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Acknowledgements

Grateful thanks and words of appreciation need to be recorded to:

Mika Hakkarainen Special Collection Curator Helsinki for supply of back-lit images of *ABCKiria*.

Claudia Ludwig and Lucy Finn at Sotheby's, New York for locating and supplying the 26th November 2013 *The Bay Psalm Book Catalogue.*

Dr. Brent Elliott and Ms. Debbie Lane, both formerly of the Royal Horticultural Society, who were leaders in recognizing, encouraging and supporting watermark research at the Lindley Library.

Staff at the Vilnius University Library for not only allowing the imaging of *Cathechismus,* 1547 but also enabling it. Aušrinė Aurelia Apanavičiūtė for her recordings of the music in the Vilnius copy and for the ready approval for those recordings granted by Father Petras Tverijonas at St Casimir's Lithuanian Roman Catholic Church in London.

Mr. Simon Green for his expert guidance about paper moulds.

Allard Pierson at the University of Amsterdam for efficiently supplying the Sheremetew watermark image, and to Alexander Khmelevsky for the fulsome comments on the Sheremetew family.

Dr Fred Hocker, Head of Research, Vasamuseet Stockholm for his immediate and most helpful information about cannons and heraldry.

The Bibliographical Society, The Paul Mellon Centre for Studies in British Art and The Lutheran Church—Missouri Synod for their considerable and essential funding support.

Charlotte Tancin at the Hunt Institute for Botanical Documentation, Carnegie Mellon University, to Catherine Sambrook at King's College London, Foyle Special Collections Library and to Stephen Tabor at the Huntington Library for their invaluable suggestions for improving the early draft.

Alessandra Anzani of Academic Studies Press, who has patiently guided the production of the book through many months.

Introduction

Researchers have long appreciated the potential of watermark research, but it is the advent of digital resources which is allowing that potential to be achieved. Not only is security being improved, but valuable research resources are being created.

The First Part of this book opens with a description of the *PaperPrint* method, devised by the author, as used at the Lindley Library, Royal Horticultural Society for prints, at Marsh's Library, Dublin for copies of a Cyrillic printed book, and at the Boston Public Library for *The Bay Psalm Book*. *PaperPrint* effectively creates a digital 'fingerprint' of the paper and enhances the security.

The Second Part gives brief background information about locating watermarks in hand-made paper. This is followed by the description of a simple digital procedure for recording watermarks. Details are given about overcoming problems, such as the way that, not uncommonly, watermarks in books are divided over two or more pages.

The Third Part is *Case Study—Lithuania to Russia and Sweden—Cultural—The Danzig Connection,* which illustrates the further potential of watermark research. It connects the history of the first book printed in Lithuanian (the 1547 *Catechismusa* by Martynas Mažvydas) with Danzig, with Belarus and with the enormously powerful Russian family Sheremetew.

The Fourth Part concerns the only surviving fragments of the first book printed in Estonian (a Lutheran catechism), which are rightly regarded as emblems of the national spirit. The number of pages had been uncertain but is proven in this Fourth Part. In addition the evidence from the watermark suggests a paper connection with Martin Luther.

The Fifth Part concerns the first book printed in Finnish (*ABCKiria* by Mikael Argicola) and uses the evidence from the watermark to question the accepted date, to recommend another and to illuminate the composition of book.

The Downloads section includes links to two items of supporting material. The first link shows how an octavo is made from one sheet of paper. The second link reveals the watermark found in the Vilnius copy of the above-mentioned first book printed in Lithuanian.

First Part

PaperPrint—Security

E. Forbes Miley III was a highly respected dealer of antiquarian maps.[1] However, on 8 June 2005 he was arrested at the Beinecke Library at Yale. Later investigation revealed that he had been involved in stealing at least ninety rare maps valued at some $3,000,000. A decade earlier Gilbert Bland had been found guilty of stealing maps worth some $500,000 from American universities.[2] In 2020 Michael Vinson's book related the full story of the dramatic life and death of the Texan Johnny Jenkins,[3] revealing how the man who had once achieved the largest rare book deal of the century was also a book thief. Jenkins was also suspected of forging items including a copy of *The Texas Declaration of Independence.* At the time of his death—his body with a shot to the back of the head, was discovered in a river—he was under suspicion for arson, forgery and liable for huge gambling debts. These three cases are not exceptional. The known extent of the problem of thefts is international. Thieves include priests, who were defrocked and sentenced to a year and a half in prison,[4] and insiders such as a former Bibliothèque Nationale de France conservator of Hebrew manuscripts.[5] Thefts continue up to the present day.[6] In addition, the full extent of the problem is unknown, partly because it does seem that the default attitude of those who know they have been targeted is reticence if not silence. Also, by definition, no one knows what items have been stolen if no theft has been noticed.

