THE FEASIBILITY OF CASTING ALUMINUM RELIEF SCULPTURES WITH CONTROLLED DIVERSIFIED TEXTURAL PROPERTIES

DISSERTATION

Presented to the Graduate Council of the
North Texas State University in Partial
Fulfillment of the Requirements

For the Degree of

DOCTOR OF PHILOSOPHY

By

Glenn Bill Williams, B.S., M.Ed.
Denton, Texas

December, 1973

Williams, Glenn B., The Feasibility of Casting Aluminum Relief Sculptures With Controlled Diversified Textural Properties. Doctor of Philosophy (Higher Education), December, 1973, 225 pp., 5 tables, 34 illustrations, bibliography, 22 titles.

The problem of this study is twofold: casting aluminum relief sculptures which have controlled diversified textural properties, and the development of a technical teaching process in the form of a pictorial documentation.

The purposes of this study are several and are interrelated with the duality of the problem itself. The first purpose is to develop procedures of producing and controlling a variety of textures such as porosity, oxidation, and other surface irregularities in open-mold aluminum reliefs. This process included the testing of the textural casting in sculptural reliefs of selected irregular dimensions; simplifying open-mold casting methods to facilitate less expense, equipment, and effort, and fewer facilities; developing specific casting techniques capable of being easily taught at the college level to the young sculptor in need of casting fundamentals; and identifying and recording the safety factors in all phases of casting the open-mold reliefs. The second purpose is to develop a technical teaching process in the form of a pictorial document of the open-mold casting process.

The information on which the conclusions and the pictorial document are based was derived for the most part from personal observation of practices in foundries, previous experiences with sculpting and casting, and finally from the the information provided by three separate series of casting experiments. The first series was performed to determine the effects of extremely high temperatures of the melted metal on open-mold casts. The second series was performed to determine the effects of super-heating the melted metal and allowing the metal to cool to various predetermined temperatures before pouring the metal into the casts. The third series of casts was performed to determine the effects of various binding materials used in making the molds.

After exploring the historical background of sculpture and casting, an investigation was made into available literature on methods of casting open-mold reliefs in aluminum and on various causes of porosity and other textural surfaces in cast aluminum.

The results of the open-mold aluminum casting experiments are relief sculptures with a wide range of textures. Basically, the textures are of three different levels of porosity. The first texture is the same as that produced by standard procedures--dense, non-porous, metal. The second texture is porous, sometimes to the degree that the master pattern for the cast is poorly duplicated. The third texture is so spheroidal that it in no way duplicates the image of the master pattern. Serendipitous findings include some unusual coloration in various casts. From these findings, serendipitous and other, conclusions are drawn as to how to achieve porosity in open-mold aluminum casting, how to cast aluminum in the open-mold with safety, how to introduce the beginning sculpture student to the fundamentals of open-mold aluminum casting, and finally recommendations are suggested for additional study.

Four conclusions are made. Castings utilizing Series III processes will produce greater textural porosity than castings utilizing the other processes described in the study. As a binder, sodium silicate works better than syrup in producing porosity. Super-heating aluminum causes shaping and finishing difficulties, and oxidation of the aluminum finish results in a poor reflective quality of the aluminum.

Additional study might profitably be made to develop a means of permanently protecting polished aluminum sculpture and to explore the use of crystallized molds to produce more accurate casts than those molds using liquid binders.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

Figure		Page

CHAPTER I

INTRODUCTION

An examination of sculpture done by early twentieth-century American sculptors reveals their preference for wood and stone and their reluctance to use cast metal. Fuller summarizes the position taken by contemporary American sculptors:

> For several decades and until recently, there was a strong feeling among American sculptors that any indirect technique employed in creating a work was phony. To be considered valid, the process had to be direct carving in wood or stone, or welding in metal. All mold-making or casting was highly suspect. The origins of this passionately-held conviction were several; suspicion of the commercialism that is often involved with reproduction, revolt against the look of most metal sculpture that was cast from clay or wax originals and which had that ambiguous surface of the soft material made hard. Possibly another reason for the low status of casting among sculptors was a defense against the impossible. They could not afford to have a sculpture cast in metal; only commercial sculptors could (4, pp. 57-58).

Feldman elaborates,

> As in translation from one language to another, some loss of meaning inevitably occurs. Hence, the indirect method, which is also involved in any casting process, stands between the sculptor and his intimate contact with materials (3, p. 351).

As numerous as the disadvantages may be, casting will probably continue intermittently as it has for the last forty-four centuries. Some artists accept the disadvantages of metal casting as problematic challenges to be solved because casting also has its advantages. The most recent revival of casting has taken place in America. Fuller (4, p. 58) recalls the deadlock of creative casting being broken on the West Coast in the 1950's by Peter Voulkos using an amalgamation of casting individual shapes, subsequently modifying the cast, and then assembling and welding it into a final sculpture.

Most of the American sculptors currently casting art works have had to develop their techniques through an arduous and expensive trial-and-error procedure because there are few schools in the country which have qualified foundrymen teaching sculpture (7, p. 615). Therefore, casting is usually omitted from the education curriculum in favor of recent material-oriented techniques such as welding, assemblage, fiberglass impregnated with synthetic binding resins, and mixed media. As a result of the omission of casting from the university art curriculum, the process is seldom taught and teachers have little or no formal training in casting. With the expansion of higher education, however, many college and university art departments, aspiring to be comprehensive, include or are planning to include facilities with which they can to some degree cast metallic art forms.

Statement of the Problem

The problem of this study was twofold: the feasibility of casting aluminum relief sculptures which have controlled diversified textural properties, and the development of a technical teaching process in the form of a pictorial documentation.

Purposes of the Study

The purposes of this study were

1. To develop procedures of producing and controlling a variety of textures in open-mold aluminum reliefs. The parts in this process were

   a. To test the textural casting system in sculptural reliefs of selected irregular dimensions.

   b. To identify and report safety factors pertaining to all phases of casting the open-mold aluminum reliefs.

   c. To refine open-mold casting methods so that they can be accomplished with a minimum of financing, facilities, and effort.

   d. To develop specific casting techniques that can be taught at the college level to acquaint the young sculptor with casting fundamentals and safety precautions.

2. To develop a technical teaching process in the form of a pictorial documentation of the process and of the

results. The parts in this process were

a. To develop a filmstrip portraying sculptural casting with the open-mold process, here-to-fore unavailable to classroom teachers, and providing relevant information, especially, safety factors.

b. To develop a pictorial documentation specifically designed to assist in the replication of the process.

Questions

In order to fulfill the purposes of this study, answers to the following questions were sought

1. What visual results occur when unorthodox pouring temperatures and sand binders are employed?

a. What temperature and binder combination produced the most porosity?

b. How well did each binder and temperature combination render detail?

2. What related metal properties developed from this experiment?

a. Does the resulting metal hinder the operation of the sculpting tools?

b. Could the metals be polished?

c. What degree of reflection of an image was there?

3. What was the cost per pound of the completed sculpture?

a. What was the specific weight loss in the transition from scrap metal to the finished products?

b. How did the cost of aluminum compare with the more traditional casting metal, bronze?

4. What form should the technical teaching process take for:

a. portraying open-mold sculptural casting for classroom use?

b. replicating the procedures for casting textures in the open mold?

f. In a sculpture student's program of study, when should the open-mold casting process be taught?

Definition of Terms

One of the most confusing factors in the field of academic art is the difficulty of standardizing terminology. Ocvrick, Bone, Stinson, and Wigg state, "It is impossible to find agreement among people on terms, their significance, or their interpretation" (9, p. vi). This is further complicated when one considers that the visual communication, art, is intended to fill the gap that could not be fulfilled adequately with any form of verbal communication. It is for these reasons that a glossary of these terms is formulated or stated in Appendix B.

Background and Significance

In reality the background and significance of casting aluminum relief sculptures with differing textures are separate studies in themselves. However a brief treatment is necessary here.

Metal in general has taken precedence as the leading medium in sculpture. Herbert Read (8, p. 30), art historian, estimates that four-fifths of all contemporary sculptures exhibited in commercial galleries are made of metal.

Concerning casting in general, Ralph Mayer states,

> Metal casting is ordinarily done in foundries by craftsmen experienced in the careful handling of sculptors' models; only a small minority of sculptors have sufficient first-hand experience or knowledge to even criticize or guide the work in progress (7, p. 615).

Due to the lack of sculptors' research into foundry procedures, this statement justifies an experimental casting problem in the field of sculpture. Moreover, Mayer continues, referring specifically to aluminum

> The use of more modern innovations such as aluminum, stainless steel and Monel metal, is so recent compared with the traditional use of bronze, that no standards have been established, and sculpture in such materials may still be classed as experimental (7, p. 615).

David Von Schlegell, American sculptor, states,

> It [referring to wood] had too many qualities you admire for themselves, and it had a tendency to dictate the form of your work. Metal [Von Schlegell sculpts basically in sheet aluminum]

> is stronger and yet less assertive of its own character (6, pp. 50-53).

In spite of the values of aluminun implied by Schlegell, some authoritative instructional sculpture textbooks such as Sculpture Inside and Out have omitted aluminum-casting techniques completely or have included a small number of references, usually concerned with the properties aluminum adds to the alloy, bronze. This lack of information on aluminum casting contributes to the significance of the study.

Concerning relief sculpture, Frank Eliscu says,

> Bas-relief is a very highly specialized and sophisticated art form. A sense of drawing, perspective, and delicacy is more necessary here than in other art fields. Because of the great importance of detail and texture, wax is very often used. It must be admitted that the average medallist will work in plasticine, cast and then work on the mold in the reverse (2, p. 141).

While Eliscu indicates the difficulty of creating the master relief and the mold, one must also take into account the spatial concepts utilized in most contemporary sculpture; Riley clarifies this by stating,

> Just as most of our contemporary painters suggest only a limited depth, or three-dimensional quality, in their paintings, so many sculptors now work within a two-dimensional, or two-sided, framework (10, p. 316).

Drawing upon the previous statements, some sculptors might question the validity of contemporary free-standing sculpture. Further investigation into the relief casting might prove that a relief sculpture will satisfy the demands of the contemporary connoisseur.

Texture, the axis upon which this problem was basically focused, in its simplest definition was the smoothness or roughness of a surface. Orvick and Bone expand the definition to include a statement about the differentiation of texture from the other physical elements of art.

> Texture: The actual or the illusion of tactile value of the surface of an area as created by nature or by man through his manipulation of the visual elements. Texture is unique among the art elements in that it activates two sensory processes at the same time. Hence, there may be vivid feelings of touch, vicariously experienced, and complementing the sensations of vision (9, p. 73).

Coleman relates texture to sculpture and explains the two primary types:

> There are two primary sources of texture in sculpture: That which is indigenous to the medium and that which the artist produces on the surface of the sculpture in addition to, or in spite of, the natural texture of the material (1, p. 17).

Eliscu strengthens the importance of texture to sculpture by stating that "for what chiaroscuro is to painting--that important element of light and dark--texture is to sculpture" (2, p. 119).

The aesthetic properties of the textures are unlimited. This dissertation, in exploring the problem of textures might help sculptors achieve integral (as opposed to the contrived, labored or hand-produced) textures that they have never considered. Spontaneous, porpous textures could embellish a sculpture and help it overcome its previous limitation of a smooth, non-porous surface. Also, the texture could be isolated to particular areas to emphasize or de-emphasize that area.

Construction of the Equipment

Due to the dangers involved in casting sculpture, several precautions were taken to prevent accidents. The first step in safety precautions was construction of sturdy equipment. For example, a kitchen table will not substitute for a specially constructed, heavy sculptor's table. The following list was composed of the specialized equipment that was constructed specifically for the problem.

1. A movable, hinged panel was constructed and painted flat black. The size of the panel was 8' x 24'. It was made of 1/4" exterior plywood reinforced with 2" x 4" studs and 2" x 8" frames and was used for the following:

a. protection of the surrounding area from drifting spray paint and from damaging welding rays,

b. as a background to mask any cluttered and distracting objects from the photography,

c. as a device to aid in the addition of reverse copy,

d. as a viewing panel for visual analyzation and criticism of the sculptures at various points of their construction, and

e. as an exhibition panel for the finished art pieces.

2. An 8' x 12' tarpaulin was purchased and one side was painted flat white and the other side flat black. This tarpaulin was used in addition to the panel for protection of the surrounding area and for covering cluttered backgrounds for the photographs. The white side was used as a photographic background where overburn copy was needed on the photographs.

3. A sculptor's tool chest with a removable wooden tray was designed and constructed of plywood. The chest was 18" x 18" x 42" and mounted on casters. This chest was used for tool storage and the tray for the carving and cutting tools, since the plywood, unlike the harder metal chest, did not dull or damage the tools.

4. A sculptor's workbench was designed, built and fitted with a vise. The bench was 35" wide x 56" long x 31" tall with 2"-thick top and sturdy 4" x 4" firmly braced legs. This bench was designed for high speed grinding operations and heavy hammering. The bench was painted flat black to assist in the clarity of the photographs.

5. A multiple purpose worktable 36" wide x 80" long x 31" tall was built and equipped with folding legs. The working surface was covered with masonite and the entire table was painted flat black.

6. Flasks designed for casting bas-reliefs were constructed of wood. The outside dimensions were 22" x 28" x 6" which allowed 20" x 26" x 4" inside dimensions and permitted a maximum sculpture size of 18" x 24" x 3". The casting problem required two flasks of these dimensions.

7. Five sandbags were constructed; two were 16" long x 30" middle circumference, and three were 11" long x 12" middle circumference. The sandbags were constructed of a heavy, tightly woven fabric and only 90 per cent filled with coarse sand. The sandbags were used to secure the sculptures for shaping, grinding, and polishing.

Procedures

I. Shaping of the master patterns was done in a variety of techniques and materials. One shaping technique is illustrated in frames 1 through 16 of the filmstrip (page 77). The other master patterns used the following materials and techniques:

A. Styrofoam was a principle material for a master pattern. The end result of any technique of sculpting styrofoam would usually produce a typical styrofoam texture. To control this texture, an investigation was made into the materials that would penetrate the porous surface and form the desired texture.

1. By the use of sharp gouges and saws, the bulk of the negative area of the styrofoam design was removed. Additional detail was rasped and filed into an irregularly shaped master pattern. Respirators were worn during all shaping of styrofoam.

2. Burning away concave areas of styrofoam with acetylene torches usually produced smooth round biomorphic shapes. With the use of a small penlike flame, detail could be accomplished. The safety precautions described in part B were utilized.

3. Concave areas of styrofoam were burned and melted away with an electrically heated spatula. This method was best suited for sharp, distinct edges. The safety precautions described in part B were utilized.

4. Sandblasting was another technique of shaping styrofoam. This method was best suited for rounding edges. The safety precautions described in part A were utilized.

B. Plaster of Paris was utilized as a master-form material which was poured into an impression of another master and then intricate detail was carved into the surface. This allowed some design modifications without losing the original master.

C. Ready-mixed concrete, because of its strength and durability, was used in casting in a manner similar to plaster of paris. Rubber gloves should be worn while working with concrete.

D. Combinations of the above listed techniques and materials were incorporated in order to produce an amalgamation of various types of forms.

E. Various discarded materials called "found objects" such as cogs, bolts, and gears were welded together and used as a master form.

II. Upon completion of sixty master patterns, the master patterns were sprayed one uniform value, light gray. This single value controlled those variables of chroma, saturation, and intensity which might interfere with the objectivity in criticism and analysis. The light gray also approximated the aluminum metal that would be used for the casting.

The selection of the master patterns consisted of two steps. First, the master pattern had to be technically qualified for the casting process. In Series I and III, the master pattern could not have underbiting shapes, since the masters were removed before the melt was poured. Secondly, the aesthetic properties of the sculptures were analyzed and those possessing the higher qualities were chosen. The criteria for choosing the particular sculpture are discussed in the section titled "Criteria for the Creation of Sculpture."

III. A series of experiments in casting, designed to create a variety of textures, was performed. Records of the foundry events and conditions and the studio analyses were kept. An example of this form is on page 73. In order to isolate and control those variables related to texture, the experiments were performed in this order:

A. The first series of experimental casts was to determine the effects, if any, that heat within and beyond the recommended limits for aluminum had on the textures. (Temperature limits are hardly standardized for aluminum, considering that previous research had shown that the best temperature would range from 1150°F to 1350°F.) In Series I the aluminum was poured as soon as it reached the pre-planned temperature.

B. The second series of experimental casts (designated Series II) was made with extreme (extreme for aluminum) temperatures. The sequence consisted of heating the metal to the highest degree possible (exact temperature was 1725°F), then pouring at that temperature and at six equal intervals down to and including 1325°F. These experiments revealed the effects of the extreme temperatures, called super-heating, and then the cooling.

C. The third series of casting experiments (designated Series III) was designed to determine the effects of the binder added to the sand immediately before mold construction to prevent evaporation. The temperature was held constant at 1500°F, while:

1. using a binder combination of one-half syrup and one-half water,
2. using a binder combination of one-third H_2O (water) and two-thirds Na_2SiO_3 (sodium silicate).
3. using a binder combination of two-thirds H_2O (water) and one-third Na_2SiO_3 (sodium silicate).
4. using only H_2O (water) as a binder.

IV. The processes and end results of all three series were photographed. Standardized enlargements of the textures were made for those students of sculpture and interested readers.

Limitations of the Study

The location of the foundry outside helped disperse toxic fumes and furnace heat. Climatic conditions, however, changed considerably (temperature ranged from 80°F to 101°F, and humidity ranged from 30 to 96 per cent) and could have had some effect on the various series of casts.

Criteria for the Creation of Sculpture

Aesthetic criteria established for the creation of the master patterns follow the principles of organization that Ocvirk, Bone, Stinson, and Wigg (9, pp. 13-16) have dealt with in depth. The following list and discussion were extracted from their writings.

Proportion is the size relationship between shapes and space. Proportion is an interesting relationship between spaces and masses. The success of any arrangement of combination of materials depends upon a satisfying relationship between a whole and its parts and between the parts themselves.

Rhythm is a series of recurring accents that produces a sensory experience such as grace, order, strength, et cetera. Rhythm is dependent upon repetition to exist.

Repetition is the repeating of lines, shapes, and values to unify a design.

Balance is the equilibrium of a design to create unity. It may be formal or informal in style. The two types of formal balance are symmetrical (perfect balance on both sides) and bisymmetric (perfect balance on all four sides). Asymmetric or informal balance is achieved by arrangement of areas, values, color or line.

Dominance or Center of Interest is the featured or controlling part or parts of a work of art. The dominating factor should be the center of interest. This is achieved by contrast of color, value, lines, or shapes.

