FIBERGLASS AS A MEDIUM FOR SCULPTURE

by

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INTRODUCTION

In the last decade the plastic industry has taken great strides in producing products that can compete with metals and different alloys. In sculpture bronze which has long reigned as the ideal casting medium is being challenged by fiberglass (a plastic product). Although the technique of casting fiberglass is a standard procedure, the character of each work may differ considerably. The purpose of this paper is to discuss the new medium and the possibilities it has for sculpture.

A series of heads were created by the candidate and from these fiberglass casts were produced each of a different character. This was achieved through different types of coloring effects. Because of size the head was used for the experiments. Each phase of the experiments is discussed with emphasis on the nature of fiberglass and why it has a potential for sculpture. This is preceded by a brief history of polyester resins based on the research of John R. Lawrence,[1] and a discussion of the chemical properties of fiberglass which had been prepared by Rohm & Hass.[2]

THE HISTORY OF POLYESTER RESINS

According to Lawrence[3] the first attempt to make any alkyd

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1 John R. Lawrence, "Polyester Resins", p. 1. Chapter one is taken from Mr. Lawrence's "History of Polyester Resins".

2 Rohm & Hass Company, "Chemistry of the Paraplex P-series resins," p. 5. The main body of Chapter two is taken from Bulletin 343a (see bibliography).

3 John R. Lawrence, "Polyester Resins", p. 1.

of polyester resin is attributed to the Swedish chemist Jons
Jacob Berzelius who, in 1847, reacted tartaric acid with glycerol
to obtain a resinous mass. Maleates and furmerates of ethylene
glycol were prepared in Germany in 1894 by D. Vorlander.
Berzelius' experiment was repeated in England in 1902 by Watson
H. Smith with the replacement of phthalic anhydride for the tar-
taric acid. As early as 1916, resinous compositions based on the
combination of glycerin and phthalic anhydrides were used as
finishes for wood and metal.

The combination of fatty acids from drying and nondrying
vegetable oils with alkyds by R. H. Lienle at the General Electric
Company's laboratories in 1927 was a major step toward useful
products similar in composition to the vehicles used in many of
our modern finishes. Lienle is given credit for coining the word
alkyd (derived from ALcohol-aCID and spelled phonetically).

In 1937 Carleton Ellis discovered that the addition of un-
saturated monomers to polyester containing unsaturated groups in-
creased their setting speed by more than thirty times. The com-
bination of curing speed and properties of the resulting polymers
gave the first thermosetting polyester resins which could be put
to commercial use. For his key discoveries in the development of
polyesters which could be used for commercial applications
Carleton Ellis has sometimes been called the "father" of unsatu-
rated polyesters.

The first commercially produced unsaturated polyesters ap-
peared in 1941-42 spurred by the war-time shortage of acrylics.
The Pittsburgh Plate Glass Company developed one of the first

resins, which had considerable success as a cast resin for glazing applications in their "Allymer CR 39" (allyldiglycol carbonate). This material is actually a diester capable of curing to a thermoset compound through the two unsaturated groups in each molecule. It does not belong to the same family of polyesters as those which are cross-linked by means of monomers such as styrene.

Early in 1942 the Army Air Corps developed a critical need for a protective shield for its self-sealing gas tanks. The United States Rubber Company discovered that laminates made with "Allymer CR 39" and glass cloth prevented fingers of torn metal caused by the penetration of bullets or shell fragments from blooming into the rubber tank lining. Production of fiber glass-reinforced laminates as fuel cell backing started immediately. An equally important application of polyester resin which developed at approximately the same time was in the fabrication of radomes for aircraft use. Reinforced polyester radomes were widely used during the war, and at the present time radome applications involve some of the largest reinforced plastic structures which have been fabricated. Other war-time applications for polyester resin included body armor and a variety of non-structural aircraft parts.

In the period since a laboratory discovery and war-time necessity combined to launch polyester resins on a commercial basis in the early 40's, they have had more than their share of growing pains. For the first few years they were very much like a first grandchild, flooded with ready-made markets with virtually no competition. The termination of war markets left them like

an orphaned child.

The ease of fabricating fiber glass-reinforced plastics, the relatively small investment required, and the highly glamorized markets attracted a flood of enthusiasm in polyester resins for a variety of uses. Many applications came, temporarily caused a lot of excitement, and faded out, usually because of cost. For several years it was questionable whether the industry would survive. By 1948, however, the market for polyester resins was definitely increasing.

A steady core of products for basically sound applications, well engineered and marketed, continued to develop improvements in resins, equipment, techniques and marketing methods. These products included trays, furniture, fishing rods, continuous laminates, translucent panels, boats, etc. The fabricating industry realized that it was dealing with a material which could compete with other materials of construction and could demand a premium not just from a replacement standpoint but on the basis of durability, lightweight, corrosion resistance and electrical properties. With the start of the Korean conflict the industry which had been created as a war baby was again infused with military money and given a chance to solidify its gains.

