Line, Shade & Shadow: Researching Architectural Drawings
(With a Brief Preliminary Aside on the Joys of Conservation)

When I was asked to give this talk, I returned to the notes for a talk I gave to the Conservation students at Winterthur during one of our Wednesday afternoon Student's Choice seminars when each of our second year students hosts a speaker who is either visiting the area or within a few hours travel. I was flattered to be asked since they saw me daily, and inquired what had prompted the request. They wanted to know about my research, which I had alluded to in class and wanted to know how, and why I had begun on this decades long study and where it fit into conservation. All good questions, and I am guessing similar to some you may have though from a slightly different perspective – maybe what is a book and paper conservator doing writing about architecture?

Conservation is a small but incredibly diverse profession that is international in scope and populated by equally diverse individuals united by an intense commitment to their work. Aside from places like Winterthur it has taken me to the Hurricane Katrina ravaged shores of Mississippi and currently to help create a conservation training program in Iraq. It is called art conservation to differentiate it from environmental conservation. If you mention conservation to most people they think of Smokey the bear, soil erosion problems and wilderness areas.

The slides scrolling in the background represent some of the amazing objects are students have worked on in the last few years – from a bitumen funeral boat from Ur to C3P0 to large murals and Damascene ceilings to an Apollo space suit and George Washington's saddlebags. Art conservation actually deals with many materials and issues that are not normally thought of as art. ART calls to mind paintings, frescos, old master drawings and prints, Japanese scrolls, fine porcelain, sculpture, and tapestries. Conservators work with these materials, but they also work with human skeletal remains of indigenous peoples, natural history specimens in jars, historic adobe structures, digitization programs for brittle books, water logged wood excavated from marine archeological sites, and rock paintings by aboriginal peoples in Australia.

In short, we deal with the fabric and foundation necessary for the study of material culture – all those pieces of our collective human past not embodied by the written word. How do you put the light and texture of a Winslow Homer watercolor, the metallurgical sophistication of Chinese bronzes, the craft of Anastasia cliff dwellers or the emotional impact of the family photographs and possessions of holocaust survivors into writing? Objects often speak eloquently for people who have no other historical voice or reveal an otherwise hidden side of a culture or person. Think of the slave cabins that have survived on Southern plantations or the quilts of otherwise illiterate Depression era Appalachian women. The immediacy of the physical artifact can be a powerful tool in any effort to fully understand an event or culture.

Conservation is about insuring that these artifacts continue to speak to us as accurately and eloquently as possible. Unfortunately, all these objects deteriorate with time. Remember the principle of entropy – chemistry… The tendency of all matter to move toward increased randomness and a lower energy level.

Most cultural artifacts are highly ordered constructions – metals refined from ores, marble buildings quarried from mountains, purified cellulose fibers formed into paper, even baskets made of reeds that, had they not been harvested, would have died back and decomposed with the next seasonal change. Entropy means that metal corrodes in an effort to return to the ore, that wind and rain gradually erode the Parthenon, that paper become brittle and the basket collapses as the cellulose fibers decompose.

Conservation cannot change the principle of entropy, but we can slow it down. Sometimes we can slow it down a lot. A knowledge of the chemistry, technology and culture that formed each artifact allows us to prescribe environments, storage enclosures, research and repair techniques that can stabilize artifacts and greatly slow the process of deterioration as well as returning the artifact to something close to its original appearance. These prescriptions must always respect the integrity of the object with the goal of never adversely effecting future research or any treatment the object might need in the future. Careful documentation is essential and treatments often require varying degrees of research and creative problem solving as well as good hand skills and a thorough knowledge of the chemical and physical properties of the artifact and the repair materials.

Conservators usually specialize in one type of material, be it paintings textiles, photographs, archeological or natural history collections. My specialty is books and paper and I have been fortunate to work on some truly amazing objects in the course of my career including one of Jefferson's hand-written drafts of the Declaration of Independence and both American copies of the Treaty of Paris as well as a lot of architectural drawings. Following my graduation from Winterthur University of Delaware Program in Art Conservation (WUDPAC), I took a job at the Conservation center for Art and Historic Artifacts (CCAHA) in Philadelphia, which is where my odyssey with architectural drawing began. CCAHA is a non-profit regional center that serves cultural institutions throughout the eastern US and specializes in paper-based materials – books, art on paper, photographs and documents.

