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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

STRUCTURAL AESTHETICS IN FURNITURE DESIGN

by

James Clark

May, 1980

CONTENTS

THESIS PROPOSAL	i
ILLUSTRATIONS	ii
CHAPTERS	
I. INTRODUCTION	1
II. INDIVIDUAL THESIS PROJECTS.....	7
Dining Table	8
Chest of Drawers	11
Coffee Table	15
Writing Desk	19
Desk Chair	23
III. CONCLUSION	27
IV. BIBLIOGRAPHY	31

The purpose of my thesis will be to incorporate structural members as aesthetic elements in furniture design. In architecture, structure is a major design concern. As a result of the interrelationship between these disciplines, I will apply architectural principles to furniture design.

In my thesis I propose to expose and use structure for defining form. More specifically I plan to utilize structure in ways that reveal its own beauty through its functional purpose. I plan to explore this idea by producing as many pieces as possible during the year of my thesis work. Each piece done will involve techniques and processes new to me.

ILLUSTRATIONS

<u>FIGURE:</u>		<u>PAGE</u>
I.	TOM HUCKER DINING TABLE	4
	TOM HUCKER DINING TABLE	4a
II.	DINING TABLE	10
III.	DINING TABLE DRAWING.	10a
IV.	CHEST OF DRAWERS.	14
V.	CHEST OF DRAWERS DRAWING.	14a
	CHEST OF DRAWERS DRAWING.	14b
VI.	COFFEE TABLE	18
VII.	COFFEE TABLE DRAWING.	18a
VIII.	WRITING DESK.	22
IX.	WRITING DESK DRAWING.	22a
X.	DESK CHAIR DRAWING.	26

I. INTRODUCTION

I chose the topic "Structural Aesthetics in Furniture Design" to achieve three objectives: to explore structure, which is inherent in all furniture; to be unrestrained by any particular technique or style; and to experiment with structure as it relates to both furniture and architectural design.

These same considerations of structure, design, and technique were important in the creation of furniture constructed for this thesis. It was important that each piece clarify the thesis problem and utilize innovative techniques that I had not used in my previous wood or design experience.

Structures are a means of transferring forces. Furniture design involves the use of solid materials both to resist and to transfer forces.

"Solid materials can resist three different types of forces: tension, compression, and bending.

Members in compression require more material than those in tension."¹

When making decisions on structural requirements for furniture, considerations of tension, compression, and bending are the product of an intuitive process. By contrast, in architecture very little is left to one's intuition.

¹Otto, Frei, Light Weight Structures, Berkeley, California: Berkeley Press, May 1963. Copy No. 80 of 600, p. 2.

With the extensive use of steel and reinforced concrete, structure has assumed such significant importance that it has become a central feature of architectural design. The forces which come to bear on large buildings and bridges become evident in the shape and design of their structural elements. The bridges of Robert Maillart and the buildings and structures developed by Pier Nervi exemplify expressive structural relationships in their design.

The elements of structure in each piece completed for my thesis are not obvious expressions of their forces of tension, compression, and bending, but they are honest in their purpose for existence. The structural elements I have worked with express a required need in each particular case, but they have not become design elements solely by themselves. A flamboyance often astounds the viewer with the sheer complexity of joinery, bending and shaping techniques in furniture construction. This direction may or may not concern itself with the design as a whole. An example of structure as design direction is Thomas Hucker's* dining table (Fig. I, p. 4). The elegant handling of the legs has met structural requirements and become the main visual consideration. The flamboyant style exhibited in Tom's dining table is an obvious expression of tension, compression, and bending forces which becomes more important unto

*Thomas Hucker, a graduate of Boston University's program in Artisanry in Woodworking, presently is teaching at the Appalachian Center for Crafts in Smithville, Tennessee.

