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**L.B. Alberti's *ad unguem*:  
Longing for unhindered productions**

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**Unhindered Touch**

Francesco Colonna, *Hypnerotomachia Poliphili*, (1499)

Writing during a time of great change in the profession of architecture, Renaissance architect L.B. Alberti wrote in his treatise on architecture, *The Art of Building in Ten Books*:

*...avoid using the same color or shape too frequently, or too close together, or in a disorderly composition; gaps between pieces should also be avoided; everything should be composed and fitted exactly [ad unguem], so that all parts of the work appear equally perfect.*<sup>1</sup>

Alberti's Latin describing a perfectly fitting joint, *ad unguem*, translates literally as 'to the fingernail'. *Ad unguem* was a common phrase employed by Roman sculptors and stonemasons for judging correct fit, testing the work through the tip of the fingernail by gliding unhindered across a well-fitting joint.<sup>2</sup> Presumably, parts which fit together poorly, which have 'gaps', cannot be identified by the sculptor with the eyes alone. Rather, the fingernail must be employed as a means for probing the work for proper fit. In this way the sense of touch, extended from the outermost point of the body, is employed as the best and final instrument for refinement. Alberti, by invoking *ad unguem*, is not only speaking about the physical gaps between the parts of a building, he is also cautioning against intellectual 'gaps' as well – those places in the work which are manifest in "disorderly composition". The continuity between mind and material implied in *ad unguem* is indicative of Alberti's carefully constructed theory of architecture. In the prologue of

the Ten Books, for example, Alberti explains that the “building is a form of a body [*corpus*], consisting of “lineaments and matter [*lineamenta et materia*], yet depends on the “hand of the skilled workman to fashion the material according to the lineaments”, as supplied by the mind of the architect.<sup>3</sup> Consistently within Alberti’s treatise, formal correctness has a reciprocal relationship with material correctness, as is emphasized in the recurring theme of the building as a body.<sup>4</sup> This is well stated early in the treatise in the book on lineaments:

*...each member should therefore be in the correct zone and position; it should be no larger than utility requires, no smaller than dignity demands, nor should it be strange and unsuitable, but right and proper, so that none could be better.*<sup>5</sup>

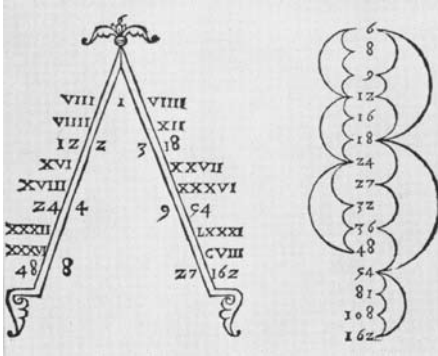
Alberti refers to this refinement as *concinntas*, describing it as the “absolute and fundamental rule in Nature”.<sup>6</sup> Buildings following this principle are a complete and consonant body, judged according to outline [*finutio*], number [*numerus*], and position [*collocatio*].<sup>7</sup> Reinforcing the interdependence of mind and material, Alberti introduces the intellectual concept of *concinntas* in his book on materials. Here he states that the parts of a building, “imbued with refined variety [*concinntas*], ought to marry practical convenience with the “demands of proportion and harmony”.<sup>8</sup>

*Ad unguem*, as a metaphor determined through *concinntas*, is indebted more to classical poetry than to that of ancient marble-workers. Dating back to the earliest Latin poets, *ad unguem* was borrowed from the workshop as a metaphor for describing a perfectly proportioned and refined poem. The Augustan poet Horace famously invokes *ad unguem* in his censure of a badly proportioned poem, writing in his treatise on poetry, *Ars Poetica*:

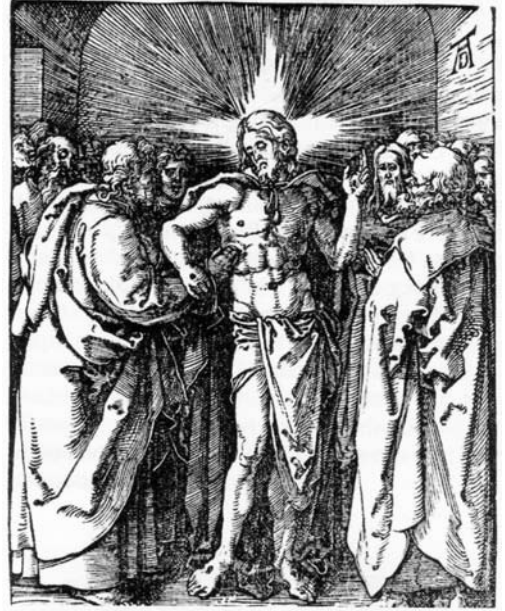
You, O

*Sons of Pompilius, condemn that poem which  
many a day and many an erasure has not pruned and  
whittled down and chastened tenfold to the nail [ad unguem].*<sup>9</sup>

This fluid rhetorical adoption of a practical convention by Horace reflects an inherent transparency between the material and the poetic imagination. This is well summarized by philologist Armand J. D’Angour, in his commentary on *Ars Poetica*, “The oeuvre is thus imagined as something whittled down from a block of marble or a lump of clay, and the image is rounded off at its close by *ad unguem*.”<sup>10</sup> The digits, then, become the check for ‘fit-ness’, both speculatively and practically, seeking the most refined arrangement of parts within a harmonious whole. The fingernail, as was likely known by Alberti, was a periodic metaphor employed in classical texts on the making of art and poetry.<sup>11</sup> Alberti reintroduces *ad unguem* back into the physical realm of architecture, further solidifying its power as a crafty metaphor and his status as a scholar of classical texts. Recalling Horace’s *ad unguem*, for example, Plutarch quotes from an earlier Greek saying:

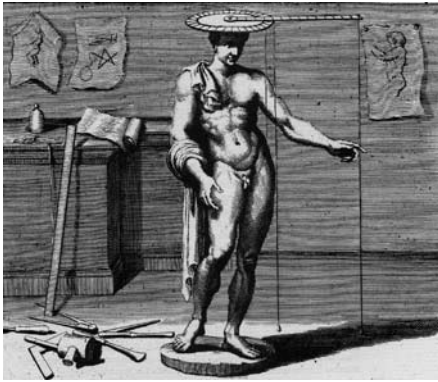


Da harmonia mundi Fra Giorgi (1525)



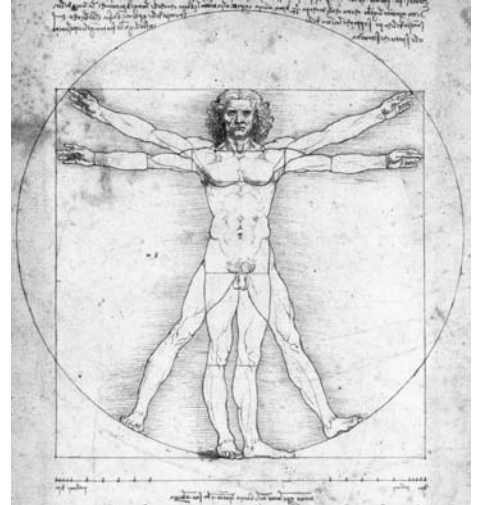
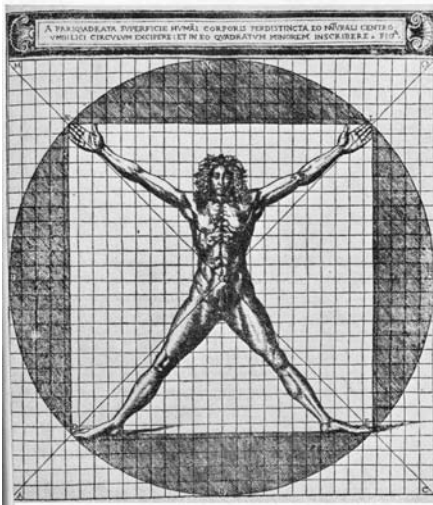
Outstretched finger of the Vitruvian man

