# INTEGRATION OF SELECTED WOOD-JOINING TECHNIQUES INTO THE DESIGN AND PRODUCTION OF MULTIMEDIA SCULPTURE

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A THESIS

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# CHAPTER I

# INTRODUCTION

## Statement of the Problem

The problem of this study was to integrate, both technically and aesthetically, selected assembly type wood joining techniques into the design and production of multimedia sculptures to be developed by the researcher.

## Purpose of the Study

The purpose of this study was to create a selective series of modified wood joining techniques that could be integrated, technically and aesthetically, with the design and structure of multimedia sculpture.

## Justification for the Study

The justifications for this study were as follows:

A. The limited documentation concerning the production of multimedia sculptures that utilized selected wood joining techniques justified further exploration and study.

B. There was an insufficient amount of documented research completed in the area of sculpture concerning the integration of these wood joining techniques into the design and structure of a multimedia sculpture. This fact further motivated the researcher to investigate the technical and aesthetic components of the proposed study.

C. There was a need for the documentation of the research to provide information for the researcher and other interested individuals with an emphasis on methods of aesthetically incorporating the selected wood joining techniques into the design of multimedia sculpture.

D. There was a need to produce sculptures that used selected wood joining techniques which had been technically and aesthetically integrated into the design. This need existed to open new fields of artistic expression for the researcher and for other persons who might have read this research document.

E. Further justification for the study was the creative statement made by the researcher during the completion of the research and experimentation. The creative statement concerned the aesthetic use of wood joining techniques in the production of multimedia sculpture.

## Delimitations

The researcher did not cover all of the wood joining techniques which have been developed and documented as such research was too exhaustive and expensive.

The researcher used selected wood joining techniques integrated technically and aesthetically, into the design and production of multimedia sculptures. The wood joining techniques were modified to meet the design criteria of the artist. The modifications were also used to supply additional strength in the joint or to facilitate the production of the physical joint in the selected media.

The study was conducted according to the following delimitations:

I. The wood joining techniques included:

  A. Slip Joint or End Mortise and Tenon

  B. End Lap Joint

  C. Cross Lap Joint

  D. Any combination of the listed wood joining techniques for the creation of methods adapted to the production of the sculptures in the selected media.

II. The researcher used the following materials:

  A. A variety of dimensioned lumber and rough cut wood.

    1. Dimensioned Lumber

      a. 2 by 12 inch Oak

      b. 1/4 by 18 inch Zebrano wood

      c. 4 by 4 inch cedar

      d. 4 by 6 inch cedar

2. Rough cut wood
    a. 7 1/2 by 9 inch untreated oak timbers
    b. 3 1/2 to 4 1/2 inch diameter treated fence posts
    c. 2 to 2 1/2 inch diameter treated fence posts
3. This lumber was bought at Payless Cash-ways Lumber Yard and The Woodpile in Dallas.

B. Various types and forms of metal
1. Brass and bronze
    a. 16 gauge sheet brass
    b. 16 gauge Phospher Spring Bronze
    c. 1/16 and 1/8 inch diameter brass rods
    d. The brass and bronze was purchased at McMurray Metals in Dallas, Texas.
2. Mild steel
    a. Plate steel
        (1) 1/8 inch thick plate
        (2) 1/4 inch thick plate
    b. Steel pipes
        (1) 3 inch outside diameter straight pipe
        (2) 3 inch outside diameter curved pipe

(3) 25 inch diameter straight pipe

(4) 3 inch outside diameter to 2 inch outside diameter pipe reducers

c. Steel tubing

(1) 4 inch by 4 inch square tubing

(2) 4 inch by 6 inch rectangular tubing

d. Steel rod and bar

(1) 1/4 inch diameter steel rod

(2) 5/8 inch diameter steel rod

(3) 1 1/2 inch diameter steel rod

(4) 3 inch diameter steel rod

(5) 4 inch diameter steel rod

(6) 1/8 inch thick by 1 1/2 inch wide steel bar

(7) 1/2 inch by 1/2 inch square steel bar

e. Steel fasteners

(1) 1/2 inch diameter lag screws

(2) 5/16 inch diameter lag screws

(3) 3/8 inch diameter lag screws

(4) 1/2 inch diameter threaded rod

(5) 1/2 inch nuts

f. Welding electrodes

(1) (AWS) E6011 welding electrodes were used because of high penetration.

(2) (AWS) E6013 welding electrodes were used for fill welding

g. The steel was purchased at

(1) Fulton's Recycling Yard located in Denton, Texas

(2) Hoop's Machine Shop located in Denton, Texas

(3) Winningham Iron and Metal located in Waxahachie, Texas

(4) Lawson Brother's Steel located in Midlothian, Texas

C. Commercial adhesives

1. Titebond wood glue

2. Duro Epoxy

3. The adhesives were purchased at The Woodpile located in Dallas, Texas

III. The researcher used the following tools

A. Assorted hand tools

1. Wood chisels

2. Wood rasps and metal files

3. Jewelers saw, hack saw, and dovetail saw
4. Miter box and back saw
5. Hammers: ball peen hammer, sledge hammer, plastic hammer, riveting hammer, rawhide mallet, and wood mallet
6. Clamping devices: C clamps, pipe clamps, vise grips, C clamp vise grips, and bar clamps
7. Measuring devices: tape measure, 4 foot yard stick, carpenter's protractor, sliding caliper, carpenter's square, tri square, T-bevel square
8. Planes and forming tools: jack plane, rabbet plane, bullnose plane, surform rasp, and sculptor's adze

B. Hand power tools

1. 7 1/2 inch circular saw
2. Electric chain saw
3. 3/8 inch chuck drill motor
4. Portalign drill stand
5. Finishing sander
6. Belt sander
7. Electric power planer
8. High speed router

9. Disc grinder--7 inch diameter disc
10. Disc grinder--4 1/2 inch diameter disc
11. High speed die grinder
12. Dremel flexible shaft tool

C. Power tools available at Texas Woman's University in Denton, Texas

1. Horizontal band saw
2. Vertical band saw
3. Drill press stand
4. Metal turning lathe
5. Electric arc welder
6. Oxyacetylene cutting torch
7. B-tank soldering torch
8. Stationary belt sander
9. Stationary disc sander

D. During the development of the modified wood joining techniques and multimedia sculptures, the researcher used those tools necessary for the study.

IV. The researcher used the following reference sources:

A. Literature

1. <u>Complete Book of Woodworking</u> by Rosario Capotosto

2. _Woodworking Technology_ by James J. Hammond and others

3. _A Yankee Way With Wood_ by Phyllis Meras

B. Resource person: Finis P. Turner, Industrial Arts Instructor Waxahachie High School

C. Resource Institutions

1. Dallas Museum of Fine Arts

2. Nicholas P. Sims Library, Waxahachie, Texas

3. University of Texas at Arlington Library

4. North Texas State University Library

5. Texas Woman's University Library

6. U.S. Department of Agriculture, Forest Products Laboratory

V. This study and experimentation was done in

A. The studio and sculpture areas at Texas Woman's University

B. The researcher's residence in Waxahachie, Texas

VI. The research was set up within a budget which had to be exceeded.

VII. At the conclusion of this study the researcher presented an exhibit of the developed sculptures to include not less than eight sculptures.

VIII. The sculptures varied in size from those which could be effectively displayed on a pedestal to larger sculptures displayed on the floor.

IX. The researcher did not copy all of the wood joining techniques described in this paper.

X. The wood joining techniques functioned to effect changes or contrast within the work. However, all of the contrasts or changes were not used in each individual sculpture. The researcher was selective and reserved the prerogative to use each in order to execute his ideas for the design of each particular sculpture.

XI. The researcher made minor changes in the selection of the materials, and not all of the listed materials appeared in each and every work.

XII. This paper did not deal to any great extent with the numerous methods for finishing woods, metal, or plastics.

XIII. All techniques and findings discovered through this research were presented in a study upon completion of the experimentation and research.

## Definition of Terms

1. Adhesive--compounds used for joining two or more similar or dissimilar materials together (M. J. Bryant, 1981).

2. Auger Bit--a general classification of wood bit used for boring round holes in wood. Each bit consists of a screw, a spur, a twist, and a shank (Woodworking Technology, 1972).

3. American Welding Society (AWS)--society involved in improving the specifications and methods of classifying electrodes and filler rods. Electrodes are designed to meet the needs of each welding application.

4. (AWS) E6011--a number designation for a specific welding electrode which has a tensile strength of 62,000 p.s.i.

5. (AWS) E6013--the number designation for a welding electrode which has a tensile strength of 67,000 p.s.i. Both of these welding electrodes can be used in all positions and have mild to deep penetration qualities (Welding Principles and Practices, 1981).

6. Cross Cut--a saw cut made across the grain of a piece of wood (M. J. Bryant, 1982).

7. Cross Lap Joint--an interlocking joint used to change direction in which two members usually of equal thickness are joined. Half the thickness of each is cut away so that when lapped together a thickness equal to that of one member is formed (Woodworking Technology, 1972).

8. Design--the art of combining the visual elements (such as line, direction, shape, size, texture, value, and color) and/or physical materials (i.e. wood, metal, plastics) into a three dimensional sculpture or wall relief (M. J. Bryant, 1977).

9. Dimensioned Lumber--lumber which is two to five inches thick and includes strips, boards, and framing members (studs, joists, and rafters); dimensioned lumber is graded by length and the condition of that length (Woodworking Technology, 1972).

10. Electrician's Auger Bit--an auger bit 18 inches long used to bore holes through thick beams (M. J. Bryant, 1982).

11. End Lap Joint--two members of approximately equal thickness and usually of the same width are joined in a modified type of butt joint to extend length or to change direction. Half the thickness of each member is cut away so that when lapped together a thickness equal to that of one member is formed (Woodworking Technology, 1972).

12. Groove Cut--another name for a plough cut (M. J. Bryant, 1982).

13. Integration--to bring parts together in a whole; unify (Webster's New World Dictionary, 1969). For the purpose of this study the integration was concerned with the

unifying of the selected wood joining techniques and resulting fabricated joints with the design and materials of multimedia sculptures. The modified wood joint functioned to fasten various materials together so that the joint became a part of the design of the piece. The joint was modified to repeat shapes and forms within the sculpture and facilitated in changes and contrasts within the sculpture (M. J. Bryant, 1977).

14. Media--the physical material or materials used to construct a single sculpture (M. J. Bryant, 1977).

15. Mild Steel--steel containing only a small percentage of carbon (less than 0.35 per cent) (*The World Book Encyclopedia Dictionary*, 1965).

16. Mitre Cross Lap--a cross lap joint in which the cross lap is cut at an angle instead of straight across the grain of the wood (M. J. Bryant, 1982).

17. Mortise--a notch or hole cut, as in a piece of wood, to receive a projecting part shaped to fit (*Webster's New World Dictionary*, 1969). The mortise is the female part of a mortise and tenon joint (M. J. Bryant, 1977).

18. Multimedia Sculpture--sculpture constructed using two or more different materials (i.e. wood combined with mild steel). The materials for this study included the combination of wood with bronze, brass, steel, or acrylic plastics (M. J. Bryant, 1977).

19. Multi-spur Bit--a wood bit used for boring round holes in wood. This bit consists of sawteeth cut into the rim, a single cutter, a spur center, and a shaft (Woodworking Technology, 1972).

20. Plough Cut--a square groove cut with the grain of a piece of wood. The cut has two sides and a bottom to form a channel in the wood (Woodworking Technology, 1972).

21. Rabbet--a recess cut along the end or edge of a board. The recess is usually one-half to two-thirds the thickness of the stock (Woodworking Technology, 1972).

22. Rip Cut--a saw cut made along the grain of a piece of wood (M. J. Bryant, 1982).

23. Rough Cut Lumber--lumber which is cut or shaped at the saw mill only. Rough cut lumber may vary in dimensions as much as one inch. The lumber is not jointed or dimensioned (M. J. Bryant, 1982).

24. Selected Wood Joining Techniques--those techniques employed in this study (i.e., end lap, cross lap, and slip joint) (M. J. Bryant, 1977).

25. Slip Joint--an interlocking wood joint in which the tenon fits into a mortise cut in the end of a board. This joint can function to extend length or change direction of the stock (M. J. Bryant, 1977).

26. Tenon--a projecting part cut on the end of a piece of wood for insertion into a mortise to make an interlocking wood joint (Webster's New World Dictionary, 1969). The tenon is the male part of a tenon and mortise joint (M. J. Bryant, 1977).

27. Timber--a piece of lumber five inches or larger in its smallest dimension (Woodworking Technology, 1972).

28. Wood Joining Techniques--the methodology used to construct one of the ten or twelve basic wood joints or the several varieties of these basic joints (Woodworking Technology, 1972).

29. Woodworking Joint--the place or part in which two separate pieces of wood are joined either rigidly or so as to permit motion (Woodworking Technology, 1972).

# CHAPTER II

## REVIEW OF RELEVANT LITERATURE

The process of attaching two or more pieces of wood together through the use of a wood joint can be traced back to ancient civilizations. From primitive beginnings wood joints have evolved to the point that there is a different wood joining technique for every conceivable need. Furthermore, these wood joining methods have been used in virtually every type of woodworking profession. The more common areas generally associated with wood joining techniques include architecture and the woodworking trades. Sculpture has been associated with these wood joining techniques to a much lesser extent.

> By definition a woodworking joint is the place or part in which two separate pieces of wood are joined, either rigidly or so as to permit motion. There are ten or twelve basic joints; however, the varieties of these basic joints number more than twenty-four.[1]

Some of the familiar joints include lap joints, cross lap joints, and slip joints (end mortise and tenon). These were the joining techniques chosen for the study. The joints

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[1]James J. Hammond et al., Woodworking Technology (Bloomington: McKnight and McKnight Publishing Company, 1972), p. 272.

were chosen for their simplicity and because the researcher felt that these joints fit the design concepts used during the completion of the study.

There are two basic methods of producing wood joints: the "lay-up type" and the "assembly" type. The "lay-up" types of wood joints are used for building up the dimensions of stock. Lamination is a good example of the "lay-up" type of wood joining technique. Sculptors have used this method extensively. The "assembly" type of joining techniques are used in fabricating members which have been cut to specified shape and dimension. These "assembly" joining techniques are used to extend the length or change the direction of the stock. An end lap is an example of an "assembly" type woodworking technique. These types of wood joining techniques have not been thoroughly explored within the field of sculpture. The design of the basic joints combined with possible design modifications fit the researcher's ideas for the study. The researcher was primarily interested in methods of extending the length and changing the direction of the stock. The "assembly" types of joints was the most expedient choice.

Within the field of architecture, both methods of construction have been employed. From a concentration of ornamental embellishments, building techniques and design concepts have experienced considerable change. Construction techniques have evolved to keep up with the diverse and increasing list of building materials. This evolution of materials and techniques has been responsible for architectural philosophy as it exists in contemporary society.

In the period known as the grand style,

> the older school of builders confined itself to plans for public buildings and mansions for the upper classes. With undiminished skills these men decorated their buildings with odds and ends from the past. These architects tacked onto their buildings facades which consisted of Greek and Roman motifs done in wood, cast iron, or plaster. In their hands, architectural design became synonymous with ornamentation.[2]

This school of architecture was obsessed with creating imitations of the great buildings and temples of past civilizations. In their zeal to accomplish this task, they covered and concealed the building techniques used in the construction. Facades were utilized to conceal beams and girders along with any of the joining techniques employed in the skeletal framework of the building.

It was at the opening of the Crystal Palace in 1851 that this philosophy began a transition into a new era. Designed by Josephy Paxton, the structure was constructed of prefabricated cast iron sections and glass panels. The assembled panels were bolted together, and no attempt was

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[2]John Peter, <u>Masters of Modern Architecture</u> (New York: George Braziller, Inc., 1963), p. 14.

made to cover the construction techniques which had been employed. This innovation, thrust upon a society accustomed to elaborate facades, was not readily accepted.

In America, the new style was beginning to appear in the buildings of Louis Henri Sullivan. He believed function implied more than mere mechanical efficiency and his statement, "form follows function," was to become the watch-word for a new generation of architects to follow.

Sullivan, along with other architects from the Chicago School, was responsible for a transition in the design of architecture. From tacked on facades, architectural concepts changed to reflect Sullivan's beliefs. Buildings were designed so that there was no attempt to cover either the materials or the techniques used in the construction. One of Sullivan's notable designs is the Wainwright Building in St. Louis. This building, built in 1890-91 is considered to be the first example of a skyscraper. The building was designed in such a way that the materials stand in harmony with the overall design. Only the very top story stands apart as a result of the varied decorations which were added. Another example of Louis Henri Sullivan's work is the Guaranty Building in Buffalo. This building was constructed in 1894-95 and best exemplifies Sullivan's philosophy of "form follows function."

Sullivan did not imply something merely mechanical in this statement; rather, he was interested in the vital spirit of the building. Well-designed buildings and well-designed materials should be united into a well-designed unit. Facades to cover materials and mask building techniques were not necessary.

One of Louis Henri Sullivan's students was Frank Lloyd Wright. Wright, like Sullivan, believed that materials should stand by themselves and that no attempts should be made to cover or mask either the materials or the techniques used in the construction. In the buildings and designs produced by Wright, the philosophy of his teacher was further developed. It was Wright who has been credited with being the only practicing modern architect of the 1900's in America.

During the first decade of the twentieth century, Wright made several trips to Japan and the Japanese methods of construction were to have a profound effect on his career. Wright saw in the Japanese home a simplicity of materials and function that he assimilated into the design of many of his buildings. This Japanese influence is evident through Wright's use of exposed beams and large overhanging gables with exposed joints. Wright was a revolutionary in that he let materials stand by themselves. This concept of utilizing materials and techniques which stood out within a structure was to have profound influence in the field of architecture.

Wright emphasized wood in many of his house designs and the wood joining techniques were sometimes left exposed. He employed the joints as a secondary element to the entire design. They became a complement to the structure.

The woodworking trades is another field which utilizes wood joining techniques. This field employs a greater number of the wood joining techniques than any other profession. Furniture manufacture is a good example of a woodworking profession which uses many of the wood joining techniques.

One method of construction used in this field includes the use of "assembly" type joining techniques. The process includes the fabrication of a frame for a piece of furniture. The builder fabricates the frame from dimensioned lumber. The lumber is marked and cut to specific measurements then assembled. The framing is sometimes covered with some type of veneer. Once this veneer has been added, the joints are completely covered and thus hidden from view. Some woodworkers make arduous attempts to completely cover all of the joining techniques used in the fabrication of the piece.

With the invention of new building materials, construction techniques have changed. Large 4 by 8 foot sheets of stock such as plywood are of sufficient strength to stand without the use of a frame. Generally, the joints are so constructed that when the piece is completed the wood joints remain hidden from view. In most common construction techniques, the wood joints remain so well hidden that the object gives every appearance of being constructed from one continuous piece of wood.

There has occurred within the field of furniture design a change in the concepts used for construction. In some contemporary furniture, the wood joints are left exposed. For example, pegging is used to effect a contrast within the work. The peg is made of a contrasting material. Another example is the lamination of sheets of plywood to affect a contrast in color. However, even when such techniques are used, the finished product still serves a utilitarian purpose. The primary function of joints remains the attaching of two materials together. The joints are used to extend the dimensions of the stock or to assemble members which have been cut to specified lengths and configurations.

Based on related study, the researcher found that wood joining techniques have not been fully explored in the field of sculpture. As the study progressed, it was discovered that little consideration had been given to the "assembly" type wood joining techniques. Sculptors have preferred to concentrate on the more traditional processes such as carving or casting. Most of the books which the researcher was able to secure all but delete the "assembly" type of wood joining techniques from the text.

Even those authors who dealt with joining techniques did so in a very traditional manner. The most common wood joining techniques which were documented in sculptural text are pegging and laminating. Pegging could be considered an "assembly" type of wood joining technique. Laminating is considered a "lay-up" process.

In the process of pegging, holes are drilled through all of the pieces of stock being joined. A wooden dowel is inserted and glued into these holes, thus bonding the materials together. In some instances, a plug of the original wood is inserted on top of the shortened dowel in order to cover the joining technique. Another method of joining used in sculpture is laminating. Laminating is the process of gluing stock of predetermined dimensions together in order to obtain a larger and stronger piece of material. The pieces are clamped together while the glue dries. This process might also be used to effect changes in color or texture. For the most part, the resulting material is carved using the traditional subtractive approach. The main objective of the joining technique employed was to secure a larger piece of material. Little consideration has been given to the additive process or to assemblage types of sculptures.

It was the intent of this research and researcher to consider wood joining techniques as they are used to fasten materials together. The wood joint would serve to extend the length or change the direction of the stock. Just as important was the consideration of the aesthetic design which went into the work. The researcher modified selected wood joining techniques and integrated the resulting joints with the overall design of a series of multimedia sculptures. It was the intent of the researcher that this manuscript would serve as a guide to improve the understanding of the processes used in the fabrication of the sculptures. It was also intended that the modified wood joining techniques would be a process the researcher could use to design and develop methods of constructing multimedia sculptures.

Sculptors oftentimes draw ideas for their work from pieces or segments of a whole object. Because of the enjoyment of assemblage and construction, the combination and synthesis of divergent materials both intrigued and challenged the researcher as a sculptor. This study helped in the development of ideas and concepts which can be assimilated into assemblage types of sculptures. The researcher developed a simple technology which could be modified to meet the needs of the researcher. It was also hoped that the research would be of benefit to other persons interested in the concepts embodied in the paper.

## CHAPTER III

## METHODS AND PROCEDURES

From the beginning, the researcher directed the study toward a technology of very complicated joints. The modified wood joints were an assemblage of various parts fabricated from metal and wood. The components were assembled to form the complete sculpture.

The first sculpture constructed for the study was a small piece called "dvwkyit." This sculpture was constructed of Phosphor Spring bronze and dimensioned oak. The bronze segment of the sculpture was constructed using traditional metalsmithing techniques. The oak unit was matched to the bronze.

The bronze shape was fabricated from ten individual pieces cut with a jeweler's frame saw. Three curved sections were formed by bending and hammering 1 1/2 inch strips around a 1 inch hardwood dowel. The ends of each of the curved sections were trimmed so that a 1 inch semicircle was left. The three semicircles were soldered to a flat strip of the bronze. This strip measured 1 1/2 inches by 7 1/2 inches. The middle sections of bronze were trimmed and filed to the edges of the three semicircles. The ends of the bronze strip were not trimmed. This unit was soldered to a curved strip of bronze 1 1/2 inches by 13 inches long. The ends of the straight strip of bronze were cut and filed to match the edges of the 13 inch curved piece. This fabricated bronze strip formed the perimeter for the metal portion of the sculpture. The sides of the bronze unit were cut out of the sheet bronze. Each side was cut oversized to minimize the chances of ruining the bronze section when the sides were soldered to the perimeter. Each side section was soldered in position and trimmed of excess metal separately. Some preliminary filing and polishing was done at this time.

The wood components were cut from 2 inch by 12 inch dimensioned oak. The pattern for the shapes was traced directly onto the wood. The centerpoints for three 1 inch holes were marked and the holes were bored with a 1 inch multispur wood bit. The centerpoint of the first hole was marked 1 7/8 inches from the edge of the oak shape. The centerpoint for the middle hole was marked 1 5/8 inches from the first centerpoint. The third centerpoint was marked 1 5/8 inches from the second centerpoint. All of the centerpoints were marked so that one half of each of the bored holes laid on the waste side of the shape. In addition to the primary shape traced on the wood, six secondary shapes were traced and then marked for drilling. The centerpoints for 1 inch holes were marked at the top edge of the secondary shapes. A 1 inch multispur wood bit was used to bore these secondary holes. One half of each of the resulting holes laid on the waste side of the shape. After all drilling had been completed, the individual shapes were cut out with a vertical band saw. Some preliminary shaping was done with a disc sander. The oak shapes were assembled, glued, clamped, and set aside to dry.