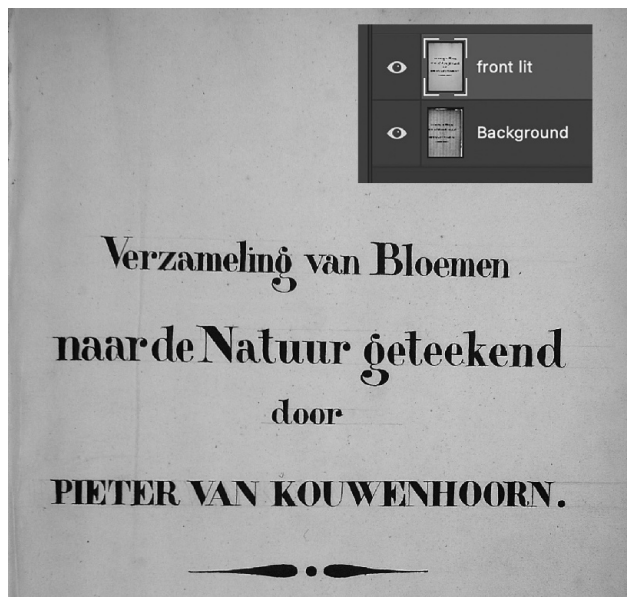
Clearly there is a pressing need to protect items on hand-made paper. The security of such items can be enhanced by the *PaperPrint* procedure, which was devised by the author for use at the Lindley Library of the Royal Horticultural Society. The first book there to have every page imaged using front lighting and back lighting was the 1526 *Grete herball*. Subsequently selected pages of a large number of other early printed books at the same library were imaged for research and for security enhancement. A full set of *PaperPrint* images was archived with that library. In addition, thanks to support from the Paul Mellon Centre for Studies in British Art, other copies of the *Grete herball* in London, Oxford, Texas, California and Pennsylvania have been imaged using the same procedure.

Method

The following image shows the imaging system used to capture the front-lit and the back-lit images required for a *PaperPrint* file.

The camera is mounted on the column with the twin front lights switched on so as to illuminate the book in the cradle. The electro-luminescent light sheet is under the page to be imaged. The pink coloured light sheet (switched off here) is 1 mm thick and remains cool when switched on to give a bright uniform white light. Note the mm scale placed on the light sheet to the right of the page.

PaperPrint calls for a front-lit image:



Front-Lit Van Kouwenhoorn Title Pieter van Kouwenhoorn / RHS Lindley Collections.

and a back-lit image to be captured:

Back-Lit Van Kouwenhoorn Title Pieter van Kouwenhoorn / RHS Lindley Collections

Both images are captured under the same conditions. There should be no displacement of camera or subject so that when the images are archived as two layers on one digital file they are perfectly aligned. The images above have been annotated to show the layers on which they were archived.

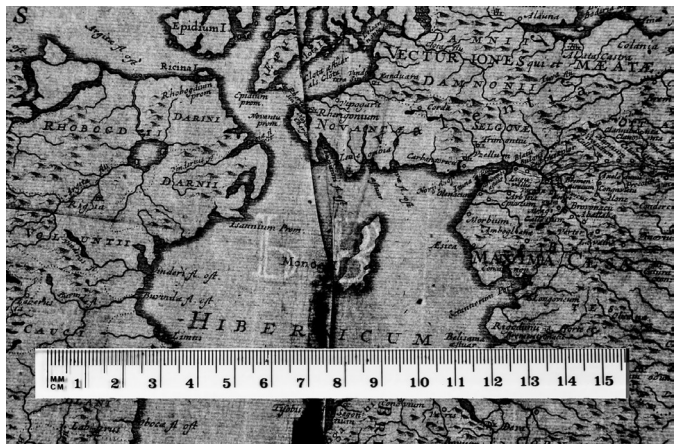
The first consequence of creating that single file is that the equivalent of a digital 'fingerprint' of that paper item is available. In the event of theft and recovery the *PaperPrint* file provides indisputable evidence of provenance. Another consequence of creating the *PaperPrint* file is that a valuable research resource is created. First example—any watermark is recorded, as in the Van Kouwenhoorn Title page above. The following image shows the watermark plus a mm scale. The scale is taken from the original back-lit image and placed on its own separate (Photoshop) layer. Once on that layer the scale may be

moved thus allowing accurate measurements of chain lines and laid lines for instance. The resultant (Photoshop) image has three layers—the front-lit image; the back-lit image; the mm scale.

