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A method for casting sculpture in fiberglass reinforced plastic using a plaster waste mold

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A METHOD FOR CASTING SCULPTURE IN FIBERGLASS REINFORCED PLASTIC USING A PLASTER WASTE MOLD.

by

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INTRODUCTION

My interest in fiberglass reinforced plastics stems from the needs of my sculpture, rather than a desire to do research in new materials.

I like to work in clay. However, clay is not a good permanent medium, so that works done in clay must be cast in some other material. The traditional casting media--bronze and plaster--have some serious disadvantages. Bronze is a beautiful material, but it is extremely expensive and special equipment is required to cast it. Plaster is relatively easy to cast, but it is fragile and cannot be placed outdoors.

Fiberglass reinforced plastic, though by no means the perfect casting medium, does have enough desirable characteristics to allow it to be considered as an alternative to the traditional casting media. It is extremely strong and lightweight and it is reasonably weather resistant. Its cost is not prohibitively high and it can be accurately cast in a mold. Making a fiberglass reinforced plastic laminate requires no expensive equipment and should be within the capacities of most sculptors.

The sculptural use of plastics is not new, but detailed information on procedures for casting large works in plastic seems to be scarce. The following discussion will deal with a method for casting in fiberglass rein-

forced plastic from a plaster waste mold. The techniques employed are not original and are largely derived from my experience in boat-building and in the aircraft industry. The casting process is time consuming and unpleasant, but no single step is particularly difficult. If instructions are carefully followed, no serious problems should arise.

I. FIBERGLASS REINFORCED PLASTIC LAMINATES

The piece of sculpture produced by the following process will be a hollow fiberglass reinforced plastic laminate. A basic understanding of its construction is necessary before proceeding to the discussion of materials and procedures.

A plaster waste mold is made from the clay model. This mold is dried and then treated to prevent the plastic from sticking to it. A layer of liquid plastic is painted on the inside surface of the mold. This first layer is called the gel coat. It will form the outside surface of the finished cast. After the gel coat has hardened it is strengthened by additional layers of plastic, applied in the same manner but containing fiberglass fabric as reinforcement. A layer of plastic is brushed on, then fiberglass fabric is laid on the wet plastic, followed by another coat of plastic. When the plastic hardens the fiberglass fabric is embedded in it and acts as reinforcement in much the same way that steel is used to reinforce concrete structures. This process of building up layers of fiberglass fabric and plastic is called hand lay-up or lamination. The structure produced by this process is a fiberglass reinforced plastic laminate.

After the laminate has completely hardened, the mold is broken away to expose the surface of the cast.

II. MATERIALS

Liquid Plastics

The two types of liquid plastics generally obtainable and suitable for the hand lay-up process are the polyester and epoxy resins.

The epoxies have several advantages over the polyester resins, such as higher strength and better adhesive qualities, but their cost is very high. The polyester resins, on the other hand, cost only about one quarter as much but still possess more than adequate strength for most sculptural uses. They are easy to work with, requiring no expensive or elaborate equipment, and are readily obtainable due to their wide use in boat-building.

The difference in cost between the two resins, together with the fact that the author is somewhat familiar with the polyesters and their use in boat-building and in the aircraft industry, lead him to choose the polyesters for his experiments. Though the methods for handling the two resins are somewhat similar, they are different materials and specific instructions are needed in dealing with each. The following discussion deals only with the methods of working with the polyester resins.

Polyester Resins

The polyester resins are syrupy fluids which when combined with catalysts and accelerators convert to rigid solids. This process is called polymerization. The time required for its completion is determined by the amount of catalyst and accelerator used as well as other factors such as temperature, light, and humidity. The speed of the polymerization or curing process is particularly sensitive to heat. The higher the room temperature is, the faster the resin will cure. This characteristic can be used to advantage in the hand lamination process.

When the catalyst is added to the resin, the chemical action which causes hardening begins. The change from liquid to solid is quite sudden. It is easy to be left with half a container of hard resin unused. To avoid making this expensive mistake, one can mix less than the recommended amount of catalyst with the resin. After the work is completed heat can be applied to the laminate to speed the cure. Heat lamps and electric heaters work well and are easy to control. Avoid carrying this idea to extremes. Adding too little catalyst might result in an uneven or incomplete cure while too much heat can cause cracking or warping.