Top, Cesariano (1521); below, Leonardo da Vinci (c.1487)



The consonant body (finitorium)

De statua, L.B. Alberti, Fresne (1651)



*The objects of art are initially quite formless and shapeless; then later each part of the figure is articulated in precise detail. This is what Polyclitus the sculptor meant in saying that the work is hardest when the clay is at the nail.*<sup>12</sup>

As both a formal and material instrument for refinement, these examples suggest that the fingernail is well equipped to inspire the material imagination. For Polyclitus the fingernail is simultaneously the symbol of both refinement and shear labor. Even though the passing of the unhindered nail-tip signifies the perfected *opus*, Polyclitus' clay-filled nails are reminiscent of the necessity of obsessive labor in achieving the well-pared work.

Situated most remotely from the center of the body, the fingertip naturally houses the miraculous point of touch; "the sense of the body in its entirety", as Lucretius writes.<sup>13</sup> Touch is often represented as the point of exchange for both the divine and the material imagination. Michelangelo most famously records this in the extended finger of Adam on the ceiling of the *Cappella Sistina*, revealing the *imago dei* as a metaphor for divine touch. In contrast, Albrecht Dürer, in his depiction of Saint Thomas, reminds us of the power of touch for verification in the material world, to reveal what our mind and eyes cannot see.<sup>14</sup> In perhaps the most interesting for architecture, Renaissance depictions of the Vitruvian man reinforce the extension of touch to mitigate between the ideal and the real. The privilege of tracing the outline of the ideal human proportion is often left to the out-stretched fingertip.

Alberti's invocation of *ad unguem* performs a dual purpose: on the one hand, *ad unguem* further strengthens Alberti's sense of the affinity between formal and material refinement; and, on the other, it serves to elevate his intellectual position as an architect through the borrowing of a known classical metaphor. This distancing from the medieval convention of architect as carpenter or mason is characteristic of Alberti's treatise, which sought to wrestle the architect from his traditional status in Hugo of St. Victor's *artes mechanicae*.<sup>15</sup> Although the nature and extent of this transformation is frequently debated, the profession of architecture was nevertheless undergoing enormous changes during the transition from the medieval to the Renaissance.<sup>16</sup> The architect was moving away from his roots in the craft guilds and embracing new responsibilities as an intellectual concerned with building.<sup>17</sup> Alberti sought to construct an intellectual structure which elevated the authority of the architect through both speculative and practical knowledge. To this end the architectural idea became increasingly solidified within off-site speculation as embodied in drawings and models, paving the way for the now largely accepted notion that architecture is produced prescriptively away from the building site.<sup>18</sup> The privilege of dictating the work of architecture through drawings and models came largely through the elevation of practice by knowledge of geometry. Through the making of a drawing produced away from the building site, an architect could now describe the building process with greater entirety. Still, even though the architect would relinquish a direct hand on construction, Alberti asks the architect to imagine the potentials and pitfalls of construction "...as though we were ourselves about to construct the building with our own hands [*manu aedificatur*]"<sup>19</sup>. As Renaissance painter Lorenzo Lotto captures in his



**Medieval architect with set square and tracing compass**

Vie de Saint Offar (13th cent)



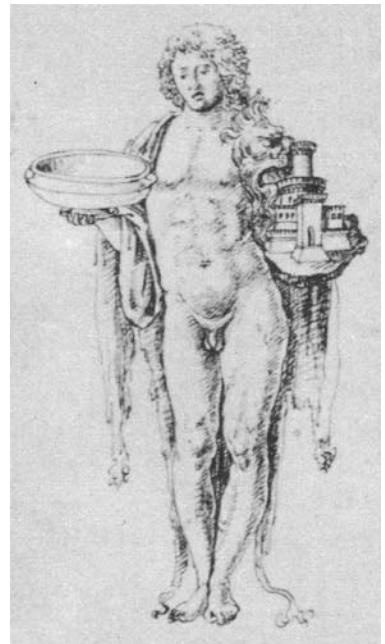
**Ad unguem as embodied in the architect's drawing**