Van Kouwenhoorn Title Pieter van Kouwenhoorn / RHS Lindley Collections

Second example—it is possible to so manipulate the two images that hidden data is revealed. Third example—it is possible to so manipulate the two images that unwanted data can be digitally 'removed' thereby revealing watermarks. The following (greatly reduced) front-lit image is of a 1695 Copper Engraving in the author's own collection.

The following image shows the centrally placed Isle of Mann by back light:



The chain lines, the laid lines and items such as specks and flecks in the paper are clearly visible. The distribution is unique to that item—a digital 'fingerprint' has been created.

Secondly, use of graphic handling software allows the front-lit and the back-lit images to be so manipulated that overprinting may be digitally removed or at least reduced. Typically this is done, with the two grey scale images being archived as one data file with the front-lit image on the upper layer and the back-lit image on the lower layer. First the shades of grey in the upper layer are inverted, so that a 'negative' image is created. When the opacity of that upper layer is reduced, typically to 50%, any data on that layer cancels out the same data which is also on the lower layer. Data which is not on both layers eg a watermark, is unaffected and free from overprinting. This is shown in the following image:

The Lindley Library and Other Examples of *PaperPrint* in Use

The Lindley Library at the Royal Horticultural Society (RHS) archive *PaperPrint* files of selected items. Here are excerpts from a presentation by Dr. Brent Elliott, formerly of the Lindley Library given at Gresham College in May 2013:

RHS Lindley Collections

The Royal Horticultural Society (RHS) is the world's largest horticultural society—membership passed the 400,000 mark in 2013—and it also has the world's largest horticultural library. In 2011 the RHS Lindley Library was given Designated status by the Museums and Libraries Association as a collection of national and international importance.

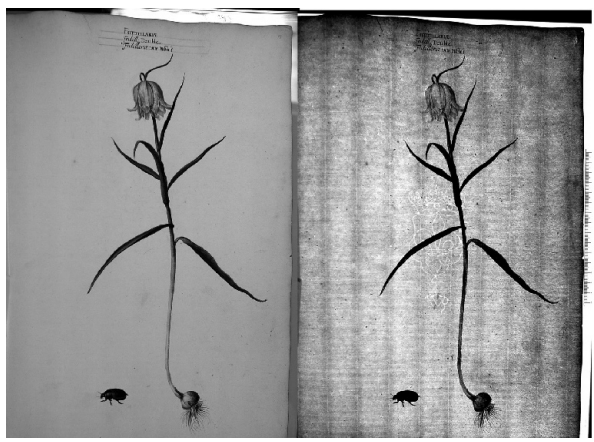
Dr. Brent Elliott described the collections and the work of the RHS Lindley Library and showed that the Library plays a key role in the preservation and study of the United Kingdom's horticultural heritage. It is the primary collection for the study of garden history in all its aspects.

See his Conclusions with regards to imaging watermarks here[7]:

> *In the course of this work, I am proud to report the Library's role in pioneering a contribution to the protection of antiquarian books. As with any collection of early printed books, the Library contains a variety of types of early paper, in many cases with watermarks. At the end of the last century, the Library sponsored a project on the imaging of watermarks, conducted by Dr Ian Christie-Miller. The analysis of the paper and watermarks in early English and French books resulted in*

