The Project of Architecture and the Tools of its Construction: The Shifts and Delays in the History of Drawing Media and Equipment

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INTRODUCTION

Until recently it went without saying that full fledged architects possessed the superior mastery of the trade's tools. When dealing with charrette projects, in times of economic distress, or just trying to boost the office's moral, white headed men and women rolled-up the sleeves of their dress shirts to push pencils, ink the drawings, and to put final strokes of brush on presentation boards. Today, most leaders of our profession admit – some with bravado some with bitterness – that in terms of architectural representation they depend on the lower echelon of their offices.

Since the 1990's, architectural tools and technique have come and gone with such lightning speed that few professionals and historians find it fashionable to ponder the longevity of our craft. And yet, it is worth reminding that remarkably few changes occurred to architects' drafting equipment between the beginning of the 19th century and the 1990's. In fact, several of these tools could be traced much further back in history. Accordingly, among the few drafting instruments' manufacturers who survived the computer revolution there are some who produce today the exact same tools they patented in the middle of the nineteenth century — an endurance that almost no other profession could report about their tools.[1]

The interest in instruments of the past transcends the nostalgia of the old guard and the fond gaze of antiquarians. These are the tools with which many principles of the professional practice of architecture were built. Numerous features that distinguish contemporary architectural professionalism from pre-modern and early-modern practices were formulated by the end of the 19th century. The triumph of the International style never challenged this essentially Beaux-Arts model. Nor has the computer revolution proposed any strong alternative. Up until now BIM or full size fabrications have not changed the essence of the information flow between clients, architects, their consultants and builders.

The history of drafting equipment can teach the users of the computer an important lesson: The same tool can be used in the variety of ways. As stated by French philosopher Gilles Deleuze, "society is defined by its amalgamations, not by its tools. Tools exist only in relation to the intermingling they make possible, or that make them possible."[2] The present paper's conclusion also draws from Maurice Merleau-Ponty's concept of *symbolic conduct* and Paul Ricoeur's notion of *symbolic action*. Seen in the context of these philosophers' argument the history of architects' tools suggests a more meaningful approach to the toolbox at our disposal today.

THE PROJECT OF ARCHITECTURE

A leading French historian of architectural practice Jean-Pierre Épron argues that the contemporary concept of the architectural project emerged in France in the course of the first half of the 19th century. According to him, until this time period architects had been concerned with just "the portrait of a building."[3] This transformation was accompanied by a radical change in architectural graphics.

The new approach to architectural drawings consisted of the following characteristics:

1. Drawings prepared by architects cover all aspects of the building construction.
2. Drawings are developed – and presented – starting with those covering the general information over the entire building following with those that show smaller sections and details thereof. A system of cross-references ties together individual drawings.
3. The drawings describe the shape of the building and its parts, the quantity and dimensions of its elements, and the relation of details to the whole. Written texts, such as specifications and many of the written notations on drawings, are reserved for description of physical composition of construction materials and products, their brands, requirements of their performance, and compliance to various regulations.

The last point needs special exploration. The roles we assign today to visual and textual explanations are easy to take for granted. These roles are routinely described in professional literature and textbooks for architectural students.[4] And yet as late as in the second half of the 18th century architects considered written texts to be more reliable means of communicating their designs to builders. Architectural drawings were accompanied by textual descriptions conveying information such as overall building dimensions and the sizes of individual elements.[5] In America, the contemporary conventions were instituted only in the late 19th and the early 20th centuries. Mario Carpo convincingly argues that the invention of the printed book at the end of the 15th century forever changed the way texts and graphics have been used in architectural discourse and practice.[6] However, it took three more centuries before architects entrusted builders with the capacity to understand their drawings.

To be sure, occasional drawings issued for the purpose of communicating technical information to builders were produced during much earlier periods.[7] There is little evidence, however, that such drawings were developed in any systematic way. Conversely, quite a few documents show that architects did drawings for their own purposes, while communicating with builders and craftsmen through written specifications.[8]

Contrary to what we consider a simple matter of common sense, written texts – not drawings – were originally used to convey information about size, shape, and quantity. Late Medieval specifications – the first known examples of construction documentation in Western Europe – contain precisely this type of information.[9] The first Renaissance architects also had to rely on specifications for the same purposes, in spite of their argument in favor of drawing. This approach did not change in the late seventeenth and eighteenth centuries – even as the principles of contemporary descriptive geometry were formulated during the same time period.

As late as in the beginning of the nineteenth century, French architect, theorist, and educator Jean Batiste Rondelet expressed the same concept with exceptional clarity:

> A detailed description of a project to be built is called specifications. Such specifications serve to explain its form, the dimension of each of its elements, the manner of their execution. … The contractors and the construction workers are usually dealt with by the means of specifications. … The specifications is an instruction which will be followed by contractors and workers. … Therefore, prior to drafting its conditions, it is necessary to determine, by the means of scale drawings and details, the volumes and dimensions of the project.[10]

As important as they were, drawings to Rondelet still remained an intermediate phase—not self-sufficient to establish mutual understanding between the builder and architect. Besides, the example that he provided at the end of his treatise demonstrates what he considered as drawings that could determine all "the volumes and dimensions of the project." Small scale floor plans, elevations and sections show the limits of what Rondelet considered to be adequate graphic material to accompany a 46-page-long model specification. These specifications called overall building dimensions, the sizes of main elements, the thicknesses of the walls and other information that today we would expect to find in drawings.[11]