After the glue dried, the bronze and oak components were prepared for assembly. The researcher used various grits of abrasive papers stapled to a hardwood dowel, 1 inch by 6 inches long, for extensive sanding and shaping. This simple tool was used to control the contour of the semi-circles which had been bored in the wood and fabricated for the bronze segment of the sculpture. Flat files and planes were used to adjust the fit between the wood and the metal where necessary. Gradually a satisfactory fit was obtained between the bronze and oak components. When the bronze unit was properly aligned on the oak shape three holes 1 inch in diameter were formed. One half of each of the three holes was composed of oak while the other half was formed by the bronze shape. A plexiglass rod, 1 inch in diameter, was cut into three 3 inch lengths. The plexiglass dowels were

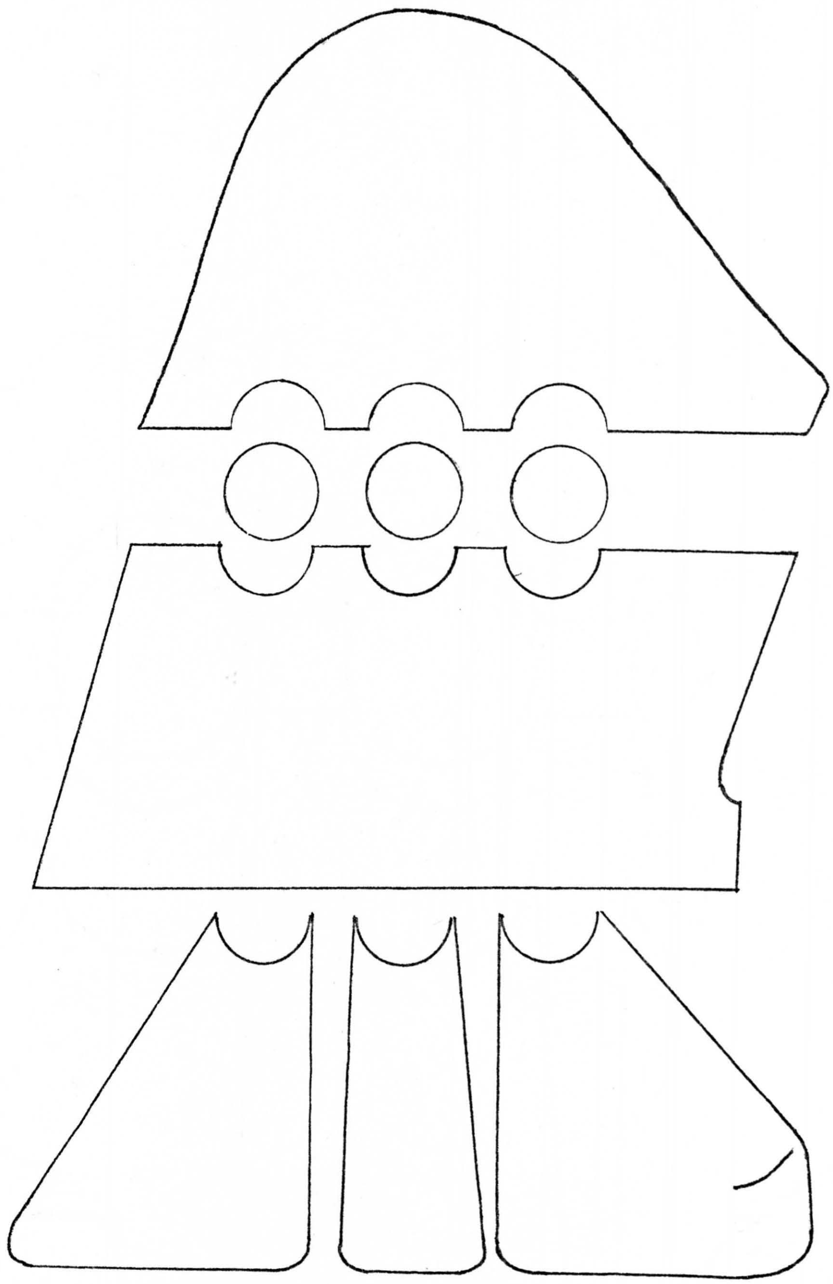

Fig. 1 Schematic of components used to construct oak and bronze "dvwkyit": a. fabricated bronze unit, b. one inch plexiglass rod, c. basic oak component, d. oak extensions glued to basic oak shape.

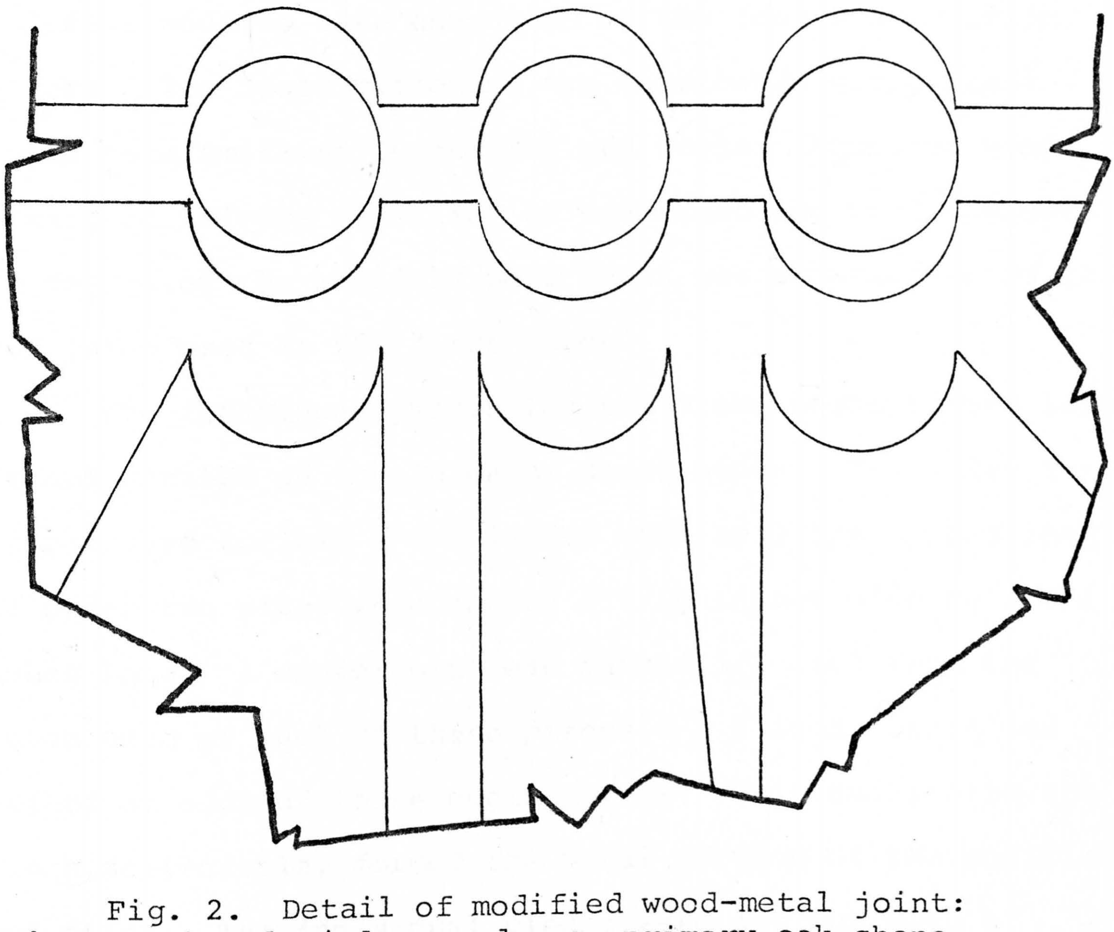

Fig. 2. Detail of modified wood-metal joint: a. bronze, b. plexiglass rods, c. primary oak shape, d. secondary oak shape.

inserted into the three 1 inch holes formed by the modified wood joint. The entire sculpture was polished and assembled.

The next sculpture made was a tall cylindrical box the researcher titled "Linear Homage." For this box the researcher used 16 gauge sheet brass and Zebrano wood 1/4 inch thick. The Zebrano wood, commonly called Zebra wood, had been quartered-sawed to minimize warpage. The researcher used this wood to take advantage of the long linear grain pattern. The brass component was fabricated using traditional metalsmithing techniques and tools. Accepted woodworking techniques were used to construct the wood segment. The design of the modified wood joint was a variation of the wood joint used in the first piece.

The individual pieces for the brass segment were laid out and scribed on the 16 gauge sheet stock. Two sides for the box were scribed 1 7/8 inches wide by 3 3/4 inches long. The other two sides were marked 1 9/16 inches wide by 3 3/4 inches long. A centerpoint was marked 1/2 inch from the bottom edge of each of these pieces. A 1 inch circle was scribed at each of these centerpoints. This edge, with the 1 inch semi-circle, formed the metal portion of the modified wood joint. The individual pieces were cut out with a jewelers frame saw. Holes were drilled around the perimeter of the bottom edge of each side. The researcher used a number 42 high speed steel twist drill and a drill press to bore the holes. A total of forty holes were drilled: nine in each of the 1 9/16 incy sides and eleven in each of the 1 7/8 inch sides. The sides of the brass pieces were filed straight and square in preparation for soldering. Two sides of the box were soldered together to form an L-shaped unit. The remaining two sides were matched and soldered to form a second identical unit. The two L-shaped units were soldered together to form the metal portion of the box and the modified wood joint. The brass segment measured 1 9/16 inches deep by 2 inches wide by 3 3/4 inches tall.

The Zebra wood was cut into strips. Two of these strips were 2 1/8 inches wide. The other two strips were 1 3/8 inches wide. A centerpoint was marked 1 inch from the top edge of each of the strips. The researcher then drilled a 1 inch diameter hole in each of the strips at each of the centerpoints. All of the holes were bored 1/8 inch deep. The researcher used a 1 inch spade wood bit in order to drill a relatively flat bottom hole. A line was scribed across each of the wood pieces 1 inch from the top edge. This line was marked so that it intersected the centerpoint of each of the 1 inch diameter holes and was parallel to the top edge of the wood strips. A small back saw was used to make a cut 1/8 inch deep along each of the marked lines.

The vertical band saw was used to trim 1/8 inch of wood from the thickness of each of the strips. This cut was made from the top edge of each strip to the center line which had been cut on the strips. This procedure formed a 1 inch half-lap with 1 inch semi-circles in the Zebra wood strips. These modified half-laps formed the wood portion of the metal and wood joint.

After this task was completed, two rabbets were cut along both edges of each of the 2 1/8 inch strips. The rabbet cuts were made 1/8 inch deep. A 1/2 inch straight bit and a high speed router were used to make the cuts. The rabbet cuts were made on the inside edges of the 2 1/8 inch strips. The two 1 3/8 inch wide strips were glued to the 2 1/8 inch pieces along the inner edges of the four rabbet cuts. After being assembled the four strips formed a rectangular tube 1 5/8 inches deep by 2 1/8 inches wide by 18 inches long. At the top of this rectangular tube, the half-lap on each piece combined with the others to form a tenon 1 7/16 inches deep by 1 7/8 inches wide by 1 inch long. This tenon was inserted into the brass section of the box.

Both the brass and wood sections were sanded and filed simultaneously so that a cohesive unit was formed when the individual components were assembled. After all fitting was completed, the brass and Zebra wood units were sanded and

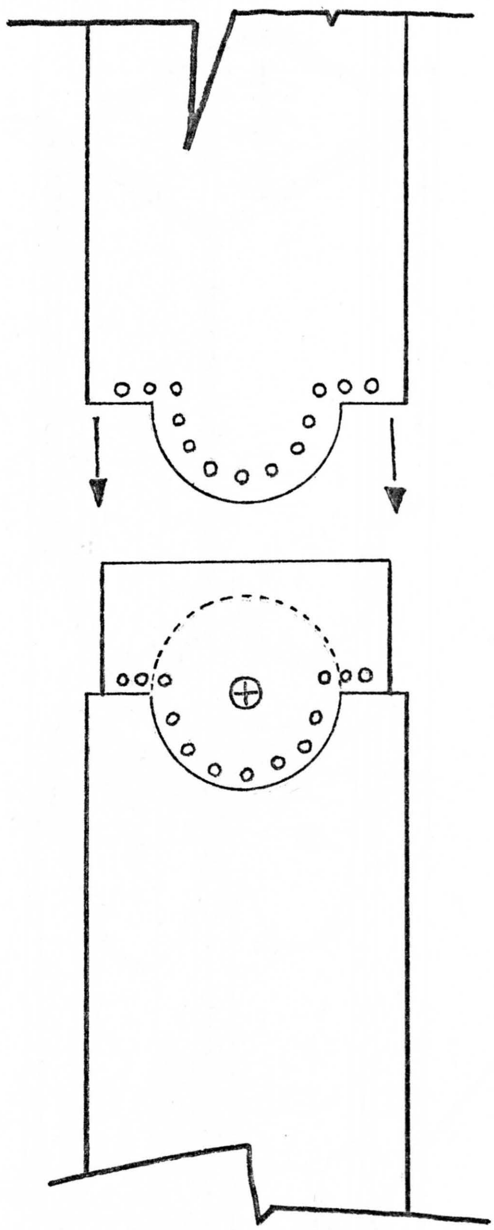

Fig. 3. Schematic of modified wood joining technique.

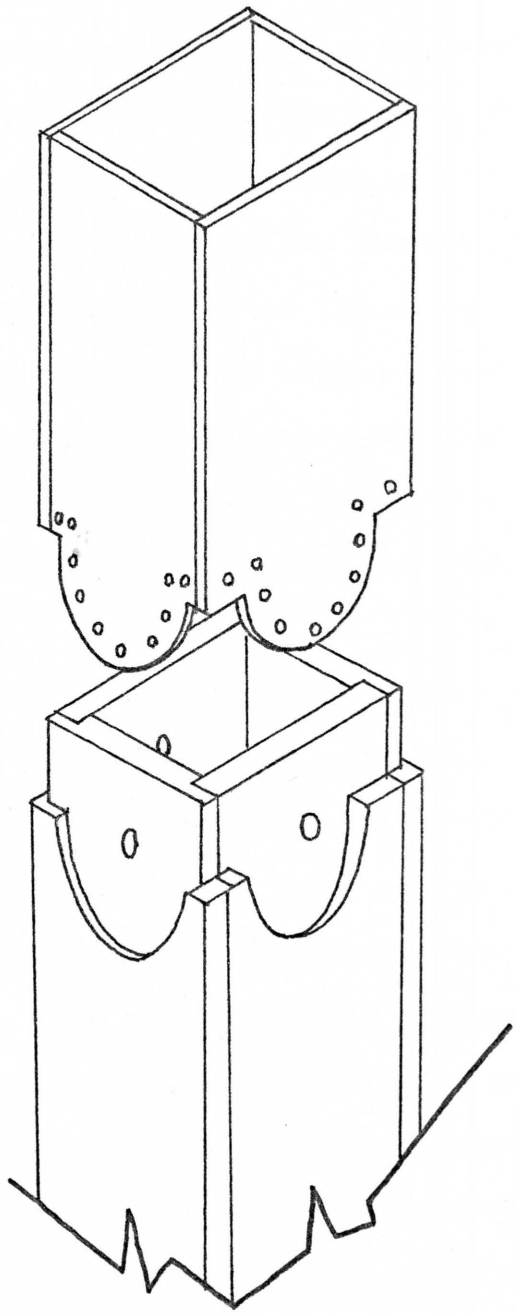

Fig. 4. Detail of wood joint brass and Zebra wood components.

polished to the desired finish. Last, the pieces were joined with brass rivets.

The next sculptures were fabricated from standard sized steel tubing. The beams used in each of these sculptures were common sizes available at commercial lumberyards. The researcher discovered that the dimensions of the lumber matched the inside dimensions of the steel tubing. This discovery made it necessary to change the design concepts. Either a simpler more direct method of joining metal and wood could be used or, the metal shapes needed to be fabricated from plate steel. Both of these changes were eventually used.

The researcher selected 4 by 6 inch rough cut cedar beams and 4 by 6 inch mild steel rectangular tubing. The walls of the steel tubing were 3/16 inch thick. The steel components for "As You See It" were constructed, using basic mathematical and geometric principles. The researcher used a table of mitres from Complete Book of Woodworking, a book written by Rosario Capotosto. The angles needed for each segment of steel tubing were taken from these tables. The curved shapes were based on an octagon, a plane figure with eight angles and eight sides. Using an adjustable T-bevel square and a protractor, the researcher scribed a line to mark the ends of each segment of tubing. Three segments, of equal length, were marked so that a 22 1/2 degree angle could be cut at the ends of each section. These mitres were canted toward the center of each individual segment. Two longer segments were scribed to complete the figure. The two longer segments were marked at a 22 1/2 degree angle at one end. The other end was scribed at a 90 degree angle. Five segments were needed to produce each steel unit. The mitre gauge on the horizontal band saw was set at 22 1/2 degrees. This saw was used to cut all of the mitres in the individual segments. After cutting was completed, the matched segments were welded with (AWS) E6011 welding electrodes and an arc welder. When welded, the five segments formed a semi-circle with extended ends. The extended ends were parallel.

After the steel shapes were welded, the researcher discovered that it was impossible to complete fabrication of the metal portions of the sculpture. The researcher was forced to remove the ends of the steel sections so that the fabrication could be completed. A center line was scribed on two opposite sides of the four arms. A center point for the top hole was marked on this line 2 3/4 inches from the top edge of the steel end. All of the center points for the holes were spaced 2 1/2 inches apart. The longer arms were marked in the same manner except that the top center point was marked 4 inches from the top edge and the center points were spaced 3 1/2 inches apart. After being marked, each piece was clamped to the table of a stationary drill press one at a time. The holes were cut in two sides of the tubing with a 1 1/2 inch high speed steel hole saw. The holes were cut at a quill speed of 250 rpms. Six holes were cut in the sides of the steel arms, three in each of the two opposite sides. A total of twenty-four holes were cut.

When this portion of the metal fabrication was accomplished, the cedar beams were cut with a mitre box and back saw. Four lengths were needed; two sections were cut 62 inches in length and two sections were cut 58 inches in length. After very minor planing the cedar beams were hammered into the steel sections with a five pound sledge hammer. With the addition of the wood to the steel, the piece was almost complete.

All that remained was boring 1 1/2 inch holes in the cedar beams and the fabrication of the lag screw pegs. The holes were bored into the cedar beam with a 1 1/2 inch multispur wood bit and a Portalign Drill Stand. Using the holes drilled in the steel tubing as guides, the portable drill stand was clamped in position on the tubing. The 1 1/2 inch holes were bored 2 inches deep. The modified lag screw pegs were fabricated from 1 1/2 inch mild steel

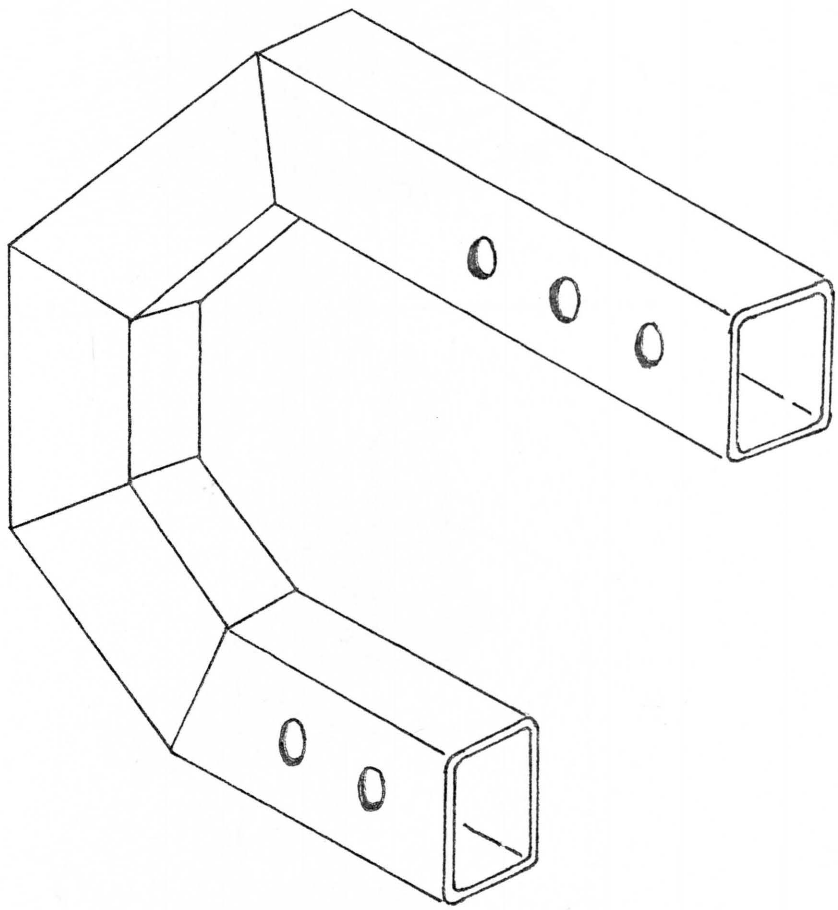

Fig. 5. Basic steel component for "As You See It."

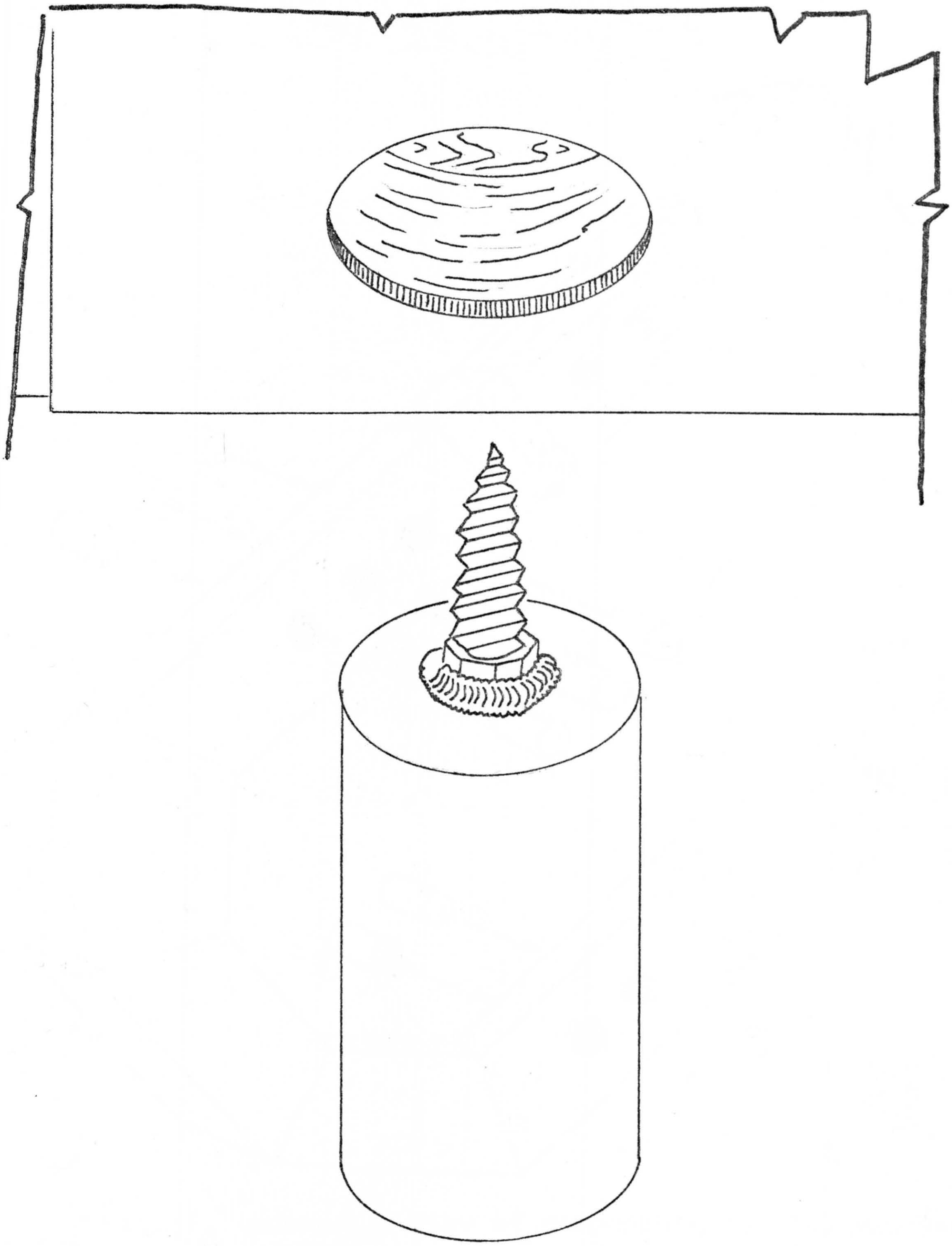

Fig. 6. Detail of lag screw peg.