Opposition is the contrast of directions of lines or shapes causing a focal point in a design.

Pattern is the guide to the movement of the eye throughout the underlying compositional structure, generally decorative in character and emphasizing the unifying qualities of an organization.

Economy or Simplification is stripping away the superficial detail, making the work clear and intelligible.

Harmony is the combination or adaption of parts, elements, or related things, so as to form a consistent and orderly whole.

Unity is the harmonious relation of the principles of art within a design. Unity means that all component parts of a work of art combined in such a way that the final result is a whole.

Unity and organization in art are dependent upon dualism; a balance between harmony and variety. This balance does not have to be of equal proportions; harmony might outweigh variety, or variety might outweigh harmony. Harmony is achieved on a picture surface through transitional rhythms and repetitions, variety through diversity and change. The problem for the artist is one of balance between harmony and variety.

ART BALANCE

UNITY

<u>HARMONY</u>	<u>VARIETY</u>
Gradations	Contrast
Rhythm	Opposition
Repetition	Elaboration
Relation	Diversity

The preceding principles of organization are mentally applied to a work of art. For the studio aspect of the sculpture, Coleman has compiled a general list of rules for the student to follow. The rules are

1. Always be a craftsman.
2. Solve each problem as quickly as possible. In the beginning a variety of experiences will be more valuable than ownership of a belabored student sculpture.
3. Work on more than one project at a time.
4. If an impasse is reached, put the work out of sight for some time. When again viewed, it may be seen in a new and revealing light.
5. Accept failure as normal. A failure is easier to analyze than a success. Study failures and learn from them. Failure is justified, if it results from an intelligent attempt to solve a particular problem, and is not thoughtlessly repeated.
6. Student works are primarily exercises; therefore, rarely is one so magnificent that it is too wonderful for the student to take a chance on improving it, even at the risk of complete failure.
7. Observe the work of others and learn from them.
8. Care for your tools. Use them as if they are extensions of your body and personality.
9. Sculpture is an arduous discipline. If the labor involved is too strenuous, seek another medium.
10. Be safety-conscious! Take protective measures before fatalities occur (1, p. viii).

Criteria for the Pictorial Documentation

The criteria for a pictorial documentation had been researched by Michael Roach. Essentially, Roach has compiled the work of many authors on the subject of communication. Through this consensus, Roach has an instructional dissertation which is designed to aid the non-professional filmstrip maker to develop a filmstrip in a step-by-step technique. In addition Roach developed criteria for sequential pictures and a form (12, p. 58) for evaluating a filmstrip. It was this form that was used to evaluate the audio-visual aspect of this problem. A copy of this form is included in Appendix A.

CHAPTER BIBLIOGRAPHY

1. Coleman, Ronald L., Sculpture, Dubuque, Iowa, William C. Broan Company, 1968.

2. Eliscu, Frank, Direct Wax Sculpture, Philadelphia, Chilton Book Company, 1969.

3. Feldman, Edmund Burke, Art As Image and Idea, New Jersey, Prentice-Hall, Inc., 1967.

4. Fuller, Mary, "San Francisco Sculptors," Art In America. 52 (June, 1964), 52-59.

5. Hoffman, Malvina, Sculpture Inside and Out, New York, Bonanza Books, 1939.

6. Jacobs, Jay, "The Artist Speaks: David Von Schlegell," Art In America, 56 (May-June, 1968), 50-58.

7. Mayer, Ralph, The Artist's Handbook of Materials and Techniques, New York, The Viking Press, 1968.

8. Meilach, Dona, and Donald Seiden, Direct Metal Sculpture, New York, Crown Publishers, Inc., 1966.

9. Ocvirk, Otto G., and Robert O. Bone, Art Fundamentals--Theory and Practice, Dubuque, Iowa, Wm. C. Brown Company, 1968.

10. Rich, Jack C., The Materials and Methods of Sculpture, New York, Oxford University Press, 1967.

11. Riley, Olive L., Your Art Heritage, New York, McGraw-Hill Book Company, Inc., 1963.

12. Roach, Michael N., "The Relationship of a Model of Audio-Visual Perception and a Selected Communication Model as a Function of a Filmstrip Design," unpublished doctoral dissertation, Department of Education, North Texas State University, Denton, Texas, 1970.

CHAPTER II

HISTORICAL REVIEW OF CASTING

The Background of Sculpture

Any attempt to solve problems in casting must inevitably involve the background and reasoning behind the field of sculpture in general. Most art historians believe sculpture had a utilitarian beginning. The sculpture was, and still is in some societies, presumed to perform some magic feat. For example, authorities speculate that the hunter cavemen would incise intaglio animals into the walls of their cave before a hunt. These fourth-dimensional intaglio reliefs, indicating a time concept, would exhibit the drama of a hunter spearing the animal. Theoretically, the magic sculpture would cause the depicted event to take place. Later, sculpture was created for religious rituals. The shamen, priests, and other religious leaders would christen or instill the souls of gods into these sculptures, many of which were protecting totems. Only recently has sculpture been partially relieved of the many magical, spiritual, heroic, heraldic, and other utilitarian reasons. In reference to the academic attitude toward utilitarian sculpture, Feldman continues with this:

> Public buildings and parks still abound with statuary of this kind, and it continues to

> be commissioned by conservative patriotic groups and municipal bodies. But, sculptors who can or will create such works are a diminishing minority (2, p. 348).

Concerning the origin of casting, Hoffman says,

> The reader may be surprised to learn, for instance, that the Cretans used copper for their implements as far back as 3500 B.C., and that it was not until a thousand years later that the Trojans used bronze with an alloy of ten per cent tin and developed the art of casting in Greece and Italy (6, p. 26).

In Italy and Greece a form of hollow bronze casting was invented approximately 600 B.C. The existing pieces are always backed by some wooden structure. It may never be known for certain if all the sculptures had wooden backing or any other pecularities, because much of the great Greek sculpture was melted down by invading warriors to produce weaponry. This destruction of bronze sculpture and the leaving of the marble statues projects a misleading conception that more marble sculpture was produced than bronze. A comprehensive study of casting concluded that most authorities of Grecian art believe that a majority of the sculpture was bronze (2, p. 348).

In the following centuries, artists produced sculpture, but, basically, much of it was commissioned by the clergy and monarchs. Consequently, the work was basically functional and the figures were sometimes horrifying. The Medieval period is noted for its guardian monster statues such as gargoyles.

During the Renaissance, sculpture was again to come alive with such greats as Donatello, the first sculptor to cast a life-size, empty-cavity bronze, Michelangelo, and DaVinci. The great Renaissance sculptor Michelangelo worked on the theory of releasing those imprisoned figures from the marble (2, p. 350). Although Michelangelo cast only two known bronzes, he did create a new pinnacle in sculpture with marble. Leonardo DaVinci's equestrian monument, which was made of plaster, unfortunately was destroyed by warriors, for it would have been the greatest casting feat of that time.

A decline in sculpture set in after the baroque period. Feldman states the general opinion of modern criticism: "Very few major sculptors intervened between Bernini and Rodin" (2, p. 360). Hale says, "Auguste Rodin was the new emerging master. Every figure he sculpted exuded an overwhelming power, a force untamed. Rodin was above all interested in conveying motion" (5, p. 10).

The late nineteenth century marked the beginning of a great change in art, manifested in Cezanne's painting theory and articulated in Ocvirk and Bone's book by the statement that "pictorial forms are more important than the copying of the forms of nature" (11, p. 32). Artists, freed from the meticulous chore of copying nature, evolved many schools of thought: Impressionism, Fauvism, Futurism, Fanatacism, and Surrealism. Because most of these schools were founded on imagery, basically painting, sculpture, as a field, had once again taken a place second to painting. Some of the most inspired sculpture from this period was executed by the painters, particularly the Impressionists, rather than by trained sculptors.

Many artists, accomplished in graphics and painting, gradually underwent a transition, which propelled them into the broader fields of sculpture. Seitz states: "In May 1912, Picasso finished a small oval still life into which was pasted a fragment of oil cloth that simulated chair caning and around which, in lieu of a frame, he wrapped a piece of hemp rope" (13, p. 9). These collages or papiers colles of Picasso and his friend Braque led to the idea of assemblage. Many artists--Marcel Duchamp, Kurt Schwitters, Joseph Cornell, and others--joined the movement and made their individual contributions. In 1913 Duchamp exhibited a bicycle wheel attached to a stool. This not only was the first piece of readymade sculpture but also a forerunner in the field, not yet named "Kinetic" sculpture.

Following the origin of assemblage, a new concept in sculpture evolved. In summarizing the new sculptural concept, Constructivism, Feldman states:

> Constructivism was the twentieth-century movement which formally abandoned the monolith as the basic sculptural form and the central axis as the core around which sculptural volumes must be organized. It introduced new materials

> into serious sculptural practice--materials like plastics, plexiglass, and metal wire--on the ground that several kinds of materials could be combined in one work. Finally, it made a complete break with the figurative tradition, placing geometrical shapes and volumes at the foundation of sculpture. Its leading personalities were Vladmir Tatlin (born 1885), and two Russian brothers with dissimilar names, Naum Gabo (1890-1965) and Antoine Pevsner (1886-1962). They advocated an approach to sculpture which would bring it into harmony with new concepts in physics and mathematics, and hence, via engineering, with production and industrial design (2, p. 362).

Although other schools of art were undergoing various independent stages of development, the constructionists were the first to use the then new plastics as a sculptural medium. This new application, with the ingenuity of Gabo, Tatlin, Pevsner, and Archipenko, created sculptures of immense sophistication and developed the idea of negative space to instill a feeling of continuum of matter rather than an element totally foreign to matter (2, p. 365).

Although an intaglio relief of a bison, created approximately 10,000 B.C., dealt with the problem of the illusory impression of movement and, to some degree, suggested the motion of the bison, the sculpture was static nonetheless and only used optical devices such as multiple linear incisions to convey movement. Feldman says, "It was not until 1920, that Naum Gabo created the first modern work to be designated 'kinetic' sculpture and [the sculpture] was exhibited in Berlin in 1922" (2, p. 386). The statement made by Gabo and his brother Pevsner in their

Manifesto (1920) serves as a foundation principle for kinetic sculpture as well as constructivists aesthetics.

> We free ourselves from the thousand-year-old error of art, originating in Egypt, that only static rhythms can be its elements. We proclaim that for present-day perceptions the most important elements of art are the kinetic rhythms (14, p. 179).

But Gabo turned his energy to constructions, not kinetics, and he produced few works which actually employ movement as an element. The American sculptor, Alexander Calder, with his formal education in engineering, was the first to successfully integrate sculpture and motion (2, p. 386). At first, Calder used electric motors to move his mobiles. The viewer could activate the motion by a conveniently placed switch. Later, however, Calder's mobiles were so sensitively balanced that the gentlest of air currents would move them.

Paralleling Calder's mobiles were Moholy Nagy's luminal sculptures which projected light while in motion. The light emitted would have, and still has, various dimensional shapes, depending on the physical dimensions of the room in which it was displayed. Other kinetic sculptors gained prominence. One outstanding kinetic sculptor operating within a Dadaist philosophy was Jean Tinguely. Tinguely's work, such as <u>Homage to New York</u>, was designed to make music, create drawings, issue reports, give birth to machine off-spring, set itself on fire, and finally to destroy itself.

Tinguely's work was, and still is, interpreted to have made many ambiguous statements about our society. One critic (2, p. 291) calls the event a poem about the absurdity of machines and, by implication, of a civilization which permits itself to be governed by them. Another critic, James Johnson Sweeney, claims the sculpture was a prediction of the probability of man's self-destruction by atomic and hydrogen power.

While one might logically conclude that sculpture which destroyed itself might be the ultimate in social statement, the term ultimate would not be accurate. Since 1960, many unprecedented developments have occurred to alter the face of the conventional, three-dimensional medium almost beyond recognition. Many new sculptural directions, such as Minimalism, Environments, Conceptualism, Happenings, Body-works, Post-studio sculpture, Earthworks, System sculpture, Documentary sculpture, and some which defy classification, have evolved. These directions imply an obvious surge in sculpture (7, p. 263).

Current Status of Casting

As stated in the first chapter, a multiplicity of purposes and reasons has caused American sculptors to explore and experiment with various new materials. The sculptor, David Weinrib, is an artist who feels that technology is, at best, only the handmaiden to inspiration.

"The ideas you have," he explains, "force you to try new materials, not the other way around" (16, p. 45). This mental and material exploration has been so expansive that classification is exceedingly difficult. Not only is some of the work confusing as to whether it is painting, sculpture or graphics, but it is difficult to classify as sculpture, ritual, statistics, drama or dance. For example, William Thomas Wiley uses costumed people in his "Happenings," and consequently the art work bears a strong resemblance to drama. This expansion has caused a loss of potential in the traditional fields of modeling, carving, and casting.

At the time of this writing, no significant metal casting sculptor has emerged from the new surge in sculpture. Actually, casting in the traditional sense may be dead. This is not to state a probability but a possibility that casting bronze sculpture in the traditional sense is no longer useful as a creative medium.

Recent casting has frequently utilized the new plastics. One California sculptor, Bruce Beasley, after two years of research and experiment, has found a means of casting complex cubic volumes in acrylic (14, p. 269). Previously the material could only be cast in sheet form. DuPont's chemical engineers said casting complex forms in solid acrylic could not be done (16, p. 45).

Research in casting metal has been most inclusive in industry, especially for the manufacturing of automobiles, guns, and other machinery requiring close tolerances. Some of the investment-type castings are now so accurate that they are measured by an instrument sensitive to single thousandths of an inch. A cast that is off a few thousands of an inch may be thrown back in the crucible. Of course, metal shrinkage, called lagging up, is allowed for when such accuracy is required.

At the beginning of the twentieth century, a few methods of forcing molten metal into a mold were invented. One of the most successful of these methods was the centrifugal cast. Neuman, an authority in jewelry, states,

> This method had its first application in dentistry for the construction of false teeth, bridges and crowns. Several decades later it was first used in making jewelry; it is now a basic process for the mass production of costume jewelry. Other industrial applications have caused centrifugal casting to be developed as a highly controlled, almost automated technique. Precise and accurate forms in many non-ferrous metals and alloys are manufactured in this way for the electronic, aeronautical, automotive, and surgical tool industries (10, p. 80).

In addition to the centrifugal cast there is the vacuum cast. As the name implies, the cavity of a mold is decomposed, causing a vacuum to develop. A release mechanism allows the adjoining melt to be forced into the mold by the suction of the vacuum. While both the vacuum cast and the centrifugal cast are of higher quality than the gravity cast, both also have the disadvantages of additional expense and of extensive procedures which must be meticulously executed and which are too complicated for the beginning sculpture student and too automated for the spontaneous approach used by most contemporary artists (4, p. 58).

The latest innovation in the field of casting is the Full Mold Process®, which uses the expanded plastics such as styrofoam, polystyrene, and polyurethane for masters. The master is embedded in the investment, the melt is poured on the expanded plastic, the plastic melts, then evaporates. By gravity, the melt fills the void simultaneously as the plastic turns to a gas and escapes through the vented investment. See Figure 1, adapted from Fitzpatrick's thesis (3, p. 23), for the correct technique of green-sand casting of the Full Mold Process®.

The disadvantages of the Full Mold Process® are somewhat complicated. The process is patented; therefore, to produce sculptures that are to be sold, one must acquire the right to legally use the technique. A second disadvantage is that the master pattern is lost when it is burned out in the casting process. This means a new master must be made for each individual cast. A further possible disadvantage is that the particular textural surface of the styrofoam is duplicated on the sculpture's surface, limiting the textural possibilities.

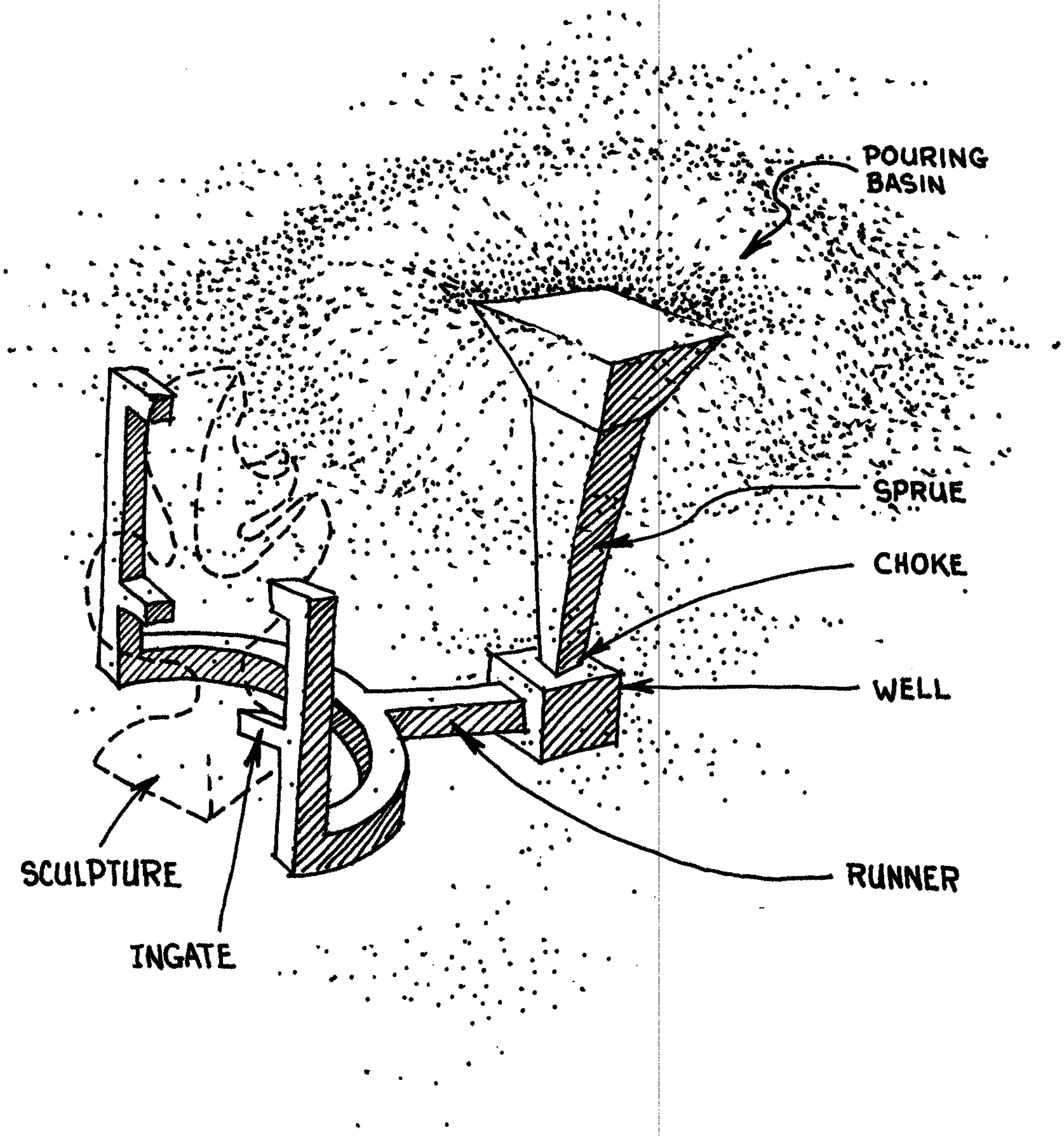


Fig. 1--The sprue system utilized in green-sand casting of the Full Mold Process®. All of the line drawings are a part of the spruing system which is constructed of styrofoam. The dash drawing outlines the sculpture to be cast, while the dots indicate the sand in which the system is buried.