I have a long standing interest in architecture dating from a passion for building things as a kid through an undergraduate honors thesis on the social and cultural significance of nineteenth century American architecture and occasional near accidents when I become pre-occupied with interesting chimneys or gables along the road. This predilection intersected a revived interest in architectural drawings among cultural institutions in the early 1980's. The resulting exhibitions and collection activity brought increasing numbers of drawings in various stages of deterioration into the Conservation Center. And the growing interest in architectural preservation brought architects with design or as-built drawings for their projects – often in appalling condition. Architectural drawings were in

the forgotten; 'we don't know how to deal with these' parts of many of the institutions that asked us to do collection surveys. They were rolled and stuck in acidic cardboard tubes, or barrels or the backs of closets. In one historical society, an enterprising staff member or volunteer had arranged them in accordion folds and hung them from hangers; another institution had stored them inside a Conestoga wagon they had on display in an outbuilding. I was enraptured with them from both an aesthetic and historic perspective and I didn't have to risk driving off the road to enjoy them.

There was a hitch, however. In examining them for treatment, I kept seeing things I did not understand – strange pinpoint holes, incised lines, thinned area, unfamiliar media, bizarre supports and, most alarming of all, copying processes of totally unknown technique and chemistry. For every beautiful, familiar drawing executed in watercolor on drawing paper, there were stacks of working drawings on some kind of coated fabric, mounds of images on tracing paper and those mysterious copying processes. With the exception of the blueprint, they didn't resemble anything I had studied in my course work on historic photographic processes. So I went to all the secondary sources I could find and found precious little about the materials and techniques architects had used in the nineteenth and early twentieth centuries.

So my next idea was to interview architects and ask them about the materials they used. Since the Architectural Archives at UP was a client, I talked to the director who arranged for me to meet with some of the emeritus faculty. They were happy to talk about their work, but totally disinterested in my questions about drawings. I heard about commissions won and lost, competitions, who had screwed them out of a job and who they had bested. Questions like what tracing papers did you use and how did you decide which? What is the coating on tracing cloth? And how did you copy your drawings? Produced blank stares or answers like – I used whatever was around. Or, we sent them out and the copies came back. Drawings were seen as unimportant ephemera – a means to an end – the building is what mattered. Even the most beautiful rendering was no more than a sales document. Since drawings were only a means to an end, architects and rooms full of drafters, took full advantage of any technology that would speed the process (time is money) or produce a more alluring sales document. Long-term durability was not an issue. So architectural drawings have become ephemeral in form as well as function.

During their useful life, drawings were tacked on walls, dragged to conferences and presentations, sent on multiple trips through copy machines, and rolled and unrolled numerous times. Blueprints and photo-reproductions of all kinds were considered totally expendable and treated accordingly during the construction process. Following possible exposure at the construction site, if the drawing or print survived this long, it was discarded or rolled or folded for storage in some out-of-the way corner of the architect's or contractors office. A few lucky drawings or prints would be consigned to those responsible for maintaining a building to be used (and used-up).
Then, if an architectural drawing or print was really lucky, it was deposited in a library, archives or historical society – institutions that often have limited resources to care for

these large, complex, tattered, torn, stained and misunderstood artifacts. Well this certainly helped explain why so many drawings and prints were in such poor condition.

And so began the research that resulted in the book. Encouraged by the directors at CCAHA and the Athenaeum in Philadelphia, a major repository for American architectural drawings, I applied for my first research grant and took a leave from work. All told I wrote 12 grant proposals during the course of my work and received funding from 5 of them for salary support and some very limited travel. Fortunately, my background as an undergraduate history major and the research methodologies I had learned for my first graduate degree in the W/UD program in Early American Culture served me very well. I turned to the primary resources most likely to have the information I sought.

Trade Catalogs – told me what they used and how it was marketed
Manuals and design books by architects and their predecessors, the master builders of the colonial and early republic years – told me how and why they used it
Nineteenth century photographic manuals - that detailed a myriad of experimental processes, some of which became the foundation of the reprographic industry
Histories of architectural education and the architectural profession – put architectural drawings in the context of changing professional practices and priorities
Architectural drawings – provided examples of materials and techniques that could be matched to descriptions in the printed sources; careful examination and analytical work revealed the chemical composition of many copying process and materials.

