HANDMADE PAPER

METHOD CINQUECENTO

RENAISSANCE
PAPER
TEXTURES

DONALD FARNSWORTH

A traditional papermaker's hat sits atop a book in this early 18th century etching

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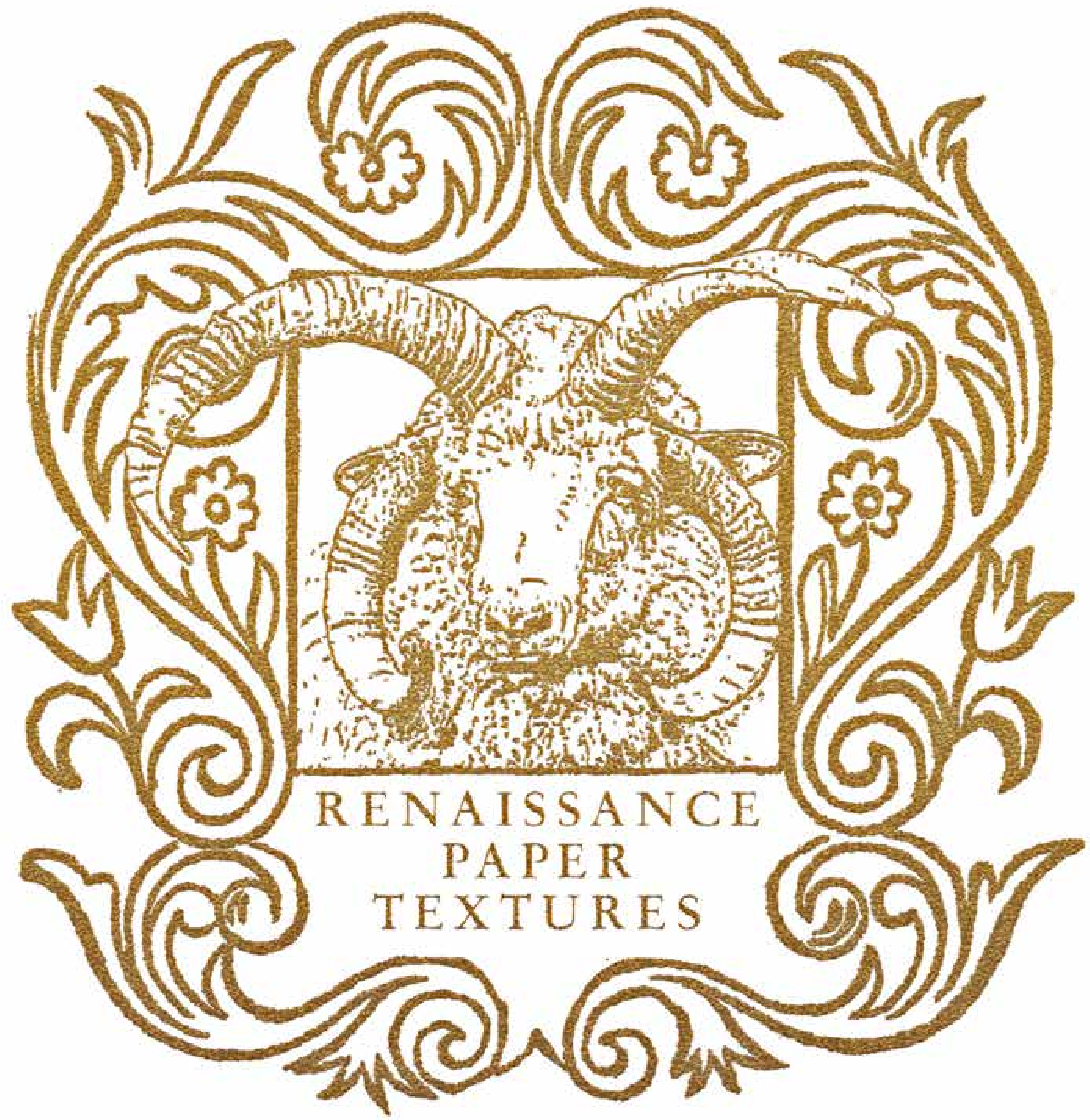

DONALD FARNSWORTH

Black and red quarried chalk, chalk holders, linen and hemp paper

Hand made wire watermark sewn on a laid mould

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> “Paper is not only the physical support of the creative message but also its design space, its secret laboratory…”
>
> PIERRE-MARC DE BIASI

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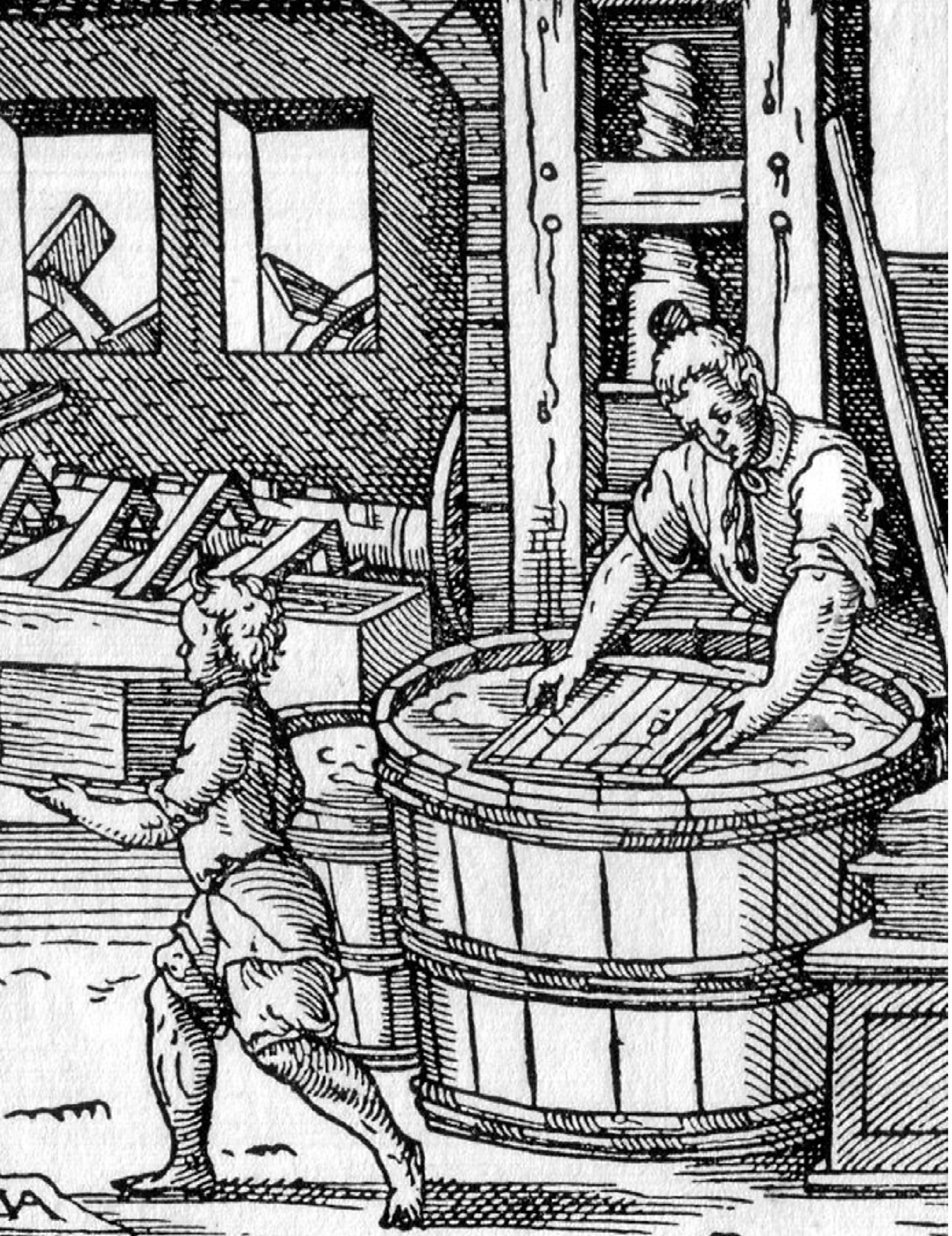


Introduction

Research & re-creation: *Renaissance-style paper*

Contemporary artists wishing to try their hand at drawing or painting on linen and hemp papers similar to those used by Leonardo or Michelangelo would be well advised to forego the disappointment of trying to buy such papers at an art supply store. For all of the myriad varieties of paper in existence—many created and marketed specifically with artists in mind—not a single contemporary paper, whether mass-produced or made by hand, offers the strength or the endless variety of surface textures imprinted into the Old Masters' papers by coarse woolen felts.

In my quest to produce a decent sheet of linen and hemp paper that looks, feels, and reacts like the paper an Old Master may have used, I have had dozens of false starts and unintentional results at every stage of the process (Figure 7, p. 85). Every naturally occurring and handmade misstep is instructional and some – if not most – are desirable. Such marks create a varied landscape like a unique fingerprint on every sheet of paper, reminiscent of the Heraclitan maxim: "You cannot step twice in the same river." Likewise, one cannot draw the same chalk stroke on Cinquecento paper twice, as the underlying paper texture that defines the stroke is never the same. While most humans may now regard paper artifacts as undesirable flaws, some Renaissance artists may have selected a sheet precisely because it possessed an intriguing, distinctive, and unique texture and characteristic. They may have coveted the felt hair marks, laid lines, and animal skin size, all incorporated in a thin yet substantial paper with texture one could get lost in – air-dried and unrestrained.

The aesthetic heights of the Renaissance – across all disciplines, whether in sculpture, drawing, painting, or architecture – benefited enormously from the refinement and availability of affordable, durable handmade paper. Crucially, access to paper enabled iterations: ideas building on ideas, allowing creators to generate increasingly sophisticated versions of a sketch or plan. I cannot say enough about the importance of tracing, gridding, pricking (perforating), and even cutting shapes – all accessible techniques using paper that contributed to the aesthetic sophistication of the time. Michelangelo used all of these techniques: for example, cutting paper to capture the profiles of moldings and column bases. Renaissance architecture reached new heights because of paper and the builder's newfound ability to iterate and reiterate architectural plans, elevations, and sections—profoundly influential throughout the world to this day.

Unfortunately, the lack of extant research and scholarship regarding important artifacts in paper reflects a common art-historical tendency to ignore the sheet entirely when exhibiting Renaissance works on paper. It is not uncommon to see the medium as simply "ink" or "black chalk" with no mention of or commentary on

Opposite page: Jost Amman's 1568 woodcut depicting papermaking (Der Papyrer, from the Book of Trades)

What would an Old Master drawing in "red chalk over traces of black chalk" look like without paper? This pile of chalk on a slab of marble offers one distinctly underwhelming possibility.

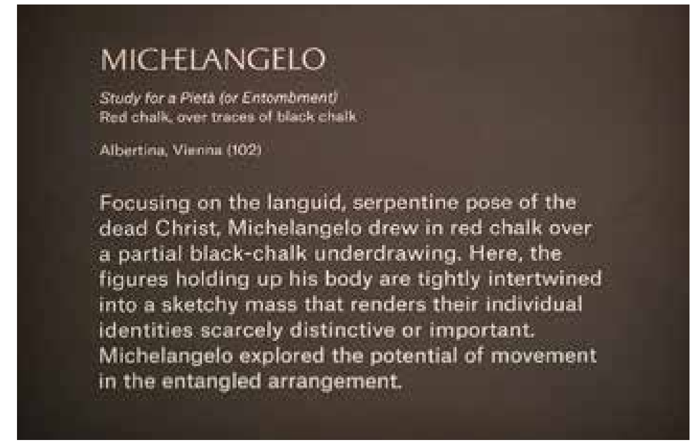
the ground upon which this pigment rests. "Few truly evocative and informative descriptions of paper are found in the literature of art," writes Margaret Holben Ellis in the enormously helpful 2014 compendium, *Historical Perspectives in the Conservation of Works of Art on Paper*:

> *Not only are observations about the paper substrate of prints and drawings rarely recorded, but there is a curious lack of language to describe paper; many of the terms that are employed are vague, misleading, or outdated. Yet most readers will agree that the substance and the appearance of paper vary enormously and play a critical aesthetic role.*

The lasting aura and appeal of Renaissance drawings must be attributed, at least in part, to the unique qualities of that era's paper. Many surviving Old Master drawings are stunning in their facility and draftsmanship, while others are merely dashed off sonnets, notes, and to-do lists; hand-manufactured sheets of paper lent gravitas to both the scribble and the masterpiece. It is possible that the Old Masters took their paper for granted and gave it little consideration in their day. Still, the 16th-century sheet became a versatile, flexible, portable, and archival vehicle for memories lasting a thousand years.

Sadly, it seems quite likely that conservators and misdirected "restorers" of an earlier era – unaware of artifacts such as the loft drying back mark – might have encountered such marks, misidentified them as mere creases, and used moistening, relaxing and flattening to rid the work of such "flaws"—thus unwittingly reinventing and smoothing the history of the work. Rather than relegating paper to the category of "support," we must develop descriptive terminology and standardized syntax to document the surface and physical attributes. The 2014 Philadelphia Museum of Art publication *Descriptive Terminology for Works of Art on Paper* provides an excellent model for such a terminology's possible development in the years to come.

Treasured Cinquecento works on paper were not created by a single hand. They represent an indirect collaboration between the artist, rag merchants, felters, master carpenters, and mill workers, to name a few*. Discovering more about the genesis of a single sheet can provide a window into the entire world surrounding a five-hundred-year-old artwork's creation. Perhaps more information, attention, and insight will one day subvert and undo the contemporary confusion or indifference to the substrate that documents our world and which the Old Masters employed to such great effect.



Museum wall text for a Michelangelo drawing describes the medium as "Red chalk over black-chalk underdrawing" with no description or even a mention of the "support" —the sheet of paper that provided an important textural counterpoint to the maestro's mark-making.

My goal is not to radically change anyone's opinion of a particular paper; nor is it to divine why an artist of the Renaissance may have chosen a specific sheet (e.g., surface texture, dimensions, weight, economic necessity, scarcity, availability, etc). Instead, I wish to create and document a coarsely hair-textured linen and handmade hemp paper and make sheets available to artist friends and colleagues. One need only to open a Renaissance-era book and pull out the endpapers (flyleaf) for an opportunity to draw on Cinquecento paper in its aged, antique form; however, my goal is to document and make a brand-new, crisp, freshly minted sheet of Renaissance paper, as yet unaltered by the passing of time – such a paper as Michelangelo might have purchased from a Florentine paper merchant. Artists' cravings and desires haven't changed all that much over the past 500 years – offer a contemporary artist a sheet of interesting, unique, and versatile paper, and their eyes light up. Watch their spirits lifted as they contemplate the paper's potential, like a carver who looks at a block of marble and sees the Pietà ready to emerge. My quest aims to deliver to this community an anti-corporate, non-Arts-&-Crafts-Movement, non-Industrial-Revolution paper that will receive chalk and ink marks as rugged yet beautifully as some papers did five hundred years ago: a paper with tantalizing flaws and inconsistencies. As Pierre-Marc de Biasi predicts in a 2011 essay, the digital age may yet witness a revival of handmade paper as a "pleasure material":

> *At the threshold of a world dominated by virtuality and intangibility, perhaps we are inexorably headed for an era of art paper or sensation paper—a passion for its visual and tactile density, an "Asian-style" culture of paper, where the ancient and subtle surface of the graphosphere could advantageously metamorphose into a pleasure material and become the universal medium of a new aesthetic relationship to the world.*

**To name a few more: the shepherds; fullers and felters; rag men; those who carded, wove, and made the linen and hemp garments; those who wore, used and laundered the cloth, thereby softening and fraying the fibers, transitioning new fabric to rags; the paper mill equipment designers and fabricators (waterwheel stamper, vat, press, and mould); the workers at the mill; the makers of animal-hair ropes; and of course, the workers quarrying natural chalk, the conveyancers... the list goes on.*

Forming a sheet

Lifting the deckle – transferring to empty mould

Laying aka pitching a felt

Couching on coarse non-woven Churro felt

Pressing a post

Hanging a spur on horsehair rope to dry using a "T"

Papermaking methods & resultant texture

Before the Industrial Revolution, European paper was made from composted (retted), hammer-beaten linen and hemp rags, and sisal rope. In this handmade paper process, each sheet was formed on what is now called an "antique laid" mould, a ribbed wood frame fitted with a sieve-like wire screen. A vatman stood at a vat filled with pulp (aka furnish) and scooped up the slurry of dilute, beaten pulp onto the laid wire covering of the mould; as the water drained, a layer of wet fiber formed on the screen surface.

In seconds, the glistening wet surface turned satin as the dripping wet, newly formed layer of furnish drained. With the wooden deckle removed, the mould was passed to the coucher, who pulled the mould up to a sloping angle, leaning it on the asp with his left hand. Next, he pulled a felt off the felt stand and covered his previously couched sheet. Again grasping the mould, he deftly inverted the mould onto the felt in an arcing motion, pressing gently and transferring (couching) the sheet from the mould to the blanket. Concurrent to the couching, the vatman formed another sheet on a twin mould using the same deckle. The vatman and coucher repeated this process, building up a large stack of alternating paper and felt, known as a post.

The sheets in the post were pressed multiple times before being air-dried in the upper stories of the paper mill, called the drying loft. The paper's first post pressing between felts removed the bulk of the water and required the most pressure – 50 tons. In the second pressing, called pack pressing, the damp sheets were separated (parted) from the felts and were gently pressed, stacked, and in contact with one another – at about 2.5 tons. For finer, less textured paper, the sheets were separated while still wet from the second pressing, shuffled (exchanged), and re-pressed. With each additional shuffle and re-pressing, the paper became incrementally smoother – with less noticeable felt hair marks (from the first pressing) but not necessarily less chain and laid line texture.

After pack pressing one or more times, the paper was separated in groups of 3 to 8 (more for very thin sheets), temporarily adhering together as small groups called spurs. Each spur was hung separately on waxed horsehair and cow-hair rope (or wooden poles) and allowed to dry slowly in a controlled, humid environment. The waxed and bristly animal hair rope allowed the paper to dry without the staining caused by a common rope made from sisal. After pulling and separating the spurs, the dry sheets were cured for approximately two weeks and then dipped in hot, dilute animal hide glue (sized) and again hung to dry. Once sized, the dry, cockled sheets were gently pressed, over time, to coax them flat.

The revival of handmade paper by the Arts and Crafts movement and more recent industrial papermaking "advances" modified these processes. Hollander beaters and refiners supplanted the stamper mills. Wove moulds (which impart no laid pattern) came into use; cotton rags and cotton linter displaced linen and hemp. A selection of more delicate wool fleece and synthetics, woven and needled, replaced natural felts. Hotpress platen, drum, and stack dryers now speed the paper smooth, dry, and flat. Internal chemical sizings (chemicals added directly to the furnish) make paper water-resistant but add no surface hardness. Paper is harshly whitened using chlorine bleach and optical brighteners – a questionable "progress."

Paper hung to dry on horsehair rope suspended on a framework ("treble lines")

Coating the loft's horsehair rope with bee's wax

Finish pressing coaxes the cockled sheets flat over time

Artifacts and marks in rope hung spurs handled differently:

1. This spur was well pressed but had too few sheets in the spur relative to the weight of the paper (four sheets). Additionally, the furnish was slightly over-hydrated. These two factors make for a more cockled group.

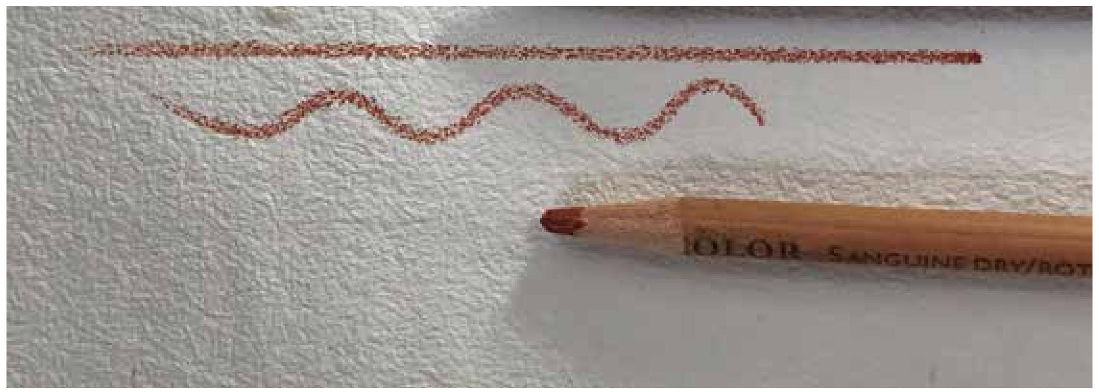
2. A five-sheet spur, correctly pressed and dried, slowly producing fewer cockled sheets.

3. The top sheet of the spur is seen separating from the group due to an overly gentle pack pressing.

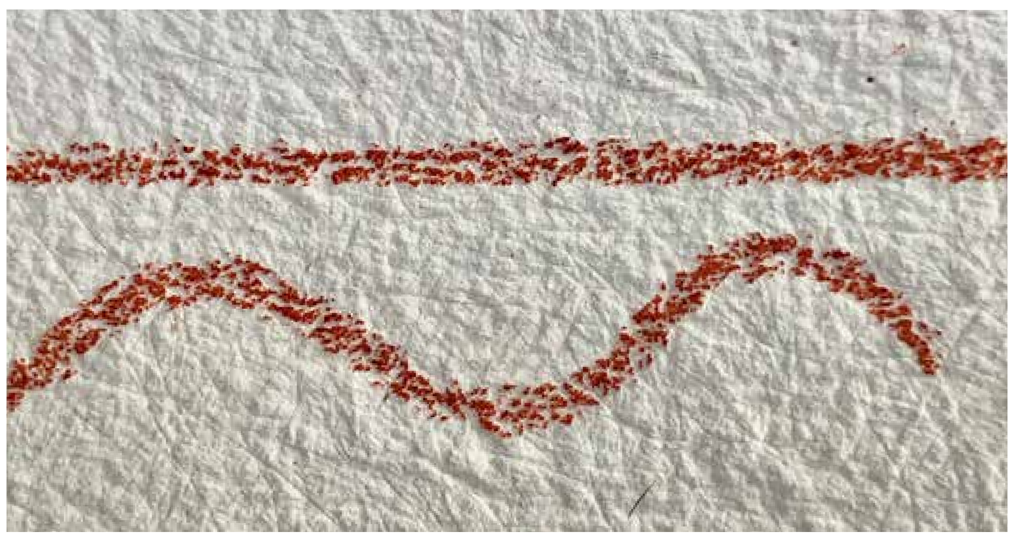
4. Shows flaws created by sloppy handling of the spur during parting and hanging. Additionally, this group consisted of only a three-sheet spur, allowing for excessive cockling. (I could only have done worse by dropping and stepping on it.)

(Not shown: the resulting back marks)

The Navajo-Churro breed (Spanish Churra sheep) was obtained by Native American nations, including the Navajo and Hopi, during the Spanish Conquest in the 16th century; ink drawing on a linen test paper.



Chalk – Sanguine Dry/Rotel Trocken 462 12



Chalk – Sanguine Dry/Rote Trocken 462 12 (detail)

CHAPTER I

Felt Hair Marks

RENAISSANCE PAPER TEXTURES

Magnolia Editions

> "…the appealing felt-hair textures of Renaissance drawing papers can only have been the result of felts made from a non-woven blend of inner coat and outer coat wool, particularly the water-repellent thick outer coat hairs…"
>
> DONALD FARNSWORTH

The search for coarse heritage wool felts

Felt hair marks found in Cinquecento papers are not an embossment (i.e., dents in dried paper)—they are part of the manufacture, a structural component etched indelibly in the memory of the paper's cellulose fibers. The unique peaks and valleys of felt-hair marks, formed as the paper dries, are made permanent and persistent by hydrogen bonds. In the parlance of the computer age, felt hair marks in Renaissance-era papers are not a bug—they are a feature.

Artists working with media such as chalk, for example, know that the medium demands a paper with enough tooth to hold the pigment effectively, and lovers of Renaissance drawings instinctively appreciate the unique interaction of pigment with the papers of the day. The tooth textures of these papers are an imprinted record of the coarse wool felts used during couching and pressing. When drawing on such papers, these textures become the shadow detail in the image area. To accurately recreate such textures requires the use of non-woven wool felts that approximate those used in the 16th century as closely as possible.

With that sentiment in mind, my wife Era and I traveled to Umbria, Italy, in 2016 on a quest to find coarse wool from sheep whose DNA had not changed since the Renaissance. First, we needed to find a sheep geneticist who could let us know if cross-breeding had made such an animal extinct or if, in fact, such a beast still walks the earth. Through the kindness of our good friends Elizabeth Wholey and Gianni Berna, an Italian alpaca shepherd living not far from the early papermaking city of Fabriano, we contacted Carlo Renieri. Mr. Renieri is a member of several wonderfully named International Societies, including Anthropozoologica and COGNOSAG: the Committee on Genetic Nomenclature of Sheep and Goats, who answered our burning question: are there any sheep alive today with the same DNA as the sheep of the Renaissance? Professor Renieri's answer was an emphatic yes: the Fabrianesi and Apenninica breed both possess DNA that has not changed for half a millennium. As luck would have it, Italian felt artist Cristina Biccheri made felts from these very breeds, which were used in many of my early tests.

In early 2017, Janice Arnold, an artist and felt maker from Washington State, suggested that fleece from the Churro, a sheep known for its coarse outer coat fleece, might yield the texture I sought. Raised by Native American nations and Hispanic communities in the Southwest since its introduction by Spanish conquistadors in the 16th century, the breed is commonly associated with the Navajo tribe and referred to as Navajo-Churro. With papermaking introduced to Europe via the Iberian Peninsula, it is not farfetched to imagine that the Churro or related breed might have been used in early Italian papermaking; papermakers fleeing the Inquisition in Andalusia may even have brought Spanish felts when establishing paper mills in Italy (theories in need of peer review).

I located a Navajo-Churro felt maker in Taos, New Mexico named Minna White (of Lana Dura) and wrote to her asking if she could make me large, 3 x 4 ft. coarse Churro felts. In addition to sourcing the coarse wool, Minna also introduced me to Connie Taylor, the current registrar for the Navajo-Churro Sheep Association and a specialist in wool color and genetics. The Churro breed felts I received from Minna were large, coarse, and felted with no woven underlayment; paper couches nicely on these felts, and they spring back easily from 50 tons (230 psi) of pressure. The outer coat hairs of this felt measure 50 to 65 microns in diameter (0.050 to 0.065 mm) – similar to my measurements of the marks in Renaissance paper, and a far cry from the 10 to 24-micron diameter measurements found in delicate wool garments and contemporary papermaking felts. To mimic a 16th century felt more precisely, Minna White is making felts with a finer nap on one side and coarser on the verso. The coarse fleece side ensures efficient de-watering. Couching on the finer side ensures a sheet remains on the subsequent felt of a pressed post: i.e., as felts are removed during parting, the finer wool side facing upwards minimizes the tendency of paper to adhere to the underside of the felt being removed.

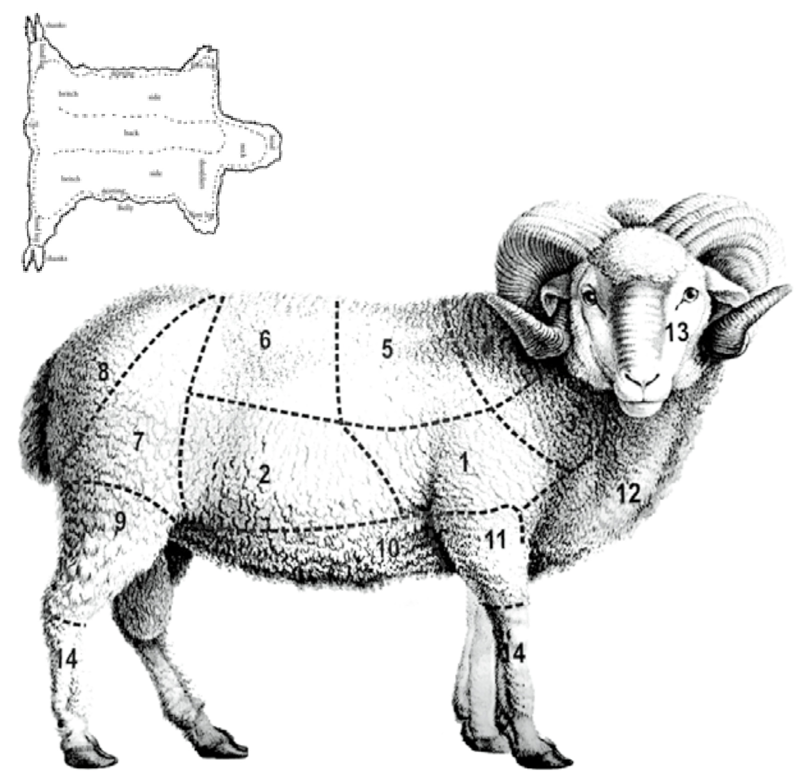
According to my experiments and research, the appealing felt-hair textures of Renaissance drawing papers can only have been the result of felts made from a coarse, likely non-woven blend of inner coat and outer coat wool, particularly the water-repellent thick outer coat hairs (incredibly thick when taken from the "britch," or thigh). While initially I wondered if financial considerations had prompted Cinquecento papermakers' use of the cheaper coarse wool, I now recognize that this choice was strategic. Such felts perform better for de-watering in post pressing, an important trait for early papermakers whose presses had not yet developed the pressure of those built-in later centuries. Early papermakers could not employ 100% fine fleece felts until mechanics and hydraulics came of age in the mid- to late 1700s. The percentage of papers devoid of felt hair marks manufactured in the Cinquecento were likely the results of a more aggressive pack exchange practice,* or made by mills with a more efficient wooden press (finer thread pitch and/or equipped with a "Samson post.") More effective de-watering allowed for the use of finer felts. Hydraulic presses would later herald the demise of all felt hair marks. Increased demand for books, broadsides—and to some extent writing papers and manuscripts—influenced 18th-century papermakers' move toward smoother paper. As mechanical advantage and finer woolen felt practices were adopted, less textured paper became favored, and the distinctive texture of Renaissance chalk drawing paper went extinct.