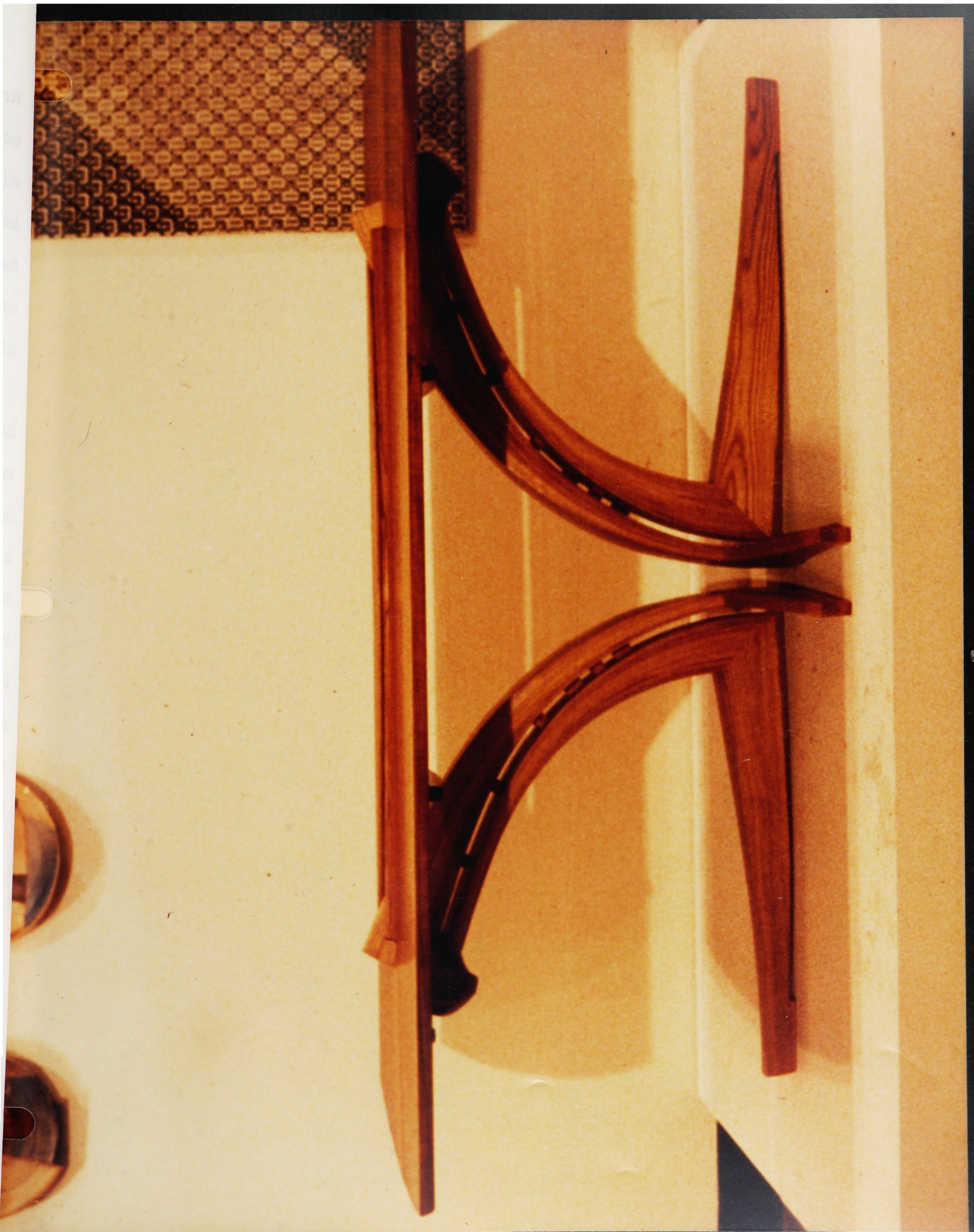


FIGURE I



-4a-

itself than a structural requirement for a fully usable dining surface. A strong technical direction may become self-determinant, which can lead to a decorative element that alludes to its structural purpose. Elements such as these are present in revivals of architecture and furniture styles which the advancements in technology have dated.

"Structural elements in both architecture and woodworking are sometimes used in a desire to achieve a contemporary idiom but end up producing a decorative element or gesture."²

Each piece designed and executed for this thesis was influenced by a variety of ideas. While at Rochester Institute of Technology, I became interested in sculpture as an attempt to focus on a pure visual element. This required that I stop associating form with function. The result of this sculpture exploration becomes evident in all my pieces, some more than others. All pieces are developed three dimensionally and all views are given equal consideration. Each piece, therefore, becomes more than a statement of function or technique.

Success with sculpture is dependent upon an idea that permeates the piece and conveys a wholeness in the finished work.

²Gouldie, Sinclair, The Appreciation of the Arts and Architecture, London: Oxford Press, 1969, p. 87.

Furniture can have that same wholeness without compromising its traditional functional rule. Therefore, the primary objective of this thesis is to explore and incorporate structure as form.

In the remaining pages of my thesis I will describe the structural aesthetics of each piece and discuss the photographs enclosed. In addition, there are drawings which represent each piece and further clarify the design and structure.

II. INDIVIDUAL THESIS PROJECTS

Dining Table

Walnut

I designed a large, functional, rectangular table to comfortably accomodate four persons (see Fig. II, p. 10).

This project was my first exposure to both table construction and steam bending processes. The structural members are minimal, intended to function as a strong design statement.

The table base assembly uses only four rails, all of which are located at the top of the legs. With just four rails another device is required to prevent racking (the flexing of a joint and material under compression and tension forces) of the base structure. The top, already a functional part of a table, is used to add rigidity to the structure in the base. By fastening all rails to the top with pivoting brackets, the top acts like a large flat beam connecting all parts and resisting the forces of racking.

The legs are the only members which were steam bent. The curves on all rails were sawed, then hand shaped. The shaping would indicate a distortion which might exist if a compressive force was exerted along the long side of a rectangle. All shaping of the rails and legs are in response to this implied force.

The table structure is minimal, utilizing only what is necessary for a stable construction. I feel that the struc-

tural minimum for parts and dimensions for this type of table has been reached. The joinery is clean and simple with the rails half lapped and locked into the leg with a bridle joint. The top has been left thin, in keeping with the proportions of the piece. The table as a whole is both visually and physically light.

The distortion of the top and base was a design element to express an idea of pressure which becomes destructive at times. The assimilation of this idea into all parts of the table gives it a harmony and completeness that takes it beyond its basic structural form.

The use of the table top as an integral part of the structure is reminiscent of flooring and roofing in building structures. The strength and rigidity of this structure requires that all parts connect to the horizontal slab.