The absence of surviving artifacts does not necessarily mean that no working drawings were produced during earlier periods. However, architects certainly did not make much effort to conserve them. The situation changed in the second half of the 19th century. Architects started making considerable efforts to collect and carefully file such drawings, bragging about their volume and graphic excellence. Charles Garnier produced a record number of working drawings for his project of the Paris Opera between 1858 and 1870.[12] He never

used blueprint, which had been discovered 20 years earlier. However, many of his drawings survived without ever being reproduced. Similarly, American architect John Upjohn significantly changed his attitude towards working drawings in the middle of his career. According to historian Judith Hull, in the 1830's and 40's Upjohn showed little interest in keeping any record of his production process.[13] In the late 1850's and 1860's his working drawings became uniform and were produced on rather large pieces of paper. During this period Upjohn also became concerned with saving these drawings and filing them in standard folders.

No single factor can explain this phenomenon. As I have argued elsewhere, the spread of graphic literacy; the transformation of the legal environment; the novel building technology can offer important yet only partial clues to understanding both the magnitude and complexity of the transition from texts to graphics.[14] A series of vignettes on the history of drawing equipment – but most importantly, a cultural analysis of the use of this equipment – may give some additional insights.

VIGNETTES FROM THE HISTORY OF DRAWING EQUIPMENT

Paper

The invention of the paper machine at the turn of the 19th century was, perhaps, the most important factor that made the transition from words to graphics possible.[15] Paper was introduced in Europe as early as the 11th century, when it was brought there from China by Arabs via Spain. However, until the end of the 15th century it was seldom used. Thus, with some notable exceptions, most medieval drawings and many specifications and contracts were done on parchment.[16] The introduction of the printing press in the middle of the fifteenth century produced a demand for an unprecedented amount of mediums for book making. With this development, paper replaced parchment as the medium for drawing and writing. Such early sixteenth century inventions as mapmaking, newspaper printing, and etching further increased the demand for paper.[17]

By the end of the seventeenth century, France became the main source of paper making in Europe.[18] By this time paper had become relatively inexpensive when purchased in small sizes. Paper provided an excellent medium for sketching, jotting, private correspondence and recordkeeping. However, until the beginning of the nineteenth century, larger-size paper was not a thrift material. According to historian Dart Hunter, the largest paper ever produced by hand was *Emperor,* 48 by 72 inch.[19] Up to the end of the eighteenth century, however, it was extremely expensive and almost never used. So was *Grand Eagle* (28 ¾ inch by 42 inches). The size of *Colombier* (23 ½ inch by 34 ½ inch) was more commonly used for drafting, although it was also quite expensive and reserved only for special occasions. One can judge how expensive it was by the fact that up until 1818 the English law mandated the conservation of paper.[20] Using sizes exceeding 22 inches by 32 inches for newspaper printing was a criminal offense. For mundane purposes—such as study drawing, working drawings, or drawings of record—the most suitable size was called *Demi* (15 ½ by 20 inches). Eighteenth century French Royal Architects such as Robert de Cotte or Jacques-Germain Sufflot rarely used drawings exceeding this size. Correspondence paper was *Billet Note,* 6 inches by 8 inches.

A machine patented by French engineer N.L. Robert in 1798, which could produce paper of "unbelievable size"—of 24 inches in width and up to 12 meters in length—was the first step toward making cheaper paper readily available.[21] Yet, after this invention and its first implementation in 1804, it took at least two decades before the mechanical production of paper started replacing hand-made paper. When it did, the drop in the price of paper was quite radical.

Clearly, if paper was expensive and available only in small sizes, simple economics mandated describing building elements in writing rather than showing them in graphics. A written description of an architectural element would take less space than its graphic representation. Small sizes of paper also dictated rather small scales of floor plans, elevations, and cross sections. The use of these scales made it difficult to attach dimension strings to plans and sections. It was only practical to convey this information in the form of written text.

However, contrary to what one might have suspected, the reduction in the price of paper and its growing availability did not immediately influence architectural practices. Architectural treatises that appeared in the 1820s through the 1840s do not

indicate any radical change in attitude toward architectural technical drafting.[22] Even the second edition of R.G. Hatfield's book, which was published in 1852 and opened up with an ambitious promise to provide its readers with a complete knowledge of architecture, together with "the Most Important Principles of Practical Geometry," recommended a drafting board no larger than 15 inches by 20 inches.[23] Twenty years later a textbook that pursued a less overreaching goal of "teaching a very elementary course of descriptive geometry" for introductory level drafters already recommended boards at least 20 inches by 28 inches.[24] It took another thirty years before architectural drafters became preoccupied with the dilemma of finding a method to draw and contemplate a full scale drawing of decorative elements which were much larger than the ceiling height of any architect's office (Fig. 1).[25]

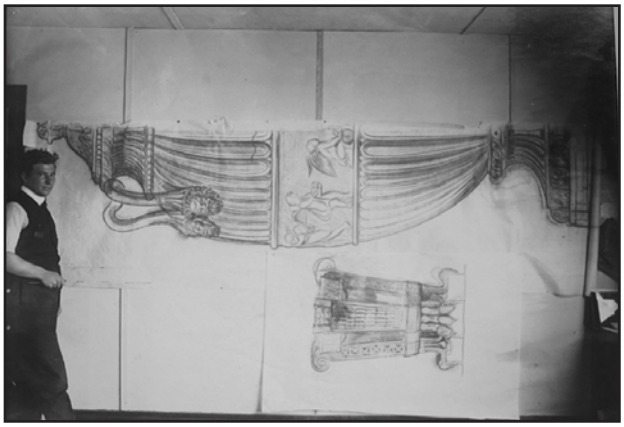

Figure 1: William Merchant, associate of Bernard Maybeck's, shown in this photograph *c.*1913 as a young draftsman with a full size drawing for the project of the Palace of Fine Arts. Environmental Design Archives, UC Berkeley

