

RECORDING WATERMARKS BY BETA-RADIOGRAPHY AND OTHER MEANS

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Paper historians have used a variety of techniques for recording watermarks. The following provides a brief overview of these, and a discussion of why beta-radiography is our method of choice at the National Gallery and how we have been using it.

Locating watermarks

While a watermark will occasionally be visible on the back of an image-bearing sheet of paper in normal light (particularly where ink penetration helps define it), more often it will only be visible by transmitted light. When a design layer further obscures the watermark, other methods may be needed to locate or clarify it. Black paper under the recto or raking light across the surface (particularly if the object is lined) may work. A beta-plate can also be used to literally "search" in the area of a partially visible or suspected mark.

Recording watermarks

Although various methods exist for recording watermarks, their value for serious scholarship differs greatly. Detailed below are elements essential to each recording system, as well as suggestions for accurate and safe execution of each technique. (For more complete descriptions of the methods consult the articles cited in the bibliography.)

1. Rubbing with the side of a soft pencil through tracing paper (as one might record the image off a gravestone), has been suggested for use where the design layer completely obscures the image. Rubbing generally does not produce satisfactory results and is potentially damaging.
2. Tracing is the traditional method. A tracing can be useful if precisely rendered and if all relevant material is included; that is, not only the watermark, but chain and laid line spacing, and the dots around the watermark where the wire has been stitched to the mold. Unfortunately tracings often provide inadequate information either because a design layer obscures watermark details or what is called a tracing is actually a rough eye copy or a perfected version of the actual watermark.

If you are using this method to record watermarks, trace through mylar to prevent damage from pencil pressure on the object.

3. In photosensitive paper techniques, such as Thomas Gravell's use of Du Pont's Dylux 503, light shines through the watermarked paper to expose the photosensitive sheet below.

The Dylux image is a contact print with the benefit of exact size reproduction. Both watermark and design layer are recorded as superimposed images, and if location of the watermark on a manuscript page is significant, then this superimposition is an advantage. We, however, felt the overlap often obscured significant details of the paper structure.

When using Dylux, ultraviolet filtering mylar might be placed under the object to help cut incidental ultraviolet radiation transmitted by the fluorescent bulbs. This protects the object and helps produce a clearer image.

4. Transmitted light photographs can present a very clear image of the paper structure, particularly if printed for high contrast. The image from the design layer, however, is again superimposed, sometimes obscuring all details except the watermark and often obscuring that as well.

It is important to include a scale (such as a transparent ruler) in transmitted light photographs and, if possible, to print to scale. Otherwise the photographs will not be useable for precise identification.

5. Low voltage x-radiography can yield an image comparable to that produced by beta-radiography (see below). Overexposure of images is, however, difficult to avoid with this higher energy radiation. An advantage of this technique over beta-radiography is that it can produce an image of the entire sheet of paper in a single exposure.

6. Beta-radiography is our method of choice. The initial investment is expensive (c. \$1,000 for a sheet 10 cm²). If cost is prohibitive, two or more laboratories might share a plate.

The beta-plate consists of less than five microcuries of carbon-14 embedded in a thin sheet of polymethyl methacrylate. As the carbon-14 decays it emits electrons in the form of beta particles, extremely low energy radiation suitable for radiographing materials on the order of thickness of paper.

In results this method is unequalled. A contact image of the paper structure is produced with little or no competing image from the design layer. This is a contact print which exactly reproduces the paper structure including not only the watermark, but chain and laid lines, sewing dots, as well as any flaws or unusual characteristics.

How long do you expose the film to get a sharp image? This depends on the mass of material traversed by the beta-rays. As the mass of the paper increases at a given point, the necessary exposure time will increase exponentially. For instance, many of the papers examined at the National Gallery were about 0.10 mm thick and required exposures of about 1 1/4 hours. Papers of not twice that thickness (0.18 mm) required exposures of five hours to obtain satisfactory images.

