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CHARACTERIZATION AND IDENTIFICATION OF

PRINTED OBJECTS

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11 de Julho de 2008

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ABSTRACT

A study about the physical appearance of pre-photographic, photomechanical, photographic and digital positive reflective prints was made, relating the obtained images with the history, materials and technology used to create them. The studied samples are from the Image Permanence Institute (IPI) study collection. The digital images were obtained using a digital SLR on a copystand and a compound light microscope, with different lighting angles (0º, 45º and 90º) and magnifications from overall views on the copystand down to a 20x objective lens on the microscope. Most of these images were originally created by IPI for www.digitalsamplebook.org, a web tool for teaching print identification, and will be used on the www.graphicsatlas.org website, along with textual information on identification, technology and history information about these reproduction processes.

Keywords: identification, characterization, prints, pre-photographic, photographic, digital photography, copystand, macrophotography, microphotography, cross-sections, UV light.

INTRODUCTION

Images made through reproductions processes have been created over the past 700 years in many ways. At first these images were made by hand, but technological innovations have allowed the chemical, optical, and mechanical capture and reproduction of images. Since the beginning of the 19th century, these developments permitted a more accurate representation of reality. Throughout the 19th and 20th centuries, photography evolved to create ever more realistic images, and generating them faster, and with greater sharpness, permanence, and even color. The development of digital imaging, particularly over the last 20 years, represents the highest technological development in photography [1].

The Image Permanence Institute (IPI), at the Rochester Institute of Technology (RIT), in Rochester (NY) – U.S.A., was founded in 1985 to conduct research on the deterioration and preservation of photographic materials. Since then, IPI has greatly expanded existing conservation knowledge, particularly in this field. One of the IPI's current projects is the development of new tools to explore graphic materials and an image methodology to characterize and identify them, and to present this research in an accessible and useful way to conservators, curators, art historians, collectors and students. On www.digitalsamplebook.org, different images of prints are shown [2, 3]. Based on the original website, a new, enhanced one, www.graphicsatlas.org will be launched. It will feature the original image viewing tool "Object Explorer", and will include pages on the identification, history and technology of each of the photographic and printing processes illustrated. Educating individuals in the identification and understanding of prints is a necessary basis for a more accurate preservation of photographic materials, giving them meaning and creating awareness in those who care for them [4].

In this paper, descriptions of different materials and techniques are made, supported by the imaging techniques described in Appendix I (pp. 32-41). The examples presented were chosen as representative of each process, but cannot represent all the variants of each process that were (and in some cases, continue to be) created. Well-established commercial processes often tend to perfect its technology, contributing for their diversity. The appearance of a print can also be dramatically affected by deterioration, which constitutes as another factor to have in mind when describing them.

This work is composed of general descriptions of processes selected from the www.digitalsamplebook.org website, that will accompany them in the www.graphicsatlas.org site, in the appropriate sections. For example, developing-out gelatin silver prints are being studied in more depth by Ryan Boatright and the characterization team at IPI, focusing on the great variations this same process allowed, based mostly on Kodak samples; iron based photography, as the name points out, isn't based on the light sensitivity of silver salts nor is related with the materials used in the manufacture of photomechanical prints (as opposed to carbon prints, included in the text); instant photography is a very complex subject, since the final print is also the same object that was exposed to light and developed chemically, and therefore different from the approached processes.

CHARACTERIZATION AND IDENTIFICATION OF PRINTED OBJECTS

Pre-photographic processes

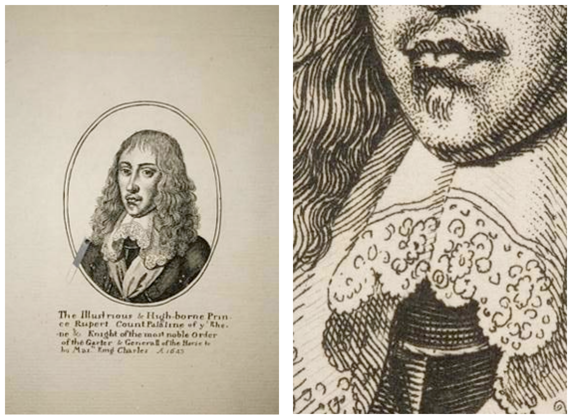
This type of process is defined here as those used for reproduction of prints that do not use any photosensitive materials at any point in their creation. The resulting prints are composed of a paper support with transferred ink. They are generally separated into three primary printing methods: *intaglio*, relief, and planographic (Appendix II, Figure 132) [1].

The pre-photographic processes mentioned in www.digitalsamplebook.org are etching, gravure, woodcut, and lithography. Other processes, mainly variations of the *intaglio* process, like aquatint and mezzotint, are not studied here [1, 2].

Pre-photographic techniques are defined according to where the ink sits on the printing plate to then be transferred onto a dampened paper support (generally made from rag fibers such as linen and cotton). This has an impact on the final physical appearance of the print. In the relief process, height differences are created in the printing plate, so the ink is placed on its surface rather than its groves. Woodcut is a relief process, obtained from carving a wood block and inking its surface. The opposite happens in *intaglio* plates, since the ink is pressured out of the depressions while its surface remains clean. Gravures and etchings are *intaglio* processes, prepared on metallic surfaces, usually copper. To transfer the ink into paper great pressure is required, which explains the plate marks that accompany this type of prints, when they aren't cropped. Planographic processes don't need to use depth differences in the printing plate. Instead, it relies on the repulsion of water and oil based inks. Lithography is a planographic process, where an image is created over a stone surface (Appendix II, Figure 132). [1, 5, 6]

Image structure depends on the technique used. **Woodcuts**, popularized in Europe in the early 14th century, have dark image areas corresponding to where the wood block wasn't carved and the black greasy ink was applied with a dabber. Non-image areas match regions where the wood was taken out with a sharp tool, and didn't come in contact with the paper surface. Gradations are difficult to obtain through carving, so most prints have good definition between inked and non-image areas (Figures 1-2). The evolution of the technique allowed greater detail, but woodcuts lost their appeal with the popularization of *intaglio* processes in the 16th century. In the 19th century they were reutilized for reproduction of illustrations in magazines and books [1, 7-9].

Figures 1 and 2 – Woodcut. Normal view and 50x view (left to right) at 45º lighting. The dark image areas are well defined.



Figures 3 and 4 – Engraving. Normal and macro views (left to right) at 45º lighting. The image is composed of more detailed lines.

Engravings were first used in the mid-15th century, and are commonly found in 17th and 18th century book illustrations. A tool called burin was used to make depressions on a surface (usually metal), creating line or dot shapes [9]. Consequently, these forms, where the ink gets deposited, compose the image, while non-image areas, on the surface of the plate, are cleaned and don't transfer any ink into the paper (Figures 3-4; Appendix II, Figure 132).

Etchings were made by drawing with a sharp needle point over an asphalt-covered plate. After the design was incised, the resin was taken out on those areas, exposing the metal. The plate went into an acid etching bath, using different acids for different metals. The exposed metal was etched and an image was produced on the plate. Corrections could be done, a great advantage over other techniques. They could be done by reapplying resin over the plate, after it was scraped and burnished to cover the etched line. The longer the bath, the more ink the plate could retain. Darker areas have more ink, and this relief may create differential gloss (but not in this sample) (Figures 5-7; Appendix II, Figure 132) [1, 7, 8, 10].

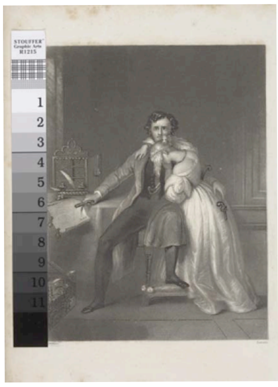


Figure 5 – Etching. Normal view at 45º lighting.

Figure 6 – Etching. Macro view at 45º lighting. The dark areas are the ones with more ink.

Figure 7 – Etching. Macro view with 90º lighting. This lighting reveals the texture of the darker areas and their relief.

Senefelder introduced **lithography** and planographic processes in the late 18th century. Lithographs were made on polished stone surfaces (like limestone's, but in modern times metal or plastic are used). A drawing is made with a greasy crayon; an acidic water solution with gum arabic is spread on the surface, filling the limestone pores where the crayon wasn't used. Oil-based ink is then applied to the surface, adhering to the crayon, and being repelled by the water filling non-image areas. The applied ink is transferred to a paper support in a lithographic press. The obtained image lacks relief, since the ink layer is thin and it's printed from a plate or stone with no relief or incisions (planographic) (Figures 8-9; Appendix II, Figure 132). It's a versatile technique that can be difficult to identify, if it emulates characteristics of other processes [1, 7-9, 11].

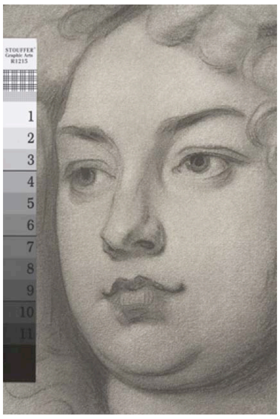
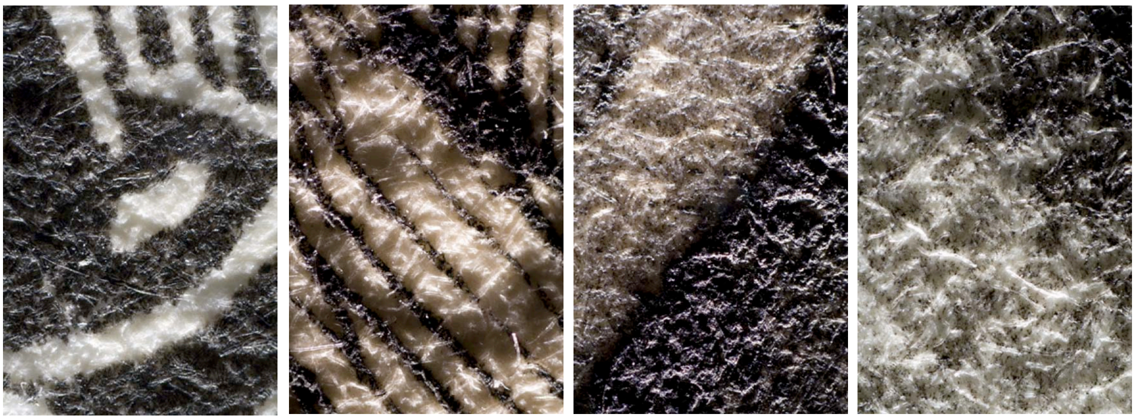


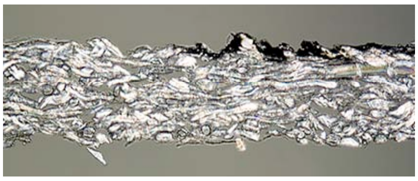
Figure 8 – Lithogravure. Normal view with 45º lighting.

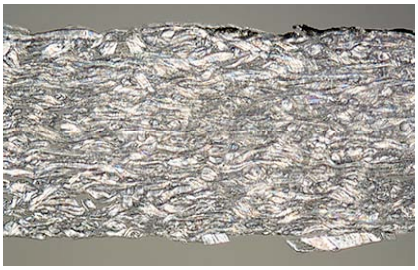
Figure 9 – Lithogravure. Macro view with 45º lighting. There are no significant changes when viewed under 90º lighting.

At high magnification paper fibers of pre-photographic prints can be seen, particularly in non-image areas (Figures 10-13). They only have a paper layer covered with greasy ink, since it doesn't penetrate the paper fibers. Cross-sections show the variation on thickness of paper bases and how the ink is it deposited on its surface (Figures 14-15). Rag paper is a non-fluorescent material (Appendix II, Figures 149-150) [5]. See also Table I, Appendix IV.



Figures 10-13 – Woodcut, engraving, etching and lithograph (left to right), seen at 50x with 90º lighting. In all the examples paper fibers are visible, even under the ink layer.





Figures 14 and 15 – Engraving and etching (left to right). Cross sections at 200x, with BF reflected light. In this case, the ink layer on the engraving is thicker than the one on the etching, while they have opposite proportions in what concerned the thickness of the support.

Photomechanical processes

Photomechanical processes combined machinery like the ones used for traditional printmaking with photographic techniques to create a photographic image printed in ink. The final print doesn't have light sensitive material to record the image, and often (but not always) presents a patterned image when observed under magnification. The pattern was specific to each process, making this a good identification characteristic [4, 12, 13]. All the photomechanical prints mentioned in www.digitalsamplebook.org are approached here [2].

Like the pre-photographic processes, and with the exception of Woodburytypes, the images are formed by oil-based inks mixed with pigments with very high stability [14]. The paper support could of rag paper or wood pulp, depending on when it was made and the quality of the print (cheaper prints were often done on the less expensive wood pulp papers, that has less quality). Sometimes a surface coating was placed on the paper, to smooth it and give more image definition, a practice common after the 1850s (Figure 34) [1].

Before the 20th century, dichromated gelatin was used in some stage of the production of photomechanical prints, to create the image mould. When gelatin is mixed with chromium salts, it hardens when exposed to light and becomes insoluble in water. Mungo Ponton first discovered this effect in 1839. After light exposure in contact with a positive or negative transparency, the surface containing the gelatin was washed in hot water, removing the unexposed, soft gelatin. The relief gelatin mold was used accordingly to the technique the print was made in, which is described in the following paragraphs. With a press, the inked plate was placed against a dampened sheet of paper, like in traditional printing techniques [1, 13, 15].

In 1855, Poitevin invented the **collotype** process. Josef Albert improved the manufacturing process in 1873 by using a rotary press. By 1876 he was producing colored collotypes [16]. Collotypes were used for high quality reproductions of photographs, at the time obtained through wet plate negatives, but also reproductions of drawings and watercolors. It was used in postcards and book illustrations until the 1960s (Figures 16-19) [1, 4, 9, 12, 14, 17, 18].

Collotypes were obtained through a glass or metal plate covered with dichromated gelatin. It was exposed to light with a negative, and washed (Appendix II, Figure 133). The reticulation pattern was obtained by washing the plate in cold water after it had been heated on an oven. The expanded gelatin was forced to shrink with the contrasting temperatures (Appendix II, Figure 134). The result was a reticulated, cracked surface. The dried plate was inked and then pressed into a smooth surface paper support, creating the final print (Figures 16-19). Because the ink stayed on the surface of the plate, this is considered a planographic process, creating a surface that doesn't have differential gloss. The amount of applied pressure was relatively small, not creating plate marks [1, 4, 17, 19].

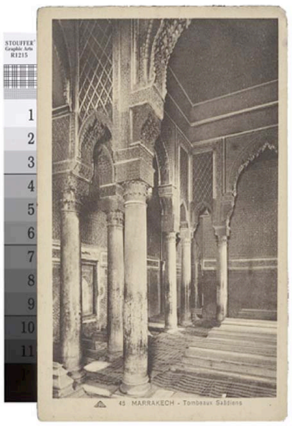


Figure 16 – Collotype. Normal view at 45º lighting.

Figure 17 – Collotype. 50x view at 45º lighting. The pattern is formed across the inked areas.

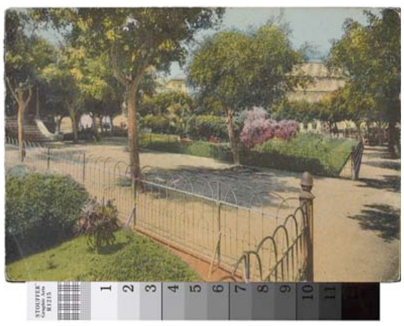


Figure 18 – Color collotype. Normal view at 45º lighting.

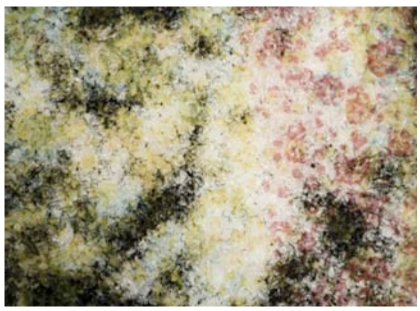


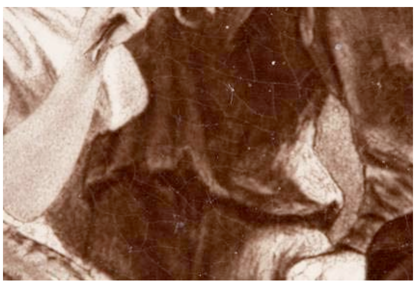
Figure 19 – Color collotype. 50x view at 45º lighting. Each color layer presents the reticulation pattern.

W.B. Woodbury invented the **Woodburytype** in 1864-65, with a patent published in the British Journal of Photography. By the 1870s it was an established method for photographic reproduction and to print illustrations in books. They weren't made in large formats, due to the great pressure needed in the process, which could not be obtained uniformly over very large areas. Like carbon prints (see p. 16-18), these prints were advertised as a permanent method. By 1900 other photomechanical processes, such as letterpress halftone, made Woodburytypes too expensive by comparison, leading to the abandonment of the method [4, 13, 16, 19-21].

