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***STRUCTURAL SOLUTIONS AS AESTHETIC EXPRESSION***

by

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## **ACKNOWLEDGMENTS**

*My thesis is dedicated to my wife Cheryl. Without her sacrifice, patience, understanding, and above all, love, this work would not have been possible.*

## TABLE OF CONTENTS

APPROVALS.....	ii
ACKNOWLEDGMENTS.....	iii
LIST OF ILLUSTRATIONS.....	v
THESIS STATEMENT.....	1
INTRODUCTION.....	2
STRUCTURAL INFLUENCES.....	3
FORMAL CHAIR.....	4
CATEGORIES.....	6
CHEST OF DRAWERS.....	7
HALOGEN LAMP.....	9
CABLE STAY.....	12
MAGAZINE RACK.....	14
LITTLE ASH TABLE.....	15
WALL SHELVES.....	18
CHAISE LOUNGE.....	21
WHAT BECAME APPARENT.....	24
ILLUSTRATIONS.....	27
REFERENCE LIST.....	57
SECONDARY REFERENCES.....	58

## LIST OF ILLUSTRATIONS

Fig. 1	Concrete Form.....	27
Fig. 2	Train Trestle Detail.....	28
Fig. 3	Service Pipe.....	29
Fig. 4	Bolt Pattern.....	30
Fig. 5	Tension Cable.....	31
Fig. 6	<i>Formal Chair</i> .....	32
Fig. 7	<i>Formal Chair</i> Detail.....	33
Fig. 8	Guyed Tower.....	34
Fig. 9	<i>Chest of Drawers</i> .....	35
Fig. 10	<i>Chest of Drawers</i> Bracket Detail.....	36
Fig. 11	<i>Chest of Drawers</i> Drawer Detail.....	37
Fig. 12	<i>Halogen Lamp</i> .....	38
Fig. 13	<i>Halogen Lamp</i> Articulated.....	39
Fig. 14	<i>Halogen Lamp</i> Base Detail.....	40
Fig. 15	<i>Halogen Lamp</i> Shade Detail.....	41
Fig. 16	<i>Cable Stay</i> .....	42
Fig. 17	Wooden Suspension Bridge.....	43
Fig. 18	<i>Cable Stay</i> Tension System Detail.....	44
Fig. 19	<i>Cable Stay</i> Table Support Detail.....	45
Fig. 20	<i>Magazine Rack</i> .....	46
Fig. 21	<i>Magazine Rack</i> Support Detail.....	47

Fig.22	High Tension Wires.....	48
Fig.23	<i>Little Ash Table</i> .....	49
Fig.24	Field Sprinkler System.....	50
Fig.25	<i>Wall Shelves</i> .....	51
Fig.26	<i>Wall Shelves</i> Shelf and Tension Detail.....	52
Fig.27	<i>Chaise Lounge</i> Side View.....	53
Fig.28	<i>Chaise Lounge</i> Rear Leg Detail.....	54
Fig.29	<i>Chaise Lounge</i> Pivot Detail.....	55
Fig.30	<i>Chaise Lounge</i> Without Upholstery.....	56

## **THESIS STATEMENT**

*The work developed in this thesis explores structural solutions to traditional furniture design problems and investigates their potential for aesthetic expression.*

*The relationship between the structural detail and the formal qualities of each piece was an important part of my exploration.*

## INTRODUCTION

MY BELIEF IN THE INHERENT AESTHETIC FORCE OF A GOOD STRUCTURAL SOLUTION WAS NEVER SHAKEN.

Luigi Nervi, Buildings, Projects, Structures, 1953-1963

IN THE PROCESS OF CONSTRUCTION SOMETIMES IT IS NECESSARY TO ADAPT YOUR DESIGN IF STRUCTURALLY IT DOES NOT WORK.

Luigi Nervi, The Works of Pier Luigi Nervi

Contained in the statements above by Luigi Nervi are the two thrusts that influenced the work that ultimately became the basis for my thesis. Structure as an element of design and order, and the idea of adaptability which allows for change and innovation during the actual making of the piece. Since joinery is so often subtle and concealed, it became central to the thinking of my thesis to minimize the more traditional concepts of furniture and to emphasize, rather than obscure the key elements of how forms go together and are supported.

Influences from bridges, towers, architecture and other engineered structures often proudly reveal supportive methods which then become major design elements that are both structural and decorative, as well as formal. Therefore, there is no effort to conceal bolts, cables, etc., but rather to present them for what they are while simultaneously enjoying them for their own unique aesthetic properties. The selection of the right material to describe the function and essence of the form became a major concern and effort. The compatibility of wood, metal, concrete,

glass, mechanical fasteners, and cables become a critical consideration in developing the relationship between structural detail and form.

## STRUCTURAL INFLUENCES

Library research ran the full range of traditional and contemporary solutions to architecture, bridges, and other structures (Fig. 1, 2, 3). The aesthetic appearance of many of these forms were of interest. I also found myself increasingly drawn to engineering manuals and diagrams which detailed the methods of joining materials. These included the most sophisticated approaches to suspension and tension, to the most ordinary, yet direct bolting of two parts together. In fact, one of the more interesting revelations that occurred during the research phase of the thesis is that structural influences ranged from the monumental to the common, from the heroic to the mundane. That is not to say that one is more important than the other, but rather that each characteristic contributes its own unique aesthetic quality. Where a pylon and cantilever might suggest the basic form of a table, a pattern of exposed bolts (Fig. 4) or the locking device for a tension cable (Fig. 5) could also invite closer scrutiny.

Among the forms I found most interesting were those created by architects and bridge builders. Frie Otto's unique use of cables and fabric covers were creatively inspiring. Luigi Nervi's experimentation with concrete forms and his philosophy of structure as design solutions led to the theoretical basis of much of the work of this

thesis. Though initial research was done in the library scanning the work of prominent architects, I found that many of my designs sprang from personal observations of local structures. Some of these structures that were of particular interest and influence ranged from a radio tower on Brighton-Henrietta Townline Road, to a farm sprinkler system in Wayland.

It may be appropriate at this time to briefly mention experiences and influences prior to my graduate studies at Rochester Institute of Technology. I received my Bachelor of Science degree in Industrial Design in 1986 from the University of Bridgeport. During the following five years I worked for several firms in New England as a designer in a broad cross-section of areas including electronic products, exhibit design and merchandising, consumer products, packaging, and model making. It was not until my RIT experience that I realized, in retrospect, that my interest in form, detail, and craftsmanship was always an important part of my work. Graduate work has enabled me to clarify that focus.

### **FORMAL CHAIR (THE INCEPTION)**

It was early in my first year of experimentation at RIT that I began to have a real interest and direction for a thesis topic. Previous to the spring quarter, I had experimented with a very straight forward and simple use of materials. I liked to think of it as an industrial approach through materials with an unorthodox view of the problem. The experimentation ranged from the use of concrete, sheet metal,

wire and screen reinforcement. These materials were used purely functionally with no consideration for decoration. Some of the items produced through this approach were picture frames, clocks, and a small outdoor table. I was very excited about the results of this experimentation. I found this straight forward use of materials and simple assembly techniques to be fascinating. I decided to take this approach one step further and employ it in a work of much greater proportion.

The project for spring quarter was a chair. *Formal Chair* combined traditional woodworking and joinery techniques with the simpler and more straight forward assembly method of mechanical fasteners. I also applied two more ideas to the project. The first was to use materials for their inherent qualities such as surface characteristics and strength. The second was to gain strength and rigidity through the use of less material and new approaches to furniture. This was to later be transformed to structural solutions to other furniture designs (Fig. 6).

*Formal Chair* consists of a relatively traditional seat and back with obvious influences of Charles Rennie MackIntosh combined with art deco elements. What I feel constituted this chair as experimental and potential thesis material was the treatment of the lumbar support for the *human* back and the structural support of the *chair* back. The lumbar support consists of a piece of aluminum that has both an inside and an outside roll given to it. The outside roll gives support to the human back while the inside roll allows for the bolting of the aluminum to the chair back. Because only one edge is fastened, it allows the support to flex in response to the

user (Fig. 7). Structure was achieved in the chair through a series of four stainless steel 1/16" dia. cables that were laid out to create a series of triangles through which support could be acquired. Machined aluminum and stainless steel tightening mechanisms were used and added to this utilitarian aesthetic. This project was the spring board for the concepts behind the final thesis statement.

## CATEGORIES

In retrospect I realized that the seven pieces I constructed for my thesis show fall under three structural categories:

- A. Tension support (guyed towers)
  - \* Chest of Drawers (Fig. 9, 10, 11)
  - \* Halogen Lamp (Fig. 12, 13, 14, 15)
- B. Suspended support or gravity
  - \* Cable Stay (Fig. 16, 18, 19)
  - \* Magazine Rack (Fig. 20, 21)
- C. Bow String Arch
  - \* Little Ash Table (Fig. 23)
  - \* Wall Shelves (Fig. 25, 26)
  - \* Chaise Lounge (Fig. 27, 28, 29, 30)

## CHEST OF DRAWERS

During the course of my thesis I became interested in Frei Otto and his work dealing with guyed structures. Specifically I focused my attention on a model study for a flexible membrane cement or grain silo. The containers were suspended from central steel poles guyed in three directions. This method of support is what sparked my interest and imagination.

I started investigating similar existing structures in the area. What I found mostly were radio towers. Specifically one on Brighton-Henrietta Townline road that I drove by everyday on my way to the woodshop (Fig. 8). These guyed towers were intriguing, what great possibilities they held for furniture! This approach initially resulted in *Chest of Drawers* and later developed into *Halogen Lamp*.

