PENCILS AND PIXELS

The Pencil Lead as Building Material

Paul Emmons
Virginia Tech, Washington-Alexandria Architecture Center

The pencil as an architectural tool is omnipresent and correspondingly invisible. With over two billion pencils manufactured annually during the twentieth-century, pencils are so infraordinary that, when encountered upon the ground, like pennies, they are more often stepped over than picked up. Participating with the mundane status of the pencil is the image of the architect. The metonymnic identification of the drafter as pencil continues in colloquial conversation and architectural images.[1] While the pencil as an Aristotelian tool extending the powers of the hand is a commonplace trope, this paper proposes a metonymn in the other direction, that an architectural design of pencil marks on paper becomes building material and the lead pencil becomes a construction tool.

Following the introduction of paper in the West, the beginnings of modern architectural drawing appeared in the Renaissance. These drawing practices often represented the procedures of construction on site. Construction lines in drawings related to pulling ropes on site, dimension lines imitated staffs with tied ropes, and centerlines represented plumb lines.[2]

As drawing practices slowly became conventionalized, the perceived relationship between constructing drawings and constructing buildings largely became lost. The disconnection between designer and builder has been the source of much recent experimentation in various design/build practices, but the dominant practice of architecture continues to follow the separation of design and construction. Accepting the designer located at a drawing table rather than a construction site, how can we engage a material imagination separate from the presence of the material itself? I propose that drawing materials themselves can engage the architect's material imagination. Through drawing materials, we can constructively imagine building materials.

MATERIAL IMAGINATION

Unlike the formal imagination that promotes the visuality of things as shape or outline removed at a distance, the material imagination

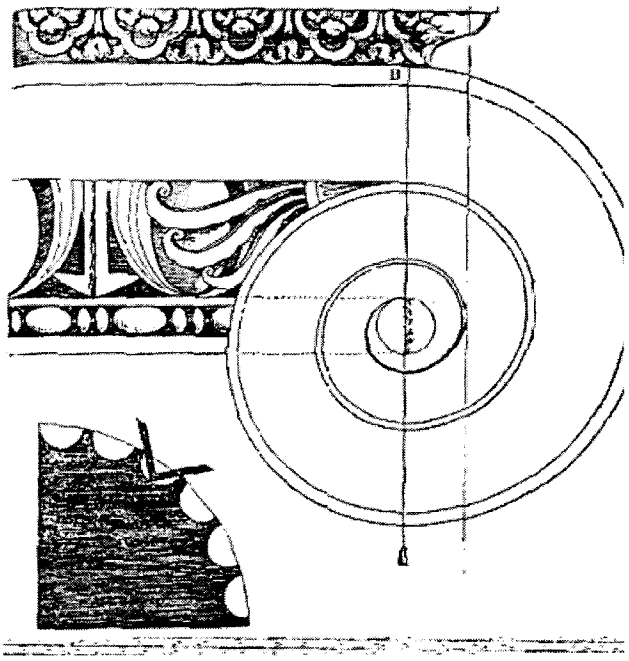

Fig. 1. Plumb line as center line in Sebastiano Serlio, On Architecture *(1537).*

requires intimately attending to the poetic substance of things. Architectural design, as a platonic practice, often emphasizes the formal imagination, treating materials as a secondary choice after the forms are determined. The primacy of form over material in architectural design is evident even in a "massing" model that defines shape rather than substance.[3] A further result of the platonic architectural practice is that mind is prioritized as idea and the design idea is presumed to be invented in the mind prior to drawing where the role of drawing is to merely record the idea. This attitude, present in the Renaissance, remains today.[4] As Denis Hollier wrote: "the architect saw his superiority guaranteed in his power to outline plans, to make projects. The forms he conceives must guarantee the domination of idea over material."[5] However, as Renaissance pentimento attests, the idea appears coincident with the drawing, coming into being through the drawing process. Since idea is not prior to but coincident with drawing, the nature and role of drawing is critical to imaginative constructions.