Although it is a photomechanical process, the woodburytype has a continuous-tone image (Figures 20-21). It's obtained in the following way: a dichromated gelatin layer is printed in contact with a photographic negative. The gelatin layer is then washed and dried, producing a gelatin relief image (Appendix II, Figure 133). This was then used as a mould to produce a relief image in a soft metal plate, usually lead. To maintain the relief of the lead plate, and consequently the print's quality, the metal plate was covered with chromium. Pigmented gelatin (not light sensitive) was pored on the cast, and the plate was pressed against paper. The relief of colored gelatin was then on paper (Appendix II, Figure 135) [19]. Pigment particles may be seen across the surface of the print, at high magnification. Darker areas have thicker gelatin layers, while non-image areas continue to show paper fibers from the support. To harden the gelatin layer, woodburytypes went through an alum bath [4, 12, 13, 16].

Woodburytypes exhibit differential gloss due to the difference in gelatin thickness between image and non-image areas (Figure 21-22). Also, due to deterioration, cracks in dark image areas are common. The expansion and contraction rates of gelatin and paper when exposed to changes in relative humidity is different, creating stress in the gelatin layer that is released by the formation of cracks [4, 17].

Figure 20– Woodburytype. Normal view at 45º lighting.



Figures 21 and 22 – Woodburytype. Macro view at 45º and 0º lighting (left to right). The darker areas have more gelatin, creating differential gloss. In this case, it also shows cracks.

The invention of **photogravure** as a practical, commercial process in 1879 is credited to Karl Klíč, but Niépce and Talbot had already made progress in the area earlier in the century. This is a process that takes *intaglio* and combines it with the use of the photosensitive dichromated gelatin. It was considered a very accurate way to reproduce tonal gradation of photographs and paintings in book illustrations, postcards and magazines, gaining popularity in the late 19th century and early 20th century (Figure 23-24) [1, 4, 9, 13, 17, 18, 22].

Intaglio processes require a series of pits in the plate in order to hold ink over broad areas, creating tonal gradation by the varying size of the pits. To create a pattern for tonal reproduction, the metal plate's surface, usually copper, was covered with resin dust and then heated to create a very fine pattern (known as aquatint pattern) (Figure 24). The plate was coated with dichromated gelatin, which was exposed in contact with a positive transparency. Carbon tissues, such as those patented by J. Swan for carbon printing in 1864, were widely used to prepare photogravure plates. The unhardened gelatin was removed with water from the plate. The plate was then placed in an etching bath, where the remaining hardened gelatin protected parts of the surface, while the metal was etched through the voids. This originated pits to collect ink (Appendix II, Figure 136). The plate went through a stop bath to cease its corrosion. Before inking, the hardened gelatin is removed from the plate, exposing the image areas. The utilized press was of the same type used in *intaglio* prints, accountable for presence of plate marks in the final print [1, 4, 12, 13, 17, 19, 22].

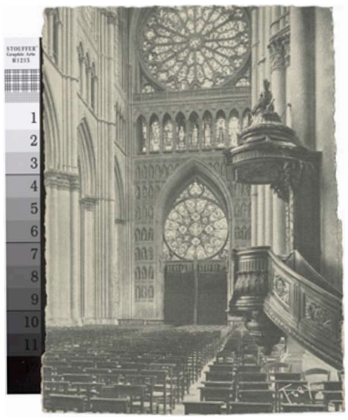


Figure 23 – Photogravure. Normal view at 45º lighting.

Figure 24 – Photogravure. 50x view at 45º lighting. The aquatint grain pattern is observed.

The **rotogravure** process, also known as screen gravure, is another of Klíč's inventions, patented in the year 1890 and used after 1895 [13]. It's a development of the photogravure process that used a rotating cylinder instead of a flat metal plate to print an image. The process relies on machinery for the inking of the cylinder, with the excess on the surface being taken away with a part called the doctor-blade (Appendix II, Figure 138). This was a faster and more accurate way to remove the excess ink than the manual wiping used in the photogravure process. It was less time consuming and cheaper, becoming appropriate for large runs of photographic reproductions such as in magazines, newspapers, postcards and book illustrations (Figures 25, 26) [1, 4, 12,17, 18].

A halftone screen was used while pre-sensitizing a dichromated gelatin layer from a carbon tissue, creating a hardened gelatin grid, needed to reproduce tonal values. This layer was re-exposed to light in contact with a positive image. The gelatin layer was transferred onto the cylinder, protecting the areas it was over from etching. The etching created a series of pits in the cylinder of varying depth. The deeper pits held more ink, while the shallow pits held less. The grid lines were not etched at all, so a pattern of “white” lines is across the final print (Figure 26; Appendix II, Figure 137). The cylinder was pressed over the paper support, creating an image formed by small, diffuse squares with varying ink density (Figure 26) [1, 4, 17, 18].

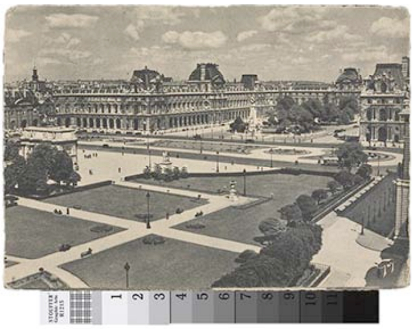


Figure 25 – Rotogravure. Normal view at 45º lighting.

Figure 26 – Rotogravure. 50x view at 45º lighting. The image is formed by squares with ink, separated by perpendicular lines with no ink.

Letterpress halftone was the most common reproduction technique up to the 1950s, because it was easily combined with the commonly used typeset text, because both were relief based. The cross-line screen needed for this process was an idea of Frederic Ives in 1885-86. It was used for newspaper illustrations, books, postcards etc. (Figure 27) [1, 9, 12, 13, 21].

It utilized a halftone screen on a glass plate to record the object to be reproduced on top of the negative, embedding the image with a pattern. The more lines the screen had per area, the more precise was the final print. Larger patterns are distinguishable even without magnification. Exposure to light was done with the negative placed in contact with a dichromated gelatin surface that covered a copper plate (Appendix II, Figure 139). More recently, like rotogravure, cylinders were used to simplify and speed up the process [4, 11, 12, 21].

The unexposed gelatin was washed off and the plate was etched by an acid bath. The positive image was protected with gelatin in the higher areas of the plate (Appendix II, Figure 139). This was the surface where the ink was later spread on, making letterpress a relief process. Pressure was applied to the metal in contact with the paper support, and the ink was transferred, creating an image composed of dots in highlights, and middle gray and dark areas in squares (Figure 28; Appendix II, Figure 140). These dots are characterized by having well defined edges, where the ink concentrates because of the pressure applied to squeeze it out on the paper. The pressure was also applied to characters, so the print has differences in relief in the text [1, 4, 11]

Figure 27 – Color letterpress halftone. Normal view at 45º lighting.

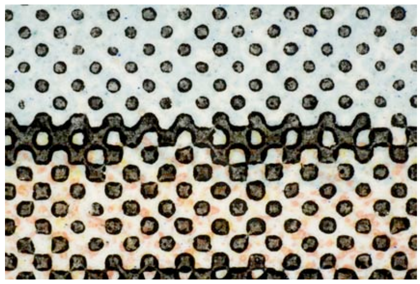


Figure 28 – Color letterpress halftone. 50x view at 45º lighting. The dots show squeeze out along the edges. Middle tones have square to circular dots, while in dark areas the square dots are merged by the edges.

The principle of **offset lithography** (also known as offset litho) was conceived in the mid 19th century, but it wasn't practically applied before 1910, when the offset press was invented. It was increasingly used during World War II, and by the 1960s it became the most common printing process, replacing letterpress. Offset litho has been used for newspapers, books, labels, posters, greeting cards, etc. (Figures 29, 30) [1, 9, 11, 14, 22].

Technically, offset litho prints are made in the same surface as photolithographs, covered with a layer of dichromated gelatin. It's exposed to light in contact with a halftone negative holding an image originally captured with a halftone screen or by using the negative in contact with the screen at the moment of exposure. As lithography, the image is constructed by the opposite properties of water and oily ink (Appendix II, Figure 141). It evolved to rotary cylinders to speed up the process, like rotogravure. When it's time to print the image, the ink isn't directly transferred onto the paper support, hence the offset stage of the process. Instead, it goes from the lithographic surface to a rubber roller/blanket, and finally transferred to the paper (Appendix II, Figure 142) [1, 11, 14, 22].

The final result is visually similar to the one achieved by letterpress halftone, because of the common use of a halftone screen to break up the image. To distinguish these two processes, it is necessary to look into the pattern structure. In offset lithographs, the ink tends to diffuse around the edges of the dots, while in letterpress the ink concentrates around the edges because of the squeeze out (Figures 28, 30) [1].

Figure 29 – Color offset lithograph. Normal view at 45º lighting.

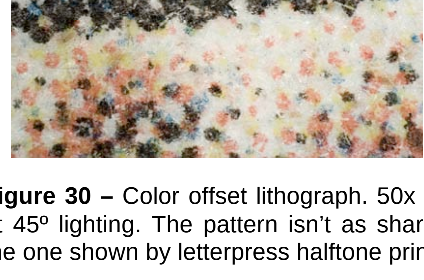
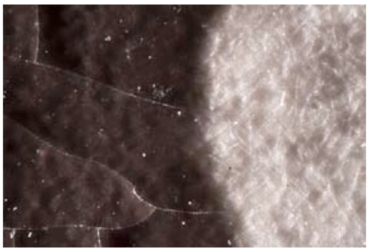
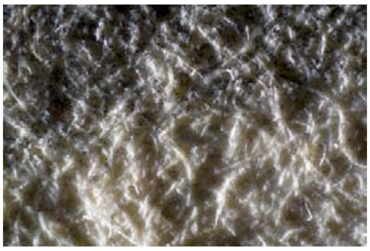
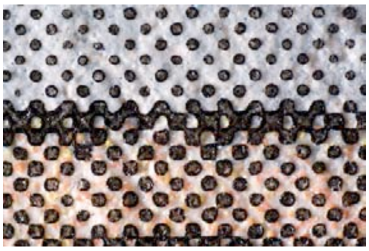


Figure 30 – Color offset lithograph. 50x view at 45º lighting. The pattern isn't as sharp as the one shown by letterpress halftone prints.

Like pre-photographic prints, photomechanical prints don't usually have other layers besides the paper support and the ink. Therefore, when observed under the microscope, it is possible to see paper fibers, in the case of the Woodburytype only in non-image areas (Figures 431-33) [4]. In the case of the samples used, in the letterpress halftone example the paper fibers aren't visible because, as seen in cross-section, there's an extra layer in the paper. This is a finishing layer applied to the paper, which is probably coated with china clay (kaolin, an hydrated aluminum silicate) to provide extra smoothness and more compatibility with the ink. Under UV light, it is shown that this layer doesn't fluoresce. (Figures 33-35) [1, 21].

These processes could be used to make color prints, as some of the shown examples (Figures 18, 19, 27-30). Colored photogravures weren't common, and Woodburytypes could use different pigments to change the general image tone [4]. To create prints in color the photographic image had to be captured with separation negatives (one sensitive to red, another green and one to blue light), or the negative had to be combined with the proper color filters. Dichromated gelatin molds were done, for cyan, magenta and yellow inks, and sometimes a fourth layer black ink was added. The combination of all the ink layers was done in strict angles to avoid the *moiré* effect in the processes that used patterns (letterpress, offset), creating the rosette pattern (Figure 85) [1, 9].

For a summarized version, check Table II on Appendix IV.

Figures 31-33 –Woodburytype, rotogravure and letterpress halftone prints (left to right). 50x view at 90º lighting. Fibers are visible on the non image areas of the Woodburytype, all across the rotogravure surface, and hidden in the letterpress halftone print, due to an extra coating.


Figures 34 and 35 – Letterpress halftone. Cross-sections at a 200x view, in BF reflected light and DF-UV light (left to right). The paper used for this print had an extra coating to prevent the ink from penetrating into the paper fibers. It is not, however, a fluorescent material.

Photographic processes

Photographic prints are here defined as the light sensitive supports that record an image obtained through a negative or positive transparency. Photographic processes can be divided in to many categories, and the approached here are non-silver processes, printing out processes and color photography (chromogenic color and silver dye-bleach). The nomenclature used here is the same as the one used in www.digitalsamplebook.org [2]

Printing-out processes

The first major photographic print processes were developed based on the light sensibility of silver halides. These processes have this designation because when light was used to print an image, the chemical change of the silver could be seen without further chemical development, a property of photolytic silver. This type of silver is composed of very small particles that group themselves in colloids. Because of their size and interactions they have a reddish brown appearance. Printing was done with sunlight and in contact with the negative (usually a collodion glass plate) in a printing frame, therefore not allowing enlargements. The image was toned to improve its stability by converting part of the image into a more stable compound. The metallic particles interacted with the silver colloids, changing their size and consequently their color into a darker brown or purplish color. Prints were fixed with sodium thiosulfate (hypo), a discovery by Hershel in 1819 [4, 12, 13, 17-19].

Salted paper prints were an invention of Talbot in the 1830s, becoming popular in the 1840s. In 1850 Blanquart-Evrard announced a similar printing process using albumen as a binder. **Albumen prints** became the main printing method of the 19th century. Albumen and salted paper prints have many similarities (Figures 36-41). Both were made by applying a coating of silver nitrate with a halide salt solution on a paper surface with a brush, or floating the sheet in this solution. When exposed to light, it formed silver halide particles [4, 12, 13, 17, 18, 28, 32].

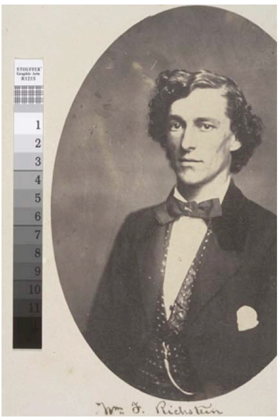
Albumen prints differ on using denaturated egg white (usually by adding an acid) that was fermented by letting it rest for a few days. It was mixed with silver halides, while salted paper has no binder at all. As a result, under high magnification, these prints look similar (Figures 37, 40). However, albumen tends to form cracks with aging, changing the overall look of the print. Some salted paper prints have a gelatin, gum or albumen overcoat, making its identification more difficult [4, 12,17, 28-32].

Supports are similar, from thin, smooth rag paper, usually mounted on a thicker cardboard support after being processed. Standard formats as the *carte de visite* (9x5,5 cm) and the cabinet card (14x10 cm), more typical after 1866, were particularly used for portraiture (Figure 39). Gold toning was a common practice in both albumen and salted paper prints [4, 12, 28, 29, 32].

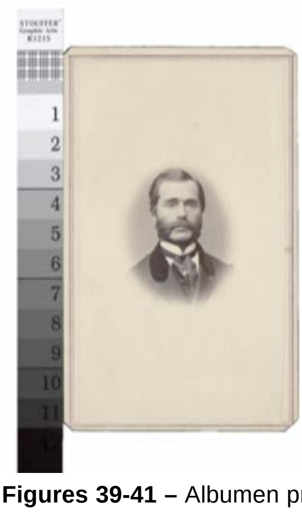
Using albumen as a binder improved image definition and density. The silver particles weren't as absorbed by paper fibers, and the emulsion remained closer to the print's surface (Figures 38, 41). Albumen changed the paper because it created a more uniform surface with less light dispersion, gaining a characteristic gloss that would amplify its popularity. Demand for glossy surfaces encouraged calendaring the paper support, applying two albumen coatings and finish the surface by burnishing it (Appendix III, Figures 151-153) [2, 28-30, 32].

When glossy surfaces were out of fashion, matte albumen prints, with little or no gloss, were manufactured, mostly in the beginning of the 20th century (Figures Appendix III, Figures 154, 155). They were made just as regular albumen prints, but used a rougher paper surface, sometimes with matting agents (like rice starch), and fresh albumen. [4, 29, 30].

Many albumen prints had color elements, either by having hand coloring and/or tinted paper supports. These are no longer seen in many cases because of light exposure and consequent fading (Appendix III, Figure 156) [4, 32].



Figures 36-38 – Salted paper print. Normal view at 45º lighting, 50x view at 90º lighting, and cross-section in the 200x view at BF reflected light (left to right). It is possible to see paper fibers at 50x with 90º lighting. The cross-section shows a very thin paper base, with the emulsion layer on the surface, due to the use of an overcoat.



Figures 39-41 – Albumen print. Normal view at 45º lighting, 50x view at 90º lighting, and cross-section in the 200x view at BF reflected light (left to right). The same aspects can be seen in these images as in the salted paper print. The albumen is in this case in relative good condition, therefore showing few cracks on the 50x view. The cross-section shows the emulsion slightly absorbed by the paper fibers.