The way I set out to solve the design problem was to remove all previous preconceptions that I had of furniture and apply only the inspiration of a structural solution to the particular function the furniture had to meet.. *Chest of Drawers* was the first step toward this goal (Fig. 9). Each successive design problem brought me closer and closer to a total structural solution.

The carcass is traditional in construction. What sets it apart is the turned bottom panel. The thickness of the bottom panel originally was 4". I lathe turned the shape so that the center section would belly down to meet the stem and then feather out to a uniform thickness of about 3/4" on all four sides. The reason for the shape was structural. It had to be thicker in the middle where the stem met the base to

accommodate the pounds per square inch that would be focused at that juncture. In order to disperse that force to the sides of the carcass the panel was feathered to 3/4" at the perimeter.

The stem of *Chest of Drawers* utilizes the same principle. It is a solid piece of cherry with four sides approximately 29" high. The stem's tip is aluminum, 2" long and shaped to follow the lines of the stem. It has a 2" x 1" square tenon on the other end to secure it to the carcass. The stem is approximately 3" in the middle and tapers down to 1/2" at the bottom tip and 1 1/4" at the top. It is thicker in the middle because that is where the most material is needed for strength.

The base consists of two concrete abutments about 6" high x 6" wide x 28" long. The outside face is angled in at 30 degrees. They are set 18" part. The two concrete slabs are connected by an "H" configuration of cherry that is keyed into pre-cast notches in the concrete. The "H" is also curved, being thicker in the middle where the stem meets it. Because the hard material of the aluminum on the tip of the stem is what the weight of the cabinet rests on, there also had to be a mating piece of aluminum set into the "H" for the tip to socket into.

This cabinet is not free standing. It is supported by four cables. There are two in the front and two in the back that criss-cross to restrict movement of the cabinet. The cables are keyed into aluminum rods that have 3/8-16 threaded rods tapped into the end. The rods run through the outer legs of the cherry "H", through pre-cast holes in the concrete and are kept from pulling through by a large washer and nut.

Tightening and loosening the nut allows for fine adjustment and positioning of the cabinet. Rod ends are silver soldered onto the other ends of the cables. The rod ends fit through machined aluminum brackets and are secured with a washer and a nut (Fig. 10). The brackets are machined in such a way as to gently direct the force of the cables down to the base. Tightening and loosening of the cable for leveling purposes can also be done at this end.

The carcass has two inset doors that cover three drawers and a shelf. There is an aluminum handle on each door shaped to the profile of the belly in the bottom of the carcass. The doors part near the bottom allowing the drawer pulls to emerge through the gap. Each drawer pull is also shaped to reflect the profile of the carcass belly (Fig.11). The fronts of the drawers are shaped similarly with the centers bowing out bringing them closer to the surface of the cabinet. The drawers also step out so that the bottom handles protrude out further than the top. The back of the doors are coved out in the bottom to accept the drawers and also to create a thinner edge where the drawer pulls protrude through the doors. The finish is a natural hand rubbed polyurethane varnish.

### HALOGEN LAMP

*Halogen Lamp* was the second project based on the guyed tower principle. The only difference between the lamp and the chest of drawers is that the lamp can articulate in one direction along the lines of the cables. In one of the many

discussions with Rich Tannen about the chest of drawers, it was decided that the piece lacked a sense of immediacy . One way we decided that a sense of immediacy could be achieved in the chest of drawers was to secure it at a slight angle. This would give the piece an appearance of lunging forward or to one side thus creating a sense of excitement or impending action. This advice was taken to heart when I was designing the halogen lamp. It can be moved from a vertical position to one where the shade is almost touching the table surface (Fig. 12 & 13).

The lamp has a base of turned mahogany about 14" in diameter. It is approximately 3/4" of an inch thick in the center and tapers to 1/2" on the outside edge. There is a 1/8" disk of aluminum of equal diameter secured to the bottom. Evenly spaced around the outer edge of the base are four 1/4" aluminum cable fasteners that go through the base and are fastened with a socket capscrew. In the center of the base is an aluminum disk with a concave center and an integral pin (Fig 14). The stem is similar in shape to the chest of drawers. It is about 18" long and flares in the center to about 1 1/2" square. There is a 2" long aluminum tip at the bottom that tapers to 1/2" . The tip has a hole drilled in the bottom allowing it to lock into the socket of the base. The top of the stem is also aluminum and is similar in dimension to the bottom tip but it makes a transition from square to round. There is a 1/2" horizontal hole drilled through it. Through this hole a 1/2" diameter aluminum out rigger is secured with a set screw. The cables from the base run over the outriggers and are secured at the base again. The cables are tightened from the bottom using the socket capscrews and the system becomes rigid, supporting the

stem. Because only two cables are used that are not secured at the top, the stem can articulate along the length of the cable.

The head of the lamp is created with a series of disks and rods. This houses the bulb and supports the shade (Fig. 15). The shade is spun 16 gauge aluminum. The sectioned hemisphere is 5" high and 19" in diameter. There is a 2" hole in the top of the lamp to release light and heat. The interior of the shade has been bead blasted to enhance the reflection of light. The original tool marks have been left on the exterior. The shade is fastened on with four 7/16" aluminum balls that screw over the threaded rod that passes through the shade. A 50 watt halogen bulb is housed in the head of the lamp. The bulb rests in a ring and is held in place by four clips. A ceramic fixture attaches to the bottom of the bulb for the power transfer. A black and white wire comes out of the ceramic fixture and passes through an aluminum disk. The wires run through two stainless steel springs down the outside of the stem and into a machined aluminum junction box in the base. A gray outlet cord continues on to make the connection to the wall. The flexible spring was used as conduit to protect the wires when the lamp was articulated. All aspects of the bulb and wiring were left exposed (except where an electrical connection was made - for safety reasons). I felt this was necessary in order to be consistent with the thesis.

## CABLE STAY TABLE

*Cable Stay* was the first piece I constructed with a clear understanding of what the critical issues of my thesis were going to focus on and what approach I was going to take to explore these issues (Fig. 16). I started to research bridges. My attention was immediately drawn to the wide array of connection methods that I saw and also to the different ways that structures were supported in order to span distance (Fig. 17). What I found interesting was the way that cable systems were handled, particularly guide saddles, jacking screws, methods of anchorage, and tensioning systems. Each cable system provided a pleasing and sculptural form. Through my research I became very intrigued in the way that bridges were built. Structures start from opposite banks of the void to be spanned and meet in the middle. This piece was inspired by this and inherits its name from the term *cable stayed*, meaning “a deck directly supported from pylons by straight cables without vertical suspenders” (Bridges. 1993, 168).

I started my design from the ground up. A heavy base was very important to my representing a firm and solid footing from which the rest of the structure was anchored. First I cast a large triangular concrete base 16” high x 10” wide x 12” deep with one vertical face and one angled at 65 degrees. Pre-cast into the base were six 3/8"-16 threaded rods set in two rows of three. A 1/2” aluminum tube spacer slipped over the bolts to stand off a 2” x 6 1/2” x 48” maple beam or pylon. The pylon was secured in place by six serrated flange nuts that had been given a black

oxide finish. The nuts were counter sunk 1/16" into the maple pylon. Pre-cast into the top of the concrete anchor are four additional 3/8"-16 threaded rods. Again a 1/2" tube spacer is slipped over the threaded rod to support a 6 1/2" x 4 1/2" x 1" maple block angled in the front to follow the angle of the pylon. The maple block is bolted in place with black oxidized serrated flange nuts. Bolted on top of the block, also with black flange nuts and using the same threaded rod, is a 1/16" aluminum plate. The plate has a center bend to follow the line of the pylon. On the leading edge of the bend are two machined key holes which accept two ball ends that have been silver soldered to 1/16" diameter stainless steel cables. The two cables are approximately 8" long and run up to a 1/2" x 6 1/2" aluminum rod (Fig. 18). Six rod ends run through it and are bolted in place. These six rod ends become the leveling and tension system for the table. Six cables run up to the top of the beam through a spacer then over a crown saddle with another spacer. The cables run parallel until they reach the crown and final spacer where they then splay out to the surface of the table. The cables are all different lengths and they meet the table surface at a 20 degree angle from the pylon.

The table plane is edge glued maple 15 1/2" x 40" x 1/2". The front and back edge are chamfered to a 5/16" edge. This gives the appearance of a thinner surface and also creates an aerodynamic plane similar to deck profiles in bridge construction. The table surface is not in line with the maple pylon from which the table top is hung but is canted at a 56 degree angle. It is held at 36" from the floor by a 1/8" x 6" x 1 1/2" plate of aluminum that has been mortised into the edge of the

table and the face of the pylon (Fig. 19). This is a friction fit held in check by the tension of the cables. This joint was created with the expansion and contracting joints of bridge decks in mind.

The support cables pass through the surface of the table and into a 2' aluminum angle that has been bolted to the bottom of the table with black oxidized 1/4"-20 serrated flange nuts in line with the cable pattern. the cables are secured to the bottom of the aluminum angle by keyholes and ball ends that have been silver soldered to the ends of the cables. Two additional aluminum angles have also been bolted to the underside of the table surface in a zigzag pattern to keep the table surface from warping. The wood components have a clear lacquer finish and the aluminum has been waxed.

## MAGAZINE RACK

*Magazine Rack* (Fig. 20) consists of two ceiling mounted brackets made of two levels of aluminum with an intersecting triangle of copper to which the cables are attached. The brackets are placed 14" apart. It does not matter how high the ceiling is because the cable can be adjusted to any length. The extra cable is coiled and stored in the top bracket. There are two cables, one to each bracket that stretch parallel down to a concrete pylon. The pylon acts as the anchor or foundation of the piece.