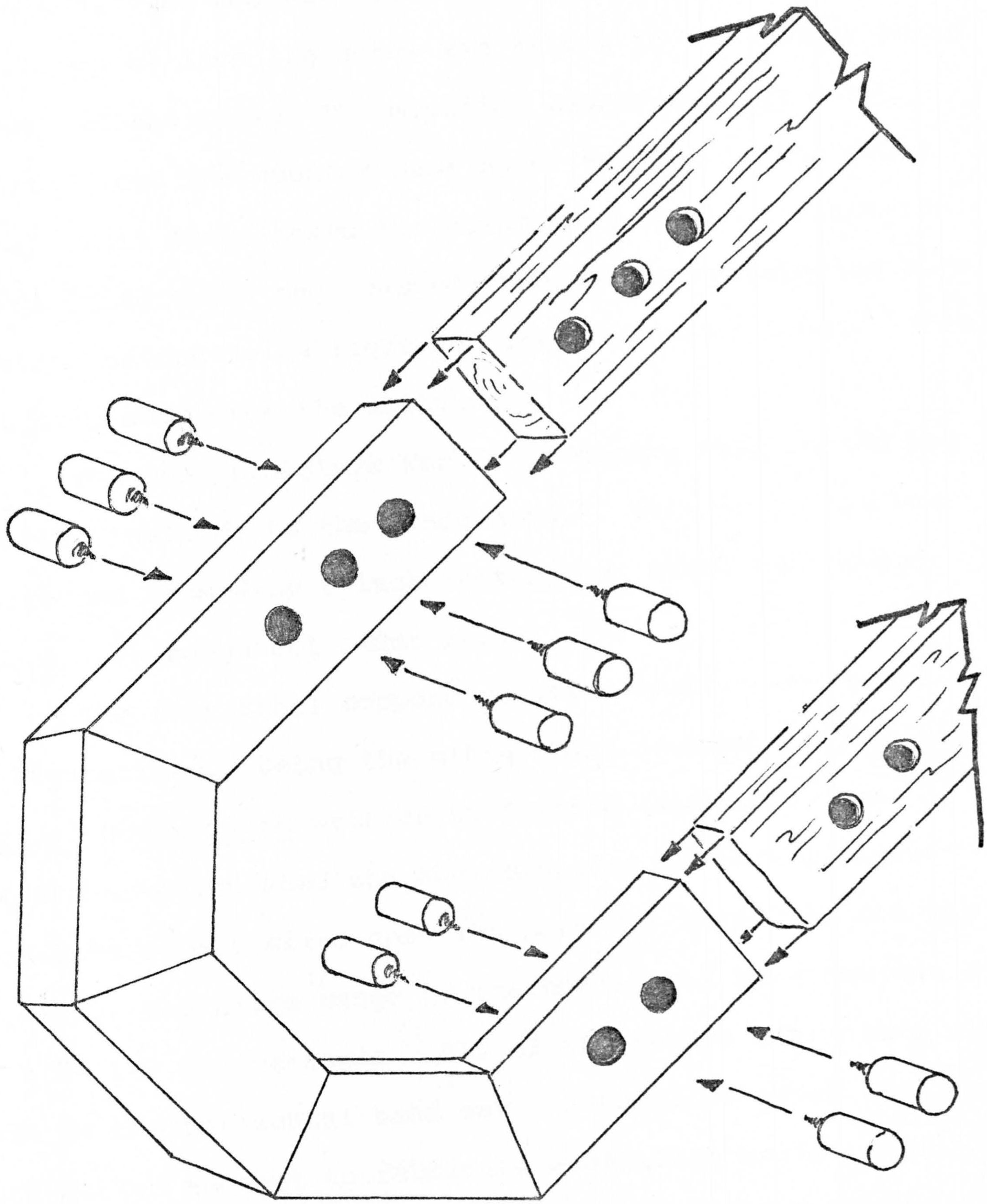

Fig. 7. Schematic view of components for "As You See It."

round rod. The rod was cut into 5 inch increments; then, a 1/2 inch by inch lag screw was welded to the center point of each of the rods. The modified lag screw pegs were inserted into the counter sunk holes drilled in the cedar beams. This step locked the components together since the modified lag screw pegs passed through the rectangular steel sections before being tightened into the cedar beams. This last step completed the sculpture.

The next sculpture worked on during this period was entitled "Welcome to the Hindu Arms." This sculpture was fabricated from 4 by 6 inch rectangular steel tubing and 4 by 6 inch rough cut cedar beams.

The four steel components were based on octogonal configurations. Using the mitre chart located in Complete Book of Woodworking written by Rosario Capotosto, the researcher calculated the angles needed to form a figure much like an oversized question mark (?) turned on its top or side. The mitre gauge on the horizontal band saw was set at a 22 1/2 degree angle. All of the needed mitre cuts were made on the horizontal band saw. A total of seven sections were marked and cut to fabricate each steel unit. Four segments of equal length were marked at a 22 1/2 degree angle at each end. The two opposing angles canted toward the center of the segment. One segment of the steel tubing was marked so that the 22 1/2 degree angles at each end were parallel to one another. The other two segments were marked at a 22 1/2 degree angle on one end. The other end was marked at a 90 degree angle. Three of the equal segments were used to form the major curve of a semicircle. The segment with parallel angles was used between the major curve and the remaining canted segment. The segments with one mitred end were used to extend the steel shape at the ends. One segment completed the semicircle and served as the base. The other segment completed the 90 degree angle extending vertically to the base line. The individual segments were aligned and arc welded with (AWS) E6011 welding electrodes and an electric arc welder. These welded components formed a major part of the steel portion of the sculpture.

As noted before, rough cut cedar beams actually measured 3 5/8 inches by 5 5/8 inches. This meant that the wood components could be fitted into the steel units with very little planing and shaping. Therefore, it was only necessary to cut the cedar beams into the proper lengths. Each of the cedar sections was cut with a 4 inch back saw and a mitre box. The wood was cut into three different lengths. Two pieces were cut 31 inches long. Two sections were cut 45 inches in length. Two segments were cut 54 inches long. A total of six lengths were cut.

After completion of the initial cuts, a plough cut was made into each side of all of the cedar lengths. The plough cuts were made with a high speed router and a 1/2 inch straight cut router bit. The researcher constructed a cutting jig thereby making it possible to control the position and length of each plough cut. With this jig clamped in position, the plough cuts were completed with the high speed router by making numerous passes along the edge of the cutting jig. To prevent damage to the router motor, the depth of the plough cut was increased in 1/16 inch increments with each pass. Eight passes were made to complete a 1/2 inch by 1/2 inch plough cut. Twenty-two plough cuts were made. Eight of the plough cuts were 16 inches long. The other fourteen plough cuts were 12 inches long.

After the plough cuts were made, 1/2 inch square steel rod was cut into eight pieces 16 inches long and fourteen pieces 12 inches long. A center line was scribed on one side of each length of steel rod. A set of center points were marked 1 inch from the bottom of the rod. A second set of center points was marked four inches above the first set. The center points in both sets were spaced 1 1/4 inches apart. Holes were drilled with a floor model drill press and a 1/4 inch high speed steel twist drill. The top of each rod was ground to match the rounded end of the plough cuts.

Oversized pegs were fabricated from 3 inch and 4 inch diameter round steel stock. The researcher cut this stock into 2 inch segments with the horizontal band saw. The surface of each piece was squared on a metal working lathe. In addition to this squaring, a 5/16 inch hole was drilled in the center point of the diameter of the rods. The heads were cut off 5/16 inch by 2 1/2 inch lag screws. These lag screws were inserted into the holes drilled in the rods. The lag screws were welded in place with an electric arc welder and (AWS) E 6011 welding electrodes. The researcher fabricated ten lag screws with 4 inch diameter steel rod heads and twelve lag screws with 3 inch diameter steel rod heads.

After these parts were fabricated, the 1/2 inch square rods were fitted into the matching plough cuts in the cedar beams. The beams were then hammered into the ends of the 4 inch by 6 inch rectangular steel components. The position of the square rods were marked; then, the cedar beams were removed. The researcher used each square rod as a template to mark the center points for a set of three holes in the steel tubing. These center points matched the bottom set drilled in the square rod. Three 1/4 inch holes were drilled with the Portalign drill stand and a 1/4 inch center drill. The center hole of the set was enlarged to 5/16 inch.

The cedar beams and 1/2 inch square rods were positioned in the ends of the rectangular steel tubing once more.

Using the top set of holes drilled in the square rods as guides, the researcher drilled corresponding holes in each of the cedar beams. These holes were drilled with the Portalign drill stand and a 3/16 inch high speed steel twist drill. The holes were drilled 1/16 inch undersize in order to obtain a friction fit when 1/4 inch diameter steel pegs were driven into the holes. These holes were drilled to a depth of 2 inches. A length of 1/4 inch diameter steel rod was cut into 3 inch segments. One hundred forty of these 1/4 inch diameter by 3 inch steel pegs were cut.

After all of the necessary parts were fabricated, the units were assembled. The 1/2 inch square rods, the cedar beams, and the rectangular steel components were assembled. The 3 inch diameter head lag screw pegs and the 4 inch diameter head lag screw pegs were inserted into the 5/16 inch holes in the rectangular tubing and the square rods. This locked the cedar beams, the square rods, and the fabricated steel units together. The lag screw ends were tightened into the cedar beams. The 3 inch steel pegs were inserted through the square rods and hammered into the 3/16 inch holes in the cedar beams. This locked the cedar beams and the square rods together. Four of these units were fabricated for the sculpture.

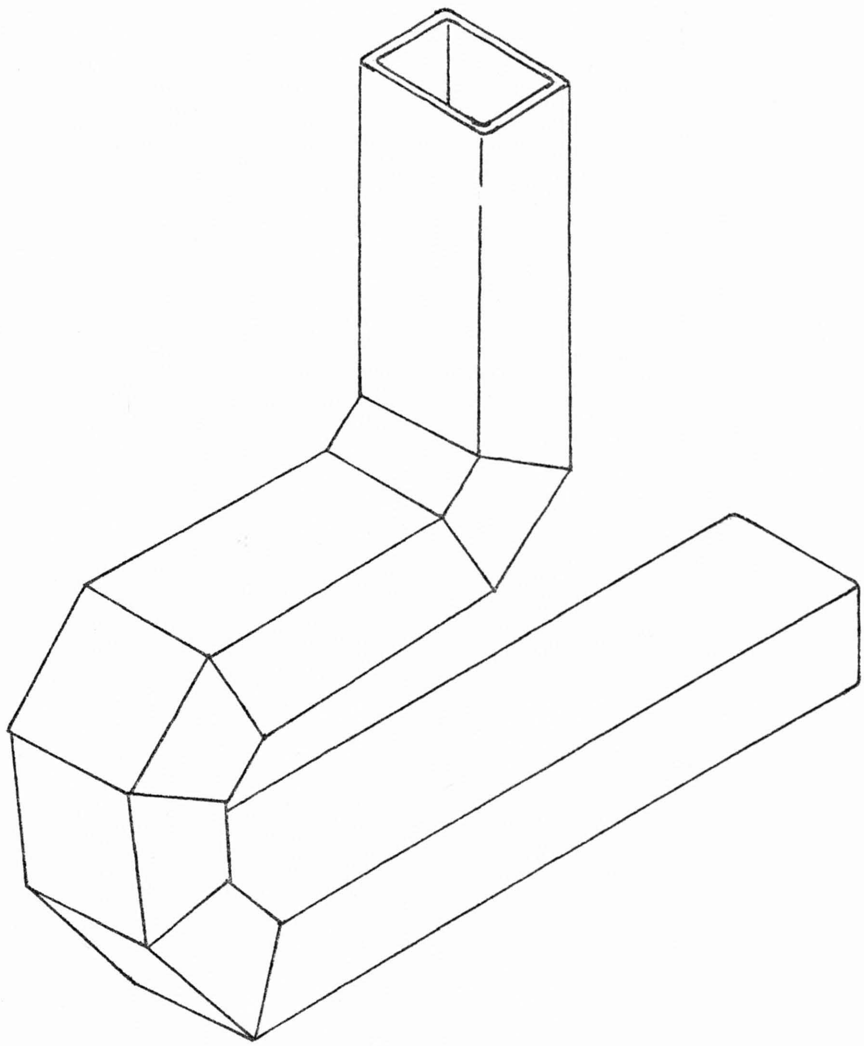

Fig. 8. Basic steel unit for "Welcome to the Hindu Arms."

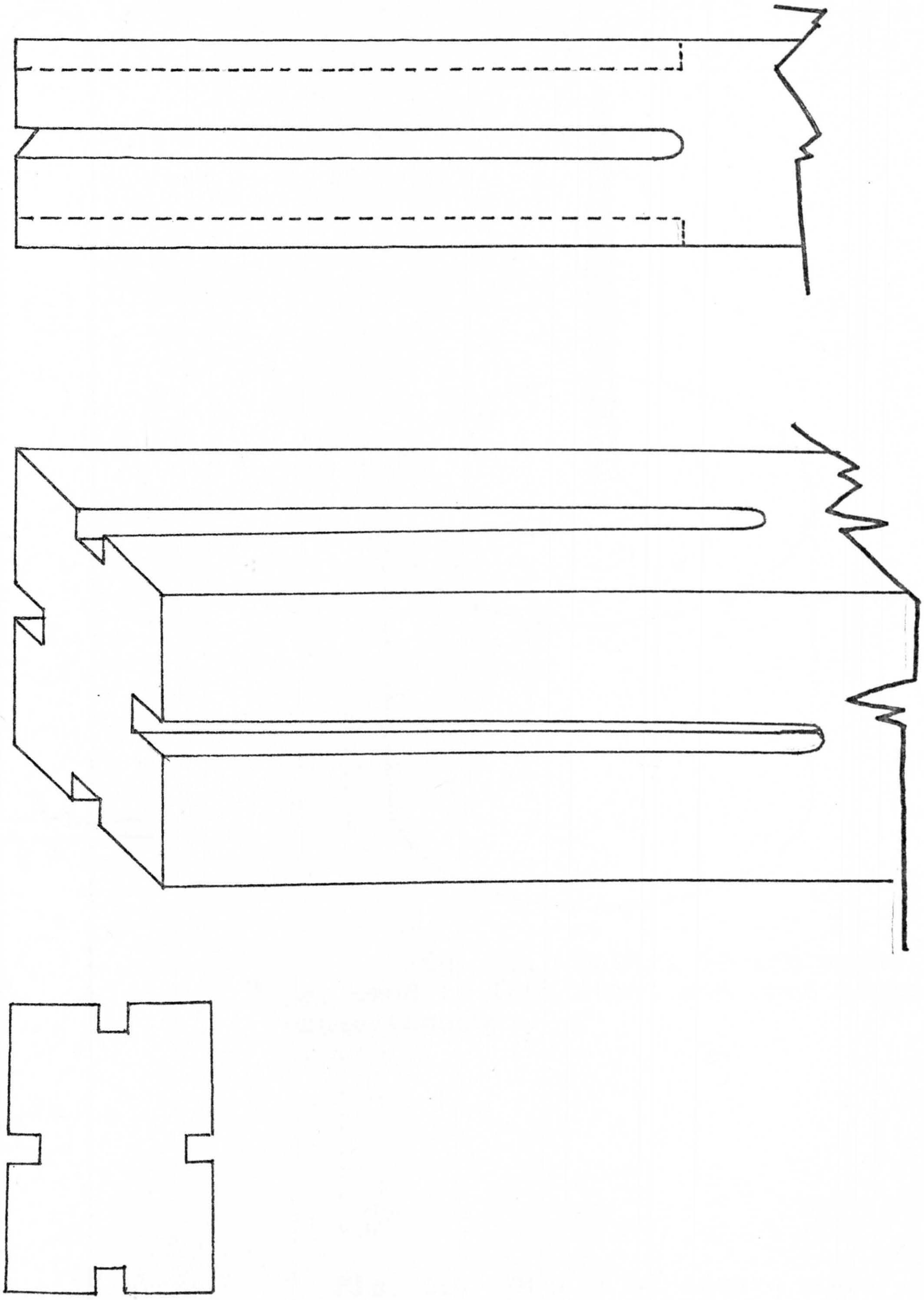

Fig. 9. Plough cuts made in cedar beams: a. side view, b. oblique view, c. end view.

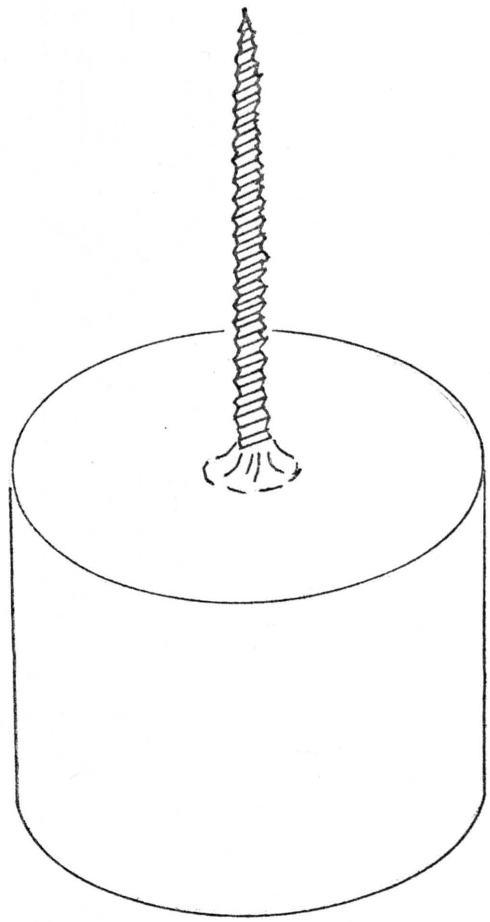

Fig. 10. Detail of lag screw peg used to lock steel and wood components together.

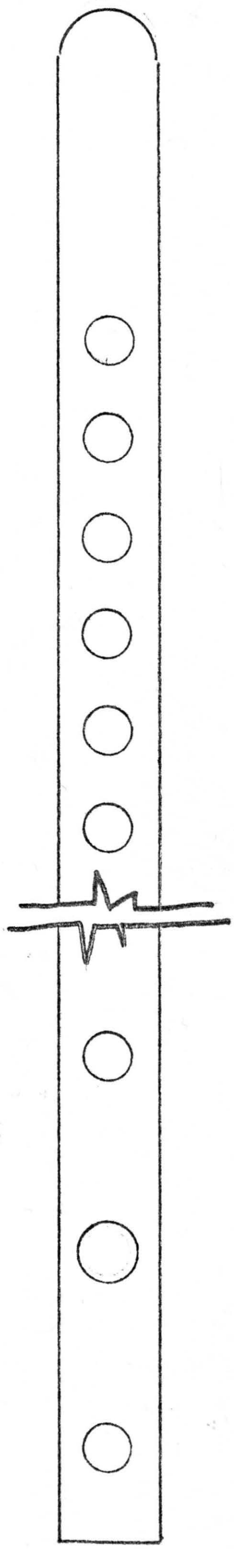

Fig. 11. Detail of square rod drilled and fitted into plough cuts. Rod was drilled and then fitted into plough cuts.

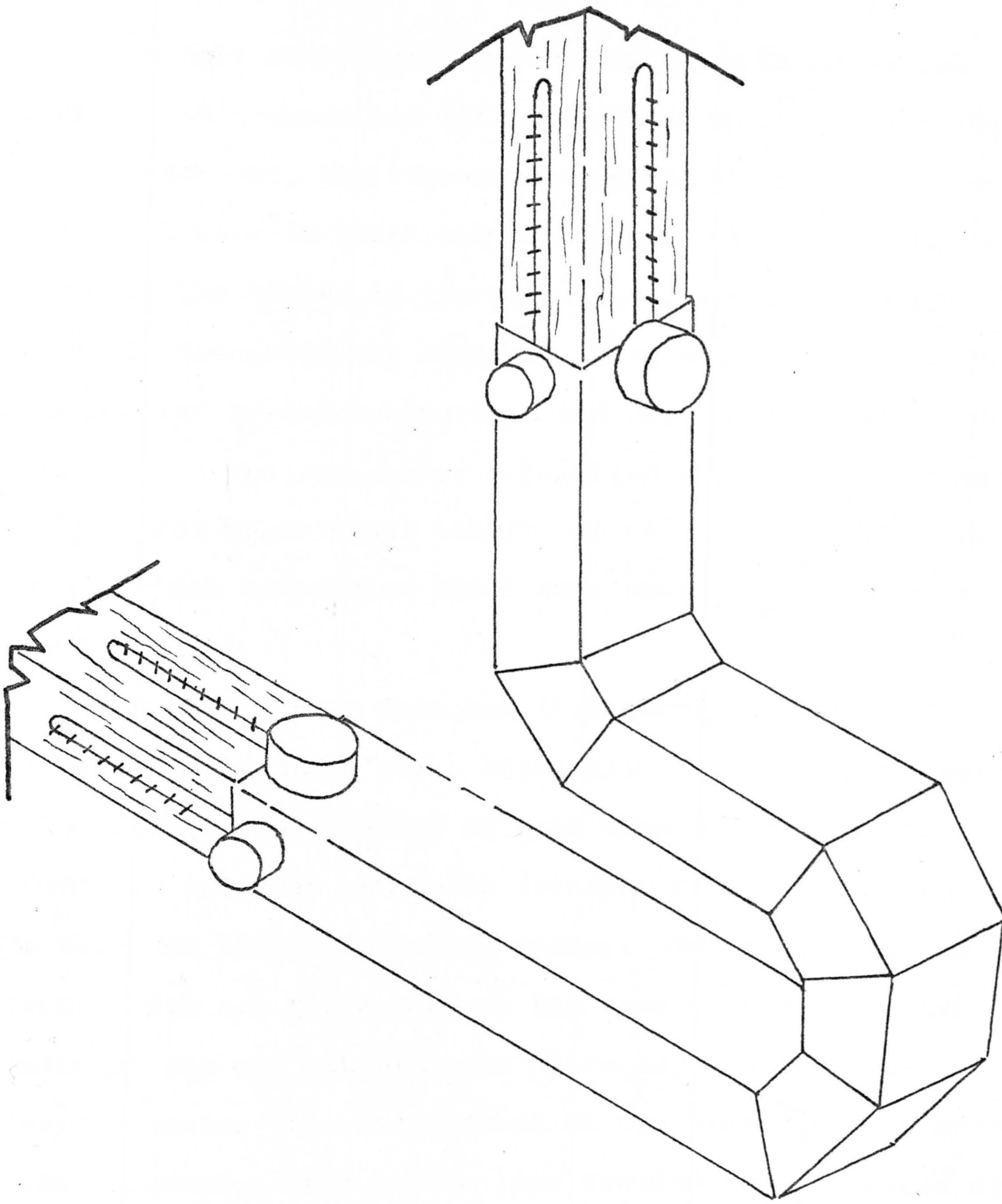

Fig. 12. Schematic view of steel and cedar component. Four of these units were fabricated for the sculpture.

The next sculpture was constructed with rough cut untreated oak timbers and 1/8 inch plate steel. Since the oak was rough cut, the researcher understood that the dimensions might vary in width and depth as much as 1/2 inch from one end of the timber to the other end. For this reason the researcher discarded any ideas of using manufactured steel stock similar to the tubing that had been used in the previous works. The researcher fabricated a large equilateral triangle from three equal lengths of the oak. In addition to this, three triangular steel caps were fabricated from the plate steel.

The oak timbers were cut into three equal lengths with an electric chain saw. After all of the sections were cut, a mitre lap was marked on both ends of the sections. In order to half lap the three sections of oak the mitre laps were cut in the following manner. Two of the sections were cut with the mitre laps on the same side. The other section of oak was cut with the mitre laps on opposite sides. A center line was scribed on two sides and the ends of each segment. This center line divided the thickness of the oak beams in half. Next, a line was scribed across the width at a 60 degree angle. Two of these 60 degree mitres were scribed on each segment of the oak. The mitres were marked to cant toward the center of the segment. The first cut was made through this mitre line. The second cut was made through the center line scribed on the oak beam. These two cuts were made to rough out the mitre laps on the ends of the oak tie. All of the mitre laps were cut in this manner. An electric chain saw was used to make all of the cuts. The finished sizing and fitting was done with an electric planer, a belt sander, and assorted hand tools. After each half of the mitre laps had been sized, the oak triangle was assembled.

Center points were marked on the mitre laps joints of the oak triangle. These center points were used for countersinking and boring the holes for bolting. The researcher clamped the Portalign drill stand in position on the center point. First, countersinking was done to prevent the threaded rod, nut, and washers from protruding above the surface of the wood. This countersinking was done with the Portalign and a 1 inch multispur wood bit. The hole was bored to a depth of 1 inch. Next, a hole was drilled completely through the mitre lap with a 1/2 inch electrician's auger bit. This process was repeated for the other two mitre laps. Finally, the entire triangle was turned over and a 1/2 inch diameter wood dowel was inserted into each of the 1/2 inch diameter holes. This wood dowel provided a surface for boring the hole needed for countersinking. Countersinking was done with the Portalign and the same 1 inch multispur wood bit. After all of the drilling was completed, the triangle was bolted together with 1/2 inch threaded rod and bolts.

The researcher fabricated the steel caps so that each one repeated the negative shape formed within the juxtaposed arms of the oak triangle. Each triangular cap consisted of two equilateral triangles and two rectangles. The rectangles were designed 1/4 inch smaller than the thickness of the oak ties. All of the pieces were scribed on the 1/8 inch plate steel. The cuts were made with an oxyacetelyene cutting torch. The parts were welded with an arc welder and (AWS) E6011 welding electrodes. Three of the triangular steel caps were fabricated.

After the ends of the oak triangle were planed and sanded, the steel caps were fitted to the wood. The sides of the mitre laps were planed to a depth of 1/8 inch on the front and back. The caps were hammered into position with a four pound sledge hammer. All that remained was the fabrication of a steel component which repeated the negative space contained within the oak triangle. This triangular piece also repeated the size and shape of the steel caps. The piece was fabricated from plate steel.

