
Casting to Acknowledge the Nature of Paper

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Introduction

The following discussion is a distillation of a more comprehensive lecture-demonstration that I give concerning casting techniques for paper. It concentrates on two methods I have developed and use for my own work. One of these is a relatively new process.

Traditional paper sheet forming is really a flat casting method. Casting is an activity made possible by the labor of moldmaking. My approach to paper casting starts from these obvious very basic ideas and from the conviction that any material or process should be used with close attention to its specific nature as this complements the user's thought.

The way a sheet of paper holds itself together is inspiring to me: hydrogen bonding tightens and locks the physical mesh of the beaten fibers. The extent of the bonding is controlled by the fiber type used and its preparation. Bast fibers and seed fibers have different characteristics which are intensified by different preparation processes. The same fiber may yield papers of varying shrinkage, translucency, hardness, color, and strength depending on whether it is retted, cooked, stamped, or hollander beaten (or some combination of these processes). In this lies paper's life as a physical substance.

This same analysis may be extended to evaluate the activity of casting: a mold is used to produce a form. Normally, this is an indirect process because the mold is conceived as a way to duplicate something which already exists and the making of the mold is simply labor,

however skilled. The sculptor Julius Schmidt, influenced by early Chinese bronze casting techniques, sought to develop mold making as a sculptural thinking strategy. He never made a positive pattern. Instead, he built his molds directly. His sculptures started "outside-in" I find this idea of working in the negative very useful both to subvert my own formal preconceptions and because it acknowledges the essence of casting and thereby makes it very direct. Thus, my own casting strategies owe a great deal to Julius Schmidt's example. The mold types I will discuss employ both Eastern and Western papermaking techniques and use mold making as a direct process.

Fiber Types & Pulp Preparation

Absolutely essential to paper casting is a familiarity with paper fiber types and pulp preparation. The most basic way to begin to develop a knowledge of the effects of different fibers, variously prepared, is by doing a series of shrinkage tests. Records are kept of fiber and preparation method and fresh sheets are both loft-dried and board-dried. The sheets are then examined for differences in surface, translucency, etc. and particularly for degree of shrinkage from the stretched board-dried sheets to the completely contracted loft-dried sheets and this is recorded and samples kept for future reference. Thus, in a comparison of flax, cotton, abaca, and gampi papers, for example, the following differences may be observed: A flax paper from fiber processed 12 hours in a hollander beater with care to preserve fiber length (i.e. by not lowering the roll

too close to the bed) will be very translucent, crisp, and hard with a slight sheen. In fact, it will look a bit like parchment. It will also shrink excessively in drying, losing as much as half of its original area as revealed in a comparison of a board-dried to a loft-dried sheet. A paper made from unbleached linen canvas boiled in a lime (CaOH) solution for two hours, rinsed, and then beaten for six hours will still be dense and crisp. However, due to the shorter beating time and the lime cook, it will shrink less, although it still will lose about one-third its original area. Also, the paper will be less translucent and paler. Modification of either of these pulps by adding one-third to one-half by volume of cotton pulp from unbleached muslin beaten three hours will lower shrinkage, translucency, and crispness still further.

A pure unbleached cotton muslin pulp beaten for three hours will yield paper that shrinks by less than 20% and which will be opaque, with a matt, medium soft surface. A pure abaca (unbleached manilla hemp) paper, made from abaca half stuff, will make paper having negligible shrinkage, excellent tear strength, a soft luster, but, also, a comparatively soft surface. If you cook and handbeat your own abaca, these qualities may be varied. Gampi paper prepared by cooking and handbeating the fiber in the traditional manner will have shrinkage comparable to a twelve-hour beaten flax pulp, but it will be more translucent, with a much more pronounced luster as well as a different color. All of the above fibers, if dyed, will take the same color differently; sometimes the differences are quite extreme.

Obviously, fibers and preparation may be combined to adjust surface, sheen, density, dye retention or natural color, and shrinkage to a variety of requirements. In terms of

casting, perhaps the most useful thing to remember as a general rule is that high shrinkage pulps will give denser surfaces and crisper edges and the paper, if used fresh and undried, will stick to itself without the addition of paste or size. However, there occur considerable problems in controlling the stresses created by shrinkage. Low shrinkage pulps present fewer casting problems, but give softer, more easily damaged surfaces and edges and the paper will not stick to itself without the addition of sizing or paste. Often such paper may not be crisp enough to supply rigid strength to a casting if that is an important factor. The preceding remarks presuppose casting in thin sections by lamination or pouring and often thin enough to ensure translucency. Thick section, mass casting will give rigid results in either case but is not necessary nor even desirable to achieve strength.