In the early 50's the relative ease of producing basic polyester compositions attracted an increasing number of resin producers into the field and forced premature price reductions. This served to reduce the expenditure of money on basic research at a time when it was required to keep pace with an adolescent industry trying to reach maturity. As many as forty manufactures

have produced significant quantities of polyester resins, although in any given year probably more than 80 per cent of the resin manufactured was produced by not more than half a dozen manufactures.[4]

Today almost every building constructed has some polyester product. Its uses are innumerable, and recently sculptors have been beginning to take advantage of its possibilities. Just what are its possibilities will be discussed after a chemical analysis of polyester resins.

THE CHEMISTRY OF FIBERGLASS

The term polyester resin encompasses a variety of materials. However, technically, by virture of usage, the compositions which are generally recognized by this designation are the unsaturated polyester resins dissolved in and later cross-linked to thermoset copolymers with vinyl monomers-usually styrene and are widely employed in reinforced plastics. These resins have been referred to variously over their years of usage as "low-pressure laminating resins," "contact resins," "polyester resins," and "polymerizable polyesters." Since there are a number of other compositions which also fall into the broad classification of polyester resin, there is often confusion as to the material being referred to by this designation.

By chemical definition a polyester is formed by the reaction of a polybasic acid and a polyhydric alcohol to form a series

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4 John R. Lawrence, "Polyester Resins", p. 1.

(poly-many) of ester linkages. The type of polyester resin is
determined by the particular types of acids and alcohols select-
ed and other modifications of the polyester structure. There are
many different forms of polyesters, but this paper will deal with
the unsaturated polyesters, that is, linear polyester resins
based on dibasic acids and dihydric alcohols capable of cross-
linking with vinyl monomers to form thermoset copolymers.

The following discussion concerns the basic principles
which govern the use of the Paraplex P-series resins. This series
is one similar to the resin used for the sculpture created for
the candidate's research. The Paraplex P-series resin is a pro-
duct of Rohm & Hass, and it is from one of their technical bul-
letins that the candidate refers.[5] A full understanding of this
discussion is by no means vital to the skillful and successful
use of polyester resins. It is simply the candidates objective
here to provide some of the background for the technology which
has become highly developed through much research and experience
in the field.

The Paraplex P-series resins are solutions of unsaturated
polyesters in polymeriazable monomers. The solutions frequently
contain, for special purposes, other additives, among others,
inhibitors for increasing stability during storage and stabiliz-
ers against the effects of ultra-violet light.

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5 Rohm & Hass Company, "Chemistry of the Paraplex P-series
resins," p. 5. The Chemical formulas, definitions, and technical
data in the remainder of this chapter are quoted verbatim from
Bulletin 343a.

Some of the terms commonly used in this field are subject to variable interpretation. The following brief explanations are offered for the purpose of clarifying the later discussion.

Unsaturated A compound is said to be unsaturated when double or triple bonds exist between at least two adjacent carbon atoms in the compound. Since the more inert kind of bond uniting two carbon atoms is a single bond in which two electrons are shared, carbon atoms having double or triple bonds can usually be made to undergo reactions which eliminate the "excess" bond or bonds by union with other addends. Thus, unsaturation is a invitation to ready reaction.

$$H_2C = CH_2$$

Etylene-one of the simplest unsaturated organic compounds.

Polymer A compound of high molecular weight derived by the combination of two or more similar units.

$$CH_2CH_2$$

$$n$$

Polyethylene, a simple polymer.

Polyester A polymer derived by the condensation of compounds containing hydroxyl and carboxyl groups; i. e., a combination wherein water is eliminated as a by-product of the condensation and the simple molecules are united by the formation of ester groups. The structure of the parent compounds is such that the polymerization (condensation) can repeat itself. Since molecules of water are lost, the ultimate analysis of the polymer is slightly different from that of the compounds from which it is formed.

$$\text{HO--CH}_2\text{CH}_2\text{OCH}_2\text{CH}_2\overset{\text{O}}{\text{C}}\text{-CH} = \text{CH-}\overset{\text{O}}{\text{C}}\text{O--H}$$

$$n$$
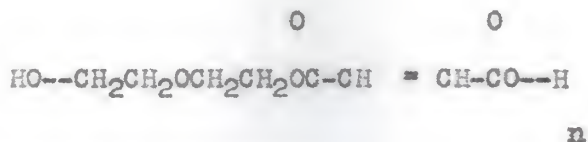
A typical unsaturated polyester.

Addition Polymer is a polymer formed by the combination of two or more monomer molecules without the evolution of any chemical by-products. When two or more types of monomer are used, the product (known as a copolymer) contains all types of the initially interacting units. The monomer molecules entering into the formation of an addition polymer are unsaturated, possessing one or more double bonds.

Thermoset polymers, by definition are those which do not readily flow under the application of heat and pressure. On a molecular scale, they are highly cross-linked and have a network structure.

Free radical Free radicals are compounds which contain at least one unpaired electron in place of the more normal and more stable bond consisting of shared electrons. Free radicals are produced when certain compounds (notably the peroxides) are decomposed, for example by heating.

