The Atlas of Analytical Signatures of Photographic Processes

PHOTOGRAVURE

Dusan C. Stulik | Art Kaplan

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The Getty Conservation Institute
1200 Getty Center Drive, Suite 700
Los Angeles, CA 90049-1684
United States
Telephone: 310 440-7325
Fax: 310 440-7702
Email: gciweb@getty.edu
www.getty.edu/conservation

The Atlas of Analytical Signatures of Photographic Processes is intended for practicing photograph conservators and curators of collections who may need to identify more unusual photographs. The *Atlas* also aids individuals studying a photographer's darkroom techniques or changes in these techniques brought on by new or different photographic technologies or by the outside influence of other photographers. For a complete list of photographic processes available as part of the *Atlas* and for more information on the Getty Conservation Institute's research on the conservation of photographic materials, visit the GCI's website at getty.edu/conservation.

ISBN number: 978-1-937433-10-9 (online resource)

Front cover: Plate photogravure printed in green-black ink, 1904–5. Printed by J. J. Waddington Ltd.

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PHOTOGRAVURE

English: photogravure
French: *héliogravure*
German: Photogravür

HISTORICAL BACKGROUND

The photogravure process was invented by William Henry Fox Talbot (British, 1800–1877) and Karel Klíč (Czech, 1841–1926) (key inventors). Patents by Talbot (1852 and 1858). Never patented by Klíč, but some process variants patented later (1879).

The photogravure process (see the print in fig. 1 for an example) has a long history, starting with manual printing techniques and aquatint printing. The roots of the photogravure process can be traced back to William Henry Fox Talbot (1852), who used a "screen" of black crepe for the mechanical translation of tone values on a steel plate coated with a light-sensitive layer of dichromated gelatin. This was the starting point for both the photogravure (the use of dichromated gelatin) and halftone processes (the use of a screen). In Talbot's 1852 method, the steel plate was etched with a solution of platinum chloride to form a printing plate. Talbot changed the process in 1858 by depositing a resinous powder on the surface of the exposed, sensitized, gelatin-coated copper plate. When heated, the resin microparticles bonded to the gelatin layer and facilitated the formation of a delicate grain pattern after etching with a solution of ferric chloride. Talbot also introduced consecutive etchings of copper plates using solutions of different concentrations of ferric chloride to improve the tonal scale of the printed images.

Charles Nègre (1820–1880) published his early version of the photogravure process in *La Lumière* (1854). Nègre's process utilized the "self-graining" property of etched steel, which eliminated the need for using the resin grain. Even though simpler in theory than Talbot's process, Nègre's often required heavy retouching and hand correction of the etched steel plates before printing. A number of other researchers developed different experimental variants of the photogravure process, but these did not find wide-scale use and application.

The main breakthrough came in 1879, when Karel Klíč combined elements of Talbot's photoglypty process with the use of carbon tissue and developed a variant widely adopted by artists, photographers, and printers. This process is still used today in high-quality photographic reproductions of original artwork.

Figure 1 Plate photogravure printed in green-black ink, 1904–5. Printed by J. J. Waddington Ltd.

The carbon process of photography was invented by Alphonse-Louis Poitevin in 1855 and further developed between 1864 and 1874 by Joseph Swan and John Sawyer, whose research led to the introduction of so-called carbon tissue, which became a key component of both photogravure and rotogravure printing during the nineteenth century and the first half of the twentieth century.

The light sensitivity of dichromate-sensitized carbon tissue attracted the attention of Klíč, who was aware of the Talbot process and was trying to improve upon it by depositing a grain-forming, resinous powder directly on the surface of a copper plate. In 1877 Klíč succeeded in depositing a highly uniform layer of resin on a copper plate; he then bonded resin particles to the copper plate by heat. He later experimented with transferring dichromate-sensitized carbon tissue to a resin particle copper plate and exposing it under a positive. This was followed by the removal of the paper substrate from the copper plate–carbon tissue–paper substrate sandwich. The resin grain coated copper plate was then etched, through the exposed but undeveloped carbon tissue, using a series of ferric chloride solutions of decreasing concentrations. After fully cleaning the etched copper plates to remove all traces of carbon tissue, the resulting photogravure plates were printed using flatbed graphic presses.

Klíč announced his photogravure process in 1879 but never published or patented the details, though he did sell the process as a trade secret to several printing establishments in Austria and Germany. Because the photogravure process as it is used today was based on the research of both Talbot and Klíč, it is often called the Talbot-Klíč photogravure process and was used in printing illustrated books as well as photo and art journals. Some photographers and artists also used the photogravure process directly as a creative medium.

As photography and fine art printing benefited from the introduction of the flatbed photogravure process, the commercial publishing industry benefited from the introduction of rotogravure, which allowed for high-volume, high-speed printing of quality images.

The rotogravure process was developed and introduced by Klíč in the early 1890s. The first commercial rotogravure press was set up in 1893. Rotogravure was based on a principle similar to flatbed photogravure, but instead of using a resin powder to develop the image grain, the carbon tissue was exposed twice: once under a special gravure cross-line screen and again under a continuous-tone positive. The double-exposed carbon tissue was then mounted on a copper-plated cylinder and etched. The role of the rotogravure screen was not to divide the image into dots (as in the case of halftone printing) but to enable the cleaning of the surface of a rotogravure cylinder between individual image cells (wells) before printing. This was done using a thin steel plate known as a doctor blade. The printing was done using special rotogravure presses.

Rotogravure is still widely used for the printing of large-circulation mail-order catalogs, graphic reproductions, book illustrations, and commercial product labels and wrappers. Many early photo-illustrated magazines, weekly newspaper supplements, postcards, and posters were also printed using the rotogravure process.

Later developments included a number of hybrid printing processes that combined advantages of both the rotogravure and halftone processes. These were known under names such as intaglio halftone, Mertens process, Intaprint process, Dultgen process, Henderson process, convertype, and round-dot gravure. Only some of these process variants provide microscopic signatures typical enough (as, for example, the Intaprint process) to allow for clear identification of the process variant.

The majority of rotogravure printing cylinders used by today's industry are not prepared using the classic photochemical and chemical etching processes developed by Klíč. Instead, they are prepared using electrochemical etching and engraving using a diamond stylus or a high-power laser beam. These methods of creating printing cells on rotogravure cylinders also allow for direct digital control of these etching or engraving tools through computer software.

All photogravure and rotogravure printing processes were fully adopted for the printing of color images. Even a classic hand-pulled photogravure process was affected by new technology. In 1989 Eli Ponsaing developed a new variation of the photogravure process based on the use of light-sensitive polymers developed previously for the letterpress printing and microelectronics industries. Compared to the traditional copper-based photogravure, the polymer photogravure process is faster and much safer. Thus far, the results of polymer photogravure printing cannot be fully compared to copper-plate photogravure, but this may be only a matter of time and future advancement of the technology.

Classic copper-based photogravure printing may face future setbacks based on the projected lack of availability of the carbon tissue needed for the process. In 2009 MacDermid Autotype, the main supplier of carbon tissue, announced the discontinuation of photogravure carbon tissue production. Several small manufacturing companies stepped in and have been able to cover the needs of the photogravure art market and small-volume photogravure printers.

Figure 2 shows a historical timeline of the photogravure printing process.

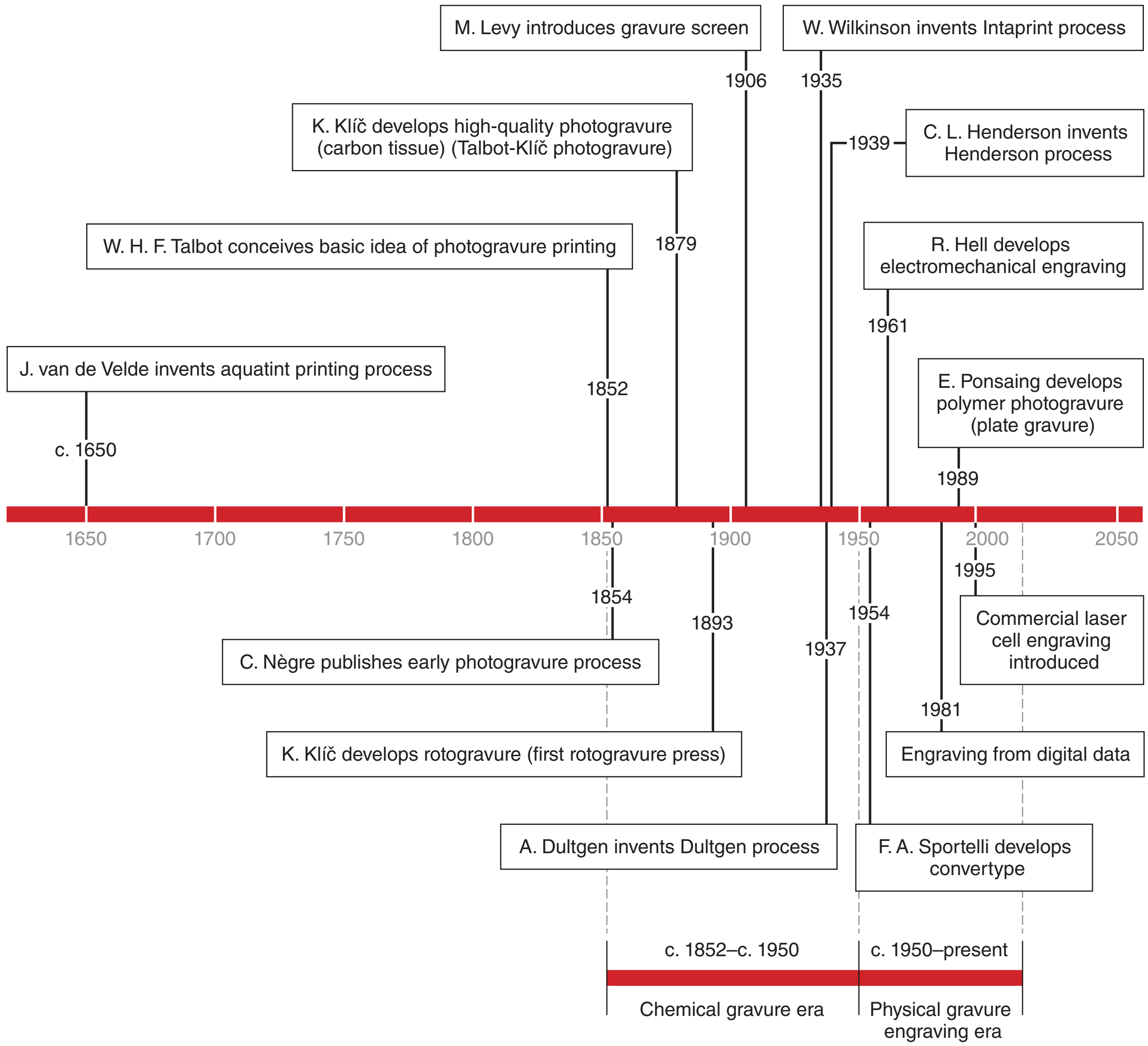


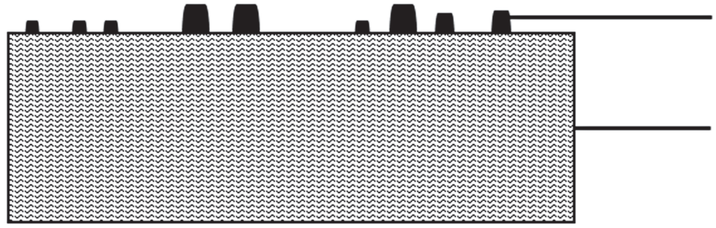
Figure 2 Timeline of the photogravure process.

Process Description (Plate Photogravure)

The following is a classic procedure for making photogravure prints developed by Klíč. A number of small modifications have been introduced over the years by photogravure printers and researchers, but the basic procedure has survived mostly unchanged until now.

- Positive transparency is made from an original negative.
- Copper plate is polished and cleaned with acid and potash.
- Aquatint grain (bitumen) particles are deposited on a copper plate and adhered by heat.
- Carbon tissue is exposed to light under a positive transparency.
- Cold water–treated, exposed carbon tissue is attached by squeegeeing carbon tissue side down to the grained copper plate.

Figure 3 Schematic cross section of an uncoated photogravure print.



- Warm water treatment is used for removal of the paper substrate of the tissue.
- Carbon tissue is developed by using hot water to dissolve the less exposed and more soluble gelatin, leaving the more exposed and less soluble gelatin on the surface of the grained copper to act as an etching resist.
- Prepared plate is etched in several ferric chloride solutions of different strengths.
- Fully etched plate is washed of remaining carbon tissue and dried.
- Finished photogravure plate is inked using gravure inks and printed using a gravure or intaglio graphic press.