Portrait of an Architect, Lorenzo Lotto (c.1525)



**Portrait of L.B. Alberti: Anon.**

(c.1450), Biblioteca Nazionale, Rome



**Dinocrates presenting his model**

Francesco di Giorgio (1489), Biblioteca Nazionale, Florence

*Portrait of an Architect*, *ad unguem* now operates through the medium of the architect's drawing. Holding a drawing compass and gently touching a rolled drawing, Lotto's architect expresses the dual mode of the hand as both active and contemplative. The rolled drawing, now in transit between the drawing board and building site, becomes the symbol of reflective practice.<sup>20</sup> By the fingertip and compass, Lotto's architect prudently tests and measures his idea to refinement.

Central to this discussion and to *ad unguem* is the question of authorship. *Ad unguem* implies that the one testing by the fingernail is presumably the one who has the most direct control over its further refinement. Alberti, in invoking *ad unguem*, suggests that it is possible for the architect to become the maker of a building in a similar way as Horace is to a poem. In the *Ars Poetica* the material of the idea is the word, as constructed into verse. For Alberti the material of the idea is the drawing or model, as realized in a constructed building. Echoing Vitruvius, who stated that only the architect has "a definite idea of the beauty, convenience and propriety that will distinguish it",<sup>21</sup> Alberti suggests that that the task of refinement resides firmly within the chief author of the idea, and not in the hands of the mason or the carpenter. Now, through the making of a drawing, a single hand can direct many hands, further solidifying the emerging professional separation between the architect and the builder.<sup>22</sup> The authority of drawing was largely achieved through the elevation of architecture into a the realm of the *artes liberales*, conceived in the realm of mathematics through the study of geometry.<sup>23</sup> Now the architect could strengthen his status as an intellectual concerned with theory while at the same time leveraging such knowledge through its practical application on the building site. To this end Alberti writes, in the prologue of the *Ten Books*, "the carpenter's hands are but an instrument to the architect".<sup>24</sup> There can be little doubt that Alberti viewed this removal of the direct hand in construction as a solidification of authorship rather than a diminishing of it. Thus the authority of *ad unguem* is transmitted not only through the direct access of the extended fingernail, it also resides in the metaphorical extension of the idea into the material realm.

While drawings and models would become the predominant medium in the production architecture, Alberti was careful to warn against techniques of drawing and model-making which distract from an unmitigated examination of the relationships among the parts.

*...the presentation of models that have been colored and lewdly dressed with the allurements of painting is the mark of no architect intent on conveying the facts; rather it is that of a conceited one, striving to attract and seduce the eye of the beholder, and to divert his attention from a proper examination of the parts to be considered.*<sup>25</sup>

In other words, the idea does not reveal itself solely through visual, formal representations, but requires a careful examination of the facts of construction and proportion to reveal the true ingenuity of the architectural idea.<sup>26</sup> To judge the work *ad unguem* presumes a direct access to the material of the idea as expressed in a drawing or model, a privilege which brings new responsibilities. To know a building is also to know how it is realized, which is why Alberti sought a treatise composed, like the body of a building, of both *lineamenta and materia*. An architect

working *ad unguem* cannot be seduced by visual effects but must demand a deeper, more probing examination in order to judge according to *concinnitas*. He must, as Polyclitus might advocate, get his fingernails dirty, since to work an idea *ad unguem* requires unrelenting, agonizing effort. For both the poet and the sculptor, the material of the idea cannot be expected to align perfectly after the first fitting; rather, it must be minutely whittled, measured, and tested until nothing can be added or removed but for the worse.<sup>27</sup> Material which is hard enough to be tested by the nail is presumably highly resistant to both the mind and the chisel. For Horace in the *Ars Poetica*, verses are as impenetrable as sculptor's marble, allowing them to be worked to the point where imperfections are undetectable by even the closest scrutiny.