The cable ends are soldered into rod ends that are fastened through the aluminum rod and secured with a copper washer and an 8-32 nut. The aluminum rod floats on two threaded rods that are pre-cast into the concrete base. Both these connections allow for final tightening of the cable. Threaded onto each one of the cables are alternating cubes and spheres (a total of four shapes per cable) that can be adjusted and locked into the desired position by a counter sunk cap head machine screw. Each sphere and cube has a slot machined into it through which a 22 gauge piece of copper is fit and bolted in place with another cap head machine screw. The copper is cut so that it is wider in the middle where maximum support and rigidity is needed. The copper beam supports were first heat treated, textured, and then given a patina with a liver of sulfur solution to give them an aged appearance. The magazines are draped over the copper beams and are supported by their spines (Fig 21).

*Magazine Rack* was inspired by a series of high tension wires on Scottsville road that I stopped to photograph on my way to Wendell Castle's studio (Fig. 22). That inspiration coupled with a desire to find the best way to support and display a magazine is how the rack was conceived.

### LITTLE ASH TABLE

*Little Ash Table* was a project designed to clear my mind. It was meant to be fast, simple, and to focus on one structural idea instead of several. Because of the

time frame allotted for this project (one week) it was suggested that I have no visible hardware. Simplicity was to be the major design criteria. The structural system that I chose for this particular project was an adaptation of the “bowstring arch”. A bowstring arch is defined as an arch whose ends are linked to resist outward thrust (Bridges, 1993, 168). This structural system was to become the primary system that the last two pieces of my thesis were based on. The design phase of this project was a little rocky at first. Visible hardware, connectors, and complexity were buried deep within my design philosophy and were hard to break away from. In the end, however, I came up with a piece that was successful in maintaining simplicity (Fig.23).

The main support element in the table is a  $1\frac{3}{4}'' \times 7\frac{1}{2}'' \times 39''$  piece of ash. There are two additional ash legs that are much thinner,  $\frac{1}{2}'' \times 1'' \times 40''$ . These two legs pierce the larger support at about 32" from the ground and flare out several degrees. These legs were steam bent to assist in the creation of the bow string arch. A single cable is attached to the bottom of each leg about 2" from the floor and is held in place with a pin, the ends of the cable have been thimbled. The cable pulls the ash legs in to create an arch with a 24" radius. The cable runs through a groove on the main support element at 2" from the floor. The cable and thin arched legs create a tension compression system, or bowstring arch, that is very rigid. The top 3" of the main support element have been sliced off. This piece will later be used as a cap to cover the minimal hardware that secures the glass table top.

The glass top is 36" x 14" x 12" and is 3/8" thick. Tennoned into the main support at approximately 3" down from the top is another arch. This arch is 1/2" x 1/2" x 13" and bends up to meet the glass. It is held rigid by a thimbled cable that is secured to the end with a steel pin. The other end of the cable is secured to the top of the main support piece just under the glass by an aluminum rod and a set screw. This system creates another bowstring arch and is extremely rigid. Two 3/8"-16 threaded rods are epoxied into the top of the main support piece 4" apart. Two corresponding holes have also been drilled into the glass top . The glass is secured to the main support via a 1/8" aluminum plate washer that goes over both threaded rods and is tightened into place with two black oxidized serrated flange nuts. A heavy duty hook and loop fastener have been applied to the aluminum plate washer and to the bottom of the ash cap that was sliced off the main support element. This method of attachment is strong, hidden, and allows for easy removal if necessary. The table was finished with a clear lacquer before it was assembled.

The way the different components of the table interacted with each other was very important, not only to the design process, but also throughout construction. The dimensions of the lighter legs, glass top, and the distance of the cantilever were considered very carefully in order to give the perception of lightness and delicacy while still maintaining stability and strength for functional purposes. In this respect I feel *Little Ash Table* was a success. People's reactions at my thesis show and subsequent shows have been very satisfying. People want to know if the table is

functional (can it actually support anything) or if it is strictly for show. One particular individual wanted to know if the glass would break sticking out so far. All of these comments are testimony to the success of this piece.

## WALL SHELVES

Many of my pieces are based on structural forms that are common to many landscapes. The radio tower became *Chest of Drawers*, high tension wires became *Magazine Rack*, and *Cable Stay* was inspired by bridge construction techniques. One of my favorite pieces and the one I feel best addresses the issues of this thesis was designed after a field sprinkler system (Fig. 24). I had often driven by these sprinkler systems in Wayland, New York, and knew these structures held great possibilities for my thesis. I played with a variety of ideas and concepts for several months. Experimentation with this structural frame ranged from support skeletons for tables to non-functional sculpture. I finally focused on one structural concept for a shelving unit. After long discussions with Rich Tannen on material, I decided the selection should be based on the intrinsic structural value of the material. Consequently, 1/8" aluminum plate was chosen to construct the shelves because of its strength while maintaining a thin edge. The next issue to confront was how to support the shelves. I had originally planned to create a concrete base. The bottom of the shelving spine would be bolted to a tall thin concrete pylon to create a slender shelving unit. I discussed this option with Doug Sigler and he said, "why lose your

momentum". I had just finished the little ash table where its success was clearly its thin members and simple execution (why go backwards?). Already having three pieces with concrete bases, Doug suggested something simpler that would not compromise the structural design. I decided to utilize a wall bracket. The structural system for *Wall Shelves* is virtually identical to the sprinkler system, both are a variation on the bowstring arch (Fig 25).

The main support for the shelves consists of a steam bent piece of mahogany, 83" long x 2 5/8" wide x 7/8" thick. There is a 45 degree chamfer on both sides of the inside curve. Wood was chosen for the spine because of its light weight and spring back characteristics. Mahogany was chosen for its straight grain pattern and its stability. At each end of the spine a 1/8" aluminum reinforcement plate is slotted into the mahogany. It is held into place by two 1/8" aluminum pins. A 1/2" hole is drilled through both the wood and the reinforcement plate to accept a 1/2" x 7" aluminum rod that will secure the cable ends. A 1/2" diameter cove is cut every 12" on the inside curve of the spine, this will act as a socket in keeping the back end of the shelf from dropping down. There are three different size shelves and there are two of each size. The largest size is in the center and the smallest is at the top and bottom of the shelving unit (Fig. 26). The shelves are triangular in shape with a rounded front and a flat back. The back has a 1/2" aluminum rod slotted over it. At the front corners of each shelf there is a 3/16" dia. sleeve with a set screw. The cables run through the sleeves of each shelf and secure into the 1/2" x 7" rod at the

top and bottom of the shelving unit. The 1/2" rod at the back of each shelf sockets into the cove of the spine. The system was then tightened to create a rigid structure. The final shape resembles the rib work of a kayak.

It was my original hope that the forces created by this rigid system would be great enough to keep the back of the shelves in place. It was not. This was a situation where the structure had to be adapted during construction in order to succeed. Consequently, a strip of wood had to be glued onto the inside surface of the spine in order to lock the shelves in place. The 1/2" rod on the back of each shelf was needed to act as a pivot. All the machining of the spine had to be done before it was bent, so there was no way to know how the shelves would fall, thus they could not be fixed to the spine. Final leveling of the shelves can be done with the sleeve and set screw at the front of each shelf. The shelves have a vibration finish and are waxed to prevent corrosion. The mahogany spine has a tung oil varnish finish.

The only objection to this piece in final evaluation was to the stud end fittings that I used to secure the cable ends. The objection being that they looked too mechanical and "store bought" for the lightness and elegance of the design. During the construction of this piece I had felt that the stud end fittings were the best solution, however, should I reproduce this piece I will reevaluate this detail.

## CHAISE LOUNGE

*Chaise Lounge* was the culmination of 18 months of work (Fig. 27). It addresses all of the aspects and issues of my thesis to this point. In the piece I further explored structure and how one's perception of structure can become a positive visual focal point. The selection of materials were once again based on their intrinsic structural characteristics such as strength and flexibility. The design of the piece was philosophically and visually compatible with the other six pieces. Its visual compatibility, however, was most complimentary to *Halogen Lamp* and *Wall Shelves*. As with *Little Ash Table* and *Wall Shelves*, *Chaise Lounge* utilizes the bow string arch as a means of maintaining lightness and strength.

The chaise's main method of support was also created through the use of the bowstring arch. This was done by laminating four layers of 3/16" thick x 3" wide mahogany to create an arch with a cord of about 48". The chaise was created with two mirror image halves, with the exception of the absence of a left arm. The bow string arch is used in the front portion of the chaise. The rear section, the part that supports the human back, also utilizes a bent lamination. The ends of this arch are not connected allowing it to flex with the weight of its occupant. There are only three additional glue joints in this piece. One is used to laminate two pieces of 8/4 mahogany to create the back legs. The rear arch is then glued to the bottom of the leg in a way that allows it to flex back when pressure is applied. The last glue joint is used to secure the left arm to the top of the rear leg. The front lamination or leg

intersects with the rear leg through an aluminum bracket. This aluminum bracket has been machined to continue the gentle curve of the arch and is bolted to the back portion of the leg. The aluminum slides through the surface of the rear leg on both sides and makes contact with the floor (Fig. 28). The chaise makes contact with the floor in eight locations. I believe that this intersection is the most successful part of the piece. Oddly enough, it was not part of the original design. As mentioned in the introduction of this thesis, the idea of adaptability was one of the main concepts that kept this body of work from being contrived by the execution of carefully calculated designs. Adaptability allowed intuitive reactions to individual design issues. Originally, a pivot joint was designed for the leg intersection. It was machined and assembled but upon evaluation it was determined to be inappropriate and clumsy. A number of options were discussed with members of my thesis committee before coming up with the final solution.