When preparing the aquatint grain for the photogravure process, the basic procedure was identical to the procedure developed when preparing aquatint grain for classic aquatint printing. Some alternative grain-forming procedures not requiring the use of an aquatint-coating box were developed and introduced later. One of these procedures was based on the formation of an aquatint grain from a solution of resin and camphor. Another alternative used olive oil and “flower of sulfur,” an extremely fine sulfur powder. Many modern printers now use a double-exposure technique and create the grain by exposing the carbon tissue to commercial or self-made aquatint screens. For longer runs of photogravure prints, the copper plate is often “steel faced” to make it harder and longer lasting.

An uncoated photogravure print has a simple cross section consisting of the paper substrate and islands of ink of various thicknesses (fig. 3).

Main Application of the Photogravure Process

High-quality reproductions of photogravures were widely found in books and specialized art and photography journals. Hand-pulled photogravures were and still are printed as individual prints in photographers’ portfolios and single-sheet prints. Some photographers use the hand-pulled photogravure process as their primary medium. The process is also used for printing high-denomination postage stamps and some stock certificates.

Noted Photographers Using the Photogravure Process

Thomas Annan
Alvin Langdon Coburn
Edward Sheriff Curtis
Peter Henry Emerson
Paul Strand
Doris Ullman

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IDENTIFICATION: PHOTOGRAVURE PRINTS

Visual Signatures

Visual Characteristics

During visual examination, unvarnished, hand-pulled photogravure prints are characterized by their high-quality "photographic look," well-developed details, and broad tonal range (see fig. 1). The surface is matte and the image can be printed in almost any color. Most photogravure prints were printed in black and various shades of brown, dark green, and blue to mimic tonalities of original untoned or toned photographic prints. An important visual clue is the presence of a plate mark that usually appears as an embossed line some distance around the image (figs. 4a, 4b). The presence or absence of the plate mark is not a fully reliable visual signature because some photogravures were trimmed around the image area, and in some cases machine-printed gravures (rotogravures) were overprinted manually with a faux plate mark to make them more special.

In many instances, plate marks may contain a small amount of ink from the edges of inked but not completely cleaned printing plates. A total absence of any traces of ink in the plate-mark area may indicate overprinting with a clean plate.

Figure 4a Hand-pulled photogravure print showing the plate mark as an embossed line around the image.

Figure 4b Detail showing the corner of the plate mark in fig. 4a.

Microscopic Characteristics

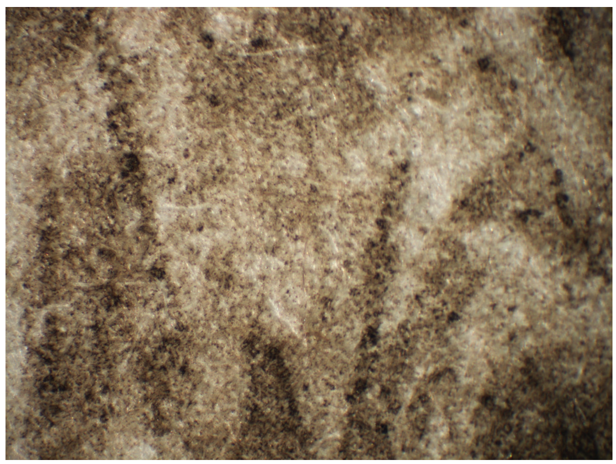
Under a high-power loupe (15×–20× magnification) or a microscope or stereomicroscope (20×–50× magnification), a hand-pulled photogravure can be identified by the presence of a highly irregular grain pattern known as an aquatint (figs. 5a–5c).

The best place to study the fine microstructure of photogravure prints is in the light midtone areas or at the areas where two different tone boundaries meet. The printing ink rests clearly on paper fibers instead of being deeply imbedded among them.

Figure 5a Detail of the photogravure print in fig. 4a, showing aquatint grain (6.3× magnification).

Figure 5b Microscopic structure of the Dmin area of the print in fig. 4a at 25× magnification.

Figure 5c Microscopic structure of the Dmin area of the print in fig. 4a at 40× magnification.



Analytical Signatures

XRF

Elemental signatures of photogravure prints are directly related to the elemental composition of pigments used to formulate the gravure ink used, and to the minor or trace inorganic components of the paper substrate (figs. 6a, 6b).

FTIR

ATR-FTIR analysis of most photogravure prints does not provide enough sensitivity to identify the organic components of the gravure ink. The most prominent part of the ATR-FTIR spectrum is the cellulose substrate. Low-intensity C-H peaks around 2924 and 2852 cm^{-1} may indicate the presence of additional organic components such as an oily ink binder and sometimes the presence of organic dyes of color photogravure inks (fig. 7).

When a hand-pulled photogravure print was surface varnished, ATR-FTIR would be able to identify the presence of the main organic components of the varnish.

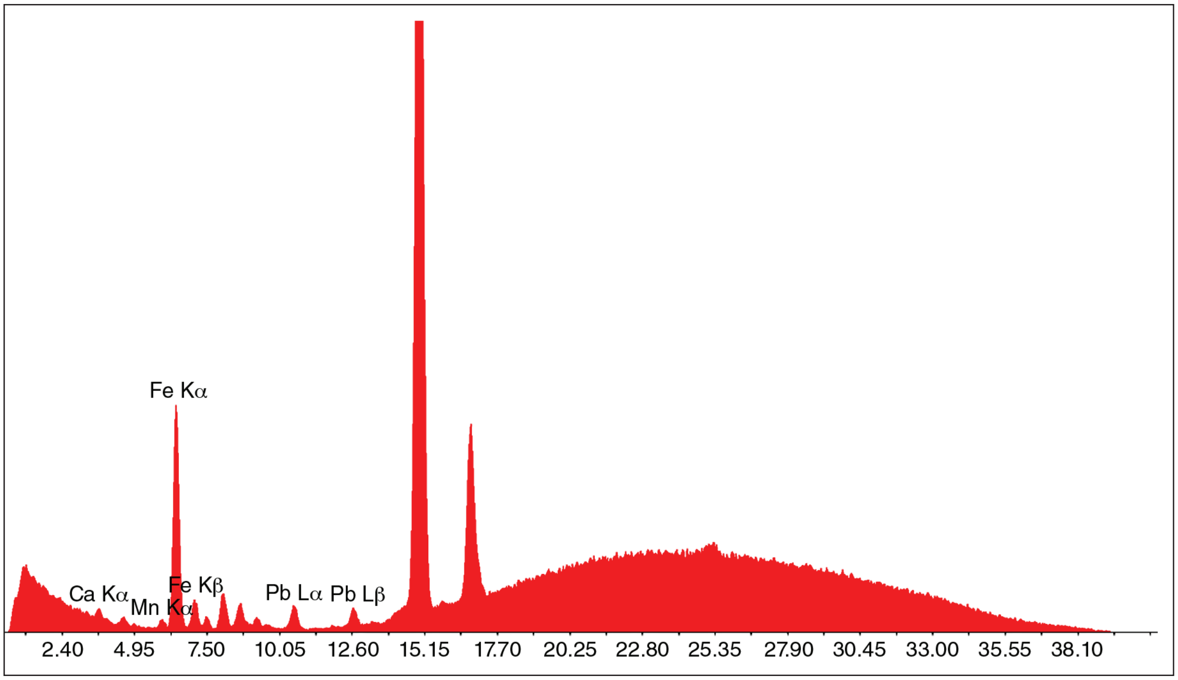


Figure 6a XRF spectrum of the black ink photogravure.

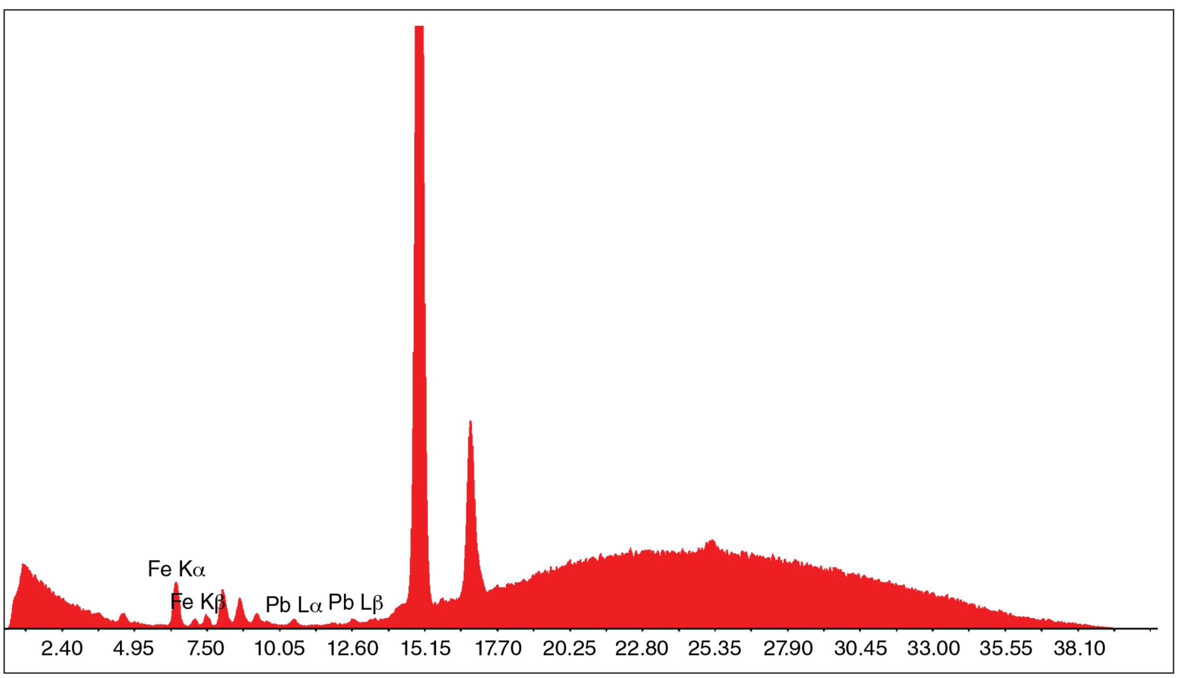


Figure 6b XRF spectrum of the paper substrate.

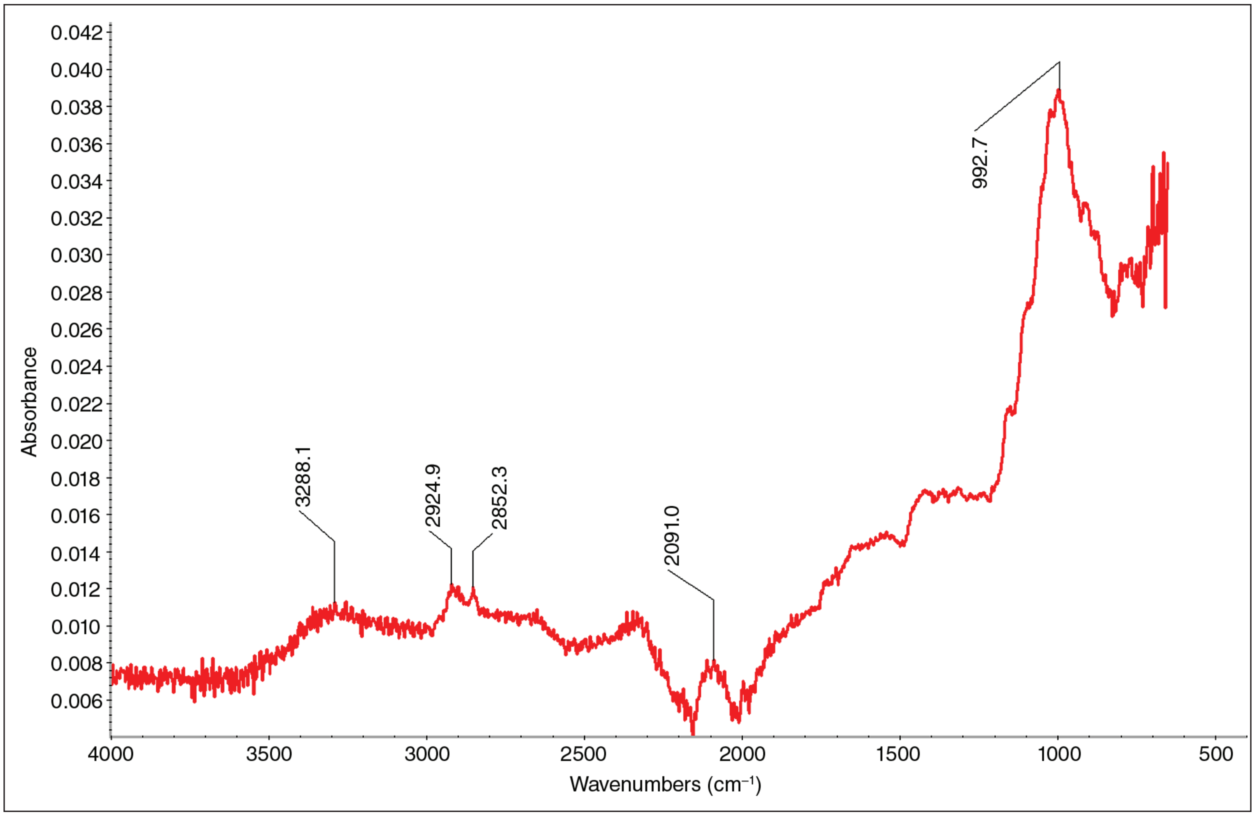


Figure 7 ATR-FTIR spectrum of the Dmax area of a typical photogravure print.

