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Topics in Photographic Preservation, Volume 6.
Pages: 41-49
Compiler: Robin E. Siegel

Topics in Photographic Preservation is published biannually by the Photographic Materials Group (PMG) of the American Institute for Conservation of Historic & Artistic Works (AIC). A membership benefit of the Photographic Materials Group, *Topics in Photographic Preservation* is primarily comprised of papers presented at PMG meetings and is intended to inform and educate conservation-related disciplines.

THE HISTORY AND IDENTIFICATION OF PHOTO-REPRODUCTIVE PROCESSES USED FOR ARCHITECTURAL DRAWINGS PRIOR TO 1930

Lois Olcott Price

INTRODUCTION

One of the great limiting factors in architecture and in the production of architectural drawings during the nineteenth century was the need to produce accurate copies in a cheap and timely way. The growing size and complexity of architectural projects during the later half of the nineteenth century resulted in the involvement of many more trades and contractors who all needed drawings. Even moderate size buildings had plumbing, heating, ventilation, gas or electric systems. Large public projects had correspondingly complex mechanical and structural systems as well as numerous decorative components involving iron work, marble, sculptural elements, woodwork, decorative brick and terra cotta. Coordinating these large projects required the free and timely flow of information, much of it in the form of drawings. Traditionally, copies were produced by tracing, one at a time, using methods that were time consuming, labor intensive and expensive. The only other alternatives were current photographic processes like salted paper or albumen that usually reduced the size of the original drawing and required the time consuming and costly production of a glass plate negative. Prints like these are relatively rare.

HISTORY

The introduction of the blueprinting process, originally called the ferro-prussiate or cyanotype process, in the late 1870's, however, revolutionized the production of architectural drawings and significantly affected the practice of architecture by facilitating the coordination of increasingly large and complex projects. The blueprint process was rapidly followed by a myriad of other processes, almost a dozen of which received widespread commercial application. 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.

It is important to note that in the contemporary literature, the terms "blueprint" and "heliographic print" became generic terms for all these processes. This contemporary literature, including manuals, trade catalogs and advertisements in trade journals, is invaluable in researching these processes and documenting their introduction and use. [1]

These processes all had three things in common: they depended on the light sensitivity of certain iron, silver, or diazo salts; they were printing-out-processes that reproduced the original drawing by contact printing; and they were designed for linear rather than half tone reproduction. Dependability, speed, cost and simplicity rather than subtlety of tone or aesthetic affect were the ruling criteria. Most processes originated in Europe and some became more popular there than

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in the United States, but in general, American usage appears to have paralleled that of Europe. Photo-reproductions could be printed from originals drawn on almost any type of paper support, but in practice, translucent tracing papers and cloths were consciously used as supports for drawings intended for photo-reproduction because they produced better, clearer prints more quickly. These drawings on tracing paper or cloth were commonly called tracings.

Although tracing papers and cloths had been used by architects before the introduction of photo-reproductive processes, the variety and quantity manufactured and used after 1880 increased rapidly. By 1900, trade catalogs had begun to rate them by their suitability for use as originals for photo-reproductions. To define an unfamiliar term, tracing cloth, also known as drafting linen, is a plain woven fabric, usually cotton by this period, that has been heavily sized with starch to which various waxes and resins were sometimes added. This material was usually highly calendared on at least one side and frequently had a slightly bluish tint to improve its transparency to actinic light when used as the original in producing photo-reproductions.

Photo-reproductive processes were printed on a variety of supports including paper, tracing paper and tracing cloth.
Early manuals (1880-1900) generally recommended using any good quality paper that was hard surfaced and well sized. Most drawing papers were considered suitable. Bond or currency paper was recommended for small prints and those that needed to be relatively transparent for use as negatives. By 1887, papers produced especially for heliographic purposes were readily available including one called "Helios," and papers from both Rives and Steinbach. Manufacturers of these papers consciously eschewed the use of bleaches and sizes that might adversely affect photographic processes. A catalog issued by F. Weber of Philadelphia in 1895 listed four grades of paper stock each available in different weights including Eclipse, a top quality 100% rag paper; Sun, a lower quality rag paper; Neptune, a parchment paper valued for its durability, and Star, an all linen paper considered the lowest quality of the line. The paper came in 27 to 42" width rolls and could be purchased unprepared or pre-sensitized for blueprinting as well as other processes.[2] During the early years papers were coated with sensitizing solution by hand, but machine coated papers were available by 1887, and soon dominated the market.[3]