The fact that, for Horace and Alberti, correct fit is measured 'digitally', or with the fingernail, makes this phrase a particularly potent metaphor for the examination of new digital technologies. Perhaps there is a clue in Alberti's call for refinement in the reciprocation between mind and material that can help us move beyond the simple pro/con debates which typically surround the role of a digitally inclined architect. In this way it seems the fingernail of the architect is well equipped to extend the well-pared idea into an equally refined sense of material and construction, regardless of technology. Like Alberti, who advocated drawing over a direct hand in construction, the digital architect must resolve new techniques within a changing relationship to the actual products of architecture.

Within this framework, several general attitudes seem to emerge, all of which reflect varying states of authorship with regard to the completed building. One trend is that digital fabrication allows the architect to remove him/herself further from the uncertainties of construction site, seeking to determine beforehand the building in its entirety through the integration of parametric modeling, BIM software, and the digital contractor/fabricator. The best possible scenario is that choices regarding construction, sequencing, and costs are updated in real time and are the result of known, predictable circumstances. Ideally, all decisions are made either before breaking ground or within a predictable set of parameters once construction begins. Often the BIM-driven architect must resist the pressures of technical specialization within a complex project management structure, hedging the power to see the entirety of construction as the architect's central contribution realization of a building project. In this way the chief product of the architect becomes information, as represented in a BIM model, containing all technical aspects of a building project in a single database. This central model exists as the common language between all invested parties, allowing the array of other specialists, from insurance assessors to steel fabricators, to pull relevant information. The BIM architect rests his or her confidence in a well crafted information model that will predictably allow the various pieces of construction to arrive on time, well coordinated, and within budget. Because of its potential to coordinate complex endeavors, the architectural information model is generally highly favored within large, bureaucratically oriented projects often requiring hundreds of team members within a structured management team. Many large government and commercial clients now require BIM because of its promise to minimize costly overruns. Design standards are therefore increased through better project coordination.



L'arte di costruire



L'Architettura

**Personification of builder and architect**

Relief sculpture on the Campanile del Duomo, Florence, Workshop of Andrea Pisano (c.1336)



**Filarete and His Dancing Disciples**

Bronze doors of St. Peter's, Antonio Averlino known as Filarete, Rome, 1445



**Ad unguem reaching between idea and material**

Jacopo Barozzi da Vignola, frontispiece, Regola del Cinque Ordini d'Architettura, Rome, 1562



**Genius constrained by poverty**

Emblemata, Andrea Alciato, Padua (1621)

The total integration of design and production has also been hailed as the re-emergence of the architect as master builder. The digital master builder is the modern form of the popular notion of the medieval architect-as-master mason, who led construction through both the direct hand of the chisel and the pointing finger of instruction.<sup>28</sup> Certain architects embracing a BIM-integrated practice are seeking to exploit the inherent technical bias in database modeling as an opportunity for total control within an innovative and reflective practice.<sup>29</sup> The product now becomes the architectural idea, coming from a single entity, firm or individual, as expressed in a digital model of a future building. The architect's idea is perceived as passing from a digital representation into real material, unmitigated by technique, material, and constructive realities. The master builder paradigm seeks to regain total control over the relationship between idea and construction, envisioning a direct hand in construction through the mitigation of advanced technology. The new goal is, in quoting a prominent digital fabricator "to take whatever is in the mind of the architect and make it real."<sup>30</sup>