IMPORTANT VARIANTS OF THE PHOTOGRAVURE PROCESS

Rotogravure
Color photogravure
Polymer gravure

Rotogravure

English: rotogravure, machine gravure, rotary photogravure, screen photogravure
French: *rotogravure*
German: Rotationstiefdruck, Rotogravüre

Rotogravure was invented by Karel Klíč (1890). The first rotogravure press appeared in 1893 and was introduced in the United States in 1903. Klíč did not patent or publish any details of his process.

Historical Background

Rotogravure printing (an example is shown in fig. 8) is a variant of the photogravure process. It was adopted for rotary printing of longer printing runs, which could not be accomplished

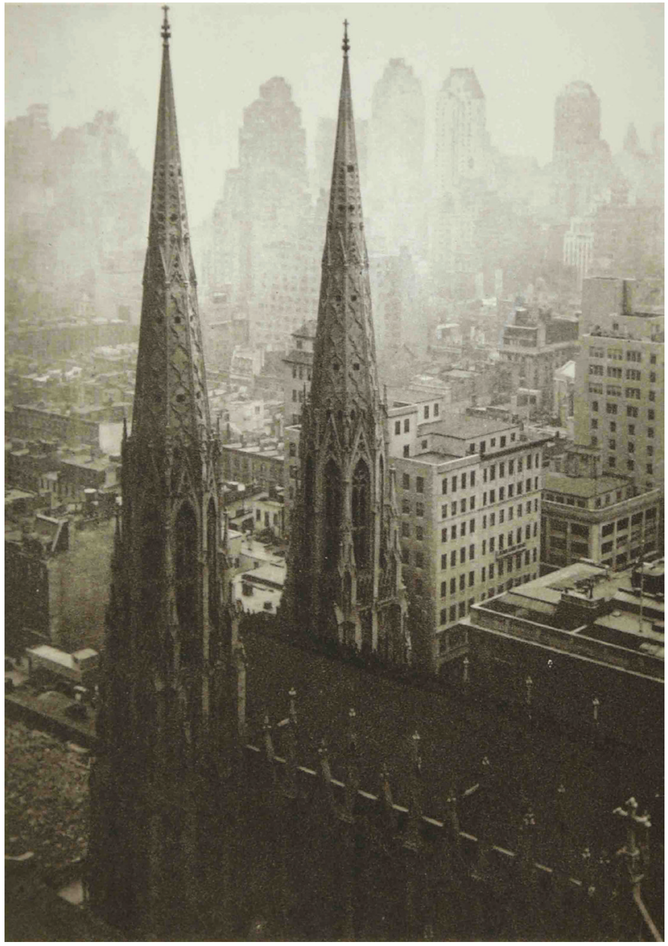


Figure 8 *City Skyline with Two Spires*. Rotogravure print. Private collection.

using the hand-pulled photogravure process. The rotogravure process was used for the printing of postcards and became widespread only during the early part of the twentieth century, when newspapers adopted the new technology. Rotogravure allowed for high-quality halftone reproductions printed at high speed on a variety of paper stock.

Rotogravure uses intaglio printing, in which metal cylinders are etched, forming recessed printing "cells" to hold the ink. Karel Klíč invented the rotogravure process in the early 1890s. The first rotogravure press was set up at the Storey Company in England. Initially Klíč kept his new printing process a secret, even as his Rembrandt Intaglio Printing Company of London popularized the production of gravure prints. The first daily newspaper to incorporate rotogravure printed pages was *Freiburger Zeitung* (1910), in its illustrated Easter Sunday edition. On Christmas Day 1912, the *New York Times* published the first complete rotogravure section. Subsequently rotogravure pictorial sections began to appear as weekend inserts in newspapers.

Many high-quality art and photography books prior to the 1960s were printed using the rotogravure process. Adopted later for three-color printing, rotogravure is still used for the commercial printing of some magazines and for medium print runs of monochrome and color printing. An example of a high-volume, high-quality photography-based publication is *National Geographic* magazine. The latest developments in the rotogravure process abandoned the use of all "chemical photography" and chemical etching steps. Advanced methods of rotogravure printing use digital files and high-power laser-beam "etching" to create printing cells on a rotogravure cylinder.

Process Description

The original version of the rotogravure process was similar to the flatbed printing process. The major difference was the use of a rotogravure cylinder and additional exposure of the carbon tissue under a special rotogravure screen.

- A continuous-tone positive is made from a continuous-tone negative.
- Sensitized carbon tissue is exposed under a rotogravure screen.
- Sensitized carbon tissue is exposed a second time under a continuous-tone positive.
- Slightly moist, exposed carbon tissue is attached to a polished copper rotogravure cylinder by a low-pressure rubber roller.
- Paper substrate of the carbon tissue is removed in a warm water bath.
- Light unexposed gelatin is removed by treatment in a temperature-controlled hot water bath.
- Fully "developed" copper cylinder is cooled and dried.
- Asphalt varnish is applied to areas of the rotogravure cylinder that need to be protected against the action of the etching solution.
- Copper cylinder is etched in several solutions of ferric chloride of different concentrations.
- Fully etched rotogravure cylinder is cleaned of any traces of carbon tissue, then washed and dried.
- Printing is done using special, relatively thin rotogravure inks on a single cylinder for monochrome printing, or multicylinder rotogravure printing machines in the case of color rotogravure printing.

Because rotogravure cylinders are expensive, they are reused after the end of a printing run. The etched layer of the rotogravure cylinders is removed using special grinding machines. Each grinding removes about a 0.7-mm-thick layer of copper. After several printing runs, copper must be added to the cylinder by electroplating.

Originally the cells in a gravure cylinder were equal in area but different in depth. Today the cells engraved in rotogravure cylinders are different in area and depth, or they can be the same in depth but different in area. The gravure cylinders with cells that vary in area and depth are often reserved for the highest-quality printing.

Because of the expense of the cylinders, gravure printing is largely performed as a rotary web process (rotogravure). It is most often used for very long runs of up to a million prints; often the press runs are even higher. For runs of a million or higher, the cylinders are plated with chromium for extra durability. During the printing process, the gravure cylinder revolves in a so-called ink fountain, where it is coated with a thin, highly fluid ink. A stainless-steel doctor blade clears the ink from the unwanted areas, leaving it in the depressions of the cylinder. The paper substrate passes between the gravure cylinder and an impression cylinder covered in rubber, and the ink from the cells is deposited onto the substrate. The microscopic depressions on the gravure cylinder create an almost continuous-tone image on the printed surface, which is why it is often used for high-quality image reproduction.

Figure 9 shows a schematic cross section of a typical rotogravure print.

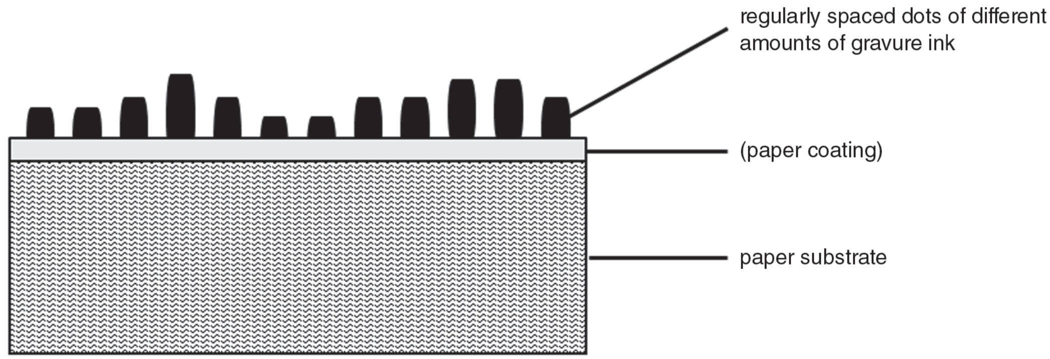


Figure 9 Schematic cross section of a typical photogravure print.

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Rotogravure-Related Patents

Paul Pretsch, English Patent 1,824 (Aug. 11, 1855)

IDENTIFICATION: ROTOGRAVURE PRINTS

Visual Signatures

Visual Characteristics

An unvarnished rotogravure has many of the same visual characteristics as a hand-pulled photogravure. Typical images are matte in appearance and can come in many different colors (mostly brown, black, dark green, and dark blue), with good tonal separation in the dark areas of the image. ***Note:*** An important differentiation is that the plate mark typical for a hand-pulled photogravure is missing in a rotogravure.

In rare cases, rotogravures might show a plate mark that was added after printing by embossing a clean plate to give the rotogravure a hand-pulled photogravure look.

Microscopic Characteristics

The most typical microscopic signature of a rotogravure print is its screen imprint detail, which is clearly visible under higher magnifications (figs. 10a–10c). The best image area for microscopic investigation is in midtone to light-midtone areas of the image.

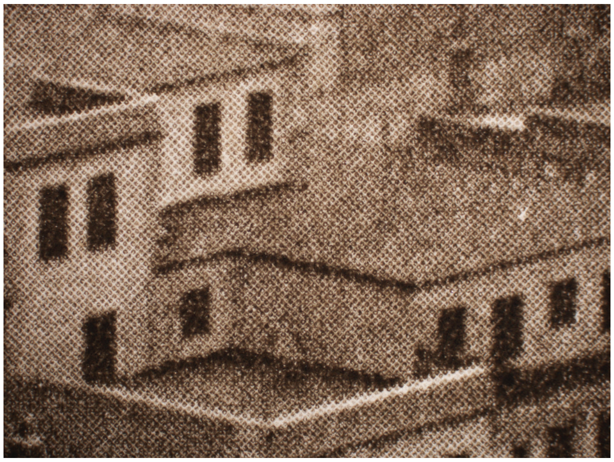


Figure 10a Microscopic pattern of a typical rotogravure print (10× magnification).

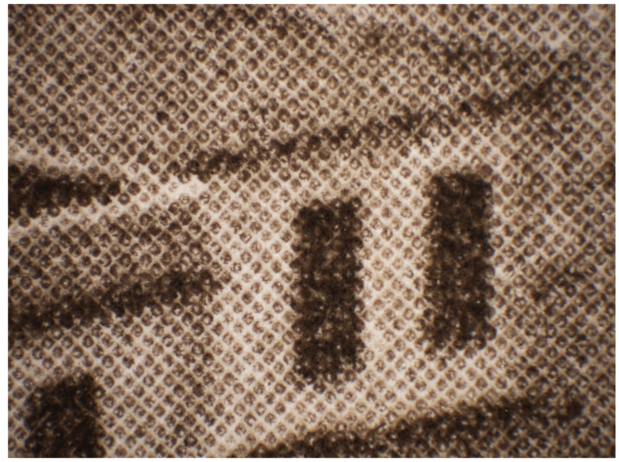
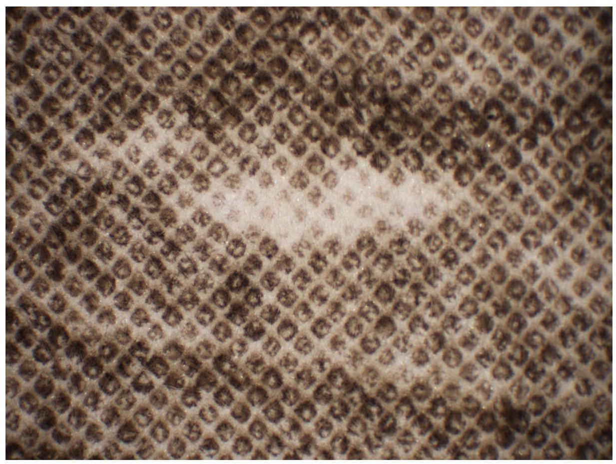


Figure 10b Microscopic pattern of a typical rotogravure print (25× magnification).

