THIN WALL CASTING IN-CIMENT FONDU

An Improved Method and Its Development

Wolfgang Peter Krol

A Thesis

in

The Faculty

of

Fine Arts

Presented in Partial Fulfillment of the Requirements
for the degree of Master of Fine Arts
Concordia University
Montréal, Québec, Canada

September 1981

ABSTRACT

THIN WALL CASTING IN CIMENT FONDU

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This paper is the result of twelve years of working, teaching, and experimenting with ciment Fondu in search of an economic, simple, and reliable casting technique capable of producing strong, lightweight sculpture in both art class and studio. The final technique described in this paper is based on a method developed by Edward Folkard, F.R.B.S. considerably modified in accordance with my own findings.

This "new" procedure saves both time and material, and widens the range of possibilities (e.g. sculputures can be hung, can lean beyond the center of gravity etc.). Works which previously took two or more days to hollow cast can now be completed easily within a three to six hour class.

A more detailed description of the process and of its evolution will be found in the Introduction and text of this paper.

DEDICATION

This paper is dedicated to Anne Kahane for having given me my first "taste" of Sculpture and for having encouraged me to continue in sculpture; to John Ivor Smith for introducing me to my first casting experience and the use of different tools and materials; to H.W. (Jimmy) Jones for showing me through his art that rules are there to be broken; to Eric Desmir who encouraged me not to accept the "accepted methods" and thus enabled me to find alternative ways of solving problems; and last but not least to all my students who have patiently suffered through the trials and errors of this casting process.

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INTRODUCTION

I was first introduced to concrete (Ciment Fondu) during my undergraduate studies in sculpture. The technique generally used at that time was as follows: An object was first made in clay. Then a simple one or two piece plaster mold was made. The plaster mold was lined with a cement/water mixture in either Ciment Fondu or Portland cement. Finally a sand/cement/water mixture was pressed into the mold until it was filled to the top. In other words molds were usually cast solid. The resulting sculptures were often heavy and difficult to handle. Sculptures one or two feet in height often weighed twenty or thirty pounds. Sculptures in the four to six foot range were almost impossible to cast because of the excessive weight. So for these larger sculptures one was forced to use either polyester or epoxy resins. Unfortunately the plastics did not have the same aesthetically pleasing random patina, not to mention their toxicity and that of the associated solvents, fillers, etc.

When my students began to experience the same short-comings of solid concrete casting, further research into the potential of this economical medium seemed indicated. Thin wall concrete (Ferro Concrete)[1] is of course widely used for boats, but the concrete steel mesh sandwich could not be made to conform to the complex interiors of relatively small molds.

Then a text came to hand, one chapter of which deals with casting in Ciment Fondu using fiberglass mat as reinforcing material to cast light

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[1] Gainor W. Jackson, JNR, and W. Morley Sutherland, Concrete Boatbuilding: Its Technique and Its Furture (2nd impression; New York: John De Graff Inc., 1969), p.II

weight hollow sculptures.[2] The strength and weaknesses of this technique as described therein led to considerable experimentation and ultimately to a system of casting now in general use in the sculpture classes of this university and one which I confidently use in my own work. This improved technique results in accurate, strong, light casts produced quickly and with great reliability. For this reason I have used the contents of that chapter by Folkard as the basis and essential reference point of this paper.

In this paper the advantages and shortcomings of various casting procedures are explored as well as the steps which led to the development of the subject technique. That technique is described in the last part of this paper under "The Complete Modified Casting Technique" in sufficient detail and in such a manner that anyone wishing to apply it should encounter little difficulty.

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[2] H.M. Percy, New Materials in Sculpture, (London: Alec Tiranti, 1965), Chapter 13, p. 124-152.

CHARACTERISTICS OF CEMENT

Portland and Ciment Fondu

The most commonly used cement today is Portland. In addition to the normal, regular Portland there are types compounded for such characteristics as low heat, rapid hardening, and resistance to chemicals.[1] Portland is "usually manufactured from limestone mixed with shale, clay, or marl"[2] and can range in color from dark grey to white.[3]

Ciment Fondu is not a Portland type cement. Instead it is a high alumina cement. It comes in white or black and is the result of limestone and bauxite burned together.[4] It is very resistant to chemical attack and hardens and cures rapidly generating a great deal of heat.[5]

> The French developed a very rapid hardening (6 hours) aluminous cement of extremely fine consistency and high density, Ciment Fondu, which costs about twice as much as standard cements, and which is recommended to sculptors as the more permanent and useful type. It is available in black and white. Fondu will register detail down to fingerprints with care, and is about as hard as cast iron.[6]

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[1] Norman Colton, All about Masonry (Toronto Canada: Key Book Publishing Co., 1977), p. 15.

[2] ibid., p. 14.

[3] Geoffrey Clarke and Stroud Cormock, A Sculptor's Manual (New York: Reinhold Book Corp., 1968), p. 80.

[4] ibid., p. 153

[5] Jackson and Sutherland, p. 62.

[6] Clarke and Cormock, p. 80.

Curing

Portland cement must be kept moist for seven days.[1] Maximum strength is not achieved until twenty-eight days at a temperature of about 60° Farenheit.[2] The concrete manual states that Portland cures between fourteen and twenty-one days.[3] To keep the cement damp one may cover it with polyethelene, damp fabric, or spray it with water. The higher the temperature the better the curing for Portland. ". . . ideal curing for concrete is to immerse the work completely in water at temperatures up to 200°F . . . "[4]

> High Alumina Cements (Ciment Fondu) cure differently. In their case, high temperature does not speed strength development and can even retard it. Because high alumina cement produces much heat during hydration it is less subject to damage at freezing temperatures than Portland cements. Moist cool conditions are important, and twenty-four hours are required for the initial curing of high alumina cement. Great care must be taken when using these cements.[5]
>
> . . . the chemical reaction between the cement and water produces heat itself. If the volume of concrete is small, the heat rise is small, but when the volume

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[1] Jackson and Sutherland, p. 64.

[2] ibid., p. 63.

[3] U.S. Department of the Interior, Concrete Manual: A manual for the Control of Concrete Construction (Washington: United States Government Printing Office, 1975), p. 376.

[4] Jackson and Sutherland, p. 65.

[5] ibid., p. 66.

> is large heat build-up can become a serious problem. With small batches the heat escapes fairly freely, but when the mass is large the heat escape rate lags behind the heat build-up from the chemical reaction.[1]
>
> The quantity of water in a mix has a considerable bearing on the strength of the concrete produced. Simply stated, the rule is this: a low water-cement ratio increases strength, a high water-cement ratio decreases strength . . . Insufficiently compacted dry mixes at a certain point.[2] . . . Too much water will cause excessive shrinkage.[3]

Definitions

Neat Cement: cement mixed only with water.[4]

"Goo":* Cement mixed only with water (another term).[5]

Mortar: cement mixed with fine filler (sand).[6]

Concrete: is cement mixed with various size fillers such as sand and gravel or any other stable material: marble chips, brick dust, iron filings, pebbles, sand, etc. Up to 50% by volume can be added to cement. Organic materials should not be used. They may contaminate the

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[1] Jackson and Sutherland, p. 64.

[2] ibid., p. 69.

[3] ibid., p. 71.

[4] Ronald L. Coleman, Sculpture: a Basic Handbook for Students (2nd.; Iowa: Wm. C. Brown Co., 1980), p. 89.

[5] Percy, p. 130. *(The term "Goo" will appear repeatedly throughout this thesis and the writer apologizes for its singular lack of technical aura. The fact is, it has gained so general an acceptance that any hope of reversing the tide would seem misplaced.)

[6] Coleman, p. 89.

cement.[1]

> Concrete is, of course, produced by mixing cement, water and mineral aggregates . . . particles of aggregates are bound together by the cement and water paste which surrounds them and do not contribute to the chemical reaction within the paste. The reaction between water and cement is a process known as hydration. Although rapid in early stages, hydration normally goes on for some years, and during this period the concrete gradually becomes harder and stronger as long as it retains moisture. If . . . the concrete dries out completely, hydration stops, and so does the tendency for increased strength . . . Painting concrete with suitable sealers helps in retaining moisture.[2]

Advantages of Ciment Fondu

Although both Portland cement and Ciment Fondu may be used in the casting of sculpture with equal success, only Ciment Fondu is dealt with in this paper as a casting material because of the following qualities and advantages:-

1) It has a very quick setting and curing time (Ciment Fondu sets in about 4 hours and cures in about 24 hours) which is ideal for the art classroom as well as the studio.

2) It has a natural exotic colouring of dark blackish green, often darkish greys as well, supplying dramatic patinas well suited to sculpture. (The white Ciment Fondu is too expensive and difficult to obtain; therefore, it is seldom used by us). When polished, Ciment Fondu will often resemble black marble. When Ciment Fondu is left in its raw state it will often have a chalkly dark grey-like coloring like Portland cement.

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[1] Coleman, p. 89.

[2] Jackson and Sutherland, p. 62-63.

3) Because of its dark coloration, seams and repairs are usually less noticeable than on light cements.

4) It is less caustic and so can usually be handled without gloves.

5) It adheres to the walls of the mold and has better resistance to sagging and flow.

GENERAL CASTING PROCEDURE: ITS DEVELOPMENT

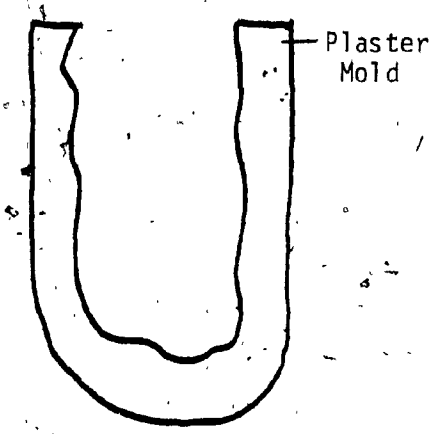
I will presume that the reader is familiar with the procedures of making single and multiple piece plaster molds. In this paper I will refer, only to the plaster mold because it is one of the cheapest and most versatile mold-making materials available. With some minor modification, all casting techniques described in this text may be applied to any mold-making material.

