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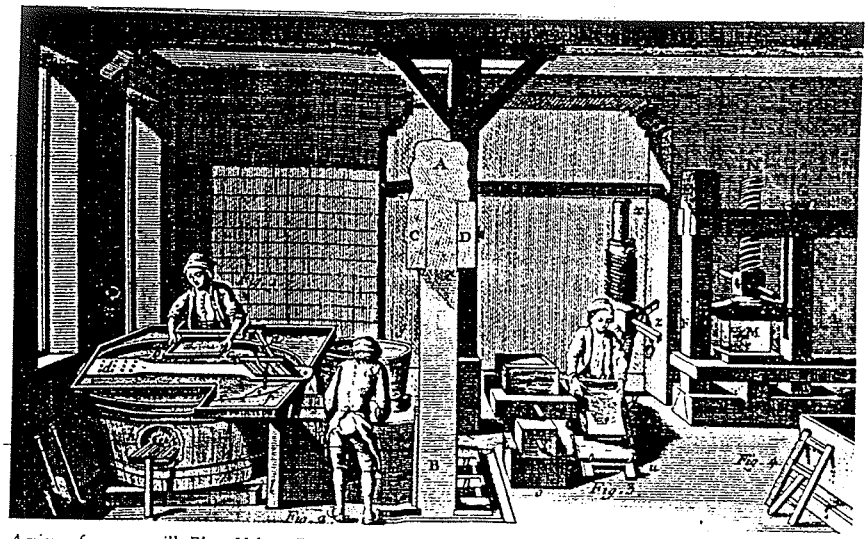

A view of a papermill, Plate X from Denis Diderot's Encyclopédie *(3rd edition, 1774).*

Pre- and Post-Industrial Handmade Book Paper: You Can See the Difference

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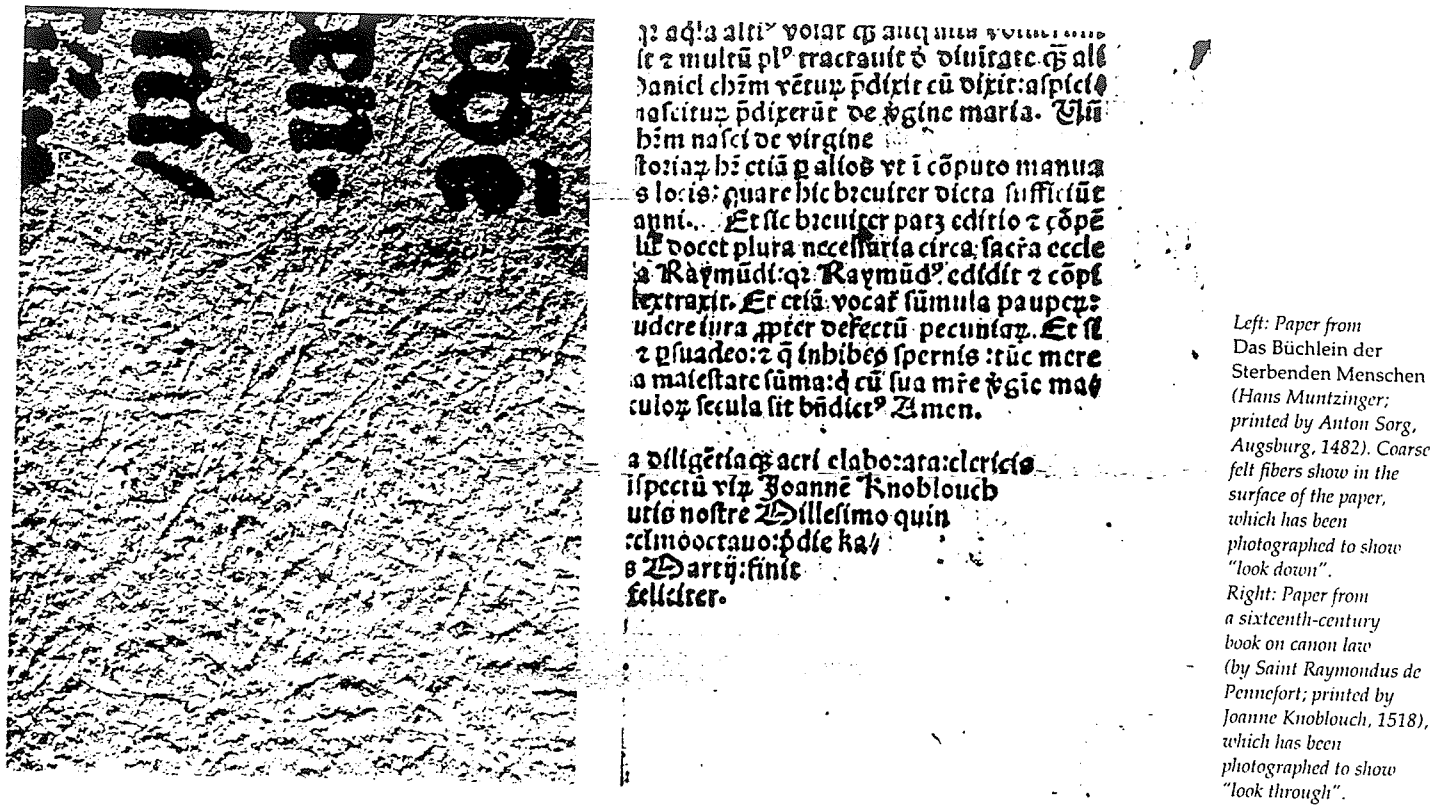
The industrial revolution[1] of the late eighteenth century and nineteenth century significantly influenced the methods of Western papermaking and, by default, the characteristics of handmade book paper. The introduction of machines into the hand papermaking process, the production of paper by machines, and the changing expectations of paper consumers all affected the physical properties of papers. We propose that these factors altered the visual and tactile properties of handmade book papers and that this relatively new aesthetic has dominated the production of handmade book paper well into the revival of hand papermaking in this century. As paper and book conservators, we believe recognizing and understanding the *visual* differences between pre- and post-industrial revolution white book papers can guide paper consumers in their description and selection of new handmade papers.