Figure 10c Microscopic pattern of a typical rotogravure print (40× magnification).



Analytical Signatures

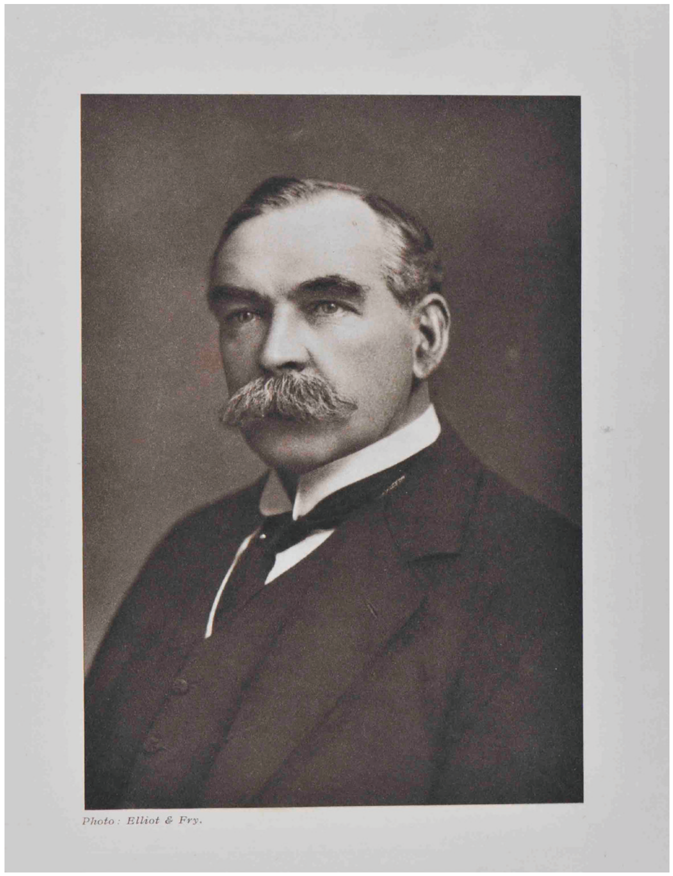
There is seldom a need to use analytical techniques (XRF or ATR-FTIR) when identifying unvarnished rotogravure prints. When recorded, analytical signatures of rotogravures are similar to those of hand-pulled photogravures.

Experience is needed to distinguish between rotogravure patterns, halftone photolithogravures, halftone gravures, halftone digital prints, and electrostatic copies of halftone images.

Some gravure prints were produced using the rotogravure process but were also embossed with a plate mark to produce an image that would have the visual appearance of more arty and more expensive plate gravure prints. Figure 11 shows an example of such a rotogravure print. Figures 12a and 12b show the detailed microscopic structure of a typical rotogravure pattern together with a detail of the false plate-mark indentation.

A number of newspapers and lower-grade magazines were also printed in monochrome, usually in brown, black-blue, or black green ink with the rotogravure process. This yielded a higher-

Figure 11 Rotogravure print with embossed "plate mark."



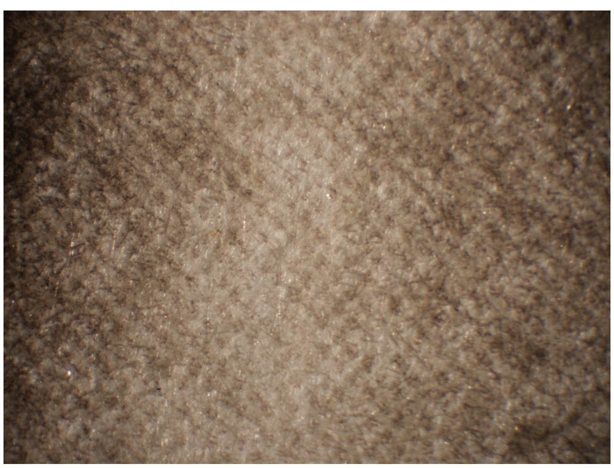


Figure 12a Microscopic detail of a rotogravure pattern in fig. 11 (40× magnification).

Figure 12b Detail of the corner area of the "plate mark" in fig. 11 (25× magnification).

quality print and a "feeling" of something more substantial than just common black-and-white newsprint with coarse halftone screens. Figures 13a and 13b show a newsprint image and its detail, respectively. Using rougher stock for the fast printing dictated by newspaper production caused some loss of detail in the Dmax areas of the image.

Figure 13a Example of rotogravure printing on common newsprint.

Figure 13b Detail of the rotogravure pattern in fig. 13a (40× magnification). Rougher stock caused some loss of detail in the Dmax areas.

OTHER IMPORTANT VARIANTS OF THE PHOTOGRAVURE PROCESS

Color photogravure
Polymer gravure
Artgravure
Hood gravure
Rembrandt gravure

A large number of different variants of the rotogravure process were developed, published, and used under special or proprietary names during the early part of the twentieth century. Many of these processes were based on slightly different printing technologies. The names of some of these variants reflected advantages of the process used (e.g., Penrose Velogravure), and some related to the process used by a specific printing company. Microscopic signatures of many of these variants are so similar that without clear identification of the process—which may be printed with the image (usually under the lower right part)—no detailed identification of the rotogravure variants is possible. Figure 14 shows an example of an Artgravure printed in 1928 by the Art Gravure Company of New York.

Microscopic investigation of the print in figure 14 shows a typical rotogravure pattern (fig. 15a). A detailed visual inspection, however, reveals a printed description of the process, located under the lower right corner of the image (fig. 15b).

Rotogravure prints produced using the so-called Hood gravure process were made by Harold Hood, FRPS (fig. 16). Figure 17a shows a detail of the rotogravure pattern of this print, which

Figure 14 Artgravure print, 1928. Art Gravure Company of New York.

Figure 15a Detail of the print in fig. 14 (40× magnification), showing a typical rotogravure pattern.

Figure 15b Detail of fig. 14, indicating the process description under the lower right corner.

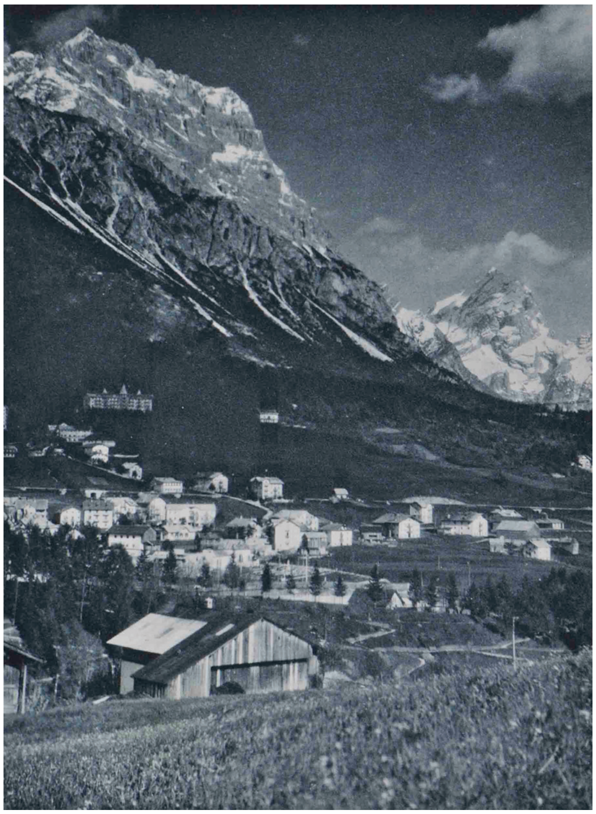


Figure 16 Harold Hood, *Cortina d'Ampezzo*. Hood gravure print.

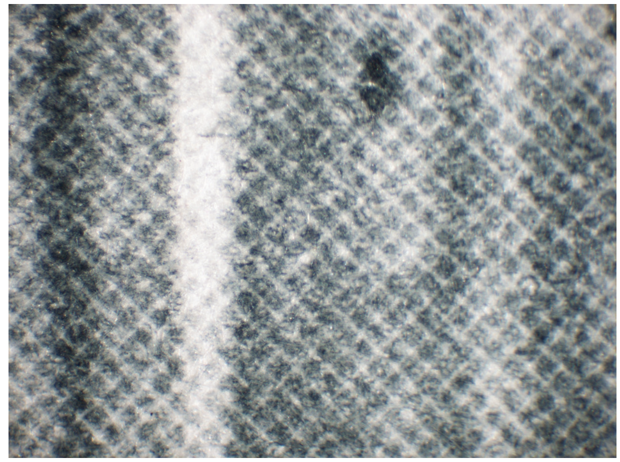


Figure 17a Detail of the print in fig. 16 (40× magnification). The rotogravure pattern is similar to that of other rotogravure prints.

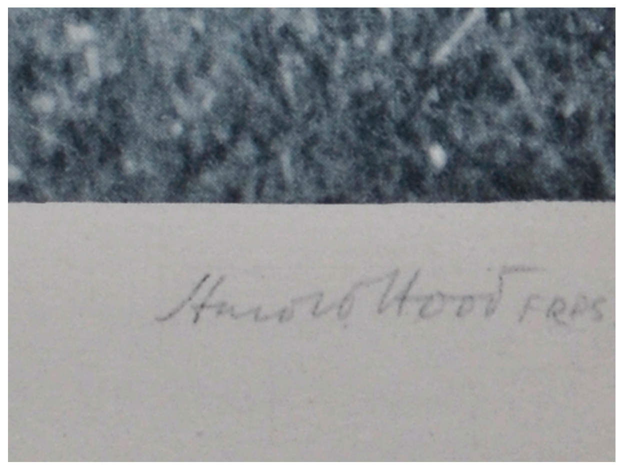


Figure 17b Detail of fig. 16, showing the print artist's signature, also made by rotogravure.

does not differ from the pattern of other rotogravure prints. A detail of the artist's signature, also produced by rotogravure, is shown in figure 17b. This Hood gravure also exhibits a "plate mark."

The names of some rotogravure variants were fashioned after the companies that used them. The so-called Sungravure process was used by the Sun Engraving Company in England, and the Allezzogravure process took its name in part from John Allen, founder of Allen & Co.

Karel Klíč, inventor of rotogravure printing (see above), was a key adviser to the Storey brothers when they formed the famous Rembrandt Intaglio Printing Company. Using the name of the great Dutch artist to convey the quality of their prints, the company specialized in producing high-quality photogravure prints and had a near monopoly on rotogravure printing in England after about 1900 (fig. 18). Following Klíč's death in 1926, Rembrandt Intaglio was sold to the Sun Engraving Company. Figures 19a–19c show the high definition of the Rembrandt gravure in figure 18, even though it was printed on relatively rough paper stock.

Figure 18 High-quality Rembrandt gravure print, 1913.

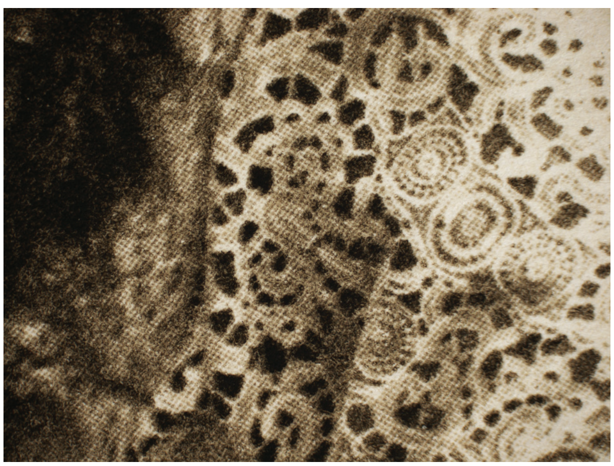


Figure 19a Detail of the print in fig. 18 (10× magnification), showing a high-definition rotogravure pattern.

