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ROCHESTER INSTITUTE OF TECHNOLOGY

A Thesis Submitted to the Faculty of
The College of Fine and Applied Arts in
Candidacy for the Degree of
MASTER OF FINE ARTS

MOTION IN METAL

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Introduction

The purpose of my thesis work was to create a body of work which exploits the plastic capacities of the material, and explore the relation of the techniques used to aesthetic considerations. For this purpose, I chose to work chiefly in sterling silver. Sterling is ideally suited to the displacement techniques I wished to use. It is also a precious metal whose beauty becomes a part of the work created in it. While it is certainly possible to create beautiful work in metal using construction techniques, I have never been personally attracted to the process of cutting something into pieces and then putting the results back together. Such techniques lend themselves to a geometric sensibility. A straight line is a sure sign of the hand of man. Nature, however, always seems to meander from point A to point B, the journey seeming more important than the end. I was drawn to metal as a medium of artistic expression by its innate ability to express this natural aesthetic through its essential properties of malleability and ductility. In this paper I will describe my own journey of exploration as I produced the sculpture and jewelry displayed in The Bevier Gallery at R.I.T. in 1985. As is true of all rites of passage, it was an arduous trip. To me, it was more than worth the effort. I would like to take this opportunity to

express my profound gratitude to all those who helped me on the way. To my family, my fellow students, and above all my professors, I extend my deep thanks for your input, assistance, and support. "No man is an island...". Thank you for making me a part of the main.

The Material

Webster's Dictionary defines metal as "any of a class of chemical elements, such as iron, gold, aluminum, etc., generally characterized by ductility, malleability, luster and conductivity of heat and electricity ... [or] an alloy of such elements, as brass, bronze, etc.". (19:1131) In my thesis, I was concerned with those attributes which contribute to the plasticity of the material, ductility and malleability.

The former is the ability to be stretched or drawn, while the latter is the ability to be "hammered, pounded, or pressed without breaking or returning to its original shape". (19:1091) Modern metalworkers, whose "raw material" is usually highly processed before they begin to use it, often obtain the metal in two basic forms which reflect the nature of the material, rod and sheet. Ductility allows metal to be drawn out into solid rods and wires or hollow tubes of various shapes and diameters. Malleability allows metal to be beaten or rolled into sheets of the desired thickness and length.

To further my goal of producing an integrated body of work, I decided to focus on one of the many metals available. Sterling silver was chosen for the main body of the work, although some details were executed, for contrast, in gold. Sterling is 92.5 per cent pure

silver. The remainder is copper. This alloy offers a great deal of ductility and malleability, allowing the metal to be worked "cold" (at room temperature), while giving the metal sufficient strength so that finished work is not too easily marred. It is also a precious metal and, to my eyes, a very beautiful one.

The Sculpture

All of the work in my thesis is three-dimensional. I prefer to consider a surface not in isolation, but as a face which an object turns to the world; not merely as a field to be decorated, but as a boundary between internal and external space. This bias is undoubtedly the result of my first serious study in art, in ceramics. The maker of vessels addresses in miniature many of the same concerns which an architect addresses on a grand scale. Both are concerned with the hollow form, with the creation of an object which defines an interior space, which in turn defines the external form of the object. Unlike a solid object, it is the inner volume which expresses the form, the outer skin being its reflection. Also, both endeavors are historically rooted in utility, even if it sometimes gives way to other priorities. As Wayne Higby has written, "Like architecture, the vessel, too, is an archetypal form that inherently touches the same emotional chord".(5:40)

Although the series of three sculptures in my thesis has shed any vestiges of usefulness, nonetheless it is clearly an outgrowth of the vessel form. Each has an outer hollow shell, which enfolds a transverse linear element. In the terms of a vessel-maker, each has a bowl and a handle. While all three outer shells were

formed from flat pieces of silver sheet cut to the same pattern, the final forms all differ; the three create a progression as the open form gradually closes up, and the small inner shell of the first piece disappears, to reappear in a much reduced form in the final piece. The linear elements were all originally cut from a half-inch square rod, the pieces ranging from two to three inches in length. Again, the final forms differ considerably, gradually unfurling.

Thus, the series contains two progressions acting in counterpoint, the one opening as the other closes, the one waxing as the other wanes. Each "bowl", beginning life as a flat sheet, takes successively greater advantage of the metal's malleability. Each "handle", beginning life as a short, thick rod and growing increasingly attenuated, exploits the metal's ductility.

Each progression also represents one of the basic elements of design. The shells are plane surfaces, starting as flat planes and becoming progressively more curved. The transverse elements are linear. Thus, each portion of the sculpture investigates a different technical aspect of the material, as well as a different phase of the aesthetic problem.

Technical Considerations:

The shells, the pattern having been cut from 18 gauge sterling silver sheet, were created using the techniques of sinking, raising, planishing, chasing, and repoussé work.

Metals are constructed of atoms in a crystalline arrangement. When these atoms are subjected to a stress, as when working a metal sheet with a hammer or other impact tool, the lattice or space between the atoms becomes distorted. If the applied stress is less than the force holding these atoms together, they return to their original positions and no distortion occurs. If the stress force is greater, the elastic limit is exceeded; the atoms become displaced along cleavage planes, and a change in their relationship or dimension occurs due to plastic flow. In other words, permanent deformation takes place. This happens when a hammer makes a dent in metal. (14:114)

Sinking was the first step in forming. The metal is worked from what will be the concave surface, or inside of the form. After softening the metal by annealing it, I placed it in a hole carved in a tree stump and struck it gently from above with a rounded mallet. I began in the center and worked in a spiral pattern with overlapping blows as I gradually approached the edge. After two courses, the metal resembled a shallow, lumpy dish. I worked on each of the three outer shells in turn, and then annealed them. Metals can become hardened and brittle when worked. When this occurs, further work must stop until the metal

has been made soft and malleable again. Each metal has critical temperature and quenching schedules that result in annealing or softening work-hardened objects. Maximum annealing of sterling silver is achieved by heating it to 1400° F and quenching it instantly in cold water or pickle. (16:79) As this requires a specially equipped furnace with a trapdoor, in the workshop it is more feasible to heat the silver to 1100° F, using a torch, and quenching or air cooling it.

As I struck the metal in the center, it started to buckle along the edges of the form. These folds were removed as I worked my way around. The length and width of the form were slightly reduced in each dimension, in each course. The depth increased considerably, from the flat to about one-half inch. In this phase the metal was moved by pressure from the mallet, over the air cavity below. The metal was stretched, thinning it in the center. The silver was annealed to soften it, as needed, during the entire forming process.

The next step was raising each shell, using steel hammers and stakes. The polished steel forms are much harder than the soft silver. If the silver is resting on a steel surface and is struck by a steel hammer, it is the softer metal which moves. When there is air behind the silver, as in sinking, the metal shifts

position. If there is steel behind it, it cannot, and so is compressed and displaced. The direction and degree of displacement is controlled by the shape of the hammer and stake, and by the direction, placement, and force of the blow. The metal is worked mainly from the convex surface.