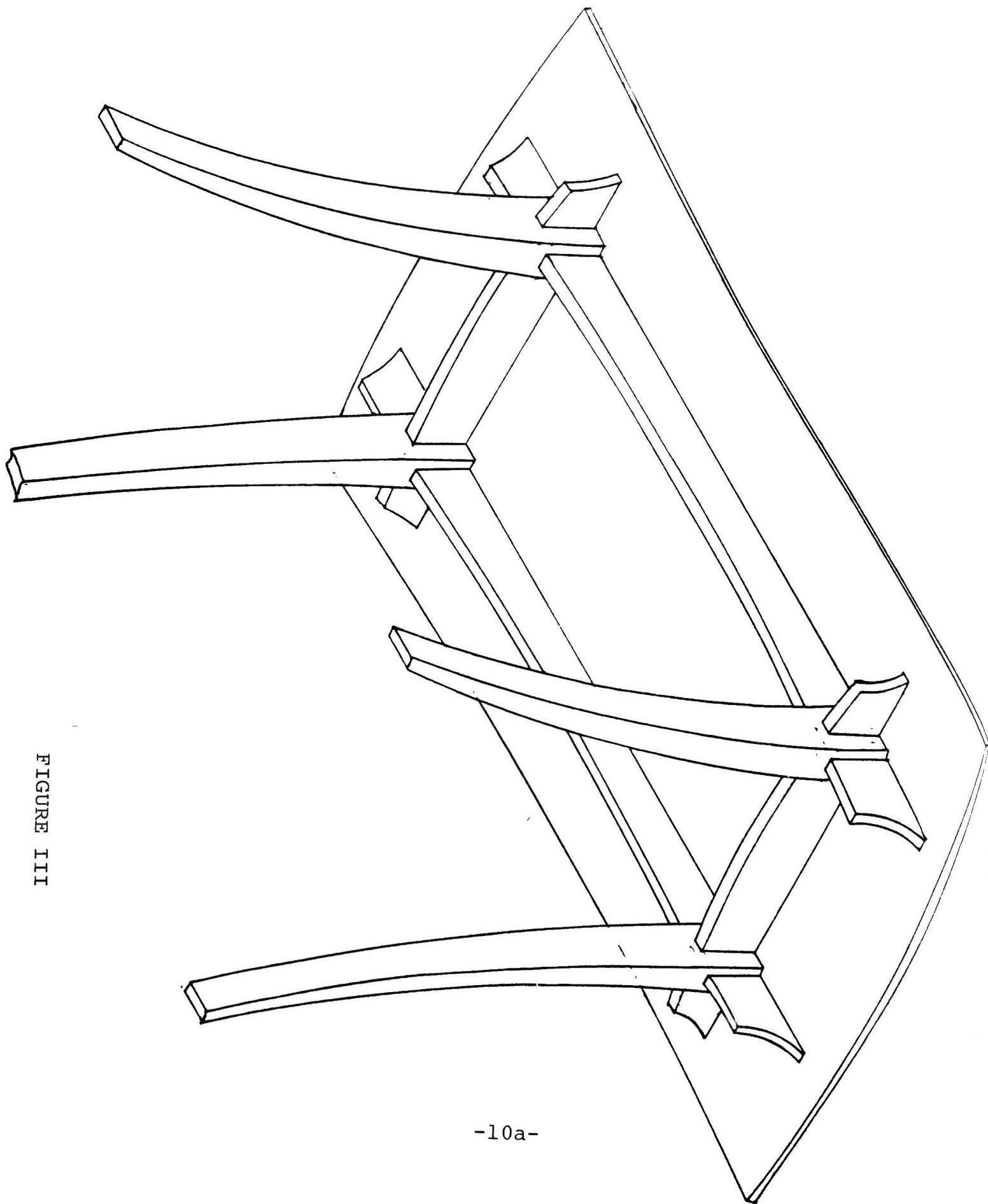


FIGURE III

Chest of Drawers

Mahogany, Maple

This chest of drawers was the most demanding piece, both mentally and technically, to design and construct. The design of the chest places demands on the viewer, the user, and on the space it inhabits. The basic form is rectangular which, like the dining table, has been distorted in most views (see Fig. IV, p. 14).

The shape does not allow the chest to be placed against a wall due to the irregularity of the back surface. My intention was to give it the same three dimensional considerations given to free standing sculpture. As a result, the chest makes certain demands of the viewer and its space in a room.

The top has not been treated as a utilitarian surface. This is an attempt to keep the surface free of objects. No one need be told that you cannot place objects on the angled top surface; the chest functionally demands to be a storage vessel, visually and structurally. By strictly defining the function, the use and purpose become clear.

The emphasis has been placed on a planar structure. The use of planes in the design and construction of the chest of drawers serves a twofold purpose: to carry the load and to enclose. This is in contrast to the frame and panel technique

which requires that the frame carry the load while the panel acts as a partition. A comparable technique is found in architecture. A load-bearing exterior wall acts as a partition as well as bearing the load of the structure. The curtain wall exterior or facade, in comparison, encloses but is supported by a framing grid which carries the load of the structure.

"A rectangular slab supported on two sides will receive the forces of the supports like a large flat beam, bending in one direction and is called a one way slab."³

The exterior planes have been distinguished visually from the interior volumetric containers (drawers) by the use of curly mahogany veneer on the front drawer plane. A further distinction between the structure and the interior space is the incongruity between the front drawer plane and the protruding edges of the carcass planes. In order to achieve continuity of form, the carcass planes were constructed to appear seamless.

Visually, the drawer handles draw attention to their function and use. Although the drawer pulls travel the major length of the drawers, there is only a small area where the hand fits

³Structure and Forms in Modern Architecture, New York: Reinhold Publishing Corp., p. 26 (translated by Thomas E. Burton).

the handle comfortably. This spot is in the center, which is directly above the drawer glides.