Dealing with Shrinkage Problems in Casting

Since shrinkage seems to be the most worrisome single problem in paper casting, I will discuss its control and use in general before proceeding to explain the two types of casting I have developed for my own work. As long as the casting activity is considered separate from the making of the paper, as if the paper were simply another, perhaps more novel, material to put in the mold, high shrinkage pulp will seem undesirable. I think it becomes clear from the preceding discussion that papers from these pulps have unique visual and tactile characteristics which render them potentially desirable for use. Two basic approaches may be taken to deal with the shrinkage factor in casting: 1) to design something to restrain the shrinkage and so prevent the paper from warping and wrinkling itself out of the mold, or 2) to use the shrinkage to develop the form of the work and, therefore,

the method of casting. The two methods I use and the mould types which accompany them demonstrate these two strategies. The first uses a rigid mold system with a lamination casting method and the second employs a flexible system and a pouring method. In both systems, the molds are built directly without the intervening activity of creating a pattern from which to make them. Both methods seek to integrate the structure of the casting system with that of the process of papermaking so that they enhance each other.

Rigid Mold System and Laminate Casting

The majority of my molds in this system follow the example of the flask system used in patterns for making sand molds for metal casting, except that I make castings rather than molds from my patterns. The molds have three basic parts: the platform, the frame or flask, and the various forms used to modify the basic shape provided by the platform and frame. In the simplest examples, a mold platform might be a piece of formica—covered particle board, cut as a rectangle. Over this might be slipped a two inch deep wooden frame which fits around the platform snugly and has corner joints that are screwed to allow easy disassembly. The frame establishes what will later appear to be the thickness of the casting. Then a variety of forms, made for example, of wood, cardboard, plaster, etc., may be fastened within the resulting container. Silicone sealer is good for attaching these pieces because, not only does it provide a waterproof bond, but also a flexible one that can be later peeled away either to facilitate removing the casting when dry (the frame unscrews for the same reason) or to allow alteration and reuse of the basic mold box and parts. Thus, one basic mold may be varied endlessly.

For this type of mold, any hard material which is impervious to water or may be so rendered is usable. Thus, wood, plastic, cardboard, ceramic, stone, and plaster are all practical. Metals are generally not advisable—unless stainless steel is used—since so many of them tend to react with the moist paper, particularly if it has an alkaline pH. Plastic, ceramic, stone, and plaster may be used without further treatment, but wood and cardboard should be well-sealed with a waterproofing product like Thomson's Water Seal or the silicone water repellents made for shoe leather. A well-buffed coat of paste wax applied after the sealer has dried frequently helps in parting the paper from the mold later, but is not absolutely necessary. If properly prepared,¹ plaster molds should not leave a white "bloom" on the paper cast against them. A plaster mold may be sealed with the same materials recommended above for wood or with shellac cut with alcohol (3 alcohol: 1 shellac), followed by paste wax. However, this is not really necessary unless particularly

¹ For those papermakers who have little plaster mold experience, here are a few tips: Store your plaster in the driest place possible. Wrap the sack in a double plastic trash bag. If plaster is exposed to high humidity, the chemical action of the setting is started with the result that the plaster will not set properly when mixed with water. When mixing plaster, use *cold* water and sprinkle the dry plaster into the water until the level of plaster and water are identical before you mix. This guarantees the ideal proportion of plaster to water. Do not use hot water since the heat accelerates the setting of the plaster and causes a more coarse-grained product. Finally, plaster heats up as it sets. It is completely set once it has cooled down again even though it is, of course, not dry at that point. It should *never* be disturbed while it is warm because it is most susceptible to damage at that time. Wet molds should always be dried with the parts assembled because plaster will warp as it dries just as wood does.

