To the Graduate Council:

I am submitting herewith a thesis written by Louminda Roberts entitled "The Application of Anthropometric and Orthopedic Data in the Design and Construction of an Easy Chair." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Related Art, Crafts and Interior Design.

Walter J. Moran, Major Professor,

We have read this thesis
and recommend its acceptance:

Accepted for the Council:

Vice Chancellor
Graduate Studies and Research

THE APPLICATION OF ANTHROPOMETRIC AND ORTHOPEDIC DATA IN THE DESIGN AND CONSTRUCTION OF AN EASY CHAIR

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee

Louminda Roberts

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ABSTRACT

The purpose of this study was to design and construct an easy chair which would be comfortable to a large percentage of users and would be aesthetically pleasing. Research was conducted on anthropometric studies, physiologic and orthopedic literature, and seating comfort studies. The recommendations of these studies were then compiled and conclusions drawn by the researcher. Application of the data to the design made possible the determination of seating dimensions that would theoretically accommodate approximately 90 percent of the adult population.

A curvalinear, open form chair was chosen to complement the low, wide profile dictated by the required dimensions. The final form was altered slightly from the clay model which was built to a scale of one inch to one foot prior to construction of the prototype.

Further research was undertaken concerning materials and construction methods. The final prototype chair was constructed of triple wall corrugated fiberboard and coated with gloss polymer medium to increase its durability. The method of construction employed was a form of lamination which added to the strength of the unit. Fiberboard was chosen for its availability on the market, its ease of construction, and its ability to be recycled.

A small scale comfort study was conducted following

the construction of the chair. A group of 10 persons, randomly selected, sat in the chair for a minimum of 30 minutes. The results of the comfort study indicated that the chair was reasonably comfortable for the majority of the subjects.

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CHAPTER I

INTRODUCTION

"There is a position we call sitting that for all we know was not originally a part of man's intended repertoire of physical posture. Many physical ailments are direct by-products of this compromise position. The reason it is a compromise is that man in his native habitat functions best when he is either erect and moving, or supine and resting. Sitting is a cultural byproduct and, in many ways, counters the natural balance of physical man and his surroundings."[1]

Regardless of how bad the position may be for his body, man does sit and spends a major portion of his day in a seated position. This poses a major problem for the seating designer--to design a seating unit which will not only be pleasing to view but which will also be "good" for the sitter and therefore "comfortable" as well.

There is an overwhelming need in today's furniture market for well designed, informal seating. In a speech at the Los Angeles Home Furnishings Mart in 1971, consumer advocate, Ralph Nader, stated:

> Furniture is not designed on a human factor basis. It's designed on what is considered an esthetic basis, and for some reason, an esthetic basis always seems to include a sharp edge or point which does not

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[1]Industrial Design, XVII No. 8 (October, 1970), 44.

> adapt to the physiological tolerances of human beings.[2]

Research has shown this to be true of the majority of easy chairs (i.e. for the purpose of reading, relaxing, or conversation) which are on the market--many of which have been praised on the basis of their "design." They are the result of the designer's intuitive feeling for what he visualizes as a unique and pleasing form. Some forms of seating designed in this manner are categorized as Sitz Art--a pure form of applied art.[3] Thus, man and his physical needs have been cast aside for pure aesthetics.

Perhaps the problem was best described in an editorial by Sherman R. Emery:

> After many years of viewing and sampling seating design, we have come to the conclusion that the more attractive the design is to the eye the less comfortable it often is to the anatomy.[4]

Mr. Emery expressed feelings that "one of the main goals of ergonomics...is to provide greater compatibility between man and the tools with which he works."[5] Therefore, the end to which this study was conducted was to combine comfortable non-task seating with attractive design.

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[2]"Furniture Design," Interiors, CXXX (May, 1971), 38.

[3]Patricia Chapman, "Can Furniture Be Fine Art?" Furniture Design and Manufacturing, XLI (February, 1969), 38-40.

[4]Sherman R. Emery, Editorial, Interior Design, XLI (September, 1970), 97.

[5]Ibid.

1. STATEMENT OF THE PROBLEM

The purpose of this study was to design and construct a comfortable and attractive easy chair based on anthropometric, human factors engineering, and orthopedic data. Further, the purpose was to employ a relatively easy and financially feasible means of construction for the final prototype chair.

2. NEED FOR THE STUDY

A review of related literature revealed several seating studies concerning human factors but little application of the information to the actual design of seating pieces. Several studies were reviewed which dealt with the process for the design of seating. However, these studies showed little or no interest in human factors data. The need for this study lies in demonstrating the advantages of designing seating--specifically non-task--according to man's physical needs and well-being.

3. DELIMITATIONS

This study was limited to the design and construction of a non-task seating unit. Data for the dimensions were taken from the areas of anthropometrics, human factors engineering, and orthopedics. Construction methods and materials were kept as easy and as low cost as possible.

4. DEFINITIONS OF TERMS

Definitions of terms as used in the study are as follow:

Anthropometry - A branch of anthropology dealing with the measurements of the human body and its parts on a comparitive basis.[6]

Corrugated - Having layers of ridges and grooves between flat layers of material. Also called flutes.

Corrugated Fiberboard - Triple Wall - The structure formed by four flat facings and three intermediate corrugated members of paperboard.[7]

Ergonomics - Used here synonomously with human factors engineering.

Fiberboard - A material made by compressing fibers (as of wood) into stiff sheets.[8] Also called paperboard.

Human Factors Engineering - Application of information about human beings, their capabilities, their limitations to the design of equipment.[9]

Ischial Tuberosities - Bony protrusions on the underside

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[6]Thomas L. Stedman, Medical Dictionary, ed. Issav Asimov and others (21st ed.; Baltimore: The Williams and Wilkins Company, 1966), p. 102.

[7]100 Years U.S.A. - Fiberbox Handbook, Chicago: Fiber Box Association, 1971), p. 15.

[8]Webster's Seventh New Collegiate Dictionary (Springfield, Massachusetts: G. & C. Merriam Company, 1972), p. 309.

[9]Ernest J. McCormick, Human Factors Engineering (2nd ed.; New York: McGraw-Hill Book Company, 1964), p. 28.

of the pelvis.[10]

Easy Chair - A non-task seating unit for relaxing, reading, etc.

Lumbar - The part of the back and sides between the ribs and pelvis. The small of the back.[11]

Orthopedics - The study of ailments of the back and spine, including posture.

5. METHOD OF PROCEDURE

Dimensional recommendations for seating were taken from the various sources (anthropometrics, ergonomics, and orthopedics) and compared. From this information, it was possible to reach what was felt to be a satisfactory compromise and to develop basic measurement specifications for the easy chair. Appendix A lists the various dimensions recommended in the major sources and those recommended for the final seating unit.

Several types of plastic and corrugated fiberboard were researched as possible construction materials. Fiberboard was chosen for its availability, its lower cost when compared with plastic, and its strength and ease of construction.