Before going into greater detail, my first objective is to familiarize the reader with the basic procedure for casting Ciment Fondu in a plaster mold as it is usually taught. For the purpose of simplification, I will refer only to the basic one or two piece plaster mold (figure 1 & 2). Once the basic casting technique is understood, more complicated problems can readily be solved.

One and Two Piece Mold

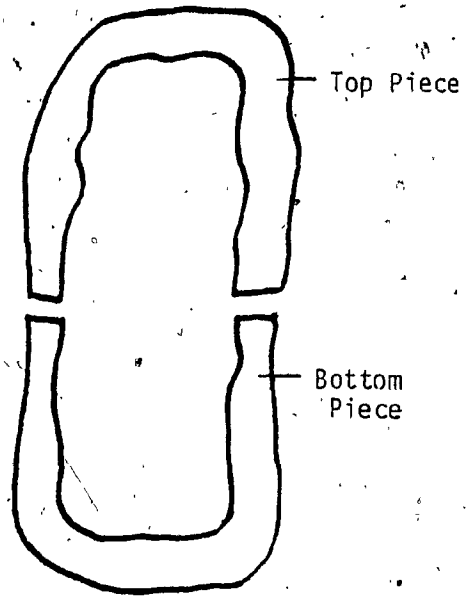
The first step is lining the mold. A mixture of water and cement powder is mixed to a consistency of yogurt or soft pudding. With a brush or by hand the inside of the pre-moistened mold is lined to a maximum depth of one eighth of an inch with a layer of "goo" or neat cement as described earlier (figure 3 & 4). Then a mixture of three parts sand and one part cement powder is mixed with enough water to produce a mortar which is moist but not sloppy. This mix is then carefully compacted into the mold and the mold is filled to the top (figure 5 & 6). Care must be taken so that the mortar mix does not penetrate through the "goo." This is, at times, difficult

TYPES OF MOLDS



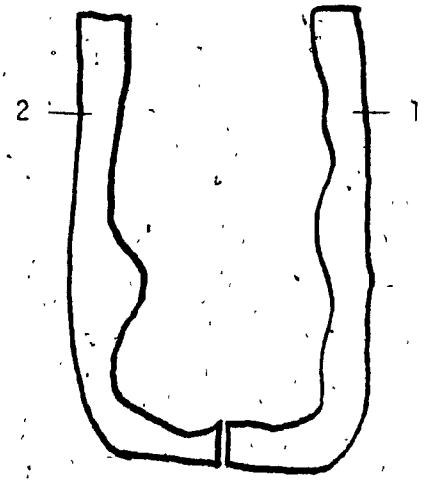
One Piece Open Mold

Fig. 1



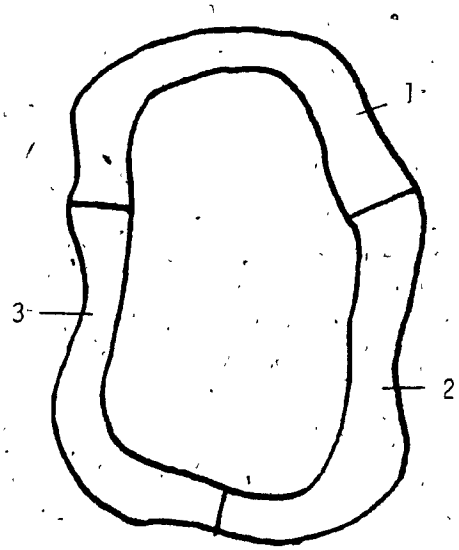
Two Piece Closed Mold

Fig. 2



Two Piece Open Mold

Fig. 2a



3 Piece Closed Mold

Fig. 2b

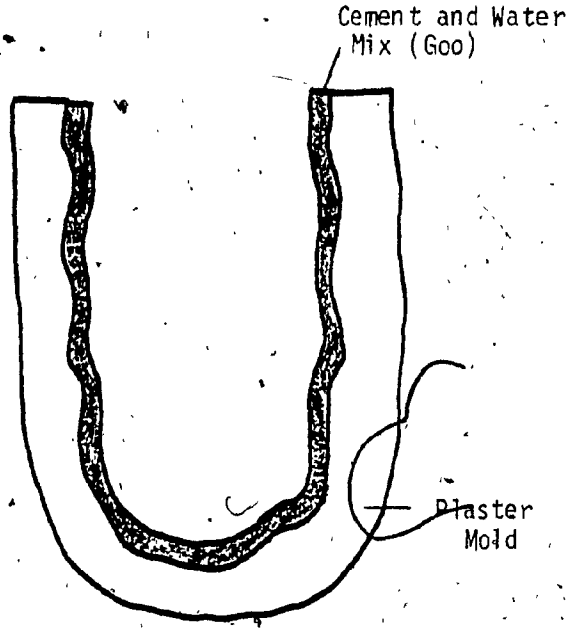


Fig. 3

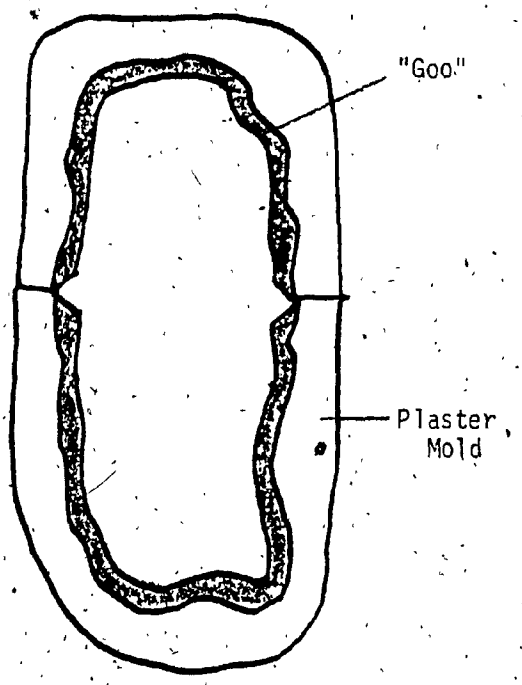


Fig. 4

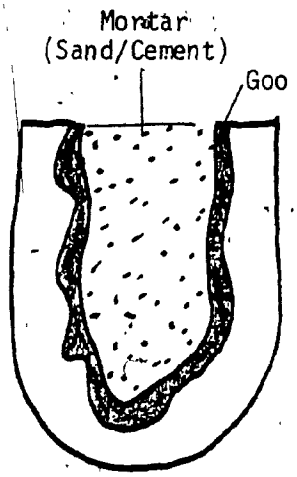


Fig. 5

One Piece Mold

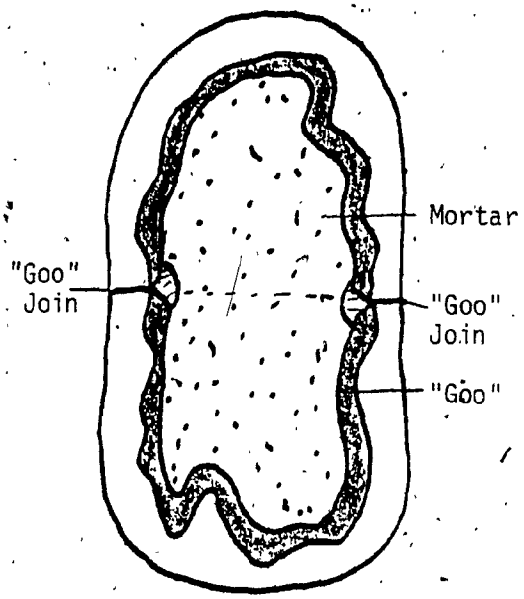


Fig. 6

Two Piece Mold

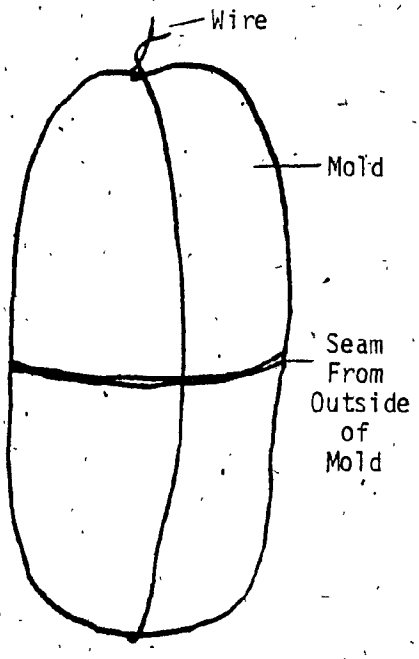


Fig. 7

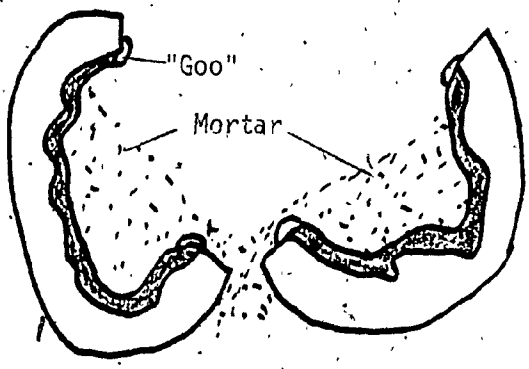


Fig. 8

to avoid and often results in the surface of the sculpture having sand showing through.

In a two piece mold the two halves are joined with "goo" (figure 6) and tied together with wire (figure 7). The mix is allowed to 'sit' for four hours and then is lowered under water to cure for the required twenty-four hours.

The two piece mold, however, does present a few difficulties. The joining has to be done gently otherwise the mortar will collapse into the mold and fall onto the edges (figure 8). This problem exists particularly with larger molds which are more difficult to handle. These often require two or three people to close and wire them up. To avoid this problem, the two halves of the mold would have to be cured individually and in twenty-four hours (in the students' case, the following week) joined with "goo." Often after this one week period, it was found that the molds had distorted due to the "wet mould sagging under its own weight."[1] To prevent this, one could fix "temporary iron tie bars . . . with scrim and plaster across the face"[2] of the mold (figure 9). In most classroom situations this procedure is found too time consuming and the student has no recourse but to patch the misaligned halves of the resulting sculpture.

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[1] Percy, p. 126.

[2] ibid.