Technically, this was the most difficult piece of furniture to construct because of the joinery and lack of right angle referencing. In addition, the drawer fronts were my introduction to veneering techniques.

The strong use of angles for visual purposes is a powerful design element here, as well as in contemporary architecture. Examples are the Rochester Institute of Technology Campus Buildings, the Eastman Dental Building at the University of Rochester, and I.M. Pei's National Museum, where the use of angles has been employed for visual reasons and has little to do with function.

From working on this piece I have concluded that there must be an ultimate balance between function and design in any area in which both are a consideration. In this piece the design was the stronger element; I have since been moving away from this direction and moderating toward a more functional view.



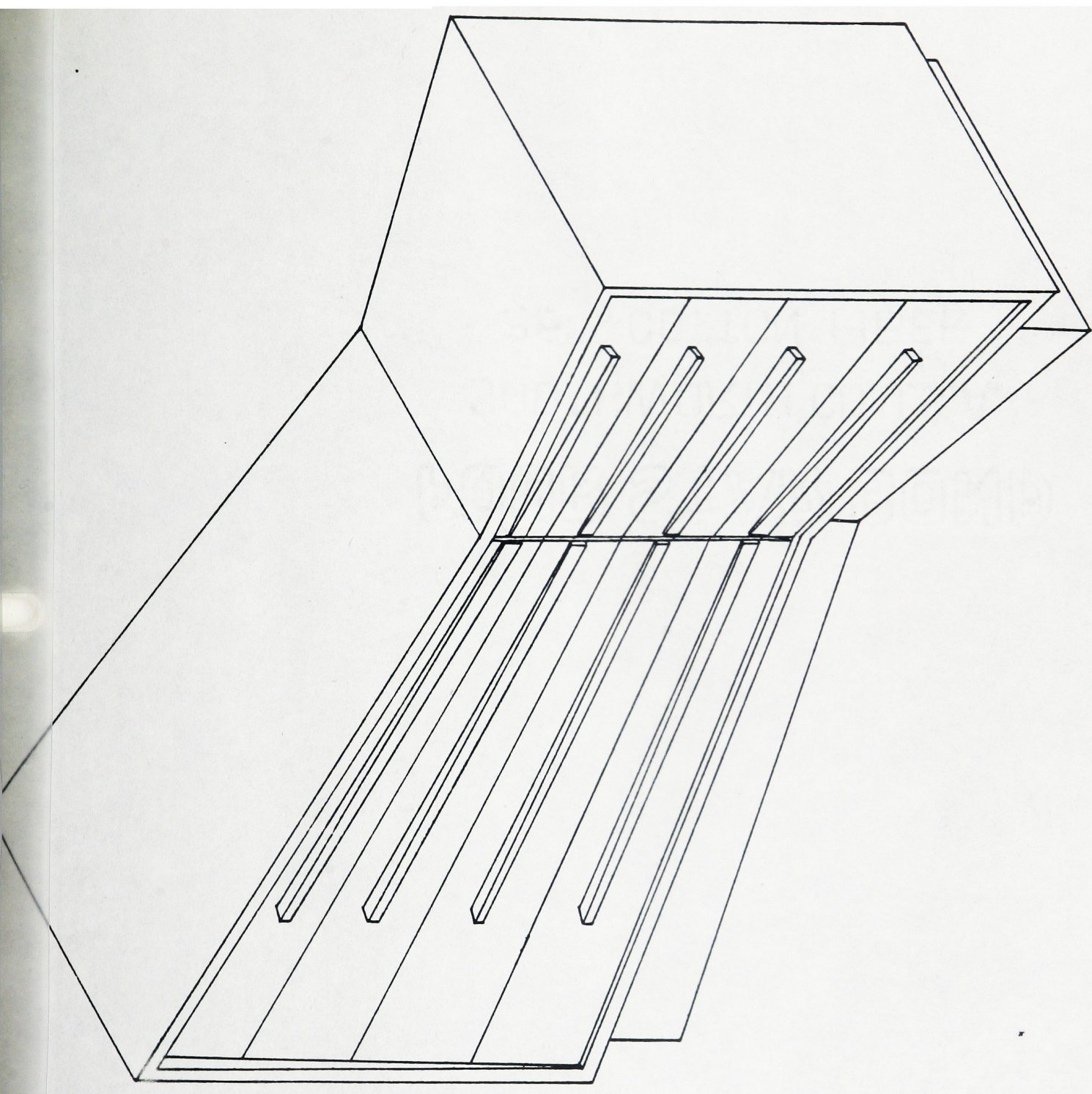
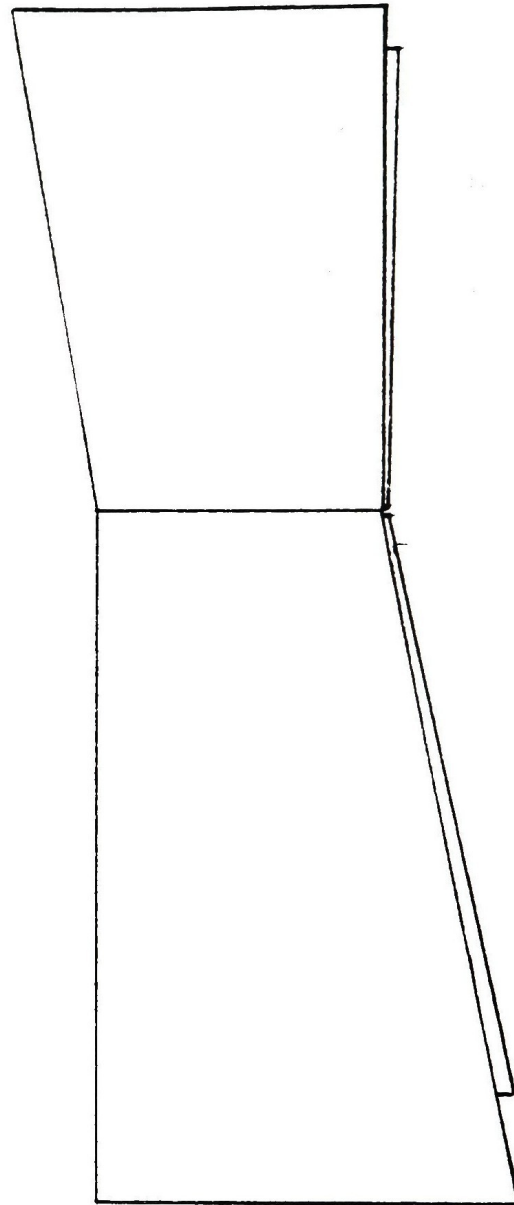