When considering handmade papers made before and after the industrial revolution, one has to keep in mind that changes occurred gradually and that hand papermakers did not change their methods or materials at the same time; some did not change at all. Nevertheless, handmade book paper followed a general trend towards the aesthetic of "machine perfect". Fifteenth to eighteenth century handmade papers differ in recognizable ways from those of the nineteenth and twentieth centuries. Visible differences occur within fifteenth to eighteenth century papers as well, but a major shift happened to the aesthetic of handmade paper in the nineteenth century which resulted in a flatter, more uniform appearance. Eventually, it even became difficult to tell the difference between handmade and machine-made. In hindsight, the aesthetic goals of machine and handmade book papers appear to have become one as the nineteenth century progressed. These visual and tactile differences are significant for anyone who works with pre-industrial revolution books or wants to simulate early book papers for their work, or for anyone interested in the way paper looks.

Any observations of paper should begin with the understanding of the inter-relatedness of paper properties. When one property is changed, other properties change automatically. As machines were introduced or methods altered, and as raw materials differed, the resultant paper necessarily changed. We do not intend to define here the reasons for every alteration in the properties of handmade paper. Much work has already been done on the permanence and durability differences. We are pointing out the aesthetic changes and their probable sources, many of which are interrelated with the working properties. We base these observations on years of appreciation and con-



Left: Paper from Das Büchlein der Sterbenden Menschen *(Hans Muntzinger; printed by Anton Sorg, Augsburg, 1482). Coarse felt fibers show in the surface of the paper, which has been photographed to show "look down". Right: Paper from a sixteenth-century book on canon law (by Saint Raymondus de Pennefort; printed by Joanne Knoblouch, 1518), which has been photographed to show "look through".*

servation treatment of papers. Basic papermaking history and hindsight contribute to our comments on industrial revolution influences.