The Preparation of Polyesters

A typical, unsaturated polyester may be prepared by reacting an unsaturated dibasic acid, such as maleic anhydride, with a glycol, such as diethylene glycol. The reaction proceeds at elevated temperatures (usually above 150 degrees C.) and is stopped at the desired point by cooling the product to room temperature.

Simple as this appears, the design and manufacture of poly-esters are complex operations. Unsaturated polyesters are not all alike. The choice of the proper dibasic acids (combination of saturated and unsaturated dibasic acids are often used), glycols, and other reactants must be made in the light of the final pro-perties desired. The average length of the polyester chain has an important bearing on the suitability of the product for spe-cific uses. The production of polyesters of uniform quality re-quired specialized control methods and equipment engineered over years of experience.

The Vinyl Monomer

Polyesters of the type just described are usually viscous or even solid materials which are dissolved in a vinyl monomer to form solutions of controllable and moderate viscosity. The monomer most commonly used is styrene. The polyester and the monomer can be made to react together to form a solid, thermoset plastic. In order for the curing process to start, a certain minimum amount of energy must be imparted to some of the mole-cules in the original resin solution. Those molecules which have been given the required energy are said to be activated. Catalysts and heat are most commonly used as activators.

An activated molecule, upon collision with another molecule containing a potentially reactive double bond, may unite with and transfer energy to it, activating the double bond of the new unit formed from the second molecule. This new active unit can react with still another molecule-uniting, transferring its energy to, and activating the new unit formed by the third molecule, and so

on. When this process is repeated a sufficient number of times, a polymer and in this case a copolymer results.

What happens during curing, then, is the type of reaction described above, occurring simultaneously at many different points in the resin mass. First, a loose, three-dimensional network is built up throughout the resin by the cross-linking of polyester molecules with monomer units as bridges. At the gel point, this loose network extends throughout the mass of the resin, although only a small portion of the potential reactivity has been utilized. The polyester molecules making up the network are joined at relatively few points, and many of the polyester and monomer molecules are merely physically entangled within the network structure.

Controlling Gelation

When the liquid resin is stored at room temperature, very few of the resin molecules possess the energy necessary for the cross-linking reactions to take place. The molecules are in constant agitated motion because of their thermal energy; however, an occasional fortuitious series of collisions occurs in which one of the participating molecules may acquire enough energy to become activated. When this happens, the activated molecule may begin to unite with other molecules in the manner described above. In time, enough such collisions would cause the resin to gel. Since such a spontaneous gelation is undesirable from the standpoint of storage life, an inhibitor is added at the time of manufacture of the resin to prevent these unwanted reactions which would lead to premature gelation at storage temperatures.

An inhibitor is a compound whose chemical structure makes it capable of absorbing most or all of the energy of activation which may be transferred to it by collision with an activated molecule. The structure of the inhibitor is such that after it has received this energy, it is unable to unite with other monomer molecules, and further growth of the young polymer is effectly halted. Thus, an inhibitor prevents premature gelation by reacting with, and blocking off, activated molecules so that polymerization and subsequent gelation are prevented.

Since at room temperature the number of activated molecules and the rate of their formation is very low at any given time, only an extremely small amount of inhibitor (as little as 0.001 percent) may be required to give the resin entirely adequate storage life. Of course, although activated molecules are being rendered impotent by reaction with inhibitor, new molecules are constantly being activated and, in time, all of the inhibitor will be destroyed; eventually gelation will occur.

It is apparent, then, that the inhibitor stands in the way of polymerization and must be neutralized or removed before gelation will occur. The effect of the inhibitor can be destroyed by the application of heat, light, catalyst, or by any combination of the three. Any or all of these will increase the rate of formation of activated molecules, and the greater the number of such activated molecules, the more rapidly is the action of inhibitor overcome.

How Catalysts Aid in Controlling Polymerization

Catalysts for use with polyester resins are compounds which

are relatively stable alone, but which break down into free radicals in the presence of the resin, especially under the influence of heat or light. The free radicals which result from the decomposition of the peroxide catalysts serve to initiate polymerization and/ or to react with inhibitor molecules. The rate of peroxide decomposition, with the formation of free radicals, increases with increasing temperature. Thus, by regulating the temperature and the amount of catalyst used, the rate at which inhibitor molecules are "neutralized" and polymerization initiated can be controlled. The interval during which the free radicals are overcoming the inhibitor and before polymerization begins is the "induction interval."

The duration of the induction interval is inversely proportional to the peroxide concentration and directly proportional to the inhibitor concentration.

In the polymerization of simple vinyl monomers (such as styrene) the period during which long chains are built up (called the "propagation interval") is considerably longer than the induction interval. With the polyester-monomer solutions, long chains-contributed by the polyester component-already exist. The role of the additional polymerization here is to connect the polyester chains at a number of places, the monomer acting as the connecting unit. In this case, the propagation interval may be no longer than the induction interval; perhaps even shorter.