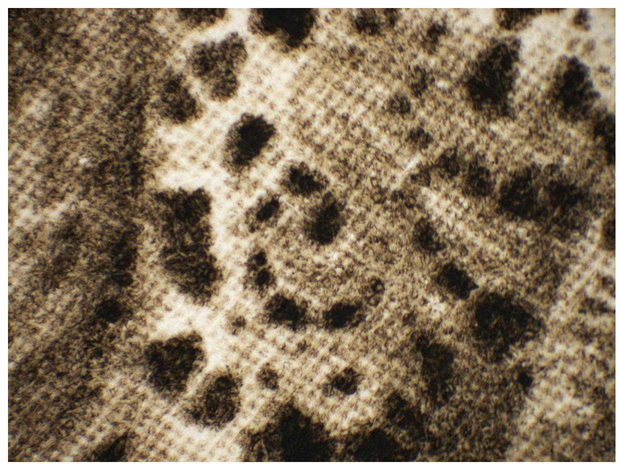
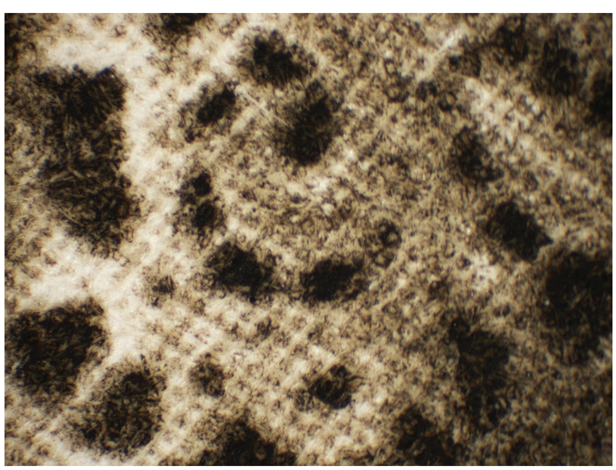


Figure 19b Detail of the print in fig. 18 (25× magnification), showing a high-definition rotogravure pattern.

Figure 19c Detail of the print in fig. 18 (40× magnification), showing a high-definition rotogravure pattern.



Color Photogravure

Both plate and rotogravure processes were modified for printing color images. During the era of chemically based photography and photogravure printing, production of three-color photogravure prints required preparing three high-quality color separation positives and etching these positives onto three photogravure plates or rotogravure cylinders. Inking the plates with cyan, magenta, and yellow gravure inks and printing them in perfect registration resulted in color gravure, or rotogravure, prints. The quality of the black areas of three-color prints usually was not very good, and many photogravure printers opted for a so-called key black-ink printing plate that could be balanced with three-color plates to produce wider-tonality, higher-quality four-color photogravure prints. Plate registration of hand-pulled color photogravure prints was rather difficult, and so they were not produced often. In comparison, the modern color rotary photogravure process produces the highest-quality color photogravure prints. Some printers also use additional color inks beyond the classic CMYK pattern. This is similar to current high-quality ink-jet printers that use up to twelve different inks. Due to the high production cost of engraved photogravure cylinders, color photogravure is used only for high-volume catalog, product, and magazine printing.

High-quality color photogravure prints of subjects of limited color range could be printed using just two colors. Figure 20 shows a color still-life print that was made with orange and blue inks using the Sungravure process. Different proportions of orange and blue inks produced both the blue-green of the pineapple leaves and its brownish skin. XRF analysis identified the presence of an iron-based blue pigment and the presence of lead in both the blue and orange areas of the print (figs. 21a, 21b).

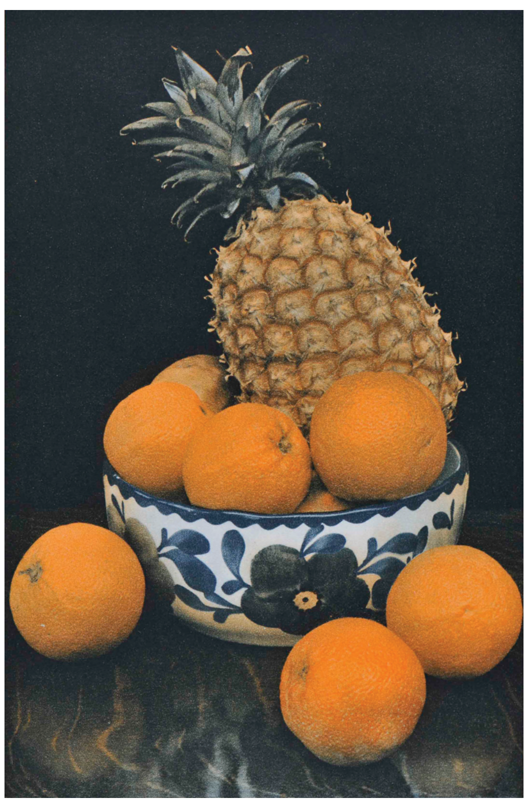


Figure 20 Still-life photogravure print from 1933, made using a two-color (blue and orange) Sungravure process.

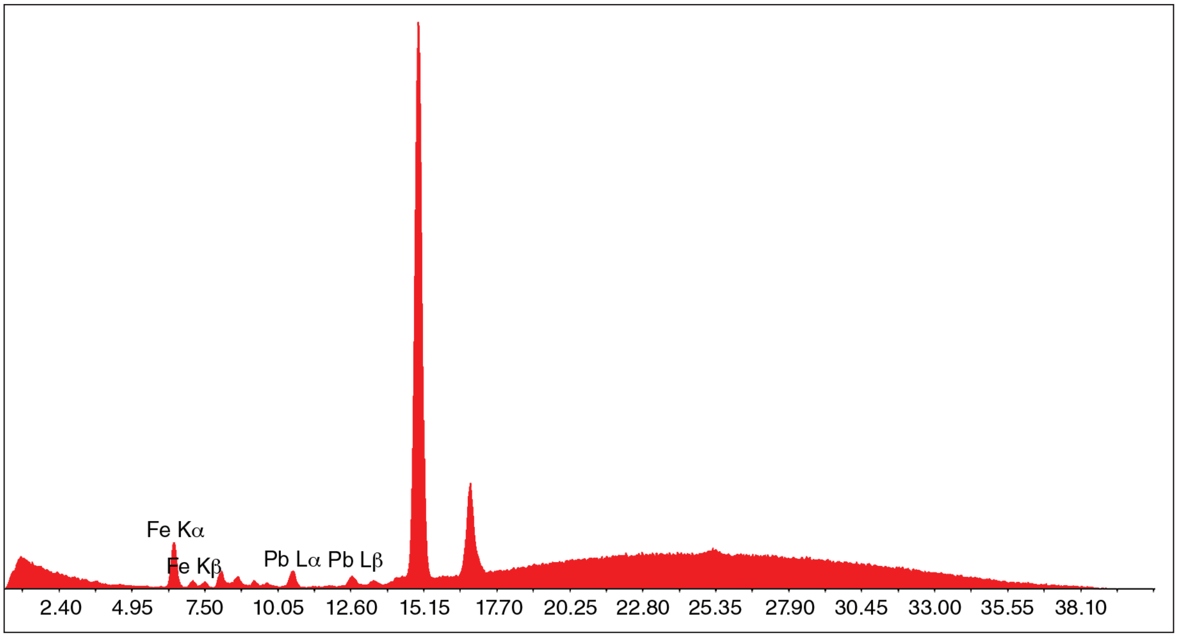


Figure 21a XRF spectrum of the blue area of the photogravure print in fig. 20.

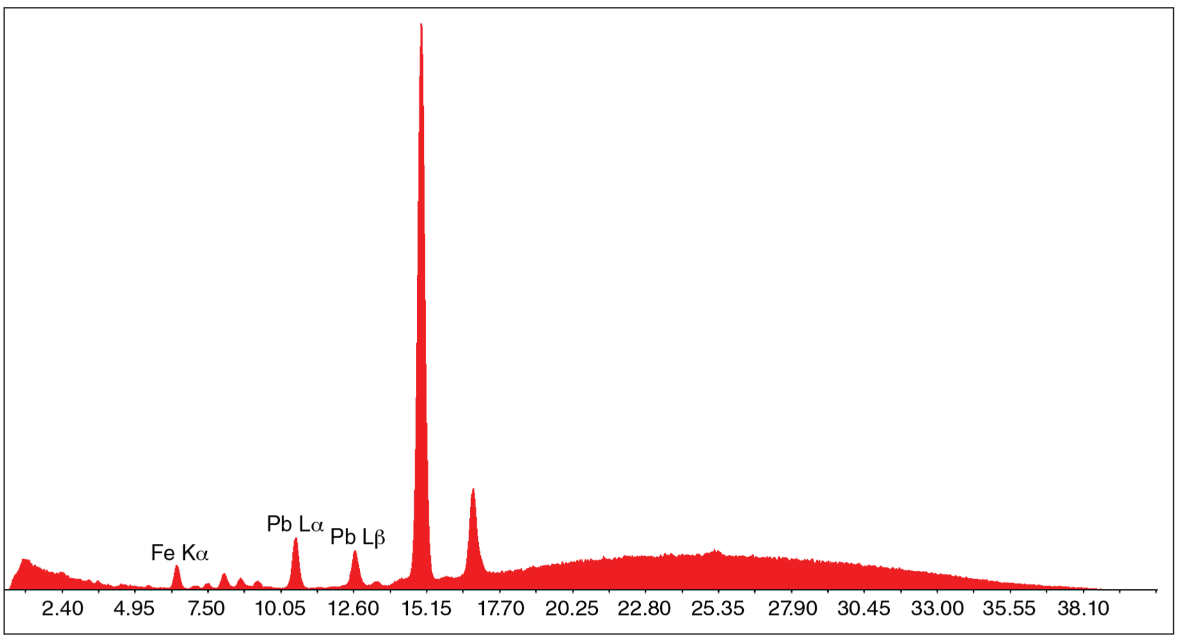


Figure 21b XRF spectrum of the orange area of the photogravure print in fig. 20.

ATR-FTIR analysis of the blue area helped to identify Prussian-blue pigment as the main colorant of the blue ink. The identification was based on the XRF detection of iron and on the presence of the cyano (carbon nitrogen stretch) (C≡N) bonds (at 2096 cm^{-1}) of the blue iron hexacyano complex of the Prussian-blue pigment (fig. 22). The analytical signal of the yellow-orange organic dye that was suspected in the orange area was too low to provide clear identification of the dye.

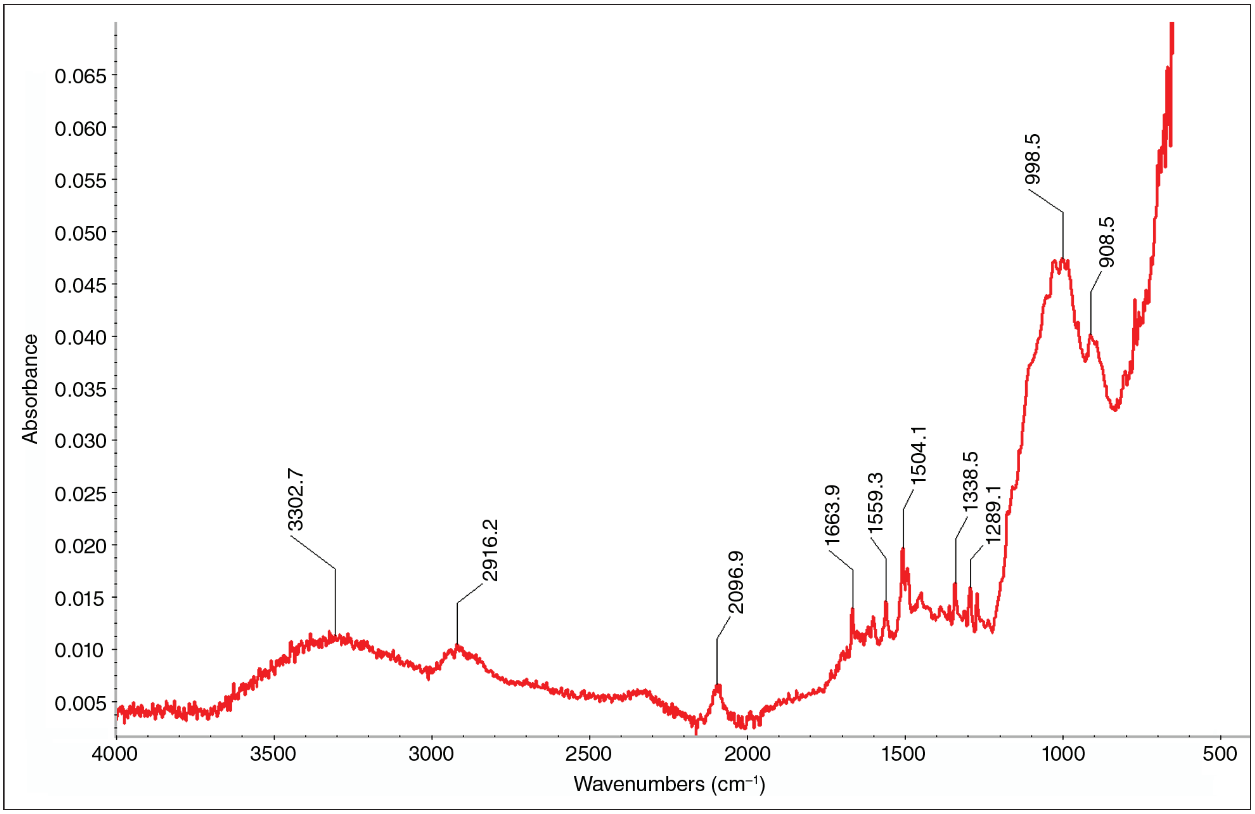


Figure 22 ATR-FTIR spectrum of the blue field of the two-color print in fig. 20.

