from within the school.

The atmosphere within the building is enhanced by use, site, and atmospheric conditions, and the constant rhythmic changes to which all are subject. Many different patterns and qualities of light are experienced within the dance school through full height windows, skylights, and light screens. Translucent and perforated walls reveal the dancers' flickering shadows, presenting the lived movements of the dance school to the city.

ENCOUNTERS WITH THE MINOTAUR
KNITTING'S MONSTROUS ARCHITECTURAL OFFSPRING

Minotaurs, monsters conceived by inconceivable unions,
demonstrate the possibility of union between different kinds of realities.

Marco Frascari¹¹⁹

¹¹⁹ Monsters of Architecture, 108.

Pasiphae...let Daidalos, the skillfull master, make a false cow in which she hid herself. The bull which had come from the sea let her deceive him, and thus the Minotaurus, 'the Minos-bull,' called Asterios, a child with the head of a steer, a mixture of man and animal was born, and it had to be hidden. The Minotaurus grew up in the labyrinth, a mine with many false tracks which had been built by Daidalos for this purpose.¹²⁰

The minotaur is a monster, a fabulous hybrid compounded from different beings and, like all monsters, is located at the limits of the unknown.¹²¹ Concealed within the labyrinth, the minotaur devours Athenian youths and maidens. The word 'monster' is derived from the Latin *monēre*, to warn. In the Etruscan/Roman tradition of divination, monsters were "...untouchable sacred signs of a possible future...enigmas to be interpreted with vague precision."¹²² Depictions of the labyrinth often show the minotaur at its centre. The architectonic symbolism of 'centre' (understood as the intersection of vertical and lateral axes), is the meeting point of (or gate between) heaven, earth and hell; the centre is the zone of the sacred.¹²³ By killing Asterios, Theseus gains dominion over death and leaves the minotaur to haunt the labyrinth. After this, the monster is no longer confronted at the gate (centre) but is encountered in the very fabric of the labyrinth, in its infinite margins. Frascari states:

"In architecture, the margins of the built environment determine the phenomenon of the spatial environment, and they are the locus where the transformation of space takes place."¹²⁴

¹²⁰ Frithjof Hallman, "The Labyrinth", *Essays in Memory of Karl Kerényi* (Washington, D.C.: The Institute for the Study of Man, 1984), 43.

¹²¹ Frascari, 16. "In medieval Psalters, the monsters are not only inserted in the maps but also fill the margins of the text."

¹²² *Ibid.*, 51.

¹²³ Eliade, 15.

¹²⁴ Frascari, 21.

Located at the limits of the known and the unknown, at that infinite surface where the visible and the invisible touch, the monster can never be separated from its surroundings. The minotaur demonstrates what can be connoted but never precisely denoted: that is, the very nature of the labyrinth.

THE UNION OF KNITTING AND ARCHITECTURE: PRECEDENTS

Within architectural practice, the term “knit” is frequently used metaphorically. In Frank Lloyd Wright’s ‘Textile Block’ projects, the concrete blocks are ‘knit’ together (as Wright put it) with concrete cast over vertical steel rods inserted in joints (fig.80). Wright meant ‘knit together’ to mean closely joined /inseparable as when a bone knits.¹²⁵ As the following quote reveals, Wright conceived his block system as a form of weaving not knitting:

Why not weave a kind of building? Then I saw the “shell.” Shells with steel inlaid in them. Or steel for warp and masonry units for “woof” in the weaving...Floors, ceilings, walls—all the same—all to be hollow.¹²⁶

Peter Zumthor’s Gugalun House offers another interpretation of knitting as a metaphorical joining. The project is an extension to a log cabin built in the vernacular tradition of “strickbau” (literally translated as “knitted structure”) typical of Graubünden. Zumthor’s design theme is “knitting a bit on.”¹²⁷ The connection of new to old refers metaphorically to the knitting operation of ‘picking up stitches.’ The new extension carefully interlaces new wooden beams with the original logs,

¹²⁵ Similarly, the ‘knitlock’ concrete block system invented by Walter Burley Griffin was named for its closely joined interlocking blocks.

¹²⁶ Frank Lloyd Wright, quoted in Robert L. Sweeney, *Wright in Hollywood*, (MIT Press: Cambridge, 1994), 2.

¹²⁷ Peter Zumthor, *Peter Zumthor, Works* (Basel: Birkhäuser, 1999), 104.

matching the existing rhythms and dimensions. Although Shigeru Ban's 1995 Curtain Wall House applies Semper's textile theory quite literally, it metaphorically tests knitwear clothing practices. Like a knit cardigan, the 'drapes' used to construct the house's walls can be opened to increase air flow (fig.92) or closed for privacy and to retain heat (fig.91). Referring to the Weald and Downland Museum (2002), Edward Cullinan says: "Making this building was like knitting with great threads of architecture."¹²⁸ As he clarifies, Cullinan employs the term knitting metaphorically referring to the hands-on construction methods employed compared to architecture that is what he describes as "the end product of computers and extruded construction techniques."¹²⁹

Textiles have a long tradition as architectural materials. Gottfried Semper posits textile production and use as the primordial precedent for architectural production:

the [German] word *Wand* (wall) which has the same root and basic meaning as *Gewand* (garment), directly alludes to the origin and type of the *visible* spatial enclosure.¹³⁰

Frascari argues that the "...textile is in itself a construction of critical knowledge. This knowledge is based on the twofold being of any product generated by a technology, the processes of construction and construing."¹³¹ Semper primarily understood a textile as a woven panel. Although he notes knitting's unique properties

¹²⁸ Edward Cullinan quoted in Jonathan Glancey, "A long time coming" *The Guardian*, 15 Oct 2007.

¹²⁹ Ibid.

¹³⁰ Semper, *Style*, 248.

¹³¹ Frascari, 118.

(elasticity and ductility) and recognizes that ornamentation (pattern or texture) arises from the making of a knit textile,¹³² Semper fails to recognize knitting as an architectural precedent.

Compared to weaving, knitting is a very different way of making. Weaving starts on a frame (loom) and uses two different sets of fibres referred to as the ‘warp’ and the ‘weft’. The warp is tensioned on the loom, and the weft is inserted across the warp in an alternating over-under pattern. A woven fabric is constructed as a flat panel, built row by row from the interlacing of long, linear elements. As such, it can be understood as a field within a frame that lends itself to ornamental subdivision. In contrast, knitting is ‘frame-less.’ The oldest forms of knitting do not require and are not predicated on the use of long, linear elements, in fact, finger and single-needle knitting pre-date spinning technologies¹³³. Knitting generates a fabric by looping—unit by unit, one knot at a time. As opposed to ancient woven fabrics which were constructed in flat panels, ancient knits (e.g. vessels for carrying water, socks, gloves, and hairnets) were often constructed in the round. When knitting in the round, loops are worked in a continuous spiral. Unlike flat knitting the work is not turned so the sense of the ‘course’ is lost. Knitting is thus better understood as a kind of cellular construction formed by the aggregation of units.

¹³² Semper, *Style*, 221. Semper observes ... “[knits] carry the elements of their richest ornaments *in themselves* in their *construction*.”

¹³³ Schoeser, 19-22.

Semper's architectural theory divides built form into two distinct material procedures: "the *tectonics* of the frame in which members of varying lengths are conjoined to encompass a spatial field and the *stereotomics* of compressive mass that, while it may embody space, is constructed through the piling up of identical units."¹³⁴ He posits the woven fabric panel as the textile precedent for the tectonic wall. In contrast, stereotomy is described as a "secondary technique"¹³⁵ not directly derived from textile production and thus not embodying textile forms or functions.

If the tectonic wall finds its textile precedent in the woven panel, it is reasonable to speculate that stereotomy finds its textile roots in the knitted cylinder fabricated by the aggregation of identical units. Knitting is a structural system that acts in tension, but if we imagine masonry units are substituted for the knit voids then the system works in compression. The simple, brick masonry dome (fig.84, 86), may be a surviving example of an ancient translation of knitting technology into architectural construction.¹³⁶ Semper notes: "All stone structures...have in common that they are *divided into many parts* while remaining *unarticulated*"¹³⁷ and "a whole is made up of visibly *small* units."¹³⁸

¹³⁴ Frampton, 21.