A survey of recent metal casting indicates that industry has made the great contributions while sculptors have busied themselves with various new ideas and new materials. In the section on sculpture cast in metal, Mayer states, "The use of more modern innovations such as aluminum, stainless steel, and Monel metal, are so recent compared with traditional use of bronze, that no standards have been established, and sculpture in such materials may still be classed as experimental" (9, p. 615).

Aluminum as a Medium for Sculpture

Aluminum, frequently referred to as the wonder metal of this era (1, p. 322), is the metal chosen for this project. Rich says, "Less than 100 years ago, aluminum cost five hundred and forty-five dollars a pound and was considered more precious than gold" (12, p. 132). The reason for the expense was the long, complicated process of refinement. In 1885, Charles Martin Hall discovered an inexpensive process of refining aluminum from bauxite ore by electricity. In a brief description, Fierer states, "It takes 4 to 6 pounds of bauxite ore, 10 to 12 kilowatt hours of electrical energy, and 12 ounces of carbon to produce one pound of aluminum that sells for a small fraction of a dollar" (1, p. 323). Since bauxite ore is found in almost every country in great abundance, aluminum is the most plentiful of all metals (1, pp. 322-323).

In addition to being inexpensive, aluminum has several other outstanding characteristics. Rich summarizes these characteristics

> Aluminum is a silvery white metal extremely light in weight. The metal can be cast and welded, is fairly malleable, and has a high tensile strength. It is excellent as a positive medium and may be cast in either a pure or alloyed form. The metal does not corrode to any great degree, since a protective oxide forms on the aluminum surface, forming a remarkable resistance to the action of air even in the presence of heavy moisture. Aluminum may be regarded as permanent when used indoors, and when it is given a protective surface treatment, it is fairly permanent outdoors also. The ornamental aluminum spire on the Washington Monument has withstood for many years the effects of atmospheric corrosion, owing to the formation of a thin, superficial coating or film of aluminum oxide (Al_2O_3), which serves to protect the rest of the metal from further corrosion by the atmosphere (12, p. 131).

For a comparison of the characteristics of aluminum and other common metals, the following table was adapted from Feirer's General Metals (1, p. 63), Rich's The Materials and Methods of Sculpture (12, pp. 129-130) and Untracht's Metal Techniques for Craftsmen (15, p. 464).

From Table I, one can readily determine that aluminum is basically average in relative characteristics of common metals. However, most sculptors are more concerned with the characteristics of resistance to corrosion and malleability, where aluminum is rated third, than with hardness and tensile strength, where aluminum is rated sixth and fourth, respectively.

TABLE I

RELATIVE CHARACTERISTICS OF COMMON METALS ARRANGED IN DESCENDING ORDER FOR EACH PROPERTY

Hardness	Resistance to Corrosion	Malleability	Tensile Strength
Steel	Copper	Lead	Iron
Iron	Lead	Copper	Copper
Nickel	Aluminum	Aluminum	Zinc
Copper	Tin	Tin	Aluminum
Zinc	Zinc	Zinc	Tin
Aluminum	Iron	Iron	Lead
Tin	Steel	Nickel	
Lead			

Other Studies and the Status of Research in the Field of Art

A review of dissertation abstracts since the year 1940 did not produce one single sculptural-casting study. This may be due to the fact that the Master of Fine Arts is the terminal degree in the studio areas of art. The Master of Fine Arts is a performance degree requiring the student to perform to a high level of competency in his studio field. This performance-type foundation of the Master of Fine Arts thesis and the requirement of higher education's terminal degree have neglected developmental and problem-solving type theses in the field of art.

One developmental thesis was done on the Full Mold Process® of casting by B. S. Fitzpatrick (3). This thesis would be very helpful to all sculpture students who want to know more about the newly invented Full Mold Process®. The thesis, "Techniques of Casting Sculpture Using the Full Mold Process," was approved, but a later meeting of the university's fine arts council ruled that no similar research theses would be done and that all theses in the future would be performance theses.

At this time there is no evidence that anyone has attempted to develop various porous textures in cast metal sculptures. If someone had developed porosity as an element of texture to be used in casting, the development was not readily available, particularly in sculpting manuals.

CHAPTER BIBLIOGRAPHY

1. Feirer, John L., General Metals, New York, McGraw-Hill Book Company, Inc., 1959.

2. Feldman, Edmund Burke, Art As Image and Idea, New Jersey, Prentice-Hall, Inc., 1967.

3. Fitzpatrick, Barney Stewart, "Techniques of Casting Sculptures Using the Full Mold Process," unpublished master's thesis, Stephen F. Austin State University, Nacogdoches, Texas, 1971.

4. Fuller, Mary, "San Francisco Sculptors," Art in America, 52 (June, 1964), 52-59.

5. Hale, William Harlan, The World of Rodin, New York, Time Life Books, 1969.

6. Hoffman, Malvina, Sculpture Inside and Out, New York, Bonanza Books, 1939.

7. Hunter, Sam, American Art of the 20th Century, New York, Harry N. Abrams, Inc., 1971.

8. Maillard, Robert, editor, Dictionary of Modern Sculpture, New York, Tudor Publishing Company, 1960.

9. Mayer, Ralph, The Artist's Handbook of Materials and Techniques, New York, The Viking Press, 1970.

10. Neumann, Robert Von, The Design & Creation of Jewelry, Philadelphia, Chilton Book Company, 1961.

11. Ocvirk, Otto G. and Robert O. Bone, Art Fundamentals, Dubuque, Iowa, Wm. C. Brown Company, 1968.

12. Rich, Jack C., The Materials and Methods of Sculpture, New York, Oxford University Press, 1967.

13. Seitz, William C., The Art of Assemblage, New York, Doubleday and Company, Inc., 1961.

14. Smith, Edward Lucie, Late Modern The Visual Arts Since 1945, New York, Frederick A. Praeger, 1969.

15. Untracht, Oppi, Metal Techniques For Craftsmen, New York, Doubleday & Company, Inc., 1968.

16. Weinrib, David, "Sculpture," Time, 91 (February 9, 1968), 40-45.

PATENTS

The Full Mold Process® was granted U.S. patent number 2,830,343 to Harold F. Shroyer in 1958, and eventually licensed to the Full Mold Process Company, Lathrop Village, Michigan.

CHAPTER III

THE FEASIBILITY OF CASTING POROUS TEXTURES

The Porosity Concept

Traditionally a porous texture on a cast sculpture has been considered a flaw or defect in the sculpture; it was not a quality strived for, and if the flaw was great enough, if the porosity was marked enough, the work was melted and recast. The idea of incorporating porous textures into the design of the cast came while trying to eliminate the porosity that mistakenly occurred in a sculpture designed to have a conventionally smooth surface. Since sawing the two-inch thick metal relief into long strips that could be replaced in the furnace would have proven quite laborious, an attempt was made to fill the porosity. When filling proved unsuccessful, an attempt was made to incorporate the textures into the sculptural design. It was during these times that porosity presented itself as a potentially significant design element. The concept developed that one might control porosity to create more desirable textures than those textures indiginous to the metal. Porosity could become a virtue, not always a defect.

The initial step of this study was to investigate the known conditions that would cause defects in metal casting relating to porosity. The investigation included examination of sculpting and casting manuals and visits to foundries to acquire knowledge on casting porosity and safety factors. The second step was to organize this material into some system for evaluation. The result of the second step was a comprehensive table that lists all the conditions which cause porosity in all types of casting and indicates those authors who emphasized the conditions. From this broad table, a second table, Table II, was made. Table II indicates those factors which are relevant to open-mold casting. A general concept was formed of the condition that might best produce porosity by noting the number of references by the various authorities.

For all types of sculptural casting, there were sixteen explained causes of porosity in the ten casting manuals examined. Seven causes were dismissed because they could exist only in a closed mold, in the sprue, or in a vented system. Of the sixteen causes of porosity, only nine causes are applicable to casting with an open mold. The remaining nine causes of porosity are cross-referenced and listed in Table II for evaluation. (Note that the page number is indicated in the appropriate space in line with the author.) Table II also gives some idea of the comprehensiveness of the ten different authors. Untracht's

TABLE II

A LISTING OF KNOWN CAUSES OF CASTING POROSITY WHEN USING AN OPEN-MOLD

	MELT			MOLD				POUR	
Authors	1. Improper furnace flame	2. Excessive heat of melt	3. Gas within the metal	4. Permeability of investment	5. Trapped gas in the mold	6. Gas made by liquid binders	7. Pattern irregularities	8. Height of pour	9. Pour irregularities
Untracht		323 326 329	323 323	327	323	326		329	329
Feirer		248		240 243					
Coleman	96			67 92					
Rich			139	139	139	140			
Hoffman						291			
Mayers						616			
Fitzpatrick	35	36		28		25			37
Neuman	85	93 95			95	91 93 95	95		
Eliscu						139			
Struppeck	231		231	231		231			
Total references	4	7	4	8	3	10	1	1	2

Metal Techniques for Craftsmen (10) proves to be most comprehensive, especially from the standpoint of listing safety factors.

In Table II, the causes of porosity are grouped in a sequential order or as they normally take place. The very top of Table II lists the three basic divisions of casting--the melt, the mold, and pouring. The divisions of the mold and the pour overlap at one point because they are dependent upon each other.

The design of the casting experiments was derived from the study made of the casting manuals, including Table II and first-hand practice, research, and observation of professional foundry operations. In addition, some information, which usually substantiated previous knowledge, was obtained from foundry personnel and sculptors.

Listed under the three basic divisions are the nine causes of porosity that are related to open-mold casting. Like the basic divisions of casting, the nine causes of porosity are numbered in the sequence of the casting procedures causing porosity. For instance, number 1 is concerned with the flame (which must be adjusted properly in order to melt the metal), then number 2 is concerned with the amount of heat, and so on.

Control of Some Causes of Porosity

Some of the nine causes of porosity presented insurmountable problems in finances and equipment. Several of these causes of porosity were controlled in or deleted from the design of the experiment.

Improper furnace flame (number 1 on Table II) was not utilized for two reasons. The first and most important reason was the fact that the furnace used could not be controlled sufficiently to create an oxidizing or reducing flame. Factually, the flame was troublesome to keep burning without consideration of the type of flame. (This was unfortunate because Neuman (7, p. 87), without giving a reason, states that the reducing flame is safer.) The second reason was a lack of agreement among authorities as to which type of flame (oxidizing or reducing) causes porosity.

Ordinarily the permeability of the investment (number 4 on Table II) is determined by the coarseness of the sand selected and by the type of binder employed. However, in an open mold the permeability of the sand has a smaller role in venting the gas than in the closed mold. The reason is that gases escape upwards since the gas is lighter than the molten aluminum. The permeability of the investment, being on the underside, will have no difficulty in absorbing the gases that might be forced downward.

Due to the near flatness of the open mold (compared with other types of molds) the occurrence of trapped gas is remote. A sculptor could design such patterns to trap gases, but that design would necessitate an attempt at trapping gas in the open mold and, consequently, limiting aesthetic design. Even if a sculptor were successful in designing gas traps, the gas probably would escape through the metal unless the metal was almost in a frozen state when being poured. Due to the particulars that had to be allowed for, trapped gas was not used in the design of the experiments.

The height of the pour techniques (Table II, number 8) was not used because high pours deteriorate the mold and cause a loss of detail and shapes. The turbulence caused by high pours induces porosity but the designs do not duplicate the master because the force of the melt destroys the mold. Accuracy in the duplication of the master was an objective in this problem.

The last of the controlled causes of porosity was pouring irregularities (number 9 on Table II). Pouring too fast adds porosity but it occasionally adds slag or dross which will destroy details. Pouring too slow causes "cold shuts" or solid areas that prevent the rest of the flow. Regarding safety, irregular pouring is considered dangerous in a fast pour because of the lack of control over the crucible and the tendency for the melt to splatter. Consequently, a standard height was used in all pours, and, once the pour started, it was continued until the mold was full.

Foundry Controls

Although ambient temperatures ranged between 80°F and 103°F, most castings were poured in 97°F ambient temperature. Exact temperatures are on the foundry records in Chapter IV. With furnace heat added to the ambient heat, an average mold would dry in approximately thirty minutes. In the experiments utilizing water as a binder, the investment would dry and collapse with movement. To control this drying, the investment was mixed in metal containers to prevent absorption. To facilitate speed and thoroughness in blending the various components of the investment, an electric drill with a metal paint mixer was used. The mixing was done in the shade, with a wooden panel shielding the investment from the furnace heat. Finally, the investment was mixed just prior to pouring to minimize the time for evaporation.

In sand casting, most authorities suggested mixing the sand and binder until, when squeezed by hand, the investment retains a form when released. Normally, only enough liquid binder should be used to obtain a stable shape. Too much binder is indicated by the granules sticking to the palm and fingers. A second check should be made by breaking the shape into two parts. The break should be straight and should occur without the two pieces crumbling.

The type of aluminum used was invariably that which could be obtained as scrap or trash. Although many aluminum beverage cans were used, they were very light and made a small contribution to the total weight. Lightweight pieces of aluminum lawn furniture as well as storm-proof type doors and windows were also used. Aluminum roofing and siding were also used as well as any aluminum household object that could be obtained. Many such aluminum items can be found at city dumps at no cost. However, the larger cities' garbage personnel usually gathered the clean aluminum to sell to foundries. Clean aluminum, as defined by foundrymen, is that which is free of other types of metal parts, for instance, steel screws, bolts, and brackets. When scrap aluminum could not be found, it was bought from scrap-metal dealers.

Casting Designs to Produce Porosity

The casting design was derived from the remaining four causes of porosity on Table II (numbers 2, 3, 6, and 7). Number 2, "excessive heat of the melt," was the primary factor in the design of the casts. Two series, designated Roman numerals I and II, were planned for the purpose of casting several reliefs at different temperatures. Series I melt temperature started at 1210°F and, in 50°F intervals, advanced to 1550°F. The second series, Series II, was heated to 1725°F and poured in 100°F intervals down to include 1325°F. Both Series I and II used the same investment, pour technique, flame and height of pour to control possibilities of other causes of porosity.

Because melt contains gas, most foundries add a flux or degasser prior to the pour to eliminate the gas. This gas contributes to the possibility of a more uniform porosity; therefore, no flux or degasser tablet was used. Another reason that degassers were not used is that they were expensive and the type specified for aluminum was not readily available.

Number 6 on Table II, "gas made by liquids" was used in Series III. Four different investments were planned to determine which causes porosity and to what degree. The first cast, designated 1500, used one-half syrup and one-half water as a binder. The syrup had proven an excellent and inexpensive binder in the previous series, but it did not produce porosity. The water was added to create porosity.

The second and third casts, 1501 and 1502 respectively, made use of water and sodium silicate as a binder. Normally, the sodium silicate would be charged with carbon dioxide to cause solidification of the investment. Previous casting with sodium silicate and without the carbon dioxide charge had produced elaborate porosity. The binder in 1501 utilized a binder proportion of one-third water to two-thirds sodium silicate. The 1502 binder reversed these proportions to two-thirds water, one-third sodium silicate.

The fourth cast of Series III, designated 1503, utilized only water as a binder. The first attempt to pour in the mold cavity was held back because the water evaporated from the silica sand and the sand collapsed in some parts of the matrix. The remaining investment was removed and an investment of the same proportions was mixed immediately prior to the pour to prevent evaporation. As discussed in controls, other precautions were taken to prevent evaporation.

Series III was designed to hold the melt temperature at 1500°F. The pyrometer measures temperature in twenty-five degree increments; consequently, the single degree differences identifying the pieces of sculpture in Series III could not be recognized and were recorded solely for purposes of identification. As in the other two series, those other casting variables such as height of pour, furnace flame, and pour irregularities were held constant in Series III.

All masters had basically five concavities and five convex shapes vertically. Horizontally, there were basically seven concave and convex shapes. Using similarly shaped masters contributed to the uniformity of the flow of the melt across the face of the mold matrix. Therefore, on Table II, number 7, "pattern irregularities" made a consistent contribution to the turbulence of each pour.

CHAPTER BIBLIOGRAPHY

1. Coleman, Ronald L., Sculpture, Dubuque, Iowa, William C. Broan Company, 1968.

2. Eliscu, Frank, Direct Wax Sculpture, Philadelphia, Chilton Book Company, 1969.

3. Feirer, John L., General Metals, New York, McGraw-Hill Book Company, Inc., 1959.

4. Fitzpatrick, Barney Stewart, "Techniques of Casting Sculptures Using the Full Mold Process," unpublished master's thesis, Stephen F. Austin State University, Nacogdoches, Texas, 1971.

5. Hoffman, Malvina, Sculpture Inside and Out, New York, Bonanza Books, 1939.

6. Mayer, Ralph, The Artist's Handbook of Materials and Techniques, New York, The Viking Press, 1970.

7. Neumann, Robert Von, The Design & Creation of Jewelry, Philadelphia, Chilton Book Company, 1961.

8. Rich, Jack C., The Materials and Methods of Sculpture, New York, Oxford University Press, 1967.

9. Struppeck, Jules, The Creation of Sculpture, New York, Henry Holt and Company, 1952.

10. Untracht, Oppi, Metal Techniques For Craftsmen, New York, Doubleday & Company, Inc., 1968.

CHAPTER IV

ANALYZATION OF THE SCULPTURAL TEXTURES

Description of the Casting Results

In an attempt to depict the results of the foundry experiments without the reader seeing the actual sculptures, three methods of depiction were used. The first method is a verbal description of the data. The second method of description is a photographic documentation of the sculptures with the textures produced, and the third method utilizes tables--Table III, Table IV and Table V. Through a study of the three methods of depicting the data, the reader can best comprehend the data and the factors causing the data. The identification numbers of the individual pieces of sculpture are the temperatures of the melt at the time of the pour.