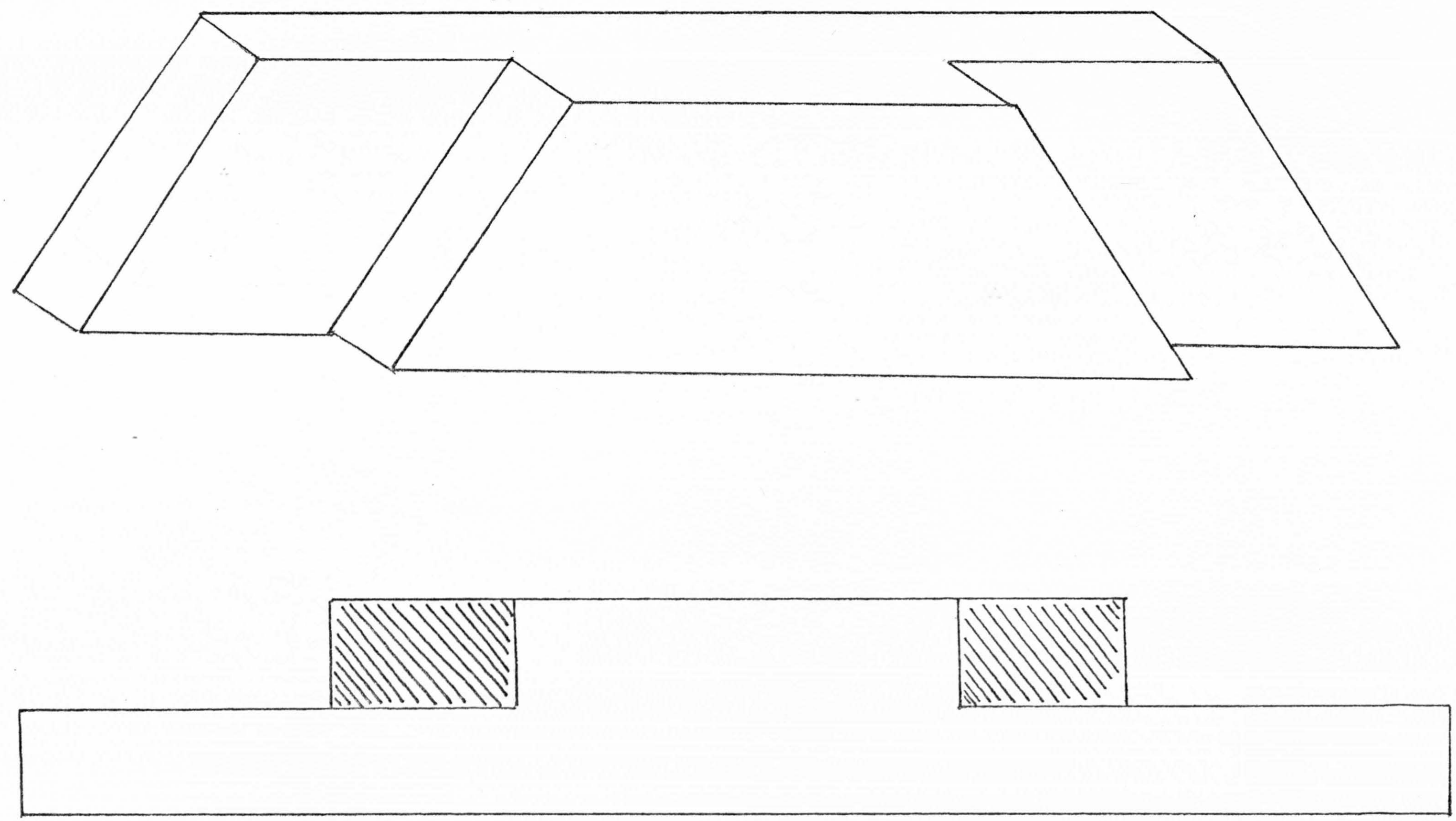

Fig. 13. Views of mitre end laps. Two lengths of oak were cut to match this configuration.

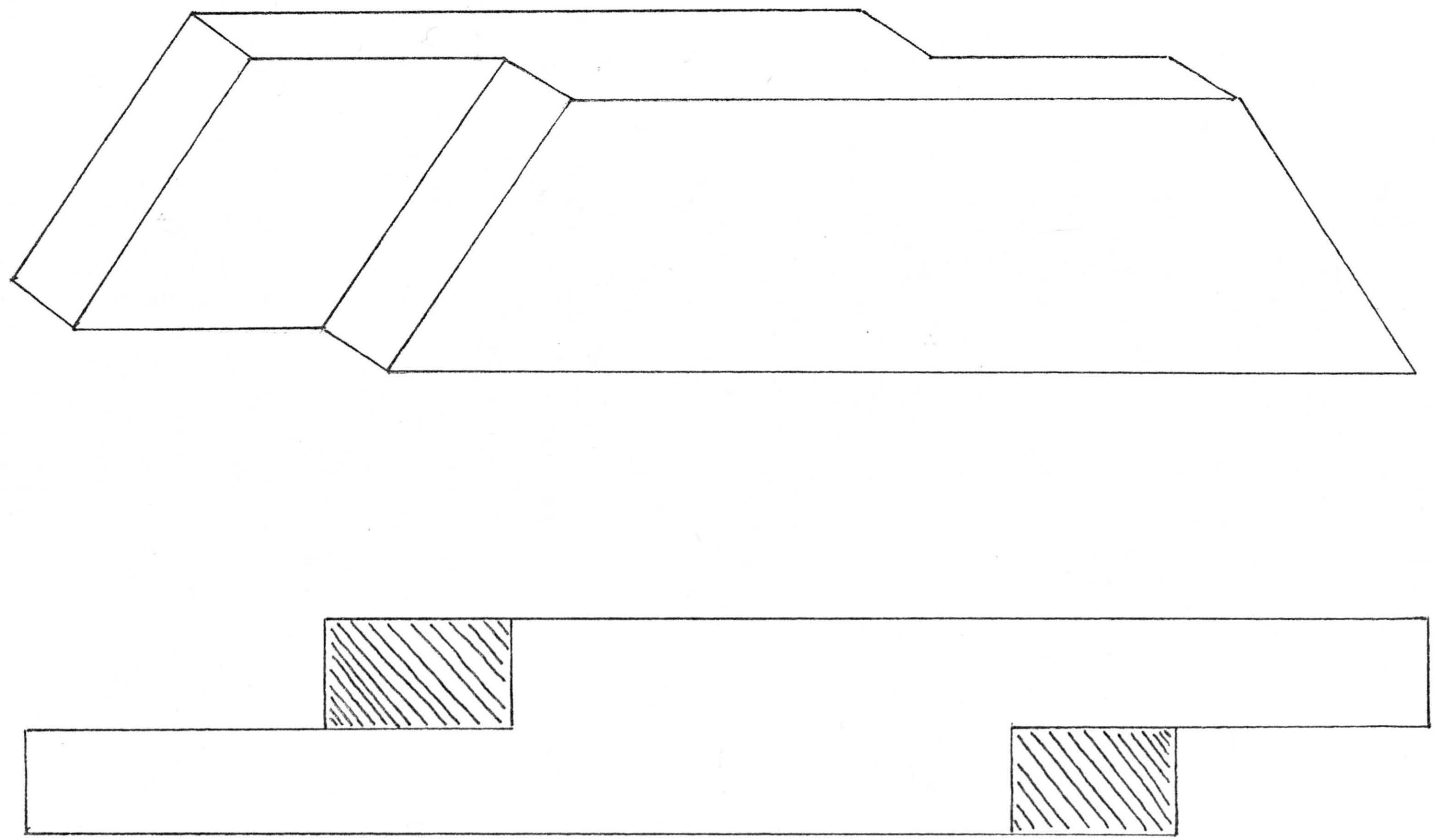

Fig. 14. Views of mitre end laps. One length of oak was cut to match this configuration.

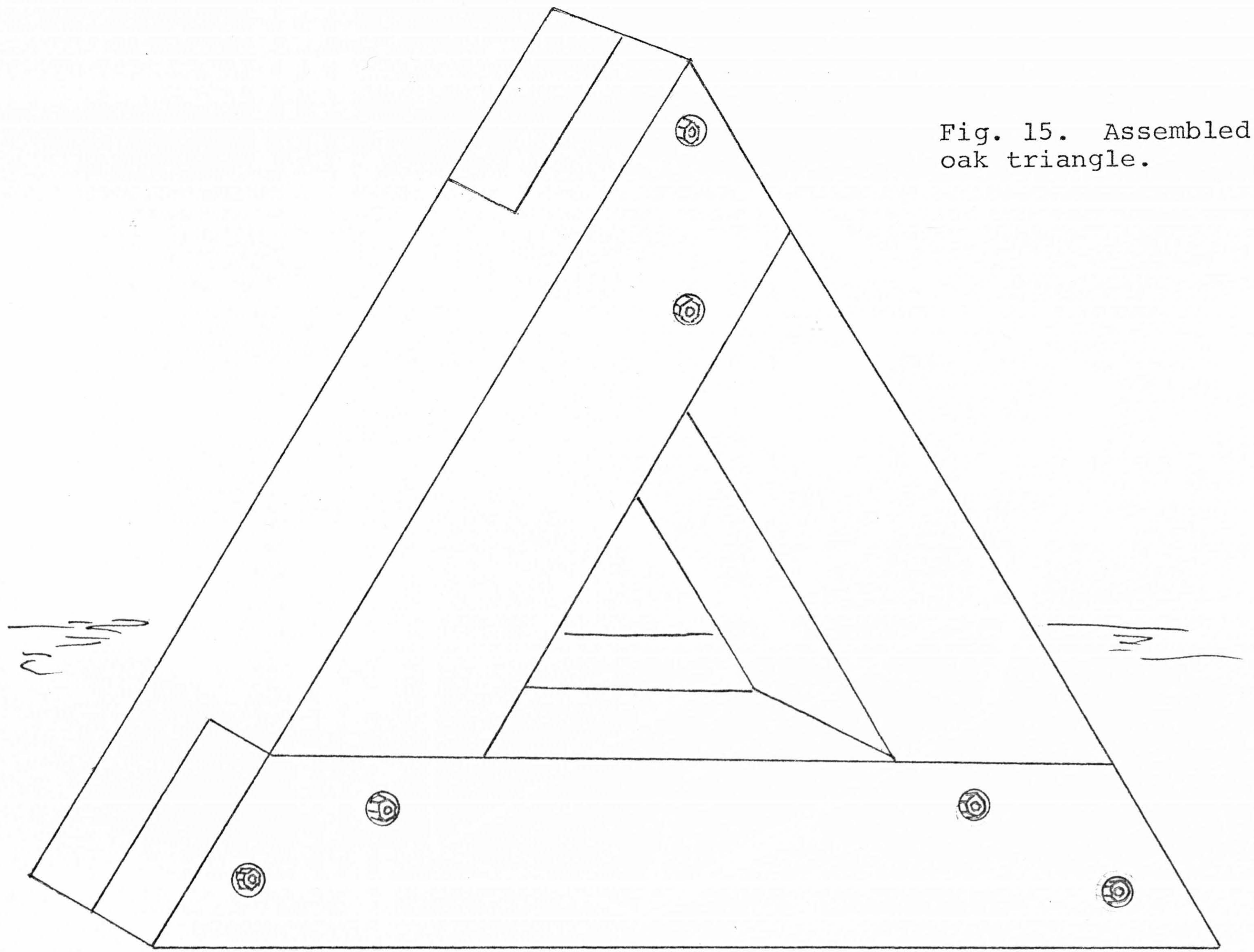

Fig. 15. Assembled oak triangle.

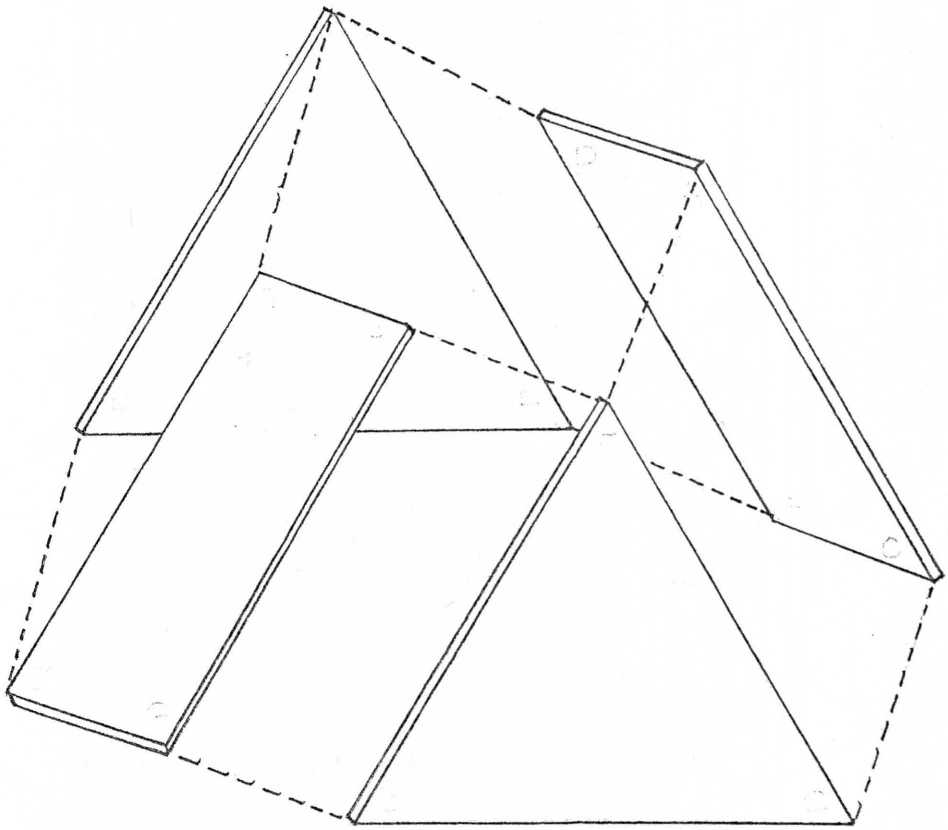

Fig. 16. Schematic view of steel cap. Four sections of mild steel were used to fabricate each cap, two equilateral triangles and two rectangular section. Capital letters indicate edge alignment. Three steel caps were fabricated.

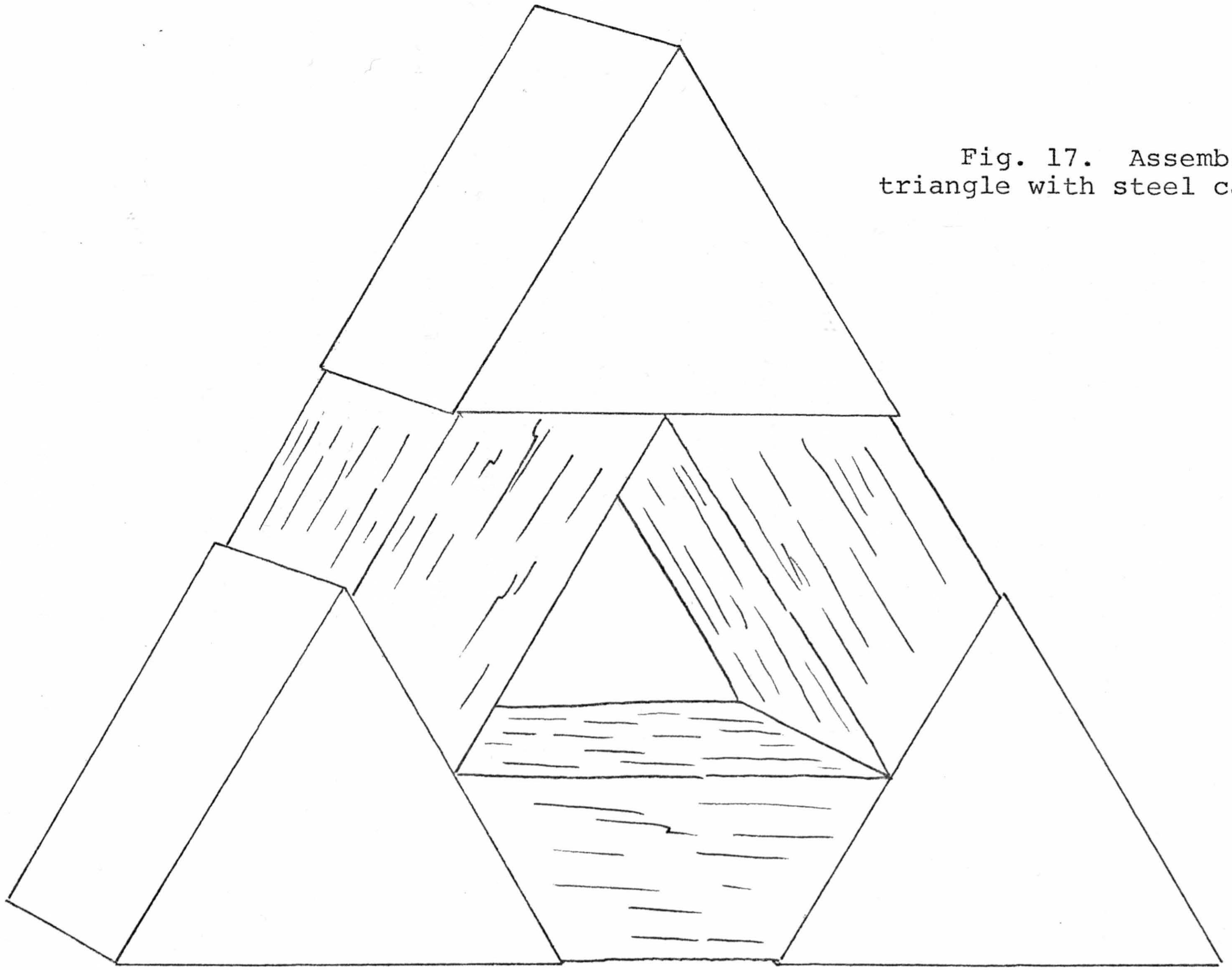

Fig. 17. Assembled triangle with steel caps.

A second sculpture was fabricated from the untreated oak timber and plate steel. This sculpture consisted of six arms inserted into a steel hub. The six arms were fabricated from the oak timbers which cross lapped at 60 degree angles. The hub was fabricated from 1/4 inch plate steel.

A modified cross lap joint was used to fabricate the wood portion of the sculpture. All of the dimensions for the mitred cross lap joints were marked on the oak beams. The two outside arms were marked with a cross lap on one side. The center section of the oak was marked with a cross lap on two opposite sides. The center cross laps matched the cross laps marked on the other two sections of the oak. All of the cross laps were marked so that each of the oak beams was bisected at a 60 degree angle. When the oak beams were assembled one-half of the thickness of the wood sections cross lapped. The depth of each half of the cross laps was marked 1 7/8 inches (one-fourth of the thickness).

After all of the mitre cross laps were marked, an electric chain saw was used to make the cuts. A series of cross cuts were made within the dimensions of the cross lap joint. These cuts were made at a 60 degree angle and 1 3/4 inches deep. A 1 1/2 inch hand chisel and wood mallet were used to remove the ridges of wood left between each cross cut. When sufficient wood was removed, the beam was turned on edge. The remaining portion of the cross lap was made by making a rip cut with the chain saw. The rip cut was made parallel to the depth line 1/4 inch on the waste side of the joint. This procedure was followed to make all of the mitre cross laps cuts. A total of four mitre cross laps were fabricated. After all of the cuts were made, the surfaces were leveled with an electric power plane, a jack plane, and assorted hand chisels. The oak unit was assembled and clamped together.

The steel hub was designed after the oak beams were clamped together. The hub was designed to complement the series of geometric planes formed by the juxtaposition of the oak beams. Each major geometric plane was formed from either an equilateral triangle or a series of such triangles which shared common sides. The shapes used to fabricate the steel were a trapezoid, formed by the juxtaposition of three equilateral triangles; a parallelogram, formed by the juxtaposition of two equilateral triangles; and the equilateral triangle alone. After measuring and designing were completed, 1/4 inch plate steel was marked and cut into the necessary shapes. All of the pieces were cut with an oxy-acetelyene cutting torch. When the cuts were completed, the metal components were chipped and ground so that the shapes would lie flat and could be clamped directly to the oak beams for spot welding. The individual shapes for one-half of the steel hub were laid out, clamped, and tacked in position on the oak beams. The steel was then removed from the oak unit and the entire oak unit was turned over and re-assembled. The shapes for the other half of the steel were laid out and clamped to the oak beams so that they could be spot welded in the proper position. Following this step, the second half of the steel unit was removed from the oak beams. The two halves were spot welded together. The seams in the steel hub were welded with (AWS) E6011 welding electrodes and an electric arc welder.

The sequence used to construct the steel unit lessened the possibility of mistakes in alignment which might have occurred if assembly had been attempted without the oak beams to serve as a foundation. Such precautions did not prevent the occurrence of minor problems when the numerous elements were welded. These problems were a direct result of metal expansion. This expansion caused warpage of the metal shape. In addition to the warpage, there was also the problem of the irregularities which were present in the dimensions of the oak beams. These two factors necessitated a change in assembly of the oak units which formed the complete sculpture. The oak beams were cut in half along a line drawn through the center of each of the

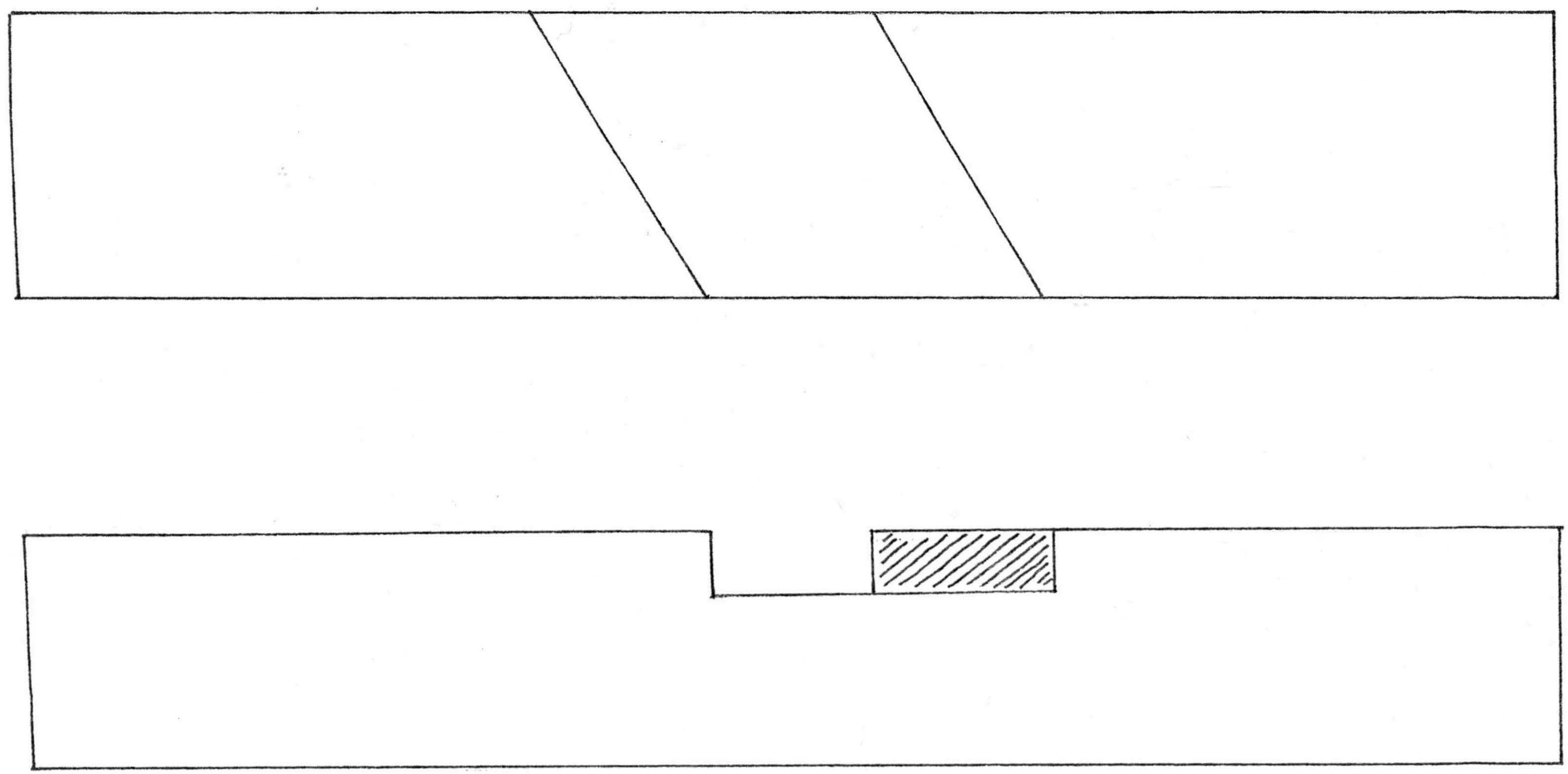

Fig. 18. Views of mitre cross laps. Two lengths of oak were cut to match this configuration.