Tracing Paper and Graphic Reproduction Equipment

The history of tracing paper shows an even greater gap between the discovery and its implementation. This medium was used in Europe as early as the 17th century. By the turn of the 19th century it was widely used in architectural education.[26] However, architects discovered its possibilities for the purpose of duplicate drawings only in the 1860's.[27] Even then American architects continued using the antiquated method of "pricking"—puncturing holes through key points of the original drawing in order to create guides for a copy on a piece of paper underneath (Fig 2).[28] One can conclude that tracing was rarely used because the very need for copying architectural drawings was not yet there.

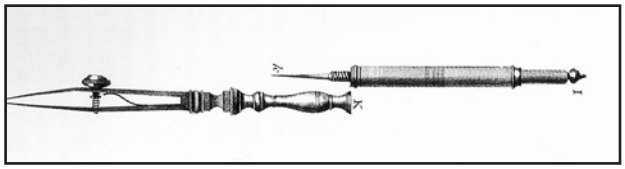

Figure 2: English ruling pen with a pricker. Early 19th century. Maya Hambly, *Drawing Instruments, 1580 – 1980*. London: Sotheby's Publications, 1988.

The history of graphic-reproduction equipment supports the above hypothesis. The blueprinting process was discovered by Sir John Hershel in 1842 and described in a paper published during the same year in "Philosophical Transactions of the Royal Society."[29] However, it was not until 1878 that it was first mentioned in America and not until 1883 that supplies for its implementation were first advertised.[30]

As it was mentioned, this lapse prompts a question regarding a widely held assumption that the paucity of surviving examples of earlier working drawings resulted from the absence of effective techniques of graphic reproduction.[31] According to this assumption, the survival of drawings from later periods, such as the second half of the nineteenth century, was due to the possibility of producing multiple copies. Some of them disappeared in the process of construction, while others survived. The same argument suggests that during the periods preceding the invention of the blueprint technology copying a complete set of drawings was too time consuming and expensive and therefore the single copy was left to gradually deteriorate on the construction site.

This proposition, no doubt, must have been true in many cases. However, in the cases of Garnier and Upjohn it cannot be applied.[32] Both architects developed interest in saving their working drawings around the middle of the 19th century, right after the invention of the blueprint technique, yet before it was implemented in architectural practices. Moreover, certain methods of mechanically copying drawings existed well before the invention of the blueprint, and these techniques were often used during the construction of notable projects. Thus, during the construction of the Church of Sainte Geneviève in the second half

of the eighteenth century, several technical drawings were engraved and duplicated in relatively large quantities. However, rather than communicating the architect's ideas to builders, these copies were used to record the progress of construction.

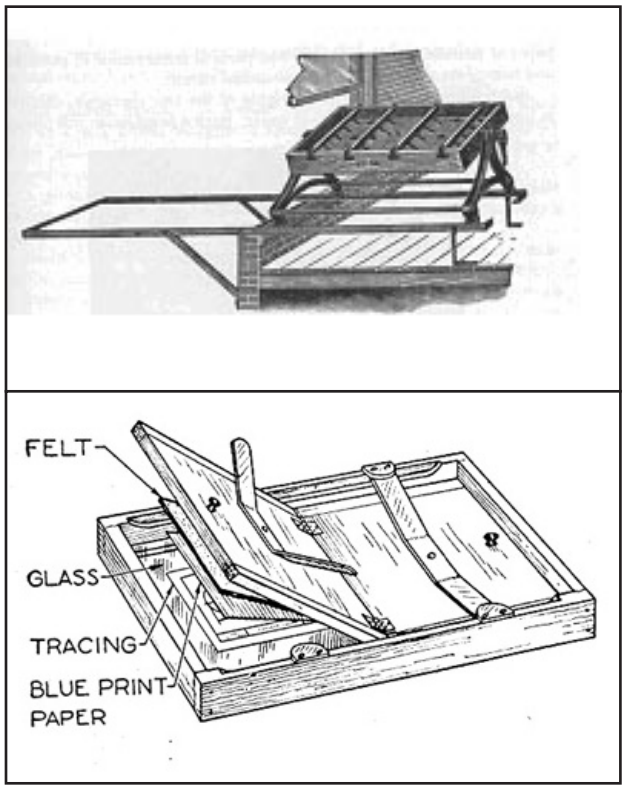

Figure 3: Two drawings showing the construction of the sun frame blueprint device and its use. Frederick E. Giesecke, Alva Mitchell and Henry Cecil Spencer, *Technical drawing*, New York: The Macmillan company, 1940

It should be stated that in the beginning blueprinting was rather cumbersome. The original drawing and a piece of photosensitive paper had to be exposed to the sun for a considerable amount of time and then individually developed in a tub of water with chemicals.[33] Blueprint machines were therefore installed on the upper floors of buildings with skylights—which explains why several big architectural offices in the 1890s occupied upper floors—with pivots and tilts to follow the sun throughout the day (see Fig. 3).