** Multiple pack pressing and reshuffling (exchange) to reduce felt hair marks.*

Churro handmade felt at left; an industrial woven and "needled" wool felt at right

Paper texture through a magnifying loupe: my effort at left compared to a 16th century paper at right

Coarse Navajo-Churro (wool) felt



Coarser fleece is found on the legs, neck, britch and head; higher numbers in the diagram above correspond to coarser areas

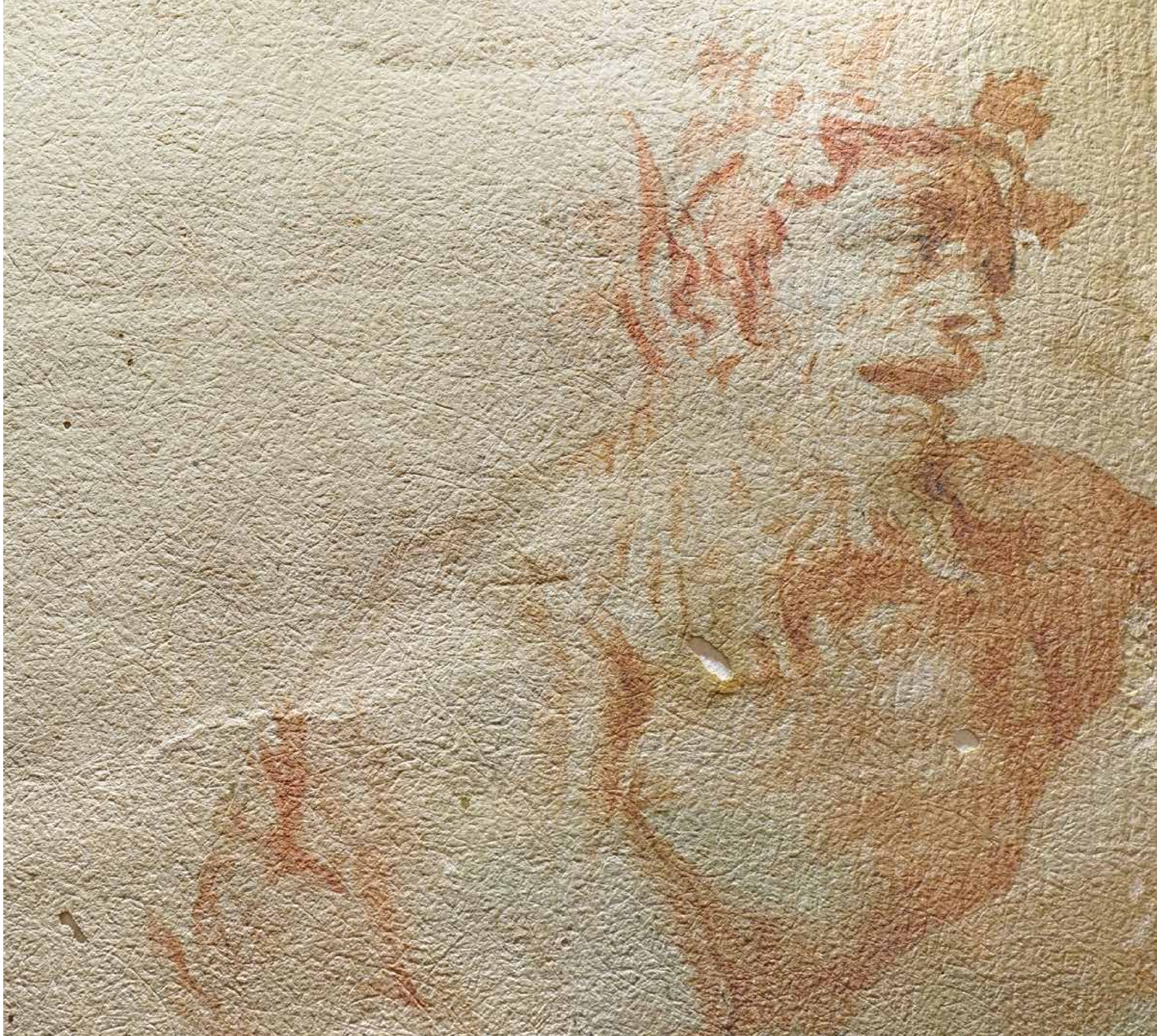
Minna White's carding machine

The ideal felt hair texture

Examples of Renaissance paper with impressive felt hair marks can be found in museums worldwide; perhaps the finest example of the target paper I desire to create is a drawing of satyrs by Guido Reni. This masterwork can be viewed (by appointment) in the prints and drawing study room at the Victoria & Albert Museum in London. Reni's satyrs occupy a linen/hemp laid sheet exemplifying the texture and show-through that served as a foundation for many inspirational master drawings. This stunning sheet remains the benchmark for my efforts.

Reni, Guido, 1575—1642: Male & female Satyrs embracing… on their knees…, *Red chalk, washed, 8.6 x 15.9 in. Victoria & Albert Museum, London*

At right: Detail from Reni's Male and female Satyrs



Charting the decline of felt hair marks

This chart, reproduced from J.N. Balston's invaluable publication The Elder James Whatman, Vol. 1, records the incidence of felt hair marks in a sample of papers from the turn of the 18th century. It is clear from the sharp dropoff in the "Severe" column that papers produced prior to 1700 bore significantly more evidence of felt hair marks than those produced only thirty years later. Balston writes that the disappearance of these marks "represents an evolution of the hand felt," as papermakers sought to "improve" their felts in order to make a smoother sheet without the undesirable defect of felt hair marks.

Incidence of Felt Hair Marks in a sample of papers (697 pieces) used between 1694–1732 and all taken from one source, a continuous series of parish documents (Bills) belonging to All Saints', Maidstone, Kent. (KAO P 241 12/4–12/14).

		(1)	(2)	(3)	(4)	(1 + 2)	(3 + 4)
Years	Sample	Not Visible	Very Slight	Slight	Severe	Not Noticeable	Blemished
1694–99	7	14%			86%	14%	86%
1701–04	115	29%	5%	11%	55%	34%	66%
1705–07	91	45%	3%	14%	38%	48%	52%
1708–09	79	68%	11%	8%	13%	79%	21%
1710–12	99	65%	14%	7%	14%	79%	21%
1713–16	36	67%	19%	3%	11%	86%	14%
1724–26	83	78%	13%	4%	5%	91%	9%
1727–29	38	66%	18%	3%	13%	84%	16%
1730–32	149	76%	13%	5.5%	5.5%	89%	11%

April 1981 J.N. Balston

Source: J.N. Balston, The Elder James Whatman: England's Greatest Paper Maker (1702-1759), *Vol. 1; J.N. Balston, West Farleigh, Kent, 1992; pp. 202-203.*

A Short History on Navajo-Churro Sheep

by Ron Garnanez

In the early 1600s, Navajo acquisition of "la raza churra" sheep from the Spanish colonists inspired a radical lifestyle change to an agro-pastoralist way of life and expanded mobility. In the high deserts and wooded mountains of Diné Bikéyah (Navajo Land) Diné pastoralists developed the Navajo-Churro breed, which thrived under the spiritual and pastoral care of their new companions and assumed a central role in the People's psychology, creativity, and religious life. With songs, prayers, and techniques taught to them by Spider Woman and looms first built by Spider Man, traditional Navajo weaving evolved to utilize the special qualities of the glossy Navajo-Churro wool.

As the Navajo managed their flocks for over 350 years, they evolved the Navajo-Churro, a breed recognized by the American Sheep Industry. They are hardy and have excellent mothering instincts and successfully lamb out on the range with little assistance. Smaller than many commercial breeds, they eat less and do well on forage alone. They do not need grain. Their legs, faces and bellies are free of wool so they do not pick up burrs. They are tall, narrow in build with fine bones, making them sound, agile and fast out on the range.

Carpet-wool sheep have two lengths of fiber, an inner coat of fine wool with an outer coat of hair. Navajo-Churro fleece is low in lanolin requiring little water for washing. It may be spun directly from the raw fleece without time-consuming carding. The wool comes in natural colors and is very high in luster which [is] highly-prized by hand-spinners. Yarn spun from this type of wool is extremely strong and durable, making it excellent for the Navajo rugs, horse cinches, and belts. In addition the wool can be easily felted for a variety of uses including hats and outer garments; the distinctive long-haired pelts are highly valued. [...]

A series of Federal government actions led to the almost total eradication of the Navajo-Churro breed, disrupting the chain connecting Navajo culture, weaving, traditional lifestyle, and self-sufficiency. In the early to mid-1900s, market forces, ignorance, and misguided attempts to "improve" Navajo wool, depressed the economic value of Navajo-Churro sheep and led to their almost complete extinction. During the 1930s, Navajos were forced by the United States to radically reduce their herds – the wellspring of their Good Life.

Government agents went from Hogan to Hogan, shooting a specified percentage of the sheep in front of their horrified owners, who love their sheep and regard them as family members. First to be shot were the Churro, because the agents thought this hardy breed was "scruffy and unfit." Today, elders tearfully recall that time and can describe in detail each sheep that was killed and the exact location of the massacre. At the same time, traditional summer grazing lands in the mountains were appropriated by the U.S. government and a system of allotments was instituted which disrupted the traditional way of family land management. In the late 1930s and '40s, Federal agents discouraged raising the Navajo-Churro encouraged cross-breeding with other fine wool genotypes. This practice has led to wool that is very undesirable for both the commodity market and the specialty wool market.

The shorter wool fibers of commercial breeds break easily when hand spun using traditional Navajo methods and do not take the native, natural dyes very well. Navajo weavers became discouraged with trying to process this new wool by traditional means, and many began buying commercially produced and dyed yarns. While beautiful weavings have been created with commercial yarns, their use has contributed to breaking the traditional tie between sheep, wool, land, and weaving. Weavings made with commercial yarns are not as durable, and the texture and quality are not the same as those created with Navajo-Churro wool. Among today's informed collectors, weavings from Churro wool command premium prices.

By the 1970s, only about 450 of the old type Navajo-Churro existed on the entire Navajo Nation, and only a few specimens were preserved in other locations. The conventional wisdom of the time was "the breed is not useful – let it die out," an attitude often directed towards the traditional cultures, themselves. The disappearance of the Churro has adversely affected the Navajos' health, as well as economic opportunities for specialized niche markets for meat and wool.

In the mid-1970s, animal scientist Dr. Lyle McNeal, sheep industry expert with Utah State University, recognized the genetic and cultural significance of the Navajo-Churro. He searched out enough remaining Navajo-Churro sheep to start a foundation flock. From this flock he has been able to re-introduce Navajo-Churro Sheep to the Navajo people. In 1977, Dr. and Mrs. McNeal founded the Navajo Sheep Project. The project has placed many breeding stock with Navajo families and helped form the nucleus of Ganados del Valle/Tierra Wools flocks in Los Ojos.

The Navajo-Churro Sheep Association was founded 25 years ago to maintain a breed registry and ensure quality. Today, there are several thousand sheep of this breed from throughout the United States registered with the association. Yet the numbers are too low for the breed to be safe and Navajo Churro Sheep continue to be listed by the Livestock Breeds Conservancy as "threatened by extinction."

Ron Garnanez
President, Dine Be' Iiná Inc

Excerpted with permission from:
http://navajolifeway.org/a-short-history-on-navajo-churro-sheep/

Navajo Sheep Project

Churros were the first sheep to come to the New World through the Spanish conquerors from Spain in the 1540s. The sheep thrived on the semi-arid Southwest and became an integral part of Navajo culture, tradition, and religion. The sheep provided meat, milk, and wool for the Navajo people. The Churro wool was the foundation of Navajo weaving and Hispanic Rio Grande textiles.

However, like the buffalo of the Plains Indians, the Churro were systematically destroyed by federal soldiers and agents to subjugate the Navajo people. By 1950 Navajo sheep raising was considered to be on a sound basis for continuance, which meant at a dead level of production and a marginal enterprise. The income for most Navajo families was extremely low compared with Anglos and was the lowest of any Indian group in the Southwest.

Income off sheep raising provides barely 1/3 of the tribe's standard of living. By 1973 there were fewer than 450 Churros among the more than 300,000 sheep on the reservation.

Learn more at https://www.navajosheepproject.com

Navajo-Churro Breed Criteria

Inner coat: Wool fibers range from 10-35 microns, comprising 80% of the fleece.
Outer Coat: Hair fibers measuring 35+ microns, comprising 10-20% of the fleece.
Kemp: Short opaque fibers of 65+ microns not to exceed 5% of the fleece
Source: www.navajo-churrosheep.com

Navajo-Churro wool felt magnified x10

Photo: Don and Era Farnsworth;

Detail view of Pier Francesco Mola: Adonis Departing for the Chase, *ca. 1625-1666. Victoria & Albert Museum, London*

Cristoforo Roncalli, called Il Pomarancio: Half-Length Study of a Youth with a Raised Left Arm, *c. 1609. Victoria & Albert Museum, London*

Leonardo da Vinci went so far as to select a coarse, lumpy, poorly formed, cloudy sheet riddled with impurities for Study of an Old Bearded Man in Profile, *apparently finding inspiration and guidance in the paper's coarse, uneven surface. The bottom edge of a purplish-brown clump of embedded recycled paper became the inspiration for the upper eyelid of the old man. Rather than fighting the paper's uneven surface, he allows his chalk to skip and jag around inclusions, echoing the weathered features and skin texture of the old man as if melding the spirit of the paper and old man as one. It can hardly be a coincidence that the Maestro da Vinci chose to create this image on such a scrappy piece of ancient wrapping paper instead of some smooth, white, anonymous sheet devoid of character.*

Like a fingerprint, every sheet of paper with heavy felt hair marks is unique, making a more individualistic surface for the artist.

Photo: Don and Era Farnsworth

Leonardo da Vinci: Study of an Old Bearded Man in Profile *(detail with back-light)*

Coarsely-toothed paper with felt hair marks

When using coarse, woolen felts with ancient DNA, whether today or 500 years ago, the maximum possible felt-hair texture is created when sheets are made from a fast draining furnish receiving only a single pressing. After pressing, they are separated and air-dried individually, unconstrained. A less coarse but richly textured surface develops when sheets are pressed twice before loft drying, once in the post (between felts), then subjected to one pack pressing, separated into spurs, and hung to dry. In general, whether intentional or simply practical, unrestrained drying and a minimum of (or no) pack pressing(s) retain strongly embedded marks in a sheet.

To make loft-dried sheets suitable for pen and ink, Renaissance papermakers dipped the waterleaf sheets into a hot bath of 2 to 8 percent gelatin solution—hide glue[2]. After a short while, the gelatin soaked paper received gentle pressing (to remove excess size), then separated and allowed to dry individually a second time (not in spurs). Once sized and dry, the sheets were cured (finished) by patiently pressing, shuffling, and re-pressing stacks of dry paper for some months to remove cockling and achieve the desired flatness. With enough time and pressure, the surface texture was reduced. In the case of the coarsely textured papers, no effort was spent calendering or burnishing the sheets.

Minimal pressing and lack of finishing likely made for a less expensive paper. These coarser felt hair-marked papers were ideally suited for the red, black, and white chalk drawings of the Old Masters. An artist could use light pressure to deposit colorant on the surface for lighter passages and hard pressure to fill the hair-trough-surface-tooth for darker elements. The entanglement and complexity of the millions of fibrous indentations made by the felt and papermakers contributed to the work's brilliance.

For example, Cristoforo Roncalli uses the texture of his chosen sheet of paper to great effect in the red chalk drawing *Half-Length Study of a Youth with a Raised Left Arm*. The process of its making is evident in the detail view, showing both the felt hairs and the visible laid and chain lines left by the paper mould's laid screen. In the detail of an ink wash by Pier Francesco Mola, we see the impression of felt marks transferred to the paper in the first pressing and vertical impressions of the chain lines from the laid wire covering on the mould, making for an exemplary collaboration between the artist and an anonymous papermaker.

Leonardo da Vinci: Study of an Old Bearded Man in Profile, *c. 1513. Royal Collection Trust, Windsor*

A closer look at the gift of paper texture

Most "art papers" marketed to today's artists are manufactured on a moving screen or rotating screen-covered drum (a Fourdrinier or cylinder machine) and transferred to a long continuous felt that wraps around hot drums to dry. The use of woven felts in their manufacture often creates repetitive marks on the paper's surface: i.e., the tooth and texture of each sheet is uniform and predictable. Renaissance papers possessed an endlessly diverse topography of random felt-hair marks from contact with coarse felts. Today's paper often has some degree of repetitive tooth structure – designed, one supposes, not to "get in the way" or "interfere" with the genius of an artist's mark.

Leonardo da Vinci – The Head of the Virgin in Three-quarter View Facing Right, *1510–1513 Black chalk, charcoal, and red chalk, with some traces of white chalk (?); some remains of framing outline in pen and brown ink at upper right (not by Leonardo) on paper. Sheet: 8 x 6 1/8 in. (20.3 x 15.6 cm) image courtesy the Metropolitan Museum of Art*

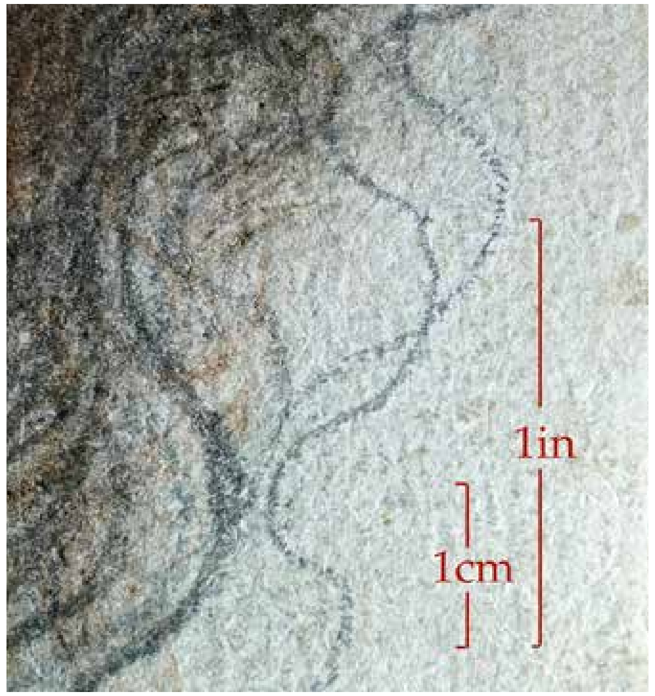


Photo: Donald & Era Farnsworth

In the above detail of Leonardo da Vinci's *Head of the Virgin*, we see two intertwined strands of hair flowing like smoke in the lower right-hand corner of this delicate chiaroscuro chalk drawing. The hairs appear to sparkle as if backlit by a light source emanating from the upper right and slightly behind the subject. Leonardo used a light touch to create this effect, allowing his chalk to hit the peaks while skipping across the troughs of the endlessly unique felt hair marks. These marks bisect the two lines at every conceivable angle, thus allowing paper-white to break the hairs into light and dark as we might expect from a glistening strand of hair, floating and backlit. This effect makes excellent use of the unique qualities of Renaissance paper's variegated surface texture. In the strokes just to the left, the maestro applied more pressure on the strokes of the darker hairs, filling the troughs and leaving a heavier deposit of pigment on the peaks – achieving rich mid-tone-to-black shadow detail within each stroke, due again to the paper's hair marks. Leonardo's use of red chalk for a warm mid-tone was as effective as it was groundbreaking.

Graphite tests on modern vs felt-hair-marked papers

In the comparison tests shown below, artist Guy Diehl drew in pencil on sized linen and hemp hair-marked test paper (top left), using the isolated hair strands in Leonardo's Head of the Virgin as guidelines. The goal was to create a line whose continuity was naturally 'broken' by the texture of felt-hair marks (or, in the case of commercially available, art-store papers, by whatever texture the paper possessed) as the graphite interacted with the peaks and troughs of the paper's surface. Using a light to medium pressure, the artist's pencil skipped across the dense, strong, sized (2.5%) surface of our paper. The sizing combined with the firmness of linen made a surface unlike the art-store-purchased cotton papers (two upper right and three at bottom), whose soft springiness allowed the pencil to compress the paper's texture so that the line never had a single break. Furthermore, the random texture and warmth of the hair marks show in stark contrast to the controlled, patterned contemporary sheets (such as Saunders Waterford) or the smooth, even surface of the very soft papers (e.g., Arches Cover).

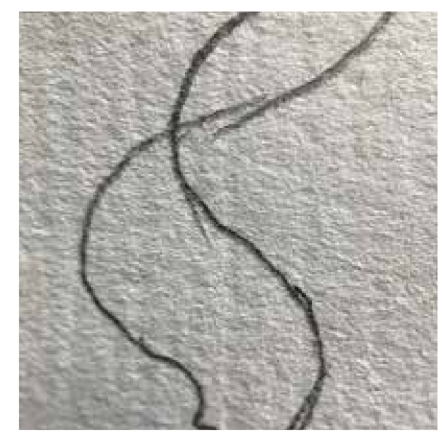
Selected Samples:

Magnolia linen test (April 18, 2018)

Saunders Waterford 90 g/m²

Hammersmith, Kelmscott (1892)

Arches Cover



Frankfurt

Hahnemuehle Ingres

17th-century cartoon of a papermaker hanging sheets to dry, thereby leaving a back mark on each sheet

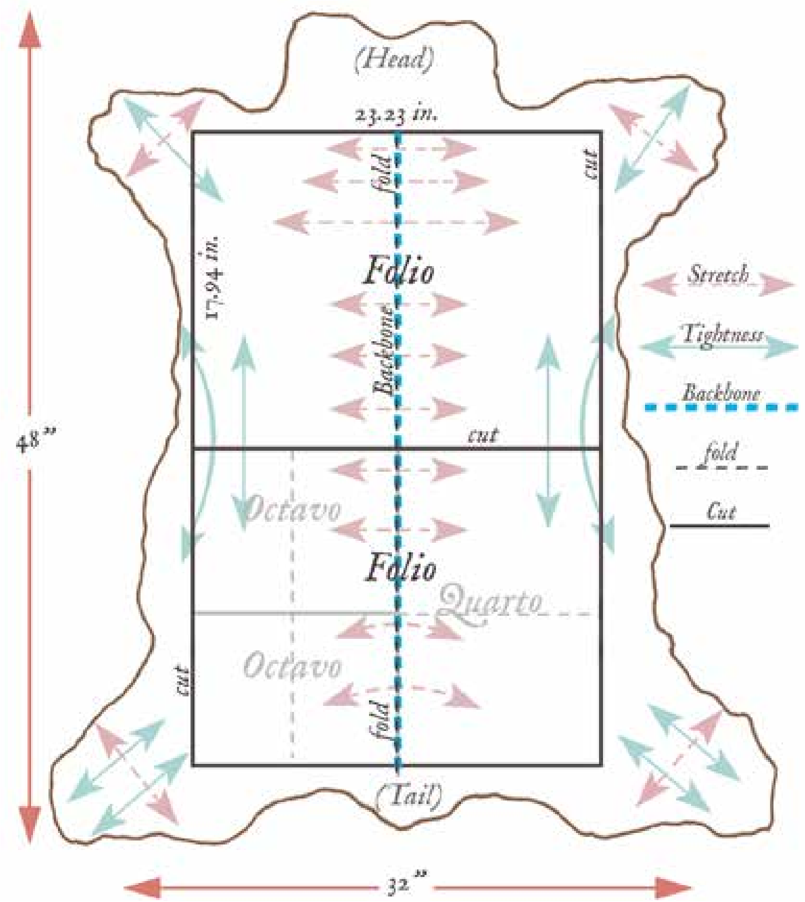
Carle van Loo, French 1705–1765, Male Nude Standing with a Writing Tablet, *1742 Nationalmuseum, Stockholm; Detail showing back mark*

CHAPTER II

Back Marks

RENAISSANCE PAPER TEXTURES

Magnolia Editions



Spurs hanging/drying on treble lines—stretched hore-hair rope

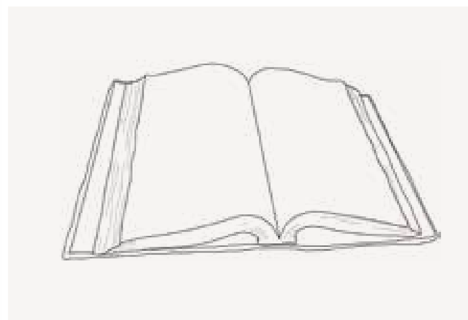
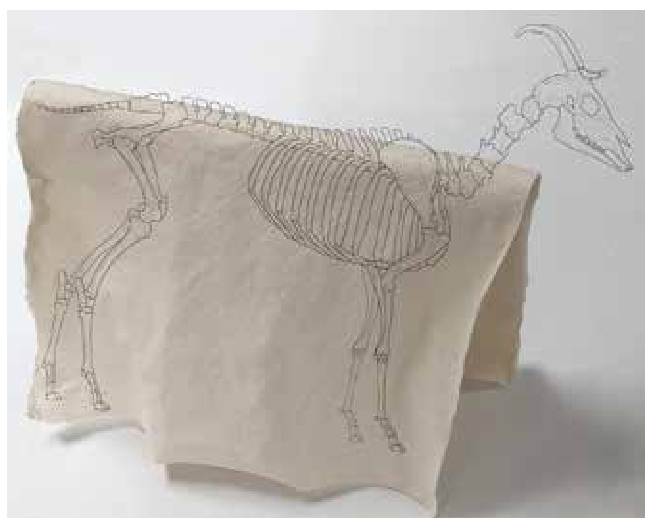


Illustration of "good draping"

Figure 2. Parchment signature pattern layout, quite likely the origin of standardized paper dimensions

Spurs pulled down from drying ropes, separated, broken and stacked already demonstrate a good drape and conformity to the codex format



Dried spur, unbroken (showing back)

Back – Derivation

Paper's back & back mark

Back is the word handmade papermakers use to describe the arch or ridge formed in a spur when it dries hung over horse or cow hair rope called "treble lines" (originally tribble), also called drying lines. The idea of describing a paper as having a back likely emerged from the earlier practice of preparing, trimming, and folding parchment from animal hides for codices. Examining the cut pattern of an animal skin used in making parchment folio signatures, we observe that the spinal column and stretch regions of the animal skin run right through the fold of two folios per hide. This arc is perfectly suited for the mechanics of opening and closing a book. Hence the hide's natural backbone warping contributes to the successful "drape" of a splayed vellum or parchment book.

As cited in Timothy Barrett's *Paper Through Time*, the folio, quarto and octavo, and standard paper sizes seem likely to have been determined and standardized by parchment bookbinders whose artisans adhered to the rules of nature's animal skin sizes and proportions. For example, Figure 2 (at left) depicts an average sheepskin (48 x 32 inches) with a pattern for two full sheets measuring 17.94 x 23.23 inches each – in other words, a "Royal" size sheet per the 14th century Bologna Stone standards for paper sizes.

To early European papermakers, the ridge formed in the spur looked like the back of a mythical beast or some headless four-legged animal. When the spurs are dry, they can stand on their own and look very much like they may walk or blindly stumble away.

The back mark is born as the spurs dry and form when flattened. To begin the flattening of the sheets, the puller (one of the drying loft workers) pulls dried spurs down from the ropes or poles. Next, they "break" the back by splaying, pressing, and smoothing the spur on a flat surface where the sheets begin to open and separate. Once the dried spurs are splayed and separated, the sheets are stacked and gently pressed to flatten further.

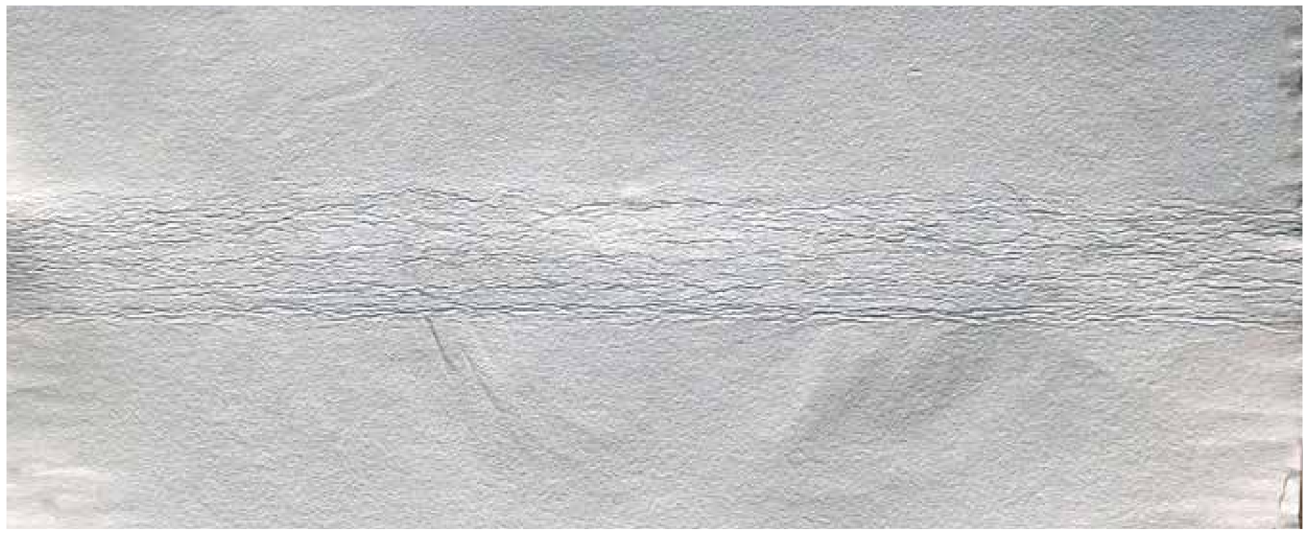
With this drying loft process in mind, and the understanding that the back refers to the dried paper's arch, it follows that the back mark refers to any marks left as a result of the formation of a back during drying or, more accurately, while breaking and flattening out the back.

Paper dries with a memory due to the entanglement of cellulose polymers and the hydrogen bonds that formed as the paper dried. In the case of rope hung, loft dried sheets, that memory – viewed shortly after removal from the rope – very much resembles the structure of a well-draped codex folio.

Codex Sinopensis, 19 11/16 x 22 1/4 in. Bibliothèque Nationale de France, Paris. Note symmetrical cockling along the backbone of the parchment.

Back mark – Formation

Visually, a back mark in a rope-hung paper looks like a band of parallel wrinkles or striations. The back mark texture varies in severity from sheet to sheet within the spur, with the most pronounced wrinkles appearing on the sheets closest to the rope.[3] Technique and process variations at different mills make a variety of back marks possible. The back mark can be greatly diminished or pressed out altogether using gentle pressing and calendaring. Whether one is created or not depends upon variables including fiber type; the wetness (drainage speed, aka freeness) of the furnish; the pressing and sheet count of the spur; the sheet's position within the spur; the speed of drying; spur handling, and flattening.



A strong back mark on an 18 x 24 inch linen and hemp sheet

The back mark forms and appears rather suddenly as the spur is splayed and forced flat. A convex topography of ridges appear on the top of the back's arch while concave, furrow-like textures form along the back's inner or underside arc.

Left: *Looking into a dry, unopened four-sheet spur, we see only the faint beginnings of a back mark along the outer edges of the back.*

Right: *Upon opening and spreading the sheets flat (also known as "breaking the back"), the back mark forms.*

Back mark – Citations

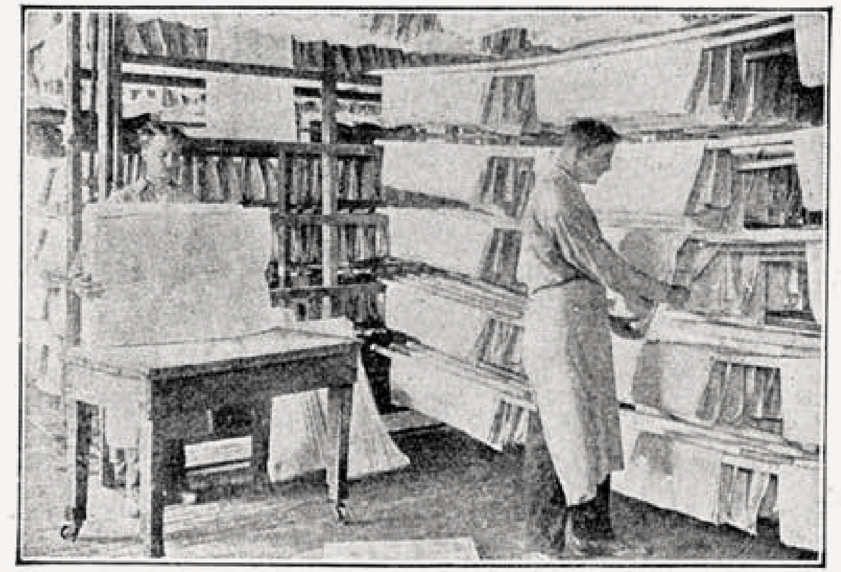


Fig. 12.

97. Pulling the Paper.—When the drying of the paper is completed, the puller takes down half a dozen spurs at one time; rests the handful on the jogging board, seen in the foreground of Fig. 12; shakes the sheets to loosen them up; jogs or straightens them out lengthwise; and puts them on a table. A second man, at the left of the picture, helps himself to a bunch; 'breaks' the 'back' (ridge) caused by the poles, *i.e*, flattens it, and straightens the sheets crosswise. He holds the paper loosely

One of the few scholarly mentions of the back: The Manufacture of Pulp and Paper *Vol. IV, ed. Tucker et al, 1924-1938*

Back mark *is the ridge or mark in handmade sheets of paper which have been (loft) dried on poles or treble lines and not on canvas drying trays. Such papers are called 'backed,' and the ridge is rolled out in the glazing or, if very bad, has to be cut out, the deckle-edge being absent on one side of each half of the original sheet. The Dictionary of Paper also has a 'stick mark' for this defect.*

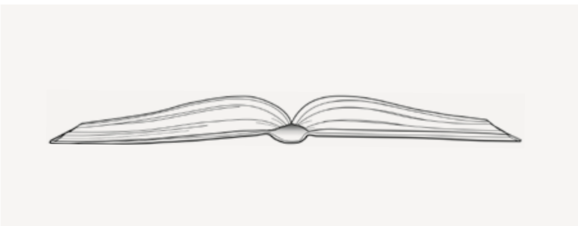
–**E.J. Labarre** *(ed.), Dictionary and Encyclopaedia of Paper and Papermaking, 1952 (kindly provided by Tim Barrett)*

Various forms have been used in the past to describe this, including rope marks (which is probably the most simple and accurate), but I have always used the word **back***. It's a kind of shorthand term in use in the handmade industry [...] It probably derives from what the sheet looks like when you start to do something about the fold after the sheet has dried: when you open the sheet out after it comes off the drying rope, you lay it down on a board, with the top of the fold upwards, and it looks like a spine.*

–**Peter Bower***, British Association of Paper Historians, in correspondence with Don Farnsworth, 2018*

Back mark's mechanical advantage

Like the grooves on your knuckles that allow your fingers to bend without placing undue stress on your skin, a back mark's parallel ridges physically predispose rope-hung paper to folding and unfolding with ease. When bound into the spine of a folio, this hinge-like mark enables the durable linen paper to flex with very little effort and without overly stressing the paper.