Two scaled clay models of the chair were included in

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[10]Archie Kaplan, "Human Factors of Seating: Part I," Industrial Design, IX (November, 1962), 54.

[11]Stedman, p. 927.

the design process to enable the researcher to visualize the aesthetic qualities and feasibility of the form. The first model was discarded for its bulky appearance and squared edges. The second model proved more satisfactory with a more curvalinear form. The design was then altered slightly by cutting an opening through the back from side to side. (Appendix B). The final prototype was constructed after this latter model.

To determine the comfort of the chair, a small scale test was conducted. Ten subjects were asked to sit in the chair for a minimum of 30 minutes. They were then asked to fill out an evaluation form. Following the study, the responses were charted and compared. This test indicated that the chair was generally comfortable for the subjects. (See Appendix C).

CHAPTER II

REVIEW OF RELATED LITERATURE

". . . Human factors engineering involves the application of information about human beings and their capabilities and limitations to the design of equipment which people use and to the (artificial) environments within which people live and work."[1] However, all of this requires the availability of the appropriate information in connection with the particular problem involved and the willingness of the designer to incorporate the data. This information comes from two primary sources: experience and research, with experience probably being the principle source being used at present in seating design. Concerning this problem, Ernest McCormick stated the following:

> Although we grant that much information about human beings has been accumulated through experience, the primary source of information for use in human factors engineering comes through research. Much such information is already available, but unfortunately is not now being put to appropriate use.[2]

The application of human factors engineering in seating design was first seriously considered about the time of World War II. Some of the first studies were conducted by the United State military equipment designers in an effort

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[1]McCormick, p. 28.

[2]Ibid., pp, 29, 30.

to increase efficiency and to decrease fatigue. One study on the civilian side of the problem was conducted by Dr. Ernest A. Hooton in 1945 on railway coach seating.[3] An earlier study in 1940 by Lay and Fisher was carried out to aid in the design of automobile seats.[4] Finally, the first collection of human factors engineering data was published in 1955 by Henry Dreyfuss.[5] Since then, the area of human factors engineering has advanced at only a moderate pace. Nonetheless, it has brought to the present a quantity of data which is available for use by the modern designer.

For clarity, the data gathered in this study was divided into the following categories by the researcher: General Studies, Anthropometric Studies, Physiologic and Orthopedic Studies, and Comfort Studies. It was the purpose of this section to review the information provided by these studies.

General Studies

Several studies have been published about case histories of chair design development. An interesting similarity among these studies was that human factors data was not used. Many such studies included emphasis on innovative design, new

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[3]Dr. Ernest A. Hooton, A Survey in Seating (Westport: Greenwood Press, 1945), p. i.

[4]McCormick, p. 379.

[5]Henry Dreyfuss, The Measure of Man (2nd ed.; New York: Whitney Publications, Inc., 1967), p. 4.

materials, and new technological methods. In one case concerning a new seating collection by Charles Eames, the designer stated, "We've always been aware of not even attempting to solve the problem of how people should sit, but of rather arbitrarily accepting the way people do sit..."[6]

There were a few cases in which the designer spoke of concern for the sitter. A leading furniture designer stated, "...The human body is equipped by nature to stand up or lie down and...the seated position, man's own idea, is anatomically ridiculous."[7] He also noted that his central concern in design was to make the seated position stable and dignified. (No mention was made of his use of anthropometric data and/or measurements.)

Although a few more studies mentioned full scale models of seating units and of tests for comfort, nonetheless, most designs--according to studies researched--were found to be the result of designer intuition with major emphasis being placed on technological and aesthetic developments.

Anthropometric Studies

Anthropometry is one part of the field of physical anthropology. It is based on the measurement of various parts of the body, including linear dimensions, circumference

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[6]"3 Chairs: 3 Records of the Design Process," Interiors, CXVII (April, 1958), 118.

[7]"Hans Wegner," Interiors, CXVII (February, 1959), 84.

and weight.[8] This was the basis for the majority of related studies from which much of the data for this problem was collected.

In the 1940 study by Lay and Fisher, an elaborate adjustable chair, known as the "universal test seat," was tested by approximately 250 people. Not only were preferred dimensions and angles recorded, but also the average loads on the various springs of the back and seat were given. The study was carried out to aid in the design of automobile seats. Although the relevance to chair design is suggested, it should be noted that the design of an automobile seat is a compromise between the driver's need to perform his duties and the passenger's desire to relax.[9] The measurements resulting from this study bear out this compromise in relation to the major sources used in the project at hand, therefore they were not included in the relevant data.

The Hooton survey on passenger seating used another adjustable seat, built by Heywood-Wakefield Company. Hooton measured 3800 people constituting a fairly representative sample of the adult population of the United States. The major concern of the study being the physical comfort of people during long distance travel, Hooton's procedure consisted of: (1) taking eight measurements on each indi-

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[8]McCormick, p. 350.

[9]Ibid., pp. 377-380.

vidual, (2) reducing these measurements statistically, and (3) making recommendations pertaining to the design of the seats.

Due to the necessity of confining seating in railway coaches to small areas, Hooton, like Lay and Fisher, had to make certain compromises. Although his dimensional specifications were felt to be unsatisfactory for this study, certain other recommendations by him were valuable.

In regard to seat pan height, Dr. Hooton made note that it should be an absolute minimum for reasons that, if a seat is too high, it causes pressure on the popliteal area under the thigh cutting off proper blood circulation to the legs bringing about discomfort and/or numbness. It is much easier for a long legged person to sit comfortably in a low seat than for a shorter legged person to sit in a higher seat.[10]

One of the leading researchers in the field of industrial design was Henry Dreyfuss of Henry Dreyfuss Associates. Since the 1930's, this firm has been compiling human factors data for numerous working and resting positions. To do this, they adopted a system of "percentiles" dividing the American population from Percentile 1, the smallest possible frame, to Percentile 100, the largest possible frame. Omitting Percentiles 1 to 5 and 96 to 100 as extremely rare, they

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[10]Hooton, pp. 3-5; 11.

constructed male and female prototypes representing 90 percent of the American adult population and fitted them into the various working and relaxing positions. One important point made by Dreyfuss was that "working with percentiles involves some obvious compromises."[11] Nevertheless, the data published, especially that on the "Executive and Casual Chair," proved valuable in this design study.

Anthropometrics for Designers by John Croney was another major source of data. In it Croney recommended dimensions for general and leisure seating which he obtained by comparing findings of British and American surveys with his own.[12] Croney's recommendations can be found in Appendix A.

An extensive survey of seating and human measurement was made by Clara Ridder of the University of Arkansas. Her study concerned the three basic types of sitting: erect position, less erect position, and relaxed position. (The data on the less erect position were used for this study.) Her experimentation was conducted with an adjustable chair which was fitted to each individual as that individual desired it to be. Measurements were taken and fitted into percentiles.