The process became much more efficient when, in 1898, Makepeace blueprint company in Boston patented a machine equipped with carbon arch illumination.[34] This innovation reduced the time required for production of one print to 25 minutes—a great improvement over the older method. As important as it was, however, this invention did not change the use of working drawings. Big American architectural companies started using blueprints a decade before Makepeace's invention. On the other hand, blueprint production utilizing sunlight remained in use as late as in the 1950's.

A true demand for the blueprints developed in the late 1880s. However, it did not directly reflect the evolution of drawing practices nor the changes in construction technology. The demand was generated by the construction trades, and it witnessed the social struggle between architects and builders. An editorial in *Inland Architect* reported that during the debates leading to the adoption of the Uniform Contract, representatives of various building trades voiced their concern about architects using unfair tactics when assisting owners in negotiations of contracts with builders. One such tactic consisted of architects giving the prospective bidders drawings on paper or linen, which, after a contract had been executed, were altered to the owner's advantage.[35] The concerned party hoped that issuing bid documents on several blueprint copies would eliminate the possibility of such alterations. In short, a jump in the use of blue-print technology had taken place a decade prior to its considerable improvement. It happened only when social relations with builders demanded its implementation.

Ruling Pens and Pencils

Medieval drawings on parchment were produced with sharp scoring devices that would leave a groove, later filled with dry pigment.[36] The same divider with a scoring point or a sharp chisel-like instrument that was used by a master builder to mark stone or wood before cutting it, was also used to produce medieval and early-Renaissance drawings. Drawing was then literally nothing more than an initial stage of hewing a piece of hard building material.

At first, the same kinds of instruments were used to draw on paper. As late as in the second half of the sixteenth century, Andrea Palladio resorted to the technique of scoring groves and filling them with pigment.[37] Later in his career he switched to ruling pens and ink. By this time, ruling pens used for architectural drafting and mapmaking already

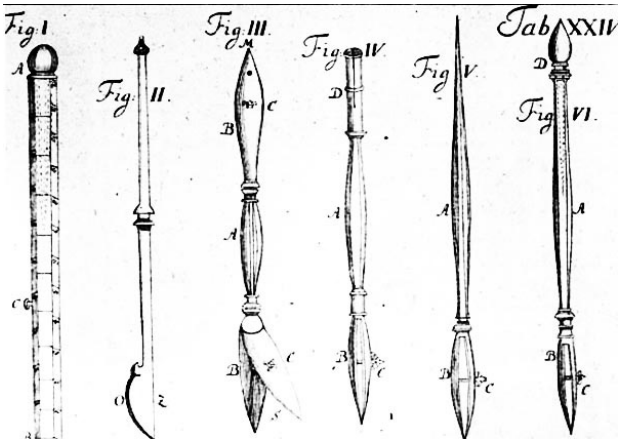

Figure 4: Plate XXIV from Jacob Leopold's *Theatrum arithmetico-geometricum* (1724), showing old-styled folded blade pens, and new, double bladed pens with thumb screws to adjust the line's weight

had a double blade with an ink hold in the middle. They were still rather crude and without any device to control the weight of the line (Fig. 4).

Such a device became a standard feature by the middle of the seventeenth century (Figs. 2 and 4). This construction has remained virtually unchanged.

The new type of ruling pens led to the increase in the import of India ink. It became, by the middle of the seventeenth century, the ink of choice for the majority of European architectural drafters. It was brighter and absorbed less into the fabric of paper than the iron-gall ink that had been used before that. After drying, India ink was also less washable with water. This quality also allowed its less concentrated solution to be used for ink washes, which, by the middle of the eighteenth century, became the medium for *chiaroscuro*—the method of representing light and shadow in architecture.[38]

It was also between the end of the seventeenth and the beginning of the nineteenth centuries that contemporary graphite pencils were added to the architect's arsenal.[39] A particular type of graphite lead that was found especially useful for the purpose of sketching and study drawing was discovered in the middle of the sixteenth century in Cumberland, England. In 1761, a firm founded by Kasper Faber made pencils with graphite rods, encased in wood jacket, and soon after it became the firm's specialty.

The next innovation occurred in 1795, when French chemist N.J. Conte invented a process to produce leads of various degrees of hardness. By the end of the first quarter of the nineteenth century, pencils classified as "2H for engineers, H for architects, and B for shading" became industry standard.[40] By the beginning of the 19th century the suppliers of products for artists and drafts persons also started selling erasing gums. However, it took another 50 to 60 years until architects developed a concept that different types of pencil were to be used during different phases of the design and production process.