FIGURE V



Coffee Table

English Brown Oak, White Oak, Birch Uniform Laminate

This coffee table was an experiment in the use of hollow core construction (see Fig. VI, p. 18). This technique is used in the fabrication of airplane parts, furniture, doors, and anywhere that a strong, light plane is required. In the examples mentioned above, paper and plastic products are used as the core materials, giving a good weight-to-strength ratio.

"In sandwich construction paper honeycomb is bonded between faces of thin material...wood. The design members using sandwich construction are based on the principle that in bending, the largest part of the load is carried near the extreme fibers of the beam and small bending stress is developed near the neutral axis."⁴

As in the chest of drawers, the design for this table uses planes as a structural and visual element. In the table, the planes themselves take on an additional importance with the incorporation of an interior grid system. This grid enables a thin surface layer (1/8 inch) to withstand the forces of compression and tension with a minimal amount of distortion.

⁴Light Weight Paper Honeycomb, Reprint Industrial Journal, 1970.

There are four planes. Three are used vertically for legs and the fourth is used horizontally, serving as the utilitarian surface. Each of the legs is a different shape; two are creased and the third is curved. The arrangement allows all three legs to be seen simultaneously from many vantage points.

The core is made up of white oak strips 1/8 inch by 1 inch which intersect at right angles every four inches. The grid, which is made up of these strips, is exposed at the edges of the top plane. The structure creates a visual interest while serving its functional requirement.

Within the primary grid is a secondary structure (1 inch by 1 inch) which is also exposed at the edges. This secondary grid is necessary in order to bolt the legs into the top. It terminates at each corner, reducing the vulnerability of the thin veneered skin at that point. The legs incorporate the same primary and secondary grid structure but are totally enclosed. Visually the structure of the legs is not revealed, but the consistency of dimensions and materials suggests a similarity in construction.

The interior structure of the top has been left rough, making a distinction between the structure and the veneered skin, a Beton Brut effect.

Strength and rigidity gained by the use of this hollow grid construction is more than adequate for its purpose. When

the dead weight factor requires a light structure, this technique should not be overlooked (e.g., large conference tables).

By veneering all exterior surfaces on this coffee table, I became more proficient in veneering techniques. The exterior skin is composed of brown oak veneer over a birch uniform laminate 1/8 inch thick.