¹³⁵ Semper, *Style*, 725.

¹³⁶ This is also true of knitting. The patterns created by the arrangement of units in brick masonry construction even resemble knit patterns. Running bond suggests the garter stitch and brick laid in a herringbone pattern resembles the stocking stitch (fig. 87-90). Semper's observation that the circular plan was the earliest form for the most primitive stone monuments (739) is also consistent with Rutt's evidence that indicates that the oldest knit fabrics tended to be knitted in the round (23).

¹³⁷ Semper, *Style*, 728.

¹³⁸ *Ibid.*, 736.

78. Storer House, Los Angeles, 1924, Frank Lloyd Wright.
Source: Sweeney Robert L. *Wright in Hollywood*. Cambridge: MIT Press, 1994, 63.
79. Storer House, south elevation.
Source: Sweeney, 61.
80. Storer House, pier and corner blocks.
Source: Sweeney, 65.
81. Gugalun House, Versam, Graubundin, 1994, Peter Zumthor.
Source: Peter Zumthor. *Peter Zumthor, Works*. Basel: Birkhauser, 1998, 99.
82. Gugalun House detail.
Source: Zumthor, *Works*, 109.

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83. Monmouth cap, Wales, U.K.
Typical 16th century knitted cap.
Source: <http://www.isca-morrismen.com/images/moncap2.jpg> (accessed Jan. 2, 2009).
84. Masons building a brick masonry dome in Mauritania.
The masonry is self-supporting throughout the process of construction.
Source: Allen, Edward. *Fundamentals of Building Construction* 3rd ed. New York: John Wiley & Sons, 1999, 269.
85. Knit study model, knitting in the round. Source: by Author.
86. Brick Domes buttressed to resist the outward thrust.
Source: Allen, 269.
87. Herringbone brick pattern.
Source: Allen, 339.
88. Knit study, stockinette, knit faces. Source: by Author.
89. Running bond brick pattern.
Source: Allen, 339.
90. Knit study, stockinette, purl faces. Source: by Author.

91. Shigeru Ban. *Curtain Wall House*. Tokyo, Japan, 1995.
East Facade (curtains drawn).
Source: McQuaid, Matilda. *Shigeru Ban*. London: Phaidon, 2003, 195.
92. Shigeru Ban. *Curtain Wall House*. Tokyo, Japan, 1995.
East Facade (curtains open).
Source: McQuaid, 193.
93. Mette Ramsgard Thomsen with Toni Hicks, knitted model of "Strange Metabolisms."
Source: http://artsresearch.brighton.ac.uk/research/academic/hicks/roboticmembranes-b.jpg/image_view (accessed Sept. 16, 2008).
94. Mette Ramsgard Thomsen with Toni Hicks, knitted model of "Strange Metabolisms."
Source: Thomsen, Mette Ramsgard. "Building Liveness," 3. <http://ambient.media.mit.edu/transitive/ubicomp07papers/thomsen.pdf> (accessed Sept. 16, 2008).
95. Mette Ramsgard Thomsen with Toni Hicks, knitted model of "Strange Metabolisms."
Source: <http://artsresearch.brighton.ac.uk/research/academic/hicks/DSCF1715>.

In collaboration with knitter Toni Hicks, architect Mette Ramsgard Thomsen is exploring knitted textiles as a means of studying the architectural potential of a tectonic surface ('robotic membrane') embedded with the capacity for sensing and programmed to act in response to its inhabitation (fig.93-95). Her key interest in knitting is its ability to seamlessly integrate different fibre types to create three dimensional surfaces whose form (including local detailing) is an emergent phenomenon arising from the making of the fabric rather than its cutting and reassembly.¹³⁹ To date, Thomsen's investigations have been tested at a 1:1 material scale. Questions of scale when the knit becomes tectonic have not been convincingly addressed.

Knit fabrics seldom survive the translation to actual construction material, although there are a few companies, such as the German firm GKD Metal, that produce knitted steel mesh cladding. Recent investigations of braiding, knotting, and basket weaving as a means by which textiles can become flexible structures, have the potential to inform knitting's architectural transformation. Two types of solutions have been explored: layering (lamination) of continuous elements to build up stiffness, and reciprocal grids of discrete elements.¹⁴⁰

The lattice gridshell construction developed by Frei Otto for the Mannheim Multipurpose Hall, exemplifies solutions generated by the layering (literal weaving) of

¹³⁹ Mette Ramsgard Thomsen, "'Robotic Membranes: Exploring a Textile Architecture of Behaviour,'" *Architectural Design* 78 (4) (2008): 97.

¹⁴⁰ Garcia, 89.

continuous elements (fig.96, 99). Lattice gridshell construction is based on the vernacular tradition of a light, demountable, and transportable lattice frame typified by the 'ger' (or 'yurt'). The 'ger' is a round, collapsible, fabric-covered, wood lath frame commonly constructed in Central Asia (fig.104). The ger's wall is formed of expanded lattice sections that are connected in a circle to meet at a post and lintel door frame, and tensioned near the top with a rope or cord. Wood rods joined to a central wooden hoop form the framework for the roof. Traditionally, the frame was insulated with layers of large pieces of felt to keep out the cold.¹⁴¹

In timber lattice gridshell construction, a multi-layered, even-mesh grid of continuous wood laths with pinned connections is first constructed flat at ground level, and later jacked into position to achieve the required three-dimensional form (fig.102). Scissor movements at the pinned nodes (fig.101) allow the lattice to be shaped during construction. Tightening the node connections locks the layers together and fixes the final form in place. Stiffness generated by layering (fig.96, 98), sometimes in combination with a cable net tensioned diagonally across the grid, resists asymmetric snow and wind loads.¹⁴² Unfortunately, wood laths often break during forming and split as they shrink over time. Until the recent use of fingerjointing technology and specialized glues in the Downland Museum project, there has been a lack of wood technology to produce laths of adequate strength, flexibility, and length. Because the

¹⁴¹ Colin Duly, *The Houses of Mankind*, (London: Thames and Hudson, 1979), 86-87.

¹⁴² Otto, 140-142.

96. Mannheim Pavilion (interior), Mannheim, Germany, 1975, Frei Otto and Ove Arup.
Source: Otto, Frei et al. *Frei Otto, Bodo Rasch: Finding Form*. Stuttgart: Axel Menges, 1995, 142.
97. Weald and Downland Museum (interior), Chichester, England, 2002, Edward Cullinans and Buro Happold.
Source: <http://www.edwardcullinanarchitects.com/projects/wd.html> (accessed March 1, 2008).
98. Savill Building (interior), Windsor, England, 2006, Glenn Howells and Buro Happold.
Source: Oosmoon. http://wikipedia.org/wiki/Savill_Building (accessed Sept. 5, 2008).
99. Mannheim Pavilion (exterior view).
Herzog, Thomas et al. *Timber Construction Manual*, 4th ed. Basel: Birkhauser, 2004, 256.
100. Wood gridshell construction detail sketch. Source: by Author.
101. Wood gridshell node connection detail. Source: *Detail* 41(5) (2001):857.
102. Downland Museum gridshell under construction. Source: *Detail*, 856.
103. Downland Museum (exterior view. Source: www.edwardcullinanarchitects.com (accessed March 1, 2008)
104. Ger, sketch diagram. Source: Wright, G.R.H. "Tents and Domes in Persia," *Man* 58 (1958):160.

timber lattice gridshell is essentially a woven wood fabric, it is difficult to maintain the structural integrity of the system when tailoring (nipping and tucking) to a desired form is required. To date, the realizable forms of this system are limited (usually hourglass-shaped).