Modern science has defined how we know building products through quantifiable criteria, such as the compressive strength of concrete and the coefficient of expansion of steel. Yet, that a stone is rough to my touch is just as much a property of the stone as its bearing capacity. The abstraction of tactile material properties to objective measures masks the expressive imagery of substances. Properties of materials are not only scientific, but also perceptual and poetic. The dynamic hand comprehends substantial qualities that the geometric eye cannot.

Gaston Bachelard (1884-1962), trained in chemistry, was an accomplished philosopher of science when he wrote a series of books on the poetics of the material imagination of the four ancient elements: earth, air, fire, and water.[6] Bachelard described air, for example, as the least dense element, promoting reveries of flight. He distinguished between a formal imagination of air relying on wings and a material imagination having no need of wings to engage pure movement.[7] In pre-modern times, it was believed that the four elements shared four qualities of hot, cold, moist, and dry. Through changing degrees of these qualities, one element could transmogrify towards another. Alchemical efforts to transmute lead into gold were theorized in this way. Thus, there is a typology of material images that are not fixed but dynamic. In considering Monet's famous cathedral paintings representing stone imbued with light, Bachelard wrote the stone is "airy in its substance, airy to the very core of its masonry."[8] Physical objects such as building materials can be understood as the transmutation of the four elements balanced in varying degrees. Brick results from water mixed with earth and through fire imparts to mud the strength of hardness.

MATERIALITY OF THE LEAD PENCIL

In conventional drawing, pencil lead is presumed to be almost immaterial, compared to its more robust siblings such as ink, chalk, or paint. The insubstantiality of pencil lines may have been due to its early and continued use for preliminary or "field" drawing. During the Enlightment, black lead was much easier to use on horseback than pen and ink. Henry Peacham in 1606 recommended the use of black lead in quills "for your rude and first draught" and John Harbeson wrote approximately the same about pencils for architectural delineation in 1927.[9] The idea of a geometric line as breadthless length can only be suggested through a physical pencil line. Even the new "pencil" developed through an Atomic Force Microscope that can draw a line one molecule thick is not a geometric line without breadth.[10] While pencil lines are used to approximate immaterial geometric lines, they remain nonetheless material entities.

In ancient Rome, a pencil was a tiny brush, *penicillus,* meaning "little tail." It wasn't until the mid-sixteenth-century that the lead pencil appeared.[11] According to tradition, a violent storm overturned a large oak tree in Barrowdale (Cumberland) England, local shepherds went into the hole left by its roots, and discovered a black substance that was useful for marking their sheep. This material, too soft to be stone and too hard to be earth, was judged by the Royal Society in London to be similar to (white) lead, and was named "black lead" or *plumbago.*[12] For over a century, Barrowdale was the premier source of black lead and today remains the site of the Derwent pencil company. Black lead was used for treating melancholia, a malady striking philosophers and artists that was thought to be an influence from the lead planet, Saturn, and was consumed as a paste with white wine. At the end of the eighteenth-century, a Swedish chemist found black lead to be graphite, a form of carbon. In the 1850 Exhibition at the Crystal Palace, Barrowdale black lead was displayed beside the Koh-i-Noor (mountain of light) diamond since they both were known to consist of graphite.

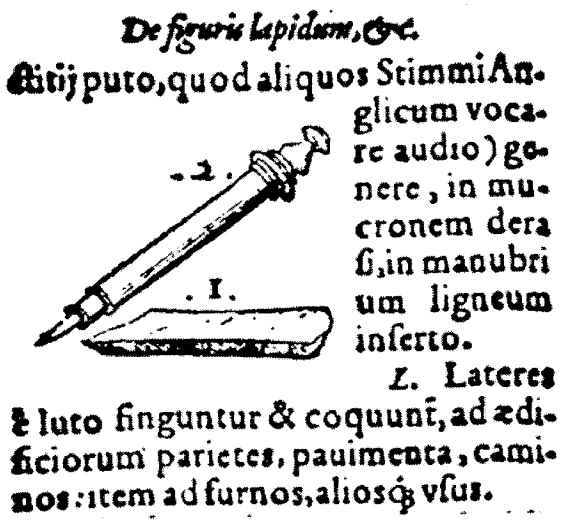

Fig. 2. Early illustration of a lead pencil in Konrad Gesner, De Rerum Fossilium *(1565).*

