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THE EXPLORATION OF THE DECORATIVE AND
FUNCTIONAL USE OF RIVETING IN
HOLLOW FORMS

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INTRODUCTION

In the search for a way in which the designer craftsman may express himself in relationship to his work, very often it is necessary to rediscover a technique which is lost or not in common use today.

"Riveting is one of the simplest and oldest methods of joining sheet metal."¹ The functional and decorative use of rivets in hollow forms is not used, to any great extent by a craftsman in metal working today. Indeed, it can be explored again as a way in which the craftsman can formulate a new approach to joining metal forms.

The purpose of this paper, then, is to gather together information on riveting, to explain its processes, and evaluate its qualities so that it can be used in the execution of hollow forms.

A thorough investigation into the properties of different types of rivets, riveted joints, and setting rivets, is necessary to gain an understanding of how they work and how the craftsman must approach his design to incorporate rivet construction.

The research that has been done on this paper has been invaluable to the preparation of the pieces related to the thesis proposal.

It is hoped that the time devoted to the research and actual work of using rivets in hollow forms will be

of assistance and help to others who, while reading this paper will be inspired to also explore the use of rivets.

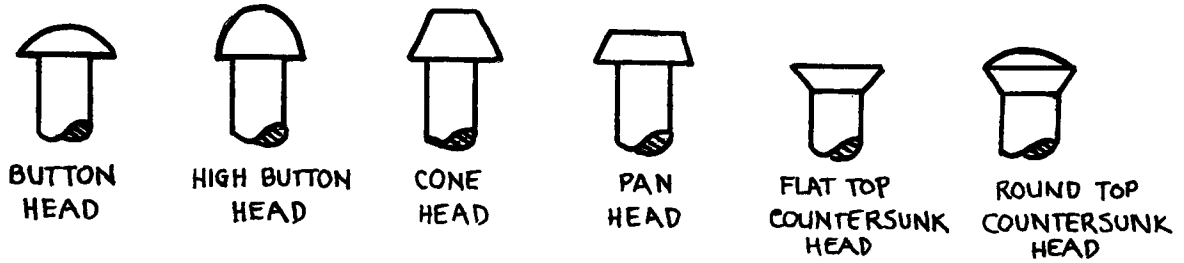
CHAPTER I

"A rivet might be described as a permanent bolt with head, body and, nut forming one piece."² All rivets contain these three basic parts, the head, the body, or shank, and the end of the shank where the riveting of the "nut" takes place. Any one, or all of the three basic parts of a rivet is important when considering them for a particular use. "The choice of rivet depends on it's appearance, use, and location."³

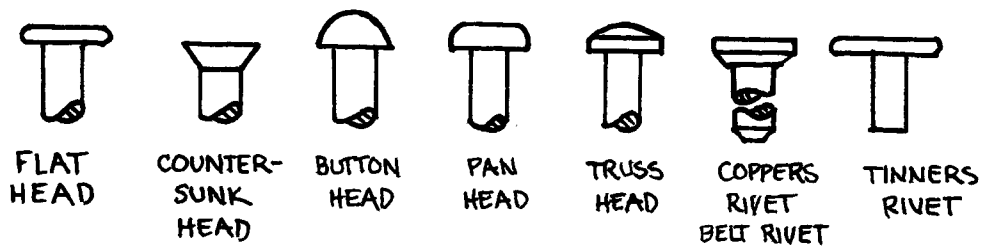
"In general, rivets for metals may be classified by types, as large, small, tubular, split, hollow, and special; by the material from which they are made; or by the purpose for which they are used."⁴ The most common materials that rivets are made from are iron, steel, stainless steel, aluminum, brass, copper, and nickle silver. Types of solid preformed rivets are usually named after the shape of the head: mushroom or button head, countersunk, flat head, cone head, and pan head.

Large rivets are usually made of steel and used in the construction of bridges, buildings, ships, boilers, etc. The size of a large rivet is measured by the bearing surface of the head of the rivet which is normally $\frac{1}{2}$ " or larger. The length of the rivet may vary and is measured from the bottom head of the rivet to the extreme end of the rivet.

LARGE RIVET HEADS



SMALL SOLID RIVET HEADS



MISCELLANEOUS RIVET HEADS

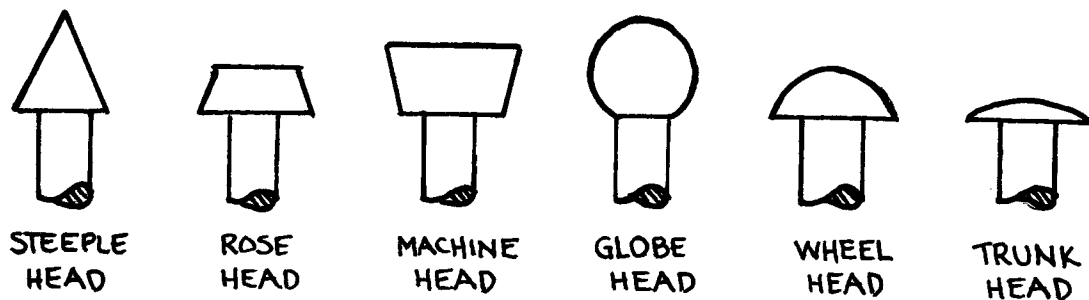


FIGURE 1

Small solid rivets made of metal are mainly used in joining sheet metal of light thickness. Like large rivets they are standardized by size and shape of the head.

Special small solid rivets are made for specific uses. "Types are produced with precious metals, such as coin silver for electrical contacts; with knurled or fluted shanks that can be used as upsets in molded or die cast parts; with special long, short or shaped shanks that can be used as pivots or cam followers; with ornamental heads for pens, pocket lighters, or similar products or with large-diameter or special head shapes."⁵

Tubular and semitubular rivets are perhaps the most widely used of all types of rivets. In addition to low cost and speed of application, small tubular and semitubular rivets, can be used to advantage in joining assemblies of non uniform thickness made of dissimilar materials or a variety of metals in lightly loaded structures.⁶ These rivets must be used where stresses on the joints are not great and where they can be easily set.