We have primarily employed two useful ways of looking at papers: the "look down" and the "look through". The look down can be seen by viewing the surface of a sheet at an angle while holding the sheet up so that light rakes across it. The light and shadows across the surface dramatize the imprinted texture of the mould screen, the felts used, any gross fiber irregularities, and any surfacing techniques. One sees the look through by looking at a backlit sheet of paper. This shows the results of fiber preparation, the fiber dispersion, the overall formation of the sheet, irregularities, and the characteristics of the mould. If one looks at paper in these two ways, paper sheets have much to tell.[2]

The papers chosen for most books prior to the nineteenth century, in our experience, were not perfect. They usually had lumps and shives or specks, an off-white color from the mix of rags, clouds of swirly fibers from fiber bundles that were not always uniformly separated, and sometimes uneven formation. Certainly some books from these early times have fine white paper, but the majority reveal a variety of imperfections. Some early books contain soft, poor quality paper, which has since turned brown. However, a wide variety of what could be called good quality book papers exists, each with a story to tell about its manufacture. In general, these good quality book papers had a rich surface texture, and were tough and lustrous.

The richness of the surface texture of early papers came from the fibers themselves, the chain and laid lines of the screens, and the texture of the felts, all of which varied. The surfaces of paper conform to the surfaces of the paper moulds and the felts. The retention of these textures results from the pressing, drying, and finishing of the sheets. By examining the surface texture of early papers, one can see multi-layered, three dimensional impressions, which reveal evidence of the laid moulds' structure and of the felts.

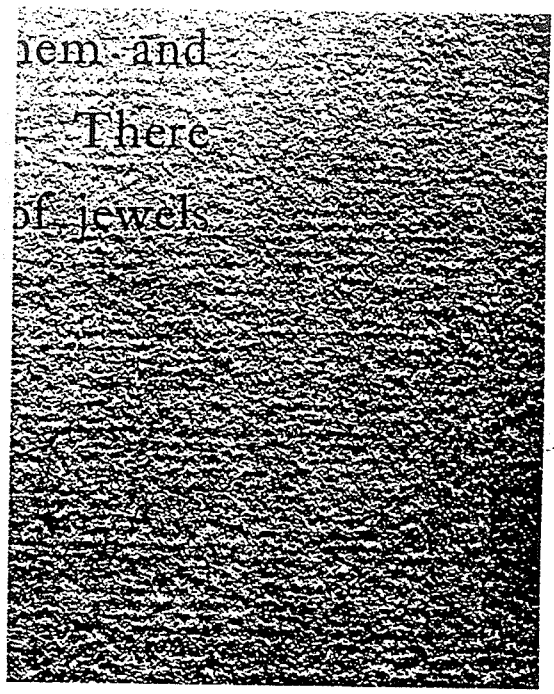
The surface textures of most early papers are impressed with the perpendicular chain and laid lines of the mould screens used to make the sheets. The pattern of laid moulds is so connected with the ideal of quality paper, that machine-made papers try to imitate this by having a laid design pressed into the paper, even today.

Most early felts were truly felted, many with coarse fibers, still visible now on the surface of papers, running through them. In some later papers, roughly woven felts were used and evidence of the weave impression remains on the paper's surfaces. Now, in the late twentieth century, hand papermakers use smooth machine-felted or machine-woven felts showing few irregularities.

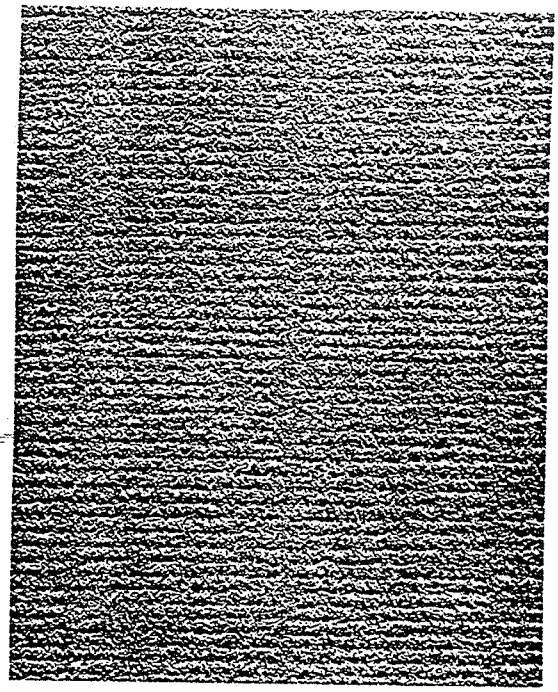
Early papermakers used hand screw presses or weight systems to squeeze excess water out of stacks of wet, newly couched paper and felts. The hydraulic press, invented in 1795, provided much more pressure. These presses were adopted by hand papermakers because they reduced drying time and created a savings. High pressure also compressed and flattened out the sheets, reducing the surface textures previously picked up from the felts and laid moulds. This difference can be seen today when comparing contemporary hand screw pressed and new high-pressure, hydraulic pressed sheets.[3]