Simple plaster
mold for laminate
casting

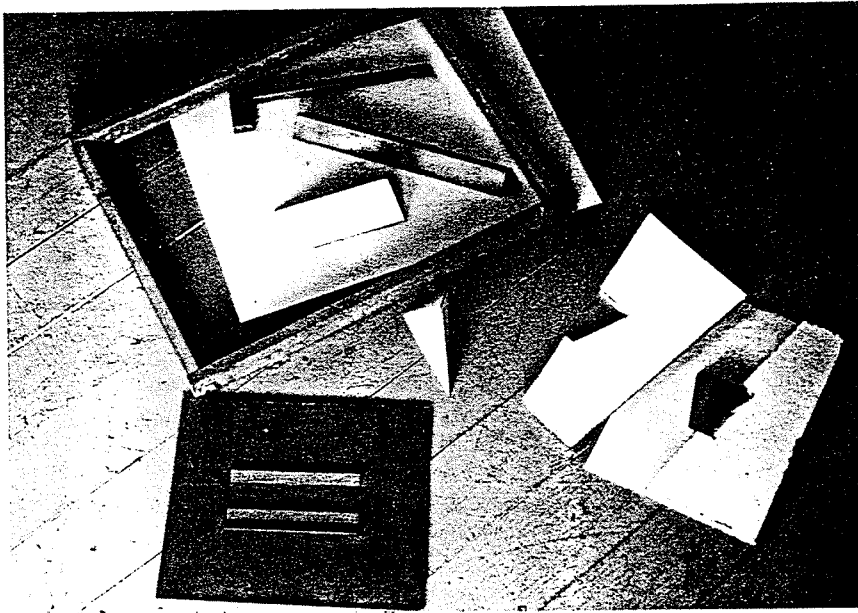
Left to right: base
mold, removable
subform to sim-
plify casting re-
moval, thin (1
mm) flax paper
casting, shrinkage
restrainer made
in sections. The
wrinkled surface
of the back-up
restrainer is the
result of using tis-
sue as a parting
agent. The sub-
form was made
directly to fit the
main mold form.



Varieties of rigid
pattern molds for
laminate casting
Lower left: water-
proofed masonite
and redwood,
subforms glued to
platform with sili-
cone sealer.

Lower right: plas-
tic platform with
redwood subform
and insulation
board shrinkage
restrainer faced
with blotting pa-
per. Restrainer is
clamped against
platform and blot-
ters changed dur-
ing drying.

Upper left: for-
mica-surfaced
platform, remova-
ble wood frame to
allow casting of
side walls in
depth, subforms
of wood and
water-proofed mat
board.



smooth shiny surfaces are needed or paste or size is to be used in the casting process. I prefer not to seal plaster molds because this prevents the plaster from absorbing excess water from the paper which is necessary for even and rapid drying of the casting.

In addition to waterproofing parts of rigid molds, great care must be taken to avoid undercuts which might impair removal of the casting. This is best done by analyzing the direction in which the form will be removed from the mold and/or the directions in which various parts of the mold will be pulled from the form. The principle is most simply stated with reference to a relief: if you are pulling the mold from the paper casting, all planes in the mold not parallel to the surface of the casting should, if extended, converge at a vanishing point behind the casting and on a straight line with the direction of removal of the mold or they should all converge at a vanishing point behind the mold and on a straight line with the direction of its removal. Planes in the mold may do both of the above but no single form in the mold should combine both vanishing points for its planes. The general rule is that if the interior surface of any piece of a mold is viewed along the axis of potential removal of the casting and there exists a horizon beyond which you cannot see, the mold has an undercut and may prove impossible to remove. Of course, as in the case of platform & frame molds, if the background of a mold is removable before the subforms placed on it (as is possible if the mold is put together with silicone sealer), then the subforms may each be removed on a different axis and so resolve what might otherwise be an impossible undercut problem.

Lamination is the method used to cast into rigid molds. Paper freshly couched without pressing, freshly couched and pressed, or dried and

rewet may be used. The best results in terms of clarity of surface detail, control in lamination, and durability of the casting come from the use of freshly formed and pressed sheets.² Edges of fresh sheets blend with each other more easily to avoid visible seams. If the fresh paper is also made of a bast fiber like flax or gampi, processed to have relatively high shrinkage, sizing or glue is unnecessary to secure lamination because the hemicelluloses released in preparation and the profusion of hydrogen bonds as a result of extended hydration and fibrillation act more effectively than any paste. If the paper is from seed fiber, or is abaca half stuff, or has been rewet, it will be necessary to use a flexible paper