There are five basic types of tubular and semitubular rivets. The two major types are made with both shallow and deep drilled or extended holes, known respectively as "semitubular" and "tubular" types.

The semitubular rivet is the most widely used and can be used for assembling a variety of materials when the full shear strength of a rivet is required. It must be used in a predrilled or punched hole for the "shallow drilled" tube is only used for clinching the rivet.

The tubular type is best suited for use with materials such as plastic, leather, canvas, or wood, in which the rivet must pierce its own hole. The deep drilling allows the slug of the hole to compress inside the rivet, providing sufficient metal for clinching.⁷

The third class of tubular rivet is the bifurcated or split type and is formed by cutting a slot in the shank of a solid rivet.⁸ The two resulting prongs are ideal for piercing its own hole when used in thin gauge metal, wood, fibre, and composition materials. Unlike the tubular type which compresses a slug of material in its shank the split or bifurcated rivet compresses the material to the sides forming a tighter fit. The prongs are then spread to fasten or clinch the joined materials.

The fourth basic type of tubular rivet is formed from a combination of a deep drilled part and a solid or blank rivet.⁹ The relative size of the drilled hole and the blank diameter are made in such a manner that they produce a compression fit when the two pieces are

riveted together. This rivet produces a fastener that has the same appearance on both ends, and is used mainly in the cutlery field.

The fifth tubular rivet type is the true full tubular rivet or sometimes called the eyelet. A tube of metal is placed through the holes of the material or materials to be riveted and allowed to extend above the surface sufficiently so that when the sides of the tube are bent over they grasp the edges of the hole securely.¹⁰ Although the strength of this type of rivet is limited, its value lies in the fact that there is a full hole after setting the rivet. This hole can be used for passing rods or wires through the joined plates.

Two other rivet types which are worth mentioning are the screw rivet and the integral rivet. The screw rivet which screws in place and is then hammered over are available. Once in place they are permanent.¹¹

The integral rivet is made from a part of one piece of material which projects through another piece. The projecting end is then closed in a typical rivet fashion.

There are many more specialized commercial rivets available for specific uses. Some of the most common of these being the cherry rivet, Huck rivet, pop rivet, Molly bolts, Southco Blind rivets and the DuPont explosive rivet. All of these demand a special tool for setting

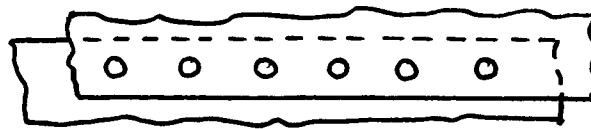
and for this reason only I have deleted them.

CHAPTER II

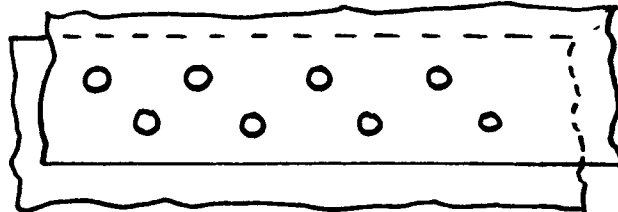
Riveting is a popular method of fastening and joining because of its simplicity, dependability, and low costs. Compared with welded joints, riveting makes possible consistently uniform results, without resort to x-ray or other costly methods of inspection.¹² Unlike the welded joint which creates heat, riveting done cold will keep the metal from reaching an annealed state and hence making it weaker, therefore a heavier gauge metal does not have to be used to keep strength at the joint. The most important aspect of a riveted joint is that any material can be joined. In joining the materials there are two principal kinds of riveted joints - the lap joints and butt joints.

In the lap joint the plates to be joined overlap each other a sufficient amount for riveting.¹³ The lap joint may be single riveted, or double riveted in chain or staggered rivet form, (figure 3.).

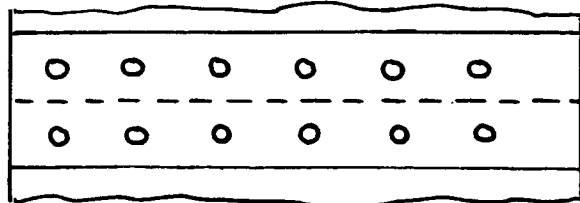
In the butt joint the plates are in the same plane and butt against each other connected by a short plate or butt strap, either on one side or on both sides of the plates to be joined.¹⁴ Butt joints may be single -, double-, triple-, or quadruple- riveted in which case one, two, three, or four rows of rivets are employed. If the rivets in the rows are in line crosswise the joint is "chain riveted". If the rivets in adjacent rows are



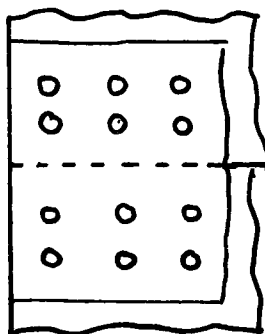
LAP JOINT-SINGLE RIVETED



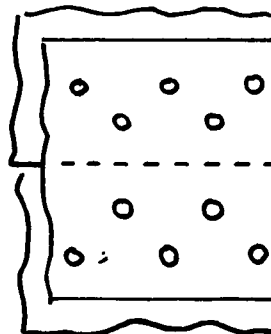
LAP JOINT-DOUBLE RIVETED-STAGGERED



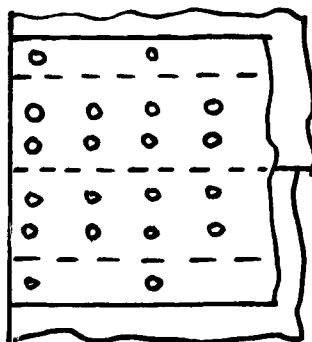
BUTT JOINT - SINGLE RIVETED



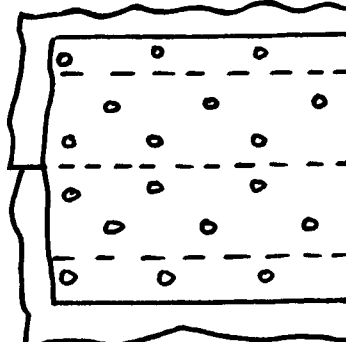
CHAIN RIVETED



STAGGER RIVETED



CHAIN RIVETED



STAGGER RIVETED



FIGURE 3

offset by one half the center to center distance the joint is "stagger riveted."