For gelation to occur within a reasonable time in the curing process, a catalyst such as benzoyl peroxide must be added to the resin and the mass heated to a temperature at which the catalyst

decomposes to form free radicals at an appreciable rate. Although
this method is acceptable for many application, there are others
in which gelation at room temperature is desirable. To effect
room temperature gelation, it is necessary to introduce another
material which reacts with the catalyst and causes the rapid for-
mation of free radicals at room temperature. Such materials are
known as accelerators or promoters. A combination of hydroper-
oxide and cobalt naphthenate is commonly used to effect polymer-
ization at moderate temperatures.

<div align="center">Termination</div>

Termination of polymerization can occur in any of four ways.

1. Chain transfer results when the growing molecule collides
with another molecule, transferring its energy to, but not unit-
ing with the second molecule. In this case, the second molecule
may be activated sufficiently to become the starting point for
a new series of polymer-forming reactions.

2. Retardation, sometimes distinguished from inhibition may
be said to result when compounds are present which can react
with activated molecules and the reaction product has a lowered
tendency to unite with additional monomer molecules.

3. Coupling and disproportionation results from the collis-
ion of two activated centers. If the two combine with the forma-
tion of a new single bond, the process is called coupling. If
they do not combine, but stabilize themselves by the transfer of
a hydrogen atom from one center to the other, the process is
called disproportionation. In either case, the activating energy
is lost in the collision and propagation ceases for the two

molecules involved.

4. <u>Depletion</u> occurs when there are no longer any molecules available for reaction. If a state of depletion is reached at a point where a large number of active centers are still present, the cured resin may show poor aging characteristics since the "excited" molecules are sensitive to attack by the oxygen from the air.

This concludes the introductory material for the thesis. The remainder of the report deals with an explanation of work creative by the candidate and the process of casting fiberglass.

MOLDING

Before discussing the actual casting of polyester resin (i. e. fiberglass) an explanation of molding should be given. Since the resin is manufactured in a liquid state, a mold must be made of the desired piece of sculpture so that the resin can be formed.

Because polyester resins adhere to most porous surfaces, it is necessary to have a mold material that will pick up all the delicate detail of the sculptured surface and to which the poured resin will not adhere. The mold material should also be fluid enough to be applied on a clay model without damaging the detailed surface and viscous enough so that it will stay on the form without slipping off. There are rubber molds on the market today that can be used for casting fiberglass but are costly and sometimes difficult to work. Frank Gallo, a Chicago area sculptor, who has been working with polyester resins for the past few years, has developed an ideal mold material; however, lack of demand by

sculptors prevents this from being commerically produced. It is a combination of wax and plastic. It is easily applied, hardens quickly and resin will not adhere to it. It can be melted down to its original state and reused either to duplicate and mass produce or for an entirely new mold.

All of the fiberglass heads included in the research have been cast using a wax mold. This type of mold material has advantages when comparing costs, but has certain dissadvantages. It cannot be used to duplicate, and resin adheres to the surface even when using a lubricant or mold release separator. Heat must be used to melt the wax, and many extra hours of working with sandpaper and steel wool are wasted in cleaning and preparing the cast surface before color can be applied.

The process of molding with wax will be described since other materials would involve similar principles. The entire process can be traced by following the diagrams at the back of this report. Plate I shows one of the heads in the clay form created for the research. The first step was to melt the wax. This was done in a small sauce pan (about two quarts). The wax was a low temperature ultraflex and when it had melted, was applied covering the entire head evenly (see Plate II). The first coat was applied with particular care starting from the bottom and working up because this layer contained all the surface detail. During this process the wax pan was removed from the heater so the wax could cool. Wax around the sides of the pan became pastelike and was used to fill large holes and to build the mold surface around eyes, ears, nose, and mouth. More wax was melted and

applied until the mold thickness was 3/16" to 1/4". After the
wax had cooled, the mold had to be divided into two sections in
order that it could be removed from the clay head when completed.
This was done with a razor blade. Then thin pieces of brass were
inserted overlapping each other forming a continuous wall sepa-
rating each section (see Plate III). Next, cheese cloth was cut
into strips of about two inches wide and six inches long. These
sere anchored to the wax by dabbing them in spots with hot wax
(see also Plate III). Cheese cloth was added to supply a texture
for reinforcing the plaster which was applied next. Molding
plaster was used for this and its purpose was to prevent the wax
shell from losing its shape. The plaster was applied covering
the whole mold area but leaving the tips of the brass separators
visible. The plaster set in twenty minutes, and the brass shims
were pulled. By inserting a knife between the mold sections,
these were separated and removed from the clay head and armature.
The final step was removing any clay residue from the mold. Be-
cause a water-base clay was used, the mold sections were placed
under running cold water and scrubbed. The cold water kept the
wax hard enabling the delicate details to be cleaned without any
damage. After the mold was throughly cleaned, it was dried and
ready for the resin to be poured.