A textile topology built out of discrete (rather than continuous) elements, typified by the Zollinger timber lamella roof, combines the inherent flexibility of textile structure with the ability to resist bending or buckling under compression required by architecture. Stiffness is generated by the ‘mutually supporting’ pattern of arrangement of elements because “the load paths are of complex nested loops, superimposed through the network¹⁴³ (fig.105). This results in the capacity to support large spans with a reciprocal grid built from short, individual elements that act equally in the system. In Zollinger construction, shells are composed of timber ribs of equal length, arranged in a diamond shape (fig.106). The intersections between ribs are offset “...so as to connect each pair of ribs with the same bolt or nail.”¹⁴⁴ Shell stiffness is provided by roof decking running diagonally to the ribs. The advantage of this system is that small (short) components are easier to handle and ribs are not bent or twisted (there is no need to transfer bending load) which simplifies connections.¹⁴⁵

For the Forest Park Pavilion, developed with architect Shigeru Ban, Arup AGU translated a Japanese wickerwork pattern called *ajiro* (typically found on the ceilings

¹⁴³ Garcia, 88.

¹⁴⁴ Thomas Herzog et al, *Timber Construction Manual*, 4th ed. (Basel: Birkhauser, 2004), 246.

¹⁴⁵ Garcia, 88.

105. Woven timber gridshell geometry generated from four entwined orthogonal grids, Arup AGU. Source: AD 76 (6) (2006): 86.
106. Zollinger timber lamella roof (interior view). Lehmbruck, Schulting and Dusseldorf architects, Church of the Transfiguration, Cologne, Germany, 1957. Source: Herzog, Thomas. *Timber Construction Manual* 4th ed. Basel: Birkhauser, 2004, 246.
107. Study model: suspended knit wood lattice. Source: by Author.
108. Rendering of reciprocal timber roof based on pinwheels of overlapping planks. Shigeru Ban and Arup AGU, Forest Park Pavilion, St Louis, Missouri, 2005. Source: McQuaid, Matilda. *Shigeru Ban*. London: Phaidon, 2003, 141.
109. Rendering of the hexagonal pattern of structural elements, Pompidou Centre, Metz, France. Shigeru Ban and Arup AGU. Source: AD 76 (6) (2006): 87.

of traditional Japanese houses).¹⁴⁶ The result of this exploration is a reciprocal grid based on a structure of overlapping laminated bamboo planks of equal length (8 feet) arranged as a series of pinwheels (fig.108). At each intersection, the orientation of the overlapping planks creates a curvature in the fabric of the single-layer gridshell. Again with Shigeru Ban, Arup developed a single-layer gridshell, this time based on a mutually-supporting, reciprocal grid of hexagonal elements, for the Pompidou Metz roof (fig.109). Individual members of equal length are joined at each end with pin connections to the centre of the neighbouring element.¹⁴⁷ The Metz gridshell differs from conventional timber lattice gridshells in that its short member components act as reciprocal beams (working in tension, compression, and bending) to accommodate both synclastic and anticlastic curvature. Departing from purely tensile form-finding, AGU's form-finding software uses geodesics (a mapping of straight, flat ribbons) to distribute "mutually attracting/repelling"¹⁴⁸ loops (like chainmail) over arbitrary surfaces.

As this brief survey has shown, although cases tend not to be documented as such, architectural precedents for knitting exist as method, material and metaphor.

¹⁴⁶ Matilda McQuaid, *Shigeru Ban* (London, Phaidon, 2003), 141.

¹⁴⁷ Garcia, 88.

¹⁴⁸ *Ibid.*, 87.

DANCING IN THE LABYRINTH

READING *KOSMOS* IN THE BODY-WRITING OF KNITTING

...it is through *making* that *kosmos* appears, or does not.

Indra Kagis McEwen¹⁴⁹

¹⁴⁹Socrates Ancestor, 43.

CONCLUSION

According to his writings, Francis Bacon (who in many ways anticipated modern science) regarded ancient myth as a “storehouse of potent images” with the potential to be reinterpreted to communicate meaning.¹⁵⁰ Every true mythologem has the capacity to “illuminate the world” (clarify meaning) yet this meaning can only be fully expressed in mythological terms (and cannot be expressed just as well and just as fully in non-mythological terms).¹⁵¹ Labyrinthic dances and drawings “...are based on a mythological idea of death, which at the same time comprises the idea of life.”¹⁵² Negotiating its perilous passages to attain the labyrinth’s centre is equivalent to consecration, a ritual act of creation that transforms chaos (formless) to kosmos (ordered form).¹⁵³ The simplicity of the visual image of the labyrinth (its graphic pattern) belies the complexity of the experience of being in the labyrinth (the dance). The act of knitting, like dancing in the labyrinth, leads to an embodiment of knowledge. Embodied knowledge is arguably much more precise and certain than so-called “exact science.” Practice ingrains a tacit understanding that permits knitters (and dancers, architect/builders for that matter) to precisely manage the unfolding of complex geometries; a task that is in no way impeded by an incomplete understanding of the science of human physiology. Learning a way of making entails the accumulation of embodied knowledge over time. As levels of understanding accumulate, certain thresholds of comprehension are reached that allow the learner to pass to another level of mastery. Embodied knowledge (like mythological knowledge)

¹⁵⁰ Peter Pesic, *Labyrinth* (Cambridge: MIT Press, 2000), 4.

¹⁵¹ Kerényi, “Prolegomena”, 3-4.

¹⁵² Ibid., quoted in Hallman, 42.

¹⁵³ Eliade, 11.

is subject to certain restrictions: knowledge of this kind can only be communicated through itself (i.e. through the body) and cannot be adequately expressed through verbal communication.

There is an architectural tradition of using thin, translucent knits to model minimal surfaces, but knitting's role in architectural production must not be reduced to structural calculations. Knitting should instead propose the maximal, because "what is missing from our dwellings today are potential interactions between body, imagination and environment."¹⁵⁴ By interpreting knitting as a logical and topological model for architectural production as a critical practice within architecture, we, like the guerilla knitters of Knitta Please, might begin to challenge current technological and cultural biases.

Our investigation of knitting as a tectonic material and methodology indicates that it is possible to translate knits into architectural fabrics and structures. Precedent research and study models suggest that at least three approaches (forming/connecting a knit field onto a stiff frame, laminating/stiffening a flexible knit over a form, and knitting a field as a series of articulated straight elements) offer plausible means by which knits can become structural at the scales required by architecture. The wood and steel knit 'fabric' proposed for the speculative dance school makes use of knitting's inherent ability to accommodate curvatures in multiple planes; synclastic

¹⁵⁴ Bloomer & Moore quoted in Juhani Pallasmaa, *The Eyes of the Skin: Architecture and the Senses* (London: Wiley-Academy, 2005), 41.

and anticlastic curvatures can be made from a limited set of prefabricated, identical, straight, components. Study has primarily focused on three stitch patterns: stockinette, garter stitch and ribbing; a multitude of other stitch patterns yielding variations in form and material properties are possible. Of course it must be noted that this investigation has dealt qualitatively with concerns that warrant further research and will ultimately need to be quantified in collaboration with engineers and builders.

In addition, as the following discussion will elaborate, an inherent tactility, the linking of interior and exterior spaces (a recto-verso procedure), the reciprocal nature of the relationship between the knit and the body (both of the knitter and the wearer), and the duration of its formation (a kind of slow-tech that acts as a record of the forces of making and of the forces required to maintain a form) are all aspects of knitting that can enrich architectural production.

TACTILITY

Contemporary architecture (of the last 30 years) primarily visualizes the architectural object as an 'image product.'¹⁵⁵ Exterior views predominate, repressing the potential experience of inhabiting the building and perpetuating the misconception that everything can be known by sight.

Knitting, as method of construction and as means of producing meaning, accords primacy to the tactile sense. Repeated actions of the hand (e.g. wrapping

¹⁵⁵ Pallasmaa, 30.

fibres around the knitting needles, drawing fibres through the loops and slipping the loops from one needle to the other) generate the work. The fabric of the knit registers the dancing movements of the hands in the size and tension of each loop. Vision is not essential to the process; the blind are capable of knitting as well as those with sight. Knitting operates spatially, through the active orienting relationships (proprioception) of the hands, the body, the knitting tools and materials. Pallasmaa observes: “Touch is the sensory mode that integrates our experience of the world with that of ourselves.”¹⁵⁶

Knit form is an inherent behavior that emerges through making and as such, offers both a logical and topological alternative to the potential misuse of CAD technology in architecture. An architectural object conceived through knitting will never be a formal exercise to which materials and textures selected from a palette can be applied at a later date. Knitting, as a model for production privileges the surface. Knitting’s innumerable stitch patterns and material variations generate a multitude of textures which, when translated into architecture, are capable of producing structure and facilitating inherent ornamentation as modulations of the construction of the architectural fabric.

