The Paper-Making Process And Its Relevance To Philately

The purpose of this presentation is to refresh the reader with some of the philatelic terms and varieties associated with the stages in the paper making process. Examples will be provided to highlight security measures taken by the stamp issuing authorities to safeguard against fraudulent stamp reproduction or reuse of cancelled stamps.

Many of the painting illustrations provided reflect the state of the paper making process in the early 1900's to give a flavor for the opportunities for process variations that could result in philatelic varieties.

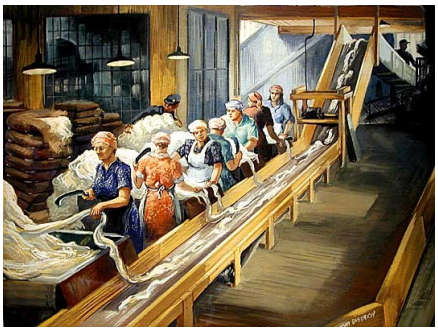
To begin, it is necessary to understand that the paper making process steps have remained unchanged for hundreds of years. Paper is made from cut and cleaned cellulose fibers that are then combined with water to form a consistency similar to wet oatmeal that is applied onto a screen, where the water is drained and the fibers interlace to form a web that is then pressed, dried and cut.

The first stamp issued for postal use was the Great Britain "penny black" in 1840, which was in the midst of the Industrial Revolution. At that time, many European countries as we know them today were still at the stage of being independent states. As new technology was developed, there was often a lag in its introduction in all of these areas, both from a cost and a population demand perspective.

From a philatelic perspective, it was not until the early 1860's that all of the smaller "states" had converted from paper produced from hand made molds to paper produced by automated machinery. Likewise, it was not until the late1800's that paper was produced from wood fiber instead of rag fibers.

The Paper Making Process

This presentation will begin with the production of paper made from rags, with the understanding that the debarking, chipping and boiling of wood pulp, removal of lignin (wood glue), would yield the same entry point into the paper making process.



The painting above reflects the fact that women were commonly employed as rag sorters and cutters. They went through the old clothing and removed buttons, seams, and hems.

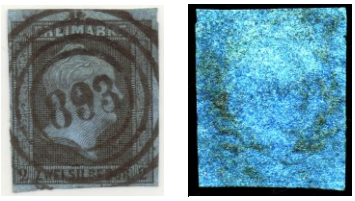
The clothes were then cut, prior to being sent to the beater.
The beater is an elongated tub divided by a fence-like partition to produce a channel, similar to a race track. A roll with steel bars or knives rotates in the tub and comes in contact with steel bars on the bedplate, thus separating the softened fibers, creating a slurry

At this stage, paper to be made from cut rags, processed wood fiber or, if purchased, dried sheets of wood pulp would enter the beater. The painting below shows the beatermen putting dried sheets of wood pulp in the beater.

The clumpy slurry then goes into a refinery machine where the slurry is forced through tiny spaces, which roughen the surface of the individual fibers by loosening the threadlike elements from the fiber wall so that they will cling together when formed into a sheet.

After the refining process, dyes and other additives can be added to give the finished paper the desired properties.

The painting above shows dye being combined with the slurry to alter the color of the finished sheet. Papermaker's alum was added to set the dyes.



Scott Prussia #4
Bluish paper

1850-
1856

Scott Prussia #3
Rose paper

Silk paper is paper with short silk threads running through the paper. The silk threads were added to many of the early stamps as a security measure to protect against counterfeiting. The silk threads were probably added to the slurry at this stage of the paper making process. Random silk fibers of different colors can be found in many of the

early US revenue stamps. Likewise, cotton threads were often added to the slurry to produce "**Granite**" paper for the same security reasons. An example of the "granite" paper is shown below.

1918-1919 Austria *Scott* #173 (Granite paper)

Hand Mold Paper Making

This is probably the best time to distinguish the similarities and differences between the hand made, single screen method of making paper and the continuous screen method.

Many of the early stamp issues were produced by the single screen method, one sheet at a time. The slurry was added to a large vat, filled with water and mixed. The screen mold and fitted cover (deckle) was then dipped into the vat of water with suspended fibers and shaken as it was lifted out of the solution, leaving a layer of fibers on the screen. The deckle was then carefully lifted off the screen mold. After a short period of time, the mold was turned over & placed on a water absorbing cloth, per the steps in the pictures below.