From this position we see the emergence of the concept of 'digital craft', in perhaps the most expressive potential of Alberti's *ad unguem*. Digital craft proposes to translate the spirit of the craftsman across technological barriers, endeavoring to merge the formal freedom provided by digital technologies with the material intimacy of traditional craft culture. In attempting to bridge this divide, however, we have to ask ourselves what really is implied in the idea of 'digital craft'. In one sense, there is no longer any craft in the actual fabrication of digitally generated products, since agency is no longer dependent on the handed intervention of a craftsman. However, as a metaphorical reading, 'digital craft' has the potential to work within the same notion of refinement as embodied in *ad unguem*. Just as the sculptor worked the material to the exactness of the nail, the new digital architect, working through advanced tools, can demand the same refinement. The pivot point in the refinement of an idea *ad unguem* is technique: the sculptor's privilege of judging correct fit lies partially in the fact that he possesses the knowledge of how to achieve it. Filarete, a sculptor himself, depicts this well in the self-portrait on his bronze doors for St. Peter's. At the head of a line of dancing workshop disciples, Filarete triumphantly points toward the sky with the traced point of a large compass. Through the difficult practical work of the *bottega*, the architect can have access to the material of the divine imagination.<sup>31</sup> A result of one of the most technical and difficult casting processes, Filarete's doors demonstrate that *ad unguem* not only signifies a refined sense of worked material, it also signifies the harmonious idea, whittled down laboriously by the nail to its most exact proportions.

*Ad unguem*, as a measure of refinement, loses some of its potency when taken in light of the emerging class of purely speculative digital architects, of which there are many current examples.<sup>32</sup> At this point mostly an academic undertaking, these architects exploit the power of computing technologies to expand formal possibilities through the manipulation of mathematical models rather than visual or material ones. Technique is raised to its highest status, with the architect seeking to work directly inside the technical language of the computer software as a method for invention. In this sense the product of the architect becomes the computer script, concealing

authorship behind the invisible hand of the computer.<sup>33</sup> In opposition to the 'master builder', the speculative architect tends to demote constructive and material realities, seeking instead to elevate the productions of architecture as ethical and aesthetic statements over material ones.

In fact, much of the current debate surrounding the employment of digital fabrication techniques parallels quite closely Alberti's 15th century concern for the transparent touch between well-fitted parts and a well-fitted idea. The modern digital architect, through a revolution in technique, once again faces sweeping changes in his or her relationship with the building site, bringing into the forefront the critical relationships between constructing and construing. Often with a hemisphere's distance between the architect's office and the building site, the material of the architectural imagination tends to reduce itself to that which is easily transmissible, often confined largely to its formal and visual aspects. Perhaps Alberti envisioned a similar conflict upon the removal of his architect from the building site, which is why he reserved a large portion of his treatise for practical matters. For him, the authority of the removed architect originated from knowledge in both mind and material.

The power of digital fabrication technologies to expand formal possibilities is well documented and easily observed. The material resistance which once empowered the Roman sculptor to test *ad unguem* has been largely overcome through technology. Since the barrier between constructing and construing is so seemingly transparent with digital fabrication, the main reward in production becomes tends to favor the visual. With this, the ease of material manipulations has raised the formal imagination to an almost universal hegemony, often leaving material and constructive realities at the service of formal desires. The seamless operations empowered with digital tools have the potential to create false illusions of refinement, since what was once extraordinarily difficult or impossible can now seem quite effortless. Digital craft, taken in the spirit of *ad unguem*, holds the potential to leverage the power of digital machines to see both the entirety of construction and its every particular.

As a recurring theme in Renaissance iconography, Genius is often constrained by the poverty of expression. Without the resistance of the world, unencumbered talent would have direct access to the divine imagination. Typically, the man of *ingenium* is portrayed with an outstretched hand, reaching for the divine idea through extended fingertip, only to be inhibited by the weight of earthly being, as represented by a brute stone tied to his wrist. While the impression of divine perfection seems within reach to the enlightened mind, the earthly bounds of material and construction must have their say. *Ad unguem* suggests that, instead of the unhindered mind, we ought to strive for a freely grazing fingernail. As a metaphor for refinement within the in-between world of mind and material, digital and traditional, the need for judging *ad unguem* has never been more important.

