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Structure, wood, and the form of furniture

William Keyser

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STRUCTURE, WOOD, AND THE FORM OF FURNITURE

by

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Rochester, New York
Preface

The nature of the material presented in Part One is such that I will maintain objectivity by employing only third person pronouns. In Part Two and the Appendix, however, where I will attempt to review my projects and to present some insight into my philosophy and process of design, I will use the first person freely.

I wish to acknowledge the time, effort and help of all those who contributed in any way with the formulation of this thesis. Among those are:

Mr. Harold J. Brennan, Dean, College of Fine and Applied Arts.
Rochester Institute of Technology.

Mr. Tage Frid, Associate Professor, School for American Craftsmen,
Rochester Institute of Technology.

Mr. Michael Harmes, Instructor, School for American Craftsmen,
Rochester Institute of Technology.
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I want to approach furniture design from the viewpoint of structure. I feel that much modern furniture is still miniature post and lintel architecture; that has not kept pace with developments such as the arch, dome, cantilever, reinforced–prestressed and thin–shelled construction. I believe by concentrating on structure as well as function, I can attain freshness and vitality in my design.

I expect my training as an engineer to have a considerable influence on my work. If I felt it justifiable I could go as far as actually calculating the structural soundness of a design. I have also thought of utilizing the compression–tension testing apparatus available in the Mechanical Department for testing structure, joints, etc. These are possibilities if time permits and need justifies. I feel I must do a lot of research on structure, theory and philosophy of structures, and calculating and testing methods now being used. Architectural structures such as those by Maillart, Nervi, Torroja and Fuller can, I believe, serve as inspiration for furniture, and many of the theories and principles applied in our field.
At this time I intend to pursue two main courses of concentration: solid wood and molded plywood. For the first of these topics I will continue works such as the vanity, stool, easy chair and coffee table with which I have recently been concerned. For the molded plywood consideration I will attempt to build a vacuum veneer press to facilitate fabrication. I will then attempt to use molded plywood as a structural element with structural properties to exploit.

I do not intend to design a complete set or line of furniture as a final project. I feel I have already done this in my vanity, stool, easy chair group. I believe it will be much more profitable to proceed piece-by-piece, leaving myself open to strike off on tangents when deemed necessary or justifiable. My thesis itself will then consist of a review of my individual pieces, the thought process and reasoning involved, and suggestions on new ideas conceived as a result of said pieces.
Introduction

In an experimental work such as this it is imperative for one to begin by explaining what one is attempting to do, clarifying what is encompassed within those few words that must be prefixed to all thesis.

In the Prospectus certain necessary limitations were established. The major restriction which determined the general area of endeavor was termed Structure. This was an indefinite sort of concept which was discovered while designing the Vanity Table and Stool. A totally new outlook for the author, it provided a point of departure in his design. On succeeding projects he found himself always pre-occupied with a structural solution.

Structure was never a concept so definite or clear that formulation in black and white was possible. While the research and writing done on the paper have helped to crystalize the concept somewhat, it is feared that the principles will always remain somewhat behind the shrouds of nebulosity: a mental attitude toward design.

A further limitation was that of restricting the actual designing and constructing to wooden furniture. Certainly the most important reason for this is the authors' instructors. These two men know wood, have spent their lives with it. It is felt not only totally unjustifiable, but a serious mistake not to restrict the crux of the consideration to wood. There is much to be learnt about wood from these men, possibly much more than they (or the author) know about any other single material or medium.

The tools and equipment readily available at the school dictate that the investigation be limited to wood, if that consideration is to be very extensive or exhaustive. Time, likewise, necessitates specialization in one material since any thorough study in a particular medium is painstakingly long.
The thesis itself is divided into two basic parts. Part One consists of background material on the problem of structure, wood and furniture in general. Part Two is a review of the furniture actually designed and constructed by the author. An attempt is made to convey the whys and wherefores of the design, in conjunction with a visual description of the projects. Both the solid wood and the molded plywood considerations are covered.

Because of the nature of the material presented, Part One will seem very vague and perhaps incomplete. The author does not claim it to be a total conclusive explanation of his concept of structure. But together with Part Two, which is more concrete and comprehensible, he hopes that some feeling for this concept will be conveyed.
PART ONE

THE INTANGIBLES
The Structural Development of Modern Furniture.

In an attempt to gain historical insight into the problem of structure in modern furniture design, an investigation was conducted. It was realized at an early stage that the search would have to be limited to one piece or type of furniture, tracing its development. It was obvious that the most convenient type from the viewpoint of the volume of material available and probably the best when considering structure, would be the chair. Not only does the chair lend itself to a structural expression, but it has attracted the attention of many of the world's leading designers.

As a result of the search, a list was formulated which, in the opinion of the author, represents the highlights in the evolution of the modern chair as a structural expression. The ten chairs represented on this list are shown in fig. 1 through fig. 10. A brief examination of each of these chairs would be profitable.
Fig. 1
1876, "VIEIWA CHAIR", BENT WOOD
MICHAEL THONET

Fig. 2
1917, SOLID WOOD CHAIR
G. RIETVELD

Fig. 3
1925, TUBULAR STEEL CHAIR

Fig. 4
1927, CANTILEVERED CHAIR, TUBULAR STEEL
MIES VAN DER ROHE

Fig. 5
1929, BARCELONA CHAIR, STEEL
MIES VAN DER ROHE

Fig. 6
1932, LAMINATED WOOD CHAIR
**Fig. 7**
1938, Leather Sling Chair
Bonnet, Kurchan, Ferrari-Hardoy

**Fig. 9**
1949, Captain's Chair, Solid Wood
Hans J. Wegner

**Fig. 8**
1946, "Petal Chair", Molded Plywood
Charles Eames

**Fig. 10**
1957, Pedestal Chair, Spun Aluminum & Plastic
Eero Saarinen
1. 1876 "Vienna" Chair, Bentwood, M. Michael Thonet, (fig. 1.)

Michael Thonet invented bent wood in 1830 and thus opened up a new esthetic development through a new technical possibility. This chair, designed in 1876, is, in the author's opinion, the most outstanding structural solution of all Thonet's Chairs. Note the flowing line of the rear legs and back. The stretcher seems to grow out of the rear legs, giving a sturdy triangulation of rear leg and seat. Giedion, speaking of the esthetic impact of this chair, said:

When the architect around 1920 could no longer endure the *art décoratif* furniture, these simple beechwood chairs offered what they were seeking: form purified by serial production.

Almost as manifestos, Le Corbusier showed these standardized chairs in his *Pavillon de l'Esprit Nouveau* at the 1925 Exposition des Arts Décoratifs in Paris. Le Corbusier himself tells us the reason for his choice: "We have introduced the humble Thonet Chair of steamed wood, certainly the most common as well as the least costly of chairs. And we believe that his chair ... possesses nobility"... (1)

2. 1917 Solid Wood Chair, G. Rietveld, (fig. 2.)

This chair, developed by Rietveld during the De Stijl movement was chosen not because it is functionally or anatomically correct, but because it is an attempt to reduce the chair to its basic structural elements. Giedion summarizes the purpose of this chair, and the means utilized to realize that purpose:

As in painting and architecture, it was necessary temporarily to forget everything and begin afresh, as if no chair had ever before been built. There should be no dovetailing. The framework of the chair is composed of square members simply screwed together. They cross one another but do not penetrate, and their overlapping distinctions is emphasized. ... Seat and back ... consist of smooth, unbent plywood planes kept at a deliverate distance from one another.

It is easy to see what was going on: Furniture was being dissected into its elements, into a system of struts and planes. The effect should be as light, as transparent, as hovering as possible, almost like an iron skeleton. 2


3. 1925, Tubular Steel Chair, Marcel Breuer, (fig. 3.)

In this chair, Breuer not only applied seamless steel tube to furniture for the first time; he also carried further Rietveld's ideas of structure and function. Breuer, like Rietveld, separated the structural load carrying elements from the non-structural elements into which the human being came into immediate contact. However, instead of using rigid plywood for the seat and back, he applied stretched canvas. Instead of building the structure from wood struts, he molded the framework from this new, attractive and strong tubular material. Comments Giedion:

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Behind it was the urge to create a light and semi-hovering structure. These seamless steel tubes, also known as Manesmann tubes, had the advantage of compactness. The lines of the first steel-tube chair, as well as the suspension of its seat, herald tendencies that will soon be further developed: The seat, back and arm surfaces use the membrane like resilience of taut cloth. The tubing flows in an endless line, as in Irish interlacement work. And instead of the two-dimensional structure, we have a spatial one, stressing transparency, expressing the new spatial conception of our time.
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4. 1927, Cantilevered Chair, Tubular Steel, Mies van der Rohe, (fig. 4.)

In this chair Mies van der Rohe built on the groundwork which Breuer had laid down. However, his innovation took advantage of a property of the material which no one else had exploited: its resilience and flexibility when employed as a cantilever. His ability to take a structure and refine it to its barest essentials resulted in the beautiful simplicity exemplified in this chair.

5. 1929, "Barcelona" Chair, Flat Polished Steel, Mies van der Rohe, (fig. 5.)

This is the first and most famous chair to employ welded steel bar stock in a structural solution. The leather cushions are supported by leather straps attached to the structure. Its sheer simplicity and elegant lines make it one of the classic chairs of all time.

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1. Siegfried Giedion, Mechanization takes command, pp. 489, 90, 91
6. 1932, Laminated Wood Chair, Alvar Aalto, (fig. 6.)

Giedion has said of Aalto:

Like the sculptor Calder, but in the field of architecture and furniture, Aalto mastered the expression of our time and fused it with the things of his native surroundings. ..1

In this chair Aalto was the first to apply successfully laminated wood and molded plywood to the manufacture of furniture. The seat is shaped so as to take advantage of the springiness of the material.

In describing this chair, Noyes relates:

the single sheet of plywood, which daringly and dramatically forms the seat and back, varies in thickness according to the structural requirement. At the seat, where the weight of the body exerts more strain on the plywood span, additional interior plies are added, thickening the sheet at this point to give more strength. This results in a sensitive refinement of proportions such as may be observed in flamboyant Gothic vaulting or in the relations in thickness of the trunk, branches, and twigs of a tree. ..2

7. 1930, Leather Sling Chair, Steel Rod, Bonnet, Kurchan, Ferrari, Hardoy, (fig. 7.)

This was the first successfully mass produced chair to employ a leather sling seat and back hung on a solid metal rod structure. Nelson comments:

The so-called "Hardoy" chair is one of the most famous of modern designs, and it is unique in its combination of sculptural quality and comfort. The entire chair is nothing more than a continuous metal frame on which a kind of pouch of fabric or leather is slung. One of the most inexpensive chairs to fabricate, it is now being made by a number of companies. ...3

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1. Siegfried Giedion, Mechanization takes command, p.505.


3. George Nelson, Chairs, p. 140
8. 1946, "Petal Chair", Molded Plywood and Steel, Charles Eames, (fig. 8.)

This chair was elected not only because of the structural expression that it is, but also because of the technological spirit of our times that it reflects. Nelson, in speaking of this chair, praises it thusly:

From the day it was first shown, the Eames chair has been given international recognition as the outstanding design of the past two decades. There is good reason for its reputation, for no other chair has reached a comparable design level, whatever the basis for evaluation. Technically, the design is impeccable. Two pads of moulded plywood are fastened to wood or metal frames with rubber shock mounts as the connectors. The result is a seating device which is comfortable, resilient and close to indestructible. The design works in terms of mass production techniques. ..1

9. 1949, Captain's Chair, Solid Wood, Hans J. Wegner, (fig. 9.)

This chair was chosen because of its pure structural solution, utilizing the time tested natural material - wood. No attempt was made to confuse the problem by introducing other materials; the wood was used in a straightforward and organic way entirely natural to the material. Yet the concept of the chair is fresh and vital. Hiort speaks of Wegner:

Wegner's strong point is that he can simplify a structure or a form until it stands forth pure and precise, without in any way being unimaginative or uninteresting. 2

10. 1957, Pedestal Chair, Spun Aluminum and Plastic, Eero Saarinen, (fig. 10.)

This chair was chosen for its purification of structural form, employing new materials. Completely eliminating any complicated structural leg system and replacing it with a single elegant pedestal, he arrived at a new concept of modern furniture. The pedestal and stem are of spun aluminum, while the seat shell is fiber glass-reinforced plastic.

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1. George Nelson, Chairs, p. 52
2. Esbjorn Hiort, Modern Danish Furniture, p. 10
In examining these structural examples several things become evident. Most of the designers applied a new material or new process for an old material to furniture design (except Rietveld and Wegner). Also, most of the designers were architects, who, simultaneously with developing this furniture, were actively engaged in shaping the new architecture. Many of the materials used for furniture were also being used in this architecture. The important relationship of furniture to surroundings was worked out by the actual men who were creating the architecture and interiors of that time.
The Materials of Structure

In order to get some idea of what materials designers and manufacturers are stressing today, a short survey was conducted of furniture review books and magazines published between the years 1950 and 1960. This list follows:

1. Knoll associates, Knoll Index of Design, 1950
2. Gerd Hatje, New Furniture, 1952
3. George Nelson, Chairs, 1953
4. Roberto Aloï, Esempi, 1953
5. Gerd Hatje, New Furniture, 1953
7. Ernest Kettiger and Franz Vetter, Furniture and Interior, 1957

All these sources were international in coverage. Some of them showed only furniture in production, while others showed experimental work, etc. The consideration was again limited to chairs, paging through the sources and counting those employing supporting structures of solid wood, bent and laminated wood, and metal. Of the total number observed the following are the percentages of chairs employing each structural medium.

1. Solid Wood 50.2 percent
2. Bent and Laminated wood 11.4 percent
3. Metal 38.4 percent

In examining these figures, some things must be kept in mind. The small number of sources available for examination immediately reduces the validity of the results. While many of the examples were pieces in full production, many of them were probably one of a kind pieces, experimental models, or limited production items. But no compensation could be made in the results to take this into consideration, so each example shown carried equal weight.
The pictures of chairs shown in these books were chosen and selected by the editors and publishers, so they do not represent all that was being done in furniture, only that which was selected because of popularity, interest, novelty, etc. Many of the chairs counted were not particularly interesting structurally; but if they were supported in any way by metal, they were counted as metal structures, if by wood, they were recorded as wood structures. No account was made of the material used in the seats or backs, such as molded plywood, upholstery, leather, etc.

However, due to the lack of better sources of information one can accept these statistics and draw conclusions from them, realizing that these conclusions are no better than the sources. Thus one might go out on the limb and say that approximately 60 percent of modern chair designers turn out chairs with wood structures. (solid wood, bent and laminated wood), while the remaining 40 percent produce metal applications. The author personally is inclined to agree with these statistics, and feels that the emphasis is continually shifting more and more in favor of metal structures. Nelson, in speaking of the modern designers concentration on metal, rather than wood structure said:

In one important area of modern furniture design the unanimity with which designers have been replacing wood supports with metal is rather remarkable. Whether this tendency is "good" or "bad" I have no idea, and I suspect that it is neither. The development itself is a fact; it certainly exposes the prejudices and preferences of a whole group of designers; it may indicate some social and cultural trends that will doubtless be clearer to posterity than they are to us. 1

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What are the reasons behind this shift?

One could first examine the manufacturing process. Basically wood is less suited for mass production than metal. Temperature and moisture changes affect the dimensions of wood radically. Jigs and fixtures that fit one day may not fit another day. Wood, being of a non-homogeneous nature, must be hand picked and selected in order for the appearance and quality of the finished piece to be satisfactory. Joining and finishing wood require skilled or semi-skilled workers, whereas many of the operations on metal can be done by unskilled labor, using automatic machines.

Raw material suppliers who handle quality lumber shaped, finished and ready to assemble into furniture are few. Wood furniture by nature, or by tastes which we have developed, require the wood members to be tapered, shaped, etc. which necessitates that the furniture manufacturer buy raw lumber, resaw, dry, process and shape it before the furniture can be assembled. This requires much costly machinery, space and time. Metal, on the other hand, can often be bought in long lengths which need simply be cut to length and welded-together. The design concept is entirely different for metal furniture than for wood furniture.

Since ours is a mass production society, and since wood does not meet the demands of mass production as perfectly as does metal, metal seems to reflect the spirit of our times better than wood. The author feels that metal furniture has kept pace with modern architecture. The new materials used in architecture have permitted new shapes to emerge. The shift to new materials, many of them being the same one's serving modern architecture, have permitted the shapes of furniture to parallel those of architecture.

But what of the case of wood? Or is there a case? Wood, the author feels, has been neglected by the modern designers in lieu of all the other new, more romantic materials. Why try to invent new forms for an old material when a
new material in itself dictates a whole new vocabulary of design, especially when many of these materials "speak the language" of modern architecture and science. On this topic Torroja speaks:

It is also true that up to now structures as suspension bridges....had not been feasible. So designers have thrown themselves with abandon into the exploitation of the pristine charm of these new forms, distaining other well-worn elements, even if the potentialities have not been ex-hausted. 1

It is felt that new forms are possible in wood, just as new forms have been adapted to stone, concrete and steel. Wood was originally used in a post and lintel way because that was what architecture was doing at that time. Actually this is quite an unnatural form for wood; a material which naturally grows quite plastically, with trunks flowing into limbs, each a part of the other, producing beautifully cantilevered structures. This is not saying that furniture should derive its form from the natural state of wood, but certainly the natural state of a material does indicate one way in which it could be used.

But then, even if "modern" forms, or say compatable forms, are possible in wood, why bother when there are so many other exciting materials, which do the job equally well? Perhaps it should be accepted that wooden furniture will soon become extinct.

One thing which must be considered here is the relationship of the individual to furniture, and of both to architecture. Furniture and the individual are very intimate, if for no other reason than because of the proximity of one to the other. People sit in chairs, eat from tables, lie in beds, store their personal clothing in drawers. The proximity of the individual to architecture is one degree more remote.

1. Eduardo Torroja, Philosophy of Structures, p. 279
Aside from one's physical contact with the floor, one seldom becomes intimate with the actual materials of architecture. Thus the materials of furniture must be a little more personal and warm, the relationship more intimate and desirable, than the materials of architecture. Wood was originally chosen to replace stone in furniture, probably because of this very reason. People wanted a warm, personal, more intimate material than stone to be in such close contact with their person. Why then go back to cold in-organic materials like steel, aluminum and plastic?

The author feels that wood, better than any other material, provides the above desirable qualities for use in furniture. The warmth, texture, grain interest and "life" which wood provides can be found in no other material. There is much to be said of the relationship of the living human body to the dead, but still organic material wood, and these two to the inorganic materials generally used in architecture. Wood provides a logical step between the organic man and the inorganic steel or concrete. It justifies its use in the interior furnishings of modern architecture.
Philosophy of Structure

Webster 1 defines structure as:

A. manner of building; form; construction.
B. something constructed or build; as a building, a dam, a bridge.
C. arrangement of parts of organs or of constituent tissues or particles in a substance or body.
D. figuratively: the interelation of parts as dominated by the general appearance of the whole; as, the structure of society.

The third and fourth definitions are obviously not of interest immediately in this consideration. The second definition refers to the noun denoting the result of building or constructing, i.e. a structure. The first definition then, comes closer to the area which the author is concerned with in this paper.

Obviously the first consideration in designing any piece of furniture must be function. Furniture must be designed to fulfill a specific purpose in the best possible way. A chair must hold and comfort, a cabinet must contain and store, a table must display. But once this function is fulfilled, or concurrently with fulfilling it, the next important consideration is the form of the particular piece. Frankl, speaking of the role of the designer said:

A chair consists of a seat, a back and four legs. It may have arms, wings; and chairs there are without any legs at all. While there can be no doubt that the perfection of a chair design is organically related to its comfort, the creative designer has a more complex problem than that of fitting the chair to our body. As futile would it be to adopt the slogan, "form and anatomy", and to measure the merit of paintings merely by the correctness of the anatomy of the figures in them. There were times when art took it upon itself to cover up and decorate structural parts and by doing so tried to conceal them. Today we are more frank regarding structure, and less inclined to conceal anatomy. 2

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2. Paul T. Frankl, Form and Reform, p. 43.
The form, or how a piece looks, is basically determined by the structure. The relationship between form and structure is the same as the relationship between the outward appearance of the human body and the skeleton. The author believes that rather than attacking the form first and deciding on how the piece will look, it is better to attack the structure first and let it determine the form. For example, in designing a table, one must let the function determine the basic size and shape of the top. But then one must determine how the top will be supported structurally, which will in turn determine the form of the table. In other words, it is believed that in furniture form follows structure follows function. Distinction is made between form and structure. Thus within a given structural system, several form solutions may be possible. In the writer's vanity stool, for instance, within the system of the leg structure, two form possibilities were exploited. There are undoubtedly many more.

While in furniture, structure and form can be separate entities, this is not as feasible in architecture because:

A. Due to the personal nature of furniture, it must be modeled and molded to conform to the human. The personal contact element, not present in architecture, demands that furniture be compatible with the human body. Therefore given a structural scheme, form is given to it, not disguising the basic structure, but making it more personal, more compatible.

B. In architecture the scale of the project is too large to "mold" or model the structure. Here the approach demands a strict honesty to the structure, letting it determine the form.

This suggests that structure is more of a concept, of a scheme, while form is an actuality, a realization, an appearance. What then are some of the principles of this concept, of this philosophy of structure.

First of all, structure is a physical concept as well as an aesthetic concept. Considering furniture with respect to structure put the designer into the role of architect or engineer. Furniture now becomes miniature architecture, a minute engineering project.
Torroja, in referring to the structural concept of design, has said:

It can be truly said that now, for the first time in the history of art, the structure has acquired an independent personality, so that its own intimate aesthetic quality can be appreciated. Thus we may refer to a Structural Art. It is not a question of discussing whether this is right or not. It is a fact. We can almost justify it in terms of the technical genius that informs our present social environment. 1

The structure of a piece of furniture should intuitively follow from the forces acting on that piece of furniture. It should not be structure for structure's sake, or to make the piece look different, it should be structure to function. Martin speaks of the sculptor Gabo's preoccupation with structures:

This intuitive appreciation of the relationship between force and form seems to me one of Gabo's outstanding contributions and certainly the one which makes his work of special interest to architects. The development of mathematical theory is indeed important to the architect, but the necessary complement to this is the development of an intuitive judgement which enables a formal development to be fused with a structural possibility. 2

Perhaps one could also quote Nervi who wrote concerning "form-resistant" structures:

It is difficult to define these particular structural systems, which I would suggest calling "form - resistant", although nature and manufactured goods of common use daily show us their application. Flowers and leaves; canes; egg, insect, and sea shells; lampshades; automobile bodies; glass containers; and even ladies' hats are all examples of form - resistant structures. 3

Thus resistance due to form, although the most efficient and the most common type of resistance to be found in nature has not yet built in our minds those subconscious structural intuitions which are the basis of our structural schemes and realizations. In other words, we are not yet used to thinking structurally in terms of form. 4

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1. Eduardo Torroja, Philosophy of Structures, p. 279
2. Leslie Martin, introductory essay, Construction and Intuition, from book Gabo p. 10
3. Pier Luigi Nervi, Structures, p. 96
4. Pier Luigi Nervi, Structures, p. 97
One of the most important attributes of functional structure is simplicity. Torroja has said, "It is essential that functionally, the transmission of forces, which from the points of application of loads to the points of reaction makes equilibrium possible, be simple, clear, without twists, we might say, without discomforts." A clean and simple structure with the smallest possible number of elements shows clearly the stress phenomena of the whole structure and of each of its individual elements.

Lightness, likewise, is another desirable quality in a structural approach to design. The problem of replacing a solid mass support with a load bearing structure suggests a solution conveying the impression of lightness. We have gone from sitting on solid rocks to relaxing in molded plastic slings suspended on thin spindlely steel rods. Lightness is important in a structure, not only from the viewpoint of economy of materials and means, but because somehow, lightness seems intuitively "right" for structure.

Any consideration of structure obviously involves a consideration of space. The Constructivists, led by Gabo and Presner, realized that the main care of constructed objects was their structure, and that this structure demanded a greater participation of space than would a monolithic volume. Exemplifying this principle in Gabo's case, Martin writes:

His conception of a cube, for instance is not simply a box with a top, bottom, and four sides. In Gabo's cube four sides are omitted and he replaces these by two vertical intersecting planes running across the diagonals of the cube. Gabo has explained that this, when constructed in transparent materials, expresses the volume of the cube without any suggestion of mass: but, in addition, he has constructed a far more rigid figure.

1. Eduardo Torroja, Philosophy of Structures, pp. 239 - 240
2. Leslie Martin, introductory essay, Construction and Intuition, from book Gabo, p.9
In an object like a chair, one of the most important considerations in the entire composition is the space or negative volume around the legs, back, etc. It is this space which gives the article its shape and form as much as the solid elements themselves.

Furniture, like architecture, must relate to its surroundings, in this case the interiors. But what is happening to interiors? Living areas are undergoing vast changes. Nelson predicts that after the "modern house" will come a prefabricated living shell, much like a factory building, free from internal supports and partitions, with built-in conditioning (air, heat, plumbing, electricity, etc.) He offers Fuller's dome as a logical solution. 1

Geodesic domes, hyperbolic paraboloids, and reinforced concrete shells are replacing cubical building cells. New materials are opening the inside to the outside. Furniture must no longer relate to slab walls, angular floor plans, prismatic living volumes. Furniture can now be designed plastically, pushed into the realm of fantasy. Nelson writes of the new "subscape" (the look of the supporting structures of modern furniture):

The new subscape also has a great many relatives in the modern world, some of them quite imposing. These include the new skyscrapers...Calder's mobiles...the doodles of Joan Miro...the newest elevated highways...the Horton spheroid found in the vicinity of refineries...diagrams of molecular structures - the list is a long one and remarkably varied to boot. 2

All of the above mentioned principles concerning structure evoke psychological and emotional responses in the people coming in contact with them. In the case of furniture it would be the people actually using, observing or living with the pieces. Gabo has said, in speaking of the reaction of people to constructed objects:

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We realized that every engineering object is, apart from its functional character, acting on us as an image. I emphasized this fact in the manifesto (Constructivist's Manifesto, 1920) and before, by saying that every object we see, be it an object of nature or created by man, a telephone a table, a chair, a house, or a tree, has an image of its own and what I meant was that it acts on us in the same way as a sculpture although it is not made for that purpose. 1

Torroja adds:

The aim of our great construction feats of today is to emphasize the triumph and power of modern techniques in the use of the materials at its disposal. An impression of power, or strength, with a simultaneous impression of lightness, gracefulness, and simplicity is often desired. We try to convey the feeling that the bridge will link a great span with the same impression of flowing strength suggested by the agile athlete who jumps easily without any suggestion of difficult effort or labored technique, suggesting indeed that the limit of his capacity lies much further off. Furthermore, it fascinates because of the danger it suggests to us; it combines a childlike simplicity with a vibrant dynamic energy. 2

Simplicity in a structure carries the connotation of cleanliness, of rightness. A structure with few and strong elements gives the impression of ease and security, of work well done. However, constructions in which elements accumulate, giving the feeling that it was necessary to keep adding them, convey the impression of suspicion and uneasiness.

Marcel Breuer has said:

Everybody is interested in seeing what makes a thing work, in seeing the inner logic of things. It is a pleasure to see a body moving—a race horse or a man. It is interesting to see the movement of bones and muscles under the skin. A tree without leaves looks, in a way, more interesting than a tree covered with foliage and hidden by it. 3

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2. Eduardo Torroja, Philosophy of Structure, p. 283
3. Marcel Breuer, Marcel Breuer: Sun and Shadow, p. 70
PART TWO

SOLIDIFICATION
A. SOLID WOOD
1. **Vanity Table and Stool**

I first attacked this problem at the most important element, the table. I wanted a covered work surface so that much of the mess and fuss of the cosmetics, etc., would be out of sight when not in use. I also wanted an adjustable mirror which could be pulled forward to put on make-up or pushed back for an over-all view.

This problem was the first that I began thinking of in terms of structure. Before this I had always thought of a table as having four legs. I now wanted to support the vanity in such a way as to permit easy movement to and from it. I felt to have legs out front would obstruct the user, especially since the vanity itself was not very wide (thirty-six inches). This line of reasoning led to the pedestal structure shown in the preliminary sketch, (fig. 11).

The reason for the structural configuration of the pedestal was this. Two vertical members were used because I thought they would give a more stable appearance than a single upright, yet remain light and graceful. These two members were made different widths to avoid monotony. Whereas in the preliminary sketch the heavier of these members is in front, after further consideration it seemed more logical to have the heavier member at the rear, where more stock was necessary for the joinery involved in the "foot" of the table. The negative area enclosed by the two uprights added interest to the result.

The inverted "V" shape of the foot was an attempt to make the vanity appear to float off the floor. I did not feel the same effect could be gained utilizing one horizontal piece of wood to form the entire foot of the table. I felt that two pieces were needed, giving a higher inverted "V" foot and adding considerable interest to the composition. An attempt to tie the two vertical members into the two horizontal members resulted in the
rather pleasing solution shown in the preliminary sketch. The joinery necessary to accomplish this had to be kept in mind throughout the preliminary design phase.

With the lower structure pretty well solidified, I began to design the upper work surface. The two drawers were an obvious solution to hold bottles, cosmetics, jewelry, etc. Without realizing it, these drawers, when open, defeated the actual purpose the supporting structure sought to serve, that is, to permit easy movement to and from the table. From the two drawers positioned atop the pedestal structure it was a short step to place a tambour covered work area between.

As mentioned previously, I wanted a moveable mirror. The solution I came up with was a mirror hub on two circular discs of plywood, these mounted to the table on a system of rollers, permitting the mirror to be swung forward. On the preliminary sketch it seemed like a simple enough solution.

The vanity stool (fig. 13) evolved from the table design, incorporating the pedestal structure. A seat frame with an integral back was designed. The back was included, not primarily for support of the back, but for the psychological well being that comes from sitting in something which exerts that slight pressure on the upper buttock. This same feeling is so important in a bucket seat or a tractor seat. I felt it would be a good feature to incorporate, while still not limiting the mobility of the occupant, which a full height back would do.

The seat frame was rather sculptural in character, as opposed to the square-ish character of the supporting structure. However, there is something to be said for this, since the seat frame, in proximity, is very intimate with the person using the vanity. Therefore I felt the seat could afford to be sculptural and organic in feeling.
On both the original vanity and stool the pedestal structure was jointed to the work surface and seat frame respectively by means of an exposed lap joint. Visually it helped to relate the supporting structure to the supported elements.

In reverse of the preliminary design procedure, I constructed the vanity stool first. When it was finished I immediately knew that the character of the pedestal structure was not right for the seat. I could therefore change either the seat frame or the supporting structure. Because of the previously mentioned feeling concerning the appropriateness of the sculptured seat frame, I elected to change the structure. Another reason was that I felt that perhaps a sculptured base would be somewhat more feminine. The lap joint between the structure and the seat frame was eliminated and a mortice and tenon used instead. Integration between the two elements was now accomplished by sculpturing one into the other. The slight step or "jog" in the lower pedestal between the "toe" and the "heel" of the "foot" was eliminated on this model, thinking that perhaps a more graceful feeling would result. This second model, (fig.14) seemed to be a much better solution than the first. The design was much more unified.

On the basis of the conclusions reached on the vanity stool, the table itself had to be completely re-designed, with a sculptural concept through out. After re-evaluating the original table design, I conceded the covered work surface and the pull-out mirror. In order to integrate the top section with the legs, I eliminated the drawers and replaced them with the tambour-covered bottle trough at the rear of the formica work surface. So the two side frames with integral pedestal structures, suspended between them the bottle-trough and the work surface.

The result (fig.12) was much more feminine and delicate than the earlier model. Likewise, the table and the stool worked together very well.
Missing Page
2. **Easy Chair**

The easy chair (fig. 15) was first considered as a living room chair, to be in no way connected with the vanity set. I wanted a seat frame containing the upholstery and supported by a wooden structure. My early preliminary sketching progressed to the point where I had unconsciously separated the seat frame and supporting structure, first attacking the seat frame. The design progressed gradually to the point where I found myself thinking in terms of a sculptural solution.

In order to brace the exposed seat and back frame, I found it necessary to introduce a diagonal brace between the two. It was then that I discovered that this brace coincided with the position of one's arms when sitting in a semi-reclined chair. And so I was able to shape these structural members to support the occupants arms; to act as arm rests.

I tried unsuccessfully to come up with a solution for a separate supporting structure for the seat frame. From time to time in my sketching I had tried to fit the pedestal structure from the vanity group to the easy chair. It never quite seemed to work, and I always tried other approaches. Eventually I came back to the vanity structure, and through scale elevation drawings, found a solution to the problem, by integrating the vanity stool structure and the seat frame I had already designed.

Modifications on the structure were necessary, however. Due to the lowness of the chair I had to lower the inverted "V" shaped foot, which in turn made it feasible to make this foot from one continuous horizontal piece of wood. An interesting effect resulted from the negative area under the foot, the area between the two vertical supports, and the negative area formed by the diagonal brace.

On this project a full scale mockup of one side of the chair was constructed (fig.15). This enabled me to realize the necessary visual weight of all the members, and also the line and contour necessary to successfully
relate these members.

I decided to lacquer the chair at the suggestion of Tage Frid. Since lacquering it, I'm not sure about the honesty of doing this to wood. On one hand, the chair could not economically be plastic or metal when considering the size of the members. It could only be wood. On the other hand though, should furniture be cold and plastic, like this type of finish gives? At the present time I have not formed any definite opinion on the matter. I want an opportunity to live with the chair, to have it in my home, and to examine my relationship to it from time to time. This is, I believe, an important part of designing furniture, that is, actually living with the results.
3. **Coffee Table**

The coffee table was an experiment to think of this piece of furniture in terms of a top area supported by some type of structure. I wanted to break away from the conventional leg system. I also wanted to make this structure as thin and light as possible. I had noticed a tendency in much of my past work for the pieces to be rather heavy and robust; every piece gave the impression of being very "safe". For once I wanted to do something at the other extreme; to make it so light that it almost looked "unsafe", or at any rate "daring".

I immediately concentrated on the structure, giving secondary consideration to the shape and material of the top; thus designing around the structure. What I was actually doing was somewhat neglecting the function of the piece, trying to come up with a novel structural solution. Neglecting function is a very easy trap to fall into when designing a piece of furniture for the sake of the piece itself, without the restriction of a definite environment or function to fulfill.

Preliminary sketches produced nothing but solutions utilizing four legs and a stretcher system of one kind or another. Finally I hit on the solution which was eventually executed. Instead of supporting the top on four legs, I supported it on two pyramid-shaped volumes set on edge. I felt that the structure would be extremely strong for a coffee table, the weakest point being in the center where the two defined volumes are connected. The statics of the structure are such, however, that the vertical end members take most of the vertical compressive load, while this center point need only resist bending in the structure, when load is applied.

Once the structure (fig.16) was designed, it was decided to use a rectilinear plate glass top, so as to emphasize the structure and to make it completely visible from all angles.
Various ideas for fastening this glass to the structure were considered and it was finally decided to "float" the top on small rubber pads set into the wood frame crossmembers. The friction between the rubber and the glass would prevent movement of the glass with respect to the base.

The joinery necessary to carry out the design was somewhat tricky, and gave me a feeling that it was a rather complicated solution to the problem. The individual members of the structure were sculptured slightly to give the otherwise strictly geometric austerity some character.

To realize the success or failure of the coffee table both structurally and aesthetically, one would have to see it with the glass top in place. Personally, I am rather disappointed with the finished product as a coffee table. Perhaps because of its feeling of geometrical precision, or because it is almost too light, the design seems somewhat foreign to wood. The cumbersome joinery involved, as I said before, conveys the feeling of busyness and complexity. Since I designed the piece, I have seen a very similar solution made of round steel rods welded together. Perhaps this is why the structure does not read well as wood for me.

However, as an experiment in structural expression and an attempt to realize lightness and fragility while retaining strength, it must be considered successful exercise.
4. **Occasional Chair**

Two objectives were intended in attacking the design of an occasional chair: one being to develop the already conceived idea for the wood batten and sewn fabric "corduroy" upholstery; the other being to develop a structure, light in nature, with a feeling other than four legs, a seat and a back.

Numerous preliminary sketches were made but I found it very hard to visualize the structure of the chair in a perspective sketch. I therefore turned early in my investigation to a scale model, (1\(\frac{1}{2}\)"=1'0") of balsa wood and paper. In this way I could concentrate on structure and realize the relationship of the elements in three dimensions.

The first model was an attempt to integrate a seat frame and a supporting structure using the principle of triangulation, not concerning myself with the joinery involved. From this model (fig.17) I decided that the back was too high for an occasional chair, and that the structure was overly complicated. But I liked the concept as a whole.

From this I constructed a second model (fig.18) which attempted to simplify the joinery while maintaining the over-all concept or feeling of the first model. Upon examination of this second model, I discovered that I could further simplify the whole chair by separating the seat frame from the supporting structure, relying on a healthy finger joint to connect the seat and back, and using triangulation to stabilize the understructure.

This then, resulted in the third model (fig.19) which I immediately became enthused with. On the basis of this third model, I built a full-size version of the chair (fig.22). I soon found that the principle of the understructure was faulty. The front leg, back leg, and seat stretcher had not been truly triangulated. Furthermore, the diagonal front leg was not possible in wood, at least not without considerably increasing its cross-sectional dimensions.
The corduroy upholstery idea proved very successful, however. With the frame contoured to match the spine curvature, and with the slight give in wood battens, the seat proved comfortable. I decided that on future models however, I would try a slight modification in the seat contour, putting a slight bump in the back to support the small of the occupants back. I also felt I could make the individual battens thinner. I had the battens 3/8" thick originally and decided on later models to reduce the dimension to 1/4"

So I built two more models (fig. 20 and 21.) disconnecting the front legs from the back legs and decreasing the angle that these front legs made with the vertical. I still attempted to spring the legs from underneath the seat frame however, a feeling that I liked very much on the first full-sized version.

After examining these two models, I decided to execute them both in full-size versions (fig. 23 and 24.) Both os these were structurally successful, however I personally prefer the "X" frame version (fig. 24). It seems to spring the legs from beneath the seat frame more successfully.
B MOLDED PLYWOOD
1. **Molded Plywood Fabrication Techniques**

   There are several techniques of fabricating molded plywood, three of which I would like to cover here. The first of these utilizes both a shaped male and a female mold or caul, as veneering molds are named. These must be accurately constructed with allowance made for the thickness of the plywood between the two caulfs. Used in conjunction with ordinary wood clamps or a screw type veneer press, this method has the limitation of unequal pressure distribution. When a deep curve is molded, the bottom curve received full vertical pressure, while the sides of the curve receive only a component of the total vertical pressure.

   The second type of fabrication technique utilizes only one caul, either male or female and a flexible rubber bag which when inflated presses the veneer against the single caul. This utilization of fluid pressure produces uniform pressure over the entire surface of the caul, permitting a wider range of curves and shapes.

   The third type of fabrication technique also requires only one caul, either male orfemale. After veneer is coated with glue and laid over the caul, both are placed inside a rubber bag. The bag is then evacuated, the atmospheric pressure serving to press the veneer to the single caul. This method likewise permits a wide range of shapes, but its limitation is the maximum pressure available, being only atmospheric pressure.

   There are many variations of these three basic types of molded plywood fabrication, many adaptations for special uses. Any of these basic types can also be used in conjunction with heat, pressure or high frequency glue curing techniques, or combinations thereof.
2. Vacuum Forming Apparatus

I chose to utilize an adaptation of the rubber bag-vacuum method of fabrication. I felt this would not only eliminate costly and complicated pressure equipment, but would also be more versatile. It was felt that atmospheric pressure would be sufficient for most forming jobs done at the school.

The actual vacuum press (fig.25) consisted primarily of a large, flat Plywood plenum chamber, a \(\frac{1}{8}\)" natural gum rubber blanket, and a Bell and Gossett SYC 20-1 High Volume Dry Vacuum Pump. The plenum chamber \((3-3/4'' \times 39'' \times 87'')\) is made of \(3/4\) inch plywood, with a honeycone core construction to permit it from collapsing. The top surface was perforated with \(1/8\) inch diameter holes every six inches on the square. Around the perimeter was mounted a rubber gasket, \(1/2\) inch by \(1/2\) inch in cross section. The bottom of the plenum chamber contained an outlet through which the chamber could be evacuated, and an outlet for a vacuum gauge. The rubber blanket, \(1/8\) inch thick by four feet wide by eight feet long is laid over the top of the plenum chamber, overlapping the gasket around the perimeter, and is sealed by means of a wood frame clamped down over the gasket and rubber blanket. The clamping is accomplished by means of DE-STA-CO Model 317 - U Quick Action Toggle Clamps mounted at six spots around the perimeter of the plenum chamber.

The vacuum pump, capable of displacing 6;57 cubic feet of air per minute, is connected to the outlet of the plenum chamber by means of a shut-off valve and copper tubing.
3. **Assembly Procedure for Molded Plywood**

Various types of cauls are possible with this vacuum forming method. Generally speaking, male cauls are preferrable because then the veneer is compressed from the center of the sheet towards the ends and down over the caul, with little danger of these ends being trapped.

The cauls themselves can be constructed in a number of ways, one being limited only by his imagination. The most important factor is strength, since these must sustain a considerable amount of pressure. I utilized 3/4 inch plywood ribs, spaced a maximum of two inches apart, covering them with two layers of one-eighth inch poplar veneer.

I used a fast setting Assembly Glue manufactured by the Franklin Glue Company for fabricating my molded plywood. It was thinned down to a workable consistency with water and spread with a paint roller. It is extremely important to get an even coat of glue on all surfaces, because glue pockets will be squeezed out by the evenly distributed pressure of the rubber blanket.

After the veneer was glued it was placed in position on the caul with wax paper on both sides and secured with two brads. Then this whole assembly was placed under the rubber blanket, sealed and the pump started. I found that by using this technique and this glue, I could remove the molded piece from the press in one hour.
4. Molded Plywood Stool

This stool was designed as an exploration into the structural possibilities of molded plywood. I had to know what radii I could bend, the correct method of building the cauls, the fabrication procedure, the structural strength of the material, and the general "feel" for molded plywood that only comes from working with the material.

The design of this stool itself (fig.26) was a take-off on the vanity stool, adopting the pedestal vase to a bent slab application. Four caulls were necessary, requiring four separate molding operations. The four pieces were then assembled, any slight springback in the individual pieces tending to be canceled out by the adjacent pieces.

The first model was constructed using five pieces of 1/28" mahogany veneer. The result was an extremely simple and clean looking stool. However, structurally, there was entirely too much bending in the vertical member of the pedestal. Another stool was then fabricated, using nine plies, and proved very satisfactory. A slight bending or rocking motion still existed but it was not excessive nor objectional.

One further idea is currently being explored. I am trying to mold the four elements in five ply mahogany, but instead of gluing them directly together, separate them slightly by the use of cross-wise solid wood spacers at strategic points. This would produce an "I" beam like fabricated structure (fig.27.) It would be a type of stressed skin construction, the skin of plywood taking all the compression and tension stress, the spacers serving merely to hold the skin elements a constant distance apart. At this writing no definite results had been obtained.
5. The Possibilities for Molded Plywood

Time did not permit me to explore as deeply as I would have liked the structural possibilities of molded plywood. I feel that the real potentialities lie in utilizing bends and folds in the plywood to obtain strength, not depending on the actual strength of the flat material itself. Much like paper construction, many interesting results could evolve. I feel that compound molding has, generally speaking, reached its peak. The shapes are too complicated to realize economically, and could just as easily be made in plastic. But I think a great future of new possibilities lie open to simple curvative structural applications, shapes made up of straight line elements.
SUMMARY

Some statements summarizing Part Two and relating it to Part One are included to tie the whole together. While little concrete or definite could be said in Part One about how to actually approach furniture design from the viewpoint of structure, it is hoped that Part Two will give some insight into the concept. I know of no better way than by example to convey this concept.

I do not feel that my philosophy of structure or my method of designing structurally is by any means complete or even partly matured. The development is a long, gradual process of formulation. However this theses has, I believe, given me a greater insight into the consideration; I believe the principles learned will influence my creative work for a long time to come. It is my hope that the material can also be of some use to others.

As a result of writing this paper and of conferences with my instructors, I am gradually becoming aware of a slight line of distinction between furniture designed for commercial application and furniture designed for residential use. A related distinction is also beginning to become evident to me between the furniture produced by industry and that by the craftsman, not only as to the material used, but also how it is used.

The first distinction mentioned seems to indicate that metals and plastics are now more prevalent in commercial furniture, where chairs, for instance, can actually be considered machines instead of the very personal things that they are in one's home. The second distinction is that the materials industry uses for furniture are unlimited. They can use metal, plastic, solid wood or molded plywood.
But the craftsmen's materials are pretty well limited to solid wood. Even molded plywood requires much specialized equipment that the average craftsman could not afford. This is the first in this theses that I have distinguished between the individual craftsman and the factory, and perhaps this is a good place to do it.

From the above it would appear that the craftsman's market was in solid wood applications for domestic use. What then of the structural approach to this solid wood (and I am excluding the use of commercial plywood as well) domestic furniture? Now why should the craftsman produce furniture that could just as well be produced by industry? Shouldn't custom designed furniture look specially designed, not like just another factory piece. By considering structure I believe I can produce furniture that industry, catering to mass tastes, could not produce for this mass market. And so then I believe I can explore new structural form possibilities, giving individuality to my work, catering to the custom market. Thus I believe the cause is great for a structural approach to wooden furniture design.

Some things must be clarified. While stressing new forms and shapes, new structures, one must be careful not to stress difference for difference's sake. This is a narrow line to draw, however, because every artist tries to impart his individuality to his work. Freshness is something to be sought after. But it must be coupled with a desire to produce a better product, not just a different one. Conversely, rejecting difference because it is for difference's sake often provides a ready-made excuse for lack of originality.

It must be realized also, that, while I approach furniture from the point of view of structure in order to gain freshness in my design, it is unlikely that I will come up with, for example, a totally new or different chair.
My occasional chairs are not basically different from many other chairs, yet they somehow have a fresh feeling to them. One cannot hope to discover a new concept for functional objects as old and as evolutionary as most pieces of furniture.

I said in Part One that I felt that metal, as opposed to wood, is being used in furniture more and more. Tage Frid has said he feels the opposite is happening; that wooden furniture is becoming more popular. Without definite figures, who is to say? We both agree, however, that wood has a definite application, and this application is becoming wider, in the interiors of modern architecture. The organic qualities of the material cannot be denied.
APPENDIX

THE PHILOSOPHY AND PROCESS OF DESIGN
What is a philosophy of design? I believe it is a system or collection of general beliefs or views concerning design and designing. I feel every honest designer or craftsman must have such a philosophy. It is fed and nurtured by your creative work, by your reading, and by your association with the world. It is a total expression of your beliefs. One's work reflects what one is, what one feels. His work becomes an outward expression of his inner self. This is why one designer designs one way, while another characteristically designs in another way.

The philosophy of design is a constantly evolving concept, or should be. Formulation and re-formulation should continually take place. However, this change should be gradual and evolutionary, not sudden and "way out", so to speak. One's aesthetic growth can be likened to an image on an oscilloscope. From time to time one deviates from the norm, goes out and tries new things; experiments. But the amplitude of this deviation in never too great, he must always build on what he had or did before. In examining a long segment of the oscilloscope pattern, i.e. in examining one's philosophy of design change over a long period of time, the end result might be quite radical when compared with the beginning condition, but the total change would be gradual, one step at a time. Naum Gabo has said:

Change is a good thing because an artist should not stagnate. He must constantly develop himself, but the artist cannot wear every day a different mask. ...an artist is bound to his personality, to his way of looking at things and he develops a certain vision, a certain point of view. During his lifetime he may undergo certain changes in the course of his development but there will always be left in his work that which is recognizably his personality, his character, and his contribution. ...In the life work of an artist there are certain stages, changes, as a sign of his development and growth, but it is not the radical kind of change which is demanded today. What is demanded today is more question of novelty than of real growth. This is a particular evil of our mercantile time and this should be condemned. An artist should fight against it and find strength in himself to pay no attention to this market-cry characteristic of our time but go on in his development without looking for so-called "periods".

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I first realized the true importance of having a recognizable philosophy of design while working on the R. T. French Competition for a decorative wall panel. At that time I wrote down a few notes in my sketch book, which, if reviewed now, might give some indication of the importance of a philosophy to me.

Projects such as the R. T. French decorative panel competition are much of a problem for me because I immediately start by thinking, "should this panel be sculptured, rather arty, or should it be sleek and industrial looking, like it was produced by an industrial designer. I immediately begin to try to imagine how it might look if done, on one hand, by artists like Moore, O'Keeffe and Calder or, on the other hand, by designers like Loewy or Eames. Now I realize that here is the crux of my problem.

I must formulate a philosophy of design, a way of attacking problems, of solving situations. I must make up my mind to be either a sculptor or a designer. This is the only way I can gain depth and meaning in my work. I must have a spirit about my work, no matter what the problem is, which personalizes it as mine; not that it must be cliche-ish, but that it must be the maturing of a way of thinking, a product of philosophical reasoning, a continuation of my feeling about how things should be built. 1

It is difficult for one to sit down and outline in so many words his philosophy of design. The concepts involved are rather nebulous and abstract. To analyze them as such would be lengthy and laborious. All philosophy is composed of generalizations rather than particular instances of the application of those generalizations. However, by examining very particular beliefs and processes of design, some indications of the general philosophy can be gained.

Everything that I said in the body of this thesis about structure, materials and the relationship of furniture to modern life reflects my philosophy of design. I would like to reiterate a few of these points. I believe a designer must at all times know his materials intimately, and sincerely respect them.

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I feel it imperative for a designer to become thoroughly familiar with at least one material as early in his career as possible. I think an intensive concentration in a single medium will teach the artist not only the nature, possibilities and limitations of that one material, but will allow him to better attack other media in as truthful and honest a way as possible. I feel one's art should reflect the spirit of the times, in this case the technological age. This spirit will affect everyone from architect to craftsman. The designer-craftsman must now be thoroughly familiar with all new processes, fasteners, and materials connected with his craft. He must make maximum use of machinery in developing his wares. The machine will be his servant, but not his master. He must be ingenious enough to make the machine do what he wants.

I believe one's design will reflect what type of a person he is. Given a sufficient amount of talent, an artist who is a basically honest and just person will probably produce an art with some worth. While given an equal amount of talent, a person with lower morals and standards will probably produce an art with lesser worth. Also is a designer is honest to himself and maintains his personal integrity, I feel his design will reflect his spirit and his backgound. For instance, I feel my design has been tremendously influenced by my previous training as an engineer.

I think a very important part of one's philosophy is what he thinks about designing and how he goes about designing. I feel that a designer must have personal contact with a design project. I could never be part of a design firm where someone works out a general concept and then gives it to another designer to smooth out the details and make it work. A designer must be constantly involved in the project. When I am designing something I think about it constantly, when eating or relaxing, as well as when working.
I find that during the process of designing a given thing, my enthusiasm constantly changes. At one time I may be totally disinterested in what I am doing, while at other times I can't even get to sleep at night. I measure the success or progress I am making by the degree of this enthusiasm. The personal involvement and enthusiasm which one has with a given project will, to a large extent, determine how successful his solution will be. I find I must be personally pleased with any solution in order to call it successful. I may come up with several possible solutions to a problem, any one of which might be acceptable to the average client. But unless I am personally pleased with it, I cannot consider it successful.

I believe designing is as much thinking as it is sketching, drawing or constructing. I think that a lot of thought must be directed toward any problem before any drawing is done. I often write many of these preliminary thoughts on paper to formulate them more clearly in my mind. These preliminary thoughts are concerned with things such as the function to be fulfilled by the design, the best way of approaching the problem, and broad schemes which could become solutions to the problem.

At some point in the design process I begin sketching ideas. This point is determined either by a spark of an idea conceived in the preliminary thinking stage, or else a complete lack of interest in doing any more "thinking" about a design. At any time during the designing process when I find my interest or enthusiasm dwindling, I have discovered that a change in media usually provides inspiration and motivation. If I have been only thinking, I try writing or drawing; if I was drawing, I try model-making.

My sketching is usually very simple, consisting of elevation views with occasional perspectives. I have found considerable difficulty in drawing and realize that it is one of my weak points to be improved upon. I think that through effective sketching ideas can be conceived and analyzed quickly and economically. Details and proportions can be worked out which
would be time consuming and expensive later in the design stage. From the sketching stage, I proceed to a scale mechanical drawing. Unless a working drawing is required, I usually draw only enough so that I myself know how to make the object. Working drawings are time consuming.

Depending on the project, I sometimes go into a model stage. This stage may come during or after the sketching stage and consist of balsa wood models to help me better visualize the product. Or it may consist of full sized mock-ups after the scale mechanical drawings are done. Usually in designing chairs, a model stage is used, but seldom in most other types of furniture.

Generally speaking, I like to get to working with the actual materials as quickly as possible. I can spend so much time on the drawing board and then I have exhausted my talent and enthusiasm for that kind of designing. Then I must see how the thing looks fully executed.

I should now like to present a design project which I believe will exemplify what I have said so far about my philosophy, particularly about my process of design.

This project the wall panel for the R. T. French Competition differs from my furniture project in several ways, which, I believe, warrant its review here:

1. It is an instance of designing for a specific environment and conditions.

2. There was no pre-conceived form to follow as there might be with a chair. The field was wide open.

3. It was a strictly decorative, non functional thing.

The "wall system," as I shall refer to it, was conceived while designing a wall panel for the R. T. French Competition. It was conceived, I believe, as a result of a thorough knowledge of the characteristics and behavior of solid wood.
This is an instance where, I believe, the material suggested, perhaps to an extent dictated, a solution to the problem. I truthfully do not feel I would have come up with this solution, had I not sincerely considered and respected my material.

I shall try to record briefly, as much as I can recognize the apparent indications, the process of conceiving this wall system.

Four or five months before I began work on the R. T. French wall, my sketchbooks indicate I spent some time playing with sketches of rectilinear planes, cutting into them to create interest. I progressed to where I was doing perspective sketches of rectilinear cubes, or cubes defined by a system of wires to form grids or modules, into which I cut or suspended shapes. These sketches began as a result of searching for background shapes for another sculptural wall (the "eye wall"), but progressed until I remember considering them as free standing metal sculptures, created within the above mentioned three dimensional grid. I remember being somewhat enthused with the sketches, but did not know immediately how to apply the idea.

Several months later, then, I was considering the R. T. French wall. Early I made up my mind that I wanted to work predominantly in wood, and probably unconsciously limited the consideration to solid wood, since I do not recall, nor do my sketchbooks reveal, any plywood, bent wood, or molded wood schemes. Another early decision was that the application called for a relief, or shallow three-dimensional solution. The dimensions of the room were such that few vantage points would show a strictly two-dimensional work off to advantage.

After many sketches and much thinking on both the spice and fish themes, which had been suggested by the company, I decided that a strictly non-objective solution was warranted. A relief from the employees' everyday contact with spices was sought, so why remind them of it by installing a mural using
spices as a theme. In the private cafeteria, little advertisement would be gained from such a mural. I also decided that the first theme was completely unjustified. No specific statistics were given as to how many people liked fishing; even if one hundred percent of the employees liked fishing, would this justify its use as a theme for a cafeteria mural? Certainly not.

And so I began to consider non-objective forms in solid wood. Naturally, one of my first thoughts when considering solid wood was how to cope with the expansion-contraction problem involved. This pre-occupation remained in my mind throughout the creative process.

Gradually I began thinking in terms of square modules of solid wood, mounted on the wall and creating a pattern in themselves. In the mounting consideration, I needed a system that would allow the modules to expand and contract freely. I felt that perhaps this mounting system could form an integral part of the design, not merely a mechanical fixing, hidden from sight so as not to detract from the design. I finally arrived at the system of horizontal rails, with the wood blocks slotted so as to be held between successive rails. Since the grain in the blocks would run in a vertical direction, the blocks could then expand or contract horizontally along the rails.

I first tried to super-impose a free-form pattern on the wood modules, so that the pattern would be most important, thus I would start with an abstract design on paper, arrange the blocks so that by cutting into them I could reproduce the pattern, then mounting this on the wall.

It is here where my earlier sketching work with the rectilinear planes and cubes became an influence. I now began thinking in terms of simply cutting into each block to make it interesting in itself, and then grouping these individual blocks on the wall. But I felt that the individual blocks
would have to be more positively related to each other to "work". Thus I decided to arrange the uncut blocks first into a pleasing design, and then, by cutting into the blocks, to relate one to the other, and in this way create an overall effect or pattern. The colored background came to mind when I decided that the wood shapes along would become monotonous, lacking vitality and interest.

After making one model (fig. 28) using only one wood and one solid color throughout, the suggestion was made that I might try using multi-hue color schemes, different kinds of wood, different depth of blocks, and also blocks with varying widths. The second study (fig. 29) a full size segment of a larger wall, was constructed in walnut, but an analogous color scheme was used. After this model was constructed, it was found that considerable interest and a secondary, subordinate pattern could be created by mis-aligning some of the background colors with respect to the foreground shapes, rather than having every background color relating directly to its wooden foreground shape. Obviously the relationship of all the elements to each other is extremely important. The color, texture and form of the background (i.e. wall), the color and placement of the colored modules, the texture and color of the metal rails, and finally the shape and texture of the wood foreground must all be compatible.
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