The method of drying paper has a lasting impact on its surface texture, from the pressing of newly formed sheets between felts to the actual drying method, unrestrained or restrained. Early papermakers air dried their sheets in lofts, in an unrestrained method. The sheets shrank as they dried, conforming to the impression left by the mould and felts, and accentuating a rich surface texture.

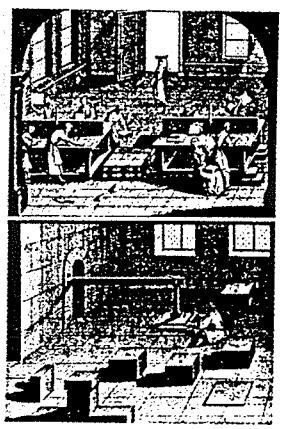
Restraint drying, an alternative to air drying sheets, involves drying paper while holding it in place by pressure. Restraint dried sheets take on the surface texture of the restraining surfaces. Some contemporary hand papermakers have developed heated restraint drying systems, which ensure flat, uncockled sheets with the regular texture of pressing boards impressed onto the surface of the paper. These papers



An early twentieth century handmade paper (from American Bookbindings in the Library of Henry William Poor, *by Henri Pène du Bois, Marion Press, 1903).*



An early twentieth century machine-made paper (from Book Repair and Restoration, *by Mitchell S. Buck, 1918).*



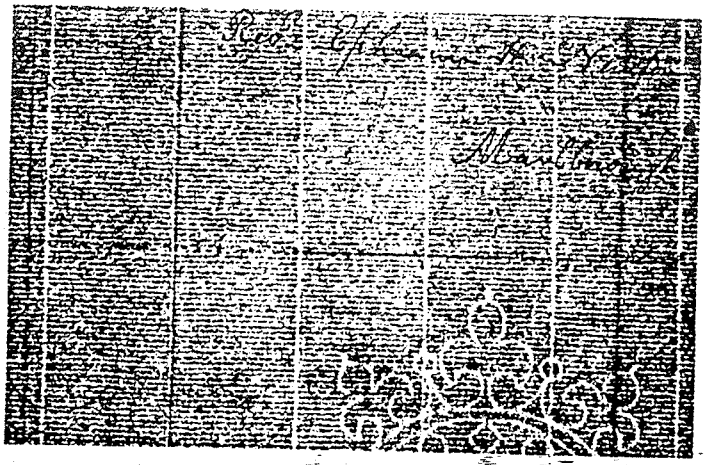
From Joseph Jerome de la Lande, Art de Faire le Papier, *(1761), Plate XIV, showing burnishing, above, and hammer glazing, below.*

simulate nineteenth century aesthetics with reduced mould and felt textures and regular patterns from pressing surfaces, rather than fifteenth to eighteenth century textures. We see these characteristics in many handmade book papers today. However, some papermakers have developed ways to maintain the texture of the mould screen through light restraint or air drying and through their choice of pressing surface.