Watertight riveted joints are not possible without using a sealer of some sort between the riveted plates. Varnish or a varnish soaked gauze is a good sealer between the plates and should be riveted when the varnish is tacky. Either the lap or butt joint may be used, however the butt joint with two butt straps is the best.

CHAPTER III

In its simplest form, riveting consists of inserting a ductile pin through two or more parts and forming over the ends of the pin so as to secure the parts firmly together. "The most common way of forming rivets are by impact (hammer blows), compression (squeezing by hand or power tool), and a combination of both."¹⁵ In either or both methods the rivet may be formed or driven in both the hot and cold condition.

Hot riveting is usually applied to large structural rivets. The rivets are first brought to a high temperature which renders it soft and malleable and is quickly inserted, while hot, through the parts to be joined and headed over by a riveting hammer. The other end of the rivet is backed up with a tool called a buck or bucking bar.¹⁶ The strength of hot riveting lies in the fact that as the metal cools it shrinks and tightens the joint. The disadvantage of hot riveting is that if the rivet cools before final setting it can be loose and of no structural value.

Rivets which are driven cold are usually of the small variety and are used mainly in manufactured products. The rivet is driven at normal surrounding temperature. Although it does not require the heat to be driven, the rivets should be pre-annealed to attain

their maximum softness for driving. In cold riveting a bucking tool will be needed unless it is of the blind rivet, pop rivet, or explosion rivet type. Cold riveting is mainly used in automatic machine riveting where it is done with equipment that feeds the rivet into predrilled stock and heads it automatically.¹⁷ Because of high set up costs it is mainly used for a high rate of production.

The disadvantages of using rivets whether driven hot or cold are:

1. Parts, once assembled, cannot easily be disassembled.
2. The tensile strength and fatigue strengths of joints made with split, semi tubular, tubular rivets are considerably lower than bolted or welded joints.
3. Joints normally are neither water tight or airtight.¹⁸
4. Clearance allowances for joining the metal parts or setting the rivets have to be larger than for soldering or welding.

Some of the most important advantages of using rivets are:

1. Either metallic or non-metallic materials can be joined.
2. Dissimilar metals having a number of parts with non-uniform thickness can

readily be fastened.

3. The fastener in cold riveting has the uniform structure and inherent strength of a forging.
4. The rivet can be made of a variety of materials.
5. The rivet can be used not only as a fastener but as a pivot, cam follower, electrical contact, or other functional component.¹⁹

When riveting, if three main considerations are followed, the riveted joints should be successful. The first two considerations involve the choice of the right rivet for the riveted joint. The rivet should have a diameter equal to twice the thickness of the metals being joined. The length of the shank should be long enough to allow the head to be formed. The third consideration involves the holes that the rivet goes through. The holes of the joining plates should be accurate in diameter and in alignment to allow the rivet stem to pass through tightly. Two other considerations of lesser importance should be followed to insure good riveted joints. They both involve the setting of the rivet itself. The first concerns spacing between rivets and/or the edge of the materials being joined which should be kept at two times the diameter of the rivet hole to avoid

splitting.²⁰ The other is that if the riveted head is spread too thin then it will become weak and could shear off.

CHAPTER IV

In the process of deciding that I would deal with riveting as the topic of my thesis, I started to look for metal pieces which used rivets. I was mainly aware of riveting in jewelry forms, in which it was employed only to fasten together work-hardened metal for springs, pin stems and catches. It was not until I had made a trip to the armor rooms of the Metropolitan Museum of Art in New York, that I realized the beauty of riveted hollow forms. Certain pieces from the collection of European and especially Japanese helmet armor, inspired me to use riveting as a method of construction in achieving hollow forms.

In early European armor riveting is mainly used in its simplest state, that of forming over the head of a ductile pin to fasten parts together. "As the functional problems of armor were solved, the armorers turned their attention more and more to ornamental details."²¹ Not only were the armor plates themselves decorated, but the rivets became important in the decoration as well. This can easily be seen in figures 4, 5, 6 and 7.

Japanese helmet armor is perhaps the finest and most beautiful application of the riveting process to achieve hollow forms. The helmet bowl called the Kabuto-