So with this research, what did I discover? Well, I could go on for hours, but, since I have not been charged with any profound didactic duty, I am going to talk about a few disparate parts of my research that I found particularly interesting. First I am going to talk about how the development of the architectural profession was reflected in their choice of media and then I am going to introduce you to those mysterious copying processes.

In considering the architectural profession and their graphics, we must ask how we got from this - to this – in the space of a century and why?

Early architectural drawings reflect the evolving role of the architect as this profession replaced the master builder who had been responsible, since the seventeenth century, for making simple drafts as necessary for construction. Almost as an aside after pages of detailed prices for construction, the book of prices issued by the Carpenters Company of Philadelphia at the end of the 18th century lists only "the making of Draughts according to the trouble." As the nineteenth century progressed, however, the traditional builder became less able to deal with new styles and building technologies, increasingly complex mechanical systems and a changing public attitude toward architectural drawings. This opened the way for a new profession – the architect – but the birth of the profession in the US was not quick or easy.

We see here, in two engravings, the architect's idealized view of himself. The left is from a mid-eighteenth century English source where the profession developed earlier than in the US, while the right is from a mid-nineteenth century American source. In both he architect appears in frock coat and the general guise of the gentleman to discuss his drawings with the owner, his peer, and provide interpretation of the drawings for the respectful carpenter builders in their shirt sleeves. In both instances, the drawings are the critical defining attribute of the architect, and this continued to be true, right through a mid-nineteenth century lawsuit that finally established the architect's ownership of drawings done for a client as his intellectual property – akin to a composer's score rather than to a commodity like bricks or lumber that became the property of the client.

The early American drawings executed by master builders and composed of thin uniformly inked ruled lines, were generally done to a small scale and included very little detail. Some included dimensions and indications of material, but many did not. Decisions like the profile of moldings, the trim around windows and doors, and the design of decorative brickwork were left to the discretion of the builder or made during the construction process through informal consultation.

This abbreviated design process was possible because of the nature of eighteenth and early nineteenth century aesthetic assumptions and building practices. Construction technology for all types of structures was based on traditional building practices that required little explanation among the parties involved. The design of vernacular architecture was guided by craft tradition and long established evolving forms. The design principles that guided more formal Georgian and Federal architecture were based on Palladio's theories of symmetry and hierarchy enriched with classical elements chosen from English design manuals and pattern books. These principles and sources were well understood and familiar to both client and builder.

All this began to change in America by 1800 with the work of Benjamin Henry Latrobe, a fully trained English architect who routinely produced sophisticated perspective drawings with surrounding landscape rendered in full color. Beside his drawings, the work of native American builders appeared naïve, but traditional attitudes and practices changed slowly. Master builders resisted the intrusion of the architect into their domain since architects claimed not only the right to design a building but to oversee its construction – a practice that adversely effected the builders profit and reduced his social status. In urban areas like Philadelphia where competition was keen and major buildings more technologically complex, local practice changed much more rapidly than in more conservative cities and rural areas. Professional architects, many trained by Latrobe, dominated the design of public buildings and competitions like those for Girard College, which Thomas Walter executed in 1833. The exhibition of architectural drawings at the Pennsylvania Academy of Fine Arts after 1810 and of competition drawings throughout the US from that decade onward elevated architectural drawings from a functional necessity to an art form in the public mind and significantly increased aesthetic expectations in a manner traditional builders could not meet.

By 1830, with the emergence of the architectural profession, the design and construction functions became increasingly separate and fewer decisions were left to the discretion of the builder and related craftsmen. With changes in style, technology and craft practices, the assumptions that had united the master builder and client in a single vision no longer existed. The introduction of historic styles beginning with the Greek Revival made the design of every detail increasingly dependent on the superior knowledge and taste of the architect as expressed in his drawings. Therefore, in addition to making presentation drawings for the client, architects began to execute detailed construction drawings for the builder that included framing, window sashes, heating and ventilating systems and other functional and decorative elements. Unlike the informal sketches in early builders' notebooks, these drawings were executed to scale on good quality paper, neatly inked and often tinted with color. These copies, bound into multiple volumes by the firm of George Dexter and his successor Nathaniel Bradlee (1836 – 1886) of Boston, illustrate the degree of detail provided as well as the finish of even these office copies drawn, inked and rendered in watercolor on handmade Whatman paper.