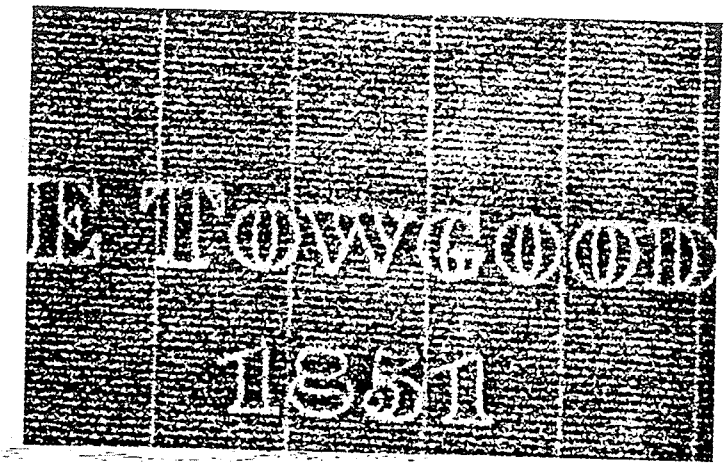
Papermakers glazed or burnished the surface of some pre-industrial revolution papers, as finish treatments. They did this by hand and using trip-hammers. Glazing closed the surface of the paper and sometimes left irregular patterns of the hammers or burnishing tools. The process was done on dried sheets and minimally diminished the surface texture. Papermakers commonly used calendering machines in the nineteenth century to polish the surface of machine-made papers. This could eliminate the surface texture to make a very smooth sheet. Hand papermakers quickly and happily added calendering machines to their equipment, as well. The difference between calendering and hand or hammer glazing can be seen in the look down of a sheet. One can hardly imagine contemporary hand papermakers, however, returning to the laborious process of glazing.

The choice and preparation of the fibers as well as the skill of the vatman, the person forming the sheets on the mould, significantly affect the look through of any handmade paper. The majority of European papers made before the nineteenth century were made from linen and hemp rags, both bast fibers. Bast fibers have varying amounts of hemicellulose in the fibers and fiber bundles. The hemicellulose can be one of the factors that contributes to transparency and it aids fiber-to-fiber bonding. When cotton became the common fiber for use, this almost pure cellulose fiber, with very little hemicellulose, helped assure more uniform opacity for the sheet, depending upon the beating. Cotton yields a matte surface whereas bast fibers are known for their luster. As the fiber content changed to more cotton, the glossiness of early sheets began to change to a naturally more matte surface.

Sorting rags for color and quality was an important part of the papermaking operation until the discovery of chlorine bleach, in 1774. Chlorine was in common use by the nineteenth century. Bleaching fibers with chlorine meant that the tedious process of separating out the differing shades of white rags became less important. The pulp could be made from a variety of rags and, because of bleaching, would end up uniformly white. Rags would also break down more easily when bleached, but so would the paper if the bleach were used unsparingly. Papermakers recognized this problem at the turn of this century, and employed a NOT BLEACHED watermark to promote longer lasting, more durable paper. As the results of using chlorine became more controllable, the color of white could be unvaried within a sheet after bleaching and any residual shives or specks could be whitened, too. The look through of bleached fibered



A mid-nineteenth century, laid, handmade paper (from the William Howard Taft Papers at the Library of Congress, 1826).



A mid-nineteenth century machine-made paper (from the William Howard Taft Papers at the Library of Congress, 1851).

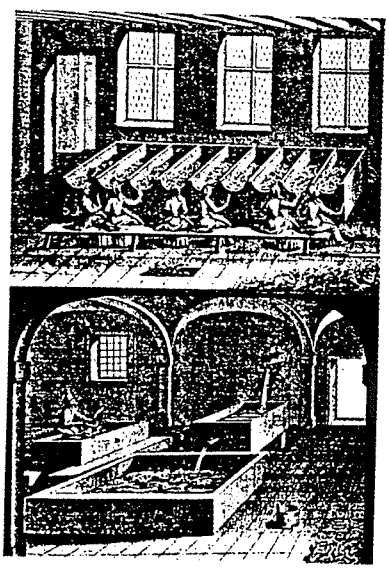
papers became more uniform, with few swirls from fiber bundles, as the fibers broke apart more.