Color images with additional colors require at least three-color printing to produce all of the necessary colors and color tonalities. Figure 23 shows a three-color rotogravure print. This landscape photograph was made using a Vivex camera, which was an important tool for photographers and printers before the introduction of Kodachrome 35 mm slide film in 1936 and roll and plate Kodachrome material later on. The Vivex was able to produce three-color separated negatives in one light exposure. Positives made from Vivex negatives were used to produce three rotogravure cylinders for color printing. Figures 24a–24c show the microscopic structure of the three-color rotogravure pattern in the print.

The slightly brown Dmax areas of the printed image in figure 23 show the need for using key (black) color overprinting. Figure 25 shows how much improvement in image tonality can be achieved by overprinting a three-color print with a well-balanced, well-adjusted black image.

The areas of black overprinting are usually visible in the Dmax areas of the image. A specially produced, well-balanced black-and-white positive was needed to prepare a black-color rotogravure printing cylinder. Positives of several different image tonalities were tested to determine the desired color and tonality effect. Local bleaching was also used to limit overdarkening of lighter parts. Figures 26a–26c show the image in figure 25 at different magnifications, detailing the overlap of all four photogravure patterns.

Figure 23 Three-color rotogravure print produced using the Vivex camera system.

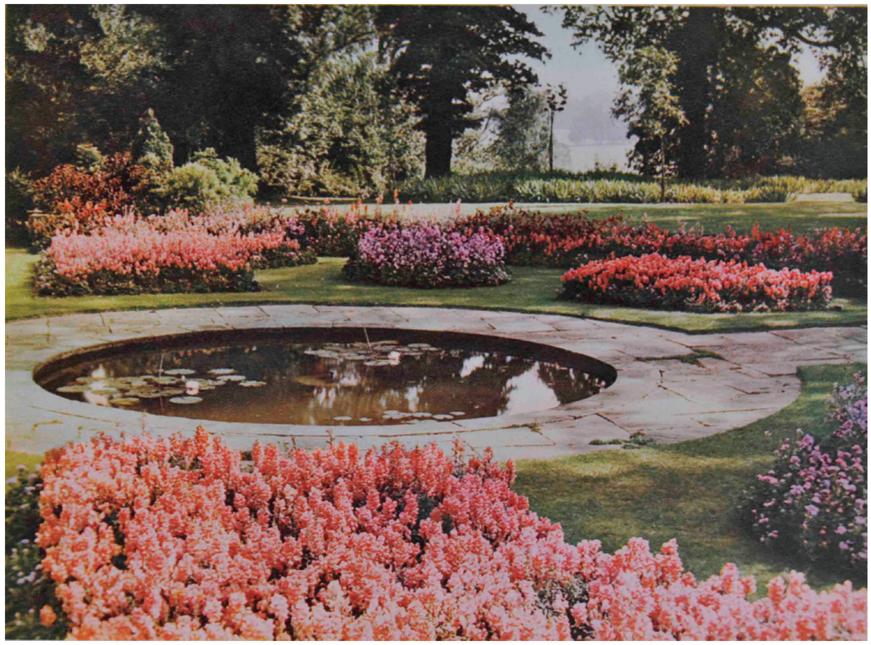


Figure 24a Detail of the print in fig. 23 (10× magnification), showing a three-color rotogravure pattern.

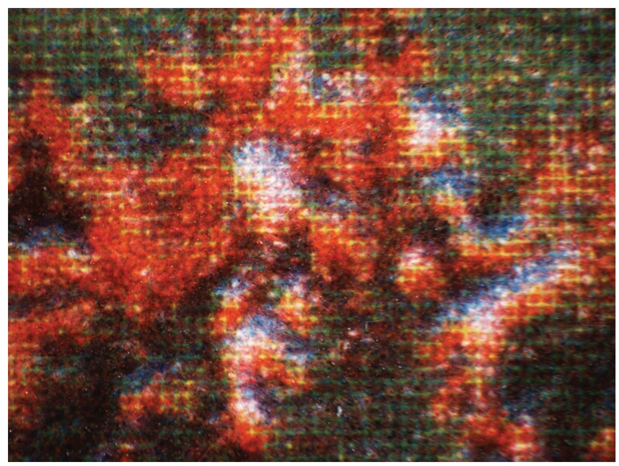


Figure 24b Detail of the print in fig. 23 (25× magnification), showing a three-color rotogravure pattern.

Figure 24c Detail of the print in fig. 23 (40× magnification), showing a three-color rotogravure pattern.

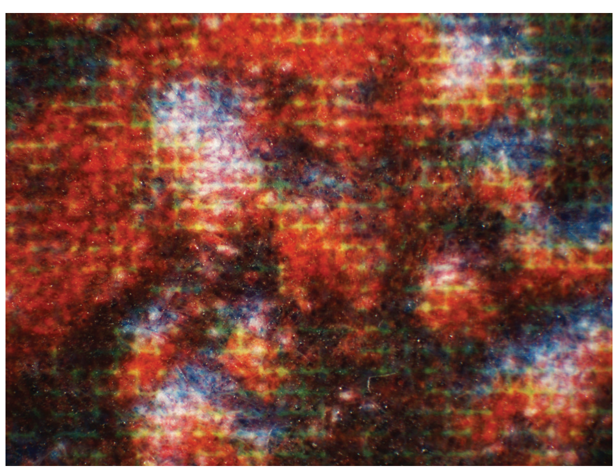


Figure 25 Four-color rotogravure print made by overprinting a three-color print with a black image.

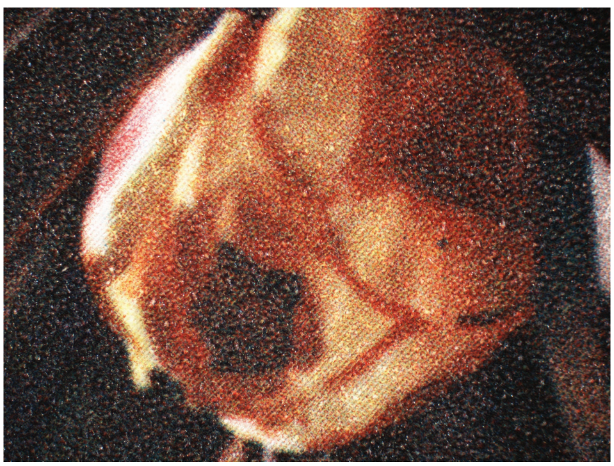


Figure 26a Detail of the four-color print in fig. 25 (10× magnification), showing the overlap of all four rotogravure patterns.

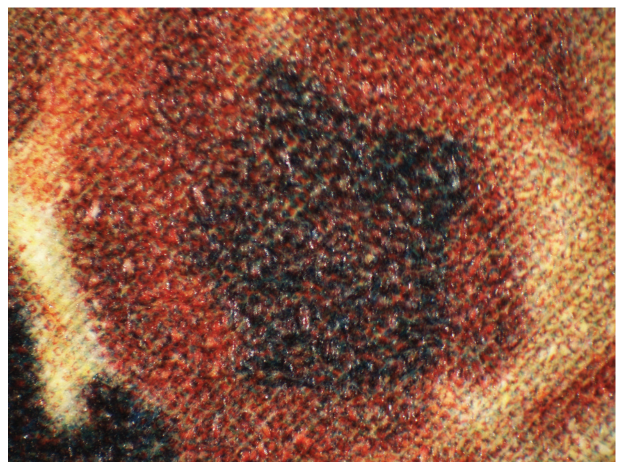
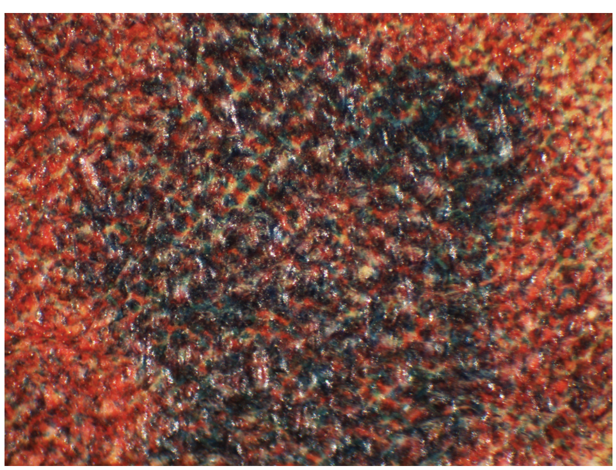


Figure 26b Detail of the four-color print in fig. 25 (25× magnification), showing the overlap of all four rotogravure patterns.

Figure 26c Detail of the four-color print in fig. 25 (40× magnification), showing the overlap of all four rotogravure patterns.



Post-Process-Treated Rotogravures

A relatively small number of existing rotogravures received further treatment after printing. Varnishing of rotogravures was done when there was a need or desire to impart high gloss to a rotogravure image (fig. 27).

Microscopic inspection does not usually provide any important clues that would help to identify a well-applied, well-preserved coating layer without any visible cracking or surface discoloration. Even though the image in figure 27 is around eighty years old, the coating of the photogravure looks solid and fully transparent and does not exhibit any cracking or layer discoloration.

ATR-FTIR analysis may be used to identify the character of an applied varnish (fig. 28). A less glossy, varnished color photogravure print is shown in figure 29. In this case, ATR-FTIR analysis indicated the use of a drying oil-based varnish (fig. 30).

Figure 27 Color rotogravure from 1934, surface coated with a varnish to impart high gloss.

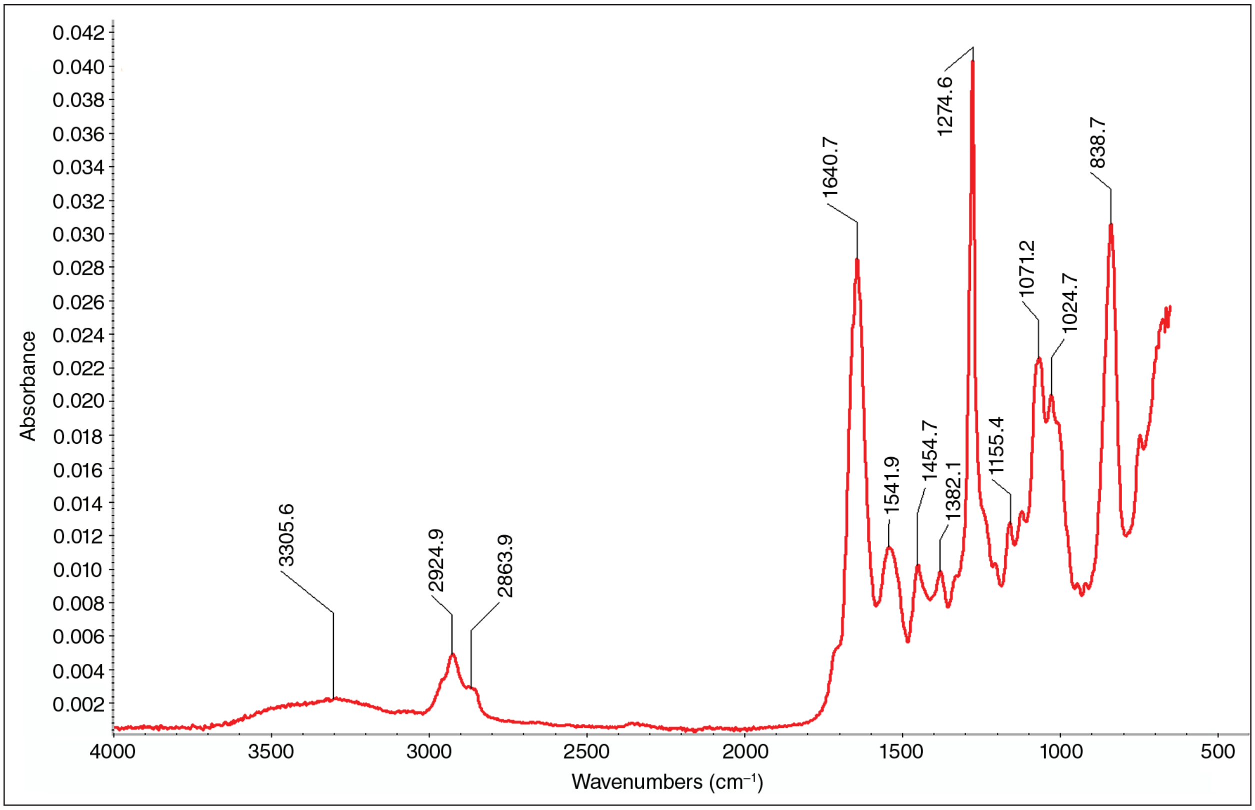


Figure 28 ATR-FTIR spectrum of the rotogravure in fig. 27, indicating the presence of a collodion varnish.