Collodion P.O.P. prints were made since the 1860s with glossy surfaces, and in the beginning of the 1890s **matte collodion** prints were popularized. At first they were hand coated, but the introduction of coating machines in 1889 by A. Kurtz made production quicker and efficient. Collodion prints were used greatly for portraiture (Figure 42, 47). They weren't as used after the 1910s, when developing out gelatin emulsions took their share of the market [4, 14, 30, 31].

Collodion was first used for wet collodion negative plates by F.S. Archer [26]. It consists of a mixture of nitrocellulose, alcohol and ether. It becomes light sensitive when mixed with silver halides. Papers were sensitized when floated in this solution, just as albumen and salted paper prints were sensitized with their corresponding emulsions. When too much alcohol was used, a pink and green iridescent effect was created on the surface of the print, which can be observed in some examples. When dried, collodion is colorless and becomes insoluble in water, being suitable to use as a binder. [4, 12, 13, 30]

This mixture didn't adhere to paper as well as albumen, so there was the need to add an intermediate layer to ensure compatibility between materials. In the 1880s, baryta, usually referring to barium sulfate ($BaSO_4$), was introduced to coat photographic papers. This practice became common in the 1890s [12, 29]. It is an opaque white material that can be manipulated to create smooth or rough surfaces, according to the desired effect, enhancing the image's contrast by covering paper fibers, without interfering chemically with other materials in the print (Figures 45, 46, 53). By itself, this is material is does not fluoresce under UV light (Appendix III, Figure 124).

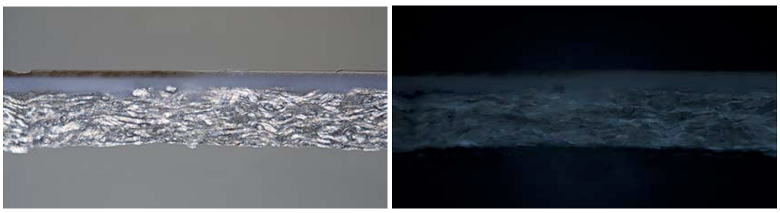
Sometimes dyes were added to the baryta to give a tint to the image, usually in pink and blue shades (Figures 45, 51) [4, 30]. To create glossier surfaces, a thick baryta layer was smoothed down, hiding the natural texture support and after printing and processing the print could be burnished (Figures 42-45). The print was processed in the same sequence as albumen and salted paper prints, and was gold toned to have a warm image tone (Figure 73) [4].

1890s matte surfaces could be differentiated by having a thinner baryta layer (Figure 47) on a non-calendared surface with matting agents (like starch). Matte collodion prints were usually toned first in a gold bath, followed by platinum (sometimes palladium), presenting a neutral color, more towards dark olive green (Figure 48). It resembled the platinotypes surface esthetics in a more affordable way, which made it a popular process (Figures 48-50; Appendix III, Figures 157-158). This type of print was produced until the 1920s [4, 12, 13, 31].

Glossy collodion prints were mounted in the cabinet card format, while it was more usual for matte collodion prints to be accompanied by grey or brown cardboard mounts (Figures 42, 47) [4, 12].

Figures 42 and 43 – Collodion POP print. Normal view at 45º and 0º lighting (left to right). This print has a pink tinted baryta layer. Because it is has a very smooth surface, it shows high gloss under 0º lighting.

Figure 44 – Collodion print at 90º lighting , 50x. No paper fibers are shown due to the baryta layer.



Figures 45 and 46 – Collodion POP print. Cross section in a 200x view at BF reflected lighting and DF-UV lighting (left to right). This print has a relatively thick baryta layer to cover the support. Under UV light, it doesn’t fluoresce.

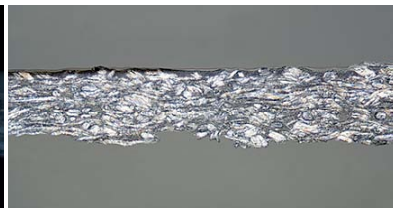


Figure 47 – Matte collodion print. Cross section in a 200x view at BF reflected lighting. The paper surface is much rougher, and the baryta layer is barely seen.

Figures 48 and 49 – Matte collodion POP print. Normal view at 45º and 0º lighting (left to right). Unlike the collodion P.O.P. print, the surface isn’t glossy, because light is being scattered by the surface irregularities.

Figure 50 – Matte collodion POP print. 50x view at 90º lighting. Because the image has a thin baryta layer, its possible to observe paper fibers.

A process that resembled collodion P.O.P. was **gelatin P.O.P.**, differentiated only by the use of gelatin in the emulsion. It was an invention of William Abney in 1882. The P.O.P. designation came from the Ilford Co. in 1891 when publicizing their gelatin paper. In the following year Eastman Kodak released their version, the Solio paper [12, 29].

Gelatin used for photographic purposes is usually from animal origin (bones, etc) and has a varying protein composition. The paper base, development and toning of the print was exactly the same as collodion prints (Figures 42, 51). Distinguishing between them can therefore be very difficult. Physical observation of the prints alone shows that they present the same interaction with light, have a very similar layer structure, image tone, etc. (Figures 42.45, 51-52). Gelatin prints are usually less vulnerable to abrasion that collodion prints. For other distinction methods, destructive chemical tests or analyses may be needed [4,12, 13].

Please consult Table II, Appendix IV.

Figures 51 and 52 – Gelatin POP print. 200x view at 0º lighting (left to right). The smooth surface reflects mostly all the light from the fiber optics.

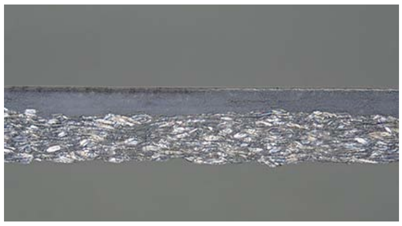


Figure 53 – Gelatin POP print. Cross-section in a 200x view with BF reflected light.

<u>Non-silver processes</u>

The initial lack of permanence of the first silver based photographs encouraged research with other materials. The two main categories of photographic processes that are not based in the light sensitivity of silver are carbon processes and iron based photography (Figures 54-62; Appendix II, Figures 157-159) [1, 13, 17]. Only the first is discussed here.

Poitevin's mid 1850s practical application of the light sensibility of dichromated gelatin influenced many photomechanical processes. This type of gelatin was also used directly onto a paper support in **carbon prints**. The name of the process is misleading since other pigments other than carbon were in this type of prints. All the pigments used, like the ones used in photomechanical prints, had the goal of ensuring image permanence. They varied according to the effect desired, for example to emulate albumen prints a brown pigment was mixed with the gelatin. Carbon prints are similar to Woodburytypes (see p. 7), because in both the final image is composed of pigmented gelatin, but in this case it's light sensitive (Figure 21, p. 7; Figure 55) [4].

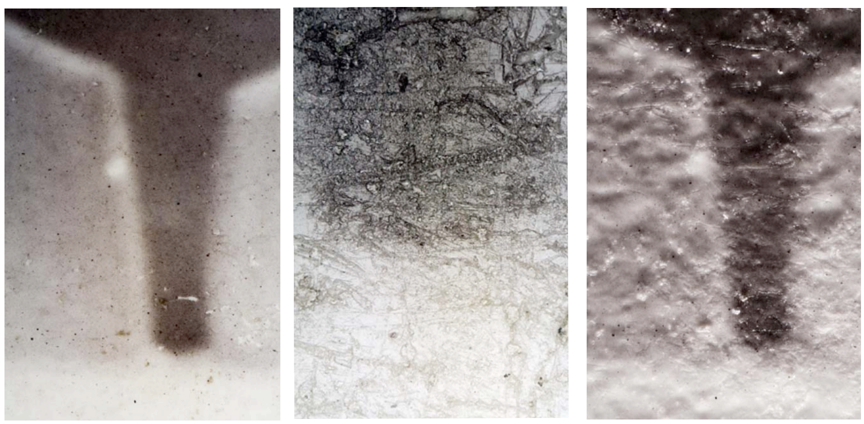
To make carbon prints, a support holding pigmented dichromated gelatin was exposed to light in contact with a negative. The positive image formed in the areas where the gelatin became insoluble. The remaining gelatin was washed off with warm water (Appendix II, Figures 143, 144). A baryta coating was applied to the paper support to conceal the paper fibers. (Figure 61-62) A hardening alum bath was needed for the print to be finished [4, 12, 13, 18].

Swan's invention of the carbon tissue in 1864, composed of a thin layer bichromated gelatin mixed with a pigment, simplified the process and allowed making of colored prints. The rights to the carbon tissue were sold in 1868 to the Autotype Company, and from then on it was available to others to make carbon prints. This process evolved in the beginning of the 20th century into other processes based on the same principle, such as Ozobrome, Carbro, Raydex and Vivex (Figure 58; Appendix II, Figure 144) [17, 19, 24, 25]. For colored prints, like Carbro, separation negatives were needed to register the corresponding parts of the spectrum. Each layer was held in a temporary celluloid support and then assembled together in a final support, usually paper, trying to avoid miss registration between them [12, 17, 19, 24-26].

As Woodburytypes, carbon prints show differential relief, because in both images the thickness of the gelatin defines high-density areas, and non-image areas have no gelatin. (Figures 55-57) [4, 12].

Summarized information is on Table 4, Appendix IV.

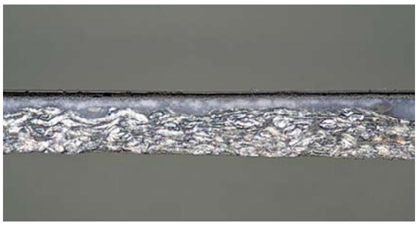
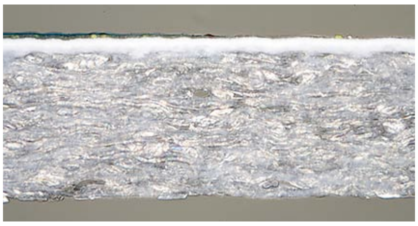
Figure 54 – Carbon print. Normal view at 45º lighting.



Figures 55-57 – Carbon print. 50x view at 45º, 0º and 90º lighting (left to right). Pigment particles can be seen at 45º. At 0º the image shows differential gloss. At 90º the paper fibers aren't seen due to the presence of a baryta layer.

Figure 58 – Carbro. Normal view at 45º lighting.


Figures 59 and 60 – Carbro. 50x view at 45º and 0º lighting (left to right). At 45º it is possible to observe pigment particles and missregistration between the blue and yellow layers. At 0º the image shows differential gloss.

Figures 61 and 62 – Carbon and Carbro. Cross-sections in a 200x view, with BF reflected lighting (left to right). Both prints have a baryta coating to separate the gelatin layer from the paper support. In the Carbro example, the color layers are tightly overlapped.

Color Photography

The fascination with colored prints took its first steps up until the early 19th century, with chromolithographs, color woodcuts, and then photomechanical prints in color, hand colored photographs and early studies on photography. In the beginning of the 20th century color photography became a possibility, with additive color (Autochrome, Joli, Utocolor, etc.). Images were obtained in a transparent support (glass or plastic), combining blue, green and red dots in the eye of the viewer. Investigations on color motion-picture film were another contributor to the inclusion of color in photographic materials, in additive and subtractive color [12, 15, 22, 25, 27, 30].

Tripack supports were developed through the concept of tripack negatives. It was first conceived by Ducos du Hauron in 1895, and consisted in having in the print or negative three layers that were sensitive to different parts of the spectrum, yellow, magenta and cyan dye layers, respectively sensitive to blue, green and red light. Images could be captured with one exposure, suppressing the need for separation negatives and assembly processes, such as Carbro. Shinzel was the first to apply this idea to printing supports in 1905, using silver halides as the light sensitive agent. Making prints in subtractive color became possible due to the discovery of dye couplers by Fischer in 1911, patented in the following year. Joining a coupler with the oxidizer to form the dye became the basis for chromogenic photography [13, 15, 16, 18, 24, 27, 30, 32].

The invention of long chain couplers, composed of hydrocarbons, to avoid dye migration in between the dye layers, was also another step forward in enhancing the quality of color photography. Agfa scientists developed this concept in the 1930s, sharing it with Ansco, since the companies became partners in 1928 [30]. Both of them released products using long chain dye coupler technology, the **Ansco Printon** in the Minicolor (6x9 cm and 13x19 cm) and Kotavachrome (21x26 cm and 77x102 cm) formats (1941) and **Agfacolor** Neu (1936), only widely available after 1949 (Figures 63-68). White pigmented acetate (with titanium dioxide) or the traditional paper fiber base was used as support for these prints. In the late 1960s white pigmented resin coated (RC) surfaces (polyester layers) were introduced to speed up the processing time. RC can be identified with UV light because of its typical blue fluorescence (Figure 67, 68). Ansco Printon was produced until 1973, while Agfacolor was continuously adapted along the years to improve dye stability [12, 13, 22, 24, 25, 27].

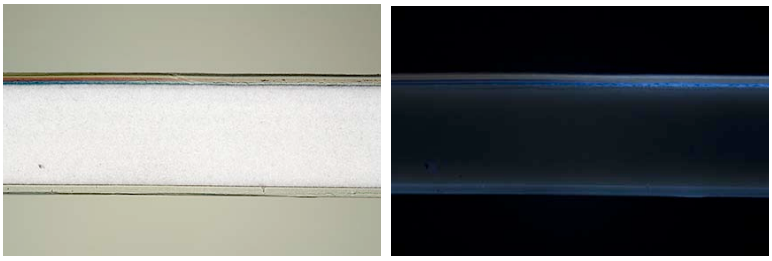
Silver halides were the light sensitive material in the color layers, at first colorless because no reactions had occurred between the silver and the couplers. In Ansco Printon prints, they were in more quantity in the bottom cyan layer, because light had to go through all the other dye layers to get there. A yellow filter between the yellow and magenta dye layers, and an anti-halation layer, to avoid transmission of light during the print's development, were also present in the layer structure of the prints. The print went through B&W development, to develop the silver. This created a negative image that was washed out, so the remaining silver, in the color developing solution, promoted the reaction between the dye couplers and the developer to form dyes in each layer. More dye molecules would form where more light was received. The silver was bleached off of the print. To finalize the print, it when through a stabilization step (Appendix II, Figure 145) [13, 22, 27, 33].

In Agfacolor, when the print was exposed to light, a color developer reduced the silver and changed it into its metallic form. This silver could then oxidize the developer, and in turn react with the specific dye coupler for each layer. The silver was removed through a bleaching step, and the colored image remained in the support. The print when through a final stabilization bath [25].

Kodachrome, a chromogenic process first used for motion picture, introduced by Kodak in 1935, didn't use long chain couplers. Instead, Godowsky and Mannes, hired by Kodak, conceived a process where the couplers were placed in the developing separate solutions for each dye. Each development acted only in a specific color layer, not affecting the others (Appendix II, Figure 146). These types of print were more stable than the previously described. Kodachrome prints were made on an acetate base, and later in RC (figs 69-71). Kodak continued to work in similar products, such as the Kodak Prestige, Kodak Ektacolor, etc. [12, 15, 22, 25, 27].

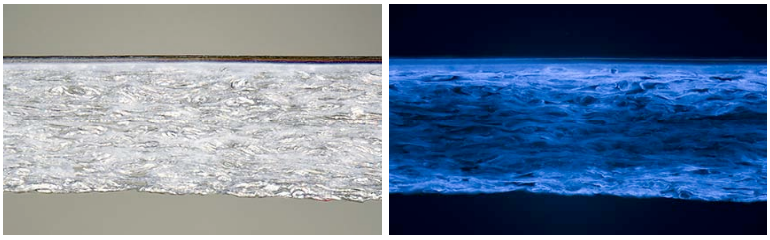
In resemblance of Agfacolor and Ansco Printon, the support had three dye layers with silver halides. A yellow filter was also present in between the blue and green sensitive dye layers. Bleaching, to take it out of the emulsion of the cyan layer, followed B&W development of the silver. Afterwards, the print went through a developing solution, to create the dye. This had to be repeated for every layer separately, which made it a complex process. Released formats were the same as the ones used by Ansco Printon, the Minicolor and Kotavachrome, renamed respectively 2X and 5X [12, 15, 22, 25, 27].

Figure 63 – Ansco Printon. Normal view at 45º lighting.



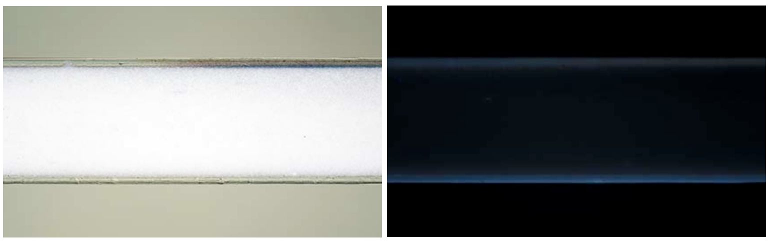
Figures 64 and 65 – Ansco Printon. Cross section at 200x view, with BF reflected light and DF-UV light (left to right). The fluorescence shown on top and bottom layers is caused by the use of an acetate base, in the middle section mixed with TiO_2.