The best known, if apocryphal, example of displacement is the tale of Archimedes jumping into his full bathtub, and crying "Eureka!" when it overflowed. In this instance the soft substance, water, was displaced when squeezed between two harder objects. The bathtub might be viewed as the stake, while Archimedes was the hammer. Fortunately, silver moves at a more sedate pace than bathwater, allowing the metalworker much greater control. Whereas a liquid will simply move, metal is also compressed at the point of impact.

Raising a shape is a method of forming holloware by which a flat sheet of metal by compression can be made into a hollow form of almost any contour. By slow stages the metal is shaped into the desired form by hammering it on anvils to effect this compression.
(15:240)

In the simplest form of raising, the silver takes on the shape of the stake against which it is held, at the point at which it is hammered. The shape of the hammer head, in combination with the nature of the blow, determines how much and in which direction it flows. A circular peen will distribute the metal evenly in all

directions in a given plane. A cross peen, oblong or rectangular with the length, running perpendicular to the handle, will move the metal chiefly in two opposite directions, perpendicular to the axis of the mark made by the hammer. Thus the cross peen hammer is appropriate for raising the metal quickly into a hollow form. In both cases, a hammer with a shallow curvature in cross section will compress and displace the metal less than one with a more pronounced curve, and a hard blow will exert more pressure than a soft one. A hammer of greater weight or size will have a greater impact. If deep hammer marks are made during this process, they will have to be removed later, if the final surface is to be smooth. It is often easier to avoid excessively deep marks, as the time saved in raising is usually less than the time spent in planishing the marks out.

Raising is done in cycles . In the first raising cycle, the hammering was followed by the intermediate step of **bouging**, in which the silver was smoothed with a mallet of wood, leather, or bone. These materials are softer than steel, and so do not mar the metal if properly used. On later cycles, as the raising marks were not very deep, I proceeded directly to the next step, planishing.

Planishing removes the marks made by the raising hammer. The steel hammers used are shallow curves or

flat in cross section. The faces are usually circular or square, to distribute the compression evenly around the point of contact. The entire surface of the form is hammered systematically, smoothing indentations and bumps, and refining the profile of the form. Planishing can be used to produce the lightly faceted surface which is the "characteristic texture ... that is associated with hand-raised pieces". (15:247) If one continues to work on a convex surface with a flat, round hammer, as I did, one can remove these marks also, leaving a smoothly curved and densely compressed surface. During the first three raising cycles, I followed the planishing by lightly hammering the edge of each shell, so as to slightly thicken it and prevent cracking. This was done with a lightweight riveting hammer, with light slightly overlapping blows struck directly against the edge at a right angle to the hammer face. In later cycles this step was eliminated, or replaced with the use of chasing and repoussé work to give the edges their final forms.

These two methods use punches and a hammer to locally stretch the metal to model the surface. Repoussage is done from the back, while chasing is done from the front of the piece.

The techniques of repoussage and chasing cooperate to develop the form to completion. By strict definition, in repoussé work, the sheet metal is given form mainly by stretching, incidentally thinning the metal

outward from the reverse side. In chasing, forms are outlined, modeled, refined, undercut, and textured mainly by pushing the sheet (or cast metal) back from the obverse or front side. Generally speaking, therefore, repoussage tools create relief effects, and chasing tools create intaglio effects. (14:119)

While working, one must support the metal from behind. This permits the metalworker to control the force and direction of the pressure brought against the surface being worked. The choice of supporting material depends on the work, and can be any substance of suitable resilience and shape. Pitch, leather, wood, lead, rubber, and sandbags are among the most commonly used supports. In forming the edges of the first shell, I used steel chasing tools and a rubber mat to refine the modelling.

These techniques differ from hammering directly on the metal in that the hammer blow which provides the driving force of the action is divorced from the placement of the working end of the punch. This separation permits great accuracy, as the metalworker does not aim and strike with the same hand, and the eye is not blocked by the tool during impact. The hammer used is light and has a broad face to facilitate hitting the tool without looking at it. The hammer handle is thin and flexible.

The chasing tools were made from water hardening tool steel. I cut and annealed the square steel rod,

and ground and filed the ends into a variety of shapes. The tools were then polished and cleaned, and a torch was used to heat the steel to harden it upon quenching. Afterwards, it was heated again to a lower temperature, at the tip, to temper it as hardened steel is too brittle. I made about thirty tools of various shapes and sizes, as the need arose.

Chasing and repoussage were used, over pitch, to form the inner pods of two of the sculptures, as well as much of the jewelry. Pitch is usually prepared by mixing it with a filler such as plaster, and a softener such as linseed oil, or can be purchased already prepared. It has the advantage of being able to be melted. It can then be poured into a hollow form, or a form can be pressed into it, ensuring a perfect fit. I prefer it to lead, which can be used in the same fashion, as it does not corrode the silver as lead can. The bowl of pitch not only supports the work, but holds it so that the metalworker has free the two hands required for holding the punch and the hammer.

As the techniques used to form the inner shells and the transverse elements were also used to create the jewelry portion of my thesis, I will discuss them in that section.

The pieces of each sculpture were assembled with rivets. A rivet is a small pin used to hold two or more

pieces of metal together "in a surface to surface relationship". (8:196) Rivets are inserted through holes in the metal pieces to be joined, and then upset by hammering them until they are wider than the holes. They can be solid or hollow, decorative or invisible, and unsoldered or soldered for extra strength. The rivets I used were silver, heated at one end to form a decorative ball. This end of each rivet was inserted through a predrilled hole in the piece and soldered to the sculpture. The other end was put through holes in the pieces to be attached, rested on a concave stake which would not mar the silver, and hammered to thicken it. The top of the hole receiving the rivet had been tapered so that the rivet could be countersunk. Countersinking allows a rivet to be wider than the hole, as it must be to hold the metal, without having to lie above the surface of the metal. Thus, I could then burnish the silver for an invisible joint.

Prior to final assembly, the pieces were polished on a buffing wheel, using a series of grits from coarse to fine. After cleaning, the portions of each piece which were to be matte were frosted with glass shot in a shot blaster. After assembly the pieces were colored white by repeatedly heating them gently, and pickling them. This brings a layer of fine silver to the surface. The other portions were given a final polish.

The Jewelry

The jewelry consisted of a series of pieces, technically and stylistically consistent with the sculpture, with the additional element of a functional relationship to the human body. The series contained two neck pieces, two pins, a bracelet, an ear ornament, and a hair ornament. The latter, composed of a chased and repousséd shell and a forged comb, served as a transition from the sculptural phase of my thesis to the jewelry phase. The transverse elements of the sculpture and the linear elements of the jewelry form a continuum of technical and aesthetic exploration.