RECTO-VERSO

Knitting as an exemplary model for construing and constructing architecture represses architecture as an object to be considered primarily from without. While traditional

¹⁵⁶ Pallasmaa, 11.

construction designates one surface as interior and the other as exterior, knitting simultaneously links inner and outer spaces; it is inherently recto-verso. Recto perspective systematizes pictorial (visual) space from a theoretical objective according to mathematical laws.¹⁵⁷ Verso perspective can be understood as *reverse* perspective, an incommensurable space drawn from a point of view that is behind or even inside. In the Western tradition of architecture, the ability to cross from recto to verso represents a creative act of transformation. The recto-verso drawing becomes the means by which the architect presents the building and also the means by which the building presents itself to the architect. Knitting as a recto-verso procedure varies according to the form of knitting employed. When the end of the row is reached in flat knitting, the work is turned over and a new row of loops is knit from the reverse side of fabric. Flat knitting is a constant dialogue between front side (recto) and reverse side (verso). When knitting in the round, while the maker knits from a position outside the work, loops are always knit from the reverse side, thus verso is constantly juxtaposed with the recto surface. The completed work embodies the synthesis of the knowledge of making from within, with perceptions of the work as a whole from without. Architect and phenomenologist Juhani Pallasmaa could be describing the process of knitting when he writes:

While working on a building or an object, the architect is simultaneously engaged in a reverse perspective, the entire bodily and mental constitution of the maker becomes the site of the

¹⁵⁷ Erwin Panofsky, Perspective as Symbolic Form (New York: Zone Books, 1997), 47-66.

work [...] In our imagination, the object is simultaneously held in the hand and inside the head
 [...] We are inside and outside of the object at the same time.¹⁵⁸

DURATION and DURABILITY

In traditional societies, duration is equivalent to “continuity”, a connection to infinite cycle of death and rebirth that gives life its meaning. “Newness” is highly valued in contemporary society but when everything is ephemeral, “novelty comes to be overvalued and mistaken for art.”¹⁵⁹ For consumers, anticipation (getting the latest thing) is more important than the operation of that thing (making durable use of it).¹⁶⁰

Time is an aspect of knitting; a hand knit fabric embodies the movements of its maker’s hand. Each loop is a record of the diameter of the tool (finger or needle) used in its formation and of the tension applied by the knitter resulting in a fabric that is an indexical record of the trajectories of its own making. Work materializes during duration and time is turned into shape, expressing the slow process of its formation.¹⁶¹

Like architecture where the built is the result of the collaboration between architect and builder, the fabrics produced by the knitting industry are the result of the collaboration between textile designer and knit manufacturer. Knitting as a handcraft is usually the work of a single individual. How can the making of a hand knit fabric be equated with the making of architecture?

¹⁵⁸ Pallasmaa, 12-13.

¹⁵⁹ David Pye, *The Nature and Art of Workmanship* (Bethel, CT: Cambium Press, 1995), 84.

¹⁶⁰ Richard Sennet, *The Craftsman* (New Haven, CT: Yale University Press, 2008), 110.

¹⁶¹ Pallasmaa, 58.

For the ancient Greek craftsman (*demioergos*) construing and constructing were inseparable aspects of making.¹⁶² Aristotle, writing on the nature of craft, declares the architect (who knows the reasons for things) to be wiser than the handworker and establishes design and workmanship as separate acts of making. Aristotle's position is echoed by Vitruvius who writes that the parents of the "science of architecture" are practice and theory, distinguishing "practice" as:

...the frequent and continued contemplation of the mode of executing any given work, or of the mere operation of the hands, for the conversion of the material in the best and readiest way.¹⁶³

Current ideas concerning making, particularly concerning handcrafts, are still heavily influenced by the poetic but imprecise ideas concerning craftsmanship that appeared in John Ruskin's Stones of Venice. Ruskin opposes 'division of labour' and what he calls the 'degradation of the operative into a machine.'¹⁶⁴ He posits the moral opinion that, (other than for objects of necessity) work of the highest artistic value (great art) is achieved only when the individual who executes the labour (workman) is free to invent (i.e. is also the designer). This seems to have led to the inverse notion that, at least with respect to handcrafts, the highest workmanship can only be achieved when the designer is the workman. A conflation of making and workmanship has occurred—in contemporary production design (idea) has somehow become separated

¹⁶² Sennet, 22.

¹⁶³ Marcus Vitruvius Pollio, *de Architectura*, Book One, Chapter 1, trans. Bill Thayer, http://penelope.uchicago.edu/Thayer/E/Roman/Texts/Vitruvius/1*.html (10 January 2006).

¹⁶⁴ Kenneth Frampton, *Modern Architecture*, 3rd ed., (London: Thames & Hudson, 1980), 42.

from making (now defined as “process”¹⁶⁵). However, David Pye distinguishes design and workmanship as follows: “Design is what for practical purposes can be conveyed in words and by drawing; workmanship is what, for practical purposes cannot.”¹⁶⁶ Both are critically implicated in making. Just as the quality of a dance is dependent on its choreography and its performance (by specific dancers), the quality of what is produced depends on both design and workmanship. There is a clear distinction between design and workmanship even when they are performed by the same person.¹⁶⁷

In a well-crafted hand knit, every loop is regular and yet irregular, similar and very slightly different. Highly regulated work indicated mastery and was the goal of traditional workmanship where precision and regularity distinguished the man-made from the natural. In nature (that which is not made by humans), diversity (i.e., difference, irregularity, variation) in things exists at every scale and continues to be distinguishable at closer and closer ranges. In particular, we tend to read the scale of diversity that is just at the threshold of perception as a significant indicator of quality (or beauty). Diversity that becomes apparent at multiple scales is inherent in work that is handcrafted but difficult to achieve in manufacturing where the quality of the result is exactly predetermined.¹⁶⁸

¹⁶⁵ Ann Richards, “A Diagram of Forces: Form as Formation in Nature and Design,” *On Growth and Form*, eds. Philip Beesley and Sarah Bonnemaison, (Halifax: Tuns Press, 2008), 124.

¹⁶⁶ Pye, 17.

¹⁶⁷ *Ibid.*, 120. With respect to regulated work (where there is a high degree of correspondence the design and the achievement), Pye rejects the supposition that “...it could ever have been designed by the workman while he was at work.”

¹⁶⁸ *Ibid.*, 62-3.

Products that endure in time achieve a diversity that is a result of age and wear.¹⁶⁹ Weathering is a subtractive process (a wearing away) that simultaneously adds the finish (sedimentation and surface accumulation of detritus) of the environment. Like ‘knitting’, in ‘weathering’ the same word refers to both process and object. “Weathering” originally referred to architectural elements including projections, mouldings and recesses that serve to guide rainwater away from the surfaces of exterior walls. Through weathering, buildings are assimilated back into the places from which they were first taken; their surface qualities (colours and textures) are modified by and in turn modify those of the environments wherein they are sited.¹⁷⁰ The work of the architect is the anticipation of accumulation of soot and sedimentation. For example, Carlo Scarpa’s Banco Popolare di Verona where the vertical drip lines at the bottom of each circular window:

...demonstrate the possible effects of rainwater on the building’s surface as they retard its effects; a virtual drip has been formed as an element of actual retardation that “reveals” what it removes and retards what it quickens.¹⁷¹

An apparent lack of diversity is often referred to as ‘clinical.’ The contemporary insensitivity to diversification is at least partly the consequence of the Modernist social agenda. For the Modernists the ‘liberation’ of architecture meant the rejection of traditional or historical styles. The desire for purity, whiteness, and

¹⁶⁹ Pye, 84.

¹⁷⁰ Mohsen Mostafavi and David Leatherbarrow, *On Weathering: The Life of Buildings in Time* (Cambridge: MIT Press, 1993), 69-72.