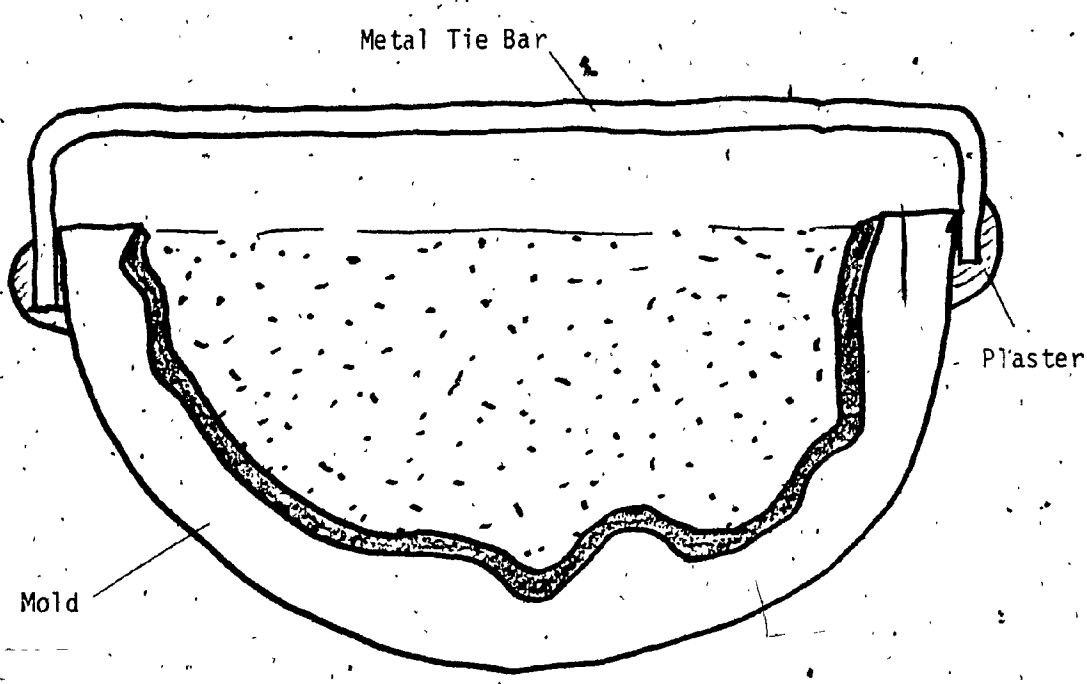

Figure 9

Variation of Metal Tie Bar

EARLY WEIGHT REDUCTION PROCESSES

Paper, Vermiculite, and Sand Fillers

The first objective was to reduce the weight of the sculpture while casting it in one continuous process and while avoiding the collapse of the mortar within the mold. Because most sculptures had to support only their own weight, and since no stress was placed from outside, reducing the wall thickness seemed to be an adequate solution. At that point I reasoned that a two inch concrete wall would be a compromise likely to afford adequate strength for the type of sculpture most commonly produced in the classroom. To prevent the pre-cured mortar from collapsing, I filled the cavity with wet paper towels and joined the two halves with "goo" (figure 10). Paper was used instead of cloth because it was easy to tear, compact, and held water well. The single piece mold presented the fewest problems: paper was merely compacted to the top (figure 11). After the four hours initial setting time, the mold was placed under water. The water, however, frequently dislodged the paper and the sides of the sculpture would then collapse into the mold. Because of this four hour setting time, it would often take eight or more hours to do a complete cast depending on its size.

In completely closed molds the paper towels remained inside the mold and decayed. It was impossible to know how well the paper has supported the sides and held them in place. Surprisingly the cost of paper towels which are compact when wet, actually became an economic factor. In one of numerous attempts to solve this problem I filled the cavity with wet vermiculite (Zonolite) (figure 12). Because vermiculite contains air and will not absorb moisture, it remained too light and springy and so

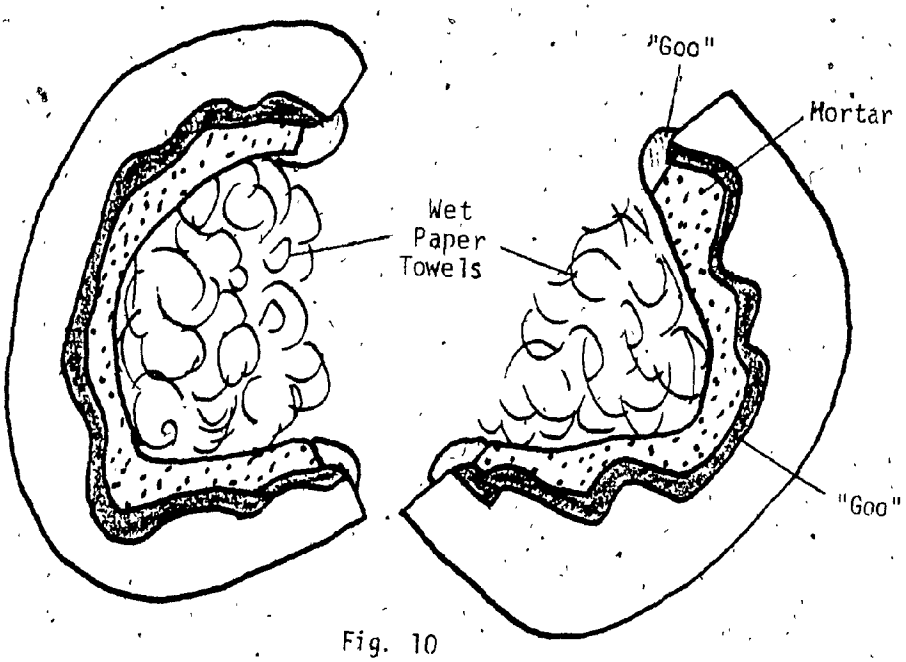

Fig. 10

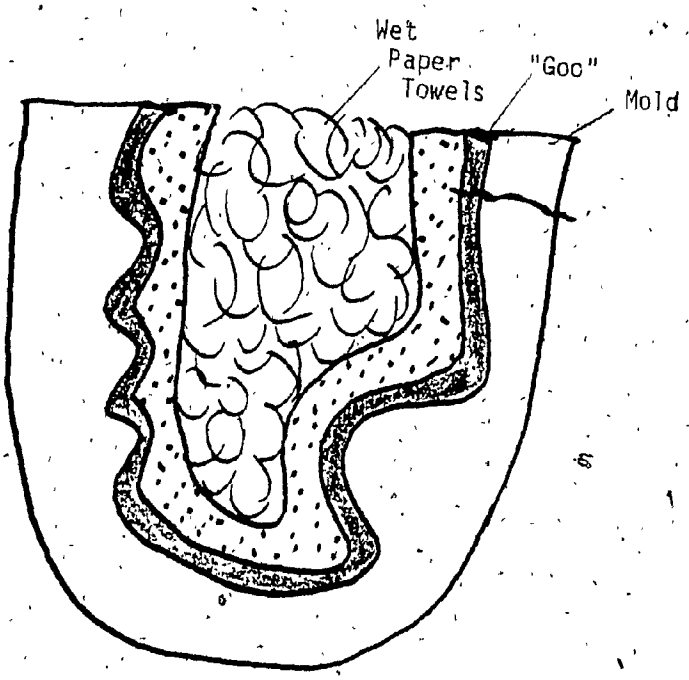

Fig. 11

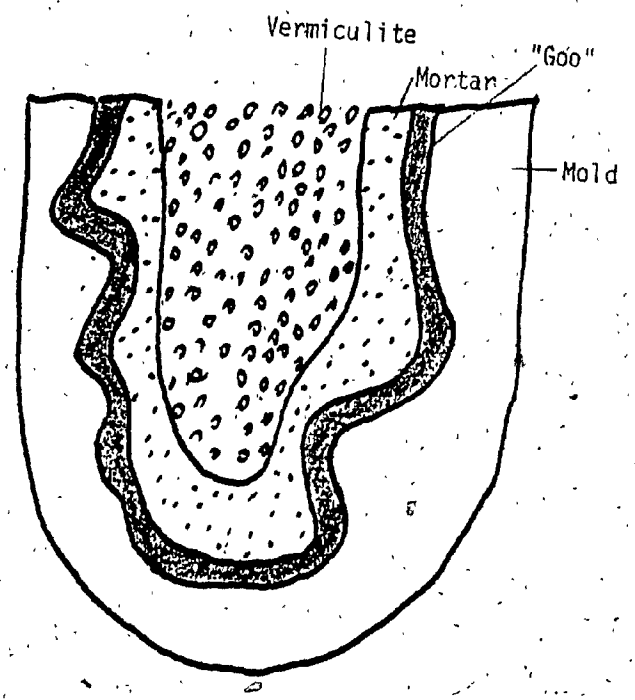

Fig. 12

proved unsuitable.

Finally I tried damp sand as a filler and it proved ideal. The sand could be tamped tightly over the regular mortar. When the mold was finally cured and taken out of the water, the sand was simply washed out of the cavity. The only important thing one had to monitor was the initial wetness of the sand. If the sand was too wet the water in the sand would pool at the bottom of the mold and mix with the mortar and weaken it. This would often create a color patch (blemish) on the cast.

The sand worked well for closed molds too. When the closed mold was finally cured and the sculpture removed, one merely had to drill a hole into the bottom of the sculpture, pour water into the hole and wash out the sand. The sand could then be reused to fill other molds. The hole would later be plugged up with a paste of pure cement and water.

Alternative to Water Immersion

Care still had to be taken lest the sand collapse within the mold during closing and the need to immerse molds posed even more of a problem. Few classrooms have facilities equal to the space requirements involved. However, I reasoned that the wet sand filler would now supply a large portion of the cement's demands in terms of moisture and heat absorption and it seemed probable that a modification of conventional concrete curing methods would therefore suffice.

> . . . Frequent sprinkling is preferable to covering with wet burlap. The surface of the concrete must be prevented from becoming dry at any time within 24 hours after mixing. Use cold water for sprinkling.[1]

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[1] Canada Cement Lafarge Ltd., Directions for Use: Curing (Montreal).