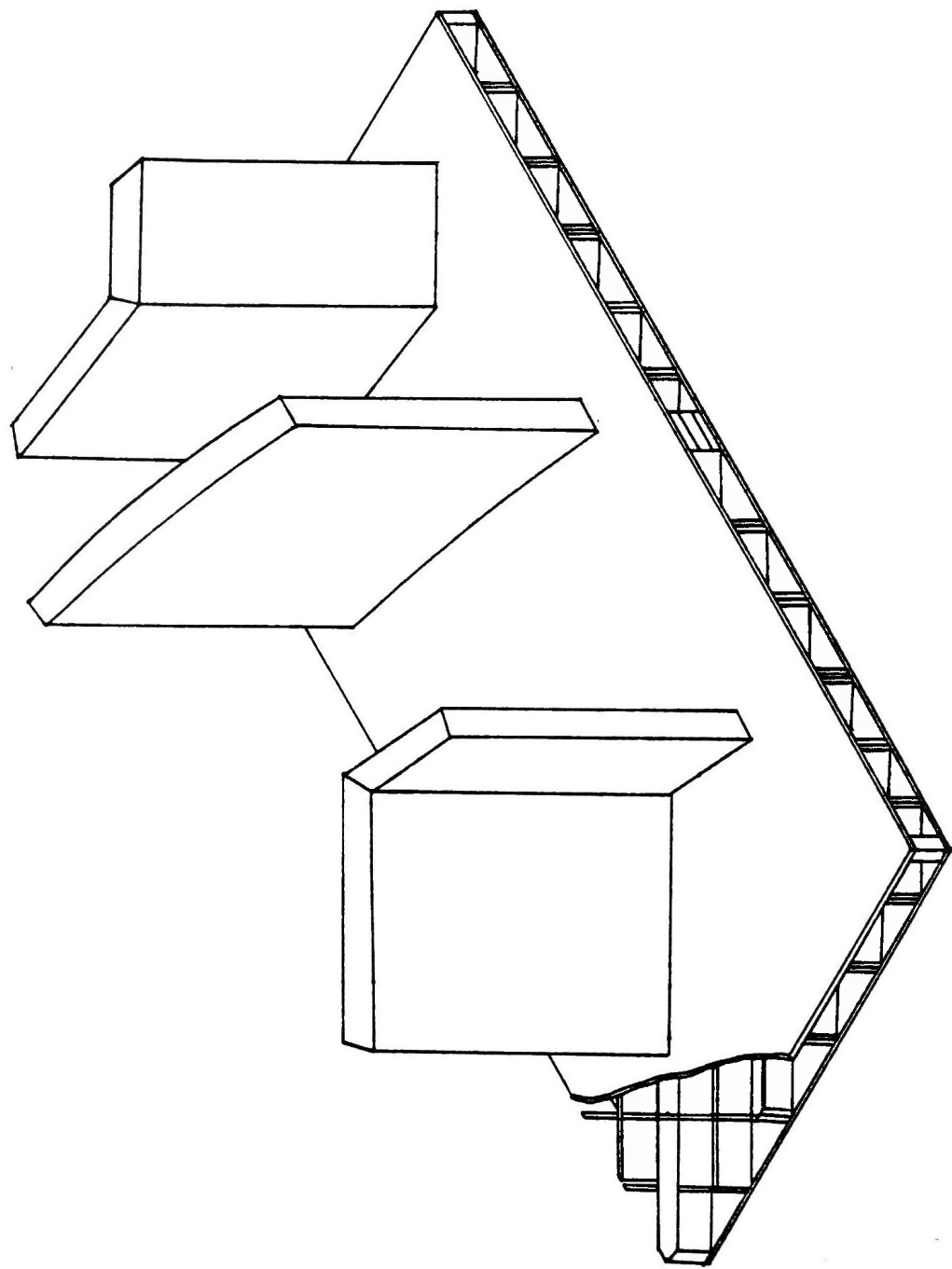


FIGURE VII

especially about an axis) at each joint, tapering away where the load is less. The horizontal members taper away from the verticals, which themselves increase in width to the floor. At the floor the corresponding horizontal members also taper away, putting the mass of material at the joint where the greatest force converges. The sides of these cantilevered members twist along their length (a twist which expresses a weight transferral), as well as softening a straight taper. This visually and functionally increases surface area at the supporting surface (underside of writing surface and floor).

The front edge of the writing surface has a concave arc similar to the one on the dining table. The gentle curve inward creates a writing surface which curves in part around the user. This yeilding of the writing surface is further expressed in the edge treatment, which twists inward to the center of the curve and then out again at the edge.

The space between the writing surface and the drawer casing serves a functional as well as visual purpose. By freeing the drawers from the writing surface, this space has become useful area. The separation of members also visually serves to keep the desk from becoming top heavy and emphasizes the transferral of forces through the vertical and horizontal structure.

The carcass is being supported by cantilevered members similar to those in the base. These supports penetrate the top

and are mortised into the base members. This structural system gives a clear line of support running to the base and eventually to the floor.

The drawer fronts and carcass are curved and angled back from the user. This combination of curves and angles produces an interesting contrast which has been repeated in the detailing of other parts of the desk.

The structural elements of this desk are strong, but not flamboyant or over-expressive in their purpose. In this piece, my use of detailing, both with the structure and the piece as a whole, became more proficient.

The use of the cantilevers is commonplace in buildings from the overhanging roofs to the porches jutting out from the faces of buildings. But none is more dramatic in structure than the porches and roof on the Kaufman House by Frank Lloyd Wright at Bear Run, Pennsylvania. Here, Wright uses reinforced concrete to propel a porch and roof out over a waterfall.