Before papermakers used Hollander beaters, stampers separated and fibrillated the fibers into a pulp. The Hollander beater, developed c. 1650, has bars that cut the fibers instead of pounding and brushing them apart. This shortened both the beating time and the fibers. The patterns of clumps of fibers, common to many early book papers, gave way to more uniform fibers. The rich play of transparency and opacity in the look through of early papers with varying fiber lengths and bundles began to change to a uniform, overall opacity.

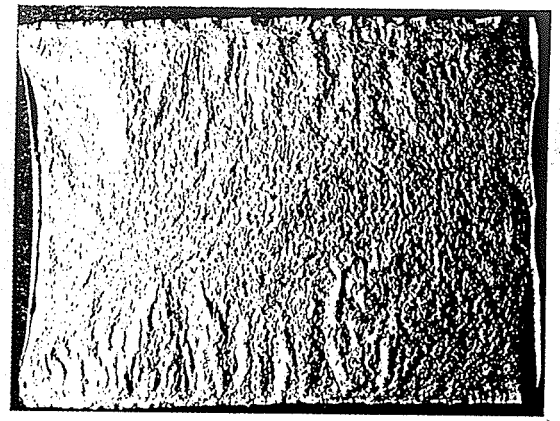
Laid paper moulds remained relatively unchanged until the late eighteenth century. The papers made on these moulds show visible shadows in the look through. The shadows were formed from the accumulation of the pulp along the wooden ribs of the mould, as the pulp drained more slowly there. In the late eighteenth century, paper mould makers added a coarse screen under the woven laid screen, which evened out pulp accumulation and virtually eliminated the shadow lines. Both types of laid paper moulds are still made today.

The invention of the papermaking machine and the development of chemical processing of fibers made it possible for the papermaking industry to develop and flourish in the nineteenth century. The burgeoning industry met the growing demand for more paper, which also created the economic incentive for faster methods and the need for more types of fiber. Papermaking machines require an even, unlumpy, uniform slurry in order for the continuous sheet to run smoothly out of the head box, travel through the felts, dryers, and calender rolls, and then be wound smoothly onto a roll.

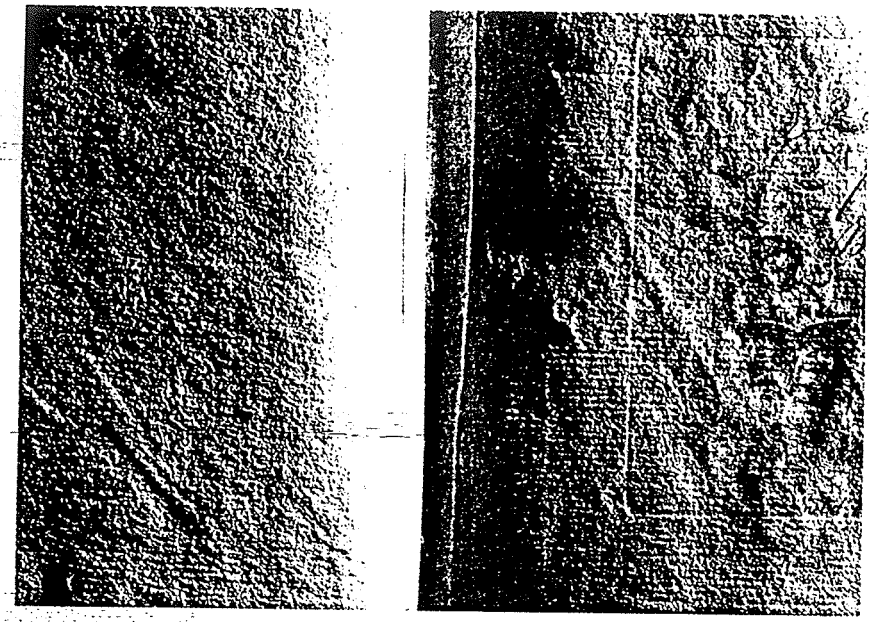
Hand papermakers had to adapt their methods to remain commercially viable in a fast-changing environment of more readily available machine-made papers. The introduction of technological advances facilitated this. Handmade papers long held the position of being stronger and more permanent than machine-made papers. Even into the 1900s, government documents were often specified to be handmade for those reasons. However, the aesthetics appeared to have changed in order to keep up with



From de la Lande, Plate I, showing sorting, above, and washing, below.