Then the back side of the wire mold was lightly wiped with a wet cloth to remove the fibers that were lodged underneath during the draining process when the mold was lifted out of the solution. The deckle gauged the depth of fibers on the wire and formed the edges of the paper sheet. Another water absorbing cloth was placed on top of the paper sheet, and through rollers or presses the water content was diminished, and the sheet was hanged out to dry.

When the paper was dry and held up to a light source, an impression of the wire pattern could be seen lighter than the rest of the paper. The paper fibers that formed between the wires produced a thicker section of paper than where the wires sat, allowing less light to pass through those areas. Thus, a watermark was formed – a thinner area of paper that allowed more light to pass through.

Note: In philately, **silk thread paper** refers to paper that "has an uninterrupted thread(s) of colored silk arranged so that one or more threads run through the stamp or postal stationery." Because of the straightness of the threads seen in the early Bavaria stamps, I believe the threads may have been pulled tight and lightly pressed into the wet paper before it was removed from the mold (3rd picture above).

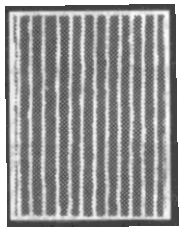
Scott Bavaria #16 (1967-1868)
with red silk thread

Paper Types

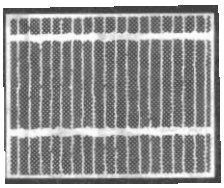
In philately, the configuration and spacing of these wire impressions into the paper are referred to as paper "types" rather than as watermark types:

An evenly spaced wire form with wires woven over and under each other produce a **Wove** paper. When held up to light, the paper will show at most occasional little light dots.

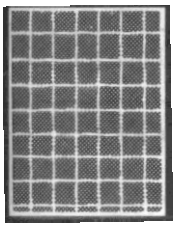
A wire form with evenly spaced wires running in parallel the length of the mold and supported by thicker evenly spaced "chain" wires underneath them produce a **Laid** paper. When held up to light, the paper will show parallel light lines.



If the above Laid paper mold were turned over (with the larger "chain" wires on top), it would be a **Batonne** paper. When held up to light, the paper would show the Laid paper light lines, crossed by the thicker "chain" light lines.

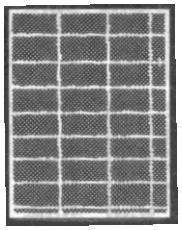


If the wires are formed in a square pattern at the same height, like a screen mold, they produce a **Quadrille** paper. When held up to light, light lines would appear in a square pattern.



France Scott #103
Quadrille Wmk.

If the square wire patter in the Quadrille mold are elongated to form rectangles, it produces **Oblong Quadrille** paper.



Watermarks

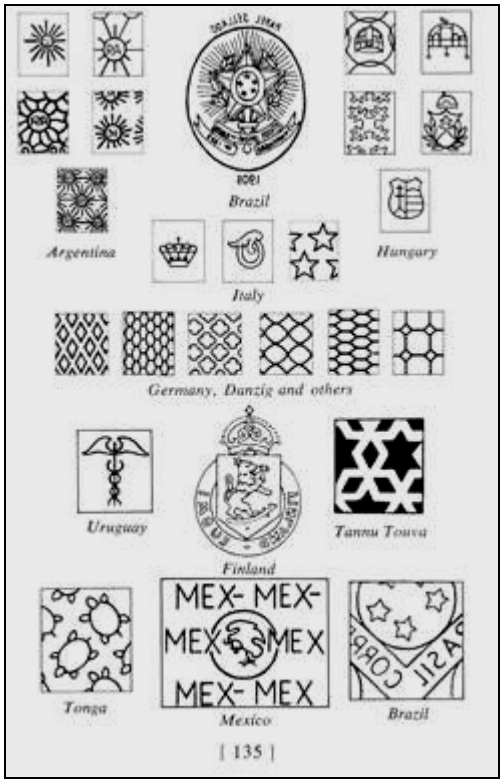
Philatelic watermarks refer to the image seen in the stamp when a wire design was pressed into the wet paper. These designs, referred to as “bits”, could be wired forms or stampings that were secured to the wire screens by either wire or solder. In the case of hand paper molds, they were attached to the top of the wire form. Because they were higher than the wire forms, they penetrated deeper into the wet paper fibers. The deeper impression made the paper thinner where the wire was set into the paper and made them more visible when held up to a light source.