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 1888, pneumatic printing frames that used an inflatable rubber pad to insure good contact between the tracing and the sensitized paper had been introduced. Sophisticated vacuum printing frames that used a compressor to evacuate air from within the printing frame were in use by 1921.[4] 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.[5] The tracing and sensitized paper 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.[6]

In the closing decades of the nineteenth century and well into the twentieth, many architectural and engineering firms printed and developed their own reproductions by hand as described in the manuals. Since commercially prepared papers became available shortly after each process was introduced, the majority probably did not prepare the papers themselves. These papers were sold directly to architects and engineers who maintained a small printing area as part of their practice. Businesses that specialized in making prints using these processes developed quickly, however, giving architects and engineers the option of sending some or all their work out. Initially, many of these printers appear to have sensitized their own paper, but as the scale of the business and the size of the capital investment grew and as the chemistry involved in producing specialized papers became more complex, only the largest continued to sensitize their own papers.

IDENTIFICATION

For purposes of identification, storage and treatment, the photo-reproductive processes can be divided into two major categories depending on the nature of the final image. In the first category are those processes that produce a final image composed of an iron, silver or diazo compound. These images may be blue, brown, black, brown-black, sepia, purple, or magenta. In all these processes, the image is either embedded in the paper fibers or in an emulsion layer of gelatin or resin on the surface of the paper. The four most common processes, blueprint, Pellet, Vandyke and ferro gallic, which will be covered in some detail below, all fall in this category. The second category are those processes that produce a final image composed of an ink, almost always carbon based, or of carbon particles. These images are almost always black with the image sitting on top of the paper fibers rather than in them.

<u>Blueprint</u>

The best known and by for the most common process used for photo-reproduction was the blueprint also known as the cyanotype or ferro-prussiate process. Although the basic chemistry was discovered by Sir John Herschel in 1842, it was not developed for commercial use until 1876, when Marion and Company, Parisian photographic publishers, began the manufacture and distribution of sensitized papers. Information about the process was first published in the United States in 1871,[7] and its use for the reproduction of architectural drawings was described in an architectural journal in 1878.[8] It was fast, easy, inexpensive and produced a print the same size as the original directly from the original. Architects adopted the process quickly and used it until it was displaced by the diazo process in the 1950's.

To produce a print, the paper was sensitized with ferric ammonium citrate and potassium ferricyanide in varying proportions, then exposed to light under a tracing. The proportion of the reactants determined the speed of the paper and its shelf life. After exposure, the print was thoroughly washed in water resulting in a print with white lines on a medium to deep blue ground. On exposure to light, the ferric salts are reduced to the ferrous state which, in the water bath, react with the potassium ferricyanide forming ferric-ferrocyanide (Prussian or Berlin blue) and ferrous-ferricyanide (Trumbull's blue). Positive prints with blue lines on a white ground could be produced using a negative print, usually a Vandyke, taken from the original drawing. Vandykes will be discussed shortly.[9]

Pellet Process

The Pellet process, also known as the cyanotype positive, cyanofer and positive ferrotype, was also based on the discoveries of Sir John Herschel. Working with Alphonse Poitevin, Henri Pellet patented the process in 1877. The value of the process was its ability to produce a positive and permanent blue line image directly from a tracing without the intermediate step of making a negative. The first to manufacture sensitized paper for this process was Clarise Zoe Joltrain of Paris under the name "Papier Gummoferric" sometime before 1881.

The paper was sensitized with an iron salt such as ferric chloride or ferric ammonium citrate used singly or in combination, an organic acid, usually tartaric, and a colloid such as dextrin, gum arabic or gelatin. It was exposed directly under a tracing and then developed in potassium ferrocyanide followed by a vigorous water bath sometimes accompanied by brushing to remove unexposed sensitizing reagents from the background. A final rinse in a dilute acid bath of sulfuric or hydrochloric acid followed by another water bath served to finish clearing the highlights. Successful development required an experienced operator.