A heavily cockled, contemporary paper unsuitable for use in conservation work.



A contemporary paper (1995) facing an eighteenth century paper (from Bellamy Band Book, *1799), right. An example of compatible surfaces.*

the times. "Machine perfect" gradually became the norm and it seems that hand papermakers strove to meet this new aesthetic.

Slow, hand processes were sped up by the use of newly developed machines adapted for hand production. Drying cylinders made it possible for sheets to be pressed and dried, and the knotter aided in removing clumps from the slurry before the papermakers added it to the vat and formed the sheets. The use of these machines and others helped the hand papermaker produce sheets that looked more like machine-made paper.

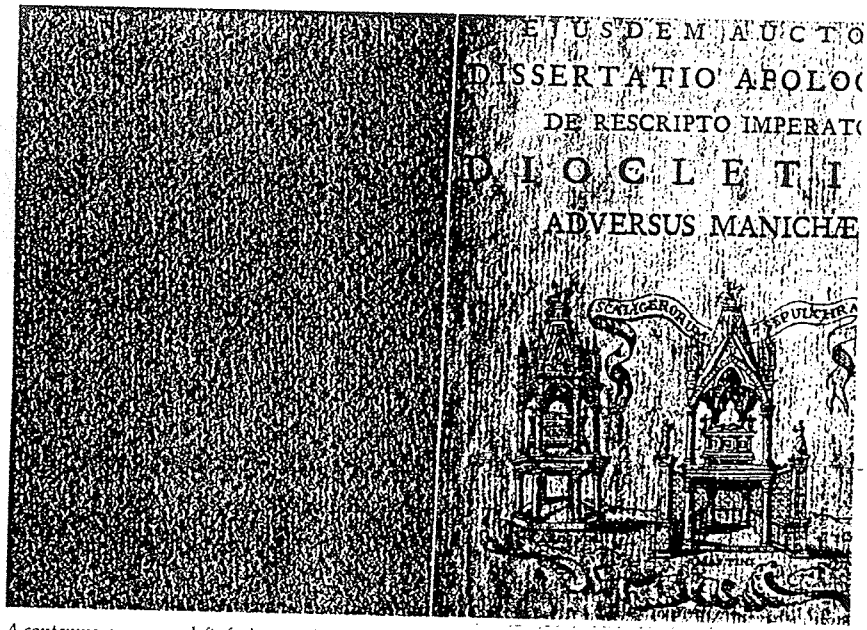
During the twentieth century, many hand papermakers started using fibers partially beaten by the paper industry, known as "half stuff", rather than starting from rags. Staple cotton half stuff can yield a pulp very even in color with uniform dispersion and homogeneous look-through, depending upon the skill of the papermaker.

Cotton linters, the short seed hair fibers, have been industrially prepared for papermaking since 1920. The short, uniform fibers provide opacity, evenness, and the look of machine-mades. However, linters also make a soft paper with little strength. Hand papermakers commonly used industrially prepared cotton linters well into the 1970s. Consequently, those handmade papers were not stronger than machine-made papers, as had been assumed.

When the separate operation of gelatin tub sizing was streamlined to vat sizing, papermakers saved much time by including the sizing material in with the pulp. Internal alkaline sizing, a vat size popular since the 1970s in hand papermaking, provides water resistance to paper, but it also changes the character of paper. An alkaline, internally sized handmade paper is softer, with a more open, matte surface than a gelatin sized sheet. Gelatin sizing puts a glossy coating on the surface of the paper. (Gelatin also tends to give paper more rattle and to increase strength and abrasion resistance.)

