

BEATER FINESSE

FOR THE ARTIST

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It is a well-known adage in the papermaking world: “Paper is made in the beater.” To learn how to use my own Hollander beaters with more efficiency and diversity, I surveyed my colleagues and conducted research on how to create different kinds of pulps for a variety of uses. As a result I have compiled 32 beater note entries, by 25 contemporary, international papermakers and paper artists. The beater note entries and a table that summarizes the notes are available on my website, www.papermakingresources.com. With the publication of the beater notes and this article which puts my research into context, I hope the reader will use these resources as a general springboard from which to base one’s own explorations. The art of beating plant fibers into pulp is quite subjective. One develops a visceral understanding of how pulp looks and feels through experimentation and avid note taking!

BEATERS

The Hollander beater was invented in the late seventeenth century in Holland for the preparation of rags or fibers into pulp for papermaking. Its main components are a cylindrical roll fitted or cast with metal flybars or knives under which lies a bedplate, a grooved and curved surface that conforms to the roll. As the roll turns, fiber and water are forced between the roll and the bedplate, resulting in a cutting, shearing and hydrating action. The fiber and water continue up and over a backfall, around an oval trough, and back to the roll.

Beater designs differ widely in the shape of the tub, the placement of the bedplate, the distance between the flybars on the roll, the width of the blades, the depth of the cell (the space between the blades), and the shape of the backfall. The Voith Valley “laboratory testing” beater, with a fixed roll and a moveable bedplate, uses an arm with attachable weights to raise the bedplate up and down to bring it closer to or further from the fixed roll. On the contrary, many contemporary studio-size beaters (such as those made by Howard Clark, Lee Scott McDonald, David Reina, Mark Lander, and Peter Gentenaar) have a fixed bedplate and an adjustable roll. My goal here is not to compare the mechanics of different Hollanders. Even two machines by the same maker can produce varying results due to user patterns, water quality, care, and maintenance. With this article I intend to focus on what they all share in common: the ability to produce a wide range of pulps.

BOTANY AND PAPERMAKING

Prior to beating, a papermaker must take into consideration the qualities of the raw material to be beaten. Howard Clark tells us “The proper fiber is whatever works for whatever your desired end results may be.”¹ And to paraphrase Wavell Cowan, it is important to choose a fiber based on how efficiently one can use the strength inherent in the raw material.² With experience comes the ability to choose one plant fiber over another for known properties or to mix particular fiber sources to achieve their combined qualities within one sheet.

Understanding the rudiments of plant fiber structure and chemistry—particularly cellulose and hemicellulose—is essential to good beater practice.³ Plant fibers are fundamentally all hollow cylinders. Their basic structure varies in the thickness of the walls, and how the cellulose molecules spiral to create the cylinder. Found in the cell wall, cellulose and hemicellulose are the stuff of paper. They are *hydrophilic* (water loving) and bond readily when brought into close proximity. During the beating process, we are refining the cellulose and hemicellulose to create useable pulps. Lee Scott McDonald outlines the variables we must keep in mind as we determine how best to beat a given fiber: the average fiber length; bulk and texture; intrinsic strength; wet fiber compactibility; and cohesiveness in bonding. He cautions us that fibers within the same plant family can also yield differences depending on how and where a plant is grown; what time of year it is harvested; and how and for how long the fiber is retted or cooked to remove the lignin and other non-cellulose components.⁴

In *Science for Handpapermakers*, Cowan asserts that beating is one of the most mystifying parts of papermaking for beginners, skilled craftspeople, and scientists alike. “The mystery of beating is greatly enhanced by the mystery of the fiber and explains why the expected results of beating the next batch of a favorite fiber can turn out, unexpectedly, to be different from the last batch.”⁵ The main effects of beating are threefold: cutting and shortening; abrading or fibrillating the fiber walls; and internal crushing, bruising, and splitting.⁶ During beating, the cellulose walls are cut and crushed between the bedplate and the beater roll, leaving jagged ends and a roughened up surface. As the abrasion increases, more and more tiny hairs (or fibrils) appear on the main shaft of the fiber. As water molecules attach to the fibrils, the overall surface of the fiber increases. “Fibrillation also creates a more flexible fiber for better interweaving, and helps flatten the fiber to increase density.”⁷ The more the fiber is fibrillated, the more debris or broken fibrils—known as fines—are created. Fines fill in between the fibers during sheet forming and can increase a pulp’s smoothness and opacity. Fibrils and fines in a pulp also promote better inter-fiber bonding, creating a sheet with a durable surface.

HISTORICAL TERMINOLOGY FROM THE INDUSTRY

As paper artists and contemporary studio papermakers, we can learn more about the terminology used in the machine-made paper industry in order to gain a common vocabulary with which to converse with our industry colleagues from whom we can learn a great deal. An important resource outlining industry terminology for the hand papermaker is a short article titled “How to Beat Paper Fibers the Right Way” by Swiss-born Fred Siegenthaler, papermaker and founder of The International Association of Hand Papermakers and Paper Artists (IAPMA). Siegenthaler apprenticed at the Biberist Papermill in Switzerland in the mid-1950s where he learned how to beat pulps for 300 different types of paper. “For example, blotting paper is made out of unbeaten long fiber pulp, whereas parchment is made out of a very highly beat, so-called short, wet stock. Both qualities contain no size at all and are totally different from each other as far as the quality and appearance, as well as the strength and water absorbency, are concerned. These differences are all created simply by beating the fibers in a different way.”⁸

In the papermaking industry, pulps are referred to in terms of their rates of drainage: pulps that drain quickly and are not swollen with water are termed *free* (or fast) and pulps that are slower to part with their water after sheet forming are termed *wet* (or slow). Wet stock (or wet stuff, as it is referred to in England) is pulp that is hydrated to such an extent that it needs intense pressure or suction to part with its water. Sigurd Smith explains in *The Action of the Beater*, “As its water

drains away, wet stuff will form a more compact and thinner layer than free stuff... The softness or plasticity of the [wet] fibres, therefore, tends indirectly in two ways to improve the strength of the sheet. Firstly, wet beaten fibres feel better than free stiff fibres. Secondly, the reluctance of wet stuff to part with its water allows more time for the shake on the wire to take effect and felt the sheet.”⁹

Besides free or wet, pulps are characterized as being short or long. To produce short-fibered pulps, it is important to have strong contact between the roll and bedplate and to use less fiber and more water in the beater. “If the quantity of fibres to water is relatively small, the shearing [or cutting] process will progress more quickly than when the amount of fibres is more substantial. In the first case, virtually all the fibres will come in direct contact with the knives. In the second case, they will protect one another and the contact with the knives will have a more crushing and shearing effect on the fibres...”¹⁰ Long-fibered pulps result from a higher fiber-to-water ratio in the beater and by increasing the distance between the roll and the bedplate in order to reduce the cutting action and promote abrading and fibrillation instead. Greasy pulp is another term suggested by the look and feel (wet, shiny, slippery) of pulp that has undergone a lengthy beating time. By crushing (rather than cutting) the fibers, water is forced into the interstices of the fiber, creating a pulp that drains very slowly and often produces a high-shrinkage paper with a crisp, ratty sound.

Siegenthaler categorizes four types of pulp:

Long Free Stock, originally used unsized for blotting and filter papers: Use 24 percent to 50 percent less pulp “as for normal beating” but the standard amount of water. The “Hollander roll must never touch the knives of the ground plate. The greater the distance between the roller knives and ground plate knives, the fewer fibers are cut and this results in an almost perfectly pulped long free stuff.”

Short Free Stock, originally used to make offset printing papers for good opacity: Dilute the stock using the same pulp concentration as above. “Lower the Hollander roll as far as you can immediately after filling the beater. The knives of the Hollander roll and those on the ground plate must cross each other perfectly, i.e., metal on metal with a lot of pressure. This is the only way to cut the fibers apart and remember, the thinner the stuff, the better. The beater actually works like scissors.”

Greasy Long Wet Stock, suitable for products that are subject to high wear such as map papers, papers for documents, and files: Use a highly concentrated stock with as much fiber as possible, and keep a small separation between the roll and the bedplate knives. “Defibrillation of the single fibers takes place by an art of kneading the fibers upon each other between the knives but not cutting them. The greater the distance between the knives of the roll and the ones of the ground plate, the longer the beating takes and the longer the fibers remain.”

Greasy Short Wet Stock, originally used for cigarette papers, transparent papers such as artificial parchment and glassine papers, and wrapping paper for meat and cheese: Use the same concentrated stock as above, and “when the stock is greasy enough, you take half of it out of your beater, dilute the rest with water and beat the fibers short by lowering the roll (metal to metal with high pressure) to shorten the fibers.”¹¹

THE CONTEMPORARY PAPER ARTIST: BEATING FOR PARTICULAR MEDIA AND SUBSTRATE USE

To summarize, when working with a Hollander beater, the papermaker can control: 1) the ratio of fiber to water (the density of the pulp); 2) the beating time; and 3) how and when one manipulates the pressure of the roll against the bedplate.¹² Finesse is gained by taking these three factors and the choice of fiber into consideration. In my recent interviews with contemporary paper artists and papermakers, I found numerous similarities in beater practices and many interesting and nuanced differences. However, before I move into a comparison of our colleagues' beater notes, I would like to make a few clarifications. As I discussed earlier, every beater beats differently, so please use this resource as a guide, not as a recipe book. Also, when I use the term "100 percent capacity" or "full fiber capacity," I refer to a high fiber-to-water ratio, one that still rotates smoothly in the beater. "50 percent fiber capacity" refers to a beater load that is diluted to half of full fiber capacity, and so on. Each fiber source has its own density and will absorb water in the beating process differently. Through experience, the papermaker will come to know what a "full" beater load might be for a particular fiber in his or her own beater. Note that it might not match the amounts recommended by the beater's manufacturer. To discern the fiber-to-water ratio for consistency between one's own paper batches, Brian Queen suggests, "Use the weight of the fiber divided by the weight of the water. Using the metric system, one liter of water weighs one kilogram (handy isn't it?). So 360 grams divided by 23 kilograms (360 grams divided by 23,000 grams) equals 1.565% or rounded off 1.6%."¹³

Among those whom I surveyed, I found that many papermakers follow a set protocol when beating, regardless of the type of pulp: they load the beater to its maximum capacity with the roll and bedplate separated to start until the pulp is circulating smoothly, then they quickly increase the contact between the roll and the bedplate to achieve "metal on metal" beating for a certain amount of time. At the end of the cycle, some papermakers lift the roll for a short period to allow the pulp to circulate which helps to beat out any knots or "high spots." Using this method, both Shannon Brock and Lynn Sures beat flax to use for pulp painting. Brock beats hers for about four hours; and Sures, anywhere from three to eight hours depending upon the length of fiber desired. For smooth sheets to use in photographic and digital printing, Marilyn Sward beats this way as well, combining flax and abaca fifty-fifty at full capacity for a total of two and a half hours. With a similar beating strategy, Betsy Dollar creates a four-hour abaca pulp (loaded to full capacity) that is appropriate for pulp spraying large 4 x 8 foot sheets for use in installation and bookworks. Priscilla Robinson utilizes the same abaca fiber, but loads the fiber amount to 60 percent capacity and beats it for twelve to fourteen hours in order to achieve a high-shrinkage pulp for sculptural embossing.

Origami artist Michael LaFosse designs pulps to accommodate the subject matter of his folded forms. When LaFosse folds an insect form, his fiber of choice is abaca because it yields an extremely thin, crisp crease with high tensile strength. To achieve the right pulp, he loads the abaca fiber to two-thirds capacity and beats it for two to three hours with the roll and bedplate at maximum pressure. This beating method creates a lot of fines in the pulp which gives him the qualities he needs. In contrast, when he folds a mammal such as a piglet or a puppy, LaFosse requires a paper that is more spongy and compressible. To achieve those qualities, he blends between 70 percent and 80 percent first-cut cotton linters with 20 percent or 30 percent abaca respectively. By loading the beater to full capacity and beating for 45 minutes with the roll and bedplate at maximum pressure, LaFosse produces sheets that are twice as thick as a soft-cover book paper. And the paper gives him a particular shaping with his wet-folding techniques. Like

the other papermakers mentioned so far, LaFosse concludes the beating cycle for his pulps by opening up the distance between the roll and bedplate to increase hydration and to “brush” or “card” the pulp in order to get rid of knots and tangles which he refers to as “twin stars” (two knots tied together by a little string) or “spectacles” (two lenses connected by a nose bridge).¹⁴

Margaret Prentice delineates various stages of brushing through auditory cues: A “light brush” occurs just when one begins to hear a louder sound when lowering the roll and a “medium brush” is louder still, perhaps halfway to a “hard beat” when the roll is in contact with the bedplate. When the roll and bedplate are at the maximum distance apart, Prentice refers to the beater action as “stirring.” She usually adds sizing or other chemistry while the pulp is being stirred.¹⁵ For woodblock-printing paper, Prentice brush beats abaca fiber (at full capacity) in order to maintain fiber length for better felting action and to hydrate the pulp for increased bonding. She strives for paper that resembles Japanese kozo paper, a soft, strong paper that will take oil-based printing ink well. The same paper can also be used for etching.

In contrast, MJ Cole makes paper for woodblock artist Maria Arango, using ripped-up cotton rags (sometimes with plant fibers added for texture). Cole brings the roll into contact with the bedplate as soon as possible after loading the fraying cloth. The timing of the beat is highly variable depending on the quality and newness of the cloth. She has found that old, well-worn cotton beats down in as little as two hours while newer “harder” fabrics may take six hours or more. Cole uses visual and tactile cues to decide when the pulp is “done.” Margareta Mannervik concurs with Cole’s timing and observational cues while beating rag. In order to keep the fibers as long as possible and strong enough to withstand the pressure required to print linoleum blocks with deep cuts, Mannervik chooses either cotton or a combination of cotton and linen rags for her embossed paper. She increases the pressure of the roll and bedplate slowly from one to three hours (depending on the rag), continuing with a hard beat for another three to six hours. She used this pulp to cast a series of rock forms in plaster molds for a collaborative installation and bookwork we produced together with four other artists. Half of the paper rocks were cast in Sweden and half in Arizona, but I used different techniques for beating.

Using cotton rag half stuff, I strived to create a long, free stock, a low-shrinkage pulp with relatively long fibers so that the casting would maintain strength but dry with good surface detail. The total beat time was 45 minutes, loading the fiber at full capacity with the roll and bedplate separated for five minutes. After feeding the beater, I brought the roll and bedplate together until just hearing a grinding sound for a twenty-minute light brushing, then let it run for a fifteen minute hard beat with a very intense grinding sound. Finally, I lifted the roll just until the point where there was no grinding sound, and brushed the pulp for an additional five minutes.

Watermarked paper requires a completely different pulp. For chiaroscuro watermarks, Brian Queen prefers a short, free stock. He uses first-cut cotton linters, loading the beater to 50 percent capacity and beating for thirty to forty minutes with maximum contact between the roll and bedplate to achieve a cutting action. He does warn that “there is a limit to how thin the concentration can be before the blades begin to wear and the furnish turns grey,” however he appreciates how the “short fibres fill in the recesses of an embossed wire (screen) without bridging in the way longer fibres do, which results in a crisper watermark.”¹⁶ Natan Kaaren beats cotton rag cloth at full capacity for a total of three hours for his watermarked artworks. Feeding the soaked cloth with the roll about a half millimeter from the bedplate, he then lowers the roll until it almost touches the bedplate for the duration of the beat, finally raising the roll for ten minutes at the end of the cycle to get rid of knots. His beater is outfitted with a washer roll (a

drum) that cleans and defoams the pulp while it travels around the beater trough. Kaaren finds that the washer is “effective with pulp made from rags, especially jeans and other colored fabric: the foam, grime and color that comes out is truly amazing.”¹⁷

To create paper for letterpress printing, Peter Thomas’s goal is to achieve a flat sheet that has high fold strength and a soft surface to receive the impression. Thomas combines 90 percent cotton rag and 10 percent short-fibered cotton linters. He loads the beater to full capacity and after the initial cutting and separation of the fiber, he raises the roll slightly, leaving minimal space between the bedplate and roll, to avoid a cutting action. By using the minimal amount of beating time required, Thomas aims to produce a paper that maintains strength and will not cockle during drying. He determines the total beating time through visual and tactile cues.

Robbin Ami Silverberg designed a pulp for a specific bookwork that offers a balance of folding strength, receptivity to letterpress printing, as well as translucency for watermarks. She loads hemp half stuff to 100 percent capacity with the roll fully separated from the bedplate. Then slowly, over the first 45 minutes, she brings the roll and bedplate into contact. Afterwards, she hard beats the pulp for another four to five hours. During the last half hour, she lifts the roll to lightly brush the fibers in order to increase the pulp’s translucency.

For lithography, Eileen Foti and John Risseeuw both seek a dense, even sheet that will accept layers of litho ink without the fibers “picking off” during multiple print runs. Foti combines 50 percent unbleached abaca and 50 percent second-cut cotton linters. She prefers to beat them together in the same beater load to achieve an integrated surface. For a particular project, Risseeuw beat separate loads of cotton linters, cotton rag, sisal, and scraps of mat board, treating each differently and combining the pulps afterwards with a Dreagerpulper.¹⁸ Although their methods differ, both combine short with long fibers so that the short fibers fill in the spaces between longer ones, creating a compact, close surfaced sheet required for litho printing.

Many artists today who employ high-shrinkage pulps for sculptural works are using techniques adapted and developed from Winifred Lutz’s explorations in the 1980s.¹⁹ The longer the pulp is beaten, the more hydrogen-bonding sites occur as the fiber is abraded, resulting in greater shrinkage in the drying sheet. Flax, hemp, and abaca fiber have properties that allow them to withstand the prolonged beats. To create a pulp that has both translucency and high shrinkage for sculptural work, Helen Hiebert beats abaca at 60 percent capacity with the roll high for one hour at first, then lowers it until she hears the roll hitting the bedplate. Gail Stiffe achieves similar qualities with unusual plant fibers such as gingerlily and strelitzia stems. Stiffe beats at 75 percent capacity and adjusts the roll and bedplate to maximum pressure immediately. Within an hour Stiffe can beat the tender fibers into a translucent, high-shrinkage pulp for her sculptural books.

When beating his high-shrinkage pulps, Peter Gentenaar strives to preserve two seemingly opposite qualities: a capacity for shrinkage (which generally requires a short pulp) while maintaining wet strength (which is usually a characteristic of a long pulp). For large sculptures that measure larger than three square meters, he combines hemp and flax with abaca, beating them for three to five hours. Roberto Mannino has found that a combination of flax and recycled tracing paper is perfect for his high-shrinkage pulp needs. He beats the two pulps separately using different methods, and mixes them to create an intriguing, waxy, oily, and translucent paper. Both Gentenaar and Mannino load their beaters to less than full capacity in order to promote a cutting action but their beat times and fiber combinations are different.

For pulp painting, Lois James prepares a short, greasy wet pulp from cotton Cheney half stuff and abaca fifty-fifty or 100 percent abaca. She loads the fiber at 75 percent capacity and beats for a long time, generally sixteen hours, with the roll and bedplate separated. The long brushing cycle fibrillates and shortens the fiber to such an extent that James can apply the pulp with a brush through a fine-lined stencil. Pat Torley-Gentenaar, another artist working in pulp painting, uses a variety of plant fibers, including hemp, linen, cotton, abaca, silk, and kozo, sometimes all in one work. She beats the fiber sources separately to achieve a range of pulps, from very short to very long, opaque to translucent, with varying textures, and mixes them depending on what she requires for her imagery.

Vicki Sigwald beats her pulp in a particular fashion to achieve a pronounced surface texture in her finished paper. Using banana trunk fibers, Sigwald removes a quantity of pulp that is partially beaten from the beater load and continues beating the rest of the pulp. She re-adds the semi-beaten pulp at the end of the beating cycle, dispersing the long fibers with a light brushing. Another artist using locally available fiber is Asao Shimura who processes piña (pineapple) leaf fibers, an agricultural waste in the Philippines. Shimura beats the decorticated piña fibers by hand for fifteen minutes and then for another fifteen minutes in his homemade Hollander which does not have an adjustable roll/bedplate. However, Shimura knows how to handle his machine well, and creates paper that works perfectly for digital printing with an Epson printer.

Sometimes artists select a particular fiber with an eye towards subject matter rather than the physical qualities and working properties of the fiber. Both John Risseeuw and Tom Leech routinely choose fibers that symbolically complement a text, or match a work's aesthetic and philosophical concerns. For Leech, a printing paper's role is to be a subtle extension of the text it will support. He asks himself, "How is it in concert with the text?" As far as fiber choices—linters, cotton rag half stuff, abaca, flax—he has used them all successfully. He offered a bit of humor in describing how he thinks through his fiber selection: "What do you want? Thin and crispy or thick and chewy? Pages to be folded? Opaque or translucent?" He continued, "Letterpress is pretty forgiving and paper can be an integral part of the final image, offering subtle contributions. Those printers who will only ever print on Rives BFK I find a bit suspect. It is like eating Wonder Bread. I like the challenge!" Leech also reminds us to listen to our beaters. "I am in the studio most of the time the thing is running. The sound can drive you crazy, but it tells you what is happening." He admits, "I am pretty abusive of my beater...they are relatively basic machines...having some subtleties but they are made to be pushed, to grind up fiber...But treat it with respect."²⁰

AUDITORY, VISUAL & TACTILE CUES PLUS TESTS FOR PULP "DONENESS"

Other artists also mention the importance of listening for auditory cues when running their beaters. Peter Gentenaar writes, "I'm near the beater all the time and 'play' the machine by ear, although I'm wearing ear protection. The sounds will tell you when to probe the pulp and fish out lumps of fiber, untangle them, and drop the fibers back in."²¹ Michael LaFosse notes that his beater starts very noisily, but starts to hum more smoothly after a certain amount of time. He uses an amp meter to measure how much power is being drawn on his beater at any given time during the cycle. By making adjustments to the roll, he can fine-tune the beat until the machine draws a specific amperage for a certain length of time, ensuring consistency from one batch of pulp to another.

Visual and tactile cues are other devices by which to know when the pulp is “done.” For high shrinkage and watermarking pulps, Helen Heibert looks for a slimy consistency that will slip through her fingers.²² Peter Thomas, Lynn Sures, and Margaret Prentice, among others mentioned as well that they inspect the pulp for desired textural quality by checking how it feels and runs against and through the fingers. After years of experience, they have learned what to look for.

Margareta Mannervik uses a knife test to check on her pulps. She pulls a knife vertically through the trough, with the blade facing up. When ready, the fibers should hang over the knife blade with uniform length. She then does a visual check of the fibers dispersed in water. Natan Kaaren, John Risseeuw, and Eileen Foti also mention the technique of putting a small amount of beaten fibers into a glass jar filled with water, capping it, shaking it vigorously to disperse the fibers, and checking to see if the fibers are of even length and disperse without clumping. For a plant fiber that beats very quickly—a “pulp that can’t really be managed by the clock”—Vicki Sigwald takes a dispersion sample in this manner every five minutes or so until she determines that it is done.²³

There are specialized tools available within the papermaking industry to monitor the pulp during beating. Brian Queen explains, “In North America, commercial papermakers measure drainage or dewatering using a Canadian Standard Freeness Tester (CSF) which evaluates the stock’s freeness by measuring the drainage time of a fixed volume of stock. In Europe, a similar but different system called Schopper Riegler (SR) is used.”²⁴ Although these tools might be helpful to us studio papermakers, it is more important to fully understand the potential of our own beaters by conducting thorough research and experimentation. Lee Scott McDonald suggests this test: run two beater batches of the same kind of pulp; pull a small sample sheet every fifteen minutes from each batch; and document carefully. For Batch #1, beat really hard right from the beginning (with the roll in contact with the bedplate) for up to three hours. For Batch #2, slowly decrease the distance between the roll and the bedplate over a three-hour period.²⁵ To fully understand the nuances of your beater using this test, you can alter the ratio of fiber to water, adjust the distance between the roll and bedplate during the cycle, or change the length of the beating time.

With the seemingly never-ending variations, we would do well to keep in mind what Siegenthaler wrote, “Remember! It is an art to beat fibers, not only a technique.”²⁶

ENDNOTES

¹ Howard Clark, lecture at the annual meeting of the Friends of Dard Hunter, Chillicothe, OH, October 2006.

² Wavell Cowan, lecture at the annual meeting of the Friends of Dard Hunter, Chillicothe, OH, October 2006.

³ For a fascinating and informative read about plant fiber chemistry related to papermaking, see W. F. Cowan, Why Paper is Paper, volume 1 of Science for Handpapermakers, on Sewanee University’s Chemistry and Art webpages, posted with permission from Friends of Dard Hunter, http://www.sewanee.edu/chem/Chem%26Art/Detail_Pages/Paper/Science_for_vol1.htm (accessed December 15, 2007).

⁴ Lee Scott McDonald, lecture at the annual meeting of the Friends of Dard Hunter, Chillicothe, OH, October 2006.

⁵ W. F. Cowan, Beating, volume 2 of Science for Handpapermakers, on Sewanee University's Chemistry and Art webpages, posted with permission from Friends of Dard Hunter, http://www.sewanee.edu/chem/Chem&Art/Detail_Pages/Paper/Science_for_vol2.htm (accessed December 15, 2007). This article, which explains the science of beating in plain language, is a must-read for anyone working with a Hollander.

⁶ James d' A. Clark, Pulp Technology and Treatment for Paper, 2nd ed. (San Francisco: Miller Freeman Publications, 1985), 278–279.

⁷ "Hollander Beaters," from the "For Beginners" column of Hand Papermaking Newsletter 44 (October 1998), posted on Hand Papermaking's website, <http://www.handpapermaking.org/beginner/beg44.htm> (accessed November 11, 2007).

⁸ Fred Siegenthaler, "How to Beat Paper Fibers the Right Way," IAPMA Bulletin 35 (Spring 2004): 31.

⁹ Dr. Sigurd Smith, *The Action of the Beater* (London: T. Batsford, Ltd., 1923), 198.

¹⁰ Peter Gentenaar & Pat Torley, editors, *Paper and Water* (Rijswijk, Netherlands: Gentenaar & Torley Publishers, 2000), 82.

¹¹ Fred Siegenthaler, 32–33.

¹² Samuel Milne, *A Study of the Beater including Further Notes* (Edinburgh: Bertrams Limited, 1936), 4–5.

¹³ Brian Queen, e-mail message to the author, November 13, 2007.

¹⁴ LaFosse learned terms like "carding" and "spectacles" when he studied papermaking at age sixteen with lab techs at a paper mill in Fitchburg, Massachusetts, and later with John Kohler at UConn Storrs and with Elaine and Donna Koretsky of Carriage House Paper. Phone interview by the author, August 3, 2007.

¹⁵ Margaret Prentice, e-mail message to the author, July 26, 2007.

¹⁶ Brian Queen, e-mail message to the author, August 25, 2007.

¹⁷ Natan Kaaren, e-mail message to the author, July 1, 2007

¹⁸ A Dreagerpulper is a hydropulper, originally purchased by Jules Heller in the 1970s and still in active use in the studio of Arizona State University. John Risseeuw, e-mail message to the author, December 21, 2007.

¹⁹ Winifred Lutz, "Shrinking to Expand," from *A Gathering of Papermakers* (Brookline, MA: Carriage House Press, 1988), 41–54.

²⁰ Tom Leech, phone interview by the author July 28, 2007.

²¹ Peter Gentenaar, e-mail message to the author, August 9, 2007.

²² Helen Hiebert added that the only way to know for sure whether the pulp is ready or not is to make a quick test sheet (using the tin-can method) to see how it dries.

²³ Vicki Sigwald, e-mail message to the author, November 11, 2007.

²⁴ Brian Queen, e-mail message to the author, November 5, 2007.

²⁵ Lee Scott McDonald, lecture at the annual meeting of the Friends of Dard Hunter, Chillicothe, OH, October 2006.

²⁶ Fred Siegenthaler, 33.