The first known illustration of a lead pencil is in Konrad Gesner's treatise on fossils in 1565.[13] Black lead was quickly adopted by artists and Lomazzo's treatise on art and architecture mentioned black lead. In 1620, architect and lawyer Sir Roger Pratt mentioned using "black lead Pencils – blackest and least brittle whereof are the best" in his architectural designs.[14] It was in 1795, while France was at war with England and could not obtain high-quality black lead, that chemist Nicolas-Jacques Conte patented a process still used today to make pencil leads; although precise recipes remain secret. He purified coarse graphite and mixed it with clay and water, kneaded it, and baked the paste. Prior to the late eighteenth-century introduction into Europe

of India rubber for erasers, bread was used to remove black lead from paper. The preferred eraser was the kneaded interior of freshly baked rye bread. Easily smudged black lead drawings on paper were sometimes fixed with milk.[15] Modern, synthetic manufactured materials lure us into forgetting the alchemic richness of ordinary drawing materials.

Black lead was early wrapped in string or bound into a wooden holder. Cennini and Vasari recommended that artists should tie charcoal to a little cane or stick to be able to stand away from the work.[16] Henry Peacham described "black lead sharpened finelie and put fast into quils" as essential for drawing in the early seventeenth-century.[17] By the eighteenth century, a *porte-crayon* (pencil holder) of brass or white metal was in general use. Black lead was beginning to be set into wood cases already by the end of the seventeenth-century. Friedrich Staedtler made early wood pencils with pure square black lead glued inside in 1662. As late as 1843, the *Complete Book of Trades* still found it necessary to announce the change of pencil from a brush to "wood with a groove into which black lead, or *plumago*, a dark shining mineral, is introduced."[18] Cedar remains the preferred wood for pencil casings due to its straight grain that facilitates sharpening as well as the delicious odor given off during that procedure. The wood began to be painted yellow in the 1890s because at that time the best source of graphite was in China, and yellow was associated with that area. Cedar wood acts as a scaffold for the soft lead, a temporary falsework to be consumed during construction.

While we have known for over two hundred years that black lead is actually graphite, the material imagination is more powerful than scientific knowledge and it is still understood as a "lead pencil" today. The material image of this everyday medium continues in modern uses, so much so that people are still concerned that innocuous graphite pencils may be toxic like lead. The idea of the drawing medium as lead remains in the German *Bleistift*, as well as in English. In France and Spain, a pencil is called a stone or *lapis*. In Italy, especially in the Renaissance, a soft red chalk was often used for drawing, and it was called *sanguine*, or blood.[19] The ancient four materials were associated with four humors or personalities in humans, including the melancholic and the sanguine. This suggests a regionalism of material images of pencil marks that could suggest differences in notions and modes of pencil drawing between different cultures. These variations demonstrate that while the material imagination is more powerful than scientific knowledge, it is not fixed or determined by physical reality but dynamically engaged with the world.

TRANSMUTATION OF BLACK LEAD INTO BUILDING MATERIAL

Without reducing architecture to cinema or reverting to craft traditions, reverie on the immediate materiality of design drawing embeds the creative act in materiality. The pressure of pencil against paper transforms the white sheet into black through the volition of the human hand. The pencil line is a furrow in the earth, the planting of seeds, seeds of ideas to be harvested during construction. Bachelard noted that we say a pencil touches the paper when the point is one ten-thousandth of a millimeter from the paper. The hardness of pencil leads is due to the proportion of clay mixed with graphite. Softer leads are not darker, but leave more fragments of graphite on the paper. Bachelard calls this graphite pollen.[20] Working between internal and external senses, the pencil brings forth images of architecture. Henry Thoreau, whose family made high quality pencils from a graphite deposit in New England beginning in 1821, called his pencil a "lever" between his imagination and the physical reality of paper.[21] It is through the resistance felt by the hand between drawing lead and paper that gives drawings depth. Bachelard, referencing Novalis' magic idealism, suggested that in the dynamic reveries of our contact with matter, each touch creates a new substance, and that materials touch us as we touch them.[22]