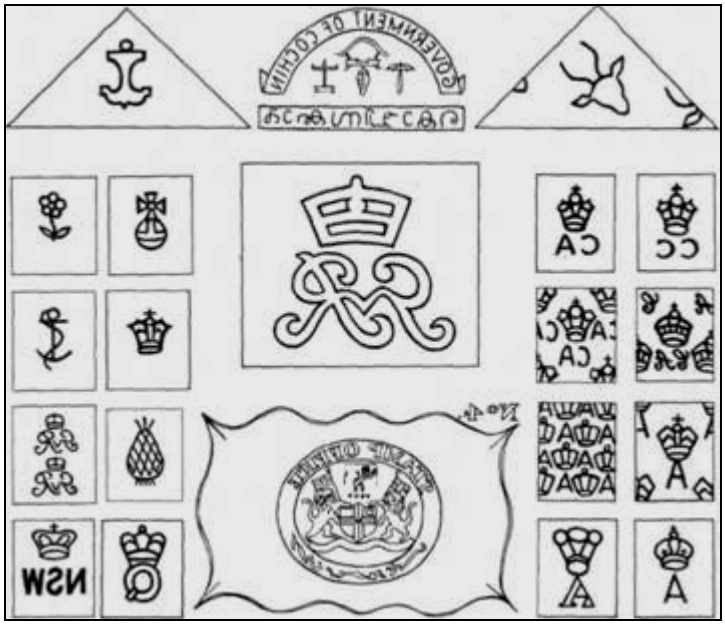
The watermark was the stamp issuing authority’s primary defense against counterfeiting. In recent times, however, it has gradually been replaced by other methods, such as fluorescent or phosphorescent dyes, optical brighteners and, finally, the realization that to counterfeit a stamp did little good unless there was a ready and willing market to accept the stamps in the first place. As stamps are sold only through postal offices and vending machines, it would be very difficult to sell fraudulent stamps to the public at large without question. None the less, watermarks were used extensively for the last century, and are an important aspect in philately.

Example of a paper maker’s watermark in the bottom of a sheet mold

Some simple as well as complex examples of the images these wire and stamped

watermark “bits” provide are shown below. **Note that in philately, watermarks represent images that appear when viewed from the back of the stamp.**





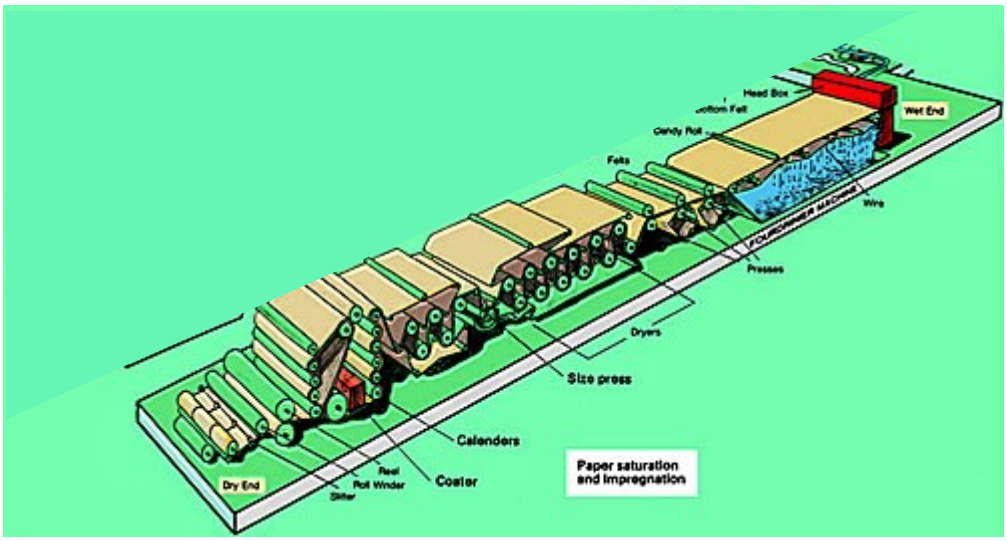
Some watermarks of the British Empire

What should appear obvious is that there are some major differences among many of the watermarks shown:

- On some stamps there is one complete watermark
- On some stamps there are multiple parts and/or multiple watermarks appearing (continuous pattern)
- The large “Brazil” “coat of arms” watermark (*Scott* wmk. 236) is a sheet watermark, meaning that no individual stamp on the sheet would have the same watermark, and only (22) of the stamps on the sheet have a watermark at all!