¹⁷¹ Ibid., 98.

newness often meant the suppression of texture in favour of the emphasis on form.¹⁷²

Le Corbusier understood ‘whiteness’ was a matter of health, beauty and morality and signified objectivity and truth (moral cleanliness). Of course wear does not necessarily improve the quality of workmanship—only if the finish “...remains nearly continuous though distorted”¹⁷³ or, in other words, does not impair soundness but creates diversity that is just at or near a threshold of perception.

In the life of a knit or a building, duration emphasizes the time of use rather than the time of initial construction, although processes and materials involved in time of construction will to a great extent determine how the building will endure. Over time, gauge (the number of stitches and rows in a given knit area) relaxes, evens out and erases the variations in tension that were the indexical traces of the knitter (although the marks of the tools and patterns of stitches remain).

The durability of a made thing depends, perhaps largely on workmanship in hand knitting, but rests almost entirely on design with respect to the machine knit products of industrial production: for there, nearly everything which affects durability has been predetermined and can be specified by the designer.¹⁷⁴ In contemporary building culture, design is, in effect, a “statement of the ideal form of the thing to be made.”¹⁷⁵ Where the mass produced is lacking in quality, it is not because of poor workmanship because diversity at medium and long ranges is entirely controlled by

¹⁷² Mostafavi, 86.

¹⁷³ Pye, 93.

¹⁷⁴ Ibid., 84-5.

¹⁷⁵ Ibid., 31.

design.¹⁷⁶ Furthermore it is within the capabilities of design to invite (deliberately enable) diversity at closer ranges.

RECIPROCITY

Form can be interpreted as a diagram of the forces that have been impressed upon it during formation (shaping) and the forces that enable it to maintain (balance) its conformation (hold its shape).¹⁷⁷ The material properties of knit are emergent behaviors arising from the human act of making whose gestures /movements in turn are dependent on the nature of human structures (thought and action). The pattern of organization of material properties operates (migrates) into radically different scales.¹⁷⁸ During formation, energy is stored within the twist of the yarn and in the spiral loops of the knit (from the looping movements of the hand). When a knit is removed from the knitting needles, some of this stored energy is released and the fabric organizes itself (form, structure, and texture). Variations of gauge, yarn and looping technique (i.e. stitch pattern variations) create variations in forces in different parts of the fabric.

Within textile practice knit form is dictated by the materials used, tools employed, intended use, intended body, and corporeal reality of the specific wearer's body. A knit varies depending on the body part it is required to clothe and its intended

¹⁷⁶ Pye, 67.

¹⁷⁷ D'Arcy Wentworth Thompson, *On Growth and Form*, rev. ed. (New York: Dover Publications, 1992), 16.

¹⁷⁸ Jesse Reiser and Nanako Umemoto, *Atlas of Novel Tectonics* (New York: Princeton Architectural Press, 2006), 148.

purpose: for example, although they are all intended for a hand, a liturgical glove is not the same as a winter glove or a butcher's glove.

The body of the user stretches the knit and reshapes or in-forms the garment so that the stories of making are modified (although not replaced) by stories of inhabitation (wear). The forces that generate the knit only indirectly influence the warmth of the garment, or the way the wind blows or rain drips off, or snow accumulates on the knit, the way that the sun bleaches the knit or the fabric pills with use. Eventually the memory of the inhabitant's body (both wear and where) gradually changes the form of the knit at rest (i.e. when it is not being worn). Like the labyrinth, the knit functions as a mnemonic device that correlates the visible to the invisible. "The world is reflected in the body and the body is projected onto the world."¹⁷⁹

Infinite possibilities are present within the knit. Unraveling a thread we recognize Ariadne's dance, a looping movement but also a story. Repetitions of gestures (or lyrics, or notes) generate patterns which in turn reveal rhythmic structures. These acquire meanings (but are not reducible to any particular meaning). Meanings in a large part are contextual (where context refers to strings that are used to tie/bind/hold down). In knitting, strings are attached only to one another and once removed from the formwork (needles) are transformed by wear (being worn and getting worn out) and where (place and culture) they are worn.

¹⁷⁹ Pallasmaa, 45.

Separating the discussion of knit meaning, established and contextualized by history and theory, from that of knitting as a material and method, has revealed a disjunction between what knitting *does* and what knitting *means*. The connection may remain unresolved largely due to the fact that the histories of knitting have been predominantly written by those who wear knits, not those who make them.

Historically knitting was done by the poor—peasants, servants and slaves; there are almost no accounts of knitting by nobility.¹⁸⁰ But if we only ask “What does this do?” and ignore the question of “What does this mean?” then we eliminate most of what has made knitting culturally consequent. What remains is the challenge to connect the apparently disparate realms of knit practice and theory. Full discussion would require further research.

Patterns revealed through knitting are a potentially fruitful model for making architecture not only because they embody structural principles that can be used in building, but also because of the possibility of attaching meaning to their trajectories. Knit materials, stitch patterns, forming operations and strategies of usage produce surfaces and forms that have the capacity to generate an infinite variety of rich architectural solutions.

¹⁸⁰ A notable exception is the account of the eight woolen scarves personally crocheted by Queen Victoria and awarded for distinguished service to eight private soldiers or non-commissioned officers for distinguished service during the South African War. The Queen’s Scarf awarded to Canadian Private Richard Thompson is currently in the collection of the Canadian War Museum. The scarf could be considered more prestigious than the Victoria Cross because only eight were ever awarded, but it was an unofficial decoration and, as such (unlike other bravery awards including the Victoria Cross), has no status as a national honour. In fact, despite receiving the scarf and recommendation of his commanding officer, Thompson was denied the Victoria Cross.

APPENDICES

APPENDIX A

A BRIEF HISTORY OF KNITTING TECHNOLOGY

Many of the materials, techniques and forms used in ancient times remain in use today demonstrating a certain “lack of logic” in a linear history of knitting.¹⁸¹ A comparison of present-day fabrics to ancient knit fabrics demonstrates that technological advances (e.g. industrialization and the continued development of faster and more sophisticated knitting machines) do not necessarily produce more refined or complex fabrics. Nonetheless, since the 15th century, the technological development of knitting has been responsible for the “most striking and fundamental changes in textiles and clothing.”¹⁸² In the effort to begin to understand how knitting production functions in society, this paper will briefly trace the chronological development of knitting technology.

Finger and single needle knitting (used since the Mesolithic age) can be worked loosely (e.g. fishing nets and ancient hairnets) or tightly (as in the sisal ‘shigra’ from Ecuador used to carry water).¹⁸³ Nets for hunting and fishing were produced using this technique because repair is simple—damage to one part of the mesh does not impair the whole system. (Semper refers to this as the “criterion” of

¹⁸¹ Schoeser, 7.

¹⁸² *Ibid.*, 183.

¹⁸³ *Ibid.*, 20.

netting).¹⁸⁴ Multi-needle knitting techniques have been used since at least the 3rd century CE.¹⁸⁵ Wool, silk and later cotton were the most common fibres used. From the 13th century, designs were increasing assisted by pattern knitting or knitting frames.¹⁸⁶ In the 16th century, cap-knitting was not a domestic activity. Like the other activities involved in cap-making, including dyeing, moulding and felting, knitting fell within the realm of ‘mystery’ and was restricted to licensed professionals (masters).¹⁸⁷ The first knitting trade guild was started in Paris in the early 1500’s.¹⁸⁸ Large, pattern-knitted panels were still required to obtain master status in the male-dominated guilds of Northern Europe into the 17th century.

Silk stockings imported in 16th century to England from Spain were very costly compared to long woven hose that had been worn by men for centuries.¹⁸⁹ Short knitted wool socks had previously existed, but the great demand for long stockings (for men and women), wide variety of fine worsted yarns spun from the wool of local English sheep, and increased availability of fine steel knitting needles, meant that long, woolen stockings could now be produced.¹⁹⁰ England became the leading producer of stockings by 1600 due to its pre-imminence in wool production and the “growing quality” of woolen stockings.¹⁹¹

¹⁸⁴ Semper, *Style*, 220.