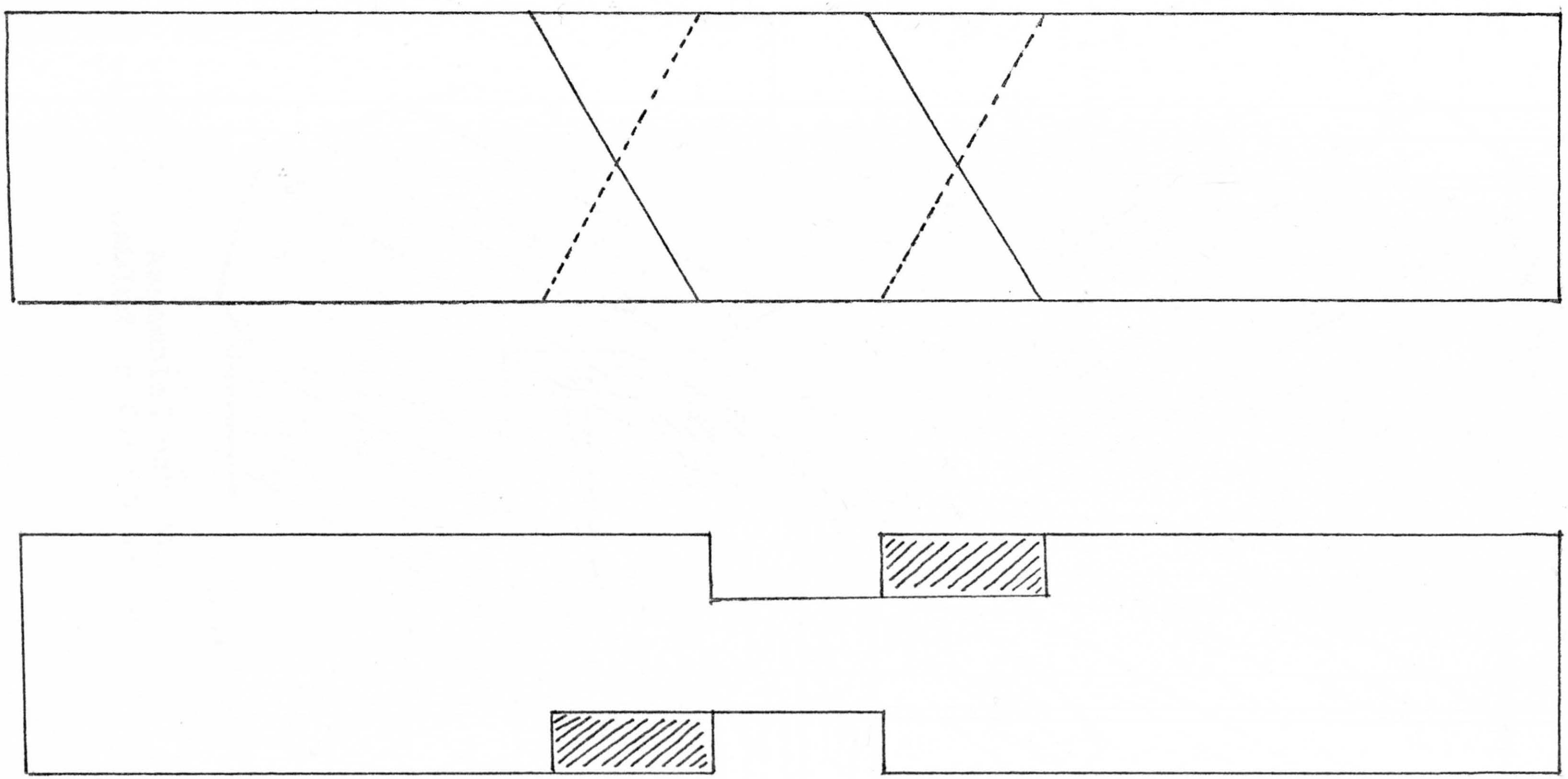

Fig. 19. Views of mitre cross laps. One length of oak was cut to match this configuration.

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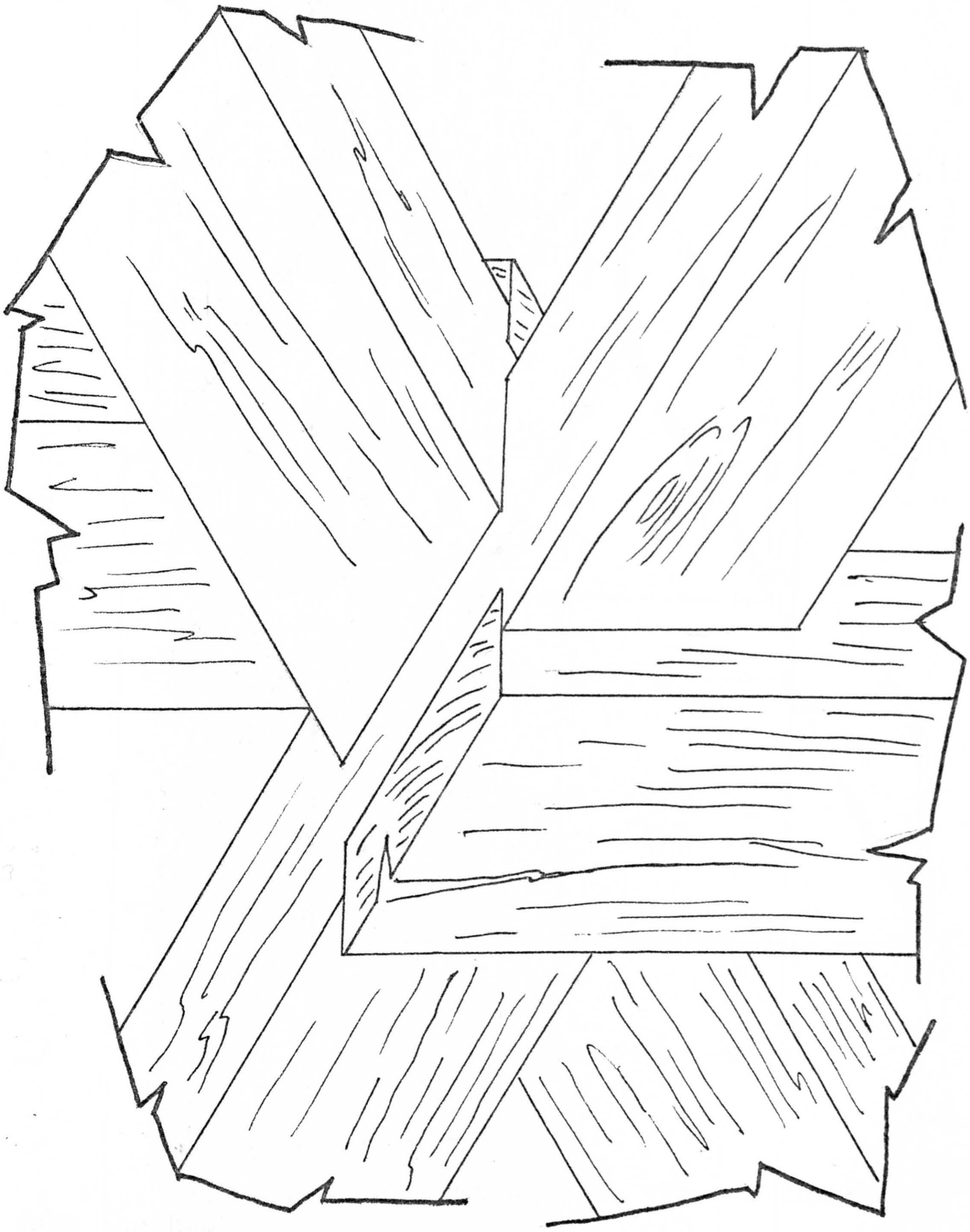


Fig. 20. Assembled oak components. The three lengths of oak were assembled to form a six armed figure.

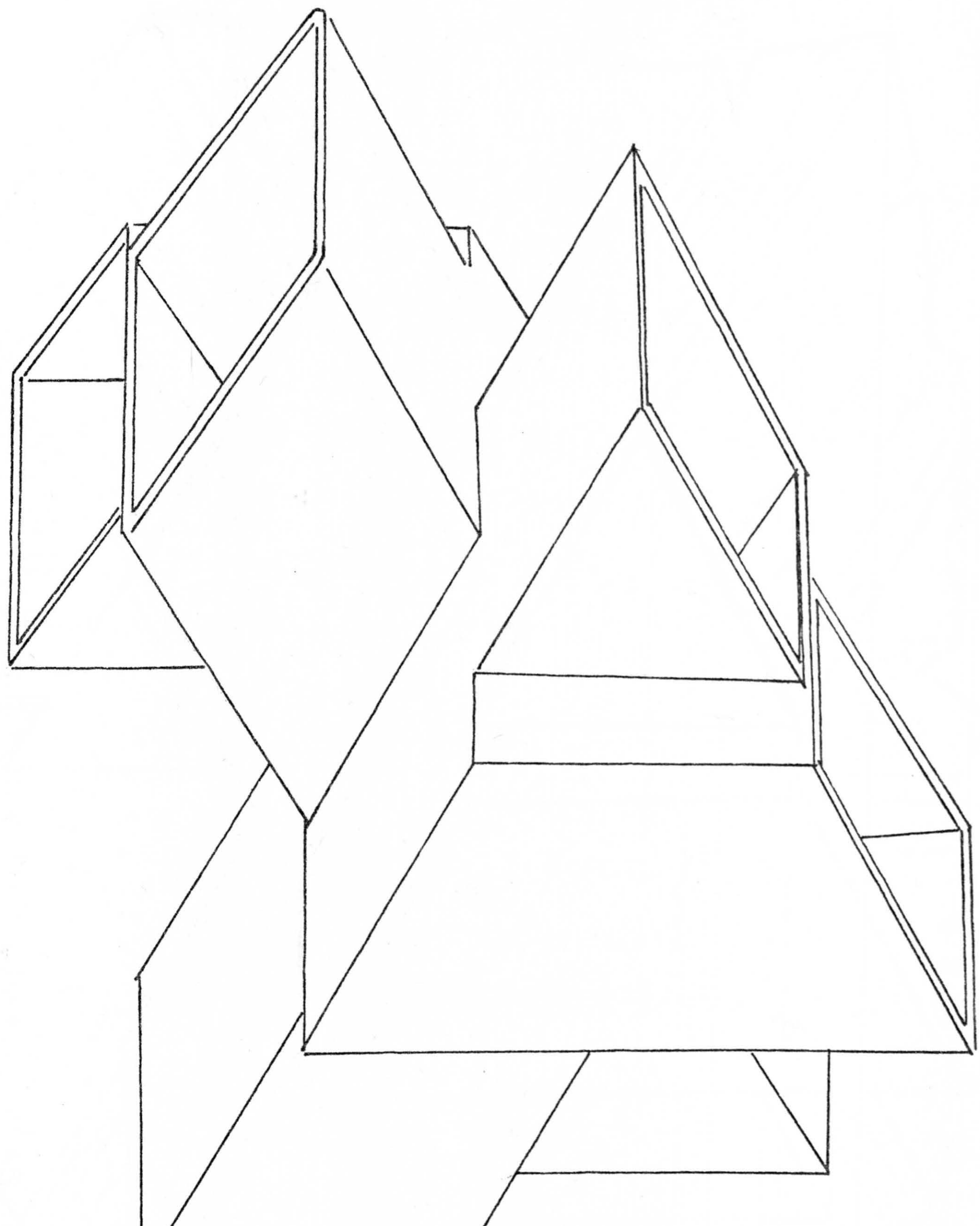


Fig. 21. Steel hub. Mild steel was cut and welded to form the hub.

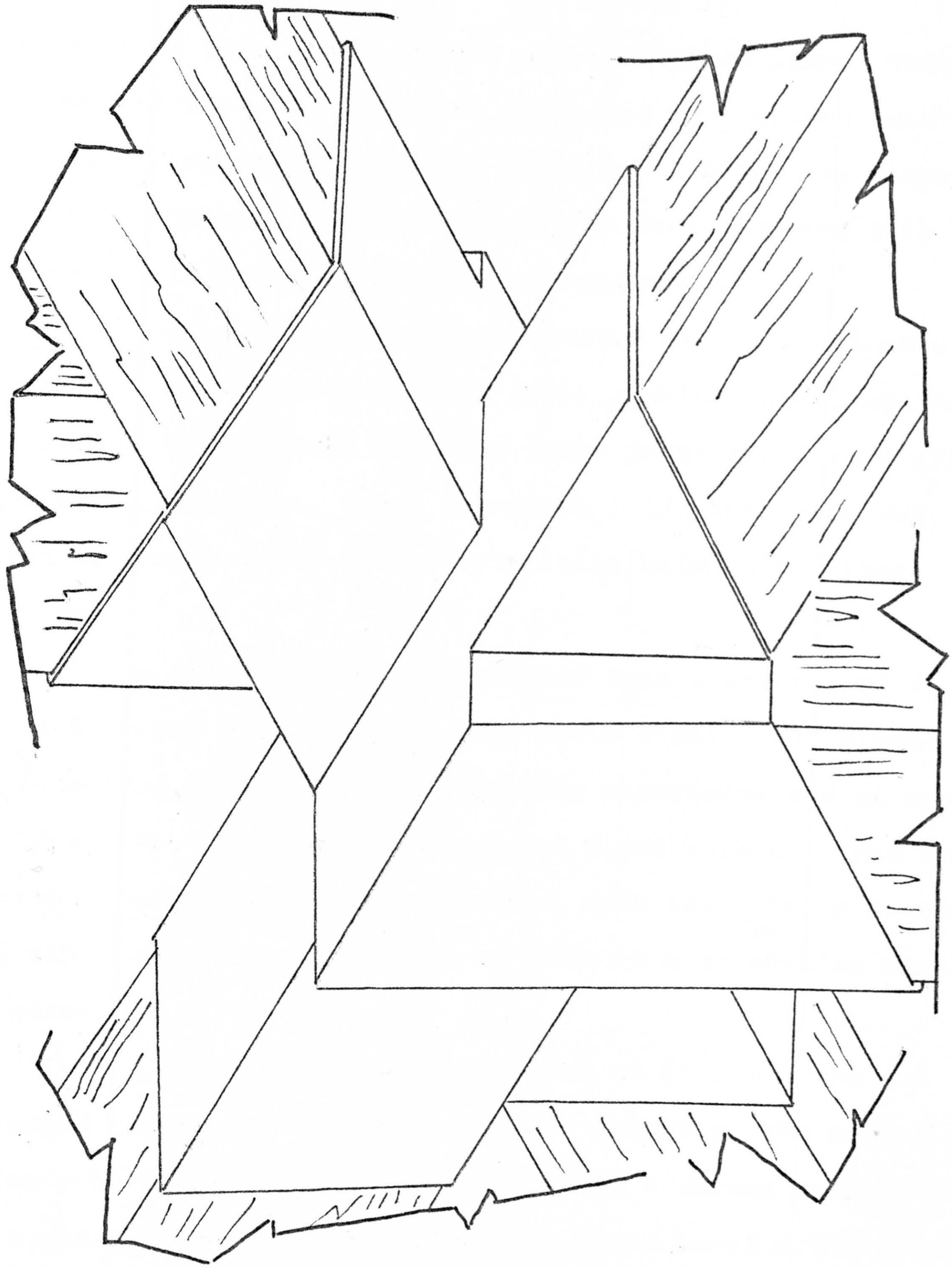


Fig. 22. Close view of steel and oak unit.

mitre cross laps, thus forming six individual arms. This allowed each of the resulting pieces to be inserted into the corresponding position in the metal hub. With only minor fitting problems, the wood components were hammered into a suitable fit to stand as the completed work.

"Bottom Side Up" was constructed of six sections of 3 inch outside diameter curved pipe, a welded steel cylinder 25 inches in diameter, and pine fence posts 3 1/2 to 4 1/2 inches in diameter. Steel strapping 1 1/2 inch wide was used to complete the visual transition between the steel and wood.

The steel drum was fabricated from a section of 25 inch diameter pipe and 3/16 inch plate steel. The pieces were welded with (AWS) E6011 welding electrodes and an arc welder. The 3 inch diameter curved pipes were cut into the various lengths with the horizontal band saw. These sections of pipe were welded to the steel drum in a triangular configuration.

The steel straps were cut into 60 inch lengths and clamped together. The top strap was marked at the center line with a set of center points spaced 6 inches apart. The six straps were gang drilled with a floor model drill press and a 5/8 inch high speed steel twist drill. The straps were then welded to the ends of the curved pipes.

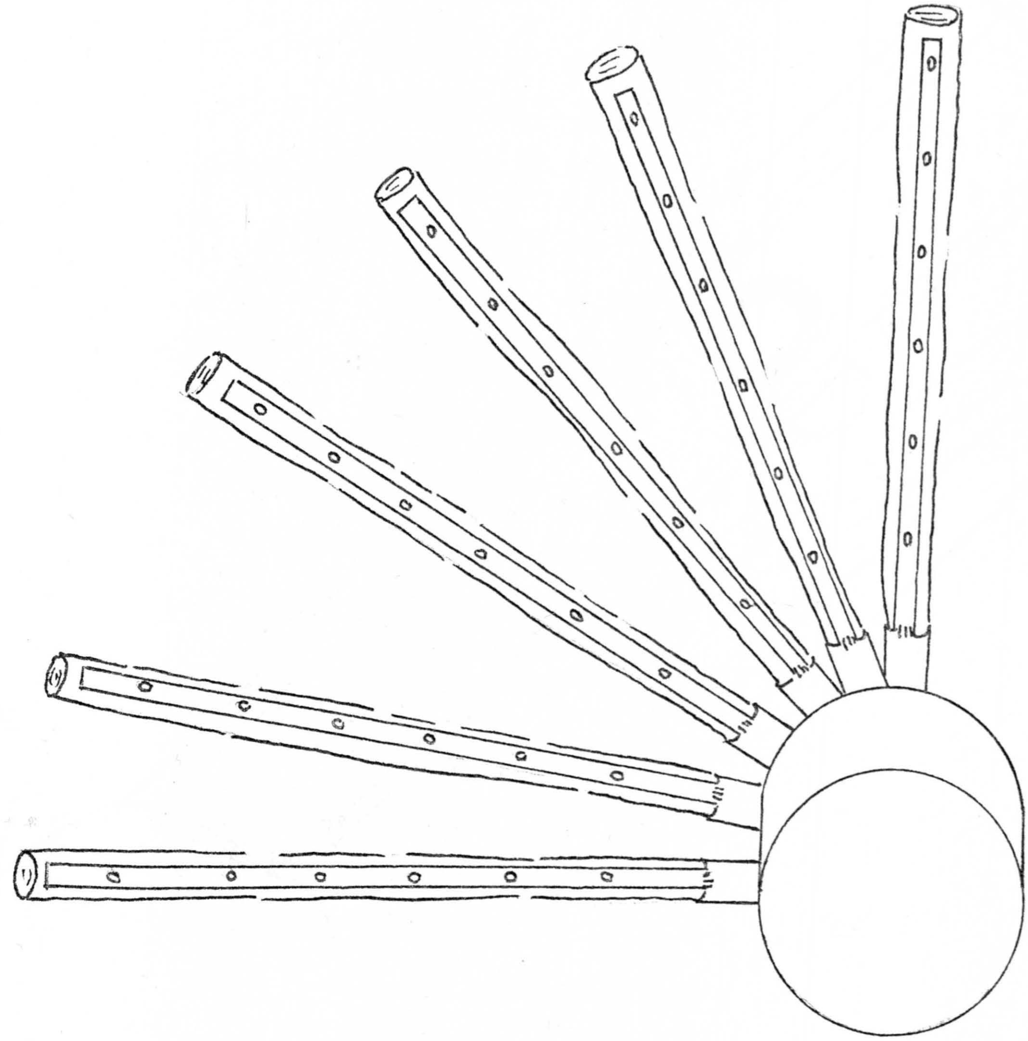


Fig. 23. Illustration of "Bottom Side Up."

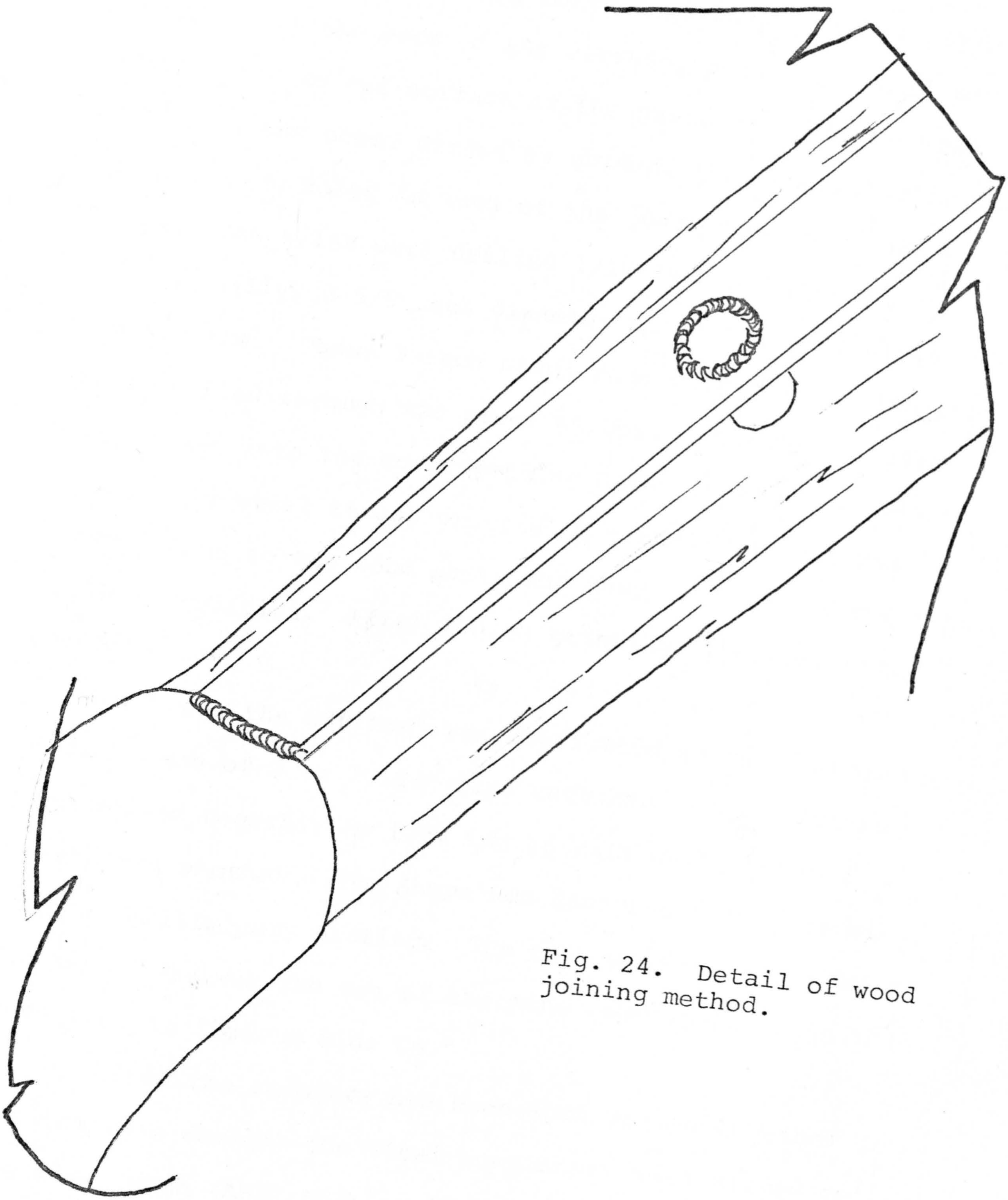


Fig. 24. Detail of wood joining method.

Next, the pine fence posts were roughly shaped and hammered into the ends of the curved pipes. The steel straps were clamped to the surface of the posts. Using the holes drilled in the steel straps as guides, the researcher drilled corresponding holes in each of the posts to a depth of 2 inches. The holes were drilled 1/16 inch undersize.

Finally, a 5/8 inch diameter steel rod was cut into 3 inch lengths. These 3 inch steel rods were welded into the holes drilled through the steel straps. These steel pegs were driven into the corresponding holes in the pine fence posts. The steel straps provided a transition from the curved pipes to the wood posts and they also locked the pine posts in position. After finish grinding, the sculpture was complete.

"Under the Big Top" was fabricated to take advantage of both ends of 3 to 2 inch pipe reducers. The reducers were welded together to form two spirals which rotated toward one another. The shape was designed spontaneously with no preliminary drawing. The only preconceived idea in the sculpture was the use of the pine fence posts like the ones used in "Bottom Side Up."