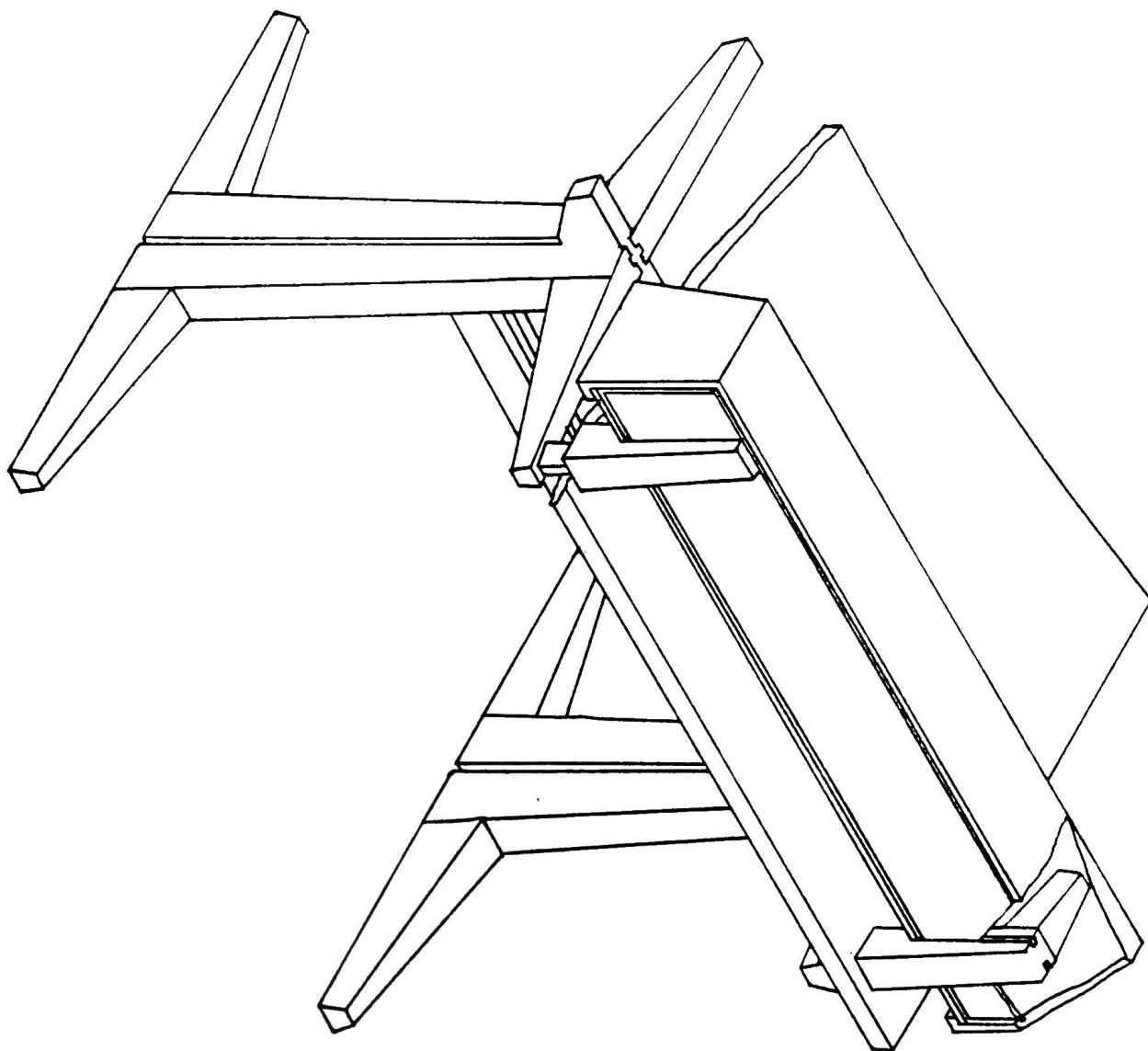


FIGURE IX

Desk Chair

Walnut

After finishing the desk, selecting a chair was a difficult process. I needed a chair which would complement the desk and preserve its integrity (see Fig. X, p. 26).

A chair is an excellent piece of furniture in which to combine both form and structure. The linear characteristics of a chair make its structure visible and clearly defines how it carries the required load.

The base structure of the desk influenced my initial ideas for designing the chair. The C-shaped member would easily lend itself to a seat and back arrangement for a chair, and through repetition of leg and base forms, pull the desk and chair together. It also would be predictable and boring. Therefore, I decided to let structure and detailing bring the desk and chair together. The structural technique that unites the two would be the use of cantilevers. The design of the chair would visually repeat the contrasting angles and curves.

The back leg of the chair was steam bent from solid stock, a difficult task considering the thickness of material (1 3/4 inches at the bend), in relation to the severity of the bend. Technically, a joint instead of a bend would have been more appropriate but visually, the taper reads clearly in the chair and to break it at the bend would have been distracting.

The front legs are shaped from solid stock. The front and rear legs meet just above the seat in a locking scarf joint. Under heavy use, this scarf joint could fail. But with a combination of the seat supports, which lock into the leg stretchers, a triangulation is formed and the chair frame is stabilized. The jointed leg structure combines to form what is architecturally known as an inverted V support.

Each seat support is made of eleven tapered laminations. This technique is the only known method to achieve a tapering curve. I attempted to steam bend the supports but the curves were too severe for the thickness of the stock.

The seat is made in five sections, each four inches wide and pressed between a two-part mold. The seat tapers in plan view to maintain a proportionally pleasing seat, yet allows ample movement and support for the legs. The contour of the seat requires that one assumes a certain position, but at the same time does not restrict the side-to-side movement which is associated with long-term seating.

I have separated the seat from its supporting structure with a space on each side. By making this separation I am attempting to distinguish the seat from the chair frame structure. The gentle curving back uses the same laminating technique as the seat. The curve holds the back in a comfortable, supportive position. The same spacing that exists between seat and frame has been repeated in the back, exposing four splines which hold the back in place.

Visually, functionally, and structurally, this chair works as a single piece as well as an accessory to the desk. Although the frame of the chair and desk are not repetitious, the structural similarities and detailing unite the two pieces.