To minimize trial and error we have graphed successful exposures by edge thickness. This gives an empirical range and has been useful with papers of average density. More exact calculations which take density variations into account are possible. These should be based on both edge thickness and optical density at the edge and at the watermark. Per Laursen will publish an article on this subject later this year (see bibliography.)

Recording large watermarks with a beta-radiograph plate

1. If the largest dimension of the watermark is greater than the length of the beta-plate, the plate might be pivoted to record the image on a diagonal. If this is aesthetically displeasing or still cannot accommodate the image,
2. Two or more negatives can be trimmed, pieced (with magic mending tape), and the image printed from the pieced negative; or
3. The entire image can be recorded on a single sheet of film by dividing the watermark into sections, and moving the beta-plate from section to section at intervals determined by test exposures.

This is accomplished with the aid of a diagram. (A similar diagram can be used whenever there is difficulty locating a watermark.)

- a. Place the object face down on a light box, covering it with mylar to protect it during tracing.

Place a sheet of paper over the mylar and trace the corners of the object, and the outer points of the watermark in pencil.

- b. Locate and mark the center of the watermark on the traced diagram.
- c. Divide the watermarked area into sections by laying a template the size of the beta-plate on the diagram overlapping the centerpoint of the watermark by a fraction. Mark its location.

Move the template to an adjacent section, keeping a slight overlap, and again mark its location.

Repeat as many times as necessary to cover the entire watermark. Extend the section lines out beyond the marked corners of the object.

- d. Under a safelight cut a sheet of x-ray film and place it on the diagram within the marked corners of the print yet covering the watermarked area.
- e. Place the object face down over the film (a safety precaution which keeps the image against the smooth surface of the film). Weight the object and film to prevent slippage.
- f. Place the beta-plate over the object and align it with the lines of the first section (see "C" above).
Weight the plate to insure intimate contact.
- g. Expose the film for the length of time determined by the test exposure. Move the plate to the next section and expose it.

Repeat as often as necessary to cover the entire watermark.