Figure 66 – Agfacolor print. Normal view at 45º lighting.



Figures 67 and 68 – Agfacolor print. Cross section at 200x view, with BF reflected light and DF-UV light (left to right). This print has a fiber core in between two RC layers, that the print this strong fluorescence.

Figures 69 – Kodachrome. Normal view at 45º lighting.



Figures 70 and 71 – Kodachrome. Cross section at 200x view, with BF reflected light and DF-UV light (left to right). This print has the same base type as the Ansco Printon example shown in Figures 63-65.

Ilford introduced in 1963 **Cibachrome**, today still marketed as Ilfochrome, based on Dr. B. Gaspar's work in the early 1930s. This is a **silver dye bleach** process, where bleach (hydrogen peroxide) is used during the development of the print. In this way, the negative silver image marks the areas where color dyes (usually azo dyes) should be destroyed, since the dyes are already formed when they are placed in the support. Color definition in Cibachrome prints had quality that came from the pre-formed, stable azo dyes and the existence of dye migration blocking layers between the dye layers. [12, 15, 22, 24, 25, 27, 34, 36, 37]. Structurally, Cibachrome prints had a yellow filter between the blue and green sensitive layers, like the supports used for chromogenic prints. The base changed from acetate to polyester, both with white pigment to allow viewing the print in reflected light and not only as a transparency (Figures 72-74) [24, 34, 36]. The oxidized bleach reacted with the dyes pre-placed in the emulsion layers, turning them into amines, which destroyed their colored structure. The remaining positive image was fixed and went through a long wash. This complicated procedure was simplified in 1974 for consumer use, and an amateur version of Cibachrome was launched, named Cibachrome A, followed by the first Cibachrome printing kit the next year [12, 37].

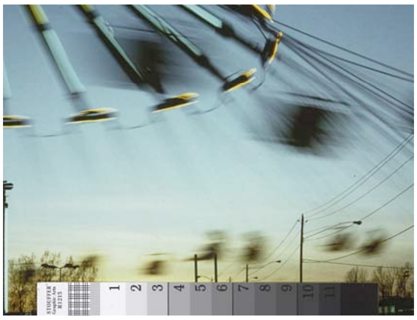
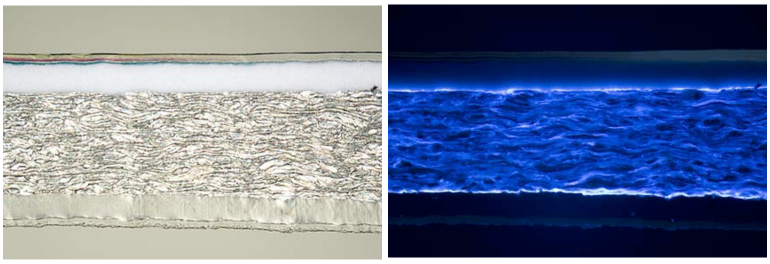


Figure 72 – Cibachrome print. Normal view at a 45º lighting.



Figures 73 and 74 – Cibachrome print. Cross section at 200x view, with BF reflected light and DF-UV light (left to right). A fiber based core is in between two RC coatings, which is shown by the fluorescence. The dye layers are over a white pigmented RC layer for more contrast.

Color prints used smooth synthetic polymer supports. Consequently, their surfaces are very uniform, causing light to reflect and create gloss (Figures 75-78). Even if they are over a fiber base, no fibers can be seen, because they are sandwiched between plastic layers (Appendix III, Figures160, 161). Check Table 5 on Appendix IV.

Figures 75-78 – Ansco Printon, Agfacolor, Kodachrome, Cibachrome (left to right). Normal view at 0º lighting. All prints are very smooth, and therefore very reflective.

Digital processes

Digitally created prints diverge from the ones made by conventional photographic processes because the final print was generally never light sensitive, just like photomechanical prints, and in addition they are obtained through a digital file, that can be manipulated in a computer, not by a negative in a transparent support [13].

There are three main digital printing processes: electrophotography, dye transfer and inkjet. It's possible for all of us to testify the daily use of these very technology dependent techniques.

Electrophotography, the process through which photocopies are made, was invented in 1938 by Chester Carlson, and was widely adopted in the 1960s. At first it was only black & white, but in 1973 Xerox released the first color printer. It later evolved with the use of laser and digital printers in the 1980s. Copies made through these methods tend to be done in glossy clay coated paper, or in ordinary uncoated paper (Figures 81, 86) [39-41].

The technological principle in which electrophotography is based implies the use of materials with opposite charge. Their charge is changed by a corona, according to the part of the printing phase. A metallic surfaced cylinder inside the copier receives light communicated electronically. This light changes the charge of the cylinder, and in these areas a latent image is formed, attracting toner particles with an opposite charge. Toner consists of a waxy medium with pigment, charge control agents (CCAs), and in an organic solvent, if they are used in liquid form. To transfer the image into paper, the electrical charge in the cylinder is reversed, so that now there's only attraction between the toner and the support [22, 40-44].

The paper holding the toner goes through a fusing cylinder to ensure the adhesion between the support and the dry toner, while liquid toner just needs to dry for the print to be finished. If the print is done in color, this process will have to be repeated for every color in sequence (cyan, yellow, magenta and black), and the image will be constructed, just like off-set, with a rosette pattern (Figures 83, 85) [39, 40, 43, 44].

Consequently, dry toner tends to be on a surface level rather than penetrating the paper support, and has more of a dusty quality related to the pigment particles being on the surface, unlike the more defined dots composed of liquid toner. Because the pigment is on the paper surface, the print shows differential gloss. (Figures 83, 84). The liquid toner print shown in this case is coated, so the pigment doesn't spread through the paper fibers, but maintains the same level of gloss as an uncoated paper. Coating exists in both sides since copiers allow using both sides of the sheet (Figures 85, 86) [40, 45].

Figure 79 – B&W electrophotographic print. Normal view at 45º lighting.

Figure 80 – B&W electrophotographic print. 50x view at 90º lighting. The dusty quality of the print can be seen.

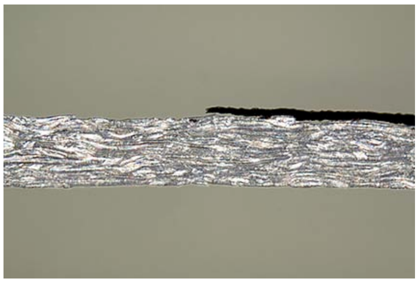


Figure 81 – B&W electrophotographic print. Cross-section at 200x view at BF reflected light. The dried toner is deposited on the surface of the print, and is not absorbed by the fibers. This can lead to the separation of the two layers.

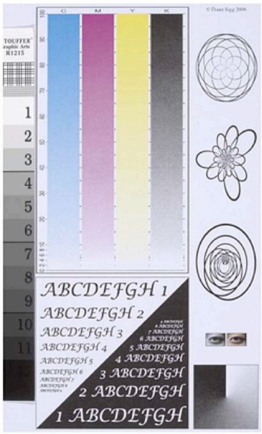
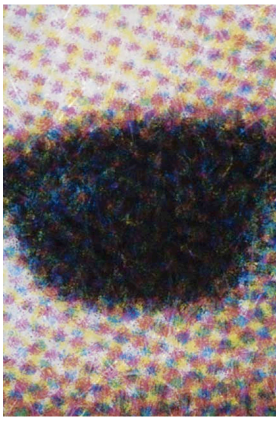
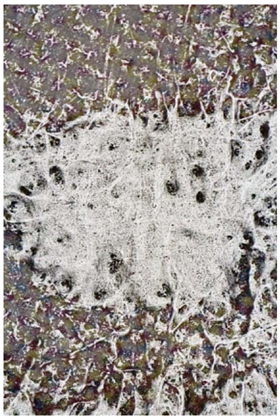


Figure 82 – Color dry toner electrophotographic print. Normal view at 45º lighting. The targets used for other digital prints have the same appearance under this lighting.





Figures 83 and 84 – Color dry toner electrophotographic print. 50x view at 45º and 0º lighting (left to right). The dots have a dusty look on a normal viewing angle. Differential gloss is very evident in this case.

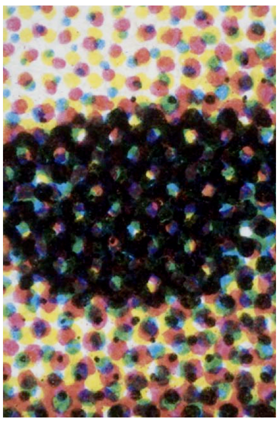


Figure 85 – Color liquid toner electrophotographic print. 50x view at 45º lighting. The liquid toner created dots with defined color edges. This sample shows also the rosetta pattern on the bottom area.

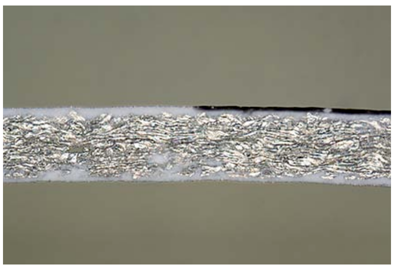


Figure 86 – Color liquid toner electrophotographic print. Cross-section at 200x, with BF reflected light.

Dye sublimation or thermal transfer dye diffusion (D2T2) is a printing process that evolved from the dye transfer (D1T1) and the dye thermal transfer (D1T2) processes. Although the process is called sublimation (passage from solid state to vapor), this physical change doesn't actually occur. Nöel De Plasse originally laid out the basis for these processes in 1947 but it was only in the 1980s that the first dye diffusion printer was made. The first photo quality printer of this type was Kodak's XL 7700, released in 1989. Since then, this process has been used in kiosk and desktop printers, to print images for identification cards, labels and signs [39, 40, 46-50].

To make an image through this process, inside the printer is a color ribbon, with heat resisting dyes in a wax medium, in separate areas for yellow, magenta, cyan and black, and also a finishing layer for protection against UV light and handling (Appendix II, Figure 147). It is heated preferentially according to the areas where an array of resistors, connected to a computer. The heat levels of each resistor can vary from between zero and 256, in relation to the RGB numbers of each pixel that compose the image in the digital file. The support is held in a cylinder, to turn for every new line that is printed. Combining different colored dots and changing the ink density in the individual dot creates a truly continuous image. Dots tend to merge with each other, and the only pattern that can be seen is this type of print comes from the array of resistors printing a line at a time (Figure 88). [42-45].

Support used for photographs can have white pigmented RC coatings, so the print has a glossy look (Figure 87, 89), inclosing a paper support. On top, a polymer receiving layer traps the diffused dyes. Right under it, there's a voided layer, composed of special polymers designed especially to avoid heat loss in the process (Figure 89) [49, 50].

Figure 87 – D2T2 print. Normal view at 0º lighting. Because it is an RC coated sample, the surface is smooth and can reflect light easily.

Figure 88 – D2T2 print. 50x view at 45º lighting.

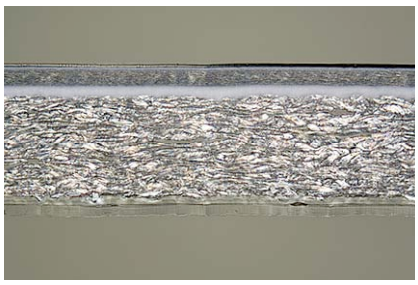


Figure 89 – D2T2 print. Cross-section at 200x, BF reflected light. The layer between the white pigmented RC coating and the top dye layer is the

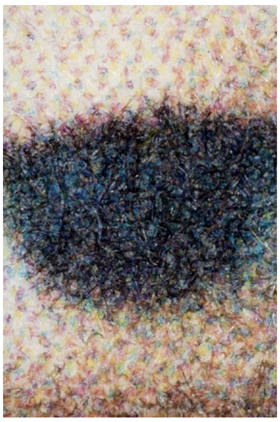
The most widely known digital printing process is **inkjet**. It was first introduced to the fine art world with the *glicée* or Iris print in 1989. Technological advanced allowed for the creation of more precise images, and by 1994 Epson released what was considered the first inkjet photorealistic printer. Concerns with the permanence of the used water based inks and their color range have also led to great development of the field. [40, 42, 46, 51-53]

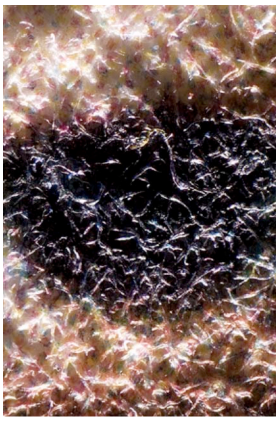
There are two main types of inkjet, both using inks based on the CMYK system: continuous and drop-on-demand (D.O.D.). In the continuous process, where there's a stream of droplets that may or may not be used in the final print, as there's a magnetic field that deviates the unwanted droplets into a gutter, where they can be later retrieved by the machine (Appendix II, Figure 48). Iris prints were made with this system, and when made in color, have a rosette pattern composed of round dots (Figure 119) [40, 43-45, 55].

The most common type of printers used D.O.D. technology. In this case, the ink is only turned into a droplet if the computer sends a signal that the drop is needed in a particular area. The combination of different color drops forms the image. Depending on the system used, the inks may be water or wax based [40, 43, 44].

The paper supports used for inkjet are chosen according to the desired final effect. Uncoated papers (usually matte) (Figure 90) were the first type used. Since ink droplets are absorbed by the paper fibers and the print loses definition, other surfaces were introduced, combining different paperweights, with RC coatings and receiving layers (Figures 93-100). An evolution towards coated layers led to two different papers with different receiving layers. Porous surfaces are typically used for pigment-based inks, and are the most common type of support for inkjet prints. These surfaces have a layer of inorganic particles (amorphous alumina or silica) with cavities that trap the pigment (Figures 93, 95-97). Swellable supports have a top layer composed of an organic polymer that swells as it receives the liquid ink, and as it dries keeps the ink inside (Figures 94, 98-100) [42, 45, 50, 56].

Please go to Table 6 on Appendix IV.





Figures 90 and 91 – Iris print. 50x view at 45º and 90º lighting (left to right). The ink droplets aren't well defined because the paper has no coating, showing all the paper fibers.

Figure 92 – Iris print. Cross-section at 200x, with BF reflected light. The ink is absorbed by the top fibers. Also, this paper support is relatively thick.

Figures 93 and 94 – Inkjet prints. Pigment based ink on a porous support and dye based ink on a swellable support (left to right). Normal view at 0º lighting. The irregular surface of the porous support doesn't reflect much light, but the opposite happens with the swellable support, that has a smooth surface.

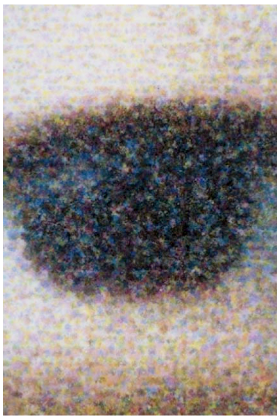
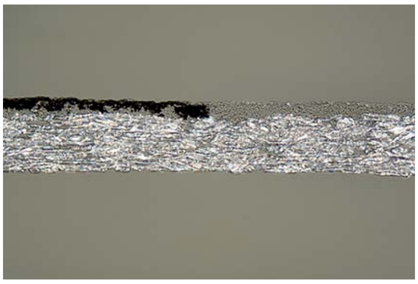
  

Figure 95 – Inkjet print (pigment) on porous support. 50x view at 45º and lighting. The surface is covered by random inkjet droplets.

Figures 96 and 97 – Inkjet print (pigment) on a porous support. Cross-section at 200x with BF reflected light and DF-UV light (left to right). The fluorescence in this support is related with the polymer used as the cavities for the pigment to be held in.

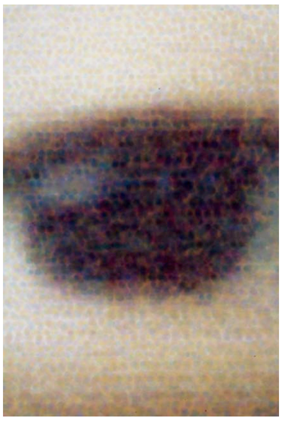
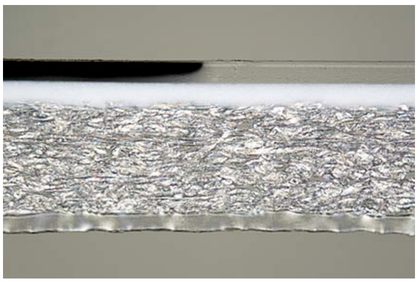
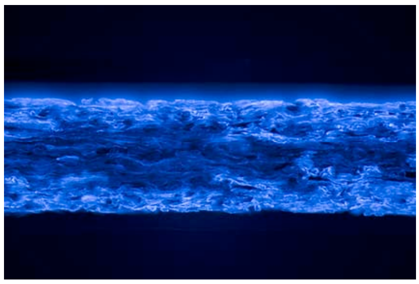
  

Figure 98 – Inkjet print (dye) on swellable support. 50x view at 45º and lighting. Ink droplets can be seen without seaming too random.