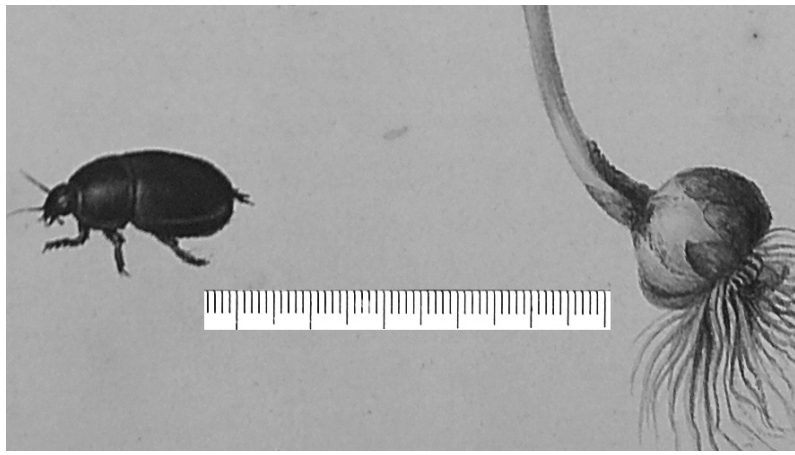
the discovery that the older the book, the more disparate the sources of paper: since there were no paper mills in Britain in the sixteenth century, British printers tended to stockpile paper wherever they could find it, and upwards of fifteen different types of paper could be used in the production of a single book. In the course of this research Dr Christie-Miller developed his system of 'PaperPrint' identification for books printed on handmade paper. Take the title-page, and one or two other pages selected at random (so a thief does not know what to remove); photograph them using both reflected light (for easy identification) and transmitted light (to show the paper structure). Handmade paper always had imperfections and inclusions, and in no two copies will these be in exactly the same places on the page; in no two copies will the pieces of type occupy exactly the same positions in respect to the chain-lines in the paper. The result is, for an antiquarian book, the equivalent of a fingerprint: if the book ever disappears, and there is uncertainty over whether a recovered copy is the correct one, the PaperPrint will allow for an unambiguous identification. This has been a brief and inadequate account of the collections and the work of the RHS Lindley Library—but, I hope, sufficient to demonstrate that the Library plays a key role in the preservation and study of this country's horticultural heritage. It is the primary collection for the study of garden history in all its aspects.

By way of example from the Lindley Library, Royal Horticultural Society, here are front and back-lit images of one of their treasured items, as archived as one *PaperPrint* multi-layered file:

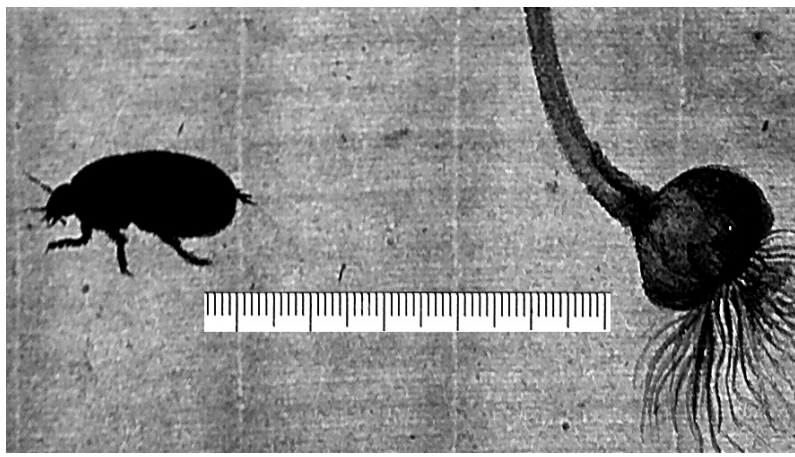


Van Kouwenhoorn, 29 Pieter van Kouwenhoorn / RHS Lindley Collections

Here are enlargements of the insect by front lighting and by back lighting:



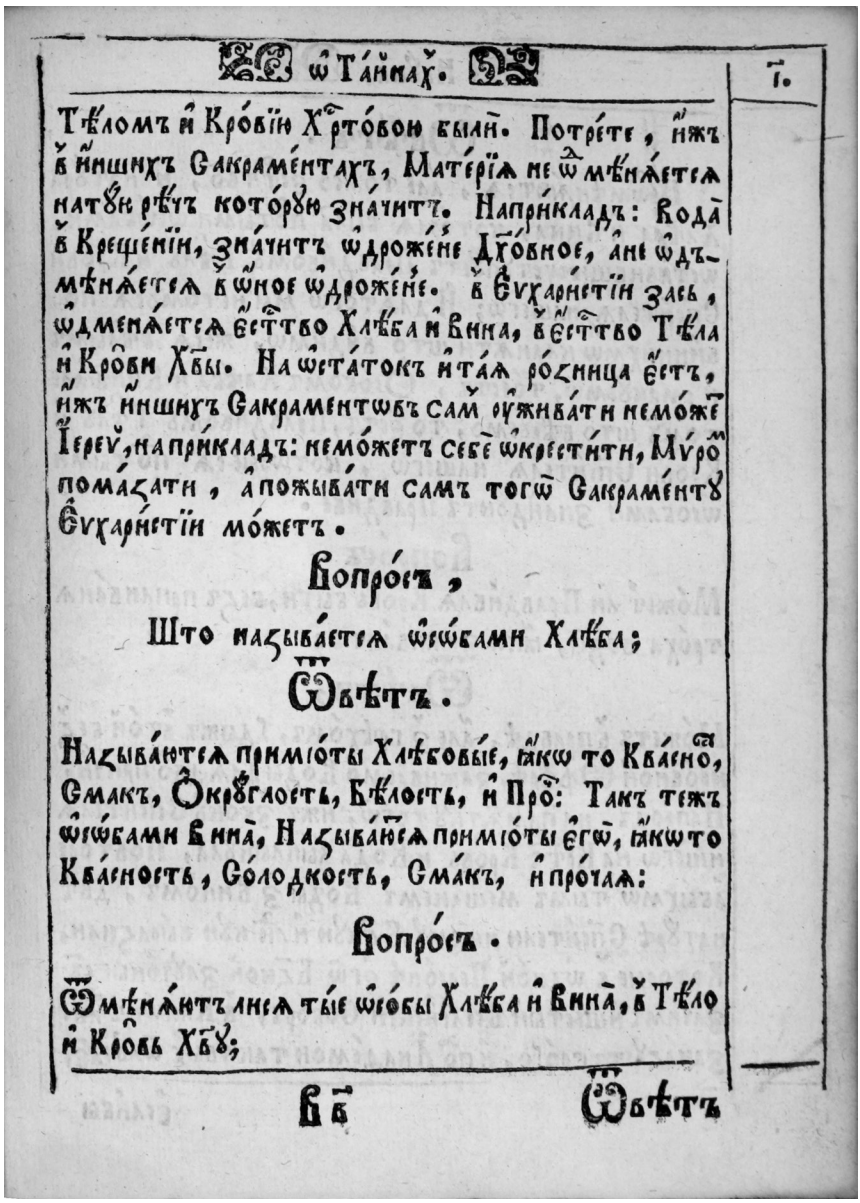
Van Kouwenhoorn, 29 Pieter van Kouwenhoorn / RHS Lindley Collections