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[11]"Tayloring a Produce to Fit," Industrial Design, XII (June, 1960), 69.

[12]John Croney, Anthropometrics for Designers (New York: Van Nostrand Reinhold Company, 1971), pp. 10; 143-153.

Concerning human measurement, the authors of Nomadic Furniture were highly sceptical of the value of the information which was available. They stated the following:

> It has become so popular to measure ourselves, that in 25 short years we have escalated that simple statistic activity from "human measure" to "human factors," to "human engineering" and finally cloaked this frenetic bookkeeping under the pseudo-scientific mantle of "anthropometrics" and "ergonomics"!
>
> ...We still lack basic size statistics for women, children, babies, the elderly, the obese, and the inhabitants of the so-called "third world." This is easy to understand, when we recall that most measuring has been done on members of various military and naval units only, and since 1942 at that.[13]

(This researcher is not in complete agreement with their statement regarding measurements by military and naval units only; however, it is true that much statistical information is lacking regarding persons other than white Americans.)

Physiologic and Orthopedic Studies

In a 1958 study for the British Standards Institute's Advisory Committee on Anthropometric Evidence for Equipment Design by W. F. Floyd and D. F. Roberts, many previous studies were drawn together and evaluated. Their conclusions are as follow:

1. In sitting, changes of posture are important. A good chair should permit this.

2. In sitting, the weight of the trunk should be borne

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[13]James Hennessey and Victor Papanek, Nomadic Furniture (New York: Pantheon Books, 1973), pp. 5, 6.

by the ischial tuberosities. The thighs are unsuited for supporting the body weight.

3. Therefore, the height of a chair seat should be no more than the length of the lower leg of the shortest person who will use the chair.

4. The maximum seat depth should be determined by the length of the thighs of the shortest persons using the chair.

5. A substantially plane seat pan is preferable to one shaped or moulded to fit the buttocks. A backward slope of up to five degrees may be suitable for some purposes.

6. No horizontal struts or other obstructions should be placed between the front legs of a chair due to the mechanics of rising from the seat.

In closing the study, Floyd and Roberts stated that designers of seating should remember to allow for the most people possible and that posture is not as static as recommendations might imply.[14]

Weight distribution, muscle control, and posture are all contributing factors to physical comfort while seated. McCormick cited studies by Lay and Fisher, Hertzberg, and the United States Air Force concerning weight distribution factors but gave no indication as to application of the data provided.[15]

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[14]W. F. F.oyd and D. F. Roberts, "Anatomical and Physiological Principles in Chair and Table Design," Ergonomics, II, 1 (1958), 2; 13; 14.

[15]McCormick, pp. 378, 379.

The voluntary muscles generally perform two functions: execute movements and maintain a position. If the body is seated in an erect position, more muscle control is required than if the trunk of the body is sloped backward at an angle. To reduce muscle power and muscle fatigue, McCormick drew upon data from Lay and Fisher for desired seating angles. The average seat pan angle was 6.4 degrees from the horizontal with the total angle of the back support plane being 111.7 degrees from the horizontal.[16] Other data concerning slope can be found in Appendix A.

A book by Dr. Fahrni emphasizes the importance of orthopedics in chair design. He points out that the curves of the spine are the parts which receive the greatest strain and damage. In his study of primative man, unschooled in the classic "stand up straight," he found the lumbar curve (small of the back) much less pronounced than in civilized, modern man. To avoid further pronunciation of this curvature and increased pressure on the discs involved, Fahrni recommended avoiding deeply sprung chairs in preference to firmer seats and suggested assuming a more slumped seating position.[17]

For a design project of an aircraft chair for American Airlines conducted by Henry Dreyfuss Associates, Dr. Janet

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[16] Ibid., p. 379.

[17] Fahrni, p. 27.

Travell was consulted as a specialist in physiology. Although it must be noted that aircraft seating is highly specialized and confined to a limited space, several important requirements were brought up. The first requirement was that shoulders should rest against a reasonably flat surface to avoid rolling the shoulders forward and compressing the lungs. Secondly, wide angles at the hip and knee joints are more desirable than tighter angles (greater than 90 degrees). Other factors already discussed were reinforced by Dr. Travell's recommendations.[18]

Comfort Studies

"...What is comfort...and how much of this is real and how much imagined?...In other words, can comfort be measured solely in anatomical terms?" Unfortunately, there are no absolute answers to these questions as man is the result of a "complicated conditioning process."[19] However, several studies have been conducted in hope of finding some of the answers.

One such study was by C. Walsh of the Furniture Industry Research Association. The main objective of his study "was to arrive at a set of figures which would enable the designer to meet the comfort requirements (relating, of course, to

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[18]Neils Diffrient, "Design With Backbone," Industrial Design, XVII, No. 8 (October, 1970), 45.

[19]"The Design Process," Industrial Design, XIX, No. 9 (November, 1972), 61.

physical chair dimensions) of a large proportion of users."[20]

In Walsh's study, as in many others, an adjustable chair was designed for use by the sample group. The subjects consisted of 10 men and 10 women between 18 and 58 years of age with an average stature of 5 feet 6.2 inches. The subjects were then divided into two groups, one of which sat in the chair for three hours and the other sat for 30 minutes during which time the chair could be adjusted to the dimensions desired by the sitter.

The results of Walsh's study showed no significant differences in preferred dimensions (1) for reading as opposed to watching television, (2) for duration of sitting, (3) between taller and shorter sitters, and (4) between older and younger sitters.[21] The major difference was found between the seated postures of men and of women resulting in differences in the preferred backrest to seat angle. This was due to the finding that men preferred lounging positions with legs outstretched to women's more upright posture. The dimensional results may be found in Appendix A.

A similar study of Le Carpentier published in 1969 utilized a similar adjustable chair and another 20 subjects. The subjects were again divided into two groups and asked

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[20]C. Walsh, "The Dimensions Which Affect the Comfort of Easy Chairs," Furniture Industry Research Bulletin, XXV (March, 1969), 7.

[21]Ibid., p. 8.

to rate the unit over a set period of time (5, 10, or 20 minutes) while reading or watching television. As the results were so similar to those of Walsh, Le Carpentier came to the conclusion that "the absence of correlation between the preferred dimensions and the corresponding anthropometric measurements for seat height and seat depth suggests that the significant negative correlation between preferred seat height and preferred seat depth was due to personal choice factors other than the simple anthropometric ones."[22]

Another comfort study undertaken by Wachsler and Learner of the General Motors Research Laboratories was concerned with a description of the factor structure of several criteria of seat comfort or discomfort. They took their data from a study by Slechta in 1957 and identified and compared eleven criteria from sitting time to average discomfort of specific parts of the body. Results indicated that comfort ratings after a short period produced essentially the same results as ratings after four hours of sitting. The researchers felt that "this correlation permits us to predict fairly long term effects of sitting in a seat on the basis of a relatively short time sample."[23]

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[22]E. T. Le Carpentier, "Easy Chair Dimensions for Comfort - A Subjective Approach," Ergonomics, XII, 2 (1969), 334.