Figure 4

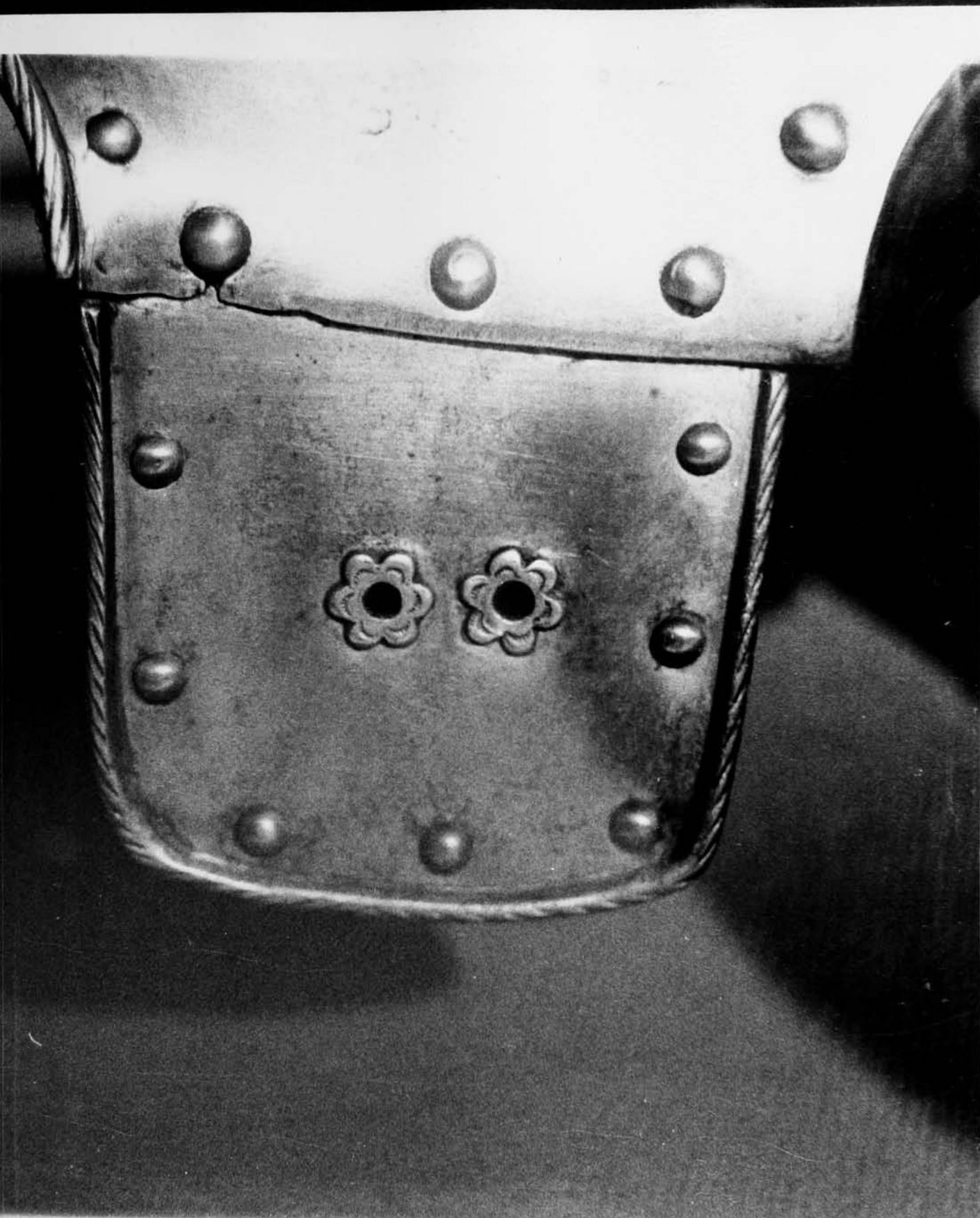


Figure 5

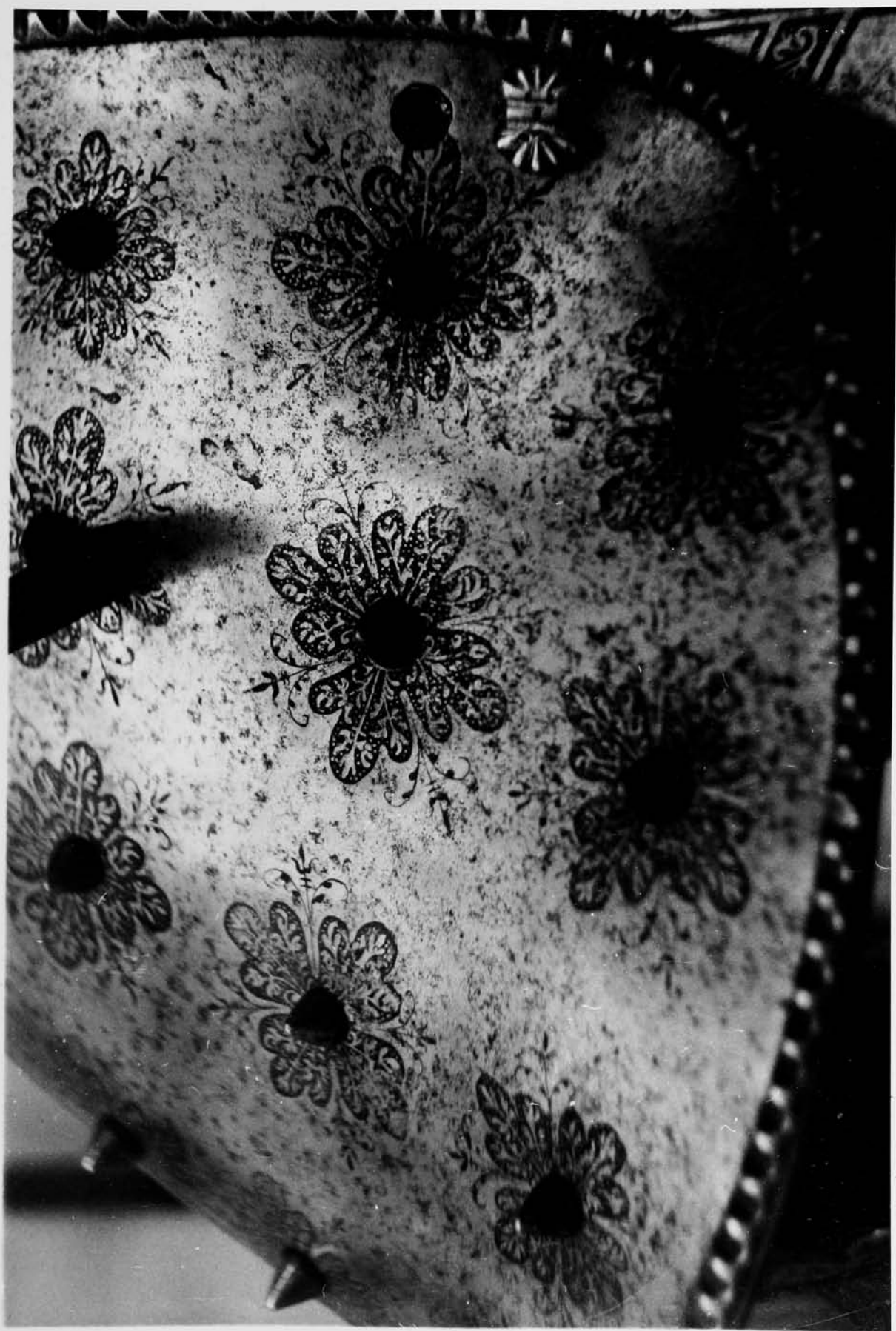


Figure 6



Figure 7

No-Hachi²³ are usually constructed of a number of overlapping plates riveted together. The earliest design of Japanese helmet (figure 8) has these features. They also remained constant in the development of the helmet design for centuries.²³ The Japanese helmet attained its greatest beauty and structural grace during the Edo period, 1615-1867 (figure 9). Here the numerous plates running from top to bottom are joined with flush rivets. The plates which are called "Suji" have a line or stripe formed by a standing flange on the metal plates. Other helmets of this period use a large or small conical, high headed rivet which has great significance to the whole art form of the Japanese armor. The translation of the individual meanings of these rivets are, embossed stars, rear power mountain, large stars, and white (silver) stars.²⁵ Each has a specific purpose or function in the whole philosophical design of the helmet.