So how did the emerging architectural profession's perception of itself influence the materials and techniques of drawings?

Papers of the 18th and early 19th century fell into three major categories – writing, printing, and wrapping. Writing papers were strong and well sized to allow the quill of a pen to glide smoothly over the surface and absorb the ink without spreading or blotting. Since both artists' and builders' drawings were relatively simple exercises in pen and ink with the occasional ink or watercolor wash, any paper considered appropriate for writing was also used for drawing.

The indifferent attitude toward drawing papers changed in the late eighteenth century about the time Latrobe began his practice and brought with him his British training in architectural rendering. The British had begun to develop and popularize the watercolor techniques and materials that revolutionized the medium and ultimately elevated watercolors to the status of oil paintings. The technical demands of the new watercolor methods resulted in papers designed specifically for watercolor work.

The need for these specialized drawing papers was most successfully addressed by hand-made English made papers from the Whatman mills. These soon became the standard among watercolorists and British architects. Whatman papers retained their pre-eminence because of their exceptional quality and Whatman's development of paper surface texture and sizing techniques that produced papers uniquely suited to watercolor work. The papers could be dampened and stretched on a drawing board, then dampened and dried through repeated campaigns of applying, softening and lifting watercolor washes without damage to the size or paper surface – properties that became increasingly important through the 19th century. While less expensive machine made papers were introduced as the century progressed, architects consciously chose the paper used by artist's for their

most important drawings as an expression of their place in the fine arts community as well as for their superb working properties. In examining hundreds of drawings, its prevalence is truly amazing. Thomas U. Walter, the mid-century architect of the Capitol would use nothing else, we saw Dexter and Bradlee using it for office copies and in the 1920's it was still advertised as the standard of excellence.

Like paper, the architect's choice of ink changed significantly in the opening years of the 19th century.

In the eighteenth and early nineteenth century, iron gall ink, commonly used as a writing ink, was the most available media. Early drawings by carpenter builders were executed in iron gall ink which continues to appear in drawings, particularly as notations, through the first decades of the nineteenth. Thomas Jefferson also used it exclusively for his architectural drawings such as those for the University of Virginia. But it turns brown with age and bleeds when exposed to the moisture in ink or watercolor washes.

With the increased availability of classes in drafting, the publication of builders' manuals and the example of professional architects like Benjamin Latrobe, common practice began to change and black carbon based ink became the standard medium for drafting by 1830. India ink, also referred to as China or Japan ink, came as a solid stick that was wet ground on a slate slab and diluted with water to produce a black ink of the desired consistency. The ink stick was composed of lamp black, a very fine carbon pigment, with a gelatin binder. It was highly valued for the dense black lines and luminous washes it produced. Its use became the mark of the rising profession.

After a drawing was inked-in, the drafter had the option of continuing to develop the image by adding shadows, monochromatic shades and tints, or local color. This too was a clear change from earlier practice and depended on knowledge of more sophisticated drafting and watercolor techniques. The addition of properly cast shadows to an elevation increased the information in the drawing by defining the depth of various projections; the addition of monochromatic tints and shades increased the clarity of the image; local color suggested the materials to be used in the structure and all these elements increased the visual appeal and artistic appearance of the drawing. It also helped a client visualize the final product and served as an increasingly important sales tool that was available ONLY from an architect. The progressively sophisticated use of these elements from the late eighteenth through the mid-nineteenth century paralleled the growing sophistication and professional consciousness of architects as they made the transition from craftsman-builder to professional architect.

Tinting is the practice of applying flat washes of varying strength without reference to light. Shapes in the foreground are generally tinted a lighter shade and receding planes progressively darker. Shading produces graduated areas of tone that suggest the modeling of three-dimensional forms or the effect of light. Shading was achieved using either flat or

graduated tints. It took considerable skill to avoid hard edges and build even gradations of tone.

Color was the final consideration of the architect in completing his rendering and watercolor was the medium of choice. In standard watercolor technique of the eighteenth and early 19th century, colored washes were laid in over washes executed in various dilutions of India ink. Ink washes established the tonal relationships and gradations within the picture while color tints expressed the local color. The final picture was a tinted drawing rather than a painting, and the ink washes muted the local color giving the overall composition a subdued tone. Later in the 19th century architects began applying colors in more directly with less use of preliminary ink washes to create livelier renderings, but they were careful not to compromise the clarity of the design, saving more dramatic pictorial effects for the surrounding landscape.