[23]Robert A. Wachsler and David B. Learner, "An Analysis of Some Factors Influencing Seat Comfort," Ergonomics, III, 4 (October, 1960), 315; 319.

D. M. Barkla, another researcher associated with the Furniture Industry Research Association, conducted a comfort study along similar lines of the studies by Walsh and Le Carpentier. An adjustable chair was provided for the 48 male subjects who were to sit and read for periods of three, five, and 30 minutes and then rate the chair for comfort. After compiling the results, Barkla concluded that ratings after 30 minutes were more reliable than those after the shorter periods.[24]

Conclusions

"During the past fifteen years, the words 'human engineering' and 'human factors' have loomed larger and larger in the designer's vocabulary. There has been so much human engineering talk that we are sometimes in danger of forgetting that the industrial designer is still an artist. From a mere tool - just one vital part of the designer's stock-in-trade - human engineering has been exaggerated into a cure-all for the designer's problems. In reality, it is no cure-all, but simply a valuable tool...Human engineering is no substitute for esthetic judgement."[25]

The sources reviewed were valuable but often in conflict on those dimensions relating to easy chairs. Appendix A

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[24]D. M. Barkla, "Chair Angles, Duration of Sitting, and Comfort Ratings," Ergonomics, VII (1964), 303.

[25]"Tayloring a Product to Fit," p. 69.

gives the dimensions from the sources and the researcher's conclusions and final dimensions that were used for the chair design.

CHAPTER III

PRESENTATION

The purpose of this study was to design and build an easy chair which was both anthropometrically correct for a large number of persons and aesthetically pleasing. Primary emphasis was placed on human factors with the form of the unit being relative to the necessary dimensions.

The sources reviewed provided valuable data applicable to the design. Of these, three anthropometric and two comfort studies proved to be the most usable: Anthropometrics for Designers, John Croney; The Measure of Man, Henry Dreyfuss; "Basic Design Measurements for Sitting," Clara Ridder; "The Dimensions Which Affect the Comfort of Easy Chairs," C. Walsh; and "Easy Chair Dimensions for Comfort - A Subjective Approach," E. F. Le Carpentier.

Although the sources were not in complete agreement, logical compromises were determined. Appendix A compares the recommendations for the sources concerning seat pan height, backrest plane height, seat pan width, backrest plane width, seat pan depth, seat pan angle, backrest plane angle, seat pan contour, backrest plane contour, seat pan padding, seat pan covering, and armrest height. The researcher's recommendations and conclusions are also included. The dimensions used in the final chair design are as follow:

Seat pan height	15.0 inches
Backrest plane height	25.0 inches
Seat pan width	21.0 inches
Backrest plane width	29.0 inches
Seat pan depth	18.5 inches
Seat pan angle	5.0 degrees from the horizontal
Backrest plane angle	115.0 degrees from the horizontal
Seat pan contour	flat
Backrest plane contour	flat

The recommended dimensions listed above denote a low, wide chair which posed a special design problem. The major problem encountered was to avoid making the chair appear too heavy and bulky. After making sketches and scale drawings as well as clay models, the researcher decided upon a curvalinear design with an open center through the chair. This design gave the chair a lighter, less bulky appearance and fulfilled the aesthetic criteria.

To determine the material(s) to be used in the construction of the easy chair, several different avenues were investigated. At first it was considered that plastic would be the most desirable medium for the chair. To this end research was undertaken including conferences with Mr. Francis Schantz of Rohm and Haas Plastics and with Mr. George Mitchell of Overman Incorporated. It was finally decided that, due to difficult construction and forming methods involving

expensive and complicated machinery, construction of the chair with plastic of any type was beyond the capabilities and finances of the researcher. However, it is felt that if the chair were ever manufactured for the retail market its design features would be developed to their best advantage in some type of plastic.

The material chosen for the final construction was triple wall corrugated fiberboard. The board was constructed of seven sheets of paperboard combined as follows: a facing, a corrugated member, an inner facing, a corrugated member, an inner facing, a corrugated member, and a facing. The entire sheet measured 1/2 inch thick. As the flutes or corrugations were available in different heights and weights which related directly to the strength of the board, it was necessary to choose the best combination for the project. Type A corrugations number 36 ± 3 flutes per linear foot and are approximately 3/16 inches high. Type B number 50 ± 3 flutes per linear foot and are approximately 3/32 inches high. Type C number 42 ± 3 flutes per linear foot and are approximately 9/64 inches high.[1] Type E flutes were also available but were not satisfactory for this situation. A combination of B-C-A, respectively, was chosen for each sheet of fiberboard. Each layer of corrugation as well as each facing and inner facing had a basis weight of 33. (The

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[1] 100 Years USA - Fiberbox Handbook, p. 16.

weight of corrugating medium is expressed as basis weight in terms of pounds per 1,000 square feet.)[2] The entire sheet of fiberboard measured a puncture test of 1,100 pounds per square inch.

The construction material was chosen for its availability on the market, its ease of construction relative to other methods researched, and its qualifications for recycling when disposed of. This latter amenity would be valuable during mass production as any waste would be recycled for further use rather than being destroyed.

When adapting the design of the chair to the material chosen, the strength properties of the fiberboard were studied closely. The strength of the board is highly dependent upon the direction of the flutes or grain. Therefore by causing the weight to be borne by the flutes perpendicular to the horizontal through proper construction, the maximum strength capabilities of the board were utilized.[3]

For the construction of the chair, a full scale pattern was made of the profile - one for the arms and one for the seat. After two 40 inch by 40 inch sheets of the board were glued together with water base glue, the pattern was traced onto the board. The profile was then cut out using a saber saw with a knife blade to prevent ripping the edges of the

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[2] Ibid., p. 14.

[3] Tri-Wall Containers, Inc., E.M.S. Division, "Cardboard Carpentry," (Revised May 20, 1969).

board. This process was repeated until enough sheets were cut out to form the arms and seat of the chair. The sheets were next layed flat, one on top of the other, and glued together with a water base glue and weighted from above.

Once the unit was firmly glued, it was noted that a slight unevenness existed due to the cutting process. The chair was then sanded with #16 and #36 sanding belts for a smooth even appearance. To protect the material from wear and from spilled liquids, gloss polymer medium was applied in several layers as a finishing coat. Photographs of the final seating unit may be found in Appendix B.

Testing of the chair was undertaken to determine whether the application of the anthropometric and orthopedic data had resulted in a relatively comfortable seating unit. Due to the nature of this thesis, the comfort study was felt to be of secondary importance giving only an indication of the comfort or discomfort of the chair. Therefore, the scale of the comfort study was kept small and in-depth analysis of the results was not undertaken.