Figure 29 Surface-varnished color photogravure print with less gloss than the print in fig. 27.

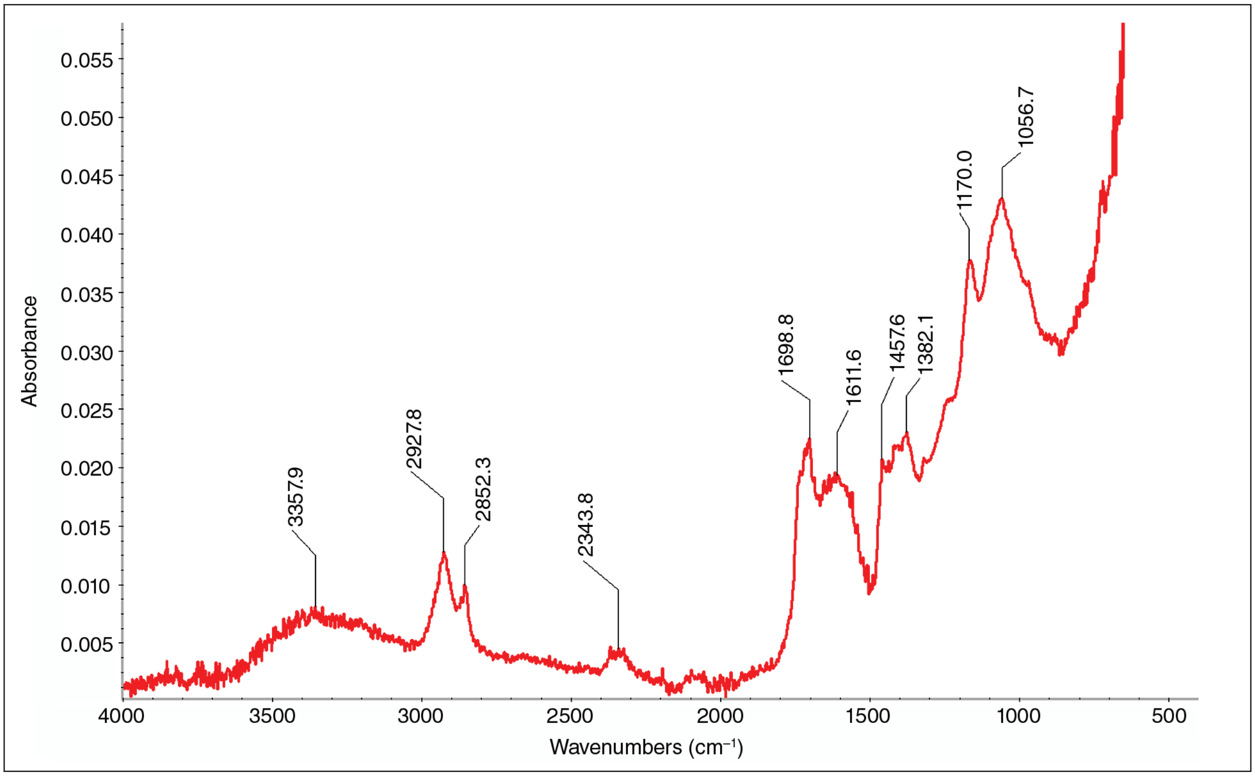
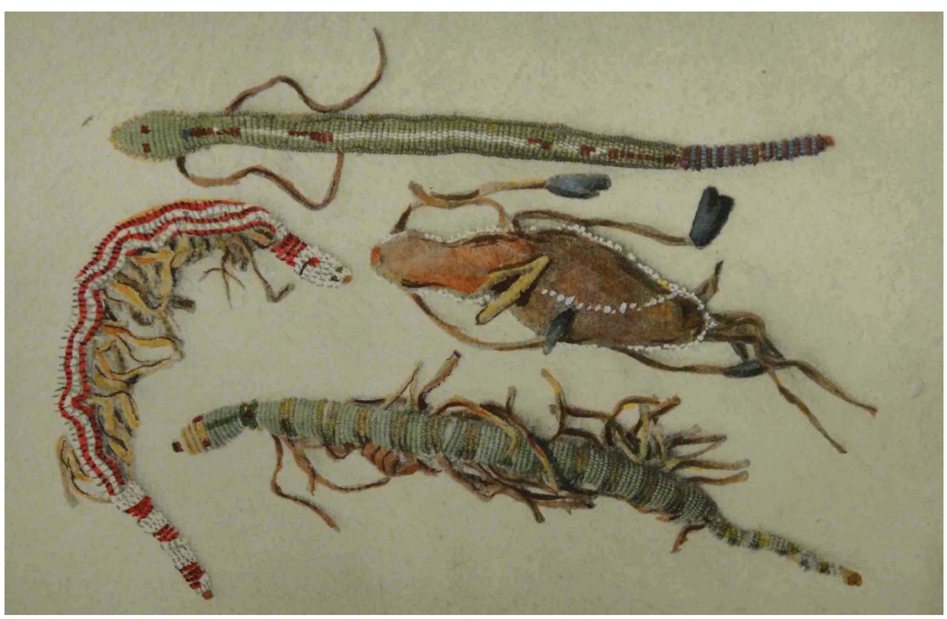


Figure 30 ATR-FTIR spectrum of the surface coating of the print in fig. 29, indicating the use of an oil-based varnish.

Tinted Photogravure Prints

Some photogravure prints were also hand tinted (see the example in fig. 31). Hand application of pigments or dyes in this print can be easily identified under a loupe or microscope. Details showing brush application in key areas of the image appear in figures 32a–32d.

Figure 31 Edward Sheriff Curtis, hand-tinted photogravure, no date.



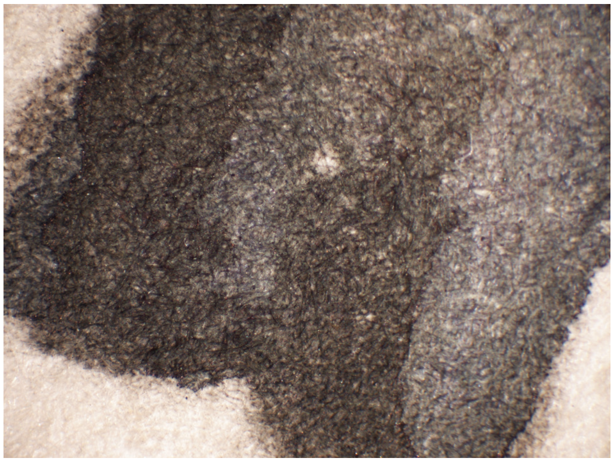


Figure 32a Detail of the hand-tinted photogravure in fig. 31 (25× magnification), showing brush application in the blue area.

Figure 32b Detail of the hand-tinted photogravure in fig. 31 (25× magnification), showing brush application in the green area.

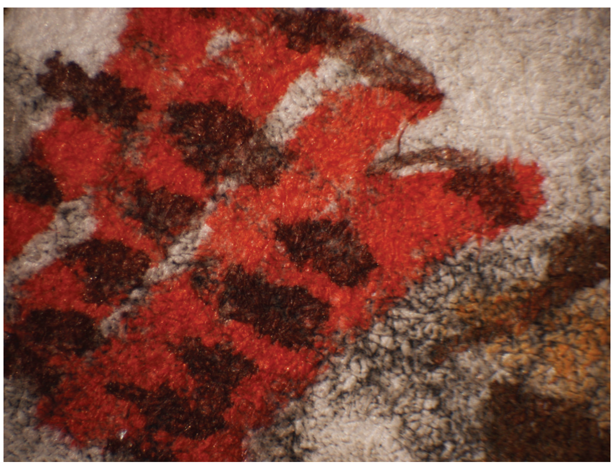


Figure 32c Detail of the hand-tinted photogravure in fig. 31 (25× magnification), showing brush application in the red area.

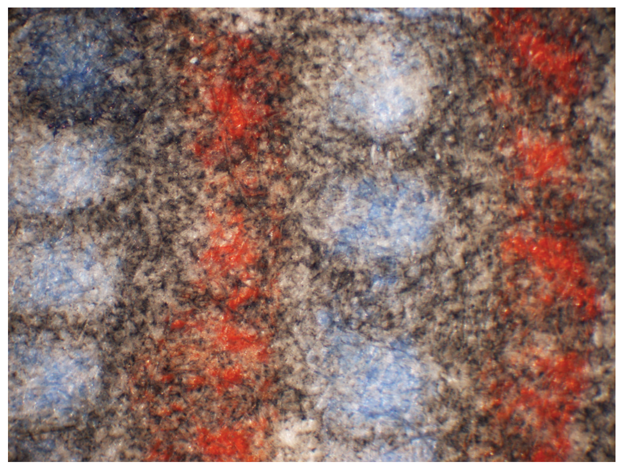


Figure 32d Detail of the hand-tinted photogravure in fig. 31 (40× magnification), showing brush application in the blue and red areas.

XRF analysis of the painted areas of the photogravure shows that the painting was done using organic dyes mixed with zinc white pigment, which also was used to put white-dot accents on the three amulets in the image (figs. 33a–33c).

XRF analysis also showed small amounts of mercury in both the blue and red areas of the painted decoration in figure 31. Higher concentrations of mercury were found in the red areas of the print indicating the use of a mercury-based (vermilion) ink. The presence of mercury in the blue areas may be due to overlap of the blue- and red-tinted areas that aren't separated by the instrument during analysis.

Tinting of some photogravure and rotogravure postcards was also done in the past. A common technique was the use of cutout stencils, which allowed for faster, cheaper production of pseudo-color images compared to the slow hand painting of individual images.

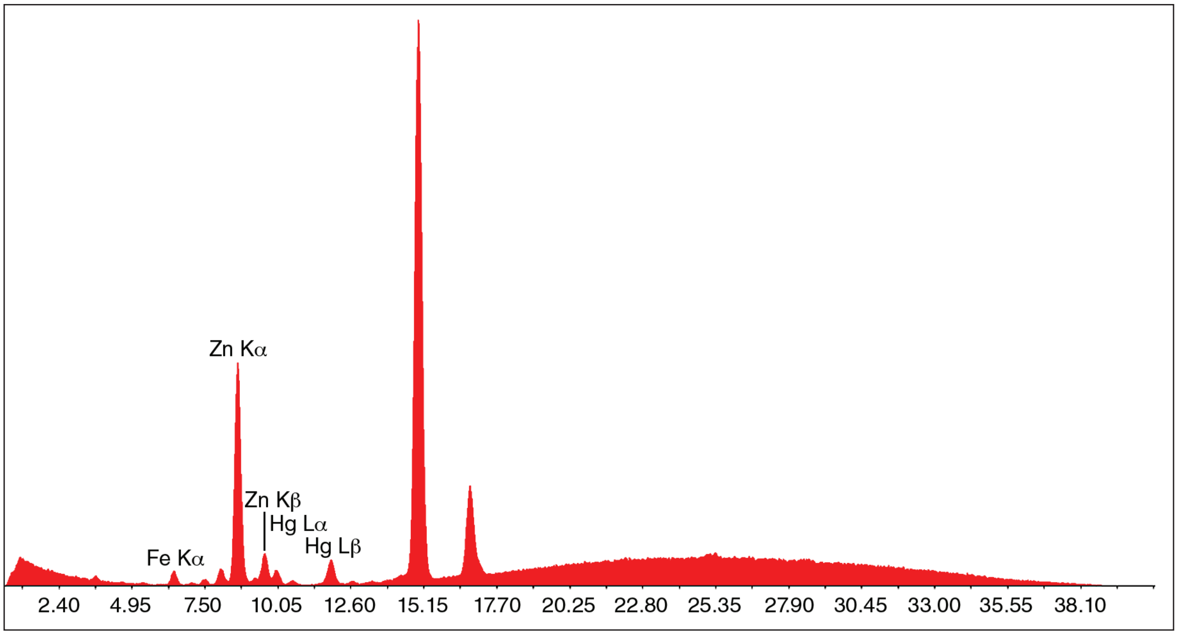


Figure 33a XRF spectrum of the white area of the hand-tinted photogravure in fig. 31.