Open book with good draping

Folio: Printers, bookbinders and publishers took notice of the mechanical advantage provided by the back mark and placed its accordion ridge marks parallel to the spine in the gutter of each folio signature to leverage the back mark's great folding endurance while at the same time, creating what bookbinders call "good draping."

Such placement also conveniently hides the back mark, allowing for a more elegant presentation.

Quarto & Octavo: In these signatures, after folding, sewing and clamping, the deckle and much of the back mark was plowed off and fell in shreds to the bookbinder's cutting room floor (Figure 4). What remained of the back mark, in the book out of reach of the plow, can most often be found on the top (or bottom) edge of each leaf of a quarto and in an octavo codex, on the fore edge of every other leaf (Figure 5, p. 42).

The naturally engineered hinge of the back mark is perfectly suited for the codex format.

*Figure 3. Jost Amman's 1568 woodcut depicting book printers (*Book of Trades*) clearly shows us the back mark in the unprinted and printed leaves in the foreground. The printers carefully place it in the gutter of the leaf.*

Finding depictions of back marks hiding in plain sight

Having long enjoyed Jost Amman's 1568 detailed woodcuts depicting printing and bookbinding, only recently did I notice that back marks are clearly depicted in both blocks from his *Book of Trades* (Figures 3 & 4).

This back mark feature found bisecting the full sheet, combined with the limited supply of animal skin (parchment) and the limited dimensions of a printing press platens, made the sheets of the early European papermaker perfectly suited for the modern codex and quite unacceptable for fabrication of that earlier information format, the ancient scroll.

Sewing signatures to hemp cords or linen tape

The binder, using a "plow" to trim the book edges: sliding the plow forward and back, with each stroke he twists the handle which slowly plunges a knife deeper into the edge of the clamped book, cutting off the deckles, leaf by leaf.

Clamp holding sewn signatures

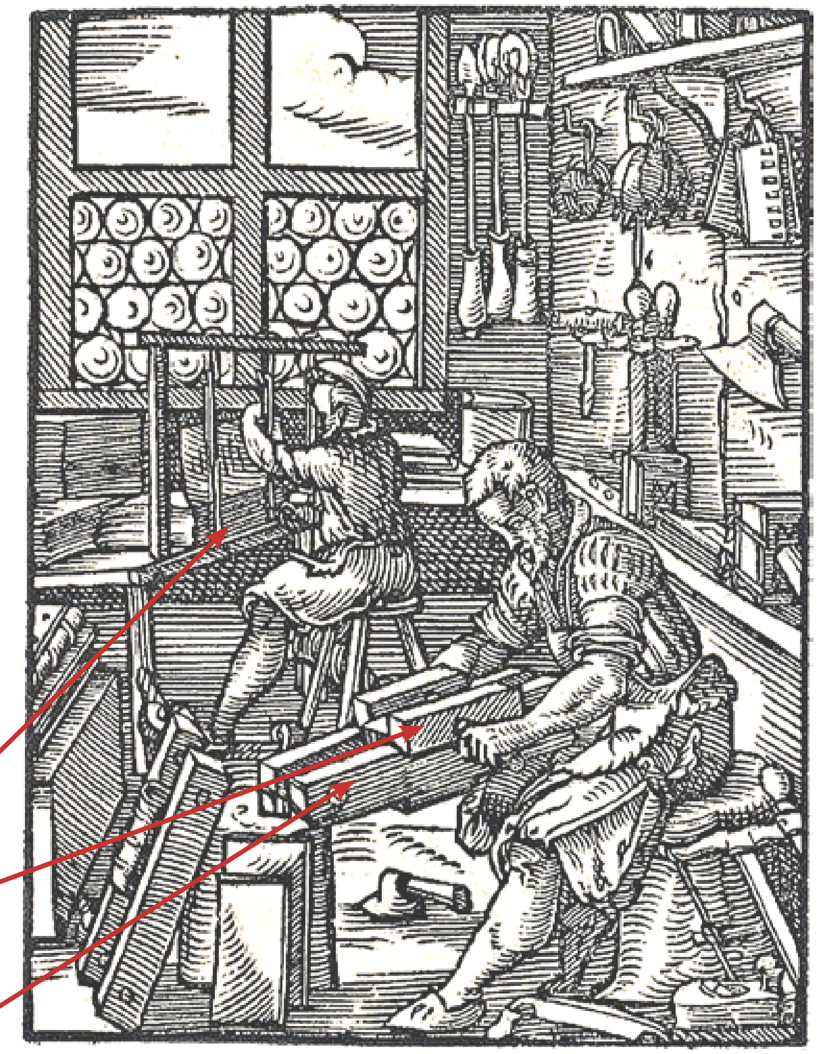
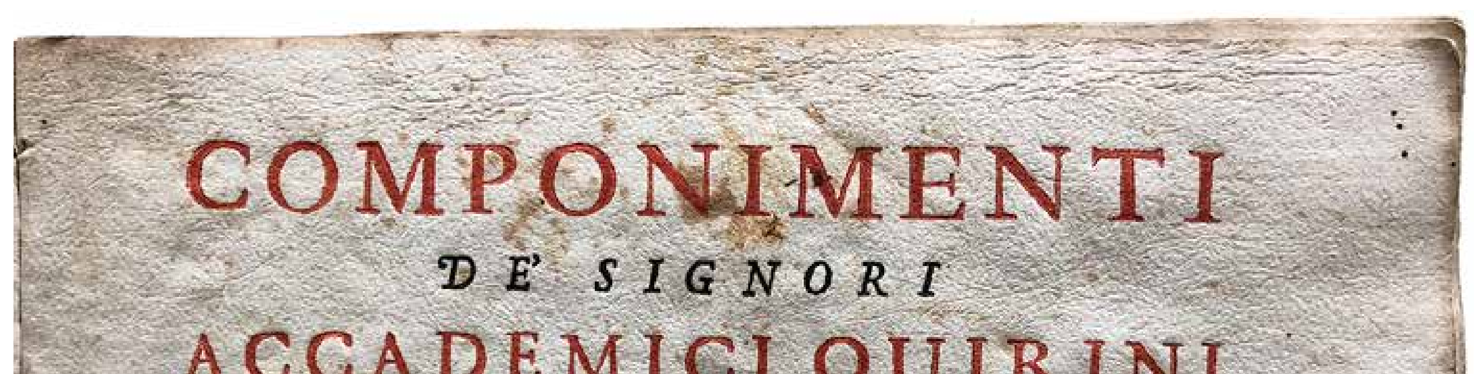


Figure 4. Jost Amman's 1568 woodcut from the Book of Trades *graphically demonstrates the use of the plow, trimming the edge of sewn signatures held firmly in a heavy wooden clamp. Like the deckle, the back mark of many quarto and octavo folded books may have been trimmed or partially trimmed off in this step.*

Back mark at top edge and beautiful felt hair marks on this Italian (quarto) publication from 1730, the year felt hair marks began to disappear.



Variations in back marks

As evidenced by the collected examples on the opposite page, back marks may vary greatly from sheet to sheet. The eight back marks seen here are not from antiquity; they were created in the studio on 18 x 24-inch (Realle/Royal size) linen and hemp paper, post pressed, then pack pressed and separated into spurs which were hung on treble lines to dry.

The wide spectrum of variation is plainly visible: the ridges may be fine, sparse, coarse or dense, deep or shallow, long or short creases, etc. These variations occur as the result of the same set of criteria and techniques employed by early European papermakers.

Variables that play a role in influencing back marks include: the paper's weight; fiber content; degree of hydration (furnish freeness); processing equipment; placement within the spur; force used during pack pressing; speed of drying; treble line diameter; degree of dryness when pulled from the ropes and separated; finishing and calendaring.

Back mark characteristics

Back marks:
- Run parallel to the chain lines
- Have parallel wrinkles/ridges
- Visible on both sides of a sheet
- Concave ridges on the wire side and convex topography on the felt side
- Traverse the center, in the short directions of a full sheet
- Found in the gutter of a folio
- Found on top edge of a quarto on all 4 leaves
- Found on outer edge of an octavo on all 4 of 8 leaves
- Within a spur, the back mark is less severe the further the sheet is from the drying rope, with the outer sheets displaying no discernible back mark
- Larger diameter ropes leave wider back marks
- Drying spurs on overly slack, sagging treble line (ropes) create irregular, perpendicular crease marks within the back mark
- Long, sharp creases result when the spur is pulled and separated (and back is broken) before drying is complete

Back mark location in period documents

Back marks are often present in Renaissance book publications along one edge of a quarto or octavo and down the center of a full sheet or folio. The mark is parallel to the chain lines, bisecting and spanning the shorter dimension of a full sheet of paper.

Cross-referencing the laid and chain line orientation of a sheet with the location of a back mark, the paper's dimensions, and locations of the deckles (if still intact) allows us to determine or approximate the original sheet size and how the sheet was used for a particular work or document.

When looking through 16th-century publications, we may or may not discover back marks: the back mark may have been soft and yielding enough to be flattened and smoothed out during finishing or trimmed, (along with the deckle) and left in ribbons on the bookbinder's floor during the finishing of the book's edges. (Outfitted with a sharp blade, the binder's plow – see Figure 4, p. 39 – cuts the edges of clamped signatures, trimming off the deckle and often some or all of the back mark.) Moreover, per the book sizes and proportions depicted on the opposite page, we can see, for example, that if the book was octavo-sized, only four of the eight octavo leaves would have had a back mark to begin with.

The standard book configurations in Figure 5 (below) give us an idea as to where back marks might commonly appear. Regarding artworks on paper, Figure 6 (p. 54) demonstrates how an artist might maximize the yield from a single sheet, avoiding the back mark altogether.

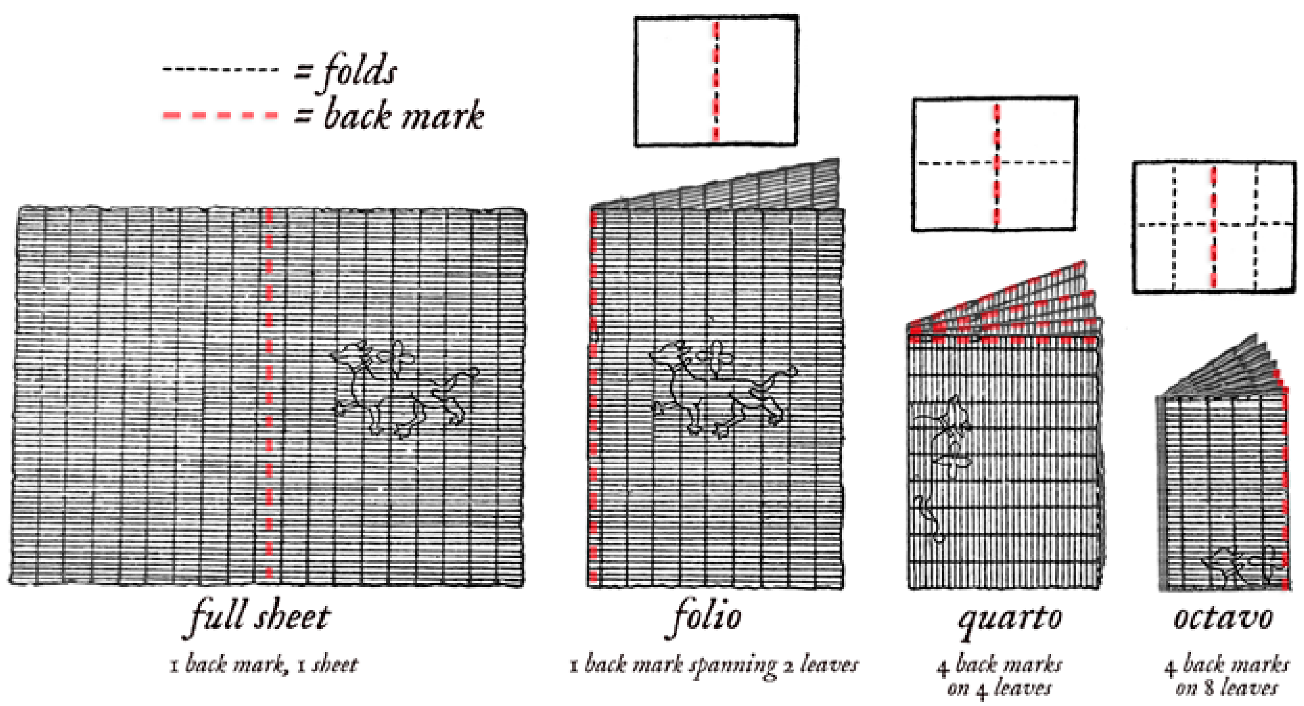


Figure 5. *Laid line and watermark orientation, bookbinder's folding, leave per format, gathering and back mark placement.*

The Bologna Stone: Medieval standardized paper sizes

As we consider the textures of Renaissance paper, an understanding of the standard sizes and papermaking protocol of the time is invaluable. For example, ascertaining sheet size and orientation is critical when determining whether an artifact is a back mark or merely a random fold or crease.

Medieval Italian cities often affixed plaques or stones establishing the official sizes for local manufactures onto the exterior of public buildings. The citizens of medieval Bologna could compare their paper with such an official stone, engraved with paper names and physical dimensions. This artifact is known to some English speakers as "the Bologna stone" despite remaining almost entirely unknown (by any name) to contemporary citizens of Bologna.

The original marble stone was affixed on the Palazzo d'Accursio building on Piazza Maggiore, which had housed the council of the city elders since the 14th century. Presently a replica limestone stone version is housed in the lapidarium of Bologna's Museo Civico Medievale. It is thought that the original marble had deteriorated and become damaged over the centuries. In the 17th century, the Guild of Pharmacistsa funded the carving of a replica, on which one can see the gilded pharmacist's imprimatur – a pestle and mortar – on either side of the inscription.

Guild of Apothecaries logo

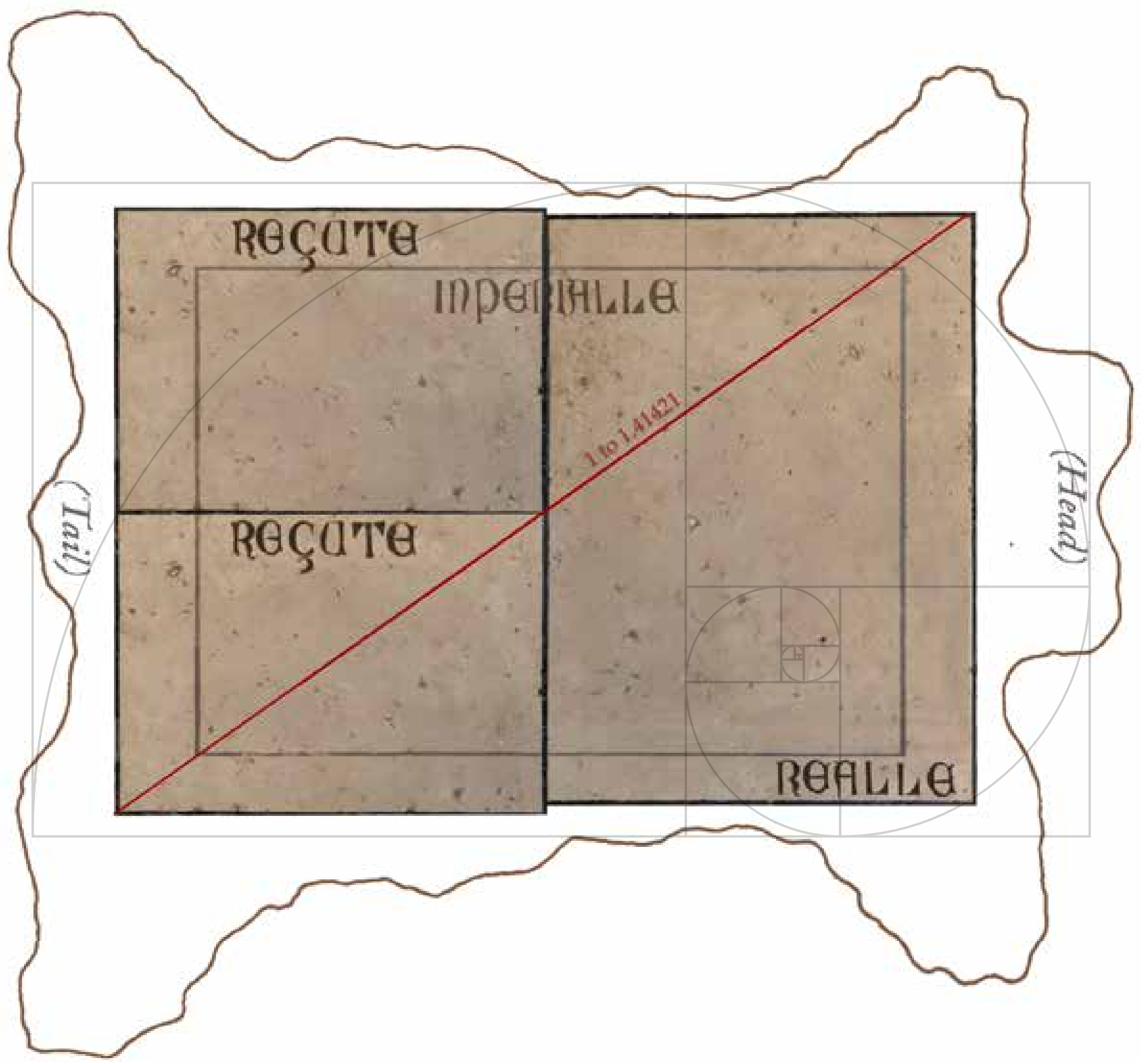
Inscribed in the stone was a system to formalize and standardize the terms and sizes for paper: Inperialle (Imperial), Realle (Royal), Meçane (Median), and Reçute (Chancery). In the case of a dispute about sheet sizes, a piece of paper could be placed on the stone and compared to the official measure. It is likely that despite the use of the word "moulds" in the inscription, the stone describes the dimensions of the paper itself, as carrying one's moulds and deckles to the city center would be much more complicated than transporting a few sheets of paper. That the inscription appears in Italian, rather than in Latin, suggests that it was intended for widespread use, even by those possessing only basic reading skills.

According to paper historian Neil Harris's excellent article "The Shape of Paper," published by the Institut d'histoire du livre in Lyons:

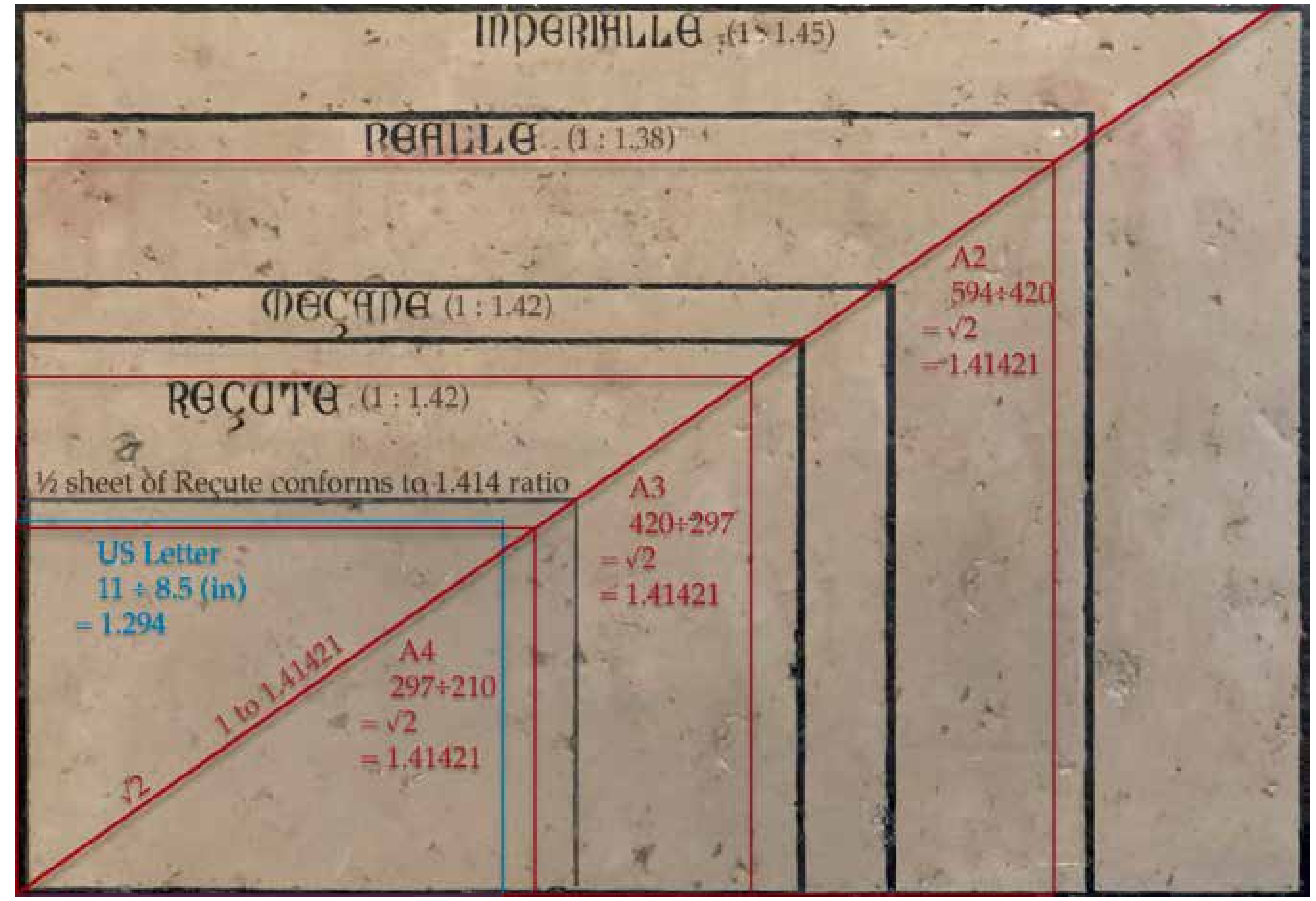
The terms "Imperial" and "Royal" applied to large sizes of paper, albeit with some variations, remain in constant use for the whole of the handmade paper period and beyond; "Medium," albeit with a greater oscillation, also survived for a long time. The fourth term reçute defines a sheet more generally known in Italian as "comune" and in English as "chancery" (itself a derivation from the Italian "cancelleresco," i.e., the Papal administration): this is the essential dimension that, albeit with minor variations, will dominate the papermaking market for centuries to come, especially after 1500 and the advent of printing. [...] The term derived from parchment making and stood for reciso or "cut", i.e., it was half of a full sheet of Royal, which was the usual size derived from the animal. The link confirms the close relationship maintained between parchment and paper in the Fourteenth century, which was only really broken by the advent of printing and the vast gearing up of the paper industry.

[...]The sheet-proportions set out on the Bologna stone therefore are not innovative; indeed it would be surprising if they were. They reflect a much older status quo, established by the handwritten Medieval book on parchment, which the city's legislators faced with the new medium are rendering official.

Tim Barrett writes that the sizes codified on the Bologna stone may have originated with Arab papermakers previously active in the Mediterranean area; he cites Josef von Karabacek's 1887 endnotes on Arab paper dimensions, a range of 10th to 15th-century sizes whose ratios are quite similar to those seen here. These dimensions were likely inherited from medieval parchment workers, who handed down their methods for maximizing the surface area of animal skin to papermakers. In both cases, we find an intriguing consistency in the geometric ratio at hand – a ratio so consistent that Barrett says J. Peter Gumbert calls it "invariant" in manuscript book studies.



"The rectangle based on the square-root of two seems to go back to well before the beginning of the Western book [...] It is a moot point as to whether the Medieval Italian parchment workers, who passed this precious snippet of knowledge on to the papermakers, were aware of all the geometry, since in cutting up an animal skin, this particular rectangle produces the least wastage. However, they knew enough to understand the principle and to construct their rectangles accordingly." (Harris, "The Shape of Paper," Institut d'histoire du livre)



A rearrangement of the four Medieval paper sizes on the Bologna Stone comparing the Medieval paper sizes to a 1 : 1.41421 ratio and to modern A2, A3 and A4 paper sizes. Shown in blue is the rather awkward-looking and ill-fitting US Letter dimension.

Whether we compare the four medieval sheet dimensions on the stone to animal skin or to Arab paper dimensions and their eventual progeny (such as the ubiquitous A4), the basic trend is that standard sheet sizes fold according to the 1.4142 (√2) ratio. It is no accident that the ratio of standard sheet dimensions hews to 1.4142 (√2). With such a ratio of length to width, a sheet folded in half is the same format as the full sheet – no matter how many times it is folded in half, the format remains the same. According to this ratio, the sheet can be doubled or halved, and the relationship between the sides will remain invariant – a principle preserved in most contemporary paper sizes, e.g., A4. (In the subsequent family tree of paper, the 8 ½ x 11-inch American Letter format, with its ratio of 1.294, is the most frustrating exception.)

Outer/inner frame	Dimensions	Ratio
Imperial [inperialle] Bologna Stone	500 x 725mm 19.69 x 28.54-in	1.45
Royal [realle] Bologna Stone	440 x 608mm 17.32 x 23.94-in	1.38
Median [meçane] Bologna Stone	345 x 490mm 13.58 x 19.29-in	1.42
Super-chancery	330 x 460mm 12.99 x 18.11-in	1.39
Chancery [reçute] Bologna Stone	310 x 440 mm 12.20 x 17.32-in	1.42
Half-median	250 x 350mm 9.84 x 13.78-in	1.40
Damascus (1339) (Arab paper size)	620 x 880mm 24.41 x 34.65-in	1.42
Lambskin/goatskin	533 x 762mm 20.98 x 30.00-in	1.43

Italian (1389) & Arab (10th-15th c.) paper sizes. Courtesy Tim Barrett

“QUESTE SIENO LEFORME DEL CHUMUNE DEBOLLOGNA DECHE GRANDEÇA DENE ESSERE LECHARTE DEBA(M)BAXE CHE SEFARANO INBOLLOGNA ESSO DESTRETO CHOME QUI DESOTTO EDIUIXADO”

These are the moulds of the city of Bologna, which say what the sizes of the sheets of cotton (linen)* paper must be, which are made in Bologna and the surrounding area, as is set out here below.

The existent stone is likely a 17th-century reproduction: it would be an improbable anachronism for the Guild of Apothecaries logo to have appeared on a 14th c. stone.

**The use of the word “cotton” here is a red herring due to ambiguity in the original terminology, meant to distinguish paper from parchment or vellum; the papers of the time were made from linen and hemp. Translation courtesy of Neil Harris/IHL.*

Book formats

Sheet & signature dimensions

Name		Fullsheet (mm/in)	Folio (mm/in)	Quarto (mm/in)	Octavo (mm/in)
Papal/Gradual	mm	520.00 x 770.00	520.00 x 385.00	385.00 x 260.00	260.00 x 183.00
	Inches	20.47 x 30.31	20.47 x 15.16	15.16 x 10.24	10.24 x 7.20
Imperial [inperialle]	mm	500.00 x 725.00	500.00 x 363.00	363.00 x 250.00	250.00 x 182.00
	Inches	19.69 x 28.54	19.69 x 14.29	14.29 x 9.84	9.84 x 7.17
Super or Law-royal	mm	440.00 x 590.00	440.00 x 295.00	295.00 x 220.00	220.00 x 148.00
	Inches	17.32 x 23.23	17.32 x 11.61	11.61 x 8.66	8.66 x 5.83
Royal [realle] Bologna stone		440.00 608.00	440.00 x 304.00	304.00 220.00	220.00 152.00
	Inches	17.32 x 23.94	17.32 x 11.97	11.97 x 8.66	8.66 x 5.98
Royal (Needham)	mm	400.00 566.00	400.00 283.00	283.00 x 200.00	200.00 x 142.00
	Inches	15.75 x 22.28	15.75 x 11.14	11.14 x 7.87	7.87 x 5.59
Super-median	mm	360.00 x 500.00	360.00 x 250.00	250.00 x 180.00	180.00 x 125.00
	Inches	14.17 x 19.69	14.17 x 9.84	9.84 x 7.09	7.09 x 4.92
Narrow Median	mm	350.00 x 420.00	350.00 x 210.00	210.00 x 175.00	175.00 x 105.00
(Aldine octavo)	Inches	13.78 x 16.54	13.78 x 8.27	8.27 x 6.89	6.89 x 4.13
Median [meçane]	mm	345.00 x 490.00	345.00 x 245.00	245.00 x 173.00	173.00 x 123.00
	Inches	13.58 x 19.29	13.58 x 9.65	9.65 x 6.81	6.81 x 4.84
Super-chancery	mm	330.00 x 460.00	330.00 x 230.00	230.00 x 165.00	165.00 x 115.00
	Inches	12.99 x 18.11	12.99 x 9.06	9.06 x 6.50	6.50 x 4.53
Chancery [reçute]	mm	310.00 x 440.00	310.00 x 220.00	220.00 x 155.00	155.00 x 110.00
	Inches	12.20 x 17.32	12.20 x 8.66	8.66 x 6.10	6.10 x 4.33
Half-median	mm	250.00 x 350.00	250.00 x 175.00	175.00 x 125.00	125.00 x 88.00
	Inches	9.84 x 13.78	9.84 x 6.89	6.89 x 4.92	4.92 x 3.46

***A caveat:** Harris notes that "since Briquet first described the Bologna stone in 1907, oscillating somewhat and rounding off his measurements to the nearest half centimeter, dimensions given for the same have varied in the literature and so it is advisable to check which and whatever source you are using [...] There is on average a difference of a centimeter between the measurements of the inside and the outside of each frame."*

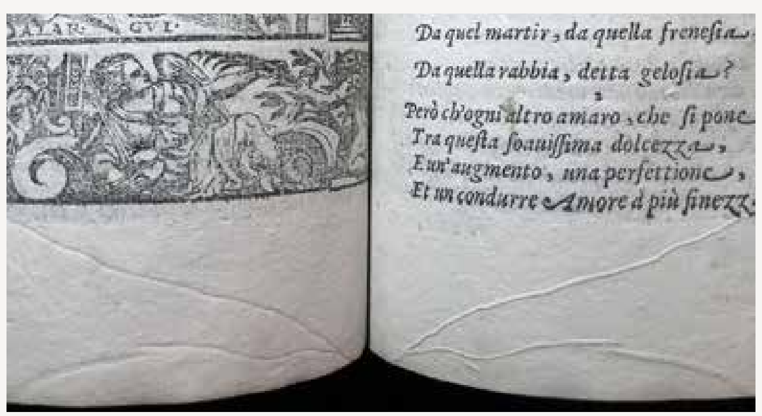
Regarding the difference, Harris provides the following data:

Name	Briquet	Outer frame	Inner frame	Ratio
Inperialle	500 × 740	510 × 740	500 × 725	1.45
Realle	445 × 615	450 × 615	440 × 608	1.38
Meçane	345 × 515	350 × 504	345 × 490	1.42
Reçute	315 × 450	318 × 450	310 × 440	1.42

Back marks: folio

In the 1732 publication pictured below, we can see back marks in the gutter of the bound folios, precisely where we might expect to discover the loft drying rope mark. Over 300 years, the pressure of stacked or cramped bookshelves has smoothed and softened the initially strong back mark wrinkles and felt hair marks. This rather stunning phenomenon of calendering over time via the pinch of a book was first introduced to me by paper historian Peter Bower.

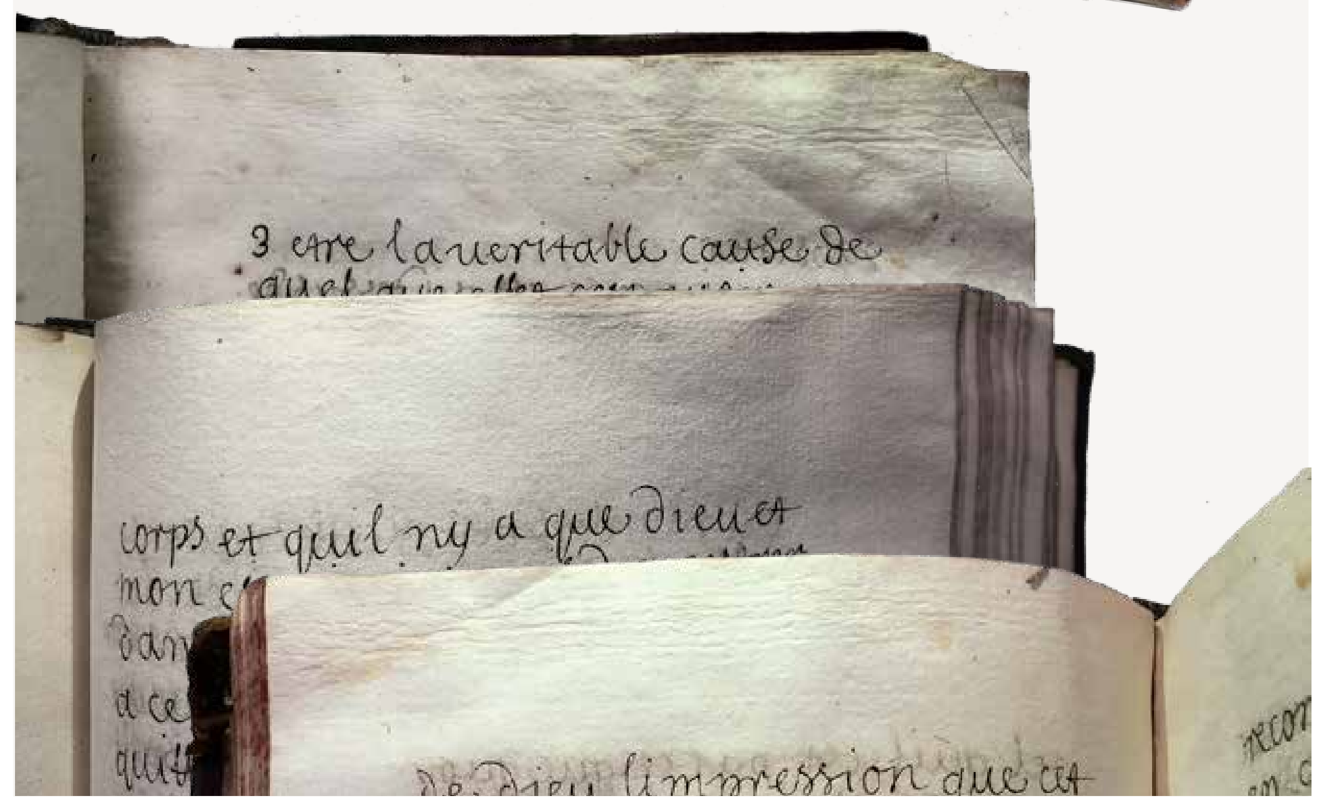
Back mark in the gutter of a folio. Portentosos Milagros de glorioso, *San Isidro, Arzobispo de Sevilla, 1732*



At the bottom margin of this 16th-century bound book, we witness a double wrinkle on the right leaf aggressively embossing its mirror image on the left leaf, demonstrating how the combination of time and bookshelf pressure creates a calendering effect and leaving us to imagine what the original texture of the paper may have been.

Back marks: quarto

In early 2018, Bruce McKinney of Rare Book Hub, San Francisco brought a 1691 manuscript by philosopher John Locke to the Magnolia Editions paper studio. This rare and hitherto unknown find demonstrates the characteristics we anticipate when looking at a book made from quarto signatures: that is, a full sheet folded two times so that the back marks fall across the top edge of each leaf (Figure 5, p. 42). The dimensions of this codex are very close to what we at Magnolia Editions have been making using 18 x 24-inch paper moulds. The leaves of the manuscript are thin, with a patina demonstrating its age, yet at the same time fresh and crisp with a look-through of fine laid lines showing a Pierre Cartelier watermark.



John Locke, 1691 manuscript, quarto, watermarked antique laid paper. Note the back marks can be seen across the top of each page – the back texture penetrates to the verso page of the leaf.

Wandering or multiple back marks

Although back marks are most often found hidden in the spine, in the gutter, or at the edge of the leaves of early European books as discussed above, they can occasionally be found embellishing pages almost anywhere. In the image on p. 51, an unmistakable back mark runs diagonally across a leaf of the 16th-century Venetian publication *Givstiniano, Lorenzo,* demonstrating the human element involved in hanging and pulling the spurs from the drying ropes.

In my own experience, it is easy to misalign, catch, or bump the damp edge of a sheet or spur draped on my "T" while hanging it to dry, causing it to hang at a slight angle. Is it better to leave the poorly-hung spur alone, or to risk more marks by pushing up with the T in an attempt to reposition the hung paper? Apparently, in the sheet below, the thought was to leave well enough alone and get back to the work of hanging the remainder of the day's production. I created a similar angular mark simply by denting or crunching the corner a wet, hanging spur. It is easy to damage a wet spur, leaving what look likes a second back mark.

As we have seen, the lovely complexity of felt hair marks is caused by pressing the paper between coarse woolen felts, not taking the time to shuffle, exchange and re-press the sheets in a pack. And as noted earlier, back marks were made in the drying loft, forming as the waterleaf (unsized) spurs of paper dried draped over ropes or poles and then expressing ridges when the spur was separated and flattened.

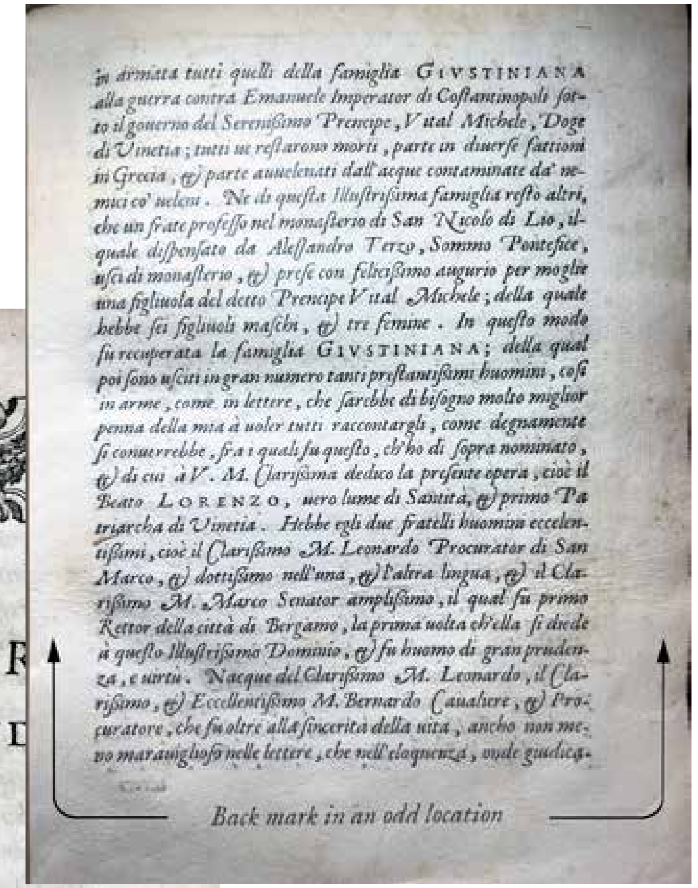
Another contributor to this cornucopia of texture was the sizing room, sometimes called the "slaughterhouse" due to the damage and high loss of paper during the tub sizing operation. The process of dipping a handful of sheets into dilute, hot animal skin glue provides many opportunities to destroy perfectly viable sheets – or looked at another way, a chance to add more artisan texture. Once impregnated with hide glue, the sheets are gently pressed to distribute each sheet's size and remove excess size. The paper must then be separated and dried again on canvas trays or over treble line ropes.

The potential for staining, tearing, cockling, wrinkling, gluing sheet to sheet, or gluing down a folded corner; over-or under-sizing is ever-present when sizing paper. Another potential flaw involves hide glue crystals (shiny spots from overly moist size). The slaughterhouse was and is a terrifying place for a well-formed sheet of paper. On the other hand, these anomalies help tub-sized paper tell us a most exciting story.

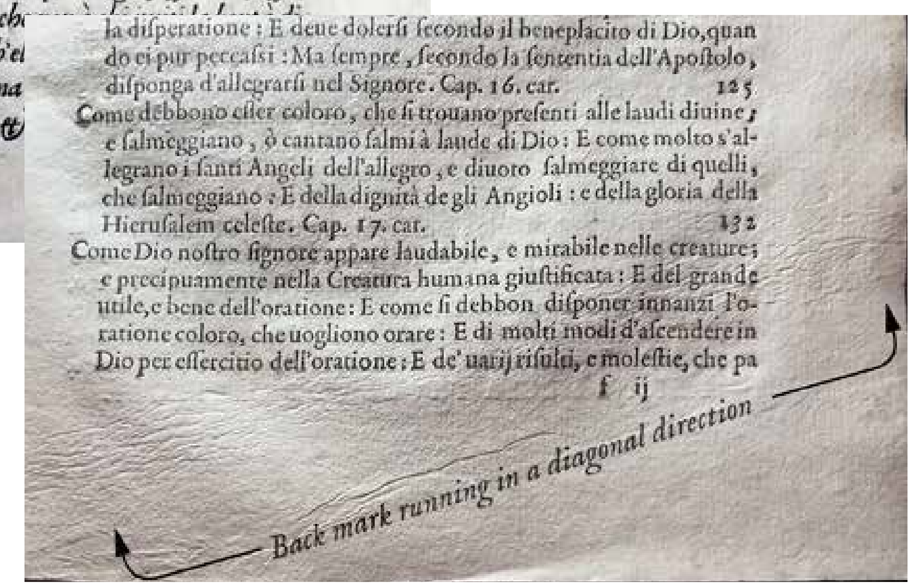
Back marks, felt hair marks, stains, wrinkles, folded corners glued down by hide glue – none of these deterred the paper merchants from bundling and selling the sheets, nor gave the letterpress printer pause when the type was inked and kissed or crushed the textured surface. Nor did they stop the binder who folded, sewed, plowed off the edges, and bound the volume. Five hundred years later, many books still look almost pristine: the imprint crisp and embossed, the sheet strong, flexible, and resilient, allowing the textures of the paper to tell a complex tale in the marginalia. The story is there for us to read, sheet after sheet, each ragged clue left to our interpretation.


AL CLARISSIMO,
PRESTANTISSIMO
SIGNOR
IL SIGNOR PIETR
GIVSTINIANO
REFORMATOR DEL STVD
DI PADOVA.
GIOVANNI GIOLITO DE' FERRARI.
A'NIVNO MEGLIO VERAmente conuiene, che ſiano dedicate l'opere del Beato LORENZO GIVSTINIANO, primo Patriarcha di queſta glorioſa Città di Vinetia, che à V. M. Clariſſima; non tanto perch'egli foſſe dell'iſteſſa nobiliſſima famiglia, quanto perch
lui, & la dottrina più di quel, ch'e
ro, & ſanto zelo di charità diuina
riti della ſantità della ſua uita, &

Givstiniano, Lorenzo, *Venice: Giolito, 1569 – From the private library of Peter Koch and Susan Filter*


in armata tutti quelli della famiglia GIVSTINIANA alla guerra contra Emanuele Imperator di Coſtantinopoli ſotto il gouerno del Sereniſſimo Prencipe, Vital Michele, Doge di Vinetia; tutti ui reſtarono morti, parte in diuerſe fattioni in Grecia, & parte auuelenati dall'acque contaminate da' nemici co' ueleni. Ne di queſta Illuſtriſſima famiglia reſtò altri, che un frate profeſſo nel monaſterio di San Nicolò di Lio, il quale diſpenſato da Aleſſandro Terzo, Sommo Pontefice, uſcì di monaſterio, & preſe con feliciſſimo augurio per moglie una figliuola del detto Prencipe Vital Michele; della quale hebbe ſei figliuoli maſchi, & tre femine. In queſto modo fu recuperata la famiglia GIVSTINIANA; della qual poi ſono uſciti in gran numero tanti preſtantiſſimi huomini, coſì in arme, come in lettere, che ſarebbe di biſogno molto miglior penna della mia à uoler tutti raccontargli, come degnamente ſi conuerrebbe, fra i quali fu queſto, ch'ho di ſopra nominato, & di cui à V. M. Clariſſima dedico la preſente opera, cioè il Beato LORENZO, uero lume di Santità, & primo Patriarcha di Vinetia. Hebbe egli due fratelli huomini eccellentiſſimi, cioè il Clariſſimo M. Leonardo Procurator di San Marco, & dottiſſimo nell'una, & l'altra lingua, & il Clariſſimo M. Marco Senator ampliſſimo, il qual fu primo Rettor della città di Bergamo, la prima uolta ch'ella ſi diede à queſto Illuſtriſſimo Dominio, & fu huomo di gran prudenza, e uirtù. Nacque del Clariſſimo M. Leonardo, il Clariſſimo, & Eccellentiſſimo M. Bernardo Caualiere, & Procuratore, che fu oltre alla ſincerità della uita, ancho non meno marauiglioſo nelle lettere, che nell'eloquenza, onde giudica-

Givstiniano, Lorenzo, *Venice: Giolito, 1569*


la diſperatione: E deue dolerſi ſecondo il beneplacito di Dio, quan do ei pur peccaſsi: Ma ſempre, ſecondo la ſententia dell'Apoſtolo, diſponga d'allegrarſi nel Signore. Cap. 16. car. 125
Come debbono eſſer coloro, che ſi trouano preſenti alle laudi diuine, e ſalmeggiano, ò cantano ſalmi à laude di Dio: E come molto s'allegrano i ſanti Angeli dell'allegro, e diuoto ſalmeggiare di quelli, che ſalmeggiano: E della dignità de gli Angioli: e della gloria della Hieruſalem celeſte. Cap. 17. car. 132
Come Dio noſtro ſignore appare laudabile, e mirabile nelle creature; e precipuamente nella Creatura humana giuſtificata: E del grande utile, e bene dell'oratione: E come ſi debbon diſponer innanzi l'oratione coloro, che uogliono orare: E di molti modi d'aſcendere in Dio per eſſercitio dell'oratione: E de' uarij riſulti, e moleſtie, che pa
f ij

Marks in Early European paper-case bindings

I was fortunate to meet paper conservator and scholar Nadine Dumain on a visit to the Le Moulin du Verger paper mill in Angouleme, France, in 2018. She kindly provided me a copy of her article *Of Fingerprints on a Binding in Paper*, a thorough examination of Cinquecento books bound in handmade paper book board. Such bookboard has a very curious 16th-century texture worthy of mention here.

I was particularly interested in Nadine's images illustrating various paper bindings, which exhibit very coarse felt hair marks. It seems likely that the older warn-out felts were used to make these "humble bindings." A consistent pattern of brief, irregular diagonal marks is also evident in these examples.

Nadine asked me what I thought might have created these indented lines running along the spine. I could not account for the strange Cinquecento marks. Book binder's cord, perhaps – or could it be the frayed, stringy edges of old felts? It seemed improbable, as felts were not necessarily woven.

Nadine explained that it was most likely that the crude book boards were created using felts so worn out that they were crudely stitched together to make larger felts. The diagonal marks were the impressions of these coarse stitches. Nadine even stitched two felts together and achieved matching results, creating a strong case for the validity of her theory.

Relatively unknown in France, paper bindings are improperly classified as "reliures d'attente." They are often looked down upon because they are bindings without decor, poor or humble bindings. As such they have often been replaced and it is now fairly rare to come across this type of book. Yet they have exceptional qualities. Nicholas Pickwoad [...] calls them "the economic paper bindings" and traces their circulation in Europe since the appearance of paper. He identifies each of their characteristics, making account of the many aspects, both structural and technical, which distinguish them from each other. Indeed, if some workshop's practices are brought to light, many books were produced by the students of the faculties themselves. These amateur bindings have an important part in the history of the book and its diffusion. Christopher Clarkson has studied a large number of paper bindings during the flood of the Florence Library in 1966. He found that the books simply bound and covered with paper resisted the tests of water better that many complex bindings protected by skin. It was after these observations that a great revelation was born regarding conservation binding: this was an inexpensive binding which would not be harmful for the book. It is a flexible binding, strong but neither hard nor brittle, glue-free, where all the materials put together move together in the same movement; finally, though resistant to manipulation, it is an easily removable binding.

Nadine Dumain
OF FINGERPRINTS ON A BINDING IN PAPER

Published in the AFHEPP journal Papiers #11 January 2017, trans. Nick Stone.

Paper binding, Consilia sev responsa of Felinus Sandeus, *printed in Lyon at Haeredes Jacobi Iuntae in 1552. Photo by Nadine Dumain*

Felt assembly by sewing. Photo by Nadine Dumain

Detail view showing coarse felt hair marks and impressions of stitches used in felt assembly. Photo by Nadine Dumain

Back marks in works on paper

Like book publishers, artists likewise had their strategies for using or avoiding the back marks. Certainly, drawing on half and quarter sheets was a common practice. Michelangelo's *Study for The Libyan Sibyl*, for example, looks to have been drawn on a quarto leaf of the royal (realle) dimensions dictated on the Bologna Stone (see p. 44), while his *Study for a Seated Sibyl* appears to have been drawn on a royal folio leaf. Both were likely trimmed to remove evidence of the back mark (Figure 6, below); the chain and laid line directions and artwork dimensions support my suspicion.[4]

Figure 6.
Examples of avoiding the back mark.

Left: Michelangelo Buonarroti, Studies for the Libyan Sibyl *(Italian, Caprese 1475–1564 Rome), ca. 1510–11, Red chalk with small accents of white chalk.*

Sheet: 11 3/8 x 8 7/16 in. The Metropolitan Museum of Art, New York.

Right: Michelangelo Buonarroti, Study for the drapery of the Erythraean Sibyl, *seated to right with legs crossed. 1508-12. Brown wash and pen and dark brown ink over a black chalk under-drawing, The British Museum, London.*

The unavoidable back mark

Larger format works required the use of a full or ¾ sheet, likely to have a back mark left by the drying loft's rope. Often, artists working at this scale drew over the back mark. The hard-edged creases of the back mark seen in Michelangelo's *Unfinished Cartoon of the Virgin and Child* suggest that this may have been an outer sheet of a spur prematurely removed from the treble lines; though the back had dried, the remainder of the sheet was likely still wet, resulting in solid and straight folds where stresses of moist and dry portions of the paper met while spurs were under pressure. Other possible causes of a back mark like this one include past conservation efforts; having been bound (folio orientation) along the back mark; storage by folding along the back mark; or having been hung to dry on a pole rather than a horsehair rope. As this was only a cartoon for larger work, this was likely the most affordable sheet available.

Above: This four sheet spur – progressing from innermost sheet at top to outermost at bottom – shows the likely source of the hard-edged back mark seen in Michelangelo's Cartoon*: note the similar marks in the two outermost sheets.*

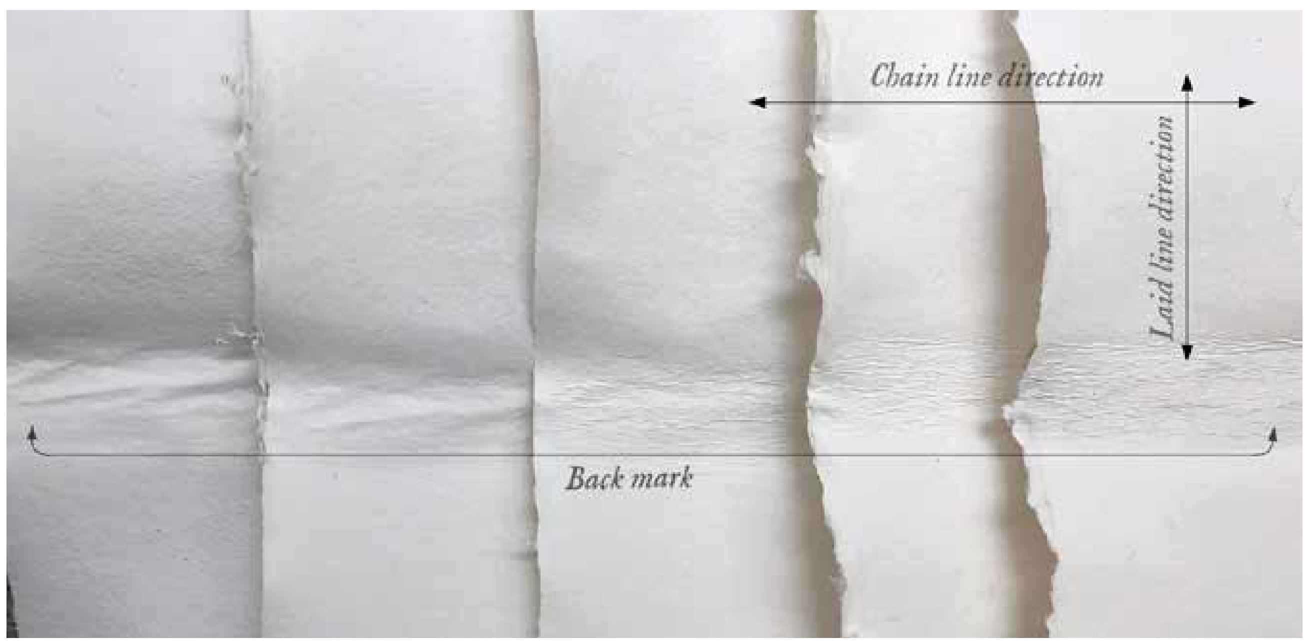
Left: Michelangelo Buonarroti, Unfinished Cartoon of the Virgin and Child—*Orientation on Royal (Realle) with back mark; Casa Buonarroti, Florence*

Back marks within a spur

It stands to reason that sheets with less severe back marks would be reserved for more prestigious projects. Conversely, folio book publications, whose folding signatures could not take advantage of the natural hinge quality of back marks, may have been quite accepting of full sheets with back marks. The preponderance of back marks in Renaissance drawings is perhaps a matter of economy: the deeply ridged inner sheets of the spur, closest to the treble line rope, may have been cheaper and more accessible to artists. Or indeed, it is possible that the pronounced hair-mark texture and unique striations of these sheets attracted artists to select them based on their appealingly nuanced character.

The (separated) five-sheet spur of 18 x 24-inch waterleaf paper shown below was dried hanging over ½ inch horsehair rope for two days and photographed shortly after being separated and having had the back broken. The furthest from the rope (at left) shows the least severe back mark, while subsequent sheets, progressing to the right, show the most articulated back marks. In the case of Renaissance papers, the processes of sizing, finishing, and bookbinding would have caused the sheets furthest from the rope to lose most (if not all) of their back mark; conversely, overly flawed or torn sheets and those with inclusions would have been deemed "broke" and recycled into the papermaking process or sold as "seconds."

As my back mark tests progressed, our paper studio's drying loft hanging system ropes needed adjusting (tightening), as the horsehair ropes began to stretch and sag. This sag created a new flaw in the paper: a spur (or a single, unconstrained sheet) dried by hanging on poorly stretched, excessively slack horsehair rope will conform to the arc of the rope, collapsing along the back and causing wrinkles perpendicular to the back mark, as seen below.



A separated five-sheet spur of 18 x 24 inch waterleaf paper dried hanging over ½ inch horsehair rope.

In Bernardo Strozzi's 1620 chalk drawing *Saint Peter*, we see a more or less full sheet that has been trimmed slightly to 13 3/4 x 9 1/8 in. (35 x 23.2cm). This idea is supported by the distinctive back mark running right through the center of the sheet, precisely where we would expect to find such a mark if it had been trimmed down from a half-median-size sheet.

Bernardo Strozzi, Italian. Saint Peter, *late 1620. Black chalk on paper with back. 13 3/4 x 9 1/8 in. (35 x 23.2cm). The Metropolitan Museum of Art (below: detail of back mark)*

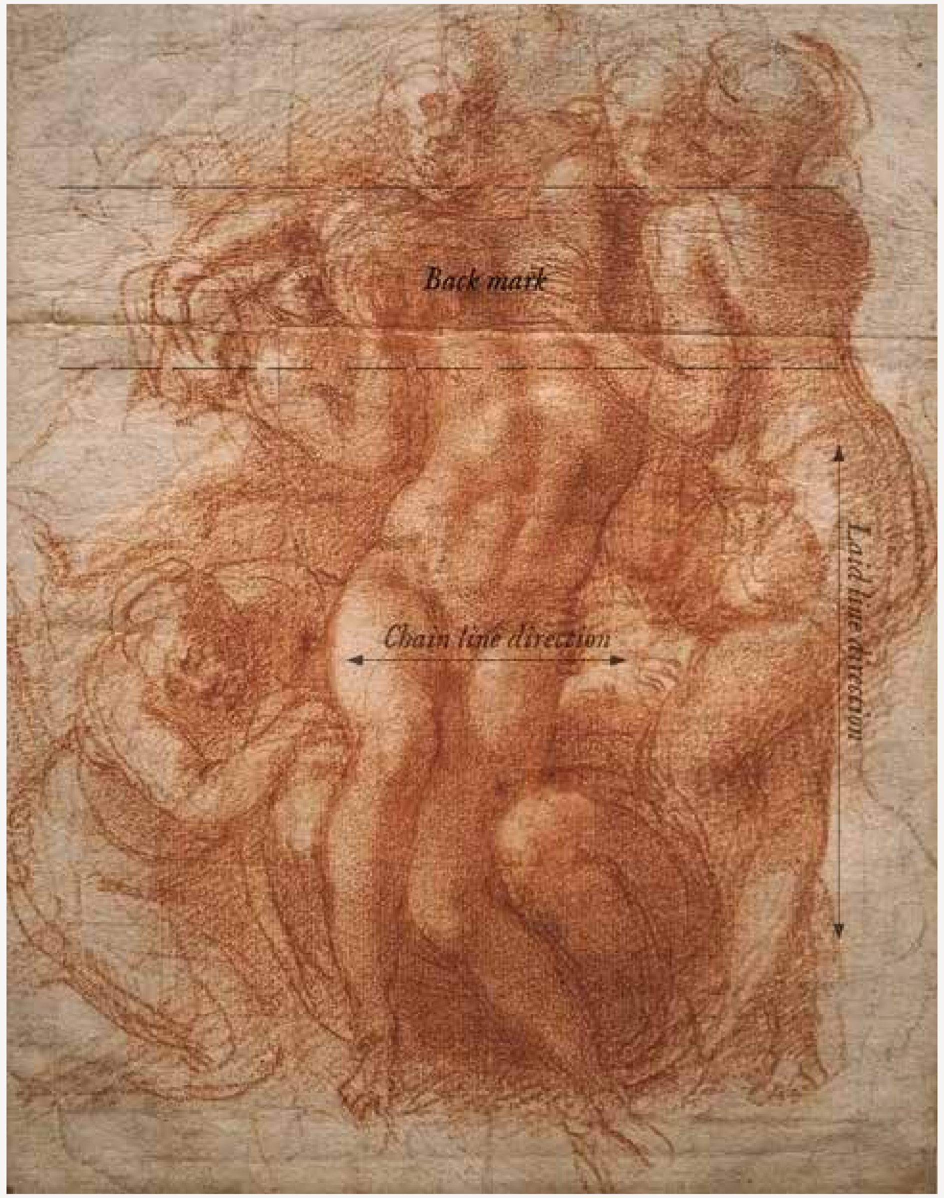
Meanwhile, in Annibale Carracci's *Nude Study of a Young Man on his Back*, Carracci simply drew over the back mark, like a wheel crossing furrows engraved by a cart in a well-traveled road:

Annibale Carracci, Nude Study of a Young Man on his Back *(Detail)*

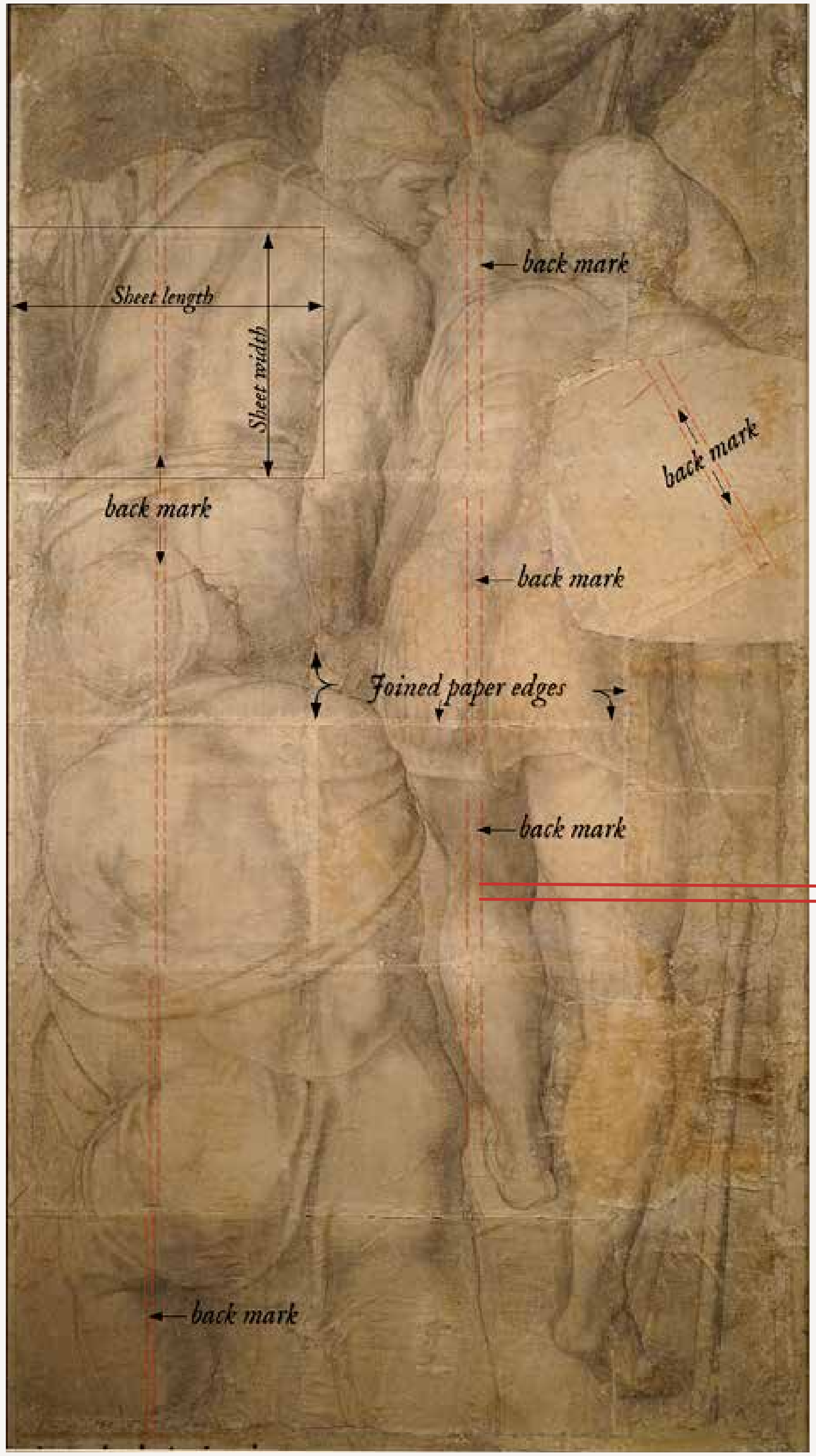
Annibale Carracci, Nude Study of a Young Man on his Back, *Nationalmuseum, Stockholm*

Back marks: Works on paper – full sheets

Often, full sheets showing back marks were used more as a means to an end, as seen in Michelangelo's *Roman Soldiers* (opposite). Full-scale preparatory drawings for frescoes also employed full sheets, which were tipped together and used as large transfer paper.



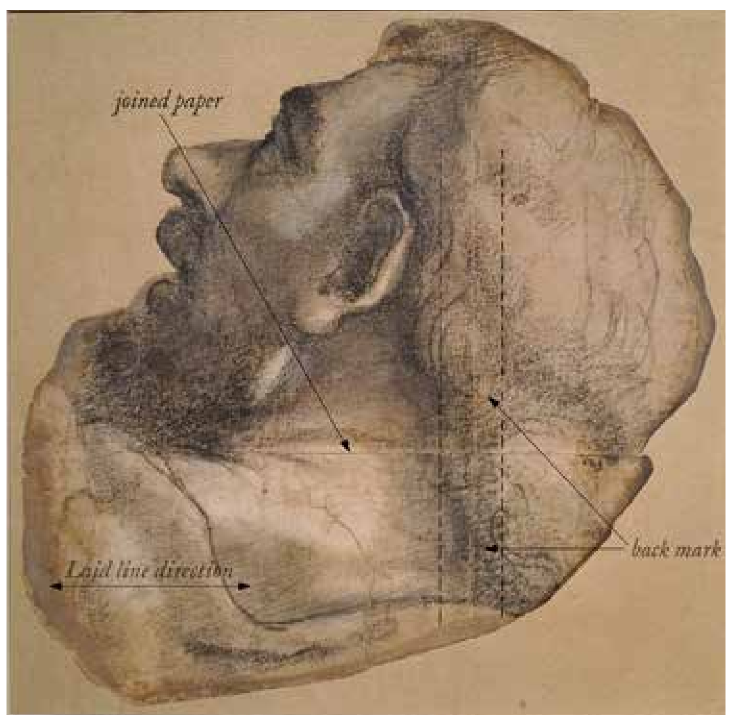
Michelangelo: Study for a Pietà, *red chalk over traces of black chalk on paper with back mark. Albertina, Vienna*



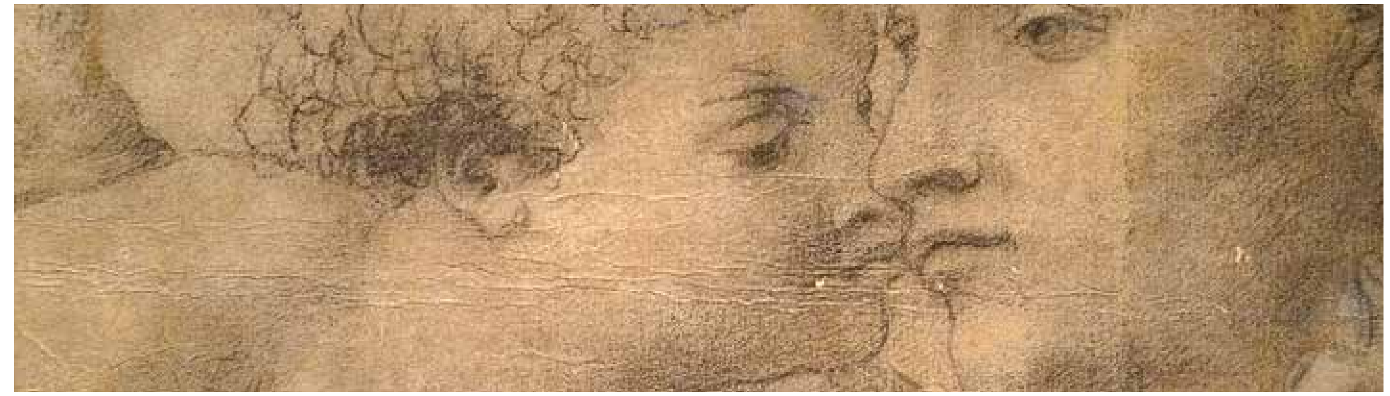
Michelangelo: Roman Soldiers, cartoon fragment for the Lower Left Part of the Crucifixion of Saint Peter in the Pauline Chapel. *A full-size preparatory drawing for a fresco. Pricked for transfer. Museo Nazionale di Capodimonte, Naples*

In the large-scale cartoon *Venus Kissed by Cupid* by Michelangelo and his workshop, 25 sheets were joined together (nine of which are full sheets) to make a larger 51 x 72-inch work surface. Here we can see that back marks traverse each sheet of paper's center (short) direction. Notice the reiteration of the outlines - either made during creation or as an artifact of the transfer process. Likewise, the cartoon by Piombo below on two joined sheets has been pricked for chalk transfer.

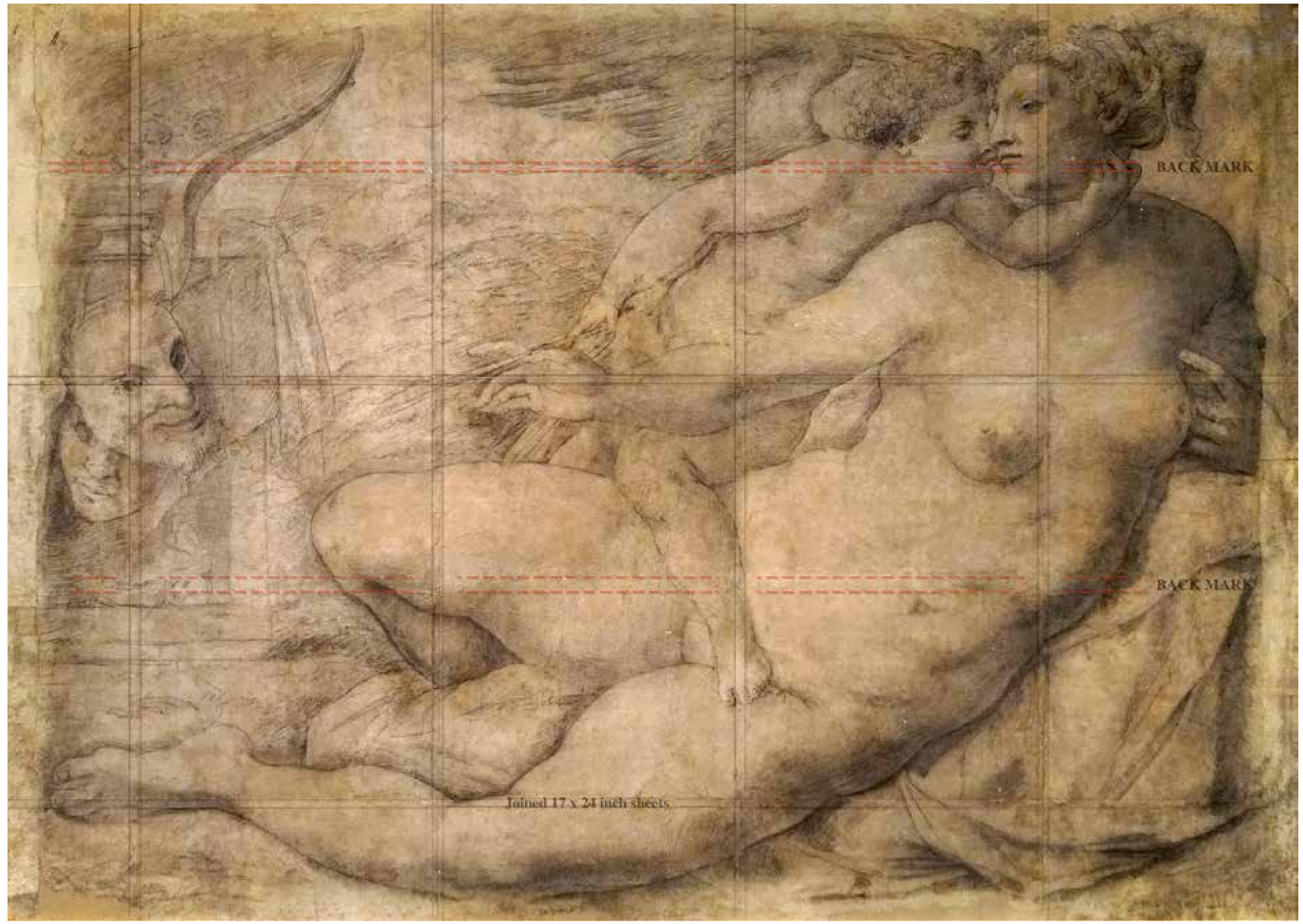
Attributed to: Michelangelo and Workshop, Italian. Cartoon of Venus Kissed by Cupid, *1532–34. Charcoal on nineteen sheets of paper mounted on canvas. 51.6 in x 72.5 in. Museo Nazionale di Capodimonte, Gabinetto Disegni, Naples*



Sebastiano del Piombo, 1485—1547, Italian. Cartoon for the Head of Saint James; *Italy, about 1520. Black and white chalk, on two joined sheets of tan paper; silhouetted; pricked for transfer; 30.2 × 30.5 cm (11 7/8 × 12 in.); J. Paul Getty Museum, Los Angeles, California*



Detail view revealing the telltale parallel back mark



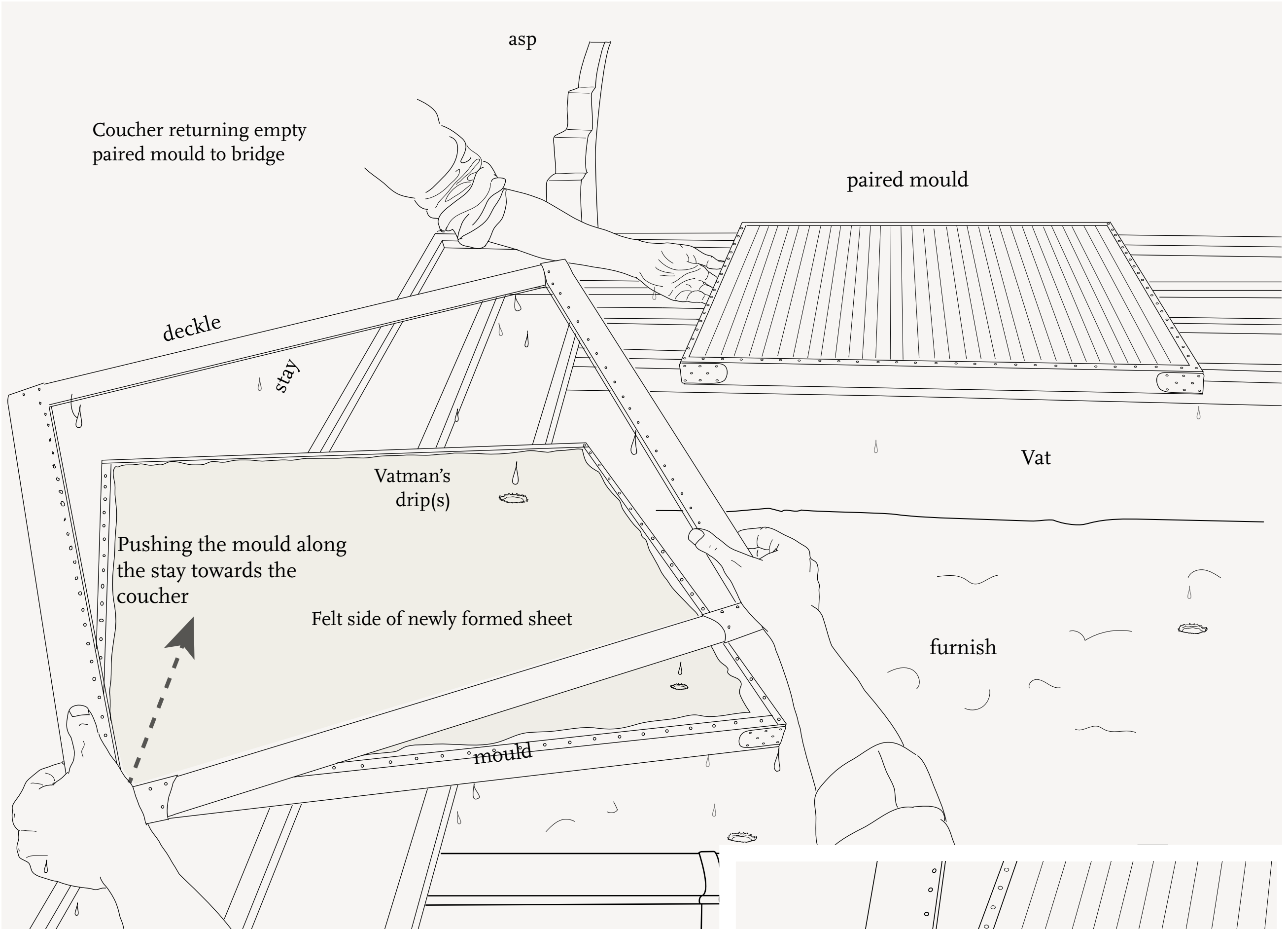
Distinguishing back marks from paper folds and creases

A seemingly outlandish series of arced back marks with twists and turns may be attributed to one or more sheets in the spur partially separating from the group. If too little pressure is used in the pack pressing or if the sheets lack the moisture necessary for good temporary adhesion, sheets will separate as they dry. This makes for wild and unpredictable cockling and back marks as seen in the Michelangelo sketch below (not unlike the flaw on spur #3 seen on p. 15).

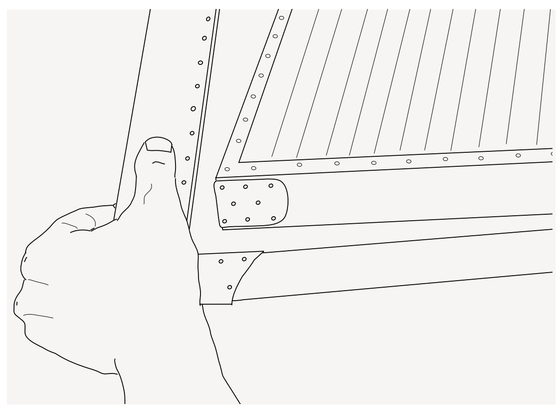
Michelangelo, Sketches for a Standing Male Figure, the Bruges Madonna, Study of a Male Nude for the Battle of Cascina, and Ornamental Motif. *Pen and brown ink, black chalk on paper. 51.6 in x 72.5 in., Staatliche Museen zu Berlin, Kupferstichkabinett*

Various striations may be mistaken for back marks until we raise the paper to the light and realize that they run perpendicular to the chain lines, contrary to what we would expect for a back mark. Additionally, creases usually lack the multiplicity of parallel wrinkles seen in a back mark.

Michelangelo, Studies for the Virgin and Child with Saint Anne, Studies of a Standing Male Nude, and Head in Profile. *Pen and brown ink, black chalk on paper, Musée du Louvre, Departement des Arts Graphiques, Paris*



The vatman is depicted here using the lower left (inner) corner of the deckle to push the mould along the stay towards the asp (also "ass," "horn," or "drainage horn") while retaining possession of the deckle. The coucher, having just delivered the empty paired mould to the bridge, will next grasp the loaded mould and tilt it to drain on the asp.



The outer corner of the mould and the inner corner of the deckle are both reinforced with bronze panels to withstand the repetitive impact of placing the deckle onto the mould.

This air-dried, folded sheet shows the wire side (top) and the felt side (bottom) on a Navajo-Churro felt.

CHAPTER III

Paper's Two-Sidedness

RENAISSANCE PAPER TEXTURES
Magnolia Editions

CHARACTERISTICS OF WIRE SIDE & FELT SIDE IN A FINISHED SHEET OF PAPER

Wire side *(right side):*

- *Chain lines and laid lines indented (if visible)*
- *Wire side fibers are more aligned, like combed hair (tending to be more parallel to the chain lines combined with the swirl of pulp in the vat during the vatman's dip)*
- *Fewer fines*—more fibrous when viewed under a microscope*
- *With fewer fines, the wire side tends to be a lighter value*
- *The curl (if any) is towards the wire side (parallel to chain lines)*
- *Couching on the shorter nap (finer wool) side of the felt and laying (throwing) coarse-hair-side-down on newly couched paper produces stronger felt hair marks on the wire side*
- *Concave back mark topography*

Felt side*:*

- *Fibers more randomly arranged when viewed under a microscope*
- *More fines—areas where the "normal" fibers are hidden by smaller, shorter fibers*
- *With more fines that oxidize faster, felt side is the darker side*
- *Couching on the shorter nap (finer wool) side of the felt produces finer felt hair marks on the felt side*
- *Convex back mark topography*

At the vat with mould and deckle, about to form a sheet

Couching on the short nap (finer wool) side of the felt (the side with more surface area vs the coarse side): the sheet will gently stick to the surface felt after pressing, during parting, ensuring paper does not stick to underside of the blankets. The coarse side provides efficient de-watering. Note that the right side (wire side) is up and the watermark is right-reading.

Paper's two-sidedness: two textural surfaces

The term "wire" side (aka the right side and sometimes mould side) in handmade paper refers to the side of the paper that touches the mould's wire covering when the sheet was formed and, therefore, the side that is face-up after couching. Except for French drawing papers and countermarks, watermarks are sewn wrong-reading to the mould's wire surface so that when couched onto a felt, the watermark is right-reading.† In general, if you hold a sheet to the light and see a watermark right-reading, you are looking at the wire side (or right side) of the sheet. The downward-facing side, the side touching the felt as it was couched, is called the felt side.

There are textural differences between the wire side and the felt side, which can be very obvious or extremely difficult to discern. Often, under raking light, the wire side reveals its laid lines more prominently than the felt side. The degree to which the laid lines show depends upon processing, pulps composition, and the paper's weight. Felt hair marks, if present, can be seen on both sides.

All sheets in post and pack pressings are oriented with the wire side facing upwards (right side up). After pack pressing, the stack of wire-side-up sheets are folded onto the "T" (aka cross – individually or in spurs) then hung on a rope so that the wire side is touching the rope. When the paper is dry and taken down from the rope, the wire side is on the interior (fold) and likely found on the inside of a signature (for better draping). Machine-made papers differ with regard to sides.[5]

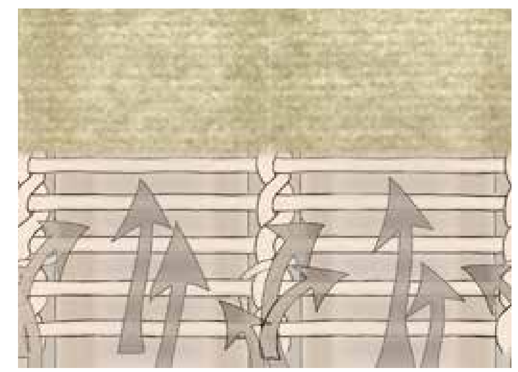


Figure 8*: Furnish flow on the laid mould covering causes a heavier build-up of fibers washed to the drainage spaces (between the laid lines and on either side of the ribs). Those varied fiber densities generate the visible shadow of the laid lines and the thick/thin profile of "antique" laid paper.*

When paper is formed on a laid mould, the initial dip starts with the lead (long) edge of the mould pulled towards the vatman from the back of the vat through the furnish as water rushes across the laid covering perpendicularly, fibers alight parallel to the chain lines. Initially, when the pulp first impacts the mould surface, the fines fall through the screen; quickly after that, a fiber mat starts to form, trapping the fines on the upper side of the sheet (the felt side). The vatman shakes the screen side-to-side and forward-to-back, crossing the grain. A more pronounced grain direction may be found on the wire side, while a more random fiber orientation is found on the upper, felt side. This initial flow direction prevents the fibers from tangling in the slots between each laid line and helps clean transfer the newly formed sheet from mould to felt.

***Fines:** *particles found in white water: finely divided matter; cellulose, hemicellulose and additives (i.e., $MgCO_3$, fillers, pigment). † If there are two watermarks in one sheet (main and counter mark) then the main mark is right reading (from wire side) and the counter mark is reversed(right-reading felt side).*

LOADING THE "T"

Step 1: place T off-center of pack. Note: wire side of paper (right side) is face up.

Step 3: Hang spur on horsehair rope.

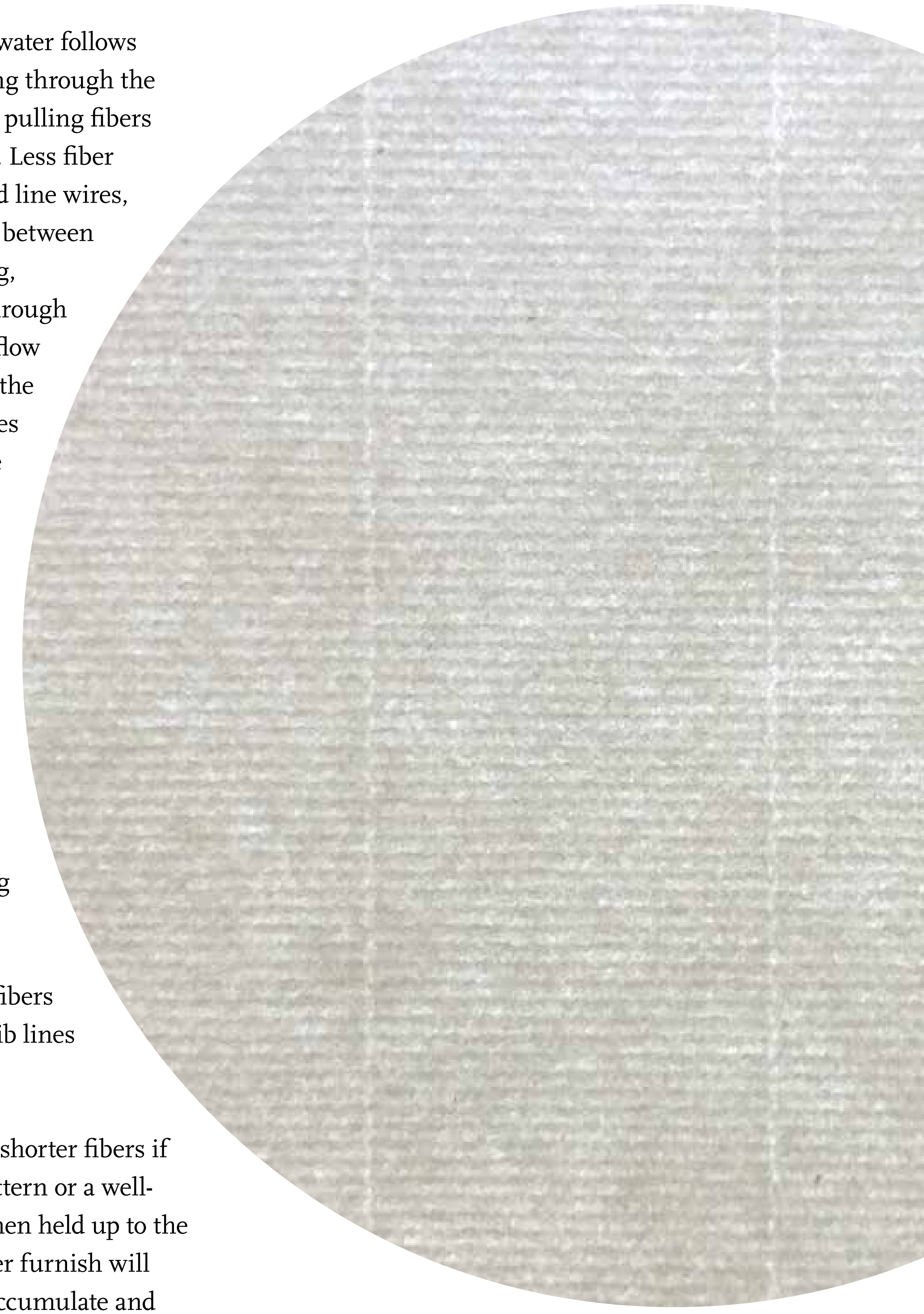
Step 2: fold spur over T.

> "Like a rushing river against a protruding rock, water flows around the ribs, depositing fiber in its wake..."

Paper's two-sidedness: two textural surfaces

As the sheet is formed, draining water follows the path of least resistance, flowing through the spaces between the laid lines and pulling fibers that follow the water's movement. Less fiber accumulates on the chain and laid line wires, and more builds up in the spaces between the wires as fibers are swept along, following the water as it drains through the sieve slots of the screen. The flow of draining water draws fibers in the flow direction, away from the wires into the laid line slots, sorting the fines and fiber into the thick-and-thin pattern, which creates the light and dark image of the watermark and laid lines when the paper is held up to the light. A further complexity occurs when the draining water, having made it past the laid screen, hits the wood ribs to which the chain lines are sewn. Like a rushing river against a protruding rock, water flows around the ribs, depositing fiber in its wake and causing a shadow line of thicker fibers seen on either side of the chain/rib lines (Figure 8, p. 67).

In general, furnish must contain shorter fibers if a visible light-and-shadow laid pattern or a well-defined watermark is desired. When held up to the light, a sheet made from long-fiber furnish will be opaque. While shorter fibers accumulate and disperse according to the pattern of the laid lines, long and unruly fibers drape themselves across the screen during formation.



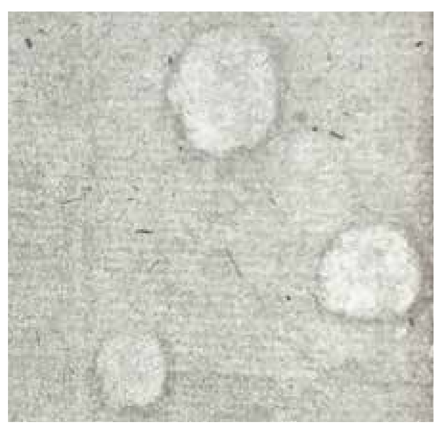
Modern laid paper (18th c.): the mould for this paper is designed with two layers of wire screen and therefore has no buildup of pulp along the chain lines.

Wire or felt side: drip watermark characteristics

The vatman's drips (below) make their mark on the felt side surface of a draining sheet that is still very wet. In this situation, the drips produce a soft-edge displacement of fiber divots. Once dry and finished, these will appear as 'soft focus' drip watermarks. Notice that the laid lines are not interrupted.

Vatman's drip marks made on the felt side while sheet is draining; inset, the same sheet after drying.

A coucher's drip makes its mark on the wire side surface of a couched sheet. These drips fall on a sheet that has already been drained and couched. With less water (furnish) to absorb the force of the impact, these drips displace fiber like a meteor colliding with the moon, producing a rim-edged crater. This drip watermark will have a hard-edged rim when dry and finished, and the laid lines will be disrupted.



Coucher's drip mark on the wire side of a couched sheet; at right, a similar sheet after drying.

Which side did Renaissance artists prefer?

I expected the Old Masters to have preferred the felt side for their chalk marks, relegating the wire side (right side) to the verso to avoid its regular pattern of laid lines. However, the museums and study rooms Era and I visited revealed that Renaissance artists were resistant to pigeonholing as my contemporary artist friends: artists are all over the map. The reasons for their choices may be intuitive, but the variety of options and the effect the two textural sides of paper contributed to the works is undeniable. Although Georges Seurat may have famously used the wire side with intention in the 19th century, he was certainly not the first artist to employ the wire side effectively.

But what looks like the wire side may be the felt side. Surprisingly, as a laid sheet dries, the indentations of the chain and laid lines transfer from the wire side to the felt side. (not so in modern machine-made papers where the laid papers "dandy roll" papers). Theoretically, one can look at the surface texture and decern sidedness; to double-check assumptions of sidedness, paper can be split down the middle, and the laid and felt side becomes apparent and confirmed.

While it is easy to tell at a glimpse that Seurat used the laid screen side of his paper, in other cases, it can be difficult and frustrating to discern the wire and felt sides from one another. A close examination of the phenomenon known as vatman's drips may help us to determine which side an artist used. Vatman's drips (or coucher's drips) occur during the papermaking process when droplets of white water fall onto the surface of a newly pulled sheet. The size and clarity of this round watermark are proportional to the height from which it falls and the drop's volume. The falling drop, hitting the paper with force, pushes fibers aside to form a crater-like dent, round and thinner than the rest of the sheet. Most frequently, these drips fall on the felt side, either dripping from the vatman's hands, arms or falling from the deckle as it is being removed. It is easy to do: the vatman passes the mould to the coucher, sliding the mould along the bridge by pushing with the lower-left inner corner of the deckle while at the same time raising the far end of the deckle. He retains possession and transfers the wooden deckle to the second (paired) mould. When the deckle is lifted dripping wet from the mould during this transfer, droplets often fall on the sheet as it is passed to the coucher. Meanwhile, although probably less common, drops can also fall from the mould as a sheet is couched. These (coucher) drops would be falling onto and damage the wire side.

Knowing at what stage of paper formation these drips occurred can lead us to draw conclusions about which side of the paper was disrupted and at which side of the sheet we are looking. An example of a vatman's drip is shown on p. 73: in the first image (1), we can see the crater topography and the fiber disruption. In the second image (2), a backlit view of the same area, we can see visible laid lines that the vatman's drip has not disrupted. This indicates that the falling drop of water landed on the top surface of a newly formed sheet, which would later become the felt side after couching. Further, we note no disruption or crater dimensionality in the verso image (3), the wire side.

In this particular example, the force of the falling water – combined with the build-up of fiber and fines, along with the accelerated evaporation along the ridges of the crater (greater surface area) – accumulated more pigment, fines, and impurities to the rim of the crater, yielding the darker, tidemark-like edge to the drip mark. This edge pigmentation is more likely to happen on the felt side, the side with the greatest concentration of fines.

"...the museums and study rooms Era and I visited revealed that Renaissance artists were as resistant to pigeonholing as my contemporary artist friends..."

DONALD FARNSWORTH

1. *Disrupted fibers from a vatman's drip—this is the side where the rather large water drop hit the paper.*

2. *Backlit and still showing laid lines. Since the laid lines have not been disrupted, it was likely the felt side which received the drop.*

3. *Verso, showing no fiber disruption nor crater dimensionality, is therefore the wire side, where the laid lines are still intact, the opposite side of the water's hit.*

Wire-side-up

Handmade sheets that are dried unconstrained tend to curl towards the wire side, parallel to the chain lines. This is due to the surface grain directionality of the wire-side fibers. As the sheet is formed, the fibers that make contact with the laid screen of the mould are lined up in parallel to the dipping motion of the vatman, while fibers that do not come into contact with the wires are distributed more randomly. During drying, fibers tend to shrink and become narrower in diameter. Since the fibers on the wire side are parallel, not randomly distributed, the shrinkage is more pronounced on that side. The net result is a contraction of the paper inward toward the surface of the wire side, causing a wire-side curl effect.

Handmade sheets dried unconstrained showing a wire side curl. This curl might be inadvertently glued down during tub-sizing.(see sidebar on following page)

Two-sidedness, back marks and a folded corner

Back marks can also provide a significant set of clues regarding the question of which side of the sheet an artist has used. Interestingly, the back mark – comprised of small broken parallel wrinkles – is almost always in total directional agreement with the surface grain (on the wire side) of the paper, the chain lines, and the horsehair rope on which the paper was hung.

Understanding this relationship is key to distinguishing back marks from folds, joins, or wrinkles unrelated to drying. Back marks run parallel to the chain lines of a sheet; therefore we may safely assume that any fold, crease, join or wrinkle that is parallel to the laid lines were not caused by drying loft ropes and are not back marks.

Moreover, the two sides of a sheet bearing a back mark will express the mark differently. The side closest to the rope (wire side) exhibits a back mark that is a series of concave striations, like miniature dry riverbeds. Meanwhile, the opposite side (felt side) exhibits the inverse: reticulated, embossed, convex ridges like a tiny mountain range.

The convex topography of this back mark indicates it is the felt side.

Conversely, the concave texture of this back mark on the verso on the sheet above identifies the wire side.

FOLDED, GLUED EDGES; AN INDICATION OF THE WIRE SIDE

Three indications we are looking at the wire side: *(in the example above)*

1. Due to paper’s predilection for curling toward the wire side as it dries, from time to time we find sheets with fixed, folded corners (as seen in above image). The paper’s curl in waterleaf and sized sheets can be very tight and spring-loaded, making it difficult to for the sizing and finishing departments to flatten. So it’s not uncommon to find the insistent curing of the sheets’ edges fixed in place by sizing, and compressed into permanent folds during the finishing pressure of the standing press. Most folded edges that arise in this manner are trimmed off by the book binder’s plow; those that are not trimmed off are most often curled or folded to the wire side.

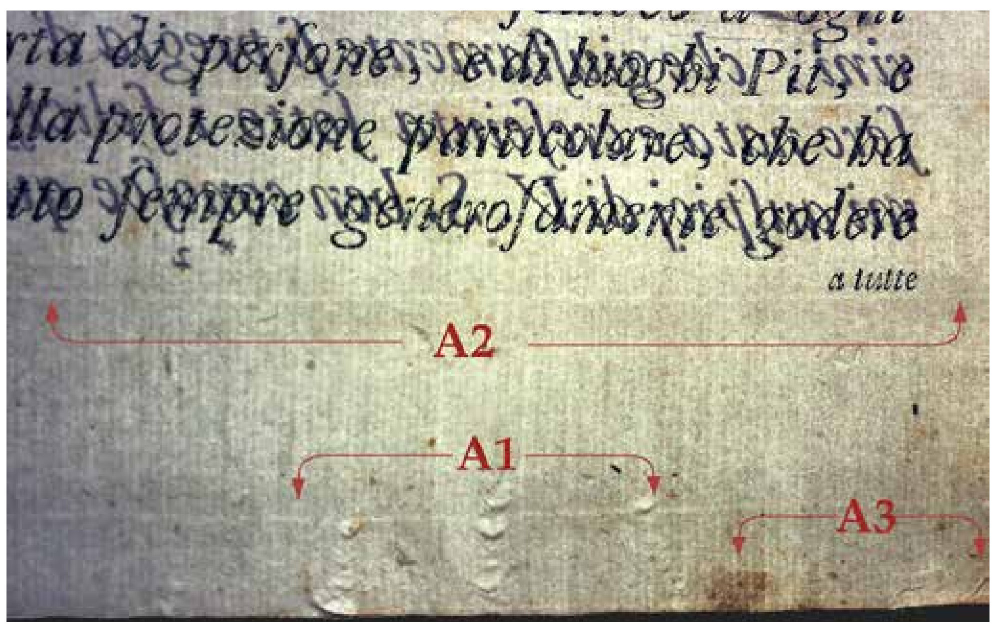
2. In this example we have a second indication that we are looking at the wire side by the concave back mark troughs visible at the top of the page; denoting that this was the rope side when the spur was hung to dry, known to be the wire side.

3. Not seen here, when back lit, the right-reading watermark also corroborates our wire side conclusion.

Using manufacture flaws to identify wire and felt side

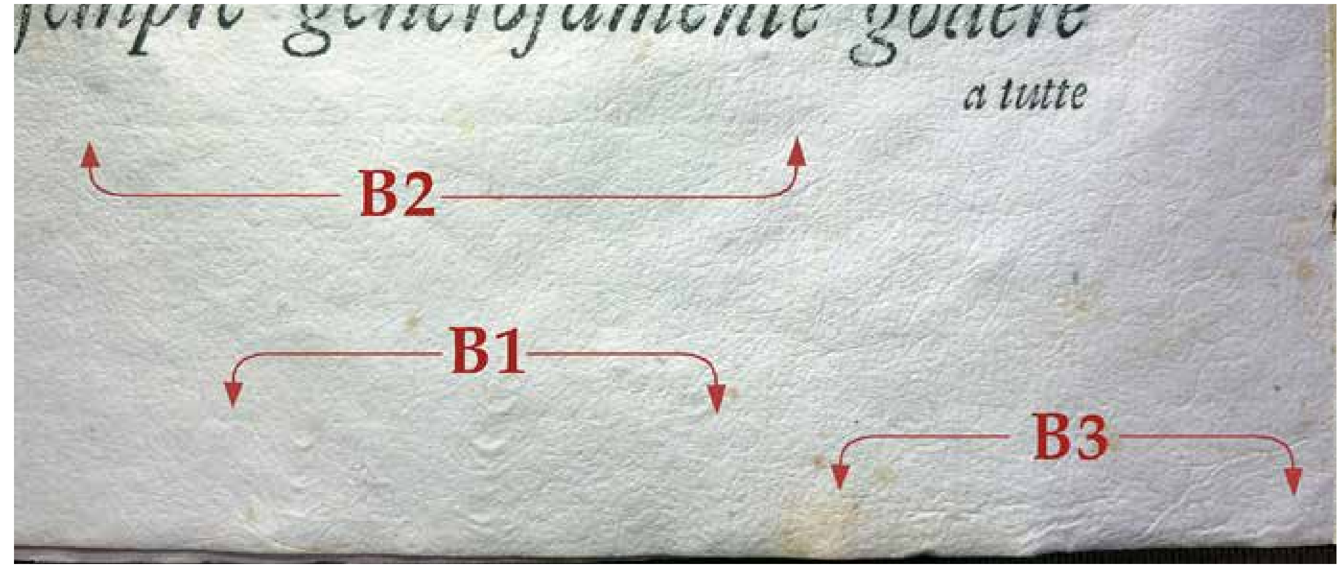
A case study: Distinguishing felt and wire side of a leaf from this quarto dating to the 1730s (from the library of Don and Era Farnsworth).

A case study sans microscope: Conservators, archivists and connoisseurs use various nondestructive approaches to determine whether the wire or felt side of sheet or leaf was used in 14th- to 18th-century Western works on paper; this knowledge can provide a more detailed description and documentation of a work on paper, incunabulum, or codex. In addition to analyzing the drip marks as mentioned above, the following example demonstrates three features found in one leaf which can be used to decisively determine sidedness. To provide maximum visual information, the leaf was photographed backlit and in raking light.



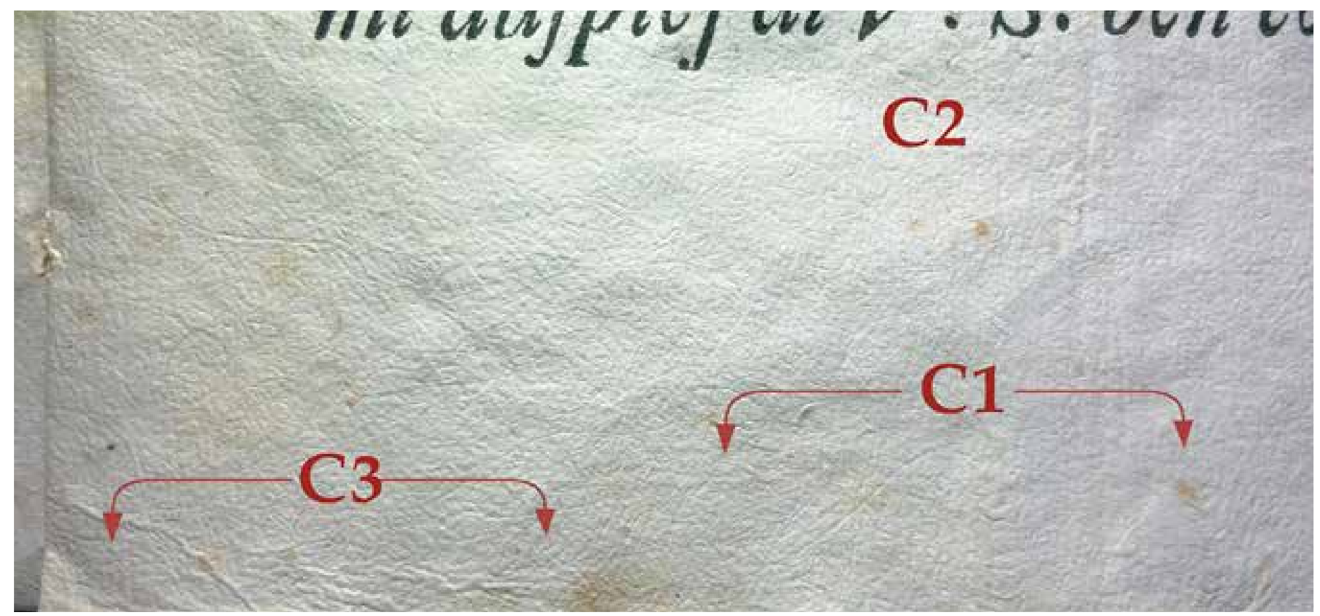
Learning from backlit (show-through) information:

A1. *Finger-sized abrasions on the sheet are our first clue. The scratches interrupt the laid lines, suggesting that the paper was distressed on the wire side (probably by the coucher).*
A2. *In this backlit view, we can easily note the location and direction of the chain lines – important for determining back mark validity.*
A3. *There is little to learn from the back mark in this backlit view, however, a raking light on the sheet (following page) will tell us more.*



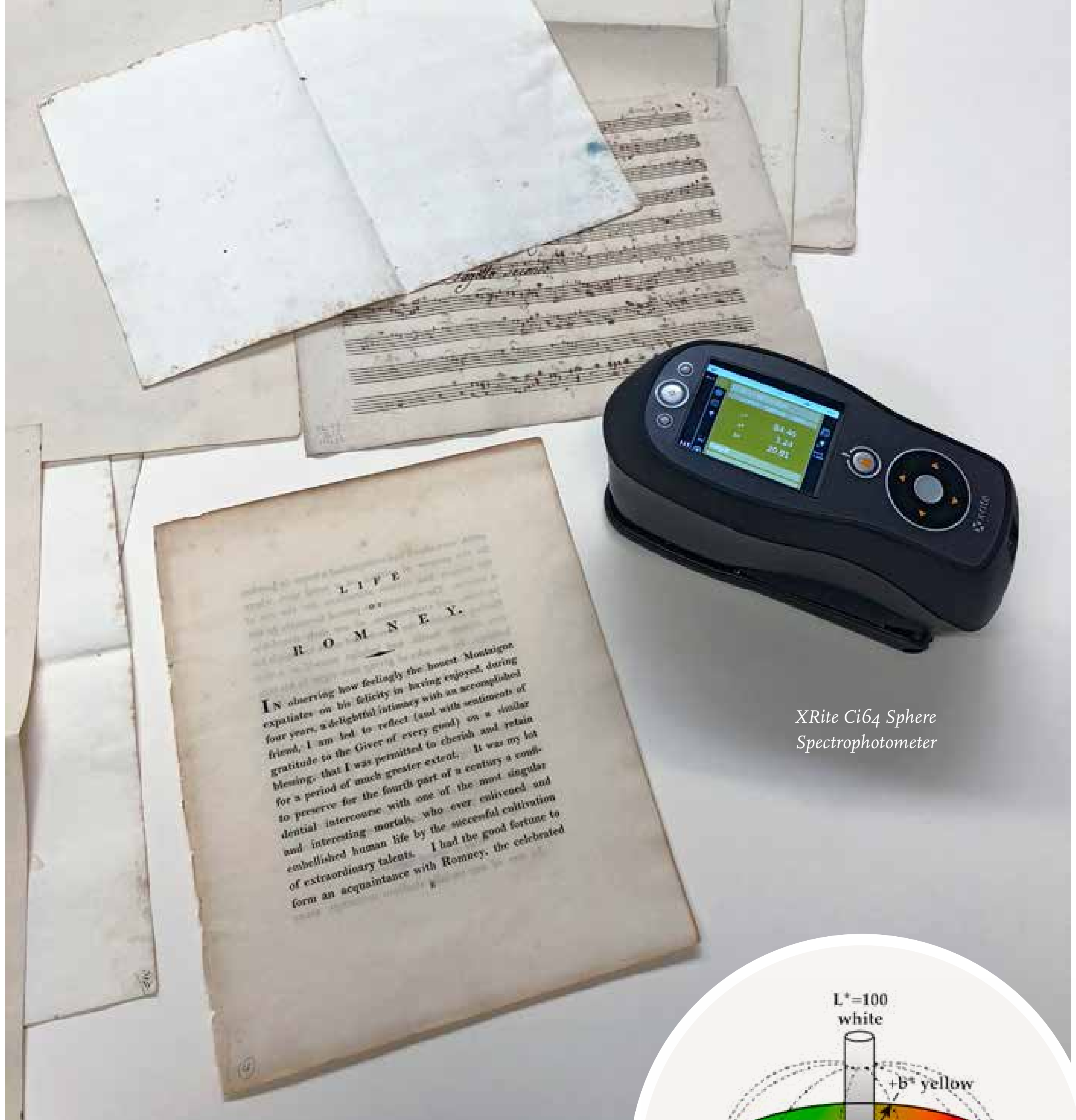
Evidence of wire side:

B1. The abrasions are dimensional on this side of the sheet; given the information offered by the backlit photo (opposite page) we can determine that this is the side that was abraded. Because the abrasion obliterated the laid lines, this must be the wire side.
B2. A visible indented chain line is additional evidence confirms that we are looking at the wire side.
B3. Indented, concave back marks on the quarto edge (parallel to the chain lines) are the third identifier of the wire side.



Evidence of felt side:

C1. The abrasions are not evident on this side of the leaf.
C2. No visible chain line.
C3. Convex back mark, decisively identifying this as the felt side.



XRite Ci64 Sphere Spectrophotometer

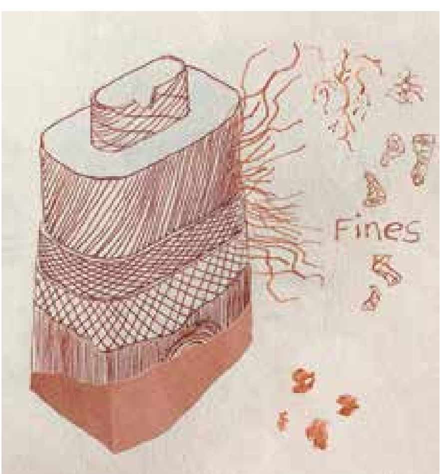


Illustration of fibrillation and fines (from top: fibrils, cut cell ends, and flaky granular material) being released from a fiber and fiber wall.

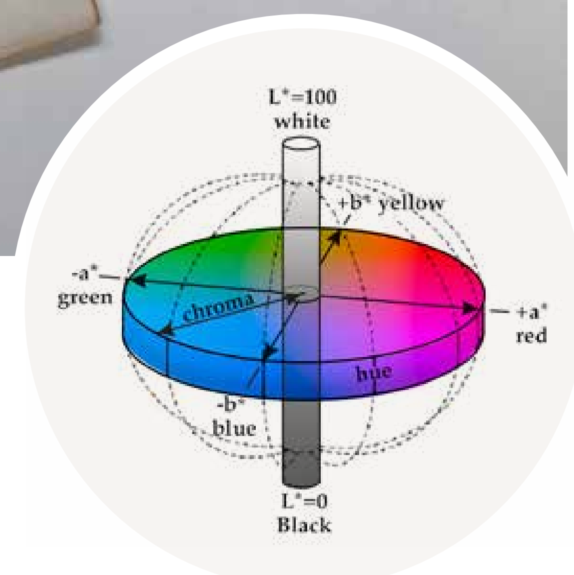


*Illustration of CIELAB L*a*b color space. Color is measured along three spectrums – L (black to white), a (green to red), and b (blue to yellow) and recorded as a set of three values. Higher L values and lower a and b values correspond to lighter colors.*

Wire and felt side color & value shift

As a sheet is formed on a paper mould, water drains through the wire side taking longer fibers out of suspension while "fines" (tiny particles of finely divided cellulose and hemicellulose) wash through the slots of the laid screen. As the sheet builds up, fewer fines fall through the laid wire gaps and are trapped in the subsequent buildup of fiber. Such fines possess exposed oxidation sites as a result of beating and processing. They are no longer intact, encapsulated fibers; having broken off from the beautiful and intricate helically wound cellulose structure. These cell wall fragments and severed polymers – their monomers now broken and exposed – are prone to degradation from environmental acids and microbial excrement, and are likely to turn brown (and brittle). We can therefore predict that the accumulation of fines on the felt side will oxidize at a faster rate than the longer, intact cellulose fibers of the wire side (with comparatively fewer fines). In short, we can theorize that the presence of fines in the felt side of a handmade sheet will cause it to grow progressively darker with age than the wire side.

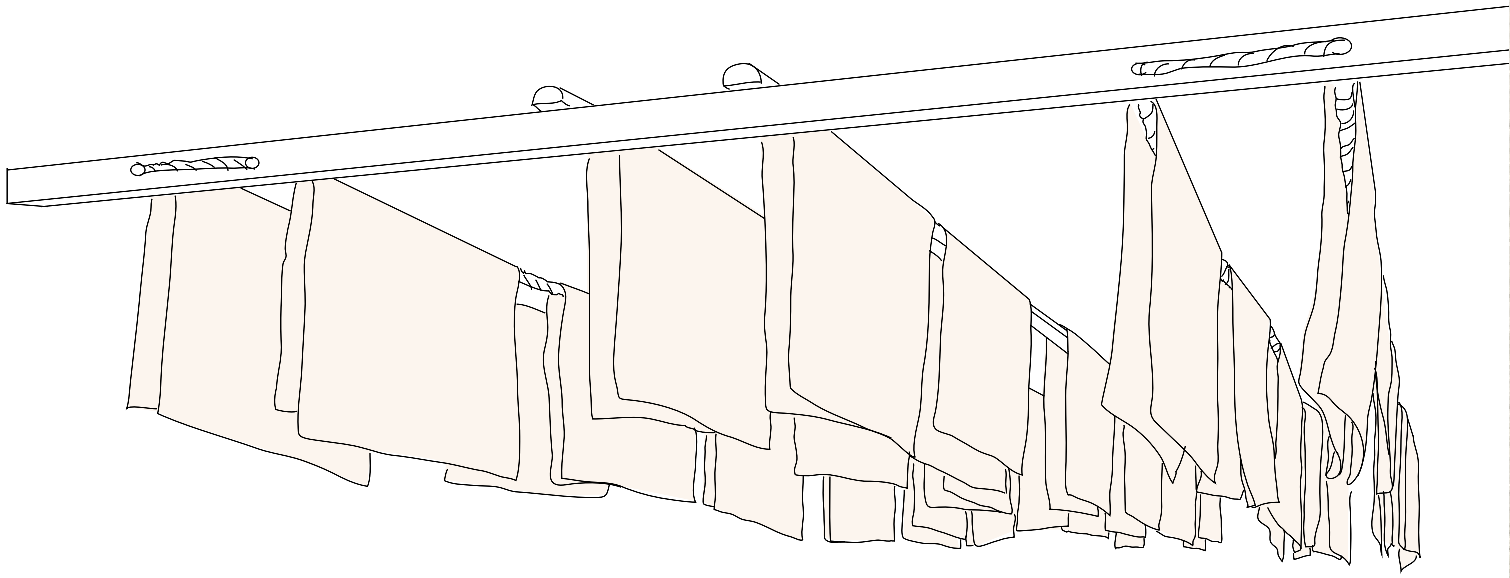
While such a value discrepancy may not be discernible to the human eye, it is light work indeed for a sphere spectrophotometer.* To test our hypothesis, we took spectrophotometer readings from both sides of 20 pre-Industrial sheets of paper from my collection. The sidedness of each sheet was determined using the methods described above and corroborated by the following criteria (viewed backlit or under raking light):

- Back mark concave and convex ridges
- Watermark indentations, right reading watermark
- Countermark indentation
- Chain line indentation on wire side
- Laid line texture on wire side.
- Coucher drip disrupting wire side
- Felt hair marks stronger on wire side
- Microscope analysis of fiber alignment

Without exception, the wire side Lab measurements were lighter and less colorful than the felt side (i.e., the wire side L values were higher and the a and b values were closer to 0), as predicted.

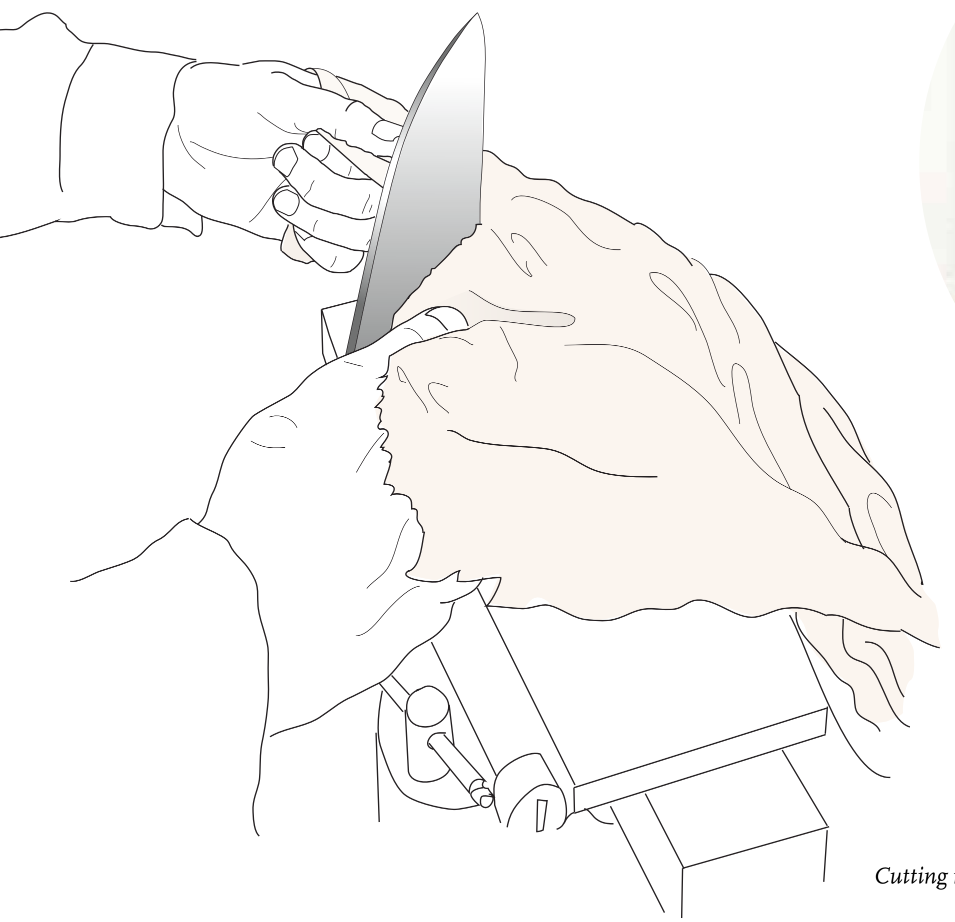
In addition to this discoloring and darkening from oxidation, if the paper were pigmented (blue paper, for example), the colorant, along with fines, would be concentrated on the felt side, lowering the L values and elevating the a and b values (in both the positive and negative direction – away from 0.00). The presence in some papers of an antioxidant like $MgCO_3$ could minimize this shift in sidedness, but combined with the other previously discussed techniques, the sidedness of paper is likely easy to discover.

***Reflective vs. spherical spectrophotometer:** *Spectrophotometers are useful and nondestructive tools for detecting differences between the two sides of a sheet. Although 10 times the cost of a standard reflective spectrophotometer, a sphere spectrophotometer's readings are not influenced by surface texture: it can measure light reflected at all angles to calculate color measurements that closely match or exceed what a human eye would see (in the Lab color space). A 45° reflective spectrophotometer, most commonly used for measuring color on smooth or matte surfaces, would have trouble accurately measuring the textured surface of handmade paper as the angled light would cast textural shadows, skewing the results.*



Sized sheets hung to dry on rounded poles (center two rows) and horsehair rope suspended on a framework called a "treble"

Modern-day mechanical rag shredder



Cutting rags

CHAPTER IV

Process

Making handmade paper in close alignment with the cinquecento process

RENAISSANCE PAPER TEXTURES
Magnolia Editions

OF FLAX WHEREBY PAPER
IS MADE OUT OF RAGS

"That shall be revered and honored and its precepts shall be listened to with reverence and love, which was at first despised and mangled and tortured with many different blows."

THE NOTEBOOKS OF LEONARDO DA VINCI

Fiber preparation: letting microbes process linen rags

The importance of retting (composting – using microbes to separate fibers from non-fiber tissues in plants) to the production of a coarse, Renaissance-style paper cannot be overstated. Initially, I labored under the mistaken assumption that my robust, Industrial Revolution-era beating engines would suffice to break down rags without the help of microbes. After searching eBay for damaged and heavily used fabrics, I found a lot described as "pure 100% Irish linen" tablecloths. After cutting and cooking them in soda ash (then rinsing), I beat these rags to a pulp in a Noble & Wood and Valley beater.

The resulting paper had many problems. The non-retted rag component needed long beating times, making for a "wet," slow-draining pulp with excessive swelling (hydration) and fraying of the cellulose, yielding a very cockled sheet with insufficient dimensional stability. In an even more distressing development, the coarse Churro felt hair mark texture diminished as the paper dried — lost to shrinkage caused by the overhydration of longer beating times. I also discovered that my linen rags purchased on eBay had been tainted with optical brighteners, whether during their manufacture or due to the detergent used during the fabric's life.

Having regrouped and now possessing linen cuttings from responsible textile manufacturers that use no optical brighteners, I began again; this time, I set up compost bins and an outdoor sun bleaching vat. I also started a worm farm and mycelium/mushroom cultivation to help the microbes along.

In addition to retting, I eventually found that shredding the rags and beating them hard and fast in a dilute slurry in the beater (more cutting action) helped to preserve the felt hair marks, freeness, and, to some extent, dimensional stability. I have concluded that increased retting, shredding, and cutting in the beater contribute decisively to creating a furnish worth using.

Composted linen fabric and associated microbes

The many creative and descriptive terms applied to flaws found in paper

AIR BELLS
BACK MARK
BAGGY
BELL
BLACKENING
BLEACH SCALE
BLISTER
BREAK
BRISTLE MARKS
BROKE
BRUSH MARKS
BUBBLE MARKS
BURNING
BURNT
BUTTON SPECKS
CALENDER CUTS
CALENDER SPOTS
CASSIE
CLOUDY
COCKLE
CONTRARIES
CORNER UP
CRACKING
CROCKING
CRATERS
CROPPED
CROSSES
CURL
CRUSH or CRUSH MARKS
DANDY BLISTERS
DANDY MARK DEAD
DEAD SPOTS
DOG-EARED
DUSTING
DYE SPOTS
FEATHERED
FIRE
FISH EYES
FOUL
FOXED
FROTH or FOAM SPOTS
FUR
GRAINY EDGES
GREASE SPOTS
GRIT
HAIRCUTS
IMPERFECT
LINT LUMPS
MULCH
PHOZY
PICKING
PINHOLES
PIPING
PLUCKING
RETREE
ROPING
SAWDUST SPOTS
SECONDS
SHINERS SIZE STAIN
SKIPPED COATING
SLAP
SLICEMARKS,
SLIME SPOTS
SLIPPED ROLL
SLIVERS
SNAILING
SPECKS
(bronze, button, carbon or cinder, iron, rosin, etc.)
SPONGY
SPOTS
(alum, color, drag, oil, water, or wax)
STAMPS
STEAM BLISTER
STICK MARK
WATER DRILLS
WET SPOTS
WHITE SHINER
WEDGY
WINDER WELTS
(or wrinkles)
WILD
WOODY

Dictionary & Encyclopedia of Paper and Papermaking, 1952

Torn and cut linen fabric ready for composting

List of textural artifacts

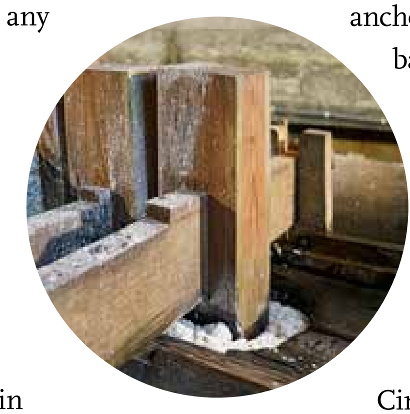
Flaw / Artifact	Relevant Stage(s)	Typical Cause(s)
Tainted with optical brighteners, synthetics fibers	Rag selection	Poor rag selection, should inspect rags with UV light source
Sheets too soft or too hard; mold spots in paper	Retting	Rags over or under retted; rags not sterilized, resulting in moldy paper
Dimensional instability issues, Poor watermark definition (show-through)	Beating and/or non-constrained drying	Over beaten pulp, dull fly bars, not enough beating pressure (or under retted rags); Sheets individually dried without constraint
Cloudy, uneven sheet	Sheet formation	Poor shaking or clogged screen during formation (or under retted /beaten pulp per above)
Droplet watermarks	Sheet formation (or occasionally, couching)	Drips from the vatman's arm (or drops falling from the deckle) as sheet was removed and transferred to the second mould
Flawed, coarse chain line or slurred chain lines, sloughed-off edges	Couching	Slipping/sliding the mould while couching or couching wrong direction (holding short side of the mould) tilting mould early
Crushing: Ripple marks along long edge of a sheet	Couching	Couching too soon; not draining newly formed sheet enough before couching
Various odd marks or rolled edge of paper	Throwing felt	Dragging felt after it lands on post
Crush marks in various areas of the sheet	First pressing (wet pressing)	Pressing too fast; exiting water moves pulp, creating uneven ripples
Torn sheet, wrinkling or damaging sheet, folded corner	Parting	Poor handling; under pressing; no slice or poor slice use
Strong felt hair marks	Pack pressing, felts	Coarse felts, only one pack pressing, free (not wet) pulp, dried without constraint.
Regular tooth – even, repetitive surface texture	Pack pressing, felts	Woven felts and single pack pressing
Cockled sheet at edges and/or center	Drying/pack pressing	Drying too fast or under pack pressing with spurs separating during drying
Torn or surface torn sheets	Pack pressing, parting	Too much pressure, possibly combined with too wet pulp, making spur parting difficult
Back mark	Loft drying spurs	Loft dried on horse hair rope or poles
Brown stains, tide marks	Drying, sizing	Contaminated rags/pulp, dirty drying surface, hide glue stains
Smooth/coarse streaks, creases	Finishing	Burnishing streaks from hand burnisher, creases from calendering

Figure 7. *Common paper artifacts and their causes as observed in the studio. Depending on the desired outcome, the same attributes may be considered flaws – or prized distinctions.*

A six hammer stamper mill

LE MOULIN DU VERGER

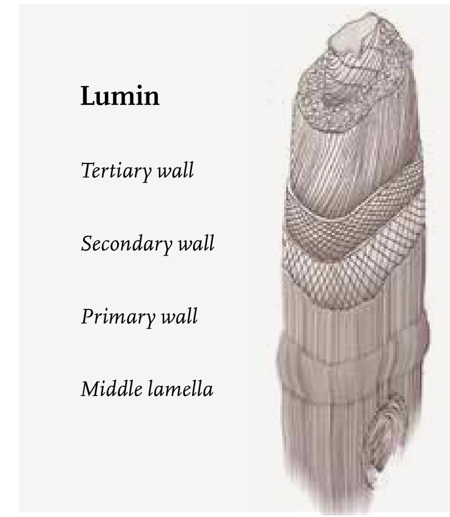
There is a maxim in papermaking that "paper is made in the beater" – one that I have occasionally revised to say that "paper is made in the compost bin," i.e., during retting. In truth, we cannot and should not generalize or oversimplify things by suggesting that the characteristic of a paper is made in any "one place" or at any one stage of the process. There are a wide variety of papers in existence, the unique qualities of which were determined in various "places" depending on the fiber source, the tools at hand, and the papermaker's intention. In particular, it is useful to consider the variance in how different equipment debundles fibers in the processing stage: depending on the use of a stamper mill, Hollander beater, or other methods, the fibers of one's rags can separate and fibrillate in a variety of ways. Even within these categories, there is room for variety. Depending on the materials and construction of the stamper head, the nascent pulp may receive a more or less direct impact. The point of paper fiber processors, e.g., stamper, Hollander beater, Jordan refiner, etc., is to deconstruct the cellulose fiber's complex, helictically wound walls, thereby making the fibers suitable for the formation of sheets.



I have concluded that in general, stampers fibrillate via a different kind of action than Hollander beaters, which separate and break down the fibers using a shearing motion. Instead, we might say that a majority of stampers have the advantage of fibering without as much cutting and hydration (of course, depending on retting duration, microbial variety, and condition). The use of a stamper generates a freer pulp, which suggests that the fibers may have remained more intact than they would have if sheared by a Hollander beater. After stamping, the fibers may be short, but they retain their naturally tapered form. (A cotton fiber is blunt at one end, anchored to cottonseed, and tapered at the other; bast fibers are naturally tapered at both their beginning and end.) These are just a few factors determining which of the millions of forms and types of paper a sheet will ultimately take. There is no question that stamper mills (supplied with well-retted linen and hemp rags) produce excellent pulp for papermaking; if done right, to my Cinquecento-obsessed mind, it is a superior pulp than that generated by the shearing action of a Hollander beater or disc refiner. To approximate the capability of a stamper using a Hollander beater, one must rely more on retting and less on mechanical beating.