The problem of which polyester resin to use may be confusing. The American Cyanimid Company alone manufac-

tures about forty varieties, each of which has some specific property required by industry. The plastics salesman can usually recommend the proper resin, but still it is best to be as specific as possible about your needs. It is usually best to ask for a laminating resin suitable for hand lay-up and boat building. Also, specify a resin that does not have a wax-like substance added to allow it to cure tack-free.

The curing of polyester resin is inhibited by the presence of air, causing the surface of each layer of resin to remain tacky long after the interior has hardened. To eliminate this tacky surface, the wax-like substance mentioned above is added to some resins. As the resin cures, the wax floats to the surface and forms a film which excludes air and allows the surface of the resin to cure hard. This wax film is permissible only on the final coat of resin. If it were to form on the inner layers, it would prevent adhesion of following layers of resin.

For this method of casting it is not necessary to use a resin which cures tack-free, even for the last coat, because the last coat of resin will be the inside surface of the final cast. The outside surface of the cast, which is the surface next to the mold, will cure hard because the mold excludes air.

When it is necessary for an exposed surface to cure hard quickly, as in patching, it can be covered with a cellophane or polyethylene film or waxed to exclude air.

Catalysts and Hardeners

As mentioned above, polyester resin requires the addition of catalyst and hardener to cure. Just how much of each is required varies with the resin, so the manufacturer's advice should always be followed. After becoming familiar with the resin being used, the amount of catalyst may be changed slightly to increase or decrease the curing time as described in the previous section.

Most resins are packaged with the hardener already added but since this is not always the case, the manufacturer's instructions should be consulted. If it is necessary to add hardener, the following rules should be strictly observed:

1. Use the exact amount specified by the manufacturer. Too much hardener can cause cracking, warping, crazing, etc.

2. Mix the hardener with the resin, then add the catalyst just before using. Under no circumstances should the catalyst be mixed directly with the hardener. A very serious explosion could result.

3. Always add the hardener to the resin in a well ventilated place. Avoid breathing the fumes because they are highly toxic.

In the interests of safety and convenience, using a resin with the hardener already added is strongly recom-

mended.

Handling the Resins

These suggestions are the result of trial and error and unpleasant experience. Following them might save considerable trouble.

1. Wear rubber gloves when handling resins, and remove any resin which gets on them with acetone before it cures.

2. Avoid skin contact with resins, catalysts, hardeners, and solvents. It might cause severe skin problems. If resin is gotten on the skin it must be removed before it cures, by washing with acetone followed by washing with soap and water and the application of a hand lotion. Individual reaction to contact with these materials seems to vary. Many people are not particularly bothered by it, but unless you find it impossible to work in gloves, it is wise to wear them.

3. Avoid breathing the fumes from resins, solvents, hardeners and catalysts and the dust from grinding the cured laminate. The fumes are toxic and the dust causes lung irritations.

Work in a well ventilated place and wear a filter-type mask when sanding or grinding the cured laminate.

While not dangerous in normal concentrations, the odor of polyester resin as it cures is rather strong and unpleasant and will spread through an entire house in spite of closed doors. The smell lasts for several days

and causes certain foods, particularly butter, to acquire a strange taste even though it is in the refrigerator. If you work at home don't plan to cast in fiberglass and have a dinner party the same weekend.

4. Be orderly. Plan each step in advance and make sure all tools and materials needed are at hand. Once the catalyst is added to the resin the curing process begins; working time is limited. Delays result in hardened, unused resin and are expensive.

5. Use clean containers and brushes when working with the resin. Partly cured resin mixing with fresh resin will cause uneven curing.

Brushes may be cleaned by washing them in acetone before the resin cures. Brushes in which resin has hardened must be discarded. Use cheap brushes; no brush will last long when used in resin.

Disposable containers are best for mixing the resin because they can be thrown away after each use. It is possible to clean the containers with acetone or lacquer thinner after each use, but this hardly seems worth the trouble. The author uses one quart plastic refrigerator containers which cost about ten cents each. Polyester resin does not stick to these and can be lifted out in one piece after hardening.

6. Protect your work area with newspapers or drop cloths as resin will eventually be spilled or dropped onto it and is difficult to clean up, especially after it has

cured.

Storing the Resins

Polyester resins have a limited shelf life, but it can be significantly increased by storing them in a cool place. Resin will usually last at least four months under normal conditions. If the temperature can be kept at forty to sixty degrees, the shelf life might stretch to six months or to a year.

Don't buy more resin than will be used within the estimated shelf life, but remember that the unit price of resin drops considerably as the quantity increases. It may be advantageous to cast several pieces at once.