During the nineteenth century, hand papermaking was able to develop and remain a viable, albeit smaller, industry alongside the fast-growing machine papermaking industry. Hand papermakers did this by meeting the changing requirements of the consumers. Nineteenth and twentieth century handmade papers, on the whole, contain short, uniformly dispersed fibers. Cotton, the most common fiber, yielded a matte, opaque sheet. The surface texture was usually flat without the bumps caused by the felts and moulds. The machine-perfect aesthetic of most papers met many of the apparent needs of printers, bookbinders, and other paper consumers of their day. While nineteenth and early twentieth century papers met the changing aesthetic needs, through the use of different fibers and techniques, many of the physical properties attributed to handmade papers changed too. These papers, made up until the 1970s, lost the benefit of using carefully prepared, long, bast fibers, which resulted in the loss of strength, luster, and toughness typical of early papers. Since the 1970s, hand papermakers have used stronger fibers to make their papers more permanent and durable.

Many of today's handmade papers meet the needs of nineteenth and twentieth century conservation book work. We suggest that most have not yet met the needs of pre-nineteenth century work. Nonetheless, some of today's hand papermakers have done considerable research and work to process bast fibers, producing very tough and lustrous papers. Some skillfully mix bast fibers, rags, and half stuff to create a range of papers. Some papermakers are able to prepare a pulp that yields a look-through like early papers, despite using Hollander beaters. Gelatin sizing is often available upon request and some internally sized papers can still have a gleam, when the fibers are carefully prepared. Some papermakers have been able to press and dry



A contemporary paper, left, facing an eighteenth century paper (from De Pace Constantiae, *by Dominici Carlini, Verona, 1763), right. An example of incompatible surfaces.*

- color
- fiber lustre
- surface texture
- look thru

their sheets so that the mould and felt textures remain prominent on papers that lie relatively flat. Having various types and sizes of moulds available gives the option of papers with different mould impressions and look through.

The conservator or other specialized paper consumer must describe for the papermaker pre-industrial revolution paper, if that is what she or he needs. If one wants a paper that looks like an incunabula paper, one needs to characterize what it looks like—its look down and look through—and to support the papermaker to make it.

One cannot possibly define the characteristics of all early papers in one generalized description. Studying early papers reveals much about the time and place of their creation and each varies in description. As a beginning, categories to consider when describing paper are color, fiber luster, surface texture, and look through. The colors of surviving papers are a mixed white, often warm, leaning toward yellow or red rather than cool green or blue. The fibers are lustrous, not matte. The surface texture boasts the topography of the screen and felt impressions. The look through often reveals different degrees of opacity, some swirly fibers of varying lengths, occasional fiber lumps, and the light shadow marks of the chain and laid lines.

The consumer should not tell the papermaker how to achieve the results; that responsibility lies with the papermaker. Papermaking is a complicated, interrelated process. The papermaker's skills of preparing and beating the fiber, sheet forming, and drying determine the qualities of the paper. Only the papermaker can create a paper containing the imperfections described by the consumer, but still lying flat and functioning as a workable sheet.

The challenge for a papermaker to make a sheet that looks pre-industrial using nineteenth century technology and twentieth century materials equals that of the book conservator to rebind a fifteenth century book using twentieth century materials and methods. The consumer can examine early papers to describe the look through and look down of the period paper needed. The hand papermaker must then work with this information and the limitations and challenges of economics and available materials. Through their combined efforts, the aesthetics of new handmade papers can also approach the aesthetics of pre-industrial revolution papers.

The authors developed and honed these observations for the Endpaper Project, sponsored by the Library of Congress Preservation Directorate to help develop end papers for use with fifteenth to eighteenth century books. The project included two paper runs and a meeting with conservators and six papermakers. Funding from the Library of Congress, the Kress Foundation, and Bookmakers, Inc. supported the meeting. The Library of Congress will soon publish the proceedings from the meeting and the Endpaper Project.

Notes

1. The *Encyclopedia Britannica* defines the term "industrial revolution" as commonly used to denote the changes in production and organization that mark the passage from an agrarian, handicraft economy to one dominated by industry and machine manufacture.
2. One can also listen to the sound of the rattle, experience the way paper rolls, and feel the surface of a sheet for texture, but these are non-visual indicators, so we have not addressed them here.
3. High pressure also compresses paper fibers and increases density. Early papers generally feel less dense than modern papers.