Figures 99 and 100 – Inkjet print (dye) on a swellable support. Cross-section at 200x with BF reflected light and DF-UV light (left to right). The RC backing and front layer cause this fluorescence.

CONCLUSIONS

This is, as many other areas of conservation, a subject that demands knowledge from many different branches: technology, history, both organic and inorganic chemistry, physics and material science. It's not a closed subject; it needs to feed from complementary knowledge. It's no wonder then that a history book about this subject will have at least a small description of the materials used for a particular print, and how they were prepared, and a technological book is likely to reference historical milestones in the evolution of the same process. There are different focuses, but the common purpose to increase knowledge about prints.

Although there are many more accurate, objective methods through which print identification and characterization can be made, such as FTIR to distinguish collodion and gelatin P.O.P. prints through their functional groups, or the XRF explain if the color of a print is more influenced by the gold or the platinum used in its toning bath, it's also true that most those analytical methods aren't available to everyone that wants to understand prints in a deeper level. It's necessary to consider that for most purposes, a simplified approach is more practical and has more use for the ordinary conservator, working in a museum with a low budget for technical equipment. A trained eye, accompanied by a hand loupe and a stereomicroscope, relatively common tool in conservation labs is, can many times be enough. Even when a conclusion isn't reached, it is usually good enough of an answer to understand the main characteristics, deterioration problems and appropriate preservation conditions for a determined print.

Most of the aspects of print technology have already been studied, and literature can be found with great detail on the subject. However, when first learning about a specific subject, an overview is always needed first. The depth of knowledge in the technology field that a conservator really needs is not as vast as the technician making the prints, but needs to be thought of, just like there's knowledge in how medieval paintings were made. Before the 19^{th} century many objects were made without the use of machinery, which doesn't happen nowadays. The loss of machines implies the loss of the knowledge of how a particular print was made. Most people can still grind a pigment, but very few or none can build up a factory to understand the complex chemistry and producing stages of something like an Ansco Printon print. And why would you want to do try to repeat it? To understand it, to feel how difficult it really was to create that, to create a new appreciation for knowledge that human kind has built up in yet another area, to add value to the resulting prints you're looking at.

All the processes studied allow creating reproductions. But are reproductions all exactly the same? They are supposed to be, but subtle differences can usually be seen with a microscope. In a general sense, it seems that the easier it is to make a reproduction, the less value it will have. It is "less unique", it becomes cheaper to make and to buy. It's not by chance that buying a fine-art inkjet photograph won't have the same market value as a B&W silver gelatin print. Still, the work behind creating the matrix to obtain all these reproductions, whether it's based on manipulating software in a computer or perfecting edges of a metal plate, may be of great extent, so the print maintains its value because they are diverse and unique in their own way.

Differentiating between photomechanical and photographic prints can immediately separate stable, pigment based images from silver images, usually more sensitive to light and humidity conditions. Separating color photographs from digital prints can be particularly difficult because there are also traditional color photographs being printed digitally.

Documenting surface qualities of prints digitally demands more equipment than just its identification and characterization, but still, standardizing lighting techniques and software may be useful, for example when for comparing prints that are not geographically close. In the case of www.digitalsamplebook.org, it acts as a reference point for print identification. The evolution towards www.graphicsatlas.org will make these images even more powerful, specially when it concerns to passing down the knowledge acquired about images through images [2].

ACKNOLEDGMENTS

I would like to thank: James Reilly, Ryan Boatright, Gawain Weaver, Zach Long, Patricia Ford and everyone else at IPI, for their acceptance and continuous support; Prof. Dr. José Sanches Ramos from FBA-UL; Prof. Dr. Pires de Matos and Ana Maria Martins from FCT-UNL; the help of Luisa Casella and Catarina Mateus; my supportive family and patient friends.

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APPENDIX I: Experimental

The main characteristics depicted on the imaging techniques described here are summarized in Appendix IV, Table 7.

Camera and system calibration

All the imaging is done with the Canon EOS 5 digital SLR camera, with 12.8 MP resolution. The lens used in the copy stand is the Canon Macro EF 100mm. For the shots done with the Olympus AX70 compound microscope, this lens is taken out. The camera is attached to the microscope it with an adaptor, so it captures the image directly from the objective lens.

Images are captured in the raw file format, extension .cr2 (Canon's format), in which it is already a digital negative. Theoretically, this makes possible for the image to be retrieved in the original conditions in which it was taken. Digital imaging is in this case very appropriate since the images are used in the web [57].

The imaging system needs to be calibrated so that the obtained images are accurate in relation to reality, and with each other. The computer monitor is calibrated with an Eye-One Photo SG, and the obtained images are also calibrated with the RAGS system. The RAGS calibration is first done photographing a 24-patch GretagMacBeth ColorChecker (Figure 101), and with the Adobe Photoshop software, creating a set of characteristics in a digital camera profile, to make it look as accurate as possible. These characteristics are saved in the calibration file, and are then applied to all the image files obtained with the same lighting angle and magnification as the target.

After the image file is calibrated, it is saved in the .dng (digital negative) format, the extension that Adobe applies to the raw file. This allows returning to the original parameters the file was made in, since it has an XMP metadata file that is always attached to it.

.

Figure 101 - 24-patch GretagMacBeth ColorChecker. In http://www.xrite.com/product_overview.aspx?ID=685&Action=support&SupportID=3308 (accessed December 11th 2007)

Copystand

The vertical copystand holds the prints horizontally, in parallel with the camera attached to the column, making it easier to avoid key stoning and other distortions. Light sources are usually mounted in the copystand, and additional lights in the room are shut down. The prints are placed over a perforated surface that is attached to a vacuum. This avoids light interferences by flattening the print, and keeps the print in the right position for shooting. The background is usually black, to avoid more reflections, and is usually edited out later on Adobe Photoshop [58].

The 45º reflected light (normal lighting) shot is used to capture an image of the complete object, therefore the distance from the object to the camera can vary (Figure 102). Right now, on www.digitalsamplebook.org, the imaging has been done all at the same distance of the print, at 76,2 cm, but bigger prints are photographed with the lens further away or it will only part of the image will be captured [2].

The copystand has four strobes (flash lights with 120 v, 21w, and 5900ºK), 2 in each side of the camera, being held by the copy stand arms, pointed at the print in a 45º angle (Figures 102, 103). This position eliminates interference from textured supports and surface gloss and avoids having less light on the corners of image [58]. Using flashlights instead of tungsten continuous lights eliminated the problem of over heating the print's surface, and no special filters are needed to calibrate the image due to the light source. The back wall next to the copystand is painted black to eliminate unwanted reflections.

The acquiring conditions are F22 aperture, sensitivity ISO 100, and 5900ºK temperature (to match the lights used). The shutter speed is adjusted. The shot is made with the Stouffer Graphic Arts R1215 grayscale (Figure 104). This view is used to see the image subject, tone, contrast and apparent sharpness. The examples shown that were captured in this way are Figures 1, 3, 5, 8, 16, 18, 20, 23, 25, 27, 29, 36, 39, 42, 48, 51, 54, 58, 63, 66, 69, 72, 79, 82, 105, 106 and 157.

The same can be done for back view, specially if there are any stamps, inscriptions or other information on the back of the support, or just to see what the base tint is. The back view isn't used in www.digitalsamplebook.org, but it is an important for documentation view (Figures 105, 106) [2].

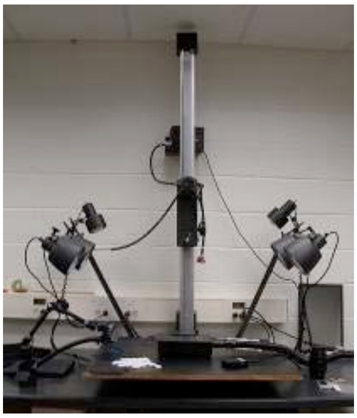


Figure 102 – Copystand setup for 45º lighting used at IPI.

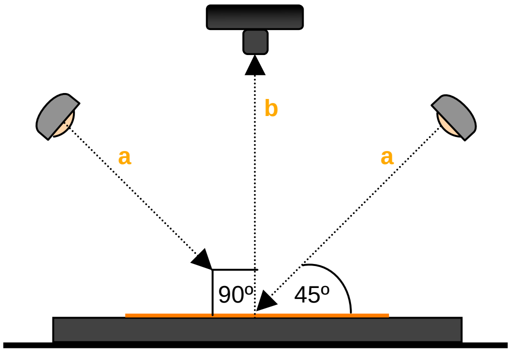
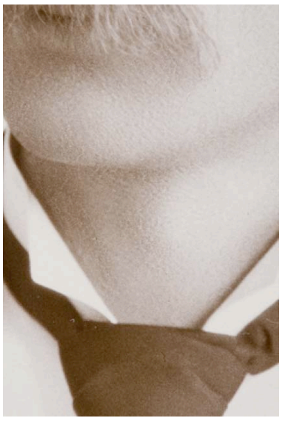


Figure 103 – Standard 45º lighting setup scheme**.** Light comes from both sides at a 45º angle (a), and is captured by the camera (b). Adapted from http://www.kodak.com/global/en/consumer/products/techInfo/am100/am100.shtml (accessed June 15th 2008)

Figure 104 – Stouffer Graphic Arts R1215 grayscale. This scale has twelve different shades of grey. In http://www.stouffer.net/graphics/12.jpg (accessed December 15th 2008)

Figures 105 and 106 – Albumen print in the *carte de visite format,* at 45º lighting. This example from the IPI collection, not on www.digitalsamplebook.com, is shown to demonstrate an example in with the back of the print has information, in this case from the studio in which the print was made.



Figures 107 and 108 – Collodion P.O.P. and matte collodion prints (left to right). 45º view in the macro shot. In these images it is possible to observe image structure (both images are continuous tone), the image tone (the collodion print has a warm dark drown color and the matte collodion has a cooler, dark green tone). Image definition is another detected feature.

At a 41,2 cm distance, for macro photography in 45º light, the conditions are changed to F2.8 aperture, ISO 100, and 3100ºK temperature, adjusting the exposure time according to the print. The images captured in this view can be useful for showing patterns or details (Figures 107, 108). This technique was used to create the images shown in Figures 4, 6, 9, 21, 107, 108 and 156.

A 45º UV light shot can be made in a different copystand, with 2 mercury lamps placed at a 45º angle from the print. However, this view has yet to be included in www.digitalsamplebook.org. There have been discussions about ways to cut down the visible light part of the spectrum of the light sources, to ensure that there's no interference from apparent fluorescence. This is preferable to using filters in the camera lens or to treat the image with software after the image has been acquired. Also, another issue is what kind of scale can be used as reference for UV light, in order to calibrate the image properly [2, 63].

The axial shots (0º lighting) are made using a fiber-optic light source that faces a half-silvered mirror. The mirror is placed at a 45º from the print and the camera lens, that is 20" (51 cm) from the print (Figures 109, 110). The image is captured with an F8 aperture, ISO 100, 3100ºK temperature and 1/2 s acquiring time. Specular reflection is greater on smooth surfaces, because light is less scattered, like in glossy collodion P.O.P. surfaces (Figure 43). On rougher or textured surfaces (with matting agents or supports without coatings or with applied textures) light will have more interferences, so it will be more likely to diffuse more uniformly, like in matte collodion prints (Figure 48). There are a particular group of prints that might show differential gloss (low and high density areas reflect light in distinct ways), caused by having the image forming material in a higher relief that the support, like electrophotography and Woodburytypes (Figures 21, 22; Figure 83, 84). Images captured using this technique can be found in Figures 43, 49, 52, 75-78, 87, 151-153 and 158.

Macro photography is also done in this view, at the same distance used for 45º light. This view is useful for detecting how gloss is shown by the surface, including differential gloss (Figures 111, 112). This magnification was used in Figures 22, 93, 94, 111 and 112.

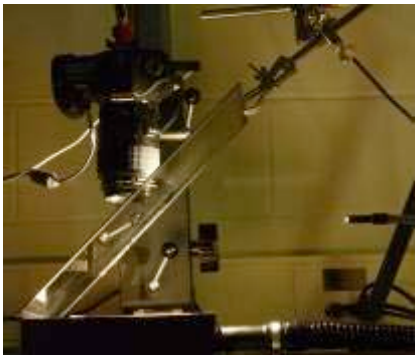


Figure 109 – Copystand for the axial light shot, showing the mirror and the fiber optic cable.

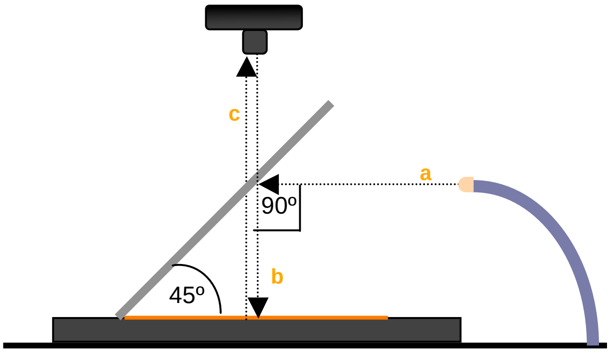
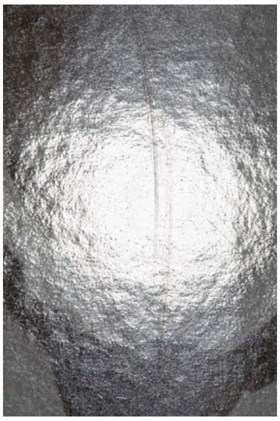


Figure 110 – Standard 0º lighting set up scheme. The light comes from the fiber optics (a), is scattered upon the print's surface by reflection from the silver mirror (b) and its interaction is captured by the camera (c).



Figures 111 and 112 – Collodion P.O.P. and matte collodion prints (left to right) at the macro shot, at 0º lighting. Because the surface is so smooth on the collodion P.O.P. sample, light is reflected almost entirely, and the silver image is barely seen. The opposite happens with the matte collodion print.

Many times, the surface upon the print is made has texture, a quality that is suppressed by 45º lighting, since the purpose of this type of lighting is to eliminate all the shadows from the paper surface [59]. To study the effect of textures in printed surfaces, a fiber optic line is placed in the side of the print, at a 90º angle (Figures 113, 114). This creates a <u>racking light</u> effect, that casts shadows caused by presence of texture, or has no effect if the surface is perfectly smooth (Figures 115, 117). The line light is placed close to the edge of the print, in the same planar level as the base of the copystand. The camera uses the 100mm lens, and has a bellows style adjustable lens hood placed in front of it to ensure that the camera records the light effect coming front the print's surface and as little stray light as possible. The angle of the lighting may cause the surface to cast unwanted shadows, if it is wrinkled or in for some reason no longer flat [59].

Images are acquired with ISO 100 and F/8 aperture. The shutter speed is adjusted to minimize clipping (loss of image information in Dmax and Dmin areas).

In macrophotography the effect of texture on the surface will be noticed (Figures 116, 118). An examples taken in raking light is shown in Figure 7.

Figure 113 – Copystand setup for the racking light shot. The fiber optics cable is on the bottom left

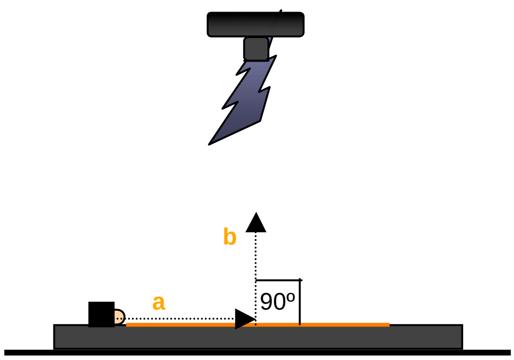
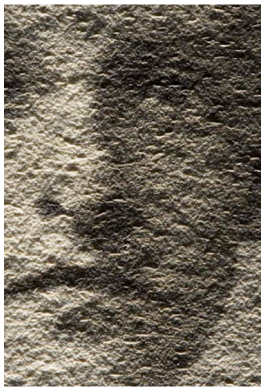


Figure 114 - Standard 90º lighting set up scheme. The light comes from the fiber optic line (a), and the camera captures the light. A bellows is used.



Figures 115 and 116 – Collodion P.O.P. print. Normal and macro shot at 90º lighting (left to right). This smooth surface doesn't show texture in either of the images.

Figures 117 and 118 – Matte collodion print Normal and macro shot at 90º lighting (left to right). The texture of the paper support can be seen in the normal shot, and further detected on the macro shot.

<u>Photomicrography</u>

Microscope

Microscopic techniques have long been used in the conservation field as a common tool for understanding the structure of objects by exploring views and properties that the human eye can't detect by itself [57].