Photographs of Relief Sculpture

To insure consistency, the photographs of the relief sculptures were taken and printed by the same professional photographer. The aluminum required special attention due to several factors such as controlling reflections and extreme range of values. An attempt was made to use commercial processing, but the automated photographs were limited in tonal range. Consequently, the detail suffered to such an extent it was, in some cases, non-existent.

Black and white photographs were chosen over color for several reasons. The first and most important reason is the accurate depiction of aluminum. Aluminum, like silver, has no color of its own--only white which is an equal combination of all colors. However, polished aluminum does reflect colors, and since these reflected colors would change with each location, black and white photography was used to eliminate the color variables. The second reason black and white film (Panatomic-X) is utilized is that it has less grain than color film and will reduce the possibility of confusing photographic grain with sculptural textures. A third reason is that black and white photography has the needed latitude to depict the reflective nature of aluminum.

Every available method was used to depict the three dimensional quality of a relief sculpture. A black-velvet background was incorporated to remove distracting objects and textures. All sculptures were placed in the same position so as to reflect the same images as much as possible. The background on the negatives was retouched for clarity. The black negative space aids in the visual projection of the sculpture. For printing, Kodak's RC paper was chosen as being the most suitable for the visual duplication.

Darkroom printing tests were made, and the enlarger exposure exhibiting the most visual dimension was used.

A photograph was made of each sculpture, and a supplementary close-up photograph was made of the texture. The first photograph depicts the entire format of the sculpture. The second photograph is a detail taken from a two-by-three inch area and enlarged to three-by-four and one-half inches. This slight enlargement was made to allow for the loss of detail in the photopictorial process.

Porosity, actually small solidified bubbles, can be differentiated from other textural effects by the fact that these openings are spherical and usually evenly shaped. The textures in the photographs also include those textures that were made by the sculpting tools, textures that were indigenous to the master material, and the coarseness of the sand used in the investment. The textures caused by the sculpting tools are characterized by a linear quality and a machine-labored appearance. The master materials, basically styrofoam, are characterized by an irregular organic texture. The sand used in the investment was the finest readily obtainable and had no more than a slight granular appearance as a texture. A small amount of buffing usually removed the texture created by the sand.

The Visual Results of Series I

The data contained in this section relate to the initial question of inquiry. The question was, "What visual results occur when unorthodox pouring temperatures and sand binders are employed?"

The first cast of Series I, number 1210, was poured at the traditionally recommended temperature of 1210°F soon after the metal had melted. The cast has the least amount of porosity of Series I. (See Figure 2.)

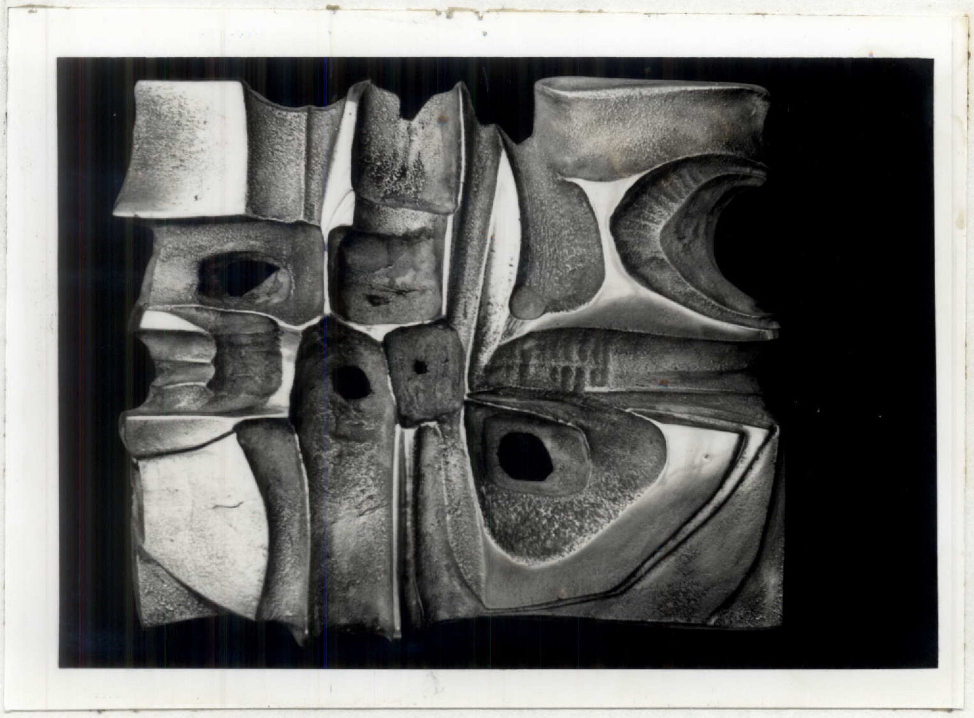


Fig. 2--Series I Sculpture cast at 1210°F

The surface of 1210 is characterized by the irregular texture of the styrofoam master pattern, linear tool marks, and some small crevices that were not in the master pattern. These small crevices are actually forerunners of cold-shuts which are called rat-tails. Rat-tail is a foundry term that refers to areas of the cast that solidify and do not fuse properly with the following melt. The visual data is further explained by an enlargement of sculpture number 1210. (See Figure 3.) The photographic quality of Figure 3 vividly depicts the texture of the duplication of the

Fig. 3--Detail of Sculpture 1210

styrofoam master pattern which is irregular in appearance. The texture resulting from the styrofoam master pattern's texture should not be confused with porosity which is spherical and evenly shaped. The linear incisions resulting from metal rasps are also depicted in Figure 3.

The second cast of Series I, number 1250, was poured when the temperature of the melt reached 1250°F. As compared with other casts of Series I, sculpture number 1250 has a small amount of porosity. (See Figure 4.) The surface of sculpture number 1250 is characterized by sparse

Fig. 4--Series I Sculpture cast at 1250°F

pinhole porosity. The irregular texture of the styrofoam master pattern is also exhibited in some areas of the surface. The texture resulting from the styrofoam master pattern's texture should not be confused with porosity, which is spherical and evenly shaped. The visual data is further explained by an enlargement of sculpture number 1250. (See Figure 5.) As compared with other casts of Series I, number 1250 has excellent detail. It should be noted that this observation of excellent detail was made from the sculpture, not from the photograph of the sculpture.

Fig. 5--Detail of Sculpture 1250

The third cast of Series I, number 1350, was poured when the temperature of the melt reached 1350°F. Number 1350 has a medium amount of porosity, as compared to other casts of Series I. (See Figure 6.) The surface of sculpture number 1210 is characterized by a medium amount of porosity. The irregular texture of the styrofoam master pattern is also exhibited in the dark areas of the surface. The visual data is further explained by an enlargement of sculpture number 1350. (See Figure 7.) The hazy quality of the photograph probably results from a slight vibration of the camera during the long exposure used to make the photograph. The long exposure was necessitated by the

Fig. 6--Series I Sculpture cast at 1350°F

Fig. 7--Detail of Sculpture 1350

poor light resulting from an overcast day. Although the hazy photography might possibly cause the porosity of the sculpture to be confused with the texture resulting from the sytrofoam pattern, the light area of Figure 7 depicts the porosity produced.

The fourth cast of Series I, number 1450, was poured when the temperature of the melt reached 1450°F. Sculpture number 1450 has densely located porosity. (See Figure 8.)

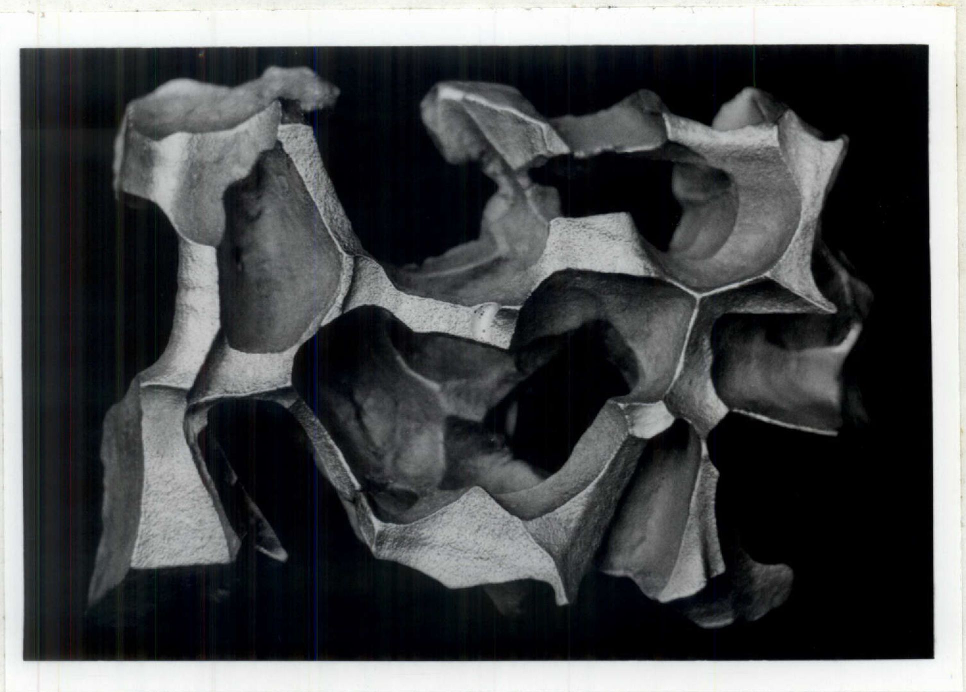


Fig. 8--Series I Sculpture cast at 1450°F

The surface of sculpture number 1450 is characterized by the irregular texture of the styrofoam master pattern and the texture of the sand utilized in the investment. The visual data is further explained by an enlargement of sculpture number 1450. (See Figure 9.) The center of 1450 was ground down to facilitate a visual comprehension of the quality of porosity in 1450.

Fig. 9--Detail of Sculpture 1450

The fifth and last cast of Series I, number 1550, was poured when the temperature of the melt reached 1550°F. As compared with the other casts in Series I, sculpture number 1550 has the most porosity. (See Figure 10.) The porosity is dense, but not to the degree that it hinders the accurate reproduction of the master. The surface of sculpture number 1550 is characterized by the irregular texture of the styrofoam master pattern and the texture of the sand utilized in the investment. The visual data is further

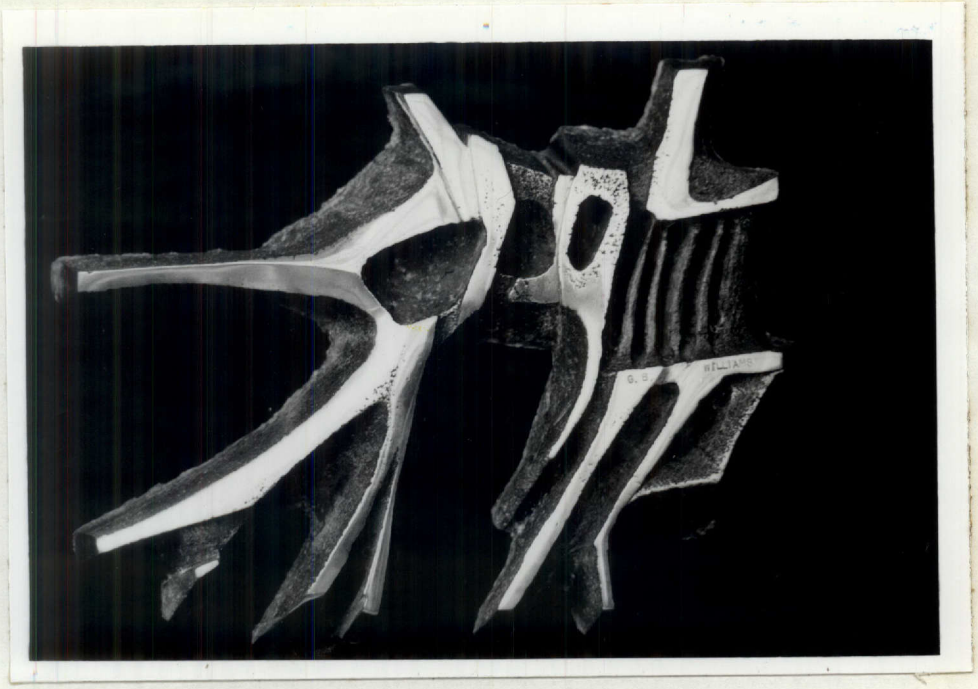


Fig. 10--Series I Sculpture cast at 1550°F

explained by an enlargement of sculpture number 1550. (See Figure 11.) Normally, overheating the melt will result in an oxidation of the metal, which causes a dull surface quality. Number 1550 does not have an oxidized surface and readily reflects an image. Table III contains relevant data concerning the foundry records.

Additional studio analysis of Series I is included on Table III, page 61. The studio analysis of the sculptures on Table III is comparative. In Table III, each sculpture was compared to the other sculptures cast in the same series. This technique of grouping was designed to determine the effects of additional heat of the melt at

Fig. 11--Detail of Sculpture 1550

the time of pouring. A final analysis of all the series is reported in the findings of Chapter V.

The first of comparative evaluations is porosity. Porosity is listed under the Studio Analysis in Table III. As can be noted in Table III, the porosity is shown to have increased as higher melt temperatures were used. Furthermore, it can be noted that the least amount of porosity resulted in a higher degree of reflectivity.

Other sculptural properties--the ability to render detail, the ease of grinding, the ease of polishing, and the polished surface's ability to reflect an image--are included under the division of Studio Analysis in Table III.

TABLE III

FOUNDRY RECORD AND STUDIO ANALYSIS OF SERIES I

Foundry Record					
Melt Temperature*	1210°F	1250°F	1350°F	1450°F	1550°F
Binder	syrup	syrup	syrup	syrup	syrup
Ambient Temperature	80°F	94°F	96°F	96°F	94°F
Ambient Humidity	38%	33%	35%	38%	32%
E. C. or F. M. P.**	EC	FMP	EC	EC	FMP
Type of Pour	reg.	irreg.	reg.	reg.	irreg.
Reaction	none	none	none	none	none
Studio Analysis					
Porosity***	least	little	avg.	more	most
Detail	good	best	v/good	good	good
Grinding Quality	poor	poor	poor	poor	poor
Polishing Ease	good	exc.	v/good	good	good
Reflective Quality	good	exc.	v/good	good	good
Unique Qualities****	A	none	B-H	none	C

*The temperature was recorded on the back of each sculpture to serve as identification.

**Empty cavity or Full Mold Process®.

***Some variation in porosity may be due to an unknown variation in ramming pressures.

****See pages 84-85 for a description of the unique qualities.

The properties of each sculpture are compared with the same properties in the other sculptures and recorded in the column that identifies the sculpture by the melt temperature.

As can be noted in Table III, the ability to reproduce detail is best when the melt is poured at 1250°F. However, the detail produced by pouring at 1350°F was almost as accurate as the detail produced by pouring at 1250°F.

The grinding qualities of all Series I casts are rated poor due to the fact that aluminum fills the abrasive crevices of the shaping tools. Although this inadequate grinding quality inherent in aluminum can be rectified somewhat by using a grinding disk specially designed for aluminum, aluminum will clog files and the metal removing attachments that are commonly used in high-speed electric drills.

In Table III, the parts of Studio Analysis titled Polishing Ease and Reflective Quality are interrelated. In other words, if a sculpture is easy to polish, then it also has the property of a higher degree of reflectivity.

The Visual Results of Series II

The data contained in this section relate to the initial question of inquiry: "What visual results occur when unorthodox pouring temperatures and sand binders are employed?"

Series II was included to determine the effects of super-heating. Super-heating is simply more heat than is normally necessary. In Series II the melt was super-heated to 1725°F and poured on the down-temperature (a foundry term meaning to over heat the melt and subsequently allow the melt to cool to a predetermined temperature) at 100°F intervals down to and including 1325°F.

The first cast of Series II, number 1725, was poured when the melt reached the temperature of 1725°F. Number 1725 has an abundance of porosity. (See Figure 12.)

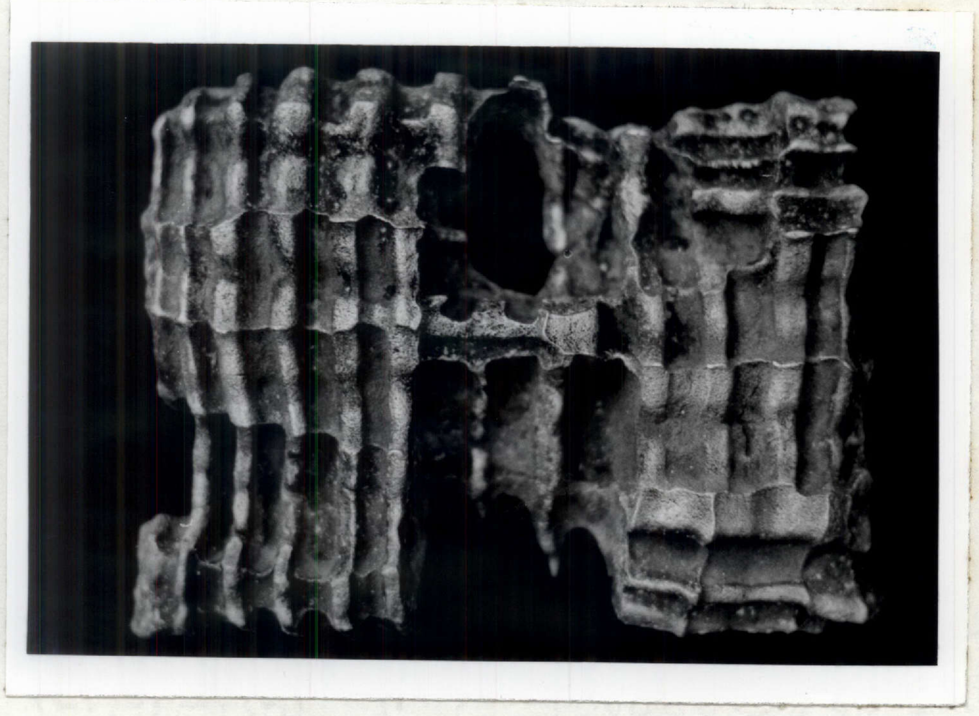


Fig. 12--Series II Sculpture cast at 1725°F

The surface of sculpture number 1725 has very dense porosity. The surface of sculpture number 1725 is also characterized by the irregular styrofoam texture of the master pattern and the investment sand burned into the metal. The visual data is further explained by an enlargement of sculpture number 1725. (See Figure 13.) The metal

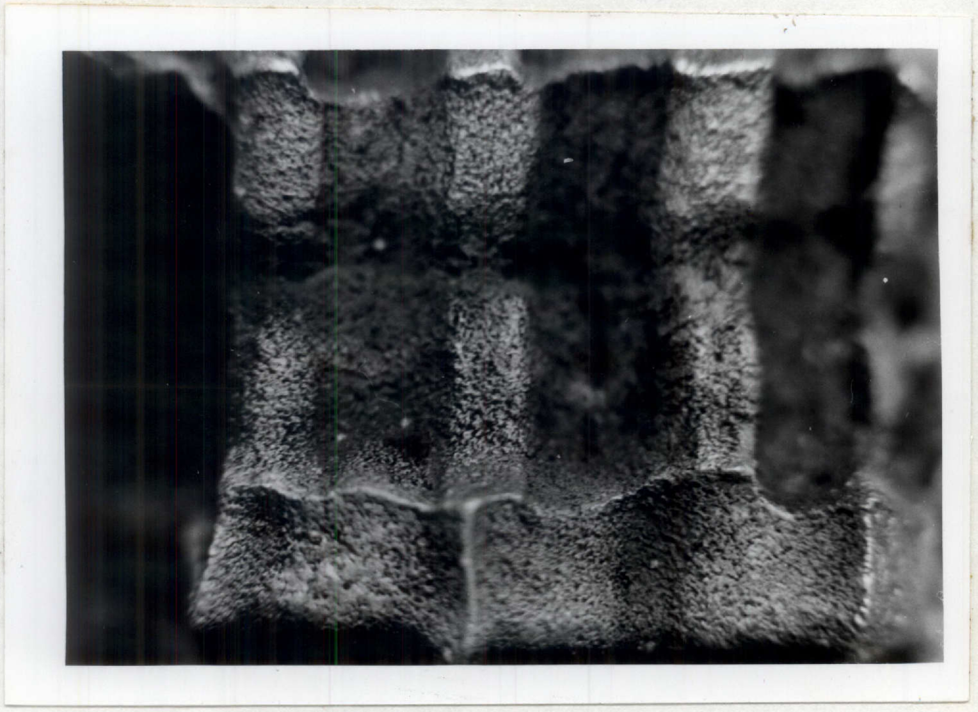


Fig. 13--Detail of Sculpture 1725

of sculpture number 1725 is oxidized to such a degree that when an attempt to polish the surface was made, the difficulties encountered were so extreme that traditional polishing was abandoned.