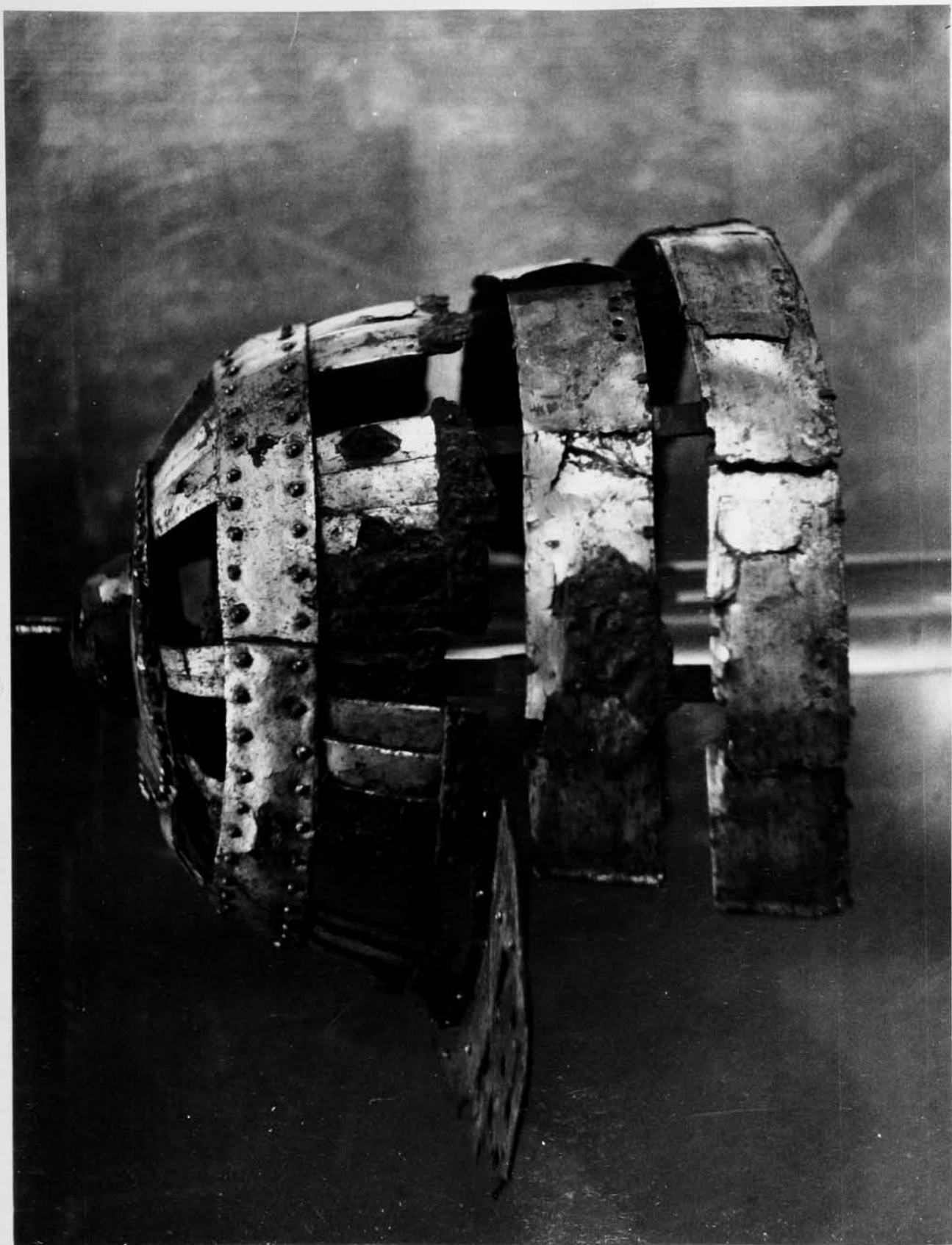


Figure 8

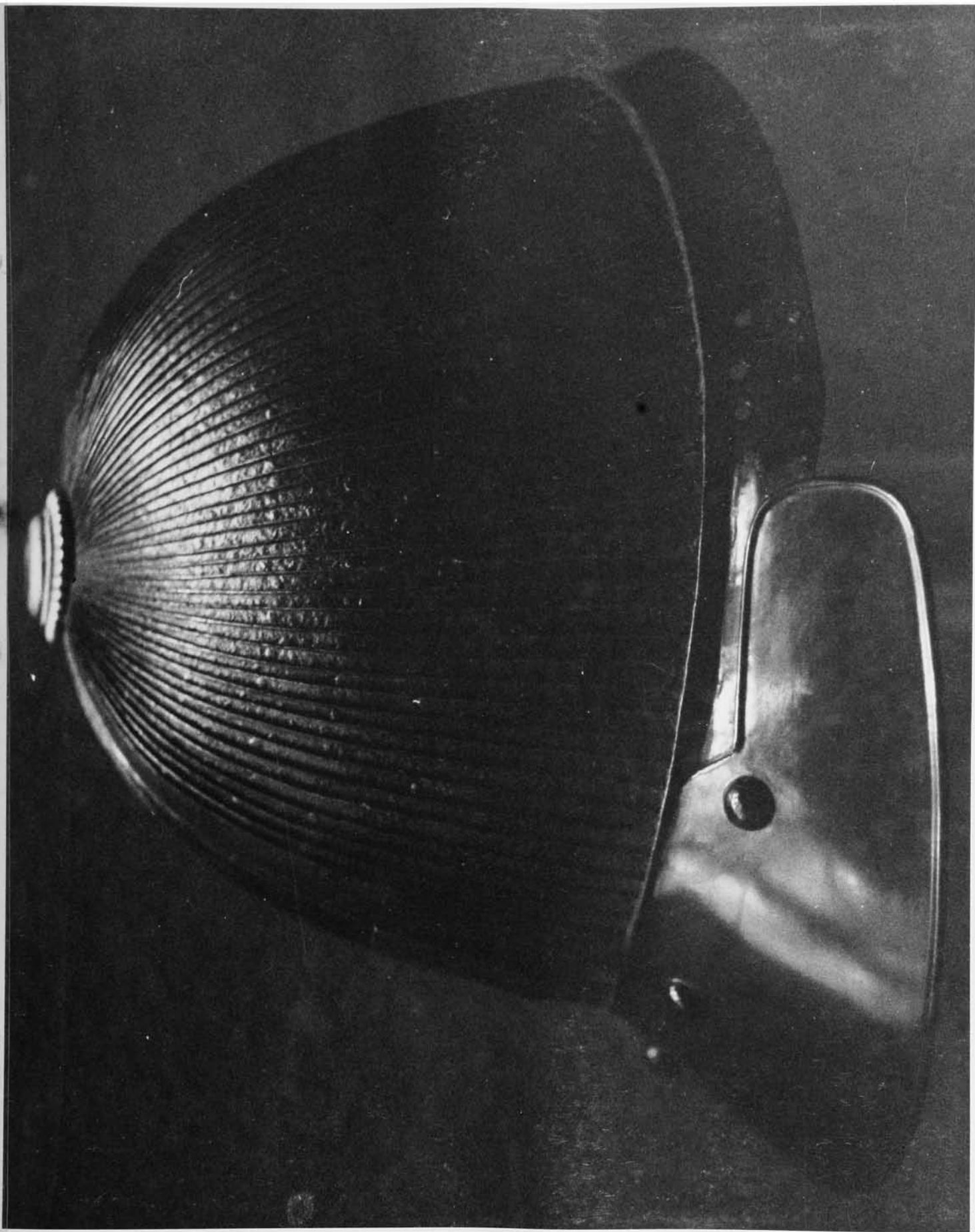


Figure 9

CHAPTER V

In the execution of pieces towards the thesis, I felt it necessary to try four different rivet types. They are the simple rivet, commercial rivets, tube rivets, and flush rivets. Each of the rivet types has its own feeling which lends itself to the constructed hollow form.

The first two pieces using rivets were done with the simple rivet. The simple rivet is made by a ductile pin which is passed through holes in two or more pieces to be joined, and a head is formed on both ends of the pin to fasten it. I felt that the nature of the riveting process lent itself to simply constructed forms. The first piece was actually an assembly of pre-constructed simple forms into a double planter (figure 10). The two tubular sections are first riveted together by three silver rivets at the back (figure 11). Next the two cup forms are riveted into the inside of the tubes. A spacer which surrounds the rivet is used to keep the rivet from bending at the space between the tube and cup forms (figure 12). In this piece the rivet is mainly for function and not decoration.

The second piece using simple rivets was a collander. In the collander the rivets are mainly serving a functional role, however they start to become decorative as well. The rivets are mainly used to attach the rim and handles