THE MIXING PROCEDURE

Polyester resins, to which metal or wood fillers have been
added, may be cast cold in a mold without the heating necessary
with metals such as bronze or aluminium. Bronze, aluminium and

lead fillers can be added to the resin and when cast will appear in their natural character. Wood chips, saw dust, and other fillers can also be used for different effects. Although the candidate has never used any metal fillers, they are included in the discussion because of their importance when considering possibilities of fiberglass as a medium for sculpture.

Polyester resin is a plastic which sets by the addition of a catalyst. Once the catalyst or hardener has been added, nothing will prevent setting. The mold must be clean and dry before any resin is poured. Setting time of mixes may be shortened by the addition of extra liquid accelerator. Hardener and accelerator should never be added at the same time or mixed together. Accelerator must be added at the time of mixing the filler. Hardener is added immediately before pouring.

Thorough mixing of components is extremely important. Inefficient mixing may well result in an uncured or partially cured gel coat (first or initial coat); such a coat will develop faults under stress or at final stage of laminating. When metal fillers are being used, it is even more important that they are thoroughly mixed with all components. For mixing the ideal container is a plastic bowl because any residue can be removed when set simply by flexing the bowl.

Resin was added first, and then mixed with components in this order; accelerator (where required), wood filler or whiting, and the catalyst. Each component was thoroughly mixed before adding the next. Ordinarily, catalyst can be added any time after the whiting or filler is mixed, but with metal fillers hardener

must be added to the mixture of resin and filler within one hour. This must be done since the metal will react with the resin and destroy the setting properties of the mix, preventing it from hardening completely for a durable finish.[6]

As mentioned earlier, polyester resins have a tendency to stick to surfaces unless they are perfectly smooth. Even then certain shapes are difficult to separate from the molds. Application of a mold release or parting agent to the molds is generally required before pouring. Parting agents are heat stable over the molding temperature range (65° to 85° F), resistant to oxidation, aging, and decomposition, and inert to both the mold material and resins. They must wet and adhere to the mold surface and should decrease the friction between the mold and molder part. If the mold surfaces are porous, as in the case of plaster, wood, and some metal molds, a sealer should be applied before the parting agent. Furane, phenolic, urea resins, waxes and modified styrene have been used. Lacquers, shellac, and varnish also have been used, but are not dependable because are likely to be vulnerable to the solvent action of the resin or the heat of the cure.[7] In the case of wax molds a silicone lubricant is satisfactory.

After the mold was cleaned and dried, the polyester mix was prepared. For all of the research experiments a whiting filler was used and in some mixes wood chips and saw dust were added.

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6 H. M. Percy, "New Materials in Sculpture," p. 38.

7 Bjorkstein Research Laboratories, Inc., "Polyesters and Their Applications," p. 73.

The mold sections were joined together with wire bands and the resin poured through the neck or open area of mold. The first coat is the gel coat and because it will hold all the detail, the resin should cover the entire surface area. Extra catalyst was added to the gel coat to minimize fatigue due to constant turning of the mold by hand. After the gel coat was poured and had hardened, the mold was removed. With this extra weight removed it was easier to turn the mold while the remaining resin coats were applied.

After the gel coat had been poured and had set, the cast was reinforced with several layers of glass fiber or mat which was bonded into place with laminating resin. The laminating mixes do not normally contain any fillers, but where a cast has very deep detail, a thin mix with filler can be used on the first lamination to back the gel coat and prevent transparency. The second and third layers should contain only resin and catalyst. The ideal temperature for laminating is 65° F. (i. e. average room temperature). Temperatures much in excess of this are likely to reduce hardening time since heat hastens the reaction between resin and hardener. Laminating between 65° F. and 50° F. can be carried out with the help of additional liquid accelerator. It is inadvisable to attempt lamination below this temperature, unless some form of heat can be used to raise the temperature of the mix (e. g. infra-red lamp). Too low a temperature in the room will prevent the laminate from curing regardless of amount of catalyst used. Even a draught may prevent laminates from hardening and dampness from high humidity also will delay hard-

ening or result in undercure.

After the final layer of laminate was applied, the mold was
allowed to set for twenty-four hours before removing all excess
mold wax. Since no known solvent will remove wax, direct flame
from a propane torch was used to melt it. The remainder was tak-
en off with steel wool. Finally, the surface was finished with
fine sandpaper and steel wool. The remaining processes include
coloring and surface treatment which are discussed in the fol-
lowing chapter.

FILLERS, REINFORCEMENTS, AND COLOR

Fillers are substances added to the catalyzed polyester
resin before curing and shaping to enhance various properties of
the final product. Fillers can be bronze, aluminium, or since
the resin is transparent, a plain white filler can be added.
Often the accelerator will give the resin a blue color which can
be changed by adding whiting and any desired color. Whiting also
thickens the mix making it easier to apply under certain circum-
stances. There are also fibrous reinforcing fillers such as
glass cloth and mat made from quartz. These are incorporated with
the resin to improve strength and do not have any influence on
color.

