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Photographic technique for identification of watermarks of old documents

Technique photographique et numérisation de documents anciens

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Introduction

The digitization of old documents generally addresses their informational content, i.e., text and pictorial information, but little attention is paid to the nature of the substrate, whether it is paper, parchment, film or other materials. The age of the document can often be better understood by an analysis of the material, but in general this involves costly and complicated chemical and physical investigations.

One useful tool for gaining more insight into the substrate is to analyze watermarks, where these are present. Until the nineteenth century, paper was handmade on moulds, wood-framed rectangular grids of brass-wire sieves that captured the plant fibers destined to make up the sheets of paper while allowing the water in which the fibers had been macerated to escape[1].

From the thirteenth century onward, European paper mills identified their products through distinctive watermarks. Watermarks are designs impressed into the paper during its manufacture by wires that are bent into desired shapes and then sewn onto the mould, normally centered in its right half. In addition to watermarks, some manufacturers also used counter-marks, smaller designs, words, or initials made in the same way as watermarks and affixed in the center of the left half of the mould. Where the wires of the watermark - and, if

[1] For a discussion of the background of watermarks, we are indebted to publications by Prof. T.-L. Pebworth of the Univ. of Michigan.

present, the countermark - occur, the resulting paper is thinner than it is elsewhere, and the resulting watermark (and countermark), more translucent than its surroundings, and can be seen by holding the paper up to the light. Generations of philatelists dipped stamps into benzene and held the transparentized paper up to bright light - but they had no permanent record.

Techniques for studying watermarks

Until forty years ago, the only way of recording watermarks for comparative study was through tracing or freehand sketching. Since tracing may harm a document, librarians and archivists objected to this method of reproducing watermarks. In addition, tracings also fail to record some of the minute details in the watermarks that can assist the investigator in making exact matches. The same is true of free-hand sketches, even when the sketcher uses calipers to ensure exact measurements. Moreover, any writing or printing on the paper often obscures the watermark to the naked eye and further limits its accurate re-production. Several methods of recording watermarks are now available to reproduce them exactly in all their details without damaging the documents in which they occur: Beta-radiography, the Ilkley technique, and Gravell's Dylux method.

Beta-radiography, pioneered in the 1950s by D. P. Erastov in the Document Conservation and Restoration Laboratory of the Academy of Sciences at Leningrad[2] involves the use of low-energy isotopes to measure differences in paper thickness, eliminating the interference from most written or printed material on a sheet of paper. Preparation of a beta-radiograph of a watermark requires darkroom conditions. A thin plastic sheet uniformly impregnated with an isotope of Carbon 14 having 40 milicuries of activity is placed on one side of the watermark and a direct exposure x-ray is placed on the other side. After 10 to 12 minutes of exposure, the film is removed and developed. From the developed negative film, a photographic print is made.

[2] D. P. Erastov in the Document Conservation and Restoration Laboratory of the Academy of Sciences at Leningrad.

The Ilkley technique, developed in the 1970s by Robert Alston of Ilkley, Yorkshire[3]. It is essentially a contact printing method. In a darkroom, a piece of Kodak Precision Line Film LPD4 is placed under the watermark; a concentrated beam of light from a photographic enlarger is directed through the paper for about 5 seconds; the film is then removed and developed, and a contact print is made from the resulting negative.

Thomas L. Gravell developed the use of Dylux 503 proofpaper, sold by E. I. Du Pont de Nemours and Co., Inc., of Wilmington, DE, USA, as a medium for recording watermarks in the early 1970s. It is by far the simplest and least expensive technique and has thus been widely adopted[4]

It was a fortunate coincidence that Gravell was interested in philately at the time that my colleagues and I at the Du Pont Company were engaged in research on a novel photoimaging material, which was introduced to the printing industry in 1969, where it is employed to make monochrome proofs of lithographic negatives, to establish whether the latter will yield satisfactory printing plates.

A mutual friend, familiar with our work and Gravell's passion for doing research in identifying watermarks of stamps introduced us and I was able to supply Gravell with equipment and materials for starting a fabulous series of scholarly achievements.

Dylux* proofpaper

The technology which is critical here came about in the early 1960s, when L. A. Cescon and I, employed as chemists by the Organic Chemicals Department of the Du Pont Company, investigated novel photochromic hexaarylbiimidazoles, which formed colored stable free radicals, that became colored on irradiation with ultraviolet light (280-400 nm). After a period of time these compounds would reverse to their colorless state. We found that a permanent color of much greater intensity could be instantly obtained when the radicals interacted with certain colorless, or leuco dyes to convert these to dyes. Addition of a visible light (400 - 500

[3] Robert Alston of the Janus Press, Ilkley, Yorkshire.
[4] T. L. Gravell in Watermarks: What they are and how they can be uses manuscripts, vol. XXXII, No.1, winter 1980, p 5.

nm) absorbing compound, which when suitably activated, blocks the color formation and results in room light stability of the imaged sheet. Subsequent irradiation with UV light will not effect color-formation in the hitherto visible-light exposed areas. The use of black light or black light blue fluorescent lamps gives optimum color formation, fluorescent lamps which emit in the visible can be used to perform the visible light exposure. A clear polyester film, coated with a UV-absorbing compound (Dylux Clearing Film) improves the visible light exposure by removing some ultraviolet light that is frequently emitted by fluorescent lamps[5].