Compass Boxes

By the eighteenth century ruling pens were assembled in sets of drawing instruments that also in-

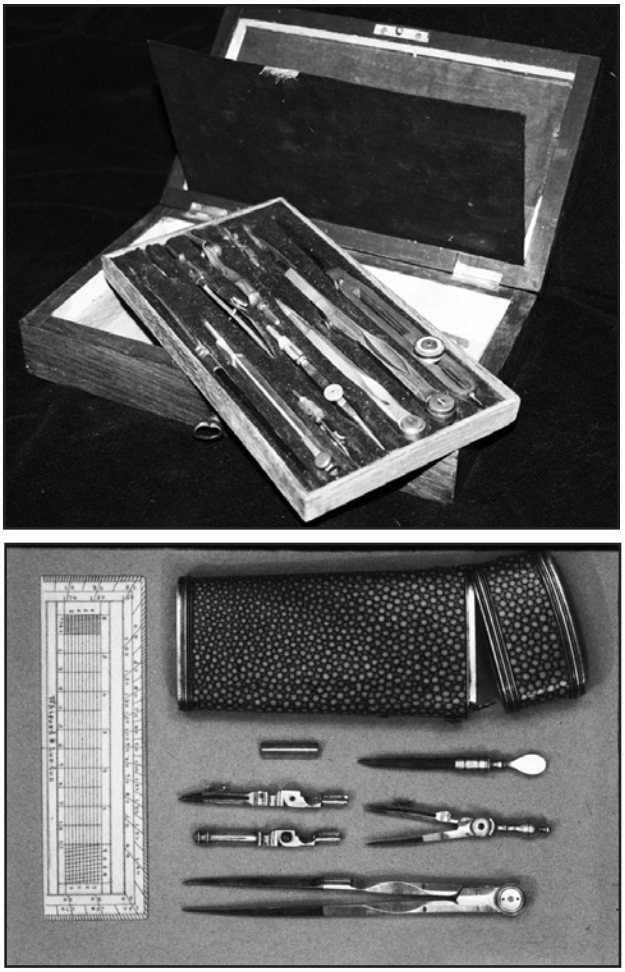

Figure 5: Top: A typical mid-nineteenth century French compass box. Photograph by author. Bottom: A typical eighteenth century compass box. Hambly, 1988.

cluded compasses and dividers. Compasses—hand compasses, hair compasses, beam compasses, and bar compasses—experienced minimal change between this time and the early 20th century. Compass boxes, however, did change, and the change in their shape reveals a lot about the different attitude of their users. The cylinder-shaped boxes, typical of the eighteenth century, were to be carried around in the pockets of their owners. The flat boxes of the nineteenth century were designed to sit in the drawers of architects' drafting tables (Fig 5).

Eighteenth-century instrument boxes were designed to be taken to the salons of architects' patrons. They were also brought to the construction site to make some *ad hoc* corrections, check the performance of builders, and calculate the quantities of materials. Interestingly, the texts of eighteenth century treatises on drawing instruments—or, as they were often called in the eighteenth century, mathematical or scientific instruments—leave no doubt that this usage was considered among the main purposes of instruments such as compasses, dividers, and King's legs rulers.[41] Their usefulness is usually described in terms of calculating physical quantities, such as pints of ale or bushels of wheat. By the late nineteenth century, however, while using the same pieces of equipment architects started seeing very different uses in them. Their main purpose then became the production of a complex system of symbols constituting a more complex, more rhetorical form of communication. And while this shift was not unrelated to the evolution of graphic equipment, their correlation was never direct.

The late 19th century approach to drawing media and equipment indicated the architect's almost complete self-removal from the construction site. Paradoxically, it also gave them a sense of full participation in the physical making of the building.

SYMBOLIC CONDUCT AND SYMBOLIC ACTION

The availability of new drawing mediums and equipment made it possible to approach working drawings in a different way. However, the novelty of this approach cannot be described in terms of pure instrumentality of construction documentation. New economic conditions and new architectural theory conditioned a major shift in architects' self-perception. The Albertian definition of the architect as opposed to the builder – with the builder being depicted in purely negative terms – no longer applied. In the late 19th century architects wanted to be perceived as belonging to the class of producers. They also pushed the model of architectural professionalism by comparing their position to that of the medieval master-builder – the first among many other craftsmen.

The new self-perception of late 19th century architects can be best understood in the context of ideology critique as developed by French philosopher Paul Ricoeur.[42] Ricoeur argues that ideology operates on three levels. Ideology works to obfuscate the reality of economic and social inequality, but it has more benign functions as well. It provides people with the sense of belonging to a tradition. It also consists of infinite number of symbolic actions, which give to agents the sense of purpose in their life and engages them into a pursuit of excellence.

Along with their instrumental role – and along with their social role of masking the different social status of architects and builders – architectural drawings and the tools of their production also played a role of a symbolic action.

In the case of working drawings symbolic action became possible because of what Maurice Merleau-Ponty describes as a symbolic conduct. In his early essay *The Structure of Behavior*, the French philosopher argues that the major difference between the humans and the apes is in our ability "to trace by our very gesture the symbol of the movement which we would have to make if we were in its place."[43] Many turn-of-the-twentieth century architects literally stated in their articles, dedicated to the subject of working drawings – and there were quite a few of those published in the 1900's and the 1910's -- that in order to produce a good drawing the draftsperson needs to be able to mentally touch the material detail.

Architect R. C. Chapman argued, in a series of articles in *Architecture* magazine, that working drawings had potential to turn the architect into a craftsman

> "In making such a drawing the designer should be mentally, if not actually, the craftsman also; the conditions and necessities of the material ever present to his mind … ."[44]

Well known early 20th century architect Cass Gilbert made similar statements.[45] He described the art of architectural draftsmanship as mediation between the sight and the touch and gave the following advice to an aspiring architect:

> Sketch mouldings and shapes of things by handling them as well as by looking at them, so that by feeling the contours of the moulding with the fingers you can determine the shape as well as by looking at it.