From the above instructions one could see that immersing the mold into water was the ideal solution; it cooled and allowed the moisture to be retained. However, it was for the most part impractical as was standing around for twenty-four hours sprinkling the mold with cold water. Therefore I tried to find the best compromise. Instead of placing the mold under water after four hours, the mold was now wrapped in a few layers of wet cloth immediately after it was packed and tied. Then it was inserted into a large plastic bag and sealed. For larger sculptures "leaf" bags were used, or bags were constructed from plastic sheets and taped together at the edges. This substitute for immersion worked well. The total environment: wet sand, wet mold, and wet cloths contained enough moisture and heat absorbing capacity for all of the concrete and the plastic bag prevented any moisture loss. If the scultpures were too heavy they could now be left where they were cast. If they were movable they could be placed into storage shelves. There was no more need to occupy sink space or valuable floor space with garbage bins filled with water.

Glass Fiber Reinforcement

Although some of the problems had now been solved I was still dissatisfied with the two inch thick casts and consequent excessive weight of the larger sculptures.

In the early 1970's I came across a book by H.M. Percy entitled New Materials in Sculpture which contained a chapter on Ciment Fondu casting by Edward Folkard, F.R.B.S. in which he described a method of casting a sculpture light in weight:

> . . . Sculpture cast in concrete can be exceedingly light in weight. By reinforcing the mix with glass fibre matting it is possible to make the end-product a very thin hollow shell. Glass fibre chopped strand mat is bought in sheets. It has great strength but is a springy and resilient material which doesn't want to stay put over sharp curves. It is for this reason that we try to eliminate the sharpness of the curves and to make the first coating of the mix both smooth and undulating.
>
> When this first coat was hardened (always remember to keep it moist while it is doing so), the surface should be painted over once more with a thin film of "goo." Pieces of glass fibre are then torn off the sheets, dipped in the "goo" and rubbed lightly between the palms to ensure their being completely impregnated. They are then pressed down firmly into the mould, each piece overlapping the other to give strength. In small moulds the pieces of matting might be about 2 inches across; in larger moulds, about six inches. In very 'finiky' moulds, the mat may be split to half its thickness for greater ease in handling. One layer of glass fibre is usually enough for small work of up to about twelve inches. Larger jobs will need two or three layers.
>
> Since the "goo" contains excess water, the job can be made much stronger if the surface is sprinkled over at this stage with a mix containing only half the prescribed amount of water, which is then patted down on to the glass fibre and "goo." This adjusts the water content in the "goo" and results in a sandwich construction of sand and cement, glass fibre and cement, and again sand and cement.

> In cases where glass fibre is not being used to reinforce the mould, the first thin coating of mix, already described, will be added to uniformly and thoroughly tamped down. For a portrait head, a final thickness of about ½ inch all over will be sufficient, and for a full-size figure about 3/4 inch, although in the latter case iron reinforcements will need to be added at a later stage.
>
> Do not forget to make sure that each section of the mould is well supported during filling, to prevent it warping.[1]

This method by Mr. Folkard seemed to be the answer to all the past casting problems (figure 13). I soon found however, that for all the problems it solved new problems were created. It was correct that this method created thinner and lighter sculptures but the method still required separate procedures. ". . . When this first coat has hardened . . ."[2] relates to a four hour set or even a twenty four hour cure before the fiberglass/"goo" layer is added, making time and warpage of the plaster mold still an issue.

Using this technique it was also impossible to judge a thickness of ½" to 3/4" on a mold having a highly textured and uneven surface. After the mortar is placed over the "goo," it becomes almost impossible (unless one has an excellent memory) to know how thick any part of the mold really was. With the "goo" being first reinforced by the mortar, the problem of sand penetrating through the "goo" still remained. To prevent this penetration of mortar through the "goo," Mr. Folkard suggests "pushing a wave of "goo ahead of the standard mix "[3] (figure 14). Unless this difficult

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[1] Percy, pp. 134-136.

[2] ibid., p. 136.

[3] ibid., p. 134.

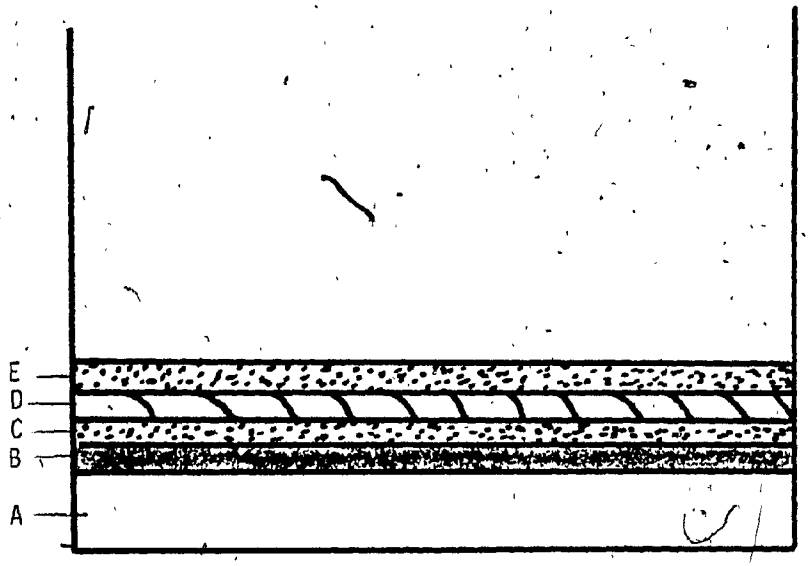

Fig. 13

Folkard' Method of
Lining a Mold

A - Mold
B - "Goo" Layer
C - Mortar
D - Fiberglass/Goo Layers
E - Mortar Mix

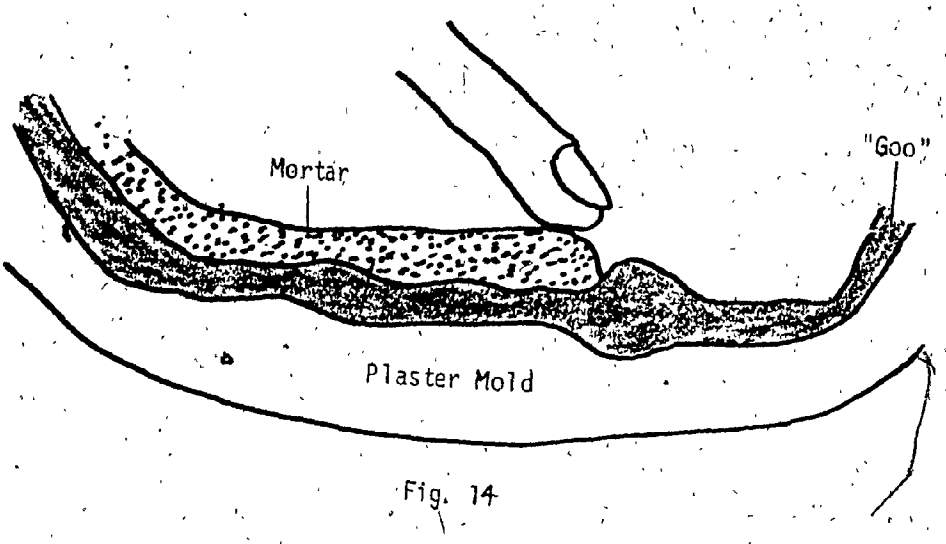

Fig. 14

technique is mastered, the mortar will usually mix with the "goo." The technique requires that one must push down and forward simultaneously and with equal pressure. If the mortar is too dry it may not compress sufficiently and air pockets may be created between the mortar and the "goo." Once cured, these fragile shells of "goo" will shatter leaving holes in the surface of the sculpture. If the mortar mix is too wet it will often soak into the "goo" and sand will penetrate to the surface. Such a mix can be thickened Folkard suggests by "mixing sand and cement with half with water. . . ."[1] This often does make a stiffer mush, but is frequently inadequate. I have found that sprinkling on a dry mortar mix using two parts sand to one part cement, and patting it into the top wet mortar will do a better job. The mix acts like a blotter and absorbs the moisture from the original mix.

Another limitation of Folkard's technique is evident in his suggestion:

> It is quite simple to work up the sides of the mould as far as the vertical by starting from the bottom and tamping the mix firmly into place as you go. However, an overhang must never be coated with mix from underneath. Wait till the following day, when the mix is thoroughly hard, turn the mould over and deal with the overhang from above, not forgetting of course to paint the set concrete first with "goo."[2] (figure 15)

Here again are the problems of time and inconvenience. Also it is in the nature of Cement Fondu that batches mixed and placed at different times will not cure to the same surface color. Thus Folkard's

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[1] Percy, p. 136.

[2] ibid.

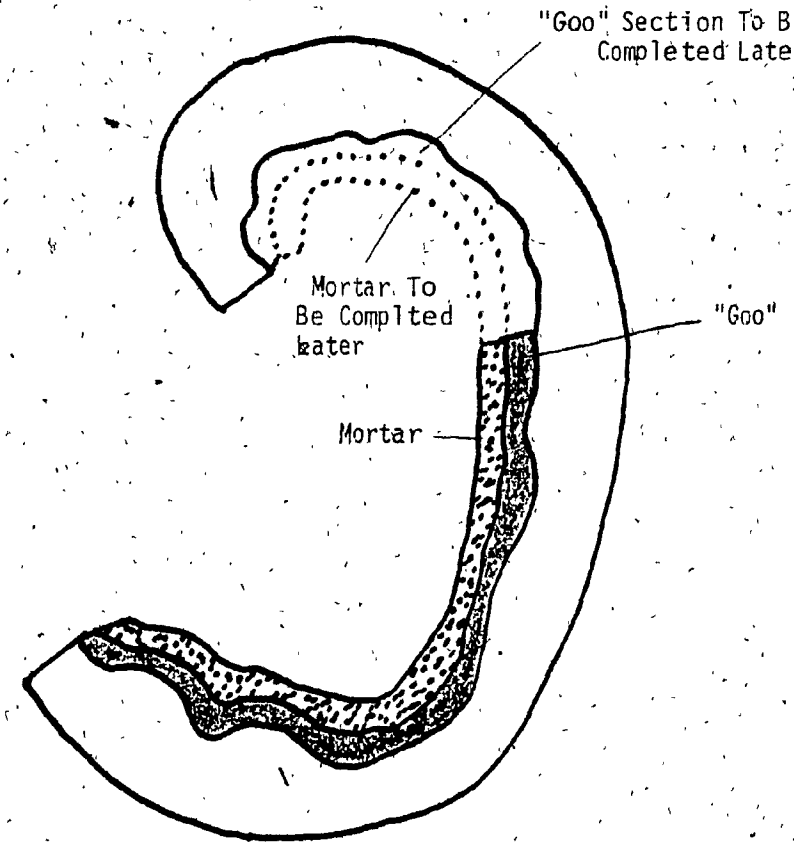
"Goo" Section To Be
Completed Later
Mortar To
Be Complted
Later
"Goo"
Mortar

Fig. 15

method of coping with overhangs will result in a line separating areas of unlike color. As already indicated, wet sand used as filler will support such overhangs saving time inconvenience, and an inconsistent coloration.