The two halves of the chaise are connected by machined aluminum brackets that are bolted to the inside of the front leg arch in specific locations. In the front, a 3/4" aluminum rod spans the 18" distance. The next span is made at the crown of the arch. It is at this location that a machined pivot has been fashioned to accommodate any flex that may occur when a load is placed on the chaise (Fig.29). The end of the arm also connects at this location. The next connection is made where the aluminum intersection meets the back legs. Another 3/4" aluminum rod joins the two halves. Two 1/16" stainless steel cables are stretched tight between the front and the rear connections. This creates the bow string arch and gives the chaise

strength. An additional connection is formed by a 1/4" x 3" aluminum plate that is slotted into and bolted to the top of the rear leg. The last lateral span is at the top of the back lamination. It is created by a piece of 1/4" aluminum plate that is bolted to the mahogany on each side.

The framework is unified by the body support of the chaise. The body support is a piece of 16 gauge cold ruled steel 26" wide x 80" long. Hours were spent doing human factor studies. Contours were developed to achieve the most comfortable semi prone position for the human body. Upon completion of these studies, a drawing was made and delivered to a sheet metal shop for fabrication. After the sheet metal was rolled, it was still very rough. The oil had to be cleaned off, the edges finished and a surface texture had to be applied. Once this was completed, the body support had to be attached to the frame. Connections are made at the foot, knee, and head braces of the frame. It is bolted directly to the frame in the area of the occupant's lumbar. The mechanical fasteners used were black 1/4"-20 bottom head cap screws, sixteen in all were used. I applied wax as the finish to the sheet metal support. but months later I found that this did not offer sufficient corrosion protection and refinished it with a catalyzed urethane.

Even without the upholstery *Chaise Lounge* was very comfortable and, in fact, looked very progressive with the exposed sheet metal support (Fig. 30). I gave some thought to leaving it in this form but in the end decided to stay with the original plan and upholster the piece. The upholstery was done in a smooth black cotton

fabric and was created in four sections. A head pillow and back section with a lumbar support were added to aid in comfort. The third section was a seat that was billowed to follow the sheet metal curve. The fourth and final section was the leg section. All four sections were contoured for maximum support and comfort. During the fabrication of the upholstered sections, it became evident that they would not stay in place on the sheet metal because the surface was so slick. In keeping with the thesis it was evident that the upholstered sections would need to be bolted on. A long sleeve of leather was sewn laterally across the top and bottom of each upholstered section, excluding the head pillow. A thin aluminum bar with holes in each end was then slid through each sleeve. The end of these bars protruded out of each sleeve and were then bolted in place by small black bottom head screws. The head pillow was left unattached and rests on top of the back upholstered section.

The mahogany was finished in five coats of clear hand rubbed polyurethane finish. The aluminum was finished with a paste wax which was adequate for interior applications

#### **WHAT BECAME APPARENT...**

As I began to organize and order my thoughts regarding the body of work that would represent my thesis, it became increasingly clear to me that the relationship between my graduate work and my previous design experience was essential. As I

struggled to "find a personal direction" for my furniture I experimented with several styles, most of which seemed to force the issue. As I continued to search for new ideas and reflect upon the previous several years, a process began to develop that permitted a synthesis between my current and previous work. Almost surprisingly, this process did not need to be forced, but rather developed quite naturally. It allowed me to acknowledge and use my design sensibilities for furniture. It was less an abandonment of my background but rather an accommodation of it. I was happy with this realization for it seemed to reveal a direction for me loaded with potential.

As was mentioned earlier in this paper there were several notions that became apparent during the development of the thesis. The dominant idea was the expression and exposure of structural details and how that became the focal point of a piece. This particular approach was inspired by common construction techniques found in architecture and engineering. Because the construction methods I ultimately developed were so closely related to these fields it became evident that similar materials would also be appropriate. I therefore began to incorporate concrete, sheet metal, various bar and rod stock, and cable into my forms. The need for construction type assembly also became apparent, particularly the use of nuts and bolts, suspension and tension. This straight forward and elemental use of materials and assembly permitted me to strip away much of the ornament often associated with art furniture. It allows, in fact encourages, the eye to focus on the constructed integrity of the piece rather than the embellished. These attributes,

which are so often hidden in furniture, are now exposed as an integral part of the expression. Once established as the basis of my thesis this approach permitted me to produce a body of coherent and related work.

Since so much of my thesis is based on perceiving furniture in a structural rather than decorative way it encouraged me to pursue new perspectives of familiar objects. Therefore, *Chest of Drawers* is held in tension rather than sitting on four legs. *Wall Shelves* are guyed in a bow shape rather than the conventional flat against the wall design. This attempt to challenge the preconceptions that are commonly held as standards for furniture helped shape my thesis and the idea continues to inspire me with its potential for additional exploration. Installation furniture utilizing the walls, ceiling and floor as extensions of the furniture's physical attributes, and furniture that is held together merely by the tension and/or weight of its members are two areas I intend to investigate and develop further. It is my belief that a new aesthetic for furniture can be forged through this structural philosophy and impact people's attitudes toward furniture.



Concrete Form (Rochester, New York)

**Fig. 1**



Train Trestle Detail (Henrietta, New York)

Fig. 2



Service Pipe (Erie Canal, Rochester, New York)

**Fig. 3**



Bolt Pattern (Rochester, New York)

Fig. 4



Tension Cable (Rochester, New York)

Fig. 5



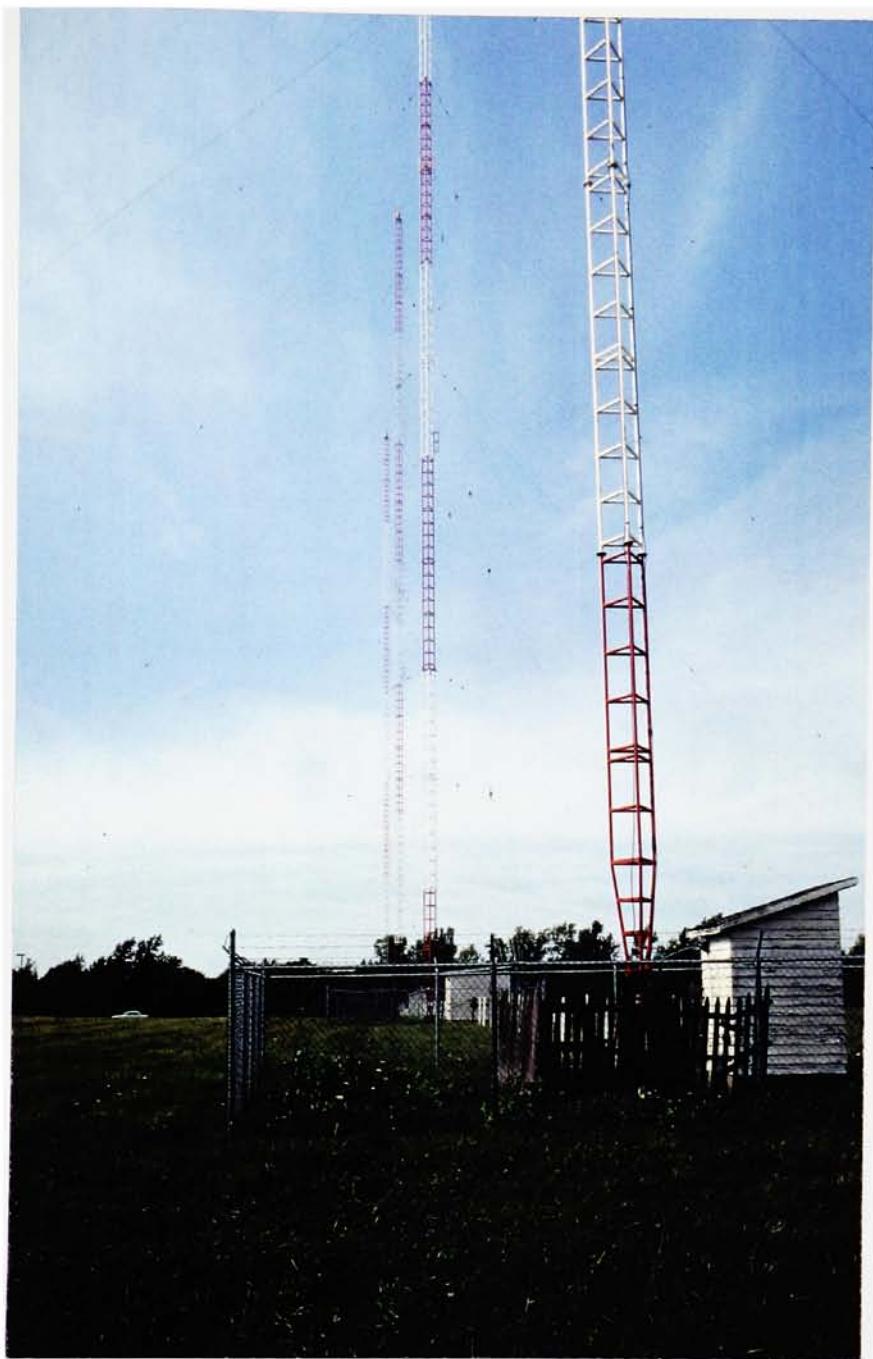
*Formal Chair* 60" x 21" x 30", 1992.  
(Dyed Maple, Bleached Curly Maple, Aluminum, Stainless Steel, Leather)