The reliance on fine drawing papers like Whatman and a demanding watercolor technique for finished drawings among American architects is consistent with their vision of themselves as artists. In their struggle to differentiate themselves from builders and establish their professional credentials as the essential element in the design process, the ability to draw was critical. Through drawing they expressed their superior aesthetic judgment and knowledge of architectural history and forms. The use of the best quality artists' materials for these drawings was therefore an expression of their status as artists as well as a means to achieving the best possible results.

As architectural design became more business oriented in the decades after 1860, architectural practices changed from small practices with an architect and a few journeymen/apprentices to large offices with business managers, drafters, construction supervisors, engineers and other specialized positions. This change reflected the growing size complexity of buildings and the planning and financing necessary to construct them. The number and complexity of the drawings required increased geometrically as well. Architects in successful firms saw themselves increasingly as businessmen as well as artists and their drawings reflect this change. Working drawings became very utilitarian, executed by small armies of draftsmen, but presentation and competition drawings continued to reflect the changing public aesthetic.

In spite of its much higher cost and the availability of innumerable machine made papers, Whatman hand-made papers remained the support of choice for full watercolor renderings, particularly those executed for design competitions and important presentation drawings. A professional delineator rather than the architect, who was busy supervising his office and construction projects, often executed these drawings.

Ink ground from sticks continued to be recommended for finished wash drawings because of its working properties and translucence, but architectural offices gladly adopted labor saving bottled inks, such as Higgins waterproof India ink, introduced in the 1870's. Bottled ink was routinely used for pen and ink drawings, working drawings and tracings The

formula of lamp black, shellac and borax continued to be the foundation, but many companies claimed to develop special improvements and proprietary secrets. Bottled colored inks and premixed colors replaced the traditional watercolor palette for many working drawings.

The air brush first appeared in trade catalogs about 1880 and architects quickly developed specialized techniques that took advantage of its labor saving properties. Colors developed for air brushes were often based on dyes and an alcohol carrier that reduced clogging and speeded drying time. Renderings also continued to use ink washes, but often in new and different timesaving ways. One favorite technique involved rendering the building in ink or monochrome watercolor, then developing the surroundings in full color resulting in a dramatic silhouette effect.

In the decades after the Civil War pen and ink drawings became prevalent. Drafters would establish the outlines of the building in pencil using standard drafting techniques and then render freehand within that framework on either the original sheet or a tracing paper overlay. Using existing photo mechanical printing processes, these black and white linear designs allowed easy publication in emerging professional journals such as *The American Architect and Builders News* and the *Inland Architect*. Publication became increasingly important to an architect's reputation and the award of commissions. Because half tone reproduction was not readily available, architects turned to pen and ink drawings that could be reproduced by photo line engraving.

The ascendancy of the Beaux Arts tradition in the education of architects late in the century lead to still another change in the attitude toward drawings and the way they were executed. The first American architect to study at the École des Beaux Arts was Richard Morris Hunt who returned to the US in 1860 and set up his own atelier. The design principles and drawings of the École became increasingly influential, and strongly informed the first university-based schools of architecture. The École teaching model relied heavily on the esquisse – design exercises solved through beautifully executed renderings characterized by detailed, fully inked drawings finished with sophisticated ink and watercolor washes. This style suited the emerging neo-classical buildings that replaced the angular and highly textures structures of the Victorian period and brought architectural drawings to a new pinnacle of finish and complexity. This archeo – a measured drawing by Harry Sternfeld, winner of the Rome Prize in 1921 of the portico of the cathedral in Civita Castellana - is one of the largest drawings I have worked on and is typical in both its size and complexity of major competition drawings in the early decades of the 20th century.

Meanwhile, back in the architect's office and those of innumerable associated crafts, the business of grinding out the hundreds of drawings necessary to construct these complex buildings continued. One major bottleneck in the flow of the critical graphic information needed to coordinate these large projects was the need to produce accurate copies in a cheap and timely way.

The most common early copying processes, used until the widespread introduction of tracing paper after the Civil War, was pricking the design. The master was laid over a blank sheet and a needle was used to mark the major elements, which were then connected with ruled lines to reproduce the original. This was the source of the numerous punctures I found on many early drawings. With the introduction of tracing paper and its sturdier but more expensive cousin, tracing cloth, drawings could be traced directly. And they were by innumerable draftsmen and, in larger cities, sweat shops of immigrants. The results were too often neither quick nor accurate.