The flammability of polyester resins is greater than that of kerosene. Precautions against fire should be taken in handling and storage.

Fillers for Polyester Resin

Fillers may be added to polyester resins as long as they are chemically compatible with the resin. A small batch may be mixed and cured to determine compatibility. In general, fillers increase strength, reduce shrinkage, and may improve the textural or color qualities of the surface.

The variety of suitable fillers is great. The choice of fillers will be determined by the physical and the aesthetic demands of the work. The author generally uses

colloidal silica and calcium carbonate as fillers and has found them adequate to meet the physical demands of this type of casting.

Colloidal silica is an extremely lightweight, fine, white powder that is essential for this method of casting being discussed. When this powder is added to the resin, it causes the resin to thicken without adding much weight. This allows the resin to be applied to vertical or to uneven mold surfaces without run-off. Colloidal silica should be added to the resin before the catalyst is added. Just how much silica is required is determined by where the resin is to be used.

For the first, or gel, coat enough colloidal silica must be added to the resin to prevent its running off high spots on the mold. A properly thickened gel coat will "stand up" or retain most of its contours. Its consistency might be compared to thin whipped cream.

Resin to be used for the laminations benefits from the addition of about two ounces of colloidal silica per quart of resin. This prevents the resin from running out of the fiberglass mat on vertical surfaces.

Leftover portions of the resin mixed for the gel coat may be thickened by further additions of colloidal silica to a putty consistency and used for patching the final cast. Colloidal silica is particularly good for this purpose because it becomes transparent when it is mixed with resin so it does not affect the color.

Care should be taken in mixing colloidal silica with the resin. The silica is extremely light and tends to float in the air when it is agitated. Inhalation of this powder may cause throat and lung irritations or respiratory ailments.

Calcium carbonate, which can be purchased as whiting or powdered chalk as well as under many brand names, is also a useful filler. It can be added to the resin in amounts of up to forty percent by weight and will reduce surface shrinkage while adding an opaque white color. The cost of calcium carbonate is very low so its use will reduce casting costs.

Mixing calcium carbonate with the polyester resin may cause problems because of its tendency to form small lumps which are difficult to break up. A smooth mixture may be obtained in the following way:

1. Mix the required amount of calcium carbonate with a small amount of polyester resin by stirring. Break up as many lumps as possible.
2. Add the remaining resin and stir thoroughly.
3. Pour the mixture through a disposable cheesecloth paint strainer then discard the portion which does not go through.

This mixing method can also be used for adding dry pigment or other types of fillers to the resin.

Fiberglass Reinforcement

Since cured polyester resin alone is brittle and has little tensile strength, it is necessary to add some sort of reinforcement. Fiberglass fabric is the best reinforcement material, being compatible with the resin, easy to use, and extremely strong. The two types of fiberglass fabrics which will concern us are woven fiberglass cloth and fiberglass mat.

Woven fiberglass cloth will produce a laminate with higher tensile strength than fiberglass mat, but is more expensive and more difficult to work with in sharply contoured areas. This fabric is best used in large relatively flat areas where a high strength laminate is required.

The catalyzed resin may be applied by brush, roller, or squeegee. The fiberglass fabric is white when purchased but becomes transparent when impregnated with resin. Pockets of air trapped under the cloth appear as opaque white spots and must be removed either by working them out under the edge or popping them with a knife.

Fiberglass mat is made of short strands of fiberglass loosely held together by a binder. It is perhaps more generally useful for most sculptural purposes because of its ability to conform to sharply contoured surfaces. It is usually available in two weights--three quarters and one and a half ounce per square foot. The lighter mat is used

for the more complex surfaces.

Resin is best applied to the mat by pouring it on then spreading it with a stippling motion of the brush. This stippling motion pushes the fibers against the work and does not disturb the mat too much. A brushing motion cannot be used on mat because it causes the non-woven fibers to pull up and bunch. Like the cloths, the mat becomes transparent when it is impregnated with resin and air bubbles show up as white spots. Bubbles under the mat can usually be worked out through the fabric by a stippling motion of the brush.

It is convenient to precut large quantities of mat into various sizes to be used as needed. Since the mat surface will be on the inside of the cast, overlapping the pieces of mat will do no harm, so there is no reason to cut each piece neatly to shape. Three or four layers of mat will build up sufficient thickness for works up to life size. The total laminate thickness will be one eighth to one quarter inch.

Coloring the Cast

The types of color used in this kind of casting may be divided into two groups--integral color and surface color--but combinations of the two may be used in a single cast.