Fig. 6



*Formal Chair Detail, 1992.*

**Fig. 7**



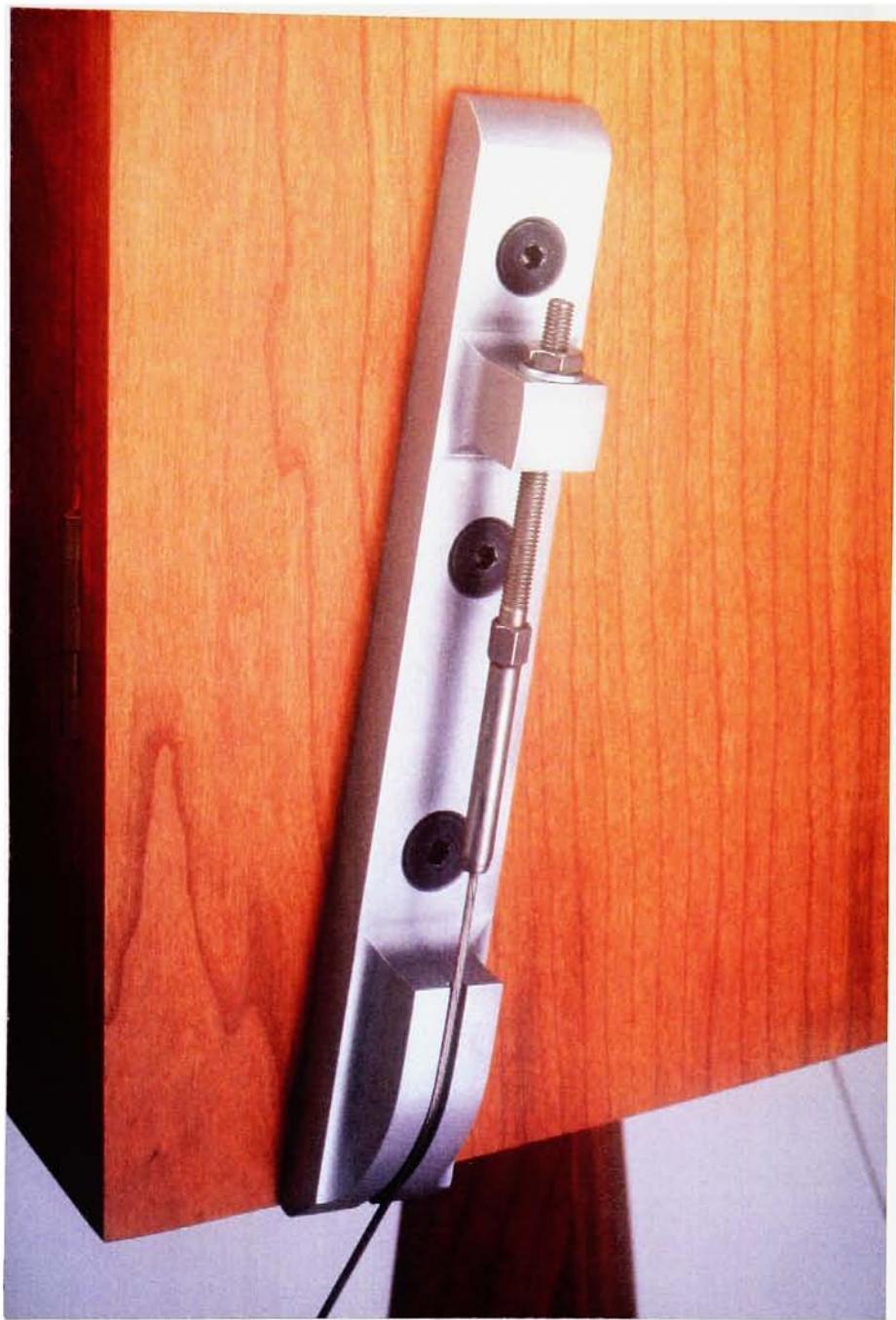
Guyed Tower (Brighton, New York)

Fig. 8



*Chest of Drawers* 28" x 28" x 72", 1993.  
(Cherry, Aluminum, Concrete, Stainless Steel)

Fig. 9



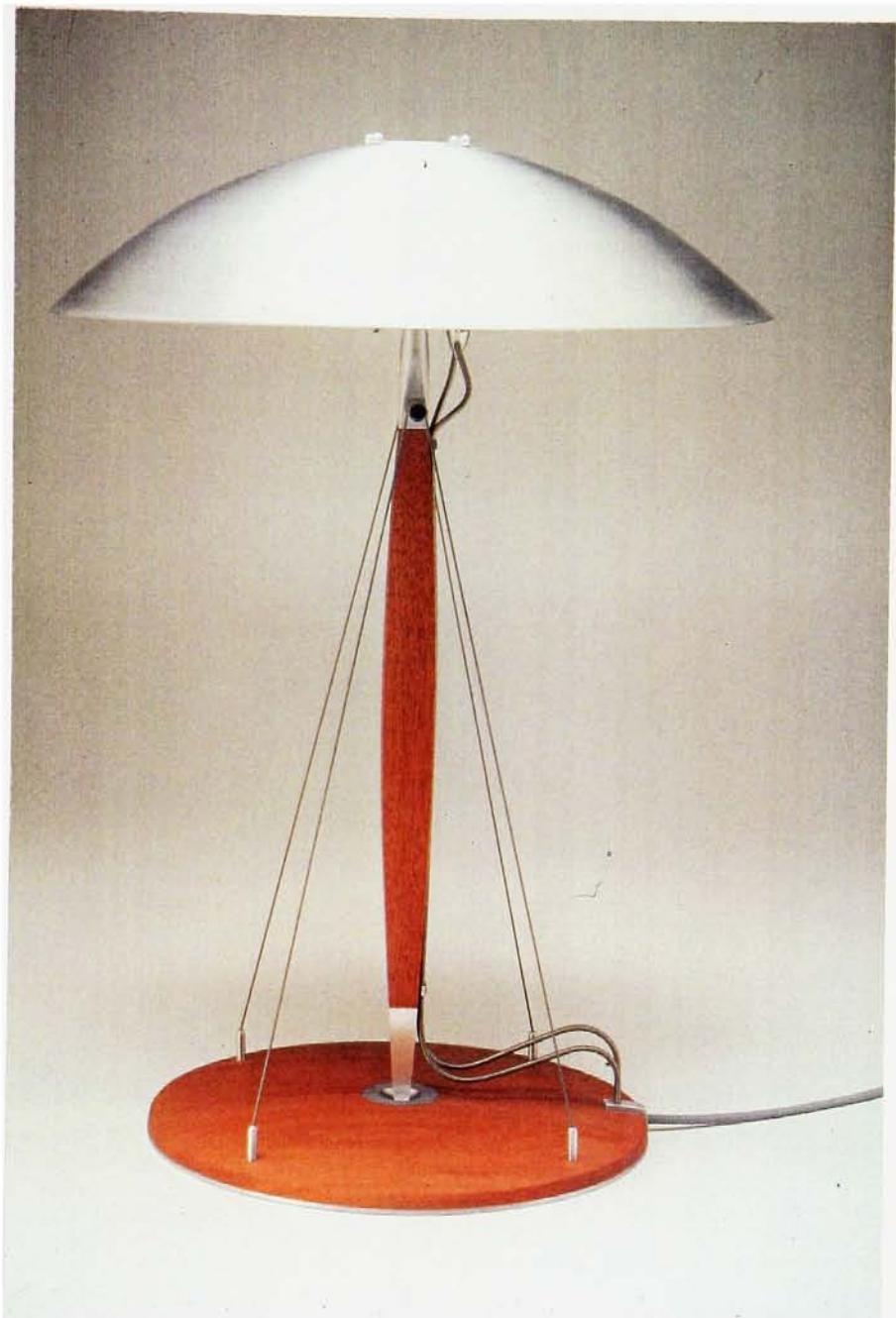
*Chest of Drawers* Bracket Detail, 1993.

**Fig. 10**



*Chest of Drawers* Drawer Detail, 1993.

Fig. 11



*Halogen Lamp* 19"dia. x 26", 1993.  
(Mahogany, Stainless Steel, Aluminum)