Technical considerations:

The techniques used for these elements included those mentioned previously, as well as **rolling** and **forging**. The shell of the hair ornament was cut from flat sheet, annealed, and mounted in pitch. The original tracing paper pattern was left on, to serve as a guide for the first cycle of chasing. It was removed after permanent marks had been made in the silver. The metal was worked alternately from front and back, annealing between cycles to soften the metal. The small inner shells of the sculpture and the upper decorative

element of the ear piece were formed in the same fashion. The comb was made of round silver wire which was bent, using pliers or the fingers, and then hammered with a planishing hammer on a steel anvil to create variations in the thickness of the line, and to harden the wire. After the pieces were finished by shot blasting and polishing, the comb was soldered to the shell. The final polish was then applied, and the comb burnished to restore the springiness to the metal.

The transverse sculptural elements and the main elements of the neck, wrist, and ear pieces were all formed from square sterling silver rod which was one half inch thick. Each started as a short piece, two to four inches in length.

The ends which were to be narrowed were tapered slightly, by forging the metal with a steel hammer on an anvil. I then used a rolling mill to do the rough shaping. Each taper was placed between a pair of steel rollers, each of which had a graduated series of " V " shaped grooves. When the rollers met, the holes formed were square. The metal was placed in the groove which was slightly smaller than its current cross section, and the rollers tightened around it. When I turned the handle the rollers turned, drawing the silver rod in and reducing the cross section to that of the

hole. The metal was compressed in girth, and elongated. This operation was repeated in each successive groove, annealing between courses, until the ends were reduced to an eighth inch diameter. In each pass, I allowed only half of the previously rolled section to go through. This resulted in a series of steps, each slightly narrower and longer than the one before it. The bracelet and ear piece were single tapers, while the other pieces were double tapers with the thickest section near the middle of the rod. The single tapers had, prior to rolling, been thickened at the large end by gripping the rod in a vise and upsetting the end by striking it with a flat hammer. "By striking a flat-faced hammer at a right angle to the end of a bar or wire ... the metal spreads in a direction perpendicular to the axis of the form". (14:247)

After this preliminary reduction, the forms were forged out to their final taper. Forging, like raising, consists of plastically deforming metal into the desired shape "by exerting compressive force upon it, mainly through the intermittent blows of a hammer". (14:236) I used cross peen hammers held at right angles to the long axis of the rod, and a flat anvil, to achieve a continuous gradual decrease in thickness. After the desired taper was obtained, I used a planishing hammer to round off the cross section of the square rod. This

was done in stages, by hammering on the corners of the rod, progressing from four to eight facets down the length, and so on until each rod had a circular section and was free of unwanted forging marks. The thickest portions of the rods were left square, with a gentle transition to the round section.

I then scribed a line around each rod at the widest point and, using a small grinding wheel in a flexible shaft, deepened this into a groove wide enough to admit a chasing tool. The groove also helped prevent slippage which might damage the surrounding silver. Each rod was then mounted in pitch, and worked with chasing tools to spread the metal on either side of the central channel. The four facets of each taper were lightly ground out, again to hasten the overall process while providing a seat for the chasing tool. These depressions were widened and deepened with rounded chasing tools of graduated sizes, creating a teardrop shaped motif which tapered into the body of the rod. These channels were textured using chasing tools, while the interstitial zones were planished to a smooth surface for contrast. The centers of the dual tapers were embellished with small forged elements in 24 karat gold. The thick ends of the single tapers had a layer of gold fused to the silver, and were accented with small gold balls and rubies.

The tapers were then bent and hammered into shape, over a variety of rounded forms. The ear piece and necklaces were fitted to the curves of my ear and shoulders, respectively. The functional elements of the pins were forged from 14 karat gold wire, chosen for its strength and color. The connections of the necklaces were formed by forging the silver flat, and driving a punch through the metal to form an openings. This displaced metal rather than removing it as drilling would have done. These holes were then widened and shaped with chasing tools, and a forged decorative gold element inserted in one, followed by the insertion of the forged taper which formed the other half of the piece. On both necklaces the two forged elements were held together by shaping the ends of the tapers into three-dimensional spiral forms.

Conclusion: Aesthetic and Historical Considerations

I have discussed the inherent properties of metal which allow an artist to move the material to express his or her ideas. I have chosen forming techniques which are direct expressions of the metal's malleability and ductility. These properties have also had a great influence on the aesthetic content of the work. The metal's capacity for motion through displacement has helped to inspire me to create objects which express the beauty of motion in their form.

Many sources have contributed to the development of my aesthetic sensibilities as an artist. The most profound of these is the natural world, which, as a source of design, provides an artist with almost an embarrassment of riches. I have also been inspired by the work of many wonderful artists, whose creativity has nourished my own. One of the greatest beauties of art is that it can enrich an infinite number of lives without consumption or diminution of the original.

Although my work is firmly rooted in natural imagery, it has not been my goal to create a "realistic" model of a specific natural form. I use the word in

quotation marks because all artists are realists, in the sense that they ceaselessly strive to create forms which express truth as they see it. Each of us, however, has a unique experience of reality. In keeping with the topic of my thesis, the theme of nature on which I have focused in this body of work is motion.

Motion is literally a vital sign, a sign of life. It has two aspects: external movement through space, and the internal motion of growth and change which all living things undergo. Just as the adult form of a plant or animal is the result of this process of transformation, the ultimate form of my thesis work is the outgrowth of the processes used to create it. While it is possible for an artist to conceal the methods used in the making of an object, I prefer not only to allow the techniques to appear, but to celebrate them by using them to create forms which express the transformations through which the material has passed. Thus, when a shell of silver seems to be curling inward, it has indeed done just that. When a tendril seems to have grown out of a heavy stem, it has. When a piece of jewelry seems to hug the body as if it were a vine hugging the tree around which it grows, it is because that piece has been formed around that body. It is precisely this capacity of metal to grow and change that led me to choose it as a medium of artistic expression.

An artist is an omnivore. Everything one sees, feels, experiences, is stored in the treasure chest of one's mind until the imagination finds a use for it. A vital part of this fund of ideas is the work of other artists. One of the historic periods of art which has been a major source of nourishment for my own work is Art Nouveau, "which flashed meteorlike across the dividing line of the 19th and 20th centuries and then disappeared from view for almost half a century". (8:28) Art Nouveau was "antagonistic to the historicism of the 19th century, with its imitation and mixture of historical styles". (8:28) In reaction to the historical forms seen as outworn and stereotyped modes of seeing, the new style sought expressive power through dynamic, asymmetric, biomorphic forms. Rather than conceal structure with surface ornament, artists created structures which were themselves ornamental. They wished to integrate subject and background compositionally, achieving unity through emphasis upon formal elements, rather than upon subject.