The point here is that if the watermark pattern is not continuous (like the Germany examples shown), the paper maker would have to coordinate the watermark placement pattern on the sheet with the stamp printer to get the desired results.

The Fourdrinier Paper Machine Process



The Fourdrinier paper machine was invented by the Frenchman, Nicolas Louis Robert in 1798, developed in England by Brian Donkin for Henry and Sealy Fourdrinier, but not placed into operation until 1804. It was the first papermaking machine to make continuous paper. Prior to this machine, paper was made in single separate sheets.

The first Fourdrinier machine in the US was imported from England and erected in Saugerties, New York, in 1827. The second was built in Connecticut by mechanic George Spafford. He and his partner, James Phelps, completed the first American-built fourdrinier in May 1829 and sold it to Amos Hubbard at a cost of $2,426.

Instead of placing the stock, or watery pulp, onto individual screens, the Fourdrinier machine used a continuous screen, or **wire**, made of woven wires, that moved like an endless belt. This innovation made today's high speed paper machines possible.

The stock was mixed with water and sprayed or dropped onto the moving wire at the head box. The water was drained and sucked out through the porous screen. The stock is

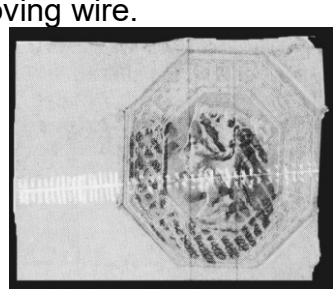
usually from 0.5% - 3% solids when it is placed on the wire and is about 7% solids by the time it gets to the end of the wire.

Man at the Head Box

Innovations in head box designs led to the development of **Converflo and Strat-Flo-** head boxes that enable different layers of stock to be placed on the wire at the same time. Using tapered flukes and baffles, they are able to lay down separate layers of fibers of different lengths and strengths, creating a sheet that, for example, has an outer layer that is smooth for printing yet has an inner layer that is stronger for better paper strength. Three layers could be formed so that the outer layers (top and bottom layer) are made from hardwood fibers (which are shorter and more uniform) and the inner layer is softwood (designed for strength).

The original Fourdrinier machines had to hang the paper in long sheets to dry. Eventually, the paper was scraped off the dryer and wound onto the dry end **winder** as part of the continuous process. Often, the paper has to be rewound on rewinders to make the paper's thickness and grain consistent

The first wire screens were made of woven wire. One of the first innovations of the wire was a **staggered weave** that eliminated the problems of wires hanging up or freezing in the suction boxes. Another important early innovation was the **welded seam** which replaced **hand-woven seams**. This eliminated the ***visible line*** created each time the seam made it way around the moving wire.



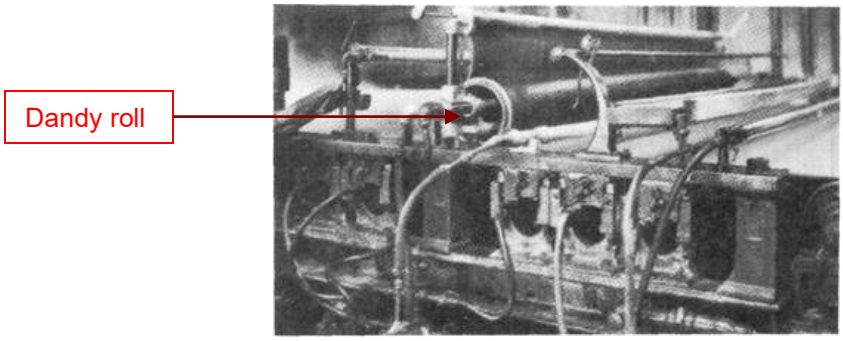
Graphically enhanced “stitch” watermark (hand woven seam)
on a British 1-shilling Queen Victoria stamp (*Scott* #5)

But wire is basically an inflexible material. If stretched, bent, or frayed, the anomalies remain in the wire and affect the look and consistency of the paper. Wire is also not very

resilient and the older wires often broke. In the early machines, wires were often replaced daily, sometimes several times a day.
The development of **monofilament forming fabric**, or **plastic thread wires** which could stretch and snap, made the higher speeds and increased productivity possible of today's machines. A monofilament fabric usually lasts at least several months before maintenance is required.