**Fig. 12**



*Halogen Lamp Articulated, 1993.*

**Fig. 13**



*Halogen Lamp Base Detail, 1993.*

**Fig. 14**



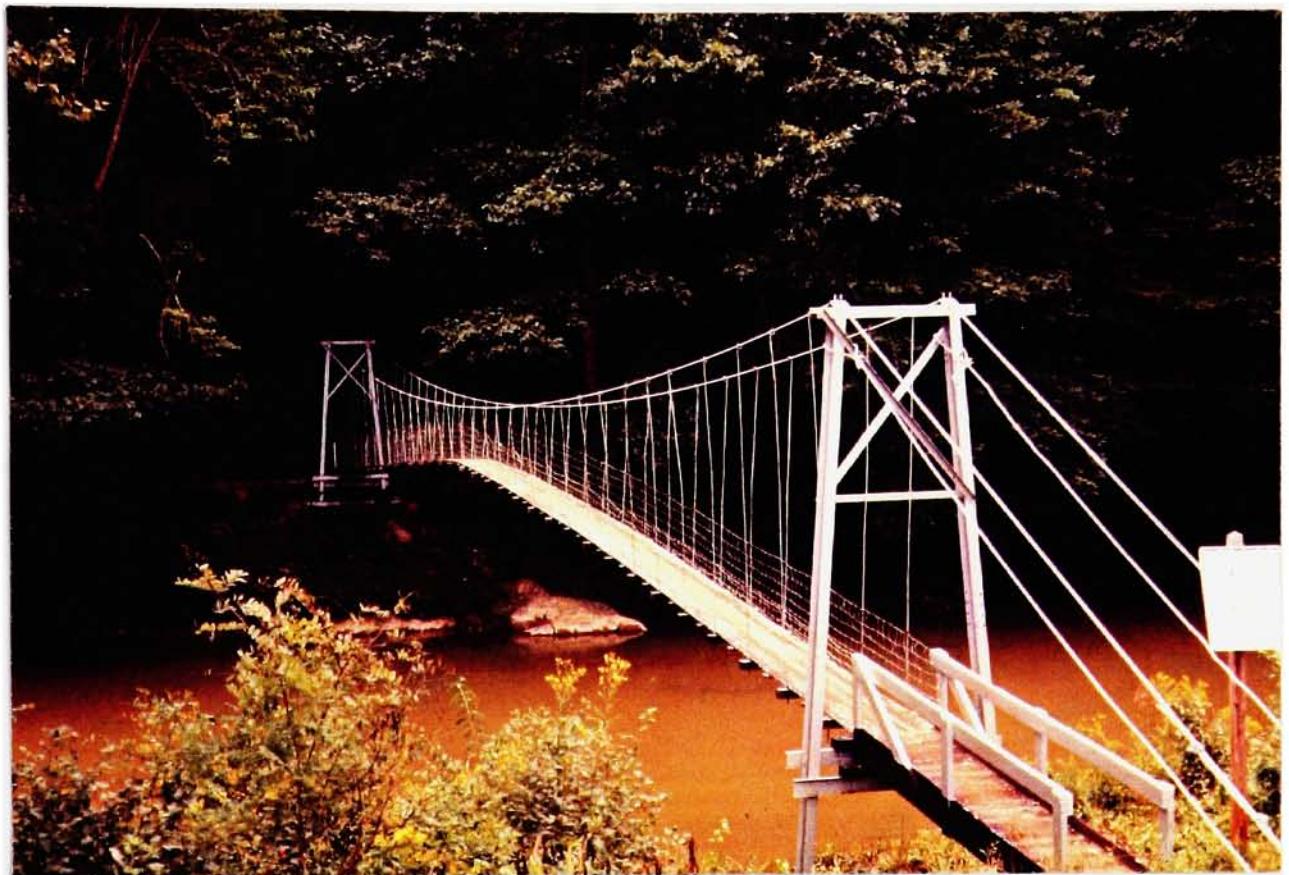
*Halogen Lamp Shade Detail, 1993.*

**Fig. 15**



*Cable Stay* 48" x 48" x 26", 1992.  
(Maple, Concrete, Aluminum, Stainless Steel)

**Fig. 16**



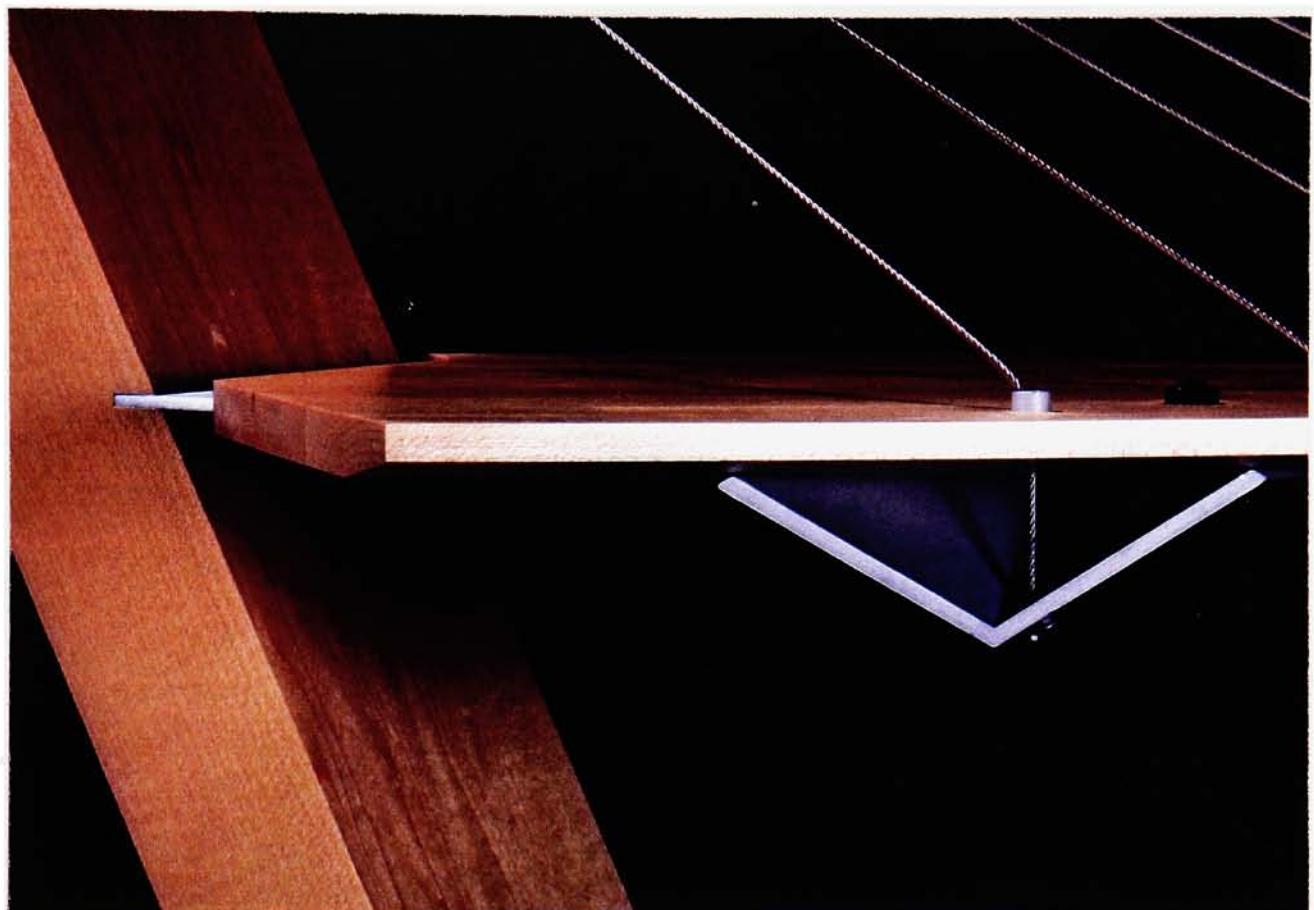
Wooden Suspension Bridge (unknown origin)

Fig. 17



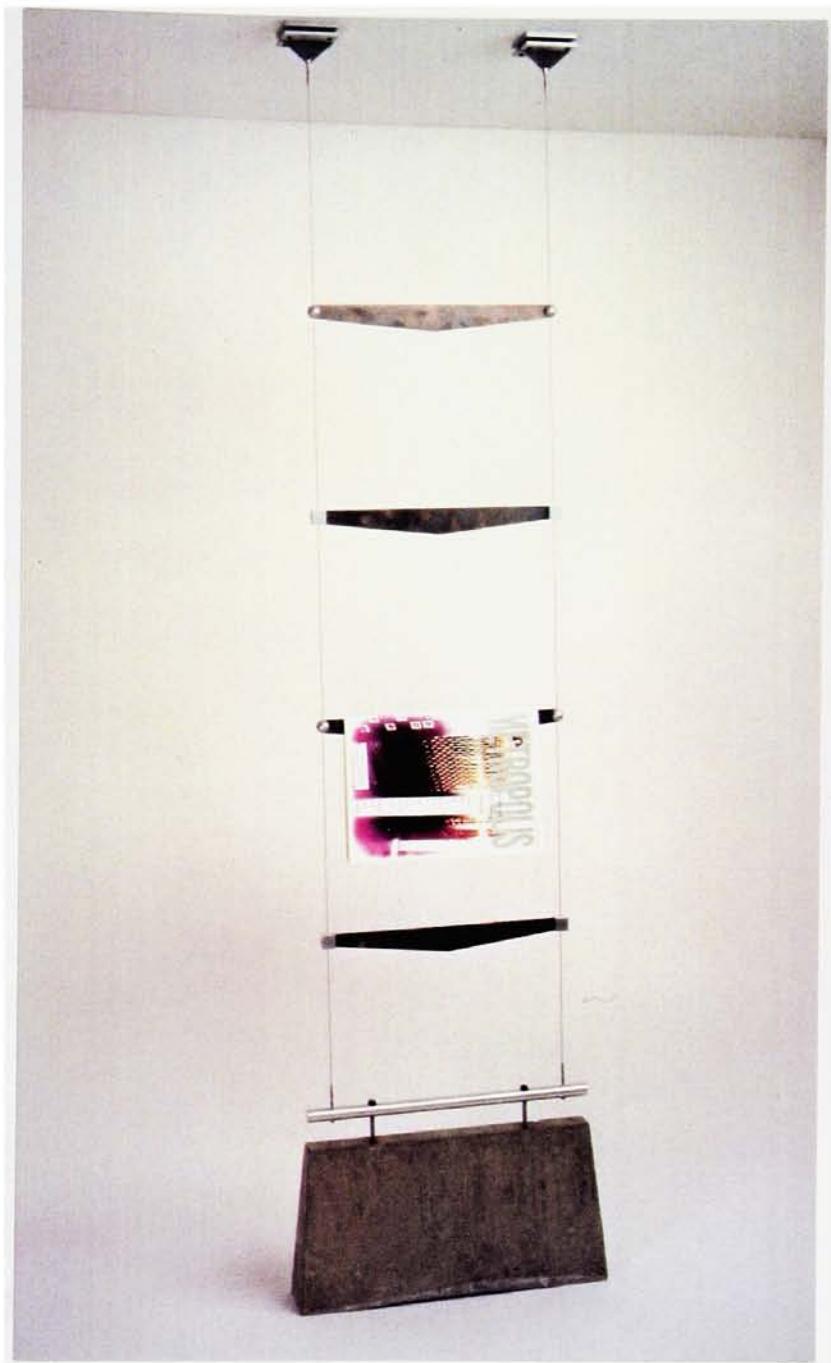
*Cable Stay Tension System Detail, 1992.*