In Art Nouveau jewelry all these aspects can be seen: the formalization of natural forms, with emphasis upon linear composition; essentially flat, even graphic design; a structure that is, in itself, ornamental and delicate; and, finally, a unity of organization incorporating every element into a totality. (8:31)

In my own work, I wish to infuse form with the energy and "sinuous line, expressive of the 'life force'," (8:31) which is the essence of Art Nouveau. Rather than use this chiefly as ornament on a plane surface, however, I try to combine this quality with the power of volumetric form. I am inspired by the work of great contemporary metalworkers, such as L. Brent Kington and Albert Paley, to go beyond the decorative by creating work which integrates the power of the tradition of the hollow form with the delicate beauty of the tradition of body ornament. My aesthetic ideal is to create a synthesis of elegance and strength.

While as a student I hope to achieve my goals, as an artist I know that my work will not be a single event, but a step in an ongoing process, a journey of the mind and heart, in which each arrival is the beginning of a new voyage.

Glossary

- burnishing** - A polishing process applied to metals by rubbing it with a burnisher, a tool of highly polished steel or other hard smooth material. Burnishing is used to remove surface blemishes, and to harden the metal.
- countersinking** - Enlarging the top of a hole in a piece of metal, etc., so that the head of a rivet, bolt, screw, etc., will fit flush with or below the surface.
- displacement** - The change in shape which the metal undergoes when it is struck, such that the force of compression exerted upon the metal exceeds its elastic or springback limit. The metal is changed in shape or size but not in mass.
- hammer** - Any of a group of percussive impact tools used as an extension of the hand. It consists of two basic parts:
a lever which is the handle, shaft, or haft, usually made of a springy hardwood or fiberglass, and a head which contains a hole into which the shaft is fastened.
The head, usually made of metal or other hard material, is fixed on the handle in a crosswise position. Hammers come in various shapes, sizes, and weights.
- peen** - Part of the head of a hammer, often flat, convex, hemispherical, or wedge shaped. It is the striking face of the hammer, which comes in contact with the metal being shaped.
- raising** - The process of making a hollow form from a flat sheet by bringing the sides up gradually in stages of hammering the metal on anvils.

repoussage (repoussé work) - A method of using the quality of plasticity in metal to shape sheet metal with punches and a hammer by degrees to form a relief. There is no loss of metal, as it is stretched locally. It is formed from the reverse side, to create relief effects. When formed from the front to create intaglio effects it is called **chasing**. The two processes normally alternate on the same piece.

planishing - Smoothing of the surface of hammered metal to remove minor irregularities and any undesirable visible sign of other work process. This is done with a flat or slightly domed highly polished planishing hammer when the surface is convex, and a somewhat more convex-faced hammer when the surface is concave. The work is placed over a supporting, highly polished, smooth surfaced stake whose contour closely corresponds to that of the object to be planished. To prevent work distortion due to stretching, the work must make contact with the stake's surface which will then support it against the hammer blows. The supporting surface area must be larger than that of the contact area of the hammer face when it strikes the work.

sinking - The process of making a hollow form from a flat sheet by hammering on the inside or concave surface of the piece, stretching the metal into a volumetric form.

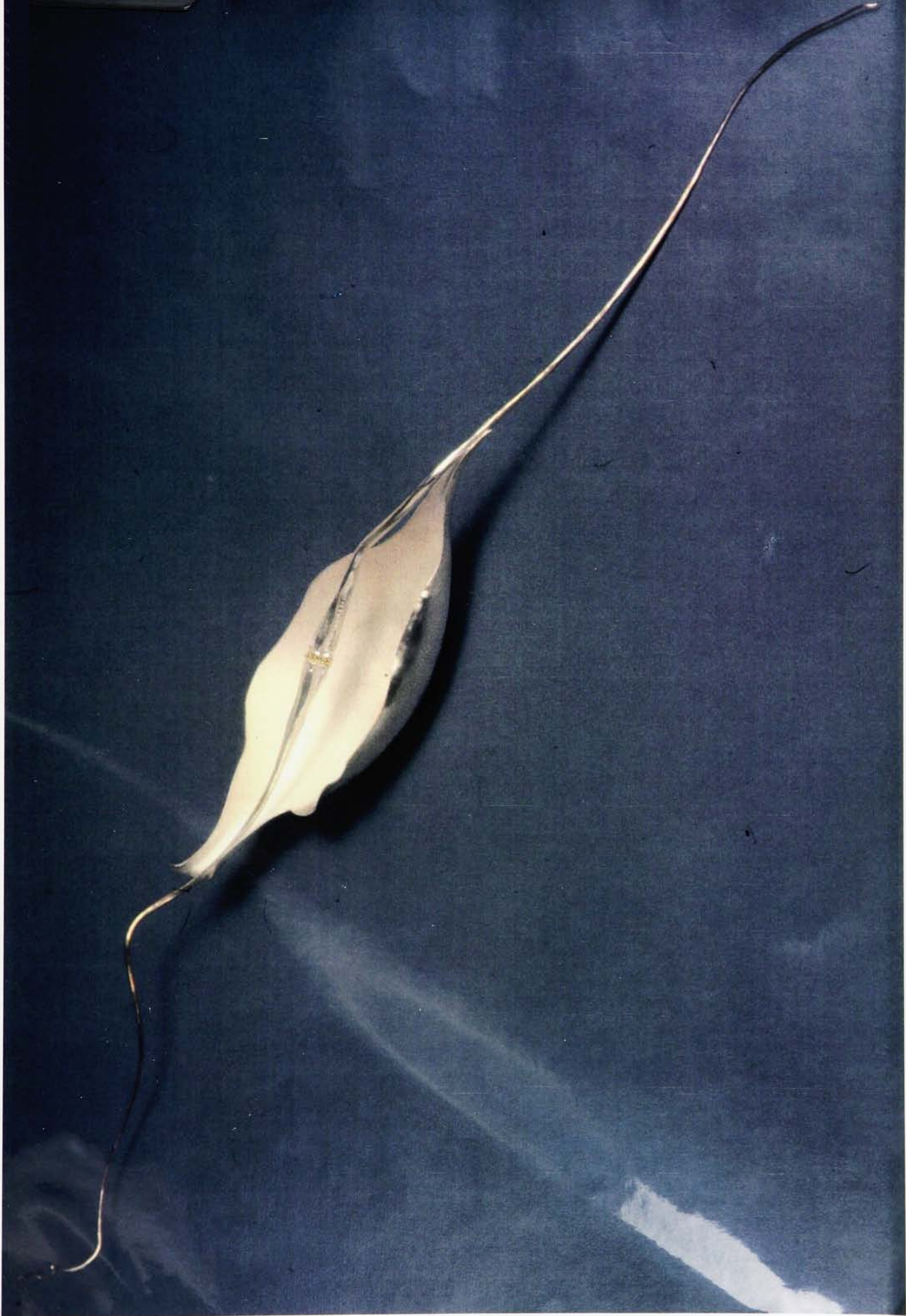
stakes - Anvils, usually made of steel or a cast iron core to which steel parts are welded, which come in a wide variety of shapes. The stake is the impact-receiving surface which supports the piece of metal being hammered. It can also be made of wood, horn, or other material.