In short, along with their instrumental purpose the transformation of turn-of-the-20th century architectural drawings that the tools made this transformation possible reveal themselves as a symbolic action of "blur[ing] the opposition between draftsmanship and craftsmanship, between constructing and construing, between visual and tangible."[46]

CONCLUSION

To recapitulate, the stories of paper, blueprint, compass boxes, and other tools of the architect's craft show that drawing equipment never followed a direct trajectory. The present research challenges theorist's Henry Petrovski's thesis that the process of one-directional "incremental improvement [which is made as soon as it is] possible without being too expensive, too demanding of existing technology or too time-consuming to achieve."[47] It argues instead, with Deleuze, that "machines are social before being technical."[48]

We tend to think of our tools as purely instrumental devices. We understand that different tasks require different tools. However, we often fail to see that, along with considerations of a rational nature, this correspondence of tools to tasks is determined by our culture and our professional ideology. This failure to understand the cultural dimension limits our ability to see alternatives to the prose of our everyday practices. It also prevents us from seeing that the same tool could be used in a variety of ways, both recognizing the limits of our modes of production and pushing these limits yet even further. Perhaps a study of the tools of the past can help to see the possibility of the more creative approach to the tools we have now.

ENDNOTES

1. German firm Riefler is an example of such longevity. See Maya Hambly, *Drawing Instruments, 1580 – 1980*. London: Sotheby's Publications, 1988.
2. Gilles Deleuze and Felix Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia*, translation and foreword by Brian Massomi (Minneapolis and London: University of Minnesota Press, 1987: 90)
3. See Jean-Pierre Épron, *Comprendre l'éclectisme.* Norma Editions, Paris, 1997
4. See Susan Greenwald, "The Construction Documents," in *The Architect's Handbook of Professional Practice*, v. 2, edited by David Havilland, Hon AIA, The AIA Press (1994) "Drawings: The construction drawings show in graphic and quantitative forms the extent, configuration, location, relationships, and dimensions of the work to be done" (p. 708). "Specifications: The specifications present written requirements for the materials, equipment, and construction systems as well as standards for products, workmanship, and the construction services to produce the work" (p. 714). These or similar definitions could be found in a great number of contemporary manuals of professional practice, architectural dictionaries and encyclopedia, and professional press.
5. See my doctoral dissertation, *Drawing Practices: The Art and the Craft of Architectural Representation,* UCLA, 2005. Also see my earlier paper presented at ACSA National Annual Meeting 2000, *19th Century Working Drawings: An Art, A Craft, An Ideology*
6. See Mario Carpo, *Architecture in the Age of Printing: Orality, Writing, Typography, and Printed Images in the History of Architectural Theory,* translated by Sarah Benson, Cambridge, Massachusetts and London, England: The MIT Press, 2001.
7. Catherine Wilkinson, for example, argues in her "Building from Drawings at the Escorial" (in *Les Chantiers de la Renaissance.* Apres des Colloques tenus a Tours en 1983-1984, De Architectura, Picard, Paris 1991) that the drawings produced by Juan de Herrera, the chief architect of the Monastery of Escorial could be compared to contemporary working drawings.
8. See my dissertation for a number of examples of written instructions produced by architects from the 16th to the beginning of the 18th century which contained information that now belongs to drawings.
9. See Salzman, L. F. (Louis Francis), *Building in England Down to 1540: A Documentary History.* (Oxford, England: University Press, 1967) for a list of Medieval building specifications from the early 14th until the middle of the 16th centuries.
10. Translated by the author. The original text reads as follows : On appelle devis, une description détaillée d'un projet que l'on se pose d'exécuter. Dans ce devis, on explique la forme et les dimensions de chacune de ces parties, et la manière dont elles doivent être exécutées. . . . Comme c'est d'après les devis qu'on a coutume de traiter avec les intrepreneures et les ouvriers pour l'exécution des ouvrages qui y sont détaillé, on ne serait prendre trop de précaution pour les rédiger de la manière à ne rien oublier. . . . Un devis bien fait est une instruction à laquelle les interpreneures et les ouvriers doivent se conformer dans l'exécution des travaux qui leur sont confié. Ce pourquoi il faut, avant de le rédiger, avoir arrêté, par les dessins et des détails exacts, la forme et les dimensions de toutes les parties de l'ouvrage qu'il s'agit d'exécuter" (Rondelet, Jean Baptist *Traite Theorique et Pratique de l'Art de Batir*.