The Olympus AX70 compound microscope is used in similar ways to what is done in the copystand, using a low and a high magnification, with the camera placed over it in a platform (Figure 119). For observation, the eyepieces need to be adjusted for every viewer. For documenting the images obtained, the 5x optical lens is used for surface shots and the 20x for a higher magnification shot on racking light and to view cross sections, where the morphology of the sample can be analyzed. Since the eyepieces are 10x, the standard for microscopes, when using the 5x, the total visual magnification is 50x, and with the 20x the total is 200x [60].

Figure 119 – Olympus AX70 compound microscope with digital camera attachment.

To simulate <u>45º</u> reflected light on the microscope, the light path is polarized and the microscope is set to bright field (BF) (Figure 120). A tungsten light source is used to emulate daylight conditions [57]. This lighting and magnification were used in 2, 17, 24, 26, 28, 30, 37, 40, 55, 59, 83, 85, 88, 90, 95 and 98.

To simulate <u>axial</u> lighting, BF is used without using the polarizers, which makes the light source come down into the print directly, therefore creating the 0º effect. This type of lighting is used in 5x magnification and also for the 20x. With the higher magnification matting agents and other surface characteristics can be depicted (Figure 121). This is done in higher density areas of the print, so that more contrast is obtained in the final image. Acquiring conditions are ISO 100, 3300ºK temperature. The aperture value (F) isn't specified, since the camera lens isn't used (just the objective in the microscope) and exposure time is defined for every print. Figures 56, 60 and 84 were captured in this way.

Because the magnification is higher, it is more difficult to obtain good depth of field for imaging, especially when relatively large particles are in the print's surface. To solve this problem, a few shots are made of the same sample (usually between two and six), varying 5 µm of distance between the sample's surface and the optical lens. The RAW images are processed in Adobe Photoshop, to adjust their contrast, brightness and saturation levels. They are then saved in the .tif file format, so they can be transferred into Image Pro Express software. This software allows composing the files into one single image, in the Extend Depth of Field option, combining all the focused areas of each file (Figures 122, 123).

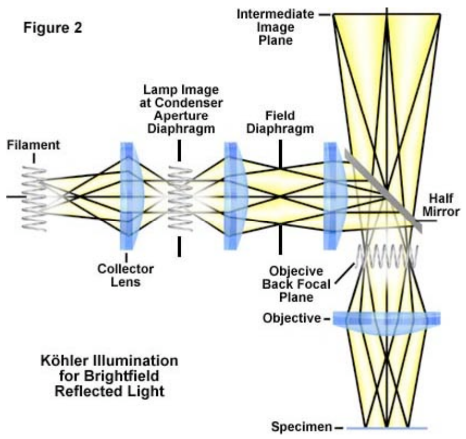


Figure 120 – Scheme for bright field lighting in the microscope. **In** http://www.olympusmicro.com/primer/anatomy/reflectkohler.html (accessed May 20th 2008)

Figure 121 – Matte collodion print at 50x magnification, seen under non polarized BF (simulating 0º lighting). The surface has many irregularities for the light to interfere with.

Figures 122 and 123 – B&W silver gelatin print form a 1937 Kodak Sample Book, named Kodak Royal Bromide Grade T. Left: regular image, with out of focus bottom left corner; Right: composite image, all focused. Non polarized BF, at 200x. Not on www.digitalsamplebook.com.

This makes the imaging technique more subjective, because it has to go through more processing steps, but at the same time objectivity has to be slightly sacrificed for understandability.

<u>Racking</u> light shots in the microscope are obtained by using an exterior small fiber optics light line, and capturing the image seen through the 5x objective (50x of total magnification). The acquiring conditions are ISO 100, and as in normal and macrophotography, the shutter speed varies.

This view shows paper fibers in paper supports that have none or little baryta layer. The images shown in Figures 10-13, 31-33, 44, 50, 57, 80, 91 and 159-161 were captured through this technique.

Cross sections are made so that the side of the paper can also be explored. It is a way of understanding the relationship of all the components of the print [57]. In the Microtome section it will be explained how the samples are prepared.

They are viewed in 20x magnification. Since samples are very thin, almost transparent, they can be observed with polarized BF transmitted light [61]. Depending on the sample, it is possible to see paper fibers or polyester support, the baryta layer, the ink or emulsion layers, matting agents, and relative thickness of every layer and the overall print. Cross-sections of this type are shown in Figures 14, 15, 34, 38, 41, 45, 47, 53, 61, 62, 64, 67, 70, 73, 81, 86, 89, 92, 96 and 99.

In dark field (DF) reflected UV light is used, obtained from a mercury arc lamp. It is possible with this lighting to identify materials sensitive to this radiation through the fluorescence shown by mostly of organic substances, such as resin-coated papers (polyester), optical brightening agents (OBAs) (in silver B&W papers) and some dyes (Figure 124). When using this light, no filters are used in the microscope. The calibration of the image is done subjectively, comparing what is seen in the microscope and the image obtained in the monitor, since there’s interference from visible light [57, 62, 63]. UV light was used in Figures 35, 46, 65, 68, 71, 74, 97, 100, 124, 149 and 150.

Figure 124 – Gelatin P.O.P. print under UV lighting. DF Reflected light at 200x. The top gelatin layer shows some fluorescence, while the remaining layers of the print (baryta layer and the paper support) don’t show the same phenomenon.

Microtome

To view the print's stratigraphy, a sample with about 10x2 mm has to be taken with a cutting knife, meaning that the sample will be visibly affected by the procedure. It shouldn't be done in valuable samples where esthetics are a factor (Figures 125-126). It's usually taken in areas where there's contrast between low and high-density areas, so that in cross-section they can be distinguished, and represent the surface. If there's an area with these characteristics along the edges of the print, it is the preferred place to take a sample from here.

To create serial sections (instead of imbedding the sample) a customized Microm HM 355 S micrometer is used (Figure 127). The sample is attached to a horizontal stand and the blade arm moves, as opposed to the normal micrometer. Ideally, the samples should have regular cross sections, so it will be focused under the microscope. To do so, a sharp blade at 0º inclination is used and the same area isn't used twice to ensure the best performance. Small samples are made different thickness, usually between 20 to 30 µm. Under this value, they tend to become too thin and detach the different layers. When they are too thick, they tend to flip and stay parallel to the lens, and what is observed is the surface of the print and not the section. [57].

The samples are collected with a dental pick and placed in microscopic slide that is then toped with a cover slip (Figure 128). White spirit is used as a medium, due to its refractive index (1.41-1.44) being closer to glass (1.52) than water (1.33), therefore allowing a more accurate visualization of the sample because there is less light interference [64, 65].

The plate is placed in the microscope's stage to be observed at 20x magnification (Figure 129). If needed, the stage is rotated to correct the positioning of the sample, so it can be photographed properly. The image placed in www.digitalsamplebook.org is the sample that shows best the print's structure and has better definition [2, 57].

Figures 125 and 126 – Cutting a sample for cross sectioning.

Figure 127 – Microm HM 355 S micrometer.

Figure 128 – Collecting sample with dental pick.

Figure 129 – Placing the glass slide under the microscope for observation of the cross sections.

Stereomicroscope

The Olympus SZH-ILLD model has been used for print observation and identification, with magnification raging from 7.5x up to 64x (Figure 130).

This tool allows viewing the prints in their real color, a very important characteristic for identification. The image is also viewed in the correct special orientation, facilitating its use. As the microscope, the eyepieces have to be adjusted for individual observation for better understanding of the samples and a more comfortable use [4, 57]

A fiber optic line is used as a light source, and its intensity and relative position is adjusted to the observed sample and the desired effect, and it is used in reflected light (Figure 131). The characteristics depicted with the light at 45º and 90º are the same as the ones seen in the microscope, ranging from seeing paper fibers, surface texture, etc.

Figure 130 – Olympus SZH-ILLD stereoscope.

Figure 131 – Print observation under the stereoscope. In this case, the fiber optics are positioned in a close to 45º, to observe image structure of the print.

APPENDIX II: Print technology illustrations

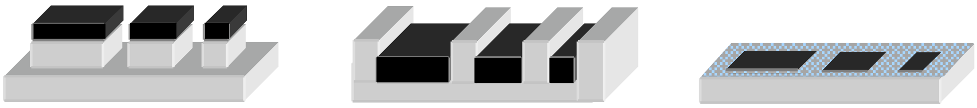


Figure 132 – Pre-photographic processes: relief (ink on the plate's surface), *intaglio* (ink inside the plate's grooves) and planographic (ink across the printing surface, where it's not repelled by water). Adapted from Hayter.

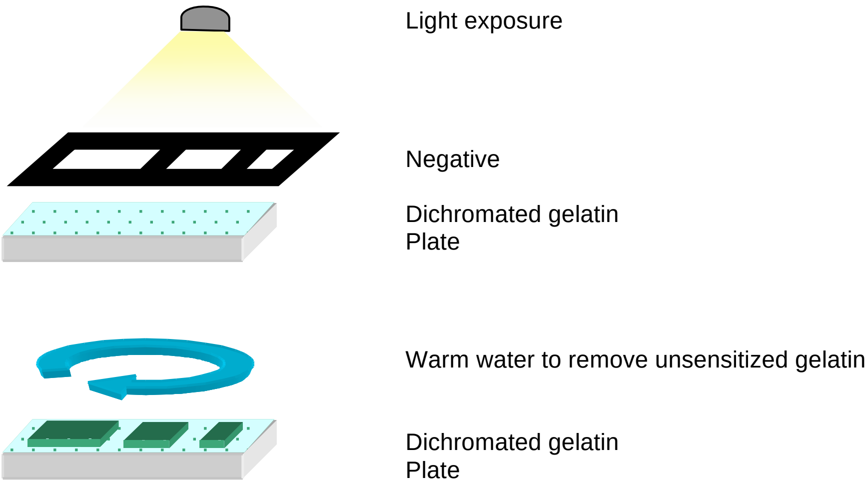


Figure 133 – The first two steps for using dichromated gelatin in photomechanical processes. A negative transparency is used, and the positive image in the gelatin hardens. The remaining is washed of, leaving a gelatin mould.

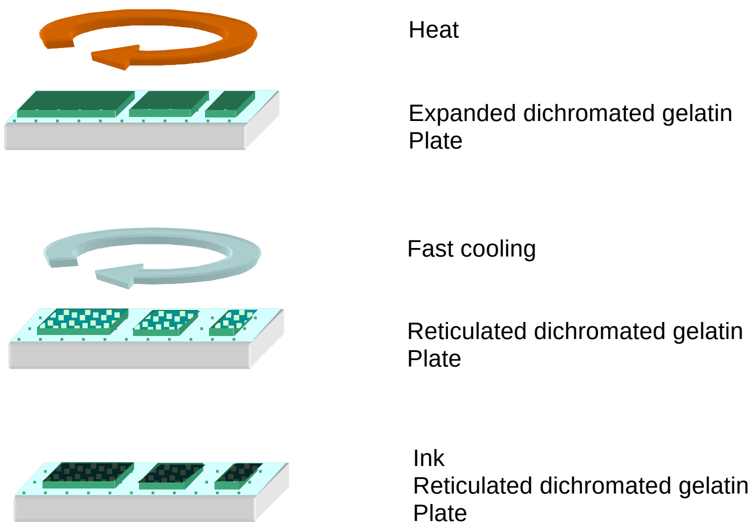


Figure 134 – Production of a collotype. After the steps depicted in Figure 162, the plate goes into an oven. This expands the gelatin. Is it cooled so it retracts and reticulates. The ink can be spread across the surface, and acquires the reticulation pattern.

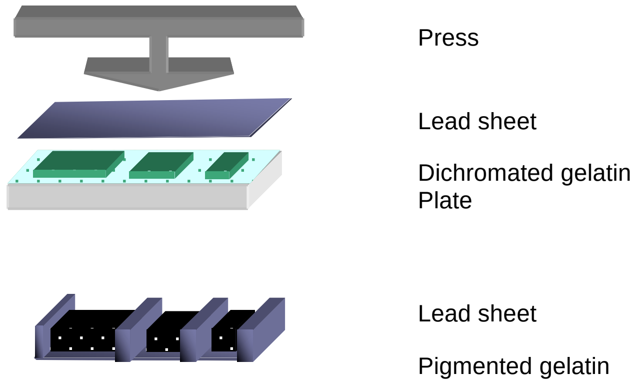


Figure 135 – Woodburytype technology. The dichromated gelatin, sensitized as shown in Figures 163 and 164, is used to create a relief mold on a lead sheet, using a press. Pigmented gelatin, not sensitive to light, will be placed in this mould to be printed on paper. Adapted from Oliver, p. 112.

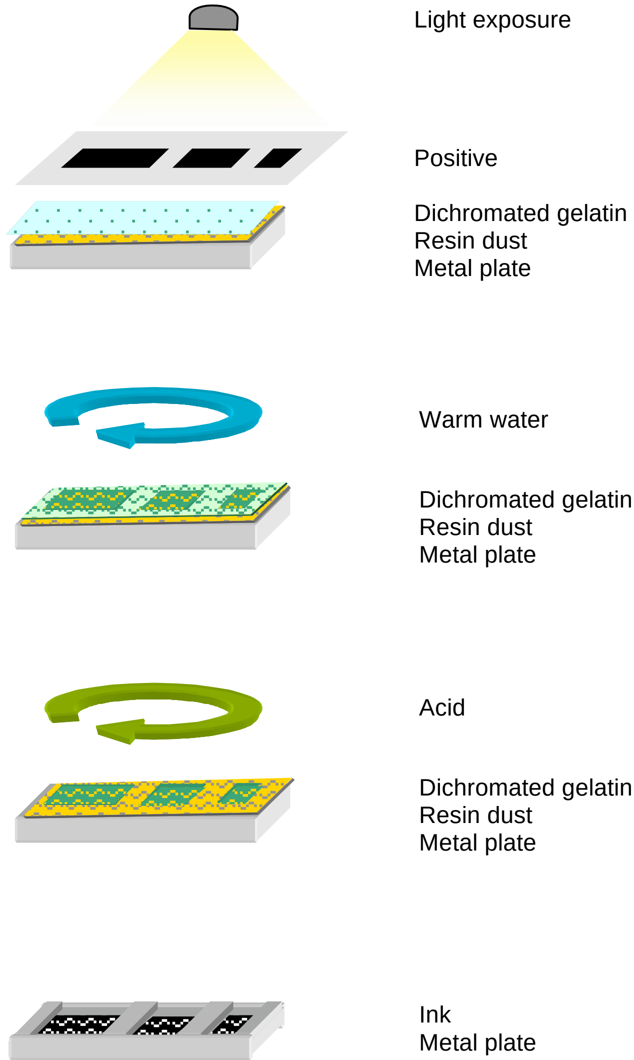


Figure 136 – Production of photogravures. Initially, a positive transparency is used over a resin dust covered metal plate. The gelatin that didn't harden is taken away with water. An acid bath will etch these areas, while the positive image is being protected by the hardened gelatin, taken away previously to printing. The resin is taken away, revealing the unetched metal surface. The ink resides inside the etched grooves.

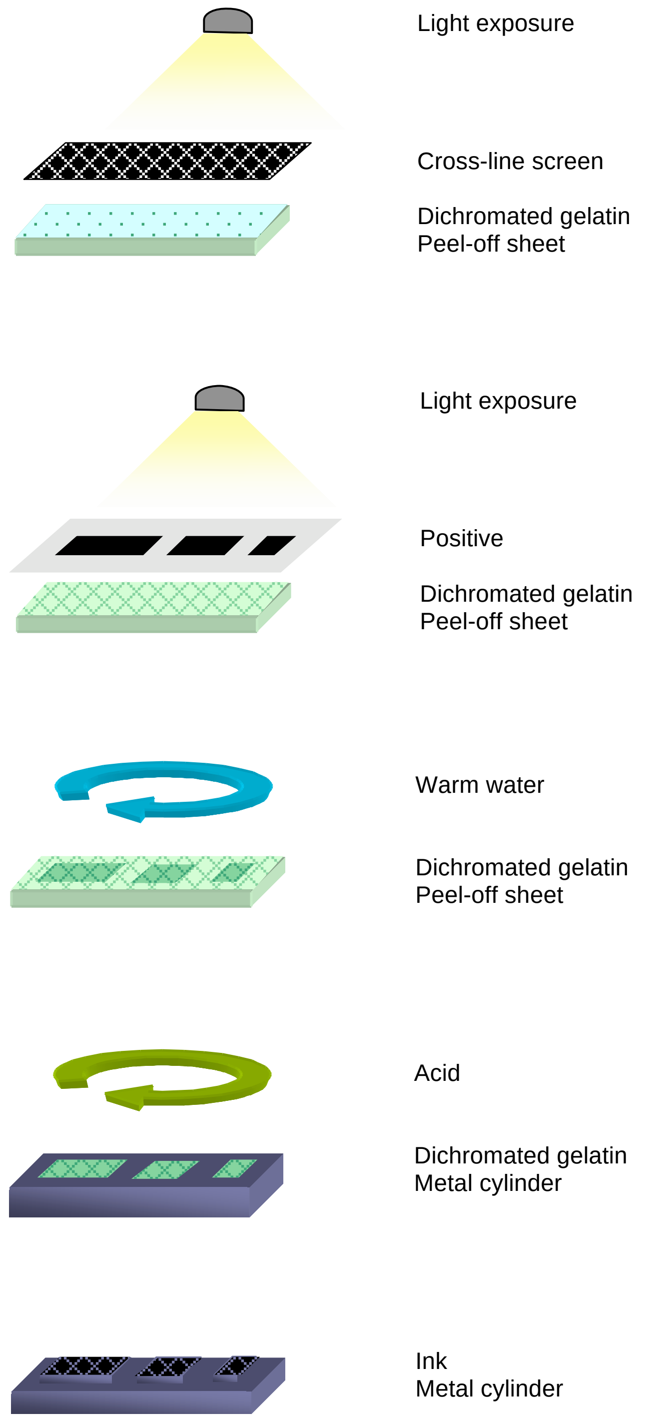


Figure 137 – Making rotogravures. The dichromated gelatin is pre-sensitized to pick up the cross-line screen pattern. After that, a positive is used under light, so the gelatin records a negative image. After being washed, the dichromated gelatin is transferred into a metal cylinder, so it is etched. The ink settles inside the etched pits, from where it will be transferred to a paper surface.