Definitions courtesy of Douglas Steakley, Oppi Untracht, and Webster's Dictionary of the English Language.

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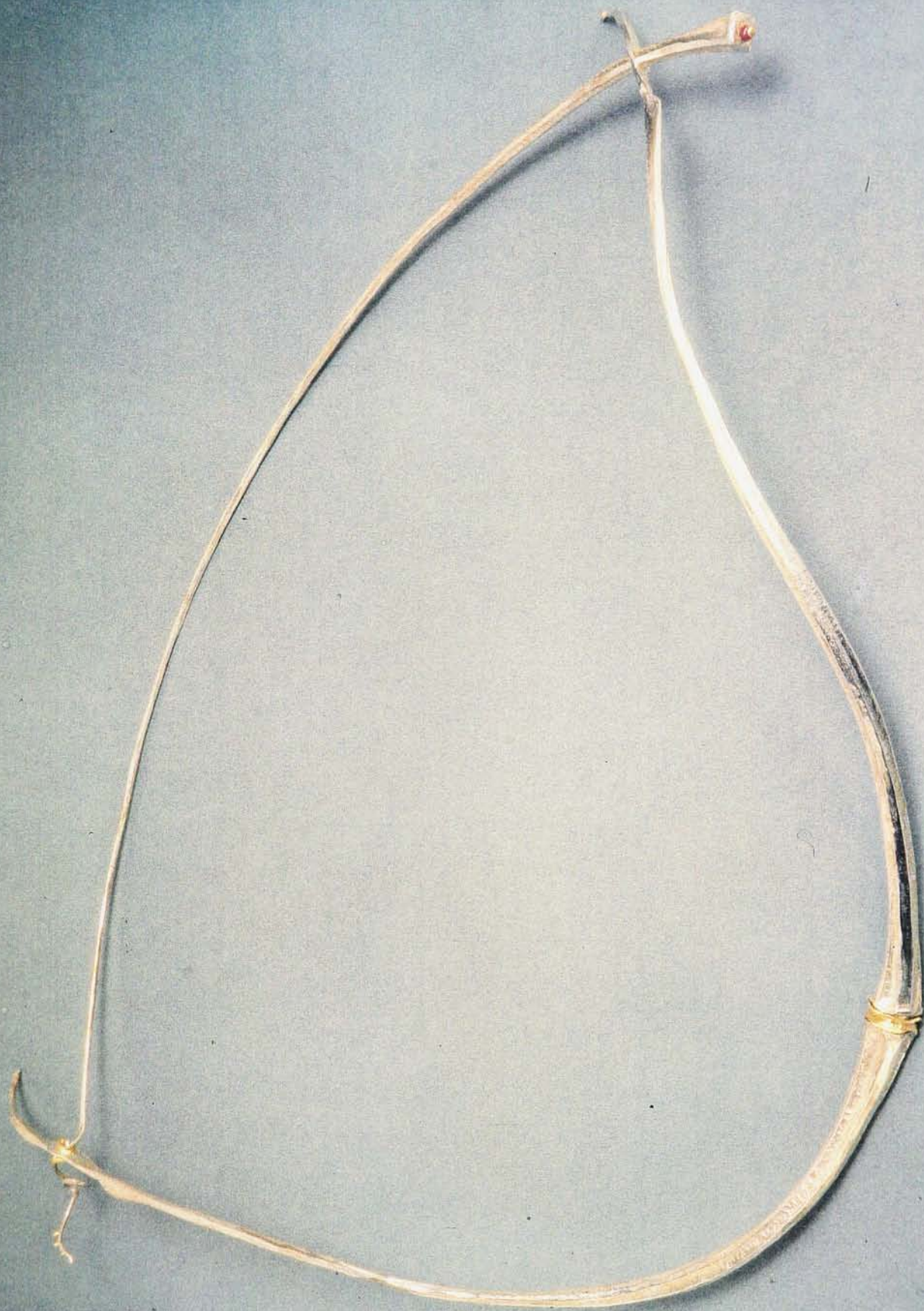
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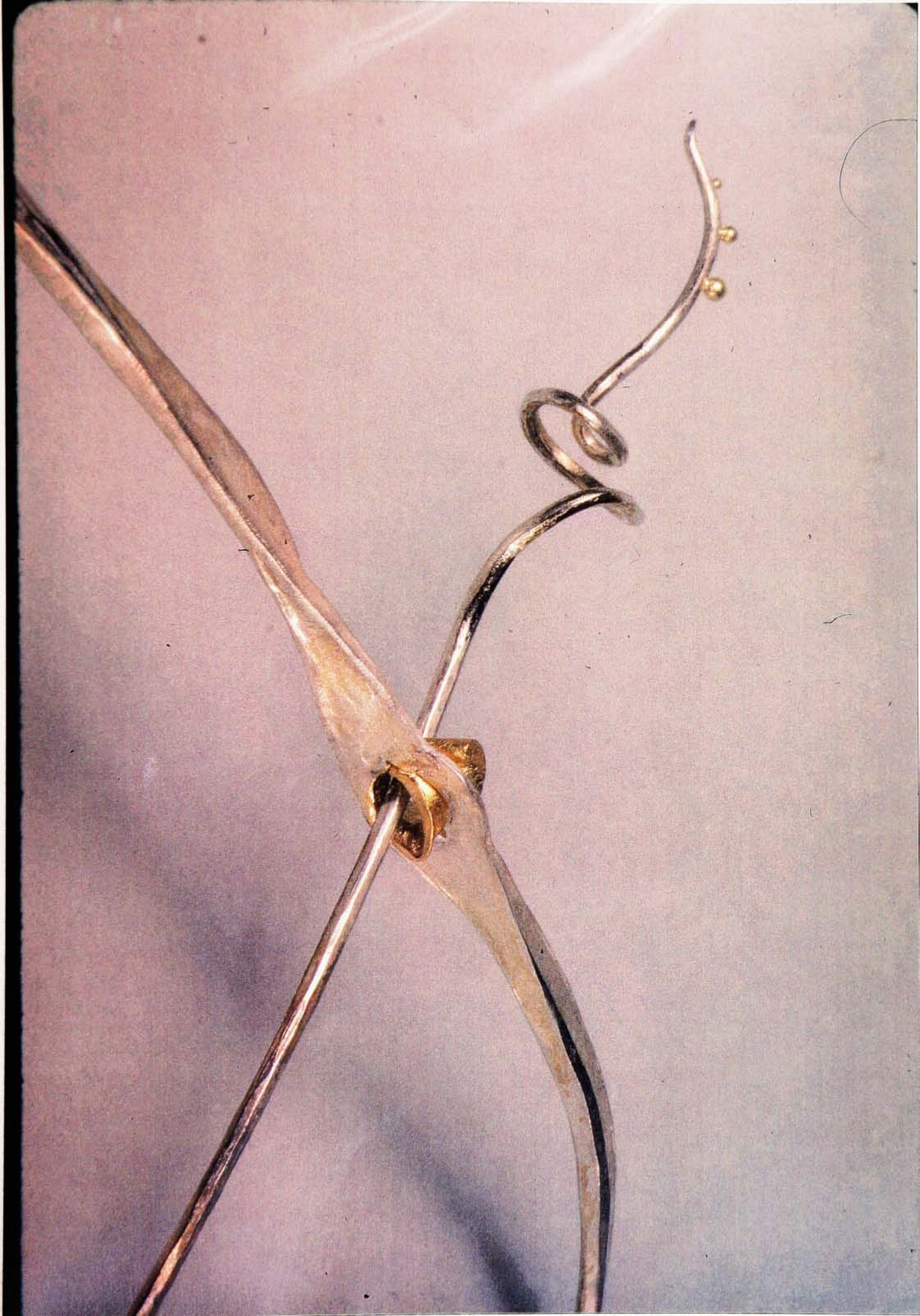