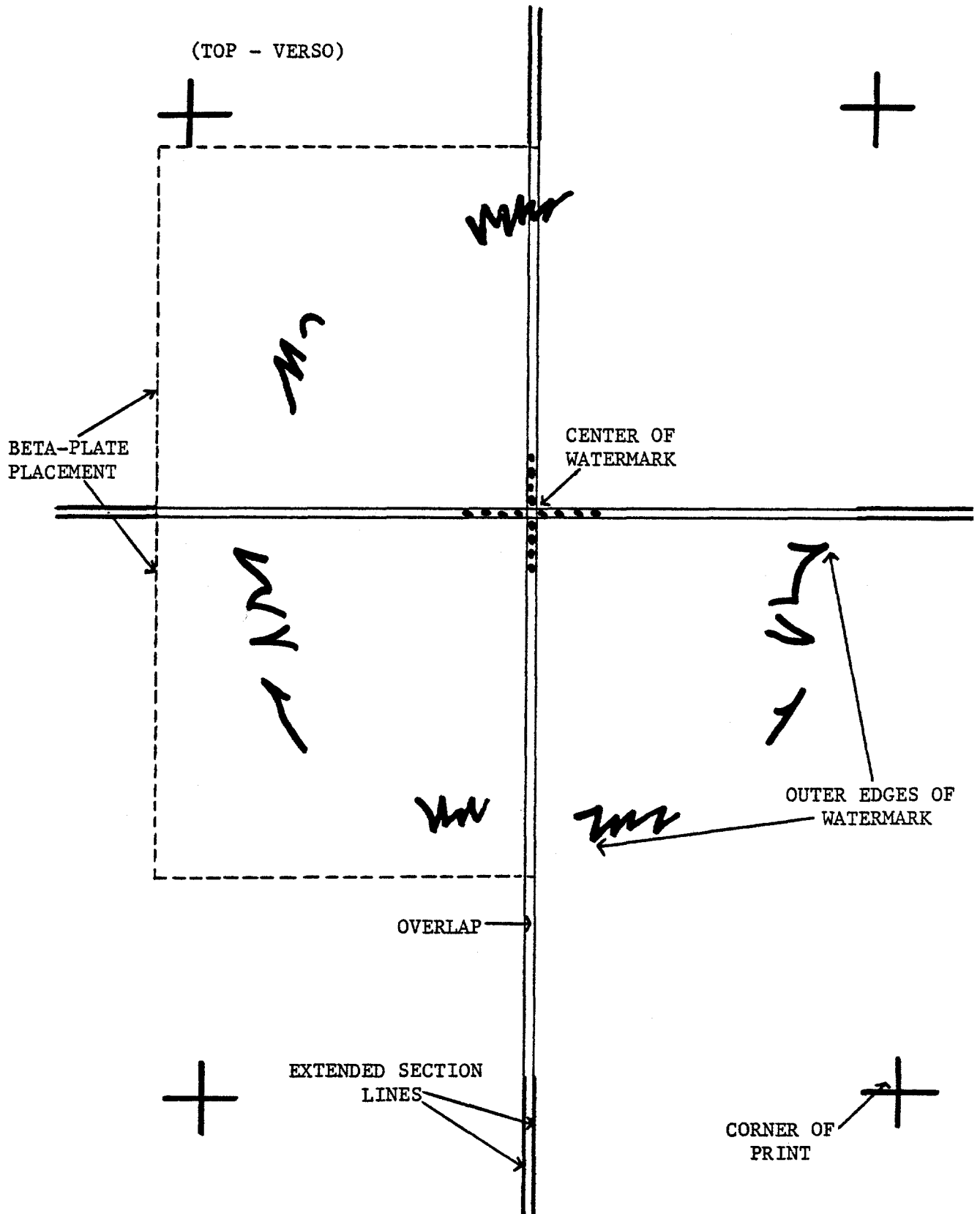
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Finally, a note about the longevity of the plate. Its life span is limited not by the carbon-14 half-life, but by the stability of the polymethyl methacrylate to the radioactive element within it, and to the physical and chemical environment in which it is stored. A reasonable useable life span is now estimated to be about ten years.

As I noted in a letter to the AIC newsletter (Feb. 1982), the National Gallery's beta-plate exhibited considerable mottling, warping and internal crizzling, causing large out-of-focus areas in the radiograph images. This began two or three years after we received the plate.

The best recommendations I can make following consultation with the manufacturer, are: keep the plate flat, in a constant moderate environment and away from halogenated hydrocarbons such as polyvinyl chloride. Since it is radioactive, however mild, handle it with fairly thick rubber gloves (thin gloves may pass the beta-rays).

Diagram for recording a large watermark using sequential beta-radiograph exposures



METHODS FOR RECORDING AND REPRODUCING WATERMARKS
with Emphasis on Beta-radiography

GENERAL

Ellis, Margaret Holben. "Watermarks and the Stories They Tell," in Drawing, 3, No. 6, 128-131 (March-April 1982).

Provides an overview of various techniques, including advantages, disadvantages and helpful hints.

Gerardy, Dr. Theo. Dr. Gerardy has published extensively, examining in detail most methods of watermark reproduction. Much of his research appears in the journal Papiergeschichte. In German.

Stevenson, Allan. "Introduction," in C.M. Briquet's Les Filigranes (a facsimile of the 1907 edition). Amsterdam: The Paper Publication Society, 1968.

Brief discussion of various methods of watermark reproduction and essential features to include in any system of recording watermarks. Bibliography.

_____. "Paper as Bibliographical Evidence," in The Library, 17 No. 3, 199 ff (Sept. 1962).

Evaluates and provides helpful hints for several methods of recording watermarks including note-taking.