Architects experimented with hectographs using soluble inks and silver based photographic techniques, but this did not address the need for quick, simple, cheap, accurate full size copies.

The introduction of the blueprinting process, originally called the ferro-prussiate or cyanotype process, in the late 1870's revolutionized the production of architectural drawings and significantly affected the practice of architecture by facilitating the coordination of increasingly large and complex projects. Like the other processes to follow, blueprints are contact printed from an original drawing on a translucent support. The blueprint process was rapidly followed by a myriad of other processes, almost a dozen of which received widespread commercial application. They come in blue, black, brown, lavender, or maroon and on every kind of paper, tracing paper or tracing cloth. The period between 1880 and 1930, was one of intense innovation that resulted in the formation of a new industry and the introduction of uncounted new products related to the photo-reproduction of architectural drawings. To give some sense of the scope of use; by 1900 William Cramp & Sons, ship and engine builders in Philadelphia, were using 11,000 square feet of blueprint paper per battleship. Here begins the trail of those mysterious copying processes generically known during the period as blueprints and heliographic prints.

My search took me to the Frederick Law Olmsted National Historic Site in Brookline, MA where Olmsted's original drafting office and home have been preserved.

Printing was accomplished using wooden contact printing frames with plate glass fronts. They were propped up on the roof of a building or run in and out of windows on specially constructed tracks. The drawing to be printed, usually referred to as the tracing, was laid directly against the glass with the sensitized paper immediately behind it. A felt blanket or rubber sheet was placed behind the paper and the back of the frame closed securely using one of several mechanisms to insure good contact between the tracing and the paper. Poor contact in any area would result in a fuzzy print. The frame could be opened periodically or test strips of sensitized paper withdrawn to check the progress of the exposure. Very large tracings were copied by wrapping both the tracing and the sensitized paper around a large cylinder which was placed on a cradle and revolved in the sun.

By 1900, machines that could make blueprints as well as other types of prints using an arc lamp rather than the unreliable and inconvenient sun had been introduced. The tracing and sensitized papers were wrapped around the glass cylinder facing inward and an arc lamp was

raised and lowered within the cylinder. With the rapidly growing demand for more and faster prints, machines like these that could expose, wash, and dry blueprints in one continuous operation were in common use by commercial blue printers by 1920, though many office maintained their own printing facilities for at least some of their work.

Now I knew how the prints were made and I had lots of examples and lots of recipes and descriptions from photographic manuals and the challenges was to match the print with the process so I could identify the media, understand its chemistry and recommend appropriate treatment and storage.

These processes all had three things in common: they depended on the light sensitivity of certain iron, silver, chromate or diazo salts; they were printing-out-processes that reproduced the original drawing, full size, by contact printing; and they were designed for linear rather than half tone reproduction. When these salts are exposed to light, the iron, silver, chromate or diazo part of the compound changes chemically in a manner that allows it to react with other substances, either directly or indirectly, to form a visible image. The image may be positive or negative. Depending on the process and whether the original translucent drawing or print used to make the copy was a positive or negative image.

I found my ally for solving this puzzle in XRF, a non-destructive analytical technique that produces spectra identifying the elements present. Once I knew the elements that were present, I could match this data to the masses of information on various processes I found in the literature. One key source, a book entitles *Modern Heliographic Process* by Ernst Lietze (1888), had identified samples tipped in which we analyzed and some prints had the process trade names stamped on the back, which I could trace back through the trade catalogs. So I gradually sorted out the many processes and established guidelines for identifying them – it was an exciting time full of Eureka moments. And it contributed significantly to the preservation of these prints – often the only surviving graphics for a building. The processes varied widely in light sensitivity and moisture sensitivity, the need for alkaline vs. neutral storage enclosures, compatibility with other materials and longevity. Some, such as diazo prints will need to be reformatted because of their inherent instability.

So this brings us full circle as we entered the door on the craft dominated 18th century, passed through the growth of the architectural profession and its graphics in the nineteenth century and ended with the creation of the reprographics industry that has made the complex modern structures we take for granted possible. And thanks to this research and the support it received over the years, we now understand the historical context, chemistry and conservation needs of these drawings far better.