¹⁸⁵ Schoeser, 79.

¹⁸⁶ *Ibid.*, 62.

¹⁸⁷ Rutt, 60.

¹⁸⁸ *Ibid.*

¹⁸⁹ *Ibid.*, 68.

¹⁹⁰ *Ibid.*, 68-73

¹⁹¹ *Ibid.*, 77.

In 1589, in response to the high demand for stockings, William Lee invented a mechanical knitting machine. This was essentially a hand-operated tool with barbed needles that manipulated loops of yarn. Lee was initially unsuccessful in promoting his knitting machine because it threatened the livelihood of the poor handknitter.¹⁹² Soon after, the widespread use of water-powered spinning machines revolutionized hand-frame knitting¹⁹³ because the uniform consistency of factory spun wool meant weight could be gauged more consistently. In the early 19th century, in protest against the introduction of mills with large stocking frames that produced stockings at prices that undercut those produced by skilled workers in the cottage industry, ‘Luddites’,¹⁹⁴ a British textile worker movement, succeeded in destroying many wool and cotton mills. As a result, “Machine Breaking” was made a capital crime (although many convicted were deported to Australia).

The stocking frame’s adapted needles and machine-assisted looping spawned a complex range of technologies including the invention of embroidery machines and the two-thread sewing machine.¹⁹⁵ Warp knitting (essentially parallel columns of loops that are worked simultaneously on multi-thread knitting machines) was invented in 1775.¹⁹⁶ The 1970’s invention of air and water jet loop insertion made industrial knitting machines one hundred times faster than in the 1800’s.¹⁹⁷ In the 1980’s, led by the knitting sector, computer controlled patterning reduced the time to change patterns

¹⁹² Rutt, 76.

¹⁹³ Schoeser, 166.

¹⁹⁴ This is where the term ‘Luddite’ (referring to someone who is resistant to technology) originated.

¹⁹⁵ Schoeser, 185.

¹⁹⁶ Ibid.

¹⁹⁷ Ibid.

which had been until this time a significant factor in machine-made knit design development.¹⁹⁸ The growth of machine knitting also supported the development of synthetic yarns (e.g. nylon, polyester and acrylic from petrochemicals) because although synthetic fibres could be dyed, they were initially difficult to print, making them more suitable for knitting than weaving.

Today, equipment very similar to stocking machines is used to produce fabrics knit with metal wire for a wide variety of uses including industrial filtering and catalytic converters for automobiles. The newest industrial knitting equipment is capable of producing knitwear made in three dimensions (i.e. formed without seams), with integrated and often complex details (such as edgings or pockets).¹⁹⁹

¹⁹⁸ Schoeser, 189.

¹⁹⁹ Tellier-Loumagne, 9.

APPENDIX B**SPECULATIVE DANCE SCHOOL PROGRAM**

1 large studio (approx. 21 x 10m)
2 medium studios (approx. 12 x 11m)
2 small studios (approx. 12 x 7m)
(Outdoor) Performance space (seating for 200)
Exhibition Space
Research Library/Video Archives/ Video Editing Room
Change rooms (incl. showers)
Health Centre
Lobby/Foyer/Reception
Café
Student Lounge
Teachers/staff Lounge/Kitchen
Administration/ Offices /Meeting room
Washrooms (student, staff, public)
Storage (equipment, furniture (seating), wardrobe)
Workshop
Mechanical/Service/Loading

APPENDIX C

DANCE SCHOOL PRECEDENTS: PROGRAM SUMMARY

Building	<u>Siobhan Davies Studios</u>, London	<u>Laban Dance Centre</u>, London	<u>National Ballet School of Canada</u>, Toronto
Architect	Sarah Wigglesworth Architects	Herzog & de Meuron	KPMB
Dancers	Professional dance troupe	350 post-secondary students	700 students (grades 5 to 12) including 50 full time students
Studios	16.5m x 11.5m 13m x 6.5m	12 studios 7 with mirror & bars 5 white max. area 210 m ²	8 'large' 3 'medium' 1 'extra large'
Performance Space	largest studio (100 pp)	Studio theatre (100pp) Theatre (300pp) Outdoor theatre (200pp)	Theatre
Change Rooms	yes	yes	divided by age group
Social Space	Parlour Foyer Kitchen	Café Foyer	Café 'Town Square'
Health	Treatment Room	Health Suite: 3 treatment rooms Dance science lab Pilates studio	Dance Therapy Clinic
Education	6m x 4.5m mtg. room	11m x 9m lecture 9m x 6m mtg. room mtg. room (16pp) mtg. room (10pp) library/archive	8 academic classrooms Computer lab science lab arts studios music room study rooms
Administration	Reception Offices	Offices	School Offices Executive Offices
Other		Workshops	Workshops Wardrobe
Information Source	Jones ²⁰⁰	Reid, ²⁰¹ Fraser, ²⁰² Ryan ²⁰³	Slessor ²⁰⁴

²⁰⁰ Peter Blundell Jones, "Vaulting Ambition", *Architectural Review* 222 (1325) (2007): 44-51.

²⁰¹ Giles Reid, "Dancing architecture," *Domus* 858 (2003): 62-79.

²⁰² Malcolm Fraser, "Showstopper", *RIBA Journal* 100 (2) (2003): 30-38, 40.

²⁰³ Raymond Ryan, "Laban Centre (For Movement)", *Architectural Record* 191 (6) (2003): 130.

²⁰⁴ Catherine Slessor, "Dance Class", *Architectural Review* 222 (1325) (2007): 36-43.

APPENDIX D

KNITTING ARCHITECTURE: PROCESS

I consider myself a knitting novice. Before I began my studies at the School of Architecture at Carleton University, my previous knitting experience consisted entirely of the eight inch square garter stitch sample I knit to earn a Girl Guide badge when I was ten years old. I became reacquainted with the garter stitch in first year studio. We were given a short list of items related to the hand and asked to pick one. It was during the winter and my children were amassing quite a collection of orphaned mitts and gloves so I chose a knitted glove. After drawing the glove, unraveling it and drawing it again, I picked up knitting needles and began to knit.

Process rather than the end product has been the focus of this thesis. Knitting by hand permits the actions of the hands, needles, and materials (yarns) to be observed at every stage. In this way it is possible to see how texture, structure, and form arise as an inherent part of making. I began research for this thesis by hand knitting samples of different stitch patterns with cotton yarn. There are literally thousands of different stitches; for this investigation I learned thirty. Learning to knit these permitted me to observe the specific material properties that are detailed in the section entitled “A Yarn of Infatuation” (page 12). Combining the process of knitting with the concept for the speculative dance school (i.e., the fabric of the proposed building as a

choreograph that records the kosmos of dance and the dance of the kosmos), meant that the material investigation was simultaneously a search for ways in which embodied rhythms (both human and *kosmic*) are revealed through the knitting process and by knit products. The size and shape of knit loops are determined by the tools used to make them and on the body actions and intentions that control those tools. These rhythms are recorded in the finished product. In an effort to understand how the dance of the kosmos might be legible in a knit, I also looked for ways in which knit textures interact with light and shadow, moisture, and gravity.

Introducing the capacity to withstand compression without sacrificing elasticity or knitting's ability to accommodate simultaneous curvature in multiple planes is the biggest challenge in translating knitting into architecture. Engagement in the activity of hand knitting suggested directions for exploring and experimenting with knitting which could extend beyond the field of textiles into the tectonic. At this point in the process, multiple potential approaches for exploring architecture were generated.

Fabric fields knit with various yarns were first stiffened using wood frames (although with these models, the frame tended to dominate the knit). Trying another approach that applied the technique of multi-stranded knitting, steel wire was interlaced within knitted fields (producing more sinuous forms compared to the wood frame models). These studies indicated that knitted fabrics have the potential to

become flexible architectural membranes fixed/stretched over rectilinear or curvilinear frames, and furthermore, that it might be possible to eliminate the frame altogether, integrating structure directly into the knit membrane, by literally knitting (interlacing) stiffer materials at key locations.