Ten subjects, randomly selected, were asked to sit in the chair for 30 minutes. During this time they were allowed to read, talk, or participate in any activity which would be suitable to sitting in an easy chair. The subjects were not allowed to take a break from sitting.

The subjects consisted of six men and four women ranging in age from 19 years to 29 years. The height of the men

was 5'7½", 5'8", 5'9½", 6'3", 6'3", and 6'3" with their weights being 145, 191, 150, 213, 187, and 203 pounds respectively. The height of the women was 5'3", 5'8", 5'8", and 5'10" with their weights being 122, 127, 110, and 155 pounds respectively.

The subjects were next asked to fill in a Comfort Study Questionnaire. In it they were to give their height, weight, sex, and age. They were then to rate the chair according to general comfort, body area comfort, and chair feature comfort. They were also asked to note any improvements which they might recomment.

Of the 10 subjects, five persons made a total of seven requests for dimensional changes. One male subject (5'7½") asked that the seat pan be raised and that the seat pan and backrest angles be increased. Another male subject (6'3") asked that the height of the backrest be raised for more support of the neck. A third male subject (5'9½") whose stocky build made his arms appear shorter than normal asked that the arm rests be raised. One female subject (5'10") and one male subject (6'3") also requested that the seat pan be raised. Three other subjects requested a seat pad.

These responses point to the difficulty encountered in designing a comfortable chair for a large number of people, each having both physiological and psychological needs which must be met. The comfort study indicated that the chair was reasonably but not perfectly comfortable to the subjects.

CHAPTER IV

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

1. SUMMARY

The purpose of this study was to design and construct an easy chair which would be attractive and reasonably comfortable for a large number of users. This involved the application of anthropometric, orthopedic, ergonomic, and other related data to the design process. Also researched were materials and construction methods. The chair was to be suitable for reading, relaxing, and conversation.

Three major anthropometric studies and two comfort studies were found to provide the most valuable information of the studies researched. By comparing the recommendations of the sources, dimensions were derived for the final design. These dimensions should theoretically be suitable for approximately 90 percent of the population.

To determine the form of the chair, drawings and two clay models were made prior to construction. The clay models of the chair were made to the scale of one inch to one foot. The full size prototype model was altered slightly from the last clay model. The final form of the chair was designed utilizing a curvalinear form.

Following an investigation of low cost materials and construction methods, the chair was constructed of triple wall

fiberboard of adequate strength and durability. After the chair was completed a small scale comfort study test was conducted. This comfort study indicated that the chair was reasonably comfortable for the ten subjects but the study was not large enough to give conclusive evidence supporting the theory that the chair should be comfortable to 90 percent of the adult American population.

2. CONCLUSIONS AND RECOMMENDATIONS

It is felt that the chair which was designed and constructed in this study adequately meets the requirements of measurements, comfort, and aesthetics as set forth earlier in this thesis. However, several problems were encountered which could give rise to further research.

One difficulty encountered by this researcher concerned the nature of the anthropometric data. It was found that among the sources there were no standard procedures for taking the measurements of the subjects. There was also noted a lack of measurement data on races and nationalities other than white Americans.

Another problem encountered concerned the comfort studies. Comfort is a nebulous term which cannot be measured in specific quantities. This is, in all probability, due to the fact that comfort is relative to the user. The study by Barkla listed seven ratings for comfort among which the subjects were to choose (couldn't feel more satisfactory, quite satisfactory,

fairly satisfactory, only just satisfactory, unsatisfactory, acutely unsatisfactory, couldn't feel more unsatisfactory).[1] The Le Carpentier study listed three ratings (most comfortable, just noticeably less comfortable, decidedly less comfortable).[2] Neither of the researchers used similar methodologies.

The information found in the various data sources was valuable up to a point, but methodology was inconsistent as were measurement techniques. It is to be hoped that, as this approach to design gains approval, a more scientific methodology will be adopted and the data resulting will, in turn, prove more valuable.

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[1]Barkla, p. 300.

[2]Le Carpentier, p. 330.

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APPENDICES

APPENDIX A

TABLE I

EASY CHAIR DIMENSIONS--COMPARISON OF STUDIES

	Croney	Dreyfuss	Ridder	Le Carpentier	Walsh
Seat height (inches)	Min.=15.0	14.0-15.0	Front lowest point=14.7 Front highest point=15.7	15.0	15.0
Backrest height (inches)	20.0-25.0 for shoulder support (25.0=95% men)	Min.=17.0 Max.=24.0	21.0	21.0	21.0
Seat width (inches)	Min.=17.0 (w/out arms) Optimum=18.0	19.0	Min.=17.0 (if sides partially enclosed)	21.0	---
Width of Back (inches)	20.0 or more (95% men)	---	Min.=14.0 at top (does not allow for position change)	21.0	---
Seat depth (inches)	20.0 when front height=14.0	Max.=18.0	18.5	18.5	18.5
Seat angle (degrees)	5.0-7.0	3.0-5.0	5.0	10.5	10.5
Backrest angle (degrees)	110-120.0	108-110.0	115.0	120.5	120.5
Seat Contour	Not sculptured	Flat, roll edges to increase comfort	Padded or molded to provide depression	---	---

TABLE I (continued)

	Croney	Dreyfuss	Ridder	Le Carpentier	Walsh
Back Contour	Radius= 2½ seat lengths (45")	---	Table 19[1]	---	---
Seat Pad	.5" depression in padded seat	.75" pad	---	3" pad on rubber strap web (2" on back)	"grades" of polyether foam
Seat Covering	Soft	Warm, absorbent, not too textured	---	Moquette* used on test chair	Moquette* used on test chair
Arm height (inches)	Best=8.0 Min.=7.5 Max.=10.0	Max.=8.5	8.5 from flat seat surface	6.5 unloaded 8.5 loaded	6.5 unloaded

*Upholstery fabric: 50% cotton and 50% wool, velvet-like.

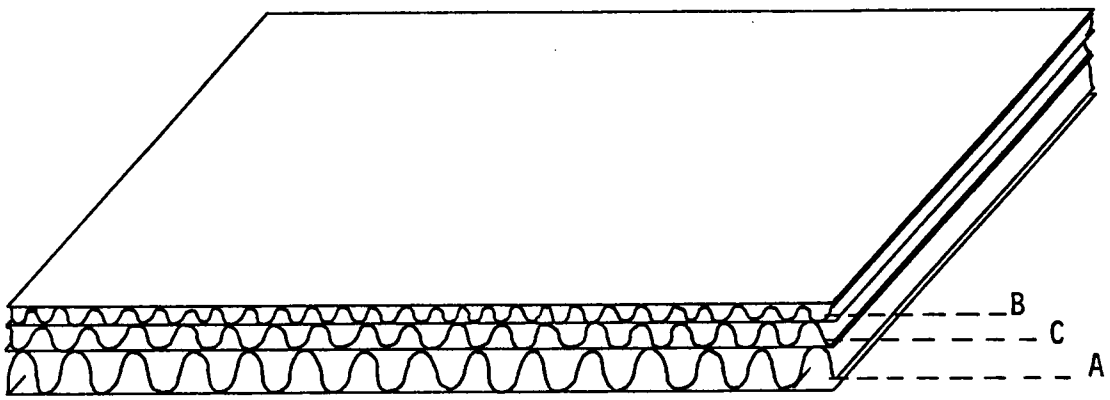
[1]Ridder, p. 79.