Dandy Roll

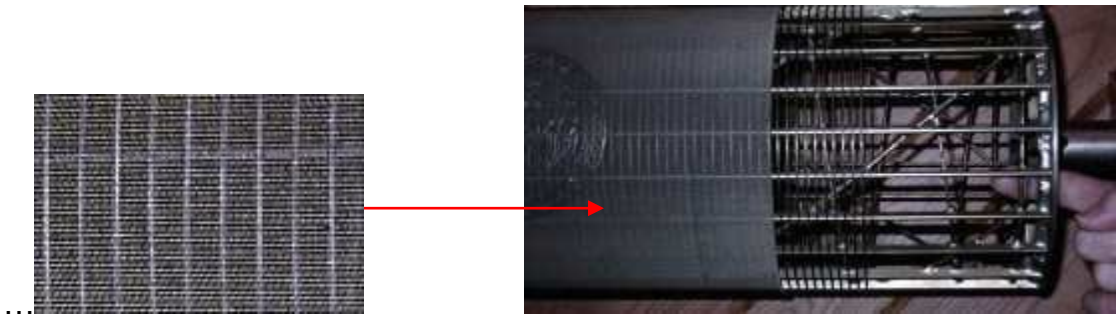
The last item at the end of the continuous forming wire is a device called a **dandy roll**.



Dandy roll at the end of the forming wire

To this point we have not discussed how the paper types (**wove** and **laid**) or watermarks were placed in a continuous paper roll. This is where the dandy roll comes into play.

The dandy roll is a hollow cylinder covered with a wire form or sleeve. It was invented by an English engineer and paper mould maker, John Marshall, around 1826. Whereas laid lines and watermarks were impressed in the wet paper on the bottom screen, the dandy roll allowed the same impression to be made from the top side of the wet paper as it passed underneath the dandy roll. Marshall's dandy rolls were used in almost every country of the world where paper was produced.



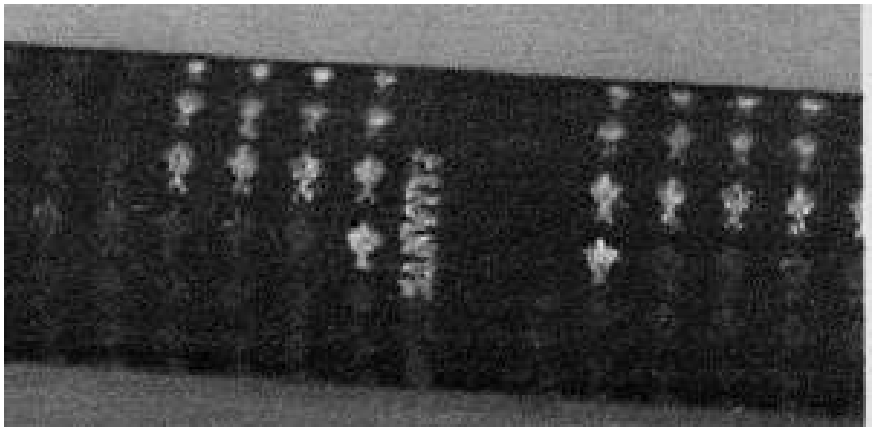
Thin parallel wires running the length of the screen lay on top of the skeleton "chain" wires

Dandy roll with "laid" paper screen sleeve

It is critical that these dandy rolls are geared to revolve at the same speed as the continuous wire screen to impart the proper image. The "chain" wires on the early dandy rolls could also be placed on the outside of the long parallel wires to produce Batonne paper.

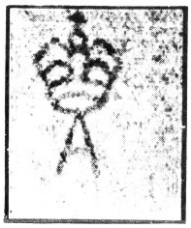
Dandy Roll & Stand, Commonwealth of Australia Postage
Metal/Wood, E. Aimes & Son, Maidstone, England, 1914

Note: The shiny watermark bits on this dandy roll were
painted with silver paint for visualization purposes



Enlargement of the painted watermark bits from the above dandy roll.
These bits produce the watermark in the stamp shown below.