² Unpressed sheets, being too soft to handle easily, are difficult to lay up evenly in a mold of any depth and intricacy. Since the fibers are not in as intimate contact as in a pressed sheet, they do not dry to give as strong a casting. However, edges of such sheets are easier to blend with each other. Rewet sheets are the least manipulable of all. Their lamination is more likely to yield visible seams. This is due to the fact that once hydrogen bonds have been formed by drying a sheet, rewetting will not reopen them nor will it soften dried hemicelluloses (note: I am not sure that my naming of this substance is correct here. When a bast fiber is sufficiently beaten in water, it releases a slippery substance which acts like a size or glue. Sheets from such pulp, if pressed together, will adhere as if pasted when dry. These same sheets will also be non-absorbent to ink or watercolor. Some paper chemists have told me that this slippery substance is hemicelluloses, swollen with water. Some paper-makers say it is "fines", a term which seems to be used as phlogiston once was to explain a multitude of effects. The important point is that it is obtained by prolonged beating with plenty of water, beating time varies with the fiber, and the more of this substance that is released, the more sticky, translucent, shrinkable, and crisp the paper will be).

glue such as methyl cellulose, or rice or wheat paste brushed between the moist layers to provide both adhesion and stiffness. Unlike the stronger rice and wheat pastes, methyl cellulose does not rot, seems inedible by worms and insects, and causes minimum discoloration and so I consider it the most desirable alternative if a paste must be used.

Properly done, lamination casting gives light, thin (1/16"–1/8"), strong castings with the potential for immaculately smooth, dense, and seamless surfaces. Lamination also allows great control over surface patterning and great variation of color, texture, translucency and opacity. No elaborate or unusual equipment is necessary. The method is basically very simple, but takes some practice and familiarity to achieve the best results. The paper to be used is torn into easily manageable pieces according to the internal configuration of the mold. Unless you wish to stress the edges where pieces come together, torn edges are important because they are more easily blended with each other to achieve a seamless quality. A layer of these pieces is firmly tamped into the mold with a stiff bristle brush³ (a stencil brush, a flat, short bristled oil paint brush, or a narrow, nylon bristle paint brush with the bristles cut short, for example). Edges of pieces must be overlapped. If freshly formed sheets of a high shrinkage bast fiber paper are being used, a second layer may immediately be tamped over the first. If not, methyl cellulose or rice or wheat paste should be brushed between overlapped edges and on the pieces of the second layer before they are tamped in place (glue

³ It is for this reason that rigid surfaces are important with this type of casting. There must be something to give resistance to the tamping action so that firm and complete contact will be made between mold surface and paper for optimum accuracy of detail.

side down, of course). Methyl cellulose is slippery and often causes the second layer to slide on the first so care must be taken in applying this layer. In any case, the seams of the second layer should also be overlapped and they should be placed to fall over seamless areas in the first layer.⁴ To insure opacity and for extra strength, third and fourth layers can be tamped in. The number of layers depend in part on the thickness of the sheets being used. It is better to use thin to medium weight sheets and more layers rather than thick sheets and fewer. In my experience, the number of layers, not the thickness, has proved a direct coefficient of strength—the more, the stronger. No less important to consider is that thin sheets are more easily tamped into intimate contact with the surface detail of the mold.

When lamination is complete, the casting may be left to dry. Slow drying, without application of fan or heater, is best because it avoids the warpage which frequently accompanies the uneven drying caused by excess heat or draft. Also, forced drying is really unnecessary because casting by this method gives a thin wall section that seldom takes long to dry. With high shrinkage papers, however, slow drying is not enough to prevent warpage and additional precautions must be taken, for in extreme circumstances the casting can actually twist itself completely out of the mold. A restrainer of some sort must be designed. If the form is a small one (fist size or smaller) and has a deep, rounded cross-section (a half apple form as opposed to a flat relief, for example), restraint of warpage may be accomplished in the final layer of lamination by using a medium to

⁴ In other words, the seams should be laid in much the same way that the joints in one course of bricks relate to those in the course preceding them.

heavy weight abaca paper with methyl cellulose. The comparatively non-shrinking abaca will dry before the higher shrinkage paper at the mold surface. It will act as a base form over which the other paper will stretch as it dries. Since the contracting forces of shrinking paper are really very powerful,⁵ with larger molds, a restraining form must be made as an additional part of the mold. The easiest way to make one is during the casting process: As soon as lamination is completed, a layer of tissue (toilet tissue or facial tissue work excellently) is tamped gently into the mold. This is lightly sprayed with water and a second layer is tamped in. If very thin tissue is used, a third layer should be added. The final layer is sprayed once more⁶ with water and then plaster is applied directly against it first with a brush and, as it thickens, with a spatula to form an even-sectioned backup of one half to one inch thickness. The backup should be made in sections, as necessary, to avoid undercuts. The tissue prevents the plaster from sticking to the casting without harming the casting. It is easily peeled from the plaster later on. The entire mold, plaster, paper, and all, is then left to dry thoroughly. The first time the mold is used, this may take as long as two weeks depending on casting size, thickness

⁵ The contracting forces of evaporation and subsequent hydrogen bonding can exert pressures of up to 1500 pounds per square inch. This contraction is known as the Campbell effect (see p. 68-69, *Nagashizuki, The Japanese Craft of Hand Papermaking*, by Timothy Barrett, published 1979, Bird and Bull Press, for a simple, clear description).