The second cast of Series II, number 1625, was poured after the melt had been super-heated to 1725°F and then allowed to cool to 1625°F. When compared to other casts in Series II, number 1625 has an average amount of porosity.

(See Figure 14.) The surface of sculpture number 1625 is characterized by the irregular texture of the styrofoam

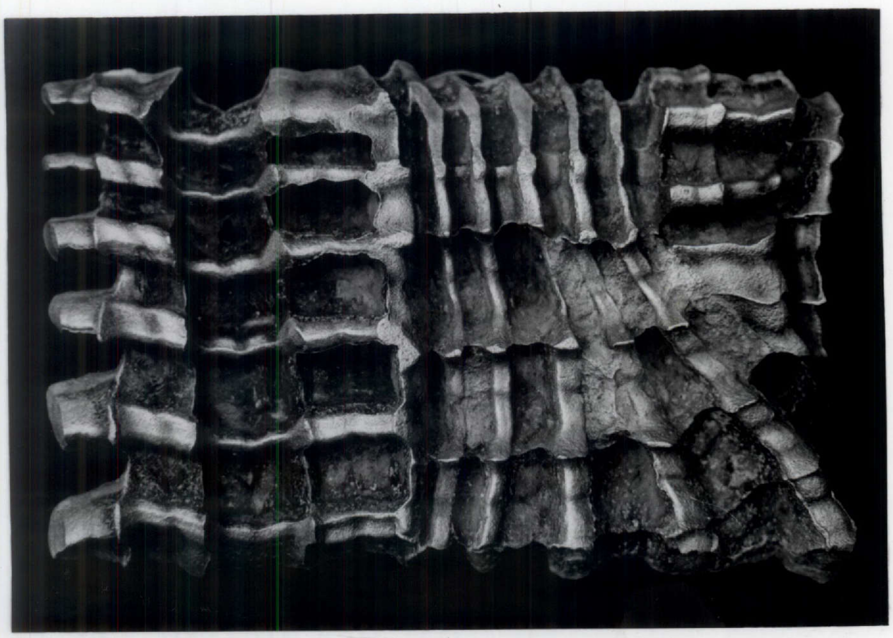


Fig. 14--Series II Sculpture cast at 1625°F

master pattern and the sand used in the investment. The visual data is further explained by an enlargement of sculpture number 1625. (See Figure 15.) The small linear ridges, called fins, are evident. The fins were caused by cracks in the mold and were broken off prior to the photography. Areas of the sculpture poorly reproduce the master pattern, which might be attributed to incorrect ramming (a foundry term meaning to pack the investment around the master with a special ramming tool) at those particular points.

Fig. 15--Detail of Sculpture 1625

The third cast of Series II, number 1525, was poured after the melt was super-heated to 1725°F and then allowed to cool to 1525°F. When compared to the other casts in Series II, number 1525 has the least amount of porosity. (See Figure 16.) The lack of porosity in sculpture number 1525 could be due to too little pressure used in the ramming procedure. This lighter ram pressure could have resulted in a more permeable investment. Such a permeable investment could have allowed the porosity forming gas to escape. The surface of sculpture number 1525 is characterized by the irregular texture of the styrofoam master pattern and the sand utilized in the investment. Casting fins are evident in 1525. These fins are caused by cracks in the mold material. A small area in the center of the

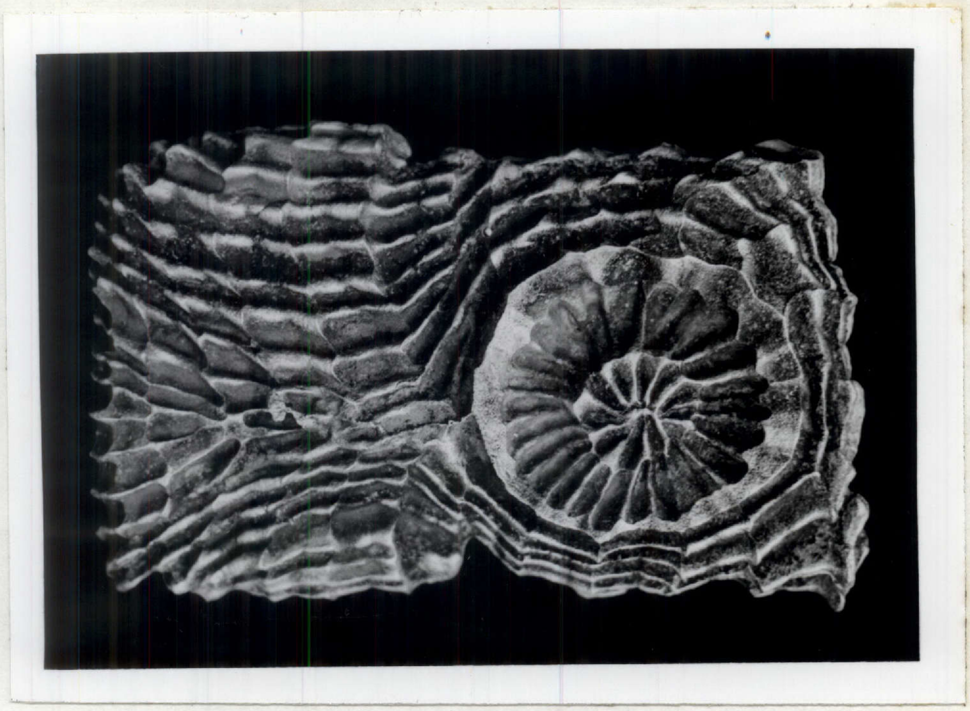


Fig. 16--Series II Sculpture cast at 1525°F

sculpture indicates poor reproduction of the master, attributable to incorrect ramming procedures. The visual data is further explained by an enlargement of sculpture number 1525. (See Figure 17.) The dark color of the negative spaces is actually carbon deposits left from the binder and the burned styrofoam.

The fourth cast of Series II, number 1425, was poured after the melt was super-heated to 1725°F and then allowed to cool to 1425°F. When compared to the other casts of Series II, number 1425 has a small amount of porosity.

Fig. 17--Detail of Sculpture 1525

(See Figure 18.) A few small fins are evident in the lower central area of sculpture. The fins were caused by cracks in the mold and were broken off prior to the photography. Also in the lower central area and on the lower right side of sculpture 1425 are inaccurate reproductions of the master pattern. The visual data is further explained by a detail enlargement of sculpture number 1425. (See Figure 19.) The metal of sculpture number 1425 is oxidized to such a degree that when an attempt to polish the surface was made, the difficulties encountered were so extreme that traditional polishing was abandoned. Number 1425 is characterized by the irregular texture of the styrofoam master

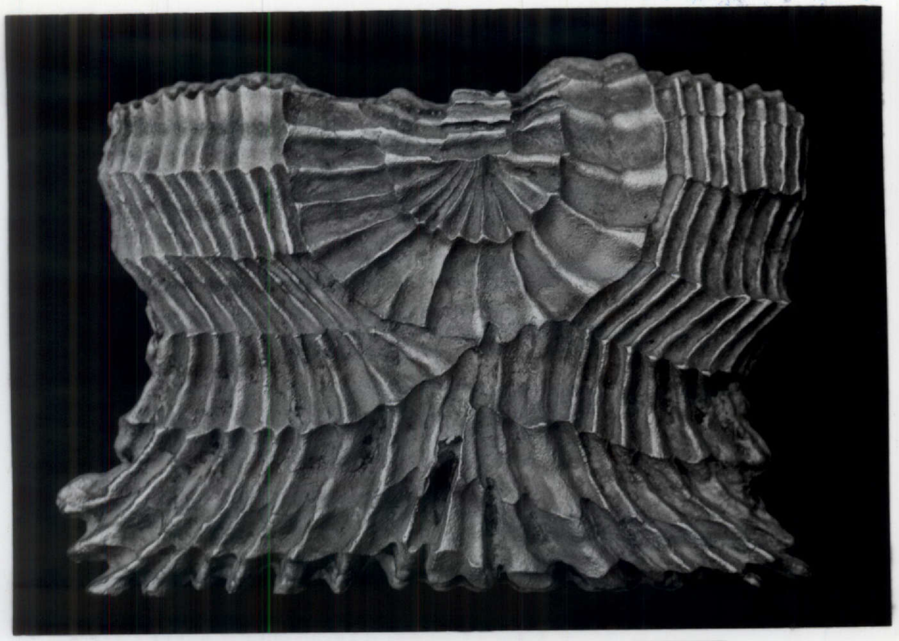


Fig. 18--Series II Sculpture cast at 1425°F

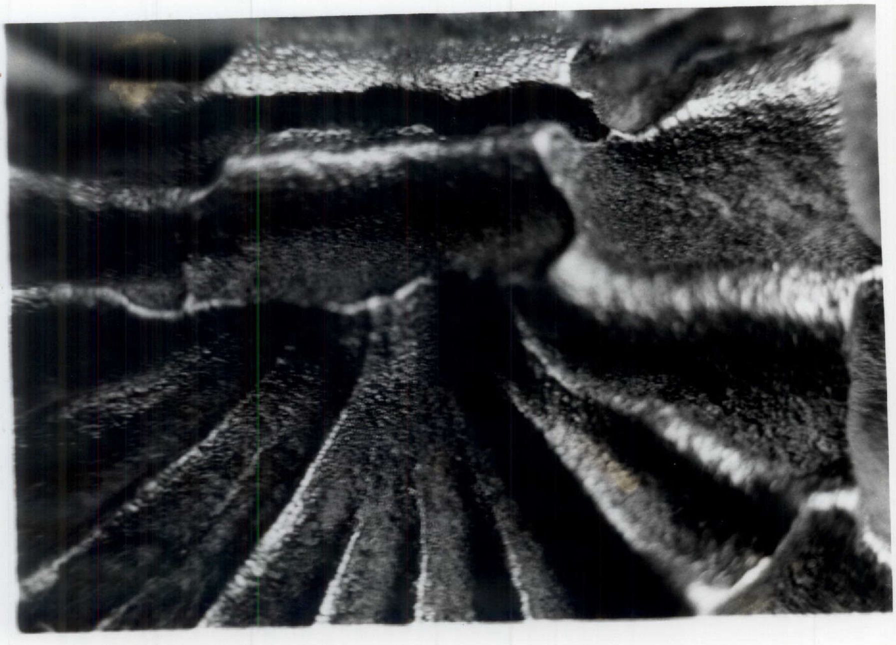


Fig. 19--Detail of Sculpture 1425

pattern, the texture of the sand used in the investment, and the carbon deposits from the binding material. The dark color of the negative space is due to the carbon deposits left by the binding material.

The fifth and last cast of Series II, number 1325, was poured after the melt was super-heated to 1725°F and then allowed to cool to 1325°F. When compared to other casts of Series II, sculpture number 1325 has the most porosity. (See Figure 20.) Sculpture number 1325 is

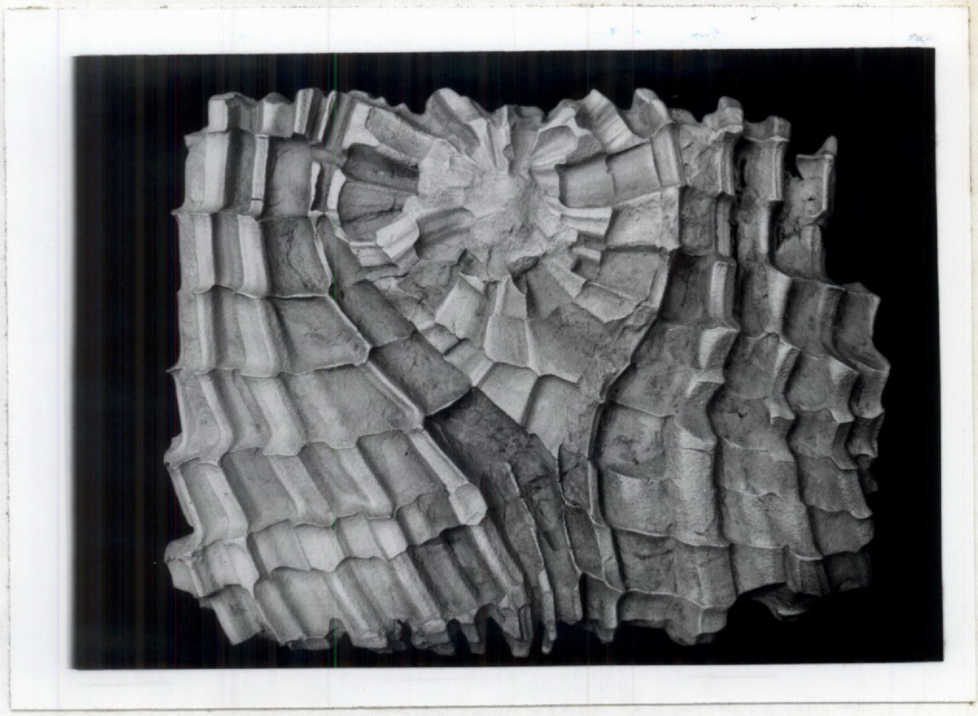


Fig. 20--Series II Sculpture cast at 1325°F

characterized by the texture of the styrofoam master pattern, inaccurate reproductions of the master pattern, small areas of blows, and some small crevices that were not in the master pattern. These small crevices are actually forerunners of cold-shuts called rat-tails. Rat-tail is a foundry term that refers to areas of the cast that solidify and do not fuse properly with the following melt. The visual data is further explained by an enlargement of sculpture number 1325. (See Figure 21.) As can be noted in

Fig. 21--Detail of Sculpture 1325

Figure 21, the surface of sculpture number 1325 is characterized by porosity, the styrofoam texture of the master pattern, carbon deposits, and rat-tails. The unusually high proportion of porosity of sculpture number 1325 might possibly be attributed to variations in ramming techniques. In order to photograph the ramming process for the technical teaching process, the person that normally rammed the molds photographed another sculptor ramming the mold. Since the other sculptor normally sculpts in bronze (bronze requires a higher ramming pressure than does aluminum), the probability exists that the mold was rammed with too much pressure. The maximum pressure used in ramming sand for aluminum casting should not exceed thirty-five pounds. Additional pressure limits the permeability of the investment causing the melt to retain the gases that result in porosity.

Additional studio analysis of Series II is included in Table IV on the following page. The studio analysis of the sculptures in Table IV is comparative. Each sculpture in Table IV is compared to the other sculptures cast in the same series. This technique of separating was designed to determine the effects of super-heating the melt and pouring on a down-temperature. A down-temperature is foundry terminology which refers to allowing an overheated melt to cool to a predetermined temperature before pouring. A final analysis of all the series is reported in the findings of Chapter V.

The first of the comparative evaluations is porosity. Porosity of Series II is listed under the Studio Analysis on Table IV. As can be noted on Table IV, the porosity is inconsistent with the melt temperatures. As discussed

TABLE IV

FOUNDRY RECORD AND STUDIO ANALYSIS
OF SERIES II

Foundry Record					
Melt Temperature*	1725°F	1625°F	1525°F	1425°F	1325°F
Binder	syrup	syrup	syrup	syrup	syrup
Ambient Temperature	96°F	96°F	96°F	96°F	96°F
Ambient Humidity	30%	30%	30%	30%	30%
E. C. or F. M. P.**	FMP	FMP	FMP	FMP	FMP
Type of Pour	reg.	irreg.	reg.	reg.	reg.
Reaction	none	none	none	none	none
Studio Analysis					
Porosity***	more	avg.	least	little	most
Detail	fair	fair	poor	poor	poor
Grinding Quality	v/poor	v/poor	poor	poor	poor
Polishing Ease	v/poor	v/poor	poor	poor	poor
Reflective Quality	poor	poor	poor	poor	poor
Unique Qualities****	C-H	C-H	C-H	C-H	C-H

*The temperature was recorded on the back of each sculpture to serve as identification.

**Empty cavity or Full Mold Process®.

***Some variation in porosity may be due to an unknown variation in ramming pressures.

****See pages 84-85 for a description of the unique qualities.

in the preceding pages concerned with the visual results of Series II, the variation of porosity in Series II might possibly be attributed to variations in ramming techniques.

Other sculptural properties--the ability to render detail, the ease of grinding, the ease of polishing, and the polished surface's ability to reflect an image--are included under the division of Studio Analysis on Table IV. The properties of each sculpture are recorded in the column that identifies the sculpture by the melt temperature.