Joining of Molds

In joining two halves of a two-piece mold together, Mr. Folkard suggests that:

> Where the seams are easily reached by hand, first fix the section in place with scrim and plaster, a wire tourniquet or string. Then from the inside work some "goo" into the seam with a brush, also pushing a band of "goo" an inch or so wide on each side of the seam. Back up on this with more concrete, and where extra strength is required use glass fibre and "goo" as well.[1] (figure 16)
>
> Where the seams cannot be reached by hand, they have to be squeezed. For this a thick "goo" is needed, made from five volumes of cement to two to water, which is ladled on to the edge of the concrete at the seams and raised into a rim all along each post to be joined. This rim must be built up well above the level of the plaster (figure 17). It is important at this stage to have an excess of "goo" on the concrete. This will create a gap between the two sections, which is now closed by hand pressure and tapping with a light mallet. As the gap closed some of the "goo" will be squeezed out at the seam. This must now be wiped off; so that the seam becomes visible, and if it has not closed properly the tapping should be continued. Neat and proper closure is extremely important. The section

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[1] Percy, p. 141.

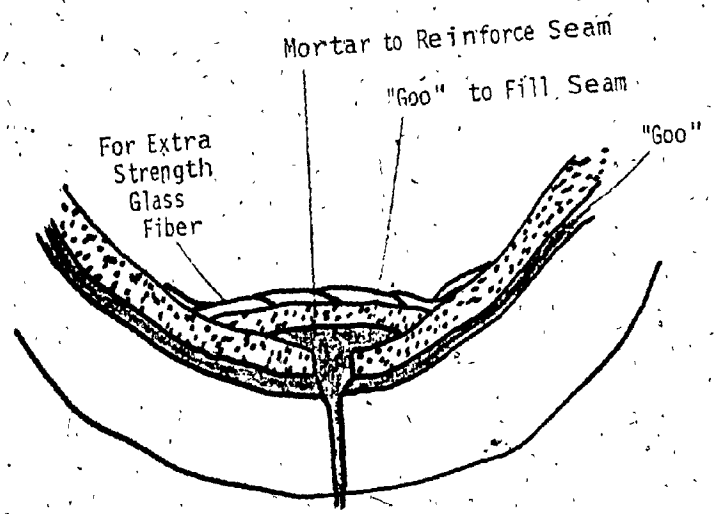

Fig. 16

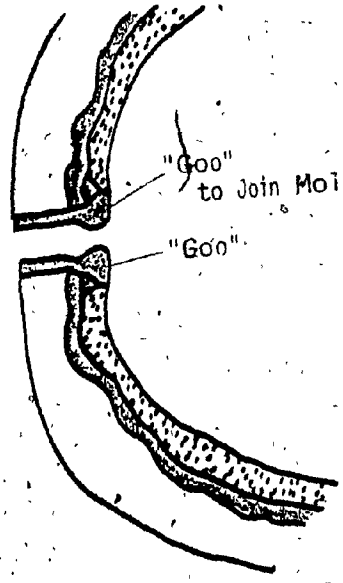

Fig. 17

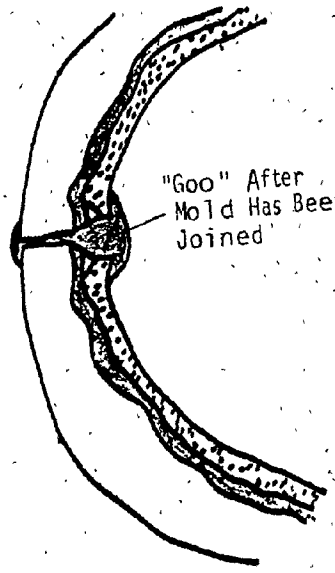

Fig. 18

should now be fixed in place so that the joint will not be disturbed before it is cured.[1] (figure 18)

The closing procedures described work well. There are, however, some unfounded assumptions and some important information is left out. Mr. Folkard assumes that if the curing (a time consuming step) was not previously done the placed cement would collapse during the tapping of the mold.

Also, the mixture of "goo" in the 'squeeze-joining' must be of a consistency relative to the dampness of the mold. That is, if the mold halves have been cured independently and are still moist, the mixture of ". . . five volumes of cement to two of water . . ."[2] will be correct as stated. However, if the molds, for whatever reason, have begun to dry out (i.e. while removing reinforcement bars or making repairs) then the mold must be resaturated or more water added to the "goo." If this is not done, the "goo" will lose so much moisture into the mold that it will stiffen and refuse to squeeze out, and the mold will not close. It is best to spray the mold edge frequently to prevent moisture loss. It will then be unnecessary to mix a watery "goo" and risk a weak concrete prone to excessive shrinkage. Such "goo" will often result in the seams opening up after the sculpture has been cured and exposed to air for a week or more.

Removing the Mold

A waste mould is chipped away as it would be from a plaster cast, and it will come away easily even if no parting agent has been used,

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[1] Percy, p. 145.

[2] ibid., p. 141.

> leaving the exposed concrete covered in bloom. The bloom should be scrubbed off with plenty of water; it is easily removed while still fresh but becomes increasingly difficult to shift if allowed to dry.
>
> If the case has a textured surface you should be prepared to spend some time in removing the specks of plaster that will be embedded in it. On a plaster cast many of these would not show and so would be ignored; but they show up strongly against the dark background colour of Fondu. The spike of a pair of compasses is a convenient tool.
>
> Should your patience become exhausted while some specks still remain, you can stain them with grey-brown water color. This will be absorbed by any remnants of plaster, but can be cleaned off the concrete surface with a damp cloth.
>
> A "fin" or "flash" of concrete will probably be found to project from parts of the cast where the "goo" has penetrated and set between the plaster surfaces at the seams. It should be easy to snap this off with the fingers, and any small part that remains may be rubbed down with carborundum or removed with a riffler.[1] (figure 19)

If the fin is thin enough it may be broken off. But it is much safer to remove half of the mold first and chisel the fin against the remaining half of the mold leaving about one sixteenth of an inch protruding from the sculpture to be filed off later (figure 20). If the fin is thick (the fin should be as thin as possible) and is broken off by hand, it will often break below the surface of the cast creating a groove which must be patched later.

If so desired, the "bloom" on the surface of the sculpture can be

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[1] Percy, pp. 142-143.

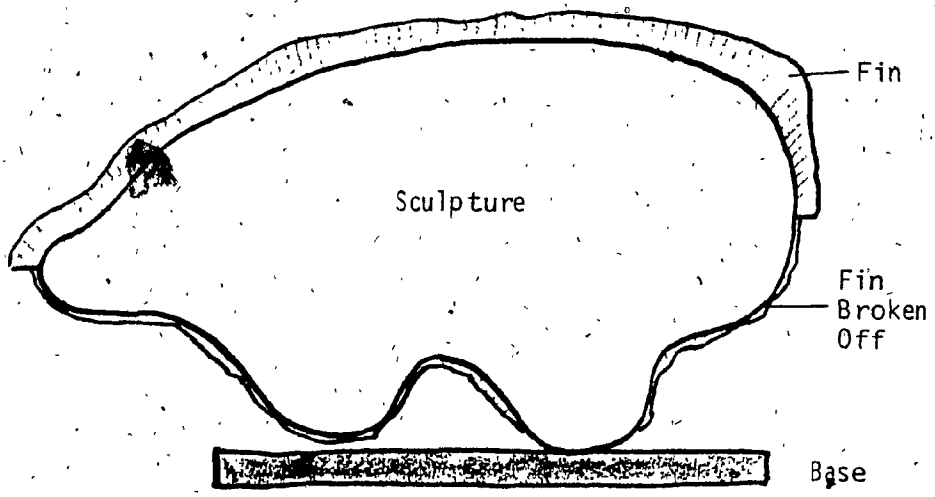
Fin
Sculpture
Fin
Broken
Off
Base

Fig. 19

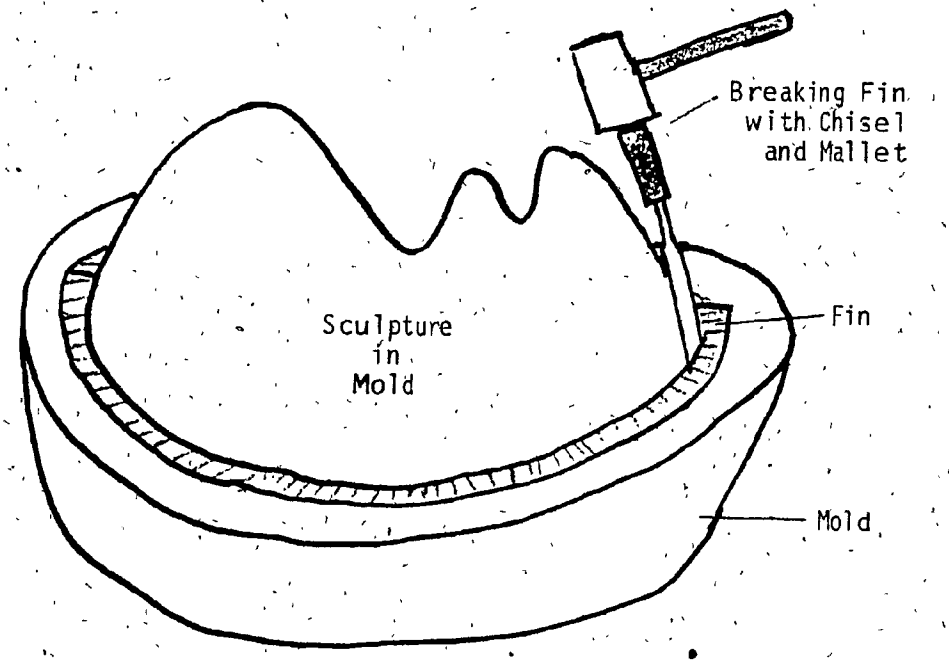
Breaking Fin
with Chisel
and Mallet
Sculpture
in
Mold
Fin
Mold

Fig. 20

removed using steel wool, wire brush, or wet and dry sandpaper. A brass suede brush will leave a film of brass on the surface. Muriatic acid will also remove the "bloom" but will leave a sandpapery surface.