Integral color is color that is added to the resin used for the cast. Usually only the gel coats are colored but it is possible to color all the resin including that

used for lamination. This has the advantage of producing a cast that is colored all the way through, so there is no danger of cutting through the color during the finishing operations. On the other hand, coloring all the resin makes the laminating process far more difficult. It prevents visually checking for complete impregnation and air bubbles. Air bubbles and dry spots cannot be seen because the resin is no longer transparent. The following is a satisfactory compromise: Use two colored gel coats then add the fiberglass laminations using clear resin. This gives a thick color layer without complicating the laminating process.

Colorants suitable for adding to the resin come in three forms: dry pigments, color pastes, and dyes.

Dry pigments should be checked for compatibility with the polyester resin before being used. The biggest problem in using dry pigment is getting a smooth mix. If the pigment is mixed with the resin in the manner described for mixing calcium carbonate in the section on fillers this problem will be overcome.

Prepared color pastes are very easy to use because the pigment is already ground in polyester resin or in a universal binder. Color pastes may simply be added to the resin and stirred. Use only color pastes prepared for use with polyester resin.

Dyes are used when a transparent color is desired. The dyes are extremely concentrated so very little is

required.

When choosing a paint to use on the surface of the cast it is necessary to be sure that it will adhere to a "Fiberglass"[1] surface. Some paints require that a primer coat be applied before they can be used on polyester resin.

Many boat and automobile paint systems are available that are prepared specifically for use on Fiberglass.

Artists' oil colors mixed with Dorland's wax medium seem to adhere well. This combination handles nicely and allows a wide variety of dependable colors to be used.

Artists' acrylic paints also seem to adhere well. They offer a good variety of colors and dry quickly.

When using any paint it is good practice to clean the surface of the cast thoroughly and to remove the gloss with steel wool to promote adhesion.

Release Agents

After the plaster mold is sealed with shellac, it must be treated with release agents to enable the cast to be removed without sticking. The recommended procedure is to give the mold two coats of paste wax followed by two or three coats of polyvinyl alcohol release agent.

Any good paste wax such as Simonize can be used, or a

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[1] "Fiberglass" is the brand name for the glass fiber used in making fiberglass fabrics, but the designation "fiberglass" is frequently used in referring to a polyester resin laminate reinforced with fiberglass fabric.

special parting wax can be purchased. The mold should be polished after each application of wax.

The polyvinyl alcohol mold release is best applied by spraying, but it can be brushed on if no spray equipment is available. A mouth atomizer can be used to spray mold release for small pieces or mold release can be bought packaged in an aerosol can.

III. THE CASTING PROCESS

The casting process is not particularly difficult and should present few major problems if instructions are carefully followed. Read the preceding sections and be sure you are familiar with the nature of the materials and the means of handling them before you begin casting.

It will be assumed that the reader knows how to make a plaster waste mold.

Mold Preparation

After a plaster waste mold is made from the clay model, it is treated in the following way:

1. The mold must be thoroughly dry. Drying can be hastened by the application of heat in the form of heat lamps, electric heaters, etc.

2. After the mold is dry, seal it with several coats of shellac which has been thinned with an equal part of denatured alcohol. When the mold is properly sealed it will have a slight gloss.

3. Give the sealed mold two coats of paste wax and polish it after each coat.

4. Apply three coats of polyvinyl alcohol mold release, allowing time for it to dry between coats.

When the above steps are complete, the mold is ready

and casting may begin.

The Laminations

To gain access to all parts of the mold it is usually necessary to treat each piece separately, and then to assemble the pieces when the laminating process is complete. The laminate is made in the following way:

1. Prepare enough resin for two gel coats for the entire work using polyester resin, colloidal silica, and whatever fillers and colorants are desired. Remember that the gel should be thick enough to hold its shape.

2. Working with not more than a quart of the resin at a time, add the required amount of catalyst, stir, and apply to the surface of the mold. While applying the first gel coat, be careful not to disturb the film of release agent. This first gel coat is very important because it will form the outside surface of the cast.

3. After the first gel coat has hardened, add a second gel coat and allow it to harden. Two gel coats are usually sufficient.

4. Brush on a coat of clear polyester resin with catalyst added.

5. To the wet resin add a layer of fiberglass cloth or mat.

6. Add more resin and work it into the cloth or mat using a stippling motion of the brush as described in the section on fiberglass reinforcement. The fabric will

become transparent when completely impregnated.