As can be noted in Table IV, in Series II the ability of the casts to reproduce detail is only fair to poor. The poor quality of reproduction could be attributed to variations in ramming techniques and to the casting quality of scrap aluminum metal.

The grinding qualities of all Series II casts are rated poor due to the fact that aluminum fills the abrasive crevices of the shaping tools. This inadequate grinding quality is inherent in aluminum but can be rectified by using a grinding disk specially designed for aluminum. However, aluminum will clog files and the metal removing attachments that are commonly used in high-speed electric drills.

In Table IV, Polishing Ease and Reflective Quality are rated as very poor to poor. This is due to the oxidation of the metal in super-heated casts. Furthermore, the scrap metal could affect the reflective quality and ease of polishing.

The Visual Results of Series III

The data contained in this section relate to the initial question of inquiry: "What visual results occur when unorthodox pouring temperatures and sand binders are employed?"

The design of Series III was to hold the temperature constant and to employ different binding materials and different combinations of binding materials. Although the temperatures have exact temperatures indicated in the following text, the exact temperature could not really be specified with the pyrometer used. These temperatures, 1500, 1501, 1502, and 1503 are designated for identification purposes.

The first cast of Series III, number 1500, utilized a binder combination of one-half syrup and one-half water. The melt was poured as soon as the temperature reached 1500°F. The sculpture is characterized by indentations in the negative spaces. (See right center portion of Figure 22.) These indentations were not included on the master pattern. As can be noted on Figure 22, sculpture number 1500 has an excellent reflective quality which results from the dense metal and high polish. The visual data is further explained by an enlargement of sculpture

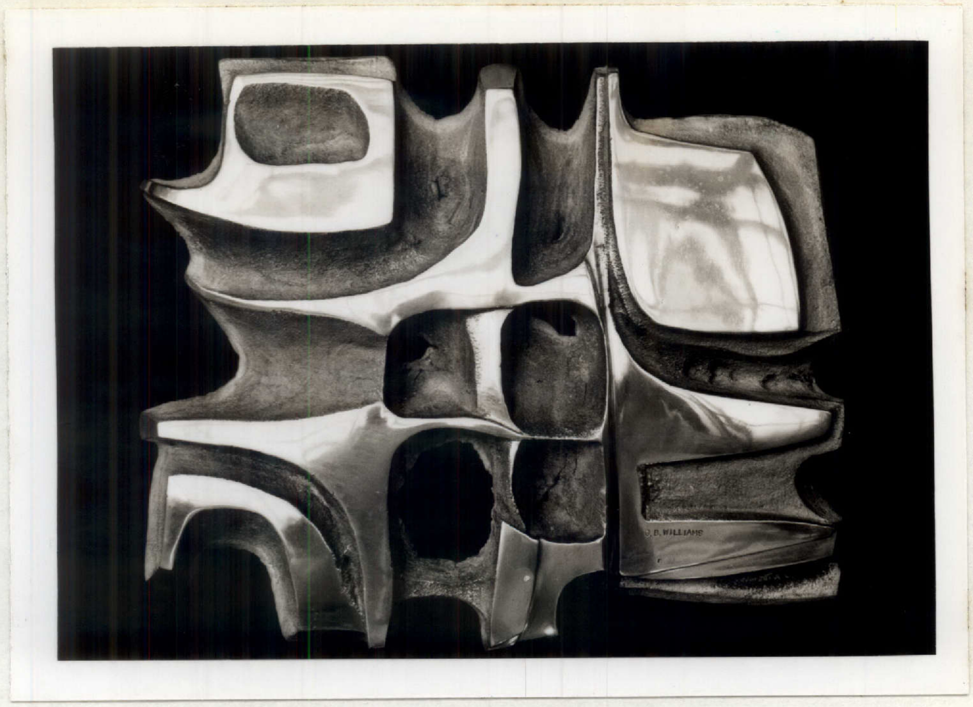


Fig. 22--Series III Sculpture cast at 1500°F

number 1500. (See Figure 23.) As can be noted in Figure 23, the porosity is sparsely located and very small in size. As stated in Photographs of Relief Sculpture, the detail photograph was taken from a two-by-three inch area and enlarged to three-by-four and one-half inches for clarity. From this information, one can determine that the porosity is actually fifty per cent smaller than illustrated in the figure. The surface is also characterized by the texture of the styrofoam master pattern and some rat-tails located on the recessed negative spaces.

The second cast of Series III, number 1501, utilized a binder combination of two-thirds Na_2SiO_3 (sodium silicate)

Fig. 23--Detail of Sculpture 1500

and one-third H_2O (water). The melt was poured as soon as the temperature reached 1500°F. The sculpture is characterized by rat-tails around the negative spaces. (See Figure 24.) The left side of sculpture 1501 did not fill, and a negative shape resulted. This was due to incorrect leveling or warpage of the bottom board. The visual result is further explained by an enlargement of sculpture number 1501. (See Figure 25.) The photographic quality of Figure 25 vividly depicts the large porous textures of sculpture number 1501. The surface is also characterized by the texture of the styrofoam master pattern and the tool marks made when the surface was ground flat.

Fig. 24--Series III Sculpture cast at 1501°F

Fig. 25--Detail of Sculpture 1501

The third cast of Series III, number 1502, utilized a binder combination of one-third Na_2SiO_3 (sodium silicate) and two-thirds H_2O (water). The melt was poured as soon as the temperature reached 1500°F. The sculpture is characterized by an area of blows. (See Figure 26.) Blows is

Fig. 26--Series III Sculpture cast at 1502°F

a foundry term referring to an area that has porosity so densely located as to ruin the cast, particularily when accuracy in reproduction is required. The visual data is further explained by an enlargement of sculpture number 1502. (See Figure 27.) The photographic quality of Figure 27 vividly depicts the porosity achieved in sculpture number 1502. The surface is characterized by the texture of the styrofoam master pattern and the sand used in the investment. The surface is also characterized by

Fig. 27--Detail of Sculpture 1502

a polished finish. Unlike sculpture 1500, sculpture 1502 required considerable effort to accomplish the reflective quality depicted in Figures 26 and 27. The extreme porosity in Sculpture 1502 could have been affected by the 96 per cent humidity of the particular day. The humidity could possibly have been absorbed in both the metal prior to melting and in the mold.

The last cast of Series III, number 1503, used only water as a binder. The melt was poured as soon as the temperature reached 1500°F. The result is not sculptural.

(See Figure 28.) Since both 1500 (see Figure 22, page 76) and 1503 utilized the same master pattern, it is obvious

Fig. 28--Series III casting result using a melt temperature of 1503°F and only water as a binder.

that number 1503 is a complete failure as a duplication of the sculpture master. The melt evaporated the water in the investment and continued to bubble for approximately fifteen minutes. One large bubble was approximately eight inches in diameter and approximately as thick as the aluminum foil commonly used in the kitchen. The resulting cast is characterized by biomorphic shapes and the large crystallization of the metal. (See Figure 29.) The crystallization is large and linear.

Fig. 29--Detail of Cast 1503

Additional studio analysis of Series III is included in Table V, which is on the following page. The studio analysis of the sculptures in Table V is comparative. Each sculpture in the table is compared to the other sculptures cast in the same series. This technique of grouping was designed to determine the effects of various binders and binder combinations.

The first of the comparative evaluations is porosity. Porosity is listed under the Studio Analysis in Table V. As can be noted in Table V, some porosity is produced when water is added to the syrup binder. More porosity is produced when water is added to sodium silicate and used for

TABLE V

FOUNDRY RECORD AND STUDIO ANALYSIS
OF SERIES III

Foundry Record				
Melt Temperature*	1500°F	1501°F	1502°F	1503°F
Binder				
Ambient Temperature	103°F	98°F	84°F	101°F
Ambient Humidity	34%	40%	96%	42%
E. C. or F. M. P.**	EC	FMP	EC	EC
Type of Pour	reg.	reg.	reg.	reg.
Reaction	none	hissing	hissing	bubbling
Studio Analysis				
Porosity***	least	more	most	bubbles
Detail	fair	poor	bad	failure
Grinding Quality	poor	poor	poor	poor
Polishing Ease	avg.	poor	poor	none
Reflective Quality	avg.	poor	poor	none
Unique Qualities****	D	E-H	E-F	E-F-G

*The temperature was recorded on the back of each sculpture to serve as identification.

**Empty cavity or Full Mold Process®.

***Some variation in porosity may be due to an unknown variation in ramming pressures.

****See pages 84-85 for a description of the unique qualities.

a binder. Furthermore, it can be noted that even more porosity will be produced as the proportion of water is increased and the sodium silicate is reduced. However, when too much water is added, the mold collapses and duplication of the master suffers.

As can be noted in Table III, the ability to reproduce detail and produce porosity is best when syrup is combined with water. Furthermore, the syrup and water combination is easiest to polish and has the highest reflective quality of Series III. A final analysis of all the series of casting is reported in the findings of Chapter V.

Serendipitous Data

A space was included on the studio analysis form for any unpredictable event. There were unique occurrences, and they are listed below. Tables III, IV, and V indicate the cast that has the serendipitous quality of

A. an iridescent burnt umber color, but the pierced openings have an encircling black charred ring.

B. a marble-like effect which consists of alternating brownish and silver layers in varying widths.

C. an objectionable slag on the back. (Note the back of the relief is the top at the time of the pouring. In other words, the slag floats to the top, which is the back of the relief.)

D. an objectionable oxidation in the metal.

E. an iridescent bluish-purple color.

F. an objectionable area of blows, which is an adjoining porosity. The size of this area is 5-1/4" by 2-1/4".

G. a complete loss of detail. The bubbling metal collapsed the mold and continued to bubble for approximately fifteen minutes.

H. a black charred color.

The Technical Teaching Process

The preceding photographic data and related tables are a documentation of the development and control of porous textures. However, this study was two-fold in purpose and the second part was to develop a pictographical teaching device to aid in the teaching of foundry fundamentals. The following four pages consist of printed versions of the filmstrip "Foundry Fundamentals."

The technical teaching process developed is versatile andcan take many forms. The first form is that of the many slides that were taken of the tools, materials, equipment, foundry procedures, and the sculptures. From over a thousand slides, a selection can be made and assembled to portray specific aspects of the sculpting process, for example how some artists obtain ideas from nature and other sources, subsequently developing the idea by drawing thumbnail sketches or modeling a maquette.

Fig. 30--Frames 1 through 18 of the filmstrip, "Foundry Fundamentals."

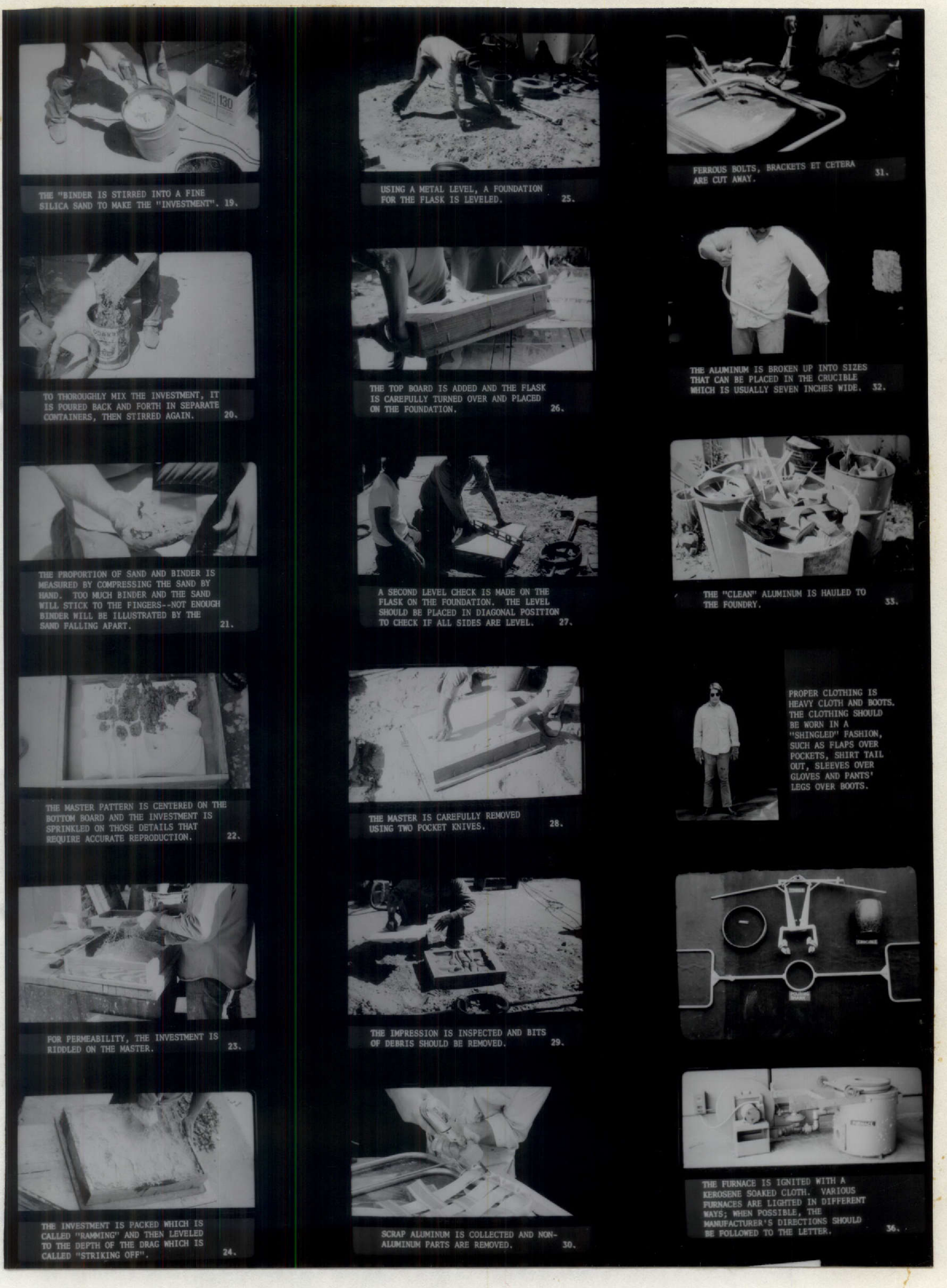


Fig. 31--Frames 19 through 36 of the filmstrip, "Foundry Fundamentals."

Fig. 32--Frames 37 through 54 of the filmstrip, "Foundry Fundamentals."

Fig. 33--Frames 55 through 72 of the filmstrip, "Foundry Fundamentals."

Other aspects of sculpting that could be shown are the building of the master patterns or the cast sculpture. By use of these transparencies the master pattern can be compared with the resulting sculpture for size and accuracy of cast.

A second form the technical teaching process took is that of a filmstrip. The filmstrip was copied from the original transparencies and is titled "Foundry Fundamentals." The procedures of open-mold casting are chronologically portrayed in the filmstrip. The filmstrip was designed to aid in the replication of this study as well as to provide an introduction to sculptural casting. The development of the filmstrip used Roach's (1, pp. 1-77) dissertation as a foundation. The filmstrip was evaluated by an evaluation form which also came from Roach's (1, p. 58) dissertation, and a copy of this form is included in Appendix A. For convenience, the same transparencies were also copied onto black and white 1/2-frame negative film; the film was printed on Kodak's RC paper.

CHAPTER BIBLIOGRAPHY

1. Roach, Michael N., "The Relationship of a Model Audio-Visual Perception and a Selected Communication Model as a Function of a Filmstrip Design," unpublished doctoral dissertation, Department of Education, North Texas State University, Denton, Texas, 1970.

CHAPTER V

SUMMARY, FOUNDRY FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Summary

A consensus was taken from ten foundry manuals on the possibility of casting porous textures. (See Table II, page 40.) Experiments were designed to test the feasibility of casting porous textures in open-mold aluminum relief.

The experiments were carried out in a foundry located outside as most representative of school foundries. Control measures were established and the foundry data were methodically recorded. Documentary photographs were taken of the process and of the results on 35 mm. film.

The results of the open-mold casting experiments were relief sculptures that had a wide range of textures. Basically, the textures were of three different levels of porosity. The first texture was the same as that produced by standard foundry procedures--dense, non-porous metal. The second texture was porous, sometimes to the degree that the master pattern was poorly represented. The third texture was so spheroidal that it destroyed the image of the master pattern. (See Figure 28, page 81.)

Foundry Findings

The primary question of inquiry, 1, asks, "What visual results occur in a sculpture when unorthodox pouring temperatures and binders are used?" The most common means of reproducing visual imagery is photography; consequently, the sculptures were photographed and the photographs were glued into Chapter IV. Two photographs were made of each sculpture--the first was of the entire composition and the second was of a two by three inch detail. (See Figures 2 through 29, pages 73-86.) It is through these photographs that one can best comprehend the findings, which are visual, of the casting experiment.

The findings to additional questions of inquiry are best understood by a combination of the photographs and the information on Tables III, IV, and V. The questions involved in this combination are 1a, 1b, 2a, 2b, and 2c. Number 1a asks, "What temperature and binder combination produced the most porosity?" The findings are stated on the tables as a comparison with other sculptures in the same series. Of all the casts, number 1502 has the most porosity. However, in some places the porosity is so dense it would have to be labeled "blows, which destroyed the detail. Number 1501, with a binder of one-third water and two-thirds sodium silicate, has the most even porosity and is the most usable of all the different casts. Usable porosity is defined as that porosity which exists in the design but does not impair detail. As was expected, Number 1210 has the least porosity of all the casts. However, 1210 also has some surface crevices that are actually small cold-shuts. These cold-shuts were caused by the combination of a low pouring temperature and a cold mold.

Question 1b states, "How well did each combination render detail?" The only series that produced good detail was Series I. Of all the casts, Number 1250 produced the most accurate detail, probably because of the syrup binder. The casts that used the highest temperatures had a tendency to burn the sand into the surface of the cast, which caused a loss of detail. As expected, the addition of more porosity resulted in a greater loss of detail. The cast exhibiting the least detail is 1503. The lack of detail was caused by the bubbling action that eventually destroyed the mold, resulting in a poor likeness of the master pattern.

Question 2a asks, "Does the resulting metal hinder the operation of the sculpting tools?" The answer is yes. The resulting metal hinders the operation of grinding tools by filling the cutting crevices, especially on metal files. However, the metal that filled the abrasive crevices on the grinding disk performed as an abrasive, thereby accomplishing the desired result.