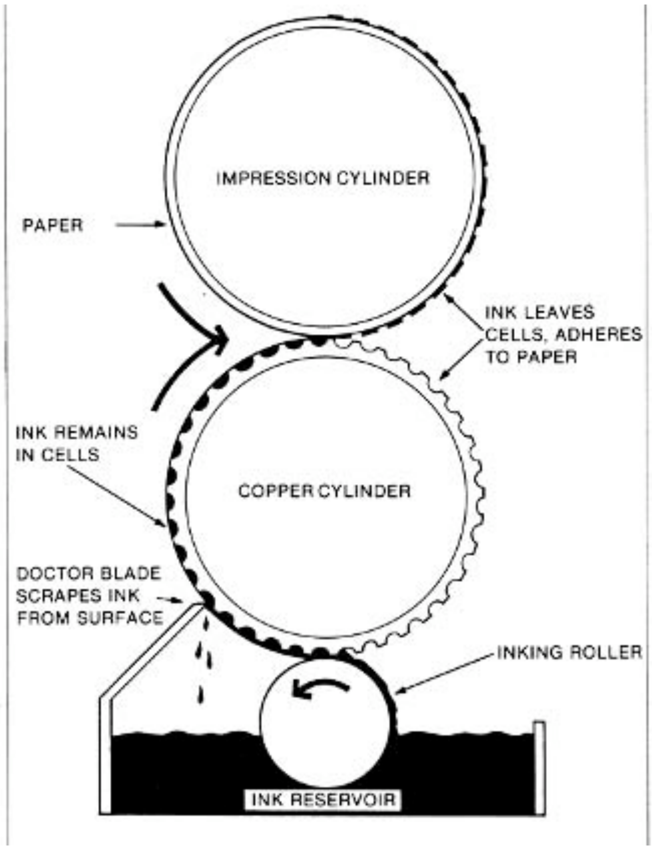


Figure 138 – Printing with a rotogravure press. The doctor blade takes the excess ink off of the cylinder, and is then transferred onto the paper surface with a pattern. In Crawford, p. 238.

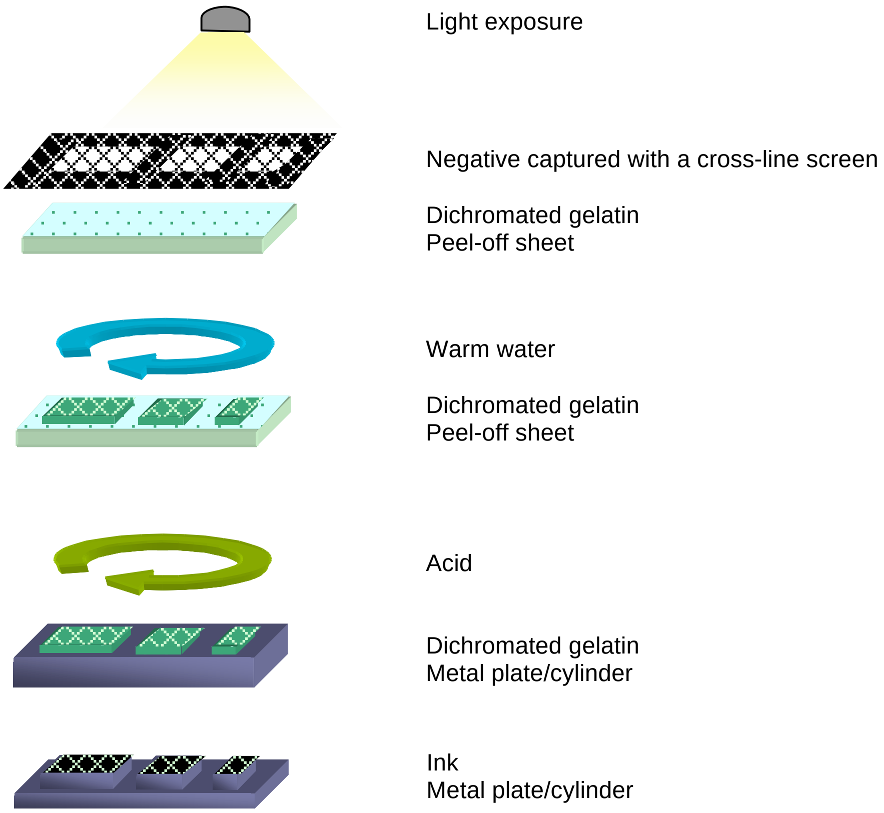


Figure 139 – Making letterpress halftone prints. A negative captured with a cross-line screen is used. After using acid to etch the plate, the gelatin is removed from it and the ink placed on the relief areas of the plate.

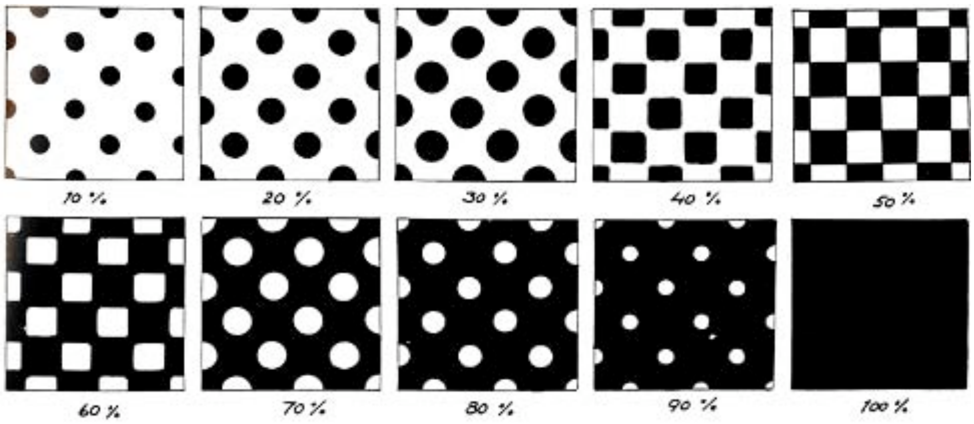


Figure 140 – Change in halftone patterns according to the percentage of area covered by the dots. In middle tone areas (between 40 and 60% of ink), the image presents a checkered pattern. In between 10%-30% and 70%-90% the image will show a dotted pattern. In Mertle, p. 95.

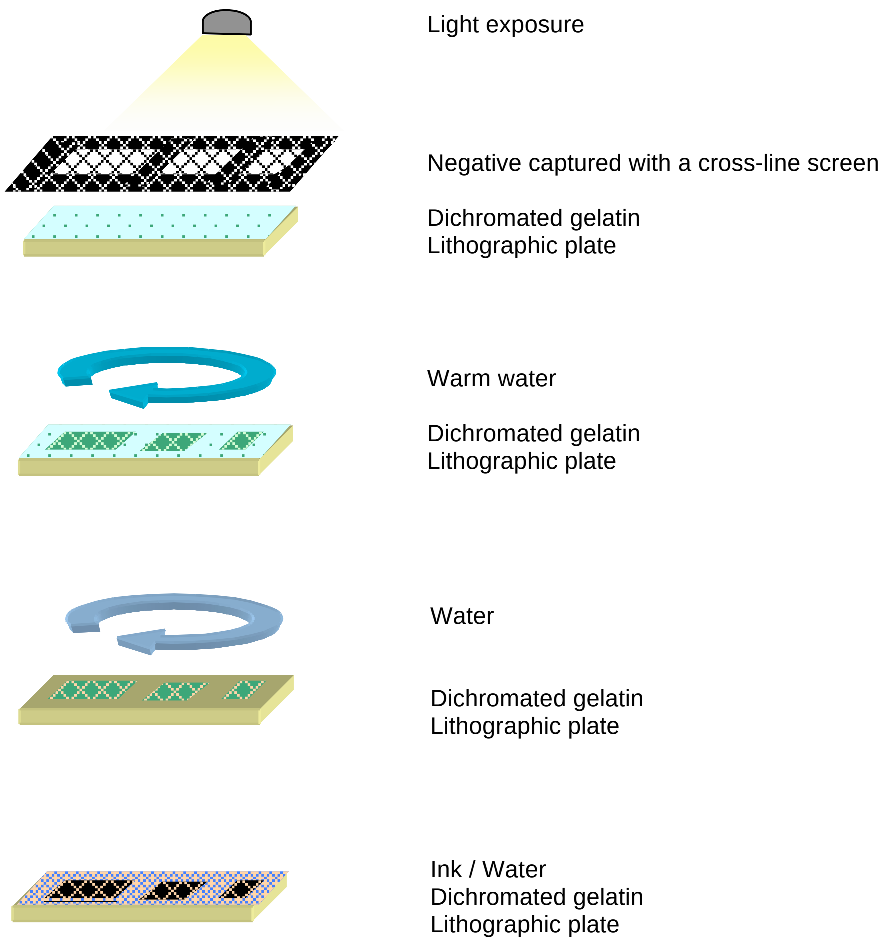


Figure 141 – Making an offset print. After the dichromated gelatin is sensitized, the remaining part is washed off with warm water. These areas are again covered with a water solution. Then, the hardened gelatin is taken off, and the plate is covered with greasy ink. It will only adhere in these areas because they were protected against water so the ink won't be repelled.

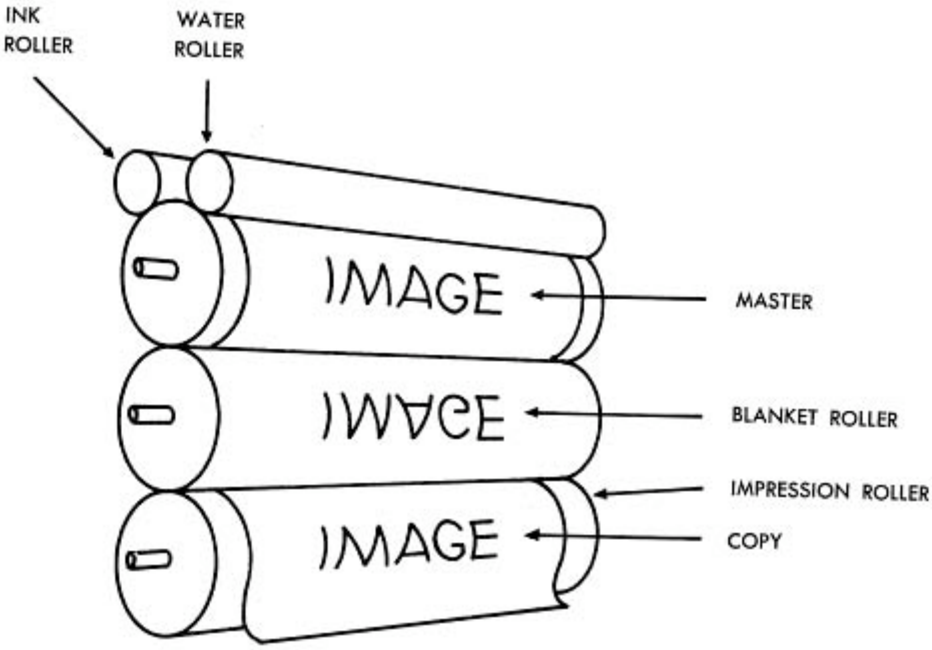


Figure 142 –Off-set printing. The original image is positive, being inverted when it is transferred to the blanket roller. The final print will have a positive image. In Hawken, p. 202.

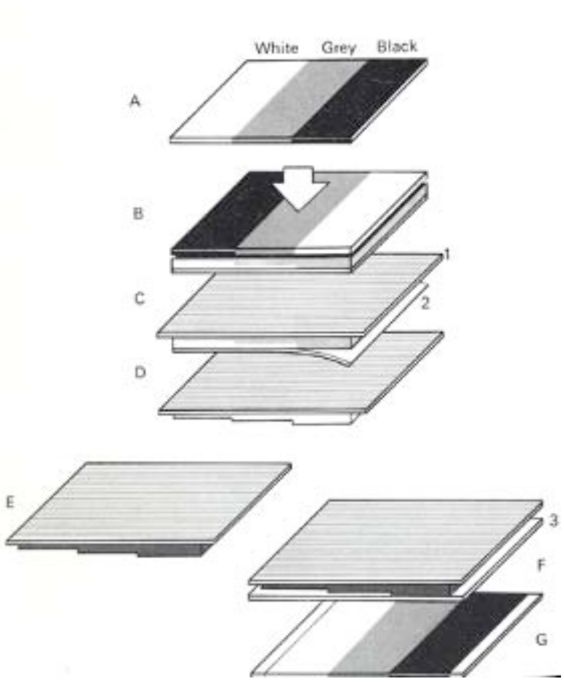


Figure 143 – The carbon process. A gelatin tissue is contact printed with a negative. The tissue is placed on a temporary support, where it is washed to remove the soft gelatin. The hardened gelatin relief is transferred to the final support. In Coe, 97.

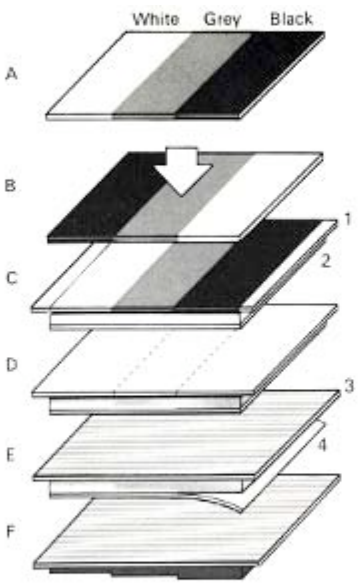
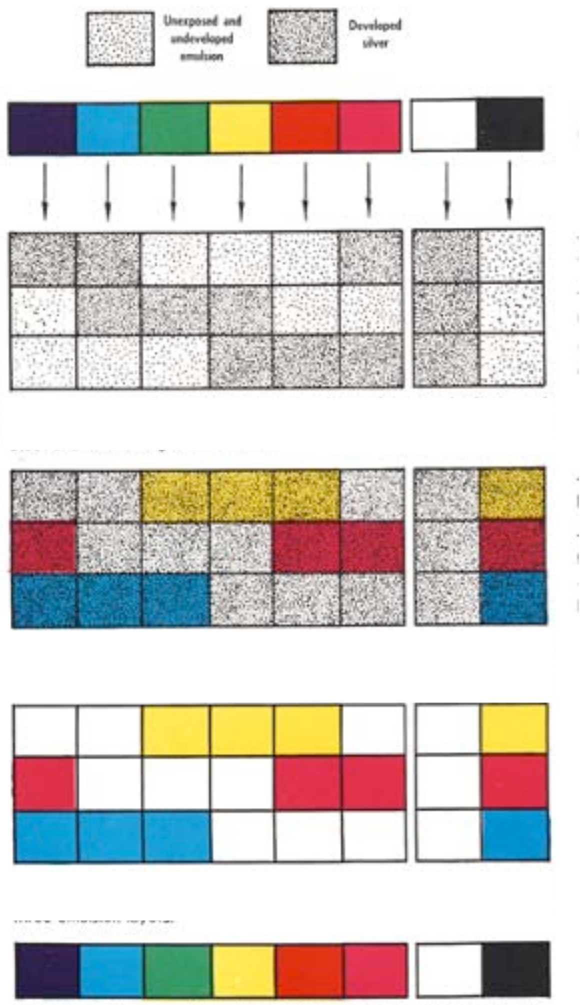


Figure 144– The carbro process. It is distinguished from the carbon process because the negative is printed on B&W silver bromide paper, and this bromide is squeeged against carbon tissue. The bleaching of the silver image will provoque selective hardening of the tissue. It is then placed on a temporary support, washed and the relief image is transferred to the final support. In Coe, 98.