⁶ The spraying is necessary so that the tissue will not absorb moisture from the plaster. Otherwise, it could cause the plaster surface next to it to be powdery when dry because plaster needs all its water for proper crystal formation in setting. With insufficient water, it will be weak and crumbly.

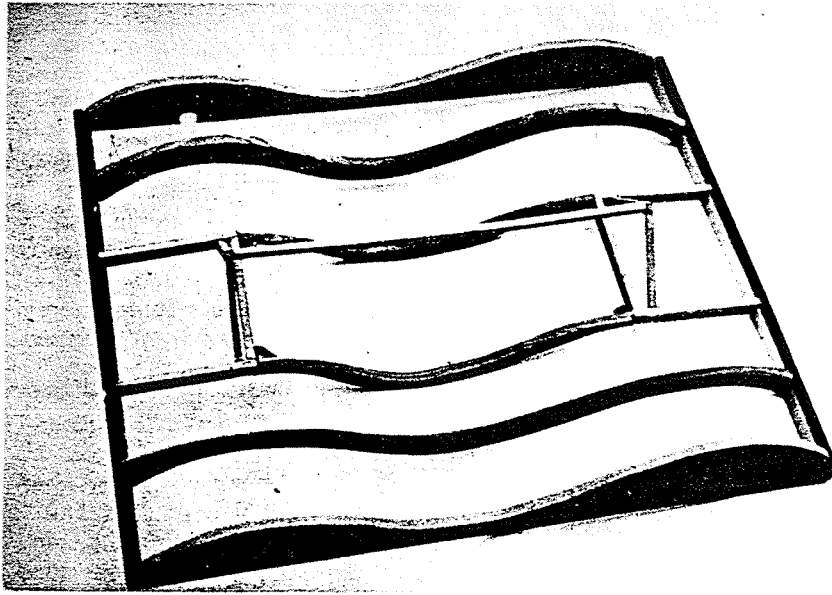
of the plaster backup, and the temperature and humidity of the studio. Remember that if the plaster is not dry (i.e. if it is still cool to the touch—this indicates that evaporation is still occurring), the paper is not dry inside. There should be no problem with mildew if you have not used rice or wheat paste or an animal size and if your fiber and water were clean to start. Drying of a small mold may be hastened by leaving it in a gas oven on pilot or in a loose-lidded, foil-lined cardboard box with a 60 watt electric bulb to warm the interior. Under no circumstances should such molds be baked in an oven to dry them, for the plaster will become brittle and crack and the risk is run of burning other parts of the mold or scorching the paper within.⁷

Molds with plaster restrainers are, of course, reusable. In fact, once the plaster is dry, the drying time of subsequent castings is shortened considerably, particularly if a layer or two of dry tissue is placed against the casting before closing the mold and is replaced periodically (every 3 hours) until drying is complete. This is similar to slipsheet drying of flat paper. A final note of caution: do not store a plaster restrainer separate from its mold because plaster warps.

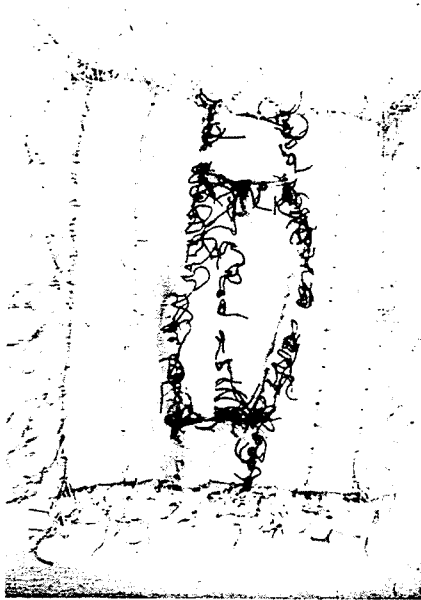
Flexible Mold System and Pour Casting

The flexible casting method which I have developed is particularly exciting to me because it combines so many influences. It is based on Nepalese papermaking, which still uses fabric screens and dries the paper on the screen; European