Questions 2b and 2c ask, "Could the metals be polished easily? To what degree did the polished surface reflect an image?" The answers are related in that the sculptures that polished easily also polished to a deeper reflective surface. The photographs of Series I and Series III illustrate how these surfaces can reflect an image. However, to accurately compare the reflective ability the viewer must see the original sculptures. The method used to evaluate the reflective quality of the different sculptures was very similar to the testing of photographic lenses. Normally, a camera with the lens to be tested is used to take photographs of a specially designed and printed card. The card is made up of many lines of different sizes. The sharpness of a lens is determined by its ability to resolve so many lines per millimeter. Similarly, when looking into the sculpture, the evaluator would distinguish the lines reflected from the same specially designed card. The more lines the aluminum can reflect, the better its quality of reflection. The aluminum that reflects most is designated excellent in reflective quality. The scale descends from excellent, to very good, to good, to average, to poor, to none.

Question number 3 asks, "What was the material cost per pound of the completed sculpture?" After adding the costs of metal, binder, and sand and dividing by the total pounds of sculpture, the cost was twenty-one cents a pound. This price does not include the cost of any equipment, tools, gas, electricity, lumber, nails, sanding disks, grinding disks, tape, bolts, or hanging wire. If all the additional costs had been added, the price would have greatly increased.

Question number 3a asks, "What was the specific weight loss in the transition from scrap metal to the finished products?" Weight loss fluctuated between three and eight per cent depending on the dampness of and the impurities on and in the metal.

Question number 3b asks, "How did the cost of aluminum compare with other sculpting metals?" Interestingly, while these sculptures were being produced, the price of aluminum increased from three to sixteen cents a pound at some dealers. Basically, readily available clean aluminum costs ten cents per pound; bronze usually costs sixty-five cents per pound plus shipping expenses. Aluminum is also readily found as beverage cans, lightweight lawn furniture, and other types of discarded household items. Bronze, on the other hand, is rarely found discarded. Bronze is an alloy composed of copper, tin, and phosphorus, all of which are expensive or not readily available.

Another consideration was the volumetric weight of aluminum compared to bronze. Calculated from Untracht's table of specific gravities (1, p. 464), a pound of aluminum is slightly over three times as voluminous as a pound of bronze. Consequently, with equal pounds of the two metals three sculptures could be cast in aluminum while only one could be cast in bronze.

The aluminum sculptures in the textural casting experiment were limited to 16" x 20" x 4" dimensions and the average weight was twenty-two pounds. Thus, the aluminum cost was $2.28 which includes the average loss of metal. Volumetrically, it would take sixty-six pounds of bronze to fill the same mold at a price of $42.90.

Question number 4a asks, "What form should the technical teaching process take for portraying open-mold sculptural casting for classroom use?" The answer is, due to the step-by-step nature of casting, the most feasible teaching technique would be that of the filmstrip, "Foundry Fundamentals." The filmstrip was developed in a chronological order, starting with the acquisition of the necessary tools and materials, continuing with the creation of a master pattern, preparation for casting, and the actual casting steps. The filmstrip also includes relevant information such as grinding, finishing, hanging of the relief sculptures, and safety factors. As compared with 2" x 2" transparent slides, Rothschild (2, p. 119) indicates the basic advantages of the filmstrip: (1) production of multiple copies reduces costs in comparison with slides, (2) filmstrips can be handled by inexperienced personnel without the danger of getting the material out of order or sequence, and (3) filmstrip projectors are relatively jam-proof mechanisms so that there is little chance of interrupting a lesson because of an unsuitable slide mount. Additional advantages of the filmstrip for the teacher are described by Roach (3, p. 12): (1) it is possible to stop the sequence on any specific frame and discuss or amplify the visual material, and (2) it is also possible to conveniently retrace a sequence of presentation or to otherwise return to a frame which has previously been shown.

Question 4b asks, "What form should the technical teaching process take for replication of the procedures for casting textures in the open mold?" The answer to this question is the filmstrip copied onto black and white film (Panatomic-X) and printed in Chapter IV. Each print includes 18 frames of the 72-frame filmstrip.

Question number 5 asks, "In a sculpture student's program of study, when should the open-mold casting process be taught?" The answer is after three-dimensional design and before the more complicated techniques of lost-wax casting. As stated in the purposes of the study, the open-mold casting technique was refined to be an introductory technique to casting. Consequently, the student can learn the fundamentals of casting without the danger inherent in the lost-wax casting process. In addition, the student will be more likely to cast a better sculpture due to the more numerous pitfalls that exist in the spruing system of the lost-wax process.

Serendipitous Results from the Experiment

Several unique occurrences during these experiments are listed below. Tables III, IV, and V indicated the casts that had the qualities of

A. an iridescent-like burnt umber color on the surface, and an encircling black charred ring around the pierced openings.

B. a marble-like effect which consists of alternating brownish and silver layers in varying widths. This marbling is probably a forerunner of cold-shuts although it might be due to an alloy metal separating in the crucible and resulting in separate layers.

C. an objectionable quantity of slag on the back. (Note that the back of the relief is the top at the time of the pouring. In other words, the slag floats to the top which is the back of the relief.) This had to be ground off before the relief could be hung.

D. an objectionable oxidation in the metal.

E. an iridescent-like, bluish-purple color.

F. an objectionable area of blows, which is an abundance of porosity. The size of this area of blows is 5-1/4" x 2-1/4".

G. a complete loss of detail. The bubbling metal collapsed the mold and continued to bubble for approximately fifteen minutes. These bubbles were not like those bubbles that produced pinhole-porosity; these were much larger--one measured eight and one-quarter inches. Consequently, the cast is not readily recognized as a duplication of the master. This bubbling should not be confused with boiling because aluminum does not boil until it reaches 3740°F.

H. a black charred color.

A color permanency test was used on all sculptures that had colors. It was found that all the colors faded, especially in bright sunlight.

Safety Factors

One of the purposes of the study was to identify and report safety factors pertaining to all phases of casting. Although some keen-minded students can foresee danger better than others, safety is basically the responsibility of the teacher and should be taught. When applicable, safety factors have been included in the written part of this study and in the pictorial documentation. The following list of safety precautions was devised to facilitate the teaching process:

1. Always read the instructions of solvents, paints, et cetera before using them. Make a special effort to

find safety precautions. When in doubt about the safety of some materials, ask the dealer who sold the product.

2. Wear an approved respirator when sanding, grinding, or otherwise creating floating dust. This is especially important when working with styrofoam or other expanded plastics and aluminum. Body chemistry cannot dissolve these particles.

3. Use adequate ventilation in addition to a respirator when necessary. When possible, spray paint, sand, et cetera outside in a breeze.

4. When sanding, grinding, and drilling, do not wear loose clothing. Tuck shirt tail in, button sleeves, remove jewelry or anything that might get caught in the machinery.

5. Protect your eyes. Brazing goggles with the dark lens removed and the clear glass remaining give excellent protection. Sunglasses and prescription glasses are better than nothing. When casting outside, both a clear face shield and sun shades should be used.

6. When casting, wear heavy clothing such as that issued by the armed services and sold at army surplus stores. Try to prevent crevices in your clothing that might catch exploded melt. Leave pocket flaps out, leave shirt tails out, roll shirt sleeves down over gloves and pull pants legs over your boots.

7. Identify all pieces of metal that will be used for casting. Never use chrome-plated metal, as the resulting gas, chromium oxide, can cause skin ulcers. Never use lead or lead derivatives in furnaces that are capable of extreme temperatures.

8. Use proper ventilation in the foundry area. Many metals give off toxic gases when being melted. For example, all brass alloys contain zinc, and, when melted, the zinc produces zinc oxide fumes. If inhaled, these fumes will cause a metal-fume fever known as zinc shakes (1, p. 52). Fumes are avoided somewhat by staying upwind. A strip of cloth attached to the top of a pole helps decide the direction of the breeze and whether it is consistently from one direction.

9. The heat caused by the furnace, molten metal, and summer sun reaches intolerable levels and could cause fainting. Therefore, casting sessions should be scheduled early in the morning after the night has cooled the area. Casting courses should be scheduled in the winter months so as to utilize the natural coolness.

10. Obviously, a crucible full of molten metal is a dangerous object and most people have an inborn fear of hot hissing objects. However, a secondary danger exists in not knowing where to pour the melt. Many cold objects can explode when the metal touches them. Concrete and water are two such materials. The melt will erupt if

poured into a cold ingot mold. The ingot mold must be preheated.

11. Equipment should be kept in good operating order. Electrical cords that have been damaged or are rotten should be replaced. No one should attempt to use electrical equipment with water on the floor. Equipment should be used only for its intended purpose and the equipment selected should be that which can withstand the load placed upon it.

12. A disorganized studio is one of the most frequent causes of accidents. At the end of each working session, all tools should be cleaned, oiled, and put in an area designed to accommodate tools. Studios should have areas for storage, and sculptures in progress should be put away. Raw materials should be stacked against a wall and out of the way.

13. The procedure should be discussed and rehearsed to clarify the various phases of all dangerous sculpting activities.

14. Working at a reasonable pace is also safer than trying to hurry the process. Each procedure should be carefully thought out before the actual step is taken.

A sculpture studio should be built with safety in mind. To a degree, the studio should be much like a workshop; therefore, the same safety factors used in the shop construction will also apply to a studio's construction.

Conclusions

Based on the findings of this study the following conclusions are made:

1. Castings utilizing Series III processes (Series III utilized various investment binders) will produce greater porosity than castings utilizing other processes described in this study. In order to reproduce detail, the sand must contain an adequate binder to hold the mold in shape. At the same time, the investment must also be permeable enough to allow the water, in gaseous form, to pass into the melt. As a binder, sodium silicate works better than syrup in producing porosity. The syrup crystallizes into a solid, impermeable mold. Once the investment has an adequate quantity of the sodium silicate binder, additional quantities of water can be added to increase the porosity. However, the volumetric amount of water should not exceed the amount of binder.

2. Super-heated aluminum can be finished by grinding and filing, but tools will tend to clog. The metal clogging the finishing tools can be removed with a short-toothed wire brush designed for cleaning files; however, the process is slow and laborious.

3. Super-heating the aluminum melt will cause a sculpture to be less reflective than a sculpture that is cast without being super-heated. However, with a furnace with adequate flame control, the results may not be the

same as those indicated in this study. If there is a difference, the difference will probably be due to whether the foundryman uses an oxidizing or reducing flame.

4. When two sculptures are cast of the exact same dimensions, the aluminum metal will cost only one-fifteenth as much as bronze metal. It costs less to melt aluminum than bronze due to aluminum's lower melting point. In addition, the number of finishing tools and materials, such as sand paper and files, is decreased due to the fact that aluminum is easier to work than bronze. For those art students who want to learn casting fundamentals and cannot afford, or do not like, bronze, aluminum should be considered.

Recommendations for Further Study

Aluminum, polished or unpolished, forms an impervious oxide film which protects the aluminum from further atmospheric corrosion. Nonetheless, this oxidation is matte gray in color and causes a reduction in the reflective qualities. (See Figure 34, page 96.) Eventually the oxidation build-up would not permit any reflection. Since most artists want their work to remain in the original condition, the oxidation would be considered a disadvantage. Further study might well include the development of a permanent means of protecting polished aluminum sculpture. Such an investigation might profitably consider lacquer, acrylic, anodizing, polyester, epoxy, and chrome plating.

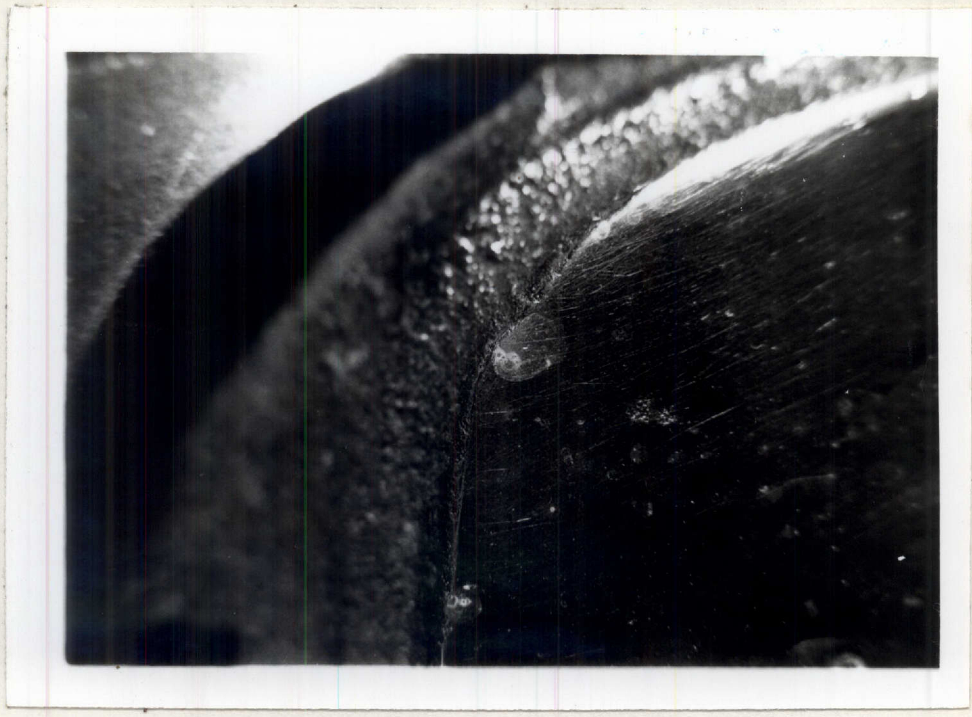


Fig. 34--A 1.5X enlargement of oxidation on a polished aluminum sculpture. This oxidation was the result of leaving the sculpture outside for twenty-four hours. No unusual weather was involved.

On extremely hot days, the syrup used as a binder would dry completely in the investment. The dryness, actually crystallized sugar, created a rigid mold material. The results were more accurate castings with less porosity. Sun or kiln-baked syrup-bonded molds would probably produce better casts than an investment with syrup in a liquid state. A study in crystallized molds is recommended as a method of producing more accurate casts than those molds that contain liquid binders.

Due to many variables, the reader should not expect to duplicate the exact results in this study. To produce porosity with different equipment and components, these experiments can serve only as a general guide. The recommended procedure is to run a group of experiments that start with the least proportion of water. The water should be increased slightly until the desired results are obtained. The open-mold process investment proportions are not recommended in closed molds. When using a closed mold, no more than one-tenth water to nine-tenths binder should be used as a starting point.

Unusual quantities of porosity will be instrumented by incorrect ramming pressures. Ramming is a manual procedure and depends upon individual application. The maximum pressure recommended for aluminum sand casting is thirty-five pounds. However, this pressure will be exceeded if the sculptor uses too many strokes. As with many of the processes involved in casting, experience will be the foundation upon which a sculptor is developed.

CHAPTER BIBLIOGRAPHY

1. Untracht, Oppi, Metal Techniques for Craftsmen, New York, Doubleday and Company, Inc., 1968.

2. Rothschild, Norman, Making Slide Duplicates, Titles and Filmstrips, New York, Universal Photo Books, 1962.

3. Roach, Michael N., "The Relationship of a Model of Audio-Visual Perception and a Selected Communication Model as a Function of a Filmstrip Design," unpublished doctoral dissertation, Department of Education, North Texas State University, Denton, Texas, 1970.

APPENDIX A

TITLE OF FILMSTRIP: FOUNDRY FUNDAMENTALS NUMBER OF FRAMES: 72

SOUND ________ SILENT ✓

TOTAL INTENT OF THE MESSAGE

A INDIVIDUAL FRAME EVALUATION...

AA TOTAL MESSAGE EVALUATION...

B GENERALIZED INTENT

GENERALIZED INTENT	
1. ATTENTION GETTING ATTENTION HOLDING	✓
2. TEACHING SKILL CLASS I GOAL	✓
3. INFLUENCING ATTITUDE CLASS II GOAL	✓

BB GENERALIZED INTENT

GENERALIZED INTENT	
1. ATTENTION GETTING ATTENTION HOLDING	
2. TEACHING SKILL CLASS I GOAL	
3. INFLUENCING ATTITUDE CLASS II GOAL	

C SPECIFIC INTENT

SPECIFIC INTENT		
1. IDENTIFICATION NAMING OBJECTS OBSERVING DETAILS	✓	✓
2. CHARACTERIZATION		
3. EVALUATION		
4. PRESCRIBING	✓	✓
5. RELATING		
GRASPING IMPORT	✓	
CONVEYING FACTS	✓	
OBSERVING FACTS	✓	
RELATING TO EXPERIENCE		✓
6. MOTIVATION	✓	✓
7. PERCEPTUAL SKILL	✓	✓

D SPECIFIC INTENT

SPECIFIC INTENT	
1. RECALL EXPERIENCES	✓
2. AID DETAILED STUDY	✓
3. CORRECT MISCONCEPTIONS	✓
4. PREVENT MISCONCEPTIONS	✓
5. COMPARE AND CONTRAST	✓
6. BUILD NEW EXPERIENCES	✓
7. GIVE MEANING TO WORD SYMBOLS	✓
8. DEMONSTRATE A PROCESS	✓
9. FORM VALUE JUDGMENTS	✓
10. CREATE AN ATMOSPHERE	✓
11. PREPARE FOR EXPERIENCE	✓
12. MOTIVATE LEARNING	✓
13. PUBLICIZE EVENTS	
14. DEVELOP INSIGHT/APPRECIATION	✓
15. DRAMATIZE A POINT	✓
16. RAISE QUESTIONS/PROBLEMS	✓
17. STIMULATE READING	✓
18. FOSTER INDIVIDUAL INTEREST	✓
19. PROVIDE SETTING	✓
20. COMPLETE RESEARCH	✓
21. PROVIDE REFERENCE	✓
22. ENRICH AND ENLIVEN REPORTS	✓
23. INVITE PARTICIPATION	✓
24. HELP LEARNER UNDERSTAND SELF	✓
25. BUILD BACKGROUND	✓
26. CREATE CENTER OF INTEREST	✓
27. DEVELOP CRITICAL JUDGEMENT	✓
28. STIMULATE CREATIVE EFFORT	✓
29. INTRODUCE A TOPIC OF STUDY	✓
30. REVIEW AND SUMMARIZE	✓
31. TEST LEARNING	

H DOES THE OVERALL DATA PRESENTATION PROCEED THROUGH DIFFUSION, DIFFERENTATION, AND INTEGRATION?

Y	N
✓	

G ARE THE AUDIO AND VISUAL MESSAGES COMPATIBLE?