Coloring of fiberglass may be done in two ways: internally
and externally. Coloring agents used may or may not be soluble
in polyester resins. The pigmentation of plastics with insoluble
types of pigments was improved by milling the pigment with a
small amount of a polyester oil, dispersing the pigment in the

monomer (mixture of monomer and polymer) to be used, and polymer-
izing the mixture.[8] The prevalent method of coloring involves
mixing the desired amount of pigment and resin. For coloring the
research pieces of sculpture dry or powdered pigments and tempera
colors were used. Plates IV and V illustrate examples of heads
cast in fiberglass to which whiting was added to change the ini-
tial color of the resin. A very small amount of yellow was also
added to achieve an ivory or bone-like surface. Care had to be
taken that not too much whiting was added since the batch would
have been too opaque when cast. This would have given the resin
a plaster-like appearance instead of a translucent quality. This
type of surface gives richness and depth to the medium such as
found in marble. In contrast to the first two heads, the third
was colored by reversing the values and pigmentation added both
internally and externally (see Plate VI). Wood chips of walnut
and pine were added to the resin and whiting mix plus burnt siena
pigment. This produced a darker wood-like effect which was desir-
ed. After the mold was removed and the surface cleaned, heat was
directed over the surface from a propane torch. The direct flame
darkened desired areas and burned some of the wood filler creat-
ing a different textured effect. Burning also darkened the ini-
tial siena coloring; so a white colorant was added to high-light
important areas. This gave some variation in color which was
lacking. The fourth experiment involved a coloring process simi-

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8 Bjorkstein Research Laboratories, Inc., "Polyesters and
Their Applications," p. 95

lar to the third (see Plate VII). Yellow ochre was used for the base color instead of burnt siena. The same filler of whiting and resin was used except with a smaller amount of wood chips. The surface was burned also with the propane torch, but not as severly; thus, the head appears lighter in tone. The final two experiments are illustrated in Plates IX and X. Instead of using one base color for the cast resin, different colored resins were used and each was poured separately in the mold. The sixth head (Plate IX) has three different colors in the fiberglass although not evident in the plate. The white band across the eyes is the most obvious. This was poured first using a thick mixture of whiting plus a white tempera colorant. The face or front half was poured next using mixture of whiting, resin, and burnt siena color. This gave the face a medium value in contrast to the of light and dark areas which was part of the objective of the experiments. The series of heads represents the wide range of color and surface possibilities that can be obtained using fiberglass as a medium for sculpture.

ADVANTAGES

To produce sculpture in bronze or other metals, by heating the metal until it is molten and then pouring it into a specially prepared mold, is extremely expensive and requires special skills and equipment. Added to this, the casting takes some time and is often not directly under control of the sculptor. But the new technique of cold casting with polyester resin is carried out by the sculptor himself with obvious enormous savings in time

and cost. The cost is approximately one sixth of the cost of conventional metal casting.[9] This new technique has many other advantages also.

A mold can be taken from the clay model, and from this the sculptor can produce any type of fiberglass cast he desires. There is no special skill required other than the basic knowledge of plaster casting. Casting can be done in the average studio without need of a foundry and expensive equipment. Possibilities of different colors, textures, and fillers are unlimited. On metal fillers such as bronze, a patina can be applied with acids for color effects. A cold cast of this type is not easily detectable by eye from a conventional casting. Polyester resin sets extremely hard and remains strong and is lightweight. Damaged casts can be easily repaired by employing the same materials used in making the cast. Polyester resin is not subject to any of the normal forms of corrosion associated with metals.

The filler-resin mix is of a consistency that is easily poured. Setting time is within the limits of twenty minutes, but can also be adjusted to the satisfaction of each sculptor. The resin can be poured into a mold or applied with a brush by lamination. In either case all the surface detail is perfectly cast. Thickness of the casting need by only 1/16" to 1/8", but it will still be durable when reinforced with impregnated glass fiber through lamination. The end result is a casting comparable with conventional types of metal casting not only in craftmanship,

9 H. M Percy, "New Materials in Sculpture," p. 17.

but in total visual appearance.

This new method of casting may well replace in many instances the more traditional casting technique. For very large works which would be mounted on walls, use of glass fiber reinforced polyester resins will obviate the necessity of structural reinforcement of the wall, due to lightness of weight. The most notable advantage is the liquid character of polyester resins. The sculptor has control over the entire casting process. He can experiment with different colors and textures and surface appearances, and he can explore the unknown; as fiberglass sculpture is still new and in the formative years. What future there is for the new medium is for sculptors to decide. The possibilities are unlimited.

EXPLANATION OF PLATE I

Clay model of head.

PLATE I

EXPLANATION OF PLATE II

Applying wax to clay head.

PLATE II   28

EXPLANATION OF PLATE III

Wax mold divided with shim brass.

PLATE III

EXPLANATION OF PLATE IV

Cast fiberglass head #1.

PLATE IV   32

EXPLANATION OF PLATE V

Cast fiberglass head #2.

PLATE V

EXPLANATION OF PLATE VI

Cast fiberglass head #3.