Many scientists and engineers developed this technology, which surfaced as a series of proofing media for the graphic arts field under the trade name Dylux. Proofing of lithographic negatives, as are used to expose printing plates, is a major activity in the graphic arts field. In the proofing of lithographic negatives, Dylux is preferred because of the simplicity of its usage; light and light alone is used, obviating the need for washing, heating, toning, chemical treatments, etc., all of which may influence the dimensional stability of the proof paper, and distort the dots which are so important to the printing industry. Additionally, the relatively low sensitivity of Dylux paper to light allows the user to work in subdued or ambient light.

In addition to the cyan-forming paper product, there is a product coated on a clear polyester base (Dylux 608) and there is a near-black image forming material (Dylux 535).

Gravell's interests

When I first met Gravell he was interested in recording watermarks of stamps. He positioned the postage stamps over Dylux paper, making certain that there was good contact, and exposed the assemblage with visible light; the watermark modulated the passage of visible light; a subsequent blanketing exposure with ultraviolet subsequently filled in the color in the areas, which had seen none or little visible light. Depending on the thickness of the paper, exposures to visible light of 1 to 3 minutes are required, followed by ca. 10 to 20 sec. exposure to ultraviolet light[6].

[5] R. Dessauer and C.E. Looney in *Imagin processes and materials*, Neblette's eighth edition, edited by J. M. Sturge, V. Walworth and A. Shepp, Van Nostrand Reinhold, New York 1989, p. 267-8.
[6] T. L. Gravell in "Wartermarking stamps on cover", *Stamps*, March 20, 1971, p. 646.

The technique of exposing the Dylux paper through the stamp gave permanent images, which occasionally showed that the watermark was inverted or reversed, due to improper insertion of paper into sheet-fed stamp printing presses. Such stamps were rare, and hence more valuable. He published his findings in a number of philatelic journals.

In time, Gravell's interest in stamps began to wane, but he found that there was interest in identification of watermarked paper of historical and literary documents, which could be better identified as a result of these studies[7]. In time, Gravell recorded over 7000 different watermarks of documents at the U.S. Library of Congress, the Folger Shakespeare Library, the National Archives, the Winterthur Museum, etc. Several books recording this work have been published. Drs. Mosser and Sullivan of Virginia Technical University will talk at length about the Gravell Archive which attest to Gravell's achievements[8].

Gravell noted that the image on a transparent base would allow the investigator to form an image, which could be superimposed on a Dylux paper image, to allow facile comparison of different samples.

Gravell generated watermarks on Dylux 503 paper and photographed these by conventional means to obtain permanent records. He usually added a ruler to the watermark photograph, to give a more accurate rendition of the size of the watermark.

Gravell's studies are the basis of considerable work by other scholars. The Gravell Watermark Archive at Virginia Technical University is a lasting memorial to this scholarship.

Extensions of Gravell's work

[7] T. L. Gravell in "A Safe, inexpensive way to make prints from glass negatives", *Restaurateur* vol. 2, 1978: 185 -190; "Reproducing Watermarks for Study", *Restaurateur* vol. 2: p 95-104, Copenhagen, Denmark; T. L. Gravell and G. Miller, "A Catalogue of American watermarks 1690-1835", *Garland Reference Library of the Humanities*, vol. 15, Garland Publishing, Inc. New York and London, 1979; "Catalogue of forgeign watermarks found on paper used in America 1700-1835", *Garland Reference Library of the Humanities*, Garland Publishing, Inc. New York and London, 1979.

[8] The Watermark Database http://128.173.125.124:591/DBs/Gravell/default.htm [nouveau site http://www.gravell.org]

The availability of computer-driven scanners allows the duplication of the Dylux image quite easily to form colored images, which are more light stable and permanent than the Dylux images, either with laser or ink-jet printers. Additionally, modern electrostatic printers may be employed to make permanent images on film or paper; under some conditions, such exposures can be made so as to increase visual contrast over that of the original Dylux image. Here it is also possible to generate a black/white transparency, which may be superimposed over a watermark recorded on Dylux paper for comparison purposes.

Gravell's method involves the sequence of imagewise exposure with visible light followed by ultraviolet light to form positive images; he believes that the image-forming exposure to ultraviolet light may damage the paper or the inks and colorants. There is some disagreement about this, as the amount of ultraviolet light involved is relatively small.

Image formation with UV light, and ambient light stabilization of the image background can also be considered. In this case, the thin part of the watermark reproduces as dark against a light field. In my work of the study of the watermarks of the classic stamps of Bermuda, I have preferred this method. For most stamps, an exposure of 1 minute to an exposure unit containing several black light fluorescent lamps is required. Additionally, I found that paper thickness of different printing runs of such stamps can be easily compared and differentiated, by measuring the amount of cyan (blue) color formed during the exposure. The measurement of the amount of color generated is easily accomplished with a densitometer, which records the amount of reflected light. Dylux 503 is designed to reach a reflectance density of 1.4; differences of 0.1 are readily discernible with the naked eye, or recorded digitally with the densitometer.

Acknowledgment

I have been fortunate in being associated with Dylux and the chemistry that is its basis for much of my professional life over 39 years. Among my colleagues at Du Pont who should be acknowledged as major contributors were J. V. Caspar, L. A. Cescon, G. R. Coraor, J. De Campi, D. R. Logrando, A. Maclachlan, W. F. Mooney, T. M. Sheets and W. S. Wartell. A

patent estate of over 40 U S patents provided the Du Pont Company with a very favorable commercial position.