Paris, chez l'Auteur, Place de Pantheon, de l'Impremerie de Fain, place de l'Odeon, 1830, v.8: 572).
Rondelet was French turn-of-the-19th century architect whose expertise in construction technology was much respected by his contemporaries. He taught the course of architecture in the *Ecole Polythechnique* and was the founder of the course of construction in the *Ecole des Beaux-Arts* (Epron, 1997). *Traité théorique*, his *magnum opus,* was written as he was developing the course. The treatise contains traces of several periods of the French architectural practice. Rondelet, who collaborated with J. G. Sufflot and then succeeded him as the architect of the Church of Sainte-Genevieve (now the Pantheon), 1757-92, displays several aspects of second half of the eighteenth century's practitioner's attitude. However, some other passages from his treatise show that the practice of architecture in France was going through a series of changes.
11. It should be stated, however, that in the case of this specification Rondelet introduced one major innovation. Thus Épron emphasizes the importance of the fact that Rondelet's model specifications were organized according to the trades (i.e., as specifications are done now)
12. According to Garnier's letter to the Minister of Fine Arts and of the Imperial House written in January 1867—i.e., four years after the start of the project—the number of drawings made on paper size "Grand Eagle" whose number approximated 30,000 (*Marché des travaux pendant l'année 1866. Rapport à S. E. Monsieur le Marechale de France, Ministre de la Maison de l'Impereur et des Beaux-Arts, Paris, le 28 Janvier 1867.* Fond Garnier, La Bibliotheque Nationale de France). This number must have been unprecedented because Garnier felt compelled to provide a physical illustration. He boasted, in the same letter, that the combined length of these drawings made 330 kms.—i.e., enough to cover the way from Paris to Versailles and back. It appears that this number and the level of draftsmanship surpassed anything that was done in other European countries. According to historian Alfred Halse (*A History of the Development of Architectural Drafting Techniques.* Ph.D. Thesis, New York University, 1952: 338), the President of RIBA visited Garnier's office in 1864, was given a tour of the construction site, and received as a gift 167 of Garnier's original working drawings (Halse, 1952: 338). Upon his return to England he organized the exhibition of the drawings, and presented a paper that discussed Garnier's methods as exceptional and as by far exceeding anything that had been done in England.
13. See Judith S. Hull, "The 'School of Upjohn': Richard Upjohn's Office." *Journal of the Society of Architectural Historians*, 52 (1993, September): 281-306
14. See my dissertation especially Chapter 3.
15. For the history of papermaking see Dard, Hunter, *Papermaking, The History and Technique of an Ancient Craft*. New York: Alfred A. Knopf, 1943 (1978).
16. An example of a document that was done on a piece of paper is the famous Sansedoni contract. For an excellent analysis of this document see Franklin Toker, "Gothic Architecture by Remote Control: An Illustrated building contract of 1340," in *The Art Bulletin,* vol. 67, No.1 (March 1985): 67-95.
17. A number of historians connect such developments as paper making and printing as art production with the rise of maritime activities, public's growing interest in the information over military actions, and the reforms of ownership of land. See Martha Pollak, *Military Architecture, Cartography and Representation of the Early Modern European City*. The MIT Press, 1994; Marijke de Vrij. *The World on Paper*. *A Descriptive Catalogue of Cartographical Material Published in Amsterdam During the Seventeenth Century,* Amsterdam: Theatrum Orbis Terrarum, 1967; David Woodward et al. *Art and Cartography: Six Historical Essays.* Chicago: University of Chicago Press, 1987.
18. Today French cold-press hand made paper remains the best medium for watercolor and ink wash, and it its fabrication has not changed (Hunt, 1978)
19. Hunter (1978: 136-7)
20. Hunter (1978: 341)
21. See Hunter (1978: 341-73)
22. The first American paper machine had started operating in 1817, and by the end of the 1820s domestically produced and imported paper became available in the United States. It took several decades before American architects started deriving benefits from the new media do not. See Benjamin Asher, Owen Biddle, *The Young Carpenter Assistant; Or, A System of Architecture, Adapted to the Style of Building in the United States* (Philadelphia, 1805); John Haviland, *The Builder's Assistant: Containing the Five Orders of Architecture, Selected from the Best Specimens of the Greek and Roman ...* (Philadelphia : John Bioren, 1818-1821); R.G. Hatfield, *The American House Carpenter: A Treatise upon Architecture, Cornices and Mouldings, Framing, Doors, Windows, and Stairs. Together with the most important principles of the Practical Geometry*, (New York: John Willey and Sons, 1844)
23. See Hatfield (1852: 2)
24. See Warren, Samuel Edward. *A Manual of Elementary Geometrical Drawing, Involving Three Dimensions: Designed for Use in High Schools, Academies, Engineering Schools, etc., and for Self-Instruction of Inventors, Artizans, etc. In Five Divisions.* New York: John Wiley, (1870: iii, 4)
25. See Edgerton Swartwout, "Working Drawings, Full Size Details," in *Pencil Points* v, V, N. 12 (December, 1924): 46. Swartwout's article, it should be stated, argues that full size details of are not always necessary. However, even as he makes his argument, he tells that his own office—and those of his colleagues—were searching for ways to show large architectural elements in full size. In his office draftsmen moved together up to three large drafting tables to draw a column's shaft in full size, to study its entasis.
26. See M.-A. Doizy and P. Fulacher, *Papiers et Moulins, des origins a nos jours* (Editions Technorama, Argenton-sur-Creuse, 1989: 117). Many sketches included in *Envois* from Rome –including Felix Duban's produced in the mid 1820's --were done on tracing paper (Archives of the Ecole des Beaux-Arts, Paris). And yet very few of Duban's draiwngs for the restoration of the Louvre seemed to have utilized tracing paper as a medium to reproduce working drawings (*Archives Nationales de France*)
27. Halse states that to his knowledge no drawings on tracing paper existed in America until 1862. My research supports his position. American catalogues of drafting equipment published in the first half of the nineteenth century never mention it. This includes a catalogue published by Johnson as late as in 1854. However,