POLYESTER RESIN CASTING TECHNIQUE APPLIED TO CASTING IN CIMENT FONDU

Folkard's method was clearly imperfect and prohibitively time consuming, and it occurred to me that the standard technique of casting in reinforced resin might supply a useful parallel for further refinement. First a layer of gel coat (filler thickened resin) is painted into the prepared plaster mold. Then layers of fiberglass mat saturated with polyester resin and catalyst are placed over the gel coat, and the molds are joined with the gel coat and left to cure. It finally occurred to me that this process might be the answer for the cement casting. I simply substituted "goo" for both the gel coat and laminating resin applying Folkard's method of saturating the fiberglass mat and using my own plaster molds for the trials.

As with resin casting, additional layers of saturated fiberglass mat results in a correspondingly stronger cast. This modification of Folkard's technique seemed to work well. The resulting sculptures were light in weight and very strong. It took a good pounding with a hammer to break through a well constructed cast. Seeing that the problems had finally been solved, I began to use this technique with my students.

Two years later, upon removing several of my own sculptures from their storage in plastic wrapping, I discovered that sections of the surface on a number of them had cracked and lifted free of the fiberglass layer. Students frequently complained that the initial "goo" mix stiffened very quickly while they were saturating the dry fiberglass mat with the "goo". I reasoned, belatedly, that the dry mat was drawing much of the moisture out of the "goo" mix stiffening it and thus preventing adequate interpenetration

of these two materials. This created a fragile outer layer of cured "goo" unattached to the supporting layers and, in fact, separated from them by a layer of dry fiberglass mat.

The solution now was obvious: soak the mat before impregnating it with "goo". This solved the problem. In this soaking process the fiberglass mat is cut into appropriately sized sections, depending on the size of the mold, and then soaked with water. When ready to use, a handful of these pieces of mat is taken out of the water and squeezed tightly until the mat is merely damp. Although this results in the addition of some water to the initial mix, it is a minor problem and is compensated for by the speed with which the mold can be lined. There was an incidental advantage to this procedure: Usually when cutting dry fiberglass mat, tiny glass particles fly around in the air, become imbedded in ones clothes, and soon irritate the skin. If the sections of mat are soaked in water before being cut and separated into layers, this problem is avoided.

The method now consisted of applying a layer of "goo " and one or more layers of saturated fiberglass mat. Although this process worked well, it was soon discovered that unless a systematic procedure was followed it was difficult to tell which parts of the mold had been covered because of the fiberglass mat floating in the "goo". Often bare spots were left or some areas had a very thin covering. As the mold was broken to free the sculpture, those thin areas would collapse or the chisel would break through them. If the covering was good, the pieces were strong and light; however, it was always difficult to be certain how thick the cast really was. So I decided to go back to part of Folkard's procedure and added a thin layer of mortar over the fiberglass impregnated mat. This would not only give a good visual contrast and enable one to see any areas that had not been covered; but would

also allow one to compress the mat more tightly against the face of the mold and thus absorb any excess "goo". This has now become the method I use. It is fast, simple, and creates light and strong sculptures. It has all the advantages of the previous techniques without the disadvantages. One does not have to worry too much about shrinkage of the plaster mold because the technique is done all in one session. The problem of the mortar mix penetrating through the surface no longer exists with the application of the mat. When the fiberglass "goo" impregnated mat is pressed into the "goo" layer of the mold, one merely needs to press the mat firmly to expel as much "goo" as possible so no air pockets remain between it and the face of the mold. The mat will seldom penetrate through the surface unless there is very little "goo", or the mat is rubbed back and forth on the face of the mold. With simple downward pressure the mat acts like a snowshoe and goes down only so far. The mat used in this manner has a gratifying tendency to prevent any collapse away from the surface no matter how severe the overhang or rough the handling of the mold. There appears to be suction created at the surface, some of the structural strength of a dome in the hollows of the mold and, because of the mat, the concrete cannot shear off at any point no matter how wet the mix. Even if the lining of damp sand collapses while joining the mold, or even if the mortar mix collapses, it will not remove the fiberglass mat layers.

It is also no longer necessary to take a great deal of care when adding the mortar. The mortar can now be pounded or pressed firmly into position with little fear of penetrating through the surface of the mold because the mat will prevent this from happening. The mortar mix seems to bind very well with the mat/"goo" mix.

Even 'life size' figures no longer need to have reinforcement

rods to add support.[1] For added strength, simply increasing the layers of fiberglass mat is often sufficient. If supports or mounting rods are needed, they can simply be glued into the cavities with epoxy glue after the sculpture has been cured and finished.

The resulting simplified process of adding a layer of "goo", one or more layers of mat/"goo", and a thin layer of mortar, can now (with or without the damp sand) easily be done during a three hour class.

What follows is a complete detailed description of this modified technique as I now use both in my classes and in my own work. This last section incorporates the best of the preceeding techniques and findings and is presented in a much more specific and detailed manner. It will enable both the student and artist to directly apply this modified technique in the casting of sculpture without having to refer to the historical and experimental aspects dealt with in the preceeding text.

THE COMPLETE MODIFIED CASTING TECHNIQUE

The Mold

It has been stated earlier that plaster will distort. The degree to which it distorts depends on the thickness and density of the mold. With this modified casting technique distortion is less of a problem because the procedure is done at one time and in one continuous process. If there are any distortions they can easily be corrected in the resulting sculpture.

The mold can be made of solid plaster, or jute or burlap reinforced plaster which makes the mold thinner and lighter depending on the nature and

[1] Percy, p. 139 (Folkard suggests using thin rods for reinforcing the thin mold).

size of the sculpture, and on the skill, knowledge, and experience of the user. One thing is important, however, the plaster mold must be wet (saturated with water) before the casting process can begin. If the plaster mold has been left in the open air and has dried out, it must be immersed in water or dampened with a wet cloth. It is ideal for the wetting process if the mold can be completely immersed under water. Before immersion the mold should be completely reassembled and wired so that as it expands the expansion will be even and consistent and will not distort the pieces unevenly. Size may prevent this and if the parts of the mold are ever too large to be soaked separately they may have to be wrapped in wet cloth and sealed in a plastic bag until they are saturated and ready to be used. If the mold is in one piece and is too large to immerse under water, simply filling the cavity of the mold with water and letting it stand for one-half hour with wet cloth wrapped around the outside will suffice.

When the mold is immersed small air bubbles will form on the surface of the water. When these air bubbles cease, the mold is completely saturated and ready for casting.

When casting in a multiple piece mold it is best to work one or two pieces at a time leaving the others wrapped or under water until they are to be used. If all the pieces are removed at the same time, some will dry out while one is working on the others. Cement may be cast into a mold that has been freshly made.

> Most of the strength of the plaster is established by the time the plaster becomes warm (heat of crystallization) but a little additional strength is gained during the following 24 hours.[1]

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[1] Coleman, p. 90.

If the mold cannot be cast right away, it is best to leave it tied up and unwrapped until it is ready to use. Then it should be soaked.

Two containers are required, one in which to mix the "goo" and the other in which to saturate the mat.

Ciment Fondu

The cement should be powdery and free from lumps. Lumps which indicate that moisture has entered the bag should be removed using window screening as a sieve. Although the cement is not then one hundred percent powder, it can still be used.

Because a mixture of Ciment Fondu and water begins to thicken after an hour, and because rethinning thereafter can cause excessive shrinkage it is advisable to mix no more "goo" than one can place in an hour. The "goo" mixture is best for casting when it is of a soft pudding-like consistency. Heavier consistencies will not adequately reproduce detail and properly saturate the fiberglass mat. While lining the mold, the "goo" mix should be stirred frequently so that the mix remains homogeneous. Failure to do so will permit the cement to drop out of suspension and the mold will be lined with too watery a mix.

When making the "goo" it is important that the cement powder be poured into the water. The container should always be filled with water to less than half of its total capacity. Adding the cement powder will approximately double the volume occupied. The cement should be sprinkled into the water and allowed to settle to the bottom without stirring. This should continue until finally an island of dry cement powder forms above the water. This proportion of ciment to water will, when stirred, supply a wet mix suitable for "goo". Stirring can be effected using a spoon or spatula;

but it is easier to ensure that all lumps have been broken if one's hand is used. Rubber gloves will be necessary if one's skin is sensitive to cement. If the mix is too thin but the container is already full some of the liquid should be poured out and more cement added. Such discarded mix should never be emptied into sinks, down drains and such like, as it will harden in the pipes. Poured into a plastic container it will ultimately set up, when, after the surface of water has been drained off, it can be thrown into the garbage.

The mold at this time should be in the water or wrapped in damp cloth. The mortar mix should now be prepared using a ratio of three parts sand to one part cement, or "2 volumes cement, 6 volumes sand (dry), and 1 volume water".[1] This ratio is similar to the one used in construction where both cost and strength are considerations.

Sand and cement must be mixed dry and this is best accomplished on a flat surface such as a tray. Water is not added until the mortar is to be used because the four hours it takes to harden may prove insufficient time in which to apply both "goo" and fiberglass.

Sand

Any type of sand may be used: beach sand, silica powder or particles, silver sand etc. It should be fine enough to be compacted without leaving air pockets and should be clean so as not to contaminate the cement.[2] In general, kiln dried sand is recommended as it is both clean and dry.

[1] Percy, p. 130.

[2] Jackson and Sutherland, p. 72.

Regular wet construction sand is unsuitable as it may not be clean and will not mix readily with the cement powder.