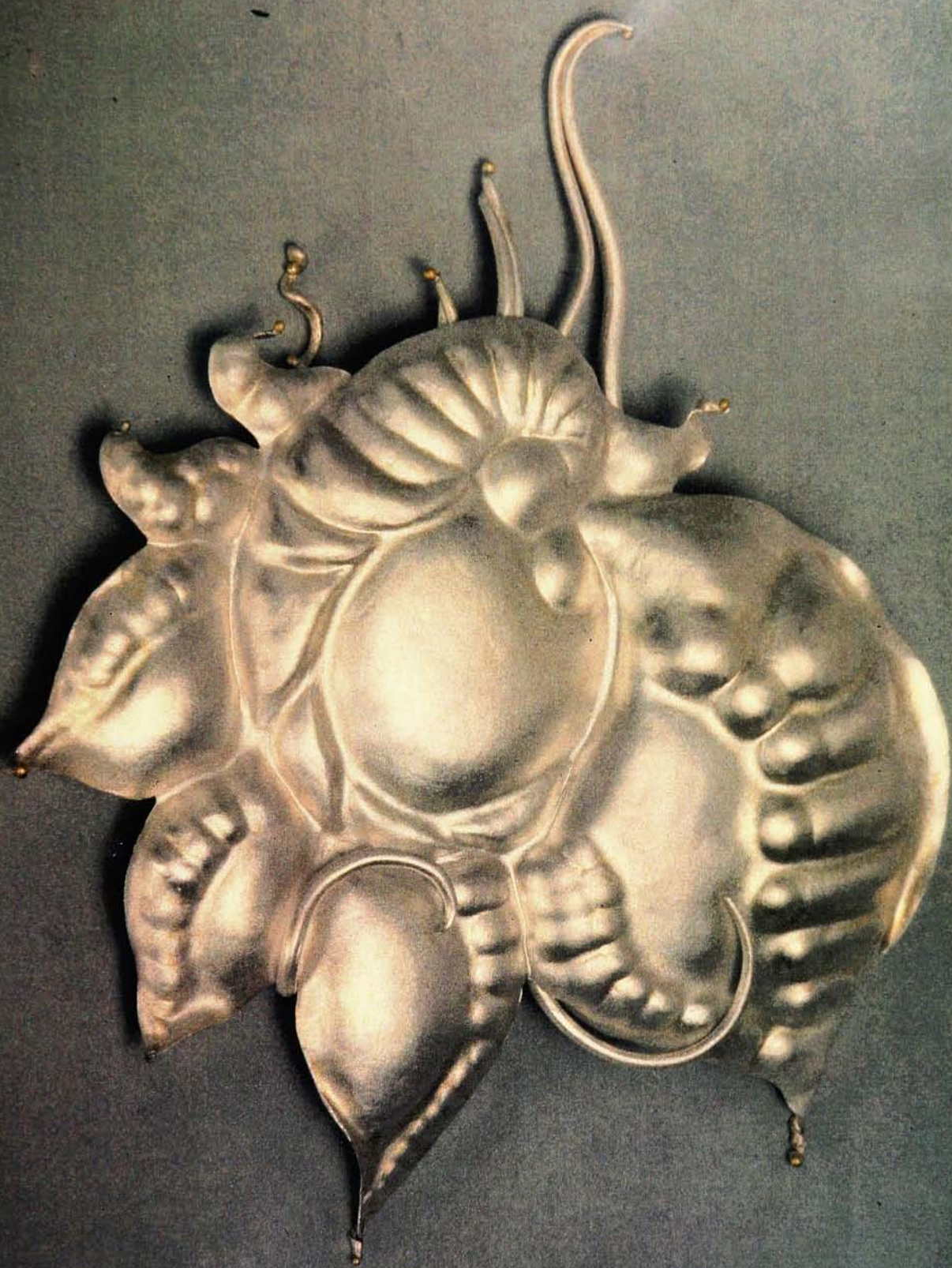


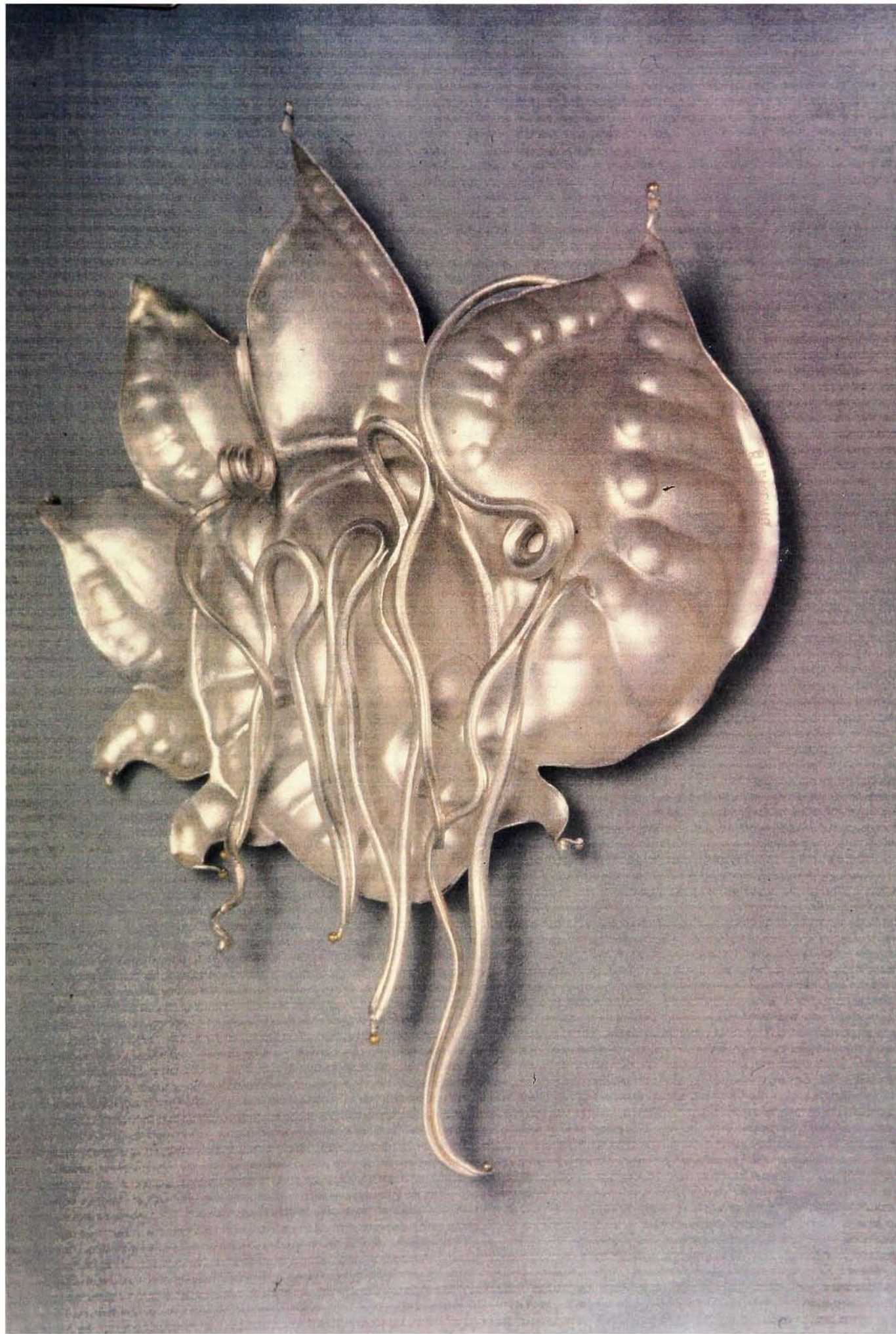