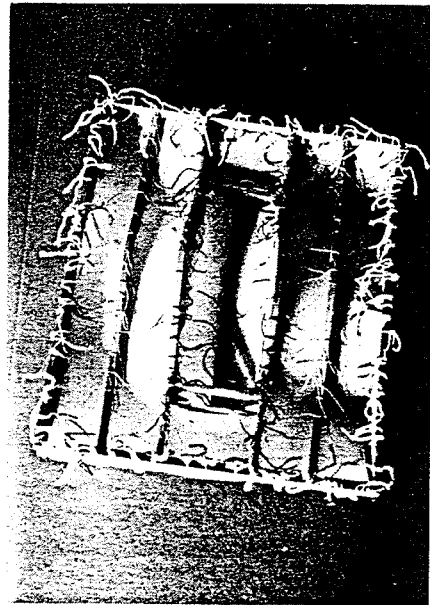
⁷ Also, papers which have a high shrinkage coefficient will put less stress on the mold and will in fact warp less if allowed to shrink gradually in natural drying. If the paper is speed-dried with heat, the stresses of shrinkage are magnified and the paper cannot adjust to the contours of the mold with the not infrequent consequence that the paper either breaks the mold or itself.



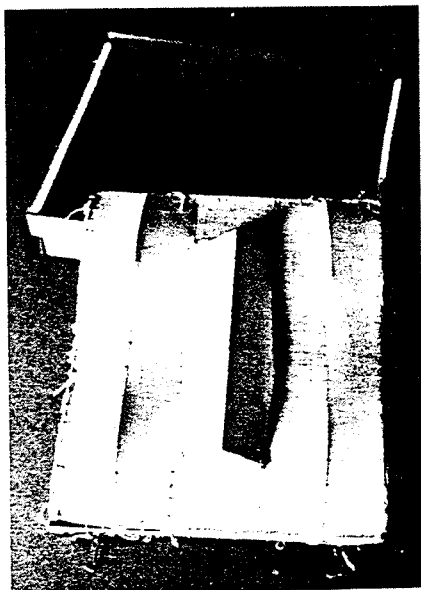
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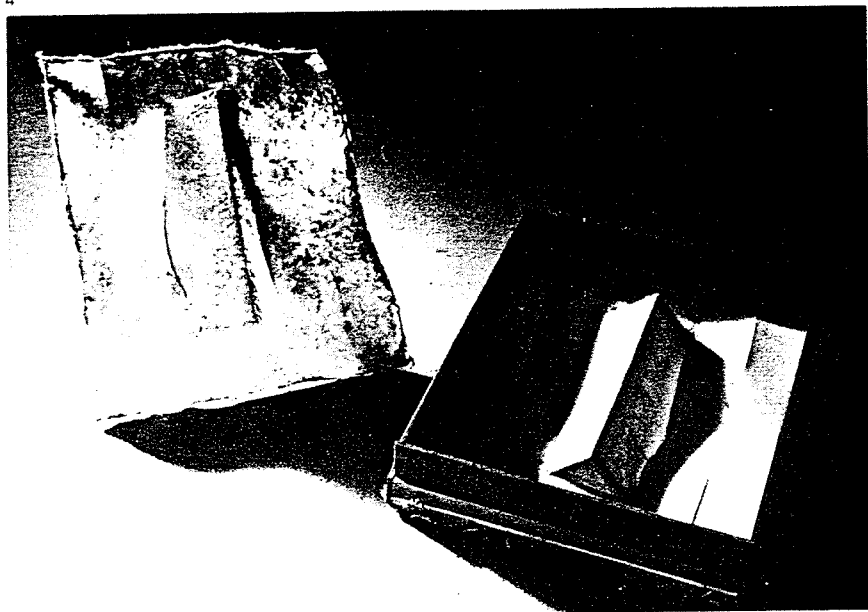
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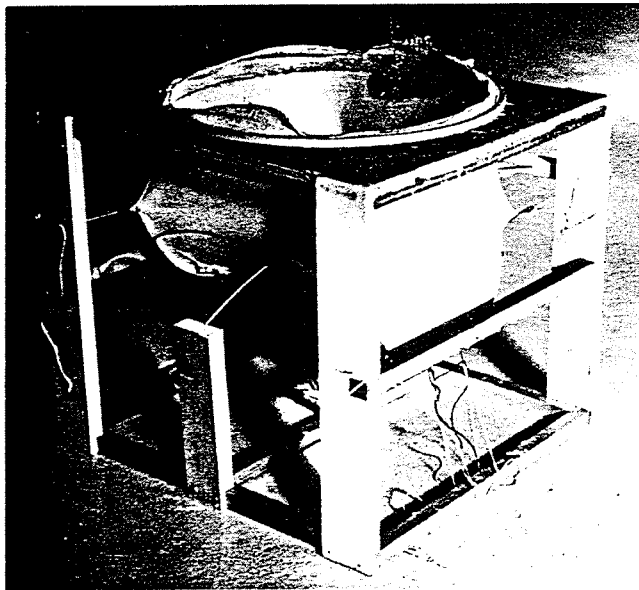
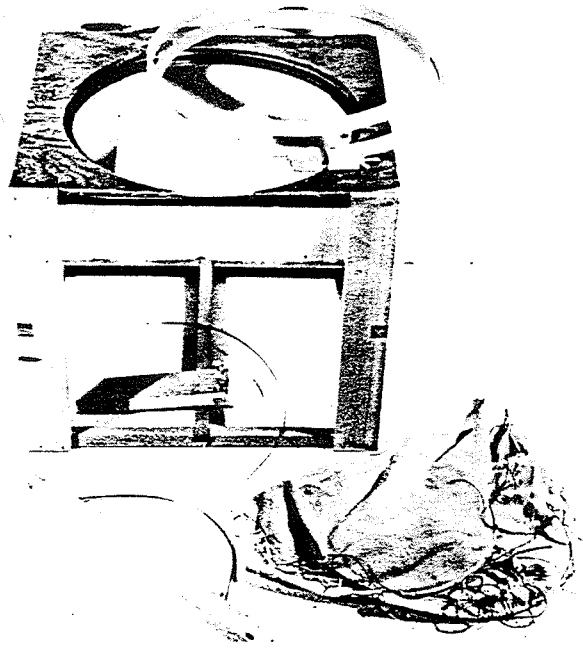
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Fabric screen mold for pour casting