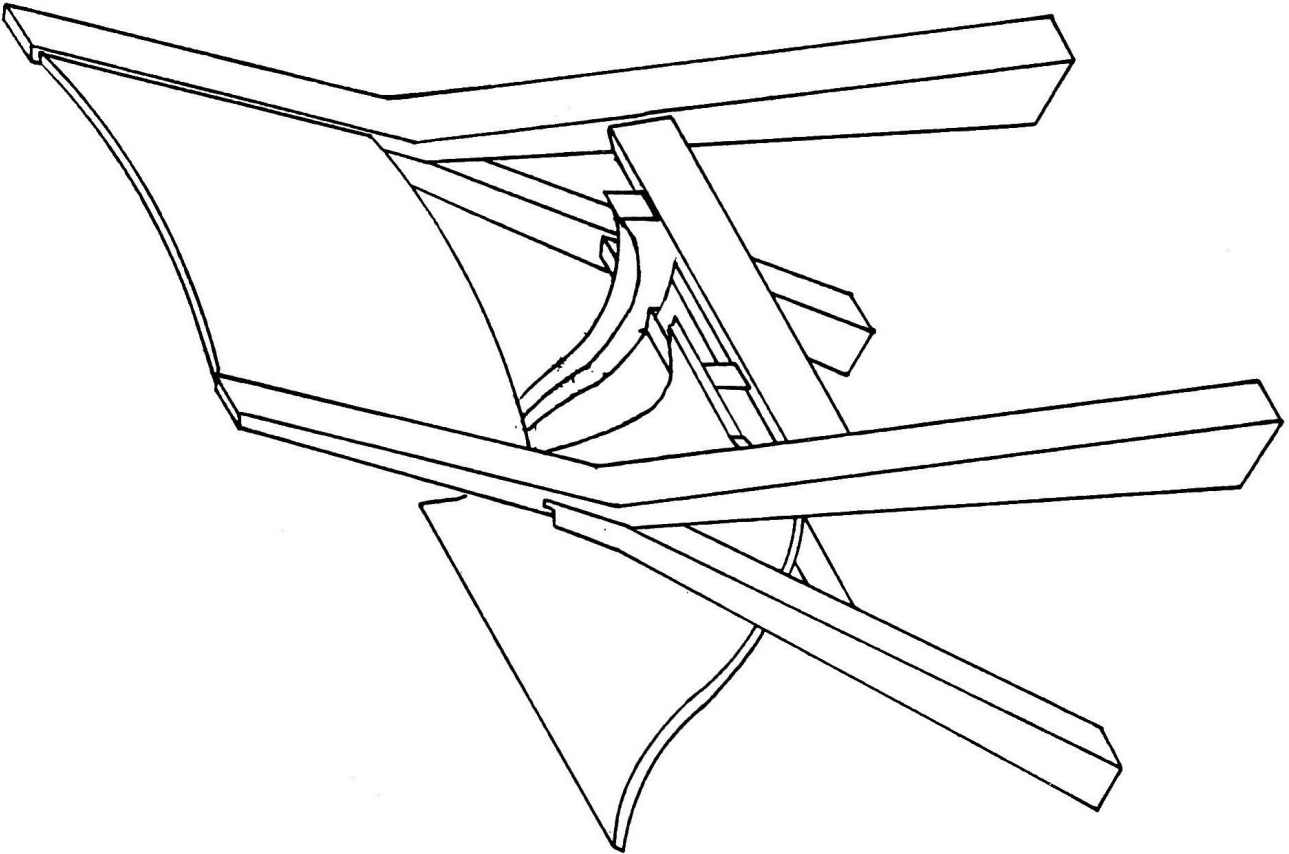


FIGURE X

III. CONCLUSION

The emphasis on exposed structure varies in each piece I have completed. The type of furniture and the construction technique determine, to a degree, the expressiveness of each structure. Structural forces are expressed more clearly in a linear work than in a planar one. In the chest of drawers the structure is planar and serves a twofold purpose: it encloses space as well as provides support for the carcass and drawer suspension system. The linear elements in the chair and the desk openly and clearly express their structural purpose.

I tried to develop a style of woodworking that expressed structural requirements as honestly, validly, and powerfully as the bridges of Robert Maillart or the building structures of Pier Nervi. The longer I worked on furniture designs and the more I studied the requirements of architectural design, the more I became aware of the strong differences in what I thought were similarities. The criteria for structural forms and the human considerations of work space and living space are different, and forms grow out of these differences.

In architecture, there are relationships between different areas of a building, transitions between these areas, and time elements involved in transition. One never sees all of a building in the same time frame; so a transition between building areas and the experience of those areas are primary considerations. These are not considerations in furniture design.

When studying past and present movements in furniture design, it appears that designs grow out of a relationship of form to material, with space becoming subordinate to mass. Space must always be considered, whether it's around an enclosed object or between parts. It appears that most furniture forms develop from ideas rooted in solid material, not ideas of how space should be defined by the material. The ornate carvings on Chippendale and Hepplewhite chairs appear not to relate functional (seating space) and nonfunctional space in many of their designs. As a result, these chairs are beautifully carved but uncomfortable to sit in.

Gerrit Rietveld, as a designer architect, contributed greatly to the De Stijl movement of the early 20th century in Europe. The use of line, planes, and color appear to be the bases for designs in Gerrit Rietveld's furniture, with space taking a somewhat subordinate position. The emphasis of solid forms over spatial form in design of furniture may have been indicative of the scale or function of furniture, and one's apparent ability to read or recognize solid forms as opposed to spatial ones.

Inherent in the scale of architecture is the ability to be more expressive in its structure. The transferral of enormous amounts of force through large structures became obvious when exposed. Through the development and execution of several pieces of furniture, and more extensive research in structural

elements of architecture, I realize that expressive structure could not be the major emphasis in my furniture unless I was willing to overbuild or overstate forces inherent in furniture.

Each piece of furniture presented here indicates a different style and construction technique. The dining table is a linear piece concentrating on curves and hand shaping. This linear element is contrasted with the chest of drawers which is sharply angular, utilizing a machine crispness. The coffee table is a departure from solid wood construction, emphasizing structural techniques more prevalent in door construction, commercial building materials, and airplane construction. The desk and chair use both hand and machine aesthetics, bringing together elements of the dining table and chest of drawers.

I chose not to create a series of works because it would have limited my exposure to experimental possibilities in wood-working while in a school setting. At this point, I have many skills yet to develop and refine, all with a strong emphasis given to the structure.

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