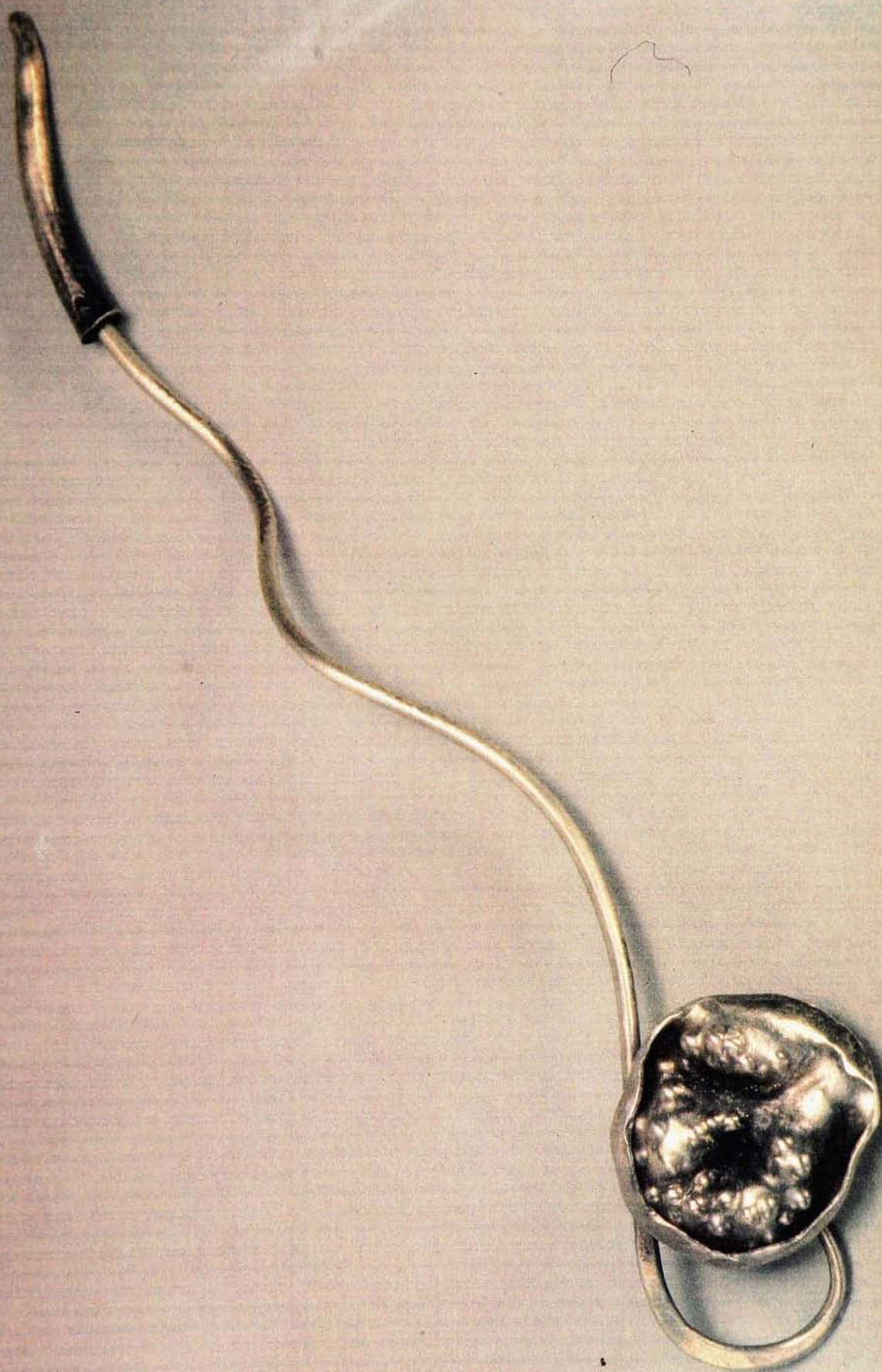


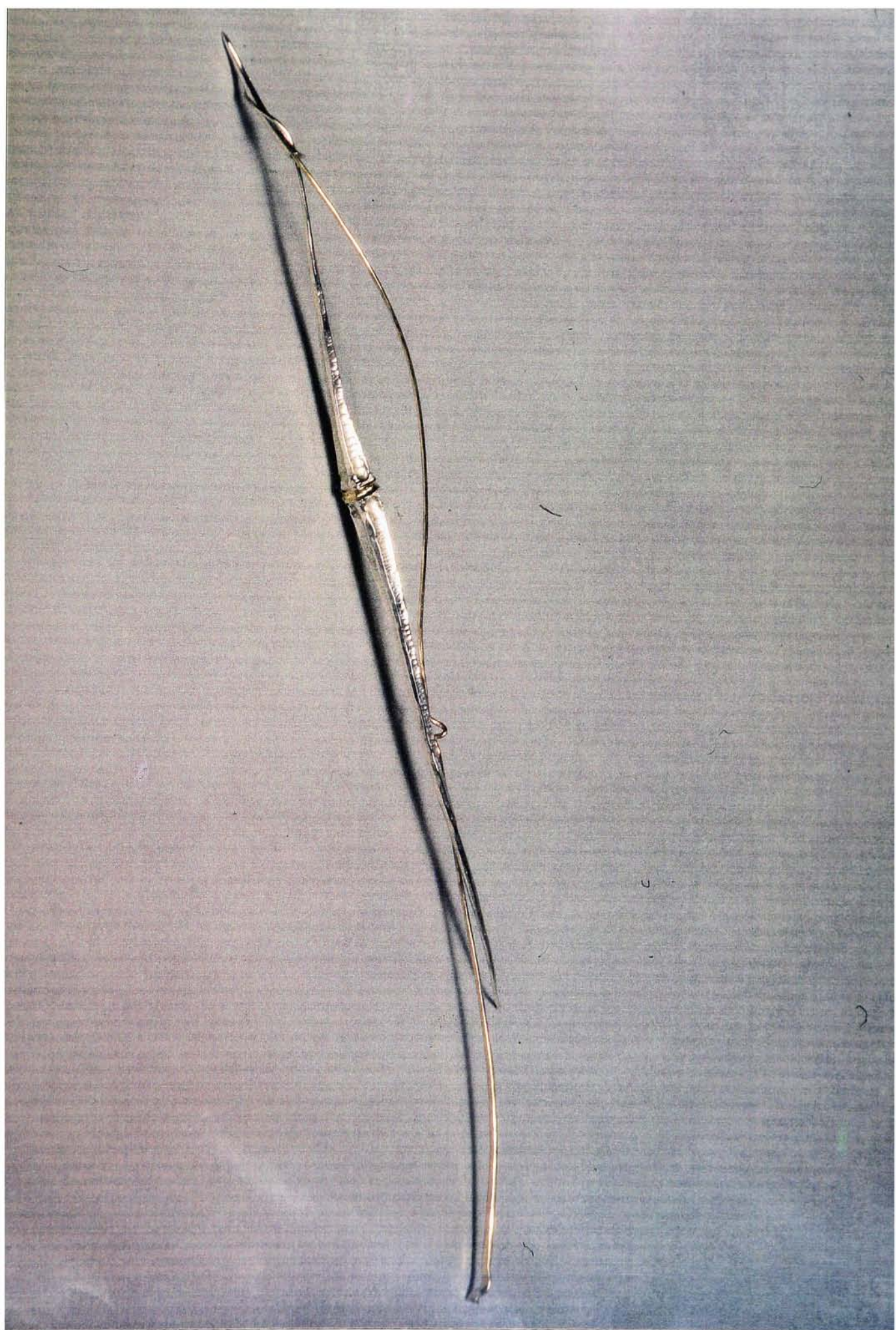