- 1) basic frame
- 2) underside of unattached screen, showing ties sewn to fabric for fastening to frame.
- 3) screen attached to frame, underside.
- 4) mold surface shown propped against deckle. Brass hooks at bottom of mold fasten deckle firmly to minimize pulp leakage and facilitate forming action.
- 5) fully-assembled mold and deckle with translucent ramie fiber casting, note brass hooks holding deckle to mold.



2

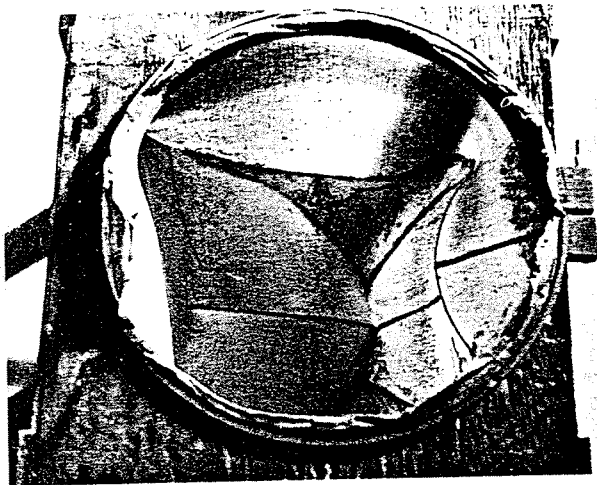
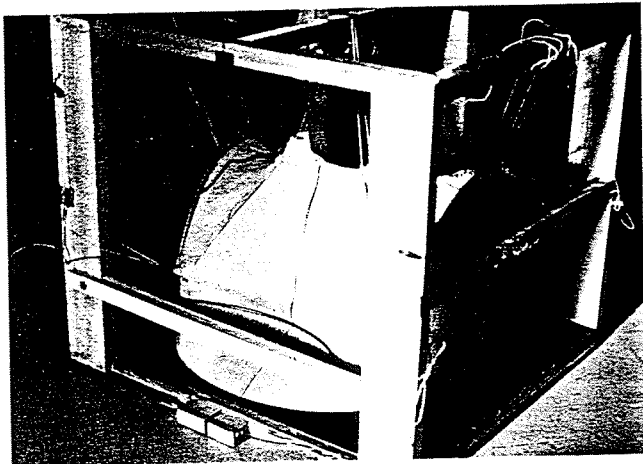
Adjustable fabric
screen embroidery
hoop mold
1) parts before
assembly
2) assembled