Y	N
✓	

F TEXT, CAPTION, OR SCRIPT EVALUATION:

SUITABILITY OF LETTERING STYLE. ✓

LEGIBILITY OF LETTERING STYLE. ✓

INTENT OF LETTERING:

- TITLE ______
- CAPTION ______
- TEXT ______

- ENIGMATIC
- MINATURE ESSAY ✓
- NARRATIVE
- ESSAY ✓

E DESIGN CONSIDERATIONS:

BALANCE
SYMMETRICAL
ASYMMETRICAL

CONTINUITY:
THROUGH
PROXIMITY
SIMILARITY
COMMON MOVEMENT

EMPHASIS:
THROUGH
COLOR, TEXTURE, LINE, SIZE, AND OVERLAP

DIVISION OF FRAME RECTANGLE
GOLDEN PROPORTION
RULE OF THIRDS

LINE — FORM — SPACE — COLOR — TEXTURE

INTERPRETATION OF THE SIGNAL BY:
1. LIGHT AND SHADE
2. FILLED SPACE
3. PARALLAX OF MOVEMENT
4. MOVING OBJECTS
5. FIXATION
6. DISTORTION

SUITABILITY OF DESIGN CANNOT BE EVALUATED THROUGH THE USE OF A CHECKLIST. DISCUSSION IS REQUIRED TO COMBINE THE VARIOUS DESIGN CONSIDERATIONS.

THIS FORM WAS ORIGINALLY DESIGNED/CONCEIVED FOR USE BY AN AMATEUR Filmstrip MAKER. A PROFESSIONAL Artist/DESIGNER SUCH G.B. WILLIAMS PRODUCES HIS WORK ON A LEVEL UTILIZING ALL THE PERTINENT CATEGORIES ON THE FORM IN A TRAINED, BUT ALMOST INSTINCTIVE MANNER. THIS FORM WOULD BE OF MINIMAL USE TO HIM EXCEPT, PERHAPS, AS A GENERAL ORGANIZATIONAL OR STRUCTURAL CHECKLIST.

Michael M. Roach

APPENDIX B

ABBOZZO: A small scale plan or model. Also called a maquette or thumbnail sketch.

ABSTRACTION: A composition or creation suggested by a concrete object or an organic subject which is transformed by the artist into a nonrepresentational design with recognizable elements, irregular curved lines, graded tones, et cetera.

ARMATURE: A framework or brace to support the wax or clay when doing sculpture. Occasionally called a skeleton.

ASSEMBLAGE: An art form made by collecting found objects and aesthetically fitting them together.

AUDIO: The explanatory lectures accompanying the presentation of a filmstrip or motion picture.

BAS RELIEF: A work of art with objects or figures projecting from a supporting background.

BINDER: An adhering material that stabilizes the sand mold while the melt is poured. The binder added to sand is the investment. Examples are syrup and sodium silicate.

BURN OUT: The process of heating wax or other matrix material until it melts out of the mold. Other more solid materials, such as wood and leather, literally burn out, leaving a cavity in the mold material in which one can pour the molten metal.

CAST: This is an abbreviation for a cast metal sculpture, cast metal bas relief, or any other object that resulted from one of the many casting procedures.

CHANCE: A term frequently used by artists as a verb meaning to risk. For example, an artist, realizing his piece of work needs an improvement, will chance a new addition, realizing such could ruin the art piece.

CHIAROSCURO: A technique of representation which concentrates on the effects of blending the light and shade of objects to create the illusion of space or atmosphere.

CHOKE: The tapering of some part in the sprue system to restrict the flow of metal. The restriction reduces turbulence and allows gas bubbles to escape before entering the sculptural cavity.

COLD SHUTS: A line that occurs on the surface of a casting because of two streams of metal failing to unite owing to an inconsistency in their temperatures while pouring.

COLLAGE: An agglomeration of fragments such as match boxes, bus tickets, playing cards, pasted together and transposed, often with relating lines or color dabs, into an artistic composition of incongruous effects. The creation of the collage is attributed to Picasso.

CONCEPTUALISM: A recent direction in art which is basically composed of artists that state that the idea is the ultimate manifestation. Consequently, the idea is sometimes constructed by skilled craftsmen rather than by the artist.

CORE: A solid form placed in a mold around which the metal is poured so as to produce a hollow cast.

CUBISM: A school of art founded on using flat planes as compositional shapes. Picasso and Braque are accredited with the creation of the idea.

DAMASCENE: To inlay one metal with another metal or material to add interest and contrast.

DIMENSION: The quality of extension. In art, the various aspects of dimension are broken down for a more thorough analysis.

TWO-DIMENSIONAL: That which possesses only length and width, usually referred to as decorative or flat.

THREE-DIMENSIONAL: That which possesses length, width, and depth, usually referred to as plastic or spatial.

FOUR-DIMENSIONAL: That which possesses width, length, and depth, and adds time or movement. From time immemorial, artists have grappled with the problem of the representation of movement on the stationary format.

DOCUMENTARY ART: A recent doctrine in art based upon the importance of the act of creating a work of art. Such works are usually photographed and the photographs become the art work.

EARTH WORKS: A school of artists that dig, plow, bulldoze or otherwise alter the face of the earth with aesthetic intent. Earth works are usually very large and measured in cubic feet, square feet or acres.

ELABORATION: To add details or to give more extensive treatment to the surface of a work of art, embellish.

ELECTROPLATE: To cover or to give a metallic coating to an object by means of electric current.

ELEMENTS OF ART: Those physical applications which are line, shape, value, texture, and color. Some artists include space as an element while others consider space a principle of organization. Also called the physical elements of art.

ENVIRONMENTS: Art works which encompass the viewer. The effect should be an all-encompassing sensation, as contrasted to painting hung on the wall to be viewed from any angle at any distance.

ESOTERIC: Art work designed for and understood by the specially initiated alone, abstruse.

FINS: Thin projections of metal caused by small cracks in the mold.

FLASK: A four-part mold box, usually composed of a cope, the top rectangular frame, a drag, the bottom rectangular frame, a top board, and a bottom board.

FORM AND SHAPE: Various authors differ in their opinions of these two terms. For the purpose of this study, form will refer to the entire structure (form being closely related to format), while shape refers to only a part of the form.

FOUND OBJECTS: Those objects used in assemblages. These objects are frequently found in junk yards, automobile wrecking yards or in the streets. Found objects are usually chosen because they reflect our society or possess artistic merit.

FOURTH DIMENSION: That which possesses length, width, depth, and time or movement (movement takes time; therefore, in the most condensed form one would only use time). Those art works that suggest or depict motion.

FREE STANDING: Sculpture which is designed to be seen from all sides including the top end which usually supports itself and is not part of, or attached to, a wall or background. Also called sculpture in the round.

FREEZING POINT: That point at which the melt solidifies. Also called crystallizing and hardening.

FRONTAL: A contemporary arrangement of the elements of a sculpture so as to produce a more forceful appearance when viewed from directly in front of the piece, although most primitive societies utilize this design.

FULL MOLD PROCESS®: A patented process of casting. The process utilizes the lightweight expanded plastics (commonly called styrofoam) as the object to be cast. The object to be cast is shaped in styrofoam and embedded in sand. Molten metal is then poured, the styrofoam pattern burns out, and the metal takes the shape of the styrofoam.

FURNACE: An oven used to produce extremely high temperatures in order to melt metal. Also called a forge.

GARGOYLE: An imaginary creature that has size and shape much like a human being but has reptilian features and scales. Images and statues of these creatures occur at various intervals in historical art.

GATE: A system of openings of channels in a mold through which molten metal is poured in order to fill the cavity.

GRAVITY FLOW: The oldest and most basic type of casting, as opposed to centrifugal and suction types of casting where the molten metal is forced into the mold.

GREEN SAND: A casting sand which has had no binders added but has a natural clay bond. Scientifically called glauconite.

HAPPENINGS: An art form which occupies a length of time vaguely resembling a dramatic play, dance, or musical event.

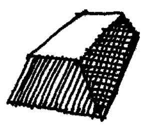
HARD EDGE: A term referring to a distinct difference between two adjoining shapes. A hard edge is contrasted to blended, soft or scumbled edges that are vague as to where one shape ends and the other begins.

HELIARC: An electric welding machine that surrounds the area of the weld with inert gas to prevent oxidation of the metal in the weld. This type is commonly used in welding non-ferrous metals such as aluminum.

IMAGERY: Imitations of any person or thing or things. Images in general. Contrasted with those art forms which are not made to represent things.

INGATE: The opening through which the melt enters the pattern.

INGOT: A casting that is to be processed further by repousse, extrusion, or other methods of forming. Usually shaped like the base of a rectangular pyramid. Virgin metal is sometimes called ingot metal.



INTAGLIO RELIEF: Sculpture in which the surface of the image is below the surface of the background.

INTUITIVE: Knowing or recognizing by an instinctive sense rather than by the application of academic rules; sensing or feeling something without a specific reason.

INVESTMENT: Refractory material used in the making of molds for the casting of metals.

KINETIC: A sculptural form that incorporates movement as an element of art.

LATITUDE: The Focal Encyclopedia of Photography defines latitude succinctly as "the range of exposure over which a photographic emulsion will yield acceptable results." It then concludes with the admonition "color films have practically no latitude; the exposure must lie within very narrow limits to achieve perfect results."

LOST-WAX PROCESS: A method of metal casting in which the molded wax form is melted away and the space left between the core and the outer mold is filled with the molten metal. The process is also referred to as the cire perdue process.

MAQUETTE: A preliminary study in the form of a small scale model for a larger sculpture.

MASTER PATTERN: A foundryman's name for the form around which the sand is packed to form the hollow in the mold; it is removed before casting. Also called a master or master form.

MEDIEVAL: Of, pertaining to, or characteristic of the Middle Ages, approximately 400 A.D. to 1500 A.D.

MINIMALISM: An art form in which all superficial detail has been removed. The reduction of chromatic expression to near invisibility occurred in the 1960's with the black canvases of Ad Reinhardt.

MOBILES: A kinetic form of sculpture which is usually suspended from the ceiling and movement is caused by air currents or electric motors. Alexander Calder invented the art form and Marcel Duchamp named it mobile.

MONEL METAL: An alloy that consists of sixty-seven per cent nickel, thirty per cent copper, and small percentages of iron, manganese, carbon, silicon, and sulphur. Monel is highly resistant to corrosion and can be soft and silver soldered, welded, and brazed.

MONOLITH: In order to fully define monolith, it is necessary to break the term into its component parts, mono refers to one, and lith refers to stone. From the preceding, one would logically derive single-stone. Such sculptures as Easter Island's stone images and Egypt's pharoahs were strenuously carved from solid stones or boulders with primitive tools. The resultant sculpture was very stable and strong in appearance. It was this strong appearance many artists sought to emulate; consequently, the term monolith came to refer to the strong, stable appearance.

NEGATIVE SPACE: In sculpture, that space designed in the sculpture but not filled with a solid material. Utilizing voids so as to replace solids. Also called negative area or pierced form. Archipenko was the inventor of this idea in contemporary sculpture.

NON-OBJECTIVE: An approach to art in which the visual signs are entirely imaginative and do not derive from anything ever seen by the artist. The shapes, their organization, and treatment by the artist are entirely personalized and, consequently, not associated by the observer with any previously experienced natural form.

OPEN MOLD: A mold with a large portion of the cavity exposed to the air, allowing gas to escape through the metal as opposed to a submerged mold which must incorporate some venting system.

OXIDIZING FLAME: A torch flame in which there is an excess of oxygen over gas. Usually recognized by blue color and a roaring sound.

OVERBURN COPY: Black or dark-colored lettering on a light part of a photograph or illustration.

PHYSICAL ELEMENTS OF ART: The five basic elements--line, shape, value, texture, and color--that are actually physically applied to a work of art. Some artists include space as an element.

PIECE MOLD: A mold constructed in sections so that it can be used repeatedly.

PINHOLE POROSITY: The condition of cast metals characterized by small holes in a cast due to the presence of gas in the metal during solidification, differentiated from porosity only be being smaller in size.

POROSITY: The condition of cast metals characterized by small spherical holes in a cast due to the presence of gas in the metal during solidification.

POST-STUDIO SCULPTURE: An art form which is conceived then executed in a pertinent location, but not in a studio. Such work does not require the skilled hands of the artist; therefore, it could be built by anyone. Carl Andre, the first confessed post-studio artist described his work as atheistic, materialistic, and communistic.

POURING BASIN: A funnel opening usually shaped of sand in which melt is poured into the sprue or downgate. Also called pouring funnel.

PRINCIPLES OF ORGANIZATION: These are the methods of application of the physical elements of art. Some of the more commonly used principles are repetition, rhythm, harmony, variety, elaboration, simplicity, contrast, dominance, space, balance in composition, balance of various differing principles (examples: elaboration-simplicity, harmony-variety) and balance in the elements (examples: value, light-dark; color, bright-dull; texture, rough-smooth). See Chapter III for a discussion of each principle of organization.

PYROMETER: A device used to measure the extremely high temperatures of molten metal.

READYMADE: Seitz said, "According to the only definition of art Duchamp will accept as true for all times and places, all man-made objects are works of art. The readymade, therefore, was for Duchamp a form of denying the possibility of defining art." Duchamp created the first readymade by having a bicycle wheel attached to the seat of a stool in 1913.

REDUCING FLAME: A torch flame in which there is an excess of gas over oxygen. Usually recognized by the yellow color and smut floating in the air around the flame.

SCHOOL OF ART: A group of artists joined to solve a particular problem in art and produce works of art relevant to the problem. An example would be the Impressionists who were interested in utilizing newly found concepts in vision to depict the radiant visual quality of reflected light.

SCUMBLED: In painting, a gradual transition of two adjoining color shapes. Also called a soft edge that could be contrasted with a hard edge. Hard edge is defined as having a distinct difference between two adjoining shapes.

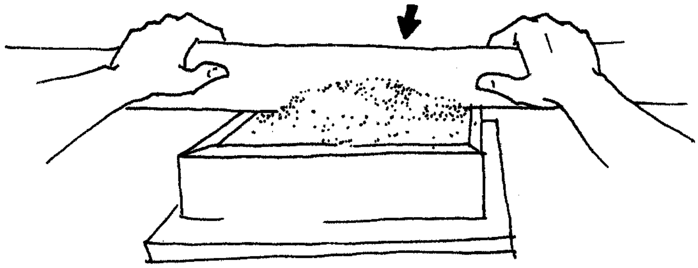
SLAG: A waste product taken off of molten metal during melting in the form of scum (a granular oxide). Also called dross.

SODIUM SILICATE: A liquid chemical (Na_2SiO_3) which is used as an investment binder. Traditionally, carbon dioxide (CO_2) is injected into the investment to cause solidification.

SOLID CAST: A cast that did not incorporate the use of a core. The advantages of the solid cast are speed, simplicity and the probability of a superior cast. The disadvantages are the requirement of more metal and in the relief, the possibility of too much weight to hang on weak walls.

SPRUE: A passageway through which the melt enters the sprue system.

STRIKE OFF: To remove the excess sand from a flask by dragging a straight-edged board with both ends overlapping the flask sides.



SYRUP: The syrup used in the casting portion is commonly used for livestock feed. This syrup contains 48 per cent total sugars as inverted 79.5° Brix, so specified by the Texas livestock feed permit number 1182-1.

SYSTEMS SCULPTURE: In Hunter's <u>American Art of the 20th Century</u>, page 435, Haacke states:

A sculpture that physically reacts to its environment or affects its surroundings is no longer to be regarded as an object. The range of outside factors influencing it, as well as its own radius of action, reach beyond the space it materially occupies. It thus merges with the environment in a relationship that is better understood as a "system" of interdependent processes.

TEXTURE: The surface feel of an object or the representation of surface character. Texture is the actual and visual feel of surface areas as they are arranged and altered by man or nature.

VALUE: The tone quality of lightness or darkness given to a surface or an area by the amount of light reflected from it. Value is composed of shades and tints.

UNDERBITING: When a shape on the master pattern projects outward in a curved manner, the sand mold will usually crumble in the curved portion of the master pattern during the separation of the master pattern from the mold.

UNIQUE CAST: A cast in which the master pattern is burned out during the pouring of the melt; consequently, the original cannot be reproduced as it can be in most methods of casting.

BIBLIOGRAPHY

Books

Coleman, Ronald L., Sculpture, Dubuque, Iowa, William C. Brown Company, 1968.

Eliscu, Frank, Direct Wax Sculpture, Philadelphia, Chilton Book Company, 1969.

Feirer, John L., General Metals, New York, McGraw-Hill Book Company, Inc., 1959.

Feldman, Edmund Burke, Art As Image and Idea, Englewood Cliffs, New Jersey, Prentice-Hall, Inc., 1967.

Hale, William Harlan, The World of Rodin, New York, Time Life Books, 1969.

Hoffman, Malvina, Sculpture Inside and Out, New York, Bonanza Books, 1939.

Hunter, Sam, American Art of the 20th Century, New York, Harry N. Abrams, Inc., 1971.

Maillard, Robert, editor, Dictionary of Modern Sculpture, New York, Tudor Publishing Company, 1960.

Mayer, Ralph, The Artist's Handbook of Materials and Techniques, New York, The Viking Press, 1970.

Neumann, Robert Von, The Design & Creation of Jewelry, Philadelphia, Chilton Book Company, 1961.

Ocvirk, Otto G. and Robert O. Bone, Art Fundamentals, Dubuque, Iowa, William C. Brown Company, 1968.

Rich, Jack C., The Materials and Methods of Sculpture, New York, Oxford University Press, 1967.

Rothschild, Norman, Making Slide Duplicates, Titles and Filmstrips, New York, Universal Photo Books, 1962.

Seitz, William C., The Art of Assemblage, New York, Doubleday and Company, Inc., 1961.

Smith, Edward Lucie, Late Modern the Visual Arts Since 1945, New York, Frederick A. Praeger, 1969.

Struppeck, Jules, The Creation of Sculpture, New York, Henry Holt and Company, 1952.

Untracht, Oppi, Metal Techniques for Craftsmen, New York, Doubleday & Company, Inc., 1968.

Articles

Fuller, Mary, "San Francisco Sculptors," Art in America, 52 (June, 1964), 52-59.

Jacobs, Jay, "The Artist Speaks: David Von Schlegell," Art in America, 56 (May-June, 1968), 50-58.

Weinrib, David, "Sculpture," Time, 91 (February 9, 1968), 40-45.

Unpublished Materials

Fitzpatrick, Barney Stewart, "Techniques of Casting Sculptures Using the Full Mold Process," unpublished master's thesis, Department of Art, Stephen F. Austin State University, Nacogdoches, Texas, 1971.

Roach, Michael N., "The Relationship of a Model of Audio-Visual Perception and a Selected Communication Model as a Function of a Filmstrip Design," unpublished doctoral dissertation, Department of Education, North Texas State University, Denton, Texas, 1970.

Patents

The Full Mold Process® was granted U.S. patent number 2,830,343 to Harold F. Shroyer in 1958, and eventually licensed to the Full Mold Process Company, Lathrop Village, Michigan.