The ferric salt renders the colloid insoluble until it is reduced to the ferrous salt by exposure to light and the colloid once again becomes soluble. The potassium ferrocyanide in the developing bath reacts with the ferric salts in the still insoluble unexposed areas forming ferric-ferrocyanide (Prussian blue). The soluble colloid and colorless reaction products in the white background are washed off in the water bath and the acidic bath brightens and deepens the blue image while clearing the background of any lingering yellow tint.[10]

The final image is usually a dense blue line sitting in and slightly on top of the paper fibers. The background is bright white with occasional blue specks. Pellet prints are subtly different from positive blueprints whose image is completely in the fibers and whose background is usually not quite as clear.

Vandyke

The Vandyke process, also known as the sepia process, solar or silver paper, was introduced shortly after 1890. It is closely related but not identical to the kallitype process which was used for producing half tone images.

The basic principle of the process was discovered in 1842 by Sir John Herschel but, like the blueprint, was not developed commercially until decades later. In 1889, H. Shawcross announced the development of sepia paper for which he took a Paris patent, followed by an English patent in 1892. Vandyke paper is often erroneously credited to F.R. Vandyke of the Survey of India Office, Calcutta, from whom it derives its name.

The Vandyke process produced a negative image from the original drawing, and this image was used as an intermediate negative. This negative image, with translucent lines and a dark brown ground opaque to actinic light, was placed over blueprint or Vandyke paper, which was then exposed and printed to produce, respectively, a positive blue line print or a brown line image.

These positive brown line images created on Vandyke papers were often used as a guide for further development in ink, watercolor or dry media by architects who used them to try out different design options or rendering schemes. Some architects, like Wilson Eyre, used these rendered brown lines as final presentation drawings. Because the negative prints tended to be used as an intermediate reproductive process, examples of negatives in most collections are fairly rare.

To produce a Vandyke print, the paper was coated with ferric ammonium citrate and silver nitrate, exposed to light under a negative or a tracing, then washed and fixed in hypo. Like the platinum process, the Vandyke processes is based on the principle that ferrous salts, formed when ferric salts are reduced by exposure to light, are powerful reducing agents themselves, and can reduce the salts of precious metals, like silver and platinum, to the metallic state forming an image. The images often have a slightly metallic, almost bronze appearance.[11]

Ferro gallic

The ferro gallic is the least known and recognized of the four most commonly used processes. This process was developed by Alphonse Poitevin but was not introduced commercially until the 1880's. It was more costly and complex to produce than some of the other processes, but its advantage was the production of a positive brown to black image directly from the original.

The reagents used to sensitize the paper and the underlying principles of the process are very similar to the blue line or Pellet process. An iron salt, usually ferric chloride or ferric sulfate, an organic acid, usually tartaric, and a colloid such as gum arabic or gelatin were used to sensitize the paper. After exposure the print was developed using gallic or tannic acid applied by one of two methods. In the original process, the exposed print had to be developed in a bath of gallic or tannic acid. In 1885, Shawcross and Thompson of London developed a variation of the process depositing the developer, in dry powdered form, on the sensitized paper. This change allowed for full development of the print in a water bath. Alcohol, oxalic acid or alum were often added to the final bath to help clear the ground. Prints made with this second process appear to be more stable.

Like the Pellet process, the ferro gallic process exploits the fact that unexposed ferric salts render the colloid insoluble until they are reduced to the ferrous salt by exposure to light and the colloid once again becomes soluble. The gallic or tannic acid in the developer reacts with the ferric salts in the unexposed areas forming ferric gallo tannate (iron gall ink). The soluble colloid and colorless reaction products in the white background are washed off in the water bath.[12]

The prints produced by this process range from light brown to almost black. The background tends to be pale brown or slightly lavender; it is never entirely clear. Like Vandyke brown line prints, these prints were often used for studies to which additional media was applied.

The following processes also rely directly on light sensitive materials to produce an image, but they are less common than the four processes already discussed.

<u>Photostats</u> were introduced in 1909 primarily for the reproduction of manuscripts and small drawings. From an original drawing they produce a negative image of white lines on a black or grey background though from a blueprint they produce a positive image. After 1920, the process was developed to produce larger prints, and in 1953, Kodak introduced a photostat process that produced a positive image. The print was produced by placing the photostat paper in a special camera where it functioned and was developed like a piece of standard photographic film. The process produces a silver image in a gelatin emulsion that exhibits the same characteristics as other silver halide photographic prints.[13]

The <u>aniline process</u> was first patented in England in 1864 by William Willis. A variation of the process using vanadium was introduced by Endemann in 1866 and the Brothers Lumiere began producing a vanadium printing paper in 1894. The vanadium process produces a fairly permanent blue-black image though other variations of the process can produce other colors, particularly blue or purple. The aniline process was considered valuable because of its cheapness, simplicity and rapidity. According to some sources, it was the only process commonly used until the blueprint became dominant in the 1880's, but the only example I have seen are post-1900. It does not appear to have come into general use among architects, but was probably used more extensively by engineers and contractors.