After the reducers had been spot welded together in the complete design, the steel components were welded on two sides with (AWS) E6011 welding electrodes and an electric

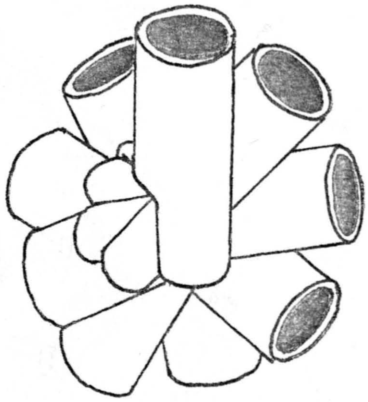


Fig. 25. Welded pipe reducers. The reducers were welded together in this configuration.

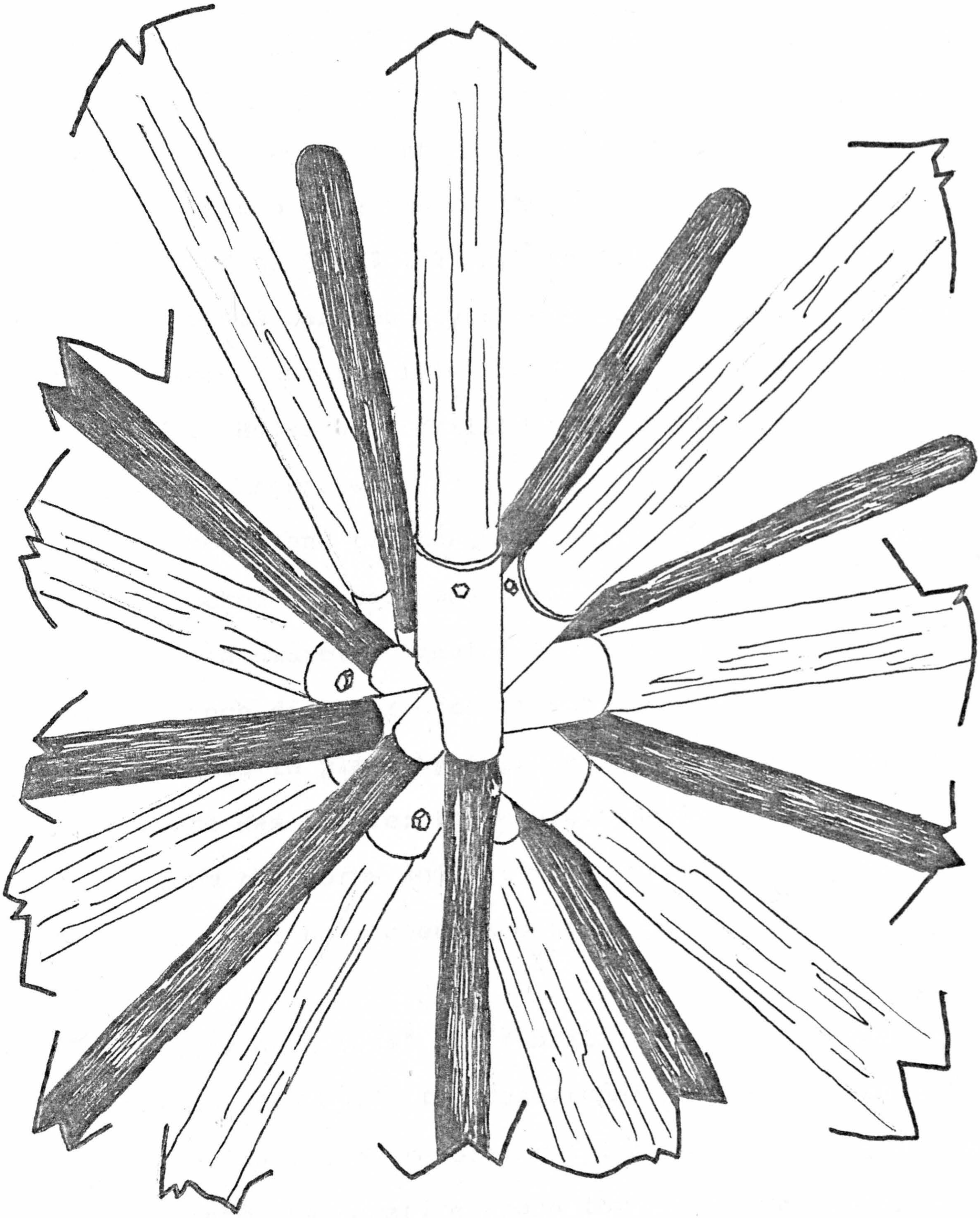


Fig. 26. Fence posts completed sculpture.

arc welder. Lengths of 3 inch diameter pipe were welded to the 3 inch end of all of the reducers. This pipe was used to extend the pipe so that the pine fence posts would fit securely in the 3 inch end of the reducers.

One end of the 3 1/2 inch to 4 1/2 inch diameter pine fence posts was roughly shaped with a sculptor's adze. The posts were hammered into the 3 inch diameter end of the steel shape. Holes were drilled in the three inch diameter steel pipes. Lagscrews, 3/8 inch by 2 inches, were inserted into these holes and tightened into the wood posts. The lagscrews locked the wood posts and the steel unit together. Smaller 2 inch diameter treated fence posts were driven into the 2 inch diameter ends of the steel posts. These posts were held in place by a press fit. The construction of this piece was simple; therefore, the image came more directly from the forms and not from multifarious fabrications which might have been made to join the materials together.

"Linear Gyrations" was fabricated much the same way as "Under the Big Top." The researcher became concerned with the fabrication of revolving spiraling forms which drew the viewer into the negative space formed by the juxtoposition of the individual units. The pipe reducers were tacked together during the design of the steel shape. This made

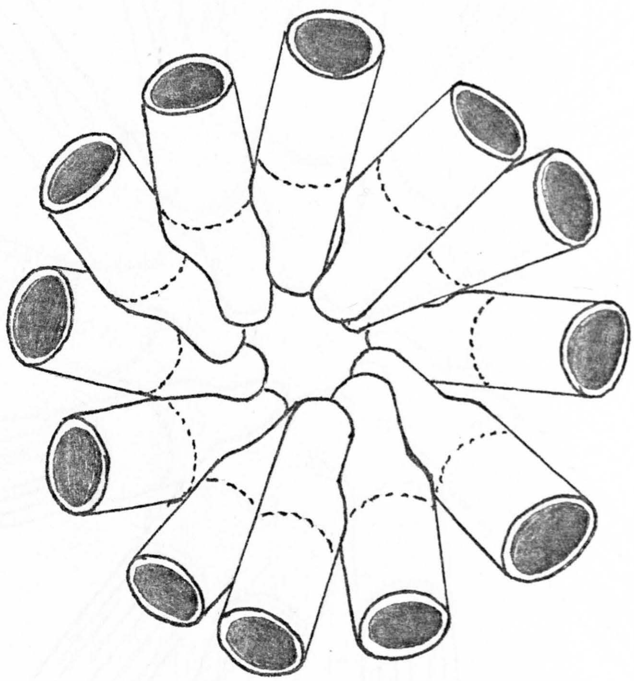


Fig. 27. Welded pipe reducers. The reducers were welded together in this configuration.

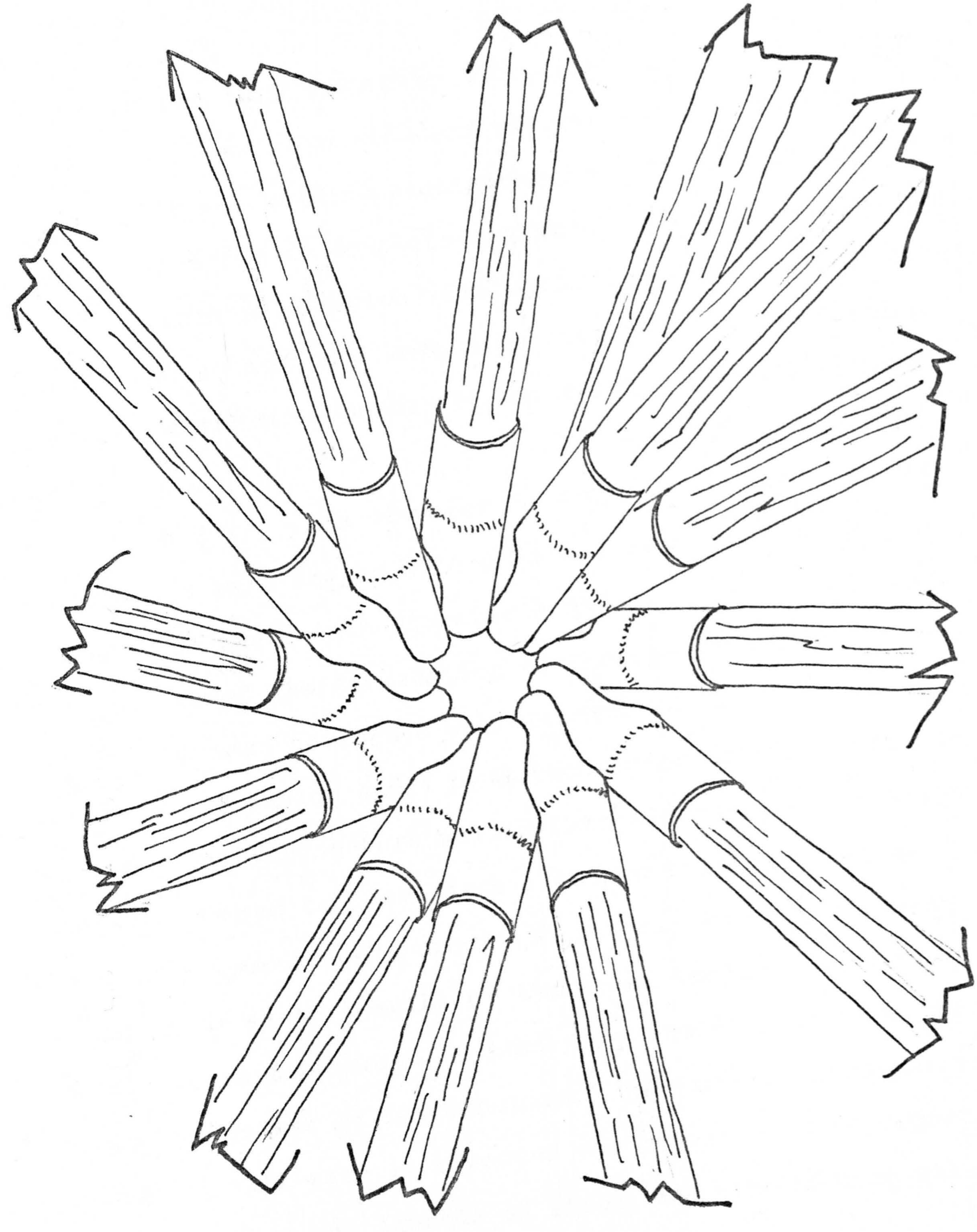


Fig. 28. Fence posts completed sculpture.

changes in the form easier to accomplish. After the design was finished, the pipe reducers were welded on two sides with (AWS) E6011 welding electrodes and an electric arc welder. In order to complete the steel fabrication, lengths of pipe 3 inch in diameter were welded to the 3 inch diameter ends of the 3 inch to 2 inch pipe reducers. This additional length made the wood posts fit securely in the ends of the steel design.

The 3 1/2 inch diameter to 4 1/2 inch diameter pine fence posts were shaped with an adze. The posts were then driven into the 3 inch diameter ends of the pipe reducers. This completed the fabrication of the sculpture.

The next sculpture was constructed of four inch square steel tubing and 4 by 4 inch cedar beams. Sections of the steel tubing were welded into circular segments and then justoposed to form three interpenetrating circles. This unit approached a spherical shape. Each circle was composed of eight lengths of the steel tubing. The three circles were fabricated so that they shared lengths of the tubing at points of intersection. The circles were positioned so that each intersected the others at a 90 degree angle. All of the lengths of steel tubing were then welded together at 45 degree angles.

The 4 by 4 inch steel tubing was cut into 5 1/2 inch lengths on the horizontal band saw. Twenty-two of these sections were cut. A circle, composed of eight lengths of tubing, was laid out and tacked together. Two sections, composed of three lengths of tubing, were laid out and tacked together. These units were tacked to the first circle. The two sections shared two lengths of tubing with the first circle and this configuration formed the second circle. The second circle was tacked to the first so that the two circles lay at 90 degree angles to each other through a central axis. Four segments were laid out and tacked in position on the other two circles to form a third circle. The third circle shared two lengths of tubing with each of the other two circles. The third circle lay in an equatorial position to the other two circles. After the twenty-two lengths of steel tubing were tacked into the proper position, the adjoining edges of the tubing were welded with (NWS) E6011 welding electrodes and an arc welder. Triangles were cut to match the negative spaces formed by the justoposition of the arms of the steel component. These were welded in place. This step completed the major portion of the metal fabrication.

The dimensions of the cedar beams were 1/8 inch smaller than the inside dimensions of the steel tubing.

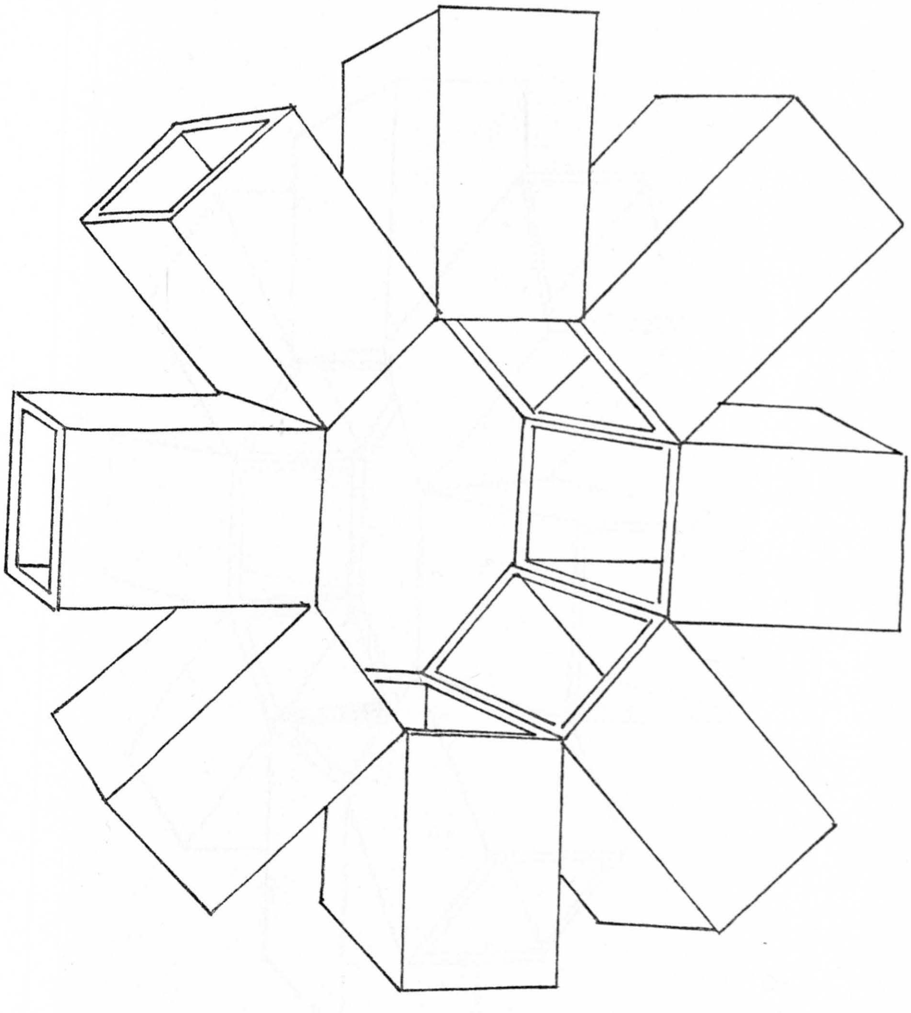


Fig. 29. Basic configuration of circular units. Drawing shows position of the first circular unit.

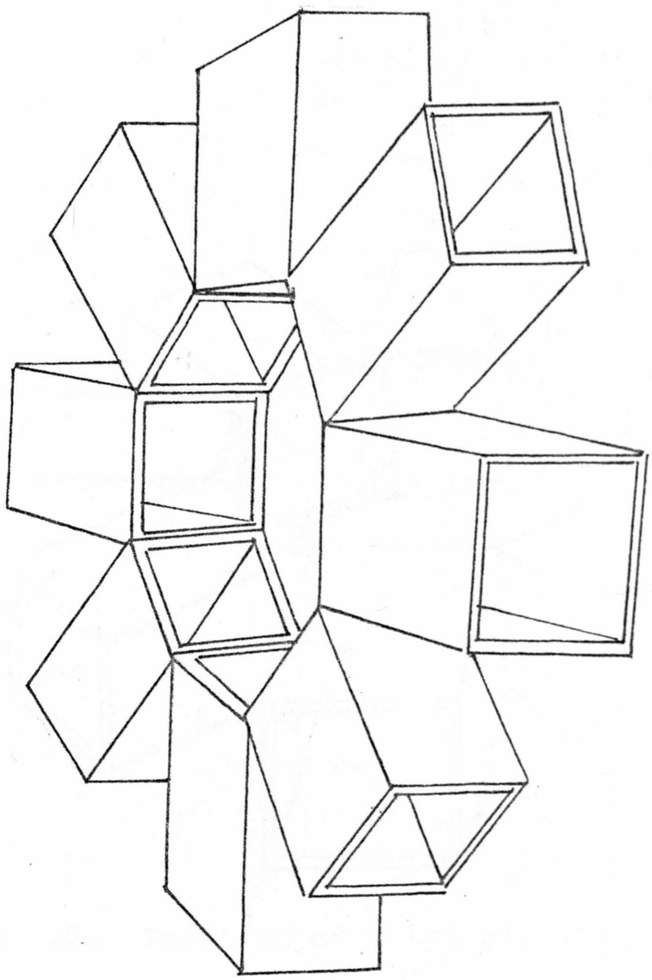


Fig. 30. Position of second circular unit.

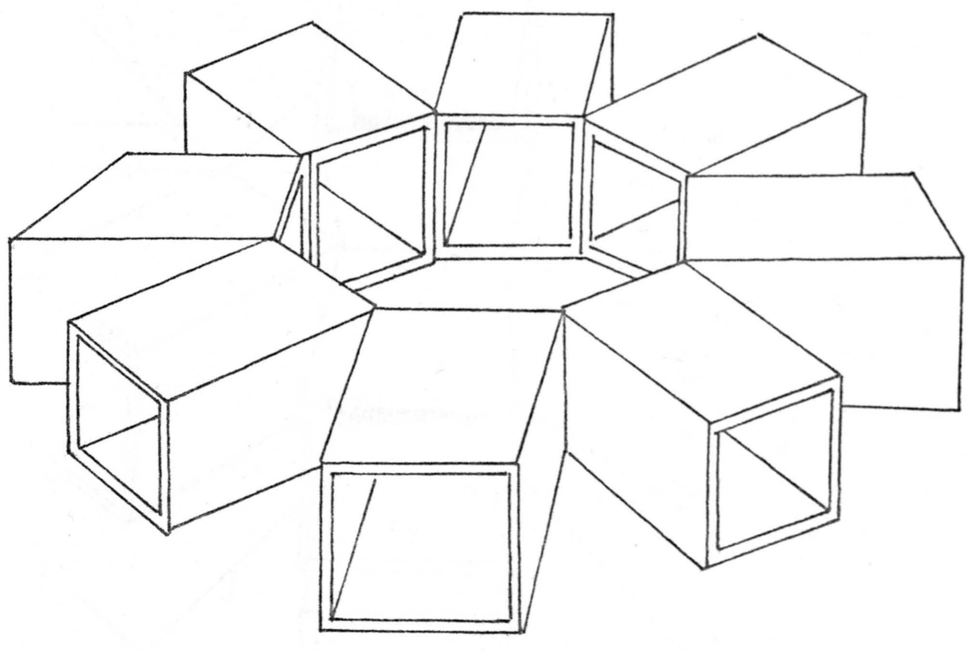


Fig. 31. Position of third circular unit.

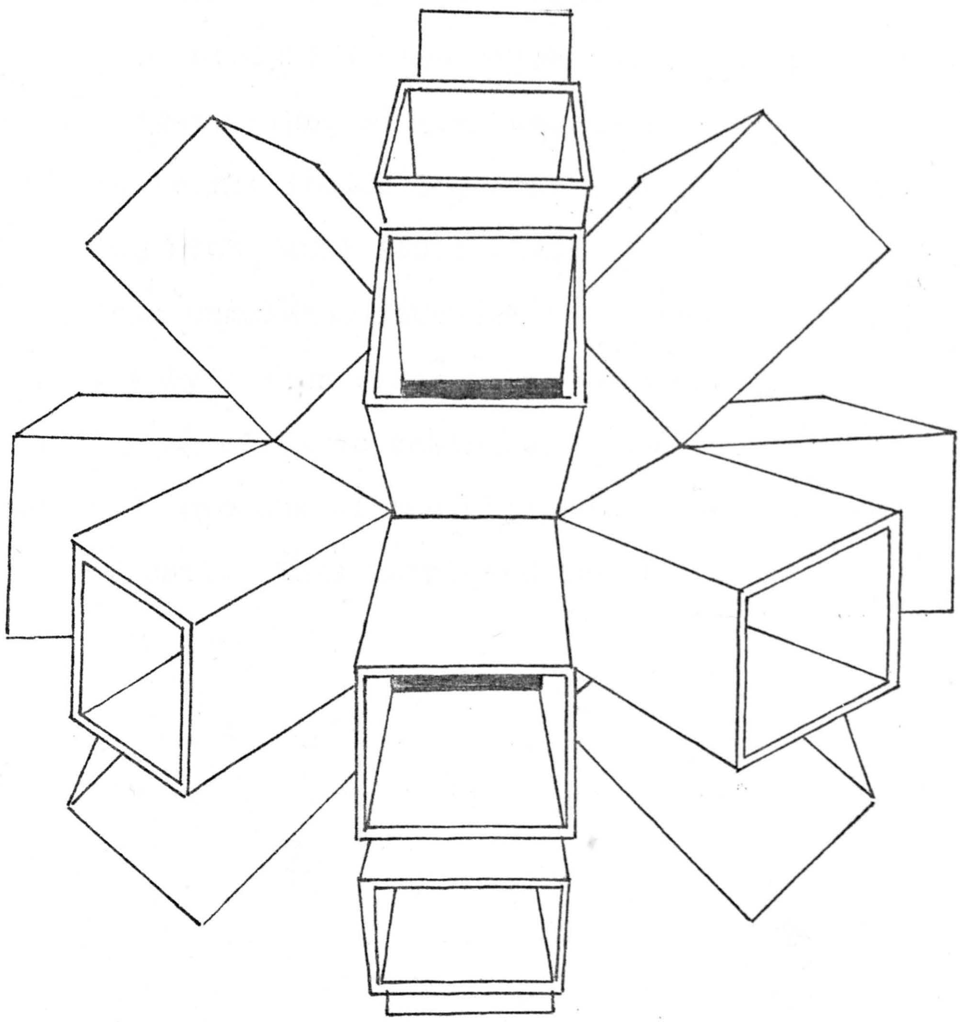


Fig. 32. Finished steel unit. The three circular units combined to form an orbital circular shape.

This prevented the cedar beams from fitting tightly in the ends of the steel tubing. To remedy this problem, 1 1/2 inch wide bar stock 1/8 inch thick was cut into 3 1/2 inch lengths. Eighty-eight of the lengths were cut. These shims were welded to the inside edges of each of the lengths of steel tubing with (AWS) E6011 welding electrodes and an arc welder. This completed fabrication of the steel unit.

The 4 by 4 inch cedar beams were cut into 4 foot lengths with an electric chain saw. Each length of cedar was hammered into one of the projecting arms of the fabricated steel unit. This completed the design of the last sculpture.

## CHAPTER IV

## FINDINGS

At the onset, the researcher had hopes of designing or rather re-designing wood joining techniques in a new and wonderful vocabulary for man, for earth, for the universe. The researcher soon discovered that almost any modification that could be devised for any given wood joining technique was only the shortest distance from one that had been designed before. There were almost no configurations which had not been designed, set in manuscript, and used.

If the researcher had insisted on approaching the thesis from that pragmatic viewpoint, the researcher would have given up and left the problem unsolved. However, it was realized that such aspirations were ludicrous; furthermore, any pursuits along these lines were destined to failure. This realization began a period of tremendous artistic growth.

As the researcher began to explore not the complexity of joining wood to metal but rather the most simplistic and direct methods of union, the work took on a new character not evident before this time. The spontaneous union became important; polish and finish began to be minor considerations.

The researcher began to see each joining as a form of modified bonding. The researcher realized that inherent in any form of constructivism was the tension created when one material was joined to another. A nail, a bolt, and a wood wedge serve to bind one material to another through tension. The wood joining techniques chosen for this study were in one form or another a type of tension. With this understanding in mind, the work progressed and this created tension became of paramount importance.