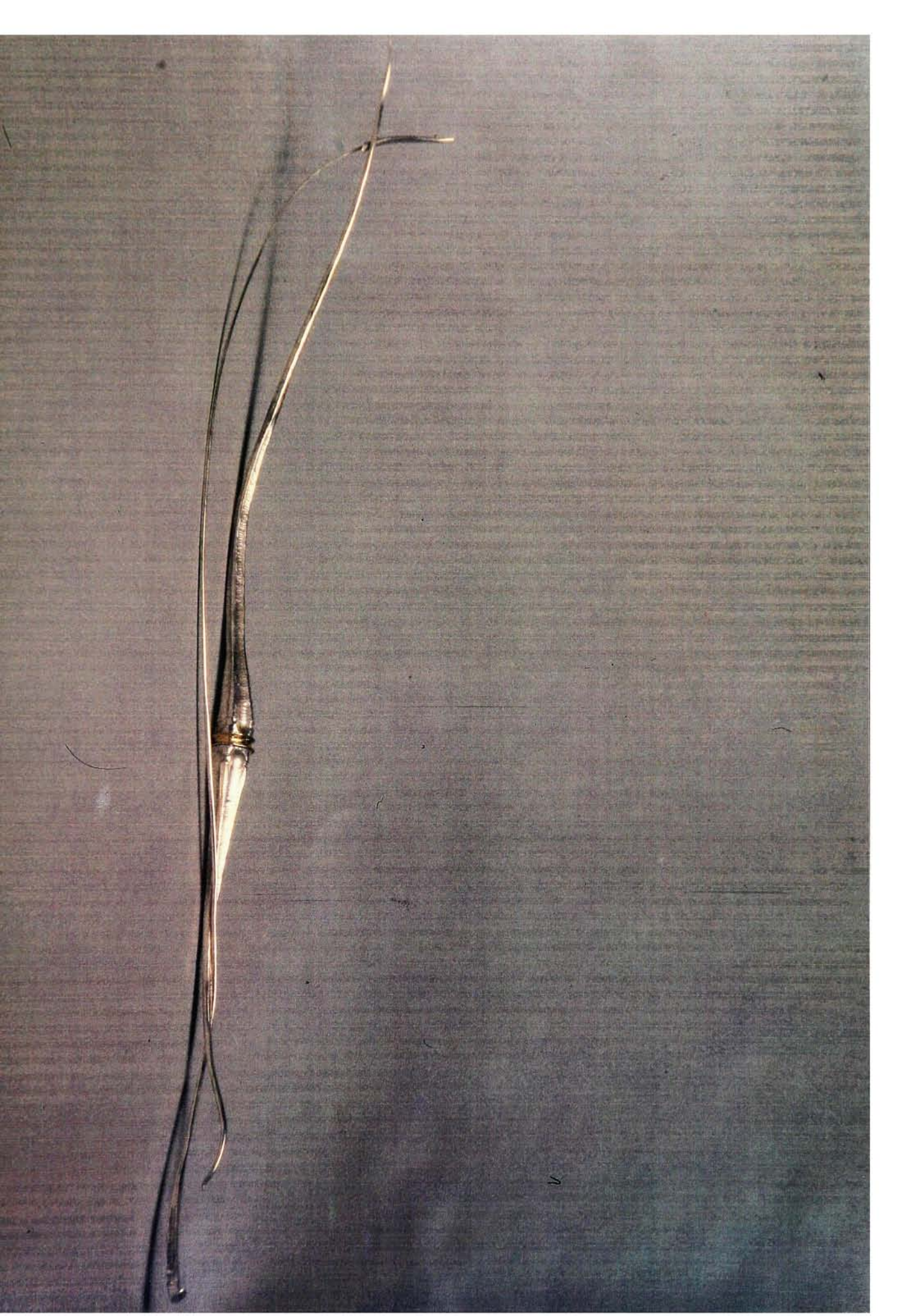












Over ear earring



Hair ornaments