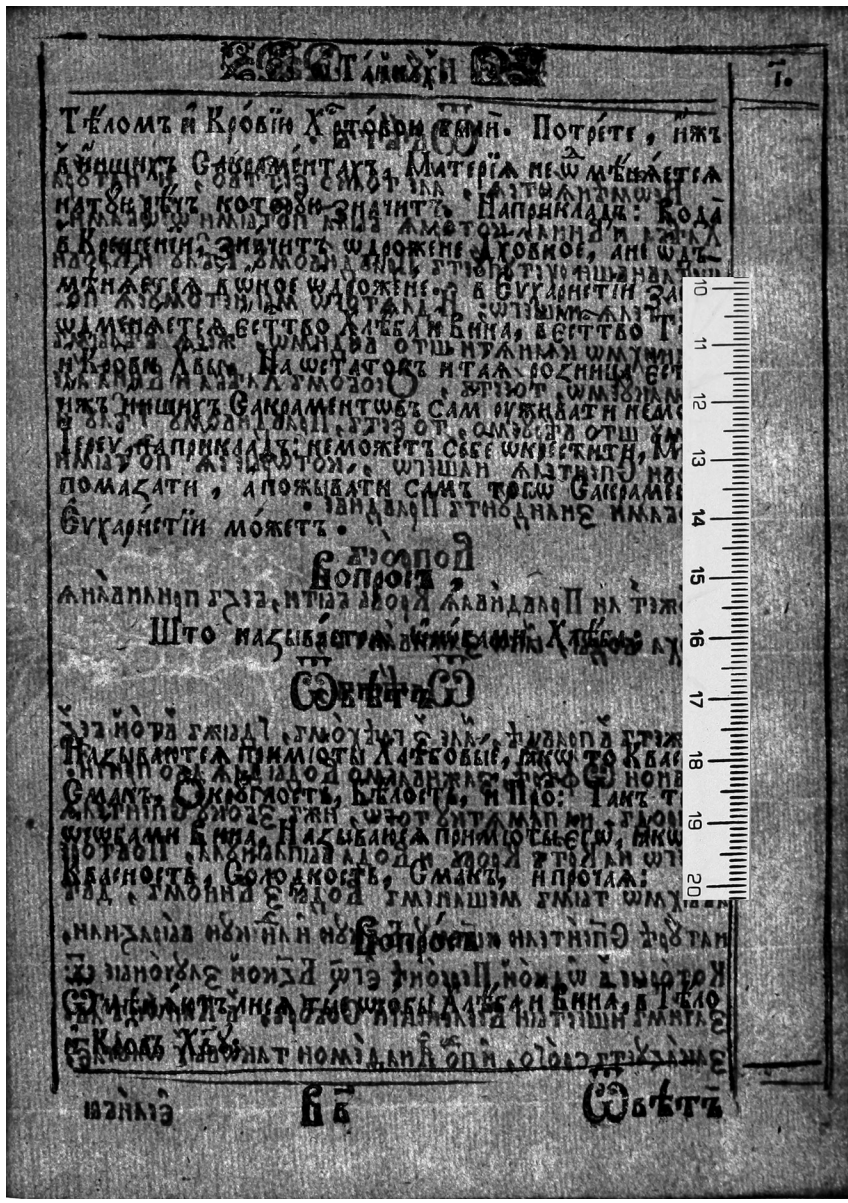
Van Kouwenhoorn, 29 Pieter van Kouwenhoorn / RHS Lindley Collections

The distribution of chain lines, laid lines and impurities in the paper is unique.

The first library outside of the United Kingdom to hold a full set of the multi-layered *PaperPrint* files was Marsh's Library in Dublin for their two copies of the rare Cyrillic *Treatise on the Sacraments*, 1657 by Kosov.[8] The following images show two of the layers of the *PaperPrint* file of B ii recto:

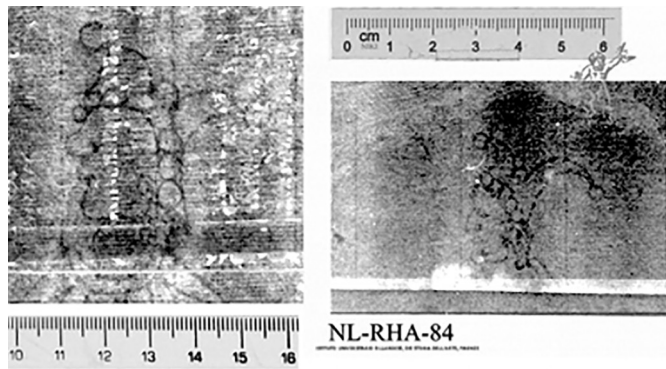


Courtesy of Marsh's Library



Courtesy of Marsh's Library

Part of the watermark can be seen half way up the left side of the page. It is a Foolscap. Despite the place of printing—Kiev—the watermark is remarkably similar to one found in paper used, in Amsterdam, by Rembrandt dated 1648 as shown below:



This similarity was recorded by the author for the British Library on-line Notepad[9] and shows that the abovementioned imaging processes not only enhance security but also reveal surprising historical connections.

In November 2013, at a Sotheby's, New York sale, a copy of the 1640 *Bay Psalm Book* was sold for $14,165,000, making an auction record.[10] That copy of the book (H.21.15), along with another copy (H.21.14), had belonged to the Boston Old South Church and had been in the safe keeping of Boston Public Library.