Renaissance writer John Evelyn, following Francis Bacon, distinguished between the large movements of the mason and the small movements of the architect. While differing in scale, these two sets of movements are analogous in the potential of awareness of effort against material resistance. Perhaps the best example of building with a pencil is Louis Kahn's admonition to architects to draw a concrete pour as a continuous line and lift the pencil at the end of each pour, creating concrete joints as a condition of drawing. In a section called *on stopping our pencils*, he wrote architects need "to train ourselves to draw as we build, from the bottom up, when we do, stopping our pencil to make a mark at the joints of pouring or erecting" because "in architecture, as in all art, the artist instinctively keeps the marks which reveal how a thing was done. ...The desire to express how it is done would filter through the entire society of building, to architect, engineer, builder, and craftsmen." In *on drawing*, Kahn emphasized the importance of material imagination over empirical knowledge: "to an architect the whole world exists in his realm of architecture - when he passes a tree he does not see it as a botanist but relates it to his realm. He would draw this tree as he imagined it grew because he thinks of constructing. ...The architect draws to build."[23]

All great architects of the pencil found techniques for working building materials with pencil lead. This was certainly true for early twentieth-century architecture. Louis Sullivan, a master pencil, used black marks like seeds planted in the vibrant whiteness of paper that corresponded to the vital life of nature. The contrasting black and white spots translate into the shadows and highlights of the glazed

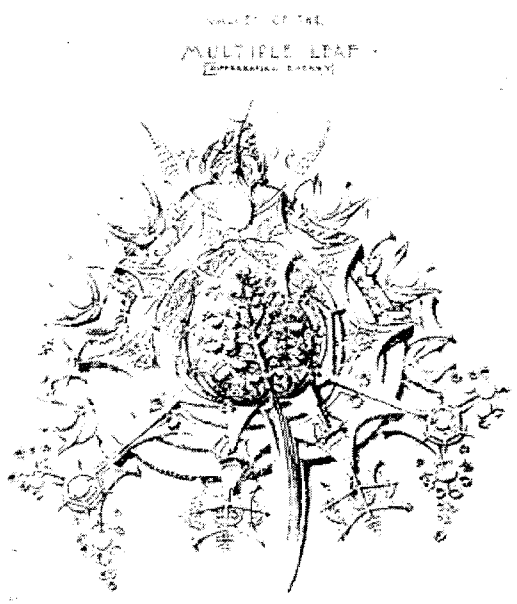

Fig. 3. Values of the Multiple Leaf in Louis Sullivan, A System of Architectural Ornament According with a Philosophy of Man's Powers *(1922).*

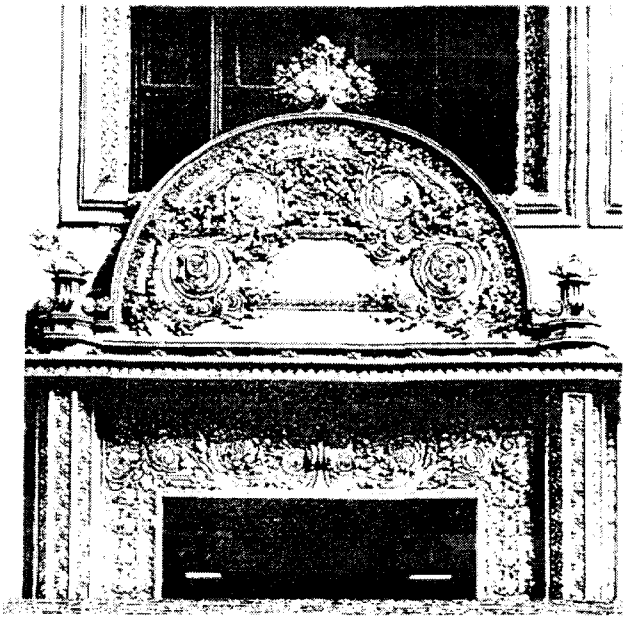

Fig. 4. Terra-Cotta entrace to the Bayard Building by Louis Sullivan (1897-99).