TABLE I (continued)

Chair Feature	Dimensions Derived for Final Chair Design
Seat height:	Optimum = 15.0 inches--all sources agree in close proximity to each other. Ridder used a molded seat thereby resulting in high and low dimensions.
Backrest height:	Optimum = 21.0 inches to center of neck rest for best shoulder support. 25.0 will accommodate 95% of the men therefore chosen for final design.
Seat width:	Optimum = 19.0 inches--will allow for easy position shifts in chair with armrests. 21.0 inches chosen for final design for maximum comfort.
Width of Backrest:	Optimum = 20.0 inches or more for greater degree of comfort. 29.0 inches used in final design--dependent upon seat width.
Seat depth:	Optimum = 18.5 inches.
Seat angle:	Optimum = 5.0 degrees from the horizontal.
Backrest angle:	Optimum = 115.0 degrees from the horizontal.
Seat contour:	Optimum = flat contour with firm foam pad if applicable to the design.
Back contour:	Optimum = flat or with a radius of 45 inches.
Seat padding:	Optimum = firm pad allowing .5 inch depression under normal stress.
Seat covering:	Optimum = soft, absorbent, giving ventilation.
Arm height:	Optimum = 8.5 inches from seat pan surface.

APPENDIX B

FINAL CHAIR DESIGN



B = 3/32" high
C = 9/64" high
A = 3/16" high

NTS

Figure 1. Cross section of triple wall corrugated fiberboard showing the different fluting heights.

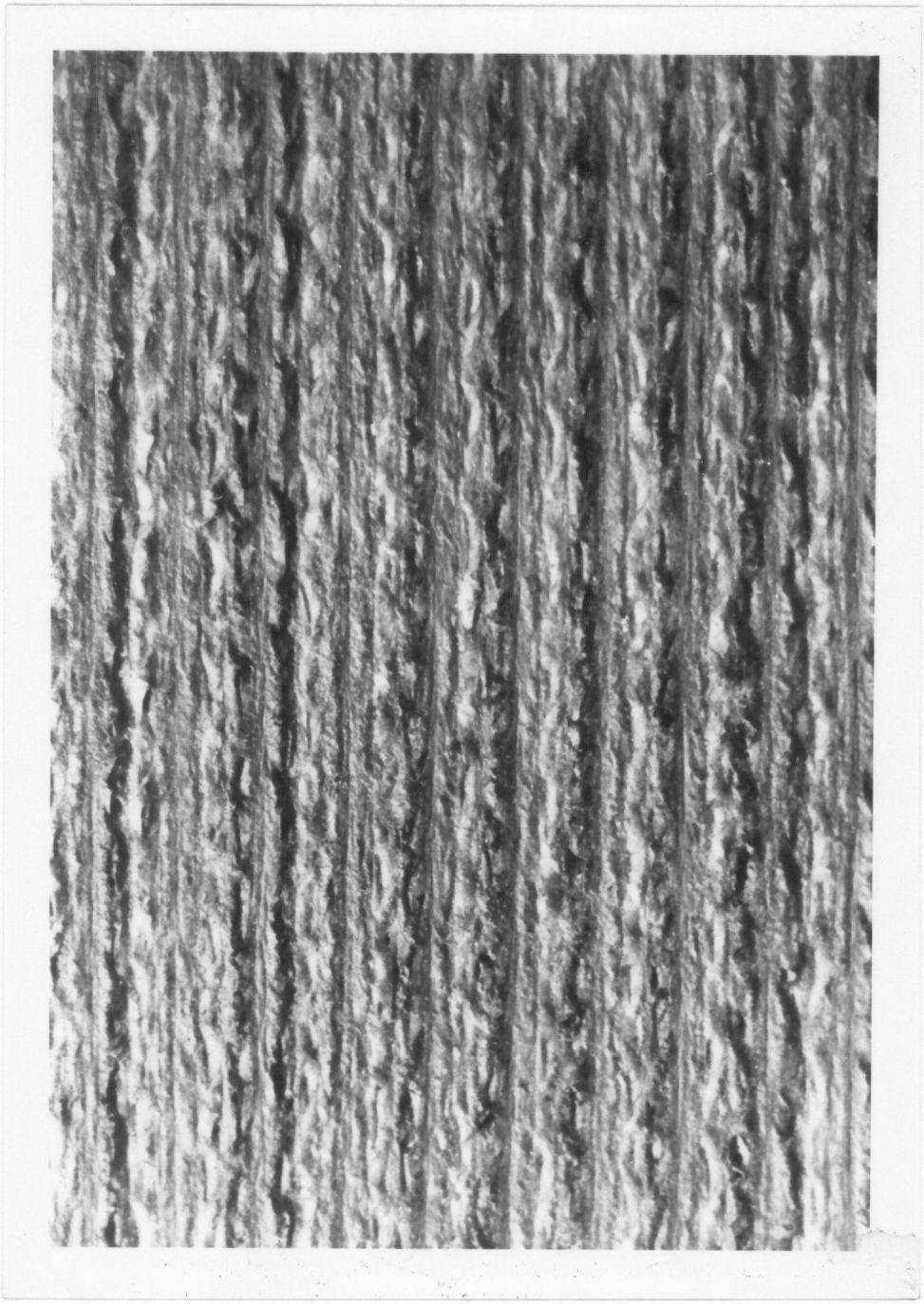


Figure 2. Texture of the fiberboard surface resulting from the sanding process prior to application of the polymer medium.