**Fig. 18**



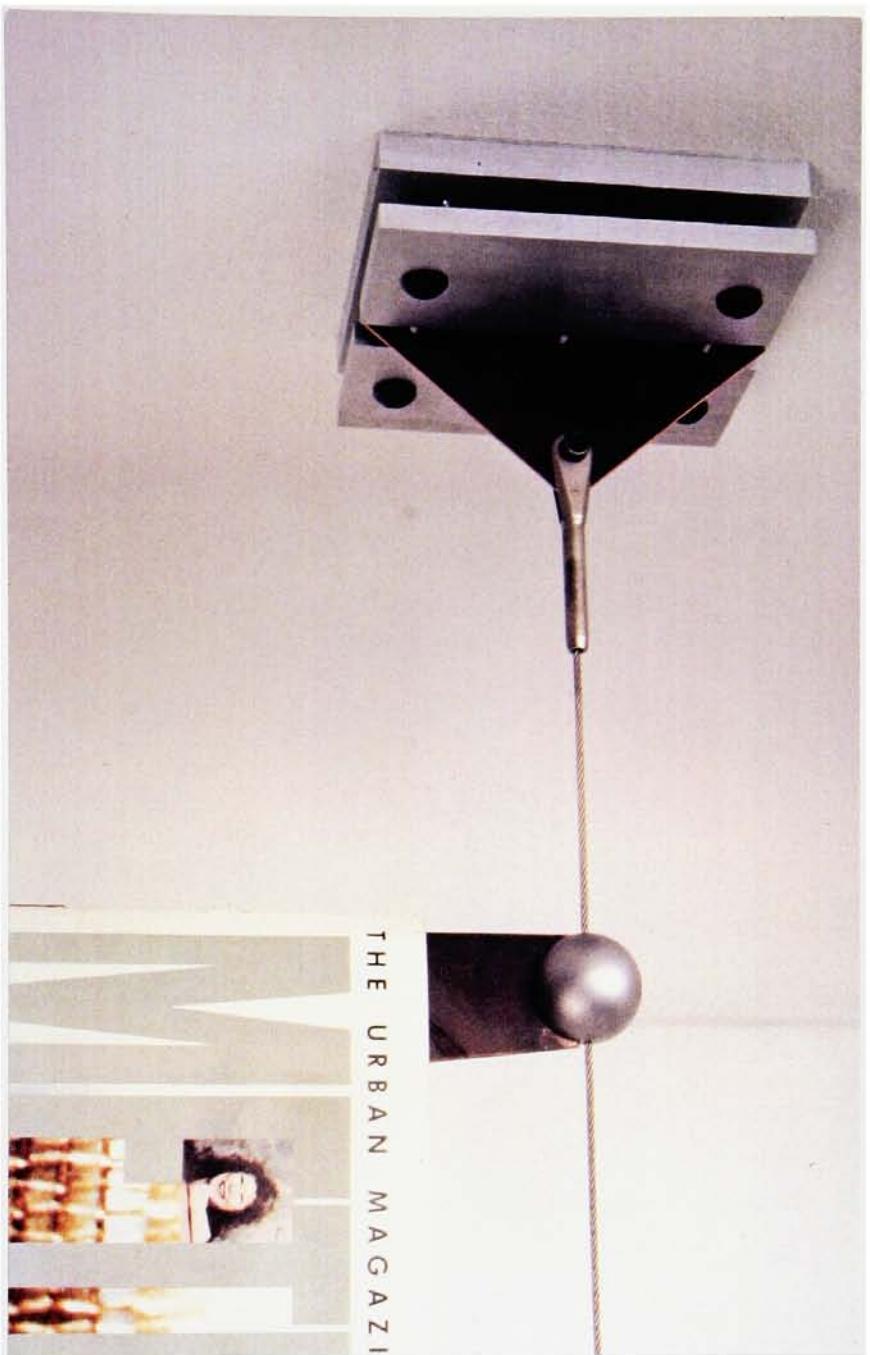
*Cable Stay Table Support Detail, 1992.*

**Fig. 19**



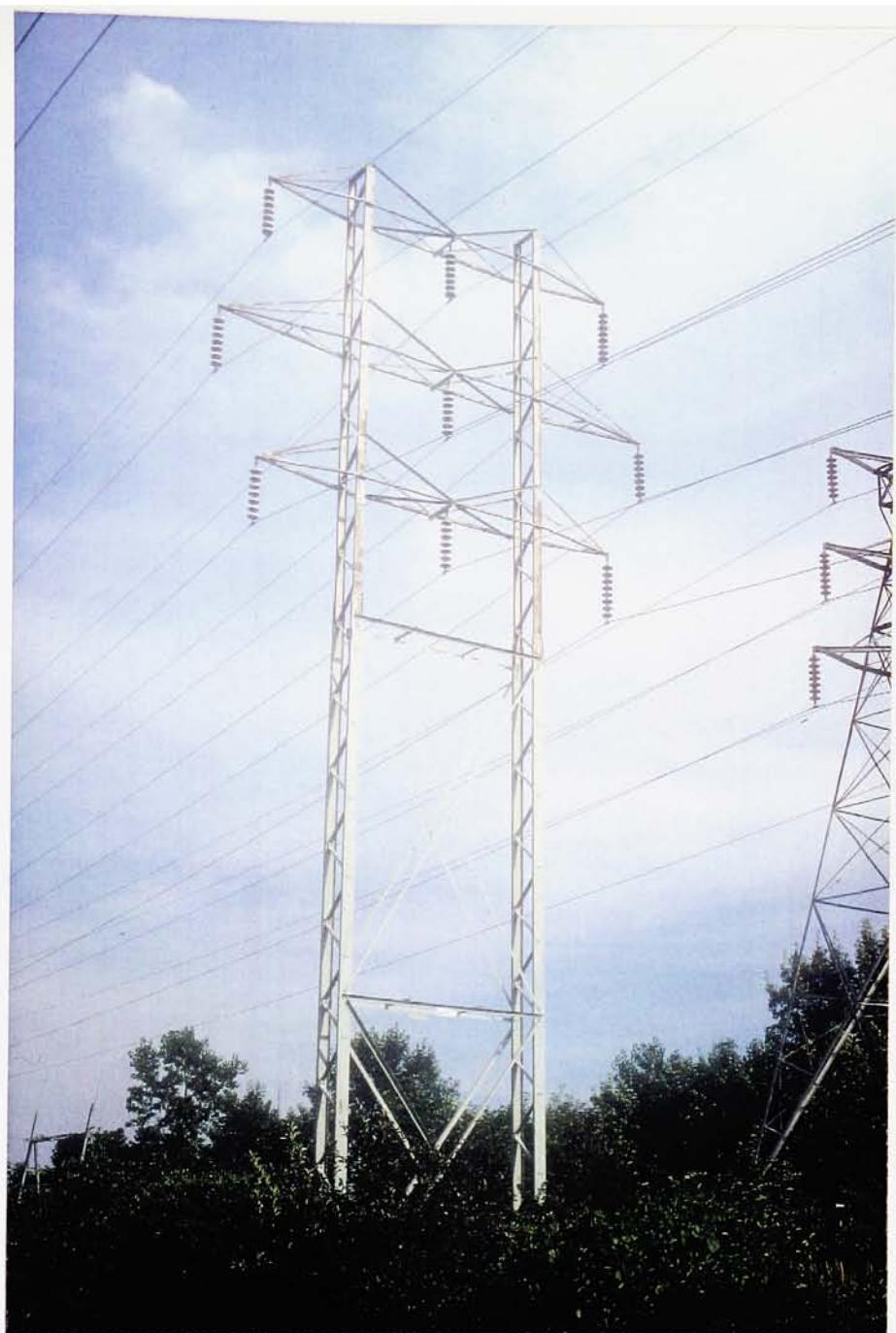
*Magazine Rack* 5" x 24" x 96", 1993.  
(Concrete, Stainless Steel, Copper, Aluminum)

**Fig. 20**



*Magazine Rack Support Detail, 1992.*

**Fig. 21**



High Tension Wires (Henrietta, New York)

**Fig. 22**



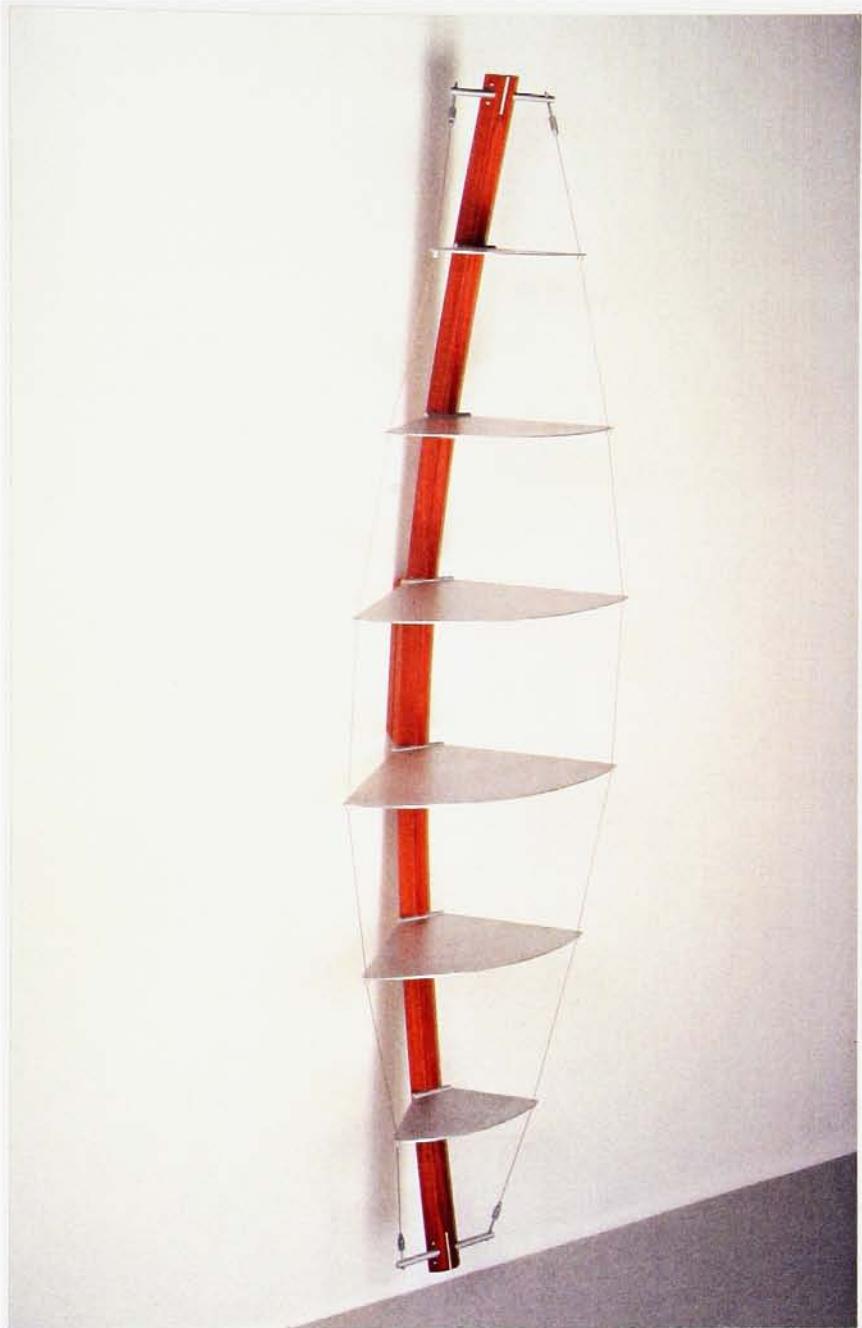
*Little Ash Table* 14" x 39" x 36", 1992.  
(Ash, Stainless Steel, Glass)