PLATE VI   36

EXPLANATION OF PLATE VII

Cast fiberglass head #4.

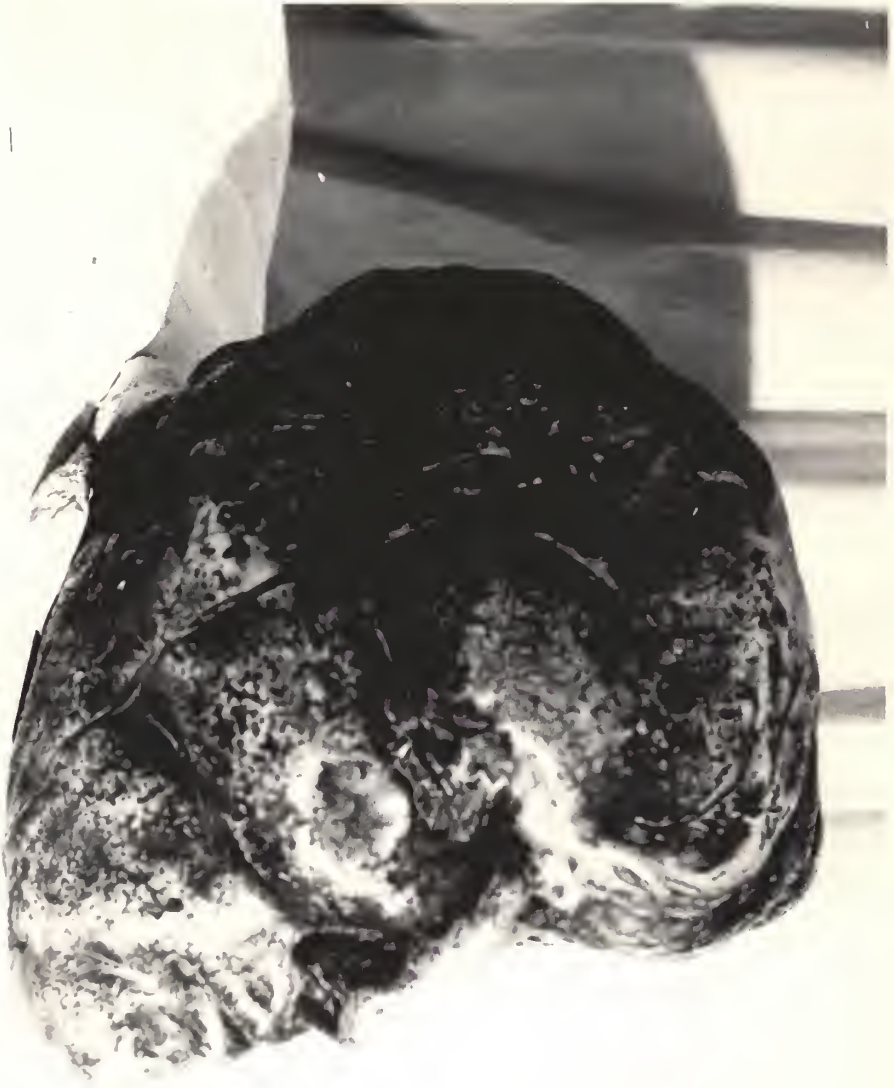PLATE VII   38
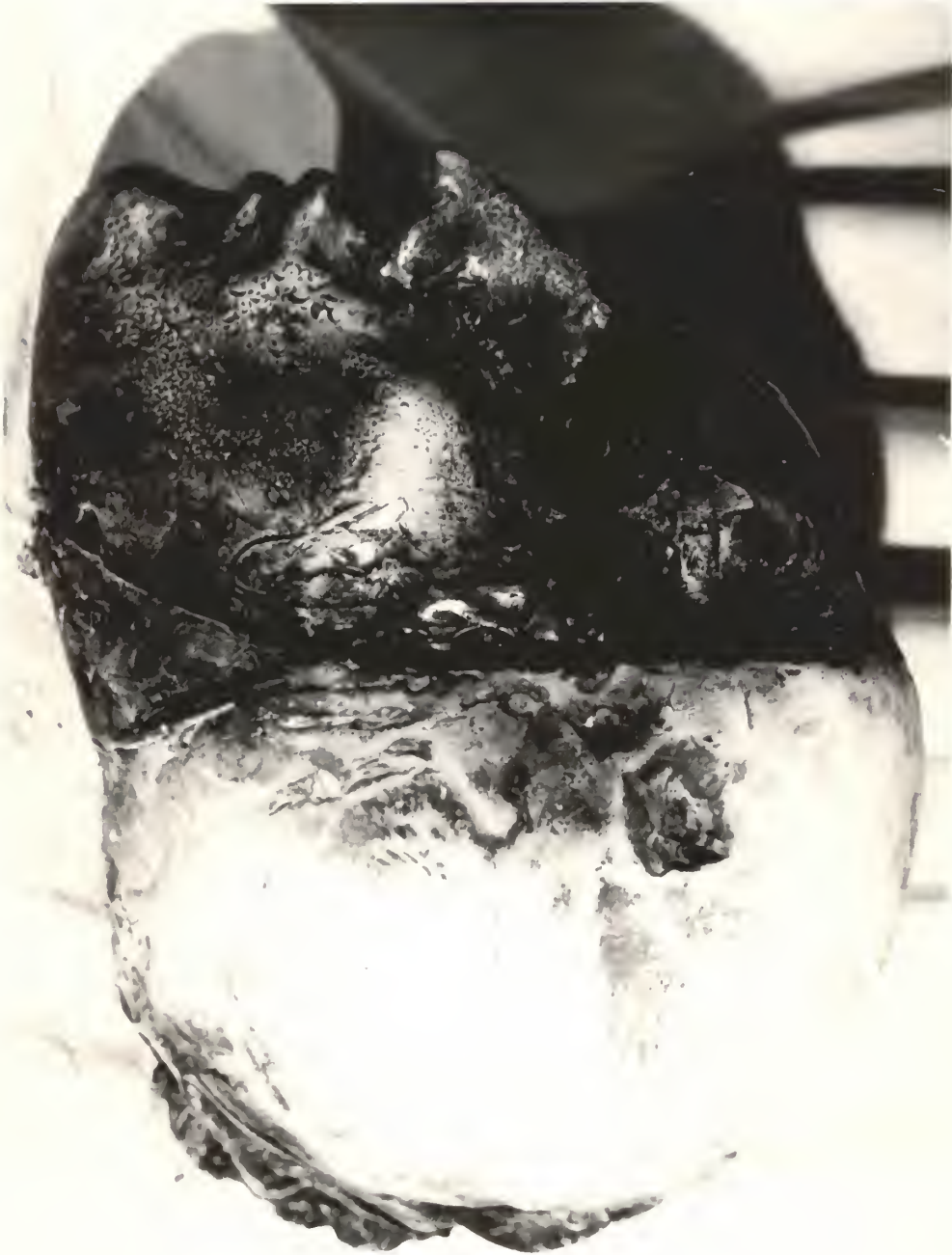
EXPLANATION OF PLATE VIII