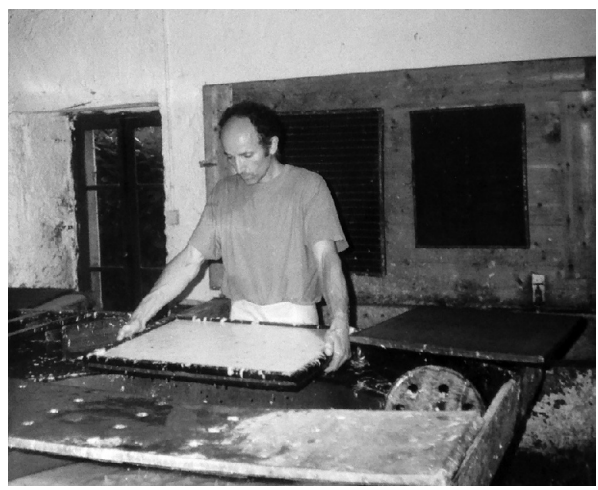
H.21.15 was sold to Mr. Rubenstein, the philanthropist, co-founder and co-executive chairman of American private equity firm The Carlyle Group. Mr. Rubenstein planned to share it with the American public by loaning it to libraries across the country, before putting it on long-term loan at one of them. H.21.14 remains at the Boston Public Library. Full sets of *PaperPrint* images of both those books have been archived with the holders.

Second Part

Paper, Pages, and Finding Watermarks

The initial production of paper in Europe relied on eastern techniques. Around 1200 the paper produced in Spain was based on Arab techniques. It was thick, made of material which was poorly beaten and without watermarks. The earliest known piece of paper in England is in Hereford Cathedral and is thought to be a Spanish/Arab paper. It was used for a letter written from Avignon around 1308.[11] Italy became an early source of paper with more northerly countries following. England was a latecomer. There is some evidence that there was a paper mill in Hertford in 1490, but it did not continue.[12]

The central activity of making paper by hand was the skilled process of immersing the mould into the vat of wet 'stuff' which was prepared, typically, from beaten rags. The mould would then be raised so that water could drain through the wires thereby beginning the drying process, as in the following picture:



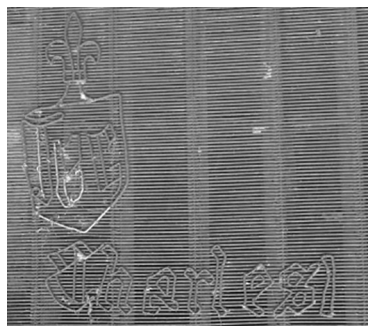
The typical mould shown above is a wooden rectangle with a base of wires.

It has been noted above that the oldest known piece of paper in England has no watermark. Watermarks are due to the presence of wire(s) in the mould which inevitably means that the paper is thinner and so more light passes at those places. The French word for watermark is 'le filigrane' derived from the word for wire. It is therefore clearer than the English word 'watermark'. The major wires, known

as chain lines, in the mould, generally, ran parallel to the shorter side. In the image below the chain lines are vertical. Other, lesser, wires running at right angles to the chain lines are known as laid lines. In the image below the laid lines are horizontal. In addition, distinctively shaped wires came to be sewn to the mould. Sometimes those wire shapes were emblems (unicorns for instance). Sometimes dates were given. Sometimes the name of the mill was given and so on.

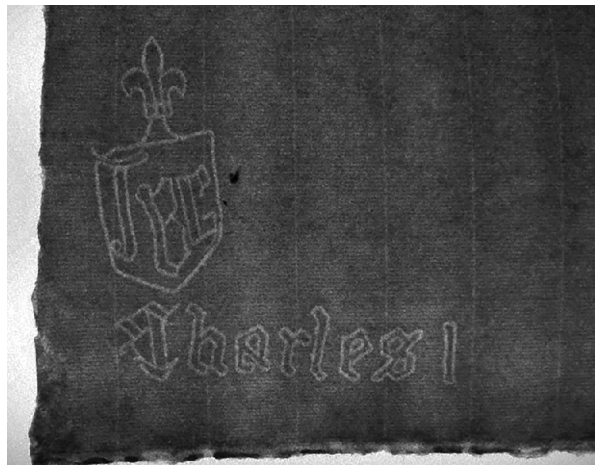
The following image shows a corner of a mould, with the watermark wires, unusually, placed near the corner.

This mould produced paper known as 'Charles I' as shown by the watermark wires above and more clearly below:



This well-used mould was developed by Jack Barcham Green (note the JBG initials in the shield) in the latter part of the first half of the 1900s and was in use until 1975. Jack Green had written the letters backwards with a pen to make them look 'ancient' and the mould maker copied the drawing. The

superior quality of such moulds is evident from the decades of use. The following image shows a 'Charles I' sheet by back lighting:



Photograph by Ronald M. Bodoh

A recent image of the mould shows the date '1975' as below: