Constructing Western Molds

Tim Moore

Hand tools can be fascinating. A good tool which has been well used often possesses a quietly mysterious, yet reassuring quality that I find very attractive. Paper molds attracted me in this way and that is probably why I now make them. Toolmaking to me is a humble, social form of sculpture in which I play a limited part; tools, after all, have independent work lives. What they will be used to make and what processes they will be part of cannot be completely known by the person who makes them.

I became acquainted with paper molds four years ago when I was asked to cut in halves an old British two-sheet mold to make a pair of molds to be used by students learning papermaking. While I cut and trimmed the facings, removed a couple of ribs and fitted new ends I became familiar with the parts of a mold and with the way they fit together. As I worked I became more and more impressed with the skill and care with which the mold had been made and by the simplicity and elegance of its design.

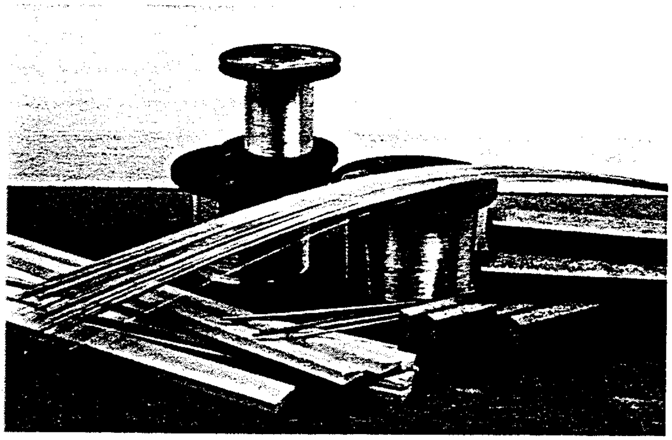
A few months later I was asked to make a mold. The wooden parts posed no great problem but the facings that I was able to locate were not very satisfactory compared to those I had seen on the British mold. Backing wire in particular was unavailable. I had to use heavy brass mesh as a substitute for the traditional laid backing. It weighed several times as much, was somewhat lumpy and soft, and seemed more difficult to sew. I found myself speculating on the possibility of making a loom for twining my own backing wire, which could also be used for making laid facings. I felt that perhaps I could fill a niche by offering these materials as well as by making molds like the one I had become familiar with.

I was very fortunate to have several dozen turn-of-the-century British molds made available to me to examine and measure.[1] I read whatever I could find about mold construction and became acquainted over time with an increasing number of practicing papermakers who provided me with needed practical advice. Soon I was filling orders and now it seems that I have most of the bugs worked out.

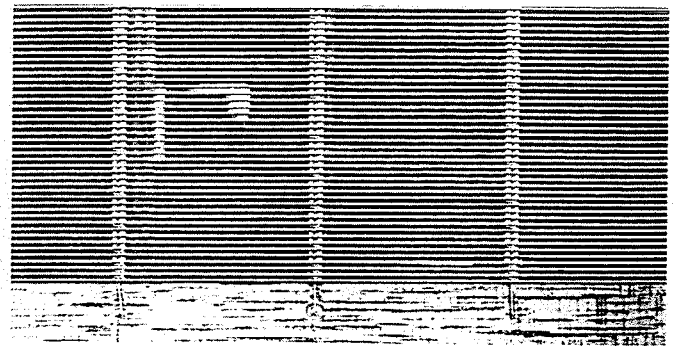
I now make all three types of Western papermaking molds. The most basic of these is the single-faced laid (also known as antique laid) in which the sheet-forming surface of straight parallel wires is sewn directly to wooden ribs which are supported in a wooden frame. The addition of an extra layer of backing wires sandwiched between ribs and laid facing makes a double-faced laid mold. A wove mold is also double-faced but has a sheet-forming facing of woven wire screen which is supported by backing wires.

Two kinds of wood are used in these molds. The frame of the mold and the entire deckle are made of Honduras mahogany, a wood often used in boat-building because it is not prone to rot and is not likely to warp if it is well seasoned. Pine or fir is used to make the ribs, a tradition which may have arisen because these long-fibered softwoods are a little tougher and less brittle and therefore more suitable for the more delicate ribs.

All of the wood is carefully selected for straightness of grain. Then it is cut into strips in such a way that the annual growth rings will have a nearly vertical orientation in the



The basic materials: carefully seasoned wood, straight lengths of spring-tempered laid wire, and spools of chain and sewing wire.



The laid facing is sewn directly to the ribs on a single faced laid mold.

Wood being seasoned.

finished mold or deckle.[2] The strips are boiled in water for several hours then hung up to slowly dry. Weeks later the strips are jointed and planed to only ⅛″[3] over their final dimension and boiled and hung to dry again, this time for several months. Since the strip of wood hangs freely as it cures it can do what it wants and any tendency to warp becomes apparent. Thus seasoned it is quite free of internal stresses and does not warp while it is worked as does much poorly cured wood. A mold and deckle made of wood seasoned in this way are much less likely to warp despite being subjected to repeated submersions in water and changes in humidity.

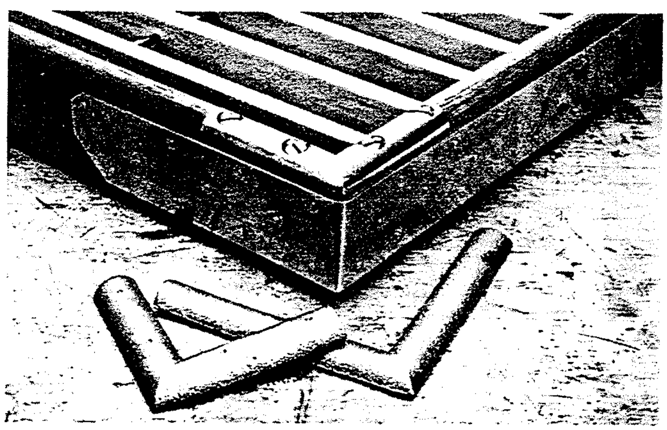
The first step in actually constructing a mold is making the frame. The four pieces are made perfectly straight and to exact dimensions. The frame has a very slight inward taper built in, so that it is trapezoidal in shape when viewed from any of the four sides with the top of the mold about 1/16″ smaller than the bottom. This seemingly small amount makes a surprising amount of difference when fitting the deckle, allowing it to slide onto the mold easily but without a sloppy fit. The dovetail joints with which the frame pieces are joined are laid out with specially made marking gauges and cut by hand, using a Japanese dovetail saw and chisels. If the mold is to be given hard use and needs rub strips to protect its bottom edges from wear, these are tacked in place. I use an extra dense form of polyethelene; it wears extremely well and can be machined with woodworking tools. Now the bottom of the frame pieces are rounded on a router table. Holes are drilled for the rib pins, small mortices cut for the waterbars, and ledges formed on the two end of short pieces of the frame.

Using a variety of jigs, ribs are made which measure less than an inch high, about a ¼″ wide across the rounded bottom edge, and taper to around 1/16″ along the top where the wire facing will later be fastened. All of the ribs for a mold are cut to length and then half-inch long 3/16″ diameter pins are formed on all of the ends. Ribs are drilled for one or two stays, ⅛″ diameter brass rods which pass through all ribs and into holes drilled in the frame. These keep the ribs lined up and working together. Individual ribs are quite delicate, yet when they are assembled with the other parts of the mold the structure is very strong.

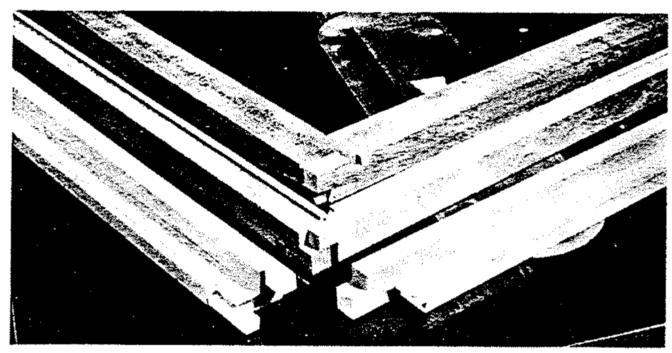
Very small holes for sewing are drilled along the length of each rib; these are about 5/16″ from the top edge and are spaced according to the facing which is to be sewn down. The spacing for a fine laid mold is about ¼″, 5/16″ is used for a coarser laid, and ⅜″ for the backing wire of a wove mold. The holes must be staggered from rib to rib so that the facing will lie flat; if the holes line up down the length of the mold the laid facing will bulge between stitches and take an undulating form. This will show up as a striped thick/thin pattern on a sheet formed on such a mold.

The frame, ribs and stays are assembled without glue and checked for square. To date this has not been a problem since all of the parts conspire to make it unlikely to be anything but square. Then the ends of the frame are removed so that epoxy glue can be applied to the joints. They are then put back in place and the corners are clamped. No glue is used to secure the ribs.[4]

After the excess glue has been pared and filed away, brass reinforcing corners are fitted to the bottom of the mold. These castings brace the mold and protect the corners from



Rough casts and a finished brass reinforcing corner in place on the mold's bottom surface.



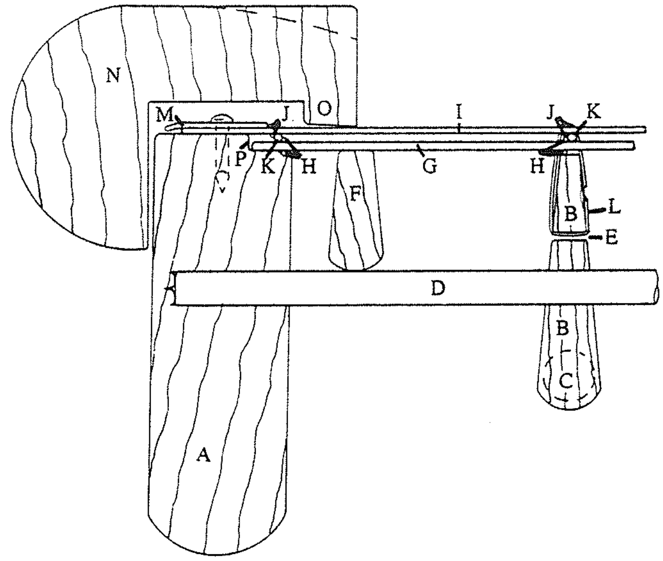
Finished deckle joints ready to be glued.

wear. Small molds are much stouter by nature and since they weigh less do not wear as badly; therefore, the corners are left plain. Next the sheet brass sheathing is cut and fitted around the four corners and across the front of the outside faces of the mold; this serves as a wear plate to protect against abrasion since in production hand papermaking the deckle is thrown on and removed from each mold hundreds of times each work day. The brass also helps bind the parts together, although with the use of a waterproof glue this is not so important.[5]

Now the top surface must be prepared to receive the wire facing. In theory the surface of a mold should be completely flat. In reality it is better to have a very slight convexity or camber to counteract the various downward stresses that the mold is subject to in use. These include suction (especially if the mold is completely submerged in dipping) and the pressure of couching. Very large molds also need this camber simply to bear the weight of the water and fibers without sagging. On normal sized molds this weight is insignificant.[6]

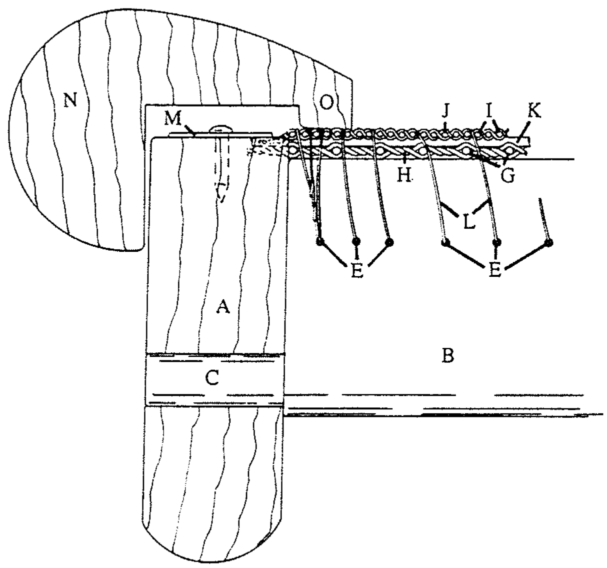
In order that the uppermost facing can be supported evenly by the backing and by the upper surface of the frame the tops of the ribs should describe a plane which is lower by the thickness of the backing wire. The ledges previously cut into the frame ends serve this same purpose. This is most important for a double-faced laid mold. If the ends of the laid wire are not supported by the frame of the mold they will buckle when the protective brass strip is applied, causing a very irregular surface in the space between the first rib and the outer rim of the mold.

The recessing of the ribs and the camber are accomplished at the same time. Steel rods are loaded evenly onto the stays between all of the ribs to cause the structure to sag slightly. Then a special scraper plane with its blade set for the backing wire thickness is used to scrape all of the ribs perfectly flat in relation to the previously flattened mold frame. When the weight is removed the structure springs upward to a slight camber.[7] This method will give a greater camber for a larger mold, where it is more important. Making most molds perfectly flat would probably be acceptable but it is almost as easy to work the camber in and a good idea, I think.[8]

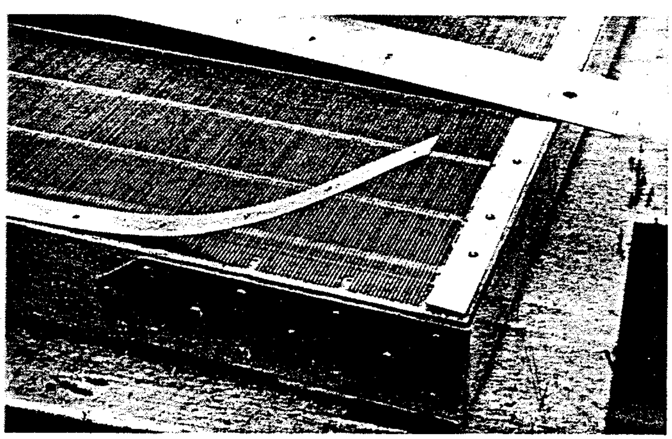


Longitudinal section of a double-faced laid mold and deckle.

Key to both diagrams
A. mold frame, B. rib, C. rib pin, D. stay, E. sewing holes, F. water bar, G. backing laid wires, H. backing chain wires or 'twists', I. facing laid wires, J. facing chain wires or 'twists', K. spacer wire, L. sewing wire, M. protective strip, N. deckle, O. deckle rim, P. ledge with groove to trap chain wires.



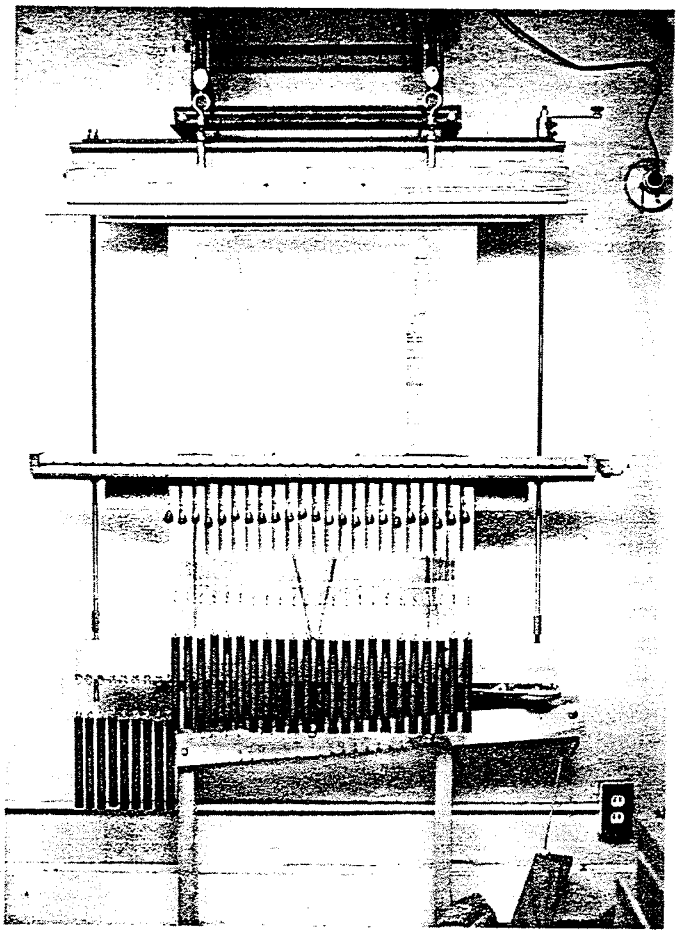
Transverse section of a double-faced laid mold and deckle.



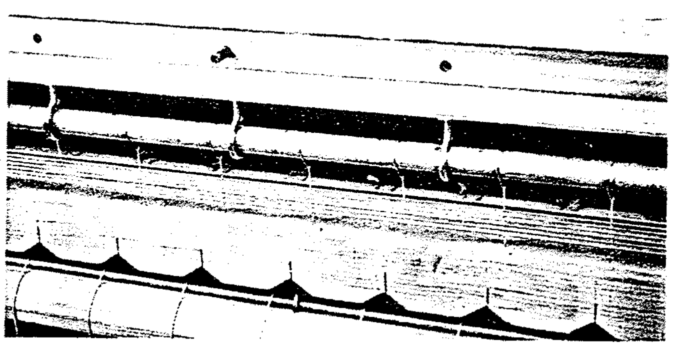
A brass strip protecting the edges of a wire facing. The ends of the laid wires have been trimmed back where the pins will be driven.

Waterbars, small extra ribs which help to de-water the short edges of the sheet during formation, are now fitted into their mortices and wired to the stays, on which they rest. That ribs help drainage can be seen in the thickening along the ribs in a sheet made on a single-faced mold. More liquid flows through the areas of the facing which contact the ribs so more fibers are deposited there.[9] Since a poorly drained area will tend to be thin compared to an area that is drained well, the waterbars help form a substantial, well-formed deckle edge.

Now the mold is ready to be covered. Depending on the type of mold one or two facings must be made on the twining loom, although the woven wire for a wove mold is purchased from a manufacturer. Backing must be made for wove and double-faced laid molds. Laid facing and backing consists of numerous straight springy laid wires which are twined together with pairs of softer and smaller diameter chain wires or twists, spaced about an inch apart. Laid wires are separated by a single half twist when a facing is made. About three half twists separate the laid wires for backing so they are much more widely spaced. Laid facings vary from fourteen to thirty-six wires per inch, approximately; backing from five to nine per inch. Spacing depends on the size of laid and chain wires and on the number of twists separating the laid wires. The hardness of the chain wire stock also has an effect.[10] All wire used in these molds is phosphor bronze, which is tougher and more corrosion-resistant than copper or brass.



The loom with an 18″ × 24″ laid facing completed and ready to cut off. This loom can make a variety of laid facings and backings.



Here the first few laid wires have been twined together with smaller chain wires to begin a laid facing.

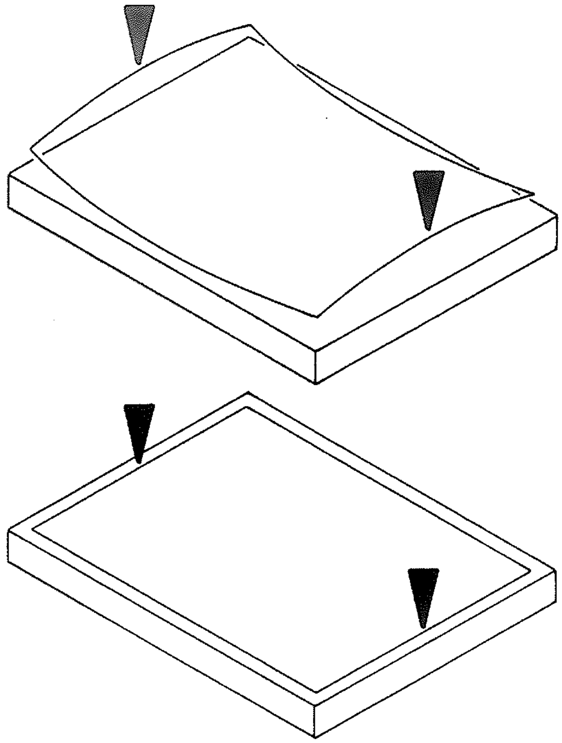
The moldmaker's loom or twining loom has a row of spindles which twist all of the chain wire pairs simultaneously. Laid wires are inserted one at a time. This sequence is repeated until the needed size has been completed, then the facing is cut off with nippers. The facing is now carefully trimmed to size and held in place on the mold with masking tape. Laid molds are sewn in one step whether single or double faced. Sewing wire is about the same gauge as the chain wires and passes over them and between a pair of laid wires at regular intervals corresponding to the holes in the ribs. One piece of wire sews the entire length of a rib. Near the ends of the rib the stitches become closer and the last three or four laid wires have a stitch apiece. When the sewing is complete the masking tape is removed and ⅜″ wide brass strips are tacked in place to protect the edges of wire where they lie along the edges of the mold.

Wove molds are sewn in two steps; first the backing is sewn to the ribs. Then a row of small brass nails is tacked along each long side of the mold, heads protruding. A wire is strung between them crossing and recrossing the mold, parallel to the ribs. These cross the laid backing wires at right angles to form a grid to which the wove facing is sewn.

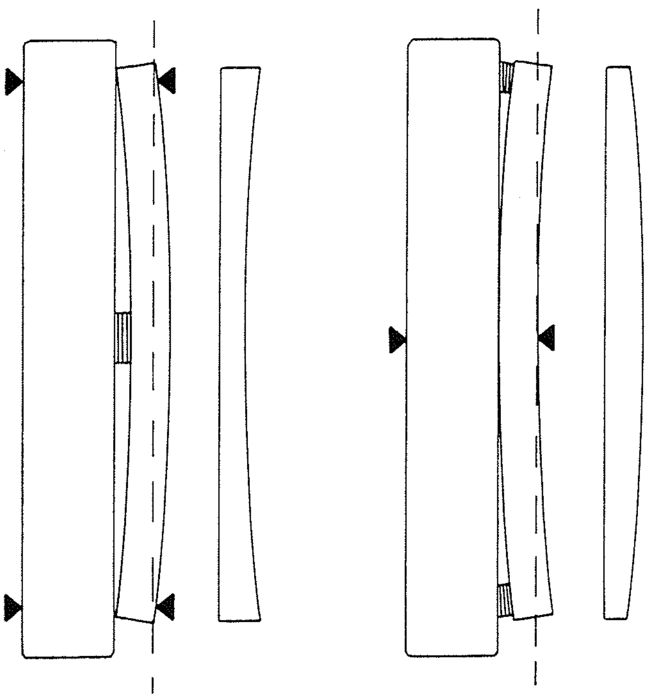
A wove mold with the backing sewn directly to the ribs. A wire is strung back and forth across the mold to produce a grid to which the wove facing will be sewn.

Sewing takes time. A tiny 8″ × 10″ laid mold may take as little as four hours while a 22″ × 30″ wove mold takes more than 45 hours to sew. Done methodically, a few hours a day, sewing is a pleasant activity. My hands work almost by themselves and my thoughts can wander freely.

Now that the mold is finished the deckle is begun. The quality of work is especially important when making a deckle. The many parts of a mold stabilize one another and there is a tendency for everything to stay flat, square, and strong even if it is has been carelessly made. A deckle is made of only four narrow pieces so its strength depends largely on the quality of the joinery. Four pieces are selected and milled perfectly straight to an L cross section. A narrow rim protrudes slightly; this is the part which will actually contact the wire facing to define the edges of the sheet. The rim must have a very slight bow, concave for the short end pieces and convex for the long side pieces. These slightly curved surfaces will later be refined so that the deckle "bites" the mold surface evenly to form a neat deckle edge as sheets are formed. By shimming the middle or the ends with layers of tape the four parts can be individually bent to a gentle curve against a straight beam. While the piece is clamped its rim is sawn straight. When the clamps are removed the wood straightens out, causing the rim to take on the desired curve.



An exaggerated diagram of the proper curvature of the deckle rim. Loosely placed, it contacts the mold surface only in the middle of the long sides. As the deckle and mold are grasped, the deckle flexes to contact the mold along its entire perimeter.

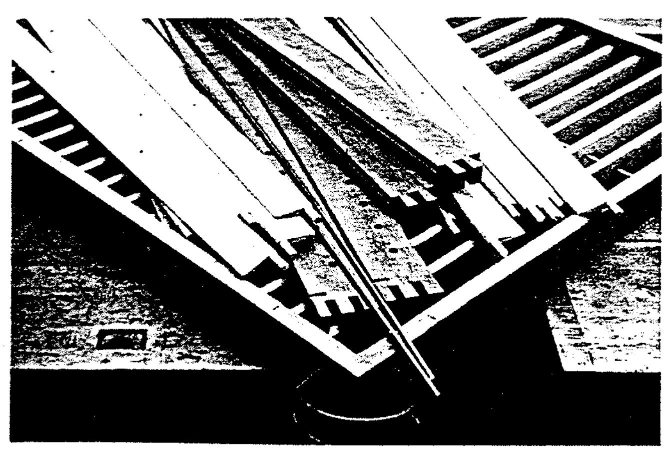


Deckle parts are individually clamped against a beam using masking tape shims. After the rim is sawn straight, the clamps are removed and the deckle takes on the concave or convex curve.

A particular joint has evolved just for fastening deckles together. Unlike the mold corner joints which are easier to cut by hand, I have resorted to using a series of jigs to cut the joint mainly by machine. Running the pieces through all of the stages is very time consuming so I try to make at least three deckles at one time. A pair of short test pieces are used to prevent errors from making their way into the actual deckles. When completed each piece has the "male" part of the joint on one end and the "female" part on the other end so the pieces fit in a revolving pattern. I find this simple solution quite elegant and it saves having to cut opposite versions of the same joint. It has another advantage which is sometimes useful. If the deckle is accidentally made too large for the mold, the joints can be trimmed slightly to improve the fit in either axis. A deckle joined with mirror-image joints can be adjusted in only one direction.

When everything fits I glue the joints and clamp them with spring clamps. After the glue has set the deckle is rough-shaped by machine. Then the deckle is given its stream-lined form, with slanting front and back sides. This is done with a spokeshave, files, and sandpaper. The amount of vertical inner edge which is left varies from under 3⁄16″ to around 3⁄8″. It is somewhat related to the weight of paper to be formed, but only roughly. After the deckle has been shaped the under corners are reinforced with brass staples. If the deckle is to be sheathed, paper patterns are made and transfered to brass sheet, which is then cut to shape with tinsnips. This is formed to the deckle by hand and taped tightly in place. Then, like the mold sheathing, it is fastened with brass pins. Deckle sheathing helps to bind the deckle together and may help to keep the hand-held areas free of stray fibers, which would otherwise become knotted by the friction of the vatperson's hands.[11]

Finally, the deckle is fitted to its mold or pair of molds. When the deckle and mold are grasped together in the proper manner for dipping, the deckle should contact the surface of the mold along its entire perimeter. In the case of a one deckle / two mold set, this is impossible unless the molds are nearly identical. The curve which has been previously cut is refined with scrapers, files, and sandpaper blocks until the fit is satisfactory. The rim, which is 3⁄16″ wide, is relieved by about three degrees so that only a very narrow edge actually touches the facing. As a deckle is loosely placed over a mold it should touch only along the middle of the front and back or long sides of the mold and should rock gently. As the hands grip the mold and deckle more tightly the area of contact should increase until the deckle makes contact with the mold all of the way around with a comfortable grip. While not so important with very small molds, since the deckle is so stiff, this spring fit is crucial for larger molds.



A pair of identical molds: one assembled and one in pieces. The bottom mold has not yet been glued.

The mold and deckle are essentially complete. I give them a couple of good soakings in a waterproofing solution.[12] This slows the passage of water into the wood and helps temper humidity extremes.

The process of making molds briefly outlined here is time-consuming. Even a small mold and deckle will take more than thirty hours to complete while a large one may take over seventy-five hours. This naturally makes them costly, but a mold will last for years if properly cared for.

The finished product closely resembles the traditional British pattern, the most obvious deviation being the plastic rub strip material. Notwithstanding the use of some modern materials, I enjoy the feeling that I am working within the tradition of quality that distinguished the old molds such as those I first saw a few years ago.

The deckle is fitted to a nearly completed mold.

Some other sources of reference on mold making:

Coleman, S. A., *The Craft of Making Moulds for Hand-made Papers, Paper Making by Hand*, J. Barcham Green, Maidstone, England, 1967.

Hunter, Dard, Papermaking, *The History and Technique of an Ancient Craft*, Dover, New York, 1978.

Loeber, E. G., *Paper Mould and Mouldmaker*, Amsterdam, The Paper Publications Society, Labarre Foundation, 1983.

In addition, the Dard Hunter Paper Museum has a large collection of paper molds from various countries in Europe. The address is: Dard Hunter Paper Museum / Institute of Paper Chemistry P.O. Box 1039 / Appleton, Wisconsin 54912.

NOTES:

1. My thanks to Walter Hamady, who first asked me to cut the mold in halves, allowed me to examine and measure his collection of molds on several occasions, and who has been very supportive in my efforts at mold making.
2. It has long been recognized that wood has more strength when the annual growth rings are parallel with the direction of load forces. Some practical uses of this strength include violin and guitar soundboards, quarter-sawn flooring, and flat-sawn floor joists in ordinary construction.
3. The following equivalents are provided for conversion purposes: there are roughly 25 millimeters per inch and 1/16 inch (the smallest measure mentioned here) equates to about 1.5 millimeters; there are approximately .45 kilograms per pound.
4. At a later stage every third rib is fastened to the frame with brass pins; this prevents the sides of the mold from spreading. The ends of the stays and corner joints are also reinforced this way.
5. About half of the molds that I make are left plain since the added cost of applying the brass is not really justified in a low-speed type of papermaking.
6. To date the largest molds I have made measure 22″ × 30″. In my experience a mold would have to be considerably larger to sag significantly with the weight of the paper stuff.
7. To get an idea of the strength of a mold consider this example: a 16″ × 20″ mold evenly weighted with 12-14 lbs. and scraped flat yielded an almost undetectable arch of about 1/64″.
8. I encountered a lot of confusing information about mold camber. I was very relieved to find the subject very clearly dealt with in *Paper Mould and Mouldmaker* by E. G. Loeber (Amsterdam, The Paper Publications Society, Labarre Foundation, 1983). Mr. Loeber essentially says that molds should be completely flat except in the case of oversized molds.
9. The backing wire in a double-faced laid mold isolates the facing from the ribs and eliminates this antique laid effect.
10. Conceivably certain papers would require a denser spacing of laid wires while others would require less density (a greater or lesser number of same-size laid wires per inch) but in practice the typical patterns that I use work fine. If the need became apparent, almost any pattern could be made.
11. As with the molds, about half of my deckles are made without sheathing.
12. I use Thompson's Water Seal.

All photos and diagrams by Tim Moore.