Glass Fiber Mat

There are several types of fiber material available. Two main ones are chopped strand mat and woven glass fiber cloth.[1] The glass cloth is a fine or coarse mesh that is woven like regular cloth. It is difficult to pull apart and impossible to separate into layers. It comes in different weights and is much stronger than chopped strand mat. This woven cloth is not suitable for use on textured molds because it does not readily conform to so complex a surface. It is however ideal for flat or simple curved surface. The lightest weave of this cloth is generally best to use. It is easy to saturate and build-up in layers in a smooth mold.

Chopped strand mat also comes in different weights and is made up of a large number of linear glass fibers compressed and overlapped into various thicknesses. This mat can easily be pulled apart and separated. For most molds, one to one and one-half ounce mat is the ideal weight. Even in this thickness, it is often difficult to saturate this mat with "goo." The best way to use the mat is to split in half and to cut the pieces to appropriate sizes to accomodate the shape and size of molds. For large molds, it is best to keep the pieces from four to six inches square. A variety of sizes will often be needed to accomodate more textured or complex molds. As was mentioned earlier, before cutting, separating and using mat it should be soaked in water.

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[1] Thelma R. Newman, Plastics As An Art Form (reprinted: London: Sir Isaac Pitman & Sons Ltd., 1967).

Filling the Mold

The process for filling the saturated plaster mold is as follows: A thin layer of about one-eighth of an inch of "goo" is brushed into the water-saturated mold. If it is difficult to manoeuver a brush in the mold the hands can be used to build a layer of "goo" on the surface of the mold. The process can be speeded up if the "goo" is simply poured into the mold which is then rotated in all directions until one-eighth of an inch "goo" has adhered to the surface of the mold. The "goo" should be built right up to the edges of the mold (figure 21) and the excess "goo" is poured back into the bowl.

If any part of the mold surface is heavily textured care must be taken to ensure that the highest projections of the texture are covered to a depth of one-eighth of an inch and that any air trapped by the uneven surface is entirely expelled. If the mold surface has been treated in some way (eg. waxed or varnished) the "goo" will slide and tend to pool at the lowest point of the mold. If this happens a layer of "goo"-saturated fiberglass mat can be used to force the surface "goo" into a uniform layer pushing it towards the edge.

The fiberglass mat (already soaked, cut, and split) must be saturated with "goo" and pressed into the mold with the fingers expelling any air bubbles and surplus "goo" from beneath the mat. It is best to apply the mat in layers starting from the lowest part of the mold and gradually working upward toward the edge of the mold. This enables all the air to escape and dislodges the excess "goo" at the edge. The excess "goo" is simply scraped away. Unlike the technique in which a mortar mix went directly over the "goo" surface, this improved method presents far less likelihood of penetration to the surface and the mat can be confidently pressed firmly ensuring good reproduction. Each consecutive piece of saturated mat should overlap

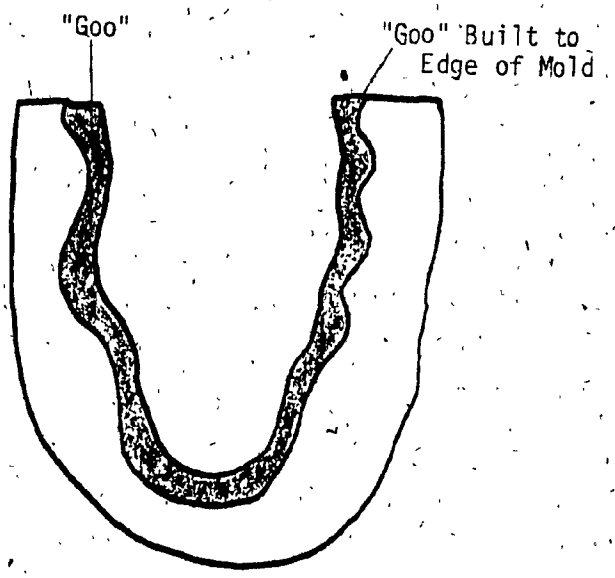

Fig. 21

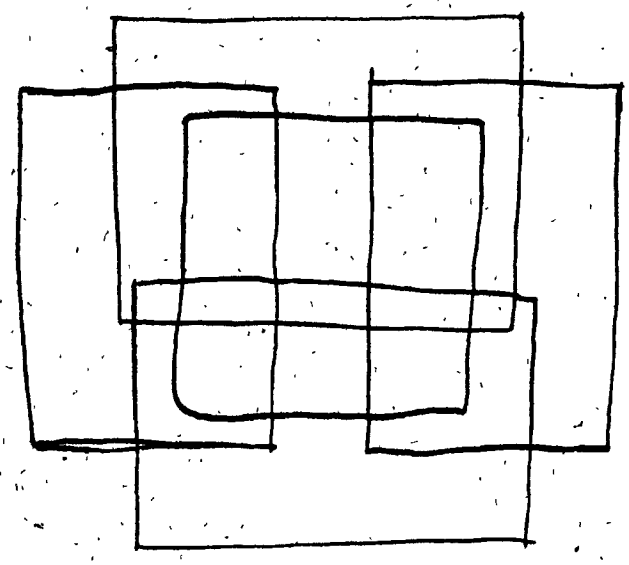

Fig. 22
Fiberglass Mat Layers

the next by at least one-third of its area so that with four pieces overlapping, the initial pieces will be completely covered (figure 22). The greater the overlap is, the stronger the resulting surface. This provides adequate strength for most student sculpture, with more generous overlaps and additional layers being used for larger works.

In order to ensure that the mat conforms and adheres to the "goo"-covered surface of very heavily textured molds, the resistance of the mat can be reduced by gently pulling and tearing the saturated fibers into a looser more tractable formation. Deep crevices and cavities can actually be filled with saturated mat pulled apart in this manner and compacted into place until all air pockets and excess "goo" have been dislodged. When placing the saturated mat into the mold, terminate it about one-sixteenth to one-eighth of an inch from the edge of the mold. This will prevent the mat from coming through the seam in the final sculpture and will not interfere with the edge of the mold when it is time to join them (figure 23). In a one piece mold, build the glass mat to the edge (figure 24). Next some "goo" which has thickened with the passage of time (or if necessary, freshly mixed thick "goo") must be used to build a small ledge about one half inch wide downward into the mold at an angle of about thirty degrees to the plane of the mold edge. This creates a v-shaped cavity at the seam when the two halves are joined. This cavity will be filled by the "goo" used to 'glue' the two halves together (figure 25).

Unless such considerations as time, economy, or weight prevent it and always if you have fewer than two layers of mat, mortar should now be applied over the saturated mat and "goo" (figure 26). This step is strongly recommended to ensure a strong cast. The amount of water added to the mortar mix should be only as much as it needed to ensure a proper cure (i.e. Damp

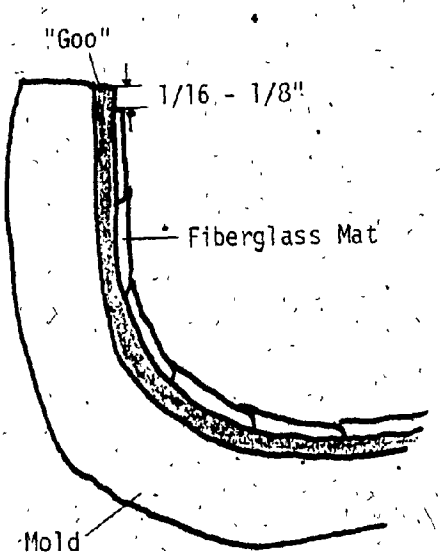

Fig. 23

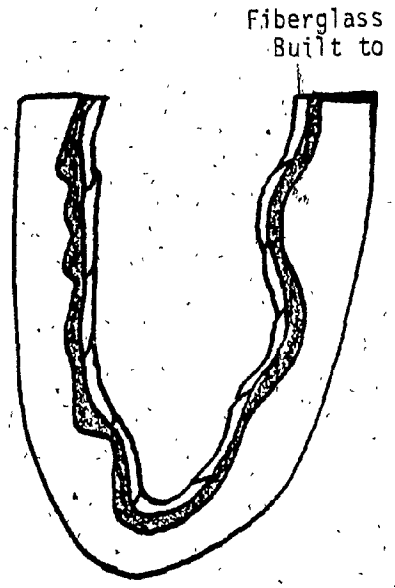

Fig. 24

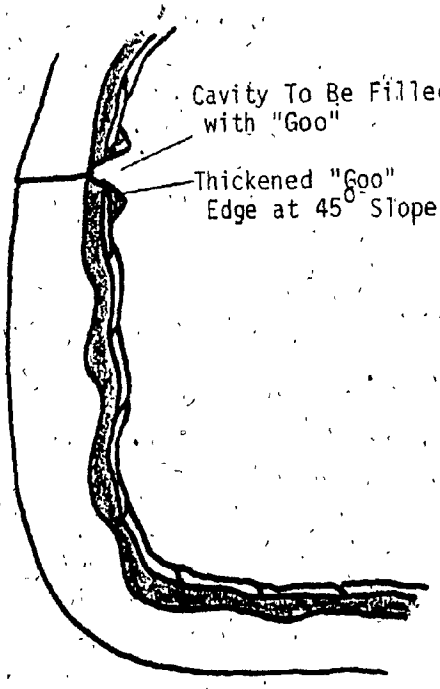

Fig. 25

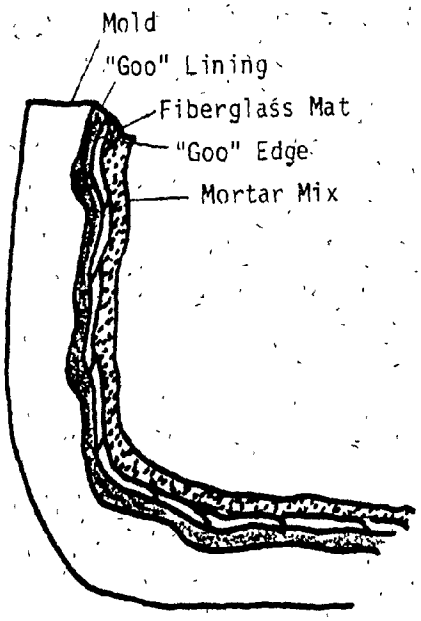

Fig. 26

enough to retain its shape after being squeezed tightly in the hand). Folkard gives a ratio of six parts sand, two parts cement, and one part water.[1] In fact, however, the correct ratio will depend upon the moistness of the "goo" saturating the mat. If the mortar is too watery to sustain firm pressure as it is compacted into the mat layer a mixture of dry sand and cement may be sprinkled over it and patted firmly while it absorbs the excess water. The mortar cannot penetrate to the surface and so may be pressed quite hard to ensure a good bond with the mat layer. Mortar should be applied only up to the ledge in order to ensure that it not enter the seam where the sand it contains would be clearly visible. Mortar may be applied to any thickness or even restricted to parts of the cast deemed in need of extra strength (eg. The bottom on which the sculpture will rest, or beside the ledges which will be pressed together.)