The paper support was sensitized with a chromate containing compound, most frequently potassium bichromate, salt (sodium chloride) and a dilute acid. The vanadium process also incorporated a vanadium compound such as ammonium vanadiate or vanadium chloride. The sensitized paper was exposed under a tracing and then developed by exposure to aniline fumes vaporized within a closed box. The aniline fumes reacted with the chromate not reduced by exposure to light resulting in a positive image. The developed print was then washed in a slightly acidic bath to clear the highlights but the prints retain a yellow green cast and are commonly called green prints by archivists who work with them. The image is usually blue or blue black, but may also be purple. Because of the acidic solutions used to process these prints, they are usually quite brittle.[14]

The <u>diazo process</u>, also referred to as the ammonia or dyeline process, was first introduced in the closing years of the nineteenth century, but the process was not successfully developed or marketed in the United States until the late 1920's. By the 1950's, it became the dominate reproductive process, replacing blueprints. The diazo process produces a positive print directly from the original and does not require wet processing.

Unlike the processes discussed previously, diazo prints do not have a single characteristic color.

They rely on two classes of compounds, the diazos and the phenols, to produce an image in the form of an azo dye. The choice of two specific compounds within these families determines the final color of the print. Both compounds are coated on the paper, but the use of an acid-inhibitor prevents any reaction from taking place. Exposure to light under a tracing destroys the diazo salt in the exposed areas. Development takes place when exposure to ammonia neutralizes the acid-inhibitor and the reactants in the unexposed areas combine to form an azo dye. Early diazo prints have a red-purple image on a "dirty" white background. Later prints, including those produced today, are generally magenta, blue, black or sepia, but other colors are possible. While the backgrounds of current diazo prints are clearer than the early prints, they are not a clean white, which provides the primary clue for identifying them. Because the phenols are not removed from the finished print by washing, they continue to oxidize over time causing discoloration and paper degradation. These prints are also very light sensitive; the image fades and the paper discolors rapidly with exposure.[15]

C. B. prints, also known as SEE-BEE and Dupro prints, were introduced in the early 1920's. They were used to produce and "ink-like" substitutes for original ink drawings that could be used as security copies and as tracings to produce blueprints if necessary. The process required an intermediate Vandyke negative and allowed any part of the image to be selectively erased during processing. Tracing cloth was the most common support. The process produces an "ink-like" image, which current incomplete research suggests is probably silver based. Under magnification, the lines lack the character of an ink line drawn with a ruling pen and the surface of the support is often unevenly discolored.[16]

This completes discussion of images formed directly from light sensitive salts. The following photo-reproductions use photographic processes to reproduce the image, but the final image is composed of carbon based ink rather than the reaction products of light sensitive salts.

Lithography and photolithography were commonly used to reproduce architectural drawings from after the Civil War well into the twentieth century. The practice became common in the late nineteenth century when large projects involving publicity, complex financial arrangements and real estate agents increased the demand for drawings to publicize and market the project. Images were created in several different ways; they could be drawn directly on the printing surface, drawn on special transfer paper and transferred to the printing surface, or transferred photographically to the printing surface. Since the final result is the same in any case, it is usually impossible to determine which method was used. Judging from accounts of the period, advertisements and the convenience factor, photographic transfer was the most common.[17]

True-to-scale prints, also known as lithoprints and gel lithos, were introduced in 1904 and widely used after 1910. Their use continued, with decreasing popularity, until the 1950's. Since the paper was never washed and therefore did not change dimensionally, the process produced a positive image in ink that was true to scale. It was produced by laying an exposed but undeveloped blueprint on a damp gelatin pad known as a graph. The unexposed iron salts in the lines of the blueprint reacted with the gelatin, hardening it, and making it receptive to lithographic ink. The pad could be re-inked and yielded up to 25 prints. Both well sized paper and tracing cloth were used as supports. Under magnification the ink lacks the character of a ruled line.[18]