The best fabric for screen material is cotton because it is absorbent but does not stretch too much. The absorbency is important because it prevents the pulp, which is slippery due to the tororo-aoi dispersion agent, from sliding on the screen surface. Cotton gauze (the type used for "peasant" blouses, not the medical variety) or cotton interfacing represent good mesh sizes to use. Polyester fabric is not as useful, chiefly because it is non-absorbent and so will not hold the pulp on steep surfaces. Also, those polyester fabrics with the proper mesh size (i.e. polyester chiffon & marquessette) have proved insufficiently tough.

The screen is attached to the mold frame by numerous strong ties, machine-sewn to the back of the screen. The best material for the ties is a heavy, waxed linen thread. It is water resistant and the wax coating seems to make it easier both to tie and to untie than other threads I have tried (i.e. woven fishline). The fabric screen would be stretched tightly on the wooden frame. Before the pulp is poured, the screen should be primed with a water spray. A deckle is necessary only if the mold does not itself have a perimeter higher than all the interior surfaces. The mold pictured has a deckle because the central wedge form is higher than the outside edges and it would otherwise be impossible to coat that part of the screen surface evenly with pulp. The deckle is high enough to allow that form to be submerged when the mold is filled. Note that the deckle is fastened to the bottom frame with brass hooks and eyes to facilitate handling during the action of forming the "sheet" (see photo).

Molds like the one described above still had drawbacks, however. The greatest of these is the time consumed in tying down and then, later, untying the screen. The mold with the wedge form and dec-

3) detail of underside showing metal ribs pressing curves into surface and curved ribs sewn into fabric and tied to establish tension



4) interior surface of mold, showing effects of both rib types. A thin, two-color gampi casting is in the mold.

kle requires three hours to tie and one and a half hours to untie. Also, the frame is only useable for the one shape of screen. I have since designed molds with frames which can support a variety of screen shapes, screens which contain their own rib supports and ribs which press into the screen to simplify the tying problem. Tents which use external armatures were part of my inspiration. One result was the embroidery hoop mold illustrated. The advantage of using the hoop is that the entire upper edge of the screen can be fastened in one motion. The simplicity of the rest of the frame allows a variety of tie-down attachments as well as the alternative of the screwed-on, curved, in-pressing metal rib attachments which hold the screen in curved surfaces by pressure rather than tying. Note in the illustration that the curved brass rods have also been sewn into the screen to create curves in the other direction with a minimum of tied attachments. This mold requires less than 15 minutes to assemble. A variety of screen designs can be used in this basic frame.

The pulp used in pour casting with these molds must be long-fibered with a relatively high shrinkage. It should be a bast fiber. The long fiber is necessary in order to give tear strength to the very thin casting so that it will not suffer damage when the screen is peeled away. High shrinkage insures that the final form will be tight, since even firmly-stretched fabric sags when wet. Bast fibers are best because, if properly prepared, they seem to release more hemicelluloses, and the resulting paper is crisper—an important factor if the thin casting is to hold its shape without sagging when dry. Even if a pulp has low freeness, it must be used with a dispersion agent (i.e. tororo-aoi) so that the screen may be coated evenly as well as thinly

and with the proper forming movement (i.e. nagashizuki) to give strength to the sheet structure of the casting.

The advantages of color modulation and variation of translucency that are offered by this nagashizuki style pouring technique with the fabric mold are readily apparent, I think. Additionally, a variety of watermark effects may be obtained by employing different fabric mesh patterns and by sewing patterns into the fabric surface. Finally, as the illustrated metal screen mold demonstrates, it is possible to make a completely enclosed translucent casting with this method.

Summary

In summary, no paper casting of quality in either the aesthetic or the technical sense can be made without careful attention to the selection and treatment of the fiber used for the pulp. With careful pulp design, a wide range of surface density, visual texture, color, translucency, and luster may be explored. Otherwise, you might as well be making egg cartons or using plaster. Casting in paper is only valid to the extent that it acknowledges the unique qualities of paper's nature and manufacture as these are extended by and serve to extend the activities of casting and mold making. Even so, casting in paper is worthless and meaningless if pursued simply as technical novelty. Technical nicety can never replace intellectual substance and should not be allowed to subvert aesthetic vision. It is, after all, an instrument, not an end.