Figure 10

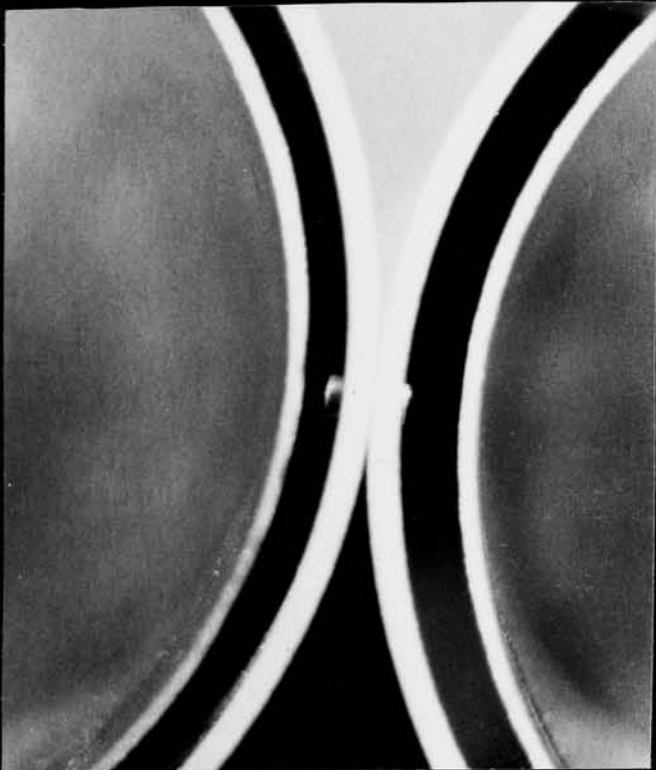


Figure 11

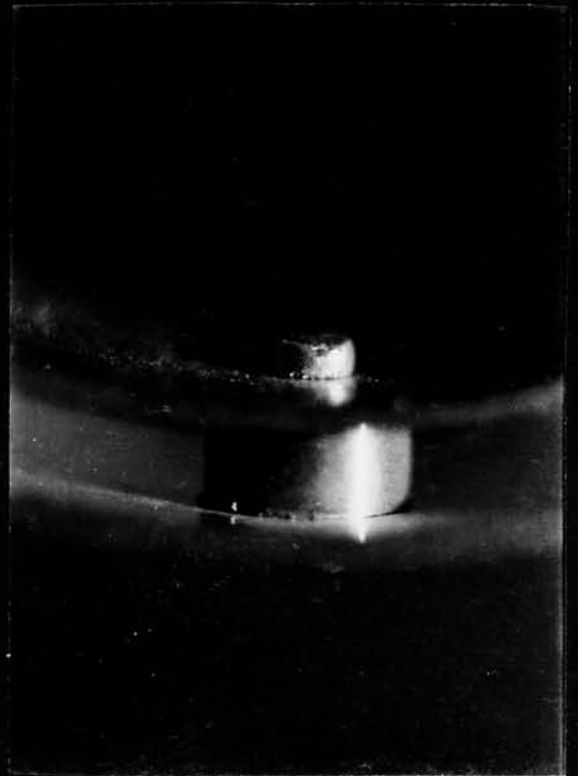


Figure 12

to the copper bowl form. They are decorative in the fact that they are visible and of a different material which is silver (figure 13).

The next series of three pieces utilized commercially made rivets. Two of the pieces are boxes made of brass and use tinnerns rivets for joining. In these pieces commercial fabrication was employed to its fullest by using bending jigs to fold the brass into box forms. The resulting flanges were then drilled and chain-riveted, lap joints were made. The rivets were set with the rivet hammer using a flat metal stake for a bucking bar.

The third piece was a sphere which was constructed of four convex quartered sphere shapes alternated by a concave U-shape. The pieces were joined using a small copper mushroom head rivet. In this piece the rivet was set using a center punch to create a decorative set instead of the normal rivet set. The head of the rivet was placed into a stake which had a concavity to accept the mushroom shape. The sphere piece was the first that managed to truly start to use the rivet as a decoration as well as serving the joining function.

The two pieces using tubing rivets are a hanging planter with chain and a bowl with a brass and plexiglass base. In these two pieces tubing is used as a rivet. The rivet is set by using a dap as the rivet set and as the bucking bar causing it to fold over and join the

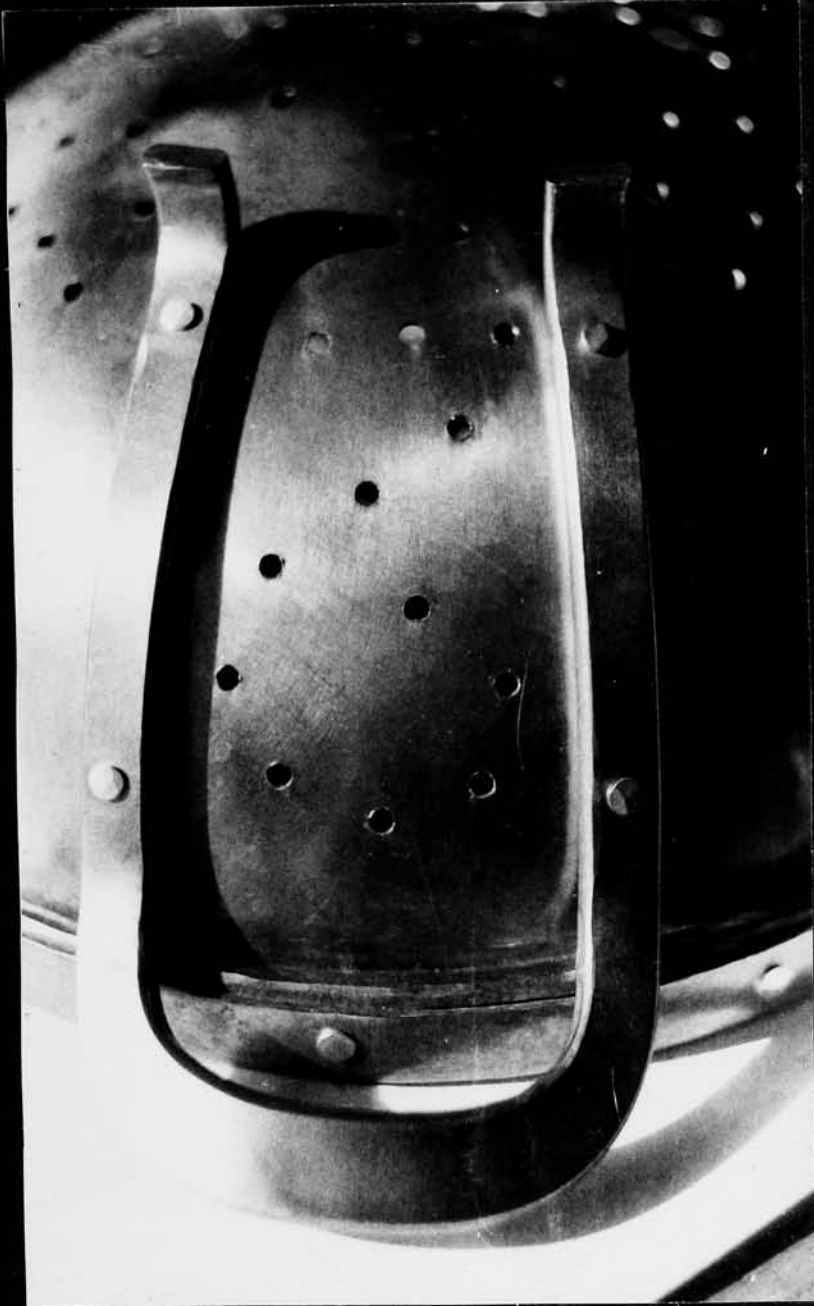


Figure 13

materials riveted together.