Fig. 23



Field Sprinkler System (Wayland, New York)

**Fig. 24**



*Wall Shelves* 23" x 15" x 82", 1992.  
(Mahogany, Aluminum, Stainless Steel)

**Fig. 25**



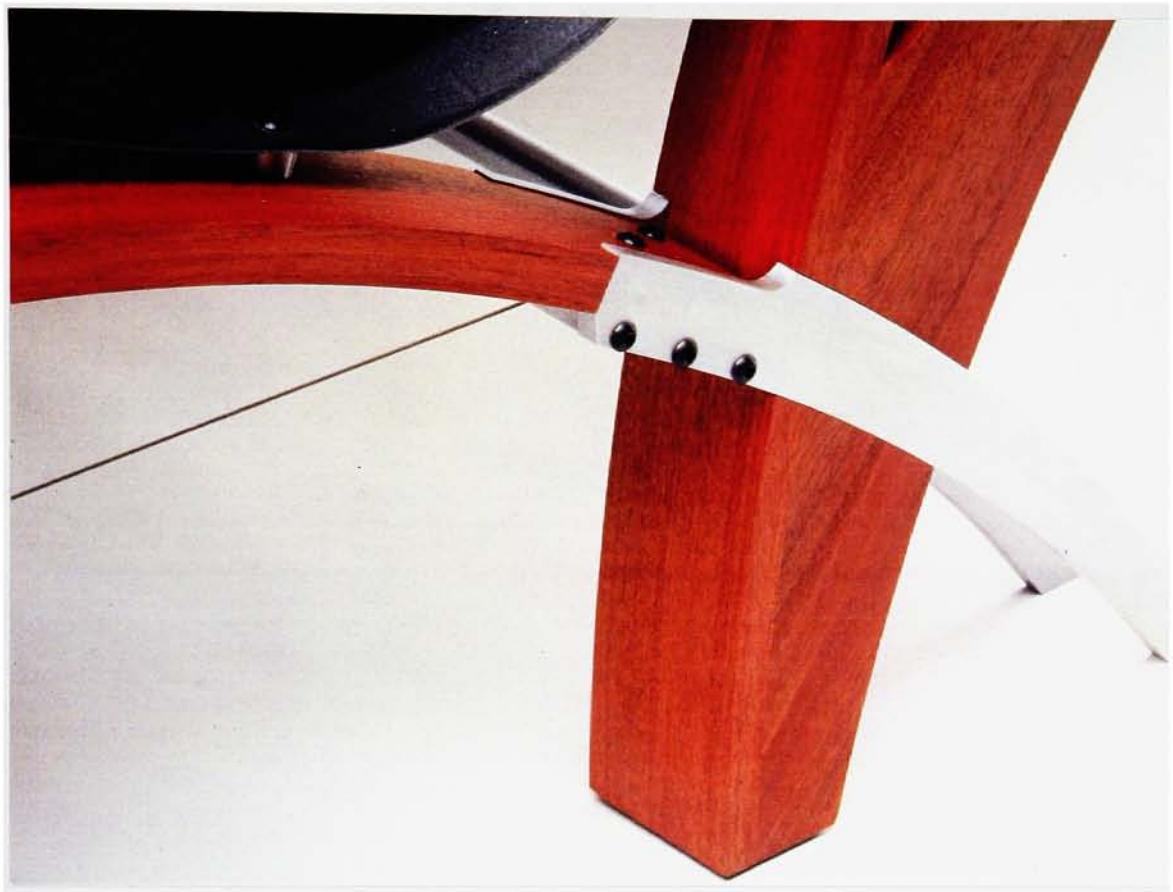
*Wall Shelves Shelf and Tension Detail, 1992.*

**Fig. 26**



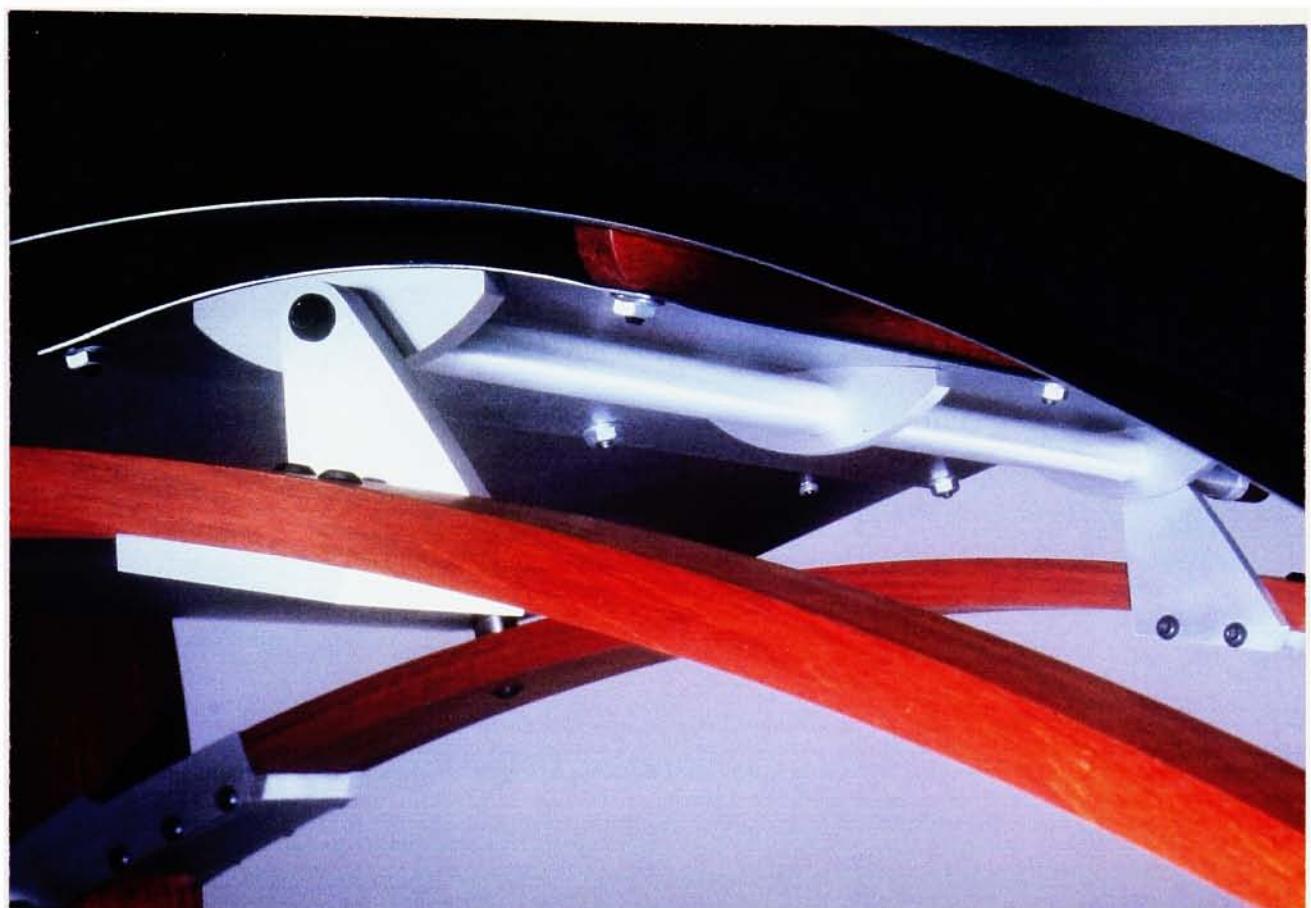
*Chaise Lounge* 39' x 27" x 74", 1993.  
(Mahogany, Aluminum, Steel, Stainless Steel)

Fig. 27



*Chaise Lounge* Rear Leg Detail, 1993.

Fig. 28



*Chaise Lounge* Pivot Detail, 1993.

Fig. 29



*Chaise Lounge Without Upholstery*, 1993.

Fig. 30

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