In the fall of 2018, I had the great fortune to visit Jacques Brejoux at a 500-year-old paper mill in Angouleme, France. Jacques uses a series of custom-built, formidably-sized wooden stampers to process his pulp. At the time of my visit, three of his six were operational, moving asynchronously, dispatched by a large roll (similar to the inside of a music box). The hammers are raised by a cam and allowed to drop. Jacques starts with linen and cotton rags which are retted for up to two years; as you might imagine, the pungency of the rag storehouse was quite overpowering. He does not wash the rags after retting; he places them directly into a Hollander beater for initial processing ("breaking" the rags), never allowing the flybars to lower beyond about ¼ to ⅛ of an inch from the bedplate, such that fibrillation is minimized. He then moves the pulp to a storage chest (a half-stuff chest where the dirty water is allowed to drain) and, as needed, to the stamper mill, where the half-stuff is beaten for about a day. On my visit, the sounds and the shaking of the earth caused by the three great trip-hammers were phenomenal, carrying far beyond the walls of the mill. I could only imagine the sound of a Renaissance-era mill with dozens or even fifty hammers pounding away. Between this din and the impressive stench of great piles of retting rags, it is no wonder that the local government of the town of Fabriano eventually implemented a ban on new paper mills.

In one respect, I found that Jacques had encountered a dilemma similar to mine: as I walked through his storehouse of rags, shining a UV light on various surfaces, it became clear that very few were not optically brightened (the sad norm in today's society). Jacques contends that naturally occurring UV light will eventually break down the lingering optical brighteners if you make paper with such rags. Though in 50 or 100 years, the optical brighteners will indeed break down, the persistent benzene rings that comprise them will surely remain. One would think that someone writing on such a paper would come away with a rash on their hand. In any case, Jacques noted that for his museum clients, he is careful only to use rags without optical brighteners.



The stamper has its own unique way of unraveling the complex layers found in bast and seed hair fibers

Jacques Brejoux and his extraordinary wooden stampers at Le Moulin du Verger in Angouleme, France

Beating and sheet formation

New textiles, in the form of scraps and cuttings from manufactured garments, are far more durable than old rags. Typically, these new linen scraps (aka carbage, cabbage, or garbage) are so strong they cannot easily be torn by hand, providing a litmus test for rags' readiness to be beaten and transformed into paper pulp. Early European papermakers likewise had access to newly produced textile cuttings; however, because they would not break down in the eight weeks allotted for retting, they reserved such scraps for lower-grade, coarse wrapping papers. The paper from carbage was often lumpy and poorly formed, peppered with partially broken-down fabric artifacts; my tests yielded similar results. The retting process for new textile linen fabrics takes years, not months. The process can be accelerated with white-rot fungus or retting the rags in a worm farm. However, patience and technique are rewarded, as well-composted fabric tears with little effort and is thus ready for additional processing. Old, worn rags have a distinct advantage, requiring shorter retting times and producing a freer pulp. I would love to use such rags, but sadly, used linen clothes and tablecloths are tainted with optical brighteners and nylon thread in the seams.

Retting often stains the rags and, depending on the desired color of the finished sheet, might require sunlight bleaching. My retting compost of rags grew white fungi and green, brown, and, sadly, black mold (an instant colorant), all colonizing in localized areas of the compost pile. Mycelium retted rags were a lovely ochre; worm farm retting produced a brown tint.
After retting, I cook the linen rags in an alkali (soda ash) to break down any remaining lignin natural to the flax and kill off any remaining microbes. Those familiar with Japanese papermaking will recognize the lignin-rich smells of cooking bast fiber.

After cooking, I rinse and dry the scraps or, to lighten, place them in the sun in a slight alkali bath of 3 - 9% hydrogen peroxide for bleaching. Sunlight bleaching, laying rags on a hillside, and allowing the sun rays to lighten the rags were all common in early papermaking.

I also reluctantly employ modern-day and industrial-revolution equipment to reproduce the pulp characteristics of early papermakers' pulp. A FilaMaker mini shredder (pictured p. 80) can tear the rags apart, shortening beating time and increasing pulp freeness. Fabric is difficult for the shredder, so I soak the rags in methylcellulose to stiffen and harden them, then rinse out the methylcellulose post-shredding.

Beating: In Noble & Wood and Valley beaters, I beat the retted and shredded linen hard in a dilute pulp to shorten the fibers (for a good look-through), then add flax and hemp half stuff and continue beating for a longer, stronger component in the paper. Some batches are beaten separately for long and shorter fibers and blend to make the furnish. The goal is to achieve a "free" pulp, a pulp that speeds sheet formation and couching via a fast-draining furnish. Renaissance mills producing 1000+ sheets per day per vat naturally required a pulp with a high degree of freeness, achieved in part by rinsing away fines, dirt, and impurities left over from the retting of the dirty rags during the hammering stage. At the same time, they often managed to create a well-processed furnish that provided optimal visibility for watermarks and laid lines. The genius of the Renaissance papermakers was to employ hammering processes in conjunction with the enzymatic pretreatment of retting. These two processes combined require less time for maceration (beating) and generate a freer pulp. The reduced maceration time, in turn, leaves much of the fibers' structural integrity intact to produce a sheet with a higher degree of crispness, strength,

Megan Bishop in Magnolia Editions papermaking studio

The author forming 18 x 24-in blue linen sheets

Newly couched paper on Churro felt

Post on left, pack on right

Pressing a small post

44 x 36 in. 50-ton hydraulic press

Valley Iron Works beater

Noble and Wood cycle beater

and skill, despite the freeness of its pulp. In other words, through a careful and considered approach to the timing of such pre-formation processes as retting, rinsing, and hammering, the Renaissance papermakers achieved all of the favorable properties of a free pulp with none of the adverse side effects. Without access to a stamper mill and old, well-worn rags, we are often reduced to approximating these highly complex processes with the resources and tools at our disposal.

A free pulp has the added benefit of being more dimensionally stable, helping sheets dry flatter with less cockling, and facilitating the sizing and finishing procedures. Calcium and magnesium carbonate are added to the furnish as buffering agents. Because the microbes are so effective, the linen is broken down in no time, and the Canadian Standard Freeness is a very high 300 to 400 CSF. To boot, the show-through (laid lines) and the felt hair marks are of high quality. In the vat, blended with other Spanish flax and hemp, the furnish is closer to 400 CSF – still very free by contemporary standards for most paper types.

Sheet formation and couching: For this project, we are forming sheets with paired 18 x 24 inch "antique laid" ribbed moulds (22 wire lines to the inch) and one deckle. It is traditional to work in pairs, with a vatman forming sheets and a "coucher" couching and throwing felts. The choreographed, rhythmic movement allows the efficient production of two sheets per minute. The non-woven felts shed fleece during handling, so a bucket of warm water for rinsing hands helps avoid getting wool clinging to the mould into the vat. Once our modest post of 30 to 50 sheets has been built, we place additional felt and wooden boards on top, insert the post centered in the hydraulic press, and then slowly press to 50 tons.

Parting: The pressed post is removed from the hydraulic press, and the top two felts are peeled off, exposing the top sheet on the interleaved post. The sheet is lifted from two corners of one end. With the edge of the sheet lifted, a slice is placed underneath. Lifting the slice lifts the sheet. Nearby, a board and single felt at a 45° incline are waiting for the pressed sheet. With a gentle flick of the slice, the sheet is laid onto the felt. The next felt is removed and a sheet exposed; this sheet is lifted on the slice and becomes the second sheet of the pack. With a flapping motion, the sheet is "thrown" and lands with a cushion of air, making it somewhat easy to align accurately on top of the previous sheet.

Pack pressing, making spurs: After press the post of interspersed paper and felts to 50 tons (~220 psi), it is separated into stacks of 8, called spurs. We press the spurs again, separated by felts, to 2.5 tons (11.5 psi). For paper with a maximum coarse texture, we skip the pack pressing and dry the sheets individually and unrestrained. Traditionally, the sheets were divided into spurs of 3 to 10 after being pressed in a large pack of 50 or more.

Loft drying (on treble lines): The spurs are hung over horsehair ropes to dry slowly in a warm, humid environment. Once dry, the sheets are separated and allowed to cure for a week or so before sizing.

Drying flat (on drying racks): Our local climate has a low relative humidity (RH). Loft-dried paper allowed to dry unconstrained in this environment tends to dry quickly and unevenly, becoming overly cockled and curled (see image below). Such sheets are time-consuming to coax flat. Consequently, I devised a simple method for the air-drying of paper that minimizes cockling and avoids leaving the dreaded diamond-shaped drying stress marks.

Drying & tub sizing

Placing a pressed sheet onto a pack

Drying: After pressing, I separate the sheets from the damp felts normally (using a slice), then immediately replace each sheet on the same damp felt and racked them to dry along with the felts. The moisture in the felt slows the drying process, allowing the paper to dry evenly. Though it may seem counter-intuitive, I must stress that sheets must be released from the felt (i.e., lifted with a slice after pressing) to develop the felt hair texture. Paper left to dry stuck to the felt after pressing will dry slightly constrained, producing an undesirable pitted texture. Further, a slightly oversize felt produces better anticockling results.

Tub-sizing: We make a dilute hide glue by dissolving refined rabbit collagen crystals in a 3% to 6% solution (we do not use alum), heated to between 100° and 130°. Traditionally twenty sheets of loft-dried waterleaf paper held between two flat sticks at one end are dipped in the hot size, soaked, then stacked on a thin felt. The stack of sized sheets is pressed to .5 to 1 ton (4 psi) to distribute the size evenly and to remove excess. Next, the sheets are removed from the press and allowed to "rest" under a felt overnight. Today we size ten sheets at a time in a photo tray and hang on treble lines to dry.

Immersing paper in hot hide glue size (3%)

Treble line drying, hung using a "T" (aka: cross)

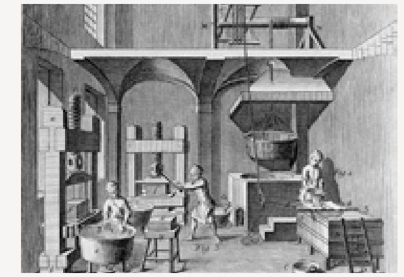
Papers dried individually, unconstrained. Sheets in the left-hand stack were dried on a moist felt; sheets at right were dried on treble lines and flat on taut screen drying rack.

Drying sized sheets: The next day, the moist, sized sheets are dried individually, laid flat on drying racks, or hung on treble lines.

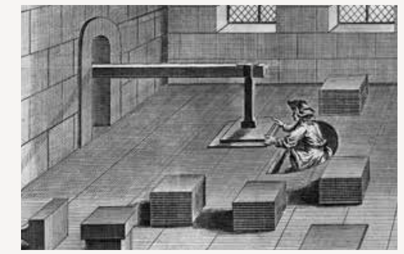
Curing and finishing: To coax a stack of sized and dried paper flat, we start with multiple 5kg weights, then transfer to a six post standing screw press (below) and a progression of gradually increasing pressure. Reshuffling and turning the sheets every day removes the cockling over time. An overly cockled sheet will crease around the edges – a particular textural feature I try to avoid. On occasion, although slow and labor intensive, we hand-burnish the sheets to a smooth and glossy finish.

Greater pressure of a standing press used in the final stages of flattening

Engravings from Diderot's Encyclopédie:



Sizing room (also called the "slaughter house")

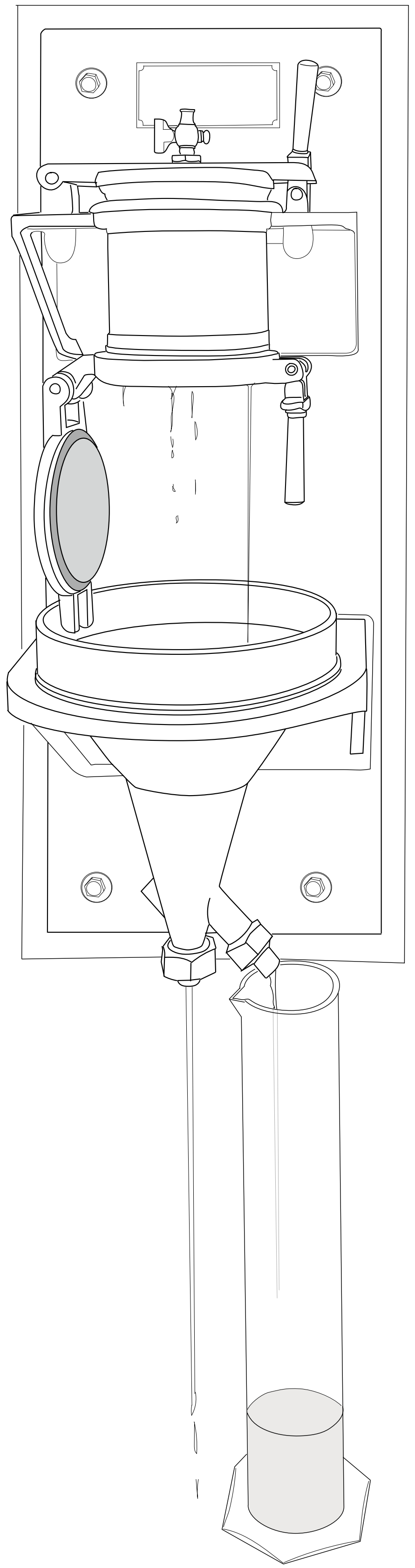


Introduced in 1540, this water powered "glazing" hammer was faster than hand burnishing.

The finishing room

Curing under the pressure of 5kg weights

Hand burnishers



Canadian Standard Freeness Tester

CHAPTER V

Freeness

More on Linen, Hemp and Cotton

RENAISSANCE PAPER TEXTURES
Magnolia Editions

Freeness

With advances in technology, paper fibers can now be tested and measured for variables including length, wall thickness, degree of polymerization, crystallinity, wet compactability, lignin and hemicellulose content, cohesiveness, elongation, and tenacity. Processed pulp can now be precisely tested for freeness, percentage of fines, filler, and pH. Meanwhile, we are able to determine the tensile strength, tear strength, burst strength, wet strength, surface strength, roughness, folding endurance and pH of a dried sheet. Measured by any of these criteria, the long, strong, thick-walled and dense fibers of linen and hemp are superheroes when compared to other papermaking fibers pressed into service today in the West. The structure of fibers in linen and hemp – specifically, their long degree of polymerization and dense crystallinity – are crucial to the successful processing, formation, and drying of a Renaissance-style paper.

Canadian Standard Freeness tester

Recreating the strong, dense sheets of 16th-century European paper with their dramatic felt hair texture requires a pulp (furnish) that is fibrillated but still "free," i.e., not overly processed. The freeness of pulp (the swelling and the inner and outer fraying of the pulp fibers as a result of beating) corresponds to the effectiveness of the refining process. A freer pulp drains faster on the mould, whereas more refinement causes more fraying, breaking and swelling, yielding a slower draining pulp. Rinsing (washing/straining) the pulp during processing aids in keeping furnish free. Sheets made from free, fast draining pulps tend to be softer and more dimensionally stable. With a dimensionally stable, free pulp, the felt hair marks pressed into the sheet from the felt under the pressure of the hydraulic or screw press remain articulated as the paper dries.

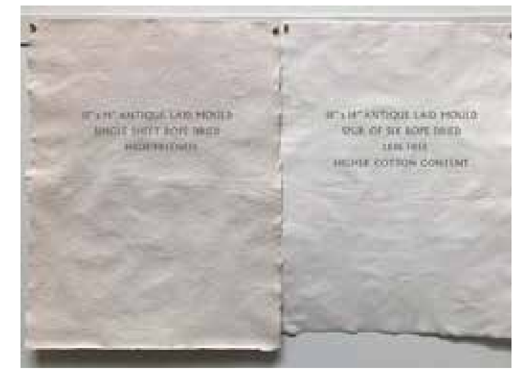
A Canadian Standard Freeness Tester measures how quickly water drains from pulp, allowing us to predict some of the characteristics of a paper while it is still in pulp form. I have found it helpful to approximate the freeness of pre-Industrial Revolution furnish – a retted linen and hemp pulp beaten to 400 to 550 CSF. With such a free furnish we can make an 18 x 24 inch sheet every 30 seconds – but keeping up that breakneck pace for more than an hour or so is daunting.[6]

A free pulp with less hydration and fibrillation (and therefore less fiber-to-fiber bonding) produces a slightly larger, more dimensionally stable finished sheet.

The stamper mills used during the Renaissance were well-suited for making free pulp. Spiky, iron-clad steel heads and flat wood faces were used at different stages of maceration to adjust the breaking, cutting, fibrillation and hydration. Importantly, while the pulp was being beaten, a trickle of water ran into the stamper basin as waste water seeped out through a woven horsehair screen placed lower in the basin. This continuous rinsing, designed to wash the dirty rags as they were beaten, also (possibly unintentionally) removes the "detritus," "fines," or "crill," cellulosic microparticles able to pass through a 200 mesh screen. These particles, separated from the fibers during beating, would otherwise cause a drop in freeness. Rinsed pulp is freer and therefore more conducive to forming a few thousand sheets a day per vat.

In my experience, freeness is best maximized by using well-retted linen, letting the microbes do the work instead of relying entirely on a stamper mill or beater. The necessity of long retting times in my experiments is also due to my use of new textile linen cuttings instead of old linen rags. While it is possible to break and beat the new linen cuttings

Slow (not free) furnish: needed more drainage time. This sheet was tilted on horn too early.



Prior to flattening and finishing, these sheets made on the same 18 x 24 inch paper mould illustrate the influence of processing and constrained versus unconstrained drying: the single sheet test at left has little or no back mark and is larger than a "spur constrained" sheet made from "wet" pulp.

These two sheets were made with the same furnish—the texture difference is a result of constrained and unconstrained drying.

"In my experience, freeness is best maximized by using well-retted linen, letting the microbes do the work instead of relying entirely on a stamper mill or beater."

DONALD FARNSWORTH

without retting, the resulting furnish is very "wet" (i.e., low freeness) resulting in dimensionally unstable sheets that shrink as they dry, thereby smoothing and obfuscating the felt hair marks. Cotton linter beats quickly and can be made free, but I find it too weak to size using gelatin without tearing; besides, my target 16th century-style papers did not typically contain cotton.

Freeness maximizes Cinquecento sheet production by virtue of the speed at which it drains during sheet formation. As previously mentioned, a free furnish also preserves the textural fidelity of the felt fibers in the dried paper surface. Further textural variations depend upon whether or not sheets are dried in spurs. The sheets in a spur constrain one another during drying, reducing texture, whereas individually air-dried sheets, free to move, show an abundance of texture. The example on page 97 shows two sheets from the same post: a spur-dried (constrained) sheet (left) compared to a single (unconstrained) sheet (right).

Note: Papermaking began in Asia, where fibers were beaten with wooden mallets or wooden stampers; a similar practice was adopted by early Western papermakers. Knowing this, I suspected there might be a similarity between the freeness of Renaissance-era pulp and the pulp of traditional Japanese papermaking (washi).

Conventional Western papermaking wisdom recommends fibrillating and cutting fibers (through processing) down to 4 to 5 mm with a freeness below 500 CSF (Canadian Standard Freeness) to make a "coherent sheet." That holds true for most paper, but not Japanese bast fibers like kozo, mitsumata and gampi with fiber lengths up to 12 mm.

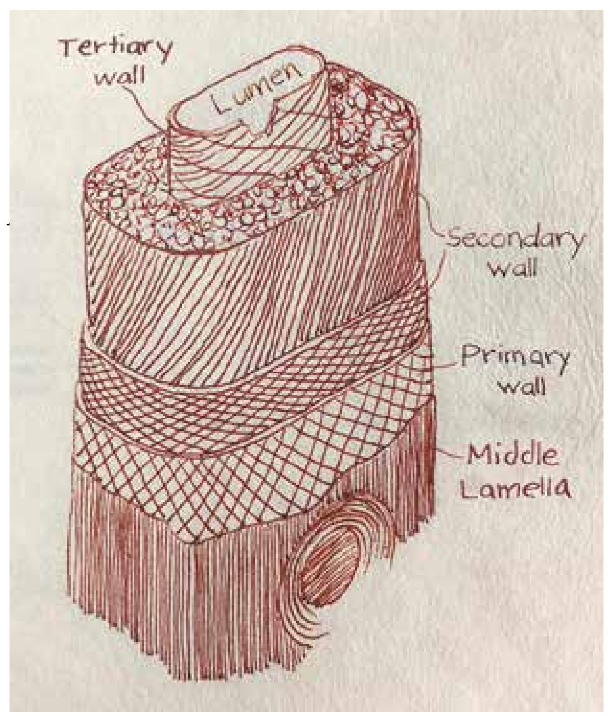
To determine the freeness of washi pulp, I soaked, then cooked kozo bark in soda ash, rinsed and hand-beat the fibers until suitable for making paper. I then dispersed the beaten fibers in water and measured the freeness of the pulp (before the addition of neri, a slippery mucilage the Japanese add as a formation aid). The result: 700^{+} CSF.

Higher freeness values of 600 to 700 may have been the norm from the dawn of papermaking up to the industrial revolution.

In 1979 I witnessed high-altitude papermakers of Nepal distribute hand beaten bast fiber on a cloth-stretched-frame, deftly lifting and tilting as the furnish drained in less than 10 seconds. These heritage techniques of fast drainage and minimal processing give us a window onto the influences on early papermaking in Europe.

Linen, hemp, and Cotton

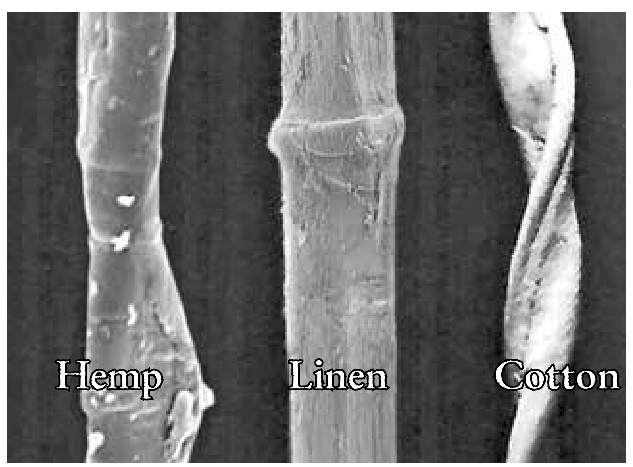
More about linen, hemp and cotton:
Although today's mass-produced fine art papers are commonly made from cotton, it is important to remember that historically, rag paper was produced mostly from linen and hemp. The common assumption that contemporary fine art paper is made from cotton is true, at least insofar as it is made not from rags per se (cotton's staple fiber) but from cotton linter (cotton's seed hair fiber). In Renaissance papermaking, however, the primary raw materials were linen and hemp rags and sisal rope. As Elizabeth Lunning writes in "Characteristics of Italian Paper in the Seventeenth Century" (1989): "There is little doubt that paper pulp was almost exclusively composed of linen and hemp until the eighteenth century." Cotton for use as a papermaking fiber first came into use during the Industrial Revolution with the cotton gin and Hollander beater.[7]



Linen fiber has small lumens and therefore thick walls and high crystallinity; unlike cotton, it is difficult to fibrillate.

Like all living things, flax contains a set of genes that make the plant able to adapt to its surroundings. Interestingly, researchers from the University of Warwick have found that historically these genes were able to thwart artificial selection by human beings, which led to its emergent suitability as a papermaking fiber. Flax became domesticated 10,000 years ago; because it was primarily used for oil, humans artificially selected for the larger, oil-laden seeds. Two thousand years later, as the plant moved through Europe, natural selection led flax's genes to alter its flowering time and architecture, making it taller and better able to survive – but also reducing the seed size, thus making the plant more suitable for use as fiber. In light of this history, it seems logical that by using linen to make our paper, we approximate Renaissance papermaking that much more faithfully: due to its resistance to human interference, the very essence, the DNA of our fibers remains the same as the DNA embedded in the flax fibers of cinquecento papers.

Source: https://phys.org/news/2019-01-impact-flax-evolution-limited-thought.html



***Hemp:** A bast fiber, straight and untwisted. **Linen** (flax): a bast fiber with pronounced nodes. **Cotton**: A seed hair fiber with right hand twists.*

The vast differences between linen and cotton:

Hemicellulose: A branched polymer polysaccharide consisting of shorter chains of 500–3,000 sugar units as opposed to cellulose, an unbranched chain of 7,000–15,000 glucose molecules per polymer. Hemicellulose is a great addition to paper, providing delectable food for microbes breaking apart fibers during retting. When present in finished paper, hemicellulose gives a crisp, dense, sheet with a strong rattle.

Lignin: Cotton has no lignin nor hemicellulose, leaving nothing for the retting microbes to metabolize but the cellulose fiber itself. Having a small percentage of lignin in your raw material during retting is likely a good thing if you want microorganisms to break apart your fibers rather than simply eating the sugars of the cellulose monomers. Lignin is acidic and negative when present in finished paper.

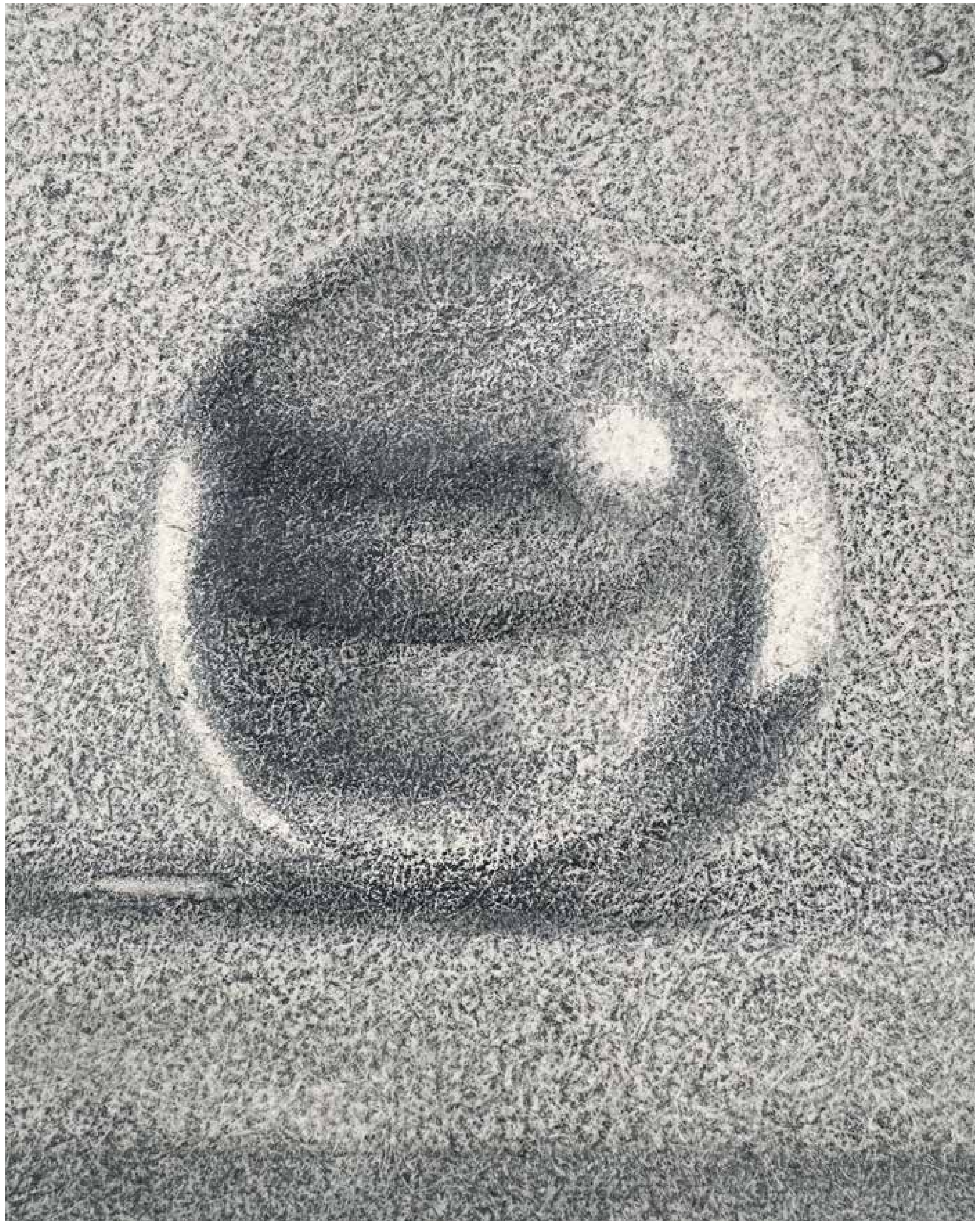
Degree of Polymerization (DP): The number of repeating molecules (monomers) that are linked together to form a polymer (like cellulose). Cotton has a DP of 7,000–15,000. Linen has a DP of up to 18,000 which makes it the longest known, (natural) linear textile polymer.

Crystallinity: Indicates that the fiber molecules are closely packed and parallel to one another. Higher degrees of polymerization and crystallinity of polymers are associated with higher strengths. The average crystallinity of linen is 90% while cotton is a lower, but still respectable 73%.

Freeness: Cotton fibrillates more easily than linen and hemp, resulting in a slow draining pulp. This would inhibit efficient sheet production, discouraging most Renaissance paper facilities from using cotton rags.

Elongation: Linen is a strong and not very elastic fiber due to the tightly packed hydrogen bonds of its highly crystalline structure. Cotton, on the other hand, with its spring-like, twisted structure and lower crystallinity, has more elasticity than linen or flax, yielding a softer sheet of paper with less tensile strength.

Tenacity: Linen's bast fibers grow in the outer layers of the flax stem, comprised of long cells rich in cellulose; its high crystalline structure allows its long polymers to form more hydrogen bonds, yielding paper with a very high tensile strength. Linen's tenacity increases with the humidity.



2018 chalk drawing by Guy Diehl; note the rich galaxy of textures created when pigment meets the coarse, felt-hair marked sheet.

CHAPTER VI

Media Tests

Marks made on Magnolia Editions test papers

Media tests on paper made at Magnolia Editions

Furnish: retted linen cuttings (from textile industry sources), sisal and hemp (with calcium and magnesium carbonate)

Other additives: pigment, Hercon 100 (internal size) and retention aid (a cationic starch)

Freeness: approximately 600 CSF

Mould: antique laid 18 x 24 inch mould (no watermark)

Drying: couched on coarse Navajo-Churro fleece felts (non-woven), post pressed to 50 tons (230 psi); no second pressing, single sheets dried flat with no restraints (no back mark)

Sizing: Waterleaf or internally sheets were tub-sized in a 3 to 5% solution of hot hide glue.

Media: chalk, graphite, watercolor, acrylic, color pencil, fountain pen and ink, handmade carbon ink using burnt coffee beans and gum Arabic

"

In works of art, paper and image are integrated physically, but they are integrated visually as well. […]Delicate variations in the tone and level of the paper surface are an inseparable part of the visual experience. The image is a part of the paper as the paper is a part of the image.

These are subtle points, and although they are very obvious and important to an artist whose pleasure is in making, or to a collector or connoisseur whose pleasure is in looking, they are often overlooked and sacrificed by conservators in the process of treatment. […] Since the paper and medium are one, we have to consider them as one whole and treat them accordingly.

"

KEIKO MIZUSHIMA KEYES,
"THE UNIQUE QUALITIES OF PAPER AS AN
ARTIFACT IN CONSERVATION TREATMENT," 1978

Cutting natural red chalk (aka sanguine)

Cutting natural (quarried) red chalk into sticks for chalk holder (below)

Modern day chalks: *Mixed, compressed and baked clay, pigment and graphite. Patented in 1795 by Jacques Conté.*

The chalk of the Renaissance: *Natural black, white and red chalk: impure minerals excavated from the earth and ready for drawing without any processing. They were cut into sticks, sharpened and inserted into a carved handle/holder.*

Guy Diehl
Reference to Georges Seurat: Portrait of Edmond François Aman-Jean, *2017. Charcoal pencil on waterleaf test linen and hemp paper, 13 x 12.5 in.*

Artists Guy Diehl, April Funcke, and Marc Goldyne made chalk drawings on early test linen sheets that, in my mind, are overly textured. I believe this paper was the best I had at that time. When the bumps on a paper's surface get exaggerated, it becomes difficult for an artist to force the chalk medium into the low pits in the surface while drawing. In such cases, shadow detail will suffer – or the artist can suffer and achieve their desired results only through determination and perseverance. I believe these artists had to suffer to arrive at these excellent works.