terra-cotta ornament of his buildings. Sullivan utilized "extensive undercutting" in his terra-cotta designs, "which was done by hand after the pieces were removed from the molds" to create a "wonderful play of light and shadow across the building's surface."[24] The craftsman's chiseling of the terra cotta corresponds to Sullivan's marking of the drawing paper. Sullivan's drawings in *A System of Architectural Ornament According with a Philosophy of Man's Powers* moved from line to point as the "inorganic became organic, the ideal real, and the subjective objective." When published in a line-cut process, Sullivan detested the plates as "dull and dead rather than alive and breathing in their own atmosphere."[25]

Mies van der Rohe, in his early charcoal studies of glass, first used a hard pencil line for the interior building structure, and by applying charcoal on top for glass, the pencil appears as a sharp white line underneath the crystalline glass expressing the spirit of the structure in proper constructional order.[26] Other architects of the pencil, Bertram Goodhue and Ralph Adams Cram, in their thick, broken lines, drew the granite of their collegiate gothic buildings in the same way the stones were produced. Large blocks were first quarried and finely finished only later to be beaten by workmen with chains to break off corners to achieve an instantaneous patina of age to give the new stones of the new world institutions the authority of the old stones of Oxford and Cambridge. Ralph Adams Cram's Princeton Graduate College was praised at the time as "instant antiquity" where "one has forgotten how entirely new it is."[27] These sorts of procedures with pencil, each developed by an individual architectural genius actively engaged in material reverie, are alchemic creations transmuting pencil lead into architectural gold. The relation between architect and builder is neither precise nor deterministic, but representational, inviting the imagination of both to comprehend the other. Care in drawing translates into care for building. Small gestures transform into large.

CHALLENGE OF DIGITAL MATERIALITY

If the architectural material imagination is best grasped through the materiality of the design drawing, is it possible to achieve materic computer drawings? Computer drafting is not transparent to hand drafting.[28] In computer drafting, the digits of the hand no longer have tactile connection to the production of the digital drawing. Like an electric typewriter compared to a manual, the pressure of the finger on the key is no longer related to the image that appears on the screen. It is not surprising that the goal of most computer rendering is a perfect visual simulacrum of a future building, akin to the realism achieved in movie special effects. The goal is to mask the process of creation so that the image is entirely "lifelike." Yet, if materic architectural drawing is the goal, then this naïve realism is only a distraction and a suggestive drawing that lets the medium engage the viewer's imagination in construing a likely future building is a more materially real representation.