The very nature of wood, including its cellular structure, can be viewed as stress and tension. Wood is under stress any time two or more pieces are joined. The wood will swell and twist with every change in atmospheric conditions. This movement and shifting can be viewed as an attempt to break that bond. Pieces cut and fitted together one day do not fit closely the next. Individual members had to be bolted together in order to restrict their movement. Only by chemical means can this shifting and swelling be completely controlled. However, if such means were employed, would not the final result be a kind of death for the wood and thus for the sculpture? Take away the tension, the swelling, the bowing, the checks and one takes away the "spirit," the "life" inherent in the wood.

Through the design process, the researcher began to add metal collars and metal caps to sculptures produced for the study. These metal pieces surrounded the wood and made the bond more permanent. It was during this transitional period that the researcher began to force the components into place; sometimes, the metal was forced onto the wood. At other times, the wood was hammered with great blows into the metal. The energy of this labor was transmitted into the sculpture.

An additional factor which surfaced during this period was a concern for the sound each piece produced as it was assembled. As the individual sections for any one sculpture were hammered into position, metal against metal, wood against wood, or any combinations, each produced its own distinctive tone. It occurred to this researcher that in order to experience each piece, a recording should be used to play back the sounds of the fabrication of each sculpture. Such recordings would better enable the viewer to fine tune his senses and more fully comprehend the energy transmitted by the sculpture.

As a direct result of this concern for "constructive" sounds (the strike of a hammer against wood or metal) the researcher began to consider the rhythms which exist everywhere. Manmade visual rhythms bombard society everyday. Things such as street signs, lamp posts, or telephone poles stretch on for miles and while one may not care for the form the existence cannot be ignored. The researcher also began to consider the repetition and hence the "rhythm" in nature. What is a tree but a repetition of line and form. A flower is the repetition of one shape. What the researcher began to discover was that man never seems to accept a single image and that all things gain power and influence through repetition. This was part of the reason the researcher designed many of the sculptures using repeated images. The researcher repeated an individual component until its influence became powerful enough to hold a viewer's attention for the time required to experience the sculpture. Once initial attention-getting had taken place, the viewer was free to explore further and really begin to appreciate the work. The researcher hoped the person would begin to experience not only the sameness but also the difference and variety that existed within each sculpture.

The researcher saw this study as a period of growth. The researcher discovered other directions to pursue. These studies are only the beginning of what will be a continuing search for sculptural images.

APPENDIX A

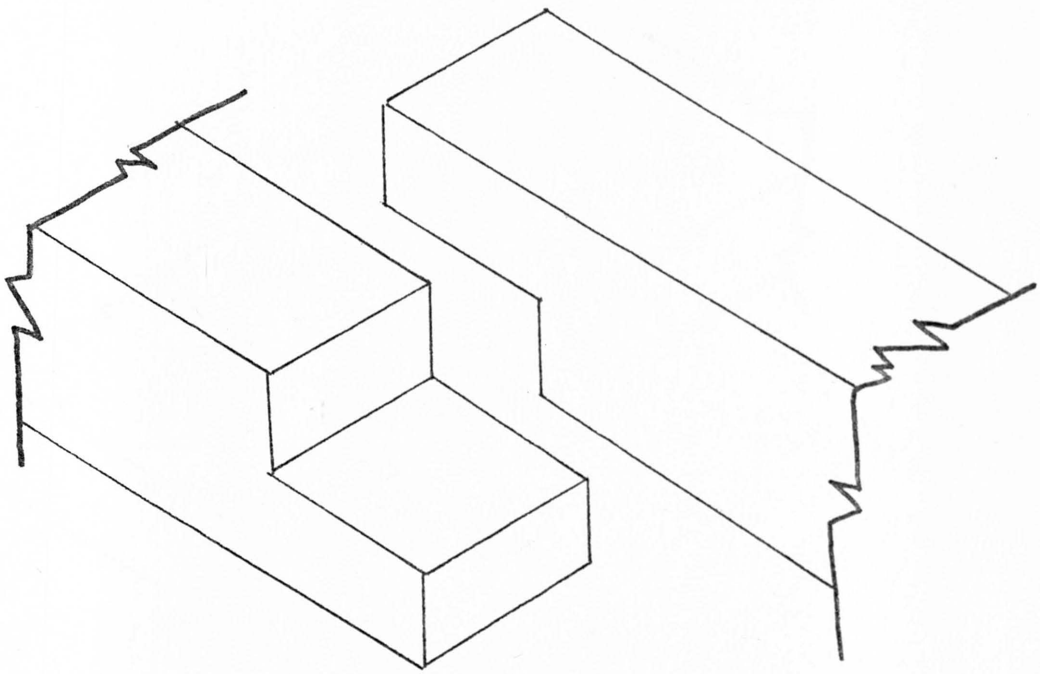


Fig. 33. End lap joint (extension of stock). Two members of approximately equal thickness and usually of the same width are joined in a modified type of butt joint to extend length or to change direction. Half the thickness of each member is cut away so that when lapped together a thickness equal to that of one member is formed.

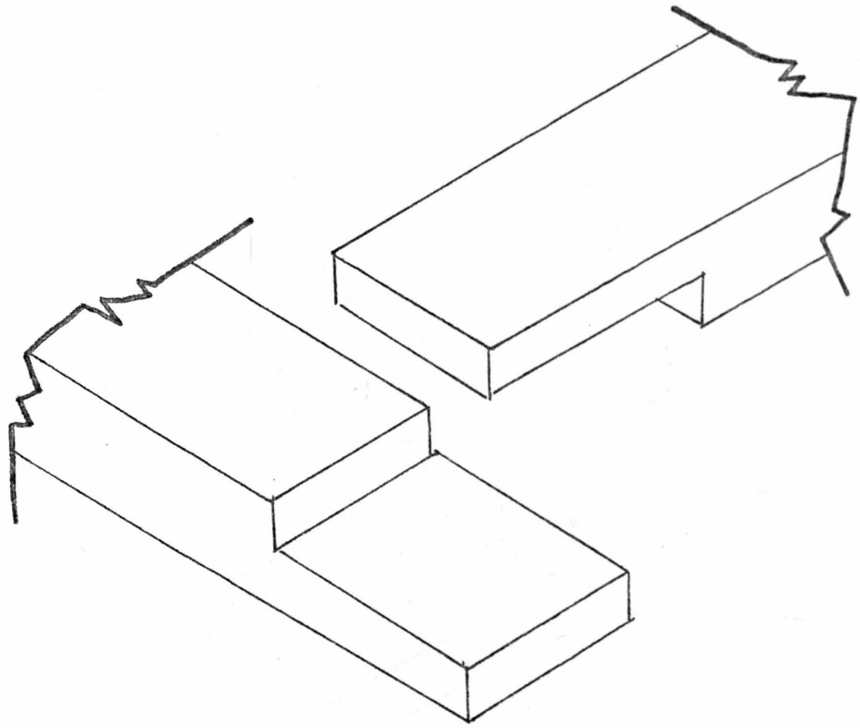


Fig. 34. End lap joint (change of direction). Two members of approximately equal thickness and usually of the same width are joined in a modified type of butt joint to extend length or to change direction. Half the thickness of each member is cut away so that when lapped together a thickness equal to that of one member is formed.

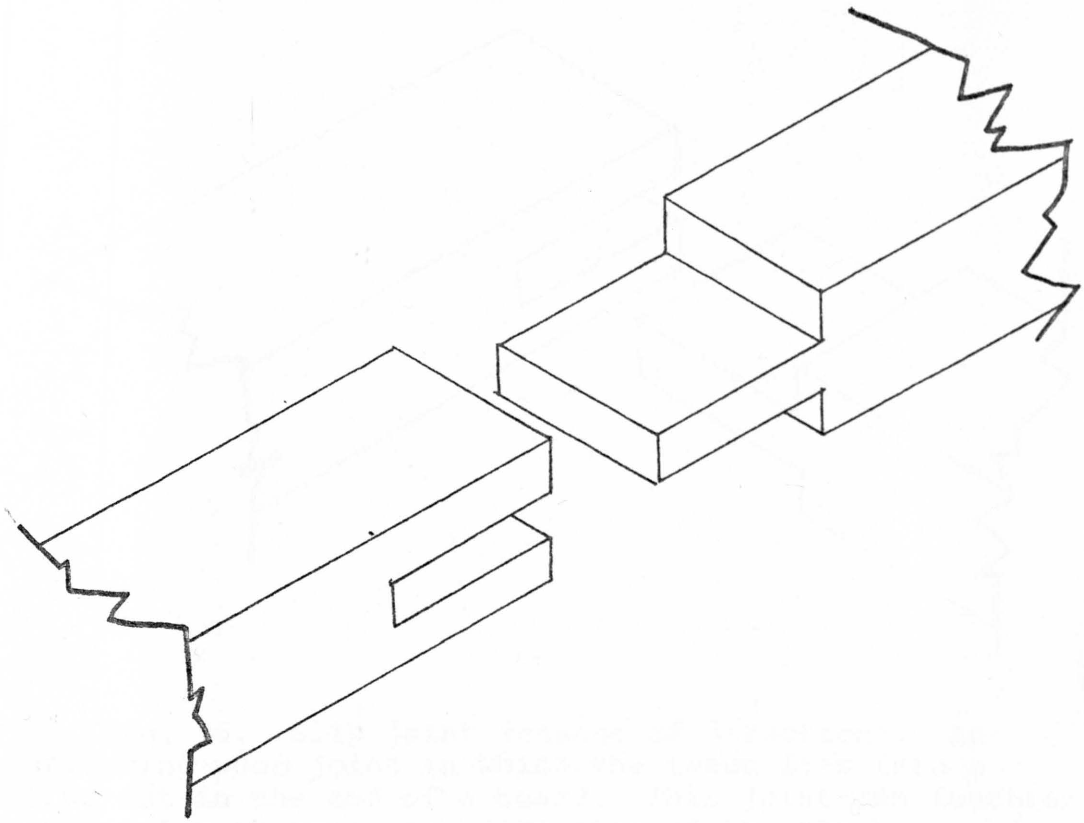


Fig. 35. Slip joint (extension of stock). An interlocking wood joint in which the tenon fits into a mortise cut in the end of a board. This joint can function to extend length or change direction of the stock.

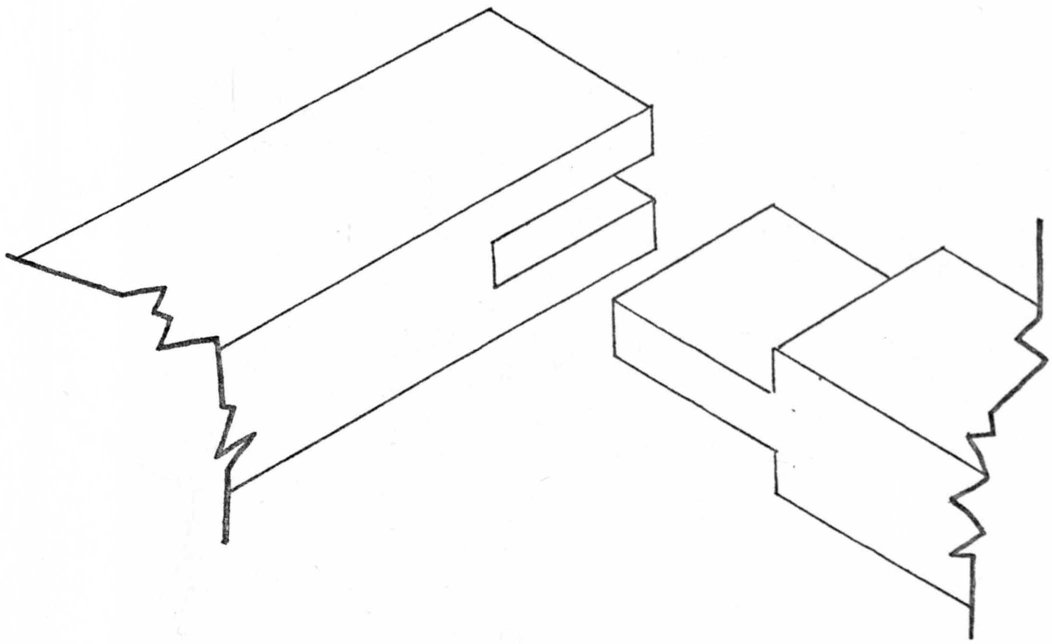


Fig. 36. Slip joint (change of direction). An interlocking wood joint in which the tenon fits into a mortise cut in the end of a board. This joint can function to extend length or change direction of the stock.

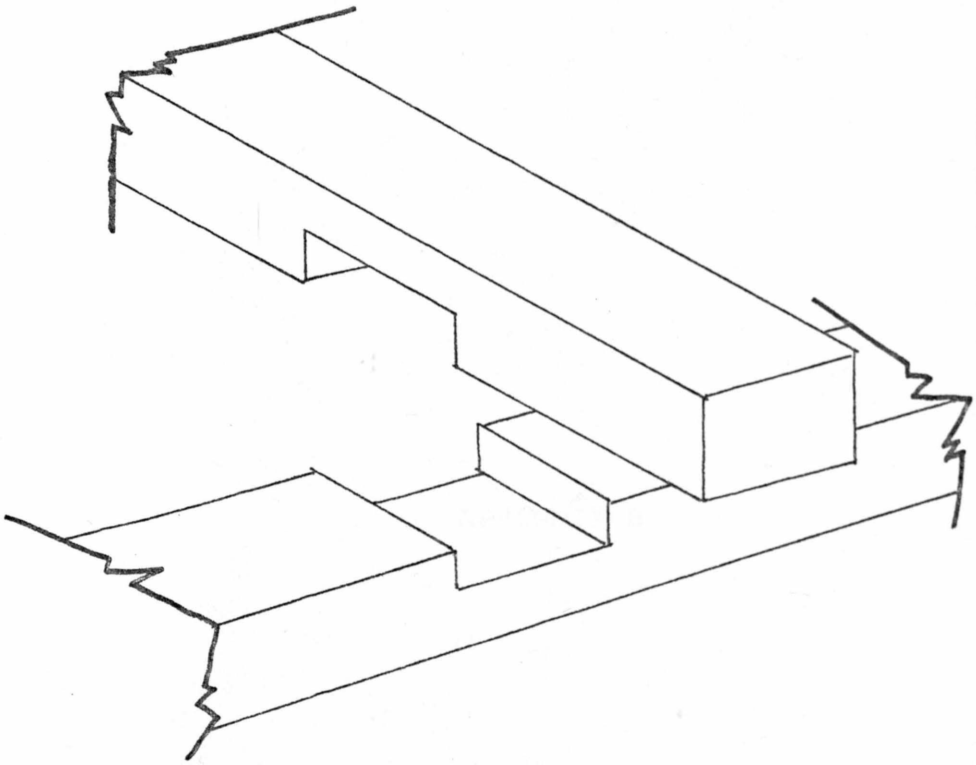
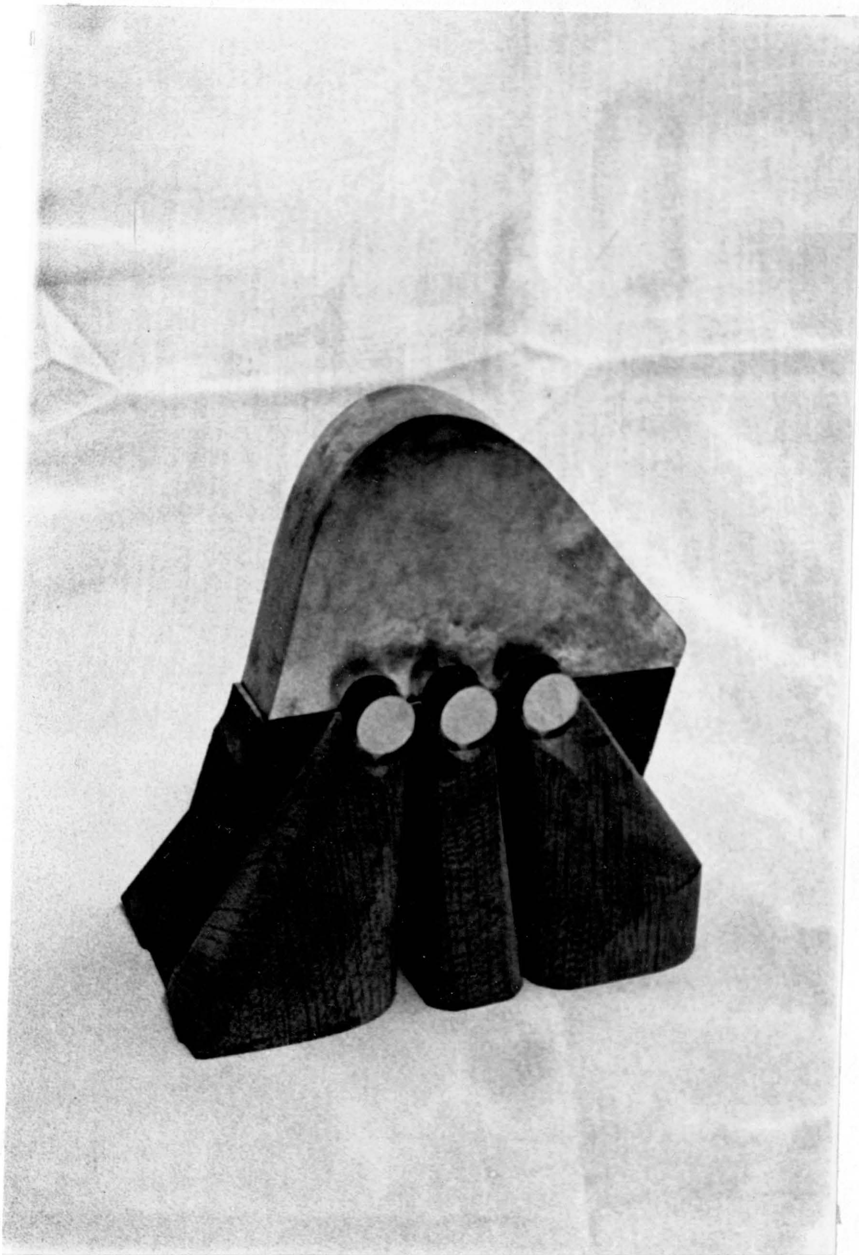
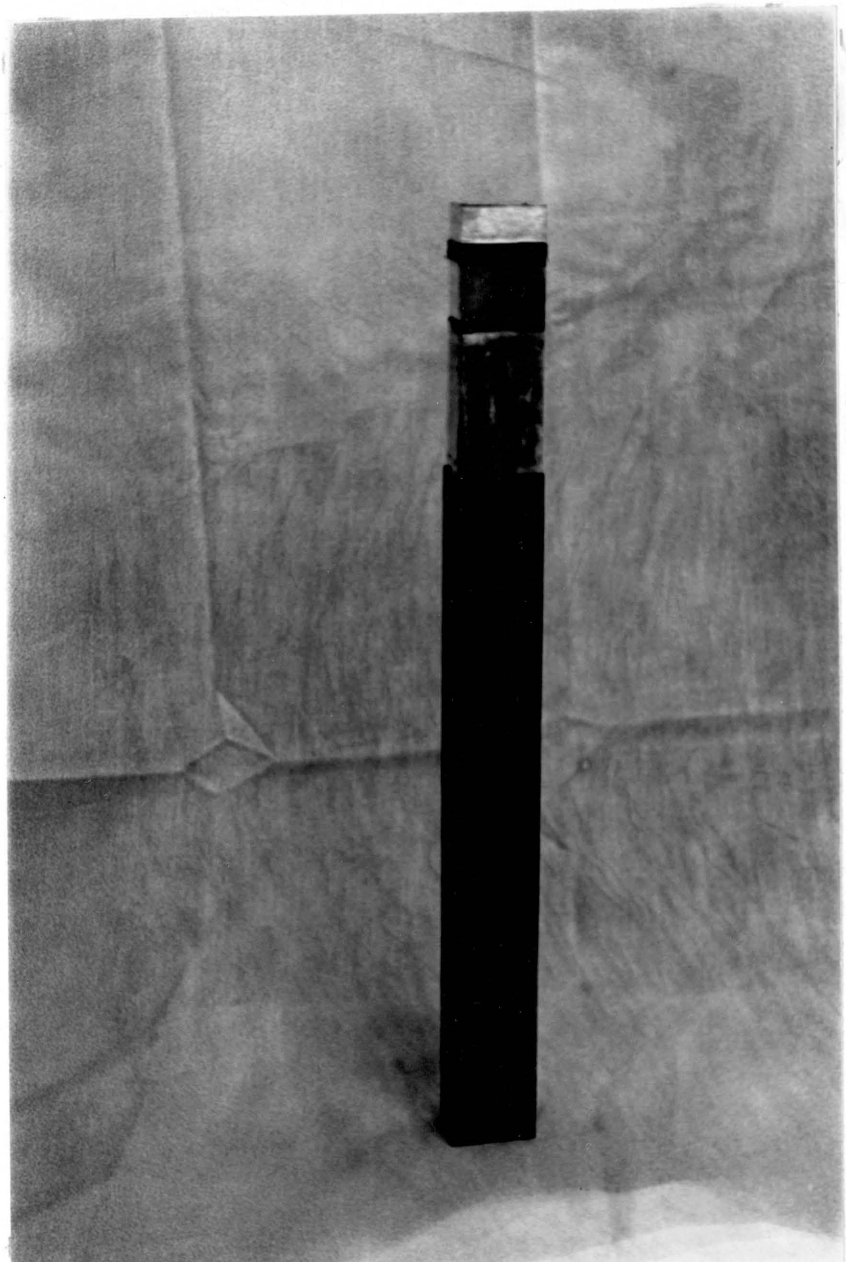


Fig. 37. Cross lap joint. An interlocking joint used to change direction in which two members usually of equal thickness are joined. Half the thickness of each is cut away so that when lapped together a thickness equal to that of one member is formed.