April Funcke, After Raphael, *2018. Red quarried chalk on 2018 Magnolia linen, hemp paper*

Detail

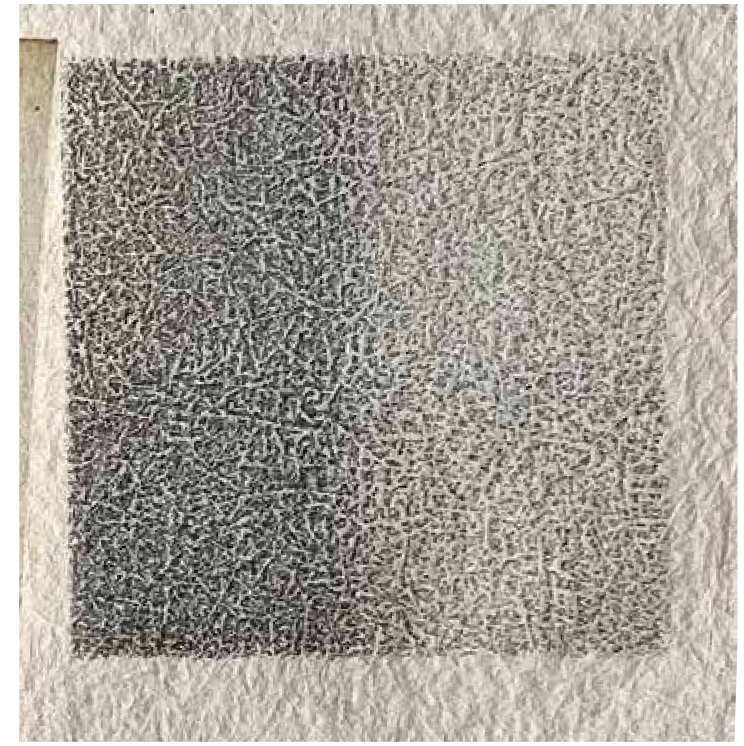
Marc Goldyne, *Red chalk drawing (after Pordenone) on 2019 Magnolia linen, hemp paper*

"Good paper, a few scratches in black ink, some red to set off the black, and there (as Aesculapius had the habit of saying to Thessalonians) you are. In short, 'let paper do most of the work.'"

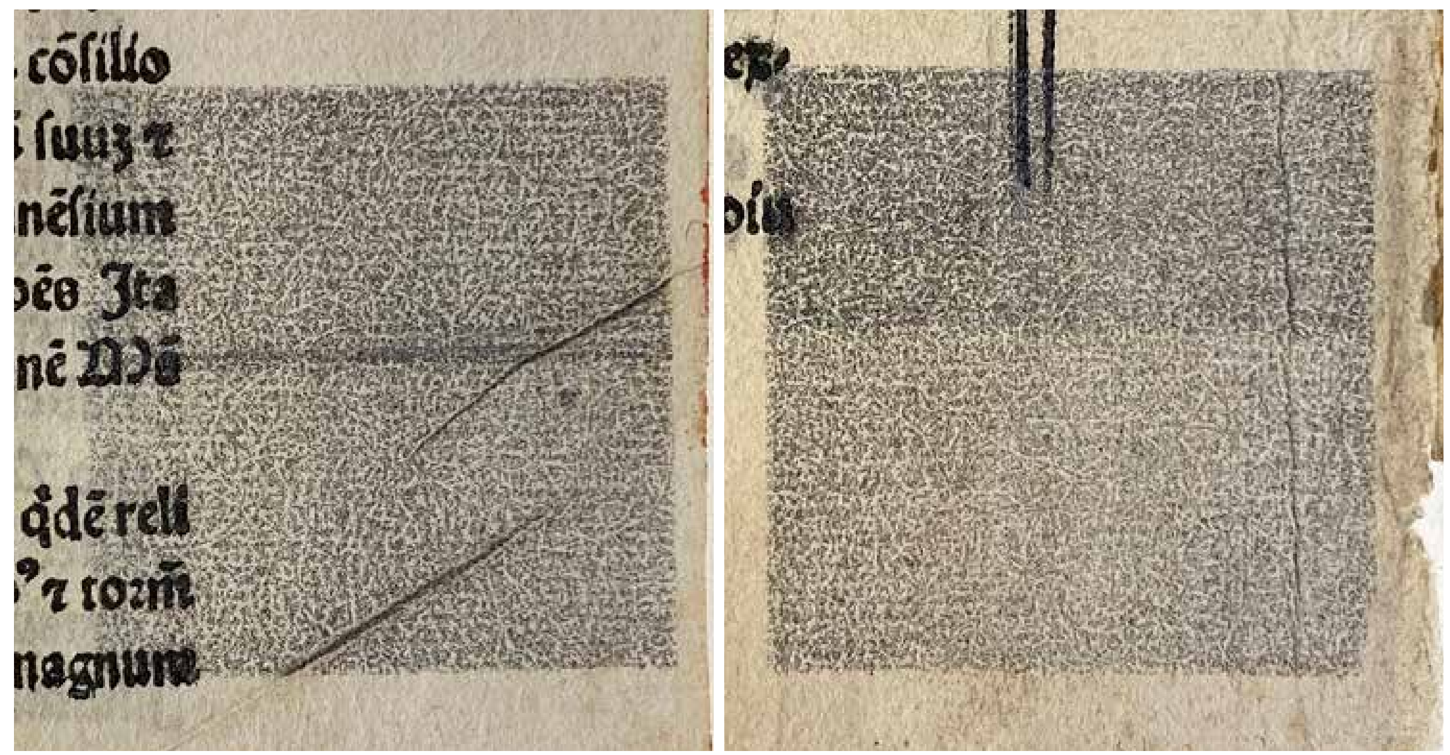
OSWALD COOPER

Mechanically comparing our paper's surface texture to 15th c. papers

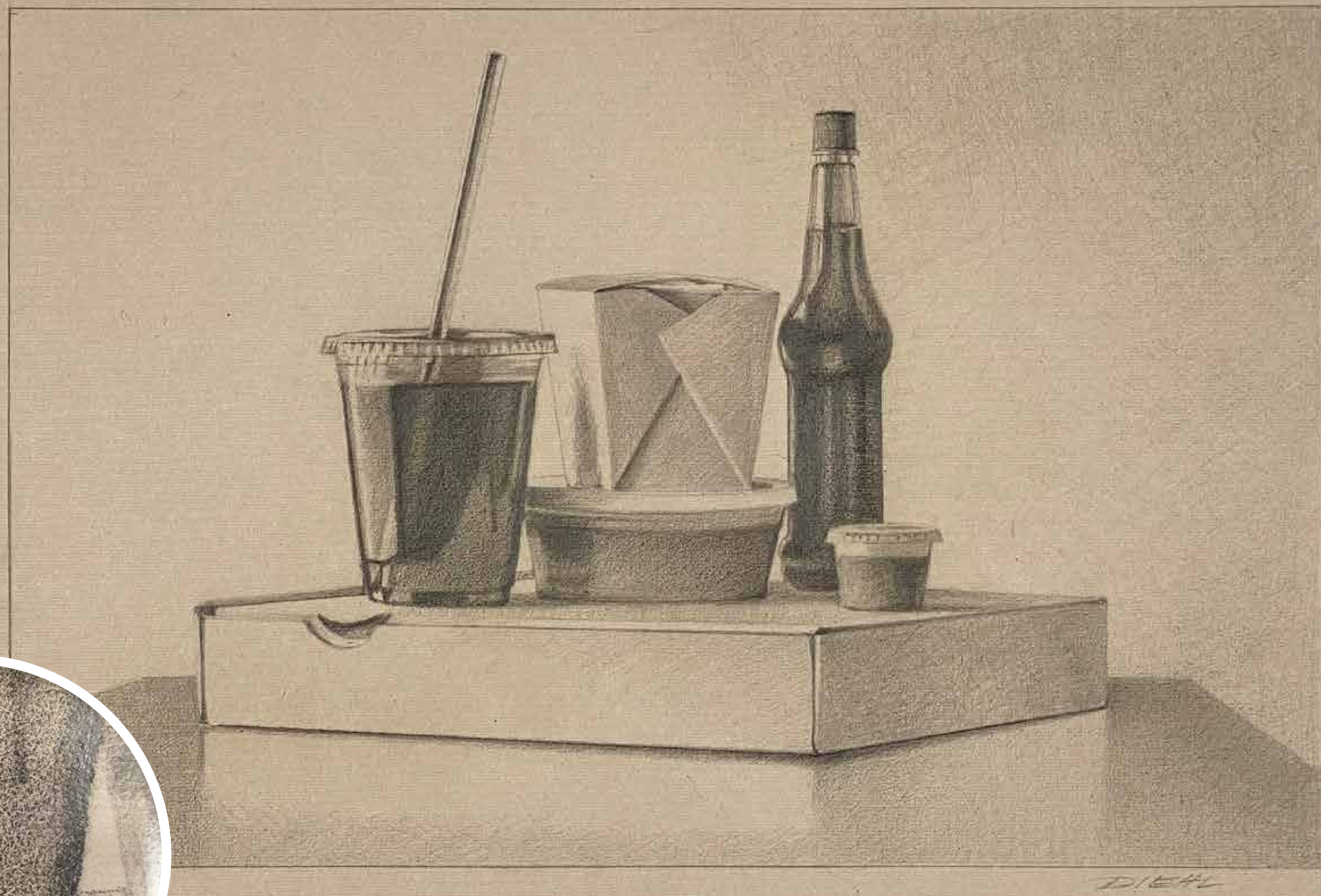
Magnolia Editions pencil drawing plotter
2B lead, .07mm, 41g pressure, 3.5 x 3.5 mm graphite



Magnolia Editions 2021 paper with felt hair marks
2B lead, .07mm, 41g pressure, 3.5 x 3.5 mm graphite



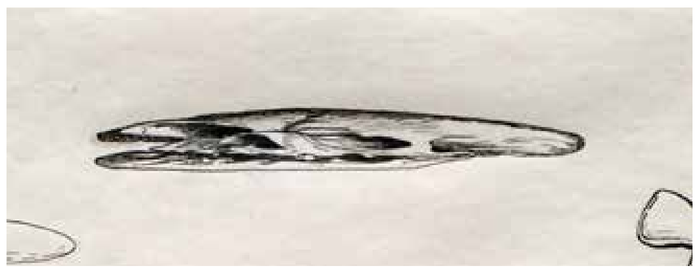
Dergomensis, *Brescia, 1485 – recto & verso with backmark. 2B lead, .07mm, 41g pressure, 3.5 x 3.5 mm graphite mechanical drawing*



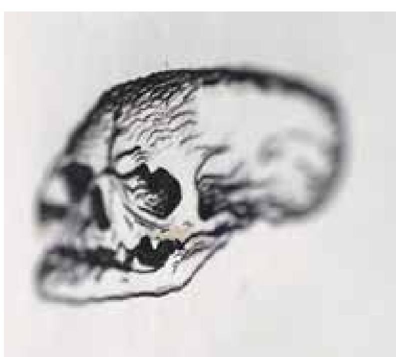
Guy Diehl
Take out still life, *August 2020*
graphite on linen and hemp, 2021. 18 x 24-in.

Detail at left

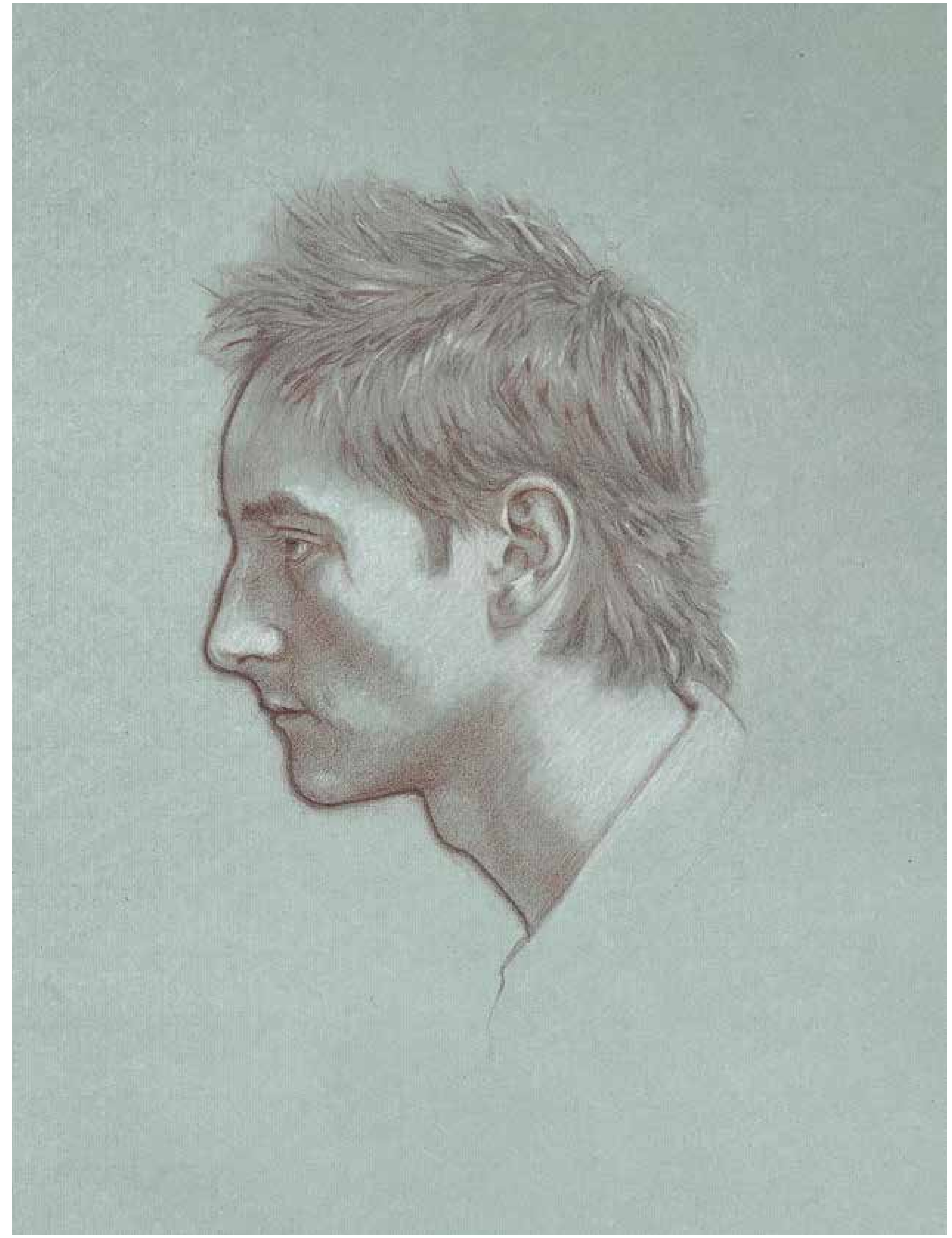
Enrique Chagoya, Anamorphic Skull, *2018*
Pen and ink on Magnolia linen and hemp paper, 18 x 24 in.



Viewed from a low, oblique angle

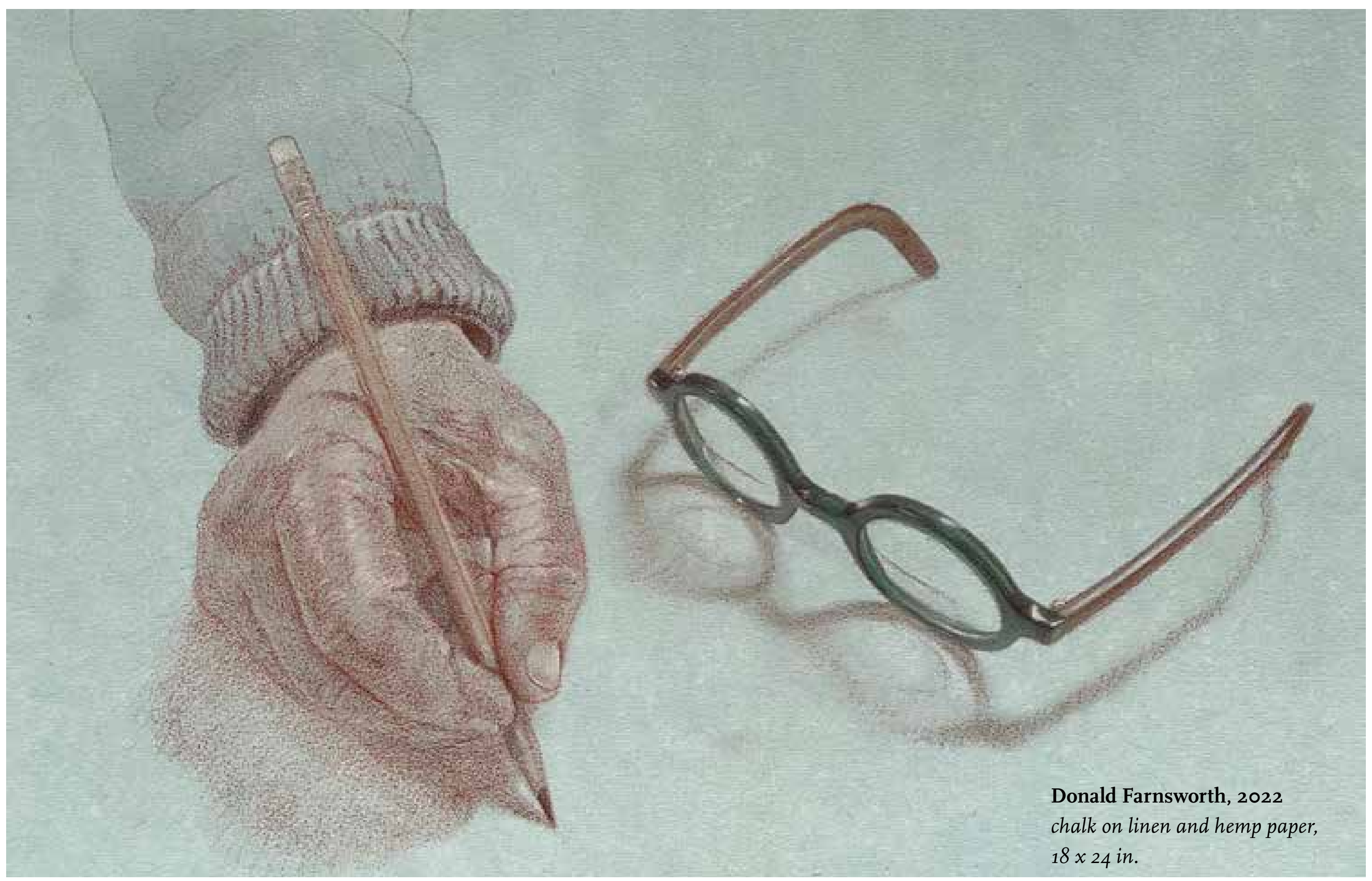


Kara Maria, Lulu, *2018*
Graphite pencil on Magnolia linen and hemp paper. 18 x 24 in. (Detail)
Enlarged detail below



Donald Farnsworth, Portrait of Max Thill, *2022*
Chalk on blue Magnolia linen and hemp paper. 18 x 24-in.

Donald Farnsworth, 2022
chalk on linen and hemp paper,
18 x 24 in.

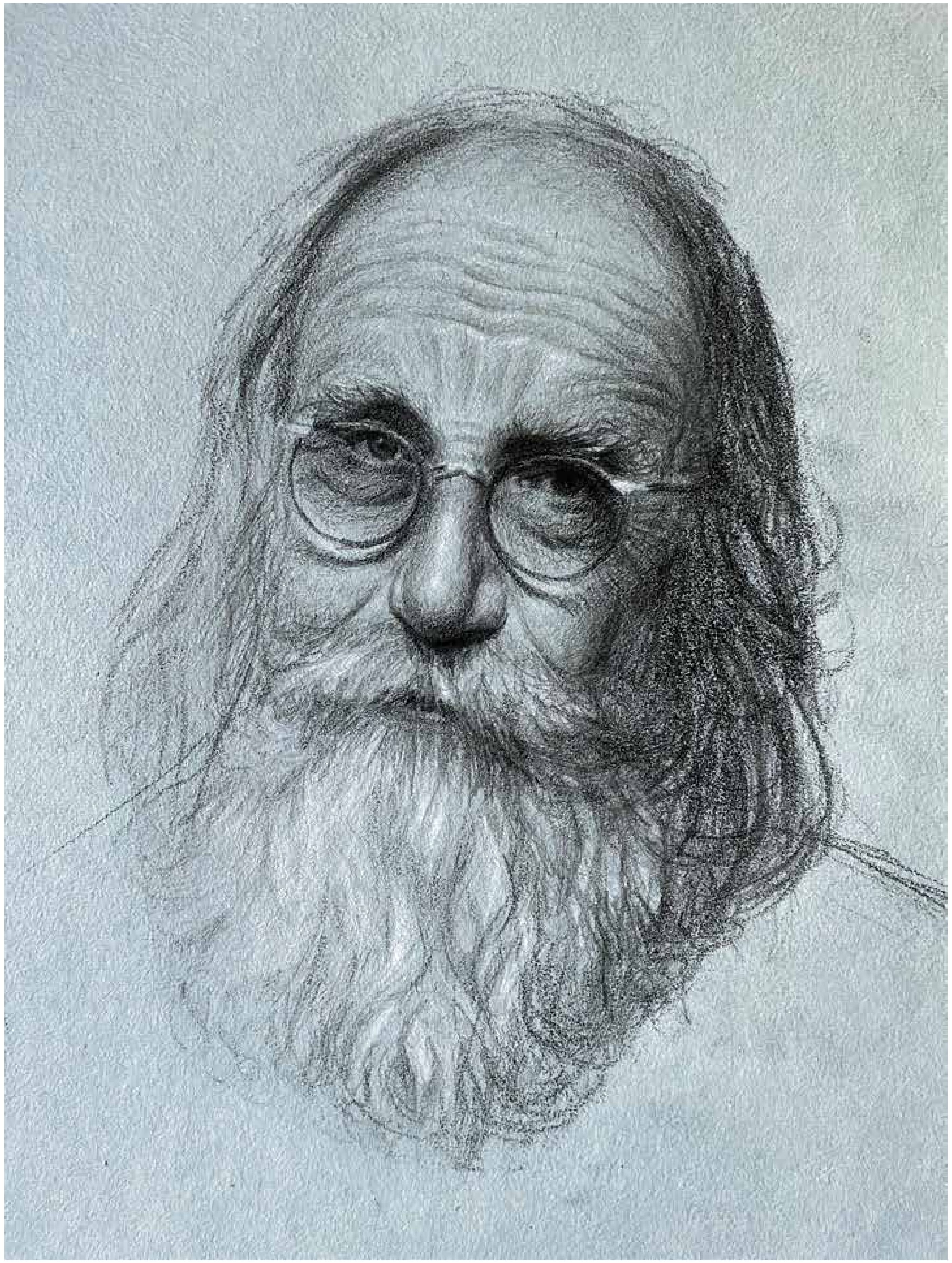


Donald Farnsworth, 2022
chalk on linen and hemp paper,
18 x 24 in.

Megan Bishop, Filoli Garden Apple Study, 2021
Pencil on test linen paper, 18 x 24 in.

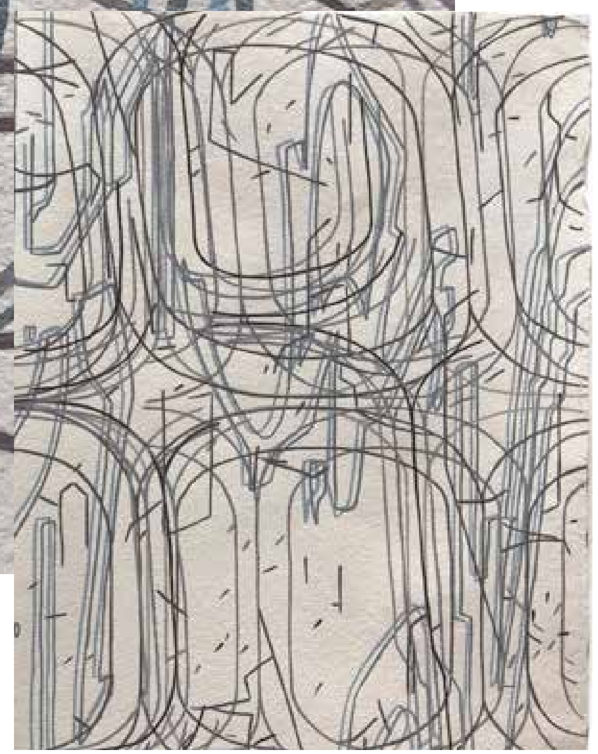
“Works of art on paper are intimate objects. They are usually small in size and were meant to be seen at close range. [...]The interplay of the paper with the medium is always crucial to the visual effect.”

KEIKO MIZUSHIMA KEYES,
THE UNIQUE QUALITIES OF PAPER AS AN ARTIFACT IN CONSERVATION TREATMENT, 1978



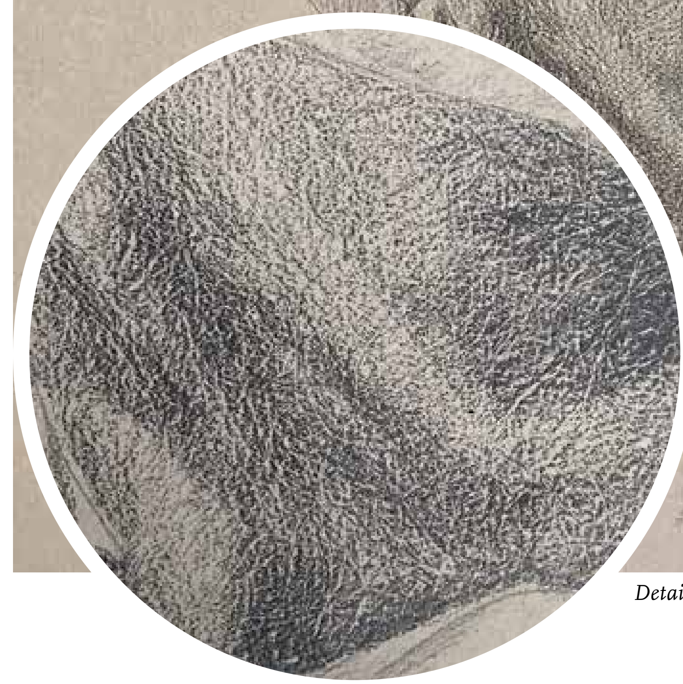
Max Thill, Portrait of Richard Seibert, **2022**
Graphite on Magnolia linen, hemp paper

Detail



Amy Ellingson, 0.7.11.18 No. 6, *2018*
Gouache and graphite on test paper, 12 x 9 in.

Detail



Detail

Hung Liu, Self-portrait, **2020.** *graphite on linen paper, 18 x 22 in.*

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Notes

1: Navajo-Churro felts (non-woven heritage wool); an "antique laid" set of paper moulds and deckle; vat, bridge and horn; press, hydraulic and standing; refining equipment, beater and mini-stamper (albeit from a later era); stainless steel pressure cookers, autoclave; couching table, felt stand and slant table for parting; composting bins; tub with accurate heating element for sizing, horsehair rope for treble lines; testing equipment; calipers, freeness tester, scale, tear tester, cobb sizing tester, microscope; smaller tools of all sorts; a slice, tweezers, etc. – all were crucial elements in assembling an appropriate setup for unraveling the early papermaker's process.

2: When sizing with hide glue, alum (aluminum sulfate, aka papermaker's alum) was often added to render the sheet more water resistant. However, alum also makes paper more acidic. (p. 29)

3: A dilemma likely faced by early papermakers: back marks could be avoided by drying single sheets one at a time hung over a horsehair rope, but at the expense of smoothness, as these sheets will demonstrate heavy felt texture and cockling. On the other hand, sheets hung to dry grouped together in a spur will possess smoother felt texture and less cockling, but will also receive strong *back* marks on the sheets closest to the rope. In the end, both issues were manageable: strong felt texture could be burnished or hammered out to some extent, and although back marks do not burnish out well, they could be hidden in the gutter of bound folio or plowed off.

4: In the process of creating their timeless works on paper, Michelangelo and his contemporaries would certainly have gained experience working with (and around) back marks. If the back mark was off-center, as is often the case when a sheet or spur is hung at an angle on the rope, then trim dimensions would need to be altered accordingly; paper with a diagonal back mark would require a creative approach to cutting down, while paper with wider back marks from heavier ropes would make for a smaller final sheet.

5: In contrast to the formation of antique paper, modern machine-made paper pulp is only shaken from side to side, producing a more pronounced grain directionality as the pulp flows from the head box. There technically remains a felt side and wire side (since furnish flows onto a moving wire mesh and shaken from side to side before being transferred onto a felt). However, a wire cylinder pushes a screen pattern and watermarks into the pulp prior to the transfer to felt: therein lies the difference. This textural device is called a "dandy roll," and causes both sides of the paper to come in contact with wire. Thus, for machine made paper, there is a discrepancy in terminology: for clarity, the terms "top side" and "bottom side" have been added to machine made papermaking's nomenclature.

6: Historical accounts suggest that Renaissance-era papermakers could make 2000 sheets per vat daily. By my calculations, even with pulp at 400 to 550 CSF and forming a sheet every 30 seconds, that quantity would require a 16 hour day with no coffee or lunch breaks! Professor Timothy Barrett with a crew of 12 students performed production speed tests at The University of Iowa Center for the Book and found that using cotton linters beaten to about 550 CSF, his crew were able to make 50 (12.5 x 18 inch) sheets in 12 min, recharge the vat, and be back at work on the next post in 3 min (totaling 15 min), yielding 200 sheets an hour, or a sheet every 12 seconds. They succeeded in forming, pressing and hanging 2000 sheets in one work day. (Video available on YouTube: search for "Chancery Papermaking 2016—2000 Sheets in One Day.")

7: Though cotton (muslin) was highly sought after during the Renaissance – whether imported from India and the Orient or grown in Moorish Spain – it was rarely used for papermaking. Microscopic analyses by Thomas Collings, Derek Milner, C.M. Briquet and Julius Wiesner indicate that cotton, although available, was not used until the Industrial Revolution.

8. Wet sheets after pressing are extremely hard to handle without inflicting damage. If the sheets after post pressing retain too much moisture and are excessively thin, more pressure and more time is needed in the press. Excessively wet sheets can also be caused by using oversized felts. The edges of these felts retain water that wicks back into the pressed sheets after the pressure is released.

Acknowledgments

Photos: Donald Farnsworth and Magnolia staff
Editor: Nick Stone

Magnolia Editions Staff:
Directors: Donald & Era Farnsworth
Master printers: Tallulah Terryll & Nicholas Price
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Interns: Sam Pelts, Willem Smith-Clark, Arlene Kim Suda, David Wild, Krista Wright, Cierson Zambo
PaperWeight coding: Nicholas Price, Alex Shepard, Jordan Grelling

With thanks to:
3-D Printed mould files: Brian Queen, Nicholas Price
Consultation: Tim Barrett, Nick Pearson, Peter Bower, and Curators from the Paper Conservation Department, Sherman Fairchild Center for Works on Paper and Photographic Conservation, The Metropolitan Museum of Art
Woodworking: Miguel Mendoza
Felt supplier: Lana Dura
Italian felt making: Cristina Biccheri
Italian research & assistance: Elizabeth Wholey, Gianni Berna
French stamper mill: Jacques Brejoux Nadine Dumain, Le Moulin du Verger
Royal Collection Trust, Windsor
Victoria & Albert Museum
Books for back mark photos: Peter Koch, Bruce McKinney
Pure linen: Rough Linen, Marin, CA and Jacquard Fabrics, Healdsburg, CA
Flax half-stuff: Celesa, Barcelona, Spain

"Save Rags" watermark, Inferior Court of Common Pleas, Suffolk, 1797 Oct. Colonial Society of Massachusetts; image Social Law Library, Boston

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