George Berkeley in an *Essay Towards a New Theory of Vision* (1709), persuasively argued that visual appearances are signs in the mind and not identical with the objects we touch.[29] He gives the example of a man born blind who later gained sight had to learn the relation between the new objects of his sight and the objects he knew through touch.[30] The relation of sight and touch is not self-evident. Berkeley cautioned against mistaking the picture with the thing. Yet this often occurs in computer renderings. The naïve realism of much computer rendering forgets that the picture is not identical with the thing, even if it is a perfect likeness. This error extends to the way modern buildings are conceived and constructed, giving the primacy to form over material. The primacy of touch in pencil drawings is disrupted in computer drawings. The Aristotelian notion of tool as an extension of the hand has been usurped by Deleuze and Guattari's concept of "abstract machines" that absorb both human and machine into larger functional systems.[31] These abstract machines threaten to eliminate the material imagination from their production of simulacra. Bachelard noted that today technological materials seem to precisely fit specific uses making their material creation seem transparent and distance us from material reveries. The friction of a material and its use makes us more aware of them especially across different settings such as kitchen, laboratory, drawing table, and construction site. Use of various materials, such as bread for erasure, explaining why we have eraser "crumbs," makes us aware of material conditions. Line thicknesses are represented in computer aided design programs on screen by different colors, not by thickness created by the hand with the pencil. The system of representation is conventionalized without relation to the building object. In the terms of semiologist Charles Peirce, the indexical relation of drawing and building through physical engagement now becomes a symbol that can only be learned through training. If the goal of computer drawing is no longer to produce a perfect visual likeness, but to achieve an alchemic material likeness through procedures of interacting with the tool, then the point is not to imitate a pencil with computer printouts, but to define the physical gestures of computer drawing and through them construct a system of architectural representation that relates to building construction. The snap-line system, which implies lifting a line up off the screen and then setting it in place, could be conceived as related to pulling a rope taught in construction and the physical snapping of a chalk-line. Squaring grids in the Renaissance were often drawn with cords dipped in ink or charcoal and snapped onto the surface.[32] For material images of architecture to be dreamed while engaged in computer drafting, the systems of input and program design need to include interactions with operators that reflect the potential of modern building construction.

Architectural drawing should be a representational lever to pry open material dreams of possible buildings. It remains a common trope even in this electronic era that any person who is a true architect cannot think or talk without pencil in hand. The material imagination needs to be encouraged through the evolution of new representational technology, just as it was with the introduction of paper in the renaissance and the architect first began to design out of sight from the construction site with lead pencil in hand.

NOTES

[1]The architectural journal *Pencil Points* often made reference to architects as pencils in the early twentieth century prior to its becoming *Progressive Architecture*. Images identifying architects with pencils can be found in sources as varied as Ernst Neufert, *Bauentwurfslehre* (Berlin, 1936), Morphosis, *Tangents and Outtakes* (Artemis, 1993), and the artwork of Saul Steinberg.

[2]Sebastiano Serlio, *On Architecture*, translated by Vaughan Hart and Peter Hicks (New Haven: Yale University Press, 1996). Filarete (Antonio Averlino), *Trattato di Architetura* (Milano: Polifilo, 1972).

[3]Bachelard notes that the notion of mass as quantitative size is a naïve realism. He proposed a "dialectical surrationalism" that anagogically dreams "why not" rather than posits "as if". Gaston Bachelard, *The Philosophy of No: A Philosophy of the New Scientific Mind*, translated by G. Waterston (New York: Orion, 1968 [1940]) 18-32.

[4]Giorgio Vasari, *Vasari on Technique*, translated by Louisa Maclehouse (New York: Dover, 1960 [1907]).

[5]Denis Hollier, *Against Architecture, The Writings of Georges Bataille* (MIT Press, 1989) 45.

[6]Bachelard's own work was devoted to studying literary images of material. Gaston Bachelard, *Earth and Reveries of Volition: An Essay on the Imagination of Forces*, translated by Liliana Zancu (Kent State University, 1975) 86.

[7]Gaston Bachelard, *Air and Dreams: An Essay on the Imagination of Movement* (Dallas Institute, 1988) 27.

[8]Gaston Bachelard, *The Right to Dream* (Dallas Institute, 1988) 26.

[9]Henry Peacham, *The Art of Drawing with the Pen* (New York: Da Capo, 1970 [1606]) 10. John Harbeson, *The Study of Architectural Design* (New York: Pencil Points Press, 1927) 161.

[10]Richard Piner, et. al., "Dip-Pen Nanolithography" *Science* 283 (January 29, 1999) 661-3. "Drawing with a Fine Line" *Washington Post*, February 8, 1999, A9.

[11]On the history of pencils, see: Henry Petroski, *The Pencil: A History of Design and Circumstance* (New York: Knopf, 1997). James Ayers, *The Artist's Craft: A History of Tools, Techniques and Materials* (Oxford: Phaidon, 1985) 54-71.