Cleaning the Mold

It is not necessary to clean the edges of all the pieces of the mold as soon as you have finished painting the cement in them. It is advisable, however, to clean immediately if the remainder of the job will take longer than four hours or if the molds are to be cured independently in plastic bags. Only the edges where the molds will join need to be cleaned but there should be no residue of cement, mortar, or sand on them. Any residue may prevent the mold from joining. One may use a brush or sponge to wash the edges of the mold, dipping them into water and holding the mold so that the water runs outward and not into the mold (figure 27). If the mold is too heavy or awkward to move, the edges can be wetted and carefully wiped with a damp sponge or cloth.

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[1] Percy, p. 130.

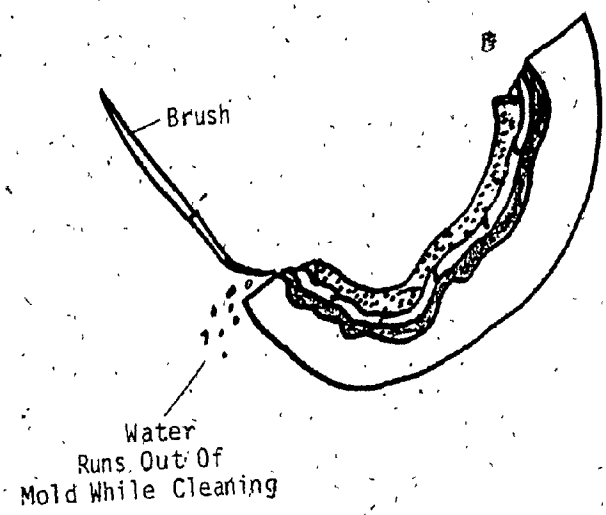
Brush
Water
Runs Out Of
Mold While Cleaning

Fig. 27

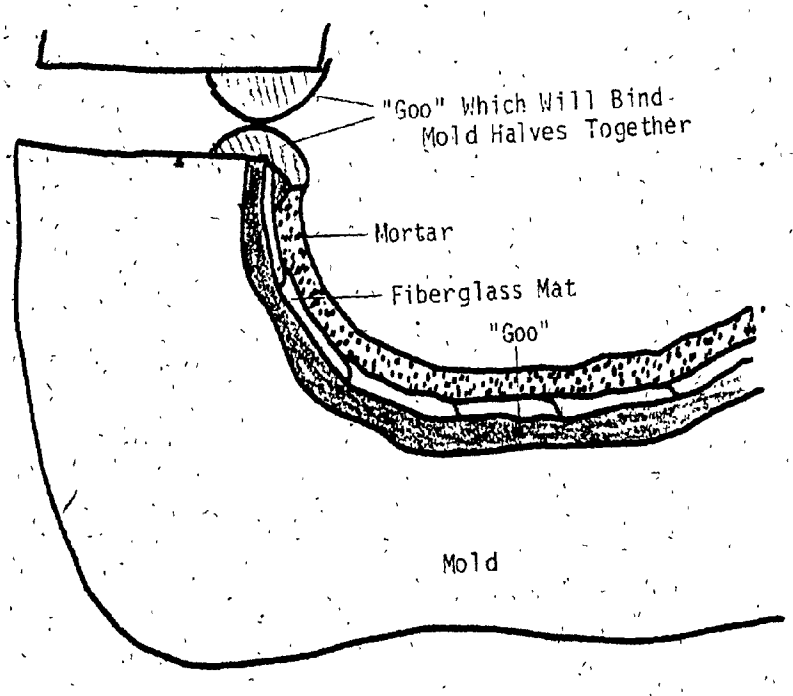
"Goo" Which Will Bind
Mold Halves Together
Mortar
Fiberglass Mat
"Goo"
Mold

Fig. 28

It is advisable to have a trial assembly of the mold sections at this point to be certain that there are no obstructions to a precise alignment. This is particularly important when internal protrusions in one half approach similar high points inside the other half. Whatever "goo" remains is likely by now to have become too thick to use and should not be rethinned by the addition of water. When joining the molds, it is always best and safer to mix a new batch of "goo" adjusted to the dampness of the mold. The "goo" should be neither runny nor stiff and is best when creamy but firm enough to not easily flow. The edges of the mold must be so saturated with water that this consistency does not change when the "goo" touches the mold.

The "goo" is now poured or spooned onto the edge of the mold. It should cover part of the edge of the mold and the whole sloping edge of the mortar and cement inside the mold (figure 28). When joining the mold pieces it is best to ease the parts together as if they were hinged with the opening of the mold closing last. It is safer not to place one section on top of the other unless the halves have been previously cured or if a great deal of tapping is required. The mold halves are held together by loops of pliable fencing wire twisted to tighten. Cement which may squeeze out between the mold halves is merely what is excess to the "fin" which will remain on the sculpture as described earlier in the text. The mold halves should again fit snugly together. Failure to do so usually indicates that some "goo" has lost moisture into the edge of the mold and therefore cannot be squeezed into a "fin". This requires a gentle reseparation of the mold, recleaning and wetting of the mold edges, reapplication of sufficiently wet "goo", and rejoining of the halves.

If after the mold has been assembled there remains access to the

interior through an opening, the following steps can be profitably taken: Some of the remaining or freshly mixed "goo" can be poured down the seams and the mold then rotated until all of the seams are covered, and any area still requiring it can be strengthened with mortar. Damp sand can now be compacted into the cavity filling it to the top edge of the mold. The sand will automatically press the "goo" into the seams, keep the walls from collapsing and also absorb the heat generated by the Fondu.

After the sand has been filled to the top of the mold edges, a straight edge dragged across the mold opening will ensure that no cement particles protrude to later prevent proper seating of the sculpture (figure 29). The sculpture should then be wrapped in a wet cloth and sealed in a plastic bag for eighteen hours or more during which time it will harden and cure.

Opening the Mold

After the required curing time, the mold is removed from the bag, unwrapped, and the wire is removed. The sand may be removed now or left until the mold has been removed. The mold is broken away from the cement cast using a blunt straight chisel and a wooden mallet. A sharp chisel may easily cut through the plaster and nick the sculpture; and in any case the mold is actually broken by impact and the wedge shape of the chisel.

The majority of damage sustained by the sculpture during removal of the mold is usually due to haste. It is never advisable to pry the mold open at the seams or to attempt to break off very large pieces. One half should be broken away first, and any remaining fin broken with the chisel against the other half of the mold. The exposed part of the sculpture should be cushioned on some cloth or foam while removing the other side of the mold. Only the weight of the mallet on the chisel should be used when

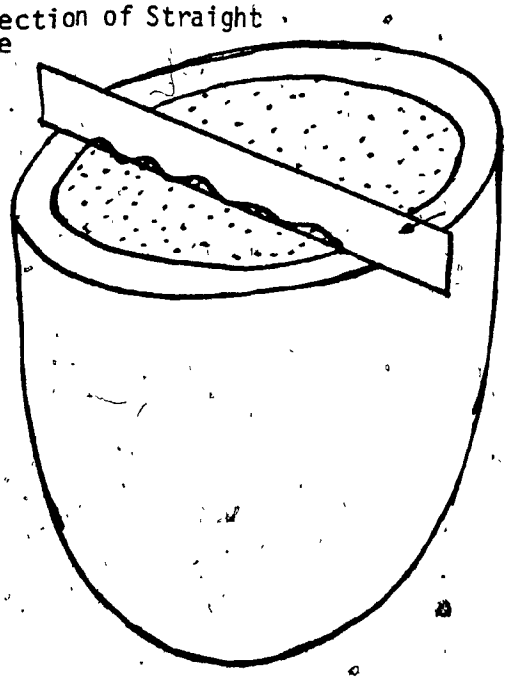

Fig. 29

Leveling Bottom of Filled Mold

breaking the mold. Extra force threatens the surface and the structure of the cast. The chisel should be held at right angles to the exposed surface of the sculpture. As the chisel goes into the plaster, a little back pressure or leverage should be applied to the chisel and short rapid taps used until the piece of the mold breaks and exposes another piece of the sculpture. Any chisel nicks in the cement surface are easily repaired.

When the plaster mold has been removed, one will quickly see that the sculpture has a greyish cover over the surface. This coating is called "bloom"[1] and is caused by the plaster being imbedded and mixed into the cement. This bloom may be removed with a wire brush, steel wool, or wet and dry sandpaper . . . or it may be retained for contrast in selected areas. Any imperfections such as bumps or seams may be filed away and later sanded. No repairs should be attempted until all recess cleaning is completed.

Repairs

There are two commonly used methods of repairing air bubbles or deep nicks caused by the chisel: The first requires that the cast be wet and for the second the cast must be completely dry.

Slightly overfilling the holes with a thick paste of cement powder and water while keeping cast and patches wet works well provided everything is then wrapped in wet cloth and again sealed in a plastic bag for a minimum of eighteen hours. A product named "Concrete Weld" if painted onto the areas to be repaired, will provide an extra measure of adhesion between the patches and sculpture. Once the repairs have cured they can be filed level with the surface and sanded.

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[1] Percy, p. 143.

In the second method, which requires a dry cast, the flaws are filled with clear "5 Minute Epoxy" glue very heavily loaded with cement powder. This technique is obviously the more rapid but produces a somewhat less precise color match. Patination of the sculpture will of course depend upon the nature of the piece. The bloom may have been retained or sanded off, as may a superficial variation in the tone which frequently occurs in the cement itself.

Among the most commonly used finishing materials are wax, oil and shoe polish, but experimentation with different sealing and toning materials is very likely to prove rewarding.

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