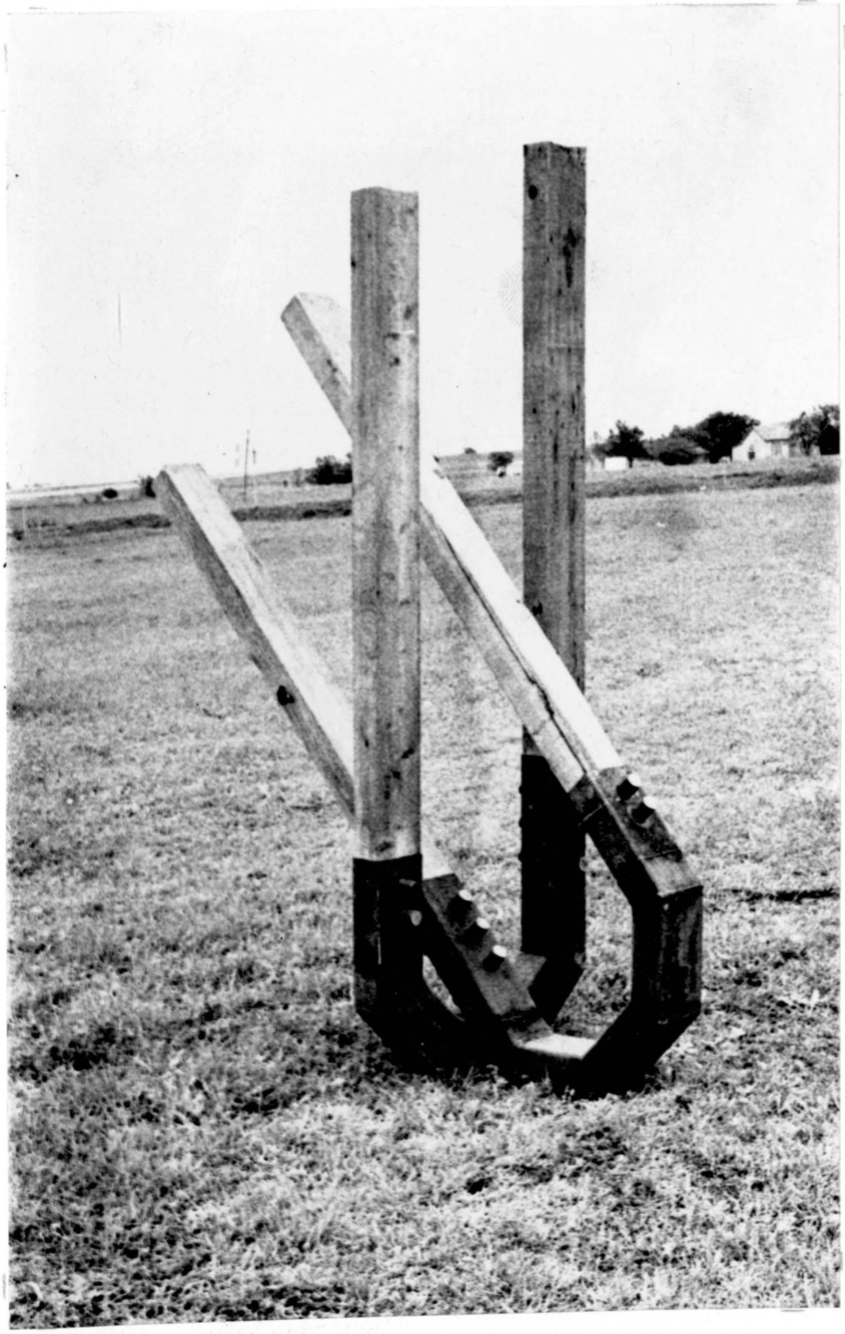
# APPENDIX B



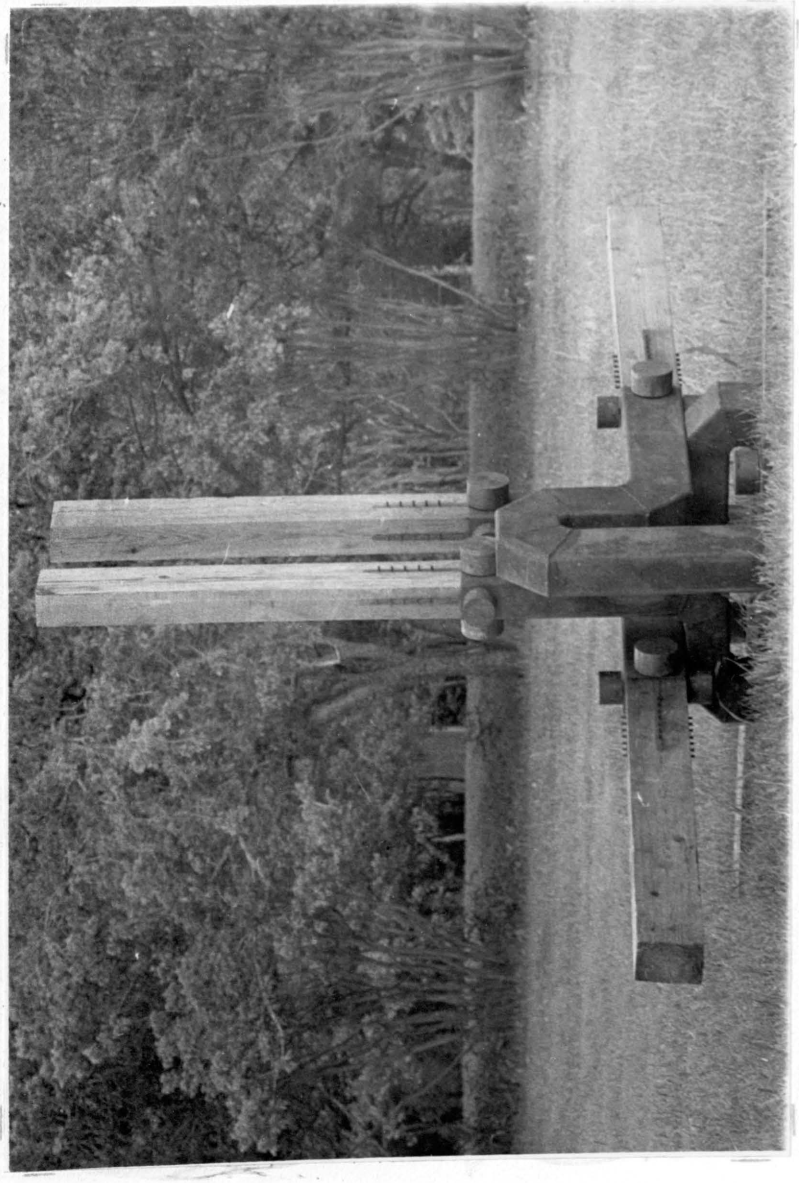
"DVWKYIT"
bronze and oak



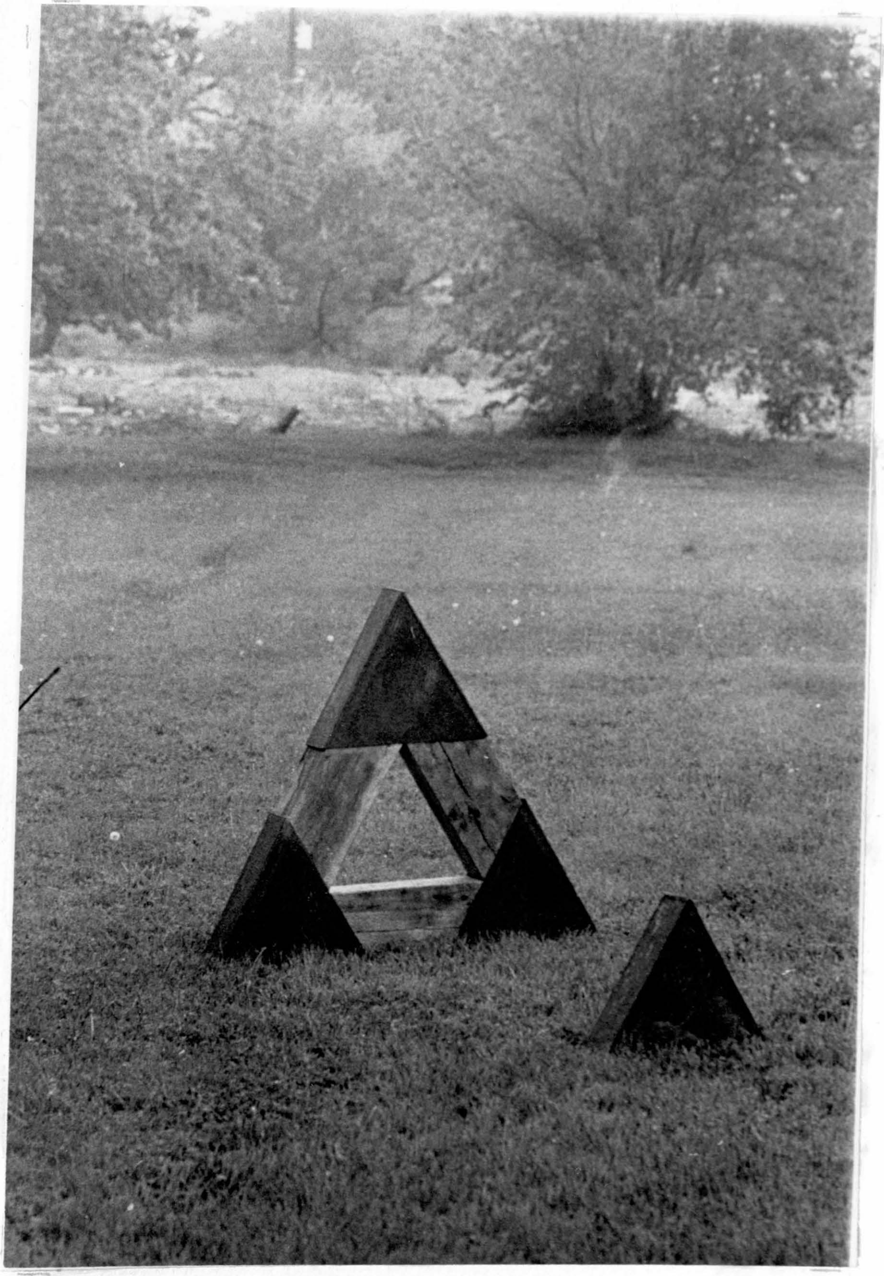
"Linear Homage"
brass and Zebrano wood



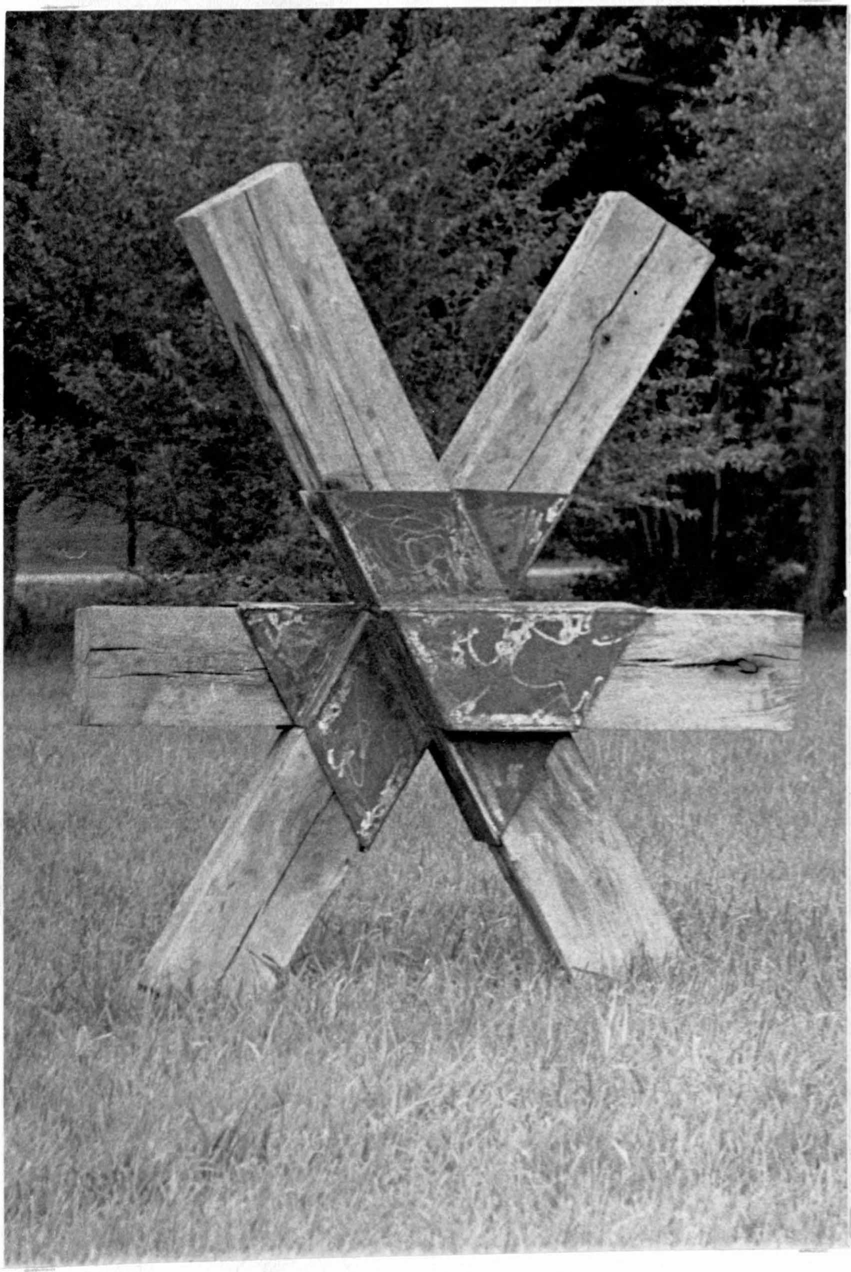
"As You See It"
mild steel and cedar



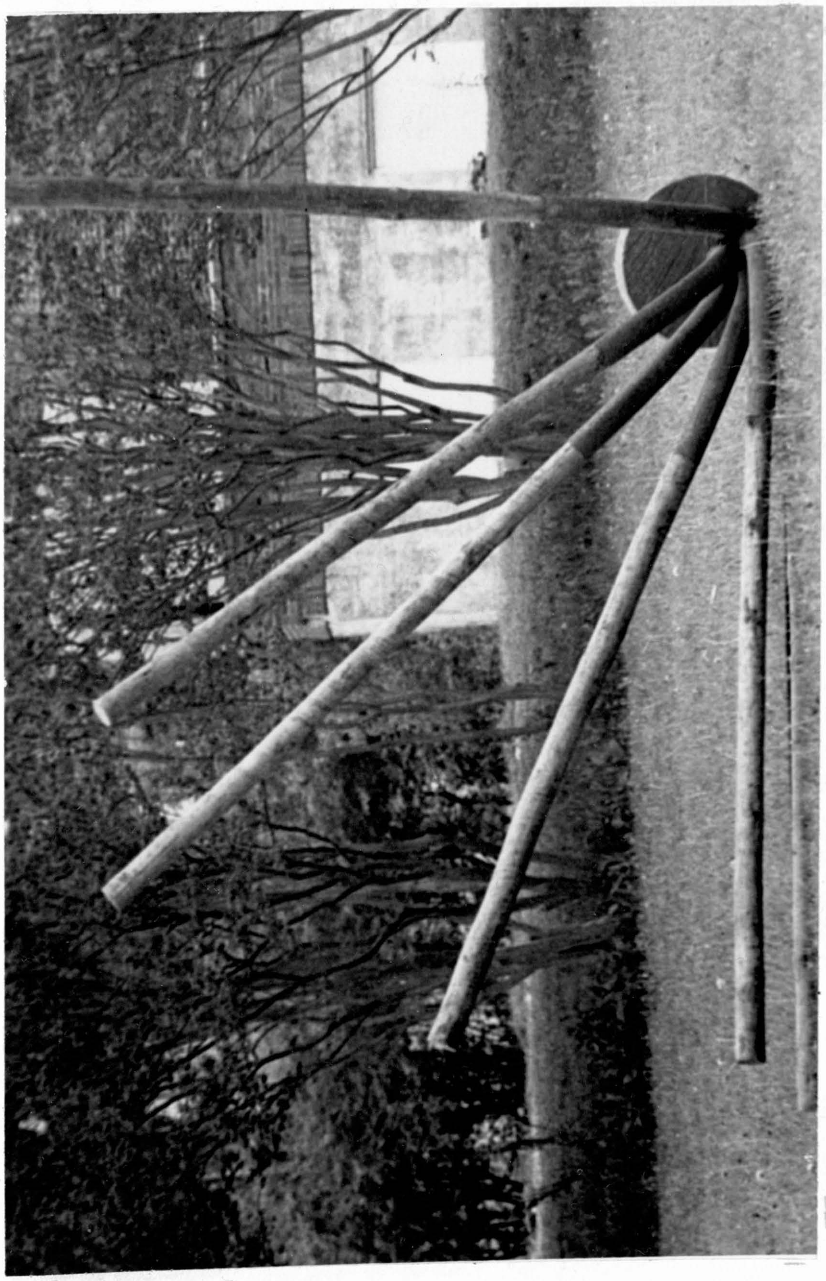
"Welcome to the Hindu Arms"
mild steel and cedar



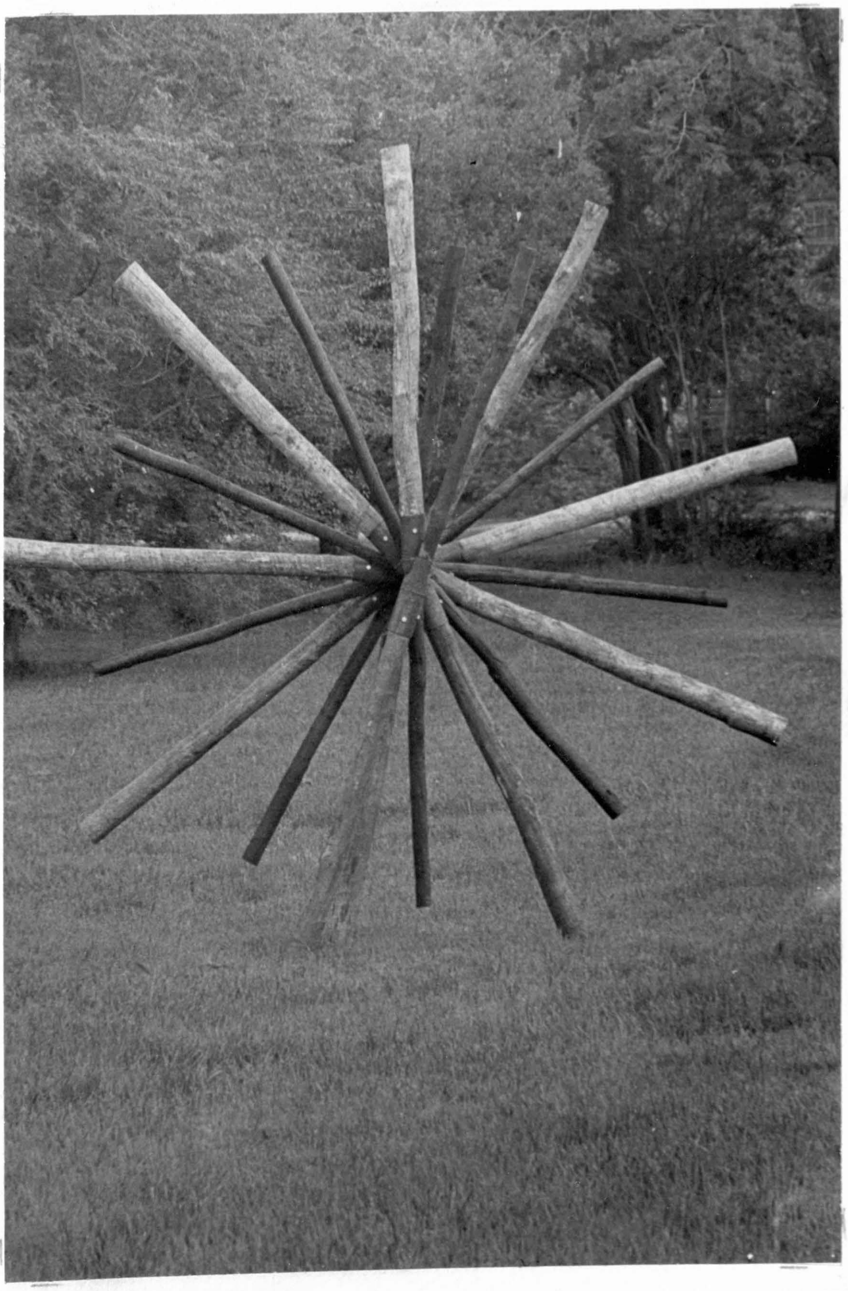
"Perceptions"
mild steel and oak



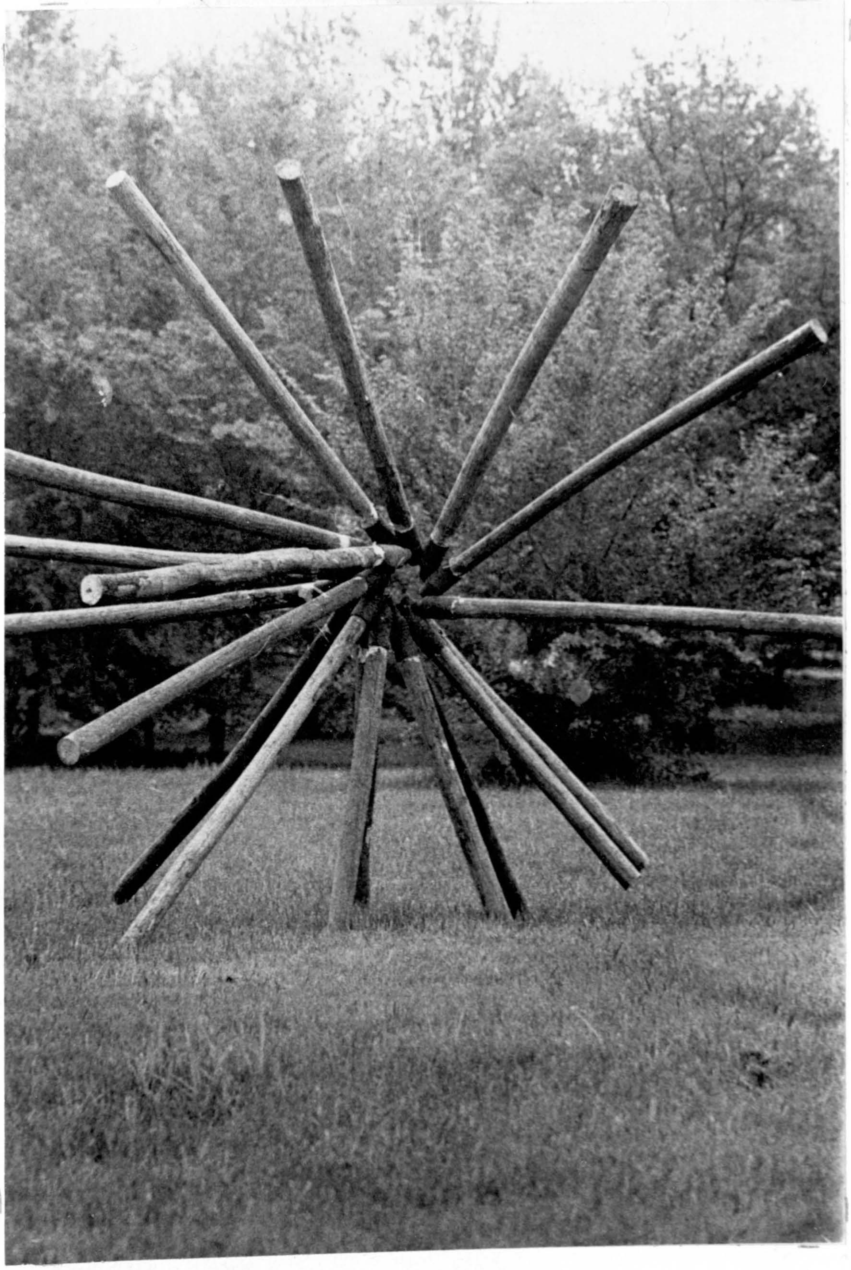
"Six Minus Three"
mild steel and oak



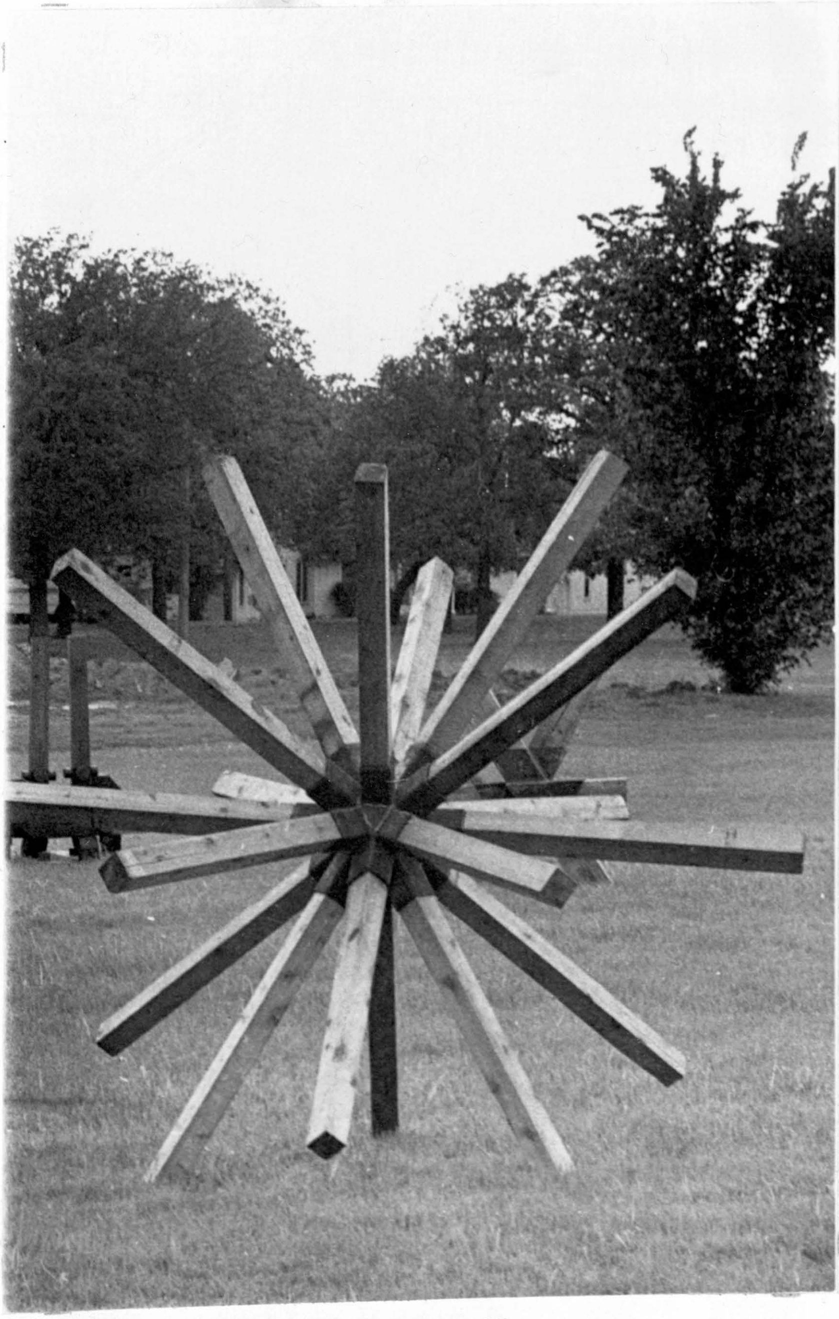
"Bottom Side Up"
mild steel and pine



"Under the Big Top"
mild steel and pine



"Linear Gyrations"
mild steel and pine



"Untitled"
mild steel and cedar

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