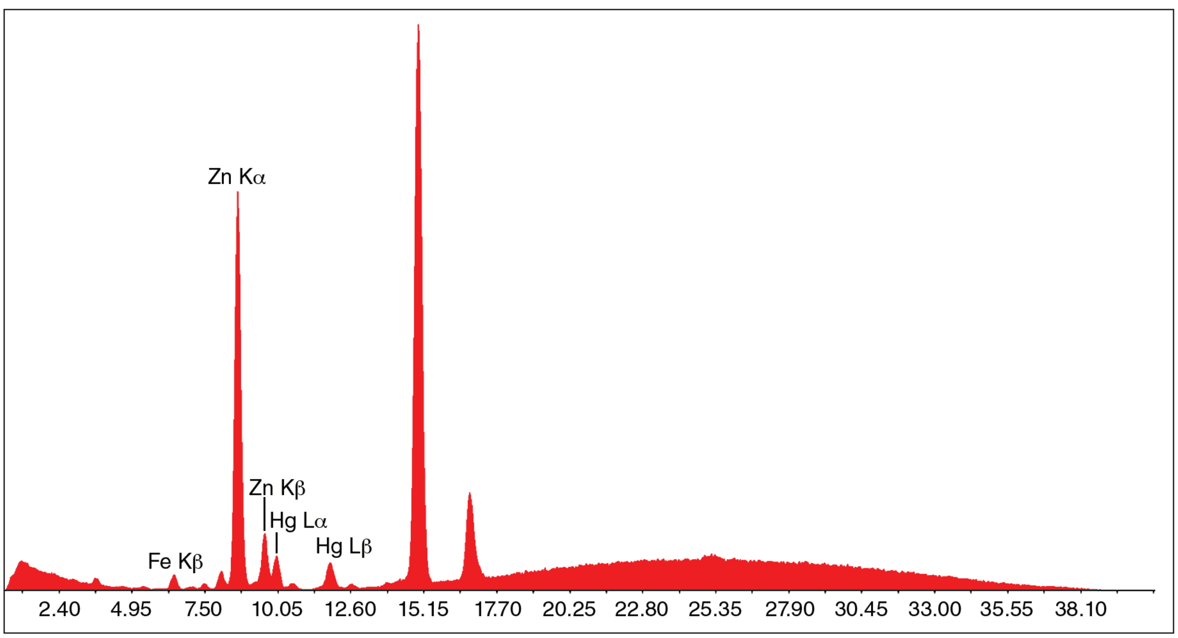


Figure 33b XRF spectrum of the blue area of the hand-tinted photogravure in fig. 31.

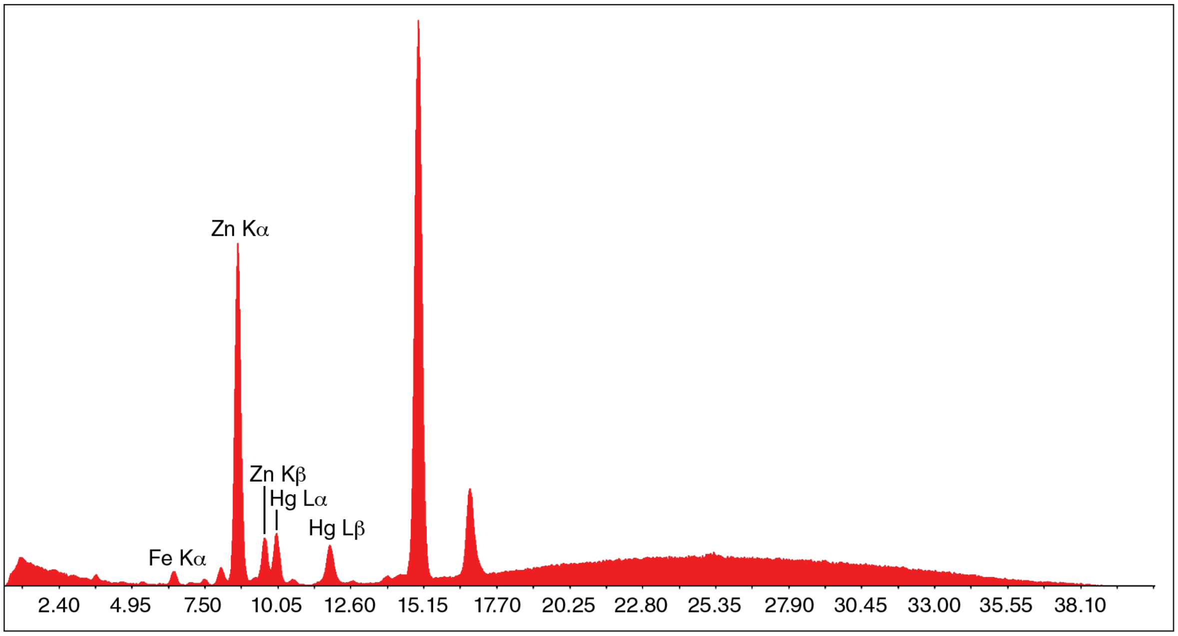


Figure 33c XRF spectrum of the red area of the hand-tinted photogravure in fig. 31.

Polymer Gravure

Polymer gravure is a modern variant of the classic copper-plate photogravure process. An example print is shown in figure 34. The Danish printmaker Eli Ponsaing developed the initial version of this process in 1989. Since that time, many artists and printmakers who did not feel comfortable using corrosive and environmentally harmful chemicals began using the process. Commercial polymer gravure plates soon became available from several manufacturers.

In general, the polymer gravure process is based on the double exposure of a steel plate coated with a photopolymer layer. First, the photopolymer plate is exposed to UV light under a regular (line) or stochastic (random dot) screen. The unprocessed plate is then exposed for a second time under UV light using a continuous-tone positive. The double-exposed photopolymer plate is developed by dissolving the unhardened areas of the polymer in warm water, creating the photopolymer gravure printing plate. The plate is then inked using regular photogravure printing ink and printed on the final paper substrate using a standard intaglio printing press (figs. 34, 35). There is still debate among photogravure artists as to whether the same quality can be obtained using the polymer gravure process. Details of the print in figure 34 show that a stochastic screen was used to create the gravure grain pattern on the plate (figs. 36a–36c).

The general notion is that the polymer gravure process does not provide the same image resolution as the classic copper-based photogravure process. For many artists and photographers, however, this is balanced by the safety advantages of the polymer gravure process. The quality of the plates is stimulated by advances in photopolymer material development for the microelectronics industry. It is reasonable to predict that the quality of polymer gravure plates and prints will at some point match the quality of classic copper photogravure.

Figure 34 Polymer gravure print, 2008.

Figure 35 Fully processed and inked photopolymer gravure plate.

Figure 36a Detail of the polymer gravure print in fig. 34 (10× magnification), showing the use of a stochastic screen to create the gravure grain pattern on the plate.

Figure 36b Detail of the polymer gravure print in fig. 34 (25× magnification), showing the use of a stochastic screen to create the gravure grain pattern on the plate.

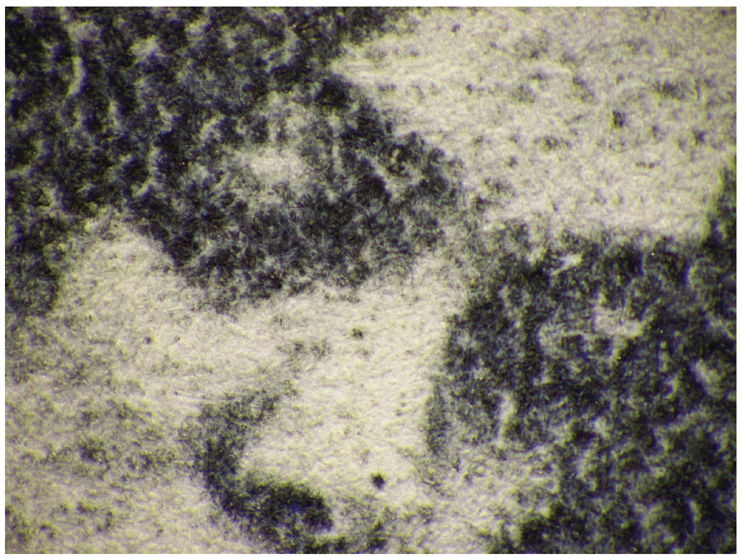
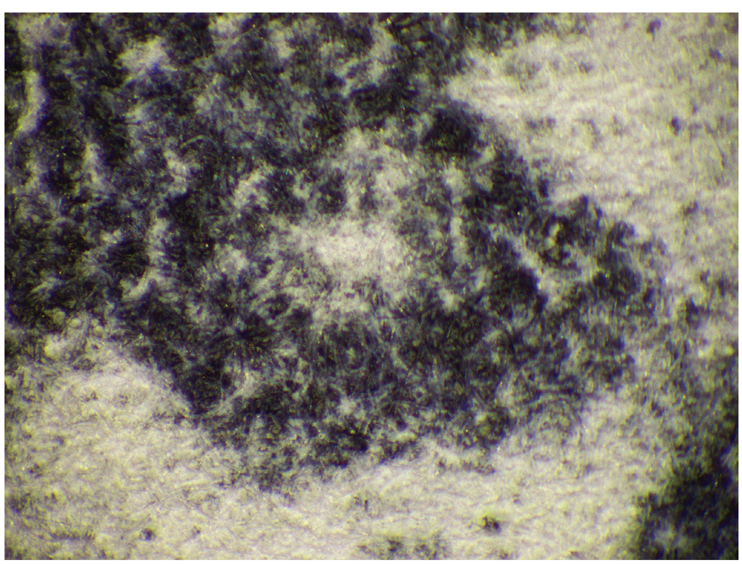


Figure 36c Detail of the polymer gravure print in fig. 34 (40× magnification), showing the use of a stochastic screen to create the gravure grain pattern on the plate.



INTERPRETATION GUIDE

Table 1 Summary of the main microscopic and analytical signatures of photogravure prints and some processes commonly misidentified as photogravure and rotogravure prints. The information below is for typical versions of each process. Exceptions to each entry may exist but are rare.

Photogravure and Rotogravure

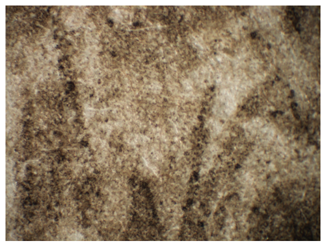
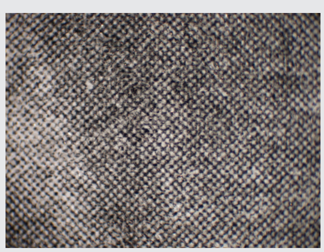
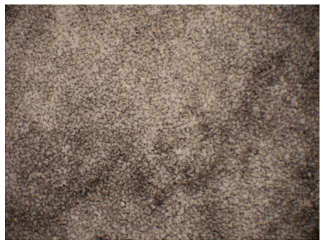
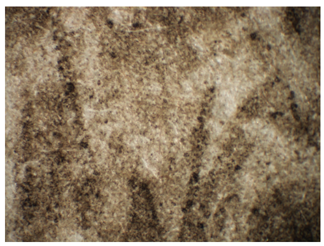
Process	Image Structure	Images	Paper Substrate	Tonality	Analysis
Photogravure	Gravure pattern		Usually plain uncoated paper	Black > brown > other colors	XRF—no signature for carbon based pigment (small addition of Prussian blue) for some block prints—detection of iron ATR-FTIR—low concentration of oil based binder; low signal of CN (Prussian blue)
Collotype	"Worm"-like grain pattern				
Rotogravure	Light, symmetrical lines				
Hybrid-collotype	Halftone pattern				

Table 2 Comparison of the microscopic and analytical signatures of photogravure and collotype prints. The information below is for typical versions of each process. Exceptions to each entry may exist but are rare.

<table>
<tr><th colspan="6">Collotype vs. Photogravure</th></tr>
<tr><th>Process</th><th>Image Structure</th><th>Images (40×)</th><th>Paper Substrate</th><th>Analysis</th><th>Notes</th></tr>
<tr><td>Collotype</td><td>“Worm”-like grain pattern</td><td></td><td rowspan="2">Usually plain uncoated paper</td><td rowspan="2">XRF—no signature for carbon-based pigment (small addition of Prussian blue) for some block prints—detection of iron

ATR-FTIR—low concentration of oil-based binder; low signal of CN (Prussian blue)</td><td rowspan="2">Grain patterns may be difficult to distinguish when printed on rough, uncalendered paper</td></tr>
<tr><td>Photogravure</td><td>Gravure pattern</td><td></td></tr>
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