dedicado a c\*

## NOTES

- 1 Alberti, Leon Battista, *On the Art of Building in Ten Books (De Re Aedificatoria)*, translated from the Latin by Joseph Rykwert, Neil Leach, Robert Tavernor, MIT Press: Cambridge, Massachusetts, 1988, pg. 179. See n93, pg. 389, for translation of *ad unguem*. Subsequent quotations from the Ten Books are from this edition, unless noted otherwise.
- 2 D'Angour, Armand J. *Ad Unguem*, *American Journal of Philology*, Vol. 120, No.3. (Autumn 1999), pg. 411.
- 3 Alberti, pg. 5. Generally referring to the formal properties of the building, *lineamenta* are "conceived in the mind, made up of lines and angles, and perfected in the learned intellect and imagination" (pg. 7). They have "nothing to do with material", as Alberti resolutely states, yet are nevertheless invoked in the visual imagination and thus have extension and consistency. In empowering the making of drawings and models, *lineamenta* are therefore well equipped to reach across the space of mind and material. In a testament to this ambiguity, *lineamente* is notoriously difficult to translate and has generated considerable disagreement among scholars as to Alberti's intended meaning. For a recent survey of the history surrounding the interpretation of lineamente, see Branko Mitrovic, *Serene Greed of the Eye*, Deutscher Kunstverlag, 2005, pg. 39-47; and S. Lang "De lineamentis: L.B. Alberti's Use of a Technical Term," *Journal of the Warburg and Courtauld Institute*, 1965.
- 4 The body is a recurring analogy throughout the *Ten Books*, solidifying the notion that a building should be ordered according to Nature, refined in composition and material. Alberti writes, for example, "In short, with every type of vault, we should imitate Nature throughout, that is, bind together the bones and interweave flesh with nerves running along every possible section..." pg. 86; cf. also Alberti, pg. 23-24.
- 5 Alberti, pg. 23
- 6 Alberti, pg. 303
- 7 Alberti, pg. 302-303. See also, Jacob Burckhardt, *The Architecture of Renaissance Italy*. Secker and Warburg: London, 1984, pg. 30.
- 8 Alberti, pg. 35.
- 9 Horace, *Ars Poetica*, 291-94, as quoted in D'Angour, pg. 411.
- 10 D'Angour, pg. 415.
- 11 See D'Angour's analysis of *ad unguem*, who demonstrates that, although Horace's use of the metaphor is the most famous, there is a rich tradition in the metaphor of the fingernail as the measure of refinement in both Latin and Greek poetry.
- 12 Plutarch, *Quaest. Conv.* 2.3.2 636B, as quoted and translated by D'Angour, p. 420.
- 13 Lucretius, *De rerum natura*, II, 434, as quoted by Jean-Luc Nancy, *The Muses*, 1994.
- 14 For a recent interpretation of the phenomenological power of touch in architecture as embodied in Caravaggio's portrayal of doubting Thomas, see Juhani Pallasmaa, *The Eyes of the Skin: Architecture and the Senses*, Chicester, Wiley-Academy: Hoboken, NJ, 2005. Saint Thomas is also the patron saint of builders and architects.
- 15 See, for example in the prologue of Alberti's *Ten Books*, "[the architect] should no doubt be accorded praise and respect, and be counted among those most deserving of mankind's honor and recognition" (pg. 5). In addition, the architect must perform above the mere *operarium faber*, workman, who can "make something that appears to be convenient for use", and instead seek that which "will be perfect and complete in its every part" (pg. 315).
- 16 For an analysis of the medieval architect, see N. Pevsner, "The Term 'Architect' in the Middle Ages", *Speculum*, Vol. 17, No. 4, (Oct. 1942), pg. 549-562. Pevsner argues that the Vitruvian definition of the architect possessing both *ratiocinatio and fabrica* was preserved across the middle ages much more in southern Europe than in the north, and that the northern use of the term 'architect' made very little distinction between those involved in speculative planning and those engaged in practical work. In addition, it seems clear that north of the Alps the gradual professional separation of the architect from the operative master-mason occurred several hundred years later than it did in the south. For a summary of the myths surrounding the role of the medieval architect, see Andrew Saint, *The Image of the Architect*, Yale University Press: New Haven and London, 1983, pg. 19-50.
- 17 Wilkinson, Catherine, "The New Professionalism in the Renaissance", *The Architect*, Spiro Kostof, ed., Oxford University Press: New York, 1977, pg. 124-125.