Experiments with knitting in the round were conducted by placing knitted tubes over balloons, inflating the balloons, shaping (tying) the knits over the inflated formwork, and then coating the shaped tube with fabric stiffener. Once the stiffener had hardened, the balloon was removed, “freezing” the formwork’s shape.

After knitting with yarns of varying thickness and fibre composition, I experimented with metal wire. Essentially, the experiments previously conducted with yarn were repeated with various gauges of steel, copper and aluminum wire. In these iterations, rather than employing a fabric stiffener, the forms were “frozen” by dipping them in plaster. The material content and structure of a yarn is crucial to the resultant form and rhythm when knitted. In some cases, a yarn seems to clarify the stitch pattern, while with other materials, the pattern seems to disappear. Compared to cotton yarn, knitting with metal wire makes individual loops more visible, but variations in stitch patterns have much less effect on the texture and form of the final knit product. Working with wire suggested the possibility that a knit metal might be achieved by knitting with metal strips. Rather than using knitting needles, knits produced with metal strips needed to be preformed into loops and then interlaced by

hand (a technique that is closer to the ancient practice of cross-loop knitting). Using a jig, metal strips were bent into rectilinear loops, and then strips were interlaced (knit) to generate a fabric. As with other knit fabrics, it was still possible to use the technique of picking up stitches (page 28) to extend the knit field in different directions and even different planes.

Once site research indicated that wood might be an appropriate material for the speculative dance school, a series of study models (described on pages 72 to 74) were developed to consider means by which it might be possible to knit with wood.

The material investigation led to a sense of what the building should feel like—its texture and atmosphere but did not generate a particular form for the building. The idea of knit form as reciprocal, generated by both the knit field and the body of the wearer, pointed out the need for a dancing body/bodies which the knit might clothe to reveal form. Suspending knitted wood fields offered the possibility of revealing forms that “dance” with gravity.

Using the technique of picking up stitches metaphorically, a saddle form was selected from the suspension models that, when repeated like a knit loop but at a much larger scale, could emerge from the rhythms of the Carbide mill’s stone bays. Rough sketch models using a ready-made knit fabric interlaced with steel wire for stiffness were produced to test ways in which the saddle forms might combine/aggregate to

further develop the architectural intervention's form. Assembly diagrams and details were developed through drawing.

Although it would be the goal of further research to integrate structure, insulation and weatherproofing within a knit fabric (the recto-verso/ interior-exterior aspects of knitting), weatherproofing and insulating layers for the speculative dance school were conceived as applied to the exterior surface of the knit. In order that knit rhythms might still be legible from the exterior, the role of modulating light was moved to a separate brise-soleil knit layer that wraps the new intervention. Wooden slats fixed between the loops of a steel cable knit screen emphasize the knit's texture while casting an ever changing dance of shadows into the dance school.

The role of the knitting tools (knitting needles/fingers) was vital to imagining how the units might get built at 1:1 scale. In general loop size is determined by the diameter of the tool around which it is formed (finger or knitting needle). In models with repetitive compressive units, the diameter of the loop is dependent on the length of the compressive unit. In order that knit wood units might be assembled into saddle forms by construction workers on-site (the dance of the workers), units were sized (approximately 1 metre in length) so that they can be easily lifted and bolted into place by an individual. Saddle forms could be assembled over formwork/scaffolding. In addition to the formwork, gravity would help to generate form. Because the saddle form would be adjustable (elastic) until node connections are bolted to freeze the

shape, the final form is imagined as the result of the interaction (dance) of the intended form (formwork), the knit material assembly, gravity, and the actions of the construction workers.

110. Dance School: Image(ined) Bodies.

Source: by Author.

111. Dance School: Ground Floor Plan

Source: by Author.

112 Dance School: Floor Plans, 2nd Floor (bottom),
3rd Floor (middle), 4th Floor (top).

Source: by Author.

113. Dance School: Cross section (top), West Elevation (middle), South Elevation (top).

Source: by Author.

114. Dance School: Long Sections, North (top and South (bottom)).

Source: by Author.

TYPICAL KNIT LATTICE STRUCTURE
 80 MM x 80 MM x 1.2 M LATHS ARE CONNECTED WITH STEEL HINGE PINS WHICH PERMIT MOVEMENT OF THE LATTICE DURING CONSTRUCTION/ERECTION AND ARE THEN TIGHTENED TO STIFFEN THE STRUCTURE. ADDITIONAL STIFFNESS IS PROVIDED BY PLYWOOD (AS BRACE) AND A CONTINUOUS BUILT-UP PERIMETER BEAM AROUND EACH VAULT. THE PERIMETER BEAMS ALSO ACT AS THE TOP CHORDS OF TRUSS-ARCHES.

DOUBLE TENSION CABLES FROM LOWER CHORD OF KNIT TRUSS ARCH. CABLES ARE ANCHORED TO SQUARE LATH PERIMETER BEAMS NEAR BASE OF EACH TRUSS ARCH.

115. Knit wood lattice: structural details.

Source: by Author.

BIBLIOGRAPHY

- Allen, Edward. Fundamentals of Building Construction, 3rd ed. New York: John Wiley & Sons, 1999.
- Bachmann, Ingrid and Ruth Scheuing, eds. Material matters: the Art and Culture of Contemporary Textiles. Canada: YYZ Books, 1998.
- Ball, Philip. The self-made tapestry: pattern formation in nature. New York: Oxford University Press, 1999.
- Balmond, Cecil with Jannuzzi Smith. Informal. Christian Brensing, ed. Munich: Prestel, 2003.
- Blundell-Jones, Peter. "Vaulting Ambition: an old Victorian school is inventively transformed into a centre for dance-dance studio, London, UK, architect Sarah Wigglesworth Architects." Architectural Review 222 (1325) (2007): 44-51.
- Bogner, Dieter and Peter Noever, eds. Frederick J. Kiesler Endless Space. Ostfildern-Ruit: Hatje Cantz, 2001.
- Braddock, Sarah E. and Marie O'Mahony. Techno textiles. New York: Thames and Hudson, 1998.
- Canadian Museum of Civilization. "Carbide Mill, Victoria Island." www.civilization.ca/hist/hull/rw_19ehtml (15 November 2007).
- Calvino, Italo. Invisible Cities. Translated by William Weaver. Orlando: Harvest, 1974.
- Day, Gordon, M. "The Indians of the Ottawa Valley." Canadian Museum of Civilization. Created: February 29, 2000. Last update: November 15, 2005. www.civilization.ca/cmc/archeo/oracles/outaouai/30.htm (6 June 2008).
- Detail. "Laban Centre in London." Detail 43 (7-8) (2003): 791-797.
- . "Weald and Downland Museum near Chichester." Detail 41 (5) (2001):856-857.
- Dodds, George and Robert Tavernor, eds. Body and Building: Essays on the Changing Relation of Body and Architecture. Cambridge: MIT Press, 2002.

- Duly, Colin. The Houses of Mankind. London: Thames and Hudson, 1979.
- Eliade, Mircea. Cosmos and History: The Myth of the Eternal Return. Translated by Willard R. Trask. New York: Harper & Row, 1959.
- Farnell, Brenda, ed. Human Action Signs in Cultural Context: The Visible and the Invisible in Movement and Dance. Metuchen, N.J.: Scarecrow Press, 1995.
- Foster, Susan Leigh, ed. Corporealities: Dancing knowledge, culture and power. London: Routledge, 1996.
- Frampton, Kenneth. "The Text-Tile Tectonic." On and By Frank Lloyd Wright. Edited by Robert McCarter. London: Phaidon Press, 2005, 170-89.
- Frascari, Marco. Monsters of Architecture: Anthropomorphism in Architectural Theory. Maryland: Rowman & Littlefield Publishers, 1991.
- Fraser, Malcolm. "Showstopper." RIBA Journal 220 (2) (2003): 30-38, 40.
- Garcia, Mark, ed. Architextiles AD, 76 (6) (2006).
- Gaughan, Norah. Knitting Nature. New York: Stewart, Tabori & Chang, 2006.
- Gschwandtner, Sabrina. KnitKnit: Profiles + Projects from Knitting's New Wave. New York: Harry N. Abrams, 2007.
- Hallman, Frithjof. "The Labyrinth", Essays in Memory of Karl Kerényi. Edited by Edgar C. Polomé. Washington, D.C.: The Institute for the Study of Man, 1984.
- Heth, Charlotte, ed. Native American dance: ceremonies and social traditions. Washington D.C.: National Museum of the American Indian, Smithsonian, with Starwood Pub., 1992.
- Herzog, Thomas et al. Timber Construction Manual, 4th ed. Translated by Gerd Söffker and Philip Thrift. Basel: Birkhäuser, 2004.
- Hutchinson Guest, Ann. Choreo-graphics: A Comparison of Dance Notation Systems From the Fifteenth Century to the Present. New York: Gordon and Breach, 1989.
- Holl, Steven. Acconci, Holl: Storefront for Art and Architecture. Bergen: Kunsthaus Bergen, Archiv Kunst Architektur, 2000.