Australia 1p
King George V
1914-1924



Scott #22
Wmk. 9

This dandy roll was designed to provide one watermark per stamp for use on a 120 stamp sheet (10 columns across the roll x 12 rows around the roll). Four (4) such “sheet” panes

are shown across the roll. There is a space between the rows on the back side of the roll for cutting the sheets. Marginal inscriptions reading *"Commonwealth of Australia Postage"* and *"Postage"* run around the mold for each of the four panes. Guidelines also appear between each pane and at the space described above as indicators for sheet cutting.

If one looks at the close proximity of the "inscription" bit to the "crown and A" watermark bits on the right side of the sheets, it is easy to see that any miscutting of the sheets or misalignment of the cut sheet in the printing process could result in the inscription watermark showing up on the edge stamps. This condition has been reported several times on other stamp issues, and can, unfortunately lead a collector to think he has a rare new watermark variety.

Also note on this dandy roll that the wire sleeve to which the "crown and A" bits are attached appears to be more of a wire fabric mesh than a defined laid wire pattern. The sleeve went through the same developmental changes as the continuous wire did above.

Example of a modern dandy roll with watermarks applied to a wire fabric sleeve

In philately, there are also a few mentions of **ribbed paper** being used for postage stamps. A steel roller, with parallel groove lines cut into it across its length, is placed at the end of the continuous wire. Like the dandy roll, it displaces the web fibers into the grooves and leaves a series of thicker paper ridges as the wet paper web passes under it. For **double ribbed paper**, the paper web is then picked up off the wire and passed **over** a second such roller to produce ridges in the **bottom** web surface.

At the end of the wire, the stock is picked off from above by a continuous felt roll which is moving at the same speed. At this point it is pressed between water-absorbing fabrics (felts) Often, the stock then goes through a series of rollers that squeeze and/or suck more water out of the stock. This section is called the **press section**. By the end of the press section, the stock is usually 40-50% solids.

The stock then moves into the **dryer section**. The dryer section can be made up of a series of dryer rolls or one large dryer. Dryers are basically heated from the inside by dry steam and from the outside by hot air. The stock is usually about 95% solids by the time it comes off the last dryers.

Next, the dry stock passes through the **size press**, which applies a starch solution to both sides of the sheet. Sizing seals the surface so that ink cannot soak into the paper during printing. Since sizing again wets the paper, the paper must again be dried by traveling

through a series of steam heated drums.

After drying the paper then goes through a ca process that provides the required surface finish to the sheet by ironing the sheet between heavy rollers. The rollers selected can provide finishes from matte to glossy.

If secondary coatings are required, the paper is then sent through the required coating process. In philately, **chalky paper** refers to paper with a clay or clay with fibers coating. This coating was used as a safeguard measure to prevent cancels from being removed from stamps and the stamps then reused. The coating provides good printing properties, but, if the printed surface is wetted and rubbed, the clay (and the printed image) will flake off. The coated paper cannot come into contact with rollers until it is dry, so it must go through a hot air blowing process to dry.

The paper is then wound unto spools to form a machine reel and then rewound and slit into smaller rolls on a winder. Some of these rolls are sent for sheeting and packing into cartons. Others are rewound to smaller sized rolls and wrapped for shipment.

Watermark Bits

In the limited information I have been able to gather on the watermark bits, it appears that at least the early ones were all made from brass. It is possible that these bits were produced from a two-piece cast mold.



Postage stamp watermark bits, brass/cloth
Perkins, Bacon & Co.
United Kingdom, c 1850


Approximate size relative to a stamp

References:
Thomas M. Dietrich's Fox River Paper Paintings Exhibit:
http://www.paperdiscoverycenter.org/exhibits/tom_deitrich.shtml
How To Make Paper: http://www.maxintl.com/OldPages/Papermaking.html
Philatelic paper terms: *Scott Standard Postage Stamp Catalogue*
Watermarks and Varieties of Paper: http://www.aboutbookbinding.com/Paper/PaperMaking-Main.html
Paper and Watermarks: http://www.stampforcollector.net/stampcollector13.php
Laid paper: http://www.mywingsbooks.com/coll-terms/pprlaid_.shtml
Stitch watermark:
http://www.linns.com/howto/refresher/watermark_20051010/refreshercourse.aspx
Laid paper dandy roll: http://csumc.wisc.edu/gallery/albums/album34/WIFFCK980410.thumb.jpg
Australian Dandy roll: http://www.powerhousemuseum.com/collection/database/ (dandy roll)
Watermark bits: http://www.powerhousemuseum.com/collection/database/ (watermark bits)