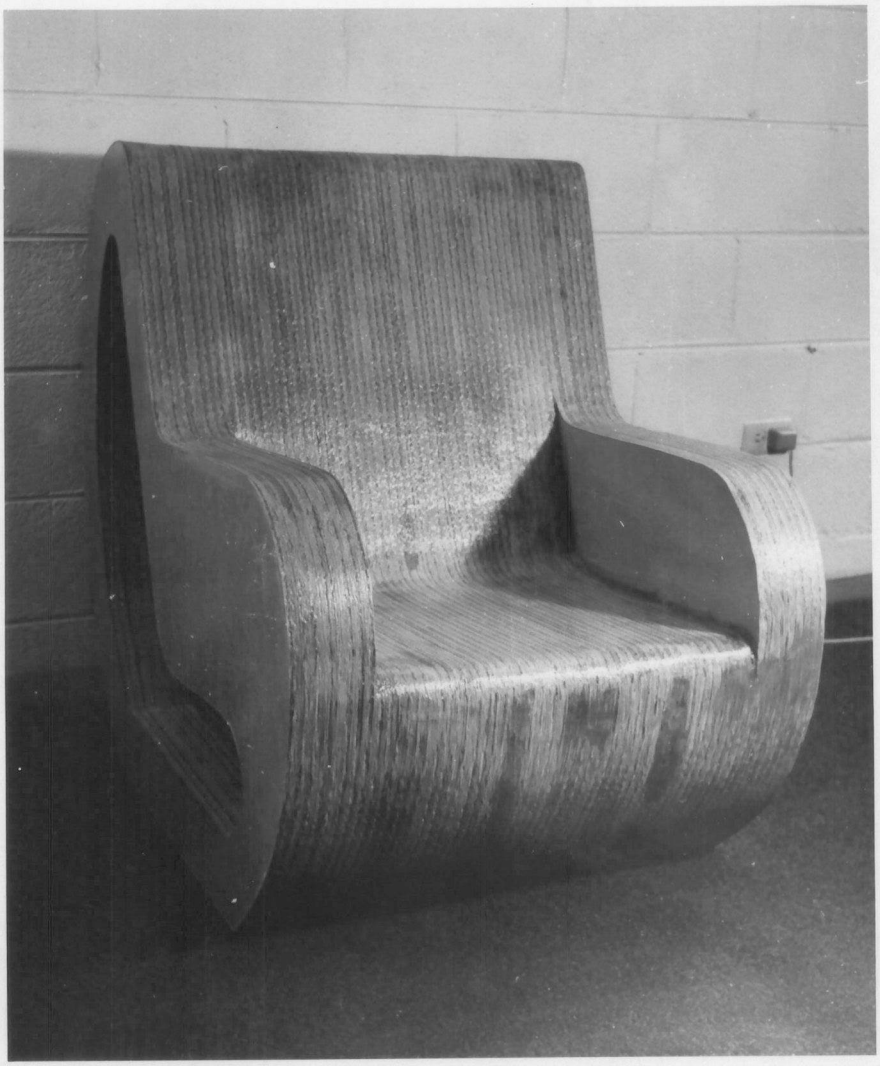


Figure 3. Prototype model, front.



Figure 4. Prototype model, side.

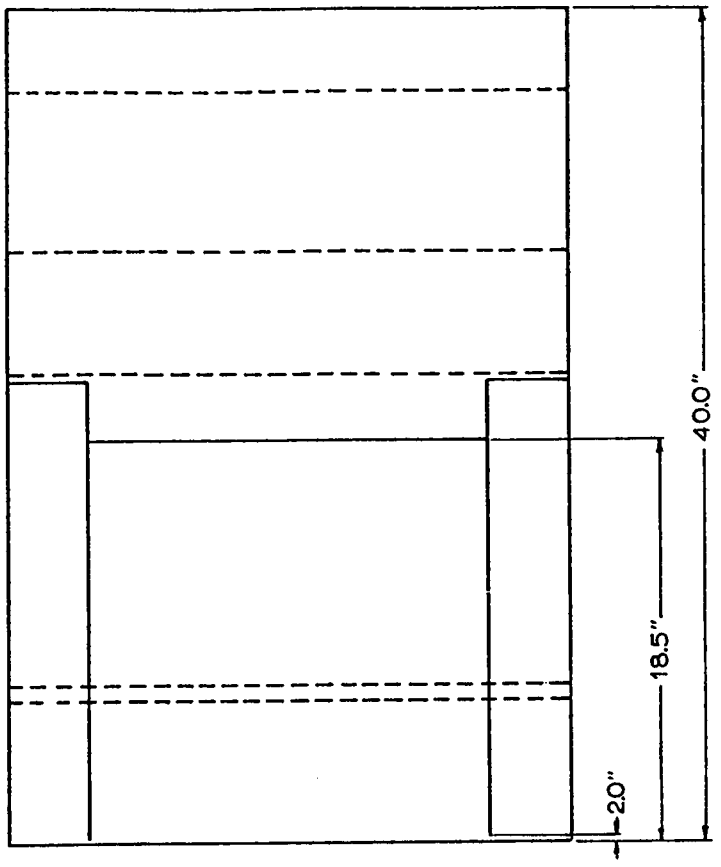


Figure 5. Diagram of the chair, top view.

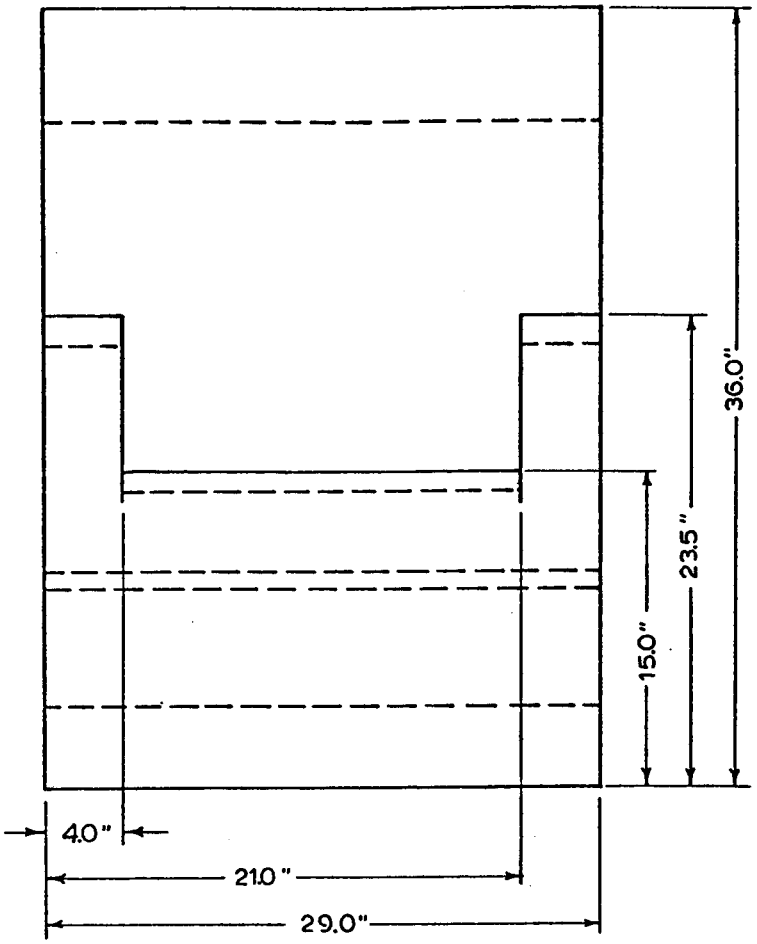


Figure 6. Diagram of the chair, front view.