- 18 cf. Alberti, p.315, "Questions such as these should be projected and debated by the use of models..."; cf. pg. 317 for an autobiographical description of the importance of drawing; and cf. pg. 318, in a plea to the architect to, ..."save your sound advice or fine drawings [*lineamenta*] for someone who really wants them."
- 19 Alberti, pg. 58.
- 20 Both Alberti and Filarete advocated the use of carefully scaled drawings to prescribe future construction. See Alberti pg. 7, "let lineaments be the precise and correct outline [prescriptio]..."; and Filarete's concept of construction drawings [*disegno proporzionato, disegno rilevato*], as opposed to those employed as a "*congetto*" or "*disegno in digrosso*", see the introduction to Filarete, *Trattato di Architettura*, testo a cura di Anna Maria Finoli, Milano, 1972, pg. 61-64
- 21 Vitruvius, Book VI, 8.10, trans. by Morris Hickey Morgan, New York: Dover, 1960, p. 192. The relationship between Alberti and Vitruvius is a complex one, well summarized in Richard Krautheimer, "Alberti and Vitruvius", *Studies in Western Art*, vol. 2, 1963
- 22 Evelyn, John, *Public Employment and an Active Life prefer'd to Solitude, and all its Appandages, Such as Fame, Command, Riches, Coversion* (London, 1667).
- 23 Emmons, Paul, "Architecture Before Art: Imagining Architectural Authority in Early Modern England," *ARQ*, Vol. 10, no. 3/4, 2005, pg. 278.
- 24 Alberti, *De re aedificatoria*, 2.26 "fabri enim manus architecto pro instrumento est." This translation is my own.
- 25 Alberti, pg. 34.
- 26 Alberti particularly advised against the use of perspective in the study of architectural constructions: "The architect rejects shading and gets projection from the ground plan. The disposition and image of the facade and side elevations he shows on different sheets with fixed lines and true angles as one who does not intend to have his plans seen as they appear, but in specific and consistent measurements", pg. 34.
- 27 cf. Cicero, *De Natura Deorum*, I.xxxiii.92.
- 28 This myth has been largely dismissed in modern scholarship as both reductive and over-simplified. See Saint, chapter 2.
- 29 There are many examples of architects successfully pursuing aspects of the total integration of technology and practice: KieranTimberlake, SHoP, Diller Scofidio + Renfro
- 30 Personal conversation with J-P. Mueller, owner of OEC engineering, Chantilly, Virginia, USA, April 2006.
- 31 King, Catherine. "Filarete's Portrait Signature on the Bronze Doors of St. Peter's and the Dance of Bathylkes and His Assistants", *Journal of the Warburg and Courthauld Institutes*, Vol. 53, 1990, pg. 296-299.
- 32 See, for example, Marc Fornes at [www.theveryman.net](http://www.theveryman.net); Skylar Tibbits at [www.sjet.us](http://www.sjet.us)
- 33 See, for example, Mark Goulthorpe and his theory of precise indeterminacy, esp. Amanda Reeser & Ashely Schafer, "Precise Indeterminacy" Three Projects by Decoi and an Interview with
- 34 Mark Goulthorpe, *Praxis* 6, 2004. Much of current research in computer driven design seeks to mimic certain natural generative processes which defy prediction yet adhere to a knowable set of principles.