[12]"Wad," another name for black lead, was perhaps the reason for inexpensive architectural tracing paper being called bumwad. Lead pencils were also known as *crayons d'Angleterre*.

[13]Konrad Gesner, *De Rerum Fossilium Lapidum et Gemmarum Maxime* (Zurich, 1565). Giovanni Lomazzo *A Tracte Containing the Artes of Curious Paintinge Carving and Buildinge*, translated by Richard Haydocke (England, 1970).

[14]R. T. Gunther, *The Architecture of Sir Roger Pratt* (Oxford, 1928) 20.

[15]Carmen Bambach, *Drawing and Painting in the Italian Renaissance Workshop, Theory and Practice, 1300-1600* (Cambridge: Cambridge University Press, 1999) 80.

[16]Giorgio Vasari, *Vasari on Technique*, translated by Louis Maclehouse (New York: 1960 [1568]) 213. Cennino d'Andrea *Cennini, The Craftsman's Handbook: The Italian Il Libro dell'arte*, translated by Daniel Thompson (New York: Dover 1960 [1933]).

[17]Henry Peacham, *The Art of Drawing with the Pen* (New York: Da Capo, 1970 [1606]) 10.

[18]Joyce Whalley, *Writing Implements and Accessories, from the Roman Stylus to the Typewriter* (Detroit: Gale, 1975).

[19]James Watrous, *The Craft of Old Master Drawings* (Madison: University of Wisconsin Press, 1957) 92.

[20]Gaston Bachelard, "Hand vs. Matter" in *The Right to Dream* (Dallas Institute, 1988).

[21]Henry David Thoreau, *Journal*, edited by John Roderick (Princeton University Press, 1981).

[22]Gaston Bachelard, *Earth and Reveries of Volition: An Essay on the Imagination of Forces*, translated by Liliana Zancu (Kent State University, 1975) 106.

[23]Louis Kahn, "Not for the Fainthearted (1971)" in *Louis Kahn, Writings, Lectures, Interviews*, edited by Alessandra Latour (New York: Rizzoli, 1991) 258.

[24]The author was discussing Sullivan's Bayard Building. Susan Tunick, *Terra-Cotta Skyline, New York's Architectural Ornament* (Princeton: Princeton Architectural Press, 1997) 29.

[25]Narciso Menocal, "The Iconography of Architecture: Sullivan's View" in Robert Twombly and Narciso Menocal, *Louis Sullivan, The Poetry of Architecture* (New York: Norton, 2000) 73-160, 157.

[26]Fritz Neumeyer, *The Artless Word: Mies van der Rohe on the Building Art*, translated by Mark Jarzombek (Cambridge: MIT Press, 1991).

[27]C. M. Price, "A Study in Scholastic Architecture" *Architectural Record* 35 (January 1914) 20, quoted in Susan Ryan, "The Architecture of James Gamble Rogers at Yale University" *Perspecta, the Yale Architectural Journal* 18 (1982) 25-42, 27.

[28]Kathryn Henderson, *On Line and On Paper* (Cambridge: MIT Press, 1999). Eugene Ferguson, *Engineering and the Mind's Eye* (Cambridge: MIT Press, 1992).

[29]George Berkeley, *Essay Towards a New Theory of Vision* (1709). This interpretation follows Margaret Atherton, *Berkeley's Revolution in Vision* (Ithaca: Cornell University Press, 1990).

[30]Ernst Cassirer, *The Philosophy of the Enlightenment* (New York) 110.

[31]Gilles Deleuze and Felix Guattari, "Balance Sheet: Program for Desiring-Machines" in *Semiotext(e)* 2.3 (1977) 117-135.

[32]Carmen Bambach, *Drawing and Painting in the Italian Renaissance Workshop, Theory and Practice, 1300-1600* (Cambridge: Cambridge University Press, 1999) 51.