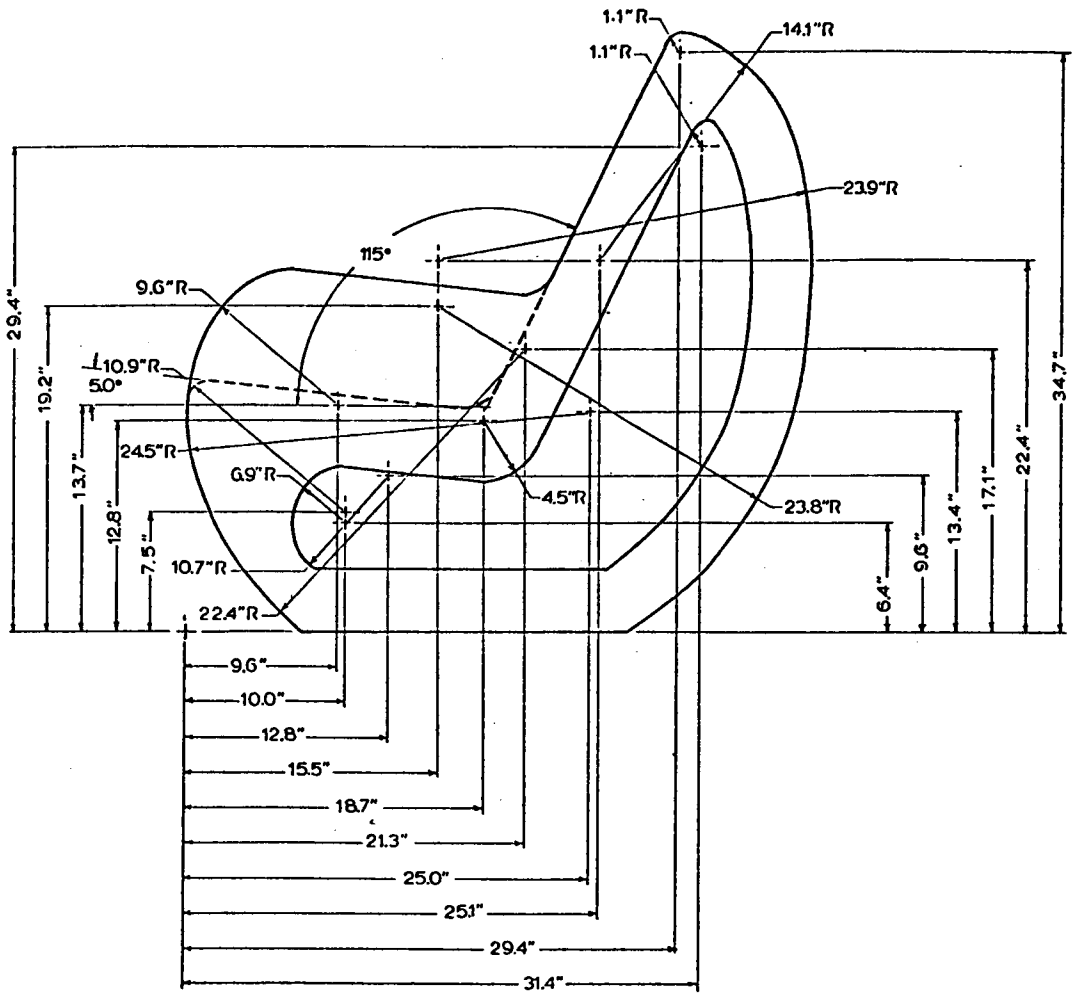


Figure 7. Diagram of the chair, side view.

APPENDIX C

COMFORT STUDY QUESTIONNAIRE

DATE_____

SUBJECT:

AGE_____SEX_____

WEIGHT_____HEIGHT_____

TIME PERIOD: From_____To_____TOTAL TIME_____

ACTIVITIES WHILE SEATED

_____

_____

EVALUATION:

1. During the test period, the chair unit was felt to be (check one)

   _____Comfortable

   _____Uncomfortable

   _____No opinion

2. Was any particular part of your body more or less comfortable than the rest? Explain. (check one or more)

   _____Under thighs _____

   _____Buttocks _____

   _____Lower back _____

   _____Shoulders _____

   _____Neck _____

   _____No opinion _____

3. Was any part of the chair uncomfortable to you? Explain. (check one or more)

_____Height of seat pan _____

_____

_____Depth of seat pan _____

_____

_____Width of seat pan _____

_____

_____Height of backrest _____

_____

_____Height of arms _____

_____

_____Slope of seat pan _____

_____

_____Slope of backrest _____

_____

_____Other _____

_____

4. What feature(s) of the chair would you like to change? Explain.

_____Height of seat pan _____

_____Depth of seat pan _____

_____Width of seat pan _____

_____Height of backrest _____

_____Height of armrests _____

_____Slope of seat pan _____

_____Slope of backrest _____

4. Continuation of question 4.

_____Other _____

_____

TABLE II

CLASSIFICATION OF SUBJECTS AND TESTING TIME

Subjects	Number	Age Range	Avg. Age	Height Range	Avg. Height	Weight Range	Avg. Weight
Women	4	21 to 29	23.5	5'3" - 5'10"	5'7"	110 - 155 lb	128.5 lb
Men	6	19 to 26	22.6	5'7½" - 6'3"	5'11"	145 - 213 lb	181.5 lb

Testing Period	Range	Avg. Sitting Time	Activities
Total sitting time	29 - 48 minutes	33.7 minutes	talking, smoking

TABLE III

EVALUATION OF CHAIR FEATURES

Chair Feature	Number Comfortable		Number Uncomfortable		Reasons for Discomfort
	Male	Female	Male	Female	
Height of Seat Pan	4	3	2	1	Too low
Depth of Seat Pan	6	4			
Width of Seat Pan	6	4			
Backrest Height	5	4	1		Too low
Height of Arms	5	4	1		Too low
Seat Pan Slope	5	4	1		Not enough
Backrest Slope	5	4	1		Not enough
Seat Plane	4	3	2	1	Needs pad
Overall Chair	6	4			

VITA

Louminda Roberts was born in Nashville, Tennessee on August 5, 1949. She was graduated from David Lipscomb High School in Nashville in June of 1967 and entered David Lipscomb College in September of that same year. After two years, she transferred in September of 1969 to the University of Tennessee Knoxville. In June, 1971, she received a Bachelor of Science degree in Related Art, Crafts and Interior Design with emphasis in interior design. During one year of professional contract interior design work in Nashville, Tennessee she attended evening school at the University of Tennessee Nashville in the Department of Fine Arts. In September of 1972 she returned to the University of Tennessee Knoxville in the Department of Related Art, Crafts and Interior Design in the College of Home Economics. She received her Master of Science degree in June, 1974.