The planter uses the tube rivet to its fullest advantage by using the opening of the tube rivet for the construction of the chain and to hold the raised piece together. The decorative and functional aspect of the rivets are indistinguishable in this piece, and I feel make it very strong.

In the bowl the rivets are used in the base to hold dissimilar materials together. A curvilinear line which follows the rivets was cut from the brass to accentuate the rivets and the plexiglass. In doing this the fullest decorative aspect of the riveting was accentuated and became of more importance than the function.

Flush riveting was used as the means of joining metal in another hanging planter. First, two hemispheres were raised and formed into an opening (figures 14 and 15). A spacing rim was then forged and planished from large stock, (figures 16 and 17), to fit the flanges on the two hemispheres. The holes were then drilled through the flanges of the hemispheres and spacing rim and countersunk with a burr on both sides, (figure 18). I then chose to use a straight pin, rather than a countersunk rivet head, to form over the rivet head and fill the countersunk hole. Sufficient length was used in the rivet to fill the hole, (figure 19). The rivet was

Figure 14



Figure 15





Figure 16



Figure 17

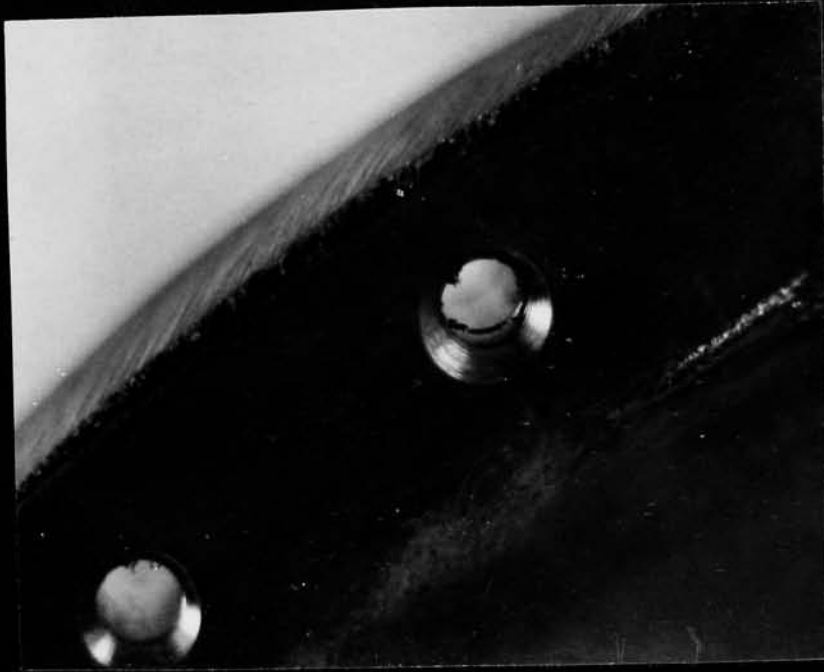


Figure 18



Figure 19

then carefully peened over, first one side and then the other, and then driven tight. The rivet hammer and a flat stake for the bucking bar was used to set the rivet, (figures 20 and 21). The rivets were then filed flush to the flanges and the piece was complete.

The only decorative quality of riveting in this piece is the subtle change of color in the oxidation of the two different metals. It is in this piece that I achieved more function and therefore let the piece itself come forth.

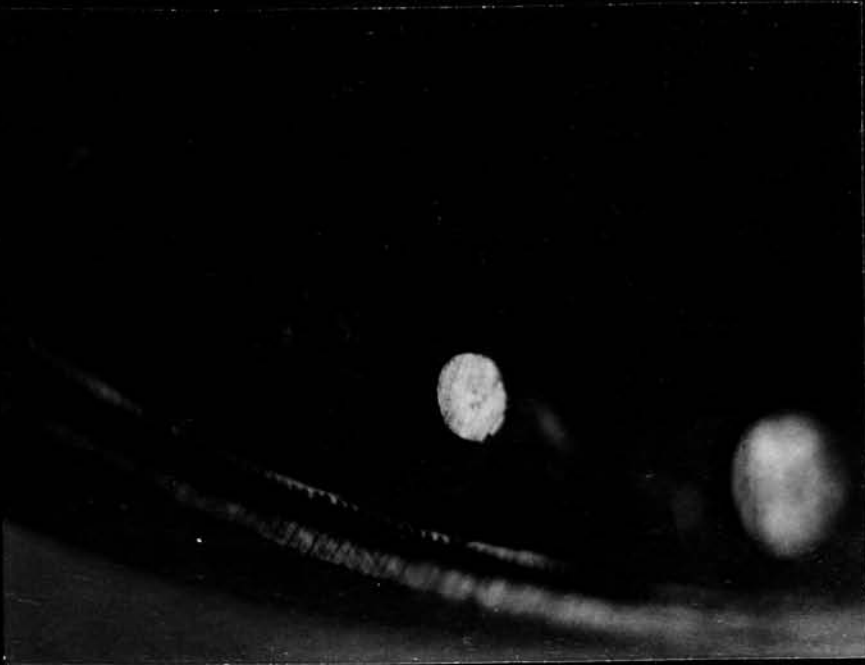


Figure 20



Figure 21

CONCLUSION

In practical application and procedures, the reading and compiling of the information on rivets, riveted joints and setting rivets was invaluable in proceeding with the actual thesis work.

The design of pieces incorporating riveting demands forethought as to how it will be constructed. If the piece is well thought out, and the construction that riveting demands is used as an element in the design, the results can be a challenge to the craftsman.

Through the research of the subject matter, I was able to avoid many of the pitfalls that riveting can have. When something did go wrong, I knew why or tried to find out why, and therefore, strengthened my approach to using riveted forms. As each piece was completed and the next designed, I could find a growth of stronger riveted design which came only from the actual execution of the pieces.

My feelings towards the Japanese armorers of the Edo period have increased as I think of the accomplishments they achieved in riveted forms. It is through them that I can see a new means of expressing hollow forms in my work.

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