Cast fiberglass head # 5.

PLATE VIII

EXPLANATION OF PLATE IX

Cast fiberglass head #6.

PLATE IX   42

EXPLANATION OF PLATE X

Cast fiberglass head #7.

PLATE X

ACKNOWLEDGMENT

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FIBERGLASS AS A MEDIUM FOR SCULPTURE

by

THOMAS JOHN TASCH

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AN ABSTRACT OF A MASTER'S THESIS

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MASTER OF ARTS

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In sculpture bronze which has long reigned as the ideal casting medium is being challenged by fiberglass a new type of casting medium. The purpose of this paper is to show the possibilities of the new medium for sculpture. This is done by a discussion of the history and chemistry of polyester resins.

The history of polyester resins dates back to 1847 when the first resinous mass was produced. In the period following, a laboratory discovery and wartime necessity combined to launch polyester resins on a commercial basis. For years it was questionable whether the industry would survive, but today nearly every new building constructed has some form of fiberglass incorporated, and recently sculptors have started using it instead of bronze.

The term polyester resin encompasses a variety of materials. By chemical definition a polyester is formed by the reaction of a polybasic acid and a polyhydric alcohol to form a series (poly-many) of ester linkages. A typical, unsaturated polyester may be prepared by reacting an unsaturated dibasic acid, such as maleic anhydride, with a glycol, such as diethylene glycol. The reaction proceeds at elevated temperatures (usually above 150 degrees C.) and is stopped at the desired point by cooling the product to room temperature. A full understanding of the chemistry of polyester resins is not necessary for using them for sculpture.

Polyester resins are manufactured in a liquid state and must be formed in a mold. Of the many different mold materials a low temperature type wax was used for the candidate's research. The melted wax was applied with a brush over the clay model of the

desired piece of sculpture. When the thickness had reached about
1/4 inch, plaster was applied over the wax to reinforce the mold.
When the mold was removed, it was cleaned in water and dried.
The next step involved the actual pouring of the resin. A cata-
lyst was added to hasten the hardening of the resin. To the re-
sin was added a filler of whiting, wood chips, and color. By
varying the filler and color a different surface and color was
created for each piece of sculpture. Some coloring was also done
externally by using oil pigments and applying direct flame from
a propane torch. The heat darkened desired areas and gave a
richer color variation over the entire head. The heads used for
the experiments represent some different possibilities of color-
ing and treatment of the surface.

The conventional method of bronze and aluminium casting is
expensive and requires special skills and equipment. Casting with
fiberglass can be done in the average studio. There is no special
skill required other than the basic knowledge of plaster casting.
The resin can be poured into a mold or laminated with a brush.
Setting time is within the limits of twenty minutes. The sculp-
tor is in control at all times, and is free to experiment with
different colors and textures. Advantages of this medium over the
traditional methods of casting demonstrate that possibilities
of this new medium for sculpture are unlimited.