7. Repeat steps four, five, and six until sufficient thickness is built up.

When the laminations are complete, the pieces should be allowed to cure before assembling.

Assembling the Cast

The pieces of the cast are usually assembled while still in the mold. This prevents warping and allows the pieces to be located accurately by using the register marks in the mold.

The assembly process is apt to be awkward due to the confined space inside the mold, but it can usually be accomplished by pouring the resin down the seam line and applying strips of mat impregnated with resin to the seams. These strips may have to be pushed into place with sticks or long handled brushes. The resin used to impregnate these strips should be the same color as the gel coats.

Plan the order of assembly so as to make the seams as accessible as possible. If the form is completely closed the last section may have to be put on from the outside.

Removing the Mold

After the seams have cured, the mold is broken off with a hammer and chisel. If the mold was properly prepared, the cast should separate from it very easily.

Finishing the Cast

After the mold is removed, the cast should be washed with soap and water to remove any traces of wax or mold release. Imperfections in the surface can then be patched with a modeling paste made of gel coat resin thickened with colloidal silica.

The cast may then be finished as desired by sanding, polishing or painting.

EVALUATION

In closing, it is appropriate to evaluate the product and process of casting in fiberglass reinforced plastic in terms of advantages and disadvantages.

The disadvantages of working in plastics lie almost entirely in the nature of the raw materials. The materials are sticky, can be physically irritating or dangerous, and have none of the pleasant handling qualities of traditional media like wood, clay, or stone. It seems unlikely that anyone will derive much pleasure from the manipulation of these materials.

The lamination process itself is difficult only in that it is demanding. Each step must be properly carried out. If any single step is neglected, problems will result. Plastic is not a forgiving medium and mistakes cannot always be easily repaired.

The justification for casting in fiberglass reinforced plastics is found in the qualities of the cast produced. The cast will be structurally strong, lightweight, relatively low cost, and weather resistant. The process can be performed in studio conditions without special equipment.

The above characteristics are important but they are essentially technical considerations and would be meaningless if there were not also some aesthetic justification

for the use of plastics. The polyester resins, liquid in their raw state, are capable of producing a tremendous variety of surface and color qualities. The variety possible within a single medium is a capability unique to plastics and sufficient to justify its consideration as a casting medium. Whether or not these qualities are relevant to any individual work must be determined by the artist and the demand of the work itself.

My personal reaction to plastics as a sculpture medium is divided. I dislike the casting process but am attracted by the qualities of the cast produced.

My aversion to the casting process is a major consideration. The sensual pleasure that I derive from working with materials like clay or wood is important to me. Part of the excitement and involvement of working in sculpture is generated by contact with--and control of--the materials. I find contact with plastics raw materials unpleasant. They give me a skin rash and make me itch. There is little sense of physical control when working with the polyester resins. They are liquids so they run downhill; after awhile they harden by some chemical process that I can neither see nor feel. I cannot identify with a syrup.

The result of my dislike for the casting process has been the minimization of its role in the sculpture process. I think of it more as manual labor than as creative work. My thinking while I work jumps around between live model, clay model, finished piece, and me. The state of the

plastics materials during the casting stage is not considered.

My objections to working in plastics vanish when the casting process is finished. The finished plastic cast can have sensuous qualities that I enjoy and find relevant to my work.

The pieces that I have done in fiberglass reinforced plastic are essentially portraits. Each is a sculptural response to an individual rather than to an ideal. One of the qualities of the model that I respond to is her physical or sensual presence. My response to this quality translates nicely into plastic. Plastics can have some of the visual and the tactile qualities of flesh, along with its temptations. At times I have gotten involved with making plastic people rather than sculpture. Beware the temptations of flesh!

APPENDICES

APPENDIX I

The following items can be obtained at any hardware store:

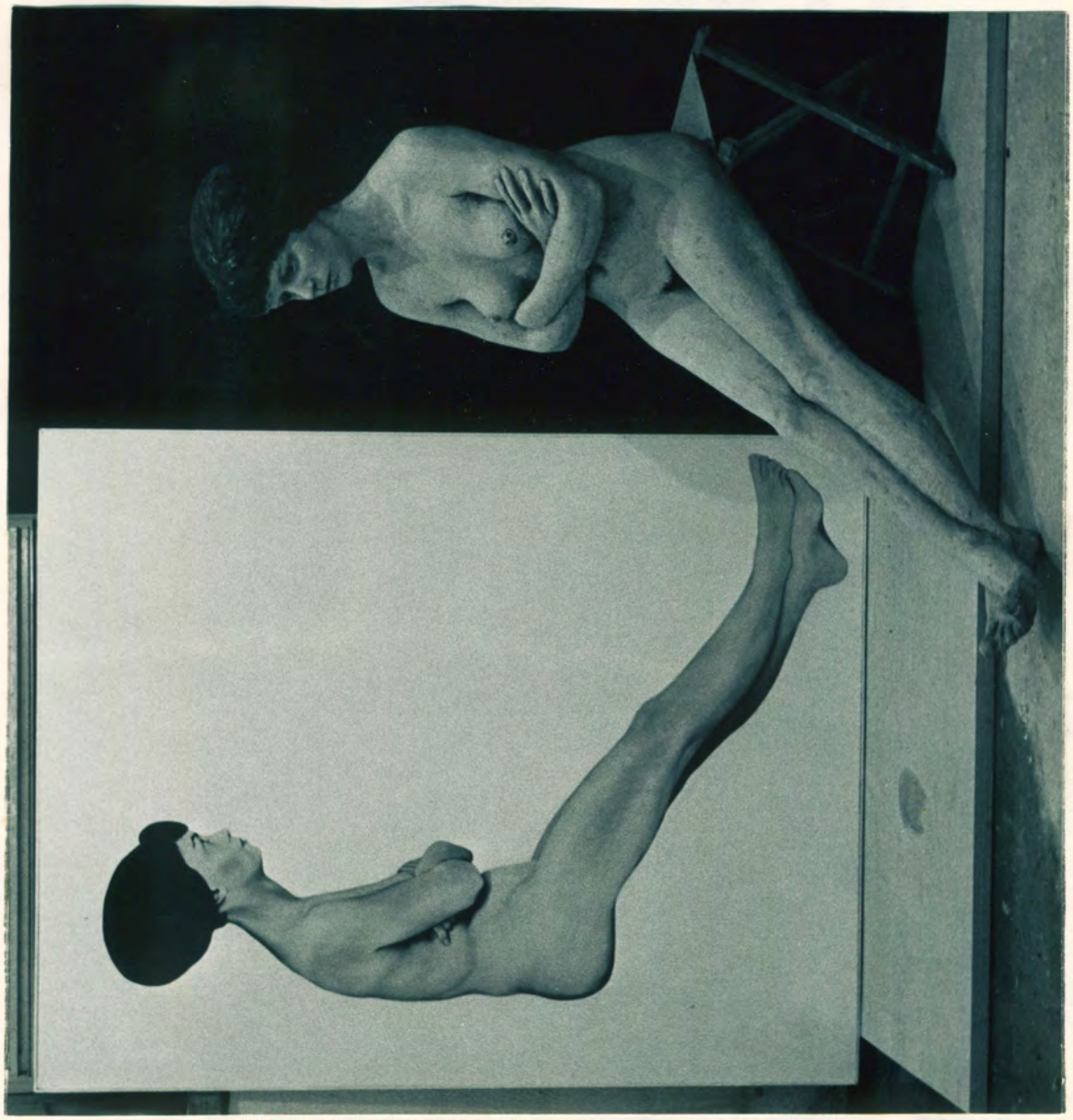
Paint brushes (for applying resin)
Scissors (for cutting fiberglass fabric)
Containers (for mixing resin)
Shellac (for sealing molds)
Alcohol (for thinning shellac)

The items below can be obtained from most suppliers of plastics materials. Check the Yellow Pages of your telephone directory under Plastics--Raw Materials--Powders, Liquids, Resins, etc. If you live in or near St. Louis, Missouri; the Biloxi Boat and Plastic Company, 3638 Tholozan, St. Louis, Missouri will supply all of the materials on the following list: (This company will also supply an excellent pre-mixed gel coat.)

Mold wax
Mold release agent
Laminating resin
Catalyst
Colloidal silica
Fillers, color pastes, dry pigment, etc.
Fiberglass fabric
Acetone

APPENDIX II

The photographs on the following pages are of works done by the author and cast in fiberglass reinforced plastic using the method described in this paper. All works pictured are life size.



Double Portrait of Judy

Marti

Irina

Judy Sunbathing

Vita Sheet

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Thesis Title

A METHOD FOR CASTING SCULPTURE IN
FIBERGLASS REINFORCED PLASTIC
USING A PLASTER WASTE MOLD

Mr. Larry Marcell, Thesis Adviser