Edward Warren (*A Manual of Elementary Geometrical Drawing, Involving Three Dimensions: Designed for Use in High Schools, Academies, Engineering Schools, etc., and for Self-Instruction of Inventors, Artizans, etc. In Five Divisions.* New York: John Wiley, 1861) discusses its use.
28. See Charles Brownell (*The Making of Virginia Architecture.* Richmond: Virginia Museum of Fine Arts; Charlottesville: Distributed by the University Press of Virginia, 1992:150-2)
29. *Encyclopedia of Architecture: Design, Engineering & Construction*, Joseph Wilkes editor-in-chief, Robert T. Packard, associated editor, New York: Wiley, 1990, s.v. "drawing instruments and equipment."
30. According to my research blueprint was first mentioned in *American Architect and Building News*, v. IV, 3 August 1878. To my knowledge, its first advertisement was placed in *American Architect and Building News*, v. XIII, 6 January 1883
31. Historian Robert Newman argues, for example, that working drawings of French Royal Architect Robert De Cotte were "normally discarded" after the end of construction (*Robert de Cotte and the Perfection of Architecture in Eighteenth-Century France*. Chicago : University of Chicago Press, 1994: 38)
Catherine Wilkinson makes a similar argument when she attempts to answer her own question: "Were are the working drawings that might in some way correspond the blueprints used in a modern office?" She gives two possible answers: "One answer is that they are gone, used up on the job; another that they never existed." While she does not completely reject the possibility of the second answer, she definitely leans towards the first one ("The New Professionalism in the Renaissance," in *The Architect: Chapters in the History of the Profession.* Edited by Spiro I. Kostof New York and Oxford: Oxford University Press, 1977:143)
It should be also stated that some late nineteenth century architects also contribute to the above notion. Louis Sullivan, for example, wrote in his *Autobiography of and Idea* about working drawings that he produced in abundance while he was working in his first architectural office in the 1860's. It may be that Sullivan was correct in his reminiscence, and that the office where he was starting his career was indeed producing a large number of drawings that were later lost. It should be also added, however, that quite a few other sources mentioned otherwise. See Harold Van Buren Magonigle's essay "Some Suggestions as to the Making of Working Drawings" (*Brickbuilder* 22, May 1913: 97), where he contrasted architectural practices in the 1870's with those in the early twentieth century, and such source as *Cyclopedia* (a textbook for architectural students in 10 volumes, published in 1906) indicated that the number of working drawings dramatically increased during the a few decades prior to its publication.
Garnier's letter that, which was mentioned above (see *n. 11*), indeed mentions a large number of his working drawings that eventually were discarded. However, it is also clear that his intention was to save quite a few of his working drawings and to keep the record of those that were discarded.
32. Garnier used hectograph as a method of reproducing some of his drawings. However, not too many of his drawings that survive are reproductions that used this technique. See Christopher Curtis Mead, *Charles Garnier's Paris Opera: Architectural Empathy and the Renaissance of French Classicism*, Cambridge, Mass: MIT Press, 1991.
33. See Internet publication "B.L. Makepeace Inc.: More Than a Century of Growth and Change," 2005. http://www.makepeace.com/files/History/history.htm
34. Ibid
35. According to historian Mary Woods, a number of turn-of-the-20th century leading American architects, such as Daniel Burnham, were known to be engaged in precisely this type of tactics. See Woods, Mary N. *From Craft to Profession: The Practice of Architecture in Nineteenth-Century America* (Berkeley, Los Angeles, London: University of California Press, 1999: 46)
36. See Maya Hambly, *Drawing Instruments, 1580 – 1980* (London: Sotheby's Publications, 1988: 11)
37. Ibid
38. See a web publication by Lois Alcott Price, *Line and Shadow: The Role of Ink in American Architectural Drawings Prior to 1860,* The American Institute for Conservation, The Book and Paper Group Annual, v.13, (1994)
39. See Henry Petroski, *The Pencil: A History of Design and Circumstance* (New York: Knopf, 1990) for the most complete history of the pencil and other writing and drawing instruments.
40. Hambly, 1988: 66
41. For examples of such descriptions see John Robertson, *A Treatise of such Mathematical Instruments, as are Usually put into a Portable Case: Containing their Various Uses in Arithmetic, Geometry, Trigonometry, Architecture, Surveying* (London : printed for T. Heath; J. Hodges; and J. Fuller, 1747) and Nicolas Bion, *Traité de la construction et des principaux usages des instrumens de mathematique,* (La Haye : P. Husson, 1723)
42. Ricœur, Paul. *Lectures on Ideology and Utopia*, edited by George H. Taylor, New York: Columbia University Press, 1986.
43. Maurice Merleau-Ponty, *The Structure of Behavior,* Trans. Alden L. Fisher, Duquesne: UP, 2006: 118.
44. See R. C. Chapman, "Unrealized Designs," in *Architecture*, v. 11 (January, 1905: 58)
45. Cass Gilbert was the architect of the Woolworth building and of many other major structures in turn-of-the-century New York. Historian Mary Beth Betts emphasizes the quality of Gilbert's working drawings. See Mary Beth Betts, "From Sketch to Architecture: Drawings in the Cass Gilbert Office," in *Inventing the Skyline: The Architecture of Cass Gilbert* (edited by Margaret Heilbrun, with an introduction by Hugh Hardy. New York: Columbia University Press, 2000: 65-66). Betts also writes that these drawings convey "a sense of pride in the skills that could produce such excellent work" (Betts, 2000: 67). This statement is especially significant as Betts describes a strong pressure from Gilbert's clients to reduce the cost and to increase the speed of the production of working drawings (Betts, 2000: 57-58)
46. I borrow this phrase form Marco Frascari's famous article "The Tell-the Tale Detail" (1984)
47. Petrovski, 1990: 26
48. Giles Deleuze, *Foucault,* translation by Seán Hand, London: Athlone, 1988