NOTE-TAKING

Stevenson, Allan. "Watermarks are Twins," in Studies in Bibliography, 4, 58 ff (1951-52).

Discusses the essential elements of a rather involved note-taking system. Valuable for establishing a consistent method of notation.

RUBBING

Haupt, W. "Wasserzeichenwiedergabe in Schwierigen Faellen," in Maltechnik-Restaur, 87, No. 1, 38-43 (1981).

Reproduction of watermarks through pencil rubbings on tracing paper when transmitted light techniques are unsuccessful. Bibliography.

TRANSMITTED LIGHT PHOTOGRAPHY

Field, Richard S. "On Photographing Watermarks," in The Print Collector's Newsletter, 8, No. 3, 75 (July-Aug. 1977).

Describes one system of photography and the necessary apparatus, including flash unit and a plexiglas stand for photographing hinged prints.

CONTACT PRINTS ON PHOTSENSITIVE PAPER

Gravell, T.L. "Watermarks and What They Can Tell Us," in Preservation of Paper and Textiles of Historic and Artistic Value II, Advances in Chemistry Series No. 193, edited by John C. Williams, 57-62 (1981).

Advantages of and technique for using Dylux paper to record watermarks. Mr. Gravell's most recent essay on the use of Dylux.

RADIOGRAPHY

Bridgeman, Charles F. "Radiography of Paper," in Studies in Conservation, 10, No. 1, 8-17 (Feb. 1965).

Discusses low-voltage radiography and electron radiography of paper.

BETA-RADIOGRAPHY

Ash, Nancy E. "Technical Notes - Beta-Radiography," in A.I.C. Newsletter, 7, No. 2, 12-13 (Feb. 1982).

Letter describes problems with the deterioration of the beta-plate at the National Gallery.

Boutaine, J.L., J. Irigoien, and A. Lemonnier. "La Radiographie dans L'Etude des Manuscrits," in Les Techniques de Laboratoire dans L'Etude des Manuscrits. Colloques Internationaux du Centre Nationale de Recherche Scientifique, No. 548, Vol. 2, 159-176 (Sept. 1972).

Concentrates on theory and techniques of beta-radiography. In conclusion compares it with other methods for radiographing paper. Bibliography.

Erastov, D.P. "The Beta-radiographic Technique of Reproducing Watermarks Found in Documents," Academy of Sciences of The U.S.S.R. Laboratory for the Techniques for Restoring and Preserving Documents and Books. Collected Works for 1958. In Russian.

The original research on the subject. A 1960 English translation exists.

Hensley, Pamela. "Contact Beta-radiography of Paper," in an unpublished paper in collaboration with the Minneapolis Institute of Arts (Sept. 1, 1972).

Succinct history and theory. Step by step details of the method.

Laursen, Per. Article to appear in next issue of Libri, International Library Review.

Will describe a technique for calculating paper thickness at the watermark to obtain more exact time measurements for beta-radiograph exposures.

"Maps, Missals and Watermarks," in Nature, 218, 620-21 (May 18, 1968).

Discusses Allan Stevenson's use of beta-radiography.

Norstrand, Ove K. "Beta-Radiographie von Wasserzeichen," in Papiergeschichte, 17, No. 3-4, 25-28 (June 1967).

History of the development of beta-radiographic techniques.

Simmons, J.S.G. "The Leningrad Method of Watermark Reproduction," in Book Collector, 10, 329-30 (1961).

Clear summary of the original article by D.P. Erastov.

Stevenson, Allan H. "Beta-radiography and Paper Research," in International Congress of Paper Historians - Communications, 7, 159-68 (1967).

Not readily available. Should be interesting as Stevenson is always an intelligent and informative source.

Tydeman, P.A. "A Simple Method for Contact Beta-radiography of Paper," in The Paper Maker, 153, No. 6, 42-48 (1967).

Most thorough description of the method. Originated beta-radiography as it is used today.