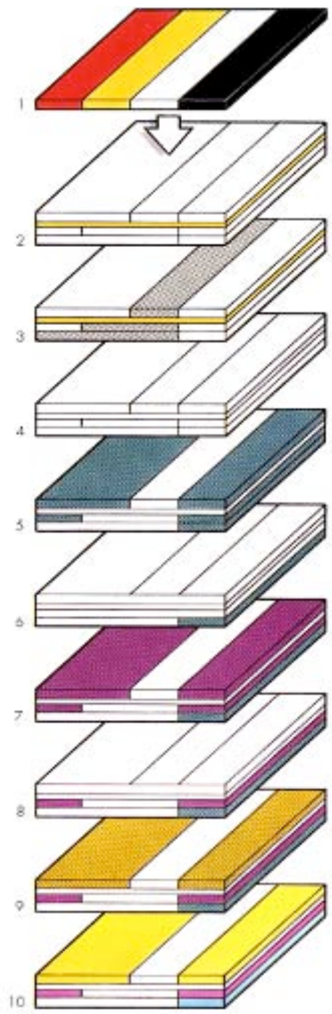


Figure 145 – Processing for Ansco Printon. The print first goes through B&W development to expose all the silver in the emulsion layers. Redevelopment (with a color developer) will lead to the formation of metallic silver and dyes. A bleaching bath removes all the metallic silver, leaving behind only the dyed image. The combination of the cyan, magenta and yellow layers will reproduce the colors of the original subject. The same principle applies to Agfacolor prints. In Sipley, Half Century.

Figure 146 – Processing of the original Kodachrome film. After light exposure, the film goes through B&W development, producing a negative silver image in each of the emulsion layers. A bleaching step is required to remove the silver and the yellow filter. This is followed by color development, done selectively for each layer, starting with the cyan, and finalizing with the yellow layer. In Coote, Illust.

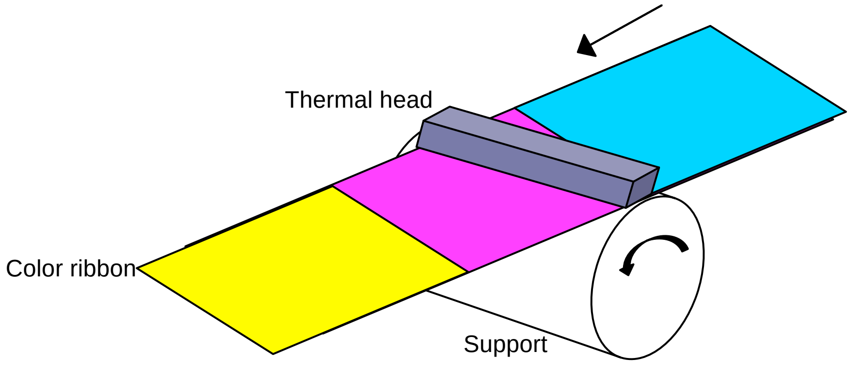


Figure 147 – Scheme for a D2T2 printer. The support is held on a roller, turning when a different part of the color ribbon is under the thermal heads. Adapted from Thompson, p.470.

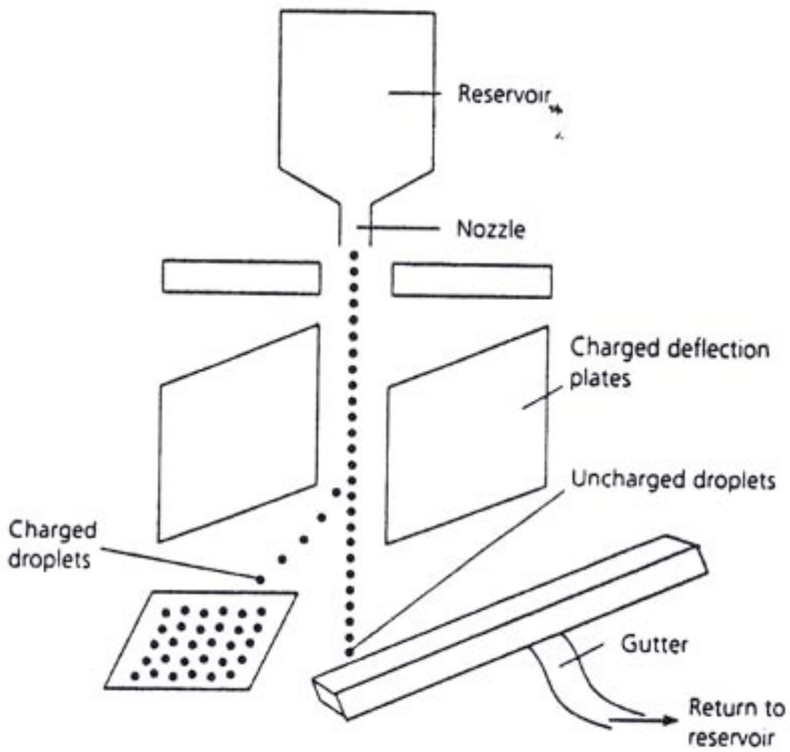
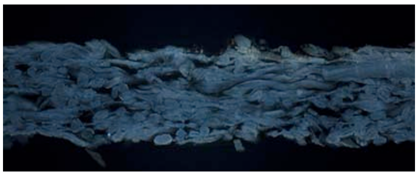
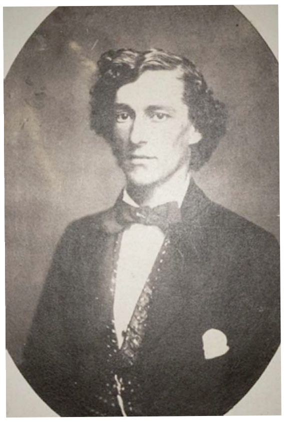


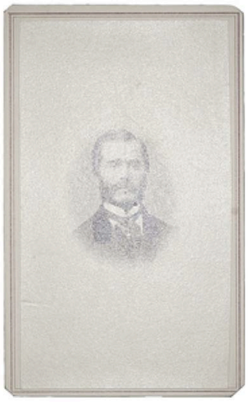
Figure 148 – Scheme for a continuous ink jet printer. In Thompson, p.463

APPENDIX III: Other images

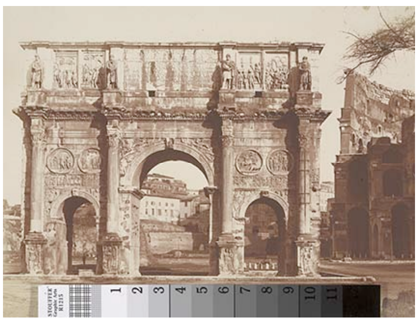


Figures 149 and 150 – Engraving and etching (left to right). Cross sections at 200x, with BF reflected light and DF-UV light. The paper fibers show no fluorescence.





Figures 151-153 – Salted paper print, albumen print and glossy albumen cabinet card print (left to right). Normal view at 0º lighting. The cabinet card is not on www.digitalsamplebook.com.



Figures 154 and 155 – Matte albumen print. Normal view at 45º and 0º lighting (left to right).

Figure 156 – Hand colored albumen print. Macro view at 45º lighting. not on www.digitalsamplebook.com.

Figures 157-158 – Platinum print. Normal view at 45º and 0º lighting (left to right).

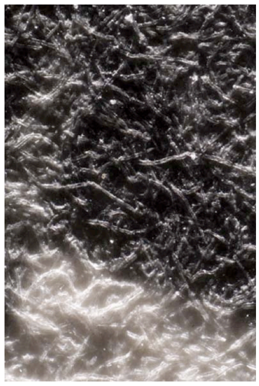
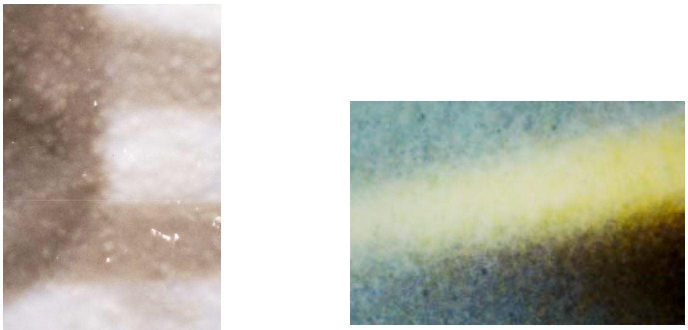


Figure 159 – Platinum print. 50x view at 90º lighting.



Figures 160-161 – Agfacolor, Cibachrome (left to right). 50x view at 90º lighting. Using a plastic coating over a paper base core prevents the print's surface from showing irregularities related to those fibers.

APPENDIX IV: Tables

The following five tables have the goal of summing up all the described information and also to refer some processes that weren't described in the main part of this paper (cyanotype, platinotype) and help in their identification. This information has been based on references used in main text and also information gathered in workshops attended at IPI. The tables can be used as a reference guide for print identification, however more aspects need to be referred to, such as the type of support used, its function, subject, size, deterioration, etc. [1, 2, 4, 8, 9, 12, 17, 24, 25, 36, 42, 45, 46, 66]

There are many different variations of the B&W silver gelatin papers that are not going to be explained here. However, their identification can be done in relationship with gelatin P.O.P. prints. B&W prints where introduced in the 1890s, and produced from there on in many surfaces. The image tone is usually neutral or cold, and the image may show silver mirroring and yellowing in the highlights due to deterioration. There are also sulfur toned papers, common between 1910 and 1950 in portraits, that show little or none image deterioration [12].

The last table is adapted from one used for reference of IPI's staff, synthesizing the qualities of each imaging technique as able to depict the main characteristics looked for in each print.

Characteristics	Main production dates	Image structure	Surface gloss	Differential gloss	Visible paper fibers	Image material	Support	Image Deterioration	Other features
Woodcut	Early 14th-19th century	Dark image areas with sharp edges			•	Oil + pigment (ink)	Rag paper		
Engraving	Mid 15th-18th century	Lines or dots			•	Oil + pigment (ink)	Rag paper		Plate mark
Etching	Late 15th - 18th century	Lines or dots, gradation	•	•	•	Oil + pigment (ink)	Rag paper		Plate mark
Lithograph	Late 18th - late 19th century	Tone gradation			•	Oil + pigment (ink)	Rag paper		Surface has a waxy feel

Table 1 – Summary of the characteristics of pré-photographic prints.

Characteristics	Main production dates	Image structure	Image Relief	Differential gloss	Visible paper fibers	Image material	Support	Image Deterioration	Other features
Collotype	1855-1960s	Reticulation pattern			•	Oil + pigment (ink)	Paper		
Woodburytype	1865-1900s	Continuous tone image; Pigment particles	•	•	On non image areas	Pigment + gelatin	Paper	Cracks on dark image areas	Prints under 20x25 cm Pigment particles Cropped around the edges
Photogravure	1879-early 20th century	Aquatint grain			•	Oil + pigment (ink)	Paper		Plate mark
Rotogravure	1895-1970s	White line grid with small, same size, inked squares			•	Oil + pigment (ink)	Paper		In dark areas the squares might not be seen
Letterpress halftone	1890s-1950s	Halftone pattern with squeeze-out			•	Oil + pigment (ink)	Paper		Merging squares on dark areas, round dots on highlights
Offset lithograph	1910-today	Halftone pattern without squeeze-out			•	Oil + pigment (ink)	Paper		Rosetta pattern; FM pattern (same size dots, different frequency) Dots: squares (up to the 1950s), elliptical (after 1950s)

Table 2 – Summary of the characteristics of photomechanical prints.

Characteristics	Main production dates	Image structure	Image tone	Color in toned images	Surface gloss	Visible paper fibers	Image Material	Support	Image Deterioration	Other features
Salted paper	1840s-1860s	Continuous tone image	Warm	Dark brown/Purple		•	Silver	Paper	Loss of highlights, change in image tone	Thin, mounted
Albumen	mid 1850s-1900s	Continuous tone image	Warm	Dark brown/Purple	•	•	Silver + Albumen	Paper	Loss of highlights, change in image tone, cracking of the binder, silver mirroring; overall yellowing; fading due to presence of metallic particles	Common on *cartes de visite* Thin, mounted prints. Unmounted: tendency to curl
Matte albumen	1890s-1910s	Continuous tone image	Warm	Dark brown/Purple		•	Silver + Albumen	Paper	Loss of image highlights, change in image tone	Grey or black cardboard mounts
Collodion P.O.P.	1870s-1900s	Continuous tone image	Warm	Dark brown/Purple	•		Silver + collodion	Baryta paper	Iridescence Loss of image highlights Silver Mirroring	Soluble in acetone Common on cabinet card Tinted support Burnishing marks in the back of the support
Matte collodion P.O.P.	1890s-1910s	Continuous tone image	Cold	Blackish dark green		•	Silver + collodion	Baryta Paper		Fine image detail; Image transfer to other supports because of platinum
Gelatin P.O.P.	1880s-1910s	Continuous tone image	Warm	Dark brown/Purple	•		Silver + gelatin	Baryta Paper	Silver mirroring Loss of image highlights,	Common on cabinet card Tinted support

Table 3 – Summary of the characteristics of printing-out process prints.

Characteristics	Main production dates	Image structure	Surface gloss	Differential gloss	Visible paper fibers	Image material	Support	Image Deterioration	Other features
Carbon	1865-1910s	Continuous tone image	•	•	On non image areas	Pigment + Dichromated gelatin	Baryta paper		Pigment particles Cracks on dark image areas Fine image detail
Carbro	Early 20th century - 1950s	Continuous tone image	•	•		Pigment + Dichromated gelatin	Baryta paper		Pigment particles; used for color images; missregistration of layers Less mage detail due to image enlargement
Platinotype	1880s-1930s	Continuous neutral tone image			•	Iron salts	Paper	Yellow circles around images formed by platinum	Fine image detail; Positive image transfer to other supports because of platinum
Cyanotype	1870s-1950s	Continuous blue tone image			•	Iron salts	Paper	Loss of contrast if exposed to light or alkaline environments	

Table 4 – Summary of the characteristics non-silver processes prints.

Characteristics	Main production dates	Image structure	Surface gloss	Visible paper fibers	Image material	Support	Image Deterioration	Other features
Ansco Printon	Mid 1940s-1973	Continuous tone image	•		Dyes + gelatin	Paper, acetate,	Dye fading (hue shift); overall yellowing due to deterioration of non used dye couplers	Minicolor and Kotavachrome formats
Agfacolor	Mid 1940s-1990s	Continuous tone image	•		Dyes + gelatin	Paper, acetate, RC coated	Dye fading (hue shift); overall yellowing due to deterioration of non used dye couplers	White borders
Kodachrome	1935-1970s	Continuous tone image	•		Dyes + gelatin	Acetate, RC coated		White borders
Cibachrome	1963-1990s	Continuous tone image	•		Azo dyes + gelatin	Acetate, RC coated and polyester		Colors with metallic reflex; deep, dark blacks; saturated colors

Table 5 – Summary of the characteristics of color photography prints.

Characteristics	Main production dates	Image structure	Surface gloss	Differential gloss	Visible paper fibers	Image material	Support	Image Deterioration	Other features
Electrophotography	1960s-today	Dots	•	•	•	Toner	Paper	Dry toner detaches from support (flacking)	Dry toner – dusty dots, loose particles Liquid toner – dots with defined edges; Rosetta pattern; AM dots (same frequency, different size dots)
Dye sublimation	Early 1980s - today	Continuous tone image	•			Dyes + waxy medium	Any type, with plastic overcoats		Parallel lines across surface from printing
Inkjet	Late 1980s - today	Ink droplets			•	Pigment /dyes + water + organic solvents	Any type (uncoated, porous, swellable, etc.)	Dye based – dissolved in contact with water (ink bleeding); sensitive to ozone Pigment based – easily abraded Dye fading (Hue shift)	Continuous – dots are evenly spaced, in a line formation D.O.D. – dots don't show pattern

Table 6 – Summary of the characteristics of digital prints.

	View	Characteristics	Image	Markings and inscriptions	Image Contrast	Image sharpness	Image tone	Base tint	Fluorescence	Texture	Paper fibers	Gloss	Matting agents
45º (normal)	Normal recto	Image color and content, base color, markings and inscriptions	•	•	•		•	•					
	Normal verso	Paper tint, markings and inscriptions		•				•					
	Macro	Sharpness of image				•							
	Micro (50x)	Sharpness of image				•							
90º (racking)	**Normal recto**	Overall texture and planarity								•			
	Macro	Pattern of texture and presence of paper fibers								•	•		
	Micro (50x)	Visibility of paper fibers and structure of texture								•	•		
0º (axial)	Normal recto	Degree of gloss										•	
	Macro	Interaction of gloss and surface microtexture										•	
	Micro (50x)	Presence of matting agents											•
	Micro (200x)	Structure, size and density of matting agents											•
Cross-sections	**Normal (200x)**	Layer structure, support thickness									•		
	UV light (200x)	Fluorescence of components							•				

- • Primary view for characterization
- • Secondary view for characterization

Table 7 – Summary of the characteristics seen in each imaging technique.