CONCLUSION

Time precludes any detailed discussion of the preservation, storage, and treatment needs of these prints, but I would like to summarize briefly by saying that they need to be treated as photographs that exhibit the same alkalinity, sulphur and light sensitivities and processing variations as other related photographic processes. Many need to be stored in unbuffered enclosures; preliminary testing of the four major processes in high humidity conditions indicated that contact with buffered enclosures caused image deterioration of blueprints and ferro gallic prints. Diazo prints also appear to be alkaline sensitive. Prints with silver based images should be stored in enclosures that pass the PAT test and meet standards generally set for silver image photographs. At a minimum, different processes should be interleaved and inherently unstable materials such as diazo prints and ferro gallic prints, which cause transfer staining in the same manner as iron gall ink, should be stored separately.

In short, I encourage you, as photographic conservators who potentially have the best understanding of the preservation needs of these materials, to get involved with them and encourage repositories that hold them to learn more about them and to treat them as photographic materials.

ACKNOWLEDGEMENTS
The research in this paper was undertaken as part of a larger project into the fabrication and preservation of American architectural drawings prior to 1930. This research has been supported by a Peterson Fellowship from the Athenaeum of Philadelphia, a Research Fellowship from the Winterthur Museum Library and grants from the Institute for Museum Services, the Graham Foundation and the Council on Library Resources. In addition, my former employer, the Conservation Center for Art and Historic Artifacts in Philadelphia, supported the project and granted the leave necessary to undertake the research.

ENDNOTES

1. There were three manuals written specifically for architects and engineers that were particularly useful:

George E. Brown, *Ferric & Heliographic Processes: A Handbook for Photographers, Draughtsmen, & Sun Printers* (London: Dawbarn & Ward), [1900].

Peter C. Duchois, *Photographic Reproduction Processes: A Practical Treatise on the Photo-Impression without Silver Salts*, ed. E. J. Wall (London: Hampton Judd & Co.), 1892.

Ernest Leitze, *Modern Heliographic Processes* (New York: D. Van Nostrand Co.), 1888. Rpt. Rochester Visual Studies Workshop, 1974.

2. F. Weber & Co., *Catalogue of Architects', Engineers and Draughtsmen's Supplies* (Philadelphia), 1895, pp. 12-13.

3. Duchois, p. 30.

4. *Catalogue of New York Blue Print Paper Co.* (New York: New York Blue Print Paper Co.), 1921, pp 229-230.

5. Brown, pp. 80-81.

6. *Catalogue of New York Blue Print Paper Co.*, p 21.

7. Thomas A. M'Colloin, *American Journal of Photography* (Nov 1984), p. 481.

8. *The American Architect and Building News*, 4(3 Aug 1878), p. 44.

9. The three manuals noted in note 1 describe the process in detail. In addition, see:

Cassell's Cyclopedia of Photography, ed Bernard E, Jones (London Cassell & Co.), 1911. Rpt. New York: Arno Press, 1973.

L. P. Clerc, *Photography: Theory and Practice* (New York: Pitman Publishing Corp.), 1940.

E. J. Wall, *A Dictionary of Photography for the Professional and Amateur Photographer* (New York: The Scovill & Adams Co.), 1889.

Edward L. Wilson, *Wilson's Cyclopedia of Photography* (New York: Edward L. Wilson), 1894.

10. See manuals in note 9.

11. See manuals in note 9.

12. See manuals in note 9.

13. New York Blue Print Paper Co., pp. 21-22. Luis Nadeau, *Encyclopedia of Printing, Photographic and Photomechanical Processes* (Fredericton, New Brunswick, Canada: Atelier Luis Nadeau), 1990.

14. See manuals in note 9.

15. See Cassell's, Duchois, Wilson and:

B. de Gorter, "The Principles and Possibilities of the Diazo-Copying Process," *The Journal of Documentation* 5:1(June 1949), pp 1-11.

Neblette's Handbook of Photography and Reprography (New York: Van Nostrand Reinhold Co,), 1977.

16. Nadeau, p. 61. New York Blue Print Paper Co., p 15-17.

17. R. Phene' Spiers, *Architectural Drawing* (New York: Cassell & Co. Limited), 1887. p. 45.

18. See Cassell's, Clerc and Nadeau.