- Hollis, James. Tracking the Gods; The Place of Myth in Modern Life. Toronto: Inner City Books, 1995.
- Jenkins, Phil. An Acre of Time. Toronto: Macfarlane Walter & Ross, 1996.
- Jung, C.G. and C. Kerényi. Essays On a Science of Mythology. Translated by R.F.C. Hull. New York: Princeton University Press, 1963.
- Kern, Hermann. Through the Labyrinth. Munich: Prestel, 2000.
- Laban, Rudolf. Modern Educational Dance, 2nd ed. London: MacDonald & Evans, 1963.
- Lawler, Lillian Brady. "The Geranos Dance-A New Interpretation." Transactions and Proceedings of the American Philological Association 77 (1946): 112-130.
- Lonsdale, Steven H. Dance and Ritual Play in Greek Religion. Baltimore: Johns Hopkins University Press, 1993.
- Loupe, Laurence, ed. Traces of Dance; Drawings and Notations of Choreographers. Translated by Brian Homes and Peter Carrier. Paris: Editions Dis Voir, 1994.
- Maletic, Vera. Body-Space-Expression; The Development of Rudolph Laban's Movement and Dance Concepts, Approaches to Semiotics 75. Berlin: Mouton de Gruyter, 1987.
- McEwen, Indra Kagis. Socrates' Ancestor; An Essay on Architectural Beginnings. Cambridge: The MIT Press, 1993.
- McQuaid, Matilda. Shigeru Ban. London: Phaidon, 2003.
- Merrick, Jay and Susan Dawson. "Glenn Howells/Savill Building." Architect's Journal 224 (1) (2006): 25-39.
- Mostafavi, Mohsen and David Leatherbarrow. On Weathering: The Life of Buildings in Time. Cambridge: MIT Press, 1993.
- Le Ricolais, Robert. "Survey of Works; Structural Research 1935-1971." Zodiac 22 (240) (1973): 1-56, 240-245.
- Otto, Frei et al. Frei Otto, Bodo Rasch: Finding Form. Stuttgart: Edition Axel Menges, 1995.

- Pallasmaa, Juhani. The Eyes of the Skin; Architecture and the Senses. London: Wiley-Academy, 2005.
- Panofsky Erwin. Perspective as Symbolic Form. New York: Zone Books, 1997.
- Pearman, Hugh. "Arcadian idyll or suburban tearoom? The English garden pavilion gets a rethink." Gabion (First published in The Sunday Times, London, 25 June 2006, as "Grounds for optimism"). www.hughpearman.com/2006/20.html (31 March 2008).
- . "The dancing building: Siobhan Davies Dance gets its London Base." Gabion (First published in The Sunday Times, London, 12 March 2006). www.hughpearman.com/2006/07.html (14 September 2007).
- Pesic, Peter. Labyrinth: A Search for the Hidden Meaning of Science. Cambridge: MIT Press, 2000.
- Porter, Gerald. "'Work the Old Lady out of the Ditch': Singing at Work by English Lacemakers." Journal of Folklore Research 13 (1/3) (1994): 35-55.
- Pye, David. The Nature and Art of Workmanship, rev. ed. Bethel, CT: Cambium Press, 1995.
- Reid, Giles. "Dancing architecture." Domus 858 (2003): 62-79.
- Reiser, Jesse and Nanako Umemoto. Atlas of Novel Tectonics. New York: Princeton Architectural Press, 2006.
- Richards, Ann. "A Diagram of Forces: Form as Formation in Nature and Design," On Growth and Form. Edited by Philip Beesley and Sarah Bonnemaïson. Halifax: Tuns Press, 2008.
- Rutt, Richard. A History of Hand Knitting. London: Interweave Press, 1987.
- Ryan, Raymund. "Herzog & de Meuron's Laban Centre for Movement ethereal glow in lime, turquoise, and magenta." Architectural Record 191 (6) (2003): 130.
- Rykwert Joseph. The Dancing Column; On Order in Architecture. Cambridge: MIT Press, 1996.
- Schoeser, Mary. World Textiles: A Concise History. London: Thames & Hudson, 2003.

- Semper, Gottfried. The Four Elements of Architecture and Other Writings. Translated by Harry Francis Mallgrave and Wolfgang Herrmann. Cambridge: Cambridge University Press, 1989.
- . Style in the Technical and Tectonic Arts; or, Practical Aesthetics. Translated by Harry Francis Mallgrave and Michael Robinson. Los Angeles: Getty Research Institute, 2004.
- Sennet, Richard. The Craftsman. New Haven, CT: Yale University Press, 2008.
- Slessor, Catherine. "Dance Class", Architectural Review 222 (1325) (2007): 36-43.
- Snoonian, Deborah. "In France, another Pompidou Center takes shape." Architectural Record. 193 (9) (2005):176-177.
- Sweeney, Robert L. Wright in Hollywood: Visions of a New Architecture. Cambridge: MIT Press, 1994.
- Taj, Masud Hasan. Doctoring Strange Loves Or: How I Learned to Stop Worrying Stanley and Love Monsters in Scholarship, Chess, Films & Architecture. Carleton University M. Arch. Thesis. Ottawa: Carleton University, 2004.
- Tellier-Loumagne, Françoise. The art of knitting. Translated by Sandy Black. London: Thames & Hudson, 2005.
- Thompson, D'Arcy Wentworth. On Growth and Form, rev. ed. New York: Dover Publications, 1992.
- Thomsen, Mette Ramsgard. "Robotic Membranes: Exploring a Textile Architecture of Behaviour." Architectural Design 78 (4) (2008): 92-97.
- Virilio, Paul. "Impact Studies", Domus 899 (2007): 53.
- Vitruvius, Marcus. De Architectura. Translated by Bill Thayer.
http://penelope.uchicago.edu/Thayer/E/Roman/Texts/Vitruvius/1*.html (12 January 2006).
- Waters, Frank and Oswald White Bear Fredericks. Book of the Hopi. New York: Viking Press. 1963.
- Webb, Mary. Knitting Stitches: Over 300 Contemporary and Traditional Patterns. Buffalo, N.Y.: Firefly, 2006.

Wright, G.R.H. "Tents and Domes in Persia," Man 58 (1958):159-160. www.jstor.org/ (10 March 2008).

Zumthor, Peter. Peter Zumthor Works; Buildings and Projects 1979-1997. Basel: Birkhäuser, 2006.

Zumthor, Peter. Thinking Architecture 2nd ed. Basel: Birkhäuser, 2006.

ABSTRACT

Marginalized as an outmoded domestic handcraft yet accepted as a prevalent industrial process, knitting's simple construction techniques inherently produce strong, lightweight, and elastic fabrics capable of curvature in multiple, simultaneous planes. Knitting is a self organizing process; its structures of pattern generate texture, surface, and form. A review of the past and current practice of knitting within textile production reveals knitting's paradoxical symbolic function; one that is simultaneously culturally loaded and ambiguous. Further exploration within the context of architecture highlights precedents for the architectural translation of knitting as method, material and metaphor. Knitting is proposed as a logical and topological model for architectural production with the capacity to generate an infinite variety of architectural solutions. Linking the ball of yarn with which one knits (a clew or clue) and the basic knit unit (a loop), the myth of the labyrinth provides the guiding thread for this investigation.